APPENDIX A

Final Regulatory Flexibility Analysis and Regulatory Impact Review

Regulatory Impact Review and Final Regulatory Flexibility Analysis

Management Measures to Implement New Technologies for the Western Pacific Pelagic Longline Fisheries

A Regulatory Amendment to the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region

March 5, 2004

I. INTRODUCTION

In order to meet the requirements of Executive Order 12866 (EO 12866) the National Marine Fisheries Service (NMFS) requires that a Regulatory Impact Review (RIR) be prepared for all regulatory actions that are of public interest. This review provides an overview of the problem, policy objectives, and anticipated impacts of regulatory actions, and ensures that management alternatives are systematically and comprehensively evaluated such that the public welfare can be enhanced in the most efficient and cost effective way.

(1) This rule is not likely to have an annual effect on the economy of more $100 million or to adversely affect in a material way the economy, a sector of the economy, productivity, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) This rule is not likely to create any serious inconsistencies or otherwise interfere with any action taken or planned by another agency; (3) This rule is not likely to materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; and (4) This rule is not likely to raise novel or policy issues arising out of legal mandates, or the principles set forth in the Executive Order.

In addition, the Regulatory Flexibility Act, 5 U.S.C. 601 et seq. (RFA) requires government agencies to assess the impact of their regulatory actions on small businesses and other small organizations via the preparation of Regulatory Flexibility Analyses.

This document examines the costs and benefits of regulatory actions proposed for the domestic pelagic longline fisheries under the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region (FMP). It also contains an analyses of the economic impacts of these actions on affected small businesses and other small organizations.

II. PROBLEM STATEMENT AND NEED FOR ACTION

On March 29, 2001, the National Marine Fisheries Service (NMFS) issued a Biological Opinion under section 7 of the Endangered Species Act for the authorization of fisheries under the FMP. The Biological Opinion (BiOp) contained a series of non-discretionary actions (Reasonable and

Prudent Alternative) to mitigate interactions between the Hawaii-based longline fishery's and sea turtles. At the 110th Council Meeting held June 18-21, 2001, staff of the Western Pacific Regional Fishery Management Council (WPRFMC) were directed to prepare a regulatory amendment recommending implementation of the Reasonable and Prudent Alternative (RPA) as required under the Endangered Species Act (ESA). This recommendation was prepared, and it was implemented by NMFS on June 12, 2002. New measures included a ban on the use of shallow-set swordfish longline fishing north of the equator and a seasonal area closure from 15° N. lat. to the equator and from 145° W. long. to 180° long. during April and May for any longline vessel fishing under the authority of the FMP.

On December 12, 2001, NMFS reinitiated section 7 consultation on the Western Pacific Region's pelagic fishery. This reinitiation was based on new information that could improve the agency's ability to quantify and evaluate the effects of the fishery on listed sea turtle populations, as well the economic impacts of the implementation of the March 2001 RPA. At the conclusion of this reconsultation NMFS issued a new BiOp (November 15, 2002), which maintained the June 12, 2002 regulations including the ban on shallow-setting north of the equator and the April-May southern area closure. Meanwhile, on September 24, 2002, the D.C. District Court vacated the 2001 BiOp and RPA, effective November 15, 2002.

At its 118th meeting in June, 2003, the Council reviewed a number of potential modifications to the southern area closure to determine whether modifications could be made to support the economic viability of the fleet without jeopardizing sea turtles. The Council subsequently directed its staff to continue its preparation of a regulatory amendment to the Pelagic FMP containing a further range of alternatives and the impacts of those alternatives on sea turtles, fisheries, and the environment. Staff were also directed to include analyses of the impacts of those alternatives on sea turtles, fisheries and the environment. The Council directed staff to work with the NMFS Pacific Islands Regional Office (PIRO) and Pacific Islands Fisheries Science Center (PIFSC) to complete the package so the Council could consider it for final action at its 119th meeting, scheduled for mid-September 2003, with the intention of implementing this change prior to the 2004 seasonal area closure.

However on August 31, 2003, the Federal Court invalidated the 2002 BiOp and the regulations put in place in June 2002. Consequently, at its 119th meeting on September 23, 2003, the Council voted to recommend an emergency action which would allow a model swordfish longline fishery north of the equator at approximately 75% of historic (1994-1998 average annual) swordfish levels of effort (sets) in conjunction with fishing experiments that stay within the anticipated takes in the model fishery. The fishery would only be allowed to operate with circle hooks instead of J hooks and mackerel-type bait instead of squid, measures proven successful in reducing and mitigating sea turtle interactions in the Atlantic Ocean.

On October 6, 2003, the Federal Court stayed the execution of the August 31, 2003 order until April 1, 2004 to allow NMFS to develop a new BiOp and hopefully render a more permanent solution than interim or emergency measures. The purpose of this action is thus to implement measures for the long-term management of the Hawaii-based longline fishery.

At its 120th meeting (October 20, 2003), the Council directed its staff to continue its development of a long-term rule package through a series of meetings of the special advisory committee, workshops and seminars, and preparation appropriate documents, with the goal of meeting the December 1 deadline. However given the abbreviated time available, the Council declined to withdraw the emergency rule package, instead recommending that, if the long-term rule package is not completed according to NMFS' timeline, NMFS should process the Council's emergency rule for implementation by April 1, 2004.

The Council's Sea Turtle Conservation Special Advisory Committee held a series of three meetings to craft recommendations for further analysis and possible Council action. Committee membership included representation from fishery managers, scientists, industry, and environmental organizations. The Committee's first two meetings resulted in five potential alternatives that were submitted to NMFS' Office of Protected Resources (OPR) for their review and feedback. At the Committee's third and last meeting, OPR's comments were circulated and discussed. In summary, OPR ranked the proposed action as representing the second lowest risk of the five alternatives considered. This assessment was based on the fact that although other alternatives would have similar anticipated interactions, under the proposed action a greater percent of loggerhead and green turtle interactions would be expected to involve shallow-set longline gear (with circle hooks and mackerel-type bait) which would minimize potential harm to these species.

Because the impetus for this action is concern for pelagic fishery interactions with sea turtles, and because the FMP's Hawaii-based longline fishery (vessels registered to Hawaii limited access longline permits) is the only Pelagic FMP fishery thought to interact significantly with sea turtles, these alternatives focus on that fishery. (The other pelagic fisheries include the American Samoa longline fishery as well as small-boat troll and handline fisheries in each of the western Paficic jurisdictions.) Thus, under all alternatives, the management of the other pelagic fisheries would remain unchanged, except for general longline permit holders who would be affected by time/area closures and prohibitions on shallow-setting north of the equator under some alternatives. No alternatives would allow general longline permit holders to participate in the Hawaii-based longline fishery (meaning to fish in Hawaii's EEZ or to land fish in Hawaii) without obtaining a Hawaii longline limited access permit.

This analysis includes a range of alternatives considered for the long-term management of the longline fisheries managed under the Council's Pelagic Fishery Management Plan. These alternatives supplement those described in NMFS' 2001 Final Environment Impact Statement (FEIS) for the Pelagic Fisheries of the Western Pacific Region through the examination of an additional range of levels of swordfish fishing, in conjunction with circle hooks and mackerel-type bait which have recently been shown to be effective in reducing sea turtle interactions, while maintaining swordfish catch rates.

On November 25, 2003, the Council held its 121st meeting via teleconference at the Council's Honolulu office. This was an emergency meeting and the measures discussed here were its sole focus. The Council reviewed available information as well as the Committee's alternatives and estimates of their relative impacts. The Council's final action on this measure was to recommend that NMFS now allow 2,120 swordfish sets to be made annually by Hawaii longline limited access permit holders to model the use of circle hooks with mackerel-type bait, dehookers and other new technologies shown to reduce and mitigate interactions with sea turtles, in addition to a continued tuna fishery

In summary, the closure of the Hawaii-based swordfish fishery greatly reduced fishery interactions with sea turtles. However, this was achieved at the expense of the Hawaii-based longline fishery, chiefly by eliminating swordfish longline fishing, which resulted in a 20% decline in landings and a 40% decline in ex-vessel revenue in the first year following its implementation (WPRFMC 2002). In addition, although tuna-targeting longline fishing has continued, it has been constrained by a seasonal longline closure of about 1 million square nautical miles (nm) of ocean bounded by 15˚ N. lat. to the equator and from 145˚ W. long. to 180˚ long.. These closures denies the fleet access to swordfish, yellowfin and bigeye catches and, if not necessary to protect sea turtles, are contrary FMP objectives 1, 2, and 7 as follow:

1. To manage fisheries for management unit species (MUS) in the Western Pacific Region to achieve optimum yield (OY).

2. To promote, within the limits of managing at OY, domestic harvest of the MUS in the Western Pacific Region EEZ and domestic fishery values associated with these species, for example, by enhancing the opportunities for:
    a. satisfying recreational fishing experiences;
    b. continuation of traditional fishing practice for non-market personal consumption and cultural benefits; and
    c. domestic commercial fishermen, including charter boat operations, to engage in profitable fishing operations.

7. To promote, within the limits of managing at OY, domestic marketing of the MUS in American Samoa, CNMI, Guam and Hawaii.

Thus, in accordance with FMP Objectives 1, 2 and 7, the objective of this action is to achieve optimum yield and promote domestic marketing of MUS on a long-term basis from the region's pelagic fishery, without likely jeopardizing the continued existence of any threatened or endangered species. Therefore, this document examines a range of potential changes to the seasonal area closure, in addition to a limited swordfish fishery using the circle hooks and mackerel-type bait that have been proven to be effective in reducing and mitigating sea turtle interactions. Finally, this document examines alternatives that include conservation measures intended to improve sea turtle recruitment and thus offset any potential harm the Hawaii longline fishery could still pose to sea turtles.

The proposed rule is being promulgated under the authority of the Magnuson-Stevens Fishery Conservation and Management Act.

III. DESCRIPTION OF THE FISHERIES

The Pelagic FMP manages unique and diverse fisheries. Hawaii-based longline vessels are capable of traveling long distances to high-seas fishing grounds, while the smaller handline, troll, charter and pole-and-line fisheries—which may be commercial, recreational or subsistence —generally although not exclusively occur within 25 miles of land, with trips lasting only one day. These fisheries are discussed below, first by sector (commercial, recreational and charter) and then by gear type.

Due to the issuance of series of court orders and BiOps focused on the Hawaii-based longline fleet's interactions with sea turtles, the swordfish sector of this fishery has been effectively closed since March 31, 2001, when the first court order prohibiting swordfish-style gear configurations north of the equator (shallow-setting) was issued.
Because the impetus for this action is concern for fishery interactions with sea turtles, and because the Hawaii-based longline fishery is the only one thought to interact significantly with sea turtles the regulatory measures in this document focus on that fishery. In addition, there are unlikely to be increased competition with the smaller fisheries so the discussion is this document focuses on the Hawaii longline fishery and not the smaller fisheries.

Commercial Fisheries: The Hawaii-based pelagic longline fleet is the largest fishery managed by the FMP. The longline fleet has historically operated in two distinct modes based on gear deployment: deep-set longline by vessels that target primarily tuna and shallow-set longlines by those that target swordfish or have mixed target trips including albacore and yellowfin tuna. Swordfish and mixed target sets are buoyed to the surface, have few hooks between floats, and are relatively shallow. These sets use a large number of lightsticks since swordfish are primarily targeted at night. Tuna sets use a different type of float placed much further apart, have more hooks per foot between the floats and the hooks are set much deeper in the water column. These sets must be placed by use of a line shooter to provide slack in the line which allows it to sink.

The Hawaii-based skipjack tuna, or *aku* (skipjack tuna) fishery, is also known as the pole-and-line fishery or the bait boat fishery because of its use of live bait. The *aku* fishery is a labor-intensive and highly selective operation. Live bait is broadcast to entice the primary targets of skipjack and juvenile yellowfin tuna to bite on lures made from barbless hooks with feather skirts. During the fast and furious catching activity, tuna are hooked on lines and in one motion swung onto the boat deck by crew members.

Handline fishing is an ancient technique used to catch yellowfin and bigeye tunas with simple gear and small boats. Handline gear is set below the surface to catch relatively small quantities of large, deep-swimming tuna that are suitable for *sashimi* markets. This fishery continues in isolated areas of the Pacific and is the basis of an important commercial fishery in Hawaii. Three methods of pelagic handline fishing are practiced in Hawaii, the *ika-shibi* (nighttime) method, the *palu-ahi* (daytime) method and seamount fishing (which combines both handline and troll methods).

Troll fishing is conducted by towing lures or baited hooks from a moving vessel, using big-game-type rods and reels as well as hydraulic haulers, outriggers and other gear. Up to six lines rigged with artificial lures or live bait may be trolled when outrigger poles are used to keep gear from tangling. When using live bait, trollers move at slower speeds to permit the bait to swim “naturally.” The majority of Hawaii-based troll fishing is non-commercial; however, some full-time commercial trollers do exist.

Charter and Recreational Fisheries: Hawaii’s charter fisheries primarily troll for billfish. Big game sportfishing rods and reels are used, with four to six lines trolled at any time with outriggers. Both artificial and natural baits are used. In addition to lures, trollers occasionally use freshly caught skipjack tuna and small yellowfin tuna as live bait to attract marlin, the favored landings for charter vessels, as well as yellowfin tuna.

The recreational fleet primarily employs troll gear to target pelagic species. Although their motivation for fishing is recreational, some of these vessel operators sell a portion of their landings to cover fishing expenses and have been termed “expense” fishermen (Hamilton 1999). While some of the fishing methods and other characteristics of this fleet are similar to those described for the commercial troll fleet, a survey of recreational and expense fishermen showed substantial differences in equipment, avidity and catch rates compared to commercial operations. Vessel operators engaged in subsistence fishing are included in this recreational category.

Hawaii Fisheries: Tuna, billfish and other tropical pelagic species supply most of the fresh pelagic fish consumed by Hawaii residents and support popular recreational fisheries (Boggs and Kikawa 1993). Most of the local consumption of pelagic species comes from Hawaii’s domestic fisheries, although some is imported (primarily frozen mahimahi). Hawaii's pelagic fisheries are small in comparison with other Pacific pelagic fisheries such as domestic and foreign distant-water purse seine fisheries and foreign pelagic longline and pole-and-line fisheries (NMFS 1991), but they have comprised the largest fishery sector in the State of Hawaii for over a decade (Pooley 1993).

Of all Pelagic FMP fisheries, the Hawaii-based limited access longline fishery is the largest. This fishery accounted for 85 percent of Hawaii’s commercial pelagic landings (28.6 million lb) in 1998 (Ito and Machado 1999). The fleet includes a few wood and fiberglass vessels, and many newer steel longliners that were previously engaged in fisheries off the U.S. mainland. None of the vessels are over 101 ft in length and the total number is limited to 164 vessels by a permit moratorium.

Hawaii-based tuna longline vessels typically deploy about 34 horizontal miles of mainline in the water and use a line shooter. The line shooter increases the speed at which the mainline is set, which causes the mainline to sag in the middle (more line between floats), allowing the middle hooks to fish deeper. The average speed of the shooter is 9 knots with an average vessel speed of about 6.8 knots. No light sticks are used. Float line lengths average 22 m (72 feet) and branch line lengths average 13 m (43 feet). The average number of hooks deployed is 1,690 hooks per set with an average of 27 hooks set between floats. There are approximately 66 floats used during each set. The average target depth is 167 m, and gear is allowed to soak during the day, with total fishing time typically lasting about 19 hours, including the setting and hauling of gear.

Table 1. Hawaii-based longline fishery landings 1999-2002 (Source: NMFS, PIFSC, published and unpublished data, 2003 data are unavailable

Item	1999	2000	2001	2002
Area Fished	EEZ and high seas	EEZ and high seas	EEZ and high seas	EEZ and high seas
Total Landings (million lbs)	28.3	23.8	15.6	17.2
Catch Composition*				
Tuna	41%	41%	52%	52%
Swordfish	9%	9%	1%	1%
Miscellaneous	32%	32%	36%	37%
Sharks	18%	18%	11%	10%
Season	All year	All year	All year	All year
Active Vessels	119	125	101	100
Total Permits	164	164	164	164
Total Trips	1,137	1,103	1,034	1,164
Total Ex-vessel Value (nominal) ($millions)	$47.4	$50.2	$33.0	$37.5

* Number of fish

Table 2. Fishery information for Hawaii small-boat pelagic fisheries for 2000 (Sources: Adapted from WPRFMC, 2002)

Gear/Vessel Type	Troll/Handline	Pole-and-line Fishery (*Aku* Fishery)
Area Fished	Inshore and EEZ	Inshore and EEZ
Total Landings	3.4 million pounds	696,000 pounds
Catch Composition	48% yellowfin 18% mahimahi 10% wahoo 8% albacore 7% blue marlin	99.6% skipjack tuna <1% <1% <1% <1%
Season	All year	All year
Active Vessels	1,455	6
Total Permits	NA	NA
Total Trips	18,700	198
Total Ex-vessel Value	$8 million	$1.1 million

Note: Data do not include all landings for recreational fishers.

American Samoa Fisheries:

Despite a 40 year history of tuna canning in American Samoa by two large processors, commercial fishing for tuna by domestic (local) vessels in the EEZ around American Samoa is a relatively recent endeavor. The importance of pelagic fish as a source of income and employment in American Samoa's small-scale fishery has increased rapidly since 1996, following the adoption of longline fishing methods patterned after those in the neighboring country of Samoa. American Samoa's small-scale fishery is presently evolving from the realm of traditional subsistence activities to more commercial activities.

The American Samoa-based longline fishery consists of vessels that fish under a western Pacific general longline permit. This permit allows the vessel to fish for PMUS using longline gear in the EEZ around American Samoa, Guam, the Commonwealth of the Northern Mariana Islands (CNMI) or other U.S. island possessions, excluding the Hawaiian Islands. Unlike Hawaii longline limited access permits, the number of Western Pacific general longline permits is not restricted.

Apart from a few larger (> 40 ft) inboards, longlining out of American Samoa generally takes place on alias, twin-hulled (wood with fiberglass or aluminum) boats about 30 feet long, and powered by small gasoline outboard engines. Navigation on the alias is visual using landmarks. The gear is stored on deck attached to a hand crank reel which can hold as much as 10 miles of monofilament mainline. Participants set between 100 and 300 hooks on a typical eight-hour trip. The gear is set by spooling the mainline off the reel and retrieved by hand cranking back onto the reel. Currently most fishing is done within 25 miles of shore, but with better equipped vessels, fishing activity may extend further. Generally, gear setting begins in early morning with retrieval in the mid-morning to afternoon. The fish are stored in containers secured to the decks or in the hulls. Albacore tuna is the primary species landed followed by skipjack tuna and yellowfin tuna. Most fish are sold to large scale canneries, but some are sold to restaurants, and donated for family functions.

Table 3. American Samoa-based longline fishery vessel operations and landings, 1999-2002.
Source: WPacFIN, 2003

Time period	1999	2000	2001	2002	
Active vessels	72	35	68	61	
Total sets	2,112	2,814	4,801	6,861	
Total landings (numbers of fish)	29,540	46,393	216,875	423,023	
Catch composition:					
Albacore	53%	69%	86%	79%	
Skipjack	15%	5%	4%	11%	
Yellowfin	15%	13%	4%	4%	
All others	<2%	<2%	<2%	<4%	

Information on small-boat fishing from American Samoa, Guam, and the CNMI is presented in Table 4.

Table 4. Small-boat pelagic fishery information for American Samoa, Guam, and CNMI, 2000. Source: Adapted from WPRFMC, 2001			
Island Area		**Guam**	**CNMI**
Gear	**Troll/Charter**	**Troll/Charter**	**Troll/Charter**
Area Fished	Inshore and EEZ	Inshore and EEZ	Inshore and EEZ
Total Landings	23,014	643,149	146,880*
Catch Composition	74% skipjack tuna 6% barracuda 4% yellowfin tuna < 4% all others	31% mahimahi 23% skipjack tuna 19% yellowfin tuna	70% skipjack tuna 11% mahimhai 8% dogtooth tuna 6% yellowfin tuna
Season	All year	All year	All year
Active Vessels	19	416	107
Total Permits	NA	NA	NA
Total Trips	283	13,204	2,084
Total Ex-vessel Value	$24,164	$641,081**	$275,758

*Landings for CNMI are recorded commercial landings, but not all commercial landings are recorded (D. Hamm, NMFS SWSFC-HL, pers. comm., November 3, 2000).
**Total ex-vessel value of landings in Guam are estimated from commercial landings, which are less than 50 percent of total landings.

<u>Other Pelagic FMP fisheries:</u>
There has been limited historical pelagic fishing activity and effort (other than that conducted by longline vessels) in the Pacific Remote Island Areas (PRIAs, Johnston, Midway and Palmyra Atolls, Wake, Jarvis, Howland and Baker Islands, and Kingman Reef). Although longline vessels that fish in the waters of the Exclusive Economic Zone (EEZ) around the PRIA have been required to be registered under a longline general permit or the Hawaii-based longline limited access permit for some time, other pelagic vessels did not have federal permit and reporting requirements until May of 2002.

Prior to that time, two Hawaii-based troll and handline vessels were known to have fished in EEZ waters around Palmyra Atoll and Kingman Reef targeting pelagic (including yellowfin and bigeye tunas, wahoo, *mahimahi*, and sharks) and bottomfish species. Catch and effort data on these vessels are unavailable.

Since the broad implementation of permit and reporting requirements, there have been no permits issued or reports submitted from non-longline vessels targeting pelagic species around the PRIAs.

Recent plans for a sportsfishery based on Palmyra Atoll appear to have fallen through, as did an earlier attempt to establish a transhipping station utilizing Palmyra's airstrip. Although a small charter and recreational fishery was based on Midway Atoll during the late 1990s, it is now defunct due to a lack of vendor interest.

Prior to current regulatory restrictions, a California-based longline fishery existed consisting largely of vessels that were based in Hawaii and registered to Hawaii permits but that would move to California to seasonally fish swordfish as this allowed them to target ground further east than they could reach from Hawaii. In the latter part of 1997, 15 longline vessels migrated to California and fished mainly swordfish for the remainder of the year. The number of Hawaii-based longline vessels migrating to California increased slightly in 1998 (WPRFMC, 1999d). There were 18 Hawaii-based longline vessels that transited to California in the latter part of 1998 (Ito and Machado, 1999). Six East Coast vessels returned in 1998 but switched from targeting swordfish to tuna (Ito & Machado, 1999). In 1999,over 30 Hawaii-based longliners fished out of California (NMFS, 2000e; Dang, pers. comm.). Effective, June 12, 2001 Hawaii permit holders were prohibited from this type of movement.

Description of the Hawaii-based Longline Fishery's Markets and Economic Impacts:
Export markets are important for tuna which are produced and traded extensively on an international scale. However, much of the highest-quality tuna never finds it way out of the Hawaii market, where consumers are among the most discriminating in the world. Historically wwordfish did not have a strong demand in Hawaii, and the bulk of landed swordfish was exported to larger, established markets on the U.S. mainland and in Japan. Subsequently, a market niche for high quality fresh swordfish developed in Hawaii, primarily in restaurants. Other pelagic species harvested in Hawaiian waters, such as blue marlin, striped marlin, *mahimahi* (also known as dolphinfish) and *ono* (also known as wahoo), are consumed largely in the local market. Marlin, prized in some markets, is considered an affordable alternative to the more expensive tuna. *Mahimahi* and *ono* have an established niche in the local market, which consumes the entire local supply, supplemented by imports of these species from other fisheries (Bartram, 1997).

Per capita seafood consumption by residents and visitors to Hawaii is twice the U.S. average. Therefore, it is not surprising that the local supply falls short of local demand. For certain grades and species of fish, such as *aku* (skipjack tuna), demand is greater than landings in Hawaii's waters. To meet the excess demand, much fresh and frozen fish is imported to Hawaii. Although the imported volume may be as high as two-thirds of local production, substantial portions of the imports are re-exported to other markets. Hawaii's central Pacific location is convenient for consolidating fish shipments from other Pacific islands for shipping on to the U.S. mainland (Bartram, 1997).

Markets for pelagic species fluctuate throughout the year. Prices for a given species may vary seasonally with fluctuations in quality, quantity, demand, and quantities of substitutes. Quality is a function of several factors. Gear and fishing method affect the condition of the fish and the quality of the meat. Fish quality is also thought to change seasonally with water temperature fluctuations.

Tuna

Tuna forms the largest segment of Hawaii's fish production and is an expanding market. Variation in uses of different species is apparent, as Hawaii has both significant imports and exports of tuna (Bartram, 1997). The high-quality tuna that is exported from Hawaii is sold mostly to Japanese buyers. Hawaii exporters and fishers target the Japanese tuna market because of its renowned high prices for fish. Tuna is also sold to mainland U.S. markets. These markets rely on sources other than Hawaii for high-quality fish. However, they import some lesser grades of tuna from Hawaii to serve the demand for lower-quality fish (Bartram *et al.*, 1996).

Although significant exports are made, annual local consumption of fresh tuna alone is approximately 6,349,000 pounds. Several niches within Hawaii's tuna market have developed, each with its own quality standards. The market for tuna served raw as *sashimi* is generally known as the most demanding. Other markets include cooking (highly variable in quality demanded), *poke* (raw cubes served with spices and condiments), and smoking or drying (with the lowest quality requirements) (Bartram, 1997).

As much as 40 percent of local tuna consumption is raw, in the form of *sashimi* and *poke*, a local favorite. Bigeye and yellowfin tunas are commonly used for *sashimi*, but bigeye is the species of choice because of its brighter muscle color, higher fat content, and longer shelf life (Bartram, 1997).

Hawaii's consumers have traditionally placed a high demand on the Hawaii market for high-quality tuna. The Hawaii market has historically supplemented its local supply by importing substantial quantities of bigeye and yellowfin tunas, mostly from the Indo-Pacific region. Imports have declined in recent years as consumers have sought to satisfy more of their demand from the local supply. The reasons for the decline in imports are somewhat unclear. One contributing cause is the decline of the tuna fleet in the Marshall Islands in the mid-1990s and changes in fleet operations in the Pacific. In addition, the Hawaii market has seemed more willing to substitute local, high-quality albacore at times when top-quality bigeye and yellow fin tunas are in short supply (Bartram, 1997).

Swordfish

During the 1990s, wwordfish was the second largest fishery in Hawaii after bigeye tuna until the closure of the swordfish component of the fishery. The majority of swordfish was exported to the continental United States. Although swordfish is used locally for *sashimi* at times, grilling is the most popular method of preparation.

Most swordfish were caught by the longline fleet using nighttime shallow fishing techniques with luminescent attractants. Swordfish are also occasionally caught by tuna longline fishers as incidental catch. Trollers and handliners also participate in this fishery, but to a minor degree.

The peak season for swordfish is the early summer months from April to July. Most of the fish are sold at the Honolulu fish auction. A portion, however, is sold directly to wholesalers and exporters. As above, most of the fish were historically shipped to the US East coast, where Hawaii swordfish brings a premium price. East coast purchasers commonly purchase swordfish in airline container quantities to realize economies of scale in shipping.

Harvest levels grew substantially during the early 1990s due to the adoption of the nighttime surface fishing techniques. In 1987 and 1988, swordfish landings averaged 50,000 pounds. By 1991, landings had grown to more than ten million pounds. Swordfish landings peaked in 1993 at slightly more than 13 million pounds and have since ranged between 5.5 million and slightly more than seven million pounds a year (WPRFMC, 1999.).

Hawaii generally is one of many suppliers of swordfish to a major US market served by a worldwide supply. In 1998 (when Hawaii landings were slightly more than seven million pounds), approximately 34.6 million pounds of swordfish were imported into the continental US market. Imports of fresh swordfish in excess of two million pounds were received in the United States from Brazil, Chile, and Australia. Singapore alone exported more than eight million pounds of swordfish to the U.S. market (WPRFMC, 1999.; Seafood Market Analyst, 2000).

Blue Marlin and Striped Marlin

Neither marlin species is targeted by commercial fishers in Hawaii. The majority of the landings are caught incidentally by the longline tuna fleet. Trollers also contribute to Hawaii marlin harvests. Sport fishers, however, target blue marlin and often sell their landings in the commercial market, with proceeds going to the boat and crew. Most commercial marlin landings are sold in the Honolulu auction. Sport fishers and trollers, however, may sell their landings directly to wholesalers, retailers, or restaurants (DBEDT, 2000).

Marlin is used as *sashimi* and *poke* in Hawaii. Large group caterers often prefer marlin because it discolors more slowly than tuna. Premium *sashimi*-quality striped marlin, which has orange-red meat and higher fat content, is thought to be of higher quality than blue marlin, although blue marlin with acceptable fat content is used as *sashimi*. Both are cooked by Hawaii restaurants. Blue marlin is popular with lower-income and fixed-income groups and often is smoked (Bartram, 1997; DBEDT, 2000).

The blue marlin and striped marlin harvests are a significant but secondary part of the Hawaii market. The combined annual landings of both species in the past ten years typically have been about two million tons. Historically, striped marlin harvests have exceeded blue marlin harvests, but in two of the last six years, blue marlin exceeded striped marlin by more than 100,000 lb (WPRFMC, 1999.).

Seasonal variability in price is greater for both blue marlin and striped marlin than for tuna. The Hawaii blue marlin season peaks between June and October. The peak of the striped marlin season is opposite, beginning in November and continuing until June. The seasonal price changes are similar for the two fish, suggesting that the prices are driven by changes in tuna supply and total demand for fish rather than by the volume of marlin harvests. Marlin prices reach annual highs from February to April and again in September and December. The high prices early in the year coincide with a period of low tuna supplies. The transition from summer yellowfin to winter bigeye is the likely explanation for the high price for marlin in September. Marlin is also likely substituted for tuna in December when demand is high. The low prices in June and July occur during the period when tuna supply is at its highest and overall demand is at a low. Low prices occur in October, when marlin and bigeye are in high supply (DBEDT, 2000).

The markets for billfish in particular have been affected by limits on mercury in imported fish. The U.S. Food and Drug Administration has a limit of 1.0 parts per million for methyl mercury in fish imports. Every lot imported is tested before release for sale. The procedures allow an importer to obtain a “green card” limiting testing requirements if the importer’s first five shipments all test below the limit. The procedure is costly for minor importers and is believed to limit the inflow of swordfish into the United States. The sampling procedure is also costly and can damage fish, further deterring imports of swordfish into U.S. markets (Bartram, 1997).

Other Pelagic Species: Mahimahi, Ono, Moonfish, and Pomfret

Most Hawaii restaurants have diversified menus that include *mahimahi* and several other species, such as marlin, *ono* (wahoo), *opah* (moonfish), and large-scale black pomfret. Demand for these pelagic species has led to substantial landings by Hawaii fishers, who sell to the Hawaii market. Harvests of *mahimahi* and *ono*, the most commonly targeted species, fluctuate seasonally. Significant quantities of *opah* and pomfret are caught incidentally. Quantities of these two species fluctuate significantly, but follow no seasonal trend. All of these species are sold fresh, because almost no market exists for frozen local landings (Bartram, 1997; DBEDT, 2000).

Most *mahimahi* and *ono* are caught by trollers, although portions of the harvest are taken by longline and pole-and-line fishers. These species are sold through the Honolulu and Hilo fish auctions and directly to wholesalers and restaurants. *Mahimahi* is a favorite in many local restaurants. *Ono* is generally substituted when *mahimahi* is in short supply. The limited local supply of *mahimahi* has led to import of substantial quantities to Hawaii from Taiwan, Japan, and Latin America. Since imported fish tend to be slightly cheaper than fresh local fish, imported fish tend to be directed toward less expensive restaurants. Little of either of these species is exported, because local consumers consume most of the local supply.

Pomfret and moonfish are also frequently sold in local restaurants. These species complement the supply of *mahimahi* and *ono* in the local fresh market. Both species are primarily incidental catch of the longline fleet and are sold almost exclusively through auctions (Bartram, 1997, DBEDT, 2000).

Sharks

Prior to its prohibition of by the Hawaii Legislature and the U.S. Congress in 2000, shark finning had been a source of significant revenue for crew members in the Hawaii-based longline fishery. Most of these revenues are generated by sales of blue shark fins sold to satisfy the demand for fins in the Asian market. A small market has also developed recently for thresher and mako sharks. The landings of these two species are small and do not contribute substantially to the overall revenue in the fleet.

The prohibitions on finning of sharks has substantially limited the activity of Hawaii-based longline vessels in the market for shark fins. No market exists for the carcass of blue sharks, which is the dominant incidental catch species in Hawaii longline fisheries (WPRFMC, 2001), and until such a market develops, the landing of these sharks is unlikely.

Economic Impacts

The Hawaii-based longline fishery has historically provided approximately 85% of fresh commercial seafood landings in Hawaii. As such it supports a substantial fishery supply sector (fuel, oil, bait, gear etc.) as well as an auction house, and numerous fish wholesaling and retailing operations. The Hawaii longline fishery, valued at $46.7 million in a 1998 baseline economic analysis, was estimated to have a total impact on Hawaii business sales of $113 million using an input-output model of the Hawaii commercial fishery (Sharma *et al.*, 1999). This model calculates the inter-relationship of industries producing inputs to the longline fishery -- what are termed "backward" linkages. The total sales figure includes the direct effect of the ex-vessel sales and the indirect and induced income effects on other industries -- what we term associated businesses. Using this model, the personal and corporate income effect of the historic longline fishery was $50 million with upwards to 1,500 jobs directly associated with the Hawaii longline fishery. State and local taxes were approximately $8 million. In addition there are "forward" linkages which refer to the supply effect of Hawaii longline-caught fish on the seafood auction, wholesalers and retailers, etc. These measures are more difficult to measure but were estimated to represent an additional $8-16 million in value-added.

<u>Foreign fisheries in the Central and Western Pacific:</u>

Fisheries managed under the Pelagic FMP compete with a variety of foreign fleets operating on the high seas and within the EEZs of many Pacific nations. Large-scale, distant-water foreign fisheries include three gear types: longline, pole-and-line and purse seine. Between 1999 and 2001, Hawaii-based longline vessels are estimated to have exerted only about 3% of the pelagic longline effort in the Pacific.

Purse seine catches form the bulk of the catch in both the Eastern and Western Pacific, with fleets targeting primarily skipjack tuna in the Western Pacific and yellowfin tuna in the Eastern Pacific. Current total Pacific purse seine catches are just over 1.6 million mt of fish.

Pole-and -line fishing has declined in the Pacific over the last 50 years, with most of the catch from this method of fishing now g produced by Japan’s long-range pole-and-line vessels. Pole-and-line fishing is highly selective, with most of the catch comprising skipjack fished from surface schools.

Longline fisheries across the Pacific catch about 260,000 mt, with most of the catch (80%) being caught in the Western and Central Pacific. Longliners target primarily yellowfin, bigeye and albacore tuna, with significant amounts of swordfish being taken by longliners in New Zealand, New Caledonia, Australia, Japan and Taiwan.

Apart from small near shore coastal trollers, which target a variety of pelagic fishes, there are over 800 high seas troll vessels which target albacore tuna in the North and South Pacific. These vessels catch annually about 18-20,000 mt of albacore, with the majority of vessels operating in the North Pacific.

Directed swordfish fisheries

In addition to the sector of the Hawaii-based longline fishery which targeted swordfish prior to 2000, there are several foreign fleets (e.g., longline, gillnet and harpoon) that target swordfish in the Pacific. While most of the Pacific longline effort targets tuna species, shallow-set swordfish longlining has a higher incidence of encountering a protected or endangered species. Information on swordfish fisheries largely comes from reviews by Takahashi and Yokawa (1999), and Ward and Elscot (2000).

Foreign longline fisheries specifically targeting swordfish occur in Japan, Chile and Australia. Moderate catches of swordfish occur as bycatch in the tropical tuna fisheries, domestic Taiwan fishery and the Japanese tuna fishery in the eastern Australian fishing zone. Japanese longline fisheries are classified into three categories based on vessel size: coastal (10-20 gt), offshore (20-120 gt) and distant-water vessels (120-500 gt). Japanese offshore and distant-water vessels produce annual catches of about 11,000 mt. In the north Pacific, the longline catch was over 9,000 mt in 1985 and 1987, declined to 4,800 mt during 1991 and fluctuated between 6,000 and 8,000 mt since 1992. The offshore and distant-water Japanese catch in the north Pacific represents about 55 percent of the Pacific-wide catch. Catches in the coastal Japanese longline fleet were less than 1,000 mt in the 1980s, but increased to about 1,300 since 1993. The coastal and offshore fleets participate in a directed swordfish fishery in the Higashioki fishing grounds where the largest longline catches and catch rates occur. The Higashioki grounds are between 140˚-180˚E. and 20˚-45˚N., geographically to the west of where the Hawai‘i-based longline fishery operates. Fishing methods by the Japanese swordfish fleets are similar to the former Hawaii-based swordfish fleet: night fishing with three or four branchlines between each float which results in a shallow gear configuration.

Activity by domestic Australia longliners increased substantially during the late 1990s, with many larger vessels entering the fishery, thereby extending the range of longline activities further offshore. Fishing effort doubled from four million hooks in 1996 to 9 million in 1998 and has
remained stable thereafter. Over the same period, swordfish catches increased from 456 mt to 1,355 mt and reached a peak at 1,844 mt in 1999. Bycatch is monitored on CSIRO research cruises and on Japanese fishing vessels. The swordfish fishery is relatively new and there is potential for longliners to interact with turtles (Ward and Elscot, 2000). In particular, the Brisbane grounds are adjacent to major nesting sites of loggerhead turtle at Mon Repos and Capricorn-Bunkers. While Australian observers have monitored over 2,000 longline sets in the Japanese tuna fishery in the Australian EEZ, the Australian Fisheries Management Authority

initiated a domestic observer program in 2003.

New Zealand has a fleet of about 140 longline vessels that target bigeye and southern bluefin tunas but which also catches over 1000 mt of swordfish. This domestic longline fleet has grown exponentially since its start in1991, although it has yet to reach a size where effort is equivalent to the historic foreign fleet activity.

Chile has a substantial longline fleet, but most vessels are involved in other fisheries (e.g., Patagonian toothfish). Swordfish fishing is highly seasonal and distributed over a wide latitudinal range (15˚-40˚S.) near Chile. Up to 143 vessels have fished for swordfish since 1985 and annual longline catches have increased to over 2,000 mt in 1998.

Gillnet fisheries that target swordfish and marlin occur in Japan, Mexico and Chile. Large-mesh gillnet operations occur within the 200 nm EEZ of Japan near the Tohuku and Hokkaido regions. Fishing effort has declined substantially since 1990 and the 1996 swordfish catch was 400 mt. A small gillnet fishery in Mexico targets swordfish and marlin beyond 50 nm off the coast. Catches were 800 mt of swordfish in 1991, declined to 100 mt in 1994 and increased to 250 mt in 1998. Similarly, artisanal gillnet fishers in Chile have fished since the early 1980s and average about 3,000 mt. Both Taiwan and Japan have harpoon fisheries that target a complex of marlins and swordfish, but encounters with protected species would be rare.

IV. REGIONAL AND SOCIOECONOMIC CONTEXT OF WESTERN PACIFIC PELAGIC FMP FISHERIES

The community setting of the pelagic fisheries of the Western Pacific Region is a complex one. While the region shares some features with domestic fishing community settings elsewhere, it is unlike any other area of the United States or its territories and affiliates in terms of its geographic span, the relative role of U.S. EEZ versus foreign EEZ versus high seas area dependency, as well as its general social and cultural history. The management of pelagic fisheries is of particular importance to the sub-regions and communities of the Western Pacific, as the harvest of pelagic species is the major component of fishing industry or activity in the region.

The sociocultural setting of the Western Pacific Region pelagic fisheries reflects the particular cultural and social history of the area, with different aspects of the fisheries encompassing, by varying degrees, aspects of lifeways of a divergent mix of groups, from the traditions of the descendants of the earliest inhabitants of the islands to those of some of the most recently arrived groups. In general, the sociocultural setting or aspects of a fishery include the shared technology, customs, terminology, attitudes and values related to fishing of a wide variety of these groups. While it is the fishermen that benefit directly from the fishing lifestyle, individuals who participate in the marketing or consumption of fish or in the provision of fishing supplies often share in the fishing culture. An integral part of this framework is the broad network of inter-personal social and economic relations through which the cultural attributes of a fishery are transmitted and perpetuated. The relations that originate from a shared dependence on fishing and fishing-related activities to meet economic and social needs can have far-reaching effects in the daily lives of those involved. For example, they may constitute important forms of social capital, i.e., social resources that individuals and families can draw on to help them achieve desired goals.

The products of fishing supplied to the community may also have sociocultural significance. For instance, beyond their dietary importance fish may be important items of exchange and gift-giving that also help develop and maintain social relationships within the community. Alternatively, at certain celebratory meals various types of seafood may become imbued with specific symbolic meanings.

The sociocultural context of fishing may include the contribution fishing makes to the cultural identity and continuity of the broader community or region as well. As a result of this contribution, the activity of fishing may have existence value for some members of the general public. Individuals who do not fish themselves and are never likely to, may derive satisfaction and enjoyment from knowing that this activity continues to exist. They may value the knowledge that the traditions, customs and lifeways of fishing are being preserved.

It is also important to note that fishing is a traditional economic activity in the islands of the Western Pacific Region, and that fishing, in many cases, represents a continuity with the past that may or may not have parallels in other aspects of life and making a living in the modern context. The degree of ‘traditional-ness’ can and does vary by vessel and gear type, with some types of fishing more closely associated with particular social, cultural, and ethnic groups than others. Culturally distinct ideas and values of relevance to the management of the pelagic fisheries are not restricted to the domain of the target species and activities associated with the use of those species. For example, issues of primary concern to the contemporary management of the longline fishery relate to the incidental mortality of sea turtles and seabirds and the controversy associated with shark finning. In these cases there are concerns that could be categorized as ‘existence’ or ‘ethically motivated’ values. For example, value may emanate from the satisfaction of just knowing that a leatherback turtle exists in a natural state. Alternatively, the public, or some portions of the public, may place an intrinsic value on sea turtles for religious or philosophical reasons. These animals may have symbolic value as a unique life form similar to the way some marine mammals have become ‘charismatic megafauna.’ However, perceptions of the value of sea turtles and appropriate protection strategies vary considerably from culture to culture and between social and ethnic groups in the Western Pacific Region. In the CNMI, for example, Saipan Carolinians have strongly argued that they should be allowed to capture green sea turtles for cultural purposes if it is determined that the stock could support a limited harvest (McCoy, 1998). Some Native Hawaiians have also requested a limited harvest of green sea turtles for traditional and customary uses (Charles Ka‘ai‘ai, pers. comm., 20 November 2000, WPRFMC).

V. PHYSICAL ENVIRONMENT

Ecosystem and Stocks

The pelagic ecosystem responds to ambient climatological and oceanographic conditions on a variety of spatial and temporal scales, and even in the complete absence of any fishing, stock sizes fluctuate, sometimes quite dramatically. It is also clear from the species accounts that initiation of very marked declines in some groups such as sea turtles, seabirds and possibly sharks coincided with prosecution of the high seas drift-gillnet fishery in the 1980s and early 1990s. Added to the serious impacts to protected species resulting from that fishery was a oceanic regime shift that markedly lowered the carrying capacity and productivity of the ecosystem at that time. Because of the long life spans and limited reproductive potential of sea turtles, seabirds and sharks, these populations are likely only beginning to recover from these circumstances.

Pelagic Management Unit Species

The Pelagic FMP focuses its management efforts on a suite of “management unit species” (PMUS). These species have been assigned to species assemblages based upon the ecological relationships among species and their preferred habitat. The species complex designations for the PMUS are marketable species, non-marketable species, and sharks. The marketable species complex has been subdivided into tropical and temperate assemblages. The temperate species complex includes those PMUS that are found in greater abundance in higher latitudes as adults including swordfish, bigeye, bluefin and albacore tuna, striped marlin and pomfret. The tropical species complex includes all other tunas and billfish as well as *mahimahi*, wahoo, and *opah*. Included in these assemblages are the species targeted by pelagic fisheries in the region, but the fisheries affect many other, non-targeted species as well as a variety of protected species. Species of oceanic pelagic fish live in tropical and temperate waters throughout the world’s oceans, and they are capable of long migrations that reflect complex relationships to oceanic environmental conditions. These relationships are different for larval, juvenile and adult stages of life. The larvae and juveniles of most species are more abundant in tropical waters, whereas the adults are more widely distributed. Geographic distribution varies with seasonal changes in ocean temperature. Migration patterns of pelagic fish stocks in the Pacific Ocean are not easily understood or categorized, despite extensive tag-and-release projects for many of the species. This is particularly evident for the more tropical tuna species (e.g., yellowfin, skipjack, bigeye) which appear to roam extensively within a broad expanse of the Pacific centered on the equator. Likewise, the oceanic migrations of billfish are poorly understood, but the results of limited tagging work conclude that most billfish species are capable of transoceanic movement, and some seasonal regularity has been noted.

Movements of pelagic species are not restricted to the horizontal dimension. In the ocean, light and temperature diminish rapidly with increasing depth, especially in the region of the thermocline. Many pelagic fish make vertical migrations through the water column, often moving toward the surface at night to feed on prey species that exhibit similar diurnal vertical migrations. Certain species, such as swordfish, are more vulnerable to fishing when they are concentrated near the surface at night. Bigeye tuna may visit the surface during the night, but generally, longline catches of this fish are highest when hooks are set in deeper, cooler waters.

Adult swordfish are opportunistic feeders, preying on squid and various fish species. Oceanographic features such as frontal boundaries that tend to concentrate forage species (especially cephalopods) apparently have a significant influence on adult swordfish distributions in the North Pacific.

None of the PMUS stocks in the Pacific are known to be overfished, although concern has been expressed for several species, and data are unavailable for others. Trends in overall catch and size composition of animals comprising the Hawaii landings indicate that the swordfish population that supports the fishery within the Council's jurisdiction appears to be capable of sustaining current levels of effort.

Blue marlin stocks are of concern to recreational trollers and charter fleets. Various recent analyses characterize the blue marlin population as stable and close to that required to support average maximum sustainable yield (AMSY). Little is known about the status of stocks of striped marlin, black marlin, short-billed spearfish or sailfish.

Because of their primary importance in many of the pelagic fisheries, more is known about tuna stocks. Most indicators suggest a reduction of bigeye tuna biomass in the past several years although biomass in the eastern Pacific seems to have stabilized. Although some analyses suggest that current levels of harvest may exceed MSY the stock is well above minimum sustainable stock threshold (MSST) and is therefore not overfished. The current population size is probably approximately at a level that can support AMSY. Recently, increased concern has arisen about the status of the stock in the face of large catches of juvenile tuna being taken from around floating objects in the equatorial regions of the Pacific.

Albacore stocks appear to be in good condition and are experiencing moderate levels of exploitation. Neither the northern nor southern stocks are regarded as overfished and current catches are likely to be sustainable.

Yellowfin tuna catch rates in the major industrial fleets (purse seine and longline) show "flat" trends and, in general, the Pacific yellowfin stock appears to be in good condition and current catch levels are considered sustainable.

All recent analyses indicate that harvest ratios for skipjack tuna are appropriate for maintaining current catch levels and that overall the stocks are very healthy. Although local depletions and variability may occur in response to local environmental conditions and fishing practices, the overall stock is healthy and can support existing levels of fishing.

Non-target Species
Pelagic fisheries catch a number of non-target species, both PMUS and non-PMUS. This is particularly true for the longline fishery. NMFS observers recorded more than 60 different species caught by the Hawaii-based longline fleet between 1994 and 1997. Of significance are the 85,523 sharks caught by the fleet in 1997, of which the majority (approximately 95 percent) were blue sharks. Up until about five years ago, most sharks caught by pelagic longline gear were released alive. However, as a result of the growing demand for shark fins in Asian markets the practice of shark finning increased during the late 1990s. This practice is now prohibited as defined in the Shark Finning Prohibition Act. About one percent of the sharks, mainly mako and thresher, are retained for later sale.

Sea Turtles
In addition to PMUS and non-PMUS fish species, pelagic fisheries interact with protected species. In particular, the longline fisheries interact with sea turtles. All sea turtles are designated under the U.S. ESA as either threatened or endangered. The breeding populations of Mexico olive ridley turtles are currently listed as endangered, while all other ridley populations are listed as threatened. Leatherback turtles and hawksbill turtles are also classified as endangered. The loggerhead turtles and the green turtles are listed as threatened (note the green turtle is listed as threatened under the ESA throughout its Pacific range, except for the endangered population nesting on the Pacific coast of Mexico). These five species of sea turtle are highly migratory, or have a highly migratory phase in their life history, and therefore, are susceptible to being incidentally caught by fisheries operating in the Pacific Ocean.

All five sea turtle species of concern forage in the waters surrounding the Hawaiian Archipelago. However, leatherback, loggerhead, and green sea turtles are the species of principal concern with regard to incidental take in the Hawaii-based pelagic longline and other commercial fisheries of the Pacific. As discussed above, these fisheries are conducted mainly by Japan, Taiwan, Spain, Korea, and, to a lesser extent, the United States.

Sea Turtle Interactions with the Hawaii-based Longline Fishery
Based on past interactions NMFS' (now invalidated) 2002 Biological Opinion estimated that the historical fishery (including both tuna and swordfish sectors) annually interacted with an average of 112 leatherback turtles (including 9 lethal interactions), 418 loggerhead turtles (including 73 lethal interactions), 40 green turtles (including 5 lethal interactions), and 146 olive ridley turtles (including 49 lethal interactions).

VI. CURRENT MANAGEMENT MEASURES

This section details the regulations in place for the Council managed pelagic fisheries as of November 25, 2003. Those considered to have been remanded by the Judge's August 31, 2003 order[1] (and reinstated through April 1, 2004 by the subsequent October 6, 2003 Court order) are

[1] The Court did not specify which specific regulations were vacated or restored.

indicated by strike outs and explanatory annotations are provided.

1 Fishing for PMUS in EEZ waters of the Western Pacific Region with drift gillnets is prohibited (52 FR 5987, March 23, 1987).

2 Vessels using longline gear to fish for PMUS in EEZ waters of the Western Pacific Region and vessels transporting or landing longline-harvested PMUS shoreward of the outer boundary of these same EEZ waters must be registered for use with a general longline permit and must keep daily logbooks detailing species harvested, area of harvest, time of sets and other information. Also, longline gear used in theEEZ waters of the Western Pacific Region must be marked with the official number of the permitted vessel that deploys the gear (56 FR 24731, May 1991).

3 Hawaii-based longline vessels must carry a NMFS observer if requested to do so (55 FR 49285, November 1990; 58 FR 67699, December 1993).

4 Each vessel that uses longline gear to fish for PMUS in EEZ waters around Hawaii, or is used to transport or land longline-harvested PMUS shoreward of the outer boundary of the EEZ around Hawaii, must be less than 101 feet in length and registered for use with one of 164 Hawaii-based longline limited entry permits (59 FR 26979, June 1994).

5 As requested by NMFS, all vessels registered for use with a Hawaii-based longline limited access permit must carry and use a NMFS-owned VMS transmitter (59 FR 58789, November 1994). Longline fishing for PMUS is prohibited in circular areas (known as "protected species zones") 50 nm around the center points of each of theNWHI islands and atolls, plus a 100 nm wide corridor connecting those circular closed areas that are non-contiguous (56 FR 52214, October 1991). To avoid gear conflicts with troll and handline fisheries near the MHI, longline fishing is prohibited in areas approximately 75 nm around the islands of Kauai, Niihau, Kaula, and Oahu, and approximately 50 nm off the islands of Hawaii, Maui, Kahoolawe, Lanai and Molokai. This prohibition is lessened from October 1 through January 30, when the longline closed areas decrease on the windward sides to approximately 25 nm off Hawaii, Maui, Kahoolawe, Lanai, Molokai, Kauai, Niihau and Kaula and approximately 50 nm off Oahu (56 FR 28116, June 1991)[2]. Longline fishing is also prohibited in an area approximately 50 nm around Guam (57 FR 7661, March 1992).

6 Domestic vessels greater than 50 feet, except as exempted, are prohibited from fishing for PMUS within approximately 50 nm around the islands of American Samoa, including Tutuila, Manua and Swains Islands and Rose Atoll (67 FR 4369, January 30, 2002).

7 Federal regulations implementing the Shark Finning Prohibition Act prohibit any person under U.S. jurisdiction from engaging in shark finning, possessing shark fins harvested on board a U.S. fishing vessel without corresponding shark carcasses or landing shark fins harvested without corresponding carcasses (67 FR 6194 February 11, 2002).

8 Any domestic fishing vessel that employs troll or handline gear to target PMUS in

[2]A few longline vessel owners qualify for exemptions to fish in portions of longline closed areas around the MHI where they can document historical longline fishing activity prior to 1970.

EEZ waters around the U.S. PRIA must be registered for use with a permit issued by NMFS and must maintain and submit daily logbooks detailing species harvested, area of harvest, fishing effort and other information, including interactions with protected species (67 FR 30346, May 6, 2002).

9 Vessels registered to Hawaii limited-access longline permits operating north of 23° N lat. must use line setting machines with a weight of at least 45 g attached to each branch line within 1 m of each hook or employ traditional basket-style longline gear when setting longline gear to fish for PMUS; use thawed blue-dyed bait; and discharge offal strategically (67 FR 34408, May 14, 2002). The operator and crew of all vessels registered to Hawaii limited access permits who accidentally hook or entangle an endangered short-tailed albatross must also employ specific handling procedures (67 FR 34408, May 14, 2002). *History: on 5/14/02 a final rule implementing the 2000 FWS BiOp was published. This rule noted in its preamble that although "shallow swordfish-style setting is currently prohibited by an emergency rule implemented to protect sea turtles, the USFWS BiOp requires that vessel operators making shallow sets north of 23 N. latitude begin setting the longline at least 1 hour after local sunset and complete the setting process by local sunrise, using only the minimum vessel lights necessary".*

10 All vessels registered for use with Hawaii limited access ~~or longline general permits, as well as domestic pelagic troll and handline vessels fishing for PMUS in EEZ waters of the Western Pacific Region~~, are required to employ sea turtle handling measures. Specifically, vessels that have a freeboard of 3 feet or more must carry aboard their vessels line clippers meeting the NMFS minimum design standards, including a 6-foot handle, as well as wire or bolt cutters capable of cutting through the vessel's hooks. These items must be used to disengage any hooked or entangled sea turtles with the least harm possible in accordance with the handling, resuscitation and release requirements. Vessels that have a freeboard of 3 feet or less must carry aboard their vessels line clippers capable of cutting the vessel's fishing line or leader within approximately 1 foot of the eye of an embedded hook as well as wire or bolt cutters capable of cutting through the vessel's hooks. These items must be used to disengage any hooked or entangled sea turtles with the least harm possible in accordance with the handling, resuscitation, and release requirements. In addition, all incidentally taken sea turtles brought aboard these vessels for dehooking and/or disentanglement must be handled in a manner to minimize injury and promote post-hooking survival. When practicable, comatose sea turtles must be brought on board immediately, with a minimum of injury. If a sea turtle is too large or hooked in such a manner as to preclude safe boarding without causing further damage/injury to the turtle, line clippers meeting the NMFS standards must be used to clip the line and remove as much line as possible prior to releasing the turtle. If a sea turtle brought aboard appears dead or comatose, the sea turtle must be placed on its bottom shell or plastron, so that the turtle is right side up and its hindquarters elevated at least 6 inches for a period of no less than four hours and no more than 24 hours. The turtle must be shaded and kept damp or moist but under no circumstances placed in a container holding water. The turtle should be periodically rocked gently left to right

and right to left by holding the outer edge of the shell (carapace) and lifting one side about 3 inches and then alternate to the other side. A reflex test must be performed at least every three hours to see if the turtle is responsive. Turtles that revive and become active must be gently returned to the sea; those that fail to revive in 24 hours must also be returned to the sea. (65 FR 16346, March 28, 2000; 66 FR 67495 December 31, 2001; 67 FR 40232, June 12, 2002). Note: Bringing sea turtles aboard vessels is only required "when practicable"; this action is not likely to be practicable on many non-longline vessels. *History: a proposed rule was published on 2/17/00 that cited NMFS' 1998 BiOp's ITS, as well as a 9/26/99 court order directing NMFS to require "every vessel with a Hawaii longline permit to carry and use line clippers and dip nets to disengage hooked or entangled sea turtles". In addition, the rule imposed handling requirements. This rule was finalized on 3/28/00. On 12/31/01 the handling requirements were slightly revised due to findings by NMFS that pumping a turtle's plastron may be detrimental. On 6/12/02, in a final rule that "implements the reasonable and prudent alternative of the March 29, 2001 BiOp", the mitigation gear and handling requirements were enlarged to include American Samoa longline, and non-longline vessels, as well as being slightly relaxed for vessels with less than 3' in freeboard (based on a request from the Council and PIRO).*

11 Operators and owners of vessels registered to Hawaii limited access permits ~~or longline general permits (after August 31, 2002)~~ must annually attend protected species workshops conducted by NMFS that discuss sea turtle and seabird biology, conservation and mitigation techniques (67 FR 34408, May 14, 2002; 67 FR 40232, June 12, 2002). *History: on 5/14/02 a final rule implementing the 2000 FWS BiOp was published. This rule appears to require both the owner and operator of Hawaii registered longline vessels to annually attend protected species workshops sponsored by NMFS. The 6/12/02 final rule extended the requirement to include operators of vessels registered to longline general permits.*

12 ~~A Hawaii longline limited access permit may be re-registered to a vessel only during the month of October, if its owner had previously de-registered that from its permit vessel after March 31, 2001 (67 FR 40232, June 12, 2002).~~

13 ~~Vessels registered to Hawaii limited access permits are prohibited from using longline gear to catch PMUS or engaging in fish transshipping operations supporting longline fishing from April 1 through May 31 in waters between the equator and 15°N lat. and from 145°W to 180° long. (67 FR 40232, June 12, 2002).~~

14 ~~Vessels registered to Hawaii limited-access or general longline permits are prohibited from using longline gear to fish for or target swordfish north of the equator. When fishing north of the equator, these vessels must deploy longline gear such that the deepest point of the main longline between any two floats, i.e., the deepest point in each sag of the mainline, is at a depth greater than 100 m below the sea surface. The length of each float line used to suspend the main longline beneath a float must be longer than 20 m with no fewer than 15 branch lines set between any two floats if the main longline is monofilament set by a line setting machine or no fewer than 10 branch lines between any two floats if the main longline is non-monofilament line set by traditional basket-style technique. In addition, the~~

~~possession or use of light sticks or any other light-emitting device, such as glow worms or glow beads, as artificial lures to attract and catch swordfish north of the equator is prohibited (67 FR 40232, June 12, 2002).~~

15 ~~Vessels registered to Hawaii limited access or general longline permits are prohibited from possessing or landing more than 10 swordfish on any fishing trip that included any fishing north of the equator (67 FR 40232, June 12, 2002).~~

In December 2000, Congress passed a bill amending the Magnuson-Stevens Act in order to implement a nationwide ban on landing of shark fins without the shark carcass. A final rule became effective March 13, 2002.

VII. DESCRIPTION OF THE ALTERNATIVES

In this section is a description of the compliance requirements of the proposed rule, a description of the skills necessary to meet those requirements, identification of duplicating, overlapping, and conflicting Federal rules, a description and history of all the alternatives that were considered, a description of the reasons for not choosing the alternatives, and a description of the non-regulatory elements of the alternatives.

Description of the Proposed Reporting, Recordkeeping, and other Compliance Requirements

As described further in Section VIII, there are two types of businesses to which the rule would apply: businesses operating under Hawaii longline limited access permits and businesses operating under longline general permits. Throughout this section, vessels registered for use under Hawaii longline limited access permits are referred to as “Hawaii-based longline vessels.”The proposed rule would:

1) Establish an annual limit on the amount of shallow-set longline fishing effort north of the equator that may be collectively exerted by Hawaii-based longline vessels (set at 2,120 shallow-sets per year);
2) divide and distribute this shallow-set effort limit each calendar year in equal portions (in the form of transferable single-set certificates valid for a single calendar year) to all holders of Hawaii longline limited access permits that respond positively to an annual solicitation of interest from NMFS;
3) prohibit any Hawaii-based longline vessel from making more shallow-sets north of the equator during a trip than the number of valid shallow-set certificates on board the vessel;
4) require that operators of Hawaii-based longline vessels submit to the Regional Administrator within 72 hours of each landing of pelagic management unit species one valid shallow-set certificate for every shallow-set made north of the equator during the trip;
5) require that Hawaii-based longline vessels, when making shallow-sets north of the equator, use only circle hooks sized 18/0 or larger with a 10-degree offset;

6) require that Hawaii-based longline vessels, when making shallow-sets north of the equator, use only mackerel-type bait;
7) establish annual limits on the numbers of interactions between leatherback and loggerhead sea turtles and Hawaii-based longline vessels while engaged in shallow-setting (set equal to the annual estimated incidental take for the respective species in the shallow-set component of the Hawaii-based fishery, as established in the prevailing biological opinion issued by NMFS pursuant to section 7 of the ESA);
8) establish a procedure for closing the shallow-setting component of the Hawaii-based longline fishery for the remainder of the calendar year when either of the two limits is reached, after giving 1 week advanced notice of such closure to all holders of Hawaii longline limited access permits (the numbers of interactions will be monitored with respect to the limits using year-to-date estimates derived from data recorded by NMFS vessel observers);
9) require that operators of Hawaii-based longline vessels notify NMFS in advance of every trip whether the longline sets made during the trip will involve shallow-setting or deep-setting and require that Hawaii-based longline vessels make sets only of the type declared (i.e., shallow-sets or deep-sets);
10) require that operators of Hawaii-based longline vessels carry and use NMFS-approved de-hooking devices; and
11) require that Hawaii-based longline vessels, when making shallow-sets north of 23° N. lat., start and complete the line-setting procedure during the nighttime (specifically, no earlier than one hour after local sunset and no later than local sunrise).

The regulatory measures listed above would replace the existing restrictions on longlining north of the equator, which will be eliminated on April 1, 2004, by the Court rulings of August 31, 2002, and October 6, 2003 (see Sections II and VI for description of restrictions that will be eliminated). Certain measures that will be eliminated by the Court ruling would not be reinstated under the proposed rule. Specifically, the proposed restrictions related to shallow-setting would apply only to Hawaii-based longline vessels, not general longline vessels; Hawaii-based longline vessels and general longline vessels would no longer be prohibited from longlining during April and May in certain waters south of the Hawaiian Islands; operators of general longline vessels would no longer be required to annually complete a protected species workshop; operators of general longline vessels and of other vessels using hooks to target Pacific pelagic species would no longer be required to employ specified sea turtle handling measures; and the period during which vessels de-registered from a Hawaii longline limited access permit after March 29, 2001, would be allowed to be re-registered to Hawaii longline limited access permits would no longer be limited to the month of October.

Skills Necessary to Meet Compliance Requirements

No special skills would be required to comply with the proposed compliance requirements. All affected entities already have the skills necessary to comply with the proposed longline gear-related requirements. NMFS may provide additional training in the proper use of the required dehookers through the protected species workshops that owners and operators of Hawaii longline limited access permits must attend and complete each year. All affected entities already have the skills necessary to comply with the proposed notification requirements (i.e., notifying NMFS each year if interested in receiving shallow-set certificates and indicating in the already-required pre-trip notification to NMFS whether shallow-sets or deep-sets will be done during the trip).

Identification of Duplicating, Overlapping, and Conflicting Federal rules

To the extent practicable, it has been determined that there are no Federal rules that may duplicate, overlap, or conflict with this proposed rule.

Development and Description of Alternatives

Because the impetus for this action is concern for fishery interactions with sea turtles, and because the Hawaii-based longline fishery is the only FMP-managed fishery thought to interact significantly with sea turtles this action focuses on that fishery. Thus, under all alternatives considered here the management of all other fisheries would remain unchanged, except in the case of time/area closures which would also affect general longline permit holders who are currently subject to the southern time/area restriction along with Hawaii-based longline vessels. General longline permit holders would also continue to be prohibited from participating in the Hawaii-based longline fishery (meaning to fish in Hawaii's EEZ or to land fish in Hawaii) without obtaining a Hawaii longline limited access permit.

As discussed in Section II, the Council's Sea Turtle Conservation Special Advisory Committee held a series of meetings in late 2003 to craft the following recommendations for further analysis and possible Council action. As stated above, all action alternatives would require night-setting by vessels shallow-setting north of 23° N., and Committee Alternatives 1-5 would require the use of dehookers in accordance with NMFS' guidelines now being written. In addition, all alternatives include the implementation of a suite of conservation measures and potential fishing trials as described below.

Committee Alternative 1.	Allow 1,060 model swordfish sets annually, in conjunction with tuna fishing with no time/area closure.
Committee Alternative 2.	Allow 1,560 model swordfish sets in conjunction with tuna fishing with no time/area closure.
Committee Alternative 3.	Allow 2,120 model swordfish sets annually, in conjunction with tuna fishing under the reimplementation of the recent time/area closure modified by opening EEZ waters around Palmyra Atoll.
Committee Alternative 4. (preferred)	Allow 2,120 model swordfish sets annually, in conjunction with tuna fishing with no time/area closure.

Committee Alternative 5.	Allow 3,179 model swordfish sets annually, in conjunction with tuna fishing with no time/area closure.
Committee Alternative 6. (current fishery)	Do not allow any swordfish sets, allow tuna fishing with recent time/area closure.
Committee Alternative 7. (no action)	No management action is taken by April 1, 2004, June 12, 2001 rules are vacated, fishery returns to previous FMP management regime.

Implementing Details
There are several available options in implementing a system that distributes and monitors and controls a restricted amount of fishing effort allowable for the model swordfish fishery. The details of how this effort is managed are not likely to significantly impact the number of sea turtle interactions or mortalities. However, they can affect the operations and success of fishery participants and thus are relevant to this action's objective of achieving OY. Due to ease and familiarity in implementation, these options assume that allowable fishing effort would be identified and monitored in number of sets, though limits on the number of trips, vessels, or other systems could also be appropriate. A series of Participation Options examine ways in which allowable effort is distributed, while two Closure Options examine ways in which the model swordfishery could be closed when allowable limits are reached. Under all options, allowable effort would not be temporally restricted, meaning that participants would be able to fish at any time during the season or year.

Participation Options 1-4 were discussed at the 120th Council meeting. The Council indicated that it preliminarily preferred Option 4, but in recognition of some outstanding issues an advisory group consisting of industry members, scientists, and managers was formed to make recommendations to NMFS concerning its technical and operational details. Option 5 (preferred) which would divide allowable effort equally among interested permit holders is the result of that group's work.

Participation Option 1-Allow participation in the model swordfish-style fishery based on "first come first served." Depending on the amount of allowable effort, this option could result in a derby-style fishery where many participants gear up and fish in a competitive manner until the effort limit is reached. This could lead to safety problems if fishing occurs during hazardous weather or sea conditions, market effects if many vessels offload simultaneously, and inefficient (excess) investment if more boats gear up than are necessary. This option could be seen as avoiding issues of equity by providing an equal opportunity for all permit holders to participate in the swordfish-style fishery and it would be relatively easy to allocate available effort. However the necessary monitoring and closure of the fishery would be difficult as on any given day there are many vessels at sea - some of which are actively fishing and others of which are in transit. In addition, not every vessel has communication capabilities that are compatible with NMFS' systems.

Participation Option 2 - Allow participation in the model swordfish-style fishery based on individual historical participation Basing participation on each vessel's fishing history could be seen as equitable by many participants although there would likely be some dissension between those permit holders whose vessels have remained in Hawaii and those that have recently based their vessels in California to continue swordfishing. In addition, it would represent an uncompensated loss of access to the tuna sector which was not historically prohibited from participating in the swordfish fishery. This option could be difficult to implement as logbooks would have to be analyzed, decisions over which historical fishing to consider would have to be made, and trails of vessel and permit transfers would need to be traced. Costs to fishery participants would be a function of which vessels were allowed to participate and whether successful vessels were currently rigged for tuna-style or swordfish-style fishing. This option may result in efficiencies if there is no method for uninterested successful permit holders to transfer their allowable effort to those who do want to fish swordfish-style.

Participation Option 3 - Divide allowable effort equally among all boats. This option would allow each permit holder to fish an equal amount of effort (days, sets, hooks etc.). Although apparently fair, it is likely to result in inefficiencies if there is no method for uninterested permit holders to transfer their allowable effort to those who want to fish swordfish-style.

Participation Option 4 - Allow participation in the model swordfish-style fishery based on a lottery. Perceptions of equity are likely to be a function of who is eligible to participate in the lottery. Opening it to all permit holders might be seen as unfair to those who have historically fished swordfish-style (although the swordfish sector has never had its own limited entry program), while only allowing historical participants in would be likely to be seen unfavorably by tuna fishermen. The issue of unused effort could be addressed by opening a lottery to all (and only) those who express an interest. Assuming that fair notice is given to all permit holders, this may be seen as a reasonable compromise.

Participation Option 5 - Divide allowable effort equally among interested permit holders (preferred) Under this refined version of Participation Option 3, certificates for allowable sets would be evenly divided among permitted vessels belonging to interested permit holders (including those whose vessels are not currently registered to their permits) based on their positive response to a letter sent by NMFS. Permit holders could either fish their shares themselves, or trade, sell, or give them to other Hawaii longline limited access permit holders to use during that fishing year. The use of uniquely numbered physical certificates for each set will allow permit holders to transfer allowable effort among themselves with no intervention or recordkeeping by NMFS. This should result in increased efficiency as effort shares should be worth more to (and thus move toward) those who believe that they have a higher likelihood of shallow-setting profitably (e.g. experienced swordfish fishermen). Restricting effort shares to those who express interest will help to ensure that allowable effort is used. This option was endorsed by the Hawaii Longline Association.

Several options for the monitoring and control of model swordfishing effort and turtle interactions have been discussed. Fishery data would continue to be collected based on logbooks and other fishery monitoring systems, with fishing ceasing each year when all allowable effort certificates were used. Interaction data would continue to be collected by NMFS through its observer program. NMFS has reported that the recent recalibration of its observer placement design to achieve random sampling should allow relatively simple and timely extrapolations of observed interactions into fleet wide estimates.

The following options consider the action to be taken when these extrapolations indicate that the model swordfishery has reached its anticipated takes. Closure Options 1 and 2 were discussed at the 120th Council meeting. The Council indicated that it preliminarily preferred Option 1, but in recognition of some outstanding issues, an advisory group consisting of industry members, scientists, and managers was formed to make recommendations to NMFS concerning its technical and operational details. Option 3 (preferred) which would apply a "hard limit" for the swordfish fishery for leatherbacks and loggerheads is the result of that group's work.

Closure Option 1- When the swordfish fishery's incidental take statement or other limit is reached close the swordfish fishery ("hard limit"). This alternative would provide certainty to fishery participants and managers that the swordfish fishery would stop fishing when its average incidental take statement or other limit is reached. If the hard limit is set correctly, it could also avoid the reinitation of section 7 consultations due to excessive interactions.

Closure Option 2 - When swordfish fishery's incidental take statement or other limit is exceeded reinitiate consultation on the swordfish fishery. As compared to Closure Option 1, reinitiation of consultation would provide a less certain outcome in terms of continued swordfish fishing. In the past, reinitiation of consultations has resulted at times in fishery closures, however some fisheries have been allowed to continue fishing during the re-consultation period.

Closure Option 3 - When the swordfish fishery's new incidental take statement is reached for leatherback or loggerhead turtles, close the model swordfish fishery (preferred). Under this refinement of Closure Option 2, hard limits would be placed on the swordfish fishery for leatherback and loggerhead turtles (the species of concern in the shallow-set fishery) and the model swordfishery would be closed each calendar year when its new incidental take statement (concerning total interactions) for leatherback or loggerhead sea turtles is reached. Interactions and incidental take statements for green and ridley turtles would be combined with those for the tuna fishery and normal ESA procedures would apply to these species (as they would also apply to leatherbacks and loggerheads taken by the swordfish fishery). Updated information on year-to-date interactions will be available from fishery managers to inform participants as to the fishery's status regarding the established hard limits. This will allow vessel operators to avoid embarking on trips that are likely to be ended prematurely, as well implicitly providing notice of upcoming closures. Fishery participants would receive formal notice from NMFS at least one week in advance of any closure. Barring other new information, the fishery would automatically reopen on January 1 of the next year. Hard limits would not be used for olive ridley and green sea turtles. Although this option could also result in a derby-style fishery, it is unlikely as incidental take statements are calculated taking into consideration total anticipated fishing effort. Therefore the threat of the incidental take statement being exceeded is low and the incentive to race to the fish (turtles) is also low.

Providing separate incidental take statements would allow early closure of fisheries that are having high rates of interactions with the species of highest concern, but allow fishing to continue by lower impact gear types. Data on anticipated interactions has historically been grouped into deep vs. shallow-set gears so this will not pose a new estimation problem. However, due to sampling procedures and the desire to maintain consistent rates of observer coverage, participants would have to declare their trip type (deep or shallow set) when they contacted NMFS as to whether they would need to carry an observer. Once the trip commenced, participants would be prohibited from switching gear types for the remainder of that trip.

In addition to the measures described above, the advisory group has suggested that NMFS hold dockside or other sessions to educate participants in the model swordfish fishery on the proper use of circle hooks with mackerel-type bait, and to educate all fishery participants on the appropriate use of dehookers. This group also suggested that NMFS consider providing 100% observer coverage for the model swordfish fishery for at least the first year, as this would provide complete information on the frequency and nature of fishery interactions with sea turtles as well as detailed information on the fishing practices of all vessels. Regardless of observer coverage, the group recommended that if realtime estimates are necessary and practicable, NMFS provide observers with a reliable means of shoreside communications for them to call-in immediately if interactions are observed.

Reasons for not Choosing Alternatives

The alternatives included two variations on the seasonal area longline closure, including one that would retain the current April-May closure in certain waters south of the Hawaiian Islands and one that would retain the current April-May closure with the exception of the EEZ waters around Palmyra Atoll (the proposed rule would eliminate the current April-May area closure). The alternatives were rejected because they would unnecessarily constrain the fishing activities and economic performance of holders of longline general permits and Hawaii longline limited access permits, and adverse impacts to sea turtles could be mitigated through other measures.

The alternatives included five variations on the amount of shallow-setting longline effort north of the equator that would be allowed by Hawaii-based vessels, ranging from zero to unlimited, as well as one alternative that would allow only a one-time trial of 1,560 sets (the proposed rule would limit shallow-setting effort at 2,120 sets, about 50 percent of the 1994-1998 annual average level). The alternatives allowing shallow-setting at levels greater than 50 percent of the 1994-1998 average were rejected because they might fail to adequately minimize adverse impacts on sea turtles. The alternatives allowing shallow-setting at levels less than 50 percent of the 1994-1998 average were rejected because they would unnecessarily constrain the fishing activities and economic performance of Hawaii-based longline vessels, and adverse impacts to sea turtles could be mitigated through other measures.

The alternatives included several variations on how the allowable level of shallow-setting effort north of the equator would be allocated among holders of Hawaii longline limited access permits. Variations included allocating the available effort by lottery, allocating it equally among all permit holders, allocating it in proportion to the permit holders' historical shallow-setting effort, and not allocating the effort in any particular way, in which case the fishery would be closed each year once the fleet-wide limit is reached (the proposed rule would divide and distribute the limit equally among all interested permit holders in the form of transferable shallow-set certificates). The lottery variation was rejected because it would impose a substantial amount of uncertainty on fishermen and might be considered inequitable by some fishermen. The equal-distribution variation was rejected because it would give each permit holder too few shallow sets to be able to make it worth investing and participating in the shallow-set component of the fishery, thereby constraining the economic performance of that component. The fleet-wide limit variation was rejected because it would be administratively difficult and could create an incentive for each permit holder to do as much shallow-setting as possible before the fishery is closed, thereby encouraging fishermen to shallow-set under what would otherwise be sub-optimal conditions (in terms of both economic performance and safety).

The alternatives included several variations on the sea turtle interaction limit(s), including no limit and a limit for every species for which there is an Incidental Take Statement issued under the ESA. The preferred alternative rule would close the shallow-set component of the fishery if the annual limit on interactions with leatherback sea turtles or loggerhead sea turtles is reached. These limits would be set equal to the annual estimated incidental interactions with the respective species in the shallow-set component of the Hawaii-based fishery, as established in the prevailing biological opinion issued by NMFS pursuant to section 7 of the ESA. The no-limit variation was rejected because it might fail to adequately minimize adverse impacts on sea turtles. The variation of establishing limits for all affected species was rejected because it would likely result in the shallow-set component of the fishery being closed more often than is needed to adequately mitigate adverse impacts on sea turtles.

Non-Regulatory Elements of Alternatives

In addition to the regulatory elements of the various alternatives, some of the alternatives included non-regulatory elements, as described below.

Fishing Trials

Committee Alternative 4 (preferred) would also potential for fishing trials within the model swordfish fishery, if recommended by NMFS' scientists. These trials would take place on commercial fishing boats and use the circle hooks and mackerel-type bait described here as a control. All fishing effort expended, and turtle interactions recorded during any such trials, would count against the swordfish fisheries effort and turtle limits. Examples of technologies that might be tried include turtle repellent bait, the use of lights that turtles perceive as flashing and unattractive but which appear steady and attractive to fish, and other techniques that could be used in conjunction with circle hooks and mackerel-type bait to further reduce and mitigate interactions with sea turtles.

Description of Conservation Projects Included in All Alternatives

Five conservation projects are being undertaken as a part of all alternatives. Although non-regulatory, these measures are designed to conserve sea turtles, as well as to mitigate the impacts of the fishery on affected populations. Of the four sea turtle species of concern, the population of Hawaii green sea turtles are increasing and olive ridley turtle nesting aggregations in the western Pacific appear to be somewhat stable or increasing slightly. On the other hand, leatherback and loggerhead turtles are the species most often captured by the Hawaii-based longline fishery and their Pacific populations are in general decline. For that reason, these species are the focus of the measures proposed here to mitigate the impacts of the Hawaii-based longline fishery on sea turtles.

For leatherback sea turtles, the emphasis of these measures is placed on the western Pacific leatherback stock because the majority of interactions with the Hawaii-based longline fishery have been with this stock (16 out of 17 sampled turtles have been from the western Pacific stock). Although geneticists have been unable to trace these fishery interactions to specific nesting beaches, beaches in Papua (formerly Irian Jaya) and Papua New Guinea are believed to comprise the majority of western Pacific nesting populations and are thus most likely to contain populations affected by the fishery. Satellite telemetry data from the electronic tagging of turtles from the northern coast of Irian Jaya has also shown that these turtles are the likely source of the majority of leatherback turtles that migrate through the areas of ocean fished by the Hawaii longline fleet. In addition to the egg protection which is a necessary component of a conservation and recovery program, leatherback measures emphasize protection of adults as the fishery is known to interact with adults and sub-adults. Loggerheads measures focus on the North Pacific (Japanese) stock because all fishery interactions have been with this population. Loggerhead measures have a particular emphasis on juveniles as that is the life stage with which the fishery interacts.

Under the proposed conservation measures, the Council will continue to collaborate with NMFS to develop and fund contracts with relevant non-governmental organizations (NGOs) such as World Wildlife Fund - Indonesia (WWF-Indo), Kamiali Integrated Conservation Development Group (KICDG) of Papua New Guinea, the Sea Turtle Association of Japan, and Wildcoast in Baja, Mexico. The conservation measures in this document have come directly from these NGOs currently working at relevant sites conducting research and population monitoring activities and were reviewed and endorsed by the Council's Sea Turtle Advisory Committee at their July 2003 meeting. This committee was established by the Council to direct and advise the Council in its activities related to sea turtle conservation and sea turtle related fishery management initiatives. Committee members include world renowned experts in sea turtle biology, conservation and recovery, including several scientists from NMFS' Science Centers. The committee concluded that the projects described here are valuable, hold scientific merit, and should be incorporated into the management measures considered by the Council. The conservation measures described below are new projects, but cost estimates are dependent on preexisting programs. In other words, proposed projects are designed to augment programs already in existence to support additional conservation objectives and projects. As noted below, establishment of some of these projects has commenced in order to protect turtles during the 2003 nesting season.

Papua (formerly Irian Jaya), War-mon Beach:

The Council is developing a contract with the World Wildlife Fund-Indonesia (WWF-Indo), commencing November 1, 2003 to hire villagers to protect the War-mon nesting beach at Jamursba-Medi, Bird's Head Peninsula in Papua (formerly Irian Jaya). This measure will build on existing programs already established by WWF-Indo and supported by the Indonesian Government at Jamursba-Medi, the largest known leatherback nesting site in Indonesia. WWF-Indo has achieved great success in eliciting the enthusiastic support and involvement of local people for nesting beach protection and management in this area.

This effort will protect 1/3 of the known leatherback nesting beach habitat along the north coast of Papua and protect between 90% and 100% of the currently unprotected War-mon beach at Jamursba-Medi. This effort has been estimated to result in the protection of approximately 1,000 leatherback nests per year (TAC 2003, P. Dutton, NMFS SWFSC) from predation by feral pigs, beach erosion and egg collectors. Protection may be achieved through the use of an electric fence to keep pigs off beach, by relocating eggs to more secure areas, and deter poachers through monitoring presence. In addition, through monitoring presence, measures are expected to conserve and additional 10 adult nesting females per year from poachers.

Western Papua coastal foraging grounds:

The Council has contracted with WWF-Indo to work with villagers in western Papua's Kei Kecil islands to reduce and /or eliminate the harpooning of about 100 adult leatherback turtles per year in the coastal foraging grounds (TAC 2003, P. Dutton, NMFS SWFSC). In addition, effort will be made to explore and identify alternative food resources.

Papua New Guinea nesting beaches:

The Council has contracted with the Kamiali Integrated Conservation Development Group (KICDG), commencing November 1, 2003 to work with up to three villages of the Kamiali community in Papua New Guinea to eliminate egg harvesting and nest predation of leatherback eggs, and move those eggs laid in areas likely to be lost to beach erosion. Current practices have a 2 km section of beach marked off as a "no take" area. This effort will provide additional protection of approximately 90% of the nesting beach, and is estimated to save about 1,000 to 1,500 nests per year (TAC 2003, P. Dutton, NMFS SWFSC).

In addition to establishing nesting beach management measures in Papua New Guinea, the Council, NMFS PIRO/PIFSC and NMFS Southwest Fisheries Science Center (SWFSC) will conduct aerial surveys of the coastal areas of northern Papua New Guinea, Solomon Islands and Vanuatu over the next 4 years to establish a comprehensive inventory of leatherback nesting beaches for which further conservation projects might be established. An initial feasibility study to conduct the initial surveys has been funded for late 2003 (WPRFMC in prep.), and funding has been identified for a more complete survey of northern Papua New Guinea in 2004.

Baja, Mexico halibut gillnet fishery:

The Council is developing a contract with Wildcoast to conduct mortality reduction workshops with fishermen and place observers on local boats to insure that all the live loggerheads that comprise the estimated 3,000 loggerhead juveniles per year caught in the halibut gillnets are returned to the ocean (TAC 2003, P. Dutton, NMFS SWFSC). Without observers these loggerheads become part of the catch.

Japan nesting beaches:
The Sea Turtle Association of Japan (STAJ) has proposed moving loggerhead eggs from locations prone to washing out and provide shading to nests that experience extreme temperatures at two nesting beaches. A contract has been developed with STAJ for this work to begin during the May 2004 nesting season. This activity is estimated to result in saving 53 loggerhead nests (TAC 2003, G. Balazs, NMFS PIFSC), and would provide valuable benefits towards establishing cooperative working relationships.

The Council will also continue to augment and expand its role in developing educational materials to support the establishment of a nesting beach management program at War-mon beach and for the establishment of similar programs elsewhere in Melanesia. In addition, a contract has been developed with the Ostional National Wildlife Refuge in Costa Rica to assist managers to convene workshops to reduce sea turtle mortalities in longline fisheries based in Costa Rica.

Finally, in addition to the measures described above, a Council advisory group including fishery managers and industry representatives formed to provide technical advice on the implementation of the proposed action has suggested that NMFS hold dockside or other sessions to educate participants in the model swordfish fishery on the proper use of circle hooks with mackerel-type bait, and to educate all fishery participants on the appropriate use of dehookers.

VIII. DESCRIPTION OF SMALL BUSINESSES TO WHICH THE RULE WOULD APPLY

Table 5 presents data for 2003 that indicate the number of fishing operations that would be directly affected by the alternatives. All the Hawaii-based vessels operate under Hawaii longline limited access permits, the number of which is limited to 164. The vessels based in American Samoa, Commonwealth of the Northern Mariana Islands, and Guam operate under longline general permits, which are not limited in number. The majority of vessels are owner operated however some individuals hold permits for more than one vessel, or own more than one vessel. Maximum fleet (vessel) percentage ownership by any one individual or entity is believed to be less than 10%. All these fishing operations are believed to be small businesses; that is, they have gross revenues of less than $3.5 million annually, they are independently owned and operated, and they are not dominant in their field. Please see Section III for a description of these vessels' gear types and operating patterns.

Table 5. Number of longline fishing operations to which the rule would apply

2003 Western Pacific longline fisheries		
Base	Number of permits	Number of active vessels (preliminary data)
Hawaii	164	126
American Samoa	65	48
Guam	1	0
CNMI	1	0

IX. COMMENTS RECEIVED ON THE INITIAL REGULATORY FLEXIBILITY ANALYSIS

One commentor stated that the IRFA's analysis of the participation options contained inadequate information concerning their genesis, refinement, and potential impacts especially concerning perceptions of fairness. Fairness can be achieved in many ways and what may appear fair to some may appear unfair to others. The primary consideration in the refinement of the preferred alternatives participation option was input from the Hawaii Longline Association which represents the affected parties (permit holders) as it is their perceptions of fairness which would seem most relevant. This FRFA contains additional text on these issues. No changes were made to the preferred alternative or the proposed rule for this action.

X. ECONOMIC IMPACTS OF THE ALTERNATIVES ON SMALL BUSINESSES

To provide a common reference point, each alternative presented here is compared to the management measures in place under the FMP between 1994 and 1999 (when the Hawaii-based swordfish and tuna fisheries were both fully active). This baseline is used as it represents the most recent long-term data used by scientists to fully analyze the relative impacts of each alternative. Data below do not include California landings by vessels which carry Hawaii permits.

However it should be noted that the peak of Hawaii's swordfish fishery occurred between 1991 and 1993 when an average of almost 12 million pounds of swordfish were landed annually. Table 6 presents the baseline (1994-1999 annual averages) for the factors used in this analysis.

Table 6. Baseline for the Hawaii-based longline fleet (1994-1999 average annual data)
Source: *Annual Report of the Hawaii-based Longline Fishery for 2000* HL Admin Report H-01-07

Number of active vessels	113

Number of vessels that targeted swordfish on at least one trip	40
Average annual swordfish trips per vessel above	3
Number of vessels that targeted tuna on at least one trip	83
Average annual tuna trips per vessel above	8
Number of vessels with mixed targets on at least one trip	49
Average annual mixed trips per vessel above	6
Swordfish landings and ex-vessel revenue	6.5 million pounds $13.8 million
Bigeye tuna landings and ex-vessel revenue	5.2 million pounds $17 million
Albacore tuna landings and ex-vessel revenue	2.5 million pounds $3 million
Yellowfin tuna landings and ex-vessel revenue	1.7 million pounds $4.6 million
Other landings and ex-vessel revenue	8.5 million pounds $7 million
Total fishery landings and ex-vessel revenue	24.4 million pounds $45.4 million
Average landings and ex-vessel revenue per vessel	215,929 pounds $401,770

In comparison, Table 7 provides 2001 available information on the fishery under the current regulations including the ban on swordfish targeting and the seasonal southern area closure.

Table 7. 2001 data for the Hawaii-based longline fleet Source: Draft 2002 Annual Report on the Pelagic Fisheries of the Western Pacific Region (WPRFMC)

Number of active vessels	102
Number of tuna trips (based on current regulations, only deep-set tuna targeting trips are allowed)	1,193
Average trips per vessel	12
Incidental swordfish landings and ex-vessel revenue	.5 million pounds $1.2 million

Bigeye tuna landings and ex-vessel revenue	5.2 million pounds $18.2 million
Albacore tuna landings and ex-vessel revenue	2.8 million pounds $3.2 million
Yellowfin tuna landings and ex-vessel revenue	2.2 million pounds $5.5 million
Other landings and ex-vessel revenue	4.8 million pounds $4.9 million
Total fishery landings and ex-vessel revenue	15.5 million pounds $33 million
Average landings and ex-vessel revenue per vessel	151,961 pounds $323,529

NMFS scientists have modeled the anticipated impacts of the alternatives on fleet-wide catches of major species and ex-vessel revenues in relation to the 1994-1999 baseline. Table 7 presents these data.

<u>Impact on Hawaii-based Longline Vessel Operations</u>

Table 8. Comparison of impacts of the alternatives on the annual catch and revenue of the Hawaii-based longline fleet. Source: NMFS PIFSC

Committee Alternative	Change in swordfish catches	Change in bigeye catches	Change in albacore catches	Change in yellowfin catches	Changes in fleet-wide ex-vessel revenue
1	-67.2%	19.2%	27.8%	18.2%	-6.6%
2	-56.6%	16.2%	23.5%	15.3%	-5.6%
3	-44.5%	11.3%	21.7%	18.2%	-4.4%
4 (preferred alternative)	-44.8%*	12.8%	18.6%	12.1%	-4.4%*
5	-22.4%	6.4%	9.3%	6.1%	-2.2%
6 (Current fishery, 2002 data)	-92.3%	0.0%	12.0%	29.4%	-27.3%
7 (No action, 1994-1999 baseline)	6.5 million pounds	5.2 million pounds	2.5 million pounds	1.7 million pounds	$45.4 million

* Modeling for these estimates did not include the 30% increase seen in swordfish catches when circle hooks with mackerel bait were used in the Atlantic longline fishery.

The impact on the seafood marketing sector, fishing supply businesses, and other associated businesses is expected to be proportional to the impact on ex-vessel revenue in an input-output perspective.

The distribution of impacts on individual vessel operators under each of the alternatives would vary according to their historical and future operating patterns. Assuming that allowable effort shares (transferable single set certificates) are distributed as in the preferred participation option (distributed equally among interested Hawaii longline limited access permit holders), it is expected that these shares will be transferred to those permit holders who are most interested in using them.. Economic theory would predict that these will be the individuals who are able to use them most efficiently (i.e. profitably) as they will be willing to pay a higher price than those who do not expect to achieve similar profits swordfishing. Since the de facto partial opening of the swordfish fishery provides an opportunity but not a restriction on current operations, the cost of doing so is essentially equivalent to exercising an option, rather than a regulatory cost per se.

These are likely to be permit holders with a history (and therefore experience) in swordfishing, and may include a significant number of vessels now temporarily based in California and targeting swordfish. These vessels are already outfitted for this fishing style as compared to vessels which have remained in Hawaii to target tuna so their costs to gear up will be low. However it is unknown how many of the now California based vessel operators have satisfactorily relocated their families to California and how many would like to return to Hawaii. In addition, there will be relocation costs for any California vessels and crews (with or without families) for the relatively limited duration of the swordfish fishery. Thus the advantages to vessels choosing to swordfish, or those who would choose to swordfish, may be reduced by the cost of acquiring sufficient certificates to enable full operations for all or part of the season, as well as the transition costs of shifting from current tuna longline operations or from swordfish operations in California. Costs for acquiring specialized equipment, including circle hooks and dehookers (which would be required for all Hawaii-based longline vessels), and for using mackerel-type bait, are minimal in the context of total longline operating costs (which are in the range of $250,000 annually) for medium-sized vessels.

Participation Option 1, which would allow fishing on a first-come first-served basis, was rejected because it could result in a derby-style fishery with the associated congestion, market gluts and shortages which could accompany a fishery that contracts its annual effort into a limited time period. Although it would be relatively easy to allocate available effort, the necessary monitoring and closure of the fishery would be difficult as on any given day there are many vessels at sea - some of which are actively fishing and others of which are in transit. Participation Option 2 which would distribute allowable effort in proportion to historical participation in the swordfish fishery was rejected in part because of the administrative challenges given the short timeline for implementing this action, and because it would exclude those participants who have historically targeted tuna, but who were not previously barred from participating in the swordfish sector. Participation Option 3, which would distribute allowable effort equally among all permit holders, was rejected on the basis that this could result in unused allowable effort by disinterested parties, which was considered to constitute a waste of economic opportunity. Participation Option 4, which would have implemented a lottery among permit holders with historical swordfishing experience, was rejected for the same reason as for Option 2, it would be difficult to implement given the short timeline for finalizing this action, and because it would exclude those participants who have historically targeted tuna, but who were not previously barred from participating in the swordfish sector. The preferred option's provision to allow transfers of effort shares among permit holders means that those who sell their effort shares will be compensated for yielding their right to participate in the model swordfish fishery. Allowing shares to be transferable will likely lead to their acquiring monetary value, this will help to ensure that all allowable effort is used, thus achieving optimum yields from the fishery which is one of the objectives of this action. The costs of acquiring such shares, as well as the reduction in operational flexibility associated with the requirement to make sets only of the type indicated to NMFS in advance of each trip (i.e., shallow-setting or deep-setting, to insure appropriate levels of observer coverage) represent costs and thus reduce efficiency to a degree. However, to the extent that reopening the swordfish fishery provides additional fishing options for certain vessels, the decision to undertake swordfish operations represents a net benefit (as also discussed in the RIR).

All participants in both the swordfish and tuna sectors of the fishery will also potentially be impacted by the limitations implicitly contained in a Biological Opinion anticipated to be issued by NMFS prior to the finalization of this action. Biological Opinions are the result of consultations conducted under the authority of section 7 of the Endangered Species Act (ESA). If a consultation concludes that an action is likely to jeopardize the continued existence of a population listed under the ESA, the resultant Biological Opinion will include an Incidental Take Statement which specifies the annual number of lethal and non-lethal fishery interactions anticipated under the action. (A Biological Opinion may also include a number of non-discretionary changes to the proposed action, if this action is subject to such changes, they will be discussed and analyzed in the final regulatory flexibility analysis for this action.) If actual interactions exceed anticipated interactions in any calendar year, the ESA provides for the reinitiation of consultation on the fishery, during which time the fishery may or may not be closed at the discretion of NMFS. Although fishery participants were not fully cognizant of this potentiality in the past, the majority of Hawaii longline limited access permit holders now understand that this implicit limitation exists and that fishery closures become more probable as each year progresses. The inclusion of a “hard limit” for leatherback and loggerhead interactions in the swordfish fishery under the preferred alternative would make this implicit limitation explicit by closing this sector if anticipated interactions (as specified in the incidental take statement to be produced by NMFS) are exceeded. This has the potential to create a derby style fishery in which participants race to use their allowable effort in advance of potentially exceeding the hard limits for leatherbacks and loggerheads. However this is unlikely as incidental take statements are calculated taking into consideration total anticipated fishing effort. Therefore the threat of the incidental take statement being exceeded is low and the incentive to race to the fish (turtles) is also low.

Impacts on American Samoa-based Longline Vessel Operations

These vessels are registered for use under general longline permits. These vessels would not, under any of the alternatives, be allowed to fish in the EEZ around Hawaii or land longline-caught fish in Hawaii. They would be allowed to engage in shallow-setting north of the equator without any of the restrictions to which the Hawaii-based longline vessels would be subject. Although this represents new fishing opportunities for these vessels, the restrictions on fishing in the EEZ around Hawaii and on landing fish in Hawaii make it unlikely to be a cost-effective option, and it is unlikely to be taken advantage of. Operators and owners of these vessels would be positively affected by any alternative (including the preferred alternative) which removes the current southern time/area closure to which they are subject. American Samoa-based longline operations would benefit from the fact that the preferred alternative would not reinstate the requirement for vessel operators to annually complete protected species workshops and to use specified sea turtle handling methods.

Impacts on Guam and CNMI Longline Vessel Operations

Although two general longline permits have been issued by NMFS for longline operations based in Guam and CNMI, neither vessel is active at this time. In the event that they or others become active, they will be largely unaffected by any alternatives as, like the American Samoa-based longline vessels, they are unlikely to be able to profit from the opportunity to engage in shallow-setting north of the equator and they are located far west of the current southern time/area closure. Guam- and CNMI-based operations would benefit from the fact that the preferred alternative would not reinstate the requirement for vessel operators to annually complete protected species workshops and to use specified sea turtle handling methods.

Impacts on Small Boat Fisheries

None of the alternatives are expected to have significant direct impacts on effort or catches by commercial troll and handline vessels, nor are they expected to have effects on the catch and effort of charter and recreational vessels in the region's pelagic fisheries. Alternatives which would allow the establishment of a Hawaii-based model swordfish fishery are expected to result in increased longline catches of blue marlin, which are an important species for charter vessels. Because prime swordfishing grounds are well north of Hawaii, it is not anticipated that these increased longline catches will affect the catches or catch rates of the much smaller Hawaii-based charter vessels which generally fish within 50 miles of shore. Non-longline vessels that fish for pelagic species with hooks would benefit from the fact that the preferred alternative would not reinstate the requirement for vessel operators to use specified sea turtle handling methods.

In summary, the preferred alternative is expected to have positive economic impacts on participants in the region's longline fisheries and other small businesses and entities as it provides additional fishing opportunities for those who choose to undertake them, as well as means of compensating those who choose to transfer their allowable swordfishing effort rather than using it themselves. It will also increase economic opportunities to shoreside wholesalers and retailers as it is expected to lead to increased landings of swordfish, and a more regular supply of tuna.

XI. IMPACTS OF THE PREFERRED ALTERNATIVE ON NATIONAL COSTS AND BENEFITS

The implementation of the preferred alternative would be expected to increase the efficiency of the Hawaii-based longline fleet and of those longline vessels currently fishing out of California who choose to relocate to Hawaii. Most of these vessels had previously chosen to target swordfish from Hawaii which exhibits their revealed preference for those operating patterns compared to regulation-required changes in their economic operations. The increase in net revenue is likely to be more than proportional to the increase in ex-vessel revenue previously modeled because of these efficiencies. This represents the primary national benefit from this proposed regulation.

The implementation of the preferred alternative would also likely to have implications beyond those on small businesses and entities participating in the affected fisheries. Non-use values, also referred to as passive-use or existence values, do not involve personal consumption of derived products nor *in situ* contact. (Bishop, 1987). Non-use values may, nevertheless, be the most important benefit derived from some endangered species, simply because such species are [so] few in number that many people are unlikely to have seen them or to have had very much tangible experience regarding them. The most visible manifestation of existence values is the donation of funds to private organizations that support activities to preserve endangered species. However, whether people enjoy existence values of resources is not contingent upon whether they donate money to support a cause. Any impact of non-use values would be a hedonic (non-market) effect.

Particularly in the United States and western Europe, there are those who consider that certain marine species represent a special group of animals that should not be killed, deliberately or incidentally, under any circumstances. Certain marine animals are viewed symbolically as unique or majestic creatures – "charismatic megafauna" – similar to African big game. From this perspective, every incidental catch of such a species would be a severe problem.

The perceived need for conservation of such species may be independent of any impact caused by fishing or of its stock status. This perception may also influence the response of resource managers to bycatch management issues. For example, the case of three ice-entrapped gray whales in Alaska might be seen as an example of where the ecological impact is minimal but where public perception and political attractiveness may lead to disproportionate effort. Such views are strongly culture-dependent (Hall, 1998).

Numerous studies have been conducted on the value of endangered species (e.g., Loomis and White 1996) and several studies provide estimates of the value of protected species in Hawaii, including the Hawaiian monk seal (WPRFMC, 2000b). Metrick and Weitzman (1996) were unable to identify a satisfactory measure of charisma in the context of endangered species but they note that eye-size or eye-body ratio have been suggested. Another possible component of existence value is the degree to which a species is considered to be a higher form of life and possibly possess (anthropomorphic) capabilities for feeling, thought and pain (Metrick and Weitzman, 1996; Kellert, 1986). There may also be existence value for the contribution of particular species to biodiversity (Metrick and Weitzman, 1996). However, no valuation studies have been conducted specifically for sea turtles in the western Pacific region and for other species of interest in FMP-managed fisheries. As a result, new research would be needed to understand the non-use value of these species and how such values would be affected by the alternatives.

Alternatives that would establish a model swordfish fishery are expected to restore some of the historic Hawaii-based swordfish longline fishing effort but which would increase interactions with sea turtles would represent a national (non-market) cost. However, at least some of of this increase in swordfish effort would be relocated from California where vessel operators are not subject to the current prohibition on swordfish fishing and will not be subject to any new requirements to use circle hooks with mackerel-type bait to reduce and mitigate sea turtle interactions. This would be a positive result for sea turtles as it would reduce overall domestic fishery interactions compared to the unregulated California fishery.

Due to the large amount of foreign pelagic longline fishing effort, as well as predation, habitat destruction, and directed takes of sea turtles at their nesting beaches and in coastal foraging areas, it is likely to require global conservation efforts to prevent a significant cumulative loss of non-use value associated with sea turtles. Beyond domestic requirements, the development and subsequent "export" of environmentally responsible fishing technologies is an essential step in recovering sea turtle populations. As long as there is demand for fish that is associated with sea turtle interactions, there will be fisheries attempting to target those fish. The US cannot begin to realistically attempt to reduce the impacts of these fisheries until there are practical and effective tools to reduce and mitigate fishery interactions with sea turtles.

How will these tools be "exported", what will motivate other nations or fleets to adopt them? It is unclear how many fishing nations have laws to protect endangered species, those that do are likely to have constituencies that would assist in raising awareness and enthusiasm for the implementation of environmentally friendly fishing methods. Assuming mitigation methods that are practical and effective, at least some nations or fleets would likely adopt them simply to reduce adverse impacts on sea turtles which are widely regarded as charismatic mega-fauna.

Simultaneously, the existence of practical and effective mitigation methods would allow for the negotiation of trade sanctions, similar to those in place for shrimp. This would provide significant support for the less prescriptive efforts described above, and improve their chances for success while also ensuring an effective and consistent underlying platform for cases in which they fail.

In addition scientists have found that recovery of sea turtle populations requires protection of their nesting beaches and coastal foraging areas as it is in these areas that the majority of adverse impacts occur. These impacts include beach degradation, foraging by dogs and pigs, and directed harvests of eggs and adults. Although located in remote areas, US fishery managers and other agencies have begun to fund protection programs for some of these important areas. A similar approach is a part of the preferred alternative for this action, with the acknowledged intent of gaining "offsets" in terms of turtles saved which then can be balanced against those interactions occurring in their fishery. Experience has shown that the inclusion of domestic fishermen and fishing organizations in the implementation and ongoing support of conservation programs has been successful not only in motivating those involved, but in raising awareness and altering behaviors of those who are indirectly exposed through educational or media campaigns.

Due to the low cost of funding beach protection and other turtle conservation programs as compared to closing domestic fisheries, such an approach also maximizes net national benefits by utilizing cost-efficient methods of achieving management objectives.

APPENDIX B

Future Research and Monitoring

Future Research and Monitoring

The circle hook and mackerel bait combination that is being implemented in the Hawaii model swordfish fishery has been shown to be very effective at reducing loggerhead and leatherback sea turtle interactions with swordfish targeting shallow-set pelagic longline fishing in a three year trial in the Atlantic. It is expected that this will also be the case in Hawaii, although the proposed management action provides safeguards in terms of a hard cap on turtle take and limits on the total amount of swordfish effort that will be allowed. The implementation of these measures in the Hawaii swordfish fishery will also be monitored closely with 100% observer coverage as required under the 2004 Biological Opinion on this action.

However the degree of effectiveness of these measures is not assured in the Pacific and modification of these measures as well as other mitigation measures should be investigated in both the model swordfish fishery and the traditional deep-set tuna fishery. Some of these measures have been investigated by the NMFS Pacific Islands Fisheries Science Center (PIFSC), some are part of the Conservation Recommendations contained in the 2004 Biological Opinion, and some are new. These include:

- continued use of stealth fishing gear – methods to make longline fishing gear less visible
- the use of circle hooks and mackerel or other types of bait to reduce and mitigate interactions in the deep-set tuna fishery
- the use of existing technologies such as sonar, to detect and alert fishers if sea turtles or marine mammals become entangled in their gear
- re-arranging branch lines to move them further from the floats – methods to deepen the average depth of hooks
- moving light sticks away from the branch lines and closer to the floats – methods to avoid drawing protected species directly toward the baited hooks while at the same time attracting target species to the gear
- making floats more attractive to turtles by attaching light sticks to the floats – again to avoid drawing protected species directly to the baited gear
- placing images of sharks on floats to scare turtles away from the gear
- movement of vessels relative to ocean features such as temperature gradients or away from initial contact with protected species.
- other methods that may be identified by the fishing industry, fishery observers, and fishery scientists based on continued monitoring of the effectiveness of the Atlantic measures.

The 2004 Biological Opinion also recommends increased monitoring of global impacts on sea turtles through analyses of sea turtle interaction data to be obtained from the Forum Fisheries Agency

Research efforts in the Atlantic and with foreign countries will also be encouraged. The PIFSC already collaborates with the Southeast Fishery Science Center including support to the Galveston captive leatherback research and in the Caribbean. PIFSC is also continuing its turtle physiology research to see if the basic structure of sea turtles might shed light on alternative mitigation techniques. Research is also being conducted using satellite tags to investigate the movement of sea turtles and their relationship to oceanographic features.

Another avenue of research to be undertaken is reduction and mitigation of interactions with cetaceans (whales, dolphins, etc.). These interactions are at a much lower rate than the already limited interactions with sea turtles but the highest interaction rate is with false killer whales. Methods to reduce these even further could be investigated using sonic alarms or “pingers” on the mainline. The use of pingers has been successful in reducing interactions between dolphins and drift gillnets deployed by the Oregon/California drift gill net fishery, although their efficacy in reducing interactions with false killer whales is unknown.

Two research projects are already underway to examine the issue of transferred effects being realized through the market place. This project is analyzing the international trade response to the recent swordfish closures and whether consumption of swordfish and tuna increased from other countries with higher fishery interaction rates over the past three years.

Another continuing project is being conducted by the PIFSC, in conjunction with the University of Hawaii’s Pelagic Fisheries Research Program. This project is conducting statistical analyses of relationships between protected interactions in the Hawaii-based longline fishery and factors related to the fishery, such as location, season, gear configuration, oceanographic features, etc.

Although the preferred alternative would implement measures to ensure that the Hawaii-based longline fleet remains in compliance with the 2000 Biological Opinion of the US Fish and Wildlife Service on the Short-tailed Albatross, research should continue on ways to further reduce seabird interactions. In addition, although the use of 18/0 10° offset circle hooks with mackerel-type bait required under the preferred alternative (as compared to the current J hooks) are anticipated to potentially reduce and mitigate seabird interactions, monitoring will be necessary to determine their actual impacts. Again, the 100% observer coverage required under the 2004 Biological Opinion on this action will ensure that this monitoring occurs.

APPENDIX C

Proposed Regulations

Draft Regulations for Proposed Action

50 CFR
Wildlife and Fisheries
CHAPTER VI
FISHERY CONSERVATION AND MANAGEMENT, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

PART 660 -- FISHERIES OFF WEST COAST STATES AND IN THE WESTERN PACIFIC

Subpart A -- General

§660.1 Purpose and scope.

(a) The regulations in this part govern fishing for Western Pacific and West Coast fishery management unit species by vessels of the United States that operate or are based inside the outer boundary of the EEZ off Western Pacific and West Coast States.

(b) General regulations governing fishing by all vessels of the United States and by fishing vessels other than vessels of the United States are contained in part 600 of this chapter.

(c) Regulations governing the harvest, possession, landing, purchase, and sale of shark fins are found at part 600, subpart M, of this chapter.

§660.2 Relation to other laws.

NMFS recognizes that any state law pertaining to vessels registered under the laws of that state while operating in the fisheries regulated under this part, and that is consistent with this part and the FMPs implemented by this part, shall continue in effect with respect to fishing activities regulated under this part.

§660.3 Reporting and recordkeeping.

Except for fisheries subject to subparts D and F of this part, any person who is required to do so by applicable state law or regulation must make and/or file all reports of management unit species landings containing all data and in the exact manner required by applicable state law or regulation.

Subpart B -- Western Pacific Fisheries -- General

§660.11 Purpose and scope.

(a) This subpart contains regulations that are common to all Western Pacific fisheries managed under fishery management plans prepared by the Western Pacific Fishery Management Council under the Magnuson Act.

(b) Regulations specific to individual fisheries are included in subparts C, D, E, and F of this part.

§660.12 Definitions.

In addition to the definitions in the Magnuson Act and in §600.10 of this chapter, the terms used in subparts B through F of this part have the following meanings:

Basket-style longline gear means a type of longline gear that is divided into units called "baskets" each consisting of a segment of main line to which 10 or more branch lines with hooks are spliced. The mainline and all branch lines are made of multiple braided strands of cotton, nylon, or other synthetic fibers impregnated with tar or other heavy coatings that cause the lines to sink rapidly in seawater.

Bottomfish FMP means the Fishery Management Plan for Bottomfish and Seamount Groundfish of the Western Pacific Region.

Bottomfish management area means the areas designated in §660.69.

Bottomfish management unit species means the following fish:

Common name	Local name	Scientific name

Snappers:		
Silver jaw jobfish..........	Lehi (H); palu-gustusilvia (S).	Aphareus rutilans.
Gray jobfish................	Uku (H); asoama (S).	Aprion virescens.
Squirrelfish snapper........	Ehu (H); palu-malau (S).	Etelis carbunculus.
Longtail snapper............	Onaga, ula'Tlula (H); palu-loa (S).	Etelis coruscans.
Blue stripe snapper.........	Ta'ape (H); savane (S); funai (G).	Lutjanus kasmira.
Yellowtail snapper..........	Palu-i' lusama (S); yellowtail kalekale.	Pristipomoides auricilla.
Pink snapper................	Opakapaka (H); palu-'Tlena'lena (S); gadao (G).	Pristipomoides.
Yelloweye snapper...........	Palusina (S); yelloweye opakapaka.	Pristipomoides flavipinnis.
Snapper.....................	Kalekale (H)......	Pristipomoides sieboldii.
Snapper.....................	Gindai (H,G); palu-sega (S).	Pristipomoides zonatus.
Jacks:		
Giant trevally..............	White ulua (H); tarakito (G); sapo-anae (S).	Caranx ignoblis.
Black jack..................	Black ulua (H); tarakito (G); tafauli (S).	Caranx lugubris.
Thick lipped trevally.......	Pig ulua (H); butaguchi (H).	Pseudocaranx dentex.
Amberjack...................	Kahala (H)........	Seriola dumerili.
Groupers:		
Blacktip grouper............	Fausi (S); gadau (G).	Epinephelus fasciatus.
Sea bass....................	Hapu' lupu'u (H)..	Epinephelus quernus.
Lunartail grouper...........	Papa (S).........	Variola louti.
Emperor fishes:		
Ambon emperor...............	Filoa-gutumumu (S)	Lethrinus amboinensis.
Redgill emperor.............	Filoa-pa'lo'omumu (S); mafuti (G).	Lethrinus rubrioperculatus.

Notes: G_Guam; H_Hawaii; S_American Samoa.

Carapace length means a measurement in a straight line from the ridge between the two largest spines above the eyes, back to the rear edge of the carapace of a spiny lobster (see Figure 1 of this part).

Commercial fishing, as used in subpart D of this part, means fishing with the intent to sell all or part of the catch of lobsters. All lobster fishing in Crustaceans Permit Area 1 is considered commercial fishing.

Council means the Western Pacific Fishery Management Council.

Crustaceans FMP means the Fishery Management Plan for Crustacean Fisheries of the Western Pacific Region.

Crustaceans management area means the combined portions of the EEZ encompassed by Crustaceans Permit Areas 1, 2, and 3.

Crustaceans management unit species means spiny lobster (*Panulirus marginatus* or *Panulirus penicillatus*), slipper lobster (family *Scyllaridae*), and Kona crab (*Ranina ranina*).

Crustaceans Permit Area 1 (Permit Area 1) means the EEZ off the Northwestern Hawaiian Islands.

Crustaceans Permit Area 2 (Permit Area 2) means the EEZ off the main Hawaiian Islands.

Crustaceans Permit Area 3 (Permit Area 3) means the EEZ of the Territory of Guam and the EEZ of the Territory of American Samoa.

Crustaceans Permit Area 1 VMS Subarea means an area within the EEZ off the NWHI 50 nm from the center geographical positions of the islands and reefs in the NWHI as follows: Nihoa Island 23°05&min; N. lat., 161°55&min; W. long.; Necker Island 23°35&min; N. lat., 164°40&min; W. long.; French Frigate Shoals 23°45&min; N. lat., 166°15&min; W. long; Garner Pinnacles 25°00&min; N. lat., 168°00&min; W. long.; Maro Reef 25°25&min; N. lat., 170°35&min; W. long.; Laysan Island 25°45&min; N. lat., 171°45&min; W. long; Lisianski Island 26°00&min; N. lat., 173°55&min; W. long.; Pearl and Hermes Reef 27°50&min; N. lat., 175°50&min; W. long.; Midway Islands 28°14&min; N. lat., 177°22&min; W. long.; and Kure Island 28°25&min; N. lat., 178°20&min; W. long. The remainder of the VMS subarea is delimited by parallel lines tangent to and connecting the 50-nm areas around the following: from Nihoa Island to Necker Island; from French Frigate Shoals to Gardner Pinnacles; from Gardner Pinnacles to Maro Reef; from Laysan Island to Lisianski Island; and from Lisianski Island to Pearl and Hermes Reef.

Crustaceans receiving vessel means a vessel of the United States to which lobster taken in Permit Area 1 are transferred from another vessel.

Dead coral means any precious coral that no longer has any live coral polyps or tissue.

Deep-setting means deploying longline gear with float lines at least 20 m in length, with a minimum of 15 branch lines (except for basket-style longline gear which is allowed 10 branch lines between floats) between floats, where the deepest sag point between two floats is 100 m or greater, and without the use of lightsticks.

EFP means an experimental fishing permit.

First level buyer means:

(1) The first person who purchases, with the intention to resell, management unit species, or portions thereof, that were harvested by a vessel that holds a permit or is otherwise regulated under subpart D of this part; or

(2) A person who provides recordkeeping, purchase, or sales assistance in the first transaction involving management unit species (such as the services provided by a wholesale auction facility).

Fish dealer means any person who:

(1) Obtains, with the intention to resell, Pacific pelagic management unit species, or portions thereof, that were harvested or received by a vessel that holds a permit or is otherwise regulated under subpart E of this part; or

(2) Provides recordkeeping, purchase, or sales assistance in obtaining or selling such management unit species (such as the services provided by a wholesale auction facility).

Fisheries Management Division (FMD) means the Chief, Fisheries Management Division, Southwest Regional Office, NMFS, or a designee. See Table 1 to §600.502 for the address of the Regional Office.

Fishing gear, as used in subpart D of this part, includes:

(1) *Bottom trawl,* which means a trawl in which the otter boards or the footrope of the net are in contact with the sea bed.

(2) *Gillnet,* (see §600.10).

(3) *Hook-and-line,* which means one or more hooks attached to one or more lines.

(4) *Set net,* which means a stationary, buoyed, and anchored gill net.

(5) *Trawl,* (see §600.10).

Fishing trip means a period of time during which fishing is conducted, beginning when the vessel leaves port and ending when the vessel lands fish.

Fishing year means the year beginning at 0001 local time on January 1 and ending at 2400 local time on December 31.

Harvest guideline means a specified numerical harvest objective.

Hawaii longline limited access permit means the permit required by §660.21 to use a vessel to fish for Pacific pelagic management unit species with longline gear in the EEZ around Hawaii or to land or transship longline-caught Pacific pelagic management unit species shoreward of the outer boundary of the EEZ around Hawaii.

Incidental catch or *incidental species* means species caught while fishing for the primary purpose of catching a different species.

Interested parties means the State of Hawaii Department of Land and Natural Resources, the Council, holders of permits issued under subpart D of this part, and any person who has notified the Regional Administrator of his or her interest in the procedures and decisions described in §§660.51 and 660.52, and who has specifically requested to be considered an "interested party."

Land or *landing* means offloading fish from a fishing vessel, arriving in port to begin offloading fish, or causing fish to be offloaded from a fishing vessel.

Large vessel means, as used in §§ 660.22, 660.37, and 660.38, any vessel greater than 50 ft (15.2 m) in length overall.

Length overall (LOA) or length of a vessel means, as used in §§ 660.21(i) and 660.22, the horizontal distance, rounded to the nearest foot (with any 0.5 foot or 0.15 meter fraction rounded upward), between the foremost part of the stem and the aftermost part of the stern, excluding bowsprits, rudders, outboard motor brackets, and similar fittings or attachments (see Figure 2 to this part). "Stem" is the foremost part of the vessel, consisting of a section of timber or fiberglass, or cast forged or rolled metal, to which the sides of the vessel are united at the fore end, with the lower end united to the keel, and with the bowsprit, if one is present, resting on the upper end. "Stern" is the aftermost part of the vessel.

Live coral means any precious coral that has live coral polyps or tissue.

Lobster closed area means an area of the EEZ that is closed to fishing for lobster.

Lobster grounds refers, singularly or collectively, to the following four areas in Crustaceans Permit Area 1 that shall be used to manage the lobster fishery:

(1) *Necker Island Lobster Grounds* -- waters bounded by straight lines connecting the following coordinates in the order presented: 24°00&min; N. lat., 165°00&min; W. long.; 24°00&min; N. lat., 164° 00&min; W. long.; 23°00&min; N. lat., 164°00&min; W. long.; and 23°00&min; N. lat., 165°00&min; W. long.

(2) *Gardner Pinnacles Lobster Grounds* -- waters bounded by straight lines connecting the following coordinates in the order presented: 25°20&min; N. lat., 168°20&min; W. long.; 25°20&min; N. lat., 167° 40&min; W. long.; 24°20&min; N. lat., 167°40&min; W. long.; and 24°20&min; N. lat., 168°20&min; W. long.

(3) *Maro Reef Lobster Grounds* -- waters bounded by straight lines connecting the following coordinates in the order presented: 25°40&min; N. lat., 171°00&min; W. long.; 25°40&min; N. lat., 170° 20&min; W. long.; 25°00&min; N. lat., 170°20&min; W. long.; and 25°00&min; N. lat., 171°00&min; W. long.

(4) *General NWHI Lobster Grounds* -- all waters within Crustaceans Permit Area 1 except for the Necker Island, Gardner Pinnacles, and Maro Reef Lobster Grounds.

Longline fishing prohibited area means the portions of the EEZ in which longline fishing is prohibited as specified in §660.26.

Longline fishing vessel means a vessel that has longline gear on board the vessel.

Longline gear means a type of fishing gear consisting of a main line that exceeds 1 nm in length, is suspended horizontally in the water column either anchored, floating, or attached to a vessel, and from which branch or dropper lines with hooks are attached; except that, within the protected species zone, longline gear means a type of fishing gear consisting of a main line of any length that is suspended horizontally in the water column either anchored, floating, or attached to a vessel, and from which branch or dropper lines with hooks are attached.

Longline general permit means the permit required by §660.21 to use a vessel to fish for Pacific pelagic management unit species in the fishery management area, excluding the EEZ around Hawaii, or to land or transship longline-caught fish shoreward of the outer boundary of the fishery management area, excluding the waters shoreward of the EEZ around Hawaii.

Main Hawaiian Islands means the islands of the Hawaiian Islands Archipelago lying to the east of 161° W. long.

Non-precious coral means any species of coral other than those listed under the definition for precious coral in this section.

Non-selective gear means any gear used for harvesting corals that cannot discriminate or differentiate between types, size, quality, or characteristics of living or dead corals.

Northwestern Hawaiian Islands (NWHI) means the islands of the Hawaiian Islands Archipelago lying to the west of 161° W. long.

Offloading means removing management unit species from a vessel.

Owner, as used in subparts C and D of this part and §660.61(i) through (m), means a person who is identified as the current owner of the vessel as described in the Certificate of Documentation (Form CG-1270) issued by the USCG for a documented vessel, or in a registration certificate issued by a state, a territory, or the USCG for an undocumented vessel. As used in subpart F of this part and §660.61(c) through (h), the definition of "owner" in §600.10 of this chapter continues to apply.

Pacific Islands Area Office means the Pacific Islands Area Office, (PIAO) Southwest Region, NMFS, located in Honolulu, Hawaii. The address and phone number may be obtained from the Regional Administrator, whose address is in Table 1 to §600.502 of this chapter.

Pacific pelagic management unit species means the following fish:

Common name	Scientific name
Mahimahi (dolphin fish)	Coryphaena spp.
Marlin and spearfish	Makaira spp. Tetrapturus spp.
Oceanic sharks	Family Alopiidae. Family Carcharhinidae. Family Lamnidae. Family Sphyrnidae.
Sailfish	Istiophorus platypterus.
Swordfish	Xiphias gladius.
Tuna and related species	Allothunnus spp., Auxis spp. Euthynnus spp., Gymnosarda spp. Katsuwonus spp., Scomber spp. Thunnus spp.
Wahoo	Acanthocybium solandri.

Pacific remote island areas (PRIA, or U.S. island possessions in the Pacific Ocean) means Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, Wake Island, and Midway Atoll.

Pelagic handline fishing means fishing for pelagic management unit species from a stationary or drifting vessel using hook and line gear other than longline gear.

Pelagic troll fishing (trolling) means fishing for pelagic management unit species from a moving vessel using hook and line gear.

Pelagics FMP means the Fishery Management Plan for Pelagic Species Fisheries of the Western Pacific Region.

Precious coral means any coral of the genus *Corallium* in addition to the following species of corals:

Common name	Scientific name
Pink coral (also known as red coral)......	Corallium secundum.
Pink coral (also known as red coral)......	Corallium regale.
Pink coral (also known as red coral)......	Corallium laauense.
Gold coral................................	Gerardia spp.
Gold coral................................	Callogorgia gilberti.
Gold coral................................	Narella spp.
Gold coral................................	Calyptrophora spp.
Bamboo coral..............................	Lepidisis olapa.
Bamboo coral..............................	Acanella spp.
Black coral...............................	Antipathes dichotoma.
Black coral...............................	Antipathes grandis.
Black coral...............................	Antipathes ulex.

Precious coral permit area means the area encompassing the precious coral beds in the management area. Each bed is designated by a permit area code and assigned to one of the following four categories:

(1) *Established beds.* Makapuu (Oahu), Permit Area E-B-1, includes the area within a radius of 2.0 nm of a point at 21°18.0&min; N. lat., 157°32.5&min; W. long.

(2) *Conditional beds.* (i) Keahole Point (Hawaii), Permit Area C-B-1, includes the area within a radius of 0.5 nm of a point at 19°46.0&min; N. lat., 156°06.0&min; W. long.

(ii) Kaena Point (Oahu), Permit Area C-B-2, includes the area within a radius of 0.5 nm of a point at 21°35.4&min; N. lat., 158°22.9&min; W. long.

(iii) Brooks Bank, Permit Area C-B-3, includes the area within a radius of 2.0 nm of a point at 24°06.0&min; N. lat., 166°48.0&min; W. long.

(iv) 180 Fathom Bank, Permit Area C-B-4, N.W. of Kure Atoll, includes the area within a radius of 2.0 nm of a point at 28°50.2&min; N. lat., 178°53.4&min; W. long.

(3) *Refugia.* Westpac Bed, Permit Area R-1, includes the area within a radius of 2.0 nm of a point at 23°18&min; N. lat., 162°35&min; W. long.

(4) *Exploratory areas.* (1) Permit Area X-P-H includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of the State of Hawaii.

(ii) Permit Area X-P-AS includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of American Samoa.

(iii) Permit Area X-P-G includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of Guam.

(iv) Permit Area X-P-PI includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of the U.S. Pacific Island possessions.

Protected species means an animal protected under the MMPA, listed under the ESA, or subject to the Migratory Bird Treaty Act, as amended.

Protected species study zones means the waters within a specified distance, designated by the Regional Administrator pursuant to §660.66, around the following islands of the NWHI and as measured from the following coordinates: Nihoa Island 23°05&min; N. lat., 161°55&min; W. long.; Necker Island 23°35&min; N. lat., 164°40&min; W. long.; French Frigate Shoals 23°45&min; N. lat., 166°15&min; W. long.; Gardner Pinnacles 25°00&min; N. lat., 168°00&min; W. long.; Maro Reef 25°25&min; N. lat., 170°35&min; W. long.; Laysan Island 25°45&min; N. lat., 171°45&min; W. long.; Lisianski Island 26°00&min; N. lat., 173°55&min; W. long.; Pearl and Hermes Reef 27°50&min; N. lat., 175°50&min; W. long.; Midway Island 28°14&min; N. lat., 177°22&min; W. long.; and Kure Island 28°25&min; N. lat., 178°20&min; W. long. The protected species study zones encompasses waters within 50 nm of the geographical coordinates listed above.

Protected species zone means an area, designated under §660.26, measured from the center geographical positions of certain islands and reefs in the NWHI, as follows: Nihoa Island 23°05&min; N. lat., 161°55&min; W. long.; Necker Island 23°35&min; N. lat., 164°40&min; W. long.; French Frigate Shoals 23°45&min; N. lat., 166°15&min; W. long; Gardner Pinnacles 25°00&min; N. lat., 168°00&min; W. long.; Maro Reef 25°25&min; N. lat., 170°35&min; W. long.; Laysan Island 25°45&min; N. lat., 171°45&min; W. long; Lisianski Island 26°00&min; N. lat., 173°55&min; W. long.; Pearl and Hermes Reef 27°50&min; N. lat., 175°50&min; W. long.; Midway Islands 28°14&min; N. lat., 177°22&min; W. long.; and Kure Island 28°25&min; N. lat., 178°20&min; W. long. Where the areas are not contiguous, parallel lines drawn tangent to and connecting those semi-circles of the 50-nm areas that lie between Nihoa Island and Necker Island, French Frigate Shoals and Gardner Pinnacles, Gardner Pinnacles and Maro Reef, and Lisianski Island and Pearl and Hermes Reef, shall delimit the remainder of the protected species zone.

Receiving vessel permit means a permit required by §660.21(c) for a receiving vessel to transship or land Pacific pelagic management unit species taken by other vessels using longline gear.

Regional Administrator means the Director, Southwest Region, NMFS (see Table 1 of §600.502 for address).

Seamount groundfish means the following species:

Common name	Scientific name
Armorhead................................	Pentaceros richardsoni.
Alfonsin.................................	Beryx splendens.
Raftfish.................................	Hyperoglyphe japonica.

Selective gear means any gear used for harvesting corals that can discriminate or differentiate between type, size, quality, or characteristics of living or dead corals.

Shallow-setting means deploying longline gear in a manner that does not meet the requirements for deep-setting as defined in this section.

Single shallow-set certificate means a paper certificate valid for one shallow-set of longline gear (more than one mile of deployed longline gear is classified as a complete set).

Special Agent-In-Charge (SAC) means the Special Agent-In-Charge, NMFS, Office of Enforcement, Southwest Region, or a designee of the Special Agent-In-Charge.

Transship means offloading or otherwise transferring management unit species or products thereof to a receiving vessel.

Trap means a box-like device used for catching and holding lobsters.

U.S. harvested corals means coral caught, taken, or harvested by vessels of the United States within any fishery for which a fishery management plan has been implemented under the Magnuson Act.

Vessel monitoring system unit (VMS unit) means the hardware and software owned by NMFS, installed on vessels by NMFS, and required by subpart C of this part to track and transmit the positions of longline vessels or the hardware and software used by vessels to track and transmit the positions of vessels permitted under subpart D of this part to fish in Crustaceans Permit Area 1.

§660.13 Permits and fees.

(a) *Applicability.* The requirements for permits for specific Western Pacific fisheries are set forth in subparts C through F of this part.

(b) *Validity.* Each permit is valid for fishing only in the specific fishery management areas identified on the permit.

(c) *Application.* (1) A Southwest Region Federal Fisheries application form may be obtained from the Pacific Area Office to apply for a permit to operate in any of the fisheries regulated under subparts C, D, E, and F of this part. In no case shall the Pacific Area Office accept an application that is not on the Southwest Region Federal Fisheries application form. A completed application is one that contains all the necessary information, attachments, certifications, signatures, and fees required.

(2) A minimum of 15 days should be allowed for processing a permit application. If an incomplete or improperly completed application is filed, the applicant will be sent a notice of deficiency. If the applicant fails to correct the deficiency within 30 days following the date of notification, the application will be considered abandoned.

(d) *Change in application information.* A minimum of 10 days should be given for the Pacific Area Office to record any change in information from the permit application submitted under paragraph (c) of this section. Failure to report such changes may result in invalidation of the permit.

(e) *Issuance.* After receiving a complete application, the FMD will issue a permit to an applicant who is eligible under §660.21, §660.41, §660.61, or §660.81, as appropriate.

(f) *Fees.* (1) PIAO will not charge a fee for a permit issued under subpart D or F of this part, or for a Ho'omalu Zone limited access permit issued under §660.61.

(2) PIAO will charge a fee for each application for a Hawaii longline limited access permit (including permit transfers and permit renewals) and Mau Zone limited access permit (including permit renewals). The amount of the fee is calculated in accordance with the procedures of the NOAA Finance Handbook, available from the Regional Administrator, for determining the administrative costs of each special product or service. The fee may not exceed such costs and is specified with each application form. The appropriate fee must accompany each application. Failure to pay the fee will preclude issuance of a Hawaii longline or Mau Zone limited access permit.

(g) *Expiration.* (1) Permits issued under subparts C, D, and F of this part are valid for the period specified on the permit unless transferred, revoked, suspended, or modified under 15 CFR part 904.

(2) Permits issued under subpart E of this part expire at 2400 local time on December 31.

(h) *Replacement.* Replacement permits may be issued, without charge, to replace lost or mutilated permits. An application for a replacement permit is not considered a new application.

(i) *Transfer.* An application for a permit transfer under §§660.21(h), 660.41(e), or 660.61(e), or for registration of a permit for use with a replacement vessel under §660.61(k), must be submitted to the PIAO as described in paragraph (c) of this section.

(j) *Alteration.* Any permit that has been altered, erased, or mutilated is invalid.

(k) *Display.* Any permit issued under this subpart, or a facsimile of the permit, must be on board the vessel at all times while the vessel is fishing for, taking, retaining, possessing, or landing management unit species shoreward of the outer boundary of the fishery management area. Any permit issued under this section must be displayed for inspection upon request of an authorized officer.

(l) *Sanctions.* Procedures governing sanctions and denials are found at subpart D of 15 CFR part 904.

(m) *Permit appeals.* Procedures for appeals of permit and administrative actions are specified in the relevant subparts of this part.

§660.14 Reporting and recordkeeping.

(a) *Fishing record forms.* The operator of any fishing vessel subject to the requirements of §660.21, §660.41, or §660.81 must maintain on board the vessel an accurate and complete record of catch, effort, and other data on report forms provided by the Regional Administrator. All information specified on the forms must be recorded on the forms within 24 hours after the completion of each fishing day. The original logbook form for each day of the fishing trip must be submitted to the Regional Administrator as required by this paragraph (a). Each form must be signed and dated by the fishing vessel operator.

(1) The operator of any vessel subject to the requirements of §660.21(a) through (c), §660.41, or §660.81 must submit the original logbook form for each day of the fishing trip to the Regional Administrator within 72 hours of each landing of management unit species.

(2) Except for a vessel that is fishing in the U.S. EEZ around Midway Atoll as specified in paragraph (a)(3) of this section, any operator whose vessel is registered for use with a PRIA pelagic troll and handline fishing permit under §660.21(d) must submit the original logbook form for each day of fishing within the U.S. EEZ around the PRIA to the Regional Administrator within 10 days of each landing of management unit species.

(3) The operator of a vessel fishing in the U.S. EEZ around Midway Atoll and registered for use with a PRIA pelagic troll and handline fishing permit under §660.21(d) must submit an appropriate reporting form as required and in a manner specified by the U.S. Fish and Wildlife Service for each day of fishing within the U.S. EEZ around Midway Atoll, which is defined as an area of the Pacific Ocean bounded on the east by 177°10' W. long., on the west by 177°30' W. long., on the north by 28°25' N. lat., and on the south by 28°05' N. lat.

(b) *Transshipment logbooks.* Any person subject to the requirements of §660.21(c) must maintain on board the vessel an accurate and complete NMFS transshipment logbook containing report forms provided by the Regional Administrator. All information specified on the forms must be recorded on the forms within 24 hours of the day of transshipment. The original logbook form for each day of transshipment activity must be submitted to the Regional Administrator within 72 hours of each landing of management unit species. Each form must be signed and dated by the receiving vessel operator.

(c) *Sales report.* The operator of any fishing vessel subject to the requirements of §660.41 must submit to the Regional Administrator, within 72 hours of offloading of crustaceans management unit species, an accurate and complete sales report on a form provided by the Regional Administrator. The form must be signed and dated by the fishing vessel operator.

(d) *Packing or weigh-out slips.* The operator of any fishing vessel subject to the requirements of §660.41 must attach packing or weighout slips provided to the operator by the first-level buyer(s), unless the packing or weighout slips have not been provided in time by the buyer(s).

(e) *Modification of reporting and recordkeeping requirements.* The Regional Administrator may, after consultation with the Council, initiate rulemaking to modify the information to be provided on the fishing record forms, transshipment logbook, and sales report forms and timeliness by which the information is to be provided, including the submission of packing or weighout slips.

(f) *Availability of records for inspection.* (1) *Pacific pelagic management unit species.* Upon request, any fish dealer must immediately provide an authorized officer access for inspecting and copying all records of purchases, sales, or other transactions involving Pacific pelagic management unit species taken or handled by longline vessels that have permits issued under this subpart or that are otherwise subject to subpart C of this part, including, but not limited to, information concerning:

(i) The name of the vessel involved in each transaction and the owner or operator of the vessel.

(ii) The weight, number, and size of each species of fish involved in each transaction.

(iii) Prices paid by the buyer and proceeds to the seller in each transaction.

(2) *Crustaceans management unit species.* Upon request, any first-level buyer must immediately allow an authorized officer and any employee of NMFS designated by the Regional Administrator, to access, inspect, and copy all records relating to the harvest, sale, or transfer of crustacean management unit species taken by vessels that have permits issued under this subpart or that are otherwise subject to subpart D of this part. This requirement may be met by furnishing the information on a worksheet provided by the Regional Administrator. The information must include, but is not limited to:

(i) The name of the vessel involved in each transaction and the owner or operator of the vessel.

(ii) The amount, number, and size of each management unit species involved in each transaction.

(iii) Prices paid by the buyer and proceeds to the seller in each transaction.

(3) *Bottomfish and seamount groundfish management unit species.* Any person who is required by state laws and regulations to maintain records of landings and sales for vessels regulated by this subpart and subpart E of this part must make those records immediately available for Federal inspection and copying upon request by an authorized officer.

(g) *State reporting.* Any person who has a permit under §§660.21 or 660.61 and who is required by state laws and regulations to maintain and submit records of landings and sales for vessels regulated by subparts C and E of this part must maintain and submit those records in the exact manner required by state laws and regulations.

§660.15 Prohibitions.

In addition to the prohibitions in §600.725 of this chapter, it is unlawful for any person to:

(a) Engage in fishing without a valid permit or facsimile of a valid permit on board the vessel and available for inspection by an authorized officer, when a permit is required under §660.13 or §660.17, unless the vessel was at sea when the permit was issued under §660.13, in which case the permit must be on board the vessel before its next trip.

(b) File false information on any application for a fishing permit under §660.13 or an EFP under §660.17.

(c) Fail to file reports in the exact manner required by any state law or regulation, as required in §660.14.

(d) Falsify or fail to make, keep, maintain, or submit any logbook or logbook form or other record or report required under §§660.14 and 660.17.

(e) Refuse to make available to an authorized officer or a designee of the Regional Administrator for inspection or copying, any records that must be made available in accordance with §660.14.

(f) Fail to affix or maintain vessel or gear markings, as required by §§660.16, 660.24, and 660.47.

(g) Violate a term or condition of an EFP issued under §660.17.

(h) Fail to report any take of or interaction with protected species as required by §660.17(k).

(i) Fish without an observer on board the vessel after the owner or agent of the owner has been directed by NMFS to make accommodations available for an observer under §§660.17, 660.28, 660.49, or 660.65.

(j) Refuse to make accommodations available for an observer when so directed by the Regional Administrator under §660.28, §660.49, or §660.65, or under any provision in an EFP issued under §660.17.

(k) Fail to notify officials as required in §§660.23, 660.28, 660.43, and 660.63.

§660.16 Vessel identification.

(a) Each fishing vessel subject to this subpart must display its official number on the port and starboard sides of the deckhouse or hull, and on an appropriate weather deck, so as to be visible from enforcement vessels and aircraft.

(b) The official number must be affixed to each vessel subject to this subpart and subparts C, D, E, and F of this part, in block Arabic numerals at least 18 inches (45.7 cm) in height for fishing and receiving vessels of 65 ft (19.8 m) LOA or longer, and at least 10 inches (25.4 cm) in height for all other vessels, except vessels subject to Subpart F and 65 ft (19.8 m) LOA or longer must be marked in block Arabic numerals at least 14 inches (35.6 cm) in height. Marking must be legible and of a color that contrasts with the background.

(c) The vessel operator must ensure that the official number is clearly legible and in good repair.

(d) The vessel operator must ensure that no part of the vessel, its rigging, or its fishing gear obstructs the view of the official number from an enforcement vessel or aircraft.

§660.17 Experimental fishing.

(a) *General.* The Regional Administrator may authorize, for limited purposes, the direct or incidental harvest of management unit species that would otherwise be prohibited by this subpart and subparts C, D, E, and F of this part. No experimental fishing may be conducted unless authorized by an EFP issued by the Regional Administrator in accordance with the criteria and procedures specified in this section. EFPs will be issued without charge.

(b) *Observers.* No experimental fishing for crustacean management unit species may be conducted unless an NMFS scientific observer is aboard the vessel.

(c) *Application.* An applicant for an EFP must submit to the Regional Administrator at least 60 days before the desired date of the EFP a written application including, but not limited to, the following information:

(1) The date of the application.

(2) The applicant's name, mailing address, and telephone number.

(3) A statement of the purposes and goals of the experiment for which an EFP is needed, including a general description of the arrangements for disposition of all species harvested under the EFP.

(4) A statement of whether the proposed experimental fishing has broader significance than the applicant's individual goals.

(5) For each vessel to be covered by the EFP:

(i) Vessel name.

(ii) Name, address, and telephone number of owner and operator.

(iii) USCG documentation, state license, or registration number.

(iv) Home port.

(v) Length of vessel.

(vi) Net tonnage.

(vii) Gross tonnage.

(6) A description of the species (directed and incidental) to be harvested under the EFP and the amount of such harvest necessary to conduct the experiment.

(7) For each vessel covered by the EFP, the approximate times and places fishing will take place, and the type, size, and amount of gear to be used.

(8) The signature of the applicant.

(d) *Incomplete applications.* The Regional Administrator may request from an applicant additional information necessary to make the determinations required under this section. An applicant will be notified of an incomplete application within 10 working days of receipt of the application. An incomplete application will not be considered until corrected in writing.

(e) *Issuance.* (1) If an application contains all of the required information, NMFS will publish a notice of receipt of the application in the FEDERAL REGISTER with a brief description of the proposal and will give interested persons an opportunity to comment. The Regional Administrator will also forward copies of the application to the Council, the USCG, and the fishery management agency of the affected state, accompanied by the following information:

(i) The current utilization of domestic annual harvesting and processing capacity (including existing experimental harvesting, if any) of the directed and incidental species for which an EFP is being requested.

(ii) A citation of the regulation or regulations that, without the EFP, would prohibit the proposed activity.

(iii) Biological information relevant to the proposal.

(2) At a Council meeting following receipt of a complete application, the Regional Administrator will consult with the Council and the Director of the affected state fishery management agency concerning the permit application. The applicant will be notified in advance of the meeting at which the application will be considered, and invited to appear in support of the application, if the applicant desires.

(3) Within 5 working days after the consultation in paragraph (e)(2) of this section, or as soon as practicable thereafter, NMFS will notify the applicant in writing of the decision to grant or deny the EFP and, if denied, the reasons for the denial. Grounds for denial of an EFP include, but are not limited to, the following:

(i) The applicant has failed to disclose material information required, or has made false statements as to any material fact, in connection with his or her application.

(ii) According to the best scientific information available, the harvest to be conducted under the permit would detrimentally affect any species of fish in a significant way.

(iii) Issuance of the EFP would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose.

(iv) Activities to be conducted under the EFP would be inconsistent with the intent of this section or the management objectives of the FMP.

(v) The applicant has failed to demonstrate a valid justification for the permit.

(vi) The activity proposed under the EFP would create a significant enforcement problem.

(4) The decision to grant or deny an EFP is final and unappealable. If the permit is granted, NMFS will publish a notice in the FEDERAL REGISTER describing the experimental fishing to be conducted under the EFP. The Regional Administrator may attach terms and conditions to the EFP consistent with the purpose of the experiment including, but not limited to:

(i) The maximum amount of each species that can be harvested and landed during the term of the EFP, including trip limits, where appropriate.

(ii) The number, sizes, names, and identification numbers of the vessels authorized to conduct fishing activities under the EFP.

(iii) The times and places where experimental fishing may be conducted.

(iv) The type, size, and amount of gear which may be used by each vessel operated under the EFP.

(v) The condition that observers be carried aboard vessels operating under an EFP.

(vi) Data reporting requirements.

(vii) Such other conditions as may be necessary to assure compliance with the purposes of the EFP consistent with the objectives of the FMP.

(f) *Duration.* Unless otherwise specified in the EFP or a superseding notice or regulation, an EFP is effective for no longer than 1 year, unless revoked, suspended, or modified. EFPs may be renewed following the application procedures in this section.

(g) *Alteration.* Any EFP that has been altered, erased, or mutilated is invalid.

(h) *Transfer.* EFPs issued under subparts B through F of this part are not transferable or assignable. An EFP is valid only for the vessel(s) for which it is issued.

(i) *Inspection.* Any EFP issued under subparts B through F of this part must be carried aboard the vessel(s) for which it was issued. The EFP must be presented for inspection upon request of any authorized officer.

(j) *Sanctions.* Failure of the holder of an EFP to comply with the terms and conditions of an EFP, the provisions of subparts A through F of this part, any other applicable provision of this part, the Magnuson Act, or any other regulation promulgated thereunder, is grounds for revocation, suspension, or modification of the EFP with respect to all persons and vessels conducting activities under the EFP. Any action taken to revoke, suspend, or modify an EFP will be governed by 15 CFR part 904 subpart D. Other sanctions available under the statute will be applicable.

(k) *Protected species.* Persons fishing under an EFP must report any incidental take or fisheries interaction with protected species on a form provided for that purpose. Reports must be submitted to the Regional Administrator within 3 days of arriving in port.

Subpart C -- Western Pacific Pelagic Fisheries

§660.21 Permits.

(a) A fishing vessel of the United States must be registered for use under a Hawaii longline limited access permit or a longline general permit if that vessel is used:

(1) To fish for Pacific pelagic management unit species using longline gear in the EEZ around American Samoa, Guam, the Northern Mariana Islands, or other U.S. island possessions in the Pacific Ocean; or

(2) To land or transship, shoreward of the outer boundary of the EEZ around American Samoa, Guam, the Northern Mariana Islands, or other U.S. island possessions in the Pacific Ocean, Pacific pelagic management unit species that were harvested with longline gear.

(b) A fishing vessel of the United States must be registered for use under a Hawaii longline limited access permit if that vessel is used:

(1) To fish for Pacific pelagic management unit species using longline gear in the EEZ around Hawaii; or

(2) To land or transship, shoreward of the outer boundary of the EEZ around Hawaii, Pacific pelagic management unit species that were harvested with longline gear.

(c) A receiving vessel must be registered for use with a receiving vessel permit if that vessel is used to land or transship, shoreward of the outer boundary of the fishery management area, Pacific pelagic management unit species that were harvested with longline gear.

(d) A fishing vessel of the United States must be registered for use with a PRIA pelagic troll and handline fishing permit if that vessel is used to fish for Pacific pelagic management unit species using pelagic handline or trolling fishing methods in the U.S. EEZ around the PRIA.

(e) Any required permit must be on board the vessel and available for inspection by an authorized agent, except that if the permit was issued while the vessel was at sea, this requirement applies only to any subsequent trip.

(f) A permit is valid only for the vessel for which it is registered. A permit not registered for use with a particular vessel may not be used.

(g) An application for a permit required under this section will be submitted to the Pacific Area Office as described in§660.13.

(h) General requirements governing application information, issuance, fees, expiration, replacement, transfer, alteration, display, and sanctions for permits issued under this section, as applicable, are contained in §660.13.

(i) A limited access permit may be transferred as follows:

(1) The owner of a Hawaii longline limited access permit may apply to transfer the permit:

(i) To a different person for registration for use with the same or another vessel; or

(ii) For registration for use with another U.S. vessel under the same ownership.

(2) An application for a permit transfer will be submitted to the Pacific Area Office as described in §660.13(c).

(j) A Hawaii longline limited access permit will not be registered for use with a vessel that has a LOA greater than 101 ft (30.8 m).

(k) Only a person eligible to own a documented vessel under the terms of 46 U.S.C. 12102(a) may be issued or may hold (by ownership or otherwise) a Hawaii longline limited access permit.

(l) Except as provided in subpart D of 15 CFR part 904, any applicant for a permit or any permit owner may appeal to the Regional Administrator the granting, denial, conditioning, suspension, or transfer of a permit or requested permit under this section. To be considered by the Regional Administrator, the appeal will be in writing, will state the action(s) appealed, and the reasons therefor, and will be submitted within 30 days of the action(s) by the FMD. The appellant may request an informal hearing on the appeal.

(1) Upon receipt of an appeal authorized by this section, the Regional Administrator may request additional information. Upon receipt of sufficient information, the Regional Administrator will decide the appeal in accordance with the criteria set out in this part and in the fishery management plans prepared by the Council, as appropriate, based upon information relative to the application on file at NMFS and the Council and any additional information available; the summary record kept of any hearing and the hearing

officer's recommended decision, if any, as provided in paragraph (l)(3) of this section; and such other considerations as deemed appropriate. The Regional Administrator will notify the appellant of the decision and the reasons therefor, in writing, normally within 30 days of the receipt of sufficient information, unless additional time is needed for a hearing.

(2) If a hearing is requested, or if the Regional Administrator determines that one is appropriate, the Regional Administrator may grant an informal hearing before a hearing officer designated for that purpose. Such a hearing normally shall be held no later than 30 days following receipt of the appeal, unless the hearing officer extends the time. The appellant and, at the discretion of the hearing officer, other interested persons, may appear personally or be represented by counsel at the hearing and submit information and present arguments as determined appropriate by the hearing officer. Within 30 days of the last day of the hearing, the hearing officer shall recommend, in writing, a decision to the Regional Administrator.

(3) The Regional Administrator may adopt the hearing officer's recommended decision, in whole or in part, or may reject or modify it. In any event, the Regional Administrator will notify the appellant, and interested persons, if any, of the decision, and the reason(s) therefor, in writing, within 30 days of receipt of the hearing officer's recommended decision. The Regional Administrator's action shall constitute final Agency action for the purposes of the APA.

(4) Any time limit prescribed in this section may be extended for a period not to exceed 30 days by the Regional Administrator for good cause, either upon his/her own motion or upon written request from the appellant stating the reason(s) therefor.

~~(m) Except during October, NMFS will not register with a Hawaii longline limited access permit any vessel that is de-registered from a Hawaii longline limited access permit after March 29, 2001.~~

~~(n) Applications for the re-registration of any vessel that was de-registered from a Hawaii longline limited access permit after March 29, 2001, must be received at PIAO or postmarked between September 15 and October 15.~~

§660.22 Prohibitions.

In addition to the general prohibitions specified in §600.725 of this chapter, it is unlawful for any person to do any of the following:

(a) Fish for Pacific pelagic management unit species using gear prohibited under §660.30 or not permitted by an EFP issued under §660.17.

(b) Falsify or fail to make and/or file all reports of Pacific pelagic management unit species landings, containing all data and in the exact manner, as required by applicable state law or regulation, as specified in §660.3, provided that the person is required to do so by applicable state law or regulation.

(c) Use a longline vessel without a valid longline general permit or a Hawaii longline limited access permit registered for use with that vessel, to fish for Pacific pelagic management unit species in the EEZ around American Samoa, Guam, the Northern Mariana Islands, or U.S. island possessions in the Pacific Ocean.

(d) Use a longline fishing vessel without a valid Hawaii longline limited access permit registered for use with that vessel to fish for Pacific pelagic management unit species in the EEZ around Hawaii.

(e) Use a receiving vessel without a valid receiving vessel permit registered for use with that vessel to land or transship, shoreward of the outer boundary of the fishery management area, Pacific pelagic management unit species harvested with longline gear.

(f) Transfer a permit in violation of §660.21(h).

(g) Fish for Pacific pelagic management unit species with longline gear within the protected species zone in the NWHI.

(h) Fail to notify the NMFS Southwest Enforcement Office of intent to enter or depart the protected species zone, as required under §660.23(b).

(i) Fish with longline gear within a longline fishing prohibited area, except as allowed pursuant to an exemption issued under §660.17 or §660.27.

(j) Fail to comply with notification requirements set forth in §660.23 or in any EFP issued under §660.17.

(k) Fail to comply with a term or condition governing the observer program established in §660.28.

(l) Fail to comply with other terms and conditions that the Regional Director imposes by written notice to either the permit holder or the designated agent of the permit holder to facilitate the details of observer placement.

(m) Fish in the fishery after failing to comply with the notification requirements in §660.23.

(n) Use a U.S. vessel that has longline gear on board and that does not have a valid Hawaii longline limited access permit registered for use with that vessel or a valid longline general permit registered for use with that vessel to land or transship Pacific pelagic management unit species shoreward of the outer boundary of the EEZ around American Samoa, Guam, the Northern Mariana Islands, or U.S. island possessions in the Pacific Ocean.

(o) Use a U.S. vessel that has longline gear on board and that does not have a valid Hawaii longline limited access permit registered for use with that vessel to land or transship Pacific pelagic management unit species shoreward of the outer boundary of the EEZ around Hawaii.

(p) Enter the EEZ around Hawaii with longline gear that is not stowed or secured in accordance with §660.29, if operating a U.S. vessel without a valid Hawaii longline limited access permit registered for use with that vessel.

(q) Enter the EEZ around American Samoa, Guam, the Northern Mariana Islands, or U.S. island possessions in the Pacific Ocean with longline gear that is not stowed or secured in accordance with §660.29, if operating a U.S. vessel without a valid Hawaii longline limited access permit registered for use with that vessel or a longline general permit registered for use with that vessel.

(r) Fail to carry a VMS unit as required under §660.25.

(s) Interfere with, tamper with, alter, damage, disable, or impede the operation of a VMS unit or to attempt any of the same; or to move or remove a VMS unit without the prior permission of the SAC.

(t) Make a false statement, oral or written, to an authorized officer, regarding the use, operation, or maintenance of a VMS unit.

(u) Fish for, catch, or harvest Pacific pelagic management unit species with longline gear without a VMS unit on board the vessel after installation of the VMS unit by NMFS.

(v) Possess on board a vessel without a VMS unit Pacific pelagic management unit species harvested with longline gear after NMFS has installed the VMS unit on the vessel.

(w) Interfere with, impede, delay, or prevent the installation, maintenance, repair, inspection, or removal of a VMS unit.

(x) Interfere with, impede, delay, or prevent access to a VMS unit by a NMFS observer.

(y) Connect or leave connected additional equipment to a VMS unit without the prior approval of the SAC.

(z) Engage in shallow-setting with longline gear north of 23° during daylight hours for vessels registered for use under a Hawaii limited access longline permit in violation of § 660.35 (a)(1).

(aa) Fail to use a line setting machine or line shooter, with weighted branch lines, to set the main longline when operating a vessel that is registered for use under a Hawaii longline limited access permit and equipped with monofilament main longline, when making deep sets north of 23° N. lat., in violation of §660.35 (a)(2) and (a)(3).

(bb) Fail to employ basket-style longline gear such that the mainline is deployed slack when operating a vessel registered for use under a Hawaii longline limited access north of 23° N. lat., in violation of §660.35 (a)(4).

(cc) Fail to maintain and use blue dye to prepare thawed bait when operating a vessel registered for use under a Hawaii longline limited access permit that is fishing north of 23° N. lat., in violation of §660.35 (a)(5) and (a)(6).

(dd) Fail to retain, handle, and discharge fish, fish parts, and spent bait, strategically when operating a vessel registered for use under a Hawaii longline limited access permit that is fishing north of 23° N. lat., in violation of §660.35 (a)(7) through (a)(9).

(ee) Fail to handle short-tailed albatrosses that are caught by pelagic longline gear in a manner that maximizes the probability of their long-term survival, in violation of §660.35 (b).

(ff) Fail to handle seabirds other than short-tailed albatross that are caught by pelagic longline gear in a manner that maximizes the probability of their long-term survival, in violation of §660.35 (c).

(gg) Own a longline vessel registered for use under a Hawaii longline limited access permit that is engaged in longline fishing for Pacific pelagic management unit species, without a valid protected species workshop certificate issued by NMFS or a legible copy thereof in violation of §660.36 (a).

(hh) Fish for Pacific pelagic management unit species on a vessel registered for use under a Hawaii limited access longline permit without having onboard a valid protected species workshop certificate issued by NMFS or a legible copy thereof in violation of §660.36 (d).

(ii)-(jj) [Reserved]

(kk) Fail to carry line clippers, dip nets, dehookers, and wire or bolt cutters on a vessel registered for use under a Hawaii longline limited access permit ~~or a longline general permit that has a freeboard of more than 3 ft (0.9 m)~~ in violation of §660.32(a).

~~(kk) Fail to carry line clippers and wire or bolt cutters on a vessel fishing with hooks for Pacific pelagic management unit species within EEZ waters around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands that has a freeboard more than 3 ft (0.9 m) in violation of §660.32(a)(2).~~

~~(ll) Fail to carry line clippers and wire or bolt cutters on a vessel registered for use under a Hawaii longline limited access permit or a longline general permit or on a vessel fishing with hooks for Pacific pelagic management unit species within EEZ waters around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands, that has a freeboard of less than 3 ft (0.9 m) in violation of §660.32(a)(3).~~

(ll) Engage in shallow-setting with longline gear for Pacific pelagic management unit species under a Hawaii limited access longline permit north of the equator (0° lat.) without 18/0 circle hooks or larger with 10° offset in violation of § 660.32 (a)(1).

(mm) Engage in shallow-setting with longline gear for Pacific pelagic management unit species under a Hawaii limited access longline permit north of the equator (0° lat.) without mackerel-type bait in violation of § 660.32 (a)(2).

(nn) Fail to comply with the sea turtle handling, resuscitation, and release requirements when operating a vessel registered for use under a Hawaii longline limited access permit or a longline general permit, or fishing with hooks for Pacific pelagic management unit species within EEZ waters around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands in violation of §660.32(b).

~~(nn) Direct fishing effort toward the harvest of swordfish (Xiphias gladius) using longline gear deployed north of the equator on a vessel registered for use under a Hawaii longline limited access permit or a longline general permit in violation of §660.33(a).~~

~~(qq) Fish for Pacific pelagic management unit species with a vessel registered for use under a Hawaii longline limited access permit or a longline general permit within closed areas or by use of unapproved gear configurations in violation of §660.33(b), (c), (g), or (h).~~

~~(pp) Use a receiving vessel registered for use under a receiving vessel permit to receive, land, or tranship from another vessel, Pacific pelagic management unit species harvested from closed areas with longline gear in violation of §660.33(d).~~

~~(qq) Land or tranship shoreward of the outer boundary of the EEZ around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands, Pacific pelagic management unit species that were harvested from closed areas with longline gear in violation of §660.33(e).~~

~~(rr) Possess a light stick on board a vessel registered for use under either a Hawaii longline limited access permit or a longline general permit, on fishing trips that include any fishing north of the equator (0° lat.) in violation of §660.33(f).~~

~~(ss) Possess or land more than 10 swordfish on board a vessel registered for use under either a Hawaii longline limited access permit or a longline general permit, from a fishing trip where any part of the trip included fishing north of the equator (0° lat.) in violation of §660.33(i).~~

(oo) Engage in shallow-setting with longline gear for Pacific pelagic management unit species north of the equator (0° lat.) without a valid single shallow-set certificate, or fail attach to single shallow-set certificate(s) to federal logbooks in violation of § 660.33 (a).

(pp) Fish for Pacific pelagic management unit species with a vessel registered for use under a Hawaii limited access longline permit or a longline general permit with unapproved gear configurations in violation of §660.33(b), (c), (d).

(qq) Use a receiving vessel registered for use under a receiving vessel permit to receive, land, or tranship from another vessel, Pacific pelagic management unit species harvested with unapproved longline gear in violation of §660.33(b), (c), (d).

(rr) Land or tranship shoreward of the outer boundary of the EEZ around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands, Pacific pelagic management unit species that were harvested with unapproved longline gear in violation of §660.33(b), (c), (d).

(ss) Operate a vessel registered for use under a Hawaii longline limited access permit or a longline general permit to fish for Pacific pelagic management unit species without having onboard a valid protected species workshop certificate issued by NMFS or a legible copy thereof in violation of §660.36(c).

(tt) Use a large vessel to fish for Pacific pelagic management unit species within an American Samoa large vessel prohibited area except as allowed pursuant to an exemption issued under § 660.38.

(uu) Use a U.S. vessel employing pelagic handline or trolling methods to fish in the U.S. EEZ around the PRIA without a valid PRIA pelagic troll and handline fishing permit registered for use with that vessel.

§660.23 Notifications.

(a) The permit holder for a fishing vessel subject to the requirements of this subpart, or an agent designated by the permit holder, shall provide a notice to the Regional Administrator at least 72 hours (not including weekends and Federal holidays) before the vessel leaves port on a fishing trip, any part of which occurs in the EEZ around Hawaii. The vessel operator will be presumed to be an agent designated by the permit holder unless the Regional Administrator is otherwise notified by the permit holder. The notice must be provided to the office or telephone number designated by the Regional Administrator. The notice must provide the official number of the vessel, the name of the vessel, the intended departure date, time, and location, the name of the operator of the vessel, and the name and telephone number of the agent designated by the permit holder to be available between 8:00 a.m. to 5 p.m. (Hawaii time) on weekdays for NMFS to contact to arrange observer placement.

(b) The operator of any vessel subject to the requirements of this subpart who does not have on board a VMS unit while transiting the protected species zone as defined in §660.12, must notify the NMFS Southwest Enforcement Office (see part 600 for address of Regional Administrator) immediately upon entering and immediately upon departing the protected species zone. The notification must include the name of the vessel, name of the operator, date and time (GMT) of access or exit from the protected species zone, and location by latitude and longitude to the nearest minute.

§660.24 Gear identification.

(a) *Identification.* The operator of each permitted vessel in the fishery management area must ensure that the official number of the vessel be affixed to every longline buoy and float, including each buoy and float that is attached to a radar reflector, radio antenna, or flag marker, whether attached to a deployed longline or possessed on board the vessel. Markings must be legible and permanent, and must be of a color that contrasts with the background material.

(b) *Enforcement action.* Longline gear not marked in compliance with paragraph (a) of this section and found deployed in the EEZ will be considered unclaimed or abandoned property, and may be disposed of in any manner considered appropriate by NMFS or an authorized officer.

§660.25 Vessel monitoring system.

(a) *VMS unit.* Only a VMS unit owned by NMFS and installed by NMFS complies with the requirement of this subpart.

(b) *Notification.* After a Hawaii longline limited access permit holder has been notified by the SAC of a specific date for installation of a VMS unit in the permit holder's vessel, the vessel must carry the VMS unit after the date scheduled for installation.

(c) *Fees and charges.* During the experimental VMS program, a Hawaii longline limited access permit holder shall not be assessed any fee or other charges to obtain and use a VMS unit, including the communication charges related directly to requirements under this section. Communication charges related to any additional equipment attached to the

VMS unit by the owner or operator shall be the responsibility of the owner or operator and not NMFS.

(d) *Permit holder duties.* The holder of a Hawaii longline limited access permit and the master of the vessel operating under the permit must:

(1) Provide opportunity for the SAC to install and make operational a VMS unit after notification.

(2) Carry the VMS unit on board whenever the vessel is at sea.

(3) Not remove or relocate the VMS unit without prior approval from the SAC.

(e) *Authorization by the SAC.* The SAC has authority over the installation and operation of the VMS unit. The SAC may authorize the connection or order the disconnection of additional equipment, including a computer, to any VMS unit when deemed appropriate by the SAC.

§660.26 Longline fishing prohibited area management.

(a) *Prohibited areas.* Longline fishing shall be prohibited in the longline fishing prohibited areas as defined in paragraphs (b), (c), and (d) of this section.

(b) *Longline protected species zone.* The protected species zone is 50 nm from the center geographical positions of Nihoa Island, Necker Island, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Islands, and Kure Island, as defined in §660.12.

(c) *Main Hawaiian Islands.* (1) From February 1 through September 30 each year, the longline fishing prohibited area around the main Hawaiian Islands is the portion of the EEZ seaward of Hawaii bounded by straight lines connecting the following coordinates in the order listed:

Point	N. lat.	DW. long.
A................................	18°05[min]	155°40[min]
B................................	18°20[min]	156°25[min]
C................................	20°00[min]	157°30[min]
D................................	20°40[min]	161°40[min]
E................................	21°40[min]	161°55[min]
F................................	23°00[min]	161°30[min]
G................................	23°05[min]	159°30[min]
H................................	22°55[min]	157°30[min]
I................................	21°30[min]	155°30[min]

J	19°50[min]	153°50[min]
K	19°00[min]	154°05[min]
A	18°05[min]	155°40[min]

(2) From October 1 through the following January 31 each year, the longline fishing prohibited area around the main Hawaiian Islands is the portion of the EEZ seaward of Hawaii bounded by straight lines connecting the following coordinates in the order listed:

Point	N. lat.	W. long.
A	18°05[min]	155°40[min]
L	18°25[min]	155°40[min]
M	19°00[min]	154°45[min]
N	19°15[min]	154°25[min]
O	19°40[min]	154°20[min]
P	20°20[min]	154°55[min]
Q	20°35[min]	155°30[min]
R	21°00[min]	155°35[min]
S	22°30[min]	157°35[min]
T	22°40[min]	159°35[min]
U	22°25[min]	160°20[min]
V	21°55[min]	160°55[min]
W	21°40[min]	161°00[min]
E	21°40[min]	161°55[min]
D	20°40[min]	161°40[min]
C	20°00[min]	157°30[min]
B	18°20[min]	156°25[min]
A	18°05[min]	155°40[min]

(d) *Guam.* The longline fishing prohibited area around Guam is the waters seaward of Guam bounded by straight lines connecting the following coordinates in the order listed:

Point	N. lat.	E. long.
A	14°25[min]	144°00[min]
B	14°00[min]	143°38[min]
C	13°41[min]	144°33[min] 30[sec]
D	13°00[min]	143°25[min] 30[sec]
E	12°20[min]	143°37[min]
F	11°40[min]	144°09[min]
G	12°00[min]	145°00[min]
H	13°00[min]	145°42[min]
I	13°27[min]	145°51[min]

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§660.27 Exemptions for longline fishing prohibited areas; procedures.

(a) An exemption permitting a person to use longline gear to fish in a portion(s) of the Hawaii longline fishing prohibited area will be issued to a person who can document that he or she:

(1) Currently owns a Hawaii longline limited access permit issued under this part and registered for use with his or her vessel.

(2) Before 1970, was the owner or operator of a vessel when that vessel landed Pacific pelagic management unit species taken on longline gear in an area that is now within the Hawaii longline fishing prohibited area.

(3) Was the owner or operator of a vessel that landed Pacific pelagic management unit species taken on longline gear in an area that is now within the Hawaii longline fishing prohibited area, in at least 5 calendar years after 1969, which need not be consecutive.

(4) In any one of the 5 calendar years, was the owner or operator of a vessel that harvested at least 80 percent of its total landings, by weight, of longline-caught Pacific pelagic management unit species in an area that is now in the Hawaii longline fishing prohibited area.

(b) Each exemption shall specify the portion(s) of the Hawaii longline fishing prohibited area, bounded by longitudinal and latitudinal lines drawn to include each statistical area, as appearing on Hawaii State Commercial Fisheries Charts, in which the exemption holder made the harvest documented for the exemption application under paragraph (a)(4) of this section.

(c) Each exemption is valid only within the portion(s) of the Hawaii longline fishing prohibited area specified on the exemption.

(d) A person seeking an exemption under this section must submit an application and supporting documentation to the Pacific Area Office at least 15 days before the desired effective date of the exemption.

(e) If the Regional Administrator determines that a gear conflict has occurred and is likely to occur again in the Hawaii longline fishing prohibited area between a vessel used by a person holding an exemption under this section and a non-longline vessel, the Regional Administrator may prohibit all longline fishing in the Hawaii longline fishing prohibited area around the island where the conflict occurred, or in portions thereof, upon notice to each holder of an exemption who would be affected by such a prohibition.

(f) The Council will consider information provided by persons with Hawaii longline limited access permits issued under this part who believe they have experienced extreme financial hardship resulting from the Hawaii longline area closure, and will consider recommendations of the Pelagic Advisory Review Board to assess whether exemptions under this section should continue to be allowed, and, if appropriate, revise the qualifying criteria in paragraph (a) of this section to permit additional exemptions.

(1) If additional exemptions are needed, the Council will advise the Regional Administrator in writing of its recommendation, including criteria by which financial hardships will be mitigated, while retaining the effectiveness of the longline fishing prohibited area.

(2) Following a review of the Council's recommendation and supporting rationale, the Regional Administrator may:

(i) Reject the Council's recommendation, in which case written reasons will be provided by the Regional Administrator to the Council for the rejection; or

(ii) Concur with the Council's recommendation and, after finding that it is consistent with the goals and objectives of the Pelagics FMP, the national standards, and other applicable law, initiate rulemaking to implement the Council's recommendations.

§660.28 Conditions for at-sea observer coverage.

(a) NMFS shall advise the permit holder or the designated agent of any observer requirement at least 24 hours (not including weekends and Federal holidays) before any trip for which NMFS received timely notice in compliance with these regulations.

(b) The "Notice Prior to Fishing Trip" requirements in this subpart commit the permit holder to the representations in the notice. The notice can be modified by the permit holder or designated agent because of changed circumstance, if the Regional Administrator is promptly provided a modification to the notice that complies with the notice requirements. The notice will also be considered modified if the Regional Administrator and the permit holder or designated agent agree to placement changes.

(c) When NMFS notifies the permit holder or designated agent of the obligation to carry an observer in response to a notification under this subpart, or as a condition of an EFP issued under §660.17, the vessel may not engage in the fishery without taking the observer.

(d) A NMFS observer shall arrive at the observer's assigned vessel 30 minutes before the time designated for departure in the notice or the notice as modified, and will wait 1 hour for departure.

(e) A permit holder must accommodate a NMFS observer assigned under these regulations. The Regional Administrator's office, and not the observer, will address any concerns raised over accommodations.

(f) The permit holder, vessel operator, and crew must cooperate with the observer in the performance of the observer's duties, including:

(1) Allowing for the embarking and debarking of the observer.

(2) Allowing the observer access to all areas of the vessel necessary to conduct observer duties.

(3) Allowing the observer access to communications equipment and navigation equipment as necessary to perform observer duties.

(4) Allowing the observer access to VMS units to verify operation, obtain data, and use the communication capabilities of the units for official purposes.

(5) Providing accurate vessel locations by latitude and longitude or loran coordinates, upon request by the observer.

(6) Providing sea turtle, marine mammal, or sea bird specimens as requested.

(7) Notifying the observer in a timely fashion when commercial fishing operations are to begin and end.

(g) The permit holder, operator, and crew must comply with other terms and conditions to ensure the effective deployment and use of observers that the Regional Administrator imposes by written notice.

(h) The permit holder must ensure that assigned observers are provided living quarters comparable to crew members and are provided the same meals, snacks, and amenities as are normally provided to other vessel personnel. A mattress or futon on the floor or a cot is not acceptable if a regular bunk is provided to any crew member, unless other arrangements are approved in advance by the Regional Administrator.

(i) Reimbursement requirements are as follows:

(1) Upon observer verification of vessel accommodations and the number of assigned days on board, NMFS will reimburse vessel owners a reasonable amount for observer subsistence as determined by the Regional Administrator.

(2) If requested and properly documented, NMFS will reimburse the vessel owner for the following:

(i) Communications charges incurred by the observer.

(ii) Lost fishing time arising from a seriously injured or seriously ill observer, provided that notification of the nature of the emergency is transmitted to the Fisheries Observer Branch, Southwest Region, NMFS (see address for Southwest Regional Administrator) at the earliest practical time. NMFS will reimburse the owner only for those days during which the vessel is unable to fish as a direct result of helping the NMFS employee who is seriously injured or seriously ill. Lost fishing time is based on time travelling to and from the fishing grounds and any documented out-of-pocket expenses for medical services. Payment will be based on the current target fish market prices and that vessel's average target fish catch retained per day at sea for the previous 2 years, but shall not exceed $5,000 per day or $20,000 per claim. Detailed billing with receipts and supporting records are required for allowable communication and lost fishing time claims. The claim must be completed in ink, showing the claimant's printed name, address, vessel name, observer name, trip dates, days observer on board, an explanation of the charges, and claimant's dated signature with a statement verifying the claim to be true and correct. Requested reimbursement claims must be submitted to the Fisheries Observer Branch, Southwest Region, NMFS. NMFS will not process reimbursement invoices and documentation submitted more than 120 days after the occurrence.

(j) If a vessel normally has cabins for crew members, female observers on a vessel with an all-male crew must be accommodated either in a single person cabin or, if NMFS concludes that adequate privacy can be ensured by installing a curtain or other temporary divider, in a two-person shared cabin. If the vessel normally does not have cabins for crew members, alternative accommodations must be approved by NMFS. If a cabin assigned to a female observer does not have its own toilet and shower facilities that can be provided for the exclusive use of the observer, or if no cabin is assigned, then arrangements for sharing common facilities must be established and approved in advance by NMFS.

§660.29 Port privileges and transiting for unpermitted U.S. longline vessels.

A U.S. longline fishing vessel that does not have a permit under subpart B of this part may enter waters of the fishery management area with Pacific pelagic management unit species on board, but may not land or transship any management unit species on board the vessel. The vessel's longline gear must be stowed or secured so it is rendered unusable during the time the vessel is in those waters.

§660.30 Prohibition of drift gillnetting.

Fishing with drift gillnets in the fishery management area is prohibited, except where authorized by an EFP issued under §660.17.

§660.31 Framework adjustments to management measures.

(a) *Introduction.* Adjustments in management measures may be made through rulemaking if new information demonstrates that there are biological, social, or economic concerns in the fishery. The following framework process authorizes the implementation of measures that may affect the operation of the fisheries, gear, harvest guidelines, or changes in catch and/or effort.

(b) *Annual report.* By June 30 of each year, the Council-appointed Pelagics Plan Team will prepare an annual report on the fisheries in the management area. The report shall contain, among other things, recommendations for Council action and an assessment of the urgency and effects of such action(s).

(c) *Procedure for established measures.* (1) Established measures are management measures that, at some time, have been included in regulations implementing the FMP, and for which the impacts have been evaluated in Council/NMFS documents in the context of current conditions.

(2) Following the framework procedures of Amendment 7 to the Pelagics FMP, the Council may recommend to the Regional Administrator that established measures be modified, removed, or re-instituted. Such recommendation shall include supporting rationale and analysis, and shall be made after advance public notice, public discussion, and consideration of public comment. NMFS may implement the Council's recommendation by rulemaking if approved by the Regional Administrator.

(d) *Procedure for new measures.* (1) New measures are management measures that have not been included in regulations implementing the FMP, or for which the impacts have not been evaluated in Council/NMFS documents in the context of current conditions.

(2) Following the framework procedures of Amendment 7 to the Pelagics FMP, the Council will publicize, including by FEDERAL REGISTER notice, and solicit public comment on, any proposed new management measure. After a Council meeting at which the measure is discussed, the Council will consider recommendations and prepare a FEDERAL REGISTER notice summarizing the Council's deliberations, rationale, and analysis for the preferred action, and the time and place for any subsequent Council meeting(s) to consider the new measure. At subsequent public meeting(s), the Council will consider public comments and other information received to make a recommendation to the Regional Administrator about any new measure. NMFS may implement the Council's recommendation by rulemaking if approved by the Regional Administrator.

§660.32 Sea turtle take mitigation measures.

~~(a) *Possession and use of required mitigation gear* -- (1) Owners and operators of vessels registered for use under a Hawaii longline limited access permit or (after July 12, 2002) a longline general permit that have a freeboard more than 3 ft (0.9 m) must carry aboard their vessels line clippers meeting the minimum design standards as specified in paragraph (a)(4) of this section, dip nets meeting minimum standards prescribed in paragraph (a)(5) of this section, and wire or bolt cutters capable of cutting through the vessel's hooks. These items must be used to disengage any hooked or entangled sea turtles with the least harm possible to the sea turtles and as close to the hook as possible in accordance with the requirements specified in paragraphs (b) through (d) of this section.~~

~~(2) Owners and operators of vessels using hooks to target Pacific pelagic management unit species within EEZ waters around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands, that have a freeboard more than 3 ft (0.9 m) must carry aboard their vessels line clippers meeting the minimum design standards as specified in paragraph (a)(4) of this section, and wire or bolt cutters capable of cutting through the vessel's hooks. These items must be used to disengage any hooked or entangled sea turtles with the least harm possible to the sea turtles and as close to the hook as possible in accordance with the requirements specified in paragraphs (b) through (d) of this section.~~

~~(3) Owners and operators of vessels registered for use under a Hawaii longline limited access permit or a longline general permit, or using hooks to target Pacific pelagic management unit species within EEZ waters around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands, that have a freeboard of 3 ft (0.9 m) or less must carry aboard their vessels line clippers capable of cutting the vessels fishing line or leader within approximately 1 ft (0.3 m) of the eye of an embedded hook as well as wire or bolt cutters capable of cutting through the vessel's hooks. These items must be used to disengage any hooked or entangled sea turtles with the least harm possible to the sea turtles and as close to the hook as possible in accordance with the requirements specified in paragraphs (b) through (d) of this section.~~

a) *Possession and use of required mitigation gear* (1) Owners and operators of vessels registered under a Hawaii limited access longline permit must use 18/0 cirlce hooks or larger with 10° offset when shallow-setting for Pacific pelagic management species north of the equator (0° lat.).

(2) Owners and operators of vessels registered under a Hawaii limited access longline permit mackerel-type bait when fishing for Pacific pelagic management species using shallow-set longline gear north of the equator.

(3) Owners and operators of vessels registered for use under a Hawaii longline limited access permit that have a freeboard more than 3 ft (0.9 m) must carry aboard their vessels line clippers meeting the minimum design standards as specified in paragraph (a)(4) of

this section, dip nets meeting minimum standards prescribed in paragraph (a)(5) of this section, dehookers meeting minimum standards prescribed in paragraph (a)(6) of this section, and wire or bolt cutters capable of cutting through the vessel's hooks. These items must be used to disengage any hooked or entangled sea turtles with the least harm possible to the sea turtles and as close to the hook as possible in accordance with the requirements specified in paragraphs (b) through (d) of this section.

(4) *Line clippers.* Line clippers are intended to cut fishing line as close as possible to hooked or entangled sea turtles. NMFS has established minimum design standards for line clippers. The Arceneaux line clipper (ALC) is a model line clipper that meets these minimum design standards and may be fabricated from readily available and low-cost materials (figure 1). The minimum design standards are as follows:

(i) *A protected cutting blade.* The cutting blade must be curved, recessed, contained in a holder, or otherwise afforded some protection to minimize direct contact of the cutting surface with sea turtles or users of the cutting blade.

(ii) *Cutting blade edge.* The blade must be capable of cutting 2.0-2.1 mm monofilament line and nylon or polypropylene multistrand material commonly known as braided mainline or tarred mainline.

(iii) *An extended reach holder for the cutting blade.* The line clipper must have an extended reach handle or pole of at least 6 ft (1.82 m).

(iv) *Secure fastener.* The cutting blade must be securely fastened to the extended reach handle or pole to ensure effective deployment and use.

(5) *Dip nets.* Dip nets are intended to facilitate safe handling of sea turtles and access to sea turtles for purposes of cutting lines in a manner that minimizes injury and trauma to sea turtles. The minimum design standards for dip nets that meet the requirements of this section nets are:

(i) *An extended reach handle.* The dip net must have an extended reach handle of at least 6 ft (1.82 m) of wood or other rigid material able to support a minimum of 100 lbs (34.1 kg) without breaking or significant bending or distortion.

(ii) *Size of dip net.* The dip net must have a net hoop of at least 31 inches (78.74 cm) inside diameter and a bag depth of at least 38 inches (96.52 cm). The bag mesh openings may be no more than 3 inches × 3 inches (7.62 cm 7.62 cm).

(6) *Dehookers.* A dehooker is a NMFS approved device used to remove embedded hooks without touching or removing an organism from the water. Dehookers consist of a long handled pole ending in a clip or curved piece of metal with a covered face.

(b) *Handling requirements.* (1) All incidentally taken sea turtles brought aboard for dehooking and/or disentanglement must be handled in a manner to minimize injury and promote post-hooking survival.

(2) When practicable, comatose sea turtles must be brought on board immediately, with a minimum of injury, and handled in accordance with the procedures specified in paragraphs (c) and (d) of this section.

(3) If a sea turtle is too large or hooked in such a manner as to preclude safe boarding without causing further damage/injury to the turtle, line clippers described in paragraph (a)(1) of this section must be used to clip the line and remove as much line as possible prior to releasing the turtle.

(c) *Resuscitation.* If the sea turtle brought aboard appears dead or comatose, the sea turtle must be placed on its belly (on the bottom shell or plastron) so that the turtle is right side up and its hindquarters elevated at least 6 inches (15.24 cm) for a period of no less than 4 hours and no more than 24 hours. The amount of the elevation depends on the size of the turtle; greater elevations are needed for larger turtles. A reflex test, performed by gently touching the eye and pinching the tail of a sea turtle, must be administered by a vessel operator, at least every 3 hours, to determine if the sea turtle is responsive. Sea turtles being resuscitated must be shaded and kept damp or moist but under no circumstance may be placed into a container holding water. A water-soaked towel placed over the eyes, carapace, and flippers is the most effective method in keeping a turtle moist. Those that revive and become active must be returned to the sea in the manner described in paragraph (d) of this section. Sea turtles that fail to revive within the 24-hour period must also be returned to the sea in the manner described in paragraph (d)(1) of this section.

(d) *Release.* Live turtles must be returned to the sea after handling in accordance with the requirements of paragraphs (b) and (c) of this section:

(1) By putting the vessel engine in neutral gear so that the propeller is disengaged and the vessel is stopped, and releasing the turtle away from deployed gear; and

(2) Observing that the turtle is safely away from the vessel before engaging the propeller and continuing operations.

§660.33 Western Pacific longline fishing restrictions.

~~(a) Owners and operators of vessels registered for use under a Hawaii longline limited access permit or a longline general permit may not use longline gear to fish for or target swordfish *(Xiphias gladius)* north of the equator (0° lat.).~~

~~(b) A person aboard a vessel registered for use under a Hawaii longline limited access permit or a western Pacific general longline permit that is fishing for Pacific pelagic management unit species north of the equator (0° lat.) may not possess or deploy any float line that is shorter than or equal to 20 m (65.6 ft or 10.9 fm). As used in this paragraph "float line" means a line used to suspend the main longline beneath a float.~~

~~(c) From April 1 through May 31, owners and operators of vessels registered for use under a Hawaii longline limited access permit or a longline general permit may not use longline gear in waters bounded on the south by 0° lat., on the north by 15° N. lat., on the east by 145° W. long., and on the west by 180 long. (see Figure 1 to this section).~~

~~(d) From April 1 through May 31, owners and operators of vessels registered for use under a receiving vessel permit may not receive from another vessel Pacific pelagic management unit species that were harvested by longline gear in waters bounded on the south by 0° lat., on the north by 15° N. lat., on the east by 145° W. long., and on the west by 180° long. (see Figure 1 to this section).~~

~~(e) From April 1 through May 31, owners and operators of vessels registered for use under a Hawaii longline limited access permit, a longline general permit, or a receiving vessel permit, may not land or transship shoreward of the outer boundary of the EEZ around Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Midway, Johnston or Palmyra Atolls, Kingman Reef, and Wake, Jarvis, Baker, or Howland Islands, Pacific pelagic management unit species that were harvested by longline gear in waters bounded on the south by 0 latitude, on the north by 15° N. lat., on the east by 145° W. long., and on the west by 180° long. (see Figure 1 to this section).~~

~~(f) No light stick may be possessed on board a vessel registered for use under either a Hawaii longline limited access permit or a longline general permit, during fishing trips that include any fishing north of the equator (0° lat.). A light stick as used in this paragraph is any type of light emitting device, including any flourescent "glow bead," chemical, or electrically powered light that is affixed underwater to the longline gear.~~

~~(g) When a conventional monofilament longline is deployed in the water north of 0° lat. by a vessel registered for use under a Hawaii longline limited access permit or a longline general permit, no fewer than 15 branch lines may be set between any 2 floats when fishing north of the equator. Vessel operators using basket-style longline gear must set a minimum of 10 branch lines between any 2 floats when fishing north of the equator.~~

~~(h) Longline gear deployed north of 0° lat. by a vessel registered for use under a Hawaii longline limited access permit or a longline general permit must be deployed such that the deepest point of the main longline between any 2 floats, i.e., the deepest point in each sag of the main line, is at a depth greater than 100 m (328.1 ft or 54.6 fm) below the sea surface.~~

~~(i) Owners and operators of longline vessels registered for use under a Hawaii longline limited access permit or a longline general permit may land or possess no more than 10~~

~~swordfish from a fishing trip where any part of the trip included fishing north of the equator (0° lat.).~~

(a) Shallow-setting of longline gear for Pacific pelagic management species north of the equator (0° lat.) may only be conducted by operators of vessels registered for use under a Hawaii limited access longline permit, and vessel operators must be in possession of sufficient shallow-set certificates to cover their operation for that trip. For each shallow-set of longline gear north of the equator (0° lat.) vessel operators must attach valid shallow-set certificates to federal logbooks.

(1) Shallow-set certificates may only be held by Hawaii limited access permit holders and may be transferred, traded, bought, or sold only to owners or operators of vessels registered under a Hawaii limited access longline permit.

(b) A person deep-setting longline gear aboard a vessel registered for use under a Hawaii longline limited access permit or longline general permit north of the equator (0° lat.) may not deploy any float line that is shorter than or equal to 20 m (65.6 ft or 10.9 fm). As used in this paragraph "float line" means a line used to suspend the main longline beneath a float.

(c) When a conventional monofilament longline is deployed while deep-setting north of the equator (0° lat.) by a vessel registered for use under a Hawaii longline limited access permit or a longline general permit, no fewer than 15 branch lines may be set between any 2 floats when fishing north of the equator. Vessel operators deep-setting basket-style longline gear must set a minimum of 10 branch lines between any 2 floats when fishing north of the equator (0° lat.).

(d) Longline gear deployed while deep-setting north of the equator (0° lat.) by a vessel registered for use under a Hawaii longline limited access permit or a longline general permit must be deployed such that the deepest point of the main longline between any 2 floats, i.e., the deepest point in each sag of the main line, is at a depth greater than 100 m (328.1 ft or 54.6 fm) below the sea surface.

§660.34 Protected species workshop.

(a) Each year the operator of a vessel registered for use under a Hawaii longline limited access permit ~~or (after August 31, 2002) a longline general permit~~ must attend and be certified for completion of a workshop conducted by NMFS on mitigation, handling, and release techniques for turtles and seabirds and other protected species.

(b) A protected species workshop certificate will be issued by NMFS annually to any person who has completed the workshop.

(c) An operator of a vessel registered for use under Hawaii longline limited access permit ~~or a longline general permit and~~ engaged in longline fishing, must have on board the vessel a valid protected species workshop certificate issued by NMFS or a legible copy thereof.

§660.35 Pelagic longline seabird mitigation measures.

(a) *Seabird mitigation techniques*. Owners and operators of vessels registered for use under a Hawaii longline limited access permit must ensure that the following actions are taken when fishing north of 23° N. lat.:

(1) Begin deploying shallow-set longline gear at least one hour after local sunset and complete setting process by local sunrise using only the minimal vessel lights as necessary.

(2) Employ a line setting machine or line shooter to set the main longline when making deep sets using monofilament main longline;

(3) Attach a weight of at least 45 g to each branch line within 1 m of the hook when making deep sets using monofilament main longline;

(4) When using basket-style longline gear, ensure that the main longline is deployed slack to maximize its sink rate;

(5) Use completely thawed bait that has been dyed blue to an intensity level specified by a color quality control card issued by NMFS;

(6) Maintain a minimum of two cans (each sold as 0.45 kg or 1 lb size) containing blue dye on board the vessel;

(7) Discharge fish, fish parts (offal), or spent bait while setting or hauling longline gear, on the opposite side of the vessel from where the longline gear is being set or hauled;

(8) Retain sufficient quantities of fish, fish parts, or spent bait, between the setting of longline gear for the purpose of strategically discharging it in accordance with paragraph (a)(6) of this section;

(9) Remove all hooks from fish, fish parts, or spent bait prior to its discharge in accordance with paragraph (a)(6) of this section; and

(10) Remove the bill and liver of any swordfish that is caught, sever its head from the trunk and cut it in half vertically, and periodically discharge the butchered heads and livers in accordance with paragraph (a)(6) of this section.

(b) *Short-tailed albatross handling techniques.* If a short-tailed albatross is hooked or entangled by a vessel registered for use under a Hawaii longline limited access permit, owners and operators must ensure that the following actions are taken:

(1) Stop the vessel to reduce the tension on the line and bring the bird on board the vessel using a dip net;

(2) Cover the bird with a towel to protect its feathers from oils or damage while being handled;

(3) Remove any entangled lines from the bird;

(4) Determine if the bird is alive or dead.

(i) If dead, freeze the bird immediately with an identification tag attached directly to the specimen listing the species, location and date of mortality, and band number if the bird has a leg band. Attach a duplicate identification tag to the bag or container holding the bird. Any leg bands present must remain on the bird. Contact NMFS, the Coast Guard, or the U.S. Fish and Wildlife Service at the numbers listed on the Short-tailed Albatross Handling Placard distributed at the NMFS protected species workshop, inform them that you have a dead short-tailed albatross on board, and submit the bird to NMFS within 72 hours following completion of the fishing trip.

(ii) If alive, handle the bird in accordance with paragraphs (b)(5) through (b)(10) of this section.

(5) Place the bird in a safe enclosed place;

(6) Immediately contact NMFS, the Coast Guard, or the U.S. Fish and Wildlife Service at the numbers listed on the Short-tailed Albatross Handling Placard distributed at the NMFS protected species workshop and request veterinary guidance;

(7) Follow the veterinary guidance regarding the handling and release of the bird.

(8) Complete the short-tailed albatross recovery data form issued by NMFS.

(9) If the bird is externally hooked and no veterinary guidance is received within 24-48 hours, handle the bird in accordance with paragraphs (c)(4) and (c)(5) of this section, and release the bird only if it meets the following criteria:

(i) Able to hold its head erect and respond to noise and motion stimuli;

(ii) Able to breathe without noise;

(iii) Capable of flapping and retracting both wings to normal folded position on its back;

(iv) Able to stand on both feet with toes pointed forward; and

(v) Feathers are dry.

(10) If released under paragraph (a)(8) of this section or under the guidance of a veterinarian, all released birds must be placed on the sea surface.

(11) If the hook has been ingested or is inaccessible, keep the bird in a safe, enclosed place and submit it to NMFS immediately upon the vessel's return to port. Do not give the bird food or water.

(12) Complete the short-tailed albatross recovery data form issued by NMFS.

(c) *Non-short-tailed albatross seabird handling techniques*. If a seabird other than a short-tailed albatross is hooked or entangled by a vessel registered for use under a Hawaii longline limited access permit owners and operators must ensure that the following actions are taken:

(1) Stop the vessel to reduce the tension on the line and bring the seabird on board the vessel using a dip net;

(2) Cover the seabird with a towel to protect its feathers from oils or damage while being handled;

(3) Remove any entangled lines from the seabird;

(4) Remove any external hooks by cutting the line as close as possible to the hook, pushing the hook barb out point first, cutting off the hook barb using bolt cutters, and then removing the hook shank;

(5) Cut the fishing line as close as possible to ingested or inaccessible hooks;

(6) Leave the bird in a safe enclosed space to recover until its feathers are dry; and

(7) After recovered, release seabirds by placing them on the sea surface.

§660.36 Protected species workshop.

(a) Each year both the owner and the operator of a vessel registered for use under a Hawaii longline limited access permit must attend and be certified for completion of a workshop conducted by NMFS on mitigation, handling, and release techniques for turtles and seabirds and other protected species.

(b) A protected species workshop certificate will be issued by NMFS annually to any person who has completed the workshop.

(c) An owner of a vessel registered for use under a Hawaii longline limited access permit must maintain and have on file a valid protected species workshop certificate issued by NMFS in order to maintain or renew their vessel registration.

(d) An operator of a vessel registered for use under a Hawaii longline limited access permit and engaged in longline fishing, must have on board the vessel a valid protected species workshop certificate issued by NMFS or a legible copy thereof.

§ 660.37 American Samoa pelagic fishery area management.

(a) *Large vessel prohibited areas.* A large vessel of the United States may not be used to fish for Pacific pelagic management unit species in the American Samoa large vessel prohibited areas as defined in paragraphs (b) and (c) of this section, except as allowed pursuant to an exemption issued under § 660.38.

(b) *Tutuila Island, Manu'a Islands, and Rose Atoll (AS-1).* The large vessel prohibited area around Tutuila Island, the Manu'a Islands, and Rose Atoll consists of the waters of the EEZ around American Samoa enclosed by straight lines connecting the following coordinates:

Point	S. lat.	W. long.
AS-1-A	13° 30[min]	167° 25[min];
AS-1-B	15° 13[min]	167° 25[min];

and from Point AS-1-A westward along the latitude 13° 30' S. until intersecting the U.S. EEZ boundary with Samoa, and from Point AS-1-B westward along the latitude 15° 13' S. until intersecting the U.S. EEZ boundary with Samoa.

(c) *Swains Island (AS-2).* The large vessel prohibited area around Swains Island consists of the waters of the EEZ around American Samoa enclosed by straight lines connecting the following coordinates:

Point	S. lat.	W. long.
AS-2-A	11° 48[min]	171° 50[min];
AS-2-B	11° 48[min]	170° 20[min];

and from Point AS-2-A northward along the longitude 171° 50&min; W. until intersecting the U.S. EEZ boundary with Tokelau, and from Point AS-2-B northward along the longitude 170° 20&min; W. until intersecting the U.S. EEZ boundary with Tokelau.

§ 660.38 Exemptions for American Samoa large vessel prohibited areas.

(a) An exemption will be issued to a person who currently owns a large vessel, to use that vessel to fish for Pacific pelagic management unit species in the American Samoa large vessel prohibited management areas, if he or she had been the owner of that vessel when it was registered for use with a longline general permit and made at least one landing of Pacific pelagic management unit species in American Samoa on or prior to November 13, 1997.

(b) A landing of Pacific pelagic management unit species for the purpose of this section must have been properly recorded on a NMFS Western Pacific Federal daily longline form that was submitted to NMFS, as required in § 660.14.

(c) An exemption is valid only for a vessel that was registered for use with a longline general permit and landed Pacific pelagic management unit species in American Samoa on or prior to November 13, 1997, or for a replacement vessel of equal or smaller LOA than the vessel that was initially registered for use with a longline general permit on or prior to November 13, 1997.

(d) An exemption is valid only for the vessel for which it is registered. An exemption not registered for use with a particular vessel may not be used.

(e) An exemption may not be transferred to another person.

(f) If more than one person, e.g., a partnership or corporation, owned a large vessel when it was registered for use with a longline general permit and made at least one landing of Pacific pelagic management unit species in American Samoa on or prior to November 13, 1997, an exemption issued under this section will be issued to only one person.

APPENDIX D

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APPENDIX E

Update on the Council's Turtle Conservation Program, established 2002

Update on the Council's Turtle Conservation Program, established 2002

The Council is a significant stakeholder in the recovery of sea turtles, and in February 2002 it convened a Western Pacific Sea Turtle Cooperative Research & Management Workshop to gain direction for its sea turtle conservation program. Over the past 18 months, the Council in collaboration with National Marine Fisheries Service - Pacific Islands Fishery Science Center (PIFSC), the Pacific Islands Regional Office (PIRO), and the Southwest Fishery Science Center (SWFSC) has laid the groundwork for significant turtle conservation efforts in the Western Pacific Region.

In May 2003, the Council hired a full-time sea turtle coordinator to oversee and direct the conservation program, and implemented a Turtle Advisory Committee (TAC) to direct and advise the Council in its turtle conservation activities. This TAC is comprised of seven experts who have long-term commitments, exemplary experience and knowledge in sea turtle biology, conservation, management, research, modeling, and oceanography with cumulative expertise of all six species of turtles occurring in the Pacific Ocean[1].

Based on suggestions by the regional experts who participated at the Sea Turtle Workshop (2002), the U.S. Sea Turtle Recovery Plans and advise from the TAC, the Council has developed priorities for its sea turtle conservation program. Program objectives are directed towards the following six areas of concentration and will function in coordination with all relevant regional organizations including SPREP, SPC, FAO, ASEAN-SEAFDEC, FFA and ADB[2]:

1. Research: To fill information gaps
    a. Regional Tagging Database - SPREP
    b. Promote population assessments in the Pacific Islands Region
2. Measures to reduce direct harvest
    a. Of eggs & adults
    b. Economic incentives (to reduce harvest pressures)
3. Habitat Protection – i.e. stock enhancement
    a. Nesting beach management
    b. Implement Coral Reef MPA's
4. Education / Outreach
    a. Community involvement, Increased awareness
5. International Management / Liaison / Networking
    a. Meetings & Workshops
6. Fishery Mitigation Measures
    a. Gear technology transfer & Involving fishers in research efforts

Recommendations from the TAC concluded that conservation efforts should be divided into two

[2]TAC membership includes: Dr. Colin Limpus, Mr. George Balazs, Dr. Peter Dutton, Dr. Milani Chaloupka, Dr. Jeffrey Polovina, and newly added (August 2003) Dr. Naoki Kamazaki and Ms. Laura Sarti Martinez. The first TAC meeting convened July 29 - 30, 2003.

[2] South Pacific Regional Environmental Program, Secretariat of the Pacific Community, Food and Agricultural Organization, Southeast Asian Fisheries Development Center, Forum Fisheries Agency, and Asian Development Bank

areas. NMFS' Regional Office in Honolulu (PIRO) will focus primarily on sea turtle related management and conservation programs in the U.S. Flag States (Hawaii, America Samoa, Guam and the Commonwealth of the Northern Marianas) and U.S. Micronesian Compact Areas (Palau, Federated States of Micronesia and Marshal Islands). While the Council will direct its efforts towards international projects with a focus on those species which are of greatest likelihood to interact with the Hawaii-based longline fishery, namely loggerhead and leatherback sea turtles.

Sea Turtle Conservation Projects in Progress.

Project	**Region**	**Funding Agency**	**Purpose**
Satellite Tagging March 2003: 10 ARGOS and 4 PAT satellite tags deployed. Project to continue into the future	Papua, PNG	PIRO/SWFSC	To provide clues to additional nesting sites, and will be used as a basis to design aerial surveys. To fill information gaps regarding migratory movements.
Leatherback Aerial Survey[4]	PNG, West Papua Vanuatu, and Solomon Isl.	PIRO/SWFSC	Four year study to establish a comprehensive inventory of leatherback nesting beaches.
Sea turtle in-water survey	CNMI	PIRO	Population assessments, capacity building
Tagging & surveys	Guam	DAWR/PIRO	Population assessments, capacity building
Tagging & surveys	America Samoa	DMWR/PIRO	Population assessments, capacity building
Green & hawksbill turtle survey	Palau	PMRD/PSC/ TNC/PIRO	Population assessment, education & outreach
Tagging & surveys	Federated States of Micronesia (FSM)	MIRFA/GPA/ PIRO	Yap tagging and monitoring program, re-initiate genetic stock identification.
Education to Reduce Adverse Interactions Between Commercial Fishing Operations and Sea Turtles	Federated States of Micronesia (FSM)	PIRO (S-K grant) MIRFA/GPA/	To improve the capabilities of observers in recognizing, handling, and reporting interactions between turtles and LL fisheries. Transfer sea turtle conservation technology.

Tagging Database development	Regional: SPREP/SPC ASEAN-SEAFDEC	Council	Rehabilitation, upgrade and restoration of SPREP turtle tagging databases
Education & Outreach	Guam	Council	Education Poster
Cultural survey	Republic of the Marshal Isl. (RMI)	MIRFA/GPA/ PIRO	Define parameters for potential research. ID past and ongoing research; literature search; feasibility and logistics study
Policy Post-Doc	Pacific Ocean basin	SWFSC/PIRO	A two-year post-doctoral position in the economics of sea turtle conservation.
International Meetings: 1. 2nd International Fishers Forum -IFF 2. 23rd Annual Sea Turtle Symposium 3. Japan Fisheries Agency 4. People & the Sea Conference 5. Bellagio, Italy 6. 24th Annual Sea Turtle Symposium Other www.seaturtle.org server fund donation	Liaison & Networking: 1. Hawaii 2. Kuala Lumpur 3. Japan 4. Amsterdam 5. Italy 6. Costa Rica	Council	IFF: Forum for fishermen and scientists to exchange information and ideas on technologies and strategies to mitigate sea turtle and seabird interactions with longline fisheries 23rd Sea Turtle Symp.: Travel support to Kuala Lumpur for 30 Pacific Islanders and Asian participants. Japan Fisheries Agency: Liaison & collaboration activities to develop sea turtle mitigation measures People & the Sea: (Sept. 2003) Increase awareness of Pacific Island sea turtle issues Bellagio, Italy: (Nov. 2003) Conservation and sustainable management of sea turtles in the Pacific Ocean – travel grant for participants. 24th Sea Turtle Symp.: Participants support to Costa Rica – travel grant

[4] Aerial Surveys scheduled for four years, goals include: 1) Determine beaches with significant LB nesting (≥200 nests) outside Gulf of Huon, PNG; 2) Provide ground

counts of LB nests at 'significant' locations; 3) Estimate nesting population of LB via fixed-wing and helicopter aerial surveys and concurrent ground counts along the entire north coast of PNG; and 4) Conduct capacity building of local researchers in aerial census techniques.

The first meeting of the Turtle Advisory Committee convened July 29-30, 2003. During this meeting the TAC reviewed and critiqued the Council and PIRO's turtle conservation projects to date. The TAC had many constructive recommendations for both agencies and in general suggested that the Council redirect sea turtle conservation projects towards long-term projects to obtain demographic and population abundance data on key populations of Southwest Pacific leatherbacks and North Pacific loggerheads (i.e., those species which interact with the Hawaii-based fishery). In addition, the TAC suggested that more energy be directed towards Education & Outreach, especially in the U.S. Flag Territories and Compact States, and recommended that population assessment surveys being conducted in these areas be augmented with laparoscopy to provide more useful information on nesting population dynamics (e.g., nesting periodicity, status, fecundity, etc.).

The TAC further recommended that both the Council and PIRO extend its horizons outside the typical jurisdiction area to incorporate Fiji, Vanuatu, Solomon Islands and New Caledonia in research efforts. In particular, to identify possible leatherback nesting sites, and identify and quantify any fishery or direct harvest related threats that may be occurring in these areas impacting hawksbills, leatherbacks or loggerheads. Research efforts could be effectively be coordinated with the assistance of local community groups and/or Non-governmental Organization (i.e., The Nature Conservancy and World Wildlife Fund).

Future activities proposed for FY03 by PIRO includes taking the FSM "success" on the road to transfer sea turtle conservation technology, assist with observer training and work with local and locally-based longline fleets operating in the RMI and PNG. A goal for work in PNG is to assist with implementation of an observer program, work to determine the magnitude of fishery/turtle interactions, assist with education and outreach, and work to reduce incidental takes in the Torres Strait and Gulf of Papua prawn trawl fishery by helping to implement the use of Turtle Excluder Devices (TED's).

Future Council activities and goals for FY03/04 include the continuation of the regional tagging database rehabilitation project and assisting SPREP to acquire an appropriate Turtle Database Officer; promote nesting beach management and stock enhancement for leatherback and loggerhead turtles; contract the development of a Hawksbill simulation model; continue to support satellite tagging activities of leatherback turtles in PNG and Indonesia; and focus energy towards education and outreach activities. In addition, the Council is committed to supporting and developing sea turtle related meetings including: a conference in Bellagio, Italy (Nov. 17 – 22, 2003) on the Conservation and Sustainable Management of Sea Turtles in the Pacific Ocean; travel support for participants attending the 24th Annual Sea Turtle Symposium in Costa Rica; development and support of the 3rd International Fishers Forum (to continue the work to reduce sea turtle interactions with longline fisheries); and reconvene the Western Pacific Sea Turtle Cooperative Research and Management Workshop (May 2004 – agenda to be determined).

APPENDIX F

Summary Report of first Turtle Advisory Committee (TAC) Meeting

WESTERN
PACIFIC
REGIONAL
FISHERY
MANAGEMENT
COUNCIL

Summary Meeting Report
TURTLE ADVISORY COMMITTEE
July 29 - 30, 2003

Summary

The first Turtle Advisory Committee (TAC) meeting convened July 29 and 30, 2003 in the offices of the Western Pacific Regional Fishery Management Council, Honolulu, Hawaii. The development and designation of the TAC was based on recommendations from Council members during 115th Council meeting and finalized at the 117th Council meeting (Feb 2003). The TAC's primary duties are to direct and advise the Council in its activities related to sea turtle conservation and sea turtle related fishery management initiatives.

This first day of the meeting dealt primarily with progress of the Council and the Pacific Island's Regional Office sea turtle conservation program. The TAC considered the programs developed and implemented for FY02 and FY03, and provide valuable recommendations for future direction and activities. They discussed protocol for submitted proposals, identified priorities for the Council's sea turtle conservation plan and discussed possible agendas for the second Western Pacific Sea Turtle Cooperative Research and Management Workshop.

The second day of the meeting was dedicated entirely to conservation measures under consideration in the settlement discussions with the Hawaii Longline Association (HLA). These conservation measures pertain to activities that could be undertaken by HLA or the Council to conserve or provide benefit to sea turtles stocks that are currently being impacted by the Hawaii-based pelagic longline fishery (namely leatherback and loggerhead turtles). The other aspect of discussions involved the legal issues pertaining to using conservation measures to benefit populations or stocks outside of the fishing grounds to offset takes within the fishing grounds. Craig Johnson from the office of Protected Resources (PR), NOAA Fisheries Headquarters was in attendance to provide valuable insights to the legal aspects of evaluating conservation measures in the HLA proposal or how they may be incorporated in biological opinions and environmental impact statements (EIS).

For clarity, principal recommendations from the TAC are separated into the two areas, conservation program and conservation measures.

Conservation Program

Irene Kinan (Council) and Ray Clarke (PIRO) presented the sea turtle conservation projects developed and implemented for FY02 and FY03. After considering these projects, the TAC were supportive yet critical in that the implemented projects appear to have a "northern bias" in a region which does not have as many turtles as the South Pacific (e.g. CNMI, Guam, Palau, Am. Samoa, FSM, RMI) (Table 1). However, it was noted that many (most) of these projects are needed to address areas which have been neglected in the past. It is noted that there appeared to be a focus on "quick fix" projects (i.e., database development, satellite telemetry and aerial surveys). These projects may not be particularly useful from a policy/ management perspective. While providing information, (some useful demographic data) they will not provide answers to address immediate management issues to address population recovery.

Table 1. Council and PIRO directed sea turtle conservation activities. Primary funding agency in parentheses.

A. Research: To fill information gaps	Aerial Surveys (PIRO); Satellite Tagging (PIRO); Tagging Database development (Council); Population Assessments: Guam (PIRO); CNMI (PIRO); America Samoa (PIRO); Palau (PIRO); FSM (PIRO)
B. Measures to reduce direct harvest	Post Doc economics study (PIRO/SWFSC)
C. Habitat Protection – LB/LH stock enhancement	None yet
D. Education / Outreach	RMI "Cultural Survey" (PIRO); Guam education poster (Council)
E. International Liaison/ Networking Activities	Meetings (Council): Japan Fisheries Agency; International Fishers Forums; Belagio, Italy (Nov. 2003 - Conservation & Management of Sea Turtles in the Pacific); 2nd Sea Turtle Research & Management Workshop (May 2004)
F. Fishery Mitigation Measures Exchange	FSM (PIRO); International Fishers Forum (Council)

The TAC Recommended:

1. Council sea turtle conservation program focus needs to be redirected towards long term projects to obtain demographic and population abundance data on key populations of SW Pacific leatherbacks and North Pacific loggerheads (i.e. those species which interact with the fishery).

2. Redirect focus and resources towards Education & Outreach. Posters/fliers/ handouts & education of "most appropriate" harvest parameters will go a long

way to protect what green and hawksbill sea turtle species may still occur in the U.S. Flag and Compact States.

3. Population assessment surveys (in the U.S. Flag and Compact States) should be augmented with proven techniques in laparoscopy to provide more useful information on nesting population dynamics (nesting periodicity, status, fecundity, etc.).

4. Council to develop a "policy statement" for submitted proposals stating what sort of projects the Council will consider (e.g. LH & LB of highest priority, GR & HB of secondary priority).

5. Possible agenda for the Council's future Sea Turtle Workshop (2004): 1) Council to report on progress and program growth to date; 2) focus on 1 management issue (i.e. stock abundance of LH and/or LB, or both).

6. Reorganize the Council's developing turtle tagging database by organization rather than by person or geographic area. Purpose is to identify "repositories of data" not "who" (individuals) that may have data. Provide a range of dates pertinent to organizations with this data. An example of literature may be entered into database, but recognize that a comprehensive literature database is already in existence (e.g. Archie Carr Center Sea Turtle Bibliography). To include all literature implies that someone needs to service and update the database. Consider building a link to Archie Carr Bibliography (contact Alan Bolten for advice).

7. Extend research outside the typical jurisdiction to incorporate Fiji, Vanuatu, Solomons, New Caledonia. In particular, work to identify leatherback nesting areas, and identify and quantify any fishery or direct harvest related threats that may be impacting leatherbacks, loggerhead or hawksbills. Research efforts could be effectively coordinated with the assistance of local community groups or NGO's (i.e., TNC or WWF).

Conservation Measures

The second half of the meeting (day two) was dedicated to conservation measures, and concluded with the fishery management regimes under consideration for the southern area closure. Craig Johnson began the day by describing NMFS office of Protected Resource's policy and criteria for evaluating conservation measures. The agency will consider any beneficial actions, however, they will evaluate them on two specific criteria: 1) how certain the measures will be to be implemented, and 2) the certainty of the measures being effective. The general formula for evaluating effectiveness is "exposure, response and risk" of the species and/or stock that will be subjected to the conservation measures. These criteria will ultimately determine how much difference conservation measures will make in a consultation.

Issues that will impact the certainty of implementation or effectiveness for improving the status of sea turtles include (but are not limited to): funding and its likely duration; which organizations/agencies/communities are to be involved in the measure; history of local conservation measures and local interest therein; committed personnel and development of local capacity; likely implementation time; duration and/or permanency of measures; feedback to local people; scientific underpinning of the measures; assessment of any measure relative to the proportion of the turtle population being affected (e.g. what proportion of total nesting area is to be protected); assessment of whether measures are targeting populations which interact with Hawaii LL fishery (including Eastern Pacific leatherbacks); contingency plans or adaptive management capacity for change in measures to cope with changes in local circumstances; and a time frame addressing when the proposed action will start and when do benefits start showing.

The discussion, led by Jeff Polovina, considered the specific conservation measures at hand (Table 2). Peter Dutton identified three leatherback conservation measures and the first loggerhead measure; the second loggerhead measure (in Japan) was described by George Balazs. Cost estimates are dependent on preexisting programs. In other words, proposed projects are designed to augment programs already in existence to support additional conservation objectives.

Table 2. Conservation measures proposed to facilitate recovery of leatherback and loggerhead populations impacted by the Hawaii-based pelagic longline fishery.

Leatherback turtles (*Dermochelys coriacea*)	
1. Papua, War-Mon nesting beach	Contract with WWF-Indo to hire villagers to protect the beach (approx. 1,00 nests/yr) from predation by feral pigs. Protection achieved with electric fences to keep pigs off beach and relocate eggs to more secure areas. Also, elimination of take of about 10 nesting females/yr. Costs $30K/yr
2. West Papua, coastal foraging grounds	Contract with WWF-Indo to work with villagers to reduce/eliminate the harpooning of about 100 leatherback turtles per year in coastal foraging grounds. Cost$20K/yr
3. Papua New Guinea nesting beach	Contract with NGO's to work with up to 3 villages to eliminate harvesting of effs, dog predation on eggs, and relocate eggs likely to be losts to beach erosion. Savings of 1,000-1,5000 nests/yr. Costs $45K/yr
Loggerhead turtles (*Caretta caretta*)	
4. Baja, Mexico halibut gillnet fishery	Contract with WildCoast to conduct mortality reduction workshop with fishermen and place observers on local boats to insure that all live loggerheads that comprise the estimated 3,000 juvenile loggerheads caught in halibut gillnets are returned to the ocean. Gillnet mortality ie not presently known, but if even 10% are alive and saved that would be a savings of 300 juvenile loggerheads. Cost $50K/yr
5. Japan nesting beaches	Colleagues in Japan have proposed relocating eggs from areas prone to erosion or that experience extreme temperatures at two nesting beaches to save approx. 53 loggerhead nests. Cost $10/yr

TAC Recommendations

1. The TAC concluded that conservation measures are valuable and hold scientific merit.

2. Conservation measures should be incorporated into the suite of management measures currently being considered by the Council and NMFS for the Hawaii-based longline fishery. However, measures should be described in more detail to assist in determining the certainty of their implementation, and effectiveness for improving the status of these stocks (e.g. nesting beached be described in terms of proportion of beach to be protected rather than number of nests).

3. The leatherback measures were considered to hold greater merit than the loggerhead measures, however, these [loggerhead measures] were viewed as important in regards to establishing working relationships – especially in Japan. Once again, if the emphasis is for long term commitments, then it is valuable to establish positive relations with programs.

4. LB conservation measures should include the Eastern as well as Western Pacific stocks (e.g. 1 out of 17 (6%) of turtles sampled from HLL fishery were from the East Pacific; where population declines have been very severe).

5. Inventory mortality in directed harvests fisheries (e.g. Kei Islands traditional LB harvest) and previously unreported fishery interactions (trap fisheries in southern Australia for LHs). Try to identify if the traditional Kei Island LB take is increasing due to technological advances (i.e., use of motor boat, high powered weapons and nylon line versus woven lines or traditional canoes, etc.)

6. Work to develop partnership arrangements with agencies and organizations overseas to develop and implement conservation actions, e.g. between Council and Qld Parks for southern LBs and HB, Council and TNC regarding Solomon Island HB, and between HLA and Sea Turtle Association of Japan for northern LHs.

7. Regarding No. 4 and 5, be sensitive in the way information is presented for foreign versus local consumption, and how this might be interpreted.

8. The TAC will develop a "risk matrix" of threats and relative impacts on sea turtles for assisting in evaluating the effectiveness of turtle conservation measures.

Southern Area Closure

Following the intensive discussions regarding conservation measures, Paul Dalzell introduced the fishery management alternatives for the Southern Area Closure. This was more informative in nature and the TAC had no major suggestions to offer. Jim Linch presented the HLA's proposal which encompasses the conservation measures (previously discussed) for the mediation discussions in the hopes of settling the litigation dispute. The major recommendation by the TAC was that they not forget the Eastern Pacific leatherback stock in their proposal (see #3 above). It was suggested that HLA be specific in regards to which stock (west or east Pacific leatherback; north or south Pacific loggerhead) conservation measures are meant to address.

Recovery Plans

The meeting concluded with Tina Fahy's (sea turtle recovery coordinator for the NMFS South West region) quick mention of where NMFS stands in regards to the U.S. sea turtle recovery plans. The goal is to look at the plans and determine whether or not they need to be revised or added to. It needs to be determined if the status of species has changed, if new threats need to be considered, or if criteria for recovery has changed. It is accepted that a lot of revisions and updating may be needed, and it will be a very public process (i.e., Federal Register Notice, public input, stakeholders, scoping). In defense of the recovery plans, however, both Dutton and Balazs supported the fact that the plans really reflect what they do and how they have built their programs. They recognize that a lot of progress has been made in the past few years, and the plans should reflect this new information, but the fundamental elements are relevant and still stand.

Conclusion

The main recommendations emerging from this first TAC meeting, from the Council's perspective, will concern conservation measures. The consensus was that they were good measures. The group has asked Dutton and Balazs to go back to their colleagues to flesh out proposals in more detail, bearing in mind how they are going to be reviewed in Protected Resources in terms of certainty of implementation, effectiveness, cultural sensitivity, duration, longevity, et cetera.

Another strong recommendation that emerged from this meeting was a stronger sense for the division of labor and efforts between the Council and PIRO. It was recommended that the Council prioritize its sea turtle conservation program to those species which interact with the longline fishery, namely leatherbacks and loggerheads. Resources for greens and hawksbills at this time are best applied in education and outreach, especially in the north/central Pacific region. It is recognized that PIRO's sea turtle conservation and recovery activities, although they may work in unison with the Council, may also be prioritized differently. There was a strong consensus that large gaps in knowledge still exist in regards to population demographics, especially in the South West Pacific (Fiji, New Caledonia, Vanuatu and the Solomon Islands). Preliminary satellite telemetry data suggests that leatherbacks migrating between Fiji, New Caledonia and Australia appear to be under threat; impacted by unknown causes. The Council is encouraged to investigate the source of this threat by use of its many fishery related contacts in the region. It is suggested that the TAC will convene annually, and the next meeting may see additions to the Committee by East Pacific leatherback and the North Pacific loggerhead experts.

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APPENDIX G

Members of Council's Turtle Advisory Committee (TAC)

Council's Turtle Advisory Committee (TAC)

The TAC members which reviewed the Council's sea turtle conservation measures include:

Name	Affiliation	Experience
George Balazs	NMFS-PIFSC	A leading expert in the field with over 35 years of sea turtle experience; Member of the sea turtle recovery team; Over 200 publications on sea turtle biology, ecology, health and disease.
Dr. Peter Dutton	NMFS-SWFSC	A leading expert in the field with over 25 years of sea turtle experience; Member of the sea turtle recovery team; Over 75 publications on sea turtle biology, physiology, population demographics, and genetics.
Dr. Jeffrey Polovina	NMFS - PIFSC	Chief, Ecosystem & Environment Investigations with over 30 years of experience; Published many peer reviewed publications on the North Pacific pelagic ecosystem and on the association between turtles and oceanic habitat; Currently acting Chief of NMFS-PIFSC.
Dr. Colin Limpus	Queensland Parks Authority	A leading expert in the field with over 40 years of sea turtle experience; Over 200 publications on sea turtle biology, physiology, ecology, and population demographics.
Dr. Milani Chalopuka	Ecological Modelling Services	A leading statistician and expert in sea turtle population modeling ; Published over 30 peer reviewed publication on sea turtle biology, population demographics and modeling.

Additional TAC members added since August 2003 include:

Laura Sarti Martinez	SEMARNAT, Mexico	A leading expert in sea turtles, in particular leatherback turtles, of Mexico and Central America. Over 40 peer reviewed publications.
Naoki Kamezaki	Sea Turtle Association of Japan	A leading expert in sea turtles, in particular North Pacific loggerhead turtles. Over 90 peer reviewed publications.

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TECHNICAL ASSISTANCE BY GEORGE H. BALAZS

National Taiwan Ocean University and Council of Agriculture	6/02	Research and conservation planning for sea turtles in Taiwan.
Queensland Parks and Wildlife Service and Raine Island Corporation	6/99	Review of the Queensland green turtle research program.
Environmental Research and Wildlife Development Agency - Abu Dhabi, UAE	5/99	Satellite telemetry of hawksbill turtles in the United Arab Emirates.
Environmental Research and Wildlife Development Agency - Abu Dhabi, UAE	5/98	Satellite telemetry of green turtles in the United Arab Emirates.
National Taiwan Ocean University and Council of Agriculture	2/98	Research and conservation planning for sea turtles nesting in Taiwan.
Republic of Seychelles	1/98	Satellite telemetry of hawksbill turtles nesting at Cousin Island.
Environmental Research and Wildlife Development Agency - Abu Dhabi, UAE	2/97	Assessment and research planning for sea turtles in the United Arab Emirates of the Arabian Gulf.
Delegation for the Environment and South Pacific Regional Environment Programme	12/96	Sea turtle survey and assessment of Tupai Atoll, French Polynesia.
National Taiwan Ocean University and Council of Agriculture	8/96	Satellite telemetry of green turtles nesting at Wan-An Island, Peng-Hu Archipelago (Phase III).
National Taiwan Ocean University and Council of Agriculture	8/95	Satellite telemetry of green turtles nesting at Wan-An Island, Peng-Hu Archipelago (Phase II).
National Taiwan Ocean University and Council of Agriculture	8/94	Satellite telemetry of green turtles nesting at Wan-An Island, Peng-Hu Archipelago (Phase I).
Port of Nagoya Aquarium	4/94	Necropsies of pelagic loggerhead turtles
South Pacific Regional Environment Programme	10/91	Sea turtle survey and assessment of Scilly Atoll and Motu-One, French Polynesia.
International Union for the	9/89	Evaluation of hawksbill hatchery and Conservation of Nature (IUCN) headstart project in Palau.
Office for Tokelau Affairs	10/81	Assessment of sea turtle resources in Tokelau.

PROFESSIONAL MEETINGS ATTENDED BY GEORGE H. BALAZS

Meeting of the IUCN Marine Turtle Specialist Group	04/02	Miami, Florida
Twenty-second Annual Sea Turtle Symposium	04/02	Miami, Florida
Hawaiian Green Turtle Simulation Model Workshop	02/02	Honolulu, Hawaii
Western Pacific Sea Turtle Cooperative Research and Management Workshop	02/02	Honolulu, Hawaii
NMFS/SWFC Planning Meeting on Longline Sea Turtle Bycatch	11/01	San Diego, California
Sea Turtle Assessment Meeting	05/01	Honolulu, Hawaii
Working Group Meeting on Health Issues of Captive Reared Hawaiian Green Turtles	03/01	Honolulu, Hawaii
Twenty-first Annual Sea Turtle Symposium	02/01	Philadelphia, Pennsylvania
Working Group Meeting on Reducing Turtle By-Catch in the Hawaii Longline Fishery	01/01	San Diego, California
Southwest Fisheries Science Center Sea Turtle Strategic Research Planning Meeting	11/00	La Jolla, California
Workshop on Sea Turtle Health Assessment	09/00	Charleston, South Carolina
Pacific Region Training Workshop on the Use of Satellite Transmitters and the Argos System to Track the Post-Nesting Migrations of Hawksbill Turtles	08/00	Honolulu, Hawaii
International Training Workshop on the Use of Satellite Transmitters and the Argos System to Track the Post-Nesting Migrations of Hawksbill Turtles in the Caribbean Region	07/00	Tortuguero, Costa Rica
Sea Turtle Population Assessment Workshop	03/00	Gainesville, Florida
Twentieth Annual Sea Turtle Symposium	03/00	Orlando, Florida
National Park Service Biological Inventories Workshop	01/00	Kailua-Kona, Hawaii
Seminaire Tortues Marine - Ocean Indien 1999	12/99	Reunion Island, France

Mexus-Pacific Meeting	11/96	Mexico City, Mexico
FY1997 National Marine Fisheries Service Sea Turtle Funding Allocation Meeting	11/96	Silver Spring, Maryland
Conference on Large Pelagic Fish Resources and Fisheries	10/96	San Diego, California
Regional Marine Turtle Conservation Programme Strategic Planning Meeting	5/96	Apia, Western Samoa
Fifth Meeting and Workshop of the South Pacific Regional Marine Turtle Conservation Programme	4/96	Nadi, Fiji
Regional Meeting of the IUCN Marine Turtle Specialist Group	3/96	Hilton Head, South Carolina
Sixteenth Annual Sea Turtle Symposium	2/96	Hilton Head, South Carolina
FY1996 National Marine Fisheries Service Sea Turtle Funding Allocation Meeting	12/95	Silver Spring, Maryland
Workshop on the Status of Marine Turtles in the Pacific Ocean	12/95	Honolulu, Hawaii
Fiji Sea Turtle Conservation Meeting	10/95	Suva, Fiji
U. S. Pacific Sea Turtle Recovery Team	7/95	San Diego, California
Green Turtle Fibropapillomatosis: Epidemiological Research Needs	5/95	Fort Collins, Colorado
Workshop on Handling Techniques, Resuscitation, and Avoidance Strategies for Hooking Interactions with Sea Turtles in the North Pacific Pelagic U.S. Longline Fishery	3/95	Honolulu, Hawaii
International Workshop on the Management of Marine Turtles (JBA)	3/95	Tokyo, Japan
Fifteenth Annual Sea Turtle Symposium	2/95	Hilton Head, South Carolina
U. S. Pacific Sea Turtle Recovery Team	9/94	San Diego, California
Fourth Meeting and Workshop of the South Pacific Regional Marine Turtle Conservation Programme	8/94	Apia, W. Samoa
IUCN Marine Turtle Specialist Group Strategic Planning Session	6/94	Puerto Vallarta, Mexico

Eighth Meeting of the Ad Hoc Committee on Entanglement	6/91	Seattle, Washington
Workshop on Marine Turtle Fibropapilloma	12/90	Honolulu, Hawaii
International Symposium on the Resource Management of the Hawksbill Turtle (JBA)	11/90	Nagasaki, Japan
First Meeting and Workshop of the South Pacific Regional Marine Turtle Conservation Programme	8/90	Noumea, New Caledonia
Seventh Meeting of the Ad Hoc Committee on Entanglement	6/90	Seattle, Washington
Tenth Annual Workshop on Sea Turtle Biology and Conservation	2/90	Hilton Head, South Carolina
Second International Conference on Marine Debris	4/89	Honolulu, Hawaii
Working Group Meeting on Sea Turtle Capture Methods	3/89	Cedar Key, Florida
International Symposium on Sea Turtles in Hiwasa	8/88	Hiwasa, Japan
Seventh Annual Workshop on Sea Turtle Biology and Conservation	3/87	Wekiwa Springs, Florida
Hawaiian Sea Turtle Recovery Team	1/87	Honolulu, Hawaii
Hawaiian Sea Turtle Recovery Team	4/86	Honolulu, Hawaii
Sixth Annual Workshop on Sea Turtle Biology and Conservation	3/86	Waverly, Georgia
IUCN Marine Turtle Specialist Group	3/86	Waverly, Georgia
Symposium on Sea Turtles in the East Pacific	12/85	San Jose, Costa Rica
Hawaiian Sea Turtle Recovery Team	10/85	Honolulu, Hawaii
First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management	10/85	Galveston, Texas
Workshop on the Fate and Impact of Marine Debris	11/84	Honolulu, Hawaii
IUCN Marine Turtle Specialist Group	7/83	Tortuguero, Costa Rico

Sea Turtle Bibliography

Search: (k=Balazs) && date=2001
Hit Count: 4
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Sea Turtle Bibliography

WebLUIS

Search: (k=Balazs) && date=2002
Hit Count: 12
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☐ 1 **Adaptation of captive-reared green turtles released into Hawaiian coastal foraging habitats, 1990-99**
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APPENDIX H

Donald R. Kobayashi and Jeffrey J. Polovina, NMFS Honolulu Laboratory, *Time/Area Closure Analysis for the Turtle Take Reductions*

Time/Area Closure Analysis for Turtle Take Reductions

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(Draft manuscript, 03/21/2000)

Introduction

This report documents the steps taken at the National Marine Fisheries Service Honolulu Laboratory in response to the Order issued by Chief U.S. District Court Judge David Alan Ezra, District of Hawaii, in the case of CMC et al. versus NMFS et al.; CIVIL NO. 99-00152; dated November 23, 1999, to complete an analysis of the temporal and spatial distribution of interactions between Hawaii-based longline vessels and sea turtles to determine time and area closures that would provide the greatest benefit to sea turtles. This report will also examine the predicted effects of the emergency spatial closure of the longline fishing grounds within the area north of 28°N latitude and between 168°W and 150°W longitudes.

The Hawaii based longline fishery is a year-round, limited entry, high seas fishery targeting various billfishes and tunas in the Central Pacific Ocean. Most fishing activity takes place in the region bounded by 0-45°N latitude, 180°-140°W longitude (Figure 1). There were 114 active vessels making 1140 fishing trips in this fishery in 1998 (Ito & Machado, 1999). Sea turtle interactions in the Hawaii based longline fishery primarily involve four species with wide geographic ranges throughout the Eastern and Indo-West Pacific Ocean: loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*), and green (*Chelonia mydas*). Loggerheads are the most commonly encountered species, with an average annual fleet wide take of 370 individuals over the time period 1994-1998 (Kleiber, 1999). Leatherbacks, olive ridleys, and greens followed with averages of 166, 110, and 32 individuals taken per year, respectively. Leatherbacks are presently considered to be the most threatened of all of these species (Spotila et al., 1996); therefore, closures most beneficial to leatherbacks will be the focus of this report.

Methods

Previous analyses of sea turtle take in the Hawaii based longline fishery have primarily focused on overall take numbers (e.g., Kleiber, 1998), with less emphasis on take by area and/or time. The latter types of data are essential, however, towards constructing a time/area closure that will benefit sea turtles. The first objective of this report was to create a database of turtle take structured over time and area. This was accomplished by applying predictive statistical models to the attributes of each set of longline gear. These attributes include variables reported in the mandated federal logbook such as latitude, longitude, trip-type (a 3-value index expressing the fish species targeting practice of that particular fishing trip: swordfish, tuna, or mixed), month, and year, as well as other variables such as moon phase and satellite measured sea surface temperature (weekly 0.1 degree lat./lon. resolution MCSST) which were merged with the logbook data independently for this analysis, using exact location and date to determine the corresponding values. The statistical models for predicting turtle take were constructed from detailed observations gathered by NMFS-SWR observers, which monitor approximately 5% of the total longline fleet activity. Observers are required to tally all turtle takes, and other ancillary data. [Modeling fleet-wide turtle take from this small subset of the data is preferable to using logbook data verbatim for these controversial interactions with protected species. Earlier work has shown that logbook derived estimates of turtle take account for only about 9% of the total take; i.e., there are about 11 times more turtles being taken than logbook data alone would indicate (Dinardo, 1993).] It should be pointed out that not all turtles that are "taken" are dead or will necessarily die later. The kill rates (kills per take) vary by species with loggerhead, leatherback, olive ridley, and green having estimated values of 0.18, 0.07, 0.34, and 0.01, respectively, averaged over 1994-1998 (including turtles already dead and turtles expected to die later from hooking injuries; Kleiber, 1999). Fleet-wide average annual kills over the same time period were estimated to be 65, 37, 11, and 0.3, respectively. This report presents management scenario impacts in the form of a scale-free percent change which could apply to takes or kills interchangeably and, since the long term survival of hooked turtles is not well understood for all species, take rates were not adjusted with kill rate estimates.

The statistical models used are known as generalized additive models (GAM's, see Hastie & Tibshirani, 1990). GAM's differ from more conventional models in that they can easily incorporate complex nonlinear effects from multiple sources. Other commonly used models such as generalized linear models (GLM), analysis of variance (ANOVA), and multiple regressions all assume a form of linearity with the predictor variables. But if, for example, we are attempting to model the per-set take of loggerhead turtles against SST, we might *a-priori* expect that there is an optimal temperature where turtle take is high, and varying degrees of reduced take to either side of this optimum turtle habitat (see Polovina et al., 2000). Conventional linear approaches would fail to capture this effect, or could produce misleading and/or nonsensical predictions due to a forced linearization of the underlying process. Linearity remains a special case of the GAM, and can be accommodated if the data suggest such an effect. When dealing with a suite of unknown effects, a conservative or precautionary approach should include models that can handle complex nonlinear effects as well as the simpler linear effects. The nonlinear effects in a GAM are expressed as a "smoother" function of each variable, whose sum effect (hence "additive") results in the predicted value of interest; in our case species-specific per-set turtle take. There are several choices for smoother function specification in a GAM; in our application we chose to use smoothing splines since these generally perform better with regard to the bias-variance tradeoff than lowess or kernel smoothers (Trevor Hastie, pers. comm.[1]).

Turtle take GAM's were constructed using the software package S-Plus (v. 3.4) running under IRIX 6.5.4 on an SGI Challenge L workstation. All observer data (n=2812 sets) and logbook data from un-observed trips (n=55785 sets) from the years 1994-1998 were examined. A set of variables common to both the observer and logbook databases were evaluated in the GAM's: latitude, longitude, trip-type, month, year, as well as the added variables moon phase and satellite measured SST. Stepwise procedures were used to identify variables with a statistically significant contribution toward predicting turtle take. The stepwise procedure initially started out with a fully saturated model with all variables specified with smoother functions, then the model is simplified by eliminating variables or using linear functions instead of nonlinear smoother functions. The rearward stepwise approach is favored in this type of

[1] Trevor Hastie, Professor of Statistics and Biostatistics, Stanford University.

statistical model (Trevor Hastie, pers. comm.[2]). The statistical criteria used for the automated acceptance or rejection of terms in the GAM is called the Akaike Information Criterion (AIC, see Akaike, 1974), which is a goodness of fit index penalized by the number of parameters in the model. Individual GAM's were run for each turtle species: loggerhead, leatherback, olive ridley, and green. Degrees of freedom in the smoother functions were reduced manually to eliminate unnecessary curvature in the functions. The individual smoother functions for each of the final models are shown graphically in Figures 2-5. The final loggerhead GAM included smoothed nonlinear effects from latitude, longitude, moon phase, and SST; and categorical effects from each month and each year. The final leatherback GAM included smoothed nonlinear effects from latitude and moon phase, a linear effect from longitude; and categorical effects from each month. The final olive ridley GAM included a smoothed nonlinear effect from moon phase, and a linear effect from SST. The final green GAM included a linear effect from longitude, and a smoothed nonlinear effect from moon phase. These GAM's were used to make per-set take predictions across the entire logbook database using the selected variables for each turtle species. Exploratory plots summarizing turtle take by latitude, longitude, and month were created.

The logbook database of turtle take was then examined in a series of computer simulations mimicking the effects of various protective management scenarios. Management scenarios were restricted to seasonal and spatial closures of the longline fishing grounds. Seasonal closures consisted of single month and adjacent multi-month closures spanning all possible combinations from 1-11 months in duration. Spatial closures consisted of latitudinal closures (i.e., "no fishing north of..."), longitudinal closures (i.e., "no fishing east of..."), and box closures, which combined the characteristics of a latitudinal closure and a longitudinal closure. These constraints on fishing effort were chosen due to the predominantly northward and westward distributions of leatherback turtle take, and the orientation of the fishing grounds with respect to the Hawaiian island chain; hence, spatial closures were examined at the resolution of whole degrees with "north of" values ranging from 20°N-40°N latitudes and "east of" values ranging from 174°W-145°W longitudes. Seasonal and spatial closures were combined in two possible ways with the first being a "separated" mode where the seasonal closure impacts all areas for the duration of the closed season, while the spatial closure is in effect for all time. The second type of seasonal and spatial closure combination is a "merged" mode, where the seasonal closure only applies to the spatial closure region; similarly the spatial closure is only closed for the duration of the seasonal closure. In any given management action simulation, fishing effort, fish catch, fish catch revenue, and turtle take of all species were tabulated for two ways, the first being the "static" mode where the fishing activity is assumed to not adjust after any management action, and any lost fishing effort due to a spatial and/or seasonal closures is simply obliterated from existence. In the "dynamic" mode, the fishery is assumed to respond to the closures in a predictable manner. For spatial closures, it was assumed that complete spatial reallocation of lost fishing activity would occur, and this was modeled using monthly trip-type based expansions of open-area fishing activity. For seasonal closures, it was assumed that a maximum of one month's fishing activity could be reallocated symmetrically to adjacent months bounding the seasonal closure; operationally this was approximated by allocating each lost set with a multiplier of 0.5/(number of closed months) to each bounding month. For this report, all years of data were combined to provide an average historical effect of a given management scenario.

[2] Trevor Hastie, Professor of Statistics and Biostatistics, Stanford University.

It should be noted that reallocation is based upon existing fishing patterns and this leads to several important points: 1) reallocation could possibly *not* occur, if there were no entries in the appropriate month-trip-type-area strata, 2) unfished month-trip-type-area strata will remain unfished, i.e., we do not account for possible expansion of the fishing grounds, and 3) management mechanisms currently in place and reflected in the data are accounted for in the reallocation, i.e., protective influences of the existing 50 nautical mile longline closures around the Northwestern Hawaiian Islands are retained, and all predicted changes from *status-quo* are considered as supplemental to existing effects.

Fish catch revenue impacts of each closure scenario were calculated based upon the values of individual fish kept or lost due to the closure. These data were made available from recent economic analyses of the longline fishery (Sam Pooley, pers. comm.[3]). Ex-vessel prices ($ / pound) and values ($ / fish) were calculated for all major species by month and trip-type (broadbill, mixed, tuna) for the 1998 fishing year by merging the NMFS sample of wholesale market prices with trips identified in the NMFS logbook reports for 1998. These values were applied to estimated catches in each time-area strata to estimate ex-vessel revenues. The NMFS wholesale sample was roughly 30-35% of all longline transactions in 1998. Previous analysis has shown consistency with the HDAR longline price reports for recent years. Where no data were available for a species-month-trip-type strata, extrapolations for that month and species were used, weighted by annual average differences between trip-types. Economic values by area (1-degree square) were not available in time for the time-area analysis. While there are systematic differences in economic values by area, preliminary analysis of revenue by latitude did not indicate substantial differences between using aggregated and disaggregated price and value data. Economic values over time (e.g., 1994-98) were also unavailable. Again, however, preliminary comparison of 1998 with the 1994-98 average values did not show substantial differences in aggregate effects (although values for individual species may have varied substantially, these were usually smoothed when taking all species into account).

After accounting for all possible combinations of seasonal and spatial closures under separated, merged, static, and dynamic modes; a total of 361,194 possible management scenarios were evaluated. Evaluation was based on several important criteria such as percent change in turtle take by species or in aggregate, percent of fishing activity (longline gear sets) disrupted by the management action (i.e., static), percent of fishing activity lost after reallocation (i.e., dynamic), and percent change in fish catch revenue. For simplicity all scenarios were firstly partitioned into bins (e.g., 0-5%, 5%-10%, 10%-15%, etc.) based upon values of the dynamic percent change in leatherback turtle take, since this appears to be the primary species of concern for protective measures. Within these bins of leatherback take, the results were further sorted to discover optimal scenarios based on the criteria mentioned above, particularly the static value of fishing effort impact. This value of fishing effort disruption is an attractive criterion for gauging the impact of a time/area closure because it makes no assumptions about reallocation of lost fishing effort and is, therefore, useful in comparing different types of closure scenarios. We feel that fishing effort disrupted by the closure provides a basic measure of the impact of the closure because it provides a measure of the fraction of the effort which is impacted by the closure but stops short of making further assumptions about how the fleet responds to that disruption and the economic impacts of this hypothetical response. Our economist, Region staff, and some industry members are not confident that we can model the fleet response and resulting economics with

[3] Sam Pooley, Chief of Fishery Management & Performance Investigation, NMFS Honolulu Laboratory.

sufficient accuracy to use it as the basis to optimize the best closures. Several multi-criteria optimizations were also attempted, such as simply summing static percent fishing activity lost and dynamic percent fishing activity lost to form a sum of percents. This particular optimization would search for a scenario with a minimal combined effect of disruption of fishing activity and net loss of fishing activity after adjustment to a seasonal and/or spatial closure. Another multi-criteria optimization summed the individual turtle species' take change together. This optimization would search for a scenario that best reduced the take of all turtle species, in an equally weighted fashion. A larger multi-criteria optimization was formed by appropriately combining the two previously mentioned optimizations while paying close attention to arithmetic sign, so that the final criterion can both minimize disruption/loss while maximizing aggregate take reduction. For a given optimization, there were often many scenarios that nearly equally well met the optimization criteria, even at the resolution of whole degrees of latitude/longitude and whole months of time. The output from these exercises is lengthy, and it is difficult to pick a clearly superior solution for a given optimization. Scenarios that differ in only a few percentage points are probably not significantly different from each other based upon some preliminary analyses of variability. For this reason, many scenarios should be evaluated together with additional input and criteria from fishermen, industry, and other concerned parties.

Variability was estimated by constructing 95% variability bands around the values of interest using a randomization bootstrap procedure (see Efron & Gong, 1983). In this procedure, individual longline sets in the observer database were randomly resampled with replacement to construct a new database of the same original size. The GAM's were evaluated with this new dataset, and a new fleet-wide set of predicted turtle takes generated. This process was repeated 100 times and the distributions of the final values were used to address variability. The nonparametric or empirical variability bands were constructed by sorting the values from low to high and using the $2.5\%^{th}$ and the $97.5\%^{th}$ values to identify the medial 95% of the distribution. This approach was used to explore variability of optimal management scenarios for leatherback turtle take.

The predicted effect of the Emergency[4] closure was examined using the same fleet-wide turtle take database. The effects on fish catch and fish catch revenue were also examined, under both static and dynamic reallocation modes. These results were compared to the results from the optimizations.

Results & Discussion

The results of this report will focus on optimal time/area closures with emphasis on leatherback turtles. The exploratory graphical analyses (Figures 6-7) indicated that April and May accounted for the highest monthly leatherback takes, with a relatively widespread spatial distribution. This is in contrast to olive ridleys and especially loggerheads, which have relatively well defined latitudinal ranges. Olive ridleys tend to be taken more in the southerly regions of the fishing grounds, while loggerheads are primarily taken in the northerly regions.

Results from all scenarios are plotted graphically in Figure 8, using leatherback turtle take on the x-axis, and fishing effort disruption on the y-axis. This method of presenting the data

[4] David Alan Ezra, Chief U.S. District Court Judge, District of Hawaii.

is very similar to the "efficient frontier", a financial concept used in Modern Portfolio Theory (Markowitz, 1991). The graph displays an envelope of points representing the hyperspace of possible outcomes. The efficient frontier is the point at which one quantity of interest is optimized at some preset value of another quantity of interest (in finance the plot would be of risk versus return). In Figure 8, fishing effort disruption is the quantity to be optimized, and the efficient frontier is the trace of points at the highest elevation for a given value of leatherback turtle take. Further examination of the management scenarios focused upon values along several of these efficient frontiers.

The 5 best scenarios per take reduction bin for each of the 10 different types of management regimes are broken down in Figure 9 for leatherback turtle take and fishing effort disruption. This shows the performance and capability of various types of time and/or area closures. Note that, to achieve optimal solutions at high levels of turtle take reduction, separated mode combinations of seasonal and spatial closures are required. At lower levels of turtle take reduction, simpler merged mode combinations or spatial closures only may be adequate. Generally, combinations of seasonal and spatial closures provide the best solutions when targeting a particular level of turtle take reduction, at least when best is defined as having the least impact of fishing effort disruption.

The efficient frontier margin for leatherbacks, estimated with a high degree polynomial fit to 1% bin points, is shown in Figure 10. Variability along the leatherback turtle efficient frontier is shown in Figure 11, where each best scenario per 1% take bin is bootstrapped 100 times, with the medial 95% of values bounded by a variability band. This approach will allow construction of nonparametric or empirical variability bands around not only the efficient frontier, but also to any specific output for a given management scenario. Revenue values from the efficient frontier for fishing effort disruption are shown in Figure 12. Note that this plot does not show an efficient frontier since revenue was not the value under optimization (earlier attempts at this approach were unsuccessful due to unstable boundary solutions, i.e., proposing nearly 100% fishing effort disruption to inflate low sample size revenue values). This figure is presented to indicate how revenue is predicted to change for targeted levels of leatherback turtle take reduction at optimal values of fishing effort disruption. This is only revenue changes from changes in fish catch quantity and composition, and does not include potential additional costs associated with compliance to a management scenario (e.g., transit costs, loss of fishing days). Figures 13-15 show how the takes of other turtle species change along the efficient frontier for leatherback turtle take and fishing effort disruption. These are also not true efficient frontiers since the take rates for loggerhead, olive ridley, and green were not optimized. These show predicted changes in take for other turtle species along the leatherback efficient frontier with respect to optimized fishing effort disruption. Figure 13 is particularly interesting because it highlights some closures that reduce leatherback takes and also substantially reduce loggerhead takes. Specifically for the closures that reduce leatherback takes by 20-30% and by 50-60% there are some closures that also reduce loggerhead takes by 40-55% (Figure 13). Additionally, the true efficient frontiers of other turtle takes are plotted on Figures 13-15, these are easily distinguished from the above by their relative smoothness and magnitude of turtle take reductions. These scenarios, however, tend to disrupt the fishery to a greater extent (see Appendix 3).

Appendix 1 shows the best 10 results for 19 bins of leatherback turtle take reduction. The optimization criterion in these scenarios was to minimize disruption of fishing effort. Other criteria, including multi-criteria, were attempted, but until they are better refined, the simple disruption of fishing effort appears to provide the best optimization index. Some problems with the multi-criteria optimizations included high fishing effort disruption balanced by an assumed complete spatial reallocation to a small area; this optimization needs to be constrained to minimize disruption and loss separately, summing these two changes resulted in lost information content. The aggregated turtle take reduction optimization suffered from excessive weighting towards loggerhead solutions, since these were the most easily reduced; again, summing the take changes resulted in lost information content, a penalty function for asymmetry may be the solution. For the fishing effort disruption criterion, even this small subset of the simulation output comprises 190 management scenarios, each one worthy of consideration for a particular level of targeted leatherback turtle take. These 190 scenarios represent the most efficient management actions to consider with regard to leatherback turtle protection. It is important to present many scenarios that, while differing in only a degree of latitude or a degree of longitude or a single month, fall upon a similar location on the efficient frontier because subtle differences in management tactic may be very important from the perspective of a longline fisherman. For example, the transit time/expense for a single degree of latitude/longitude is non-trivial. If travel time increases by only a single day per trip, the net loss to a fisherman was estimated to be $4,000 per year in 1993 (Hamilton et al., 1996). The loss of a single day of fishing (i.e., approximately one longline set) per trip was estimated to incur an annual cost of $16,000.

Several scenarios from Appendix 1 will be discussed, focusing on several arbitrary leatherback take reduction bins. In sub-table #11 (50%-55%), all 10 scenarios are separated mode seasonal spatial combinations, which close the months of April and May. All 10 have similar effects on fishing effort disruption as well as fishing effort loss and fish catch revenue after reallocation. Of interest is that only the latitudinal closures allow a reduction in green turtles, and they also tend to reduce loggerheads and leatherbacks the most. In sub-table #12 (55%-60%), there are several entries that produce double-digit reductions in all four turtle species while minimizing fishing effort disruption. Considering the highly different spatial and temporal patterns of take among the turtle species, it is surprising that a single closure type can be effective for all species, while still qualifying as "best" with respect to fishing effort disruption. Several other types of separated latitudinal closures (see Appendix 1 sub-tables #5 and #6) prove to be highly effective at reducing leatherback and loggerhead turtle take simultaneously along the efficient frontier. These closures take advantage of the predictable latitudinal patterns of loggerhead turtle take.

The predicted effects of the Emergency closure are summarized in Table 1. Firstly, turtle take effects are presented with FE, LO, LE, RI, and GR referencing changes in fishing effort, loggerhead, leatherback, olive ridley, and green sea turtle takes, respectively. The additional notations 1 and 2 refer to static and dynamic mode, respectively, i.e., without and with reallocation. Since this is a strictly spatial closure, the simulation reallocated 100% of the disrupted fishing effort. The second table presents the fish catch effects for some of the major species, where SW, BI, AL, YE, and BL reference changes in swordfish, bigeye tuna, albacore tuna, yellowfin tuna, and bluefin tuna catch. The RE references the total fish catch revenue change using the entire catch, including many minor species not listed in the table. The effects are broken down by year (YY) and the multi-year average (AVG) is presented at the bottom of each table. This scenario is predicted to be somewhat detrimental to olive ridley and green turtles, while producing a relatively small protective effect for leatherback turtles, the species for which it was originally intended. It disrupts approximately 13% of the fishing effort with a small decrease in fish catch revenue. The Emergency closure scenario is quite distant to the efficient frontier for all species, when compared to other management scenarios found in Appendix 1 at these levels of turtle take reduction. The symbol "E" is plotted on Figures 9-10 to indicate the predicted location of the Emergency closure in comparison to the other scenarios. Appendix 2 lists 25 management scenarios that disrupt longline fishery effort to approximately the same extent as the Emergency closure, but with more effective leatherback turtle take reduction.

As this report was being finalized, another appendix was prepared which includes optimizations for other turtle species within each bin of leatherback turtle take reduction. Appendix 3 lists 3 management scenarios each for optimal loggerhead, olive ridley, and green turtle take reductions, as well as a multi-criteria index representing aggregate turtle take reduction. This index was created by summing all 4 turtle species' percent change with an asymmetry penalty defined as twice the difference between the maximum and minimum percent change. The asymmetry penalty was used to avoid solutions that were highly effective at reducing only a single turtle species. Thusly, solutions were discovered which resulted in an approximately uniform reduction in all 4 turtle species at each level of leatherback turtle take reduction. Appendix 3 shows that for any level of leatherback take reduction it is possible to find closures that also greatly reduce takes of other turtles but with a very major adverse impact to the fishery

Acknowledgements

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Table 1. Predicted consequences of the Emergency closure. See text for details.

YY	FE	LO1	LO2	LE1	LE2	RI1	RI2	GR1	GR2
94	-19%	-48%	-13%	-37%	-14%	-6%	6%	-10%	46%
95	-9%	-42%	-21%	-19%	-3%	-5%	1%	-8%	1%
96	-14%	-60%	-33%	-21%	-1%	-3%	6%	-13%	0%
97	-13%	-66%	-27%	-19%	-1%	-3%	2%	-11%	-0%
98	-11%	-42%	-17%	-14%	-3%	-5%	2%	-10%	-1%
AVG	-13%	-51%	-22%	-22%	-4%	-4%	3%	-11%	9%

YY	SW1	SW2	BI1	BI2	AL1	AL2	YE1	YE2	BL1	BL2	RE1	RE2
90	-4%	-0%	-1%	1%	-0%	0%	-1%	1%	0%	0%	-1%	1%
91	-49%	-18%	-16%	3%	-38%	-25%	-17%	1%	0%	0%	-33%	-6%
92	-52%	-6%	-14%	11%	-56%	-34%	-29%	-2%	0%	0%	-40%	2%
93	-42%	-9%	-15%	7%	-25%	2%	-14%	5%	0%	0%	-29%	-1%
94	-46%	-6%	-5%	2%	-21%	-2%	-6%	4%	-32%	16%	-23%	-1%
95	-25%	-5%	-4%	2%	-6%	-1%	-5%	2%	-27%	-14%	-11%	0%
96	-45%	-22%	-4%	10%	-8%	-1%	-8%	9%	-41%	-26%	-17%	1%
97	-42%	-9%	-4%	2%	-4%	0%	-6%	1%	-21%	-10%	-15%	-1%
98	-29%	-5%	-6%	1%	-5%	1%	-6%	1%	-21%	1%	-12%	-0%
99	-31%	-5%	-7%	1%	-6%	1%	-11%	-4%	-27%	-17%	-15%	-2%
AVG	-37%	-9%	-8%	4%	-17%	-6%	-10%	2%	-17%	-5%	-20%	-1%

Figure captions

Figure 1. Map of Hawaii based longline fishing effort (1994-1998) and location of Emergency closure.

Figure 2. Smoother functions for loggerhead turtle GAM.

Figure 3. Smoother functions for leatherback turtle GAM.

Figure 4. Smoother functions for olive ridley turtle GAM.

Figure 5. Smoother functions for green turtle GAM.

Figure 6. Turtle take in the Hawaii based longline fishery by month, 1994-1998.

Figure 7. Turtle take in the Hawaii based longline fishery by latitude and longitude, 1994-1998.

Figure 8. All management scenarios evaluated in the leatherback turtle take reduction simulations, showing changes in turtle take and fishing effort disruption.

Figure 9. Best management scenarios evaluated in the leatherback turtle take reduction simulations, broken down by type of management regime, showing changes in turtle take and fishing effort disruption. The "E" denotes the predicted location of the Emergency closure.

Figure 10. Polynomial representation of the efficient frontier for leatherback turtles. Points represent best values per 1% bin of turtle take reduction. The "E" denotes the predicted location of the Emergency closure.

Figure 11. 95% variability envelope of the efficient frontier for leatherback turtle take reduction and fishing effort disruption from bootstrapping.

Figure 12. Polynomial representation of the revenue frontier for leatherback turtles. This represents the changes in fish catch revenue associated with scenarios optimized with respect to fishing effort disruption.

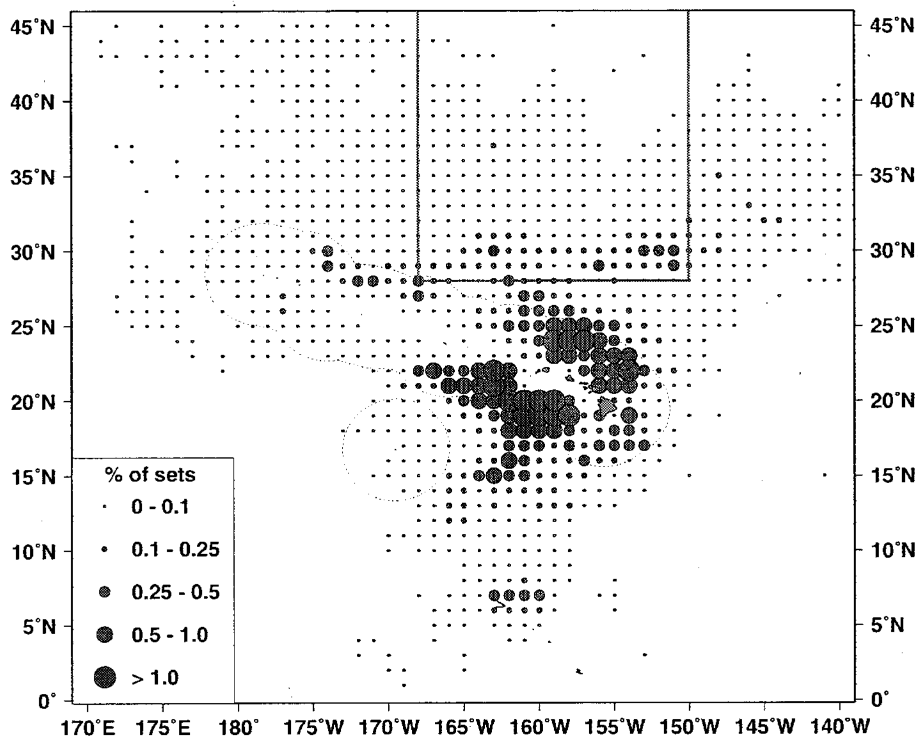
Figure 13. Polynomial representations of the loggerhead turtle take frontier for leatherback turtles. This upper data represents the changes in loggerhead turtle take associated with scenarios optimized with respect to fishing effort disruption. The lower data are optimized only for loggerhead turtle take reduction.

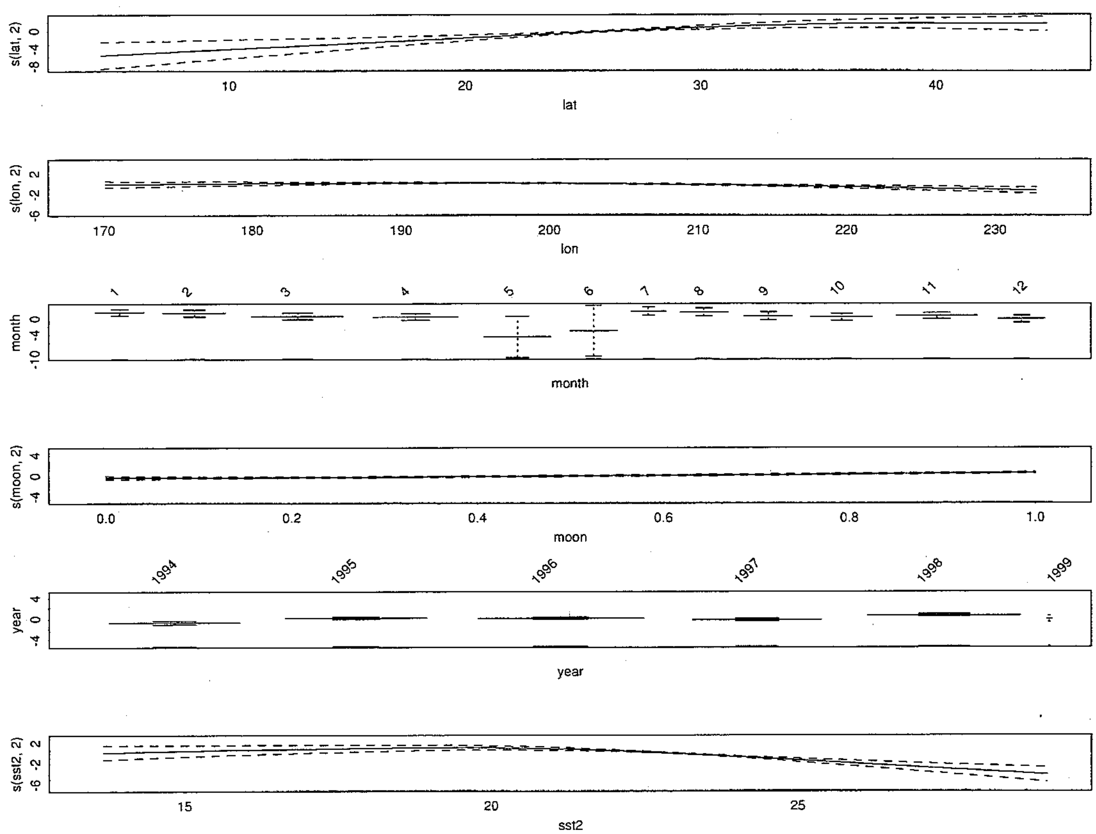
Figure 14. Polynomial representations of the olive ridley turtle take frontier for leatherback turtles. The upper data represents the changes in olive ridley turtle take associated with scenarios optimized with respect to fishing effort disruption. The lower data are optimized only for olive ridley turtle take reduction.

Figure 15. Polynomial representations of the green turtle take frontier for leatherback turtles. The upper data represents the changes in green turtle take associated with scenarios optimized

with respect to fishing effort disruption. The lower data are optimized only for green turtle take reduction.

Distribution of Hawaii based longline fishing effort (1994-1998)

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1.0
moon
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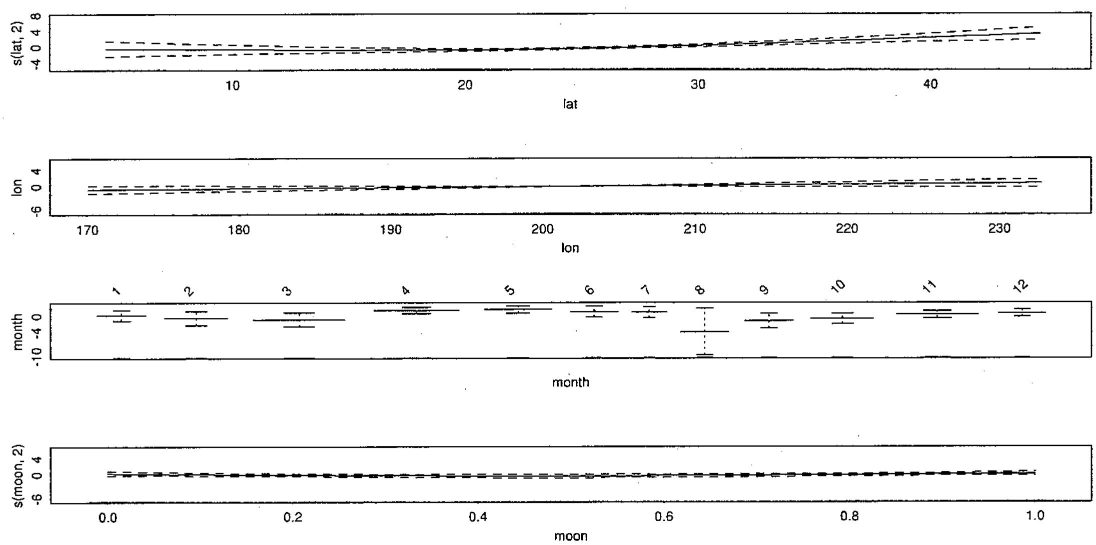
sst2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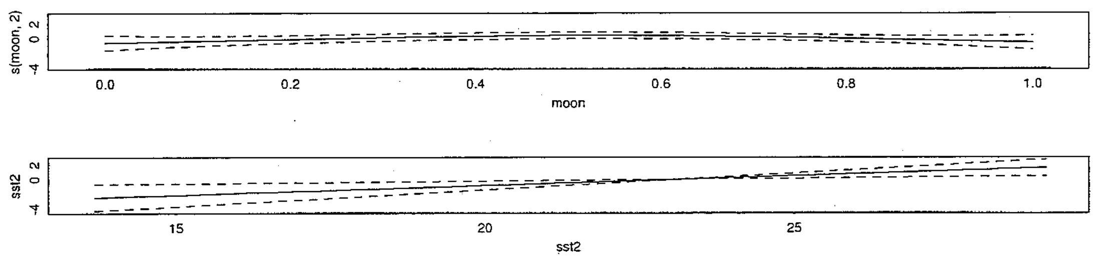
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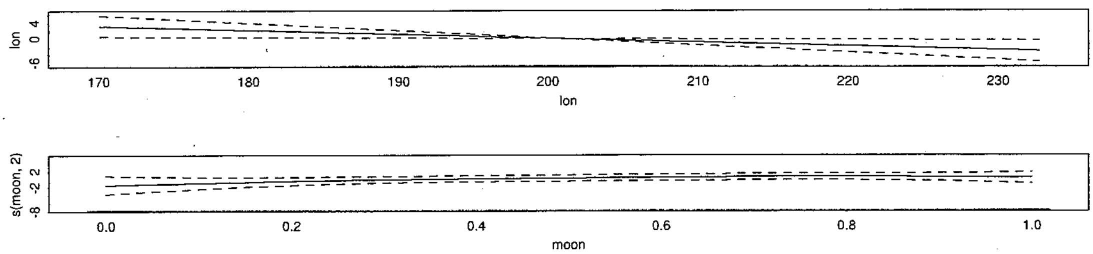
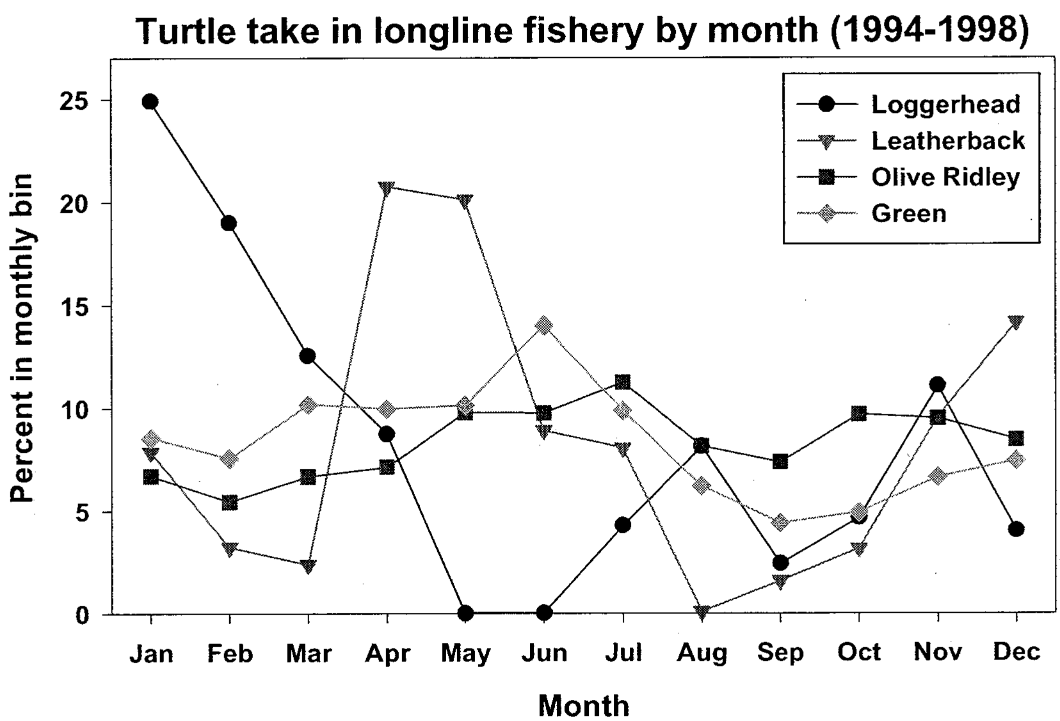
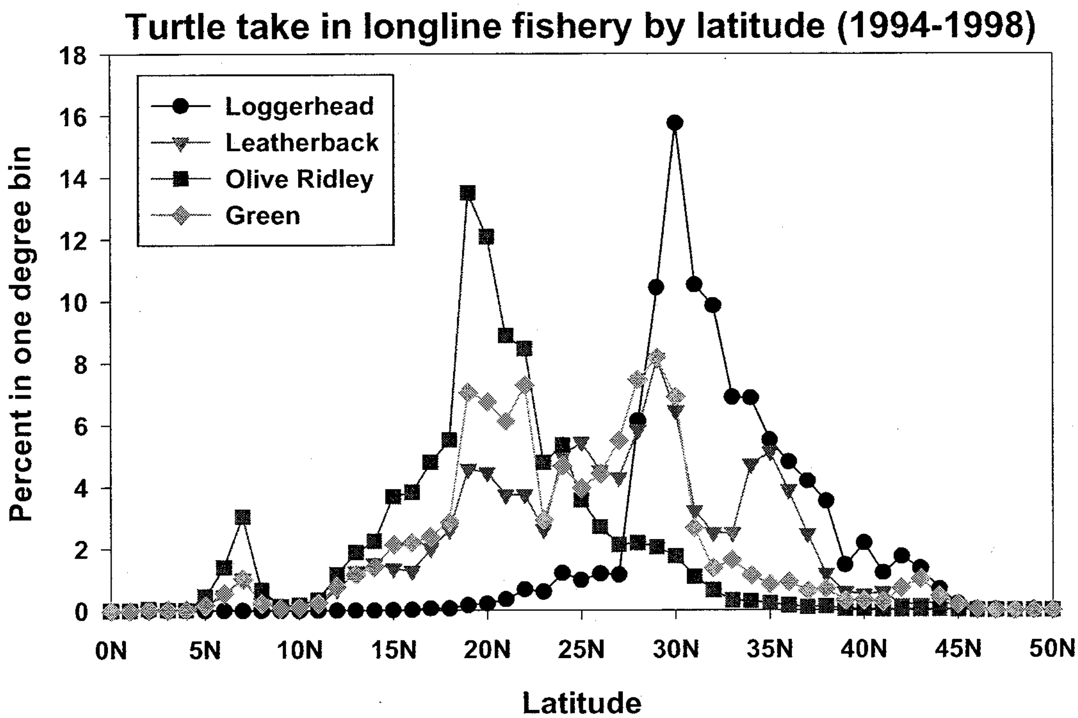


Figure 5 of 15


Turtle take in longline fishery by month (1994-1998)
Loggerhead
Leatherback
Olive Ridley
Green
Percent in monthly bin
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Turtle take in longline fishery by latitude (1994-1998)
Loggerhead
Leatherback
Olive Ridley
Green
Percent in one degree bin
0
2
4
6
8
10
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14
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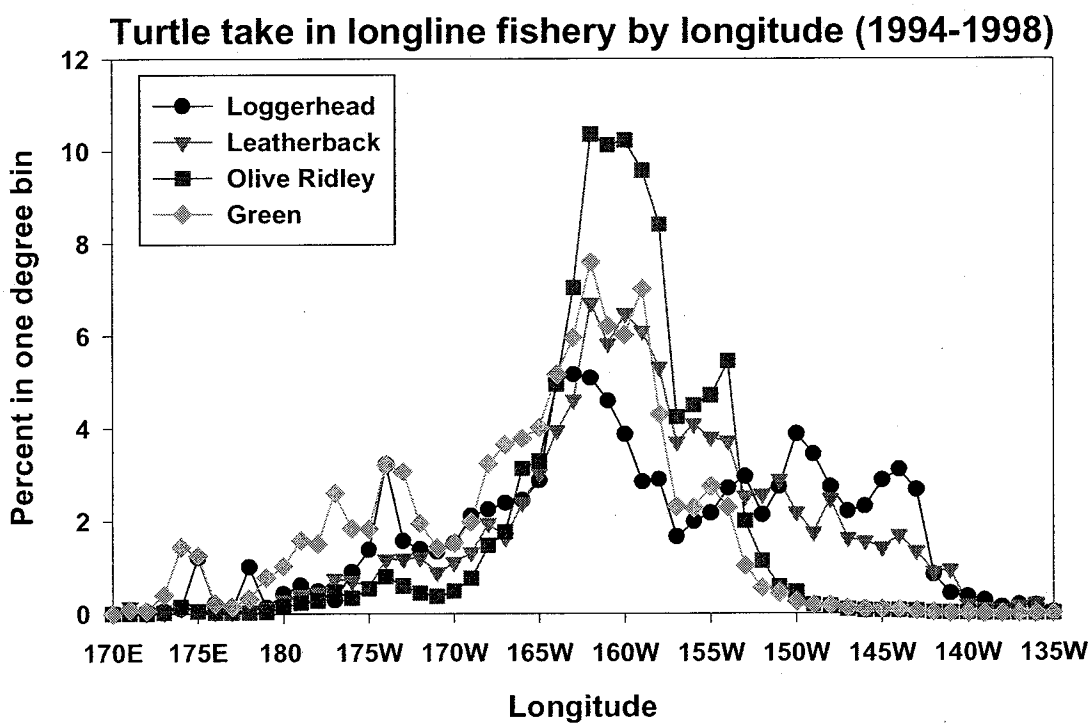
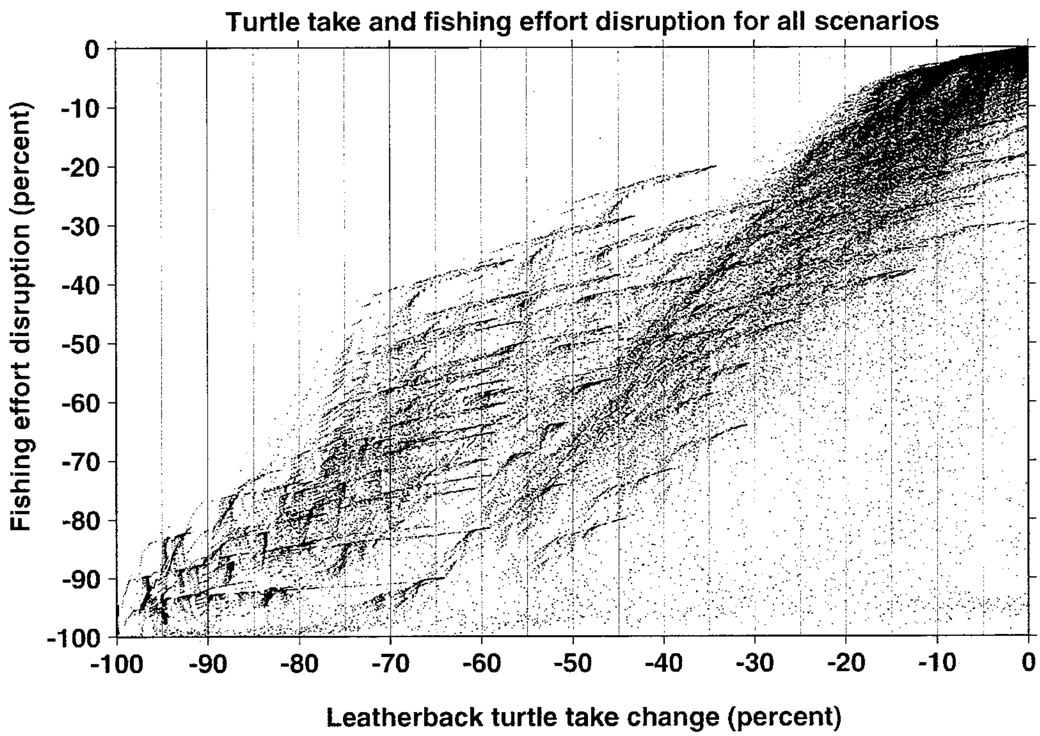
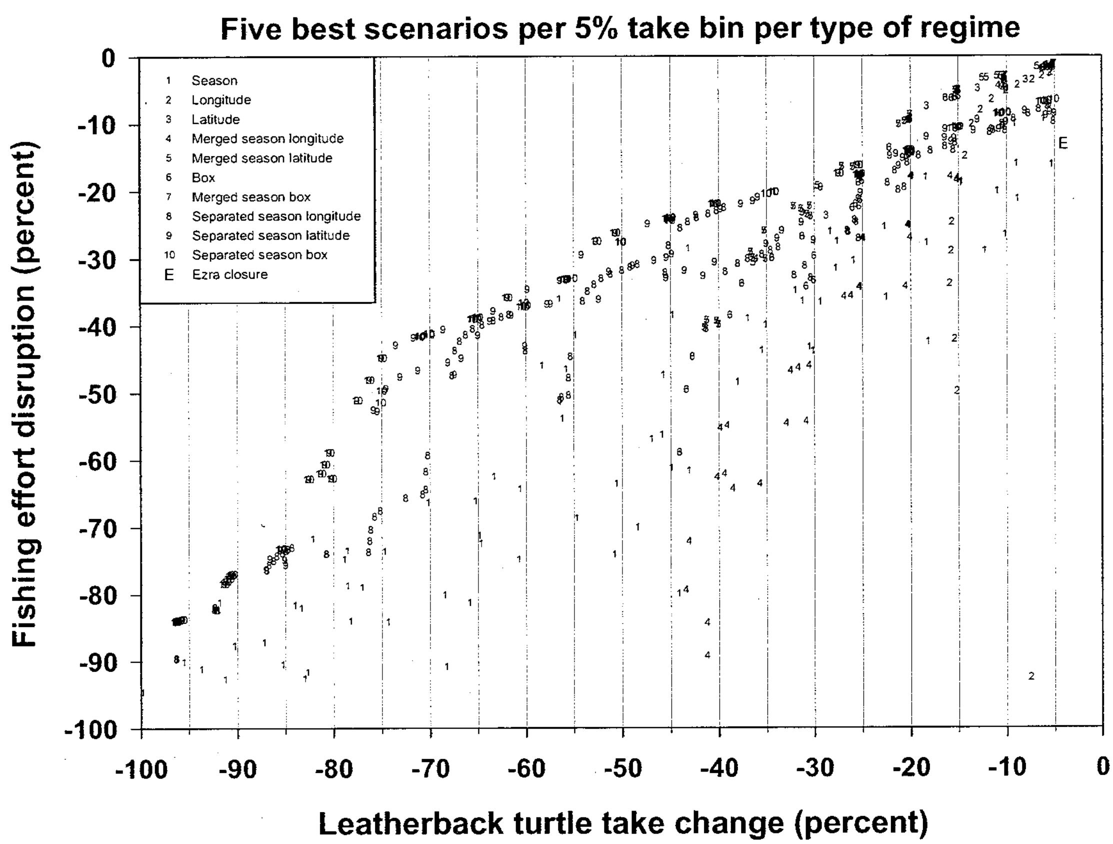
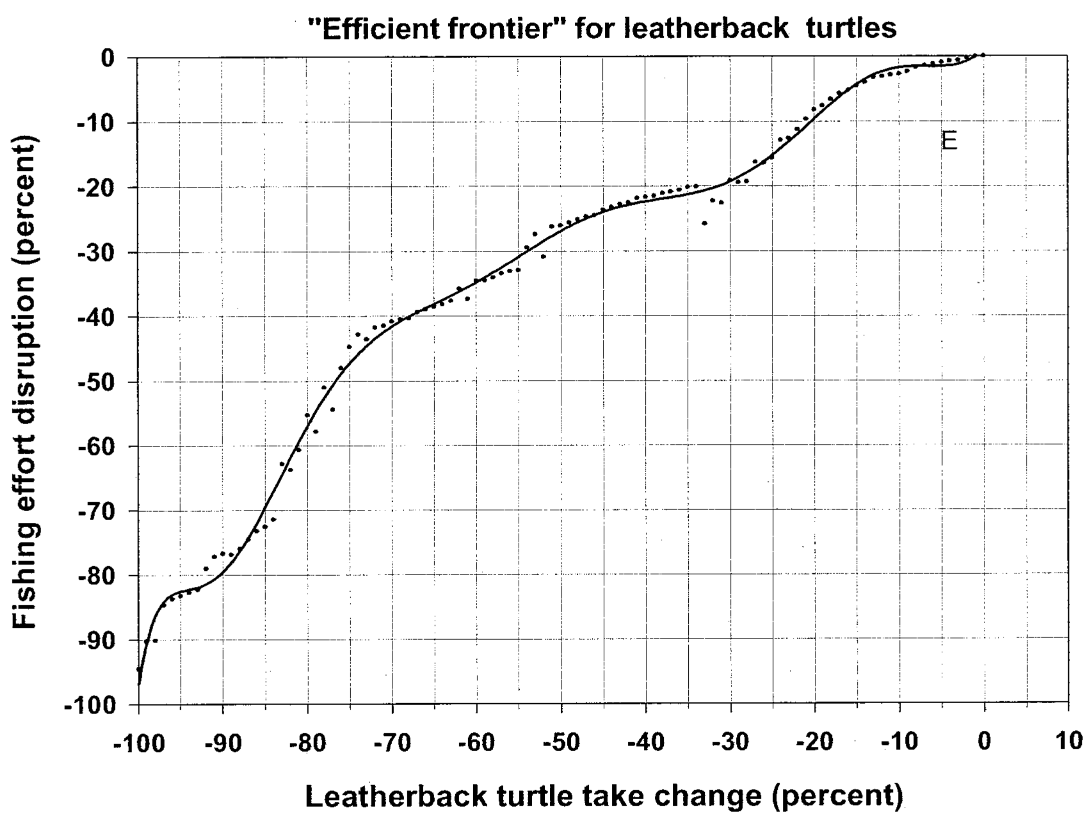
40N
45N
50N
Latitude

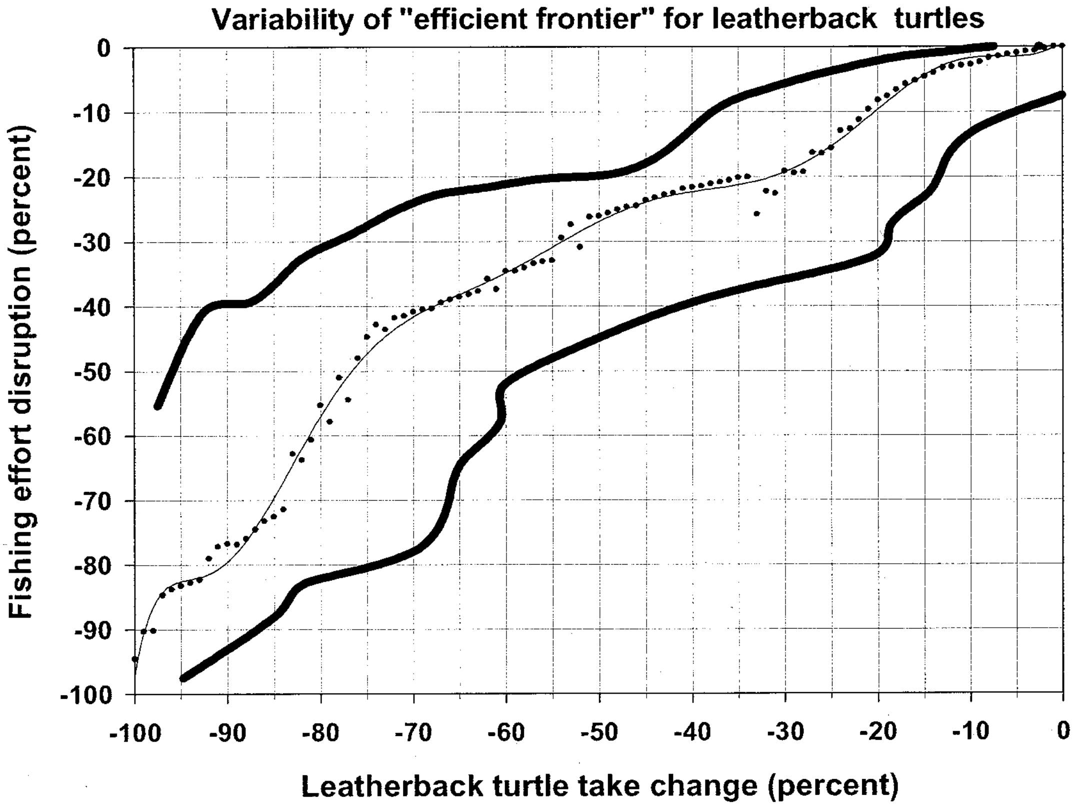

Turtle take in longline fishery by longitude (1994-1998)
Loggerhead
Leatherback
Olive Ridley
Green
Percent in one degree bin
0
2
4
6
8
10
12
170E
175E
180
175W
170W
165W
160W
155W
150W
145W
140W
135W
Longitude



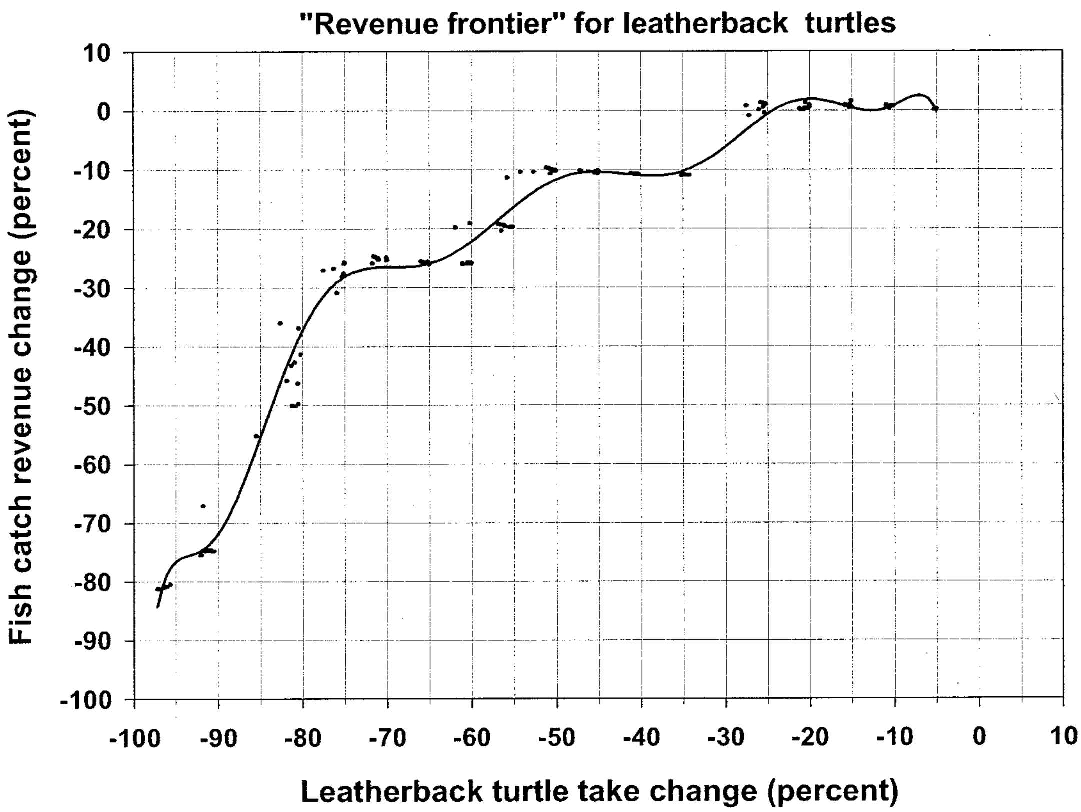
Turtle take and fishing effort disruption for all scenarios
Fishing effort disruption (percent)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
Leatherback turtle take change (percent)

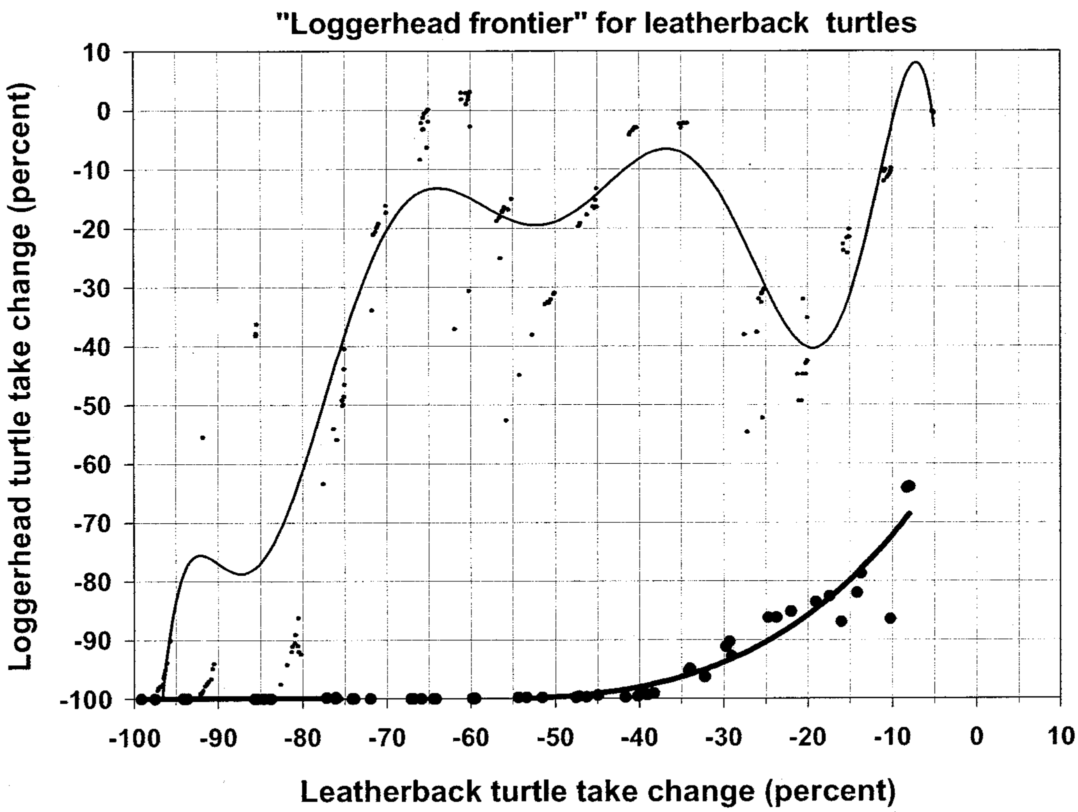

Five best scenarios per 5% take bin per type of regime
Fishing effort disruption (percent)
Leatherback turtle take change (percent)
1 Season
2 Longitude
3 Latitude
4 Merged season longitude
5 Merged season latitude
6 Box
7 Merged season box
8 Separated season longitude
9 Separated season latitude
10 Separated season box
E Ezra closure
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0

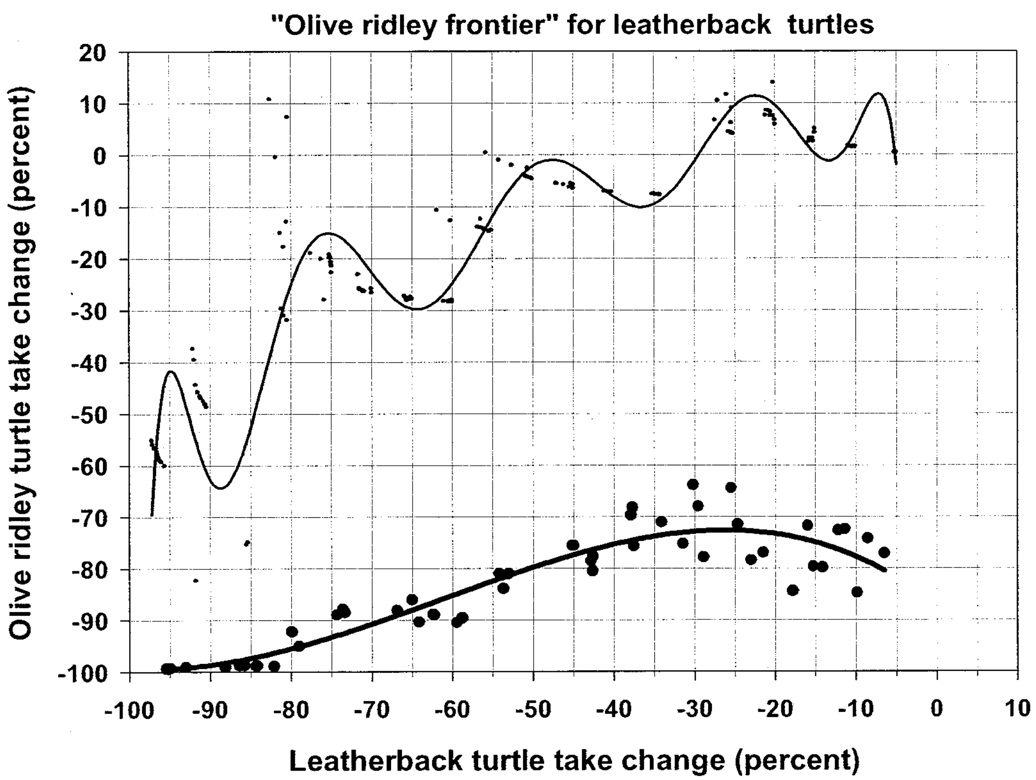

"Efficient frontier" for leatherback turtles
Fishing effort disruption (percent)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
E
Leatherback turtle take change (percent)

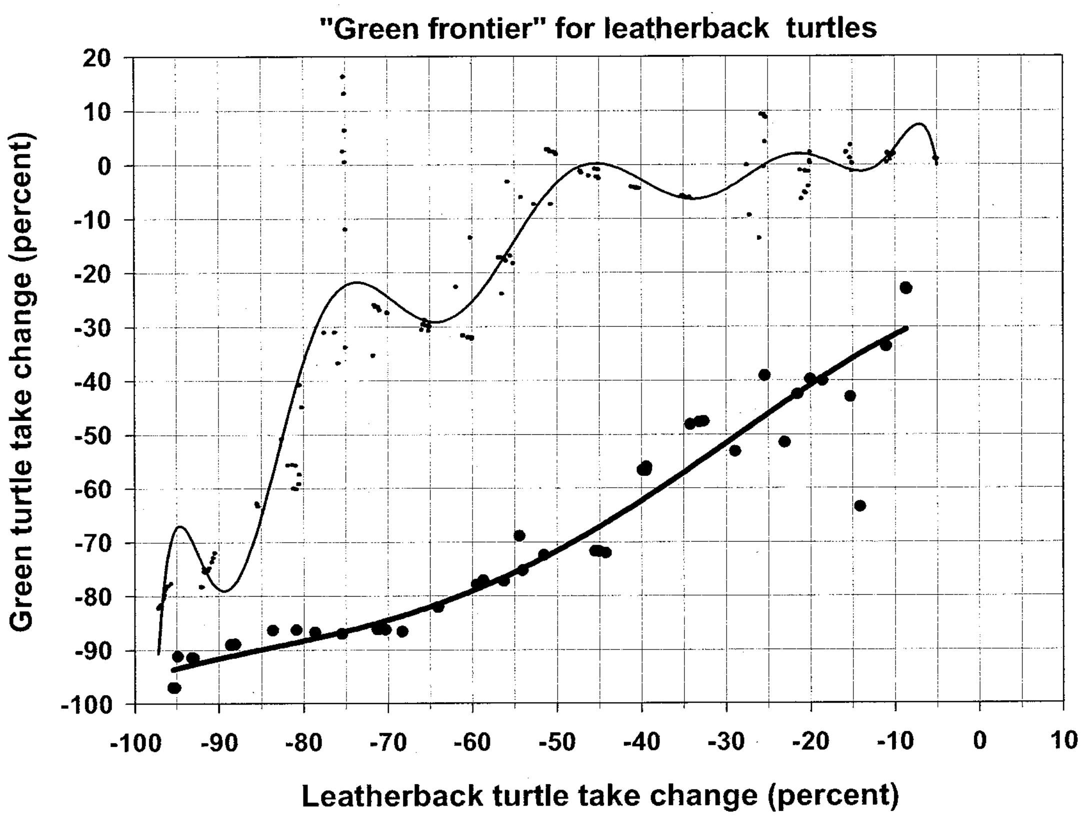


Variability of "efficient frontier" for leatherback turtles
Fishing effort disruption (percent)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
Leatherback turtle take change (percent)


"Revenue frontier" for leatherback turtles
Fish catch revenue change (percent)
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
Leatherback turtle take change (percent)


"Loggerhead frontier" for leatherback turtles
Loggerhead turtle take change (percent)
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
Leatherback turtle take change (percent)


"Olive ridley frontier" for leatherback turtles
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
Olive ridley turtle take change (percent)
Leatherback turtle take change (percent)


"Green frontier" for leatherback turtles
Green turtle take change (percent)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
Leatherback turtle take change (percent)

Appendix 1. Listings of ten best scenarios optimized for minimal fishing effort disruption per bin of leatherback turtle take reduction. Notations: #Mn = the number of months for a seasonal closure, Ms = the starting month of a seasonal closure, Lon/Lat = position of spatial closure, FED = fishing effort disruption, FEL = fishing effort lost, Rev = fish catch revenue change, Log = loggerhead turtle take change, Lea = leatherback turtle take change, Rid = olive ridley turtle take change, Gre = green turtle take change, Swo = swordfish catch change, Big = bigeye tuna catch change, Alb = albacore catch change, Yel = yellowfin tuna catch change, Blu = bluefin tuna catch change, Mah = mahi-mahi catch change, Opa = opah catch change. Other fish species included in the revenue calculations are not presented to save space. Results are not presented in any ordered sequence.

Leatherback turtle take reduction bin # 20 (-95% to %-100%)
10 best of 2327 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	9	11	28	-85.96%	-73.03%	-81.28%	-98.52%	-97.22%	-55.09%	-82.28%	-97.08%	-78.36%	-77.93%	-76.98%	-54.02%	-68.94%	-60.67%
Separated season latitude	9	11	29	-85.44%	-73.03%	-81.11%	-98.20%	-97.15%	-55.93%	-82.00%	-96.52%	-77.67%	-78.27%	-76.87%	-54.00%	-65.06%	-61.27%
Separated season latitude	9	11	30	-85.13%	-73.03%	-81.25%	-97.92%	-96.95%	-56.59%	-81.69%	-96.17%	-77.29%	-78.46%	-76.88%	-53.91%	-61.64%	-61.70%
Separated season latitude	9	11	31	-84.68%	-73.03%	-81.05%	-97.53%	-96.58%	-57.26%	-80.45%	-95.45%	-76.57%	-78.76%	-77.25%	-52.95%	-59.83%	-62.18%
Separated season latitude	9	11	32	-84.27%	-73.03%	-81.03%	-96.41%	-96.47%	-57.87%	-79.77%	-94.80%	-75.96%	-78.96%	-77.44%	-53.11%	-55.99%	-62.48%
Separated season latitude	9	11	33	-84.09%	-73.03%	-80.89%	-95.94%	-96.40%	-58.37%	-78.97%	-94.56%	-75.68%	-79.09%	-77.65%	-53.24%	-55.00%	-62.63%
Separated season latitude	9	11	34	-83.99%	-73.03%	-80.92%	-95.67%	-96.36%	-58.65%	-78.75%	-94.11%	-75.51%	-78.95%	-77.70%	-51.59%	-55.10%	-62.72%
Separated season latitude	9	11	35	-83.91%	-73.03%	-80.96%	-95.12%	-96.30%	-58.89%	-78.59%	-93.41%	-75.72%	-78.84%	-77.91%	-51.55%	-55.18%	-62.89%
Separated season latitude	9	11	36	-83.86%	-73.03%	-80.86%	-93.91%	-96.08%	-59.22%	-78.15%	-92.73%	-75.97%	-78.59%	-78.17%	-51.57%	-55.55%	-63.05%
Separated season latitude	9	11	37	-83.74%	-73.03%	-80.50%	-90.17%	-95.69%	-59.98%	-77.72%	-91.30%	-76.27%	-77.16%	-78.36%	-49.84%	-55.04%	-63.15%

Leatherback turtle take reduction bin # 19 (-90% to -95%)
10 best of 3249 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	8	12	25	-80.80%	-64.30%	-75.53%	-99.20%	-92.13%	-37.37%	-78.29%	-96.42%	-65.24%	-72.73%	-69.12%	-53.55%	-64.20%	-54.41%
Separated season latitude	8	12	26	-80.21%	-64.30%	-75.44%	-99.06%	-91.97%	-39.51%	-78.34%	-96.09%	-64.78%	-72.34%	-69.47%	-53.58%	-61.47%	-53.15%
Separated season latitude	8	12	27	-79.63%	-64.30%	-74.72%	-98.67%	-91.80%	-44.35%	-75.46%	-95.12%	-63.76%	-71.91%	-69.26%	-49.87%	-59.21%	-52.73%
Separated season latitude	8	12	28	-79.02%	-64.30%	-74.82%	-97.86%	-91.57%	-45.73%	-75.65%	-94.35%	-62.94%	-71.96%	-69.56%	-48.65%	-55.45%	-53.36%
Separated season latitude	8	12	29	-78.43%	-64.30%	-74.55%	-97.45%	-91.32%	-46.55%	-75.30%	-93.69%	-61.43%	-72.27%	-69.37%	-48.96%	-52.27%	-53.96%
Separated season latitude	8	12	30	-78.09%	-64.30%	-74.75%	-97.13%	-91.15%	-46.94%	-74.81%	-93.22%	-60.61%	-72.34%	-69.24%	-49.38%	-49.01%	-54.26%
Separated season latitude	8	12	31	-77.62%	-64.30%	-74.68%	-96.65%	-90.84%	-47.48%	-73.70%	-92.45%	-59.78%	-72.64%	-69.50%	-48.74%	-47.73%	-54.72%
Separated season latitude	8	12	32	-77.18%	-64.30%	-74.85%	-94.92%	-90.68%	-48.09%	-72.88%	-91.74%	-59.27%	-72.67%	-69.88%	-48.61%	-45.27%	-55.01%
Separated season latitude	8	12	33	-76.98%	-64.30%	-74.84%	-94.10%	-90.50%	-48.62%	-72.00%	-90.96%	-59.80%	-69.00%	-70.31%	-48.78%	-44.87%	-55.16%
Separated season box	10	4	162038	-81.20%	-73.08%	-67.12%	-55.50%	-91.80%	-82.24%	-74.86%	-67.93%	-73.58%	-82.16%	-71.62%	-38.80%	-75.87%	-81.26%

Leatherback turtle take reduction bin # 18 (-85% to -90%)
10 best of 2369 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	9	4	159032	-73.27%	-63.69%	-55.27%	-38.24%	-85.53%	-75.26%	-62.80%	-62.07%	-60.20%	-75.97%	-59.22%	-26.26%	-70.30%	-75.14%
Separated season box	9	4	158032	-73.27%	-63.69%	-55.26%	-38.14%	-85.52%	-75.26%	-62.80%	-62.00%	-60.21%	-75.88%	-59.25%	-26.29%	-70.30%	-75.14%
Separated season box	9	4	157032	-73.27%	-63.69%	-55.26%	-38.14%	-85.52%	-75.26%	-62.80%	-61.94%	-60.24%	-75.59%	-59.32%	-26.51%	-70.31%	-75.15%
Separated season box	9	4	156032	-73.27%	-63.69%	-55.27%	-38.14%	-85.52%	-75.26%	-62.80%	-61.92%	-60.24%	-75.58%	-59.31%	-26.51%	-70.30%	-75.15%
Separated season box	9	4	155032	-73.27%	-63.69%	-55.27%	-38.14%	-85.52%	-75.26%	-62.80%	-61.92%	-60.24%	-75.58%	-59.30%	-26.51%	-70.31%	-75.14%
Separated season box	9	4	154032	-73.26%	-63.69%	-55.27%	-38.14%	-85.52%	-75.26%	-62.80%	-61.92%	-60.25%	-75.58%	-59.31%	-26.51%	-70.31%	-75.15%
Separated season box	9	4	153032	-73.26%	-63.69%	-55.27%	-38.14%	-85.52%	-75.26%	-62.81%	-61.81%	-60.29%	-75.59%	-59.29%	-26.56%	-70.31%	-75.17%
Separated season box	9	4	152032	-73.25%	-63.69%	-55.25%	-37.97%	-85.52%	-75.27%	-62.85%	-61.79%	-60.32%	-75.63%	-59.33%	-26.96%	-70.38%	-75.20%
Separated season box	9	4	151032	-73.23%	-63.69%	-55.23%	-37.88%	-85.52%	-75.28%	-62.89%	-61.73%	-60.32%	-75.64%	-59.28%	-26.52%	-70.41%	-75.21%
Separated season box	9	4	150032	-73.13%	-63.69%	-55.21%	-36.31%	-85.39%	-74.87%	-63.31%	-61.67%	-60.34%	-75.68%	-59.33%	-25.89%	-70.46%	-75.22%

Leatherback turtle take reduction bin # 17 (-80% to -85%)
10 best of 4485 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	4	4	23	-62.82%	-26.95%	-36.06%	-97.58%	-82.59%	10.73%	-50.87%	-92.13%	-14.91%	-56.66%	-26.77%	-37.20%	-28.69%	-17.85%
Separated season latitude	4	4	24	-58.84%	-26.95%	-36.91%	-92.03%	-80.44%	7.33%	-40.79%	-87.62%	-12.45%	-51.53%	-23.56%	-37.38%	-14.95%	-17.33%
Separated season latitude	5	3	24	-63.77%	-36.70%	-45.85%	-94.24%	-81.87%	-0.41%	-55.67%	-88.80%	-20.24%	-54.93%	-30.73%	-37.15%	-24.00%	-24.95%
Separated season latitude	5	3	25	-61.95%	-36.70%	-43.28%	-92.02%	-81.32%	-15.04%	-55.60%	-84.05%	-18.23%	-51.99%	-30.44%	-37.35%	-23.87%	-24.44%
Separated season latitude	5	3	26	-60.63%	-36.70%	-42.79%	-90.54%	-80.91%	-17.71%	-55.73%	-81.49%	-17.87%	-49.85%	-28.18%	-36.80%	-24.89%	-23.88%
Separated season latitude	5	4	24	-62.67%	-33.11%	-41.39%	-92.44%	-80.19%	34.39%	-44.92%	-88.00%	-15.05%	-57.40%	-35.99%	-39.87%	-17.04%	-22.86%
Separated season latitude	6	2	27	-65.46%	-45.61%	-50.11%	-91.12%	-81.21%	-29.62%	-59.98%	-82.05%	-27.05%	-53.98%	-36.77%	-36.77%	-37.81%	-30.15%
Separated season latitude	6	2	28	-64.69%	-45.61%	-50.18%	-89.11%	-80.84%	-30.95%	-60.13%	-80.89%	-26.37%	-53.38%	-36.64%	-35.70%	-34.36%	-30.68%
Separated season latitude	6	2	29	-63.99%	-45.61%	-49.81%	-86.28%	-80.51%	-31.86%	-57.42%	-79.97%	-24.83%	-53.49%	-36.88%	-36.19%	-31.41%	-31.29%
Separated season latitude	6	3	26	-64.69%	-42.77%	-46.31%	-91.09%	-80.56%	-12.89%	-59.18%	-82.00%	-20.51%	-56.50%	-40.12%	-39.12%	-27.94%	-30.37%

Leatherback turtle take reduction bin # 16 (-75% to -80%)
10 best of 3965 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	4	4	29	-51.04%	-26.95%	-27.11%	-63.45%	-77.56%	-18.90%	-31.03%	-63.49%	-6.80%	-39.76%	-16.95%	-29.53%	-9.04%	-17.55%
Separated season latitude	4	4	30	-48.03%	-26.95%	-26.79%	-54.10%	-76.30%	-20.03%	-31.06%	-55.72%	-7.06%	-38.79%	-16.72%	-25.00%	-4.18%	-18.27%
Separated season latitude	4	4	31	-44.74%	-26.95%	-25.80%	-46.54%	-75.00%	-21.38%	-33.81%	-48.50%	-7.45%	-38.64%	-18.05%	-20.97%	-9.24%	-19.03%
Separated season latitude	5	4	30	-52.49%	-33.11%	-30.94%	-55.95%	-75.88%	-27.93%	-36.77%	-58.13%	-10.47%	-45.07%	-27.16%	-28.86%	-12.72%	-24.74%
Separated season box	4	4	168026	-52.33%	-26.95%	-25.92%	-43.85%	-75.06%	-20.92%	0.50%	-49.14%	-10.18%	-36.27%	-21.02%	-20.71%	-21.75%	-18.95%
Separated season box	4	4	172027	-52.41%	-26.95%	-28.08%	-50.15%	-75.24%	-19.22%	16.33%	-59.51%	-9.86%	-36.96%	-19.14%	-22.51%	-17.21%	-17.94%
Separated season box	4	4	171027	-52.20%	-26.95%	-27.62%	-49.95%	-75.14%	-19.66%	13.15%	-56.89%	-10.19%	-36.16%	-19.58%	-22.16%	-18.26%	-18.21%
Separated season box	4	4	173028	-51.66%	-26.95%	-28.21%	-49.25%	-75.28%	-19.76%	2.44%	-59.82%	-8.68%	-35.36%	-18.82%	-19.01%	-13.38%	-18.15%
Separated season box	4	4	172028	-51.40%	-26.95%	-27.83%	-48.60%	-75.08%	-20.59%	6.38%	-58.03%	-8.90%	-35.22%	-18.92%	-21.06%	-14.80%	-18.21%
Separated season box	4	4	173029	-49.61%	-26.95%	-25.78%	-40.52%	-75.00%	-22.65%	-11.91%	-52.61%	-8.20%	-35.60%	-18.50%	-17.61%	-14.41%	-18.65%

Leatherback turtle take reduction bin # 15 (-70% to -75%)
10 best of 4145 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	4	4	33	-41.75%	-26.95%	-25.90%	-33.93%	-71.73%	-23.06%	-35.41%	-41.80%	-9.08%	-35.00%	-20.35%	-14.05%	-9.75%	-19.87%
Separated season box	4	4	172032	-41.94%	-26.95%	-24.71%	-21.08%	-71.59%	-25.74%	-25.97%	-38.30%	-9.78%	-36.16%	-20.36%	-11.25%	-15.68%	-20.24%
Separated season box	4	4	171032	-41.87%	-26.95%	-24.76%	-21.06%	-71.50%	-25.88%	-26.30%	-37.82%	-9.92%	-35.33%	-20.46%	-11.62%	-15.86%	-20.31%
Separated season box	4	4	170032	-41.79%	-26.95%	-24.87%	-20.62%	-71.30%	-25.99%	-26.30%	-37.61%	-10.11%	-34.77%	-20.50%	-10.77%	-16.08%	-20.40%
Separated season box	4	4	169032	-41.69%	-26.95%	-24.99%	-19.90%	-71.12%	-26.12%	-26.33%	-37.24%	-10.34%	-34.43%	-20.62%	-10.50%	-16.39%	-20.43%
Separated season box	4	4	168032	-41.64%	-26.95%	-25.07%	-19.76%	-71.11%	-26.19%	-26.49%	-37.04%	-10.46%	-34.31%	-20.66%	-9.59%	-16.48%	-20.46%
Separated season box	4	4	167032	-41.58%	-26.95%	-25.19%	-19.60%	-71.04%	-26.24%	-26.73%	-36.94%	-10.60%	-34.10%	-20.79%	-9.96%	-16.65%	-20.47%
Separated season box	4	4	166032	-41.49%	-26.95%	-25.26%	-19.23%	-70.95%	-26.34%	-26.97%	-36.89%	-10.71%	-33.86%	-20.88%	-9.90%	-16.71%	-20.47%
Separated season box	4	4	165032	-41.30%	-26.95%	-25.39%	-17.39%	-70.04%	-26.55%	-27.54%	-36.47%	-11.01%	-33.29%	-21.05%	-10.52%	-16.91%	-20.54%
Separated season box	4	4	173033	-41.08%	-26.95%	-24.90%	-16.17%	-70.08%	-25.78%	-27.43%	-36.11%	-10.48%	-34.94%	-21.51%	-7.26%	-15.59%	-20.52%

Leatherback turtle take reduction bin # 14 (-65% to -70%)
10 best of 4977 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	4	4	152032	-39.29%	-26.95%	-26.04%	-3.29%	-65.68%	-27.98%	-28.77%	-31.83%	-13.00%	-28.69%	-22.86%	-5.82%	-17.78%	-21.04%
Separated season box	4	4	151032	-39.24%	-26.95%	-26.05%	-3.19%	-65.56%	-28.01%	-28.85%	-31.74%	-13.05%	-28.75%	-22.88%	-4.35%	-17.94%	-21.07%
Separated season box	4	4	150032	-39.07%	-26.95%	-26.06%	-1.96%	-65.01%	-27.76%	-29.22%	-31.69%	-13.11%	-28.67%	-22.97%	-3.42%	-18.04%	-21.08%
Separated season box	4	4	161033	-39.12%	-26.95%	-25.70%	-2.20%	-65.84%	-27.56%	-29.64%	-31.56%	-12.72%	-29.36%	-22.84%	-4.52%	-17.99%	-21.02%
Separated season box	4	4	160033	-38.96%	-26.95%	-25.74%	-1.30%	-65.61%	-27.64%	-29.73%	-31.29%	-12.87%	-29.37%	-22.98%	-4.86%	-18.05%	-21.02%
Separated season box	4	4	159033	-38.89%	-26.95%	-25.80%	-0.61%	-65.49%	-27.68%	-29.83%	-31.22%	-12.94%	-29.33%	-23.05%	-5.13%	-18.15%	-21.03%
Separated season box	4	4	158033	-38.80%	-26.95%	-25.85%	-0.27%	-65.18%	-27.75%	-29.94%	-31.19%	-13.00%	-29.25%	-23.11%	-5.02%	-18.22%	-21.04%
Separated season box	4	4	157033	-38.72%	-26.95%	-25.89%	0.12%	-65.00%	-27.79%	-30.01%	-31.16%	-13.03%	-29.11%	-23.15%	-5.07%	-18.22%	-21.04%
Separated season box	4	4	165034	-39.28%	-26.95%	-25.58%	-8.39%	-65.99%	-27.23%	-30.60%	-33.95%	-12.03%	-31.90%	-22.78%	-2.95%	-17.35%	-20.84%
Separated season box	4	4	164034	-39.00%	-26.95%	-25.63%	-6.33%	-65.15%	-27.41%	-30.75%	-33.02%	-12.19%	-31.03%	-22.87%	-1.64%	-17.43%	-20.90%

Leatherback turtle take reduction bin # 13 (-60% to -65%)
10 best of 3720 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	3	4	32	-35.79%	-19.00%	-19.83%	-37.12%	-61.90%	-10.68%	-22.69%	-36.01%	-4.20%	-29.07%	-7.62%	-15.69%	-8.73%	-14.33%
Separated season box	3	4	173031	-36.54%	-19.00%	-19.11%	-30.68%	-60.21%	-12.67%	-13.56%	-34.34%	-5.06%	-26.69%	-8.02%	-13.53%	-11.66%	-14.23%
Separated season box	4	4	146033	-37.51%	-26.95%	-26.10%	1.82%	-61.07%	-28.23%	-31.64%	-30.47%	-13.51%	-28.67%	-23.63%	-1.07%	-18.75%	-21.16%
Separated season box	4	4	148034	-37.36%	-26.95%	-25.93%	2.93%	-61.12%	-28.28%	-31.80%	-30.26%	-13.46%	-28.59%	-23.68%	-0.76%	-18.90%	-21.12%
Separated season box	4	4	147034	-37.13%	-26.95%	-25.97%	2.90%	-60.47%	-28.33%	-32.09%	-30.09%	-13.54%	-28.73%	-23.75%	-0.43%	-19.05%	-21.14%
Separated season box	4	4	146034	-36.96%	-26.95%	-26.00%	3.07%	-60.03%	-28.38%	-32.31%	-30.08%	-13.59%	-28.81%	-23.80%	-0.25%	-19.00%	-21.15%
Separated season box	4	4	161035	-37.37%	-26.95%	-25.80%	1.02%	-60.46%	-28.18%	-31.93%	-30.50%	-13.18%	-29.00%	-23.53%	-1.47%	-18.42%	-21.09%
Separated season box	4	4	160035	-37.26%	-26.95%	-25.81%	1.77%	-60.27%	-28.23%	-31.97%	-30.32%	-13.26%	-28.98%	-23.59%	-1.66%	-18.62%	-21.10%
Separated season box	4	4	159035	-37.21%	-26.95%	-25.84%	2.40%	-60.17%	-28.27%	-32.07%	-30.24%	-13.32%	-28.97%	-23.63%	-1.82%	-18.71%	-21.11%
Separated season box	4	4	165036	-37.47%	-26.95%	-25.85%	-2.76%	-60.02%	-28.02%	-32.00%	-31.23%	-13.09%	-30.36%	-23.53%	-0.64%	-18.29%	-21.04%

Leatherback turtle take reduction bin # 12 (-55% to -60%)
10 best of 3870 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	4	30	-33.09%	-10.04%	-11.38%	-52.67%	-55.80%	0.46%	-3.19%	-37.68%	1.26%	-17.80%	0.78%	-21.89%	-0.75%	-5.40%
Separated season latitude	3	4	34	-33.25%	-19.00%	-20.38%	-25.10%	-56.48%	-12.36%	-23.95%	-31.47%	-6.31%	-25.00%	-10.02%	-9.62%	-10.23%	-14.98%
Separated season box	3	4	164032	-33.52%	-19.00%	-19.80%	-16.87%	-55.46%	-14.74%	-16.92%	-27.41%	-7.57%	-22.58%	-10.16%	-8.27%	-14.80%	-15.14%
Separated season box	3	4	171033	-33.53%	-19.00%	-19.21%	-18.83%	-56.86%	-13.92%	-17.24%	-27.96%	-6.80%	-24.46%	-10.28%	-8.37%	-14.04%	-15.14%
Separated season box	3	4	170033	-33.44%	-19.00%	-19.29%	-18.25%	-56.54%	-14.07%	-17.25%	-27.86%	-6.95%	-23.99%	-10.34%	-7.45%	-14.18%	-15.17%
Separated season box	3	4	169033	-33.31%	-19.00%	-19.41%	-17.28%	-56.17%	-14.21%	-17.32%	-27.55%	-7.17%	-23.75%	-10.48%	-7.17%	-14.43%	-15.20%
Separated season box	3	4	168033	-33.25%	-19.00%	-19.48%	-17.12%	-56.16%	-14.28%	-17.44%	-27.38%	-7.32%	-23.73%	-10.56%	-6.25%	-14.55%	-15.24%
Separated season box	3	4	167033	-33.20%	-19.00%	-19.57%	-16.96%	-56.09%	-14.32%	-17.62%	-27.33%	-7.45%	-23.60%	-10.65%	-6.60%	-14.74%	-15.25%
Separated season box	3	4	166033	-33.12%	-19.00%	-19.63%	-16.52%	-55.99%	-14.39%	-17.79%	-27.32%	-7.52%	-23.41%	-10.71%	-6.86%	-14.84%	-15.25%
Separated season box	3	4	165033	-32.95%	-19.00%	-19.71%	-15.08%	-55.15%	-14.54%	-18.32%	-27.08%	-7.68%	-23.03%	-10.81%	-7.51%	-15.04%	-15.27%

Leatherback turtle take reduction bin # 11 (-50% to -55%)
10 best of 3393 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	4	31	-29.46%	-10.04%	-10.46%	-44.93%	-54.20%	-1.04%	-6.03%	-29.24%	0.81%	-17.55%	-0.58%	-17.96%	-5.04%	-6.14%
Separated season latitude	2	4	32	-27.43%	-10.04%	-10.46%	-38.12%	-52.67%	-1.99%	-7.31%	-25.05%	0.09%	-17.30%	-1.48%	-13.92%	-5.25%	-6.65%
Separated season latitude	2	4	33	-26.22%	-10.04%	-10.69%	-32.72%	-50.68%	-2.57%	-7.33%	-22.34%	-1.14%	-13.96%	-2.89%	-11.10%	-5.85%	-7.00%
Separated season box	2	4	173031	-28.14%	-10.04%	-9.76%	-32.93%	-51.15%	-3.90%	2.75%	-23.75%	-0.67%	-14.93%	-1.88%	-11.62%	-8.48%	-6.56%
Separated season box	2	4	172031	-27.99%	-10.04%	-9.86%	-32.61%	-50.89%	-4.10%	2.70%	-23.39%	-0.82%	-14.64%	-2.07%	-12.83%	-9.06%	-6.64%
Separated season box	2	4	171031	-27.91%	-10.04%	-9.89%	-32.60%	-50.80%	-4.23%	2.39%	-22.79%	-0.99%	-13.81%	-2.25%	-13.23%	-9.45%	-6.75%
Separated season box	2	4	170031	-27.80%	-10.04%	-9.98%	-32.09%	-50.49%	-4.37%	2.34%	-22.31%	-1.21%	-13.32%	-2.30%	-12.39%	-9.69%	-6.84%
Separated season box	2	4	169031	-27.65%	-10.04%	-10.10%	-31.23%	-50.14%	-4.52%	2.26%	-21.82%	-1.48%	-13.05%	-2.51%	-12.14%	-10.00%	-6.87%
Separated season box	2	4	168031	-27.58%	-10.04%	-10.17%	-31.13%	-50.14%	-4.59%	2.11%	-21.59%	-1.61%	-12.96%	-2.61%	-11.26%	-10.09%	-6.92%
Separated season box	2	4	167031	-27.51%	-10.04%	-10.24%	-31.00%	-50.06%	-4.64%	1.89%	-21.36%	-1.77%	-12.80%	-2.74%	-11.67%	-10.23%	-6.94%

Leatherback turtle take reduction bin # 10 (-45% to -50%)
10 best of 3650 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	2	4	163032	-24.71%	-10.04%	-10.58%	-16.34%	-45.49%	-6.25%	-0.81%	-15.97%	-3.54%	-9.88%	-4.12%	-3.96%	-11.85%	-7.55%
Separated season box	2	4	162032	-24.35%	-10.04%	-10.66%	-13.25%	-45.05%	-6.50%	-0.99%	-14.84%	-3.91%	-8.91%	-4.39%	-4.23%	-12.25%	-7.61%
Separated season box	2	4	168033	-24.82%	-10.04%	-10.18%	-19.73%	-47.19%	-5.49%	-1.20%	-16.92%	-2.91%	-11.91%	-4.27%	-4.27%	-11.22%	-7.54%
Separated season box	2	4	167033	-24.76%	-10.04%	-10.27%	-19.57%	-47.12%	-5.54%	-1.38%	-16.88%	-3.03%	-11.79%	-4.36%	-4.63%	-11.42%	-7.55%
Separated season box	2	4	166033	-24.69%	-10.04%	-10.33%	-19.18%	-47.03%	-5.60%	-1.56%	-16.87%	-3.11%	-11.60%	-4.41%	-4.88%	-11.52%	-7.55%
Separated season box	2	4	165033	-24.52%	-10.04%	-10.40%	-17.75%	-46.20%	-5.75%	-2.08%	-16.63%	-3.27%	-11.22%	-4.51%	-5.53%	-11.72%	-7.58%
Separated season box	2	4	164033	-24.21%	-10.04%	-10.50%	-15.27%	-45.18%	-5.99%	-2.24%	-15.54%	-3.52%	-10.14%	-4.68%	-3.96%	-11.85%	-7.66%
Separated season box	2	4	173034	-24.11%	-10.04%	-10.28%	-16.59%	-45.30%	-5.56%	-2.25%	-16.60%	-3.07%	-12.63%	-4.77%	-1.57%	-10.99%	-7.55%
Separated season box	2	4	172034	-24.00%	-10.04%	-10.26%	-16.40%	-45.09%	-5.71%	-2.33%	-16.57%	-3.13%	-12.33%	-4.81%	-2.63%	-11.20%	-7.56%
Separated season box	2	4	171034	-23.93%	-10.04%	-10.25%	-16.39%	-45.01%	-5.82%	-2.59%	-16.30%	-3.21%	-11.91%	-4.85%	-2.94%	-11.27%	-7.58%

Leatherback turtle take reduction bin # 9 (-40% to -45%)
10 best of 4035 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	2	4	160034	-22.15%	-10.04%	-10.68%	-4.19%	-41.19%	-7.04%	-4.09%	-12.63%	-4.83%	-7.72%	-5.69%	-1.35%	-13.20%	-7.85%
Separated season box	2	4	159034	-22.10%	-10.04%	-10.71%	-3.76%	-41.07%	-7.07%	-4.15%	-12.56%	-4.89%	-7.73%	-5.74%	-1.60%	-13.30%	-7.87%
Separated season box	2	4	158034	-22.01%	-10.04%	-10.75%	-3.41%	-40.77%	-7.14%	-4.24%	-12.53%	-4.94%	-7.69%	-5.78%	-1.58%	-13.37%	-7.87%
Separated season box	2	4	157034	-21.93%	-10.04%	-10.78%	-3.05%	-40.61%	-7.17%	-4.31%	-12.50%	-4.97%	-7.66%	-5.81%	-1.57%	-13.37%	-7.88%
Separated season box	2	4	156034	-21.90%	-10.04%	-10.79%	-2.93%	-40.57%	-7.20%	-4.32%	-12.47%	-5.00%	-7.66%	-5.83%	-1.42%	-13.44%	-7.88%
Separated season box	2	4	155034	-21.90%	-10.04%	-10.79%	-2.94%	-40.56%	-7.20%	-4.33%	-12.48%	-5.01%	-7.56%	-5.85%	-1.45%	-13.46%	-7.88%
Separated season box	2	4	154034	-21.89%	-10.04%	-10.80%	-2.95%	-40.54%	-7.20%	-4.35%	-12.49%	-5.02%	-7.55%	-5.85%	-1.46%	-13.46%	-7.88%
Separated season box	2	4	153034	-21.88%	-10.04%	-10.81%	-2.95%	-40.51%	-7.21%	-4.35%	-12.49%	-5.03%	-7.49%	-5.86%	-1.41%	-13.45%	-7.89%
Separated season box	2	4	152034	-21.83%	-10.04%	-10.82%	-2.98%	-40.35%	-7.22%	-4.39%	-12.39%	-5.07%	-7.52%	-5.88%	-1.23%	-13.47%	-7.89%
Separated season box	2	4	151034	-21.81%	-10.04%	-10.84%	-2.98%	-40.29%	-7.23%	-4.41%	-12.34%	-5.11%	-7.56%	-5.92%	-0.32%	-13.57%	-7.90%

Leatherback turtle take reduction bin # 8 (-35% to -40%)
10 best of 5630 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	2	4	146036	-20.39%	-10.04%	-10.99%	-2.28%	-35.23%	-7.62%	-5.86%	-11.46%	-5.50%	-7.64%	-6.33%	-0.22%	-13.98%	-7.97%
Separated season box	2	4	158038	-20.40%	-10.04%	-10.95%	-2.50%	-35.05%	-7.62%	-5.77%	-11.38%	-5.45%	-7.76%	-6.28%	-0.11%	-13.92%	-7.95%
Separated season box	2	4	157038	-20.38%	-10.04%	-10.95%	-2.44%	-35.03%	-7.63%	-5.79%	-11.35%	-5.46%	-7.70%	-6.29%	-0.13%	-13.92%	-7.95%
Separated season box	2	4	156038	-20.38%	-10.04%	-10.96%	-2.43%	-35.03%	-7.64%	-5.80%	-11.35%	-5.46%	-7.71%	-6.29%	-0.14%	-13.93%	-7.95%
Separated season box	2	4	155038	-20.38%	-10.04%	-10.96%	-2.43%	-35.03%	-7.64%	-5.80%	-11.35%	-5.46%	-7.70%	-6.29%	-0.14%	-13.94%	-7.95%
Separated season box	2	4	154038	-20.37%	-10.04%	-10.96%	-2.42%	-35.02%	-7.64%	-5.80%	-11.36%	-5.47%	-7.71%	-6.29%	-0.15%	-13.93%	-7.95%
Separated season box	2	4	153038	-20.37%	-10.04%	-10.96%	-2.42%	-35.02%	-7.64%	-5.80%	-11.36%	-5.47%	-7.71%	-6.29%	-0.15%	-13.93%	-7.95%
Separated season box	2	4	152038	-20.37%	-10.04%	-10.96%	-2.42%	-35.02%	-7.64%	-5.80%	-11.36%	-5.47%	-7.71%	-6.30%	-0.15%	-13.94%	-7.95%
Separated season box	2	4	151038	-20.37%	-10.04%	-10.96%	-2.42%	-35.02%	-7.64%	-5.81%	-11.37%	-5.47%	-7.71%	-6.30%	-0.16%	-13.96%	-7.95%
Separated season box	2	4	170039	-20.39%	-10.04%	-10.84%	-3.04%	-35.00%	-7.59%	-5.83%	-11.35%	-5.34%	-7.72%	-6.23%	-0.36%	-13.34%	-7.94%

Leatherback turtle take reduction bin # 7 (-30% to -35%)
10 best of 5360 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Season	2	4	0	-20.07%	-10.04%	-11.02%	-2.19%	-34.23%	-7.78%	-6.22%	-11.33%	-5.58%	-7.75%	-6.39%	-0.60%	-13.99%	-7.97%
Separated season box	2	4	146038	-20.18%	-10.04%	-11.00%	-2.24%	-34.30%	-7.70%	-6.07%	-11.33%	-5.55%	-7.67%	-6.36%	-0.36%	-13.99%	-7.97%
Separated season box	2	4	156039	-20.18%	-10.04%	-10.98%	-2.24%	-34.77%	-7.72%	-6.08%	-11.37%	-5.50%	-7.78%	-6.31%	-0.41%	-13.96%	-7.96%
Separated season box	2	4	155039	-20.18%	-10.04%	-10.98%	-2.24%	-34.77%	-7.72%	-6.08%	-11.37%	-5.50%	-7.77%	-6.32%	-0.41%	-13.96%	-7.96%
Separated season box	2	4	153039	-20.18%	-10.04%	-10.98%	-2.24%	-34.77%	-7.72%	-6.09%	-11.37%	-5.50%	-7.77%	-6.32%	-0.42%	-13.97%	-7.96%
Separated season box	2	4	150039	-20.17%	-10.04%	-10.99%	-2.23%	-34.60%	-7.72%	-6.09%	-11.37%	-5.51%	-7.75%	-6.32%	-0.42%	-13.93%	-7.96%
Separated season box	2	4	149039	-20.17%	-10.04%	-10.99%	-2.23%	-34.60%	-7.72%	-6.09%	-11.35%	-5.52%	-7.73%	-6.34%	-0.44%	-13.97%	-7.97%
Separated season box	2	4	148039	-20.15%	-10.04%	-10.99%	-2.23%	-34.36%	-7.73%	-6.10%	-11.34%	-5.53%	-7.68%	-6.35%	-0.45%	-13.95%	-7.97%
Separated season box	2	4	147039	-20.13%	-10.04%	-11.00%	-2.18%	-34.29%	-7.74%	-6.13%	-11.33%	-5.55%	-7.68%	-6.36%	-0.43%	-13.98%	-7.97%
Separated season box	2	4	146039	-20.11%	-10.04%	-11.01%	-2.19%	-34.26%	-7.76%	-6.17%	-11.33%	-5.56%	-7.69%	-6.37%	-0.47%	-13.99%	-7.97%

Leatherback turtle take reduction bin # 6 (-25% to -30%)
10 best of 5006 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	1	4	32	-17.36%	0.00%	0.80%	-38.08%	-27.48%	6.72%	-0.14%	-14.51%	6.88%	-10.27%	6.68%	-12.13%	4.84%	0.52%
Separated season latitude	1	4	33	-16.15%	0.00%	0.57%	-32.68%	-25.48%	6.14%	-0.46%	-11.79%	5.65%	-6.92%	5.29%	-9.29%	4.23%	0.17%
Separated season box	1	4	170031	-17.78%	0.00%	1.31%	-32.04%	-25.81%	4.43%	9.27%	-11.90%	5.56%	-6.36%	5.85%	-10.57%	0.23%	0.34%
Separated season box	1	4	169031	-17.63%	0.00%	1.19%	-31.18%	-25.47%	4.29%	9.21%	-11.39%	5.30%	-6.08%	5.64%	-10.32%	-0.09%	0.31%
Separated season box	1	4	168031	-17.57%	0.00%	1.12%	-31.09%	-25.47%	4.22%	9.05%	-11.16%	5.16%	-5.99%	5.54%	-9.44%	-0.18%	0.26%
Separated season box	1	4	167031	-17.49%	0.00%	1.06%	-30.96%	-25.39%	4.16%	8.84%	-10.92%	5.01%	-5.83%	5.42%	-9.85%	-0.31%	0.24%
Separated season box	1	4	166031	-17.38%	0.00%	1.00%	-30.46%	-25.24%	4.05%	8.70%	-10.57%	4.84%	-5.60%	5.37%	-9.73%	-0.44%	0.22%
Merged season latitude	9	4	27	-16.39%	0.00%	0.12%	-37.71%	-26.03%	11.62%	-13.65%	-25.98%	4.00%	-9.17%	9.95%	-11.88%	3.19%	5.96%
Merged season latitude	10	4	28	-16.31%	0.00%	-0.91%	-54.66%	-27.17%	10.46%	-9.41%	-28.10%	5.74%	-11.13%	9.30%	-17.97%	8.93%	5.04%
Merged season latitude	11	9	29	-17.68%	0.00%	-0.46%	-52.25%	-25.38%	8.99%	4.19%	-31.35%	8.00%	-11.96%	6.56%	-24.35%	12.11%	3.33%

Leatherback turtle take reduction bin # 5 (-20% to -25%)
10 best of 5955 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Latitude	0	0	31	-9.50%	0.00%	0.57%	-42.67%	-20.08%	6.71%	0.57%	-17.31%	6.43%	-9.86%	5.86%	-17.28%	9.09%	1.86%
Merged season latitude	5	9	26	-10.29%	0.00%	0.32%	-42.99%	-20.24%	13.94%	-4.04%	-17.91%	4.47%	-14.34%	3.32%	-19.54%	7.63%	2.81%
Merged season latitude	7	7	29	-10.46%	0.00%	0.11%	-49.38%	-20.68%	8.37%	-5.16%	-20.16%	6.30%	-10.79%	8.25%	-17.21%	7.32%	3.06%
Merged season latitude	8	6	29	-10.79%	0.00%	0.10%	-49.39%	-21.06%	8.49%	-6.37%	-20.29%	6.26%	-10.71%	8.42%	-17.30%	6.69%	3.07%
Merged season latitude	8	6	30	-9.49%	0.00%	0.29%	-44.88%	-20.21%	7.46%	-1.36%	-18.86%	6.14%	-10.71%	6.97%	-13.71%	8.20%	2.37%
Merged season latitude	9	4	29	-10.27%	0.00%	1.26%	-32.09%	-20.53%	8.29%	-5.32%	-18.31%	5.24%	-10.18%	6.46%	-10.62%	5.91%	3.47%
Merged season latitude	9	5	30	-9.64%	0.00%	0.34%	-44.88%	-20.62%	7.54%	-1.26%	-18.94%	6.21%	-10.82%	6.96%	-13.89%	8.02%	2.37%
Merged season latitude	10	4	30	-10.02%	0.00%	0.27%	-44.86%	-21.23%	7.60%	-1.08%	-19.82%	6.26%	-10.82%	6.67%	-14.33%	8.48%	2.65%
Merged season latitude	11	4	31	-9.26%	0.00%	0.59%	-42.54%	-20.01%	6.68%	0.27%	-16.92%	6.38%	-10.09%	5.80%	-16.68%	8.73%	1.83%
Merged season latitude	11	9	31	-8.62%	0.00%	0.88%	-35.26%	-20.03%	5.84%	2.26%	-15.67%	6.16%	-10.30%	4.86%	-16.63%	8.77%	1.42%

Leatherback turtle take reduction bin # 4 (-15% to -20%)
10 best of 9396 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Merged season latitude	3	11	31	-5.00%	0.00%	1.04%	-24.31%	-15.27%	2.55%	3.56%	-9.53%	4.58%	-8.53%	3.00%	-11.29%	5.75%	0.89%
Merged season latitude	4	9	31	-4.89%	0.00%	1.58%	-20.19%	-15.06%	5.05%	-1.24%	-10.43%	4.61%	-10.64%	2.99%	-9.82%	6.36%	1.08%
Merged season latitude	4	10	32	-5.21%	0.00%	0.78%	-23.83%	-15.76%	3.09%	2.32%	-9.61%	4.61%	-10.00%	3.22%	-10.68%	6.85%	0.82%
Merged season latitude	5	9	33	-5.09%	0.00%	0.53%	-21.57%	-15.02%	4.25%	0.14%	-9.00%	3.74%	-6.66%	2.52%	-9.63%	7.19%	0.57%
Merged season latitude	6	9	33	-5.15%	0.00%	0.53%	-21.55%	-15.06%	4.26%	0.19%	-9.01%	3.77%	-6.66%	2.58%	-9.71%	7.24%	0.57%
Merged season latitude	7	9	33	-5.21%	0.00%	0.54%	-21.54%	-15.09%	4.27%	0.27%	-9.00%	3.77%	-6.65%	2.59%	-9.75%	7.33%	0.57%
Merged season latitude	8	9	33	-5.21%	0.00%	0.54%	-21.54%	-15.12%	4.27%	0.27%	-8.99%	3.77%	-6.65%	2.60%	-9.75%	7.33%	0.57%
Merged season latitude	9	9	33	-5.22%	0.00%	0.54%	-21.54%	-15.12%	4.27%	0.28%	-8.99%	3.77%	-6.65%	2.60%	-9.87%	7.33%	0.57%
Merged season latitude	9	11	32	-5.27%	0.00%	0.91%	-22.71%	-15.78%	2.56%	2.14%	-8.31%	4.30%	-7.62%	3.30%	-10.19%	4.28%	0.81%
Merged season latitude	10	10	33	-5.08%	0.00%	0.44%	-21.69%	-15.33%	3.20%	1.15%	-8.00%	3.61%	-6.38%	2.66%	-9.06%	5.72%	0.62%

Leatherback turtle take reduction bin # 3 (-10% to -15%)
10 best of 14312 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Merged season latitude	2	11	33	-2.94%	0.00%	0.78%	-12.07%	-10.95%	1.78%	0.41%	-4.76%	2.52%	-4.22%	1.38%	-5.78%	3.11%	0.53%
Merged season box	2	11	165031	-2.91%	0.00%	0.78%	-9.77%	-10.09%	1.56%	1.95%	-4.57%	1.99%	-3.89%	1.34%	-4.59%	1.66%	0.30%
Merged season box	2	11	168032	-2.94%	0.00%	0.87%	-10.45%	-10.93%	1.63%	2.06%	-4.88%	2.31%	-4.23%	1.53%	-3.82%	1.78%	0.40%
Merged season box	2	11	167032	-2.92%	0.00%	0.77%	-10.24%	-10.87%	1.61%	2.08%	-4.82%	2.20%	-4.00%	1.44%	-4.03%	1.67%	0.40%
Merged season box	2	11	166032	-2.90%	0.00%	0.73%	-10.07%	-10.80%	1.57%	2.06%	-4.81%	2.12%	-3.86%	1.37%	-4.11%	1.63%	0.40%
Merged season box	2	11	173033	-2.87%	0.00%	0.80%	-10.99%	-10.37%	1.55%	1.61%	-4.48%	2.29%	-3.82%	1.35%	-2.45%	2.32%	0.47%
Merged season box	2	11	172033	-2.84%	0.00%	0.76%	-10.70%	-10.27%	1.50%	1.81%	-4.43%	2.23%	-3.84%	1.32%	-3.22%	2.13%	0.45%
Merged season box	2	11	171033	-2.84%	0.00%	0.75%	-10.57%	-10.23%	1.48%	1.84%	-4.31%	2.20%	-3.44%	1.30%	-3.17%	1.97%	0.40%
Merged season box	2	11	170033	-2.81%	0.00%	0.71%	-10.29%	-10.11%	1.44%	1.90%	-4.30%	2.09%	-3.04%	1.28%	-3.07%	1.86%	0.36%
Merged season latitude	9	11	34	-2.95%	0.00%	0.32%	-11.44%	-10.55%	1.46%	0.88%	-4.38%	2.02%	-3.48%	1.27%	-4.34%	2.52%	0.35%

Leatherback turtle take reduction bin # 2 (-5% to -10%)
10 best of 18589 scenarios at this take level with minimum fishing effort disruption

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Merged season box	1	12	153027	-1.15%	0.00%	0.11%	-0.21%	-5.26%	0.40%	1.06%	-1.19%	0.29%	-0.12%	0.29%	-2.94%	0.19%	0.07%
Merged season box	1	12	153030	-1.14%	0.00%	0.10%	-0.21%	-5.24%	0.39%	1.05%	-1.19%	0.29%	-0.13%	0.29%	-2.90%	0.23%	0.07%
Merged season box	1	12	153031	-1.14%	0.00%	0.10%	-0.22%	-5.24%	0.39%	1.05%	-1.19%	0.29%	-0.13%	0.28%	-2.90%	0.23%	0.07%
Merged season box	1	12	155032	-1.15%	0.00%	0.11%	-0.25%	-5.28%	0.40%	1.05%	-1.19%	0.29%	-0.18%	0.29%	-2.96%	0.21%	0.07%
Merged season box	1	12	154032	-1.15%	0.00%	0.10%	-0.26%	-5.25%	0.40%	1.04%	-1.19%	0.29%	-0.15%	0.29%	-2.96%	0.20%	0.07%
Merged season box	1	12	153032	-1.13%	0.00%	0.10%	-0.24%	-5.19%	0.39%	1.03%	-1.19%	0.28%	-0.14%	0.28%	-2.90%	0.23%	0.07%
Merged season box	1	12	161033	-1.13%	0.00%	0.20%	-0.49%	-5.06%	0.39%	0.97%	-1.19%	0.40%	-0.58%	0.35%	-2.53%	0.24%	0.07%
Merged season box	1	12	160033	-1.12%	0.00%	0.18%	-0.48%	-5.03%	0.39%	0.96%	-1.14%	0.34%	-0.59%	0.32%	-2.57%	0.22%	0.08%
Merged season box	1	12	159033	-1.12%	0.00%	0.16%	-0.44%	-5.01%	0.38%	0.96%	-1.13%	0.33%	-0.60%	0.31%	-2.57%	0.22%	0.07%
Merged season box	1	12	158033	-1.12%	0.00%	0.15%	-0.44%	-5.00%	0.38%	0.96%	-1.14%	0.32%	-0.55%	0.30%	-2.48%	0.21%	0.07%

Appendix 2. Listing of twenty-five best scenarios for fishing effort disruption bin approximating Emergency closure optimized for leatherback turtle take reduction. Notations: #Mn = the number of months for a seasonal closure, Ms = the starting month of a seasonal closure, Lon/Lat = position of spatial closure, FED = fishing effort disruption, FEL = fishing effort lost, Rev = fish catch revenue change, Log = loggerhead turtle take change, Lea = leatherback turtle take change, Rid = olive ridley turtle take change, Gre = green turtle take change, Swo = swordfish catch change, Big = bigeye tuna catch change, Alb = albacore catch change, Yel = yellowfin tuna catch change, Blu = bluefin tuna catch change, Mah = mahi-mahi catch change, Opa = opah catch change. Other fish species included in the revenue calculations are not presented to save space. Results are not presented in any ordered sequence.

Fishing effort disruption bin # 3 (-10% to -15%)
25 best of 8173 scenarios at this level optimized for leatherback

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Latitude	0	0	30	-13.54%	0.00%	-0.26%	-49.88%	-22.23%	8.15%	2.82%	-24.38%	7.22%	-9.99%	7.44%	-20.73%	14.20%	2.85%
Separated season latitude	1	4	34	-14.77%	0.00%	0.21%	-26.41%	-22.18%	5.08%	-0.96%	-10.19%	4.78%	-6.19%	4.35%	-5.71%	3.23%	-0.12%
Separated season box	1	4	170033	-14.93%	0.00%	1.27%	-20.67%	-22.46%	3.44%	5.75%	-6.81%	4.22%	-5.15%	4.12%	-3.67%	-0.83%	-0.31%
Separated season box	1	4	169033	-14.80%	0.00%	1.15%	-19.85%	-22.18%	3.32%	5.71%	-6.53%	4.02%	-4.90%	3.99%	-3.38%	-1.07%	-0.34%
Separated season box	1	4	168033	-14.74%	0.00%	1.08%	-19.70%	-22.17%	3.25%	5.59%	-6.37%	3.88%	-4.88%	3.92%	-2.47%	-1.18%	-0.37%
Merged season latitude	7	7	26	-13.54%	0.00%	-0.89%	-54.36%	-22.22%	16.00%	-11.67%	-23.96%	2.93%	-10.36%	11.71%	-21.51%	1.64%	5.33%
Merged season latitude	9	4	28	-13.60%	0.00%	0.51%	-35.22%	-23.67%	9.71%	-8.45%	-22.62%	4.34%	-9.47%	7.71%	-10.70%	6.22%	4.84%
Merged season latitude	9	5	27	-14.75%	0.00%	-0.08%	-52.63%	-23.93%	11.51%	-12.23%	-23.58%	4.60%	-9.40%	11.54%	-18.44%	-0.05%	5.23%
Merged season latitude	9	5	28	-12.64%	0.00%	-0.02%	-51.39%	-23.05%	9.90%	-8.99%	-21.64%	4.99%	-9.71%	9.81%	-17.39%	3.08%	4.23%
Merged season latitude	9	6	28	-14.93%	0.00%	-1.48%	-64.37%	-22.39%	10.57%	-8.80%	-27.76%	5.71%	-9.51%	10.86%	-22.21%	8.45%	4.16%
Merged season latitude	10	4	29	-12.91%	0.00%	-0.04%	-50.05%	-23.95%	8.97%	-4.85%	-23.67%	6.72%	-11.63%	7.88%	-17.90%	8.49%	3.66%
Merged season latitude	10	5	29	-13.91%	0.00%	-0.14%	-57.96%	-22.83%	9.34%	-4.51%	-25.40%	7.43%	-11.04%	9.03%	-21.06%	8.72%	3.15%
Merged season latitude	11	9	30	-12.55%	0.00%	0.12%	-42.43%	-22.18%	7.22%	4.91%	-22.47%	7.16%	-10.64%	5.98%	-20.20%	13.33%	2.20%
Merged season box	10	4	166026	-14.49%	0.00%	0.35%	-29.25%	-22.60%	5.38%	14.45%	-9.59%	2.49%	-5.80%	3.78%	-7.55%	-8.28%	2.10%
Merged season box	10	4	171027	-14.89%	0.00%	0.28%	-35.30%	-23.89%	5.83%	15.17%	-16.39%	4.38%	-7.01%	6.23%	-9.41%	-2.82%	3.47%
Merged season box	10	4	170027	-14.39%	0.00%	0.26%	-34.44%	-23.45%	5.58%	14.77%	-15.57%	4.45%	-6.61%	5.89%	-8.51%	-3.67%	3.19%
Merged season box	10	4	169027	-13.88%	0.00%	0.34%	-32.68%	-22.68%	5.30%	14.25%	-13.98%	4.23%	-6.42%	5.33%	-8.42%	-4.42%	3.02%
Merged season box	10	4	168027	-13.36%	0.00%	0.57%	-31.79%	-22.58%	5.08%	13.69%	-13.16%	4.30%	-6.26%	4.84%	-7.20%	-4.63%	2.87%
Merged season box	10	4	167027	-12.93%	0.00%	0.67%	-30.86%	-22.30%	4.93%	13.05%	-11.11%	3.92%	-6.30%	4.25%	-7.64%	-4.88%	2.67%
Merged season box	10	4	173028	-13.60%	0.00%	0.45%	-35.59%	-22.76%	5.53%	12.85%	-18.03%	5.29%	-7.93%	6.46%	-6.96%	4.94%	3.21%
Merged season box	10	4	172028	-13.04%	0.00%	0.38%	-35.30%	-22.60%	5.23%	13.16%	-16.59%	5.09%	-7.59%	5.83%	-8.63%	2.93%	3.16%
Merged season box	10	4	171028	-12.68%	0.00%	0.37%	-34.86%	-22.49%	5.05%	13.07%	-15.50%	4.87%	-6.99%	5.25%	-9.11%	1.77%	2.89%
Merged season box	11	3	167028	-14.91%	0.00%	0.93%	-32.70%	-22.21%	5.54%	24.00%	-12.27%	5.10%	-6.18%	3.74%	-11.02%	-0.16%	2.42%
Merged season box	11	4	169028	-14.64%	0.00%	-0.21%	-43.90%	-22.42%	5.24%	16.28%	-18.55%	5.63%	-6.00%	5.03%	-12.76%	2.77%	2.52%
Merged season box	11	4	168028	-14.24%	0.00%	0.04%	-42.67%	-22.35%	5.06%	16.02%	-16.51%	5.67%	-5.93%	4.57%	-11.58%	2.14%	2.38%

Appendix 3. Listings of three best scenarios optimized for 1) loggerhead turtle take reduction, 2) olive ridley turtle take reduction, 3) green turtle take reduction, and 4) aggregate turtle take reduction per bin of leatherback turtle take reduction. Notations: #Mn = the number of months for a seasonal closure, Ms = the starting month of a seasonal closure, Lon/Lat = position of spatial closure, FED = fishing effort disruption, FEL = fishing effort lost, Rev = fish catch revenue change, Log = loggerhead turtle take change, Lea = leatherback turtle take change, Rid = olive ridley turtle take change, Gre = green turtle take change, Swo = swordfish catch change, Big = bigeye tuna catch change, Alb = albacore catch change, Yel = yellowfin tuna catch change, Blu = bluefin tuna catch change, Mah = mahi-mahi catch change, Opa = opah catch change. Other fish species included in the revenue calculations are not presented to save space. Results are not presented in any ordered sequence.

Leatherback turtle take reduction bin # 20 (-95% to %-100%)
3 best of 2327 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	10	11	21	-95.60%	-78.86%	-88.03%	-100.00%	-97.53%	-4.48%	-88.83%	-99.24%	-86.89%	-92.16%	-82.84%	-57.45%	-89.40%	-80.39%
Separated season latitude	11	10	21	-97.85%	-86.31%	-93.03%	-100.00%	-99.13%	19.68%	-91.94%	-99.67%	-95.10%	-95.17%	-87.20%	-57.38%	-95.87%	-89.81%
Separated season latitude	11	11	21	-97.74%	-84.25%	-90.44%	-100.00%	-97.53%	-76.46%	-92.61%	-99.43%	-89.27%	-95.26%	-92.25%	-59.38%	-91.77%	-86.20%

Leatherback turtle take reduction bin # 20 (-95% to %-100%)
3 best of 2327 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	11	1	173	-99.98%	-82.54%	-87.11%	-98.52%	-95.22%	-99.42%	-97.06%	-96.24%	-96.54%	-96.34%	-99.45%	-60.00%	-96.69%	-100.00%
Separated season longitude	11	1	171	-99.98%	-82.54%	-79.74%	-98.63%	-95.44%	-99.37%	-97.03%	-96.49%	-96.66%	-96.64%	-99.44%	-60.00%	-96.63%	-99.98%
Separated season longitude	11	1	170	-99.98%	-82.54%	-81.17%	-98.63%	-95.44%	-99.37%	-97.03%	-95.25%	-93.44%	-95.92%	-99.08%	-60.00%	-98.87%	-99.98%

Leatherback turtle take reduction bin # 20 (-95% to %-100%)
3 best of 2327 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	11	1	173	-99.98%	-82.54%	-87.11%	-98.52%	-95.22%	-99.42%	-97.06%	-96.24%	-96.54%	-96.34%	-99.45%	-60.00%	-96.69%	-100.00%
Separated season longitude	11	1	172	-99.98%	-82.54%	-88.68%	-98.63%	-95.44%	-99.37%	-97.03%	-96.43%	-96.64%	-96.55%	-99.46%	-60.00%	-96.64%	-99.98%
Separated season longitude	11	1	170	-99.98%	-82.54%	-81.17%	-98.63%	-95.44%	-99.37%	-97.03%	-95.25%	-93.44%	-95.92%	-99.08%	-60.00%	-98.87%	-99.98%

Leatherback turtle take reduction bin # 20 (-95% to %-100%)
3 best of 2327 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	11	1	172	-99.98%	-82.54%	-88.68%	-98.63%	-95.44%	-99.37%	-97.03%	-96.43%	-96.64%	-96.55%	-99.46%	-60.00%	-96.64%	-99.98%
Separated season longitude	11	1	171	-99.98%	-82.54%	-79.74%	-98.63%	-95.44%	-99.37%	-97.03%	-96.49%	-96.66%	-96.64%	-99.44%	-60.00%	-96.63%	-99.98%
Separated season longitude	11	1	170	-99.98%	-82.54%	-81.17%	-98.63%	-95.44%	-99.37%	-97.03%	-95.25%	-93.44%	-95.92%	-99.08%	-60.00%	-98.87%	-99.98%

Leatherback turtle take reduction bin # 19 (-90% to -95%)
3 best of 3249 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	9	12	21	-92.00%	-70.17%	-83.35%	-99.98%	-93.65%	7.93%	-83.58%	-98.90%	-75.02%	-89.62%	-76.12%	-56.13%	-79.41%	-72.09%
Separated season latitude	10	12	21	-94.14%	-75.60%	-85.77%	-99.98%	-93.69%	-65.36%	-87.37%	-99.08%	-77.43%	-92.72%	-85.65%	-58.06%	-81.82%	-77.90%
Separated season latitude	11	12	21	-96.40%	-83.02%	-90.40%	-99.98%	-94.12%	-77.33%	-90.58%	-99.51%	-84.30%	-96.11%	-90.97%	-58.33%	-87.29%	-87.56%

Leatherback turtle take reduction bin # 19 (-90% to -95%)
3 best of 3249 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	1	173	-99.92%	-73.90%	-87.54%	-93.91%	-93.01%	-99.05%	-91.55%	-94.77%	-96.24%	-92.30%	-99.35%	-49.71%	-96.53%	-100.00%
Separated season longitude	11	12	173	-99.93%	-83.02%	-95.72%	-93.05%	-94.91%	-99.24%	-91.20%	-98.31%	-99.65%	-94.96%	-99.85%	-48.58%	-99.81%	-100.00%
Separated season longitude	11	12	172	-99.91%	-83.02%	-78.27%	-92.60%	-94.94%	-99.28%	-91.16%	-97.94%	-99.58%	-94.71%	-99.85%	-51.23%	-99.85%	-99.98%

Leatherback turtle take reduction bin # 19 (-90% to -95%)
3 best of 3249 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	1	173	-99.92%	-73.90%	-87.54%	-93.91%	-93.01%	-99.05%	-91.55%	-94.77%	-96.24%	-92.30%	-99.35%	-49.71%	-96.53%	-100.00%
Separated season longitude	10	1	172	-99.89%	-73.90%	-75.48%	-93.65%	-93.19%	-99.04%	-91.51%	-94.66%	-96.29%	-92.39%	-99.37%	-52.24%	-96.51%	-99.97%
Separated season longitude	11	12	173	-99.93%	-83.02%	-95.72%	-93.05%	-94.91%	-99.24%	-91.20%	-98.31%	-99.65%	-94.96%	-99.85%	-48.58%	-99.81%	-100.00%

Leatherback turtle take reduction bin # 19 (-90% to -95%)
3 best of 3249 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	1	173	-99.92%	-73.90%	-87.54%	-93.91%	-93.01%	-99.05%	-91.55%	-94.77%	-96.24%	-92.30%	-99.35%	-49.71%	-96.53%	-100.00%
Separated season longitude	10	1	172	-99.89%	-73.90%	-75.48%	-93.65%	-93.19%	-99.04%	-91.51%	-94.66%	-96.29%	-92.39%	-99.37%	-52.24%	-96.51%	-99.97%
Separated season longitude	11	12	173	-99.93%	-83.02%	-95.72%	-93.05%	-94.91%	-99.24%	-91.20%	-98.31%	-99.65%	-94.96%	-99.85%	-48.58%	-99.81%	-100.00%

Leatherback turtle take reduction bin # 18 (-85% to -90%)
3 best of 2369 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	7	21	-96.17%	-83.24%	-85.97%	-100.00%	-85.69%	-77.05%	-79.68%	-96.91%	-93.23%	-81.72%	-79.73%	-57.37%	-98.59%	-88.11%
Separated season latitude	11	7	22	-95.90%	-83.24%	-86.32%	-100.00%	-85.56%	-77.98%	-79.59%	-96.77%	-93.21%	-80.36%	-80.46%	-57.39%	-98.35%	-86.57%
Separated season latitude	11	7	23	-95.72%	-83.24%	-86.44%	-100.00%	-85.46%	-78.38%	-80.01%	-96.02%	-93.10%	-78.59%	-81.99%	-57.32%	-97.88%	-85.22%

Leatherback turtle take reduction bin # 18 (-85% to -90%)
3 best of 2369 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	1	170	-99.86%	-73.90%	-77.67%	-66.43%	-85.77%	-98.73%	-85.15%	-91.35%	-91.41%	-74.58%	-98.57%	-47.56%	-98.37%	-99.58%
Separated season longitude	11	10	173	-99.88%	-86.31%	-89.82%	-71.78%	-88.15%	-99.03%	-72.58%	-97.35%	-99.93%	-99.78%	-99.97%	-58.23%	-99.69%	-99.96%
Separated season longitude	11	12	169	-99.85%	-83.02%	-87.81%	-62.72%	-86.45%	-98.73%	-83.40%	-93.98%	-95.52%	-77.08%	-99.19%	-48.96%	-99.07%	-99.58%

Leatherback turtle take reduction bin # 18 (-85% to -90%)
3 best of 2369 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	8	21	-95.87%	-84.16%	-88.93%	-99.77%	-88.62%	-71.33%	-89.15%	-98.58%	-95.38%	-88.69%	-76.14%	-58.85%	-98.24%	-90.71%
Separated season latitude	11	8	22	-95.53%	-84.16%	-89.49%	-99.72%	-88.55%	-71.75%	-88.99%	-98.55%	-95.31%	-87.27%	-76.07%	-58.83%	-98.12%	-88.56%
Separated season latitude	11	8	24	-95.00%	-84.16%	-89.70%	-99.14%	-88.10%	-73.00%	-88.97%	-97.75%	-95.28%	-81.06%	-75.69%	-58.63%	-96.82%	-85.88%

Leatherback turtle take reduction bin # 18 (-85% to -90%)
3 best of 2369 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	11	1	169	-99.97%	-82.54%	-81.17%	-98.46%	-87.00%	-89.91%	-88.53%	-74.08%	-83.63%	-89.21%	-98.97%	-60.00%	-95.55%	-99.98%
Separated season box	11	12	164032	-92.54%	-83.02%	-88.77%	-85.96%	-85.83%	-80.87%	-84.68%	-91.97%	-75.85%	-79.88%	-88.48%	-46.60%	-79.73%	-83.67%
Separated season box	11	12	164033	-92.52%	-83.02%	-88.80%	-85.73%	-85.76%	-80.92%	-84.68%	-91.83%	-75.82%	-79.42%	-88.44%	-46.45%	-79.67%	-83.66%

Leatherback turtle take reduction bin # 17 (-80% to -85%)
3 best of 4485 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	7	25	-94.08%	-83.24%	-85.99%	-100.00%	-84.63%	-79.43%	-81.66%	-91.84%	-93.58%	-78.70%	-85.57%	-56.44%	-96.67%	-84.97%
Separated season latitude	11	7	26	-93.30%	-83.24%	-85.62%	-100.00%	-83.82%	-79.97%	-81.87%	-90.42%	-93.23%	-78.60%	-85.56%	-57.02%	-96.60%	-84.97%
Separated season latitude	11	7	27	-92.66%	-83.24%	-85.23%	-100.00%	-83.77%	-79.98%	-77.64%	-89.32%	-92.82%	-78.68%	-85.98%	-56.86%	-96.21%	-84.95%

Leatherback turtle take reduction bin # 17 (-80% to -85%)
3 best of 4485 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	1	171	-99.88%	-73.90%	-76.57%	-60.45%	-84.19%	-98.78%	-84.28%	-92.40%	-95.78%	-74.93%	-99.13%	-42.78%	-96.46%	-99.97%
Separated season longitude	11	12	171	-99.90%	-83.02%	-88.96%	-45.25%	-82.10%	-98.91%	-80.85%	-95.54%	-99.02%	-76.89%	-99.62%	-41.23%	-99.79%	-99.98%
Separated season longitude	11	12	170	-99.88%	-83.02%	-88.95%	-53.80%	-84.37%	-98.83%	-82.07%	-95.65%	-97.85%	-77.11%	-99.40%	-46.16%	-99.44%	-99.59%

Leatherback turtle take reduction bin # 17 (-80% to -85%)
3 best of 4485 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	12	36	-92.01%	-83.02%	-88.88%	-79.11%	-83.66%	-81.78%	-86.39%	-89.72%	-76.66%	-78.70%	-88.71%	-50.22%	-80.50%	-83.72%
Separated season box	11	12	147036	-91.48%	-83.02%	-88.98%	-73.38%	-80.87%	-82.14%	-86.33%	-87.87%	-77.23%	-76.38%	-89.07%	-47.44%	-81.29%	-83.86%
Separated season box	11	12	146036	-91.48%	-83.02%	-88.99%	-73.41%	-80.85%	-82.14%	-86.35%	-87.84%	-77.24%	-76.37%	-89.07%	-47.48%	-81.29%	-83.86%

Leatherback turtle take reduction bin # 17 (-80% to -85%)
3 best of 4485 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	12	163030	-92.34%	-83.02%	-88.74%	-81.76%	-84.53%	-81.14%	-85.02%	-91.43%	-76.31%	-79.93%	-88.74%	-47.42%	-80.12%	-83.83%
Separated season box	11	12	163031	-92.33%	-83.02%	-88.76%	-81.64%	-84.52%	-81.17%	-85.03%	-91.18%	-76.24%	-79.18%	-88.64%	-46.73%	-79.93%	-83.79%
Separated season box	11	12	163032	-92.30%	-83.02%	-88.78%	-81.47%	-84.55%	-81.20%	-85.01%	-90.91%	-76.26%	-78.87%	-88.65%	-46.19%	-79.93%	-83.76%

Leatherback turtle take reduction bin # 16 (-75% to -80%)
3 best of 3965 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	6	12	21	-80.98%	-48.02%	-65.37%	-99.86%	-77.15%	2.01%	-61.12%	-94.46%	-63.40%	-64.28%	-29.97%	-51.49%	-75.70%	-54.10%
Separated season latitude	11	5	21	-96.29%	-81.83%	-81.97%	-99.97%	-76.07%	-75.39%	-86.06%	-97.41%	-90.02%	-90.49%	-91.00%	-57.16%	-91.81%	-89.67%
Separated season latitude	11	5	22	-95.52%	-81.83%	-81.89%	-99.80%	-76.04%	-76.65%	-86.27%	-97.41%	-89.40%	-89.20%	-90.86%	-57.40%	-91.00%	-86.36%

Leatherback turtle take reduction bin # 16 (-75% to -80%)
3 best of 3965 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	7	5	173	-99.10%	-44.96%	-50.23%	-52.66%	-79.99%	-92.14%	7.59%	-68.62%	-93.04%	-88.76%	-94.56%	-50.23%	-94.35%	-99.98%
Separated season longitude	8	3	171	-99.19%	-55.75%	-49.51%	6.71%	-79.06%	-95.02%	-45.37%	-86.18%	-92.42%	-63.75%	-95.13%	-35.76%	-95.00%	-99.74%
Separated season longitude	9	2	170	-99.42%	-64.50%	-64.14%	-6.44%	-79.89%	-92.21%	-43.92%	-84.63%	-88.32%	-65.59%	-95.40%	-40.69%	-97.77%	-99.58%

Leatherback turtle take reduction bin # 16 (-75% to -80%)
3 best of 3965 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	5	24	-95.17%	-81.83%	-82.07%	-99.01%	-75.47%	-81.22%	-87.06%	-96.59%	-87.81%	-87.90%	-90.07%	-57.22%	-87.11%	-84.32%
Separated season box	11	12	166039	-91.33%	-83.02%	-88.98%	-73.50%	-78.66%	-82.26%	-86.76%	-87.71%	-77.32%	-76.52%	-89.12%	-47.75%	-81.49%	-83.86%
Separated season box	11	12	152039	-91.33%	-83.02%	-88.99%	-73.50%	-78.66%	-82.26%	-86.76%	-87.68%	-77.32%	-76.46%	-89.12%	-47.71%	-81.49%	-83.86%

Leatherback turtle take reduction bin # 16 (-75% to -80%)
3 best of 3965 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	1	162021	-93.83%	-82.54%	-76.70%	-85.80%	-79.60%	-83.63%	-81.80%	-82.33%	-71.89%	-83.11%	-77.36%	-46.03%	-85.01%	-82.44%
Separated season box	11	1	162022	-93.56%	-82.54%	-77.25%	-85.99%	-79.64%	-83.79%	-82.08%	-83.84%	-71.21%	-80.36%	-78.56%	-46.43%	-84.85%	-79.29%
Separated season box	11	1	162023	-93.33%	-82.54%	-77.62%	-86.35%	-79.80%	-83.89%	-82.40%	-84.66%	-70.53%	-77.19%	-79.55%	-46.42%	-81.62%	-77.33%

Leatherback turtle take reduction bin # 15 (-70% to -75%)
3 best of 4145 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	6	21	-95.84%	-81.74%	-83.04%	-100.00%	-74.12%	-73.64%	-83.02%	-96.84%	-90.25%	-86.88%	-86.75%	-56.37%	-96.92%	-90.80%
Separated season latitude	11	6	22	-95.52%	-81.74%	-83.31%	-100.00%	-73.88%	-74.12%	-82.92%	-96.75%	-90.11%	-85.56%	-86.48%	-56.44%	-95.92%	-88.73%
Separated season latitude	11	6	24	-94.44%	-81.74%	-82.19%	-100.00%	-71.97%	-77.53%	-84.15%	-93.66%	-89.85%	-83.93%	-87.47%	-55.98%	-94.79%	-84.62%

Leatherback turtle take reduction bin # 15 (-70% to -75%)
3 best of 4145 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	11	5	169	-99.03%	-81.83%	-75.58%	-83.01%	-74.35%	-88.94%	-53.96%	-84.06%	-97.29%	-93.43%	-95.04%	-58.06%	-93.27%	-96.93%
Separated season longitude	11	5	167	-98.47%	-81.83%	-75.18%	-80.86%	-73.35%	-88.49%	-61.35%	-80.61%	-94.79%	-83.43%	-94.01%	-58.23%	-90.30%	-90.02%
Separated season longitude	11	5	166	-98.19%	-81.83%	-76.04%	-81.20%	-73.60%	-87.91%	-63.15%	-81.65%	-94.53%	-84.17%	-94.13%	-57.08%	-89.69%	-90.44%

Leatherback turtle take reduction bin # 15 (-70% to -75%)
3 best of 4145 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	1	150035	-91.13%	-82.54%	-78.12%	-90.36%	-71.26%	-84.84%	-86.20%	-79.90%	-68.03%	-72.33%	-78.62%	-41.91%	-81.57%	-77.62%
Separated season box	11	1	149035	-91.10%	-82.54%	-78.14%	-90.38%	-71.08%	-84.85%	-86.22%	-79.87%	-68.05%	-72.26%	-78.63%	-41.60%	-81.61%	-77.62%
Separated season box	11	1	148035	-91.02%	-82.54%	-78.12%	-90.49%	-70.29%	-84.88%	-86.34%	-79.53%	-68.12%	-72.06%	-78.66%	-41.52%	-81.68%	-77.61%

Leatherback turtle take reduction bin # 15 (-70% to -75%)
3 best of 4145 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	1	146025	-91.40%	-82.54%	-78.25%	-90.49%	-74.35%	-84.55%	-85.66%	-80.27%	-68.20%	-72.15%	-78.60%	-40.97%	-81.69%	-77.57%
Separated season box	11	1	147033	-91.43%	-82.54%	-78.16%	-90.75%	-74.82%	-84.52%	-85.56%	-80.21%	-68.10%	-72.09%	-78.57%	-40.78%	-81.63%	-77.56%
Separated season box	11	1	148034	-91.38%	-82.54%	-78.07%	-90.43%	-74.65%	-84.63%	-85.63%	-80.20%	-68.02%	-72.06%	-78.54%	-40.91%	-81.59%	-77.57%

Leatherback turtle take reduction bin # 14 (-65% to -70%)
3 best of 4977 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	6	158022	-92.47%	-81.74%	-81.34%	-100.00%	-67.10%	-81.45%	-75.79%	-85.94%	-89.68%	-84.87%	-85.32%	-56.41%	-88.74%	-87.54%
Separated season box	11	6	166027	-90.61%	-81.74%	-81.03%	-100.00%	-66.83%	-81.23%	-80.37%	-86.23%	-89.01%	-84.39%	-86.02%	-56.47%	-89.42%	-85.24%
Separated season box	11	6	173029	-90.24%	-81.74%	-81.13%	-100.00%	-65.88%	-81.49%	-81.03%	-86.37%	-89.03%	-84.29%	-85.64%	-56.49%	-89.21%	-85.20%

Leatherback turtle take reduction bin # 14 (-65% to -70%)
3 best of 4977 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	6	5	171	-98.31%	-36.49%	-26.14%	18.36%	-66.88%	-88.06%	21.37%	-57.72%	-89.19%	-60.07%	-90.72%	-31.35%	-91.26%	-96.73%
Separated season box	11	5	166030	-90.35%	-81.83%	-79.18%	-85.43%	-65.00%	-86.03%	-81.64%	-80.24%	-89.09%	-85.01%	-87.89%	-55.84%	-78.93%	-85.14%
Separated season box	11	5	164030	-90.35%	-81.83%	-79.20%	-85.43%	-65.00%	-86.03%	-81.64%	-80.00%	-89.06%	-84.93%	-87.81%	-55.84%	-78.78%	-85.14%

Leatherback turtle take reduction bin # 14 (-65% to -70%)
3 best of 4977 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	1	148039	-90.79%	-82.54%	-78.25%	-90.31%	-68.33%	-84.96%	-86.66%	-78.84%	-68.30%	-72.21%	-78.80%	-40.11%	-81.80%	-77.63%
Separated season box	11	1	147039	-90.79%	-82.54%	-78.25%	-90.31%	-68.33%	-84.96%	-86.66%	-78.78%	-68.30%	-72.20%	-78.81%	-40.09%	-81.80%	-77.63%
Separated season box	11	1	146039	-90.79%	-82.54%	-78.25%	-90.31%	-68.33%	-84.96%	-86.66%	-78.77%	-68.30%	-72.20%	-78.80%	-40.08%	-81.80%	-77.63%

Leatherback turtle take reduction bin # 14 (-65% to -70%)
3 best of 4977 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	1	147035	-90.96%	-82.54%	-78.14%	-90.55%	-69.90%	-84.89%	-86.42%	-79.18%	-68.20%	-72.15%	-78.72%	-40.58%	-81.73%	-77.62%
Separated season box	11	1	146035	-90.94%	-82.54%	-78.15%	-90.48%	-69.60%	-84.91%	-86.46%	-79.09%	-68.23%	-72.22%	-78.74%	-39.58%	-81.78%	-77.62%
Separated season box	11	1	152036	-90.89%	-82.54%	-78.20%	-90.53%	-69.57%	-84.90%	-86.54%	-79.09%	-68.25%	-72.22%	-78.76%	-41.40%	-81.75%	-77.62%

Leatherback turtle take reduction bin # 13 (-60% to -65%)
3 best of 3720 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	6	148029	-89.94%	-81.74%	-81.31%	-100.00%	-64.42%	-81.83%	-81.67%	-83.69%	-88.51%	-83.28%	-84.61%	-56.17%	-86.26%	-85.07%
Separated season box	11	6	170035	-89.92%	-81.74%	-81.32%	-100.00%	-64.20%	-81.86%	-81.75%	-83.65%	-88.53%	-83.30%	-84.61%	-56.20%	-86.22%	-85.07%
Separated season box	11	6	169038	-89.92%	-81.74%	-81.32%	-100.00%	-64.20%	-81.86%	-81.75%	-83.31%	-88.45%	-83.26%	-84.51%	-56.18%	-86.00%	-85.06%

Leatherback turtle take reduction bin # 13 (-60% to -65%)
3 best of 3720 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	11	6	172	-99.36%	-81.74%	-83.16%	-99.98%	-62.38%	-88.91%	-53.70%	-88.89%	-98.01%	-97.26%	-91.12%	-60.00%	-94.68%	-98.63%
Separated season longitude	11	6	171	-99.29%	-81.74%	-83.18%	-99.98%	-62.25%	-89.00%	-55.74%	-88.99%	-98.08%	-97.27%	-90.96%	-60.00%	-94.00%	-95.99%
Separated season longitude	11	6	170	-99.20%	-81.74%	-82.96%	-99.99%	-64.15%	-90.32%	-56.84%	-89.34%	-98.01%	-97.04%	-92.46%	-60.00%	-93.97%	-95.92%

Leatherback turtle take reduction bin # 13 (-60% to -65%)
3 best of 3720 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	11	5	165034	-90.01%	-81.83%	-79.12%	-85.51%	-64.06%	-86.10%	-82.14%	-78.11%	-88.88%	-84.73%	-87.03%	-55.36%	-77.59%	-85.19%
Separated season box	11	5	146036	-90.01%	-81.83%	-79.12%	-85.51%	-64.06%	-86.10%	-82.14%	-77.48%	-88.82%	-84.63%	-86.87%	-55.31%	-77.10%	-85.18%
Separated season box	11	5	154039	-90.01%	-81.83%	-79.12%	-85.51%	-64.06%	-86.10%	-82.14%	-77.46%	-88.82%	-84.63%	-86.87%	-55.31%	-77.08%	-85.18%

Leatherback turtle take reduction bin # 13 (-60% to -65%)
3 best of 3720 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	11	5	30	-90.39%	-81.83%	-79.24%	-85.49%	-64.99%	-86.02%	-81.90%	-82.15%	-89.13%	-85.28%	-88.17%	-56.16%	-79.21%	-84.91%
Separated season box	11	5	150029	-90.28%	-81.83%	-79.20%	-85.67%	-64.95%	-86.05%	-81.66%	-78.38%	-88.94%	-84.66%	-87.13%	-55.39%	-77.56%	-85.15%
Separated season box	11	5	173030	-90.36%	-81.83%	-79.21%	-85.43%	-64.99%	-86.03%	-81.65%	-81.25%	-89.10%	-85.19%	-88.06%	-56.15%	-79.09%	-84.98%

Leatherback turtle take reduction bin # 12 (-55% to -60%)
3 best of 3870 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	10	7	31	-81.66%	-73.34%	-74.01%	-99.99%	-59.82%	-71.27%	-66.22%	-76.23%	-85.17%	-71.49%	-77.34%	-54.66%	-84.78%	-77.55%
Separated season latitude	10	7	32	-81.57%	-73.34%	-74.05%	-99.99%	-59.51%	-71.33%	-66.26%	-75.76%	-85.08%	-71.38%	-77.18%	-54.64%	-84.27%	-77.52%
Separated season latitude	10	7	33	-81.54%	-73.34%	-74.07%	-99.99%	-59.45%	-71.35%	-65.47%	-75.44%	-85.02%	-71.33%	-77.08%	-54.63%	-84.04%	-77.51%

Leatherback turtle take reduction bin # 12 (-55% to -60%)
3 best of 3870 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	6	173	-99.30%	-71.94%	-69.32%	-88.02%	-58.85%	-89.64%	-18.82%	-78.37%	-97.24%	-96.82%	-89.88%	-60.00%	-93.58%	-98.63%
Separated season longitude	10	6	172	-98.95%	-71.94%	-69.85%	-89.40%	-58.70%	-89.53%	-36.19%	-75.96%	-96.29%	-95.59%	-89.44%	-57.99%	-93.18%	-96.63%
Separated season longitude	10	6	170	-98.45%	-71.94%	-73.14%	-87.71%	-59.45%	-90.47%	-43.26%	-75.99%	-96.05%	-95.54%	-89.24%	-57.92%	-89.61%	-94.92%

Leatherback turtle take reduction bin # 12 (-55% to -60%)
3 best of 3870 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	10	6	24	-89.60%	-71.94%	-72.37%	-99.22%	-59.45%	-68.40%	-77.92%	-90.71%	-81.68%	-77.82%	-81.64%	-54.72%	-83.85%	-75.45%
Separated season latitude	10	6	25	-88.25%	-71.94%	-71.78%	-98.92%	-58.70%	-71.25%	-77.13%	-85.42%	-81.61%	-77.93%	-81.10%	-54.64%	-75.06%	-76.23%
Separated season latitude	10	6	26	-86.91%	-71.94%	-71.58%	-98.25%	-56.27%	-72.27%	-77.28%	-84.27%	-81.82%	-77.99%	-80.73%	-54.80%	-72.05%	-76.32%

Leatherback turtle take reduction bin # 12 (-55% to -60%)
3 best of 3870 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Season	8	1	0	-69.73%	-61.02%	-65.62%	-70.77%	-59.33%	-55.67%	-68.69%	-68.01%	-46.24%	-50.04%	-65.14%	-32.43%	-50.01%	-45.81%
Separated season latitude	10	6	24	-89.60%	-71.94%	-72.37%	-99.22%	-59.45%	-68.40%	-77.92%	-90.71%	-81.68%	-77.82%	-81.64%	-54.72%	-83.85%	-75.45%
Separated season latitude	10	6	25	-88.25%	-71.94%	-71.78%	-98.92%	-58.70%	-71.25%	-77.13%	-85.42%	-81.61%	-77.93%	-81.10%	-54.64%	-75.06%	-76.23%

Leatherback turtle take reduction bin # 11 (-50% to -55%)
3 best of 3393 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	5	11	21	-76.71%	-36.98%	-49.95%	-99.85%	-51.52%	18.50%	-51.38%	-89.55%	-60.50%	-53.10%	-20.37%	-48.76%	-75.84%	-49.86%
Separated season latitude	6	10	21	-78.97%	-44.63%	-55.21%	-99.85%	-53.36%	44.17%	-54.56%	-89.98%	-68.80%	-56.28%	-25.06%	-48.74%	-82.21%	-59.41%
Separated season latitude	7	9	21	-81.11%	-50.24%	-58.03%	-99.84%	-54.35%	-24.77%	-58.01%	-90.18%	-72.17%	-58.86%	-33.04%	-50.01%	-85.23%	-65.71%

Leatherback turtle take reduction bin # 11 (-50% to -55%)
3 best of 3393 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	5	6	173	-98.50%	-26.96%	-41.90%	-51.89%	-53.66%	-83.90%	40.64%	-56.76%	-90.94%	-82.10%	-85.60%	-40.00%	-89.02%	-98.61%
Separated season longitude	6	6	171	-97.70%	-35.31%	-21.54%	-22.20%	-53.05%	-81.01%	37.04%	-51.94%	-88.24%	-79.08%	-82.10%	-48.83%	-85.68%	-92.76%
Separated season longitude	7	6	171	-97.72%	-44.22%	-32.69%	-17.35%	-54.22%	-80.98%	40.17%	-55.14%	-91.40%	-81.41%	-82.55%	-48.24%	-89.07%	-92.80%

Leatherback turtle take reduction bin # 11 (-50% to -55%)
3 best of 3393 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	9	7	24	-84.61%	-63.55%	-65.97%	-99.22%	-54.42%	-57.52%	-68.88%	-85.23%	-78.32%	-64.44%	-69.93%	-53.60%	-81.64%	-67.29%
Separated season latitude	10	6	27	-85.63%	-71.94%	-70.79%	-95.53%	-54.04%	-73.46%	-75.30%	-82.55%	-82.12%	-78.13%	-80.24%	-54.59%	-70.26%	-76.50%
Separated season latitude	10	6	28	-84.27%	-71.94%	-70.29%	-92.91%	-51.51%	-74.32%	-72.45%	-80.44%	-82.41%	-78.22%	-80.17%	-54.50%	-69.71%	-76.68%

Leatherback turtle take reduction bin # 11 (-50% to -55%)
3 best of 3393 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	10	6	27	-85.63%	-71.94%	-70.79%	-95.53%	-54.04%	-73.46%	-75.30%	-82.55%	-82.12%	-78.13%	-80.24%	-54.59%	-70.26%	-76.50%
Separated season box	10	6	166025	-85.69%	-71.94%	-69.48%	-88.01%	-53.63%	-74.36%	-61.34%	-74.07%	-82.60%	-77.42%	-80.65%	-53.25%	-80.39%	-77.66%
Separated season box	10	6	163025	-85.05%	-71.94%	-69.49%	-87.58%	-52.97%	-74.52%	-62.56%	-73.02%	-82.72%	-76.96%	-79.89%	-53.29%	-79.16%	-77.69%

Leatherback turtle take reduction bin # 10 (-45% to -50%)
3 best of 3650 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	1	21	-65.63%	-9.20%	-12.36%	-99.70%	-46.30%	45.61%	-34.42%	-83.60%	-19.99%	-42.34%	12.76%	-36.75%	-38.79%	-23.00%
Separated season latitude	4	12	21	-73.11%	-28.17%	-45.11%	-99.83%	-47.49%	29.80%	-46.02%	-89.17%	-48.47%	-50.50%	-13.47%	-47.37%	-65.59%	-41.46%
Separated season latitude	4	12	22	-68.04%	-28.17%	-43.43%	-99.63%	-47.13%	26.41%	-45.92%	-88.97%	-46.16%	-44.89%	-16.39%	-48.26%	-61.96%	-31.01%

Leatherback turtle take reduction bin # 10 (-45% to -50%)
3 best of 3650 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	10	6	149029	-80.21%	-71.94%	-69.37%	-88.65%	-45.15%	-75.52%	-71.58%	-69.38%	-82.76%	-75.49%	-78.14%	-53.45%	-71.41%	-77.46%
Separated season box	10	6	151030	-80.13%	-71.94%	-69.37%	-88.49%	-45.04%	-75.53%	-71.72%	-69.64%	-82.78%	-75.45%	-78.24%	-53.61%	-71.49%	-77.48%
Separated season box	10	6	150030	-80.10%	-71.94%	-69.37%	-88.51%	-45.00%	-75.54%	-71.77%	-69.52%	-82.78%	-75.46%	-78.20%	-53.63%	-71.50%	-77.47%

Leatherback turtle take reduction bin # 10 (-45% to -50%)
3 best of 3650 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	10	6	30	-80.45%	-71.94%	-69.39%	-88.50%	-45.51%	-75.42%	-71.70%	-73.03%	-83.05%	-76.16%	-79.26%	-54.36%	-73.20%	-77.27%
Separated season box	10	6	151030	-80.13%	-71.94%	-69.37%	-88.49%	-45.04%	-75.53%	-71.72%	-69.64%	-82.78%	-75.45%	-78.24%	-53.61%	-71.49%	-77.48%
Separated season box	10	6	150030	-80.10%	-71.94%	-69.37%	-88.51%	-45.00%	-75.54%	-71.77%	-69.52%	-82.78%	-75.46%	-78.20%	-53.63%	-71.50%	-77.47%

Leatherback turtle take reduction bin # 10 (-45% to -50%)
3 best of 3650 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	10	6	156025	-82.80%	-71.94%	-69.50%	-88.04%	-49.78%	-75.15%	-67.04%	-71.17%	-82.94%	-75.96%	-78.64%	-53.66%	-73.86%	-77.56%
Separated season box	10	6	157026	-82.68%	-71.94%	-69.43%	-88.13%	-49.99%	-74.89%	-66.92%	-71.33%	-82.66%	-76.05%	-78.60%	-53.67%	-73.41%	-77.40%
Separated season box	10	6	157027	-82.43%	-71.94%	-69.43%	-88.34%	-49.81%	-74.95%	-67.37%	-71.25%	-82.57%	-76.07%	-78.51%	-53.74%	-72.96%	-77.38%

Leatherback turtle take reduction bin # 9 (-40% to -45%)
3 best of 4035 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	1	22	-58.27%	-9.20%	-18.67%	-99.43%	-44.95%	44.38%	-32.59%	-83.60%	-17.04%	-33.46%	8.48%	-40.60%	-36.61%	-8.67%
Separated season latitude	3	1	21	-69.57%	-18.90%	-32.65%	-99.81%	-41.66%	38.53%	-39.26%	-86.43%	-29.49%	-45.09%	3.87%	-37.75%	-49.93%	-28.59%
Separated season latitude	3	1	22	-62.65%	-18.90%	-27.49%	-99.57%	-40.20%	37.68%	-37.26%	-86.61%	-26.70%	-35.95%	-0.51%	-41.46%	-47.81%	-15.04%

Leatherback turtle take reduction bin # 9 (-40% to -45%)
3 best of 4035 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	5	6	171	-97.60%	-26.96%	-18.18%	13.74%	-42.64%	-80.55%	48.55%	-47.73%	-87.33%	-57.32%	-81.80%	-31.49%	-85.46%	-92.74%
Separated season longitude	5	6	170	-97.19%	-26.96%	-17.64%	35.00%	-42.60%	-77.69%	53.52%	-39.91%	-76.98%	-51.47%	-79.20%	-36.85%	-83.97%	-90.14%
Separated season longitude	11	8	169	-98.55%	-84.16%	-86.48%	-81.75%	-42.89%	-78.53%	-61.19%	-88.48%	-97.13%	-92.96%	-97.65%	-59.58%	-96.38%	-95.95%

Leatherback turtle take reduction bin # 9 (-40% to -45%)
3 best of 4035 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Season	10	6	0	-79.93%	-71.94%	-69.36%	-88.52%	-44.20%	-75.60%	-72.05%	-68.64%	-82.65%	-75.45%	-77.96%	-53.47%	-70.99%	-77.46%
Separated season box	10	6	173036	-79.93%	-71.94%	-69.36%	-88.52%	-44.20%	-75.60%	-72.05%	-69.14%	-82.72%	-75.55%	-78.10%	-53.49%	-71.33%	-77.48%
Separated season box	10	6	153037	-79.93%	-71.94%	-69.36%	-88.52%	-44.20%	-75.60%	-72.05%	-68.71%	-82.66%	-75.46%	-77.98%	-53.47%	-71.04%	-77.47%

Leatherback turtle take reduction bin # 9 (-40% to -45%)
3 best of 4035 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	10	6	148	-80.14%	-71.94%	-69.36%	-88.59%	-44.81%	-75.53%	-71.70%	-69.27%	-82.76%	-75.48%	-78.10%	-53.48%	-71.43%	-77.47%
Separated season box	10	6	148022	-80.14%	-71.94%	-69.36%	-88.59%	-44.81%	-75.53%	-71.70%	-69.26%	-82.76%	-75.48%	-78.10%	-53.48%	-71.43%	-77.46%
Separated season box	10	6	149030	-80.08%	-71.94%	-69.37%	-88.51%	-44.90%	-75.55%	-71.80%	-69.37%	-82.77%	-75.46%	-78.11%	-53.49%	-71.43%	-77.47%

Leatherback turtle take reduction bin # 8 (-35% to -40%)
3 best of 5630 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	2	21	-66.13%	-9.40%	-23.18%	-99.35%	-39.04%	46.63%	-34.64%	-86.10%	-16.58%	-43.48%	17.95%	-31.38%	-42.92%	-22.90%
Separated season latitude	3	1	23	-59.05%	-18.90%	-27.28%	-99.26%	-39.59%	37.34%	-34.77%	-84.01%	-23.55%	-25.81%	-8.56%	-42.34%	-40.64%	-4.93%
Merged season latitude	11	6	21	-52.92%	0.00%	-5.04%	-99.09%	-38.30%	49.23%	-27.27%	-75.95%	-3.71%	-39.99%	29.07%	-29.00%	-21.89%	-13.25%

Leatherback turtle take reduction bin # 8 (-35% to -40%)
3 best of 5630 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	4	7	171	-96.32%	-18.95%	-11.08%	11.86%	-37.91%	-69.69%	93.35%	-36.26%	-85.85%	-56.00%	-79.68%	-31.29%	-82.70%	-92.34%
Separated season longitude	8	10	171	-96.61%	-64.42%	-66.99%	-60.47%	-37.73%	-68.20%	7.16%	-69.07%	-94.45%	-94.58%	-95.41%	-56.04%	-89.60%	-95.77%
Separated season longitude	10	9	170	-97.96%	-78.40%	-82.59%	-55.05%	-37.60%	-75.66%	-50.73%	-83.18%	-95.75%	-95.75%	-98.08%	-57.95%	-92.49%	-97.15%

Leatherback turtle take reduction bin # 8 (-35% to -40%)
3 best of 5630 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	9	7	31	-71.71%	-63.55%	-62.09%	-88.64%	-39.87%	-65.05%	-56.69%	-62.47%	-79.32%	-63.90%	-70.98%	-52.14%	-70.18%	-69.94%
Separated season latitude	9	7	32	-71.59%	-63.55%	-62.12%	-88.62%	-39.48%	-65.10%	-56.76%	-61.82%	-79.25%	-63.75%	-70.78%	-52.00%	-69.72%	-69.93%
Separated season latitude	9	7	33	-71.56%	-63.55%	-62.14%	-88.62%	-39.42%	-65.12%	-55.98%	-61.41%	-79.19%	-63.68%	-70.67%	-51.97%	-69.43%	-69.91%

Leatherback turtle take reduction bin # 8 (-35% to -40%)
3 best of 5630 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	7	7	34	-52.74%	-45.17%	-39.38%	-52.79%	-39.82%	-54.06%	-39.34%	-38.94%	-59.51%	-52.32%	-49.71%	-34.68%	-53.89%	-57.85%
Separated season latitude	7	7	35	-52.73%	-45.17%	-39.38%	-52.78%	-39.81%	-54.07%	-39.34%	-38.62%	-59.42%	-52.26%	-49.58%	-34.58%	-53.75%	-57.84%
Separated season latitude	7	7	36	-52.71%	-45.17%	-39.37%	-52.78%	-39.71%	-54.09%	-39.30%	-38.34%	-59.35%	-52.19%	-49.48%	-34.48%	-53.63%	-57.83%

Leatherback turtle take reduction bin # 7 (-30% to -35%)
3 best of 5360 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	2	24	-48.69%	-9.40%	-19.97%	-95.23%	-34.14%	35.33%	-35.03%	-73.78%	-7.85%	-20.28%	1.60%	-34.53%	-22.54%	2.07%
Separated season latitude	3	1	26	-47.67%	-18.90%	-24.81%	-96.33%	-32.24%	8.41%	-38.09%	-60.71%	-20.93%	-22.99%	-15.18%	-41.50%	-17.67%	-5.94%
Merged season latitude	9	8	21	-45.03%	0.00%	-4.35%	-94.91%	-34.00%	44.94%	-19.06%	-64.62%	-3.94%	-41.51%	10.50%	-28.12%	-15.64%	-14.15%

Leatherback turtle take reduction bin # 7 (-30% to -35%)
3 best of 5360 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	6	12	172	-96.64%	-48.02%	-52.26%	-51.38%	-30.18%	-63.87%	29.10%	-68.35%	-94.30%	-91.87%	-96.71%	-46.11%	-89.08%	-97.35%
Separated season longitude	8	10	172	-96.82%	-64.42%	-72.95%	-57.73%	-34.10%	-71.04%	7.88%	-72.03%	-95.23%	-97.08%	-97.30%	-55.10%	-89.46%	-97.37%
Separated season longitude	9	10	170	-97.73%	-72.94%	-74.72%	-60.50%	-31.46%	-75.20%	-43.17%	-80.50%	-94.22%	-95.34%	-97.51%	-56.93%	-88.35%	-95.55%

Leatherback turtle take reduction bin # 7 (-30% to -35%)
3 best of 5360 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	8	8	30	-65.51%	-56.06%	-57.37%	-86.37%	-34.19%	-51.84%	-48.20%	-60.46%	-75.63%	-57.11%	-59.27%	-51.09%	-66.51%	-64.03%
Separated season latitude	8	8	31	-64.75%	-56.06%	-57.29%	-86.13%	-33.10%	-52.14%	-47.75%	-58.01%	-75.46%	-56.99%	-59.07%	-50.80%	-65.58%	-64.31%
Separated season latitude	8	8	32	-64.55%	-56.06%	-57.28%	-85.98%	-32.64%	-52.24%	-47.63%	-57.20%	-75.36%	-56.89%	-59.05%	-50.67%	-64.94%	-64.33%

Leatherback turtle take reduction bin # 7 (-30% to -35%)
3 best of 5360 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	6	6	31	-47.16%	-35.31%	-22.66%	-46.19%	-32.96%	-47.08%	-34.48%	-34.35%	-25.90%	-43.75%	-28.95%	-26.19%	-35.14%	-41.93%
Separated season box	6	6	173031	-47.06%	-35.31%	-22.75%	-46.36%	-32.69%	-47.21%	-34.32%	-33.48%	-25.82%	-42.16%	-28.87%	-25.95%	-35.18%	-41.95%
Separated season box	6	6	170031	-47.05%	-35.31%	-22.99%	-46.36%	-32.68%	-47.23%	-34.32%	-32.80%	-25.95%	-41.85%	-28.94%	-26.11%	-35.68%	-41.96%

Leatherback turtle take reduction bin # 6 (-25% to -30%)
3 best of 5006 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	2	2	26	-41.05%	-9.40%	-16.16%	-91.14%	-29.73%	14.11%	-31.51%	-58.32%	-7.19%	-19.50%	-1.58%	-34.50%	-8.77%	0.49%
Separated season latitude	3	1	27	-44.73%	-18.90%	-22.48%	-92.76%	-29.04%	1.65%	-32.50%	-57.22%	-19.24%	-23.38%	-16.77%	-38.00%	-14.05%	-6.51%
Merged season latitude	9	7	21	-42.04%	0.00%	-2.83%	-90.33%	-29.30%	40.94%	-21.46%	-57.87%	-5.92%	-40.05%	20.38%	-27.93%	-12.57%	-13.81%

Leatherback turtle take reduction bin # 6 (-25% to -30%)
3 best of 5006 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	8	9	170	-95.78%	-60.02%	-62.85%	-59.98%	-25.50%	-64.46%	8.46%	-62.16%	-92.06%	-89.83%	-88.09%	-57.62%	-83.95%	-91.81%
Separated season longitude	8	11	170	-97.59%	-65.39%	-70.91%	-57.04%	-29.57%	-67.99%	-21.10%	-78.33%	-93.15%	-93.60%	-96.71%	-54.26%	-85.33%	-93.97%
Separated season longitude	10	9	171	-98.08%	-78.40%	-83.61%	-52.78%	-28.90%	-77.86%	-53.18%	-82.92%	-96.03%	-96.09%	-97.74%	-57.54%	-92.61%	-96.44%

Leatherback turtle take reduction bin # 6 (-25% to -30%)
3 best of 5006 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	6	6	34	-43.68%	-35.31%	-23.45%	-31.40%	-25.41%	-48.59%	-39.17%	-27.33%	-28.21%	-39.87%	-30.91%	-15.06%	-38.50%	-42.33%
Separated season box	6	6	173034	-43.68%	-35.31%	-23.43%	-31.41%	-25.43%	-48.59%	-39.12%	-26.95%	-28.11%	-39.42%	-30.85%	-14.95%	-38.39%	-42.32%
Separated season longitude	10	9	171	-98.08%	-78.40%	-83.61%	-52.78%	-28.90%	-77.86%	-53.18%	-82.92%	-96.03%	-96.09%	-97.74%	-57.54%	-92.61%	-96.44%

Leatherback turtle take reduction bin # 6 (-25% to -30%)
3 best of 5006 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	6	6	159031	-46.31%	-35.31%	-23.82%	-38.71%	-29.99%	-48.18%	-34.22%	-27.44%	-27.56%	-39.65%	-29.79%	-18.45%	-36.24%	-42.18%
Separated season box	6	6	164032	-45.40%	-35.31%	-23.30%	-38.67%	-29.87%	-48.09%	-35.76%	-28.78%	-27.27%	-40.32%	-29.62%	-19.93%	-37.18%	-42.16%
Separated season longitude	10	9	171	-98.08%	-78.40%	-83.61%	-52.78%	-28.90%	-77.86%	-53.18%	-82.92%	-96.03%	-96.09%	-97.74%	-57.54%	-92.61%	-96.44%

Leatherback turtle take reduction bin # 5 (-20% to -25%)
3 best of 5955 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	3	1	29	-38.62%	-18.90%	-21.13%	-85.22%	-22.01%	-1.94%	-22.57%	-48.67%	-17.66%	-24.13%	-19.98%	-36.70%	-10.87%	-8.98%
Separated season longitude	9	8	169	-96.16%	-65.83%	-65.76%	-86.27%	-23.70%	-61.72%	-3.74%	-66.04%	-90.52%	-76.22%	-84.16%	-59.22%	-85.73%	-81.41%
Separated season longitude	10	8	170	-97.26%	-75.73%	-77.15%	-86.25%	-24.69%	-71.45%	-21.75%	-77.13%	-95.27%	-95.97%	-96.53%	-59.23%	-93.33%	-97.06%

Leatherback turtle take reduction bin # 5 (-20% to -25%)
3 best of 5955 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	9	10	171	-97.89%	-72.94%	-75.35%	-56.13%	-21.54%	-76.95%	-42.61%	-80.35%	-95.91%	-95.97%	-97.55%	-56.46%	-92.42%	-96.39%
Separated season longitude	10	8	170	-97.26%	-75.73%	-77.15%	-86.25%	-24.69%	-71.45%	-21.75%	-77.13%	-95.27%	-95.97%	-96.53%	-59.23%	-93.33%	-97.06%
Separated season longitude	10	9	172	-98.19%	-78.40%	-84.47%	-51.13%	-23.03%	-78.40%	-51.54%	-83.57%	-96.24%	-98.59%	-98.79%	-56.80%	-92.58%	-98.02%

Leatherback turtle take reduction bin # 5 (-20% to -25%)
3 best of 5955 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	6	6	149035	-42.74%	-35.31%	-23.72%	-28.84%	-20.04%	-49.06%	-39.78%	-24.77%	-28.47%	-38.21%	-31.18%	-12.54%	-38.34%	-42.37%
Separated season longitude	9	10	171	-97.89%	-72.94%	-75.35%	-56.13%	-21.54%	-76.95%	-42.61%	-80.35%	-95.91%	-95.97%	-97.55%	-56.46%	-92.42%	-96.39%
Separated season longitude	10	9	172	-98.19%	-78.40%	-84.47%	-51.13%	-23.03%	-78.40%	-51.54%	-83.57%	-96.24%	-98.59%	-98.79%	-56.80%	-92.58%	-98.02%

Leatherback turtle take reduction bin # 5 (-20% to -25%)
3 best of 5955 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	5	6	169033	-37.44%	-26.96%	-20.08%	-31.06%	-24.89%	-37.24%	-29.92%	-25.01%	-14.66%	-30.39%	-24.61%	-12.31%	-25.44%	-32.51%
Separated season box	5	6	168033	-37.41%	-26.96%	-20.11%	-30.77%	-24.88%	-37.30%	-29.96%	-24.84%	-14.76%	-30.56%	-24.63%	-11.62%	-25.51%	-32.53%
Separated season box	5	6	167033	-37.40%	-26.96%	-20.18%	-30.43%	-24.80%	-37.33%	-29.93%	-24.74%	-14.88%	-30.28%	-24.71%	-11.89%	-25.63%	-32.54%

Leatherback turtle take reduction bin # 4 (-15% to -20%)
3 best of 9396 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	3	1	30	-36.05%	-18.90%	-21.12%	-83.59%	-19.03%	-3.19%	-22.55%	-43.90%	-17.27%	-23.60%	-20.45%	-36.81%	-10.18%	-10.01%
Separated season latitude	3	1	31	-34.80%	-18.90%	-21.35%	-82.61%	-17.40%	-4.11%	-21.62%	-40.16%	-16.46%	-22.97%	-20.51%	-36.21%	-8.10%	-10.79%
Separated season longitude	10	8	171	-97.44%	-75.73%	-80.28%	-86.97%	-16.02%	-71.76%	-16.70%	-77.16%	-95.98%	-97.35%	-97.02%	-59.19%	-93.62%	-97.70%

Leatherback turtle take reduction bin # 4 (-15% to -20%)
3 best of 9396 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	9	9	173	-97.38%	-69.94%	-78.89%	-62.30%	-17.86%	-84.39%	-29.81%	-74.24%	-95.62%	-98.45%	-97.35%	-56.08%	-91.12%	-98.79%
Separated season longitude	9	10	172	-98.05%	-72.94%	-81.20%	-53.22%	-15.30%	-79.65%	-43.09%	-81.46%	-96.11%	-98.46%	-98.78%	-55.59%	-92.43%	-97.99%
Separated season longitude	10	8	171	-97.44%	-75.73%	-80.28%	-86.97%	-16.02%	-71.76%	-16.70%	-77.16%	-95.98%	-97.35%	-97.02%	-59.19%	-93.62%	-97.70%

Leatherback turtle take reduction bin # 4 (-15% to -20%)
3 best of 9396 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	6	6	168038	-42.39%	-35.31%	-23.79%	-28.52%	-18.56%	-49.13%	-40.08%	-24.34%	-28.69%	-38.34%	-31.37%	-11.74%	-38.53%	-42.38%
Separated season box	6	6	162039	-42.39%	-35.31%	-23.78%	-28.52%	-18.56%	-49.13%	-40.08%	-24.15%	-28.65%	-38.22%	-31.34%	-11.68%	-38.45%	-42.38%
Separated season longitude	9	10	172	-98.05%	-72.94%	-81.20%	-53.22%	-15.30%	-79.65%	-43.09%	-81.46%	-96.11%	-98.46%	-98.78%	-55.59%	-92.43%	-97.99%

Leatherback turtle take reduction bin # 4 (-15% to -20%)
3 best of 9396 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	4	6	164034	-29.27%	-19.78%	-15.35%	-20.91%	-19.20%	-27.90%	-26.40%	-19.49%	-8.62%	-22.10%	-22.27%	-5.22%	-14.64%	-19.77%
Separated season box	6	6	148035	-42.66%	-35.31%	-23.70%	-28.90%	-19.53%	-49.08%	-39.84%	-24.59%	-28.51%	-38.11%	-31.20%	-12.49%	-38.37%	-42.36%
Separated season box	6	6	147035	-42.59%	-35.31%	-23.72%	-28.92%	-19.28%	-49.09%	-39.89%	-24.38%	-28.55%	-38.14%	-31.23%	-11.99%	-38.39%	-42.37%

Leatherback turtle take reduction bin # 3 (-10% to -15%)
3 best of 14312 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	3	1	33	-33.56%	-18.90%	-22.77%	-78.76%	-13.66%	-6.03%	-20.07%	-35.27%	-17.26%	-17.02%	-21.84%	-33.07%	-5.52%	-11.48%
Separated season longitude	10	8	172	-97.57%	-75.73%	-80.24%	-86.53%	-10.21%	-71.39%	-14.65%	-79.76%	-96.83%	-97.35%	-97.76%	-59.09%	-93.52%	-97.52%
Separated season longitude	11	8	170	-98.63%	-84.16%	-87.97%	-82.02%	-14.13%	-79.84%	-63.52%	-88.61%	-97.13%	-98.99%	-99.15%	-59.67%	-96.37%	-98.52%

Leatherback turtle take reduction bin # 3 (-10% to -15%)
3 best of 14312 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	6	1	172	-97.84%	-47.37%	-57.84%	-47.89%	-11.39%	-72.37%	-23.07%	-74.48%	-91.89%	-90.96%	-97.71%	-47.77%	-88.72%	-97.97%
Separated season longitude	7	12	172	-97.86%	-56.62%	-60.86%	-46.57%	-12.17%	-72.59%	-22.60%	-77.77%	-95.17%	-93.16%	-98.18%	-46.48%	-92.06%	-97.98%
Separated season longitude	11	8	170	-98.63%	-84.16%	-87.97%	-82.02%	-14.13%	-79.84%	-63.52%	-88.61%	-97.13%	-98.99%	-99.15%	-59.67%	-96.37%	-98.52%

Leatherback turtle take reduction bin # 3 (-10% to -15%)
3 best of 14312 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	5	6	147039	-33.70%	-26.96%	-20.74%	-13.77%	-11.04%	-39.36%	-33.67%	-18.85%	-17.20%	-26.16%	-26.38%	-7.73%	-27.86%	-32.92%
Separated season box	5	6	146039	-33.70%	-26.96%	-20.74%	-13.77%	-11.04%	-39.36%	-33.67%	-18.84%	-17.20%	-26.16%	-26.37%	-7.72%	-27.85%	-32.92%
Separated season longitude	11	8	170	-98.63%	-84.16%	-87.97%	-82.02%	-14.13%	-79.84%	-63.52%	-88.61%	-97.13%	-98.99%	-99.15%	-59.67%	-96.37%	-98.52%

Leatherback turtle take reduction bin # 3 (-10% to -15%)
3 best of 14312 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	3	6	172035	-23.90%	-14.21%	-10.49%	-18.71%	-14.92%	-19.11%	-19.85%	-16.44%	-5.00%	-20.16%	-17.11%	-4.91%	-4.56%	-11.59%
Separated season box	3	6	171035	-23.84%	-14.21%	-10.50%	-18.77%	-14.79%	-19.27%	-20.26%	-16.24%	-5.03%	-19.94%	-17.11%	-5.12%	-4.72%	-11.59%
Separated season longitude	11	8	170	-98.63%	-84.16%	-87.97%	-82.02%	-14.13%	-79.84%	-63.52%	-88.61%	-97.13%	-98.99%	-99.15%	-59.67%	-96.37%	-98.52%

Leatherback turtle take reduction bin # 2 (-5% to -10%)
3 best of 18589 scenarios at this take level with maximum loggerhead turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season box	3	1	173034	-32.08%	-18.90%	-22.65%	-64.15%	-8.26%	-9.03%	-14.21%	-29.15%	-19.22%	-14.98%	-23.49%	-24.31%	-10.33%	-12.01%
Separated season box	3	1	172034	-31.97%	-18.90%	-22.64%	-63.96%	-8.05%	-9.18%	-14.28%	-29.12%	-19.28%	-14.74%	-23.53%	-25.37%	-10.53%	-12.02%
Separated season box	3	1	171034	-31.90%	-18.90%	-22.63%	-63.95%	-7.97%	-9.29%	-14.55%	-28.84%	-19.37%	-14.25%	-23.57%	-25.68%	-10.61%	-12.04%

Leatherback turtle take reduction bin # 2 (-5% to -10%)
3 best of 18589 scenarios at this take level with maximum olive ridley turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season longitude	6	12	173	-97.11%	-48.02%	-71.26%	-52.93%	-6.51%	-77.08%	3.20%	-68.72%	-94.69%	-93.47%	-96.75%	-43.06%	-90.53%	-98.76%
Separated season longitude	7	11	173	-97.18%	-56.83%	-71.79%	-52.52%	-8.55%	-74.19%	9.34%	-70.13%	-95.01%	-97.95%	-96.89%	-52.81%	-90.70%	-98.76%
Separated season longitude	8	10	173	-97.25%	-64.42%	-75.11%	-56.98%	-9.88%	-84.72%	-18.25%	-72.19%	-95.57%	-98.28%	-97.33%	-54.87%	-90.92%	-98.76%

Leatherback turtle take reduction bin # 2 (-5% to -10%)
3 best of 18589 scenarios at this take level with maximum green turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Season	3	6	0	-21.32%	-14.21%	-11.10%	-9.98%	-8.60%	-20.72%	-23.10%	-12.83%	-6.54%	-16.64%	-17.98%	-4.18%	-6.82%	-11.78%
Separated season box	3	6	147039	-21.37%	-14.21%	-11.09%	-9.96%	-8.67%	-20.67%	-22.96%	-12.84%	-6.52%	-16.56%	-17.96%	-4.00%	-6.76%	-11.78%
Separated season box	3	6	146039	-21.35%	-14.21%	-11.09%	-9.97%	-8.63%	-20.70%	-23.05%	-12.85%	-6.52%	-16.57%	-17.97%	-4.04%	-6.76%	-11.78%

Leatherback turtle take reduction bin # 2 (-5% to -10%)
3 best of 18589 scenarios at this take level with maximum aggregate turtle take reduction

Type of management action	#Mn	Ms	Lon/Lat	FED	FEL	Rev	Log	Lea	Rid	Gre	Swo	Big	Alb	Yel	Blu	Mah	Opa
Separated season latitude	3	7	36	-19.58%	-11.96%	-9.20%	-20.39%	-9.97%	-18.15%	-13.97%	-11.80%	-5.89%	-12.32%	-15.07%	-7.87%	-11.99%	-12.92%
Separated season latitude	4	8	35	-27.14%	-19.89%	-12.20%	-25.62%	-8.88%	-26.54%	-15.33%	-13.09%	-21.36%	-21.60%	-12.57%	-11.79%	-31.03%	-29.33%
Separated season box	4	8	148034	-27.37%	-19.89%	-12.16%	-24.28%	-9.93%	-26.56%	-14.59%	-11.31%	-21.12%	-20.03%	-12.27%	-9.85%	-30.22%	-29.26%

APPENDIX I

Donald Kobayashi, *Predicting Sea Turtle Take, Mortality, and Pelagic Fish Catch Under the Five WPRFMC Management Scenarios for the Hawaii-based Longline Fishery*

Predicting Sea Turtle Take, Mortality, and Pelagic Fish Catch Under the Five WPRFMC Management Scenarios for the Hawaii-based Longline Fishery

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Purpose

This analysis evaluates the 5 management scenarios suggested by the WPRFMC in the "Draft Action Memorandum -- Sea Turtle Conservation Special Advisory Committee 1st Meeting, October 27-28, 2003" with regard to sea turtle take, mortality, pelagic fish catch, and associated uncertainty. To simplify, scenario 1 allows 75% of historic shallow set effort (approximately 3179 sets) and no southern closure for deep set effort (eliminates the fishing ban south of 15N April-May). Scenario 2 allows 50% of historic shallow set effort (approximately 2120 sets) and allows the Palmyra EEZ to be fished during the southern closure months of April-May. Scenario 3 allows 25% of historic shallow set effort (approximately 1060 sets) and no southern closure for deep set effort. Scenario 4 allows 1560 shallow sets (approximately 36.8% of historic shallow set effort) and no southern closure for deep set effort. Scenario 5 allows 50% of historic shallow set effort (approximately 2120 sets) and no southern closure for deep set effort. Additionally, all scenarios require shallow set longline gear compliance with the Atlantic measures shown by Watson et al. (2003) to reduce the incidence of sea turtle take. These are the extent of scenarios as understood as of 11/14/2003 3PM HST.

Methods

Longline logbook (1994 - 1999 for historical pre-litigation baseline) and observer data (trips #1 - #1068 spanning March 1994 - August 2003) were used in a stratification / expansion approach to predict likely sea turtle takes. This approach splits the two datasets into common strata, and expands the observed sea turtle take into the entire logbook dataset using fishing effort (individual set of longline fishing gear) as the common denominator. Pertinent strata include type of longline gear set (deep vs. shallow), month of the fishing activity, and spatial strata relevant to existing or proposed management (e.g. north or south of 15N, or within Palmyra EEZ). Total fishing effort was conserved by reallocation. Fishing effort reallocation involving changes in gear type transferred fishing effort to other gear type within the same monthly and spatial strata. If reallocation could not be accomplished due to a time/area closure then the fishing effort was transferred to the adjacent spatial strata where fishing was allowed. Predicted sea turtle takes on shallow set gear were further modified using the results of the Watson et al. (2003) report documenting effective sea turtle mitigation techniques in the Atlantic (92% reduction in hardshell sea turtle take, 67% reduction in leatherback sea turtle take). To examine variability, several different approaches amenable to each of the data sources were used. For sea turtle take uncertainty, the longline observer database was bootstrapped 100 times, and a stratification / expansion exercise was accomplished for each bootstrapped data set. For uncertainty in the Atlantic measures, the region bounded by the 95% confidence intervals from the Watson et al. (2003) report was uniformly sampled for hardshell sea turtles (73%-97% reduction) and leatherback sea turtles (38%-82% reduction). This approach of sampling from a uniform distribution is considered precautionary or conservative since less emphasis is placed on a mean or any region of increased probability, and is consistent with Bayesian approaches to handling uncertainty. For each of the bootstrapped sea turtle take estimates, a corresponding randomly drawn reduction value was sampled from the Atlantic measures 95% confidence region and applied. The resultant sea turtle take distributions were sorted and sampled using the percentile method, extracting values at 2.5% and 97.5% for the 95% confidence intervals. Sea turtle mortality was estimated by multiplying the take estimates by mortality rates (Boggs, 2003 pers. comm., see Table 1) recalculated from 1994-1999 observer data, using the Hogarth Memo guidelines. For fish catch uncertainty, the longline logbook data was subset into 6 annual groupings of data. The proposed management measures were evaluated for each annual grouping for each species of interest, and the parametric 95% confidence intervals were estimated. The approach differs from that of sea turtle take estimation since fish catch is well represented in the logbook data which covers the entire fleet, whereas the relatively rare events of sea turtle takes are estimated from a small subset of fishing effort under observer coverage. Since the primary focus of this analysis is sea turtle take, the Atlantic measures were not used to modify predicted fish catch. While these measures appear to significantly increase swordfish catch and decrease bigeye tuna catch in the Atlantic, there are no data available for other species of economic value in Hawaii, and utilizing the changes for just 2 species could be misleading.

Results

Table 1 shows the predicted sea turtle takes and mortalities for each of the scenarios. Predictions are presented both in terms of absolute number of sea turtles in a year as well as the corresponding percent change from the baseline (1994-1999 average) value. The baseline values are also presented for reference. The mortality rates provided by Boggs (2003 pers. comm.) are also shown in Table 1. Table 2 shows the predicted fish catch for each of the scenarios. Predictions are presented both in terms of absolute number of fish caught in a year as well as the corresponding percent change from the baseline (1994-1999 average) value. The baseline values are also presented for reference. It should be noted that the price data used for the revenue calculation are based on a 1998 dataset of dealer prices stratified into cells of species, month, and trip type combinations. While prices have undoubtedly changed since 1998, the use of more recent data would not provide prices for all species, month, and trip type cell combinations due to management measures such as the elimination of shallow set fishing gear in March 2001. Hence the revenue estimate should be treated with some caution, since it is based on 1998 data but cannot be easily updated to reflect current price structure or supply / demand dynamics.

Literature cited

Watson, J. W., D. G. Foster, S. Epperly, and A. Shah. Experiments in the Western Atlantic Northeast distant waters to evaluate sea turtle mitigation measures in the pelagic longline fishery – Report on experiments conducted in 2001 and 2002. http://148.114.89.175/mslabs/docs/watson2.pdf

Table 1. Sea turtle take and mortality predictions, percent changes from baseline values, and baseline values for each of the 5 WPRFMC scenarios differentiated by gear type (S = shallow set, D = deep set, T = total). LOG = loggerhead sea turtle, LEA = leatherback sea turtle, RID = olive ridley sea turtle, and GRE = green sea turtle. The notations 1,2,3,4, and 5 appended to the species code signify the WPRFMC scenario #, as numbered in the original action memo. The mortality rates are also presented.

	Total annual number of takes			Total annual number of mortalities			Percent change from baseline		
	Mean	95%CI Lo	95%CI Hi	Mean	95%CI Lo	95%CI Hi	Mean	95%CI Lo	95%CI Hi
LOG1-S	24.85	11.17	82.35	8.87	3.99	29.40	*-94.04%*	*-97.32%*	*-80.24%*
LEA1-S	23.74	13.63	45.08	6.48	3.72	12.31	*-76.56%*	*-86.54%*	*-55.49%*
RID1-S	7.16	2.99	24.10	2.79	1.17	9.40	*-94.27%*	*-97.61%*	*-80.72%*
GRE1-S	2.16	0.89	7.20	0.62	0.26	2.08	*-94.16%*	*-97.60%*	*-80.57%*
LOG1-D	3.67	0.78	7.75	2.52	0.54	5.32	*387.85%*	*4.25%*	*931.20%*
LEA1-D	17.33	8.46	29.12	8.89	4.34	14.94	*59.17%*	*-22.28%*	*167.49%*
RID1-D	32.13	18.25	52.46	28.21	16.03	46.06	*50.55%*	*-14.48%*	*145.77%*
GRE1-D	4.76	1.35	10.69	3.03	0.86	6.79	*60.85%*	*-54.45%*	*260.80%*
LOG1-T	28.52	11.95	90.10	11.39	4.53	34.72	*-93.17%*	*-97.14%*	*-78.42%*
LEA1-T	41.07	22.09	74.20	15.37	8.06	27.25	*-63.39%*	*-80.31%*	*-33.85%*
RID1-T	39.29	21.25	76.56	31.01	17.19	55.46	*-73.15%*	*-85.48%*	*-47.68%*
GRE1-T	6.93	2.24	17.88	3.65	1.11	8.86	*-82.69%*	*-94.40%*	*-55.30%*
LOG2-S	16.57	7.45	54.90	5.92	2.66	19.60	*-96.02%*	*-98.21%*	*-86.83%*
LEA2-S	15.82	9.09	30.05	4.32	2.48	8.20	*-84.38%*	*-91.03%*	*-70.33%*
RID2-S	4.77	2.00	16.07	1.86	0.78	6.27	*-96.18%*	*-98.40%*	*-87.15%*
GRE2-S	1.44	0.59	4.80	0.42	0.17	1.39	*-96.11%*	*-98.40%*	*-87.05%*
LOG2-D	4.07	0.84	8.76	2.80	0.57	6.02	*442.17%*	*11.37%*	*1065.96%*
LEA2-D	9.85	4.48	18.51	5.05	2.30	9.49	*-9.54%*	*-58.86%*	*69.98%*
RID2-D	38.66	22.19	61.77	33.94	19.49	54.24	*81.10%*	*3.98%*	*189.41%*
GRE2-D	6.10	1.83	14.07	3.87	1.16	8.93	*105.91%*	*-38.33%*	*374.95%*
LOG2-T	20.64	8.28	63.66	8.71	3.23	25.62	*-95.06%*	*-98.02%*	*-84.75%*
LEA2-T	25.67	13.56	48.56	9.37	4.78	17.70	*-77.11%*	*-87.91%*	*-56.71%*
RID2-T	43.43	24.19	77.84	35.80	20.26	60.50	*-70.32%*	*-83.47%*	*-46.81%*
GRE2-T	7.54	2.42	18.86	4.29	1.33	10.32	*-81.15%*	*-93.95%*	*-52.84%*

LOG3-S	8.28	3.72	27.45	2.96	1.33	9.80	*-98.01%*	*-99.11%*	*-93.41%*
LEA3-S	7.91	4.54	15.03	2.16	1.24	4.10	*-92.19%*	*-95.51%*	*-85.16%*
RID3-S	2.39	1.00	8.03	0.93	0.39	3.13	*-98.09%*	*-99.20%*	*-93.57%*
GRE3-S	0.72	0.30	2.40	0.21	0.09	0.69	*-98.05%*	*-99.20%*	*-93.52%*
LOG3-D	4.48	0.89	9.74	3.08	0.61	6.69	*496.49%*	*18.50%*	*1196.58%*
LEA3-D	19.46	10.04	31.72	9.98	5.15	16.27	*78.74%*	*-7.81%*	*191.36%*
RID3-D	42.32	24.01	67.85	37.15	21.08	59.57	*98.24%*	*12.47%*	*217.88%*
GRE3-D	6.35	1.85	14.38	4.04	1.18	9.13	*114.56%*	*-37.38%*	*385.58%*
LOG3-T	12.77	4.61	37.19	6.04	1.94	16.49	*-96.94%*	*-98.89%*	*-91.09%*
LEA3-T	27.37	14.58	46.75	12.14	6.39	20.38	*-75.60%*	*-87.00%*	*-58.32%*
RID3-T	44.70	25.00	75.89	38.08	21.47	62.71	*-69.45%*	*-82.91%*	*-48.14%*
GRE3-T	7.08	2.15	16.78	4.24	1.26	9.83	*-82.31%*	*-94.62%*	*-58.05%*
LOG4-S	12.20	5.48	40.41	4.35	1.96	14.43	*-97.07%*	*-98.68%*	*-90.30%*
LEA4-S	11.65	6.69	22.12	3.18	1.83	6.04	*-88.50%*	*-93.40%*	*-78.16%*
RID4-S	3.51	1.47	11.83	1.37	0.57	4.61	*-97.19%*	*-98.83%*	*-90.54%*
GRE4-S	1.06	0.44	3.53	0.31	0.13	1.02	*-97.14%*	*-98.82%*	*-90.47%*
LOG4-D	4.29	0.87	9.28	2.95	0.59	6.38	*470.85%*	*15.14%*	*1135.03%*
LEA4-D	18.96	9.67	31.04	9.73	4.96	15.93	*74.12%*	*-11.22%*	*185.10%*
RID4-D	39.91	22.61	64.13	35.04	19.85	56.30	*86.99%*	*5.93%*	*200.43%*
GRE4-D	5.98	1.74	13.51	3.80	1.10	8.58	*101.89%*	*-41.41%*	*356.13%*
LOG4-T	16.48	6.35	49.69	7.30	2.55	20.80	*-96.05%*	*-98.48%*	*-88.10%*
LEA4-T	30.61	16.35	53.16	12.91	6.78	21.96	*-72.71%*	*-85.42%*	*-52.60%*
RID4-T	43.42	24.08	75.95	36.41	20.43	60.92	*-70.32%*	*-83.54%*	*-48.10%*
GRE4-T	7.04	2.17	17.04	4.10	1.23	9.60	*-82.40%*	*-94.57%*	*-57.40%*
LOG5-S	16.57	7.45	54.90	5.92	2.66	19.60	*-96.02%*	*-98.21%*	*-86.83%*
LEA5-S	15.82	9.09	30.05	4.32	2.48	8.20	*-84.38%*	*-91.03%*	*-70.33%*
RID5-S	4.77	2.00	16.07	1.86	0.78	6.27	*-96.18%*	*-98.40%*	*-87.15%*
GRE5-S	1.44	0.59	4.80	0.42	0.17	1.39	*-96.11%*	*-98.40%*	*-87.05%*
LOG5-D	4.07	0.84	8.76	2.80	0.57	6.02	*442.17%*	*11.37%*	*1065.96%*
LEA5-D	18.40	9.25	30.37	9.44	4.75	15.58	*68.95%*	*-15.05%*	*178.93%*
RID5-D	37.22	21.05	59.96	32.68	18.48	52.65	*74.39%*	*-1.39%*	*180.92%*

GRE5-D	5.56	1.60	12.53	3.53	1.02	7.96	*87.71%*	*-45.92%*	*323.15%*
LOG5-T	20.64	8.28	63.66	8.71	3.23	25.62	*-95.06%*	*-98.02%*	*-84.75%*
LEA5-T	34.22	18.34	60.42	13.76	7.23	23.78	*-69.49%*	*-83.65%*	*-46.13%*
RID5-T	42.00	23.04	76.03	34.54	19.26	58.91	*-71.30%*	*-84.25%*	*-48.04%*
GRE5-T	7.00	2.19	17.33	3.95	1.19	9.34	*-82.50%*	*-94.51%*	*-56.68%*

Baseline 1994-1999 mean annual takes

LOG-S	416.75
LEA-S	101.28
RID-S	124.99
GRE-S	37.04
LOG-D	0.75
LEA-D	10.89
RID-D	21.35
GRE-D	2.96
LOG-T	417.50
LEA-T	112.17
RID-T	146.33
GRE-T	40.00

Mortality Rate (Boggs 2003 v.4)

LOG-S	0.3570
LEA-S	0.2730
RID-S	0.3900
GRE-S	0.2890
LOG-D	0.6870
LEA-D	0.5130
RID-D	0.8780
GRE-D	0.6350

Table 2. Fish catch predictions, percent changes from baseline values, and baseline values for each of the 5 WPRFMC scenarios for the longline fleet (all gear types combined). SWO = swordfish, BIG = bigeye tuna, ALB = albacore tuna, YEL = yellowfin tuna, REV = total fish catch revenue, BSH = blue shark, MAK = mako shark, THR = thresher shark, BMA = blue marlin, and SMA = striped marlin. The notations 1,2,3,4, and 5 appended to the species code signify the WPRFMC scenario #.

	Total annual number of fish			Percent change from baseline	
	Mean	95%CI Lo	95%CI Hi	Mean	95%CI Lo
SWO1	29602	29458	29746	-22.40%	-22.78%
BIG1	74440	72482	76399	6.40%	3.61%
ALB1	52423	49557	55289	9.28%	3.30%
YEL1	21084	20367	21801	6.06%	2.45%
REV1	39804417	39272775	40336060	-2.20%	-3.50%
BSH1	43868	43268	44468	-19.79%	-20.88%
MAK1	976	921	1031	-0.48%	-6.06%
THR1	1950	1841	2058	9.65%	3.53%
BMA1	6635	6490	6781	2.99%	0.73%
SMA1	16253	15526	16980	7.14%	2.35%
SWO2	21180	20791	21569	-44.48%	-45.50%
BIG2	77848	73337	82360	11.28%	4.83%
ALB2	58371	51854	64888	21.68%	8.09%
YEL2	22624	20886	24362	13.80%	5.06%
REV2	38910996	37828711	39993282	-4.39%	-7.05%
BSH2	33057	31885	34229	-39.55%	-41.70%
MAK2	990	871	1110	1.02%	-11.14%
THR2	1851	1517	2186	4.12%	-14.71%
BMA2	6830	6547	7112	6.01%	1.62%
SMA2	17546	16119	18973	15.66%	6.26%
SWO3	12511	12080	12943	-67.20%	-68.33%
BIG3	83401	77526	89276	19.21%	10.82%
ALB3	61323	52725	69920	27.83%	9.90%
YEL3	23492	21341	25644	18.17%	7.35%
REV3	38017546	36422618	39612475	-6.59%	-10.50%
BSH3	22227	20426	24028	-59.36%	-62.65%
MAK3	966	802	1131	-1.44%	-18.19%
THR3	2293	1967	2619	28.95%	10.60%
BMA3	7021	6584	7457	8.97%	2.20%
SMA3	18420	16240	20600	21.43%	7.05%
SWO4	16545	16181	16908	-56.63%	-57.58%
BIG4	81287	76336	86237	16.19%	9.11%
ALB4	59222	51977	66467	23.45%	8.35%
YEL4	22924	21111	24737	15.31%	6.19%
REV4	38439248	37095255	39783241	-5.55%	-8.85%
BSH4	27334	25817	28852	-50.02%	-52.79%
MAK4	969	830	1107	-1.21%	-15.33%

THR4	2212	1937	2487	24.39%	8.93%
BMA4	6930	6562	7297	7.56%	1.86%
SMA4	17909	16071	19746	18.05%	5.94%
SWO5	21057	20769	21344	-44.80%	-45.56%
BIG5	78921	75004	82838	12.81%	7.21%
ALB5	56873	51141	62605	18.55%	6.60%
YEL5	22288	20854	23723	12.11%	4.90%
REV5	38910982	37847696	39974267	-4.39%	-7.00%
BSH5	33047	31847	34248	-39.57%	-41.77%
MAK5	971	862	1081	-0.96%	-12.13%
THR5	2121	1904	2339	19.30%	7.07%
BMA5	6828	6537	7119	5.98%	1.47%
SMA5	17337	15883	18790	14.28%	4.70%

	Baseline 1994-1999 mean
SWO	38148
BIG	69960
ALB	47973
YEL	19880
REV	40697853
BSH	54688
MAK	981
THR	1778
BMA	6442
SMA	15170

APPENDIX J

Memorandum from D. Knowles to J. Powers re: *Marine Turtle Mortality Rates Resulting from Interactions with Longline Fisheries (with attachments)*

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

JAN - 4 2001

MEMORANDUM FOR: F/SER - Joseph E. Powers, Ph.D.

FROM: for F/PR - Donald R. Knowles

SUBJECT: Marine Turtle Mortality Resulting from Interactions with Longline Fisheries

The Office of Protected Resources (F/PR) was tasked by William Hogarth, Deputy Assistant Administrator for Fisheries to review information on marine turtle mortality in longline fisheries and to make a recommendation regarding the estimation of post-interaction mortality. In addition, F/PR was directed to convene a workshop to further address the issue of mortality estimation. Finally, the Southeast Region (SER) requested input on this issue in order to incorporate any new information into their analyses of the impact of the Atlantic longline fishery on marine turtles.

Summary Findings

1. F/PR recommends the use of revised serious injury/mortality criteria for defining levels of injury to turtles interacting with longline fishing gear (see below).

2. F/PR recommends that 50% of longline interactions with all species of sea turtles be classified as lethal and 50% be classified as non-lethal. The 50% lethal classification is based on our analysis and evaluation of the range of mortality discussed in several investigations for lightly and deeply hooked turtles. Our recommendation assumes additional mortality under normal fishing conditions, where turtles are infrequently boarded, and gear can be assumed to be left on turtles at a greater rate than when an observer handles a turtle for a defined experiment.

Serious Injury/Mortality Criteria

In November, F/PR received from Southeast Fisheries Science Center (SEC) staff a preliminary strawman of serious injury/mortality criteria (Attachment A). F/PR reviewed the document in consultation with SEC sea turtle staff, who agreed that a revision was needed for greater clarity and to focus reviewer comments. F/PR revised the strawman (Attachment B) and solicited input from 33 persons including veterinarians, scientists, and gear and industry experts. F/PR received a total of 7 responses from 4 veterinarians, 2 scientists, and 1 gear/industry expert. A copy of all responses is attached, including comments from Science and Technology (F/ST) staff, responding to the draft strawman developed by the SEC (Attachment C).

Reviewer Comments

Respondents were not able to quantitatively assess criteria for determining whether a particular interaction between a turtle and longline gear will result in mortality. This is not surprising given the multitude of factors involved, including, but not limited to, the nature of the interaction, the duration of the interaction (i.e., time elapsed from the interaction to removal of the animal from the gear), environmental conditions at capture, species, physiological status when captured (e.g., turtle recently surfaced, turtle attempting to surface), turtle size, turtle behavior as the gear is retrieved, how the turtle is handled and the lack of baseline information on what constitutes a healthy turtle from which criteria for injury may be established. While not providing quantitative guidance, respondents did however provide important qualitative assessments of longline interactions. These assessments ranged from likely to recover (for superficial external hooking injuries) to likely long-term impact with eventual death if not treated (for ingested hooks). In general, respondents raised more questions than they answered. These questions are useful in that they will help to develop and focus the upcoming workshop to further discuss these complex issues. Despite the questions, and range of comments, there were a number of responses in common that shed light on the assessment of lethal and non-lethal interactions between sea turtles and pelagic longline gear.

Two respondents suggested variations on the injury categories described in the strawman. Their comments generally agreed with the strawman's categories, except that both suggested an additional description for 'moderate' or 'minor' injury which would include visible injuries that are determined to be superficial, and interactions where the gear has been removed and the animal is not weakened. PR assumes that injuries described in this category would not result in mortality, but might reduce the animal's fitness. Therefore, a new category of observed "minor or moderate" injury is proposed.

The remaining comments can be grouped into three general categories: hooking, hooking with trailing line, and entanglement. The respondents generally indicated that the degree of damage that may result from hooking is dependant upon where on the body the hook penetrated, the depth of penetration, and the length of time the hook is present. Infection, whether localized or systemic, was another important factor in determining whether the turtle would survive the hooking event. One respondent stated that he had seen turtles with ingested hooks that were apparently healthy while other ingested hooks can cause death. Another respondent stated that any turtle with an ingested hook could be in grave danger. Physiological stresses resulting from the hooking event (e.g., fighting the hook) was also pointed out as a concern. Respondents categorized trailing line (i.e. line that is left on the turtle), particularly line that is trailing from an ingested hook, as a significant risk. Line trailing from an ingested hook is likely to be swallowed which may occlude the gastrointestinal tract and lead to eventual death. Trailing line may become snagged and may result in further entanglement with potential loss of appendages which may affect mobility, feeding, predator evasion, or reproduction. Several respondents felt that the level of risk is dependant on the size and robustness of the turtle in relation to the length of line that is left on the turtle. Characteristics of the monofilament line may also play a role in the risk of further entanglement.

F/PR believes that the reviewer's responses clearly indicate that interactions with longline gear pose a risk to the turtle and that many variables affect that level of risk. These variables cannot be quantitatively ascertained from the existing observer records. Assigning a mortality level to each specific type of interaction based on existing records and current knowledge would be extremely difficult. Revised criteria for determining injury are provided below.

Revised Criteria for Determining Injury for Sea Turtle-Longline Fishery Interactions

I. Non-serious injuries:

1. Entanglement in monofilament line (mainlines, gangion line, or float line) where there are no visible injuries (cuts and/or bleeding), the gear is completely removed, and the turtle swims strongly away from the vessel.

II. Minor or Moderate injury:

1. Visible injuries determined to be superficial and interactions where the gear has been removed and the animal is not weakened (this category would not include ingested hooks under III. 4, below).

III. Serious injuries may result in mortality, or reduced ability to contribute to the population when released alive after the interaction:

1. Entanglement in monofilament line (mainline, gangion line, or float line) that directly or indirectly interferes with mobility such that feeding, breeding or migrations are impaired.
2. Entanglement of monofilament line (mainline, gangion line, or float line) resulting in substantial wound(s) (cuts, constriction, bleeding) on any body part.
3. Hooking external to the mouth resulting in substantial wound(s) (cuts, constriction, bleeding) with or without associated external entanglement and/or trailing attached line.
4. Ingestion of hook in beak or mouth (visible), with or without associated external entanglement and/or trailing attached line.
5. Ingestion of hook in the mouth, throat area, esophagus or deeper, with or without associated external entanglement and/or trailing attached line.

Estimating Post-Interaction Sea Turtle Mortality

F/PR has reviewed the results of research on post-hooking mortality of sea turtles interacting with longline fisheries and has discussed results with several experts. The research to determine post-hooking mortality is based primarily on satellite tracking of hard-shell turtles after their treatment for hooking/entanglement and release. The transmitters are placed on the carapace of the turtle and data are downloaded from a satellite link at pre-determined intervals when the turtle is on the surface. Some transmitters also measure the turtle's diving behavior. The lack of any satellite transmission after 30 days may be categorized as an unsuccessful track and probable turtle mortality. Properly functioning transmitters should operate anywhere from 9-18 months. The failure rate of transmitters is minimal and attachment to the turtle shell is certain, so that the sinking of the turtle after death is assumed when transmissions are no longer received after 30 days. However it is important to note that this one-month criterion cannot be evaluated for its direct relation to mortality and the actual "cut-off" for assuming mortality may be significantly higher or may be lower.

Post-Hooking Studies: *Hawaii*

Studies aimed at elucidating post-longline hooking mortality using satellite telemetry devices are ongoing in the Hawaii longline fishery operating in the north central Pacific. These studies have focused on olive ridleys, loggerheads, and to a lesser extent green turtles (Balazs, pers. comm.). Turtles selected as part of the study are limited to those that are lightly hooked or have deeply ingested hooks. The term "lightly hooked" refers to hooks that are imbedded externally on the turtle or imbedded in the mouth or beak, and that can be removed with relative ease and without causing additional injury. The term "deep ingested" implies a hook that is not visible when the mouth is open or only part of the hook can be seen when viewed in the open mouth, in either case the "deep ingested" hook cannot be removed in the field without causing further harm. Turtles selected to carry transmitters are boarded using dip nets. Observers remove the hook and all line before beginning the transmitter attachment on lightly hooked turtles. The treatment of turtles that have deep ingested hooks differs in that the line is removed to a point as close to the hook as possible, but the hook (and in some cases attached line) remains. The transmitter attachment procedure takes several hours from start to finish, after which the turtle is released. There were no turtles studied that were entangled only and no control turtles (i.e., non-hooked, wild turtles) in the same environment have been tagged as part of this study. Ongoing studies in the Eastern Tropical Pacific (ETP) may provide a control group of turtles against which to compare those tagged in the north central Pacific. However, ETP sample sizes remain small and life history stages differ for some species (e.g., mature adult olive ridleys intercepted during their breeding migrations in the ETP) thus complicating comparability (Dutton, pers. comm.).

Results of the Hawaii-based study, to date, are summarized in a November 2000 report by the NMFS Southwest Fisheries Science Center (NMFS, 2000a). The data are complex and some of the tracking is ongoing. However, initial results are available. The study included 35 loggerheads, 11 olive ridleys, and 3 green turtles. Of the 49 turtles outfitted with satellite transmitters (30 deep ingested, 19 lightly hooked), 30.6% (n=15) produced no transmissions or transmissions that did not exceed one month in duration (these are not considered "successful trackings"). Of these 15 turtles, four were lightly hooked (21.1%) and 11 were deeply hooked (36.7%). Analyses to test for differences in transmission time distribution, mean transmission time and mean distance traveled in the Hawaii-based study between lightly hooked and deeply hooked turtles revealed no significant differences. Twenty-seven percent (27%) of the lightly hooked loggerheads and 42% of the deeply hooked loggerheads were classified as non-successful tracks. Seventeen percent (17%) of the lightly hooked olive ridleys and 20% of the deeply hooked olive ridleys were classified as non-successful tracks. Sample sizes of green turtles (n=3) were too small to produce meaningful results.

Reliability of transmitters is an important consideration in studies employing satellite telemetry to elucidate the behavior and migrations of sea turtles. Four "types" of transmitters were used in the Hawaii-based study. No significant differences were found in the comparison of different duty cycles or battery types for the duration of tracking for turtles that produced successful tracks (NMFS, 2000b).

We believe the cessation of transmissions within a one-month period and the absence of transmissions post-release (collectively termed "non-successful tracks) from 30.6% of the tagged turtles can be considered a minimal indicator of post-hooking mortality in this study. We believe it is unlikely that mechanical failure of the transmitters or separation of the transmitter from the turtle would cause such a result. Satellite telemetry studies on post-nesting hawksbills in the Caribbean, utilizing similar, though not identical units, resulted in only one tagged turtle (2.5%) from which no transmissions were documented and catastrophic failure of the telemetry unit is suspected (Schroeder, pers. comm.). Studies deploying over 100 similar, though not identical tags (primarily Telonics ST-14 units and a smaller number of Wildlife Computer SDR units) on post-nesting loggerhead and green turtles in Florida and studies on post-nesting green turtles in Hawaii and elsewhere in the Pacific have resulted in no total failures (Balazs, pers. comm. and Schroeder, pers. comm.). In these studies, cessation of transmissions within short periods of time (e.g., less than one month, but not total failure) are also relatively uncommon when proven attachment techniques and transmitter designs are used.

Post-Hooking Studies: *Eastern Atlantic*

Similar, though not identical studies are being conducted in the eastern Atlantic in an attempt to elucidate post-longline hooking mortality of immature loggerheads. This research includes wild-captured turtles (i.e., not hooked) from the same area as turtles incidentally captured in the Azores swordfish longline fishery (considered "control turtles") and was conducted in two discrete segments - Fall 1998 and Summer 2000 using Wildlife Computers satellite-linked Time-Depth Recorders (Bjorndal et al., 1999; Riewald et al., 2000). Sample sizes are considerably smaller than the Hawaii-based study, 9 turtles have been wild-captured, 3 were lightly hooked (in mouth), and 6 turtles were deeply hooked. As in the Hawaii-based studies, turtles captured incidental to the swordfish fishery were "treated" - for lightly hooked turtles, hooks and all gear were removed and for deeply hooked turtles the monofilament line was cut at the wire leader. Turtles in the Azores study were typically released within 2-4 days of capture as opposed to several hours post-capture in the Hawaii-based study. Results from the Fall 1998 study indicated that several months after capture and release all of the turtles continued to transmit, though one of the control turtles was transmitting only sporadically and with insufficient to obtain location fixes (Bjorndal et al., 1999). Results from the Summer 2000 study indicate that as of the end of

October 2000, two of the four transmitters on control turtles and five of the six transmitters on hooked turtles continued to function. Using criteria similar to the Hawaii-based study for "successful tracks", one of the control turtles and one of the hooked turtles ceased transmitting within one month after release. Analyses to date have focused on diving behavior and movement patterns and directions. A diurnal pattern in dive behavior was evident for most hooked and control turtles, distribution of dives for hooked turtles were skewed toward longer dives and shallower dives and hooked turtles did not show the bimodal distributions of maximum dive depths that were characteristic of control turtles (Riewald et al., 2000). Riewald et al. (2000) opines that transmitters that provide dive profiles are necessary to determine whether transmitter failure is due to mortality or mechanical causes and describes the diving activity of one of the hooked turtles (still transmitting) as indicative of a dead, floating turtle, buffeted by waves. Data analyses are ongoing by the contractor.

Post-Hooking Studies: *Mediterranean*

A third study approached the question of post-hooking mortality in a different way. Aguilar *et al* (1995), working in the western Mediterranean kept in captivity sea turtles that had been incidentally captured in the Spanish longline fishery with the aim of estimating the mortality rate of individuals with hooks still in their bodies. While the exact details of the study are not clearly elucidated, the assumption is that turtles held in captivity for observation had ingested a hook. It is unclear whether line attached to these hooks was removed to the maximum extent possible, but it is reasonable to assume that this was the case. Of 38 turtles reported by Aguilar (1995) 11 died in captivity, 6 expelled the ingested hook prior to their release (range of days to expulsion 53-285), 15 turtles were released prior to expulsion of the hook (range of days to release 81-123), and 6 turtles taken in 1991 remained under observation at the time the paper was written and the fates of these turtles are unknown. Excluding the 6 turtles for whom the fates are unknown, 34.4% died, 18.8% expelled the hook and 46.9% were released without hook expulsion (see ranges of days in captivity above). As with the Hawaii-based study and the Azores-based study, turtles used in this study also underwent some level of "treatment", including removal of trailing line (reasonably assumed though not explicitly stated), maintenance in a captive environment where food was regularly provided and where predator avoidance was not a factor. While it may be argued that turtles are further stressed under captive conditions, we believe that the captive environment represents a less stressful environment for an injured turtle (i.e., one that has ingested a hook). Additionally, the Aguilar study assumes that the 15 turtles (46.9%) released before hook expulsion survived, an assumption that cannot be quantitatively determined. One respondent to the request for comments on mortality criteria opined that without definitive necropsies, Aguilar's results cannot be used to address post-hooking mortality. Based on our assessment of the study, we believe that the 34.4% observed mortality reported in the Aguilar paper is a minimal estimate of mortality for ingested hooks in the wild.

Entanglement

None of the studies discussed herein involved turtles that were only entangled, not hooked, in longline gear. The applicability of the results of the studies reviewed above to "entangled only" turtles is a valid question to explore. Comments on the draft strawman suggested that the characteristics of longline monofilament make it unlikely to remain on an "entangled only" turtle once the turtle is cut free from the gear. Data from the Hawaii longline fishery observer program from 1994-1999 indicate that the overwhelming majority of interactions involving hard shelled turtles involve hooking, not entanglement only (Table 1). Hawaii longline observer records indicated that leatherback turtles are more frequently only entangled in the gear, although nearly 75% of the time, hooking is involved (Table 1). Of the eight leatherbacks observed "entangled only", 25% (n=2) were dead, 37.5% (n=3) were recorded as "okay", and 37.5% (n=3) were recorded as "injured".

Table 1. Breakdown of type of gear interaction, hooked (includes lightly hooked, deeply hooked) vs. entangled only (no hooking involved), 1994-1999 Hawaii longline observer program (McCracken 2000).

Species	Hooked	Entangled Only	Not Recorded	TOTAL
C. caretta	143 (97.3%)	3 (2.0%)	1 (0.7%)	147
D. coriacea	29 (72.5%)	8 (20.0%)	3 (7.5%)	40
L. olivacea	32 (100%)	0	0	0
C. mydas	8 (100%)	0	0	8

Data from the Atlantic HMS longline fishery observer program indicate similar levels of "entanglement only" for loggerheads and leatherbacks. The vast majority of loggerheads are hooked while leatherbacks interact with the gear slightly differently - a greater percentage are "entangled only" (Table 2). All of the leatherbacks observed "entangled only" were alive when the gear was retrieved.

Table 2. Breakdown of type of gear interaction, hooked (includes lightly hooked, deeply hooked) vs. entangled only (no hooking involved), 1999 Atlantic longline observer program. (Data source: J. Hoey (unpublished report, 2000) summary of 1999 NMFS observer data for HMS Atlantic longline)

Species	Hooked	Entangled Only	Not Recorded	TOTAL
C. caretta	60 (93.8%)	1 (1.6%)	3 (4.7%)	64
D. coriacea	26 (57.8%)	12 (26.7%)[1]	7 (15.6%)	45
Unknown	1 (33.3%)	2 (66.7%)	0	3

[1] Four of eight turtles may have been hooked in addition to entangled, hooking location unknown.

Conclusions and Recommendations

The Aguilar results and the results of the Hawaii-based study, for mortality from deeply ingested hooks, 34.4% and 42% respectively, are similar. Preliminary data from the Azores study, with very limited samples sizes, indicating a 33.3% mortality from deeply ingested hooks is also in the same range, assuming one month criteria and contractor interpretation of diving behavior. Whether these results are corroborative or purely coincidental cannot be qualitatively determined. The mortality range for lightly hooked and deeply hooked hard-shelled turtles in the Hawaii-based study is 17 - 42%, based on a one-month criteria established for successful vs. non-successful tracks. This one-month criterion cannot be evaluated for its direct relation to mortality and the actual "cut-off" for assuming mortality may be significantly higher or may be lower. It is important to remember that the turtles used in all studies underwent a level of treatment (e.g., line and/or hook removal as well, recuperative time on deck, captive maintenance) that undoubtedly improved their survival outlook. We believe that mortality rates in the wild, under actual fishing conditions are likely higher than mortality rates indicated by the studies reviewed herein. Given the available information, as well as adopting a risk-averse approach that provides the benefit of the doubt to the species where there are gaps in the information base[2], F/PR recommends that 50% of longline interactions be classified as lethal and 50% be classified as non-lethal. The 50% lethal classification considers the range of mortality discussed above for lightly and deeply hooked turtles and assumes additional mortality under normal fishing conditions, where turtles are infrequently boarded, and gear can be assumed to be left on turtles at a greater rate than when an observer handles a turtle for a defined experiment. Observer efforts to disentangle turtles and to remove trailing line can sometimes be described as heroic and while we believe that some fisherpersons will undertake similar efforts, others will not. As discussed above, most of the respondents to the NMFS request for comments/information on post-hooking mortality characterized gear left on turtles as a serious problem, especially trailing line which would be a significant risk to the turtle, especially when ingested hooks are involved. While these studies are limited to hard-shelled turtles, in the absence of evidence to suggest that interactions with leatherbacks would result in higher survival rates, we recommend that the 50% mortality figure be applied to leatherbacks as well as hard-shelled turtles. One respondent to the request for input on mortality criteria commented that leatherbacks are not as resilient as hard-shelled turtles and that actions such as hooking, lifting from the water, and ingestion of hooks and lines may have more damaging and long lasting impacts. Our review of the available information does not suggest that a differential mortality estimate can be applied to lightly hooked vs. deeply hooked vs. "entangled only" turtles at this time. While we believe that lightly hooked turtles and "entangled only" turtles, especially those that have trailing line and hooks

[2]The Endangered Species Act Section 7 consultation process requires NMFS to use the best available scientific and commercial data. The Services established criteria to ensure that the information used in the Section 7 consultation process was reliable, credible, and representative of the best available data (59 FR 34271; July 1, 1994). To the extent practicable, NMFS must use primary and original sources of information including, but not limited to, anecdotal, oral, and gray literature as well as published documents. If data gaps exists that would help determine the impacts to listed species and the action agency intends to proceed with the proposed action, NMFS must proceed with the existing information and is expected to provide the benefit of the doubt to the species concerned with respect to such gaps in the information base (H.R. Conf. Rep. No. 697, 96th Cong., 2nd Sess. 12 (1979).

removed have a greater chance of survival than deeply hooked turtles, the data do not exist to provide for a differential apportionment. In reality, the figure may be higher than 50% for deeply hooked turtles and lower than 50% for lightly hooked and "entangled only" turtles. In the future, refinements to these estimates can be made if additional information is gathered and further evidence can be provided to quantitatively define post-hooking mortality. Data collected by observers must be standardized and of sufficient detail and description to assess and categorize the interaction. F/PR intends to convene an expert workshop in early 2001 to further discuss the question of sea turtle survival following interactions with longline gear and to refine, if possible, post-interaction survival rates.

Literature Citations

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ATTACHMENT A

Interim Guidelines for Determining Serious Injury of Sea Turtles Taken Incidentally by the Pelagic Longline Fisheries

The development of guidelines for determining serious and non-serious injuries is essential because NMFS is mandated to reduce the levels of mortality and serious injury as mandated by the Endangered Species Act. The pelagic longline fisheries, targeting swordfish and tuna, have interactions with leatherback and loggerhead sea turtles. Although there is a low rate of observed mortality, there is a high likelihood of serious injuries.

Leatherback turtles seldom consume baited hooks, but often become entangled in the gangions. Fishermen usually attempt to remove all entangled gear, but the large size and robust nature of the leatherback often make this dangerous and difficult to do. Loggerhead turtles, on the other hand, usually consume the baited hooks and are either hooked in the mouth or throat and are usually cut free with some monofiliment leader attached.

Criteria for determining serious and non-serious injuries of marine mammals have been developed (Angliss and Demaster, 1998). However, the criteria for marine mammals and sea turtles are undoubtedly different and need to be developed. Sea turtles, unlike marine mammals, are apparently able to sustain considerable injuries and still survive. Loggerhead turtles are able to keep feeding with multiple hooks imbedded in their mouths (Argano et al, 1992) and are even able to expel swallowed hooks (Aguilar et al., 1995). Loggerheads commonly survive severed limbs (Gramentz, 1989).

The injuries commonly observed and recorded by NMFS observers will be categorized as non-serious, serious, and serious with associated mortality.

I. Non-serious injuries:

1. Entanglement of monofiliment line (mainlines, gangion line, or float line) where there are no visible injuries (cuts and/or bleeding) and gear is completely removed.

II. Serious injuries meet any the following life threatening criteria:

1. Entanglement of monofiliment line (mainline, gangion line, or float line) could directly interfere with feeding
2. Entanglement of monofiliment line (mainline, float line, or float line) could interfere with mobility
3. Entanglement of monofiliment line (mainline, gangion line, or float line) resulting in substantial wounds (cuts, constriction, bleeding) on any body part.

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4. An animal ingests hooks in beak or mouth (visible) could interfere with feeding.
5. An animal is hooked externally in neck or flippers resulting in wound.

III. Serious injuries (with associated mortality) are those animals that:

1. Animal is hooked inside throat/esophagus hooked (28.9%) (Aguilar et al., 1995)
2. Are beak/mouth hooked with substantial line attached (>3 feet loggerheads and >6 feet leatherbacks) (unknown mortality rate).

The following are commonly observed injuries and suggested injury classification:
NS= non-serious injury, SI= serious injury, SM= serious injury with associated mortality.
(* = unknown mortality rate)

Leatherback turtles:

Entangled (cut free)	NS
Entangled (line trailing>6 feet)	SI
Hooked Externally (line trailing>6 feet)	SI
Hooked Mouth (line trailing <6 feet)	SI
Hooked Mouth (line trailing >6 feet)	SM*

Loggerhead (hard-shelled) turtles:

Entangled (cut free)	NS
Hooked Externally (line trailing)	SI
Hooked Externally (cut free)	SI
Hooked Externally (hook removed)	SI
Hooked Beak/mouth (line trailing <3 feet)	SI
Hooked Beak/mouth (line trailing >3 feet)	SM*
Hooked Beak/mouth (cut free)	SI
Hooked Beak/mouth (hook removed)	SI
Hooked Throat/esophagus (line trailing)	SM*
Hooked Throat/esophagus (cut free)	SM (28.9%)
Hooked Throat/esophagus (hook removed)	SM (28.9%)

ATTACHMENT A

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Argano, R., R. Basso, M. Cocco, and G. Gerosa. 1992. Novi dati spostamenti di tartaruga marina comune (Caretta caretta) in Mediterraneo. Boll. Mus. Ist. Biol. Univ. Genova 56-57:137-163.

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ATTACHMENT B

Developing Interim Guidelines for Determining Serious Injury of Sea Turtles Taken Incidentally by the Pelagic Longline Fisheries

Sea turtles are listed as either endangered or threatened under the U.S. Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) share jurisdiction for sea turtles under the ESA. Section 7 of the ESA requires federal agencies to consult with either NMFS or USFWS when their actions are likely to affect listed sea turtles. In the case of domestic pelagic longline fisheries managed under a federal Fishery Management Plan, the NMFS Office of Sustainable Fisheries must consult with the NMFS Office of Protected Resources relative to the effects of the fishery on sea turtles. Sea turtles are incidentally taken as bycatch in federally-managed pelagic longline fisheries. Observers accompany a small percentage of pelagic longline trips and record data on sea turtle bycatch, among other things. Since mid-1999 observers have used the attached observer reporting form to record the condition of bycaught turtles. Table 1 provides an example of the comments recorded by observers on board pelagic longline vessels. NMFS analyzes observer data to estimate the total lethal and non-lethal take of sea turtles in the fishery. These estimates are critical to understanding the population-level effects of this bycatch and the estimates are used to monitor sea turtle bycatch relative to take levels authorized in the Incidental Take Statement of the Section 7 Biological Opinion, under the ESA. While there is a low rate of observed mortality (i.e., turtles dead when the longline is hauled in), there is a high likelihood of serious injuries which may or may not eventually result in the death of the animal.

NMFS defined "Serious Injury" for marine mammals as *"any injury that will likely result in mortality"* and defined "Injury" as *"a wound or other physical harm. Signs of injury to a marine mammal include, but are not limited to, visible blood flow, loss of or damage to an appendage or jaw, inability to use one or more appendages, asymmetry in the shape fo the body or body position, laceration, puncture or rupture of eyeball, listless appearance or inability to defend itself, inability to swim or dive upon release from fishing gear, or sign s of equilibrium imbalance. Any animal that ingest fishing gear, or any animal that is released with fishing gear entangling, trailing or perforating any part fo the body will be considered injured regardless of the absence of any wound or other evidence of an injury."* (50CFR §229.2). Requirements of the Marine Mammal Protection Act (MMPA) resulted in the convening of a workshop to differentiate between serious and non-serious injuries of marine mammals (Angliss and Demaster, 1998 - enclosed). The definition of "injury" for marine mammals and sea turtles are not likely to be identical and, thus, NMFS recognizes the need to review its current methodologies and to develop sea turtle specific definitions and criteria to determine which interactions between sea turtles and pelagic longline gear are likely to result in injuries leading to mortality (serious injuries) and which are not.

The result of sea turtle interactions with pelagic longline gear include entanglement and/or hooking (external or internal). The at-sea "treatment" that a captured turtle receives is variable and depends on conditions including, but not necessarily limited to,

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federal regulatory requirements, turtle size and species, the presence of an observer, the sea/weather conditions, experience and motivation of the captain and crew, and nature of the interaction. A general description of the Atlantic pelagic longline fishery and a report of gear, environment and fishing practice parameters which may influence sea turtle interactions are enclosed for your information.

For discussion and review purposes the following categories are proposed:

I. Non-serious injuries:

1. Entanglement in monofilament line (mainlines, gangion line, or float line) where there are no visible injuries (cuts and/or bleeding), the gear is completely removed, and the turtle swims strongly away from the vessel.

II. Serious injuries that may or may not result in mortality when turtles are released alive after the interaction:

1. Entanglement in monofilament line (mainline, gangion line, or float line) that directly or indirectly interferes with mobility such that feeding, breeding or migrations are impaired.
2. Entanglement of monofilament line (mainline, gangion line, or float line) resulting in substantial wound(s) (cuts, constriction, bleeding) on any body part.
3. Hooking external to the mouth resulting in substantial wound(s) (cuts, constriction, bleeding) with or without associated external entanglement and/or trailing attached line.
4. Ingestion of hook in beak or mouth (visible), with or without associated external entanglement and/or trailing attached line.
5. Ingestion of hook in the mouth, throat area, esophagus or deeper, with or without associated external entanglement and/or trailing attached line.

NMFS is seeking comments and input on the effects of these types of interactions on the health and viability of turtles involved in such interactions. Recommendations on apportioning mortality based on detail-specific criteria are sought.

ATTACHMENT C

John Hoey
Comments on SEC
initial draft criteria

Draft criteria for determining serious injury and/or mortality for sea turtle - pelagic longline interactions (October 10, 2000 e-mail draft from Wayne Witzell).

This initial draft reflects the decision rules that were used in the June 20, 2000 biological opinion, ie. that almost all sea turtle - longline interactions cause serious injuries. While only a few were coded as serious injury with associated mortality I think there are additional non-serious injury conditions that are reasonable and would help encourage careful handling. Given the limited post-release data available the assumption that "there is a high likelihood of serious injuries" seems questionable. Given the text references in the third paragraph to turtle hardiness and resilience, the phrase "high likelihood" should be replaced by "varying levels of risk depending on the species and type of interaction". This would seem to be more in line with NMFS technical memo - SEFSC-222 which appeared to emphasize internal wounds.

Despite reference in paragraph 3 to the serious injury workshop on marine mammals and the " undoubtedly different" criteria for serious injury for sea turtles, the categorizations presented at the bottom of page 1 reflect discussions on marine mammal injuries and interactions primarily with gillnet gear and pot warps from lobster gear. As I mentioned at the serious injury workshop and in more recent discussions and written comments, there are very important gear differences between gillnets and lobster pot warps that must be acknowledged.

In the marine mammal serious injury discussions, the interaction types that are listed under item II - ie. Serious injury with respect to entanglements that interfere with feeding, mobility and cause substantial wounds - referred specifically to heavy multi-filament nylon lines in single strands and multiple strands that wrapped around appendages and/or through the jaw with the resulting drag and friction cutting through soft tissue and bone. The diameter, number of strands, weight in water, and drag associated with these gears is very different than those same characteristics and others associated with the types of monofilament lines used in the U.S. pelagic longline fishery.

The monofilament used by the longline fleet is designed to have negligible resistance and drag and extremely low weight despite having great strength. In 1998 and 1999 gangion pound tests were usually ≥ 300 lb. test (only one set with 250 lb. test), whereas mainline pound tests were usually ≥ 600 lb. test. These characteristics must be factored into the serious injury criteria along with the fact that very few longline observer comments (based on my partial examination of Atlantic interaction forms) note cutting or tearing wounds on appendages, whereas this is frequently noted for marine mammal interactions with gillnets and lobster warps. I think it is critically important to draw a distinction between the different weights, pound tests, for the monofilament line that is associated with turtle interactions. George Balazs included information on monofilament strangulation for Hawaiian Green turtles on page 130 of the Honolulu lab program review 2000 document. The illustrated entanglement was attributed to recreational shore-line fishing with 6-lb. test monofilament. I believe there have been similar observations associated with jetty fishing in the Gulf of Mexico and Atlantic. It should be part of the standard sampling protocol for monofilament samples to be taken for all stranded or nesting turtles that have attached gear.

As I mentioned at the serious injury workshop and in discussions with SEFSC and PR turtle scientists, monofilament line has memory (stretch) characteristics, especially for the pound test used for mainlines (usually ≥ 600 lb. test) and gangions (usually ≥ 300 lb. test), that make it very difficult to knot or twist and tangle strands so that the knot or tangle will hold once tension is eliminated from the line. Because of these characteristics fishermen rely on crimps to connect sections of line, especially the heavier mainline. In those cases where entangled turtles are released with trailing loops of monofilament that do not include an attached hook that is impeded in an appendage or shell, it would be very likely that the gear will simply fall off once line tension is released.

In those cases where an external hooking has occurred or where the hook is in the beak, jaw, or tongue (externally visible) and the turtle is released with limited line attached, the size of the turtle and length of attached line should be considered. There are no reports that I am aware of that specifically identify a line length threshold of 1 meter for loggerheads and 2 meters for leatherbacks, nor is rational provided in the draft for these arbitrary length thresholds. These lengths may be reasonable targets now that the fleet is required to carry line cutters, but this hasn 't been the case in the recent past and it should be discussed with observers who have experience with conditions aboard vessels especially freeboard height and hauling practices. Since the 1995 Hawaii workshop emphasis has been placed on not pulling or putting tension or pressure on the line that is entangling the turtle. Fishermen therefore chose to leave slightly more line on the turtle when freeboard was high or weather conditions limited the Captains ability to maneuver because they thought that was better for the turtle than dragging the turtle closer to the boat. This would be particularly true for leatherbacks especially when they were active. A 5 meter threshold for leatherbacks would reflect reasonable handling distances aboard US commercial vessels where an attempt to avoid straining the line and dragging the turtle is probably being made. Five meters of monofilament would probably weigh less than a pound or two in the water which would seem to be a negligible drag on a several hundred pound leatherback. Some of this concern about a line length threshold relates to post-classification (after the fact) when NMFS has not provided clear guidance to the fishermen. The same can be said for classifying all turtles as hooked by injestion including those clearly noted as hooked in the mouth when the observer guidance described in Technical memo SWFSC - 222 indicated that hooks were considered injested if the hook was "past the mouth cavity and in the esophagus".

If all turtles that are released **are all categorized similarly as seriously injured** whether they are trailing small lengths of monofilament (< 1 or 2 meters as drafted) after being either externally hooked or hooked in the jaw (hook left in), released with only the hook in the jaw (no trailing gear), and hooked turtles that are completely disentangled with the hook removed, these **criteria will undermine efforts to encourage careful handling and extra effort to maximize survival.** I can't see how this risk averse decision would be consistent with previous agency actions relative to other fisheries, handling or resuscitation guidelines, and the limited post-release data that is available.

Post-release mortality studies include Anguilar's study of survival of deeply hooked turtles from the Spanish Mediterranean fishery which uses very small hooks and baits and provides the 28.9% mortality rate listed on page 2 of the draft. Information from tracking studies from the Hawaiian longline fishery **need to be reviewed**. In the Honolulu lab program review 2000 document (page 130) it is noted that satellite transmitters have been deployed on 38 loggerheads, 11 olive ridleys, and 3 green turtles (a total of 52). "Twenty seven of the deployments have resulted in pelagic trackings ranging from 0.2 to 8.2 months duration covering distances of 13 - 7,282 km. The remaining 13 deployments have produced no tracking data, and all of these involved turtles that were classified as "deeply hooked" (hook lodged in the esophagus and impossible to remove)." This last sentence seems to be an incomplete thought and the total of 27 and 13 is 40, so an obvious question remains about the remaining 12 tracks. The next two sentences in the program review are as follows: "Of the 39 tracked turtles, 22 were deeply hooked and 17 "lightly hooked" (the hook was in the jaw or elsewhere externally allowing easy removal). There were no significant differences between these two groups for the duration of transmissions in months or the distance the turtles traveled." Additional information on these tracking results are critically important. If all 13 of the turtle deployments that produced no tracks were deep hooked what other condition notes were recorded and are these included in the total of 22 listed as deeply hooked or in addition to the 22? What was the species breakdown for the lightly and deeply hooked turtles and for the no track turtles?

If the 13 no tracks are in addition to the 22 deeply hooked then we have 39 tracked turtles and 13 no track turtles (total 52) with 35 deeply hooked and 17 lightly hooked. If the 13 no tracks only reflect short-term mortality as opposed to transmitter or battery failure or another co-variate, then 37% of the deeply hooked turtles may have died. The obvious questions include what the additional condition notes might include and whether the no track deployments all share a common characteristic (same trip, same month, similar area, similar size and species, transmitter lot, battery lot, etc.). In any case given the number of observations in both the Anguilar and Balazs studies it would seem that this data could justify assigning a mortality rate between 30% and 40% for deeply hooked turtles. I would assume given similar tracking distances and speeds a much lower mortality rate (some might argue a negligible rate) would be justified for lightly hooked turtles. Those turtles that are completely disentangled should not be categorized as injured unless wounds or trauma are evident.

In light of the preceding I would offer the following alternative categorizations of interaction types:

1. **Not Injured** - Turtles that spit hooks and baits while the gear is being retrieved and entangled turtles where hooks are not involved and where the turtle is released with no gear attached.
2. **Non-serious Injury (lightly hooked)**. - Disentangled externally hooked turtles (not in jaw, beak or tongue) released with limited[1] gear attached. Also include turtles hooked in the jaw, beak, or tongue (externally visible) if the hook was removed for those sizes of turtles that could be brought aboard with dipnets and there was no other tissue damage or bleeding noted. Externally hooked (not in jaw, beak, tongue, or neck - only carapace, flippers or tail) **large turtles** released trailing gear longer than the limited[1] gear

thresholds but less than 5 meters in length.

3. **Serious Injury - level 1 (deeply hooked but limited gear).** - Hook lodged in the esophagus and impossible to remove with the turtle released with limited[1] gear attached and observer notes indicating active and reasonable condition. Externally hooked turtles released with limited[1] gear attached and with non-critical tissue damage or limited bleeding noted, including turtles hooked in the jaw, beak, or tongue (externally visible). Different mortality ranges should be provided for these two groupings.
4. **Serious Injury - level 2 (deeply hooked with excessive gear).** -Hook lodged in the esophagus and impossible to remove with the Turtle released with more than the limited[1] gear attached and/or wounds noted to the eyes or neck. If an attached buoy was left trailing that would be a serious injury level 2 along with any turtles where the observer notes reference struggling or weak condition or a visible serious wound more extensive than a hook puncture.

Assigning rough quantitative ranges for mortality rates to the preceding categories will require a thorough review of the condition notes associated with the Honolulu tracking studies and any other information that has been developed over the last few years. This should be a topic for more extensive discussions including a range of people with greater experience than I have on events at-sea as well as vets and other biologists. It would seem reasonable however for the mortality rates for serious injury - level 1 deeply hooked turtles and serious injury - level 2 deeply hooked turtles to be different and preliminary range estimates might be reasonably established once the tracking study results are more thoroughly reviewed. I would also obviously have a 5th category for dead turtles.

[1] Refers to line distances of <1 meter for loggerheads and <2 meters for leatherbacks.

Comments from Elliot Jacobson

Developing Interim Guidelines for Determining Serious Injury of Sea Turtles Taken Incidentally by the Pelagic Longline Fisheries

Comments

1. It is clear from the Final Report 50EANA700063, that not only do the terms "injury, non-injury, and serious injury" need to be defined, but that the observations and nomenclature to describe the observations must be standardized. Here are some recommendations:

a. **Serious Injury**: having a negative effect on turtle survivorship or negative effect on the animal's contribution to the population.

b. Definition of **Injury** for marine mammal and sea turtle should be the same. The causes may be different. Injury: damage inflicted to the body by an external force (from Dorland's Illustrated Medical Dictionary).

c. While by process of elimination, a **non-serious injury** would be an injury that is not defined as a serious injury, still this needs definition.

d. A definition of "**foul-hooking**" needs to be included in any document.

2. Major problem is that we can't determine the extent of injury without establishing criteria for a healthy marine turtle. A group has been formed at the University of Florida to establish the "gold standard" for sea turtle health assessment. This will take several years to define. So when an attempt is made to try and categorize or establish criteria for injury, both serious and non-serious, realize that we are limited in our ability to stringently categorize animals. Clearly an animal that is moribund and appears to be near death because of obvious massive injury is easy to categorize. The difficulty is with those animals that appear to have minimal external damage but may have significant internal damage or are septic as a result of the injury. As all of us in medicine know, trying to get a handle on these cases is extremely challenging. So everyone needs to

know what the limitations are. To come up with a more meaningful way of categorizing these animals, ultimately turtles with certain types of injuries need to be followed through time using satellite monitoring. This will be the only way to get a scientifically based handle on outcome of injured animals. Categories of injuries can be established and criteria then developed to allow some type of categorization. Hopefully this will be an outcome of your proposed meeting.

3. We believe that any animal that is released with an intact attached hook, is at risk, especially if line is still attached. The more line, the more risk of being snagged underwater and drowning. The level of risk of drowning is dependent on the size and robustness of the turtle, as well as the area hooked. Of the 30 stranded turtles evaluated in a study done by us, at least 10% had evidence of fishing line injury severe enough to explain the cause of death. One had swallowed line, resulting in imbrication of the intestinal tract. One had a hook lodged in the larynx, associated with necrotizing laryngitis. One had an abscess ventral to the tongue which could have resulted from a fish look lodging there. I think the abscess impacted on the turtles ability and desire to eat. It should be assumed that if a turtle is entangled, that a hook could be internalized. The only way to dismiss this would be to radiograph these turtles. Even if a hook was found externally, that would not preclude an internal hook. A turtle with a swallowed hook could be in grave danger.

4. Questions to be answered:

a. How long does it take for hooks to rust out?

b. How stable is the monofilament line relative to disintegrating in salt water?

c. Is it possible to salvage any of the turtles for rehab, to conduct a parallel study with radiotransmitters?

d. In the report, there was a suggestion that some turtles could be entangled multiple times in longlines. What is the likelihood of this happening?

e. How toxic are light-sticks if they are swallowed? Are they ever swallowed?

5. There was no mention in the "Description of Longline Fishery" paper of what is used to weigh down the lines in the water. I assume that no toxic metals (for e.g., lead) are used.

HI-LINER

FISHING GEAR AND TACKLE, INC.

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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
National Marine Fisheries Service
Attn.:: Office of Protected Resources
Room 13630,
Silver Spring, MD 20910

November 16, 2000

Dear Ms. Conant,

Thank you for the opportunity to participate in your initial solicitation of input concerning sea turtle—pelagic long-line interactions. HI-LINER Fishing Gear is the largest US exporter of pelagic monofilament long-line materials to the world pelagic swordfish/tuna long-line fleets. We maintain several offices in many coastal nations to provide local inventory, product support and technical expertise. Currently, we remain the key supplier to a majority of pelagic long-line vessels fishing from Spain, Portugal, South Africa, Brazil, Uruguay, Mexico, Chile, Australia – to name a few. It is the purpose of this letter to establish the position and standing of HI-LINER among the world-wide pelagic long-line fleets, principally those plying the North/South Atlantic oceans.

HI-LINER has maintained a long history of product introduction, development and extension. The evolution of this style of fishing equipment has not been limited to the US. Acceptance of this material by other more traditional fishing nations has produced advancements and improvements in both equipment and technique. HI-LINER's emphasis on the operational success of individual international fishing vessels has left us uniquely qualified to comment on long-line gear principles, dynamics and continued product evolution.

However, your solicitation specifically requested input concerning injuries and their relative short/long term implications. It remains my strong belief that our subjective contribution to this phase of your investigation would contribute little to the attainment of the true goal of your discussions, Minimization/Avoidance of Sea Turtle//Pelagic Long-line Harmful Interactions. I would formally request that HI-LINER be consulted directly prior to any discussion of gear modifications, operational gear parameters and dynamics relative to sea turtle interactions. Combinations of traditional foreign fishing techniques

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Trinidad: 001-600 525 4327 • Mexico: 95-800-525 4327
Spain: 900931156

with modern monofilament pelagic long-line gear has proved the flexibility and malleability of this style of fishing

At your convenience, your review would be greatly appreciated.
Please advise your requirements. Thank you for your time and considerations.

Regards,

Edward R. Gaw
HI-LINER FISHING GEAR, Inc.

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
National Wildlife Health Center
Honolulu Field Station
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Phone: 808 541-3445, Fax: 808 541-3472
E-mail: thierry_work@usgs.gov

November 20, 2000

FAX

TO: Therese Conant

FROM: Thierry Work

Total Pages: 3

Dear Ms. Conant

Thank you for the opportunity to review the material on long line and marine turtle mortalities. In an attempt to make this issue more tractable, consider the following simple model:

Line is set→turtle is attracted to line→ turtle gets hooked→turtle dies or survives

Line setting:

What factors are conducive to turtle being hooked and how could these be prevented? Contract report 50WANA700063 outlines some of these including depth of line, time of set, temperature, use of light sticks, area of set, date of set.

Attraction:

What is it exactly that attracts turtles to bait? Are there certain bait types that would be equally attractive to fish but less so to turtles? Could artificial baits be developed that are repellent to turtles but not target fish? Could sonic devices be placed around lines that repel turtles? This would call for research on olfactory and visual cues that attract turtles to bait.

Hooking:

According to the contract report, this appears to be one area where more information could be gathered. 2

Once an animal is hooked or entangled in the line, how severe is the injury? The NOAA-NMFS-OPR-13 goes some way into defining that for marine mammals. Defining injury based on hook placement alone in marine reptiles may be misleading. For example, lightly hooked turtles (hook on beak only, no visible trauma) may still drown from forced submergence. On the other hand, we have seen turtles with traumatic amputations of the forelimb from fishing line that survive quite well. Also, some turtles considered deeply hooked and tracked by satellite have been shown to survive many months. Finally, an animal may be hooked in the flipper (survivable injury) but released with several feet of leader thus posing potentially lethal risk of the leader wrapping around limbs or neck and causing strangulation or limb amputation. Perhaps consider standardizing criteria to define an animal as uninjured, moderately or severely injured using something like the following criteria.

Uninjured-Animal vigorous, breathing is unremarkable, hook on beak only (easily removed with no visible trauma) and no evidence of external trauma from line or hook.

Moderately injured-Visible trauma from hook on beak, flipper or shell. visible trauma from line around flipper (e.g. abrasion or cutting into flipper). Animal vigorous, breathing is unremarkable.

Severely injured-Hook in soft tissue of mouth (tongue, soft palate), or deep into esophagus. Leader wound tightly around limb with a partial avulsion or amputation. Alternatively, no visible injuries but animal weak.

Documenting: Following data would probably be helpful to standardize reporting. Items (*) are those used to decide whether animal is uninjured, moderately, or severely injured. Items (*, **) may be useful for long term prognostication:

- -Hook number and type
- -Date and time of set
- -Water temperature
- -Type of light stick used (color, make)
- -Hook location*
- -Photo of hook set in turtle or of line-induced injury*
- -Length of turtle
- -Hooked removed (Y/N)**
- -Animal (vigorous, weak, dead)*
- -If hook not removed, length of lead left on hook.**

Any dead animals should be stored frozen and returned to a laboratory for complete post-mortem exam. Alternatively, observer puts animal aside and performs a necropsy taking appropriate samples in formalin and frozen once catch is finished

---

(how realistic this is depends on conditions on the boat). 3
Perhaps NMFS needs to dedicate observers to do this task only (documenting extent of injury and doing necropsies).

Other avenues of pursuit: Given that hooks are set in 24 hour periods, are there materials that can be used to make hooks that will have similar tensile strength as steel but will degrade or dissolve, in, say 7-10 days? For example, some darts used to immobilize animals have a needle with a barb made of a material that dissolves once it contacts body fluids thus causing less injury when the dart is removed. The key would be to find a material that would dissolve, just more slowly (>24 h) allowing desirable fish to be caught.

Turtle dies or survives:

(how realistic this is depends on conditions on the boat). Perhaps NMFS needs to dedicate observers to do this task only (documenting extent of injury and doing necropsies). 3

Other avenues of pursuit: Given that hooks are set in 24 hour periods, are there materials that can be used to make hooks that will have similar tensile strength as steel but will degrade or dissolve, in, say 7-10 days? For example, some darts used to immobilize animals have a needle with a barb made of a material that dissolves once it contacts body fluids thus causing less injury when the dart is removed. The key would be to find a material that would dissolve, just more slowly (>24 h) allowing desirable fish to be caught.

Turtle dies or survives:

Efforts should be made to satellite tag animals in uninjured, moderate, and severely injured category to evaluate long-term outcomes. Perhaps this could most readily be done in fisheries that consistently catch large numbers of turtles. A model animal could be something not critically endangered like the loggerhead.

I hope this is of some use.

Sincerely,

Thierry M. Work
Wildlife Disease Specialist

QUICK

Date: 4 Dec 00 # of Pages:	From:
To: Donald Knowles	Co./Dept: Houston
Co./Dept: Director / Office of Prot. Res.	Fax: 713-284-1334
Fax: 301-713-0376	Phone: 713-284-8342
Phone:	E-Mail:
Fax:	

4 Dec 2000

Donald R. Knowles
Director
Office of Protected Resources

Dear Dr. Knowles,

I have been working with sea turtles for approximately 16 years through the National Marine Fisheries Service Galveston Laboratory. During that time I have seen a number of sea turtles (mostly Kemps Ridleys) which have been caught on hook and line in the recreational fisheries here on the upper Texas coast. These turtles by and large, have ingested hooks and are presented within a day of capture.

Presentation has varied with size of the turtle, type of hook (size, shape, material), presence or absence of a leader, and quantity of line present. My approach to treatment has varied with the actual location of the hooking. At presentation, the hook may be present in the oral cavity, any point in the esophagus, or in the stomach. The damage done by the hook will vary with the point in the body that is hooked, the depth of hook penetration, and the length of time the hook has been present. I am never presented with animals that have had hooks for more than a few days.

In general, with a simple hook, the deeper (farther into the esophagus or stomach) the animal is hooked, the greater the chance of damage or potential damage. Important exceptions to this are animals that are hooked in the oral cavity with the point of the hook penetrating into the orbit or globe of the eye, or animals that are hooked into a major blood vessel. Hooks that penetrate through the gut wall can cause variable damage, depending on what area or which organ the hook impacts. I have observed hooks that have punctured the major vessels near the heart, resulting in nearly immediate death of the animal. The point of a hook may cause a localized infection at the point of penetration. This infection could remain quiescent, and ultimately resolve without long term harm to the animal, or could result in a generalized infection and death. It is possible that a hook without a significant length of attached line can pass through the digestive tract without harming the turtle. I cannot guess at what percentage of cases this may occur.

Hooks anywhere in the gastro-intestinal system that trail fishing line can lead to plication of the intestines and potential peritonitis (coelomitis) with a linear foreign body. I consider any length of trailing line to be a significant risk to the health of a turtle as the line passes into the intestinal tract. Long lengths of line trailing from the oral cavity can entangle the turtles neck or appendages and result in physical harm to the animal. Loss of a flipper may reduce the animals feeding efficiency, its ability to evade predators, or impact its ability to reproduce.

Animals hooked in locations other than the gastro-intestinal system have a lower risk of adverse health effects due to the hooking incident. Hooks penetrating skin or superficial muscle groups are likely to establish a localized infection, but are likely to slough with infected tissue. The turtle will heal, albeit with a defect where it was hooked. If hooked in or near a joint, the injury will be more severe. Penetration of a joint may impact the animal's mobility and is more likely to result in systemic infection.

Hooked turtles can suffer from harm caused indirectly as a result of their capture. Animals that are hooked and fight the hook may over-exert themselves, exhausting muscle energy sources and causing a severe metabolic acidosis. These animals may appear normal, may fight with great force when handled, but may not have the ability to recover if returned to the sea in an exhausted condition. The longer an animal fights, or the greater the intensity of the fight, the more likely it will have problems recovering from the hooking incident.

If an animal is hooked and is unable to surface, it will obviously drown within a relatively short period of time. The time will depend on the length of time since the animal last surfaced, the water temperature, the size of the turtle, and the amount of struggling the animal does on the line.

Houston Zoological Gardens

Turtle interactions with hooks are traumatic incidents. Although some individuals may survive relatively unharmed, the vast majority will suffer significant injury and potential mortality as a result of being hooked.

If you have any further questions please contact me directly. I apologize that this response is tardy, but I was away when the package of information arrived.

Sincerely,

Joseph P. Flanagan DVM
Senior Veterinarian
Houston Zoological Gardens
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New England Aquarium

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Donald R. Knowles
Director, Protected Species
National Marine Fisheries Service
Silver Spring, MD 20910

24 November, 2000

Dear Dr. Knowles,

Thank you for the opportunity to submit comments on the materials that your office forwarded re. effects of interactions between longline fishing gear and sea turtles.

NMFS is doing the right thing by developing criteria describing long line gear interactions that are specific to sea turtles. Although marine mammals and sea turtles share the distinction of being air-breathing vertebrates, they have very different behaviors and susceptibilities or responses to human interactions. Since we don't have all of the answers regarding gear interactions and sea turtles, it will be productive to have a suite of descriptions that accurately characterizes a sea turtle's condition, and disposition of gear left on the animal. Only then will all parties have the necessary information to proceed with mitigation that will limit or eliminate harmful interactions, and reduce burdens for fishermen if and when it is appropriate to do so. Specific comments follow below:

I. " Non-serious injuries" This category is contradictory and misleading. A "non-serious injuries" cannot be equal to "no visible injuries". If the animal is not injured, the observation should clearly state it as such.

1. Suggested alternatives to non-serious injuries that would describe animals that have run into gear but that have no visible injuries and are not suspected to have had them:
Gear Interaction 1, resolved (trailing or entangling gear has been removed)
Gear Interaction 2, gear not completely removed.

2. "Visible injury, minor (superficial)
Any visible injuries such as cuts, minor lacerations- that are not likely to jeopardize the health or impair the movements or behavior of the turtle. This type of injury would be expected to spontaneously heal/resolve.

II. Serious Injuries The five types of interactions could all be construed as serious. However, there are still some grey areas. For example, Entanglement in monofilament line.. That interferes with mobility... such that feeding, breeding or migrations are impaired." Does this mean that the turtle is released with the monofilament, or that it was impossible to free it of binding gear? If yes- then of course, this is serious injury. But if the animal were freed of the mono and then showed signs of strength and normal swimming/behavior, would the designation of serious injury still hold true? [I hope that we all are working to making this situation go away. If still alive, all badly entangled animals need to be freed of gear. I need to know/understand whether there are cases where a longliner crew would be unable to free the turtle? If the turtle is attached via float line to rest of gear, doesn't the boat always have some line to the animal that can be retrieved?]

Regarding 4. Ingestion of hook in beak or mouth... does this mean that the observer can see the hook? There are cases where sea turtles have hooks in the keratinized tomium, but because it's not in the soft tissue, there may be little or no impairment, and the hooks eventually get dislodged. This is different than cases where the hook is in the soft tissue, where it is likely to be pushed further into the tissue.

Possible alternatives could be
Gear Interaction- Hooking

1. Visible, external, no obvious injury [no mortality expected]
2. Visible, external, injured [injuries serious, mortality could result]
3. Internal/Gut hooked; serious injury suspected or likely. [mortality could result]

From Table 1 1999 NOAA Fisheries Sea Sampling Program, observers can obviously provide descriptive information that can be used to make an assessment of a turtle's status, especially in regard to serious vs. non serious injury, and whether a turtle is injured at all. There's plenty of room for improvement. For example, "hooked in mouth"- does this mean in the tomium, or in the soft tissue? Another one "swam off readily, although seem tired." My impression is that with explicit training, observers could provide unambiguous information. Photographs are also useful as supporting information.

The information provided by the Hoey report was extremely helpful. His analysis provides a good place to start to examine environmental relationships between sea turtles and longline gear, and where they are most likely to converge. However, we need more details, as temperature ranges were quite broad. We had this same problem in trying to find relationships between leatherbacks and real-time ocean frontal conditions, using limited aerial survey data from right whale and other surveys. For example, depending on geographic area, leatherbacks were found in SST's ranging from 10 -23 ° C, even though the average SST from right whale survey databases was 16 °C (Distribution of Leatherback Turtles in relation to the Environment, Cooperative Agreement #40GENF400229, report to NMFS SEFSC, M. Lutcavage). Most of our observations came from inshore surveys, and are not particularly helpful in identifying offshore habits. I understand that the NMFS SEFSC recently funded a study by Morreale to examine SST's and location of longline sets that had interactions with sea turtles. It would be very helpful if these results were made available for review. It would also be important to see Scott Eckert's results of diving habits and travel patterns of leatherbacks that he's tracked with satellite transmitters in the Atlantic and elsewhere, particularly if this study were funded by NMFS and if a technical report were available for distribution.

I was dismayed to see NMFS incorrectly use a report prepared by Greenpeace (submitted to the Sea Turtle conference but not subjected to peer review), in the recent Biological Opinion (Jun 30,2000). Page 35 states "Perhaps a better way of looking at the data is to apply the 29% mortality estimate provided by Aguilar (1995) to the average annual estimated take of 715 animals (Yeung et al., *in prep*) which indicates that an average of 207 animals annually either die or are seriously injured by pelagic longlines in the U.S. fleet." There is no way of knowing whether the Yeung et al. data is convincing, because the reader is unable to see it. The Aguilar et al. paper provides useful (although very general) information on turtles taken in the Spanish longline fishery, but is extremely flawed as a scientific paper on post release mortality or survivorship. The data shown in their Table 1, which suggests that " 20-30% of sea turtles may die after having been captured by a longline" is based on turtle survivorship of animals kept in "large aquaculture pools with the aim of estimating the mortality rate of the individuals released with hooks still in their bodies...". The authors of this study did not conduct necropsies to establish cause of death, which is an absolute requirement, nor did they conduct control experiments that would establish whether the captured turtles had a lower survivorship than animals not subject to capture but also held in the tanks. Anyone that has raised sea turtles in captivity knows that they are subject to infections, disease, and other problems that arise from culture. Without addressing all of these concerns, this study cannot be used to establish survivorship or post release mortality. It would not have passed peer review, and NMFS needs to be honest about using it as "best available science" when it is clearly does not satisfy sufficient scientific standards for establishing cause of death. Similarly, the reference to Balaz unpublished data (page 60) on a "44% mortality estimate observed by Balaz (person. comm)" needs to come forward for evaluation. A good scientist cannot simply accept an unsubstantiated estimate for this important issue. Without a report to evaluate, there is no credibility.

The report prepared by Angliss and DeMaster was comprehensive, accurate, and very well done. It clearly sets the agenda for sea turtle/longline interactions, and it should serve as a model and guide for discussion and process for establishing distinct sea turtle criteria. For example (page 4)" Participants stressed that a thorough necropsy is necessary to determine the cause of death of large cetaceans and the degree to which an entanglement may have contributed to the mortality ... (and as a footnote.... was stressed for all marine mammals in general)." The section "Collecting data on injuries" was also extremely important and clear on what needs to be done- the same holds for sea turtles: "Workshop participants identified several actions that would improve the data that observers provide on incidental injuries, such as 1) improve the training for recording interactions with marine mammals, 2) include marine mammal scientists in the debriefing... 3) encourage observers to provide more detail...". All of these points are relevant to sea turtle and long line interactions.

Although I've listed some comments above, I look forward to further discussion at our upcoming meeting. Thanks again for the opportunity to weigh in on this issue.

Sincerely,

Molly Lutcavage

Molly Lutcavage, Ph.D.
Senior Scientist, ERL

Robert A. Morris, MS, DVM
E. Alan Zane, DVM
Thomas Chelebecek, MS, DVM

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November 24, 2000

Mr. Donald R. Knowles, Director
Office of Protected Resources
National Marine Fisheries Service
Silver Spring, MD 20910

Dear Mr. Knowles:

In response to your request on sea turtles and fishing gear, I offer the following observations as a contract veterinarian for sea turtles for the National Marine Fisheries in Honolulu.

1. Some hooks remain unchanged for months in the intestinal tract of turtles with no evidence of dissolving (followed with X-rays).
2. Turtles have been seen with ingested hooks and are apparently healthy. On the other hand, hooks that perforate the G. I. Tract can cause death.
3. Hooked turtles trailing monofilament line can cause serious problems with line wrapped around the flipper, resulting in tissue and bone necrosis. We have done numerous flipper amputations because of this problem. Ingestion of the monofilament line can also cause serious problems to the intestinal tract.

The most important aspect for the survival of hooked turtles is removal of the hook, and if that is not possible, cut the trailing line as short as possible. Any hooked turtle with trailing mono line is in serious trouble.

If you require additional information, let me know.

Sincerely,

Robert A. Morris, MS, DVM

UNIVERSITY OF CHARLESTON
Grice Marine Laboratory
205 Fort Johnson
Charleston, South Carolina 29412

November 18, 2000

Telephone: (843) 406-4000
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Dr. Donald R. Knowles
Director
Office of Protected Species
NOAA/ NMFS
Silver Spring, MD 20910

Dear Dr. Knowles,

I have received the packet of information on the concerned interactions between sea turtles and longline fishing gear. The following comments are my initial reactions to the materials sent in the packet as well as my general sense of the importance of this particular conservation issue. Other than the information you sent, I do not have a good knowledge of this particularly fishery.

Observations:

1. Generally speaking, sea turtles are robust animals and can recover eventually from superficial external injuries such as would occur from a hook that is removed.

2. Physiologically, it is my impression that the leatherbacks are not as resilient hardy as the hard shelled turtles. This is suggested because of softer epidermal tissue, softer heads and beaks, heavier body mass and generally softer bodied food sources. Thus such actions as hooking, lifting from the water, and ingestion of hooks and lines may have more damaging and long lasting impacts on an individual leatherback.

3. Ingestion of a hook and line (depending on size) is likely to have long term impact on survivability of any sea turtle. We see lots of "floaters" in South Carolina. These turtles generally have a peritoneal infection which is causing gas to accumulate in the body cavity. Eventually these animals weaken and die unless treated. While I do not know this for a fact, hooks could be an initial cause of this problem. My concern is that ingested hooks may provide a long term irritant and source or bacterial entry. In addition, if the hook lodges in heart or lung tissue, or results in occlusion of the gut, the turtle may die directly for the event.

4. Leaving several yards of monofilament line hanging from the mouth is another source of potential problem. The line can be fouled and cause drag, swallowed causing an occlusion of the gut or wrapped around a flipper or caught on another object. Feeding will be impaired to some degree depending on several variables.

Recommendations:

1. A physiological study of naturally hooked animals could address some of these concerns. Variables to be evaluated are movement of hooks once the line is cut, impact on feeding ability, changes in stress hormone and reproductive hormone levels and susceptibility to local or internal infections. In an aquarium, under proper medical supervision, animals could safely studied. If and when they appeared to be suffering or taking a serious turn for the worse, surgical and antibiotic treatment could be applied to insure survival and eventual release.

2. Several veterinarians have experience in removing hooks. Their observations and results could be instructive in this regard.

3. Whenever possible, the entire line and any portion of the hook which can be seen should be cut out prior to release of the animal.

4. Additional observer work would seem to be important in zones 5, 6 and 7 and possibly 2.

I believe this fishery interaction is a serious problem for sea turtles.

Sincerely,

David Wm. Owens
Professor and Director
Graduate Program in Marine Biology

APPENDIX K

Memorandum from B. Morehead to W. Hogarth re*: Marine Turtle Mortality Rates from Interactions with Atlantic Pelagic Longline Fisheries*

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

JAN 30 2001

MEMORANDUM FOR: F - William T. Hogarth, Ph.D.
Acting Assistant Administrator for Fisheries

FROM: F/SF - Bruce C. Morehead
Acting Director, Office of Sustainable Fisheries

SUBJECT: Marine Turtle Mortality Resulting from Interactions with Atlantic Pelagic Longline Fisheries

The Office of Sustainable Fisheries (F/SF) has several comments on the recommendations stated in the January 4, 2001, memo addressing marine turtle mortality resulting from interactions with pelagic longline fisheries that occur in the Atlantic Ocean.

Summary

1. Available information on marine turtle mortality resulting from interactions with pelagic longline fisheries is sparse and incomplete. F/SF believes that observer reports, particularly handwritten notes on every interaction, constitute valuable information and often the best available in formation. Accordingly, we recommend that the observer reports be examined for detailed accounts of each pelagic longline interaction with sea turtles and coded by type of interaction (entangled, lightly hooked, and deeply hooked). These different interaction types should then be evaluated for serious injury and the differential mortality estimates by type of interaction should be incorporated in the next Biological Opinion.

2. F/SF believes that the 50% mortality level is a recommendation that does not take into account the current requirements for the Atlantic pelagic longline fishermen and does not reflect the best available science concerning post-release mortality. This concern was raised by industry representatives at the gear workshop (January 17 - 18).

3. F/SF would like to work with F/PR to develop and implement a protocol to characterize accurately and thoroughly the pelagic longline interactions with sea turtles, the response of the fishermen, and the observed injury. By ranking each factor, an overall expectation of survival could be assigned to each sea turtle interaction.

50% Mortality Recommendation

F/SF feels that there are some important issues that should be addressed concerning the 50% mortality recommendation. F/PR states that the 50% lethal classification considers the range of mortality suggested by tagging studies and assumes additional mortality under normal fishing conditions, where turtles are infrequently boarded, and gear can be assumed to be left on turtles at a greater rate. However, F/SF1 implemented regulations on November 24, 2000, requiring pelagic longline vessels to possess and use dipnets and line clippers to remove as much fishing gear as possible before releasing a captured sea turtle. These measures have changed normal fishing behavior and need to be taken into account in this mortality estimate. As the January 4 memo indicates (and several respondents concurred), gear left on turtles (especially trailing gear) is a significant risk to sea turtles and was a justification for the 50% post-release mortality recommendation. Accordingly, as the new handling and release requirements stipulate that turtles should be boarded and as much gear be removed as possible, the risk to turtles from remaining and trailing gear is significantly reduced. F/SF believes that these gear and handling requirements significantly improve sea turtle survival and should be incorporated into the recommendations on sea turtle post-release mortality estimation. Industry supported making these requirements permanent and NMFS has prepared a proposed rule to do so. Discounting the effects of these requirements would be inconsistent with the objective of the regulation.

In the serious injury assessment strawman, inputs were solicited regarding the various categorizations of pelagic longline related injuries. Several of the respondents suggested that the level of mortality depends on the severity of the interaction. Based on these inputs, F/PR revised the criteria for determining injury for sea turtle-pelagic longline fishery interactions. However, when determining post-release mortality, these criteria where ignored and a blanket 50% mortality level was recommended for all sea turtle interactions, regardless of interaction type noted by observers. The non-serious injuries and minor or moderate injury categories are not thought to have the same mortality levels as the serious injury criteria. The observer reports should be used to determine the severity and rate of interactions by type. These data represent the best available information for this fishery and should be used instead of the 50% mortality estimate that has been recommended for application to all sea turtle / longline gear interactions.

Finally, F/SF feels that more attention should be directed towards the tagging studies referenced in assessing the mortality level. F/SF staff have discussed with sea turtle scientists concerns that they have with how data from their studies have been used in this recommendation. Specifically, these scientists indicated that a uniform mortality level is not a realistic or an accurate reflection of the post-release survival of sea turtles. When the current data from the Azores and Hawaii tagging projects are combined according to hooking severity, there appears to be a discernable difference in post-release mortality (40% compared to 21.4% for deep versus light hooked loggerhead turtles). While there are concerns with these studies, (e.g. small sample size, lack of statistical significance in results) they may represent the best available science and should therefore be considered as part of these assessments.

Recommendations

F/SF recommends that the handwritten observer reports be reviewed and interactions coded by type as soon as possible according to the injury criteria presented in the January 4, 2001 memo. F/SF1 staff can be made available to help review the observer reports from the Atlantic if necessary. The recent regulations requiring pelagic longline vessels to carry and use dipnets and line clippers will reduce the level of post-release mortality and this needs to be incorporated into the mortality estimates. Finally, the tagging studies need to be utilized to provide a scientific basis for mortality determinations based on the severity of injury. By assigning mortality estimates based on the types and severities of the gear interactions, a more accurate determination of overall impact can be generated. The table below gives an indication of how the various interactions could be assessed. Based on the tagging studies (a summary sheet is attached with this memo), no injury would involve no mortality, minor and moderate injury would involve 0 or 27 % (Azores or Hawaii Study respectively), and serious injury would involve 33, 35, or 42 % (Azores, Aguilar, or Hawaii study respectively) mortality. F/SF recommends using mortality estimates of 27 % for minor and moderate injuries and 42 % for serious injuries as appropriate and reasonable risk averse assumptions, given the current scientific information.

Interaction	Response	Injury	Mortality Rate
Entangled / no hook	Disentangled	No injury	0%
Entangled / external hook	Disentangled, no gear	Minor	27%
	Disentangled, trailing gear	Moderate	27%
	Dehooked, no gear	Minor	27%
Hooked in beak or mouth	Hook left, no gear	Moderate	27%
	Hook left, trailing gear	Serious	42%
	Dehooked, no gear	Moderate	27%
Hook swallowed	Hook left, no gear	Serious	42%
	Hook left, trailing gear	Serious	42%
Turtle Retrieved Dead	---	Lethal	100%

Future Considerations

F/SF feels that the best manner to determine the post-release mortality of sea turtles following an interaction with pelagic longline gear involves characterizing the encounter, the response by the fishermen, and the observed injury. By establishing a ranking system for each of the factors associated with these categories, every turtle take could be evaluated for severity and mortality risk. When more data are available on the estimate of post-release mortality, the mortality of sea turtles as a result of pelagic longline fisheries can better be approximated. The serious injury workshop proposed by F/PR should address this ranking system. Once the characterization criteria are determined, observer data recording forms and training materials should be amended accordingly. Finally, guidance should be issued to all potential users regarding a protocol for applying the criteria for the purpose of generating annual mortality estimates.

Attachment

cc: F/NEC - Michael Sissenwine
F/NER - Patricia Kurkul
F/PR - Donald Knowles
F/SEC - Nancy Thompson
F/SER - Joseph Powers
F/ST - William Fox
F/SWC - Michael Tillman
F/SWR - Rebecca Lent

Summary of Aguilar 1995 (loggerhead)

Hooked?	# Turtles	Deaths	Mortality
Deep	32	11	34.4%

(excludes 6 turtles under observation)

Bjorndal, Bolten, and Riewald 1999 Azores Study (loggerhead)

Hooked?	# Turtles	Stop Trans	Released	Mortality	
Control	5	0	9/15/98-10/12/98	0%	Dipnetted
Light	3	0	10/28/98-12/5/98	0%	Mouth hooked

All still functioning Feb. 28. 1999

Riewald, Bolten, and Bjorndal 2000 Azores Study (loggerhead)

Hooked?	# Turtles	Stop Trans	Released	Mortality	
Control	4	2	07/15/2000	50%	Dipnetted
Deep	6	2	8/3/00-9/8/00	33%	Throat hooked

Still transmitting Dec. 2000

Mortality estimate includes one turtle that is sending signals suggestive of mortality

NMFS 2000 Hawaii Study (green, loggerhead, olive ridley)

Hooked?	# Turtles	Stop Trans	Mortality	
Light	19	4	21%	Beak or flipper hooked
Deep	30	11	37%	Swallowed hook

Successful track = at large for > one month

Hawaii - Green

Hooked?	# Turtles	Stop Trans	Mortality	
Light	2	0	0%	Beak or flipper hooked
Deep	1	0	0%	Swallowed hook

Hawaii - Loggerhead

Hooked?	# Turtles	Stop Trans	Mortality	
Light	11	3	27%	Beak or flipper hooked
Deep	24	10	42%	Swallowed hook

Hawaii - Olive Ridley

Hooked?	# Turtles	Stop Trans	Mortality	
Light	6	1	17%	Beak or flipper hooked
Deep	5	1	20%	Swallowed hook

Totals from Azores and Hawaii Tagging Studies (all species)

Hooked?	# Turtles	Stop Trans	Mortality (%)	
Control	9	2	22.2%	Dipnetted
Light	22	4	18.2%	Beak, flipper, or mouth hooked
Deep	36	13	36.1%	Swallowed or throat hooked

n=67 (Includes likely Azores mortality)

Totals from Azores and Hawaii Tagging Studies (loggerhead only)

Hooked?	# Turtles	Stop Trans	Mortality (%)	
Control	9	2	22.2%	Dipnetted
Light	14	3	21.4%	Beak, flipper, or mouth hooked
Deep	30	12	40.0%	Swallowed or throat hooked

n=53 (Includes likely Azores mortality)

Notes from conversation between Laurie Allen and John Hoey 8/17/2000.

June 30, 2000 Biological Opinion. Statements Justifying Re-initiation of Consultation.

1) Proposed time-area closure had potential to increase interactions with turtles.

- @ 6-8% increase in turtle interactions w/ proportional effort redistribution for alternative w/ large time and area closures.
- No increase with effort removal scenario.
- likely that 6% increase was an over-estimate because small boat effort was re-apportioned to northern and distant water areas (NED & Offshore south) beyond range of these vessels. With revised smaller time-area closures in final rule and re-apportionment to open southern areas, estimate will probably not be significantly different from status quo.

2) Concern that a new estimation procedure, using pooling, indicated that previous estimates of total takes were significantly lower. P6 B.O. "Additional information received on May 18,2000, during the conduct of this consultation indicates that past estimates of incidental take evaluated in the April 23, 1999 Opinion have been underestimated by as much as 50%." P55 B.O. "as the revised estimates are substantially higher than those previously reported, thus significantly elevating the degree of concern ..."

- June 7, 2000 (Yeung, Epperly, Brown) SEFSC document says revised estimates with pooling are similar to past estimates – "Page 1 Intro – "the summed total of the bycatch estimates across strata are generally not greatly different." Annual confidence intervals indicate differences are probably not significant. @ 25% increase for loggerheads and 9% increase for leatherbacks are **cumulative over 8 years.** Greatest annual differences driven by environmental events.
- Higher estimates result from pooling approach using QYN strategy which expands rare events associated with environmental anomalies (decaying eddys) to fishing effort under conditions not associated with those environmental conditions. The alternative YQN strategy, which would reduce this influence, produces lower estimates.
- Recommendations have been made to attempt to address concern with eddy trips by pooling Grand Bank observations by temperature (less than 68 vs >= 68), two month periods, and year clusters (91-93, 94-96,97-99) to reduce affect of temporal trends.

3) Established Incidental take levels and 1999 Observations (some preliminary concerns on a few problems).

- If new estimation method with pooling is better, should revise take levels using the same calculations used for past take statements since pooling provides more complete coverage..

- Previous incidental take statements were for total interactions and for the numbers of takes that observers coded as dead. The estimation procedures predicted total catch and the total number that were estimated as dead. Serious injury criteria were first applied to 1998 data in an SEFSC Technical memo published in 1999. Since ingestion has not been coded, how could it be included in a serious injury threshold now referred to as hooked by ingestion or moribund? If serious injury threshold is now needed, we need to code observer records appropriately and re-run estimations. It would also be reasonable to address questionable identifications so that incidental take statement doesn't disregard published papers indicating that the Kemps, green, and hawksbill turtles were probably loggerheads.
- Evaluation of 1999 Observations. A review of 1999 observer notes on the incidental take logs (copy provided to Laurie Allen) does not indicate that any of the leatherbacks were dead, or had ingested (swallowed) the hook. For loggerheads, 3 observer notes indicated that 10 had ingested the hooks and ~~two~~ 3 mouth hooked turtles were associated with notes indicating concern about the status of the turtles. None were noted as dead. The statement on page 57 of the B.O. indicating that the "location of the hook was not always recorded (n=60)" is difficult to reconcile with the observer notes. Observer program documentation and training has referred to terms like "hooked in jaw" or "hooked in mouth" as applying to conditions when the hook is visible, similar to protocols in the Pacific where these are referred to as lightly hooked. The Aguilar (1992) study of loggerheads captured in the Spanish Mediterranean fishery is the source for the 29% mortality estimate and it appears to reflect deep hooked turtles where the hooks could not be removed and these were moved to a rehabilitation aquarium. If hooked in "mouth/beak/jaw" is an inadequately detailed notation, it should be clarified on the recently revised sea turtle life history forms, which were recently developed by SEFSC turtle scientists and are now being used by observers. Criteria for counting turtles should not change without revising thresholds.
- Adjusting counts for differences in coverage rates requires review. The B.O. argues that the 1999 observations reflect only 3% annual coverage, whereas the threshold supposedly reflects a 5% target. While 5% coverage was the target, the realized coverage rate differed by year and the threshold values are only appropriate for the coverage rate reflected in the series of years used in the calculation.. This analytical approach is not very reliable, since we know that area-qtr coverage rates have varied dramatically and since the absolute number of turtle interactions are influenced by coverage in specific area-quarter strata. 5% or 6% annual coverage with no randomly selected trips for the grand banks can produce a very low number of interactions, whereas 3% coverage with one disaster trip can account for a very large number of turtles.

APPENDIX L

Memorandum from W. Hogarth to William Fox, Donald Knowles, and Bruce Morehead:
Mortality of Sea Turtles in Pelagic Longline Fisheries - Decision Memorandum

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

FEB 16 2001

MEMORANDUM FOR: William T. Hogarth, Ph.D.
Acting Assistant Administrator for Fisheries

FROM: William W. Fox, Jr., Ph.D.
Director, Office of Science and Technology

Donald R. Knowles
Director, Office of Protected Resources

Bruce C. Morehead
Acting Director, Office of Sustainable Fisheries

SUBJECT: Mortality of Sea Turtles in Pelagic Longline Fisheries-DECISION MEMORANDUM

Per your request, on February 9 and 10, 2001, we met to discuss the status of available information to assess mortality of sea turtles hooked or entangled in longline gear set for swordfish, tuna, and sharks, and to provide you with a recommendation for a mortality rate for application in Endangered Species Act (ESA) biological opinions until additional scientific information is available. John Oliver, Acting Deputy Assistant Administrator for Fisheries and Laurie Allen, Policy Analyst, from your office, participated as facilitators during the meeting. The goal was to come to a consensus decision, and if consensus was not possible, to provide you with discussion. We did reach a consensus on an approach, which will be described below. We also called George Balazs and Jeffrey Polovina of the Honolulu Laboratory to confirm some technical details of the Honolulu data, including an understanding of the reliability of the satellite tagging equipment.

After reviewing Don Knowles' January 4, 2001, memo on the subject, meeting notes from a nationwide internal conference call with NMFS Center and Regional Office personnel on February 7, 2001, and responses to Knowles' memo from Bruce Morehead dated January 31, 2001, supplying an alternate recommendation, it was obvious that scientific data to answer this question are inconclusive and that disparate opinions still exist among scientists and managers. We also knew that we needed to develop a precautionary process, consistent with the ESA, for development of these values. While in concept, the Knowles recommendation provided a precautionary approach, we wanted to evaluate the method to either support that conclusion, or provide a different recommendation for a value(s) that was clearly supported by best available information. We summarized scientific information for comparison to Knowles' and Morehead's recommendations in a table:

Interaction	Protected Resources	Sustainable Fisheries	Aguilar et al. Study (n=38)	Honolulu Lab Study* (n=49)	Azores Study
External (i.e. entangled or hooked externally)	50	0-27	----	----	-----
Mouth	50	27-42	----	17-27	0
Ingested	50	42	29	20-42	33
Dead	50	100	----	100	----

* Low number in each cell is olive ridley sea turtles, the other is loggerhead sea turtles.

The Honolulu Laboratory study with satellite transmitters is the largest data set that approximates real conditions, although as Knowles' memo pointed out, the turtles were treated before being released and so may have been less susceptible to later physiological or infection problems than in the real world. However, the conditions in this study were still closer to actual conditions than the conditions in Aguilar et al., where turtles were held in tanks. Consequently, we focused on that data set as the best available scientific data.

In discussing this data set to look for a precautionary process for the development of appropriate values, Knowles pointed out two factors: (1) we needed to consider error due to real world conditions and reduced compliance rates with mitigation measures for such problems as rough weather or safety or when observers were not present, and adjust upward accordingly, and (2) it was unlikely that all post-incident mortality occurred within 30 days. On the other side of error, Balazs also noted that there were legitimate reasons why some compensation for transmitter failure should be figured into development of precautionary numbers so that they are not adjusted too high. Possible transmitter complications with the models used in the study include failure due to battery life, transmitter attachment, transmitter electronic failure (the Azores study showed a 20% failure rate in a bench test), and oceanographic conditions during application. Balazs chose one month as the point to calculate the potential rate because if lack of transmission were due to electronic failure alone, it would be expected within a short period of time. Balazs expected mortality to be negligible for turtles just hooked in the mouth based on his long experience in working with sea turtles. However, the loss rate was 27% in the first month and climbed to 90% in 6 months, converging with the loss rate for deeply hooked turtles. These two facts indicated a high failure rate of the transmitters is likely in light of Balazs' expectation.

Choosing the appropriate estimate of mortality was the subject of much debate within the group. One could review the data and recommend adjustments based on professional judgement, or one could accept the data set at face value. We decided to develop a logical process, as described below, with built in precaution, go through the data and see where it led. This involved looking at the categories for which ranges of estimates were given in the studies.

Everyone was in agreement that a turtle that is not hooked (entangled), is released with no line, and was visibly uninjured, has an expected zero mortality rate from the interaction. Therefore, we recommend creating a new category for "no hooking, entangled no line" and that it be assigned zero.

The next category would then be a turtle that was externally hooked. The high value in the range of rates given in the Honolulu study for turtles that were considered lightly hooked (i.e., did not swallow hook, includes hooking in other body parts, considered lightly hooked) was 27%. Since as the Knowles memo points out, some animals that are hooked could still develop secondary infections, depending on the location of the hook, the conservative decision would be to assign the 27% to turtles hooked externally, rather than zero, including mouth hooks that do not penetrate the inside tissues of the mouth.

The loss rate in the Honolulu Lab study for turtles that were hooked in the mouth or had ingested the hook ranged from 27-42%. Therefore, we also decided that the precautionary approach for ingested hooks or hooks that penetrate the internal structures of the mouth would be to assign 42%, the high number, to those turtles. This is conservative because it combines a category that likely has a lower mortality rate (hooked in mouth-not ingested) at the higher rate. For turtles that are retrieved already dead, everyone agreed 100% would be assigned as the number. The following table summarizes the recommendation:

No hooking, no injury, disentangled completely	0%
Hooked externally or entangled, line left on animal (hook does not penetrate internal mouth structure e.g., lip hook)	27%
Mouth hooked (penetrates) or ingested hook	42%
Dead	100%

Summary: This scenario reflects our collective opinion, based on our respective expertise, of the best scientific information available, and resulted from a precautionary process to develop these numbers. We believe this apportions mortality in a manner consistent with best scientific information in lieu of applying one standard across the board. We also believe that by making a series of clearly precautionary decisions, the net effect is sufficiently conservative to include other smaller and non-quantifiable sources of mortality. The net effect is conservative and therefore meets the ESA criteria of finding on the precautionary side for the animal when there is uncertainty. As better data become available, these estimates can be refined. Morehead pointed out that the impact of new regulations in the Atlantic that require the use of dipnets and linecutters on pelagic longline vessels to reduce the impact on turtles would be expected to reduce injury and mortality. Since these measures were used in the Hawaii study it supports relying on this study in developing these numbers.

Concur ~~WA~~ Do Not Concur ________ Date 2/15/01

APPENDIX M

J.A. Musick, *Comments on Post-Hooking Mortality Estimates used by the National Marine Fisheries Service (NMFS) in its Biological Opinion for the Western Pacific Pelagic Fisheries*

Comments on Post-Hooking Mortality Estimates used by the National Marine Fisheries Service (NMFS) in its Biological Opinion for Western Pacific Pelagic Fisheries

J.A. Musick

The NMFS finding of jeopardy to sea turtles is based on their estimates of the numbers of sea turtles killed in the Hawaii longline fishery. These numbers in turn are based on *estimates* of post-hooking mortality, because turtles observed dead when captured are rare (according to NMFS itself). Therefore, the accuracy of NMFS post-hooking mortality estimates are crucial to any finding. In the BiOp, NMFS first uses McCracken's (2000) post-hooking mortality rate of 29% for deeply-hooked turtles and 0% for lightly-hooked turtles. The 29% value is based on a study on juvenile loggerheads incidently taken by the Spanish longline fleet within the Mediterranean in which animals with deeply-ingested hooks were held in captivity for several months; the study recorded a mortality rate of 28.9 % (Aguilar et al. 1995). This study was somewhat flawed because no control animals were maintained, and no necropsies were performed on the dead animals to determine cause of death. Apparently no special treatment was given these animals and no veterinarian was in attendance. Thus mortality due to disease, secondary infection associated with captivity, or other factors cannot be ruled out. Therefore the 28.9 % value should be viewed as a maximum mortality estimate for deeply hooked animals. McCracken's use of 0 % post-hooking mortality for superficially hooked turtles appeared reasonable because there was little evidence to the contrary (see below).

Unfortunately, on the following page NMFS adopts a higher mortality estimate of 27% for lightly-hooked turtles and 42% for deeply-hooked turtles. This action was based on a "consensus approach" for estimating sea turtle mortality (NMFS 2001). In reality, NMFS "consensus" approach involved a meeting between Drs. W.W. Fox, D.R. Knowles, and B.C. Morehead. All are able NMFS administrators, but none has expertise on, or experience with, sea turtles. Consequently, they adopted basic post-hooking mortality estimates of 27% for superficially or lightly hooked animals and 42% for turtles with ingested hooks. These values were based directly on satellite tagging studies done off Hawaii and which asserted that turtles that stopped transmitting within thirty days were assumed dead. These studies were seriously flawed because no control animals were used and failures of the Telonics transmitters cannot be dismissed, regardless of NMFS assertions to the contrary (Knowles 2001). The original Telonics satellite transmitters used on sea turtles were developed in part in my laboratory, and my research programs have used successive models to track at least 35 turtles including loggerheads, Kemp's ridleys, and leatherbacks. Transmission failure within 30 days of deployment has been common.

Of eight Telonics transmitters deployed on uninjured loggerheads between 1992 and 2000, two ceased transmission in less than 30 days (Mansfield et al, 2001), and Keinath et al.

reported that of sixteen uninjured loggerheads and Kemp's ridleys tagged with Telonics transmitters, four quit transmitting in less than 30 days. These failure rates (25%) are similar to the failure rate (27%) reported for superficially hooked sea turtles in the NMFS Hawaii study. In a recent study in the Atlantic contracted by NMFS itself, the authors (Riewold et al. 2000) reported transmitter failures in their control animals and stated that "High rates of non-mortality related transmitter failure could preclude the use of transmitter failure as an indicator of turtle mortality."

On three occasions in 2001, I sent letters (Musick 2001 a,b,c) to NMFS apprising the agency of the problems of transmitter failure and falacious mortality assumptions. These communications were ignored. Other scientists with extensive satellite tracking experience also cautioned NMFS about using satellite transmitter failure to assume mortality. For example, writing to Donald Knowles, NMFS Director of Protected Resources, on 8 February 2001, Dr. Molly Lutcavage, Senior Scientist at the Edgerton Laboratory, New England Aquarium, noted:

"NMFS concludes that the nonreporting tags represent post release mortality. Alternative explanations for nonreporting are dismissed with the statement that since Balasz et al had nearly perfect tag reporting rates in previous tagging studies (of nesting turtles or at-sea releases, we don't know which?), there was no reason to identify tag failure as a possible alternative explanation for nonreporting.

In our experience with deployments of satellite tags and pop-up tags (sea turtles, pinnipeds, bluefin tuna), we routinely have sporadic tag component or tag replacement failures, and rare but usually catastrophic batch failures. More often than not, battery failures and damaged antennas are prime suspects. These are all possible alternative explanations for nonreporting tags. The [Knowles] Memorandum states *'We believe the cessation of transmissions within a 1 month period can be considered a minimum indicator of post-hooking mortality in the study. We believe it is unlikely that mechanical failure of the transmitters or separation of the transmitter from the turtle would cause such a result.'* This is a bold statement! My bet is that tag manufacturers would be loathe to substantiate it, since Wildlife Computers, Telonics, and Microwave Telemetry all warn customers that their products fail on accasion, since they cannot control hardware components, battery life, or tag attachment outcomes. Tags also fall off from insufficient curing of epoxies/fiberglass resin, displacement by the turtle itself, or from mating activity. The only citations that the Memorandum uses to support the belief that tag failure, antenna damage, or tag shedding were not possible explanations are personal communications from the NMFS sea turtle coordinator and the study's first author. It is indeed puzzling that there are no references to tens of published tracking studies that present alternative explanations for nonreporting tags. I'm confused that alternative explanations for nonreporting *were* noted for the Hawaiian longline investigation in Balasz's peer-reviewed paper (Polvina et al). This suggests the authors of the NMFS Memorandum are unaware of these findings, or that that they chose to ignore them.

There were no controls released with hooked turtles in the Hawaiian study, which makes it difficult to evaluate the data that shows that deep hooked and shallow hooked turtles has similar reporting rates. One might expect that the deep hooked turtles would have higher post release mortality. Assuming that a turtle dies some time after release, one would expect that decomposition gases would cause the turtle to float, at least until decomposition was extreme. I witnessed this personally in Chesapeake Bay (loggerhead carcass) and off Florida (greens). The lung is under the carapace, so a bloated turtle should usually float carapace up, becoming a perfect tag radio transmission platform. There is no evidence that the Hawaii study was able to detect "floaters." The Azores study addressed this issue, and Bolton et.al. state that depth data was critical for determination of death. Given that the possibility that some of the Hawaiian tags may have failed or fallen off, it seems unreasonable to me to place so much emphasis on the findings of a 30.6% post release mortality rate. This is not to say that level is not possible with chelonids—but the reliability of this data needs to be viewed with caution."

average?
27+42?

The authors of the Hawaii study themselves have admitted that "One cannot attribute all these [transmitter] 'failures' to turtle mortality....Failure of transmitters with few to no transmissions could be due to electronics failure of the batteries, possible factory defects in the transmitters, or shipboard conditions causing poor transmitter attachment" (Parker et.al, in press). More recently, (Graves et.al. 2002), in a paper published in the NMFS peer-reviewed journal *Fishery Bulletin*, the authors used satellite tags on pelagic fishes and concluded that "non-reporting satellite tags introduce uncertainty that cannot be quantified in the estimates of post-release survival, thus compromising meaningful conclusions" (emphasis mine).

Satellite tracking studies done with controls on pelagic juvenile loggerheads in the North

Atlantic showed *no* mortality for a small sample (3) of turtles hooked in the mouth and tracked for several months (Bjorndal et al. 1999). In addition, a similar study (Riewold et al. 2000) done with control animals and six deeply hooked turtles found a mortality rate of 16.7 percent (*not* 30% as suggested by the table in NMFS 2001).

The NMFS "consensus" ignored the Aguilar, et al. 1995, Bjorndal 1999, and Riewold et al. 2000 studies and instead used the higher mortality values from the uncontrolled Hawaiian experiments. Thus their scientific mortality estimates may be inflated by 2- to 3-fold.

Outside of the flawed Hawaii satellite studies, there are no data to estimate the magnitude of post-hooking mortality in loggerheads that are superficially hooked. As noted above, the 1999 Bjorndal et al. study in the Atlantic found no mortality on three superficially hooked loggerheads (a tiny sample size). What data are available that might act as a surrogate for experiments on survivorship of loggerheads with superficial puncture wounds such as those caused by a longline hook? Hooks used by U.S. fishers for swordfish and tuna vary slightly in size and configuration, but on average have a diameter of approximately 5mm. They produce small lesions similar in size to those inflicted when a turtle is tagged with a metal flipper tag (diameter approximately 5 mm). NMFS actively supplied these tags to researchers around the world until quite recently, when the Archie Carr Center for Sea Turtle Research at the University of Florida assumed that responsibility. The Carr Center distributes an average of *6000* metal flipper tags each year (Allen Bolton, personal communication) with NMFS approval and support. Hence, one must ask, what kind of logic would suggest that the small puncture wounds caused by the longline fishery are lethal, while each year NMFS-supported tagging inflicts similarly-sized lesions on ten times as many turtles? Clearly, assuming a 27% post-hooking rate for superficially hooked loggerheads is illogical, in addition to being unsubstantiated by any data.

The use of the 27% and 42 % mortality assumptions for leatherbacks in this fishery is perhaps one of the most implausible elements of the Pacific BiOp. This assumption is based on the same flawed satellite tagging experiments carried out on *loggerheads* that for the most part were hooked in the mouth. Examination of the observer data for the period of 1994 - 1999 from the Pacific (BiOp Table IV-6) shows that only one leatherback was hooked in the mouth; most were superficially hooked in a flipper. The inflated estimates have resulted in high estimates of lethal leatherback takes. There is no evidence that such high levels of lethal takes occurred. The use of spurious post-hooking mortality estimates on leatherbacks based on experiments on loggerheads is unjustified. Even were the loggerhead mortality estimates to be correct, leatherbacks are much larger, stronger, more robust animals whose behavior on longline gear is vastly different. Relative to leatherback longline mortality, Dr. Lutcavage (8 February letter to Knowles) has stated:

"After reviewing all of the longline data and observer summaries in my library (Witzell, Hoey, and a collection of anonymous NMFS reports), I still can't find leatherback interaction records that would suggest that possible serious injury/lethal take would be higher than 15%. While validating observers' species identification from the NMFS NEFSC observer program photo collection from 1994-1997 (for Pat Gerrior), I personally reviewed all observer photos. Most leatherback interactions seemed to be minor/superficial hooking or line wrap, and only a few turtles were wrapped in mono beyond flipper regions. Although there may be leatherbacks that occasionally fouled to the point of immobilization, this seems to be a fairly rare event. At least one of the leatherbacks was photographed on deck, so some captains may be able to deal with extensive fouling if it were to occur.

Based on our studies of the respiratory and diving physiology of leatherbacks, I would concur with Dr. Dave Evans' remarks that in some respects , these turtles are less hearty than other sea turtle species. They have shorter voluntary dive times, higher metabolic rates, and are probably more susceptible to drowning/asphyxiation after shorter periods than large chelonids if forcibly submerged. This is clear from shrimp trawler mortalities, and stranding events in the SE. But large subadult and adult leatherbacks can carry longline gear to the surface and would not be as susceptible to asphyxiation as smaller chelonids. Again, there seems to be little justification of the 50% mortality in the US longline fishery, since observer data suggests that most US LL interactions are with large individuals."

These are the opinions of a highly respected scientist who has worked with leatherback sea turtles for more than 15 years, yet NMFS has chosen to apply post-hooking mortality rates for leatherbacks of 27% to 42 % with no supporting scientific evidence whatsoever. Clearly, by basing post-hooking mortality estimates on flawed science, the NMFS "consensus" document (NMFS 2001) did not use the best scientific information available. This has led to overestimates of sea turtle mortality and lethal takes and ultimately to a highly questionable finding of jeopardy for the longline fishery.

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APPENDIX N

R. Auguilar, J. Mas & X. Pastor, *Impact of Spanish Swordfish Longline Fisheries on the Loggerhead Sea Turtle Caretta Caretta Population in the Western Mediterranean*

IMPACT OF SPANISH SWORDFISH LONGLINE FISHERIES ON THE LOGGERHEAD SEA TURTLE *CARETTA CARETTA* POPULATION IN THE WESTERN MEDITERRANEAN.

GREENPEACE

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IMPACT OF SPANISH SWORDFISH LONGLINE FISHERIES ON THE LOGGERHEAD SEA TURTLE *CARETTA CARETTA* POPULATION IN THE WESTERN MEDITERRANEAN.

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1. SUMMARY

More than 20,000 subadult loggerhead turtles are incidentally captured every year as a result of the Spanish longlining fishery activities. Turtles are usually released alive with the longline hook still lodged internally. However, at least 20% of the sea turtles captured by this fishing gear could eventually die, due to the injuries caused by the hooks.

Observers onboard 26 fishing boats during a period of 143 days, between the summer months of 1990 and 1991, recorded the captures of 1,098 loggerhead (Caretta caretta) and two leatherback (Dermochelys coriacea) sea turtles. 94% of the turtles captured while observers were onboard were tagged and released to investigate the origin of the Mediterranean sea turtle populations.

1. SUMARIO

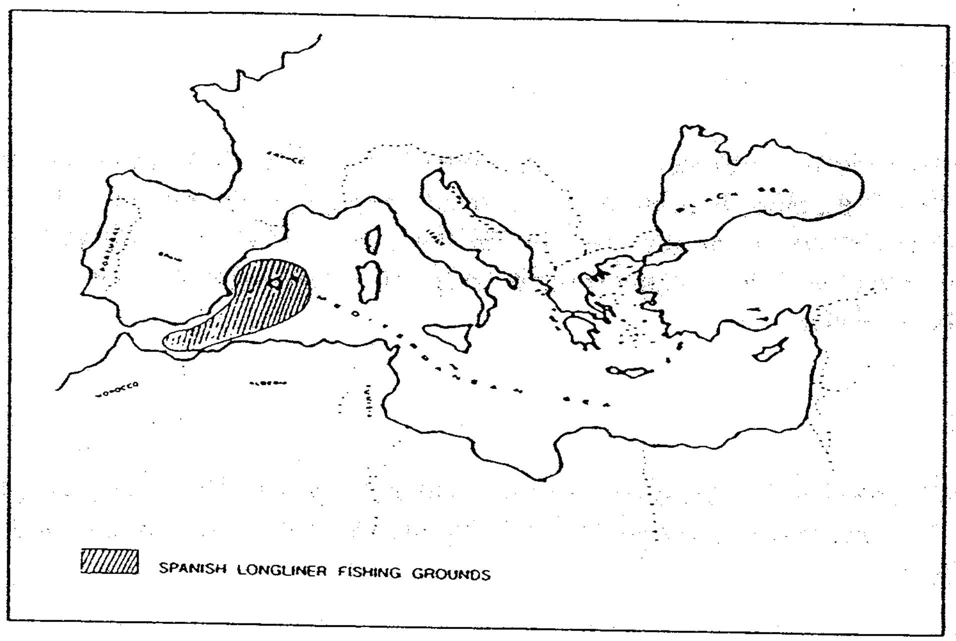
Más de 20.000 ejemplares subadultos de tortuga boba son accidentalmente capturados cada año por la flota palangrera española. Las tortugas suelen ser liberadas vivas con el anzuelo aún en su interior. Sin embargo, cabe la posibilidad de que al menos un 20% de las tortugas capturadas por este método de pesca mueran posteriormente a causa de las lesiones producidas por los anzuelos.

Los observadores, embarcados en 26 barcos pesqueros durante un total de 143 días, en los meses de verano de 1990 y 1991, registraron la captura de 1098 tortugas bobas (Caretta caretta) y dos tortugas laúd (Dermochelys coriacea). Mientras los observadores permanecieron a bordo, el 94% de las tortugas capturadas fueron marcadas y liberadas, con el fín de investigar el orígen de las poblaciones mediterráneas de tortugas marinas.

2. INTRODUCTION

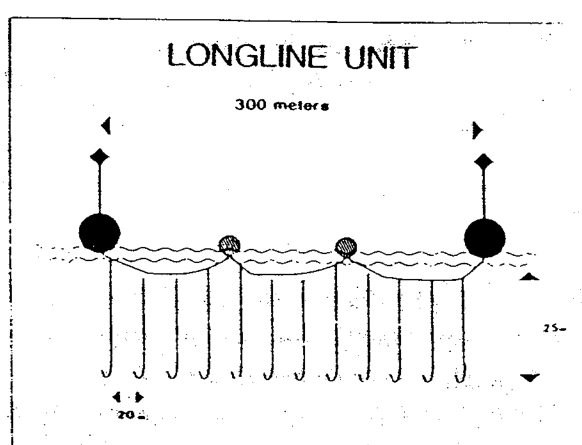
2.1. Description of the fishery

The waters of the South Western Mediterranean are the fishing grounds for a fleet of Spanish surface longliners dedicated to the capture of swordfish. The activities of this fleet seem to have an important impact on the population of loggerhead sea turtles (Caretta caretta) present in the area. The fleet is composed of some 30 boats using longlines throughout the year, and is joined during part of the year by a further 30 ships. The highest concentration of boats is during the summer months, when between 60 and 80 Spanish ships work in the area.



A typical Mediterranean swordfish longliner is a wooden boat of 15 meters length, with a gross tonnage of 40 tons and a 300 HP engine. The crew consists of approximately 8 persons.

The basic fishing gear is composed of a mother line 300 m long, stretched between two buoys. From this line hang 12 hooks, attached to thinner lines that secure them at approx. 25 meters depth. The distance between hooks is around 20 meters. As many as 200 of these longline units can be joined together, reaching a length of up to 60 kilometres, with a possible 2,400 hooks. The most usual baits are flying squid (Todarodes sagittatus), mackerel (Scomber scombrus and S. japonicus) and gilt sardine (Sardinella aurita). Hook size is 90mm per 35mm. The gear is set at sunset and the hauling-in operation begins just before sunrise. The hauling operation takes up to 7 hours.



species, such as loggerhead sea turtles (Caretta caretta), stingrays (Dasyatis pastinaca) and several species of tuna and sharks.

During the last six years, Greenpeace has been carrying out research work to determine the impact of this fishery on the sea turtle population. This work has been combined with a tagging programme attempting to determine the origin of the western Mediterranean loggerhead turtles population.

3.MATERIAL AND METHODS

3.1. Questionnaires

Questionnaires completed by the skippers of the longliners since 1986 have provided data on the number of sea turtles incidentally captured per boat and month for the duration of one year by the fleet landing its catches in the port of Alicante (SE Spain), the main harbour for this fishery. This information was later supplemented with the establishment of an observers programme onboard the boats.

3.2. Observers

In July, August and September 1990, observers were situated onboard 15 longline boats for a period of 73 days. In June, July and August 1991, 11 boats were monitored in the same way for a period of 70 days.

For every sea turtle captured by the longlines, the observers recorded several types of geographical and biological data, including date, location, species and size. Other data on parasites, pollution, wounds, etc... was also recorded. In 1991, information about the characteristics of the fishery (number of hooks, type of bait, gear setting and hauling times, time of every catch) and weather conditions (atmospheric and sea conditions, surface water temperature) was registered.

Locations were determined by the information provided by the skippers. Turtle shell sizes were measured using a flexible tape, and correspond to the curved carapace length of the individuals.

3.3. Tagging

The observers were provided with tags from the University of Florida, and 94% of the captured animals were tagged in one of their flippers. Immediately the animals had been measured and tagged, they were released into the sea. In some cases it was possible to remove the hook before their release, but in the majority of animals the hook was located deep inside the digestive tract making its removal impossible under field circumstances.

3.4. Mortality monitoring

Since 1986, a number of sea turtles captured by this fishery, with hooks still present in their bodies, have been kept alive in captivity in large aquaculture pools with the aim of estimating the mortality rate of the individuals released with hooks still in their bodies. The capacity of each pool is 7,000 litres. The salinity ranges between 43.056 ‰ and 48.070 ‰ . and the temperature range is between 9.60 C and 27.62 C. The bottom of the tanks is cleaned once a day to monitor the presence of expelled hooks and the state of digestion of food in faeces.

4. RESULTS

4.1. Sea turtles by-catch

In the period between July 7th and September 9th, 1990, a total of 673 loggerhead turtles was incidentally captured by the boats while observers were onboard. Between June 21st and August 30th, 1991, the number of loggerheads captured was 425. During that period, two leatherback turtles (Dermochelys coriacea) were also captured.

Of the total of 1,098 loggerheads, only 4 were dead when hauled onboard. 1,035 animals were tagged before being released back to the sea. The removal of the hook was only possible in 171 cases, when the hook was found in the mouth, the tongue or, in a few cases, in which it was attached externally to the flippers or to other parts of the body.

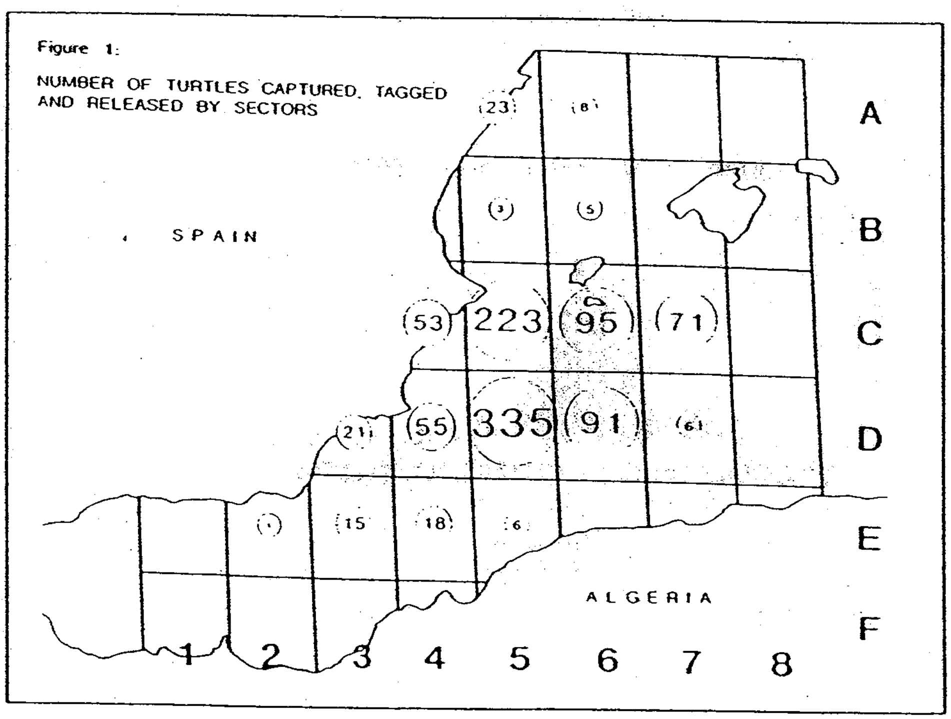


Figure 1: NUMBER OF TURTLES CAPTURED, TAGGED AND RELEASED BY SECTORS

Figure 1 shows the fishing area, divided in sectors, and the number of turtles captured, tagged and released in each sector.

4.2. Size distribution

A total of 865 individuals were measured. Of those, 473 correspond to 1990 and 392 to 1991.

Figure 2 shows the caparace length distributions for 1990 and 1991. The range of length values was between 27 cm. and 76 cm., with a concentration of values between 40 cm. and 55 cm. Mean length values were 47.4 cm. for 1990 and 48.8 cm. for 1991.

SIZE DISTRIBUTION

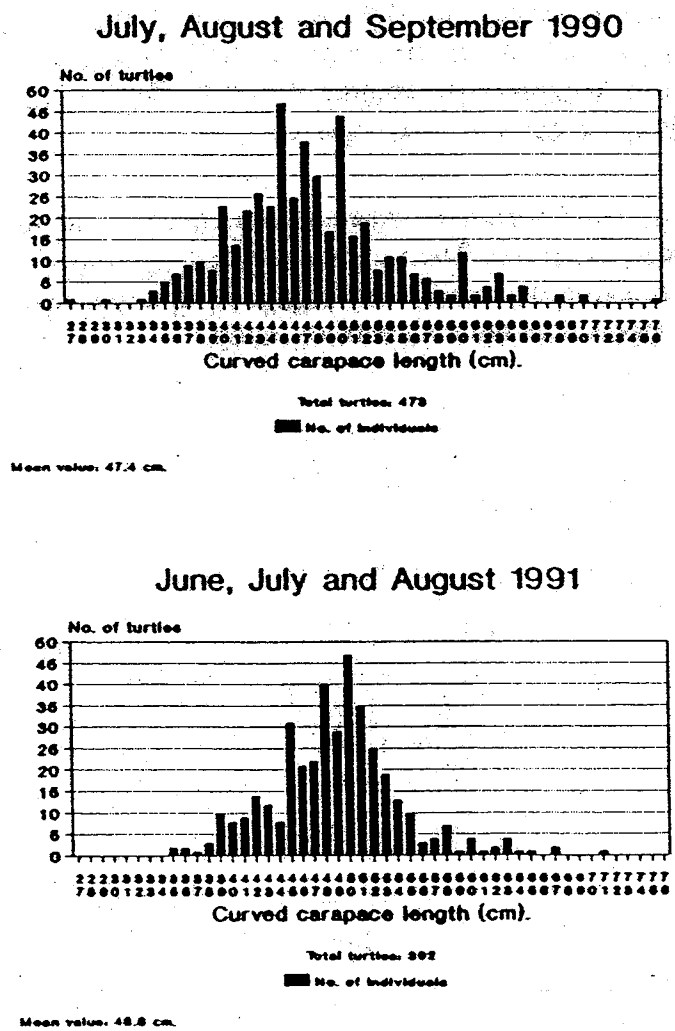


Figure 2

4.3. Turtles hauling-in time

Figure 3 shows the time of day when turtles were landed, compared to the total period of hauling back the hooks. Despite the fact that the largest effort happens between 0400 and 0800 h (LT), the largest concentration of turtles hauled in happens between 0800 and 1100 h.

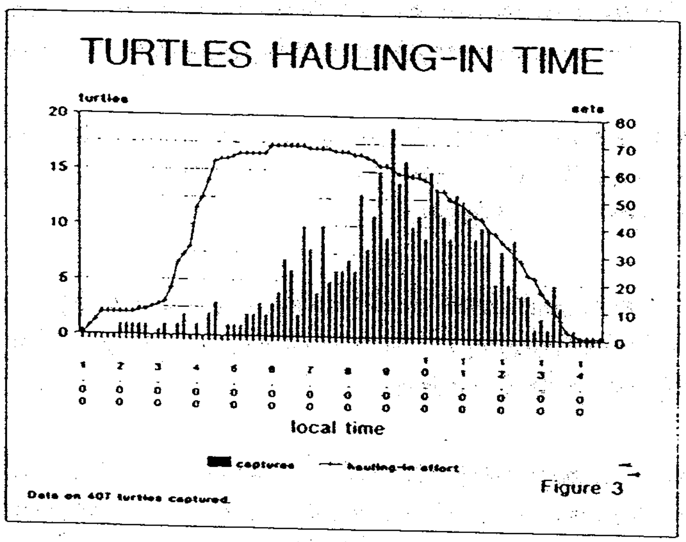


Figure 3

4.4. Mortality of hooked turtles.

Table I describes the results of the experience of captivity monitoring of individuals with the hook in the body. It shows: number of turtles kept by year, number of deaths, number of individuals which expelled the hook, number of days in captivity that the hook remained in the body before expulsion, and number of days that hooks have been in the bodies of live individuals still under observation.

MORTALITY ON HOOKED LOGGERHEAD SEA TURTLES
(Observations in captivity)

Year	No. Turtles	Deaths	Hooks expelled	Observations
1986 *	5	1	4	Hook expelled after 53, 82, 109 and 123 days
1987 *	3	2	1	Hook expelled after 285 days
1988 *	6	1	1	Hook expelled after 55 days 4 turtles released without expulsion after 93 days (1) & 123 days (3)
1989 *	7	2	0	5 turtles released without expulsion after 73 days (2) & 116 days (3)
1990	8	2	0	6 turtles released without expulsion after 81 days (2), 98 days (1) & 106 days (3)
1991	9	3	0	6 individuals still under observation.

(*) Mas & Garcia (1990)

TABLE I

5.1. Estimation of total loggerhead incidental catch in this fishery.

Only the data from the months of July and August have been taken into account to estimate the number of loggerhead turtles incidentally captured by the Spanish Mediterranean longline surface fleet. This is the period in which, during both years, there were Greenpeace observers onboard some of the boats. These months are not only those with a larger concentration of boats - at least 60 - but also the months in which, due to the favourable weather conditions, the number of sets per month is higher than average, reaching 20 sets per month and boat.

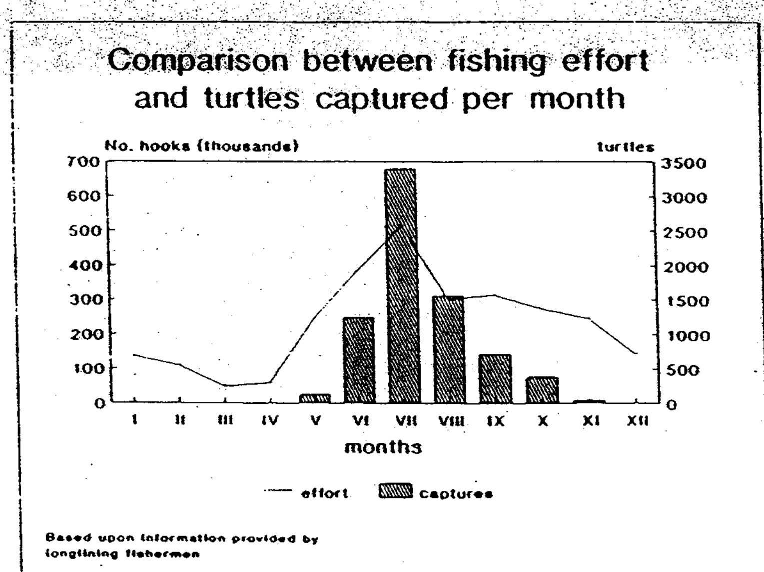
In 1990 in the monitored boats, a total of 655 loggerheads were captured in 67 sets, with a mean catch of 9.8 turtles per day and boat. In 1991, 414 loggerheads were captured in 64 sets, with a mean catch of 6.5 turtles per day and boat.

Based on this information, the incidental catch of 60 boats working during 40 days gives an estimation of 23,520 loggerheads captured by the fleet in July and August 1990. For 1991, the same method gives an estimation of 15,600 turtles.

A second method of estimation can be used taking into account the total number of hooks set in July and August 91 by 10 boats for which Greenpeace observers recorded the number of hooks that were set. 367 turtles were captured with 82,146 hooks in 60 sets, with a mean of 1 turtle every 224 hooks and 1,369 hooks per boat and set.

60 boats setting 1,369 hooks during the 40 fishing days corresponding to those two months represent 3,285,600 hooks set by the whole fleet during that period. The estimated incidental catch would therefore amount to 14,668 turtles.

The data provided by the questionnaires completed by the longline skippers indicates that 66% of the captures of turtles occurs during the months of July and August. Taking this into account, it is estimated that in the whole of 1990, the number of turtles incidentally captured was 35,637 and in 1991 the number ranges from 22,225 to 23,637, depending on which of the two methods of calculation is used for that year.



These high levels of loggerheads by-catches were already suggested by Caminas (1988) and Mayol et al. (1988).

ESTIMATE OF INCIDENTAL LOGGERHEAD CAPTURES IN SURFACE LONGLINES

Author (year)	Argano et al. (1983)	Mayol et al.(1988)	Camiñas et al. (not published)	Camiñas (1988)	Mas et al.(1990)
Year (estimate)	1978 (650 - 3.750)	1985 (17.712)	1984 (17.092)	1986 (16.697)	1989 (5.935 - 7.568)
			1985 (20.326)	1987 (16.315)	

(*) The fishermen called a strike during the months of June and August of this year. As a result, the level of incidental captures decreased considerably.

5.2. Mortality

An unknown number of individuals are repeatedly captured by the longlines. This has been proven by the fact that some of the observed turtles were carrying other hooks and few of the tagged and released turtles were recaptured in the same area.

The data shown in Table I - which is based on a small number of individuals - seems to indicate that between 20 and 30% of the sea turtles may die after having been captured by a longline. These results are similar to those obtained by Mayol (1990), also with a limited number of individuals.

5.3. Concentration of subadults.

Based on the length distribution shown in figure 2 it can be determined that all the loggerheads captured by this fishery are subadults. Although the ongoing intensive tagging programme to determine the origin and movements of this population is not expected to provide short term results, it is possible to surmise that in the South-Western Mediterranean there is an important concentration of subadult loggerheads.

5.4. Turtle by-catches produced by other fisheries

It is important to remember that the estimation of incidental captures of loggerhead turtles presented in this study deals only with the Spanish swordfish longline fleet. It is known that sea turtle by-catches also occur in relation to the longline fleets of other Mediterranean countries, particularly those of Italy and Malta. The turtle population almost certainly suffer in addition the effects of the activity of a fleet of 30 large Japanese tuna longliners and a similar number of boats of the same type under convenience flags, which enter the Mediterranean following the migration of bluefin tuna (Thunnus thynnus).

Mediterranean driftnet, gillnet and trawler fleets, among others, are known to incidentally capture sea turtles in the Mediterranean.Therefore, the total number of sea turtle which are incidentally caught in the Mediterranean is undoubtedly much higher than that suggested by the present study.

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APPENDIX O

D. Squires and P. Dutton. *Reconciling Fishing with Biodiversity: A Comprehensive Approach to Recovery of Pacific Sea Turtles*

| *11/14/03*

DRAFT: WORK IN PROGRESS

Reconciling Fishing with Biodiversity: A Comprehensive Approach to Recovery of Pacific Sea Turtles

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1. Introduction

No single approach by itself has worked to recover endangered Pacific sea turtles. Populations still continue to decline. A variety of factors have contributed to the continued population decline, which is primarily due to human interactions. Sea turtles and their eggs are prized worldwide for human consumption. Furthermore, their oils are used for lubricants and ingredients in cosmetics, and their shells for jewelry and eyeglass frames. Nonetheless, mass slaughter of turtles and plunder of their nests have been and remain a prime cause of population declines (National Research Council, 1990). Encroachment of human populations into coastal habitats further contributes to population declines by degrading nesting beaches. Harvesting of sea turtles for subsistence or commercial purposes and incidental mortality in commercial fishing and other such activities further diminish sea turtle populations. There continues to be considerable uncertainty over the status of key stocks and the extent to which bycatch in various fisheries has, and continues to contribute to declines in Pacific sea turtles. Lack of information has made it difficult to evaluate management options in a rigorous scientific manner, and this has led to controversy over best approach to take. Given this uncertainty, there is a need to evaluate a broad suite of approaches that that can be enacted that in the short run will prevent extinction of populations that are clearly in crisis, and in the long run, lead to recovery.

Sea turtles are migratory, weaving their way in and out of Exclusive Economic Zones of different nations and through the high seas. Breeding habitat can lie in one nation and their developing and foraging habitat in another nation's waters or in the high seas where this is little or no governance.[1 2] This creates a trans-boundary resource and jurisdictional problems, since there is no central authority to organize and enforce conservation. Property rights are absent or insufficiently well developed in Exclusive Economic Zones and the high seas for this Pacific common property resource. As a result of the trans-boundary and migratory nature of sea turtles, conservation strategies are required to tackle the trans-boundary issue and avert this Pacific "Tragedy of the Commons." Conservation and recovery limited to unilateral measures by individual nations are likely to fall short of the required conservation level, which instead requires cooperative and multilateral conservation, involving the efforts of multiple nations acting in tandem. Because there is no central authority to organize and enforce conservation, self-enforcing and voluntary arrangements are required.

The benefits of sea turtle conservation and recovery are diffuse across entire populations, but because costs are concentrated on particular groups, there is a misalignment of incentives for conservation and recovery. A potential "free rider" problem arises in such instances, in that there are incentives to "free ride" on the conservation and recovery efforts, including money paid by others. (A free rider is a party or person who receives the benefit of a good or service but avoids paying for it. This includes nonparticipation in international environmental agreements but nonetheless enjoying the benefits.) That is, there are few incentives to pay one's fair share. These "free rider" problems can be overcome by collective action and increasing participation in cooperative, multilateral conservation.

A unique life history makes populations vulnerable to several sources of mortality at critical stages in their life, which is aggravated by the several decades required to reach sexual maturity for many species[3]. Effective recovery requires an integrated and comprehensive approach that concentrates on recovery of sea turtle populations. A piecemeal approach, concentrating on a single component, such as nesting site protection or fisheries bycatch reduction, simply is not enough. One example of this is the Kemp's ridley, once the most endangered sea turtle on the planet, that now appears to be on the road to recovery. The Kemp's ridley is unique, in that almost all the critical life history stages occur within the territories of two countries, Mexico and USA, and so the transboundary issues could be addressed under a bi-lateral framework. Nevertheless, there are important lessons from this case, since recovery only began to occur once a broad suite of measures were put in place.

To date, one of the most sustained, vigorous, and successful conservation efforts among nations has been the bilateral, joint program between the governments of Mexico and the United States for the Kemp's ridley. Mexico initiated conservation efforts in 1966 at Rancho Nuevo, Tamaulipas, the species' only nesting area; however, the population continued to decline for the next two decades[4] The bilateral program was established in 1978 and by the late-1980s the decline stabilized, and since then this species appears to be on the road to recovery. It now appears that this early intervention pioneered by scientists at the Instituto Nacional de Investigaciones Biologicos Pesqueras was important in preventing the imminent extinction of the Kemp's ridely; however, the recent signs of recovery are generally acknowledged to be the result of the expanded bilateral effort that provided additional resources and a forum to craft and implement a broader recovery strategy. This bilateral program has involved both formal and informal collaboration between government agencies, including the Instituto Nacional de la Pesca (INP), U.S. Fish & Wildlife Service (USFWS), the U.S. National Marine Fisheries Service (NMFS), and the U.S. National Park Service, and private institutions, which include the Gadys Porter Zoo, HEART (Help Endangered Animals Ridley Turtle). Bilateral conservation programs have focused on the nesting process and have included beach and nest protection, establishment of additional nesting areas to extend the range and reduce risks, headstarting programs, and implementation of measures to reduce fishing mortality[5]. Much of this collaborative work has been done under a formal bilateral Cooperative Agreement between the NMFS and INP, known as MEXUS-Golfo. The Kemp's ridley program is a success story that has served as a model for sea turtle conservation, providing the framework for a similar approach currently underway with the Pacific leatherback under the MEXUS-Pacifico Cooperative Agreement between NMFS and INP. However, unlike the Kemp's ridley, the leatherback is pelagic and highly migratory, whose nesting and forgaing habitat encompass the entire ocean basin[6] Clearly the bilateral approach that appears to have been successful for Kemp's ridley is inadequate to address recovery in the case of the severely depleted nesting population in Pacific Mexico. While mortality of eggs and adult female leatherbacks has been reduced as a result of bi-lateral (US-Mexico) conservation efforts since 1995, the population continues to decline. Although progress has been made on protection of nesting populations, current efforts in the Pacific are limited by insufficient financial resources and competing economic interests from land development. In Mexico, a dedicated group of people from private and governmental institutions have undertaken an effort to protect nesting leatherbacks and their eggs. However this work is logistically challenging, and there is insufficient money to implement a completely effective program, so at best 45-50% of the nests are afforded protection each year. In addition, critical nesting habitat is being encroached by land development; for instance in Costa Rica, one of the most important nesting areas comprises 3 beaches in Guanacaste. A national Park was established (Las Baulas) recently to protect most of this nesting area, however, the land (high dune area inland) adjoining the nesting beaches is not protected, and the habitat has been encroached by development of luxury homes. The Costa Rican government is interested in embarking on an ambitious program to purchase land, however does not have the funds available to implement this immediately. With the eastern Pacific leatherback at such critically low numbers, it is unlikely that the present level of beach protection will be sufficient to reverse the population decline.

In some instances, fisheries management has attempted to conserve Pacific sea turtles. One solution has been simply shut down fisheries. But with trans-boundary turtles migrating across exclusive economic zones and through the high seas, fish formerly caught in the closed fishery are likely to be caught by other nations and imported back into the nation with the closed fishery – production and trade leakages -- and little or no net conservation gain is likely for sea turtles. Vessels might also reflag or shift their operations to other fisheries that remain open, also a form of production leakage and export their fish or shrimp to the now open market – a trade leakage.. Shutting down all or most longline and gillnet fisheries in the Pacific plugs these production and trade leakages, but this may not come to pass or could require considerable time – time which vulnerable sea turtle populations may simply not have.[7 8] In this instance, fishing and sea turtle mortality will continue, which then begs the question of the best conservation and recovery approach to take in a world of continued fishing.

In this scenario of continued fishing, the bycatch and mortality of sea turtles in commercial fisheries would be reduced as much as possible by adopting appropriate fishing practices and gear technology standards. Nonetheless, even reduced mortality from commercial fishing may be insufficient to induce the recovery of sea turtle populations, since there are other important sources of mortality. The reduction of sea turtle populations to critically low numbers aggravates and compounds the problem of reducing sea turtle mortality from fishing alone. Instead, a broader-based and integrated recovery approach is required that tackles all of the sources of sea turtle mortality and at critical stages in the life cycle by an integrated conservation and recovery package and recognizes the entire suite of existing biological, ecological, political, legal, economic, and social factors that need to be faced. The several decades required to reach sexual maturity compounds the difficulty faced.

In contrast to conservation challenges of many marine mammals, such as dolphins or whales, sea turtles offer a unique opportunity to increase population levels through a broad-based recovery strategy. Thus rather than a defensive strategy simply focusing on reducing at-sea mortality from commercial fishery interactions, a recovery strategy can become proactive and widen its approach to include measures that directly increase the population and address all sources of mortality. These recovery measures include protecting nesting females, protecting against harvest of eggs and killing of adult females at nesting sites, protecting against beach degradation, collecting eggs and incubating them, head starting, relocating eggs to minimize risk, hiring local villagers to protect nesting sites, introducing alternative sources of income to substitute for subsistence or small-scale commercial harvests, egg rescue schemes, grassroots environmental education programs, bilateral conservation programs such as between Mexico and US, improving habitat at all stages of life cycle, along with technology or even production standards.

This paper addresses this requirement of an integrated, multilateral recovery strategy that deals with multiple sources of sea turtle mortality at different life stages in the face of continued fishing, and explores a variety of policy tools that can be used. We consider the myriad sources of sea turtle mortality at different life-cycle stages and evaluate the approaches that can address these different sources. We discuss the roles played by harvesters and consumers of sea food, and the provision of economic incentives where practicable to bring about recovery rather than through direct fiat or laws. Positive economic incentives help contribute toward self-enforcing, cooperative recovery strategy. This overall approach has been codified by the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (hereafter MOU) and its Conservation and Management Plan.

Three broad components comprise the different recovery approaches. First, they must cover the entire life cycle, migration range and habitat, and users and sources of anthropogenic mortality in the Pacific Commons. Second, multilateral and cooperative conservation efforts among nations and other parties are required, i.e. international agreements. Third, a comprehensive conservation framework is necessary that is a mixture of biological, economic, political, and legal conservation measures.

2. Economic Incentives

Adverse economic incentives threaten sea turtle populations (Conservation and Management Plan, MOU).

Market-based approaches to environmental protection are premised on the idea that it is possible to confront private firms, individuals, and even other levels of government with the same kinds of incentives they face in markets for labor, capital, and raw materials – that is prices that force them to economize. The rationale for market-based approaches is thus to try to put the powerful advantages of markets to work in service to the environment.

An agreement on sea turtle conservation should produce for its parties a favorable benefit-cost ratio or else it may either never enter into law or collapse (Barrett 1998, p. 38). Reducing sea turtle mortality in general, or even achieving a prescribed overall level of mortality, that is cost-effective raises the benefit-cost ratio. Performance and/or technology standards will have to be negotiated for both developed and developing countries. Offsets will necessarily require investments in the developing countries where almost all of the nesting beaches are located and where an important source of mortality from harvests of eggs and adults is found. As discussed above, this developing country participation does not necessarily mean that the developing countries need to pay for all of these conservation measures. Broadening participation is not to redistribute costs so much as to lower the total costs and raise the total benefits of conservation, since the marginal mortality reduction may be higher and marginal cost of implementation may be lower in these countries. The Montreal Protocol capped emissions of ozone-depleting substances in developing countries, and these countries did not have to pay to stay within these limits; instead, the incremental costs of their compliance were paid by the developed countries. Broadening participation to developing countries also raises the benefits and thereby the benefit-cost ratio. The problems of non-compliance and free-riding would at the same time be eased, since the incentives to deviate in these ways would be reduced.

3. Different Sources of Pacific Sea Turtle Mortality

Sea turtles are subject to mortality at every stage in their life cycle. The relative impact of these sources of mortality may be different for each species, and in many cases is unknown. Mortality sources include directed take of adult turtles and harvest of their eggs on nesting beaches; directed take of juveniles and adults on their foraging areas; indirect take as a result of fishing activity, land development, human encroachment and pollution; "natural take" from predation, disease, and environmental pertubation (storms, floods, etc); and finally largely unknown effects from long-term global climactic and environmental change that may include long-term natural cycles (Southern Oscillation; global warming).

3.1 Pacific Leatherbacks

Sea turtles have been around for 30-100 million years, and have evolved to withstand high mortality of eggs and hatchlings. They are long-lived and have high reproductive output, producing tremendous quantities of eggs over their lifetimes. In general therefore, sea turtles populations can, in theory, withstand a high level of take of eggs, as long as survival of later stages remains high (e.g. later juvenile through adult). However, the wholesale harvest of eggs that occurred when this practice became commercialized this century has rendered populations vulnerable to the other impacts in the marine environment, and most likely set the stage for the rapid catastrophic declines that we are now seeing in some populations. This has been well documented in the Malaysian leatherback population that nested in Terenganu, once one of the largest rookeries in the Pacific, that now is all but extinct (Chan & Liew 1996). For almost 50 years every egg laid at this beach was harvested, and in the late 1970's there was a sudden decline in numbers of nesters from several thousands, to just two or three nesting annually since the 1990's. There were attempts to reverse this decline by protection measures (harvest quotas, beach hatcheries), but these appear to have been too little, too late. In addition, habitat degradation on the nesting beaches now appears to have contributed to the inability of these measures to be effective at increasing hatchling production. The extent that impacts at sea contributed to the Malaysian population collapse is unknown, but clearly the demographic erosion caused by the total harvest of eggs over at least one leatherback generation (9-20+ years), would have meant that any take of adults had a relatively larger impact, than had there been a large pool of younger generations to sustain this population.

This may be a pattern that is repeating itself to some extent for leatherbacks in the eastern Pacific, although this is not as well documented. The nesting populations in Mexico and Costa Rica have recently collapsed, most likely as a result of convergence of several factors; mortality caused by the high seas driftnet fisheries of the 1980's, coastal artisanal gillnet fisheries in South America into the 1990's, and a long history of intensive egg harvest beginning in the 1970's, killing of females on nesting beaches, and possibly environmental factors that we have yet to understand. It is possible that by the time high-seas driftnetting was banned in the 1980's, the damage had been done to the breeding population, as harvest of eggs continued unabated until relatively recently (1990's-see Dutton *et al.* 2002). Take of eggs has been significantly reduced now in Costa Rica and Mexico, but with the breeding population reduced to such critically low numbers, the take of any leatherbacks from this breeding stock will have a relatively large negative impact on recovery than for populations with a healthy pool of younger generations on their way to maturity. There is great controversy and uncertainty over the extent of impacts of longlining on leatherbacks. Although historically gillnetting and drift netting may have been more destructive to turtles than longlining[9], (turtles have a high probability of drowning in nets, and may have a better chance of survival if entangled or caught on longlines), the cumulative effect of low levels of mortality most likely now plays a relatively greater role in preventing the recovery of these species, (despite reduced mortality on the nesting beaches), since there are now so few turtles. In addition the indirect take of leatherbacks in high seas fisheries, illegal take of leatherbacks continues in the subsistence fisheries in Peru (Alfaro *et al.,* In Press).

Perhaps the largest leatherback population that remains in the Pacific comprises rookeries that occur in Papua and Papua New Guinea in the western Pacific. While there is uncertainty over historic status of this population, data from recent surveys do not indicate that the Papua population has collapsed in the way that the Malaysian and eastern Pacific populations have (Hitipeuw, 2003). Also, there is not a history of whole scale commercial harvest of eggs. There is however, directed take of reproductive adults on foraging grounds around Indonesia (Suarez and Starbird 1996, Hitipeuw, pers comm..), feral pig predation, beach erosion and human subsistence harvest of eggs in Papua and PNG. In addition, evidence suggests that leatherbacks from these western Pacific stocks migrate to foraging and developmental areas across the North Pacific and off the west coast of North America (Dutton et al.), and it is these turtles that are caught incidentally in high seas longline fisheries and coastal driftnet fisheries. It appears that these last remaining western Pacific populations have so far been better able to withstand the impacts at sea than the Malaysian, and eastern Pacific populations, perhaps because the absence of intense historic egg harvest in Papua has allowed somewhat of a demographic buffer. Given the broad suite of mortality factors affecting this population, long-term decline of these populations may be inevitable; however, the fact that there still relatively large numbers of turtles nesting means there is better opportunity for population recovery through enactment of a broad suite of conservation measures, and in particular for aggressive beach conservation measures to be effective (as opposed to the case of Terenganu, where it was too late).

3.2 Olive Ridleys

The eastern Pacific Olive ridley "arribada" populations have increased dramatically in the last decade, since closure of the nearshore fishery for olive ridleys in 1990 (Marquez et al...). Prior to that large scale commercial harvest of eggs and directed commercial take of juveniles and adults for leather were the primary sources of mortality that led to a decline in the nesting populations. The large scale commercial harvest of turtles occurred exclusively in Mexican EEZ, and appears to have dwarfed other sources of mortality. Furthermore, this fishery appears to have targeted sub-adults, effectively removing animals from the population before they had had a chance to breed. The dramatic and rapid recovery of this population following cessation of this mortality probably occurred because there were sufficient hatchlings and juveniles recruiting into the population to allow recovery once this pressure point on a crucial life stage was removed. Presently illegal harvest of eggs and incidental take in pelagic longline fisheries, and coastal gillnet fisheries, artisenal fisheries throughout central and South America, and trawl fisheries are primary sources of mortality. There is a legal harvest of eggs in Costa Rica at Playa Ostional carried out by the local community that has been acclaimed as a rare example of rational use. The harvest is carefully controlled by stakeholders, and takes advantage of millions of eggs that are laid during the fisrt "arribada" or mass nesting of olive ridleys each year. These eggs would all be destroyed by seasonally poor beach conditions and by the second arribada, where tens of thousands of turtles dig up and destroy the nests from the first arribada before they have had a chance to hatch. Revenues from the sale of eggs in part go towards conservation effort to ensure success of the second arribada, the rationale being that the first arribada would have been destroyed.

3.3 Loggerheads

In the North Pacific loggerheads nest almost exclusively in Japan, and these stocks have declined greatly. Sources of mortality include human encroachment and egg harvest on nesting beaches; incidental take in coastal fisheries (which take larger juveniles and adults; incidental capture in high seas fisheries all across the North Pacific (longline, drift/gillnet), and massive mortality due to incidental and directed take in artisinal and commercial fisheries operating in areas where juvenile feeding aggregations occur off Baja California, Mexico[10]. In the Southern hemisphere, the primary nesting beaches occur on the Southern Great Barrier Reef, Australia, and this stock has declined greatly over the last 30 years (Chaloupka and Limpus 2001). Sources of mortality include drowning in Australian otter trawl fisheries, feral fox predation of eggs in the 1960's and 1970's, and incidental capture in longline fisheries operating in the South Pacific including in the southeast Pacific (Alfaro et al., in press; also see Chaloupka 2003).

3.4 East Pacific green turtles

Eastern Pacific populations that nest in Mexico have declined considerably, despite ongoing beach conservation that began in the 1970's. Historic sources of mortality included harvest of eggs and directed take of breeding adults near nesting beaches, which have been largely reduced following legislation and conservation, although some level of illegal take occurs. The primary source of mortality has recently been identified as massive illegal take of juveniles and adults at foraging grounds around Baja California (Nichols et al, 2000), and it is likely that this mortality has negated conservation efforts on the nesting beaches and continues to prevent recovery. Since green turtles are largely coastal foragers, they are also caught incidentally in trawl and coastal artisinal fisheries throughout Mexico, Central and South America (see NOAA-NMFS 2002).

4. At-Sea Measures: Performance and Technology Standards for Responsible Fishing

Performance standards directly address the issue of sea turtle mortality through limiting the incidental take and mortality of sea turtles in pelagic longlining or drift gillnetting and shrimp trawling or direct takes through small-scale non-commercial and commercial activities. Dolphin Mortality Limits used in the International Dolphin Conservation Program or caps on emissions of greenhouse gases in the Kyoto Protocol are prominent international examples.

Technology standards refer to mandatory design and equipment requirements and includes operating standards. Restrictions on tuna purse seine fishing in the

International Dolphin Agreement, such as use of the fine-meshed Medina panel, prohibitions on sundown setsand requirement of the backdown procedure. Turtle excluder devices with shrimp trawling and the use of circle hooks and mackerel bait rather than J hooks and squid bait with pelagic longline fishing are important examples of technology standards aimed at reducing the incidental take of sea turtles.

The Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia's Conservation and Management Plan includes a provision to "Mitigate Threats and Bycatch," by reducing "...the incidental capture and mortality of marine turtles in the course of fishing activities to ensure that any incidental take is sustainable through regulation of fisheries and through development and implementation of measures such as turtle excluder devices (TEDs) and seasonal or spatial closure of waters."

In order for a technology standard aimed at lowering sea turtle takes and mortality to be effective there must be a transparent monitoring system, not only to verify compliance with standards, but also to quantify the sea turtle bycatch and scientifically evaluate the effectiveness of the measures in reducing bycatch mortality. Presently, most fisheries in the Pacific do not have observer programs in place to collect information on sea turtle bycatch, and this lack of information in itself is an impediment to sea turtle recovery. There is also often a fear on the part of fishers, industry and governments that reporting this information will encourage efforts to shut down fisheries, and this too, is an impediment to establishing transparent and effective monitoring. Provision of incentives to participate in standardized and verifiable monitoring programs would greatly enhance efforts to develop and implement effective measures to reduce at-sea mortality of sea turtles. Unlike TEDs that were developed some time ago as a technology standard for shrimp trawling, there are no well established technological fixes as yet that allow fishing without sea turtle mortality for the longline and gill net fisheries. Recent research using circle hooks and various baiting techniques shows great promise in this regard, but up to now the approaches used to mitigate sea turtle mortality in longline fisheries have depended primarily on time-area closures and procedures to remove hooks and line (using specially designed line-cutters and de-hookers) and resucitate turtles in order to enhance post-release survival[11].

Performance standards tend to require cooperation among nations, rather than simply coordination of activities (Barrett 2003, in press). Turtle mortality limits, for example, would require real cooperation among nations to determine the overall turtle mortality limits and allocation among nations, develop a compliance system through an observer or other program, and other such factors.

Technology standards, in contrast, tend to require coordination rather than the more demanding cooperation among nations (Barrett 2003, in press). Thus it is often the case that technology standards are easier to implement than performance standards. For example, with TEDs, a technology standard, nations do not have to actually cooperate. Instead nations simply adopt TEDs and coordinate their technical designs, and compliance is far easier to verify. International environmental agreements based on performance standards thus tend to be comparatively narrow but deep and in contrast, international agreements built on technology standards tend to be comparatively more broad but shallower.

5. Offsets and Mitigation Projects

Performance standards or technology standards can be coupled with offsetting measures that together limit ***net*** emissions or mortality.[12] For example, the Kyoto Protocol provides allowances for "sinks" – credits for the absorption of carbon dioxide by forests, cropland management, and re-vegetation (Barrett 2003, p. 371). These "sinks" offset the emission of greenhouse gasses through the sequestration of CO_2 (sucking CO_2 out of the atmosphere through growing trees, storage in the soils and oceans, etc.). The Clean Development Mechanism for the Kyoto Protocol, which allows an Annex I country to offset its emissions by undertaking abatement within a non-Annex I country (Barrett 2003, p. 380).[13] Within the domestic United States, the Endangered Species Act allows for offsets to environmental degradation. For example, timber companies in the southern U.S. are allowed to purchase timber lands with sufficiently high densities of nesting sites for a listed woodpecker (red-cockaded woodpecker) to satisfy the Endangered Species Act requirements, i.e. to serve as an offset, which allows harvests of timber from other lands with lower densities of woodpecker nesting sites (Heal 2000).[14] In the USA, the new policy of Wetlands Mitigation Banking (WMB) focuses on curtailing wetlands loss and regaining acres (Fernandez 1998). The WMB policy encourages protection and rehabilitation of wetlands as a precondition for developing other areas. In order to obtain permission to develop a different wetlands area, a developer is required to have credits from investment in the completed rehabilitation of a WMB site. The developer is allowed to use these credits in exchange for permission to develop other wetlands. Restoration activity is required prior to further development.[15] [16] For example, a coastal wetlands (lagoon) in San Diego County was restored by the Port of Long Beach to offset a loss in wetlands that occurred when the port was expanded.

Sea turtles provide a unique opportunity for offsets through formal mitigation programs because they return to nesting sites to lay eggs. Conservation measures to protect the turtles, sites, eggs, and hatchlings can serve to actively increase the sea turtle population beyond that which would otherwise occur in the absence of such conservation policies (Dutton, Sarti, Márquez, and Squires, 2002). In short, depending on the program design, offsets can actually create a **net increase** in turtles, even after explicitly accounting for uncertainty.[17]

Mitigation projects (offsets) can be directly established between developing and developed countries.[18] Both the Montreal and Kyoto Protocols established a mechanism that could support offsets - emission reductions in ozone-depleting or greenhouse gasses -- in developing countries, through the Multilateral Fund for the Montreal Protocol and the Clean Development Mechanism for the Kyoto Protocol (which allows an Annex I country to offset its greenhouse gas emissions by undertaking abatement within a non-Annex I country) (Barrett 2003, p. 380, Victor 2001, p. 39, Victor, Raustiala, and Skolnikoff 1998, pp. 16-17) and the Global Environment Facility, which was established to provide help for developing countries with climate change, threats to biodiversity and water pollution.[19] [20]

Polovina and Dutton (2003) have identified several specific offsets for leatherback and loggerhead turtles in the Pacific that are expected to yield a net increase in turtles. These offsets for leatherbacks include hiring villagers to protect nests from predation by feral pigs in West Papua (Irian Jaya) War-non Beach, working with villagers to reduce and/or eliminate the harpooning of adult females in coastal foraging grounds in West Papua (Irian Jaya), and to eliminate harvesting of eggs, dog predation on eggs, and moving eggs laid in areas likely to be lost to beach erosion in Papua New Guinea nesting beaches. These offsets for loggerhead turtles include mortality reduction workshops with fishers and placing observers on local boats to insure that all the live loggerheads caught in halibut gillnets are returned to the ocean in Baja, Mexico and moving eggs from locations prone to washing out or that experience extreme temperature at two nesting beaches in Japan (Polovina and Dutton 2003). These offsets are in addition to work that is already ongoing, so that funding them would result in an expansion of conservation that is already underway. Although beach protection is being carried out, this work is under-funded, and the full potential of many conservation initiatives remain unrealized. For instance, opportunities exist for expanding effort for the critically endangered populations in the eastern Pacific. There is a major initiative underway to purchase critical nesting habitat adjoining the recently created Baulas national Park in Costa Rica, however, progress has been slowed by lack of funds. In Mexico, the tremendous progress that has been made over the last few years (Dutton et al 1999) has at best achieved protection of only 50% of the total nests laid by leatherbacks. Other species and populations, such as the eastern Pacific green turtle populations and hawksbills remain critically endangered, and there are many opportunities to greatly expand beach conservation work so that ideally at-sea mortality measures will be enhanced and more effective at recovering populations, (and at least, so that declining populations continue to remain viable).

A mechanism with sea turtles that is analogous to the Montreal and Kyoto Protocol offsets would be a whereby industry, conservation, or government parties finance or establish turtle mitigation conservation projects that at a minimum prevent decline in populations or even lead to a net increase in population, after allowing for uncertainty in both cases.

6. Taxes or Fees Levied on Producers and Consumers

Taxes, fees, or charges can be levied on swordfish or shrimp landings, on the basis of sea turtle mortality, or on consumption of swordfish or shrimp. These (Pigouvian) taxes or fees can be levied either unilaterally on domestic producers or consumers or multilaterally through the auspices of an international agreement.

Taxes or fees levied on the swordfish or shrimp landings of producers and/or on consumers of these catches, when these seafood products are caught with interactions with sea turtles, can potentially yield several dividends.[21] The first dividend is reduced sea turtle mortality. The second dividend is to raise revenue to finance sea turtle conservation and recovery.

There is an equity argument in favor of fees in that the users of the globe's resources – the producers who initially exploit the resources and environment and the consumers who consume the final products – should bear the costs and compensate the public for their use.

6.1. Taxes or Fees, External Costs, and Market Failure

Producers and consumers of seafood do not pay the cost of sea turtle mortality when there are sea turtle interactions with fishing gear. This creates adverse economic incentives. Instead, producers and consumers pay only the direct costs associated with harvests.[22] [23] These "external costs" of sea turtle mortality are not included in the price of swordfish or shrimp; instead, only the direct production costs are incorporated these prices. Because the economic value of unpriced swordfish and shrimp resources and external costs of sea turtle mortality are excluded from seafood prices, the incomplete and "low" seafood prices contribute to consumer demand for seafood which is too high, which in turn contributes to excessively high fishing pressures and turtle takes. Seafood consumers also do not pay their share of the full costs of swordfish or shrimp consumption when there is sea turtle mortality. Other consumer benefits from sea turtles – such as sea turtle existence – are not captured by markets and there is "market failure."

6.2. Taxes or Fees Levied on Swordfish or Shrimp Landings or Consumption

A tax or fee unilaterally levied on domestic producers and/or consumers of swordfish or shrimp would help to incorporate the otherwise unaccounted for "external" cost of sea turtle mortality into the market price of seafood. The proportion of the tax that is borne by producers and consumers is *a priori* indeterminate,[24] but the higher cost of production will help lower sea turtle takes[25] and the higher seafood price will reduce consumption of seafood to some degree as seafood markets fully price the entire cost of swordfish or shrimp production.

A tax or fee unilaterally levied on domestic swordfish or shrimp producers with an aim to reduce sea turtle mortality does not fully accomplish its ostensible goal, since sea turtles are migratory and swordfish and shrimp are caught throughout the Pacific Basin. The domestic tax, to the extent it raises domestic producers' harvesting costs of swordfish or shrimp, lowers the scale of domestic catches and hence lowers domestic sources for consumption which can be replaced by lower-priced imports. As a result of these production and trade "leakages," the problem of sea turtle mortality is not fully addressed.[26]

A tax or fee levied on production of swordfish or shrimp within a multilateral agreement can plug production and trade leakages as well as help to incorporate the full external costs of swordfish and shrimp production (i.e. sea turtle mortality) into the seafood price. The multilateral context will only plug the production and trade leakages to the extent that all producers are part of a collective agreement and are effectively taxed; otherwise, leakages will persist, albeit dampened, and swordfish or shrimp catches will not be fully priced – market failure will persist.

A tax or fee can be either lump sum, such as part of an annual license fee, or if on production can be levied on swordfish or shrimp landings at either the ex-vessel level or at some point in the processing chain. The details and ramifications remain to be worked out. Nonetheless, one advantage of a tax or fee related to production of swordfish and shrimp is that larger producers pay more tax, reflecting their generally greater probability of turtle interactions.[27] Swordfish or shrimp are jointly harvested with sea turtles. To the extent that sea turtle mortality is roughly proportional to swordfish or shrimp landings, there is more direct control over sea turtle than initially appears. An analogous situation occurred with the transferable permit system that accomplished the U.S. phase-out of leaded gasoline. Stavins (1998, p. 487) observes, "The currency of that system was not lead oxide emission from motor vehicles, but the lead content of gasoline."

The size of the tax or fee that fully costs the otherwise unaccounted for cost of turtle mortality is difficult to estimate. As a consequence, any tax may over- or under-charge for the unaccounted for cost of sea turtle mortality. Ideally, taxes or fees that aim to exactly capture these unpriced costs would also have to be continuously recalculated as the costs of production and market conditions change, and most importantly, to ensure that the sea turtle mortality standard is attained.

The problem with a tax on swordfish or shrimp is that the sea turtle mortality standard is not directly addressed, but only indirectly through a tax or fee on its joint product, swordfish or shrimp. Hence, reliance on a tax or fee on swordfish or shrimp landings or consumptiojn to reduce sea turtle mortality to its "optimal" level (rather than simply nudging it in the desired direction) could required a large tax and could make seafood production prohibitively expensive. In addition, the presence of inflation lowers the real rate of taxation (adjusted for inflation) over time, unless the process to determine the fee includes some on-going means of temporal adjustment.

6.3. Tax or Fee Levied on Sea Turtle Interactions or Mortality

A tax or fee can also be levied on the number of sea turtle interactions or on sea turtle mortality. Ideally, the tax or fee sums up to the expected mortality from the accumulation of sea turtle mortality of adults and sub-adults. This approach is very similar to the cap-and-trade or sea turtle mortality limit approach, since this system creates the same set of incentives. That is, the vessels that can reduce their sea turtle interactions inexpensively will invest in doing so because each interaction or turtle killed reduced is that much less paid in taxes or fees. Vessels that find it very expensive to reduce their sea turtle interactions will continue to interact and pay the taxes and rely on offsets. A similar tax was levied on the production of chlorofluorocarbons (CFCs) during the time mandatory phase-out was taking place under the Montreal Protocol, creating a hybrid system under which a phased decline in CFC production was augmented by a pollution tax (Portney 2003).

A limitation of a tax on sea turtle interactions to directly control sea turtle mortality is the uncertainty about the effect on sea turtle mortality, although it is certain that the higher the tax, the lower amount of sea turtle mortality.[28] It is also well known that setting the optimum tax – in order to achieve an exact level of control – is notoriously difficult and that recomputing the tax as the underlying conditions change is equally difficult. An advantage with a tax, however, is that sources of sea turtle mortality know that they will never have to pay more for sea turtle mortality than the tax. In addition, imposition of a sea turtle interaction or mortality tax requires an observer system to monitor the interactions and achieve compliance. In contrast, a tax on swordfish or shrimp landings does not require at-sea observers, but it also has an even more indirect effect on reducing sea turtle mortality.

Spatial differentiation is an important issue arising with taxes or charges. Sea turtles nest in different hemispheres and different countries and their migrations also vary spatially. In addition, sea turtle mortality varies spatially, even within a hemisphere, with some "hot spots" of high frequency mortality and others with lower frequency of interactions and mortality. Lump sum fees would have to be explicitly tailored but fees on landings might roughly correspond to spatial variations in sea turtle mortality. A direct tax on sea turtle mortality obviates the issue of spatial differences.

6.4. Second Dividend: Revenue to Finance Conservation and Recovery

The second dividend of a tax or fee, particularly on landings of shrimp or swordfish, is to raise revenue to finance conservation and recovery measures for sea turtles.[29 30 31] The primary benefit of a tax or fee on swordfish or shrimp production or consumption is to raise revenue for conservation and only incidentally to directly lower sea turtle mortality. Pacific sea turtles, because they are a Pacific common property resource, are subject to excessive mortality from takes and insufficient "investment" in conservation and recovery, such as beach protection or adoption of technology standards that require new investment and which raise production costs and lower productivity. The revenues raised help to finance this new investment.

Stavins (1998) observes that while taxes in the U.S. have been imposed on certain products that are limited to pollution, like gasoline and chemicals, this has typically been done as a way of raising revenue, such as with gas taxes to fund highway construction or chemical taxes to fund cleanup of Superfund toxic waste sites, rather than as incentive devices intended to reduce externalities (such as sea turtle mortality from fishing).

6.5. In-Kind Taxes and Fees

In-kind taxes or fees occur when producers or consumers directly finance and sponsor conservation and recovery measures. For example, direct sponsorship of a nesting site by a fisher or fishing groups or by a restaurant, processor, or retail chain represents an implicit tax that is paid in kind rather than an explicit tax where funds are collected.

6.6. Fees versus Subsidies[32]

A direct subsidy or tax break to swordfish or shrimp producers can also lower interaction rates with, and mortality of, sea turtles by subsidizing adoption of a technology standard. Such a subsidy can be effective in adopting new technology or altering fishing practices. A subsidy can even be paid to producers to produce no swordfish or shrimp, i.e. to shut down through vessel buybacks or to switch to say longline tuna through deeper sets. However, a subsidy from the public sector to producers for an external cost of sea turtle mortality raises the issue of whether the "polluter" or the damaged party pays.

Another potential problem with subsidies for adoption of a technology standard is that they can unintentionally counter reductions in sea turtle mortality or perhaps even increase mortality. A subsidy lowers costs and allows higher-cost producers to continue fishing that otherwise may have gone out of business. A subsidy also promotes or sustains fishing effort, which in turn counters reductions in sea turtle mortality. A subsidized performance standard does not face this problem found with a technology standard, but nonetheless represents an expenditure of real resources by the public and also confounds price signals in the market by masking the direct costs of fishing and the unpriced external costs of sea turtle mortality.

The research required to develop a new technology standard is often considered to be a public good (a good or service which can be consumed by all without depeleting or diminishing the good or service). In these circumstances, research to develop a new technology, such as a technology standard that lowers turtle mortality, can legitimately be financed by the public sector since the benefits accrue to all. Without subsidies for research or finance by the public sector, there are often insufficient incentives for individuals to conduct this research, since the investors do not capture the full benefits of their investment. Public finance or subsidy of research for a new technology standard that reduces sea turtle mortality is also a way to funnel the intangible benefits the public enjoys from the existence of sea turtle mortality, which otherwise do not have a means of expression.

6.7. Tax or Fee Combined with Import Tariff

A tax, fee, or charge on domestic producers and/or consumers can be combined with a tariff on imports of swordfish or shrimp – an "eco-tariff."

6.8. General Considerations with Taxes, Fees, and Charges

Taxes or fees have to be determined by an administrative process. When the function of the charge is to raise revenues for conservation and recovery, charge rates may be determined by the costs of achieving that process. When the costs of achieving the purpose rise, the level of the charge must rise to secure the desired outcome.

Taxes or fees levied raised to finance conservation and recovery can be levied and collected by individual governments, international commissions and through international agreements, or by producers, processors, or final markets. Revenues can also be voluntarily raised by industry, environmental, or consumer groups.

Taxes or fees work particularly well when transactions costs associated with bargaining and transfer of transferable turtle mortality limits are high. When transactions costs are high, due perhaps to widely dispersed vessels or many small vessels or infrequent need for trades, only large trades can absorb the high transactions costs without jeopardizing the gains from trade. "For this reason charges seem a more appropriate instrument when sources are individually small, but numerous (such as residences or automobiles). Charges also work well as a device for increasing the rate of adoption of new technologies and for raising revenue to subsidize environmentally benign projects." (Tietenberg, p. 391)

7. Performance Standards

Performance standards directly address the issue of sea turtle mortality through limiting the incidental take and mortality of sea turtles in pelagic longlining or drift gillnetting and shrimp trawling or direct takes through small-scale non-commercial and commercial activities. Performance standards have serious compliance requirements through monitoring, verification, and enforcement, both to punish identified cases of non-compliance and to deter non-participation. A free rider problem (enjoying the benefits without bearing the costs through nonparticipation) can arise without effective compliance.

The Inter-American Convention for the Conservation and Protection of Sea Turtles prohibits the intentional capture or killing of sea turtles (with exceptions of subsistence takes under specific conditions), a performance standard (Gibbons-Fly).[33] The Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia's Conservation and Management Plan includes a provision to "Mitigate Threats and Bycatch," by reducing "...the incidental capture and mortality of marine turtles in the course of fishing activities to ensure that any incidental take is sustainable through regulation of fisheries and through development and implementation of measures such as turtle excluder devices (TEDs) and seasonal or spatial closure of waters." The Conservation and Management Plan of this Memorandum of Understand similarly lists a program to "Reduce to the greatest extent practicable the incidental capture and mortality of marine turtles in the course of fishing activities."[34]

Performance standards can be strengthened to form use or property rights. Strengthening the characteristics of property rights, most notably exclusive use, transferability, duration, and divisibility, leads to a stronger property or use right (Scott __). Dolphin Mortality Limits are a form of use right, since they allow exclusive use for a single year and are not transferable. Marketable emission permits, such as those in the Kyoto Protocol, are a property right since they contain the stronger characteristics of exclusive use, transferability, divisibility into smaller or larger units, and relatively long duration.

8. Marketable Turtle Mortality Limits As A Transferable Property Right and Wildlife Use Rights

8.1. Marketable Turtle Mortality Limits

When there are performance standards for takes or mortality of sea turtles, introducing transferability with a use right of at least one year's duration creates a market-based approach to environmental protection. One approach is a "cap-and-trade" system, whereby each vessel is given an initial turtle mortality limit. It can elect to meet this limit any way it sees fit, through a technology standard, redirecting its fishing operations to other times and places, or any other means. Each vessel can elect to reduce its sea turtle interactions using the least expensive approach available to it. An additional option is available under the cap-and-trade system: a vessel actually increases its interactions with sea turtles more than it is required so long as it buys at least equivalent turtle mortality limits from one or more other vessels or through offsets (discussed below). All that matters is that the total amount of sea turtle mortality reductions that take place from all sources are equal to the total turtle mortality limit established at whatever level is required for recovery of each affected species' population. Those vessels that will elect to make significant sea turtle mortality reductions under this cap-and-trade system are those that can do so easily or inexpensively, while those that elect to buy transferable sea turtle mortality limits will be those that find it expensive or difficult to reduce. In addition, all vessels, or sources of sea turtle mortality in general, have a continuing incentive to reduce their sea turtle mortality, since the more a vessel's sea turtle mortality falls short of its limitation, the more sea turtle mortality limits it will have to sell to other vessels. The overall sea turtle mortality limit and the individual holdings can also be progressively tightened over time. The transferable sea turtle mortality limit and trading area would correspond to the nesting sites and migratory routes of each species.

A cap-and-trade approach is used in the United States to control emissions of sulfur dioxide with the 1990 amendments to the Clean Air Act.[35] More than 100 coal-fired power plants were given initial emissions reductions, and these plants could meet their emissions reductions targets themselves, through any means they selected, including purchase of excess emissions reductions by other plants that found it easy to reduce their sulfur dioxide. Cap-and-trade approaches have also been proposed to reduce water and smog pollution. The European Union will use a cap-and-trade system to control carbon dioxide to comply with the Kyoto Protocol.

Transferable turtle mortality limits could conceivably be used in the year it is issued or "banked" or stored for use in any subsequent year. With banking, allowance could be made for expected growth in sea turtle numbers. In addition, transferable turtle mortality limits could be allocated gratis or auctioned off (which would give an effect similar to a tax); the key issue is the distribution of the rents. (Auctions do have the advantage of facilitating the price discovery process and the development of a market.) Transferable sea turtle mortality limits may work best when there are wide divergences in producers' costs and costs of transactions, monitoring, and enforcement are not excessive.

Transferable sea turtle mortality limits might also provide economic incentives for induced process innovations, such as bundling of limits with swordfish or shrimp supplies or the invention of new or modified technology standards, such as TEDs or circle hooks, in exchange for generated limits. The flexibility of a transferable limit also accommodates dynamic market changes, allowing shifts in industry structure and production methods while assuring that total mortality does not increase.

Monitoring and enforcement of an international transferable turtle mortality limit system could well prove a formidable and costly task. Regional or national programs might prove more feasible. Similar issues confront the international system for transferable emissions of greenhouse gasses, particularly CO_2, with the Kyoto Protocol and for sulfur dioxide (SO_2) with the Helsinki Protocol.

8.2. Wildlife Use Rights

International environmental agreements based on an allocation of internationally transferable rights to wildlife use would be analogous to the Kyoto Protocol. Wealthier nations, or their citizens and civic groups, could purchase rights to wildlife from poorer nations for the purpose of conservation or preservation (Giordano 2002, p. 626). Poorer nations would then have the option of benefiting from the sale of non-consumptive wildlife use rights rather than finding themselves limited to a derivation of wildlife value through extractive means only. Such an approach serves the same goal as side payments in which developed countries directly or indirectly provide compensation or economic incentives to developing nations for biodiversity conservation.

The notion of benefiting those in developing nations who may bear much of the burden of conservation from resource use foregone is an important one. Wildlife use values may be stripped away while the costs of wildlife conservation remain (Giordano 2002, p. 626). Economic incentives for conservation and compensation to communities and subsistence users of sea turtles and their eggs is thus an important element not to be overlooked.

9. Trade Restrictions

Trade restrictions achieve two things: they can be used to punish countries that do not cooperate and to correct for a loss in competitiveness of the countries that do cooperate (Barrett 2003, p. 307). A trade restriction, to be effective, needs to be sufficiently severe (so that, when imposed, behavior will be changed) and credible (meaning that, given that a country chooses not to participate, or not to comply, the cooperating countries are better off for imposing the restrictions) (Barrett 2003, p. 388).

Trade restrictions restructure incentives by providing positive economic incentives to countries that participate in, and comply with, an international environmental agreement or technology standard such as with the use of turtle excluder devices. Trade restrictions also provide negative incentives by punishing those countries that fail to participate in, and comply with agreements or standards. Trade restrictions also plug production and trade leakages. Trade restrictions impose a cost on member nations of an international sea turtle agreement by foregoing the gains from trade, which reduces the credibility of trade restrictions.[36] Trade restrictions also face legality issues with the World Trade Organization.

"Eco-tariffs" on imports are a price form of a trade restriction on quantities of imports allowed into a country. Eco-labeling, in contrast to trade restrictions and "eco-tariffs" can provide a positive incentive, and when used in conjunction with a trade restriction, import tariff, or side payments, can provide additional and positive incentives for compliance and participation.

A licensing system for imports of "turtle safe" shrimp and swordfish provides one means of implementing a trade restriction. A licensing system and other steps would reduce black market trade in shrimp and swordfish that is not "turtle safe."

Production and trade leakages can arise with protection for sea turtles when participation in an agreement is not full. Sea turtles migrate for long distances, weaving in and out of Exclusive Economic Zones of coastal countries and the high seas. Efforts at protection in one or more nations can shift harvests of swordfish or shrimp, and hence incidental takes of sea turtles, to harvesters of other nationalities, a production leakage. Attempted protection of turtles and the subsequent production leakage might well not change sea turtle mortality rates, since swordfish or shrimp harvests from non-protecting nations can replace the diminished harvests of protecting nations through the active global import markets, a trade leakage.

10. Eco-Labeling and Environmental Product Certification

Eco-label or environmental product certification offer a way to provide economic incentives to adopt technology or even production standards – a "carrot." At a minimum, they certify turtle friendly standards defined as adoption of technology standards such as mortality reduction measures (e.g. line cutters, de-hookers, etc.), or more strongly, participation in verifiable observer program (100% coverage). Such certification also guides consumers to make ecologically responsible decisions on seafood and thereby help convey consumer preferences to markets and from there to the fishing and processing sector.

11. Direct and Indirect Conservation

Performance and technology standards can be combined with direct conservation payments or actions, such as payments for wildlife use rights, to communities for nesting site protection and egg collection and protection, and for education of small-scale commercial fishers or exploiters of turtles, or for indirect conservation payments, such as to establish eco-tourism. Such direct or indirect conservation payments can occur as side payments from developed to developing nations in the context of an international environmental agreement. Direct conservation payments can be made from producer and consumer groups in developed nations to recipients in developing nations.

12. Side Payments

Side payments have both distributive and strategic functions (Barrett in press). Side payments, such as through technology transfers, payment of incremental costs to adopt technology standards by developing country fleets, and access to otherwise restricted markets for shrimp and swordfish, may help increase participation and help make the agreement fair.[37] [38] Side payments, by which gainers of a policy can compensate those who bear the burdens, help insure that nations that would otherwise lose by participating instead gain.[39] Side payments also acknowledge the "common but differentiated" responsibilities to biodiversity conservation of developing and developed countries, as explicitly recognized by the London Amendment to the Montreal Protocol in 1994.

This factor of fairness may be especially important if trade restrictions are included in the agreement by legitimizing these restrictions. The Inter-American Convention for the Protection and Conservation of Sea Turtles addresses this issue, as for example, Article XII, "International Cooperation," where rendering assistance to developing States is explicitly mentioned.

Several key factors pertaining to sea turtle conservation complicate side payments by which gainers compensate those who bear the burdens. First, beneficiaries of conservation, who gain through sea turtle existence, are in both the present and future generations (where the latter do not have a voice). Second, benefits are non-market, that is, they are unpriced and a market for these benefits does not exist, so that benefits are uncounted. Third, benefits are diffuse throughout the population of present (and future) generations and are spread across many countries. The voice by which benefits of preservation are expressed, through willingness to pay, is louder in richer countries. Fourth, losers tend to be concentrated among localized and specific groups, who largely bear the full burden of conservation. Fifth, producers and consumers of seafood do not pay the full cost of production and consumption, which is not captured by any market (an external cost and market failure). Sixth, the absence of property rights for sea turtles and over the oceans in general, and especially on the high seas, can complicate the issue of compensation. Producers have made investments to harvest an unpriced migratory resource (swordfish). Lastly, ostensible benefits from unilateral or limited multilateral conservation of sea turtles can be illusory and dissipate because sea turtles and swordfish are highly migratory, so that conserved turtles in one area are simply taken in another area. In sum, the heart of the compensation issue is to collect from diffuse beneficiaries who receive unpriced benefits and transfer some of these gains to localized and specific losers.

Side payments or compensation to private landowners of nesting site beaches raise another set of issues. Papers in Shogren and Tschirhart (2001) discuss this issue in considerable detail.

In sum, side payments can be an important component to any international agreement for both distributive and strategic purposes. Side payments contribute to the effectiveness of an international agreement through compensating those who bear the burden of environmental regulations; ensure that developing countries do not lose by participating in an agreement; help provide technology transfers; legitimize the threat of trade restrictions; pay the incremental costs of adopting technology standards; and foster fairness.

Concluding Remarks

In order to reconcile continued fishing with sea turtle recovery, it will be necessary to adopt a comprehensive approach that goes beyond merely reducing fishery bycatch mortality of sea turtles. A broad suite of approaches are needed that include effective beach conservation to protect nesting females, their eggs, and critical breeding habitat in order to maximize hatchling production for all depleted populations, reduce subsistence takes of turtles, as well as measures to enhance at-sea survival of juveniles and adults at critical foraging areas and as they move into different developmental habitat. The current level of conservation effort appears to be inadequate in reversing the decline of several critically endangered species of sea turtles in the Pacific, and if fishing is to continue, these efforts must be greatly enhanced by integrating fishery management into a more comprehensive sea turtle recovery strategy.

If fishing is to continue and sea turtle populations are to recover, some important building blocks of a comprehensive recovery strategy include offsets (such as nesting site and other habitat protection, community involvement in conservation, or financing of adoption of technology standards by developing country fleets); technology standards to reduce bycatch of sea turtles; possibly performance standards; side payments to increase participation and compliance, to equitably distribute the burdens, and to finance offsets and adoption of technology standards in developing nations; and trade restrictions to provide positive economic incentives for responsible fishing and negative economic incentives to deter destructive fishing practices, and to also plug trade leakages. Additionally, taxes and fees (including in-kind) deserve consideration as a way of raising revenues to fund some of these offsets and side payments, as opposed to the traditional role of taxes and fees of solely trying to correct the unpriced external cost of sea turtle mortality.

There are opportunities to immediately implement these recovery measures under existing global international treaties and possibly augmented by additional bilateral or broader multilateral agreements. Furthermore, there is considerable precedent, and lessons to be learned, to comprehensively begin recovery of Pacific sea turtle populations in existing international agreements for other environmental issues that contain these fundamental building blocks that we have outlined in this paper.

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[1] This creates a transboundary resource externality, where the outcome that any one country can realize depends not only on its own actions, but also on what others do. Thus, there is interdependence among nations.

[2] Habitat, as defined by the Memorandum of Understand for the Conservation and Management of Sea Turtles and their Habitats of the Indian Ocean and South-East Asia, "...means all those aquatic and terrestrial environments which marine turtles use at any stage of their life cycle."

[3] The endangered or threatened status of sea turtles and the difficulties in their conservation and management stem from a number of factors, but most importantly are due to: a unique life history that makes their populations vulnerable to several sources of mortality at critical stages in their life, which is aggravated by the fact that many species require decades to reach maturity; their generally migratory nature, where their migrations may extend across national jurisdictions and the high seas, creating a transboundary resource and jurisdictional problems; degradation of nesting sites; incidental mortality in harvesting of shrimp, swordfish, and other fisheries; and the open-access nature of extended economic zones and the high seas. Conservation and management strategies thus need to focus on the implications of different conservation measures on different stages of sea turtle lives for overall population growth and on strategies that tackle the transboundary issue requiring cooperative conservation and management by many different nations.

[4] Based on an amateur film by Andrés Herrera in 1947, Hildebrand (1963) and Carr (1963) guessed that 40,000 turtles nested at Rancho Nuevo (Márquez, 1999). No data were available until 1965, at which point the biggest *arribada* numbered less than 5,000 turtles. In 1973, the largest *arribada* contained only 200 individuals. Despite beach protection, this number continued to drop for the next 20 years, by which time total nestings for the season were only numbered in the hundredsSurveys conducted between 1978 and 1988 indicated an average of about 800 nests per year, declining at about 14 nests per year, to an all time low in the late 1980s (Marquez et al., 1999). The total number of nesting females may have been as low as 350 on beaches where tens of thousands of Kemp's ridley used to nest
This initial failure to respond to protection indicates that recruitment was jeopardized by prolonged near-total harvest of eggs and shrimp trawling in the Gulf of Mexico, the primary juvenile and sub-adult habitat and the only habitat of adults (Pritchard). In 1990, the mortality from shrimp trawling was estimated to lie between 500 and 5,000. Collectively, other trawl fisheries, passive gear fisheries, and entanglement fisheries were estimated in 1990 to yield between 50-500 deaths a year. Deaths due to dredging and collisions with boats were estimated in 1990 to lead to a further 5-50 deaths every year. Additional sources of anthropogenic mortality were estimated in 1990 to come from oil-rig removal, intentional harvests, entrainment by electric power plants, ingestion of plastics and debris, and from accumulation of toxic substances, especially from ingested petroleum residues. Mortality also occurs from human and non-human predation of eggs in nests, predation of hatchlings and juveniles by crabs, birds, fish, and mammals. The nesting population reached a low in the mid-1980s and in the last few years has begun to modestly and steadily increase (Marquez et al 2001)

[5] Turtle Excluder Devices were implemented in Gulf of Mexico to eliminate sea turtle mortality in shrimp trawls.

[6] Recent studies using satellite telemetry and molecular genetics have shown that leatherbacks migrate from their nesting beaches in Papua, Indonesia to foraging areas found across the North Pacific as far as waters off US West coast. In the eastern Pacific adult females migrate from nesting beaches in Mexico and Costa Rica to the southeast Pacific to forage off the coast of Peru and Chile.

[7] For example, the Inter-American Tropical Tuna Commission (IATTC) vessel data base indicates 1,156 IATTC-authorized longline vessels in the Eastern Pacific Ocean from 12 nations as follows: 23 from USA, 140 from Taiwan, 1 from Peru, 53 from Panama, 9 from Mexico, 177 from Korea, 516 from Japan, 14 from France, 125 from Spain, 20 from Ecuador, 1 from Costa Rica, and 77 from China. In addition, there are longline vessels fishing in the Eastern Pacific Ocean from nations that are not members of the IATTC.

[8] The Pacific high seas drift gillnet fishery was shut down by the United Nations in the 1980s. However, only a handful of nations were involved and it is questionable whether the extensive longline fleets of the entire Pacific can all be effectively shut down. A more likely scenario is termination of some fleets and continued, and perhaps even expanded, longlining by the remaining fleets, which leads to production and trade leakages and continued sea turtle mortality. Moreover, there still remains the source of sea turtle mortality from shrimp trawling.

[9] See NOAA-NMFS Endangered Species Act Section 7 Consultation 2002 Biological Opinion for more detailed synopsis of fishery and non-fishery related take and mortality of sea turtles. Includes estimates of take and kills for Pacific longline fisheries.
[10] See NOAA-NMFS 2002 BiOp for details of loggerhead take and kills in Pacific.
[11] See NOAA-NMFS Observer Manual for Hawaii-based Longline Fishery; NOAA Tech Report on NED Experiments.
[12] Offsets are sometimes called "shadow projects" in the sustainable development literature (Hanley, Shogren, and White 1997,Hanley and Spash 1993). These are projects or policies designed to augment then stock of natural capital (in this case sea turtles) to offset reductions in the stock of natural capital from a specified collection (portfolio) of projects or policies. The idea is to impose either a "weak" or "strong" sustainability constraint as a rule for sustainable development. In its weak form, the discounted sum of environmental costs must be no greater than the discounted sum of offsetting benefits over the time period in question. In the strong form, not only is the total natural capital stock non-declining, but the environmental costs are no greater than environmental benefits in each time period, a more restrictive condition. In addition, it recognizes some elements of "critical" natural capital such as biodiversity. The definition of weak sustainability corresponds to "favorable conservation status," of the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia.

[13] For example, Barrett (2003, p. 380) observes that a US company might convert a power station in China from coal to natural gas, claiming credit for the associated savings in greenhouse gas emissions. Annex I countries face an emission ceiling and Annex II countries do not face an emission ceiling. (Annex I countries are the industrial countries listed in the original climate convention that preceded the Kyoto Protocol, the Framework Convention on Climate Change, which was signed by over 150 countries at the Rio Earth Summit in June 1992.)

[14] See also Bean (1993), Olson, Murphy, Thornton (1993), Robert (1999), and Welch (1995).

[15] Credits are denominated in Habitat Units (HUs) and are a measure of habitat value (Fernandez and Karp 1998). The number of HUs is the product of the number of species or functions per acre of a wetlands times the number of acres. WMB is intended to create large, high-quality habitats which incorporate entire ecosystems and bugger areas. Multiple investors in the WMB can pool their financial resources, planning and scientific expertise. The value of restored wetlands can be viewed as an option value. If wetlands are restored in the current time period, a developer preserves the option of cashing in for future development.

[16] The heterogeneity of wetlands poses problems is determining offset values (Polasky 2002). Wetlands provide many different ecosystem functions. Polasky (2002, p. 1379) observes, "Comparing wetlands is difficult because wetlands can differ on a number of different dimensions, with one wetland providing more of some services and less of others. Because there are typically no markets for these services, and so no market prices, there is no direct way to aggregate across services to calculate the value of a wetland or to establish whether different wetlands are in any real sense equivalent."

[17] One issue with offsets is the "moral hazard" problem that vessels taking sea turtles as incidental catches will have less reason to avoid interactions.

[18] Care must be taken that country investing in offsets in other countries is not investing in offsets that would have been taken anyway. Not only do recipient countries have incentives to offer projects they would have undertaken anyway, but investing countries have incentives also to select these projects. (This adverse selection problem is a manifestation of the free-rider problem in international environmental agreements. Barrett 1998, p. 30)

In addition, some investments in offsets are lumpy and costs, and when combined with the relatively delayed age at sexual maturity for sea turtles, mean that offset projects require very long lifetimes.

[19] The Kyoto Protocol's Clean Development Mechanism encourages investment in economies where control of greenhouse gas emissions is least costly and where investments in new technologies today can "lock in" cleaner development paths that will persist into the future. It exists because emissions from developing countries are growing rapidly, so that significant effort to control world emissions should include controls in the developing countries. (Victor 2001, pp. 40-41).

[20] The Global Environmental Facility is an example of countries paying other countries to supply public goods, such as biodiversity preservation. The Global Environmental Facility was established in 1991 by the World Bank, the United Nations Development Programme and the United Nations Environment Programme. The Global Environmental Facility was relaunched at the 1992 Earth Summit in Rio.

[21] This discussion is based, in part, upon Goulder (1998), Kolstad (1999), Cropper and Oates (1992), Baumol and Oates (1988) and Tietenberg. In addition, shrimp and swordfish markets are predominately competitive and most producers, processors, and restaurants and fish stores are limited in size and scale of production. Thus, the (implicit) assumption of price-taking behavior may be reasonable.

[22] These external costs include foregone benefits from the continued existence of sea turtles and the preservation of sea turtles for future generations, and any foregone benefits (indirect use values) derived from non-consumptive uses as eco-tourism.

[23] The detrimental externality is not fully domestic, but instead is transboundary, requiring a multilateral and cooperative solution. Thus both consumers and fishers harvesting the population elsewhere are free riders to unilateral or bilateral conservation measures, and the social benefits provided by this global common property resource exceed the private. This free rider problem among both individuals and nations leads to substantial under-investment in conservation and management measures, and an increase in the investment needed to augment the population of turtles will have to be undertaken under the auspices of cooperative multilateral agreements.

[24] They depend on the elasticities of supply and demand.

[25] A higher cost of production through the Pigouvian tax which raises the private marginal cost of harvest to the social cost of harvest (by the amount of the external cost) introduces both a substitution effect, whereby incidental takes of sea turtles are minimized to the extent practicable for any level of swordfish catch, and an expansion effect, where the higher cost of production lowers the amount of fishing effort and thus the quantity of interactions. Over a longer time period, there is a dynamic effect through induced innovation. When producers and consumers of swordfish or shrimp must now pay the full cost of production and consumption, the higher swordfish price and costing of sea turtles could induce technical change that lowers the take rate of sea turtles. This point has been raised in the context of pollution by Wenders (1975) and Magat

(1978). Completely shutting down a fishery in effect raises the sea turtle cost to infinity and can lead to technical change that lowers takes of sea turtles.

[26] The full economic consequences of taxing consumers or producers is unknown in this instance of joint production of a desirable output (swordfish or shrimp catch) and an undesirable output (sea turtle mortality) with and without full cooperation and participation in an international environmental agreement. In a somewhat analogous situation, Hoel (1994) and Bolombek, Hagen, and Hoel (1995) show that when all countries participate in an agreement to reduce CO_2 emissions, taxes on the consumption and production of fossil fuels have identical economic consequences, provided the tax revenues are identical in the two cases, but that this is no longer true when there is only limited participation in the international environmental agreement.

[27] Much depends not only on time spent fishing, but fishing gear and practices, which can differ by vessels and between larger and smaller producers.

[28] Weitzman (1974) is the classic paper in this area. With perfect information, tradable permits sold at auction have the same effect as a tax. Under uncertainty, the relative efficiency of transferable permits and fixed tax rates depends on the relative slopes of the relevant marginal benefits and marginal cost functions. If uncertainty about marginal conservation costs is sizeable, and if marginal conservation costs are relatively flat and marginal benefits of conservation fall relatively quickly, then a quantity control, such as a transferable turtle mortality limit, is more efficient than a price control, such as a tax. When there is also uncertainty about marginal benefits, and marginal benefits are correlated with marginal costs, then there is an additional argument in favor of the relative efficiency of quantity controls (Stavins, p. 486).

[29] In a revenue-neutral framework, the tax revenues are rebated to the payors. This revenue recycling is not considered here. Revenues from taxes, fees, or charges are designated for sea turtle conservation rather than as a source of overall tax revenue.

[30] Comparable charges are used in Europe and Japan to address water, and to a lesser extent, air pollution (Tietenberg, p. 377). France and the Netherlands use charges designed to raise revenues to fund activities that improve water quality. Water discharges in Germany give incentives to firms to meet minimum standards of waste water treatment for a number of defined pollutants. Discharges meeting or exceeding standards have to pay only half the normal rate. The Italian effluent charge system encourages pollutees to achieve provisional effluent standards as quickly as possible. The charge is nine times higher for non-complying firms and is scheduled to expire once full compliance is achieved. The French air pollution charge encourages early adoption of pollution control equipment with revenues returned to those paying the charge as a subsidy for installing the equipment. Charges in Sweden increase the rate at which consumers purchase cars equipped with a catalytic converter. Cars without one are taxed and new cars with one are subsidized.

[31] In theory, taxes intended to raise revenue in competitive markets distort resource allocate and create economic inefficient through what is called a dead weight loss. However, when there is a pre-existing market failure and inefficiency due to an external cost (like sea turtle mortality from fishing), a tax or fee both raises revenue for conservation and recovery and addresses the market failure, thereby inducing efficiency.

[32] This discussion draws from Kolstad 1999, pp. 124-128.

[33] The Convention provides a general prohibition on the takes of sea turtles and their eggs in the territories the Parties and in waters under their respective jurisdictions, but allows subsistence take to satisfy the needs of traditional communities under certain circumstances (Gibbons-Fly). The Convention requires that the take be reported to the other Parties. The Convention also

provides that countries with subsistence takes agree to take into account the relevant recommendations of the Consultative Committee and to ensure that such take does not undermine the overall objectives of the Convention.

[34] The elements are: (a) Develop and use gear, devices and techniques to minimize incidental capture of marine turtles in fisheries, such as devices that effectively allow the escape of marine turtles, and spatial and seasonal closures; (b) Develop procedures and training programmes to promote implementation of these measures, such as vessel monitoring systems and inspections at sea, in port and at landing sites, and national on-board observer programmes; (c) Exchange information and, upon request, provide technical assistance to other signatory States to promote these activities; (d) Liaise and coordinate with fisheries industries and fisheries management organizations to develop and implement incidental capture mitigation mechanisms in national waters and on the high seas.

[35] Tradable emission permits are called "allowances." This program was designed to cut acid rain by reducing sulfur dioxide (SO_2). Allowances can be bought or sold without restriction to cover emissions anywhere in the continental U.S. (Schmalensee *et al.* 1998). Emissions everywhere in the U.S. do not have the same marginal damage, but continent-wide trading helps insure that the allowance market is not too thin, i.e. that there are sufficient number of trades to insure a well-functioning market and price discovery.

[36] This is a key reason they are often ineffective. However, if the trade restriction deters relocation of production or emissions (production leakage), then the countries imposing the sanctions gain by imposing them. This then reinforces the credibility of sanctions.

[37] Costs and benefits of an agreement do not always fall equally on nations and willingness to pay varies by income levels for many environmental goods and services. By adopting technology standards or performance standards, gains to cooperation are created and all parties deserve to receive a share of this gain.

[38] Barrett (2003, p. 15) for example, states, "...the Oslo Protocol ignores the need for side payments. As noted previously, if the winners of acid rain controls do not compensate the losers, the losers will have little incentive to participate or to reduce their emissions by more than they would have absent Oslo."

[39] Side payments redistribute the additional gain from cooperation and help guarantee that all parties are at least as well off as before cooperation. Barrett (2003, p. 351) observes, "...side payments on their own have little effect on international cooperation. Side payments make the recipients more inclined to participate, but lower the payoffs of the donor countries, and so make them less inclined to participate. They do not on their own fundamentally alter the cooperation problem. In particular, they do not make punishments for free-riding any more credible." Barrett (2003, p. 351) later observes about the role of side payments through the Multilateral Fund of the Montreal Protocol, "On their own, trade restrictions might have deterred non-participation by the developing countries, but such an outcome would not have been fair. Side payments not only helped to increase participation. They also legitimized the threat to impose trade restrictions. It is really the combination of carrots and sticks that succeeded in protecting the earth's ozone layer." In addition, side payments to otherwise non-cooperating countries, while increasing the coalition of cooperating countries, may create an incentive for them initially to stay out of cooperation (Hoel and Schneider 1997). In the Kyoto Protocol, the surplus of emission entitlements created by allowing economies in transition to choose an alternative base year to 1990 (that may not be exhausted by economic growth in these countries) allows the economies in transition surplus emissions to trade with Annex I countries and in effect to receive a side payment to foster participation (Barrett 1998, p. 30).

APPENDIX P

Proposals for conservation measures received to date by the Council

Leatherback Conservation at *Warmon* Beach, Papua-Indonesia
Concept Proposal

I. BACKGROUND

The first aerial survey when jamursba medi discovered to hosting a large aggregation of leatherback nesting population, was carried out during in the absence of breeding in Warmon beach. The importance of Warmon beach as nesting habitat for leatherback turtles was identified in early 1984 when a consultant (hired by WWF) started an intensive fieldwork in Jamursba Medi. Knowing that the adjacent beach (Warmon) also landed by nesting leatherbacks, his fieldwork was then expanded. He recorded an average of 16 clutches laid per night. Starbird and Suares (1994) carried out a 21 days survey on a 4.5 km War-Mon Beach and recorded a total of 101 nesting females were encountered on nightly patrols.

Warmon beach lies on about 30 km further east of Jamursba Medi and stretches along a six kilometer halfway between Welos Cape and Wau Village. The beach compose of dark gray sandy beach. The dynamic of the beach is the same as Jamursba Medi but the extreme started a bit late (in January), as the beach is partly sheltered and facing northeast. The beach has half on each side of the Mon river mouth, two km west and 4.5 km to the river east. The later stretch is more favored by nesting turtles. The eastern beach is further separated into four segments by one perennial stream and the two dry streambeds.

<u>Threats</u>
Being unprotected made egg harvest accounted for over 60% has being practiced on the beach (Suares, 1994). The practice is being done mostly by nearby villagers for own consumption, sale to transit passengers on a weekly passing boat or letting the outsiders to collect the eggs at the expenses of household stuffs. Recently, a group of outsiders have settled down in certain part of the beach for wild boar hunting, thus also collecting turtle eggs for consumption.

As in Jamursba Medi, pig predation is another threat to the survival of eggs. Suares 1994-recorded less than 40% nest disturbance resulted from the pig predation. Fortunately, an increase of population and protein needs in recent years induced high rate of hunting activities (with snare and spear). This resulted in fewer pigs and a lower rate of predation in Warmon than in Jamursba Medi.

A problem in which conservation work is conflicting with development activity identified during this reporting period. A forest concessionaire operates at the lowland forest adjacent to the beach is proposing the conversion of the beach for log-pond, which is in conflict with the idea of protecting the beach for turtle nests. The conflict magnifies with the short term financial benefit provided by the company.

II. EXISTING INITIATIVES

Different from the situation in Jamursba Medi where community support is obvious due to the long term in conservation activities, the start up of activity in Warmon is with a group of local young people to collect information on turtle nesting activities and genetic sampling (dead hatchlings). The assessment was started in mid December 2002 by a local researcher and a small group of young villagers on a 4 km beach of Warmon where the largest nesting density is usually found (15 km east of Jamurba Medi), under permission from the landowner. This project aimed at assessing the population status and threats, and conducting coastal patrols to prevent disturbance and exploitation on the beach. Warmon beach hosts a breeding population in different season (November-March) and may imply the use different foraging areas than those nesting at Jamursba Medi. When this is the case, different management regime is required. Therefore, similar management related research especially on migration and foraging ecology is also needed for this particular population. This monitoring activity was originally planned for November-March period, but as laying eggs turtles were still coming beyond the period, the monitoring extended until zero evidence of nesting (June 2003).

III. PROPOSED PROJECT

Protection of major leatherback rookeries in North Papua and Inclusion of turtle critical habitats and sustainable co-management strategies in MPA design in the Bismarck Solomon ecoregion is a set three-year goal for WWF's Turtle conservation Program in Papua. Increase an understanding of the status; threats, and critical habitats of Papuan leatherbacks as well as promotion of community participation in conservation activities are some of the objectives developed to achieve the goal. Hence, proposed project is done to meet the program objectives.

Project Objective:

- Protection of nesting beaches, nesting leatherbacks and their nests in Warmon Beach through a community based patrol and monitoring and other relevant initiatives that demonstrate the benefits of conservation in improving the people's quality of life.

Proposed Activities

In order to achieve the short-term objectives the following activities will be conducted:

1. Community consultation

A problem in which conservation work conflicting with development activity encountered during recent WWF's activity in Warmon. A forest concessionaire operates at the lowland forest adjacent to the beach is proposing the conversion of the beach for log-pond, which is in conflict with the idea of protecting the beach for turtle nests. The conflict magnifies with the short term financial benefit provided by the company. This is a common case where conservation efforts compete with development activity for economic revenue, especially in areas with poverty problem like Papua. Conserving the biodiversity will succeed only when the local people perceive the efforts as ultimately serving their economic and cultural interests. Conservation strategies must therefore reflect the dual objectives of simultaneously improving the natural resources management and the people's quality of life. Unless the people who most directly impacted by conservation projects perceive these as serving their long-term economic and cultural interests, then biodiversity conservation is not feasible. Therefore, more consultation with local people and landowners are to be conducted before the beginning of next nesting season, to ensure their continued support to the monitoring work in particular and turtle conservation in general. Focus of this activity will be a larger involvement of local communities in conservation activities.

2. Beach patrol and monitoring activities using standardized census techniques

Building on the existing monitoring initiative, a standardized technique for data recording will be applied. PIT tagging will be introduced during the coming activity to allow a better estimate on the number of turtles. During the monitoring period, possibility to conduct satellite tracking and DNA sampling will be consulted with community and proposed to NMFS to be conducted during the peak season.

3. Management related activities

In addition to population monitoring/ and beach patrol aims at reducing egg harvests on the beach, field observation on nests disturbances was recorded and intervention will be taken. So far, it was known that feral predation and beach erosion (during January-February) threatened the survival of the eggs and careful removal of the eggs to a safe place is needed. Identification of the safe place and proper training will be conducted to ensure mishandling that might reduce the hatching success.

Furthermore, as the eggs are mostly harvested for cash, job provision such as for beach patrol, population monitoring and removing potential inundated, eroded or predated nests offers potential to involve large numbers of local people. Income generating activities is identified as important when the protection of nesting beach is concerned due to the potential further development of log pond (by forest concessionaire) that might expand to favored beach for turtles to lay their eggs as well as the continuation of egg harvesting. This initiative will be a short-term show case how people will gain economic benefit as a return in doing conservation work. In a long run, the project will be further developed with greater likelihood of achieving long-term success in which community will be capable in managing, monitoring, and benefiting from their own resources.

<u>Outcomes:</u>

- Information on number of turtles obtained.
- Nesting beach protected from human based threats
- Management intervention to increase hatching rate implemented
- Relevant income generating models/ economic incentives for turtle protection identified.

<u>WWF Indonesia (Region Sahul) Staff responsible for implementation of the program:</u>

Creusa Hitipeuw, EAP manager Bismarck-Solomon and coordinator of Species, Ocean-Coast TDPs in Sahul Bioregional Program

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Reducing Leatherback's Mortality due to Traditional Practices

Participatory Monitoring and Evaluation of Indigenous Hunting of Leatherbacks in Kei Kecil islands, Maluku (Proposal Concept)

I. Background

Kei islands and threats to the leatherback populations

The Kei Islands group located in the Maluku Province of Indonesia (5°43'S; 132°50'E), on the Sahul plate between New Guinea and Australia. Six sea turtle species; Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Olive ridley (*Lepidochelys olivacea*), Loggerhead (*Caretta caretta*), and Flatback (*Natator depressus*), are among other marine life inhabit this islands group. Leatherbacks locally known as *Tabob* is the most important marine species for indigenous people at several villages at Kei Kecil islands since they serve the subsistent and ritual needs to the locals. The species frequently occurs in the waters of southwest of Kei Kecil islands to feed on certain species of jellyfish, which are seasonally found in large numbers in this area.

Tabob have been traditionally hunted for generations in Kei kecil islands for both subsistence and ritual purposes. The local belief is that the ancestors require villagers to hunt for their ritual ceremonies and daily subsistence. Trading of leatherback meat is considered violation to the customary (*adat*) rules. The capture level of leatherbacks by the villagers of Kei is estimated as intensive as approximately 100 leatherbacks per season (Suares, 1999). Lack of protein resources from the forest, such as birds, deer and pigs and the increased population are suspected to be the reasons behind the traditional practices. However, the critical endangered status of, and the multi-dimensional threats to the Pacific leatherbacks require closing down of such intensive traditional captures.

II. Project Context

The traditional practices of natural resources utilization are of high socio-cultural values to many indigenous people. These practices reflect the vital linkage of people to land/water, reinforce the spiritual beliefs that govern their existence and responsibility to their natural resources, and serve as a tool for passing on the socio-cultural knowledge to the future generations. Accordingly, sustainable development plans in a broader term including conservation need to consider both the social and cultural aspects of the local communities. Careful assessment of the local socio-cultural and economic perspectives in relation to leatherback hunting is needed for determination of the best approach to conservation issues and adaptation of the local customary institutional frameworks.

The following process oriented steps are identified strategic to gain community interests in turtle conservation that associated with traditional practice. Process will be emphasized on grassroot level including intensive consultations, participatory planning and activities:

I. **Evaluation of Indigenous Harvest of Leatherback (Social, economic and cultural assessment).- *on-going.***

Currently, a locally experienced specialist in community organizing from a local NGO is hired to assess the socio-cultural and economic aspects of the traditional leatherback fisheries in eight villages of Kei Kecil islands. The assessment includes the socio-cultural perspectives and the traditional knowledge on the bio-ecological aspects of turtles, the existing local management wisdom associated with the hunting, and the local institutional framework relating to customary decision making. The main outcome will be strategies to obtain communities' support to turtle conservation, including the effective communication strategies. The final report is expected to be available by mid November 2003.

II. **Community based Harvest Monitoring**

Exploration of potentials for a community based harvest monitoring as well as alternate substitutes for the traditional practices is also part of the above-mentioned assessment.

The occurrence of known feeding area for leatherback turtle in Kei islands provides opportunity for gaining our scientific understanding on the foraging ecology of the species; including migration route, habitat characteristics, feeding behavior, population structure (size, sex), etc. This valuable scientific knowledge will significantly contribute to the conservation management of this critical endangered species. Community based harvest monitoring is useful tool to gain a set of information beside specific scientific studies.

This participatory project aims at generating community support and involvement in conservation project. It emphasizes the value of traditional knowledge and practice while recognizing that the adoption of modern/ scientific methods and techniques are essential. Indigenous people are unlikely to provide information about their harvests unless they see that it is in their interests to do so, particularly if they think the information is likely to be used unfairly to restrict their hunting activities. If they see a benefit for themselves, such as contributing to a management system that will ensure wildlife resources and indigenous rights to use them are protected, then cooperation is far more likely.

The set of information obtained through monitoring project and possibly scientific findings will be disseminated and communicated to evaluate the existing practice in a participatory way including distribution of information on the endangered status of the leatherbacks in the Pacific. Community organizers (outreach) person will be hired to facilitate the overall process. Depending on the assessment and organizing results, harvest monitoring is planned for the coming hunting period (November 2003-February 2004).

III. **Alternate Substitutes to hunting practices**

The on-going assessment will also explore and identify possible substitutes for the practice and strategies for further development of related community based activities (pilot project) that will lead to at least the significant reduction of the current level of human induced mortality. The community- based activities may include producing other source of animal proteins (e.g. farming) or traditional hunting regulations. However, this is really dependent on the output of the assessment. Further development and implementation of strategies will be done during and post monitoring project using community organizing approach.

Proposal to save doomed eggs and pre-emergent hatchlings of the Pacific loggerhead sea turtles

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Background

As a results of the dedication and hard work of an extensive network involving many independent field teams in Japan, annual census data are available from most nesting beaches. The current population level of Japanese loggerheads is considerably lower than the population levels of the other ocean basins. For example, in 1998,1999, 2000, 2001, and 2002 seasons, a total of 2,479, 2,255, 2,589, 3,122, and 4,035 loggerhead nests, respectively, were recorded on Japanese beaches.

In contrast to dedicated nesting survey, hatching success and number of emergence for clutches *in situ* are hardly examined systematically in many rookeries. However, owing to various factors such as predation, inundation, erosion, and excessive heat, mortality of eggs and pre-emergent hatchlings seem to be pretty high. For example, hatching success in Minabe-Senri beach were: 24%(1996), 50%(1997), 53%(1998), 48% (1999), 62%(2000), 41%(2001), 34%(2002). It should be noticed that these figures do not include many clutches that were washed out and were not examined.

The purpose of this proposal is to acquire funding to support a project to reduce mortality of loggerhead eggs and pre-emergent hatchlings on Japanese beaches from extreme temperatures, beach erosion and predation.

Methodology and effectiveness

This project is scheduled for the following two beaches. With additional funding, geographical areas and conservation activities can be expanded.

<u>Minabe-Senri beach</u>

Minabe-Senri beach is located in Minabe-town, Wakayama prefecture. This 1,360 m long beach is one of the 9 major nesting beaches in Japan; 350 clutches were recorded in 1991 (61 clutches in 2002 and 75 clutches in 2003). As mentioned above, one of the feature of this rookery is the relatively lower hatching success; for example, about 50% of the clutches exhibit low hatching success (less than 10%) in 2002 season. The high mortality is associated with predation by raccoon dogs (*Nyctereutes procyonoides*), beach erosion, inundation caused by heavy rain and flood tide, and excessive heat (the dark-colored sand of this beach induces sand temperature that exceeds the lethal level for embryos and pre-emergent hatchlings).

Daily and nightly patrols are conducted on this beach from May through October. All clutches *in-situ* are marked with stakes, ropes, and underground-coil markers. To conserve nests from beach erosion, clutches laid below the high tide mark or on slopes beside streams are relocated immediately after nesting to an open hatchery or to higher elevations within the same beach. Sand temperatures are monitored using data loggers. To save embryos and pre-emergent hatchlings from lethal heat, nests are cooled with water or shaded with cloths when the sand temperature at the depth of 40 cm exceeds 31.6°C during the post-rainy season. In addition, to protect eggs and hatchlings from predation, safeguards are put on top of the nests. These barriers are built of iron frame (1m × 1m × 5 cm) and covered with 5 mm meshed wire.

The number of eggs and pre-emergent hatchlings we can save by relocating nests from erosion prone areas, cooled with water and shade to prevent overheating, and covered with protective barriers to prevent predation will depend on beach and seasonal weather conditions. However, on average, we expect more than half of the total nests (approximately 30 nests) can be rescued from foreseeable destruction.

Hii-Horikiri beach

Hii-Horikiri beach, Atsumi-town, Aichi prefecture is located around the tip of the Atsumi Peninsula. This 4 km long beach has suffered serious erosion. The beach is armored with ranges of tetrapods (concrete blocks) between the shore line and the vegetation line. These blocks obstruct loggerhead females from getting to the vegetation line and are forced to nest close to the shoreline. All eggs laid in the shoreline will eventually be washed out or drowned. In 2002 and 2003 season, a total of 23 and 30 loggerhead nests, respectively, were counted.

Daily and nightly patrols are conducted on this beach from May through October. All the clutches are translocated to an open hatchery located in a safety zone above the beach armament. Sand temperatures are monitored to prevent lethal overheating of nests, and safeguards against overheating and predation are put on the egg chambers. In addition, hatchlings that emerge from relocated nests occur above the beach armament concrete block area and are unable to get to the water. These hatchlings must therefore be assisted into the water. Assisting hatchlings into the water, and utilizing the same measures as at the Minabe-Senri beach (relocation, nest cooling, and predation barriers), it is expected that all nests and emergent hatchlings can be saved (approximately 30 nests).

Kamiali Integrated Conservation Development Group

Project Title:	Community based conservation and monitoring of leatherback turtles at the Kamiali Wildlife Management Area.
Facilitating & Implementing Agency	Kamiali Integrated Conservation Development Group
Implementation Schedule	October 2003 – March 2004
Contact Officer	Karol M. Kisokau, OBE, MSC P.O. Box 3339, Lae, Morobe Province, PNG

Introduction

The main goal of the community-based monitoring program is to promote the long term survival of the prehistoric marine reptile (leatherback turtle) from extinction.

The Kamiali Community has demonstrated their commitment by supporting and directly participating in the population census of the nesting female leatherback turtles from 1998 up till now. Secondly, the community has become aware of the importance of protecting the species through the staging of education and awareness building workshops. As a result of this, (it is the first in PNG) for Kamiali Community to declare a moratorium or ban on egg harvesting by the villagers for the October 2002 to March 2003 nesting season. [There was joy amongst the villagers to see for the first time ever, young leatherback turtle hatchlings swimming in abundance in Nasa bay of the Kamiali Wildlife Management Area.]

The turtle monitoring program has attracted multi-national agencies to work in partnership with Kamiali Community to manage and protect the leatherback turtle species.

Briefly, from year 2000- 2001 nesting season, US National Marine Fisheries Services base in La Jolla, California (NMFS), collaborated with the community to determine the migratory routes by use of satellite telemetric devices, collection of tissue for DNA analysis to determine population stock and also carry out health assessment of the leatherback turtle. This will continue during year 2003-2004 nesting season. In addition to this, from January to March 2004, NMFS will carry out aerial and ground survey of the nesting sites and determine nesting season, population stock analysis and deployment of satellite telemetric devices on leatherback turtles to determine their migratory routes and foraging habitats during the nesting period.

To understand more about the population dynamics of the leatherback turtle, the trained parabiologists will also be tasked to collect data/information on the incubation of hatchlings to determine the survival/mortality rate. After 60-65 days of incubation, the nests will be dug up and the number of broken shells (i.e., number of live hatchlings), dead hatchlings (i.e., unhatched eggs) and sterile eggs will be recorded. This will be implemented from October 2003 to March 2004.

Goal
To protect and manage the leatherback turtle from extinction

Objective
To determine the sustainable management level of egg harvest of the leatherback turtle by the Kamiali Community.

Activities
The objective will be achieved through the following activities:

Activity 1: Carry out census of the nesting population (use of Pit Tagging, etc.) and qualify recruitment and also determine the mortality survival rate of the leatherback turtle hatchlings including their sex ratio.

Activity 2: Carry out mapping of existing nesting beaches by aerial and ground survey along the northern part of New Guinea Island and where possible determine the population stock (DNA analysis), deployed satellite tracking device (migratory routes, foraging habitats management).

Activity 3: Carry out awareness, education and workshop activities and update the community of the latest development with leatherback turtle research and other important issues relating to the Kamiali Wildlife Management Area.

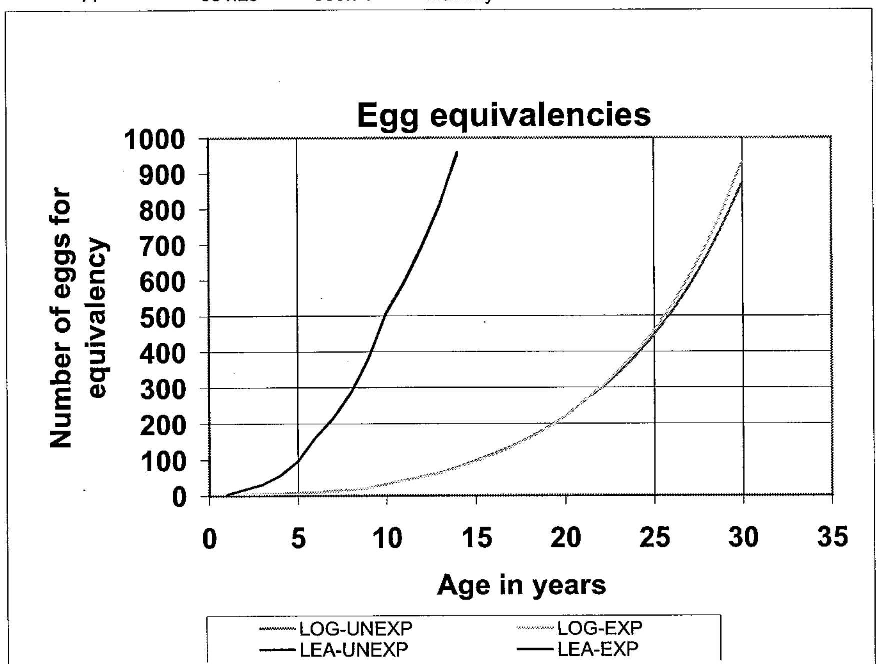
APPENDIX Q

Egg Equivalencies Data

Equivalencies.xls -- July 3, 2003.
Egg equivalencies using Chaloupka models. Values estimated using equilibrium population snapshot ratios.
500 population trajectories averaged, exploited configuration was a long term "coastal fishery" hazard.

Leatherback

Age	Unexploited	Exploited	
1	3.18	3.16	
2	16.74	16.67	
3	30.45	30.31	
4	55.34	55.10	<=Begin exposure to pelagic fisheries
5	96.60	96.18	
6	161.59	160.86	
7	215.47	214.45	
8	287.20	285.75	
9	382.88	380.83	
10	510.33	507.44	<=Begin exposure to coastal fisheries
11	596.29	592.77	
12	696.72	692.44	
13	814.09	809.33	
14	951.23	959.71	<=Maturity



Loggerhead

Age	Unexploited	Exploited	
1	2.38	2.37	
2	2.85	2.83	<=Begin exposure to pelagic fisheries ages 2-12
3	3.79	3.77	
4	5.06	5.03	
5	6.74	6.69	
6	8.99	8.91	
7	11.98	11.86	
8	15.97	15.78	
9	21.30	21.01	*ages 10-12 not shown because data not in model output
13	62.95	61.84	<=Begin exposure to coastal fisheries ages 10-onward
14	78.70	77.33	
15	98.37	96.67	
16	115.76	114.16	
17	136.19	134.76	
18	160.22	159.09	
19	188.48	187.79	
20	221.72	221.66	
21	260.82	261.63	
22	298.42	301.40	
23	341.38	347.14	
24	390.57	399.84	
25	446.80	460.49	
26	511.16	530.36	
27	584.78	610.79	
28	669.01	703.42	
29	765.36	810.07	
30	875.59	932.88	<=Maturity

APPENDIX R

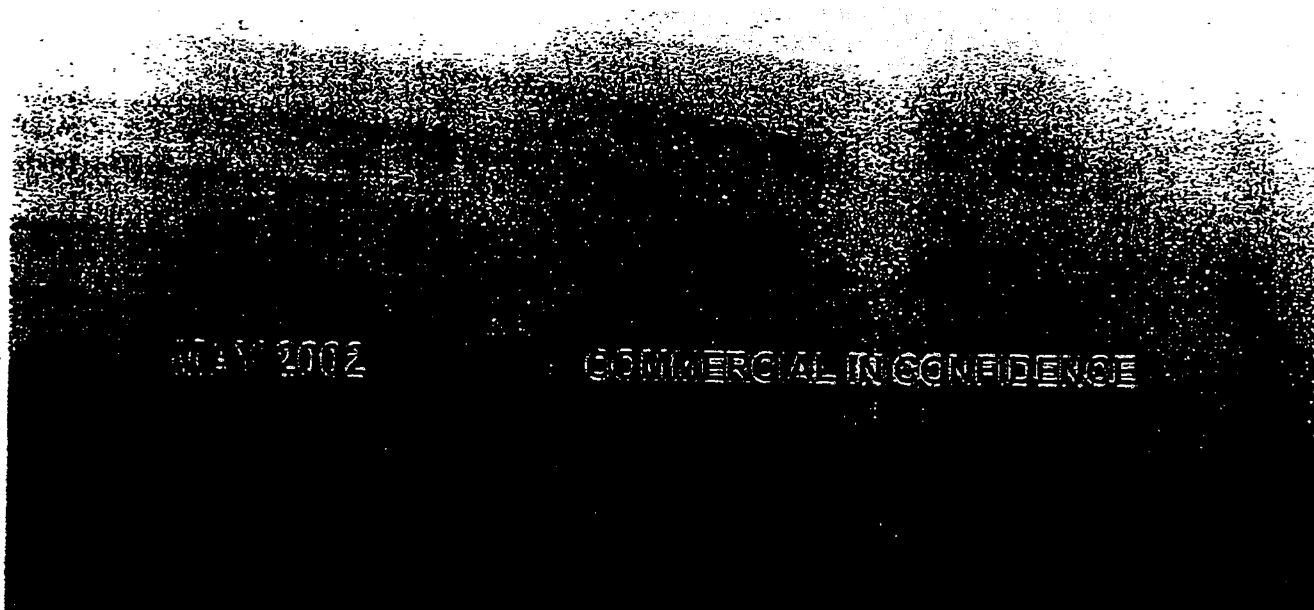
Centre for Environment, Fisheries, and Aquaculture Science, *Review of Three Simulation Models for Sea Turtle Biology and Management in the Pacific*

CEFAS

The Centre for Environment, Fisheries & Aquaculture Science

REVIEW OF THREE SIMULATION MODELS FOR SEA TURTLE BIOLOGY AND MANAGEMENT IN THE PACIFIC

FOR THE UNIVERSITY OF MIAMI INDEPENDENT SYSTEM FOR PEER REVIEW



CONTENTS

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1. Executive Summary

1.1 Impetus and goals for the review

The consultant is required to provide a review of three simulation models examining sea turtle population biology. The reviewer shall analyze these reports, which examine loggerhead and leatherback sea turtles, focusing on the following:

1. Assumptions in defining the stock structures based on genetic or other information;
2. Application of the most recent biological, nesting beach, and fishery interactions data;
3. Underlying dynamics of the population models;
4. Applicability of the population models to the ongoing protected species recovery and fisheries management issues.

1.2 Main conclusions and recommendations

The models of Chaloupka are specifically designed for Pacific-wide turtle population analysis, and appear to require the least additional effort before they can provide the best information on which to proceed with protected species recovery and fisheries management analysis of relevance to the Hawaiian longline fishery and other U.S. interests. Wetherall's leatherback model concentrates on the Mexican leatherback population, and is likely to require considerable modification to incorporate the interactions of the other turtle meta-populations and anthropogenic impacts necessary to examine the wide range of issues of relevance to NMFS. The models of Chaloupka for leatherback and loggerhead turtle populations are perhaps biologically more realistic than that of Wetherall, and are certainly more complex. The values and functional forms of many of the parameters in the models of Chaloupka are unknown due to the paucity of suitable studies on the relevant turtle populations. This increases uncertainty in model outputs. Sensitivity analyses of the impact of the values and forms of these parameters on model outputs, assessments and perception of the population (recovery) need to be extended to identify those biological parameters which are important to the dynamics of populations. This will focus data collection on parameters which will best support the derivation of management. Wetherall's model is less data intensive, offers useful insights into the performance of the models of Chaloupka under uncertainty, and could be used to test the robustness of those models.

Scientific studies to populate the parameters will take a number of years to complete. It can be foreseen that management options will need to be developed in a shorter time frame. Chaloupka's models must therefore be used to derive management interventions which are robust to model uncertainties.

In their current form, Chaloupka's models will be useful for the identification of the likely causal factors of population decline. With development of management strategy simulation frameworks, for example, the models will be suitable for the examination of robust management interventions which halt declines in the short term, and result in long term stock recovery. They should also be used to inform the derivation of management targets for recovering turtle populations, and to develop practical early warning monitoring indicators for vulnerable sea turtle populations. The models should form the basis of discussion workshops examining potential management interventions.

A number of recommendations have been made throughout the text of this report. At present, the models of Chaloupka represent the best available information on which to proceed with species recovery and fisheries management in the Pacific. Consideration of the recommendations in this report will improve the models, and ensure that model outputs will provide suitable information of a quality sufficient for basing development of management strategies.

2. INTRODUCTION

Both leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) populations in the Pacific have been strongly affected by human activities. These activities include, for example, the loss of nesting habitat due to beach development, egg and female mortality on nesting beaches, hunting in coastal waters, and incidental mortality in fisheries. Declines in the numbers of female turtles returning to nesting beaches has led to considerable concern for the welfare of these populations. In the recent NMFS Biological Opinion (2001) leatherback turtles were listed as endangered, while loggerhead turtles were listed as threatened. As a result of the status of these populations, there is a need to develop appropriate strategies to halt declines and promote recovery.

2.1 Background

Simulation models have been developed by the U.S. National Marine Fisheries Service (Southwest Fisheries Science Center) to provide a quantitative foundation for assessing the impacts of the Hawaii-based pelagic longline fishery and other human activities on sea turtle populations. Two independent studies have been completed recently. In the first, two stochastic simulation models were developed under contract by a sea turtle modeling specialist, assisted by interactive workshops of invited experts. The first modeled Pacific leatherback sea turtles, with emphasis on western Pacific populations of this species. The second modeled the northwestern stock of Pacific loggerheads. In the second study, a simulation model of the Mexican leatherback population in the Pacific was developed.

An independent review of these models was requested, and forms the basis of this report.

2.2 Terms of Reference

The reviewer shall analyze the reports for loggerhead and leatherback sea turtles, focusing on the following:

1. Assumptions in defining the stock structures based on genetic or other information;
2. Application of the most recent biological, nesting beach, and fishery interactions data;
3. Underlying dynamics of the population models;
4. Applicability of the population models to the ongoing protected species recovery and fisheries management issues.

2.3 Description of Review Activities

The reviewer traveled to the NMFS Southwest Fisheries Science Center, Honolulu, Hawaii, for a two-day meeting with the model authors on the 2nd and 3rd May, 2002. During this useful meeting, the models were demonstrated and issues discussed. The green turtle workshop described in the Statement of Work did not go ahead, as work on that model is still underway.

Personnel met during the two-day meeting were from NMFS:
Dr Mike Laurs
Dr Jerry Wetherall
and the sea turtle modeling specialist:
Dr Milani Chaloupka

Documentation made available to the reviewer is summarized in Appendix A.2.

3. REVIEW OF THE MODELS

The documentation for the three models was reviewed and discussed at the two-day meeting in Hawaii. The first two models were developed by Dr Chaloupka, and modeled populations of western Pacific leatherback sea turtle stocks and northwestern Pacific loggerhead sea turtle stocks respectively. These models are discussed together in Section 3.1. The third model was developed by Dr Wetherall, in collaboration with a number of Mexican scientists, and simulated the responses of Mexican Pacific leatherback populations to anthropogenic impacts. This model is discussed in Section 3.2.

3.1 Chaloupka turtle models

Dr Chaloupka developed two models which are similar in basic structure and approach. These stochastic simulation models were developed for the western Pacific leatherback sea turtle stock (which includes a sex- age class- and substock-structure) and northwestern Pacific loggerhead sea turtle stock (which comprises a sex- and age class-structure). In both cases the structure is linked by correlated time-varying habitat- density- and temperature-dependent demographic processes, incorporating environmental and demographic stochasticity.

3.1.1 Assumptions in defining the stock structures based on genetic or other information

In this section, issues relating to assumptions in defining the stock structures based on genetic or other information which are unique to each model are discussed.

Leatherback model

Meta-populations are modeled as discrete sub-stocks, originating from Malaysia and Melanesia. Although current opinion is that there is no evidence of dispersal between leatherback substocks, the model is flexible enough to allow this capacity to be enabled if data are collected subsequently that prove otherwise.

The east Pacific population (Mexico stock) is not included currently in the model. However, there is genetic evidence that Mexican leatherbacks are caught in the Hawaiian longline fishery (NMFS Biological Opinion, 2001). Hence, this metapopulation should be included in the model. As a result of the model's formulation, it appears sufficiently flexible to allow this population to be added.

Loggerhead model

The model concentrates on the northwestern Pacific ('Japanese') loggerhead stock. This stock is known to interact with the Hawaiian longline fleet, and fisheries on the US Pacific and Mexican west coast. The southwestern loggerhead stock, with nesting sites around eastern Australia, is not currently included in the model since best information suggests that the two stocks do not mix. However, while the NMFS Biological opinion supports the fact that the vast majority of individuals caught in the Hawaiian fishery originate from the Japanese nesting stock ("nearly 100 percent"), it does state that that "the rest derived from Australia", referencing a personal communication with P. Dutton (Jan 2001). Consideration should be given on whether the Australian metapopulation should be simulated within the model or whether the level of interaction with fisheries of interest is sufficiently minimal for its impact to be ignored.

3.1.2 Application of the most recent biological, nesting beach, and fishery interactions data

In this section, issues related to application of the most recent biological, nesting beach, and fishery interactions data which are unique to each model are discussed.

Leatherback model

The model appears to be based on the latest knowledge of the biology of leatherback turtles. Limited biological information is actually available for western Pacific leatherback stock. As a result, the author sensibly used biological data from leatherback stocks from the Pacific, Atlantic and Indian Oceans to parameterize the model. Inevitably, this introduces uncertainty into the outputs from the model when attempting to simulate the western Pacific stock. The impact of this is discussed further in Section 3.1.4.

On page 12 of the manuscript, the assumption is made that there are no sex- or substock-specific differences in survival probabilities. However, it is noted in the next paragraph that clutch loss to tidal inundation or beach erosion is low for the Malaysian substock but quite significant for the Melanesian substock of the northern Papuan coast. Egg predation by veranids and pigs is also high in this area, but not for the Malaysian substock. The default assumption of no sub-stock differences in survival probabilities for eggs and hatchlings therefore appears unrealistic. Since the capacity to adjust survival probabilities for stocks is available within the model, the impact of stock-specific survival probabilities at various developmental stages should be examined.

Suarez *et al.* (in press, in NMFS Biological Opinion, 2001) noted that 40-60% of leatherback nests on Jamursba-Medi were lost to inundation and erosion, and that 90% of those nests not taken by poachers or the sea were destroyed by feral pigs (see above). This suggests that egg survival probability in specific locations may be significantly lower than the bounds currently operating in the leatherback model (for example). The effect on model performance of wider survival probability distributions should be examined. A related issue is raised in Section 3.1.3.

Discussion on the form of the probability of leatherback eggs hatching as a nonlinear function of nest temperature in the manuscript would be supported through reference to the form of this relationship for other turtle species. Based on the data available for leatherbacks presented in Figure 9a, there is little information to define the functional form selected. However, the choice of this form is supported by the greater data set available for loggerhead turtles.

In general, different populations in the model are appropriately affected by different area-specific hazards (be they natural or anthropogenic). However, recent evidence suggests that western Pacific turtles may suffer mortality in fisheries operating in Chilean waters (NMFS Biological Opinion, 2001). If correct, this additional interaction and source of mortality should be added to the model.

The y-axis in Figure 8b needs more explanation, since it implies that 'individual leatherback frequency' can be negative.

An explanation of the age class groupings for all age classes should be added to the legend of Figure 11.

Loggerhead model

Loggerhead turtles have a different biology and demography to that of leatherbacks. This is simulated appropriately within the model. A greater volume of biological information is available for loggerhead turtles in the Pacific compared to the leatherback stocks of interest. However, there is still relatively little information available on loggerhead turtle demography in the northwestern Pacific stock. As a result, the author sensibly used data available from stocks in the Atlantic Ocean and other areas of the Pacific Ocean, most notably from Australia (the 'southwestern' stock). It is unknown whether these data accurately reflect the demography of the northwestern stock, and further data collection and analysis is required to better parameterize the model.

It is difficult to reconcile the age classes in Table 2 with the growth patterns and age class divisions detailed in Figure 3 and the prose on page 10. For example, the prose indicates that loggerheads recruit to the benthic phase at around 70-80cm CCL, while in Table 2 benthic juveniles are 95cm+ and 10-14 years old (and are described as having just spent 10-15 years in the pelagic habitat). The comparison between Table 2 and Figure 3 a and b is also confusing. I suggest that a clearer explanation of the process is given. For example, a figure of the potential age distributions of each stage would be useful, to illustrate the degree of overlap.

The incidental capture of pelagics in the western U.S. coast fisheries is viewed as negligible in the model, based on the information available (23 leatherback and 24 loggerhead turtles since 1990, according to the NMFS Biological Opinion, 2001). Since data on loggerhead mortality is limited, it would be prudent to ensure that additional sources of mortality can be easily added on the relevant age class stage in the event that further information changes the current opinion.

3.1.3 Underlying dynamics of the population models

In this section, issues relating to the underlying dynamics of the population models which are specific to each model are discussed first. Issues common to both models are then detailed.

Leatherback model

In the leatherback model report, Figure 16 shows considerable fluctuations in the proportion of age classes/stages for one realization of the model. This appears to result largely from the use of stock proportion to display trends. Low recruitment levels of the year 1 age class result in warmwater juveniles representing a higher proportion of the stock, despite the fact that their numbers may be little different from previous years. To allow easier interpretation of the dynamics, it would be better to show the numbers or biomass of each stage in such graphs. This should provide a clearer indication of the interactions between age groups.

Loggerhead model

Figure 17 presents the relative age class proportions in the stock for one realization of the model. However, if this is a measure of the proportion of total stock, these proportions add up to more than 1. While the sum of the pelagic and benthic substocks in Figure 17a may equal 1, what is the proportion of the year 1 age class relative to? This needs further explanation.

Issues common to both models

A number of issues were identified relating to the underlying dynamics, which are common to both the leatherback and loggerhead models. These are detailed below.

It was interesting to note that demographic stochasticity does not appear sufficient to recover a population from low levels. Density dependence, the existence of which is controversial for turtles (as noted in the model documentation), is relied upon to recover depleted populations. Currently, the model does not incorporate random events which may stimulate stock recovery (e.g. favorable environmental conditions) Conversely, catastrophic events (e.g. random events such as hurricanes which may increase the levels of mortality in many age classes) are also not simulated. The incorporation of these events in the model, through conditional distributions (defining the probability of an event occurring, and if that event occurs, the likely magnitude), and the option to 'switch' events on or off, should be considered.

Variability in the number of nesting individuals has been shown to decrease at low population sizes (Chaloupka, pers. comm.). This may be a useful indicator against which to parameterize and tune the model. For example, superficial examination of model performance suggests that the level of density dependence set in the model may influence the level of fluctuation in simulated nester abundance relative to population size. However, it should be noted that there will be many parameters interacting in this dynamic, which may render the causal relationships unclear. A more thorough test of the model performance should be made before tuning goes ahead.

Empirical derivation of the survival probability values for the majority of age classes is done through tuning of the model (required due to the lack of data to define the values and distributions). The survival probabilities are within very narrow distributions. Since the model is likely to be highly sensitive to these values and distributions, further examination of their forms is appropriate to examine their impacts on model performance (e.g. examine the use of correlated normal distributions, log-odds). Further data collection and experimental analysis to improve these estimates, and hence reduce the requirement for tuning, is important.

Given uncertainty over the value for initial population size used to seed the model, robustness of the model to changes in initial population abundance estimates should be examined. Particularly where density dependence is operating, model performance under changing initial estimates may not be straightforward.

A factorial experimental design was used to examine the influence of particular variables on model outputs. The parameters examined were not sampled over a particularly large range. Multiple equilibria may result if a larger range is examined. This would be an important finding for the model in its current form, and something users should be made aware of, since it could be misconstrued as evidence for phase-shifts. It would also assist in the identification of areas where data collection and analysis should be focused. It is therefore recommended that wider parameter ranges are examined in the factorial experimental design.

3.1.4 Applicability of the population models to the ongoing protected species recovery and fisheries management issues

In this section, all issues on applicability of the population models to ongoing protected species recovery and fisheries management issues were common to both models.

The models of Chaloupka have identified a number of biological parameters which are important to the dynamics of populations. The values and distributions of these parameters are often unknown, due to the paucity of studies which have been performed on study populations. This renders model outputs open to uncertainty. However, as noted in Section 3.1.3, these models are useful tools to identify those parameters and processes own which data collection and analysis should be concentrated.

Studies required to populate many of these important model parameters are likely to take a number of years to produce; answers to management questions will undoubtedly be required in a shorter timescale than this. The models must therefore be used to identify management interventions which will lead to population recovery, and are also robust to uncertainties in the model.

The models already allow simple management analyses to be performed, by setting the level of stock abundance assessment error in harvesting strategy evaluations. Currently the perceived stock level is selected as a random value around the true stock level, as defined by a lognormal probability density function with an adjustable coefficient of variation. However, this is not very realistic. In general, one might expect that if stock size is overestimated in one year, it is more likely to be overestimated in the following year as well. Therefore, it is strongly recommended that the level of error is correlated between years in these simulations.

A more realistic approach would be to perform management strategy simulations. Here, the manager's perception of stock status is determined by the stock assessment methodology (rather than as a random variable around the true stock level). Management action (determined by management control rules) is then applied to the actual stock through a harvest strategy (e.g. reduction in effort if stock shows a decline). Stock status following management intervention is then re-assessed after a particular time period, and the action cycle repeated. Monte Carlo simulations can then assess the likely impacts of management over time. Management strategy simulation has become relatively common in fisheries (e.g. Kell *et al.*, 1999; Punt, 1995; 1997). Incorporation of a management strategy simulation structure within the models would allow the impact of interventions such as the closure of the fishery, (the models are already capable of modeling this action), gear modifications (which might be simulated through a reduction in mortality in fishery or catch rates, for example, although this must realistically relate the level of mortality reduction to the modification made) or conservation efforts leading to a decrease in juvenile mortality, as seen in Mexico (perhaps initiated through a modification of the egg or juvenile survival probabilities) to be assessed. The feasibility of incorporating management strategy simulations should be examined.

Management strategy simulations, and management action in general, require a goal against which the performance of management interventions can be related. However, no goals or targets appear to exist currently for sea turtles. Without such goals, it is difficult to state whether there are deficiencies in the current model structure and outputs. Wetherall *et al.* (2002) provide an excellent discussion of the need to quantify recovery objectives and the reductions in human-caused mortality necessary to achieve it.

The models currently have the facility to measure the performance of interventions through quasi-extinction curves, which provide managers with a measure of the likelihood of adult population abundance falling below a set level of initial abundance within a particular time scale. This is a sensible measure, but is most useful in a situation where the aim is sustainable exploitation. For many of the stocks in question, what is desired is a recovery of population numbers to a sustainable level (whatever that level may be). Recovery targets are very different from those of steady-state management.

Some suggestions for recovery targets are:

- the recovery of the stock to level X over Y years (examined within the model as the probability of the population achieving this);
- a particular increase in survivorship of mature adults (which may be practically identified through tagging);
- an increase in the percentage of first time breeders (although this would be open to variations in the number of experienced nesters returning each year, and would also require a time series of data collection to confirm trends).

Recovery plans will involve reductions in the anthropogenic impacts on stocks. The impact of plans must also be examined from the socio-economic/fleet perspective. This could be examined either within or outside the model (using model outputs).

Management strategy simulations also require the development of performance criteria, so that the relative success of different management approaches can be judged. Examples of management performance criteria include:

- the time taken for the population to achieve the management target;
- the ratio between biomass at the end of a management period (e.g. 20 years) and unexploited levels.

An appropriate set of performance criteria need to be identified so that they can be added to the model, as necessary.

Once a turtle population has recovered, there is a need to identify further, practical, early warning monitoring indicators for management. These need to allow suitable mitigation approaches to be put into effect in good time if a recovered stock shows signs of decline. These indicators are frequently different from those used as recovery goals. Potential indicators may include:

- number of females on nesting beaches (but see discussion below);
- number of juveniles successfully hatching;
- for loggerheads specifically, the number of 'clean' recruits to the benthic phase.

The Chaloupka models appear to be suitable and valuable tools to identify these practical recovery and monitoring indicators for management.

The number of females nesting on beaches has been suggested as a criteria with which to monitor population status (see above). However, since beach nesting numbers fluctuate considerably in healthy populations, its use as an indicator may be reduced. Short term trends provided by most monitoring studies may give incorrect impressions of the population; downward trends in a healthy population which arise merely due to random variation may lead to management action when it is not required. However, the recovery signal may be stronger if the population is recovering from extremely low levels (or is crashing). This should be examined through simulations where management decision rules are based upon the monotonous increase or decrease in the number of individuals breeding (e.g. a decrease over three years leads to management intervention).

As noted, the models are excellent discussion tools. They can form the focus of workshops discussing the use of selected management interventions, using the simulations suggested above (as well as others). It is essential that structured conclusions to workshops be produced. These may include handouts to be taken away by participants. Handouts should present the findings graphically, showing trends of decline or recovery resulting from particular interventions for example (e.g., 95% of runs achieve performance measure if a particular intervention is initiated). An alternative suggestion is the basic traffic light approach (Caddy and Mahon, 1995; Caddy, 1998). Given the development of a battery of suitable indicators, a system of red/green lights for these indicators for a given situation/intervention can be produced. Each indicator can then be weighted for 'desirability' by the workshop participants to identify the most appropriate outcomes.

3.1.5 Specific items

In this section, issues specific to each model are discussed first. Issues common to both models are then detailed.

Leatherbacks

There are a number of mis-spellings and grammatical errors in the manuscript, the majority of which will be picked up by a spell-check or grammar search.

On Page 11, the second paragraph refers to benthic recruitment, which is not a stage of the leatherback lifecycle.

Loggerheads

There are a number of mis-spellings and grammatical errors in the manuscript, the majority of which should be picked up by a spell-check or grammar search.

In the introduction, the common species name referred to in the first line should be leatherback, not loggerhead.

Issues common to both models

These comments focus on the issue of handing over the models to other users. Methods to assist the handover process are suggested.

These complex models offer a potentially bewildering array of parameters for adjustment. Most of these parameters are referred to by acronyms, which give little insight into the processes they control. It is recommended that a list of parameters available within the model is developed, listing the acronyms, full names, what they represent, and suitable ranges for these parameters based on the available data. These lists or tables should be broken down into sections, with related parameters grouped together (e.g. under reproduction, dispersal, fishery related parameters etc). Also, the acronyms presented in graphs in the documentation are not transparent – for ease of model use, these variable names should be spelt out in full.

The problems encountered when running the model (required screen resolution in IBM PCs, for example) should be documented for other users.

There needs to be some simple diagnostics within the model (including the capacity to add statistical fitting routines for a time when sufficient data are available) to identify and highlight unrealistic changes or pathological model behavior. Considerable training will be required for users new to the model, and even simple diagnostics would enable them to identify poor or unrealistic model performance, and examine or discuss the likely causes.

Given that the processes modeled contain considerable uncertainty, the focus on single model runs in the documentation can be highly misleading. I would suggest focusing on runs with uncertainty displayed in the outputs, to avoid the impression that users can rely on single runs to identify trends. In turn, it would be useful to be able to set the level of uncertainty to be displayed around the output trends (e.g. be able to set probability levels for each output).

3.2 Wetherall Mexican leatherback model (TURTSIM)

The TURTSIM model allows discrete-time simulation of marine turtle population dynamics and human-caused mortality on nesting beaches and oceanic habitat. The model assumes populations are structured by carapace length, sex, and state of maturity, and incorporates biological details pertaining to egg and hatchling production, somatic growth, natural and human-caused mortality, maturation and remigration. Density-dependence is incorporated into growth, remigration and hatchling production functions.

3.2.1 Assumptions in defining the stock structures based on genetic or other information

In its current form, the model concentrates on the Mexican leatherback population, as a population which is independent of other stocks. Based on the available genetic information, this appears appropriate. However, if this model were to be used to examine the impact of mitigation measures in the Hawaii longline fishery, other stocks would need to be included (e.g. those from Malaysia and from Melanesia). This is discussed further in Section 3.2.4.

3.2.2 Application of the most recent biological, nesting beach, and fishery interactions data

Growth parameters for the leatherback population are based on 15 individuals aged from a dump in Peru. This represents a limited data set on which to base estimates of von Bertalanffy growth parameters, although the data do appear to produce a reasonable von Bertalanffy growth curve. It would be interesting to see how estimates of growth for this stock compare with those for other leatherback stocks.

The estimation of variability in growth ignores length-at-age data from the diseased individuals, since these individuals show low growth rates compared to those sampled from Peru. However, these diseased individuals may represent a natural extreme in the level of individual growth variability. Since information suggests that these diseased individuals could still reproduce, their length-at-age data should be included in estimates of individual variability.

Growth in the model is density dependent. This is modeled through changes to the von Bertalanffy growth parameter K. However, the majority of density dependent growth models (e.g. Beverton and Holt, 1957; Lorenzen, 1996) have related changes in population density to changes in the von Bertalanffy growth parameter L_∞ (or the related asymptotic weight W_∞), rather than to changes in K. The von Bertalanffy growth function describes growth as the net result of anabolism (the build up of body materials, related to L_∞) and catabolism (the breakdown of existing body materials, related to K). Catabolism (K) is presumed to be affected by the amount of body material to be broken down (weight of the organism, level of metabolic activity) and therefore independent of population density. Anabolism (L_∞) is dependent on the food resources available to individual fish, and therefore population density. While density dependent growth has been modeled in K in the past, the author should be aware of the current convention.

The model does not have implicit relationships between the action of density dependent growth and natural mortality (the ratio between M and K has a significant influence on the theoretical maximum yield and optimum effort levels in calculations of the yield-per-recruit type) or density dependent growth and fecundity. At present density dependence acts on these characteristics via its effect on growth. This may lead to unexpected model behavior. These interactions should be investigated, and the development of relationships between these parameters considered.

Since little data exists on density dependence, assumptions on the form of its relationship with parameters are arbitrary. Quite frequently, however, a sigmoid form is selected, which may be more biologically realistic than those presented in Figure 8 of the manuscript. In this form, levels close to the maximum density have little effect on a parameter, while further decreases in density have an increasing effect. This effect decreases to a biological asymptote at very low densities. It would be interesting to examine the effect of this form of density dependent relationship on model outputs.

On page 10, the assumption of 85% survival for adults does not appear to match with the calculation of 30% for M in section 4.4 of the manuscript. This needs explanation.

On page 19, the calculation that 1/8th of Hawaii longline mortalities were from Mexico needs explanation; ¼ of mortalities are from the eastern Pacific, and there is a 50:50 split assumed between Mexico and Costa Rica populations, hence the value of 1/8th.

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3.2.3 Underlying dynamics of the population models

Initially, survivorship levels in the model are tuned based on the adult natural survivorship levels, to achieve equilibrium. This has led to a 10-fold increase in the survivorship levels for the youngest age group where there is low adult survival, compared to the situation where adult survival is high (Table 1 of the manuscript). This is unlikely to be biologically realistic, and may explain the surprising and somewhat contradictory differences in recovery times between low and high survivorship simulation runs (page 23 of manuscript) where higher rates of recovery were predicted under assumptions of low natural survivorship and nonlinear density dependence. A situation where low survivorship achieves recovery goals more quickly represents a problem for conservation. If correct, mitigation measures increasing the survivorship of populations would slow the rate at which the population recovered, an effect which may also be found where density dependent growth is operating (increasing population size decreasing growth rates, and therefore biomass recovery). To confirm whether this is a result of model tuning, it would be appropriate to attempt tuning the model with survivorship in each developmental group constrained within likely bounds.

3.2.4 Applicability of the population models to the ongoing protected species recovery and fisheries management issues

In the documentation, the model of Wetherall *et al.* is used to examine the influence of various anthropogenic influences on the Mexican leatherback population specifically. Following examination of the points detailed in previous sections, this model appears suitable for this purpose.

However, extensive work would be required to modify the model to realistically focus on the impacts of the Hawaiian longline fishery on Pacific leatherback populations. As shown by the model of Chaloupka, there are a number of meta-populations which interact with that fishery, with varying biological and anthropogenic characteristics. The dynamics of these would need to be incorporated into the model of Wetherall, if a focus on the Hawaii fishery were the ultimate goal.

While management studies can be performed, as are examined in the manuscript, the model contains no stochasticity, besides the influence of density dependence on growth and related factors. This limits simulations to less realistic deterministic studies.

One of the advantages of the approach taken in this model is that it is less data intense. This lower complexity offers a useful opportunity to compare outputs with the more complex leatherback model of Chaloupka. This is discussed in Section 4.

4. CONCLUSIONS AND RECOMMENDATIONS

The models of Chaloupka are specifically designed for Pacific-wide turtle population analysis, and appear to require the least additional effort before they can provide the best information on which to proceed with protected species recovery and fisheries management analysis of relevance to the Hawaiian longline fishery and other U.S. interests. Wetherall's leatherback model concentrates on the Mexican leatherback population, and is likely to require considerable modification to incorporate the interactions of the other turtle meta-populations and anthropogenic impacts necessary to examine the wide range of issues of relevance to NMFS.

The models of Chaloupka for leatherback and loggerhead turtle populations are perhaps biologically more realistic than that of Wetherall, and are certainly more complex. The values and functional forms of many of the parameters in the models of Chaloupka are unknown, due to the paucity of suitable studies on the relevant turtle populations. This increases the uncertainty in model outputs. Sensitivity analyses of the impact of the values and functional forms of these parameters on model outputs, assessments and perception of the population (recovery) need to be extended to identify those biological parameters which are important to the dynamics of populations. This will focus data collection on parameters which will best support the derivation of management. Wetherall's model is less data intensive, offers useful insights into the performance of the models of Chaloupka under uncertainty, and could be used to test the robustness of those models.

Scientific studies to populate the parameters will take a number of years to compete, and it can be foreseen that management options will need to be developed in a shorter time frame. Chaloupka's models must therefore be used to derive management interventions which are robust to model uncertainties.

In their current form, Chaloupka's models will be useful for the identification of the likely causal factors of population decline, and provide the best information on which to proceed with protected species recovery and fisheries management in the Pacific. With the development of management strategy simulation frameworks, for example, the models will be suitable for the examination of robust management interventions which halt declines in the short term, and in the longer term result in stock recovery. They should also be used to inform the derivation of management targets for recovering turtle populations, and to develop practical early warning monitoring indicators for vulnerable sea turtle populations. The models should form the basis of discussion workshops to examine potential management interventions.

A number of recommendations have been made throughout the text of this report. The main recommendations were:

Chaloupka models:

- add the east Pacific (Mexico) metapopulation to the leatherback model;
- consider whether the Australian metapopulation should be added to the loggerhead model;
- examine the impact of stock-specific survival probabilities at various developmental stages in both models;
- support the choice of nest temperature relationship for leatherbacks with information from other turtle species;
- add potential mortality arising from mid/south American fisheries to the western Pacific leatherback metapopulation;
- add the capability to simulate random favorable and catastrophic events to the models;
- examine alternative distributions (form and value) for age class specific survival in both models;

- examine the robustness of models to changes in the initial population abundance estimates;
- examine wider ranges for the parameters tested in the factorial experimental design;
- correlate the level of stock abundance error in the harvesting strategy evaluations;
- examine the feasibility of expanding models to incorporate more realistic management strategy simulations;
- use the models to identify suitable recovery and monitoring criteria for turtle populations (which may not be the same);
- use the models as discussion tools within workshops to develop management strategies based on such criteria.

Issues and recommendations relating to the handover of the models were also discussed (Section 3.1.5), including the inclusion of simple diagnostics within the models to assist new operators in model use and interpretation.

Wetherall model:

- consider whether the model should be expanded to include other leatherback stocks in the Pacific of relevance to the Hawaii longline fishery, or whether the model should concentrate on analysis of the Mexican stock only;
- the length-at-age data from diseased individuals should be included in the estimates of individual variability;
- consider whether density dependence should be changed to act on the von Bertalanffy growth parameter L_∞ rather than K;
- examine and consider implicit relationships between the action of density dependent growth and both natural mortality and fecundity;
- consider different forms of density dependence in the model;
- tune survivorship of each developmental group to eliminate the compensatory shifts in that of the youngest age group when adult survival is modified;
- examine the addition of further stochasticity to the model to render it more realistic.

At present, the models of Chaloupka represent the best available information on which to proceed with protected species recovery and fisheries management in the Pacific. Consideration of the recommendations in this report will improve the models, and ensure that model outputs will provide suitable information of a quality sufficient for basing development of management strategies.

5. OTHER ISSUES OF POTENTIAL INTEREST TO NMFS

Comments in this section do not fall under the information required by the terms of reference. They are raised as they may be of interest to NMFS staff.

CEFAS have been collaborating with NMFS Southeast Fisheries Science Center (Miami) to develop specific models and methodologies to improve the estimates of bycatch (in particular of dead bluefin tuna discards) in the U.S. pelagic longline fishery in the Atlantic, and the calculation of uncertainty about these estimates. The methods may prove effective in improving estimates of turtle bycatch from the Hawaii longline fishery, and may identify related factors (e.g. areas, time periods, fishing methodologies or characteristics) that could suggest potential mitigation measures.

The issue of seabird bycatch in longline fisheries was noted as an important factor in the EIS. The problem of seabird (in particular albatross) incidental mortality in longline fisheries has been noted in the fisheries operating under the auspices of CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources; www.ccamlr.org), of which the USA is a member. A number of mitigation measures have been developed, some of which may be adaptable for fisheries in the Pacific.

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APPENDICES

A.1 Report Generation and Procedural Items
A.2 Review and Background Documents
A.3 Center for Independent Experts Statement of Work

A.1 Report Generation and Procedural Items

1. The report should be prefaced with an executive summary of findings and/or recommendations.
2. The main body of the report should consist of a background, description of review activities, summary of findings, conclusions/recommendations, and references.
3. The report should also include as separate appendices the bibliography of all materials provided and a copy of the statement of work.

A.2 Review and Background Documents

Chaloupka, M. (2002). Development of a stochastic metapopulation model for the western Pacific leatherback sea turtle stock. Report prepared for the US National Marine Fisheries Service, Southwest Fisheries Science Center, Honolulu Laboratory, Honolulu, Hawaii. 109p.

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A.3 Center for Independent Experts Statement of Work

Consulting Agreement Between The University of Miami and Dr. Graham Pilling

May 29, 2002

General

Simulation models have been developed to provide a quantitative foundation for assessing impacts of the Hawaii-based pelagic longline fishery and other human activities on sea turtle populations. Two independent studies have just been completed. One study involved the development and application of a stochastic simulation model of Pacific leatherback sea turtles, with emphasis on western Pacific populations of this species, and a second simulation model of Pacific loggerheads. These models were developed under contract by a sea turtle modeling specialist assisted by interactive workshops of invited experts. The other study involved the development and application of a simulation model of the Mexican leatherback population in the Pacific by a NMFS modeler in collaboration with two Mexican leatherback experts, using a different modeling approach. These analyses, which evaluate the dynamics of sea turtle populations and their sensitivity to longline fishing and other human-caused mortality factors, need to be reviewed independently. The reviews should examine the assessment methods, models, and findings.

These reports are expected to play an important role in the development of mitigation and recovery efforts by the NMFS Southwest Region through fishery management regulations and other measures, likely in the context of an ESA biological opinion on the Hawaii longline fishery. As a result, the review should consider not only the basic population science underlying these models, but also the applicability of the models to evaluation of mitigating effects and the analyses' use of the best available information on both population modeling and sea turtle biology.

The reviewer shall analyze the reports for loggerhead and leatherback sea turtles, focusing on the following:

1. Assumptions in defining the stock structures based on genetic or other information;
2. Application of the most recent biological, nesting beach, and fishery interactions data;
3. Underlying dynamics of the population models;
4. Applicability of the population models to the ongoing protected species recovery and fisheries management issues.

Specific

The reviewers duties shall not exceed two weeks – several days to review the reports (two of which are parallel in structure and simulation methodology); participation in a two-day workshop in Honolulu, Hawaii, on May 2-3, 2002, which will focus on the use of the first (stochastic simulator's) approach for developing a model of the Hawaiian green sea turtle population; and several days to produce a written report of the findings. Finally, no consensus, pre-final review, or rejoinder comments are required.

The itemized tasks of the review include:

1. Analyzing the following documents provided to the consultant by the NMFS Honolulu Laboratory:

a. Leatherback turtle stock assessment simulation report by Dr. Milani Chaloupka, including narrative description, workbooks, and model code;
b. Loggerhead turtle stock assessment simulation report by Dr. Milani Chaloupka, including narrative description, workbooks, and model code;
c. Mexican leatherback simulation model report by Dr. Jerry Wetherall, Laura Sarti, and Dr. Peter Dutton.

2. Reading (no commentary required) the following background documentation provided to the reviewer by the NMFS Honolulu Laboratory:

a. 2001 Biological Opinion on the western Pacific pelagic fishery;
b. 2001 final Environmental Impact Statement (EIS) on the western Pacific pelagic fishery; and,
c. Materials for the green sea turtle workshop provided by the consultant.

3. No later than May 20, 2002 submitting a written report of findings, analyses, and conclusions concerning the three sea turtle stock assessment simulation reports. This report must address the utility of the population simulation models and methodology to answer questions concerning the status of Pacific leatherback and loggerhead sea turtle populations and the assessment, mitigation and reduction of human-caused mortality. The report must include the following elements:

a. Executive summary of findings and recommendations.
b. Main body consisting of background; description of review activities; findings and conclusions; and recommendations. The conclusion must contain a statement as to whether the analyses represent the best available information on which to proceed with protected species recovery and fisheries management, and whether the information quality is sufficient for basing development of management strategies.

The report should include as separate appendices the bibliography of all materials referenced in the review, including those documents provided by the Center for Independent Experts and the Southwest Fisheries Science Center; and a copy of the statement of work.

Full photocopies (or PDF files) and citations of all papers, reports or other written materials cited by the review should be provided separately.

The final report[1] should be addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Die, via email to ddie@rsmas.miami.edu.

Reviewer name: ______________________

Signature: ______________________ Date: ______________

[1] The written report will undergo an internal CIE review before it is considered final. After completion, the CIE will create a PDF version of the written report that will be submitted to NMFS and the consultant.

APPENDIX S

B. Taylor, *Review of the Stochastic simulation models for sea turtle dynamics Developed by Milani Chaloupka*

7/29/02

Review of the Stochastic simulation models for sea turtle dynamics Developed by Milani Chaloupka

by Barbara L. Taylor
Protected Resource Division
Southwest Fisheries Science Center, La Jolla laboratory

Several models of sea turtle population dynamics were developed for the Southwest Fisheries Science Center, Honolulu laboratory. Evaluating these models depends on what questions the models are intended to address. Increasing our biological understanding of turtle population dynamics (heuristic models) and making management decisions (management models), such as whether fishery impacts are significant, are completely different objectives and in all likelihood would require fundamentally different models. It is not clear from reading the documentation of the models (both the User's Guide and the Reports from workshops) what the objective of these models are. For example, the abstract of "Development of a stochastic metapopulation model for the western Pacific leatherback sea turtle stock: background material and documentation" states:

> *"The model was designed to support robust evaluation of the effects of competing mortality risks on substock abundance and also on substock-specific sex and ageclass structure. Hence the model can be used for simulation experiments to design policies to support the long-term conservation of the western Pacific leatherback sea turtle stock."*

Yet, the introduction states:

> *"The model is demographic-process based and heuristic and is designed to help improve our understanding of leatherback sea turtle population dynamics."*

I will, therefore, begin by discussing these two different classes of models (heuristic and management) and then discuss the Chaloupka model in context of the management problems facing turtles.

Heuristic models

The objective of a heuristic model is to learn about the dynamics of the model subject: in this case to learn about the population dynamics of sea turtles. Heuristic models are valuable exploratory tools that are particularly useful when there are many gaps in what is known about a species. Usually, funding constraints force knowledge to be gained incrementally and these exploratory models can guide decisions on prioritizing which gaps to fill. Given that our understanding of marine turtles remains poor, particularly for Pacific leatherback turtles, development of heuristic models is appropriate.

One common approach is to examine the sensitivity of population dynamics to different aspects of life history. Such sensitivity analyses accomplish two important tasks: 1) finding the life history aspect (such as adult survival rates) that have the greatest impact on the rate of population increase, and 2) seeing how much improvement in our understanding of the status of a population can be expected from a research activity aimed at improving the estimation of a particular parameter (such as how egg survival changes with temperature). The first task *can be*

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accomplished through analytical equations or very simple models and much work has already been accomplished in this area to establish several general principles. For example, rate of increase is most sensitive to the ages when individuals have the highest chance of contributing to the next generation (also called reproductive value). Thus, for long-lived species, which by definition have high adult survival rates, it is common that the survival of individuals just becoming mature together with the adults is very important to the population's ability to grow.[1]

Another important role of sensitivity models involves choosing which research will result in the greatest reduction of decision uncertainty. Although this is not unrelated to the demographic sensitivity analysis described above, it also takes into account our level of uncertainty about different factors and also the cost to reduce that uncertainty.

In both cases the model is judged on the same basic features. First, does the model utilize the available data correctly? For example, if the population or a component of the population experiences wide fluctuations, does the model adequately mimic those dynamics. The second feature of a good heuristic model is that it is technically sound. Many models involve hundreds or thousands of lines of code, and making sure the code is sound is technically difficult. Often model code or structural flaws can be spotted through using examples where the resulting dynamics are known. For example, a harvest of eggs starting in year zero should first appear as a reduction of adults at approximately year zero plus the age of sexual maturity. The third is that the model includes all the salient features of the biology relevant to the questions the model is attempting to address. For example, if there is more than one discrete population that occupies different areas in both feeding and breeding seasons, is that spatial structure accounted for in the model? Finally, the model should be sufficiently user friendly that the biologists that know the animals best can use the model to help them think about future research.

Management models

Management models differ fundamentally because they are designed to facilitate management decisions despite uncertainty about both the biology of the target species and the human-caused risk factors. Thus, the primary measure of model performance is the quality of the management decisions. Although there is some overlap with heuristic models because both can be used to prioritize future research, they strongly differ in the treatment of uncertainty and in the evaluation of model performance. Management models tend to be created to address very specific

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[1]Although the factorial design used in the Chaloupka model's may be a technical improvement over single factor sensitivity analyses, they suffer in transparency to the user. Both the Guide and the Report need a longer description of what has been done but more importantly need to step the biologists and managers through some examples so that they can better understand the sensitivity measures. As it stands, I would guess that most users would remain unenlightened as to how to prioritize future research. The other very influential factor that is neglected in this sensitivity analysis factorial design approach is spatial structure. It seems taken for granted that spatial structure is known and that demographic parameters are the only unknowns.

questions. For example, what fisheries management options will ensure that an endangered species will not be placed at further jeopardy of extinction? The possible actions may include: 1) no action, 2) complete closure, 3) season/area closures, 4) gear modifications, 5) closure when kills exceed a quota, etc. The outcome should always fully incorporate our ignorance about the target species and risks such that the resulting decision errors (either over- or under-protecting the target species) are as precise as possible. When our ignorance is great, for example not knowing what population is being affected by the fishery, then the errors will be large. Decisions can then be made with full realization of the level of precaution being exercised.

The Chaloupka models

The Chaloupka models in their essence are heuristic models. The conclusion of the leatherback report states:

> *"The model was designed to support evaluation of the potential effects of habitat-specific competing mortality risks on stock abundance and sex-ageclass structure. Given the demographic data limitations, the model appears able to capture the essential processes of western Pacific leatherback demography. This is especially so from a heuristic stand-point–a tool to integrate existing knowledge and to support a learning-based approach to understanding leatherback demography given exposure to competing mortality risks."*

The conclusion also notes that the model involves approximately 100 differential equations. There are 150 parameters in the model. Although the documentation in the report notes that there are demographic data limitations, the extent of the limitations are not highlighted in a way that makes clear to the manager the enormous extent of our ignorance about this species in the Pacific. The user can easily alter most of the parameters and can even alter as many parameters as desired simultaneously, but the user cannot incorporate parameter uncertainty in any of the parameters except total stock abundance. Even for stock abundance, the coefficient of variation is limited to 1.0, which still probably underestimates the precision with which we can estimate the total abundance of turtles in the western Pacific historically (or even now!). To make the problem of not being able to incorporate uncertainty into simulations more concrete, let me state what some of the major uncertainties are about leatherback turtles in the Pacific, specifically with reference to the long-line fishery interaction, and then discuss different ways that models could treat this uncertainty.

Since there are so few direct data on western Pacific leatherback turtles, these data should be presented in some detail. Maps are an excellent tool to communicate the level of data available, particularly when management questions center on a particular area. There is only one map shown in the leatherback report and it is for the entire Pacific. From the genetic data from animals sampled in the long-line fishery (n = 14) it is clear that most, if not all, of the animals are from the western Pacific. The map shows three nesting sites in the western Pacific although four are mentioned with nesting seasons in Table 1. What isn't mentioned is what is known about other areas, i.e. are these the only extant beaches or are there large areas about which little to nothing is known? It would be useful to convey our extent of knowledge by indicating with shading the areas that have good data and those for which there are no surveys on a more detailed map of the nesting area (Malaysia to the Solomon Islands). The legend to this map could also indicate basic information on the quality of the studies such as number of genetic samples, duration studies, and the proportion of the beach or nesting season covered. Also, known locations of the different age and sex categories at sea should be indicated. I believe this would be a few satellite tracks (probably not available when this workshop was conducted) and a handful of dots on the map. This clearly indicates to the manager that virtually nothing is known about these animals except at the few nesting beaches that have been studied.

If NMFS intends to use this model for decisions about the effect of the long-line fishery then there should be a section that details all that is known about that fishery, which would include the season and locations of turtle catches together with any genetic data. Although data are sparse with only 14 samples, they are extremely influential in assessing the risk posed by the fishery. For example, there is only one sample that could plausibly have come from the eastern Pacific. There are only two samples that could have come from Malaysia (although the Malaysian sample size is small, n = 9) but there are 9 samples that are common in Jamursba-Medi, Papua, which may have a population of around 1000 nesters in the mid 1990s when it was last surveyed and has certainly not experienced the population collapse as has Malaysia. From these data, it is extremely likely that the pelagic distribution of adults from the western Pacific is not random, which is an assumption made in the model. Thus, **the structure of the model is clearly incorrect for assessing the impact of the long-line fishery because of incorrect assumptions about the pelagic spatial distribution of turtles.**

Further, the use of the terms "stock" and "sub-stock" is confusing to the reader. The difference in genetic composition between Malaysia and Jamursba-Medi is extremely different (they share no haplotypes) even though they are geographically relatively close and share the same peak nesting season. Thus, for conservation purposes, they are as separate as the eastern "stocks" are from the western "stocks". In the Chaloupka model, they are lumped into the same "sub-stock" which is clearly inappropriate. Interestingly, the turtles from Papua New Guinea, which have a peak nesting season 6 months different from Malaysia and Jamursba-Medi, showed satellite tracks heading into the southern Hemisphere. These offset nesting seasons for beaches nearly on the equator may mean that turtles from these beaches utilize very different pelagic habitats probably in opposite Hemispheres. From these early genetic and tracking data, the most likely scenario for the long-line fishery turtles is that they originate from some beach(es) in the western Pacific excluding Papua New Guinea and probably Malaysia. Thus, although the origin remains uncertain, it is clear that pelagic distributions are not now a random selection from even the western-most area of the western Pacific and that there are some beaches from the western Pacific that likely have Southern Hemisphere pelagic distributions even though they match the long-line fishery samples genetically. It is also clear that because the nesting beaches for the turtles affected by the long-line fishery are unknown, we have a very high degree of uncertainty as to the abundance of the affected population or the risks posed to that nesting population on the nesting ground. That is, we have no certain knowledge of harvests of eggs, nesting adults, beach temperature, beach condition (erosion or increased temperature due to forest clearing).

It is important for managers and turtle biologists to be able to easily identify for which parameters there are direct data, for which parameters there are data from the same species but in another location, for which parameters there are data from other sea turtles (and the caveats to using such data) and for which parameters there are absolutely no data whatsoever. The list of parameters for which there are direct data would be very short. There are data for some nesting beaches for a variable number of years on the number of nesting females, the number of clutches laid for those females, the number of eggs per clutch and how temperature affects hatching success and sex ratio, and age at first reproduction. There are genetic data for a few of the beaches, the feeding area off central California and from the long-line fishery. There are a few (but highly important) satellite tracks. The list of parameters for which there are data from other leatherback populations would also be short but would, importantly, include adult survival and could also include maximum observed rate of increase. Again, there are so few data that there should be much more detail presented on the quality of the data. At a bare minimum, each parameter should be presented with sample sizes and estimates of precision. It is not sufficient to simply note that there is small sample size (as was done in several cases). There is a great difference, for example, between a curve for the proportion reproductively mature by age that is based on 20 samples distributed evenly across the ages when maturation occurs versus 20 samples that all came from one end of the range of maturing ages. Whenever possible, figures of the raw data (not the fitted curve) should be provided. Looking at abstracts from a special issue on Leatherbacks available on the web, it appears that there is still a great deal of uncertainty about the average age of sexual maturity (ranging between 5 and 15 years) and that this parameter has a strong influence on population dynamics.

Several other parameters used data from other turtle species. There should be discussion of whether this is appropriate. Leatherback turtles have followed a different evolutionary path than the hardshell sea turtles and occupy a unique ecological niche. Leatherbacks occupy the coldest waters, dive deeply and eat jelly fish, which may have patchy distributions and may vary differently in time than do the prey of other sea turtles. Using data on density dependence from green turtles, which primarily feed on sea grasses and are much more fixed in space, is questionable. Even loggerheads, which feed on crustaceans, may have much more site fidelity to their feeding grounds than the leatherback, which is truly pelagic and probably more influenced by currents and oceanographic features. Site fidelity and the amount of patchiness and variability in food resources will clearly affect the functional form for density dependence. What we do know about leatherback turtles regarding density dependence is that there are two cases (St. Lucia in South Africa and St. Croix) where beaches have been effectively protected and the populations have demonstrated that they can and do grow.

Treatment of uncertainty for management decisions concerning the long-line fishery impact
A good management model should have the following properties: 1) uses all available data including uncertainty, 2) allows timely management decisions despite inevitable uncertainties, 3) decisions are based on transparent criteria, 4) analysis is repeatable, and 5) the results provide managers and constituents with the probability of making decision errors (over-protecting turtles by over-restricting fisheries or under-protecting turtles by under-regulating fisheries). Such models could have features that allowed managers to see the benefit of research investments. For

example, if the distribution of potential growth rates minus the distribution for fishery kill rates led to a realized growth rate could be either increasing or decreasing, a useful management model would allow scientists and managers to estimate how much precision in the kill rate would need to be increased to definitively answer whether the fishery kill alone was unsustainable. Another use would be to see whether the decision error rates can be substantially reduced by research investments in the areas where data can be readily gained.

However, there is a minimum amount of data that is required before it is worthwhile doing any model. For example, it is not possible to estimate a kill rate without knowing the stock origins of the turtles being killed. Although recent research is helping to narrow the range of possible nesting beaches that are the stock origin for the long-line fishery, it will probably take several more years to obtain this critical primary data. Once the beach or beaches of origin are known, additional data will need to be gathered on the competing risks and the general trend of the stock(s). Given that it is likely that these stocks nest in remote areas it may take several more years to obtain these data.

Another important factor for the agency to act on is whether these nesting beaches are Distinct Population Segments. The first step in creating an appropriate management model once the critical data are available is knowing what populations to include in the model. If the affected stocks prove to differ significantly genetically (both mitochondrial and nuclear DNA) then examination of listing the affected stocks as either Distinct Population Segments or Recovery Units is warranted. It is unlikely to be appropriate to use the severe decline in Malaysia that may be resulting from degradation of nesting habitat as a reason that the long-line fishery is not significantly increasing jeopardy because these are almost certainly different DPSs under the ESA.

Utility of the Chaloupka models and recommendations

Although the Chaloupka models are inappropriate (at least for leatherback turtles) to use in making management decisions about effects of the long-line fishery they can still be used for heuristic purposes by turtle scientists with some alterations. The structure of the model needs to be adjusted to allow for partitioning of the pelagic habitat by different nesting beaches. One easy way to deal with this problem is simply to run the model only for one nesting beach at a time, which is probably appropriate because they have trivial levels of dispersal between nesting beaches and may have little overlap at sea where harvests occur. If there is substantial overlap of "stocks" where they could be subjected to the same mortality source (say around the Kai Islands) then this simple solution won't work.

It makes no sense to me to assume that a depleted population would have a population growth rate of zero, i.e. that a depleted population would not have a positive population growth rate if the mortality risks that caused the depletion are removed. As I understand the calculation of survival rates, the survival rates between the first year and the age of sexual maturity are solved to yield a growth rate of zero. Density dependence is only accounted for in reproductive parameters. Even if density dependence does occur primarily through reproductive parameters, the survival rates in this model are essentially frozen in time unless the user selects human-caused mortality factors. Thus, is seems quite important that the base-line levels for survival rates be selected correctly as that severely constrains the maximum growth rates. There are several causes for concern in the way survival rates are calculated. First, survival rates for adults (from other populations) are likely to contain some unknown amount of human-cause mortality. Thus, these rates can only be considered minimum natural survival rates. Second, I am very skeptical about the estimate of survival within the first year, especially after the hatchlings leave the beach. This phase seems like an obvious point where Alee effects could occur. The natural history of sea turtles clearly takes advantage of predator satiation by having hatchlings emerge en masse during a particular moon phase or at least most emerge at the same time of the night. Predators (both above and below the water) become gorged allowing many hatchlings to escape into safer habitats. As nests become rare it can be expected that hatchling survival could dramatically decrease. Thus, it becomes particularly important to obtain direct data.

APPENDIX T

S. Heppell, *Review of Chaloupka model*

1. Executive Summary

This report is a review of the stochastic simulation model of Western Pacific leatherback sea turtle metapopulation dynamics developed by Dr. Milani Chaloupka for the U.S. National Marine Fisheries Services, Honolulu Laboratory, Honolulu, Hawaii. The files examined were the Berkeley Madonna (Copyright 1997-2001, Robert I. Macey and George F. Oster) file, *leatherback(User).mmd*, and the associated user manual, *Stochastic simulation model of Western Pacific leatherback sea turtle metapopulation dynamics: User's Guide (January 2002)*. Berkeley Madonna version 8.0.1 was used to run the simulation model.

The report examines the Chaloupka simulation model within the context of modeling in general. Parameter uncertainty, suggested protocol to assess the impacts of fisheries, and sensitivity analysis of model parameters on critical endpoints are discussed. The report concludes with a summary and statement of research recommendations

The Chaloupka simulation model has the potential to serve as a key component in a suite of analytical tools to assess the viability of sea turtle populations. We recommend that such research address the following tasks:

- Perform external validation to search for points that validate and define the boundaries and validity of the Chaloupka model.
- Identify sentinel variables (observable indicators of trends that are sensitive to parameter settings) to determine when the model can be applied and produce results consistent with real-world conditions.
- Perform prediction risk to determine consequences of incorrect model results.
- Construct a meta-model of model accuracy (below).

The complexity of the Chaloupka simulation model justifies making the tool itself and the results it produces objects of study. Sensitivity analyses will inform analysts and decision makers about inherent variability in model results. In particular, a "meta-model" that focuses on parameter values deemed speculative by expert analysts is warranted to gauge confidence in specific instantiations of the model. By varying all of those speculative parameters simultaneously, this meta-model would serve as a complement to the simulation model to alert analysts to possible interactions among certain parameter values that might potentially produce non-additive effects. These synergistic effects are potentially dangerous because they can precipitate rapid model population declines.

While this model provides a good framework for heuristic evaluation of "what if" scenarios, we strongly recommend that the research tasks listed above be completed before the model is used to make quantitative predictions for management. This is particularly true for leatherbacks, which are a poorly understood species, at best. It is critical to understand how the model results are affected by parameter uncertainty and assumptions that are incorporated into the structure of the model (which are not necessarily obvious to users), and to anticipate the potential for conflicting, yet equally valid, results that may be generated by various stakeholders.

2. About This Report

This short report represents the opinions of Dr. Selina Heppell, a fisheries ecologist at Oregon State University and author of several papers on sea turtle demographic models, and Dr. Jane Jorgensen, a private consultant with expertise in ecological models and Bayesian belief networks. We were unable to do more than a precursory review of the model and its potential as a management tool due to the short time frame allotted for review (1 month). Our goal was to determine the general structure of the leatherback model and to offer suggestions for how the model should be used by NMFS. We did not review the other simulation models (green and loggerhead turtles); although the general structure of those models is quite similar, far more empirical data exists on those species. Nevertheless, our concerns about the complexity of the simulation, given the available data and the precision of those data, apply to all of the models.

3. Overview: How Models are Created, Parameterized, Analyzed, and Applied to Management Problems

The Chaloupka simulation model is a powerful tool for detecting and projecting trends in sea turtle populations. Careful use of this model can help us heuristically evaluate the relative merits of alternative management programs under a range of plausible biological scenarios. It creates a common forum for discussion by creating a framework within which to relate multiple observations and hypotheses.

However, as with any fine tool, the quality of the resulting product will depend in large part on the quality of the raw materials (input data) and the skill of the user. Levins (1966) described models as tradeoffs among generality, realism and precision. He listed three model-building strategies:

1. Sacrifice generality for realism and precision. Models produced using this strategy yield precise predictions for tightly constrained situations. This approach has been adopted by natural resource managers to formulate precise, testable predictions based on the short-term behavior of organisms.
2. Sacrifice realism for generality and precision. This approach yields very general models that generate very precise predictions. However, the equations may be unrealistic given the conditions in the natural world. Small departures from initial assumptions often have large effects upon predicted outcome.
3. Sacrifice precision for generality and realism. This approach produces models that focus on change in terms of relative change among variables in complex dynamic systems. The results of the models are very generalizable in terms of the qualitative nature of behaviors, but do not contain numerical precision.

The Chaloupka simulation is realistic because it has a sound scientific basis, and precise because it can produce more or less exact results based on parameter estimates. Generalizability in the simulation is provided by the user-driven input of model parameter values using slider bars. However, as Levins noted, no modeling strategy can fully exploit all three strategies simultaneously. The Chaloupka simulation model most closely adheres to Levins's second strategy, maximization of realism and precision.

There are at least 151 user-defined parameters in the model, including survival rates, harvest levels, periods of time in which harvest occurs, density-dependent effects, nesting beach temperatures, and the level of stochastic environmental variability. This level of biological realism has not been available in other published sea turtle models (e.g., Crouse et al. 1987, Heppell et al. 1996), and is appealing to biologists (S. Eckert, *personal communication*). Input parameters can be entered into the simulation using a slider-bar interface. These input values may be driven by observational data or by expert opinion mediating these data. Because of the migratory habits of the sea turtles, the difficulties associated with observing them in their natural state, and the surreptitious manner of many anthropogenic hazards (e.g., poaching of adults and eggs), the observational data are inadequate for the leatherback. There are many facts about sea turtles that remain unknown, such as dwell-time in fishing areas, response of individuals and vital rates (growth, survival and reproduction) to population density, and quantified data on human-induced and natural mortality. Even age at maturity is somewhat speculative in leatherbacks.

While uncertainty within the model may be controlled and explored, the data from which parameter estimates are drawn may contain substantial uncertainty. Schmitt and Klein (1996) identified four sources of uncertainty, all of which are present in the data regarding sea turtles:

1. Missing information. Information is unavailable. It has not been received or has been received but cannot be located when needed; for example, information about dwell-times in fishing areas.
2. Unreliable information. The credibility of the source is low, or is perceived to be low even if the information is highly accurate; for example, by-catch by non-US longline fisheries and nesting beach data from several Pacific locales.
3. Ambiguous or conflicting information. It is difficult to integrate the different facets of the data; for example, radio-transmitter data for migratory patterns of individuals and migratory routes by genetic stocks.
4. Complex information. It is difficult to integrate different facets of data; for example, the estimated abundance of nesting females may be dependent upon a host of associated factors, including sampling error.

Sea turtles, particularly leatherbacks, suffer from all four of these sources of uncertainty. It is crucial to accept and incorporate that uncertainty into any assessment, regardless of how precise the model output from individual simulations may be. Unfortunately, uncertainty in the covariance of these parameters may be impossible to assess.

Analyses using this model will produce a wealth of "data" that may be used to formulate and prioritize management actions as alternative hypotheses. The flexible modeling framework invites the creation of alternative models for discussion and analysis. Managers should be aware, however, that the end result of this increased modeling and analysis activity may not be increased clarity. Shenk (1997) refers to this phenomenon as the "Sixth Law of Data Smog – Too many experts spoil the clarity". The New York

Times calls the plethora of models generated by opposing experts "volleys of data." Managers should prepare for extended argumentation that although scientifically sound, is not definitive. Communication of the reasons for management activities to stakeholders may likewise become more difficult as the complexity of the arguments driving these activities increases.

The User's Manual is well written, at least for ecologists moderately familiar with modeling terminology, and provides an excellent introduction to the simulation model. The graphical interface is intuitive enough to allow naïve users access to the model. As an accessible model that may be used to evaluate management alternatives, the Chaloupka simulation may encourage relatively inexperienced decision makers to approach the formulation of management plans by adjusting parameters until a desirable output is produced. Glover et al. (1997) found that structured aids influenced these novice analysts to approach aided tasks "mechanistically, without becoming actively involved in the task or judgment." Paradoxically, while this tool has been designed to enhance understanding of sea turtle population dynamics, as a decision-making aid it may have the opposite effect on some subset of user analysts. This phenomenon applies to all structured decision making aids and in not unique to natural resource management models. However, in a supervised learning environment, the simulation model may prove immensely valuable as a didactic tool to demonstrate the way that complex effects are coherently related through an expert's eyes.

4. Appropriate Consideration of Parameter Uncertainty for Assessment of Management Alternatives

The complexity of the Chaloupka simulation model justifies making the tool itself and the results it produces objects of study. The tool, as described in the User's Guide allows for the incorporation of 100s of parameters. There are over 150 easily modified (user-defined) parameters alone, and many more within the program itself. The model incorporates environmental and demographic stochasticity by adding temporal variability within stocks and probabilistic variability in fecundity and survival probabilities. The choice of parameter values and the perceived precision of the result encourage a very mechanistic approach to management of these species. When results about the numbers of individuals that might be impacted are derived from very small changes in parameter values, the tendency to trust these numbers as reflective of more than a general trend may arise. An analogy familiar to biologists would be the tendency of novice data analysts to run through a list of available models in a Windows-based statistical program until the "p-value" generated for the data was <0.05.

For example, as a tool for monitoring and detecting current change to support management decisions that seek to optimize human activity while maintaining sea turtle populations, the simulation model may produce results from the model that are perceived to be precise and encourage generation of targets that are perceived to be equally as precise. In reality, given the amount of information that remains unknown about this species, such narrow targets may be inappropriate. At minimum, users of this model and its results must be aware that any statement such as "Given these risk criteria, it is apparent that the Western Pacific leatherback sea turtle stock would most likely be well on the way to extinction given harvesting of 15%of adults each year for 100 years or more" (Users Guide, p.34) *must* be prefaced with, "The model results, given user-defined parameter set A, are..." because *any* result will depend on that parameter set (as well as those parameters set by Dr. Chaloupka in the program code). Parameter sets should be included explicitly wherever quantitative results are presented, and effort should be made to assure that results are consistent over a wide range of plausible parameter sets.

As a tool for guiding restoration efforts, such as habitat restoration, where both management activities and their concomitant effects on sea turtle populations will become manifest at some future date, the Chaloupka simulation model provides a valuable structure for prioritizing and evaluating the relative impacts of alternative management strategies. However, the recovery of sea turtle populations will also be affected by influences that cannot be incorporated into the model, and the response of the population to a management strategy may be entirely unexpected. This is a problem with any model, and is one of the reasons why continuous updates and modifications are needed as new data are acquired. Even if the population behaves exactly as theorized in the model, the environment may vary in such a way to make predictions inaccurate. It is important to monitor the environment as the context for the simulation model, and to incorporate them expeditiously, as forecasts may be affected. Assessment of prediction risks should be integrated into any management decision taken.

The development of new and sophisticated analytical tools has been anticipated for many years. Walters and Holling (1990) cautioned that even with the advent of these tools, "we must not pretend that process research and diligent data analysis alone will provide answers that resource managers can trust." Likewise, in his seminal paper on the future of conservation biology, Caughley (1994) stressed that over-parameterized models for poorly-known species give is a "false sense of precision" that may overstep our understanding of how populations respond to perturbations.

5. Suggested Protocol for Use of the Chaloupka Model to Assess the Impacts of Fisheries

Levins (1995) admonishes us to prepare for surprise. Holling (1995) cautions: "... knowledge of the system we deal with is always incomplete. Surprise is inevitable. Not only is the science incomplete, but the system itself is a moving target, evolving because of the impact of management and the progressive expansion of the scale of human influences on the planet."

We recommend that:

- management decisions be supported by several modeling approaches whenever possible, including approaches that reflect coarser granularity (i.e., Levins's third modeling strategy, maximize generality and realism at the expense of precision), such as life history perturbation analysis models (Heppell et al. 2000), qualitative community models (Puccia and Levins 1985) and coarser-grained temporal stochastic models.

- prediction risks (risks of incorrect predictions) should be assessed when comparing management alternatives.
- multiple reference points should be evaluated for each set of alternative scenarios, including short-and long-term reference points that may be used in decision-making.
- sensitivity of the model to reasonable changes in parameter inputs should be carefully examined. These are discussed in greater detail in (6.) following.
- clusters of model inputs should be evaluated as variables themselves. Conflicting models may be reducible to a small set of scenarios more amenable to other types of models.

Furthermore, we suggest that two general questions be considered each time the model is used in decision-making:
Question 1. How do two reference points (one short-term, one long-term) change with varying input parameters?
Question 2. Under what range of input conditions can we achieve the same endpoint?

We strongly advise that each user group carefully review the entire list of parameters. Only a subset of user-defined parameters is included in the default list for the slider toolbox; at minimum, the list of user-defined parameters should be understood and assessed using available data.

In a summary review of the model, Donald Kobayashi of the NMFS Honolulu Lab describes a simulation scenario for determining the effects of the Hawaiian longline fishery on loggerhead populations. The number of adult turtles in 2085 was used as a reference point, and the effects of all possible anthropogenic hazards available in the model were evaluated by removing each hazard individually and recording changes in the model endpoint. This analysis suggested that the Hawaiian fishery has little or no effect on the number of mature loggerheads in 2085, regardless of the intensity of its effect, when the other hazards were included – "a minor component of the aggregate anthropogenic hazard". While the loggerhead model is quite likely more reliable than the leatherback model, given that the range of inputs for each parameter is grounded in empirical data, this analysis is insufficient for policy guidance. The analysis was only performed with one set of possible input parameters, and should be repeated for a range of potential input sets. Without such an analysis, far too much faith is put on the user's available input data and the preset "defaults" of the model, and there is no guarantee that a different group of model users would come to the same conclusions.

6. Sensitivity Analysis of Model Parameters on Critical Endpoints

Sensitivity analyses will inform analysts and decision makers about inherent variability in model results. The goal of such an analysis can be to locate:

1. A single point that produces an inconsistent or implausible result;
2. Proximal points that produce very different results.

The systematic study of the Chaloupka model by changing one parameter at a time is physically impractical due to large number of parameters that may be included in any one model. A factorial analysis of the changes in model output following systematic changes in multiple parameters is out of the question. Nevertheless, we encourage the use of sensitivity analyses to assure that results are robust to a wide range of plausible inputs.

Sensitivity of clusters of parameter values could be accomplished by construction of a meta-model of model accuracy, a knowledge-engineered model that describes parameter regions that produce valid results and that can be used to identify plausible and implausible clusters of parameter values. Pearl (1988) has referred to this approach of representing confidence in terms of higher-order probabilities as 'probabilities of probabilities.' In this approach, the event P(A) = p is a random variable that depends on the occurrence or nonoccurrence of some other event in the model. For example, the parameter settings for the scenario shown in Figure 3 of the User's Manual (at risk group adults; constant annual harvest rate = 0.15; harvest duration = 100 years starting from 1975) might fall in one cluster of input parameters. Annual harvest rates of 0.2 or greater might be deemed speculative by expert analysts, reducing confidence in that instantiation of the model. Probabilities regarding confidence can be assembled into a Bayesian belief network (BBN) that, like the simulation model, serves as a framework within which to relate multiple observations and hypotheses. As new evidence about the biology, ecology, environment and anthropogenic hazards to sea turtle species is discovered, it can be applied incrementally to the BBN of model confidence.

Such a model would be an attempt to circumscribe the state of knowledge in the field. It defines regions of parameter space where experts feel comfortable and can express their level of comfort with their belief that what is known accurately represents natural processes. It incorporates ranges of parameter values with which we have experience, ranges of values with which we have little or no experience, but are confident that overall behaviors within this range will not change, and ranges of parameter values where there is significant uncertainty. The contribution of this model over the parameter processing provided by the Chaloupka simulation is that it can alert analysts to possible interactions among certain parameter values that can produce non-additive effects. These synergistic effects are potentially dangerous because they can precipitate rapid population declines. Construction of the belief model is a nontrivial task, but it may be a potentially valuable complement to the Chaloupka simulation model.

The Chaloupka model simulation is a sensitive tool for predicting trends in the present and future. It is important to remember, however, that any result produced by the model will be mediated by current environmental conditions and anthropogenic hazards. The granularity of proposed management actions must acknowledge the uncertainty contained in the model and in the surrounding context of the model. One strategy to monitor context would be to identify sentinel variables (observable indicators of trends that are sensitive to parameter settings) to determine when ranges of parameter values can be applied to produce results consistent with real-world conditions.

7. Conclusions and Research Recommendations

The Chaloupka simulation model has the potential to serve as a key component in a suite of analytical tools to assess the viability of sea turtle populations. The interactive method by which human analysts can adapt the model to specific scenarios increases its potential for extended use. While the simulation models the behavior of sea turtle populations, the complexity of the model is sufficient motivation for the study of the behavior of the model itself. We recommend that such research address the following tasks:

- Perform external validation to search for points that validate and define the boundaries and validity of the Chaloupka model.
- Identify sentinel variables (observable indicators of trends that are sensitive to parameter settings) to determine when the model can be applied and produce results consistent with real-world conditions.
- Perform prediction risk to determine consequences of incorrect model results.
- Construct a meta-model of model accuracy: Construct a knowledge-engineered model (a Bayesian network) that describes parameter regions that produce valid results. Use to identify plausible and implausible regions of parameter values, singly and in combination.

Dr. Chaloupka himself has stressed that the primary use of this model is to learn how sea turtle populations might behave under various scenarios – heuristic, rather than predictive, analyses. The User Guide for the Dermochelys Model runs through a variety of examples in its tutorial that emphasize the heuristic nature of the simulation. The primary task for users of this model is to determine how robust the various model endpoints are to a wide range of user inputs and parameter uncertainty. It is perhaps unsurprising that, relative to the many potential sources of mortality experienced by sea turtles, the small fleet of Hawaiian longliners are not to blame for population declines. At a meeting in Honolulu in 1995, many different models, both simple and complex, came to the same conclusion (Bolten et al. 1996). Thus, this result IS likely to be robust to many model formulations, but others will not be.

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APPENDIX U

M. Chaloupka Memorandum to S. Martin (HLA) Re: *HLA Proposal for Management Regime Change for the Hawaii Pelagic Longline Fishery - Revised WPRFMC Take.*

MEMORANDUM

TO: Sean Martin
HLA, Hawaii

FROM: Dr Milani Chaloupka
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RE: HLA proposal for Management Regime Change for the Hawaii Pelagic Longline Fishery — revised WPRFMC take

DATE: 30 September 2003

Background

The Incidental Take Statements in the HLA proposal for Management Regime Change for the Hawaii Pelagic Longline Fishery outline the expected incidental take and expected mortality of 4 species of sea turtle in the Hawaii-based tuna-style and swordfish-type fisheries (Table 1). The possible impacts of the proposed take and mortality schedules on sea turtle population viability were evaluated in a previous memo.

The status of these 4 sea turtles stocks in the Pacific are shown in Fig. 1.

The WPRFMC recently revised the incidental take and mortality schedule in an Emergency Interim Rule for Management of the Hawaii-based pelagic longline fishery — these revised estimates for the proposed swordfish fishery are also summarised in Table 1. A qualitative evaluation of this revised schedule is given below for greens, loggerheads and ridleys. A quantitative stochastic simulation based evaluation is given below for leatherbacks.

Table 1 HLA incidental take statement with WPRFMC proposed management alternative takes and mortalities shown in brackets

		expected		
fishery	species	take	mortality	ageclass
swordfish-type	green	8 (8)	3 (7)	adults
	leatherback	25 (41)	7 (12)	adults
	loggerhead	120 (29)	42 (9)	immatures
	olive ridley	16 (54)	5 (45)	adults/immatures

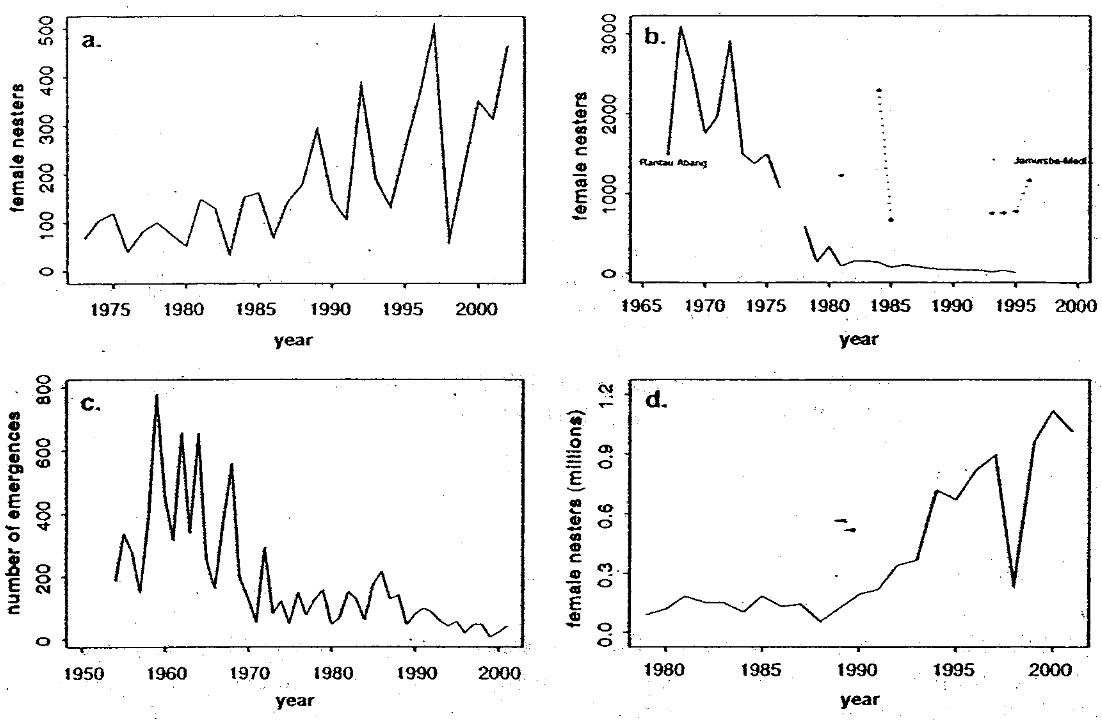

Figure 1 Trends in nester abundance of the 4 sea turtle stocks exposed to the Hawaii-based pelagic longline fisheries. Panel (a) shows female green turtle nesting abundance at the East Island rookery for the Hawaiian green turtle stock (Balazs and Chaloupka 2003). Panel (b) shows female leatherback nesting abundance at the Rantau Abang and Jamursba-Medi rookeries for the western Pacific stock (Chua 1988, Chan and Liew 1996, Suarez et al. 2000). Panel (c) shows female loggerhead nesting abundance at the Kamouda, Tokushima Prefecture for the Japanese loggerhead stock (Kamezaki et al 2003). Panel (d) shows female olive ridley nesting abundance at the La Escobilla rookery, Mexico for the east Pacifc stock (Penaflores et al. 2000; Dr F Alberto Abreu 2002, pers comm).

Impact evaluation

The historical impacts of various fisheries and other anthropogenic hazards on the 4 sea turtles stocks are unknown — what is known is that these stocks have been and continue to be exposed to many of these hazards. Despite this exposure, 2 of the stocks are clearly increasing in abundance as evidenced by increasing trends in female nester abundance while 2 stocks are clearly decreasing (Fig. 1).

The revised take and mortality of Hawaiian green turtles (Table 1) would have no detectable marginal impact on stock abundance. This conclusion is based on the following points. The annual loss of Hawaiian green turtles to the tumour-forming diseases, fibropapillomatosis, is substantial greater than the proposed loss to the Hawaii-based swordfish fishery (see Chaloupka & Balazs 2003). Despite ongoing exposure to disease and various fisheries, the Hawaiian green turtle stock continues to increase in abundance (Balazs & Chaloupka 2003). There are no proposed conservation measures to offset any pelagic longline loss, however, the Hawaiian stock is clearly increasing.

The revised take and mortality of eastern Pacific olive ridley turtles (Table 1) would have no detectable marginal impact on stock abundance. This conclusion is based on the following points. The annual loss of eastern Pacific olive ridleys turtles to incidental take in various fisheries along the Mexican Pacific coast is substantial greater than the proposed loss to the Hawaii-based swordfish fishery (see Chaloupka & Balazs 2003). Despite exposure to all fisheries, the eastern Pacific olive ridley turtle stock(s) continues to increase in abundance (Fig. 1d, see also Penaflores et al 2002). There are no proposed conservation measures to offset any pelagic longline loss, however, the eastern Pacific stock(s) are clearly increasing.

The revised take and mortality of Japanese loggerhead turtles (Table 1) would have no detectable impact on stock abundance. The revised loss is substantially less than the scenario modelled previously that involved an annual loss of 42 immatures — the revised annual loss is 9 not 42 (Table 1). An annual loss of 42 immatures would have no detectable marginal impact on stock viability so clearly an annual loss of 9 would also have no detectable marginal effect. Hence no additional simulation modelling is required here. The proposed conservation measures that could result in an additional 295 immatures pa to offset the proposed annual loss of 9 immatures attributable to the Hawaii-based longline fishery seems worthwhile. No modelling is required to draw this conclusion. The recovery of the stock will, however, depend on a much broader range of conservation measures.

The marginal effect of the revised take for the western Pacific leatherback stock(s) was evaluated against the expected steady-state stock abundance assuming no exposure to any other anthropogenic hazards. This was modelled here using a 2-substock western Pacific leatherback simulation model developed for the US NMFS and provided to the HLA. The previous modelled scenario used an annual loss of 25 adult leatherbacks (tuna- and swordfish-type fisheries combined). No marginal effect was detectable for that loss of 25 adults pa. The revised loss is an additional 5 adults pa over the previous scenario so the modelled scenario here was 30 adults pa for a 25 year period starting in the year 2000. The runs are for a simulation period from 1900 to 2100, which is 75 yr beyond the cessation of the incidental loss to review possible recovery of the stocks. The 25 yr intervention period is arbitrary but sufficient to determine any marginal effect of the proposed losses. The model results are shown in Fig 2 as the expected stock abundance (± 1 standard deviation) derived from 1000 Monte Carlo trials.

It is apparent given model assumptions (see previous memo) and the reference used that there is no detectable marginal effect of the loss of either 25 or 30 adult leatherbacks pa on the western Pacific leatherback stock. The stock is declining due to a range of effects other than any possible marginal effect due to the Hawaii-based longline fishery. The proposed conservation measures that could result in an additional 258 adults pa to offset the proposed annual loss of 30 adults attributable to the Hawaii-based longline fishery seems worthwhile, although this will only be useful for the melanesian substock not the near-extinct malaysian substock. No modelling is required to draw this conclusion. The recovery of the Malaysian substock will, however, depend on a much broader range of conservation measures.

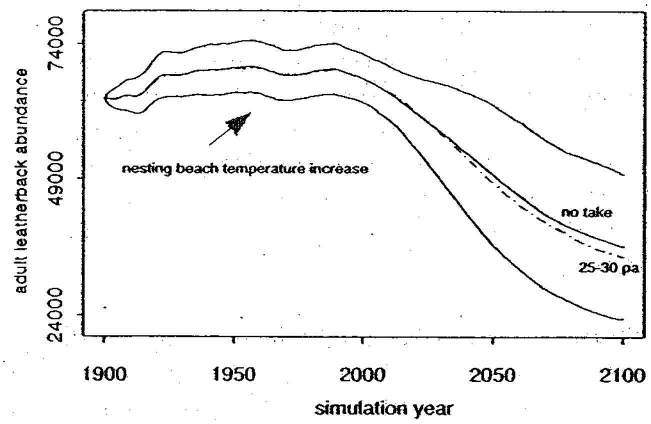

Figure 2 Expected stock abundance (± 1 sd) from 1000 Monte Carlo trials given annual loss of 25 or 30 adults from the western Pacific leatherback stock. The loss of 30 adults is based on the additional loss of 5 adults listed in Table 1 compared to previous modelled scenarios that used a loss of 25 pa. The difference between a loss of 25 or 30 adults pa is indistinguishable.

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APPENDIX V

NMFS' February 23, 2004 *Biological Opinion on the Authorization of Pelagic Fisheries under the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region*

ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Action Agency:	National Marine Fisheries Service, Pacific Islands Regiŏn, Sustainable Fisheries Division
Activity:	Proposed Regulatory Amendments to the Fisheries Management Plan for the Pelagic Fisheries of the Western Pacific Region.
Consulting Agency:	National Marine Fisheries Service, Office of Protected Resources
Approved By:	Laurie K. Allen
Date issued:	FEB 23 2004

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. § 1531 et seq.) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency may affect a protected species, that agency is required to consult with either the National Marine Fisheries Service (NOAA-Fisheries) or the U.S. Fish and Wildlife Service, depending upon the protected species that may be affected. For the actions described in this document, the action agency is NOAA-Fisheries' Pacific Islands Region- Sustainable Fisheries Division. The consulting agency is NOAA-Fisheries' Office of Protected Resources.

This biological opinion represents NOAA-Fisheries' assessment of the effects of the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region (Pelagics FMP) and associated fisheries threatened and endangered species. Specifically, the effects of the fisheries on endangered humpback whales (*Megaptera novaeangliae*), endangered sperm whales (*Physeter macrocephalus*), endangered Hawaiian monk seals (*Monachus schauinslandi*), endangered fin whales (*Balaenoptera physalus*), sei whales (*B. borealis*), endangered right whales (*Eubalaena japonica*), threatened and endangered green turtles (*Chelonia mydas*), endangered hawksbill turtles (*Eretmochelys imbricata*), endangered leatherback turtles (*Dermochelys coriacea*), threatened loggerhead turtles (*Caretta caretta*), and threatened and endangered olive ridley turtles (*Lepidochelys olivacea*), in accordance with section 7 of the ESA.

This Opinion considers information provided in NOAA-Fisheries' January 14, 2004, biological assessment, the January 8, 2004, regulatory amendment to the Fishery Management Plan for the Pelagics Fisheries of the Western Pacific Region, the draft supplemental Environmental Impact Statement on the fisheries, recovery plans for the humpback whale and Hawaiian monk seal, the most current marine mammal stock assessment reports, sea turtle recovery plans, past and current research and population dynamics modeling efforts, observer and logbook data on fishery effort and protected species interactions within the Hawaii-based longline fishery, and biological opinions for this and other relevant fisheries.

1.0 CONSULTATION HISTORY

Consultation histories for earlier consultations on the Fisheries Management Plan for the Pelagic Fisheries of the Western Pacific Region (Pelagics FMP) can be found in the November 3, 1998, biological opinion on the reinitiated consultation for the Pelagics FMP Hawaii North Central Pacific Longline Fishery (NOAA-Fisheries, 1998a). That opinion found that the proposed action was not likely to jeopardize the continued existence of listed sea turtles or Hawaiian monk seals, and established anticipated incidental take levels for sea turtles captured by the Hawaii-based longline fishery. The opinion also required continuation of the observer program for the fishery and required handling procedures for incidentally captured sea turtles and review of the circumstances surrounding the observed capture of any leatherback turtle.

Since then, the Hawaii-based longline fisheries have been the subject of several court-orders and was operating under a restricted fishing regime to protect listed sea turtles when NOAA-Fisheries completed a new consultation on the Pelagics FMP on March 29, 2001. In that opinion, NOAA-Fisheries determined that the proposed action was not likely to jeopardize the continued existence of the listed marine mammals or olive ridley sea turtles or destroy or adversely modify designated critical habitat affected by the fisheries. NOAA-Fisheries did determine, however, that the Pelagics FMP fisheries were likely to jeopardize the continued existence of green, leatherback, and loggerhead turtles. The March 29, 2001, opinion included a Reasonable and Prudent Alternative (RPA) designed to avoid the likelihood of jeopardy to these species and an Incidental Take Statement with terms and conditions designed to minimize the impact of any incidental take of all four species of turtles that would occur as a result of implementation of the RPA.

Subsequent to completion of the March 29, 2001, opinion, the Pelagics fisheries have been operating pursuant to the requirements of regulations issued to implement the RPA and to comply with the agency's ESA obligations to protect sea turtles (66 FR 31561, June 12, 2002). However, on December 12, 2001, NOAA-Fisheries reinitiated consultation on the Pelagics Fisheries to account for new information which may improve NOAA-Fisheries' ability to quantify and evaluate the effects of the United States' pelagic fisheries under the FMP and the reasonable and prudent alternative in the March 29, 2001, opinion on listed sea turtle populations. The agency issued the biological opinion resulting from that consultation on November 15, 2002.

On December 11, 2003, the Acting Regional Administrator of NOAA-Fisheries' Pacific Islands Regional Office sent a memorandum to the Director of NOAA-Fisheries' Office of Protected Resources that asked the OPR to reinitiate formal consultation on the Pelagics FMP, as amended by the Council in response to the court's vacating the sea turtle protection regulations.

On January 14, 2004, the Acting Regional Administrator of NOAA-Fisheries' Pacific Islands Regional Office delivered a copy of a January 14, 2004, biological assessment on the proposed fisheries, which was prepared by the Western Pacific Regional Fisheries Management Council on behalf of the Hawaii Longline Association, to the Director of NOAA-Fisheries' Office of Protected Resources.

On January 14, 2004, the Acting Regional Administrator of NOAA-Fisheries' Pacific Islands Regional Office delivered a copy of a January 8, 2004, regulatory amendment to the Fishery Management Plan for the Pelagics Fisheries of the Western Pacific Region, which was prepared by the Western Pacific Regional Fisheries Management Council, to the Director of NOAA-Fisheries' Office of Protected Resources. This proposed regulatory amendment included a draft supplemental Environmental Impact Statement.

On January 21, 2004, representatives of the Office of Protected Resources and the Southwest Region's Protected Resources Division met with representatives of the Pacific Island Region's and Southwest Region's Sustainable Fisheries Divisions, NOAA-Fisheries' Pacific Islands Fisheries Science Center, the Hawaii Longline Association, and the Western Pacific Regional Fisheries Management Council. At that meeting, representatives of the Office of Protected Resources provided a comprehensive overview summary of the approach the office is using to assess the effects of the pelagic fisheries of the western Pacific region on threatened and endangered species.

On February 2, 2004, NOAA-Fisheries' Office of Protected Resources provided a partial draft biological opinion (everything except a draft incidental take statement, conservation recommendations, literature cited section, and appendices) to NOAA-Fisheries' Pacific Islands Regional Office, which transmitted the draft to the Hawaii Longline Association (as applicants) and representatives of the Western Pacific Regional Fisheries Management Council.

On February 4, 2004, representatives of NOAA-Fisheries' Office of Protected Resources, Southwest Regional Office (Protected Resources and Sustainable Fisheries Programs), Pacific Islands Regional Office, and Pacific Islands Area Science Center, the Hawaii Longline Association, and Council held a video- and teleconference to discuss NOAA-Fisheries' February 2, 2004, draft biological opinion. At the meeting, the Office of Protected Resources received initial comments on the draft opinion.

On February 6, 2004, NOAA-Fisheries' Office of Protected Resources provided a draft incidental take statement, conservation recommendations, literature cited section, and appendices to NOAA-Fisheries' Pacific Islands Regional Office, which transmitted the draft to the Hawaii Longline Association (as applicants) and representatives of the Western Pacific Regional Fisheries Management Council (including the sea turtle working group).

During the week of February 16-20, 2004, NOAA-Fisheries' Office of Protected Resources received written comments on the entire draft biological opinion from NOAA-Fisheries' Pacific

Islands Regional Office, Stoel-Rives LLP on behalf of the Hawaii Longline Association (as applicants) and representatives of the Western Pacific Regional Fisheries Management Council.

2.0 DESCRIPTION OF THE ACTION

The National Marine Fisheries Service's Pacific Islands Regional Office, Sustainable Fisheries Division proposes to approve regulations for fisheries managed under the Fisheries Management Plan for pelagic fisheries in the western Pacific Region (Pelagics FMP) and to manage those fisheries pursuant to those regulations. The purpose of fishery management plans, including the Pelagics FMP, has been established by the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 *et seq.*; MSA).

The U.S. pelagic fisheries in the central and western Pacific region are managed under the Pelagics FMP, as amended[1]. The Pelagics FMP and its amendments are developed by the Western Pacific Regional Fisheries Management Council (Council) under the authority of the MSA. The stated purpose of the Pelagics FMP is to maximize the net benefits of the fisheries to the western Pacific region and the Nation. Background information on federal fisheries policy and management under the MSA, the fishery management plan development process, and the Pelagics FMP is described in the March 2001 FEIS (Section 1.3, pages 11 - 34).

The current management regime under the Pelagics FMP primarily regulates the domestic pelagic longline fisheries, although certain permit, reporting, and sea turtle mitigation measures apply to non-longline pelagic fisheries in the region, such as the domestic troll, handline, and pole-and-line fisheries. NMFS has no specific regulations pursuant to the Pelagics FMP for the domestic tuna purse seine fishery operating in the western Pacific. If problems or issues arise in the future in this fishery, the Pelagics FMP can be adjusted as necessary.

As proposed, the fisheries managed under the Pelagics FMP would be prosecuted under the combination of the following existing and potential management measures:

1. All fishery management measures for the western Pacific pelagic fisheries in existence on the date of initiation of consultation, December 11, 2003, except those that will be eliminated as a result of the court orders of August 31 and October 6, 2003, in *Hawaii Longline Association* v. *NMFS* (D.D.C., Civ. No. 01-0765). These orders vacated, effective April 1, 2004, a set of regulations promulgated June 12, 2002, to mitigate the adverse effects of the western Pacific pelagic fisheries on sea turtles (67 FR 40232).

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[1] The U.S. tuna purse seine fishery is managed under the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (the South Pacific Tuna Treaty). Although they occur in the action area and are subject to management under the MSA, for the most part this fishery is not regulated under the Pelagics FMP (one regulation prohibits large vessels, including U.S. tuna purse seiners, from fishing in waters within approximately 50 nm of the islands of American Samoa). This fishery will be subject to separate section 7 consultation on federal options to implement the Treaty and will not be evaluated as part of the effects of this action.

2. The regulatory management measures in the proposed regulatory amendment to the Pelagics FMP, "Management Measures to Implement New Technologies for the Western Pacific Pelagic Longline Fisheries," dated January 8, 2004 (hereafter called "new technologies regulatory amendment"). The measures proposed in this regulatory amendment, together with the effects of the court orders cited above, are in a proposed rule published January 28, 2004 (69 FR 4098).

3. The management measures proposed in Pelagics FMP Amendment 11, which would establish a limited access program for longline fishing in the EEZ around American Samoa.

4. The following existing management measures, which will be eliminated by court order on April 1, 2004, but which are expected to be re-implemented through separate rule-making within the next year (hereafter called "future measures"):

   (a) A requirement that operators of vessels registered for use under longline general permits annually attend a NMFS-conducted protected species workshop and carry on board a valid certificate of completion of the workshop (see 50 CFR 660.34);

   (b) a requirement that owners and operators of vessels registered for use under longline general permits that have a freeboard of more than three feet carry line clippers and dip nets meeting certain minimum design standards and wire or bolt cutters capable of cutting through the vessel's hooks and use these items in specified manners to disengage sea turtles, and that certain turtle handling, resuscitation, and release methods be employed (see 50 CFR 660.32); and

   (c) a requirement that owners and operators of vessels registered for use under longline general permits that have a freeboard of three feet or less carry and use line clippers capable of cutting the fishing line or leader within about one foot of the eye of an imbedded hook and wire or bolt cutters capable of cutting through the vessel's hooks and use these items in specified manners to disengage sea turtles, and that certain turtle handling, resuscitation, and release methods be employed (see 50 CFR 660.32).

In summary, the management measures that constitute the action under consideration, along with their sources, are.

- Fishing for pelagic management unit species (PMUS) in the western Pacific EEZ with drift gillnets is prohibited *(52 FR 5987, March 23, 1987).*

- Fishing vessels that use longline gear to catch PMUS in the EEZ around American Samoa, Guam, Commonwealth of the Northern Mariana Islands, or the U.S. Pacific remote islands areas (PRIA), such as Palmyra and Johnston Atolls, Kingman Reef, Jarvis, Howland, Baker and Wake Islands, and vessels used to transport or land U.S.

longline-harvested PMUS shoreward of the outer boundary of these same EEZs, must be registered for use with longline general permits or Hawaii longline limited access permits, and must keep daily logbooks detailing species harvested, area of harvest, time of sets, and other information, including interactions with protected species. Also, longline gear must be marked with the official number of the permitted vessel that deploys the gear *(56 FR 24731, May 26, 1991).*

- Fishing vessels that use longline gear to catch PMUS in the EEZ around Hawaii, or are used to transport or land longline-harvested PMUS shoreward of the outer boundary of the EEZ around Hawaii, must keep daily logbooks detailing species harvested, area of harvest, time of sets, and other information, including interactions with protected species *(56 FR 24731, May 26, 1991).*

- Longline fishing for PMUS is prohibited in closed areas 50 nm around the center points of each of the Northwestern Hawaiian Islands, plus a 100 mile wide corridor connecting those circular closed areas that are non-contiguous (protected species zone) *(56 FR 52214, October 14, 1991).* In the main Hawaiian Islands longline fishing, except as exempted, is prohibited in areas approximately 75 nm around the islands of Kauai, Niihau, Kaula, and Oahu, and approximately 50 nm off the islands of Hawaii, Maui, Kahoolawe, Lanai, and Molokai. This prohibition is lessened from October 1 through January 30, when the longline closed areas decrease on the windward sides to approximately 25 nm off Hawaii, Maui, Kahoolawe, Lanai, Molokai, Kauai, Niihau, and Kaula, and approximately 50 nm off Oahu *(56 FR 28116, June 14, 1991).*

- Longline fishing is also prohibited in an area approximately 50 nm off Guam *(57 FR 7661, March 2, 1992).*

- Vessels registered for use under Hawaii longline limited access permits ("Hawaii-based longline vessels") must carry a NOAA-Fisheries' observer when directed to do so by NOAA-Fisheries *(58 FR 67699, December 22, 1993).*

- Fishing vessels that use longline gear to catch PMUS in the EEZ around Hawaii, or are used to transport or land longline-harvested PMUS shoreward of the outer boundary of the EEZ around Hawaii, must be less than 101 feet in length and be registered for use with one of 164 Hawaii longline limited access permits *(59 FR 26979, June 24, 1994).*

- As directed by NMFS, all vessels registered for use with Hawaii longline limited access permits (Hawaii longliner) must carry NMFS-owned "vessel monitoring system" transmitters *(59 FR 58789, November 15, 1994).*

- All Hawaii-based longline vessels and fishing vessels registered for use with longline general permits are required to employ sea turtle handling measures specified by NMFS, including mitigation gear, sea turtle resuscitation, and sea turtle release procedures, to maximize the survival of sea turtles that are accidentally taken by fishing gear *(65 FR 16346, March 28, 2000; future measures).*

- Domestic longline fishing vessels greater than 50 feet (length overall), except as exempted, are prohibited from fishing for PMUS within approximately 50 nm around the islands of American Samoa, including Tutuila, Manua, and Swains Islands, and Rose Atoll *(67 FR 4369, January 30, 2002).*

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- Federal regulations that implemented the Shark Finning Prohibition Act prohibit any person under U.S. jurisdiction from engaging in shark finning, possessing shark fins harvested on board a U.S. fishing vessel without corresponding shark carcasses, or landing shark fins harvested without corresponding carcasses *(67 FR 6194, February 11, 2002).*

- Any domestic fishing vessel that employs troll or handline gear to catch PMUS in the EEZ around the U.S. Pacific remote islands areas, e.g., Palmyra and Johnston Atolls, Kingman Reef, Jarvis, Howland, Baker and Wake Islands, and Midway Atoll in the Main Hawaiian Islands, must be registered for use with a permit issued by NMFS and must also maintain daily logbooks detailing species harvested, area of harvest, fishing effort, and other information, including interactions with protected species *(67 FR 30346, May 6, 2002).*

- Hawaii-based longline vessels operating north of 23° N. must: when using traditional basket-style longline gear, ensure that the main longline is deployed slack to maximize its sink rate; when making deep sets using monofilament main longline, use a line-setting machine or line shooter and attach a weight of at least 45 gm to each branch line within 1 m of each hook; use thawed blue-dyed bait; and discharge offal strategically *(67 FR 34408, May 14, 2002).*

- The operator and crew of all Hawaii-based longline vessels that accidentally hook or entangle an endangered short-tailed albatross must employ specific handling procedures *(67 FR 34408, May 14, 2002).*

- Operators and owners of Hawaii-based longline vessels and operators of tered for use under longline general permits are required to attend annual protected species workshops conducted by NMFS that cover sea turtle and seabird conservation and mitigation techniques *(67 FR 34408, May 14, 2002; future measures).*

- There is an annual limit on the number of longline shallow-sets that may be collectively made north of the equator by Hawaii-based longline vessels, set at 2,120 shallow-sets per year, which is divided and distributed each calendar year in equal portions in the form of transferable single-set certificates to all holders of Hawaii longline limited access permits that respond positively to an annual solicitation of interest from NMFS. Shallow-setting means the deployment of longline gear with any float line less than 20 meters in length, with less than 15 branch lines between any two floats (except basket-style longline gear, the threshold for which is 10 branch lines between any two floats), with the use of light sticks, or resulting in the possession or landing of more than 10 swordfish at any time during a given trip. Hawaii-based longline vessels are required to have on board, and to submit to NMFS at the end of each trip, one valid shallow-set certificate for every shallow-set made north of the equator (*new technologies regulatory amendment*).

- Hawaii-based longline vessels, when making shallow-sets north of the equator, must use circle hooks sized 18/0 or larger with a 10-degree offset and only mackerel-type bait (*new technologies regulatory amendment*).

- There are annual limits on the numbers of interactions between leatherback and loggerhead sea turtles and Hawaii-based longline vessels while engaged in shallow-setting. The limit for each species is equal to the annual estimated incidental take for the species in the shallow-set component of the Hawaii-based fishery (either incidental captures or incidental deaths, whichever limit is reached first) as established in the prevailing biological opinion issued by NMFS pursuant to section 7 of the ESA. When either one of the turtle interaction limits is reached, as determined from estimates derived from vessel observer data, the shallow-set component of the Hawaii-based longline fishery is closed for the remainder of the calendar year, after giving 1 week advanced notice of such closure to all holders of Hawaii longline limited access permits (*new technologies regulatory amendment*).

- Operators of Hawaii-based longline vessels are required to notify the Regional Administrator in advance of every trip whether the trip will involve shallow-setting or deep-setting, and such vessels are required to make sets only of the type declared (*new technologies regulatory amendment*).

- Operators of Hawaii-based longline vessels are required to carry and use NMFS-approved de-hooking devices (*new technologies regulatory amendment*).

- Hawaii-based longline vessels, when making shallow-sets north of 23° N. lat., are required to start and complete the line-setting procedure during the nighttime, specifically, no earlier than one hour after local sunset and no later than local sunrise (*new technologies regulatory amendment*).

The governments of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands do not specifically regulate pelagic fishing activities, although fishing vessel registration is required. The State of Hawaii (State) prohibits the sale of yellowfin and bigeye tuna (both known in Hawaii as *ahi*) smaller than three pounds landed by all domestic fisheries. State statutes establishing longline area closures around the main Hawaiian islands and prohibiting shark finning activities[2] complement Federal fisheries regulations. The State also requires fishermen who sell any portion of their catch to hold a commercial marine license and file catch reports.

2.1. Pelagic Fisheries in Hawaii

This section covers pelagic fisheries of Hawaii managed under the Pelagics FMP. These fisheries employ a variety of techniques (longline, troll, handline, and pole-and-line) and operate in areas that range from near shore to beyond the U.S. EEZ. A detailed description of each of these fisheries is provided in the March 2001 FEIS.

2.1.1. Hawaii-based Pelagic Longline Fishery

The Hawaii-based longline fishery as it operated until March 2001 is described in detail in the March 2001 FEIS (Section 3.10.3.1, pages 195 to 256). Since 2000 the fishery has been operating in a highly dynamic regulatory environment, so the operational characteristics of the fishery have been quite dynamic, as well. The fishery's regulatory history is described in the March 2001 FEIS and the proposed new technologies regulatory amendment (WPRFMC, 2004).

The Hawaii-based longline fishery is a limited access fishery, with a total of 164 permits that are transferable (Table 2.1). Vessels active in this fishery are limited to 101 feet in length. The area fished ranges as close as 25 miles from Hawaii to thousands of miles from port. These Hawaii-based longline vessels compete with foreign distant water fishing fleets operating on the high seas.

Table 2.1. Summary Information on the Hawaii-based Longline Fishery, 2002. Source: NMFS, unpublished data, 2004

Area Fished	**U.S. EEZ around Hawaii and PRIAs; high seas in the central and mid-North Pacific regions**
Total Landings	17.1 million lb
Target Species	Bigeye, Yellowfin, and Albacore Tuna
Composition of Landings	72% tuna, 2.6% swordfish, 8.3% marlins, 2.3% sharks, 14.7% miscellaneous pelagic species
Season	Year round but highest during fall and winter
Active Vessels	100
Total Permits	164 (transferable, limited entry)
Total Trips	1162
Total Ex-Vessel Value	US$37.5 million

2 Hawaii Revised Statutes Chapter 188, enacted in June 2001, prohibit shark finning in State waters. All sharks caught by fishermen must be landed whole; that is, fins must be attached to the shark.

2.1.1.1. *Hawaii-based Longline Tuna-target (Deep-Set) Gear Configuration*

Tuna-target longline fishing is also known as deep-set longline fishing. In general, longline gear consists of a continuous main line that is set on the surface and supported in the water column horizontally by attaching floats. Longline fishing allows a vessel to distribute effort over a large area to harvest fish that are not concentrated in great numbers. Overall catch rates in relation to the number of hooks are generally low. Plastic floats are commonly used though radio buoys are also used to keep track of the mainline. A line shooter is used on deep-sets to deploy the mainline faster than the speed of the vessel, thus allowing the longline gear to sink to its target depth (400m for bigeye tuna). Deep-set longline gear is set in the morning and hauled in the afternoon (Ito and Machado, 2001). The main line is typically 30 to 100 km (18 to 60 nm) long. A minimum of 15, but typically 20 to 30, branch lines (gangions) are clipped to the mainline at regular intervals between the floats. Each gangion terminates with a single baited hook. The branch lines are typically 11 to 15 meters (35 to 50 feet) long. *Sanma* (saury) or sardines are used for bait. Lightsticks are not typically attached to the gangions on this type of longline set. A typical deep-set (one day of fishing) consists of 1,200 to 1,900 hooks.

2.1.1.2. *Hawaii-based longline Swordfish target (shallow-set) Gear configuration*

Swordfish-target fishing differs from tuna target fishing as it is set at a shallower depth, usually between (~30-90m) . Shallow-set longline gear is generally set at night, with luminescent light sticks, thought to attract swordfish, attached to the gangions. 4-6 gangions are typically clipped to the mainline between floats. A typical set for swordfish uses about 700-1,000 hooks. The historical swordfish fishery used squid as bait, but under the proposed action circle hooks with mackerel bait will be required for shallow-sets. The proposed action only allows for 2,120 shallow sets each year by the Hawaii longline fleet. These 2,120 sets will be distributed equally allocated between holders of Hawaii longline limited access permits

2.1.1.3. *Vessel Activity*

The Hawaii-based longline fishery is the largest commercial fishery in the western Pacific region. In 2002, 100 Hawaii-based longline vessels were active. The number of active longline vessels has decreased by about 25 since 2000. The decrease was due to Hawaii-based longline vessels that relocating to California to fish for swordfish as a result of turtle conservation and mitigation measures that prohibited Hawaii-based longline vessels from targeting swordfish. These vessels that relocated to California de-registered their vessels from their Hawaii longline limited access permits in order to continue fishing for swordfish. Approximately 35 vessels fished out of California in 2001, almost all of which had some history of fishing in the Hawaii-based longline fishery.

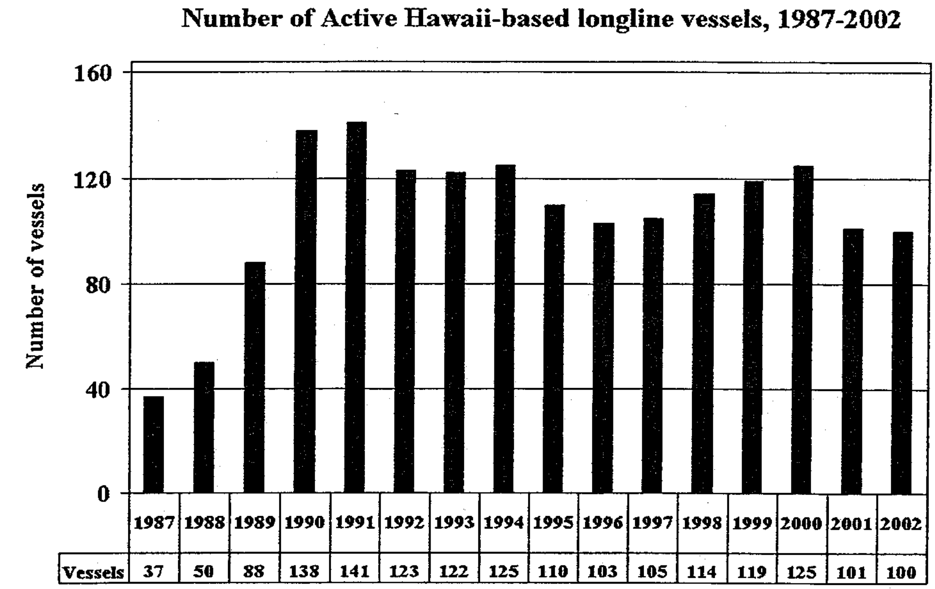


Figure 2.1. Number of active Hawaii-based longline vessels, 1987-2002. Source: NMFS unpublished data

The number of active vessels in the Hawaii-based longline fishery increased dramatically in the late 1980s and peaked at 141 vessels in 1991 (Figure 2.1). The number of vessels has since ranged from101 to125. The longline fishery operates year-round although vessel activity increases during the fall and is greatest during the winter and spring months.

The proposed action may result in an increase the number of fishery participants, but the likely number is unknown. Potentially important factors include the costs of relocating, the costs and risks associated with having to acquire a sufficient number of shallow-set certificates to enable full operations, and the regulatory environment in the west coast based fishery.

2.1.1.4. Number of Trips

In 2002, Hawaii-based longline vessels made 1,162 trips up by 128 trips from 2001. Trips were categorized on the basis of target species as tuna-, swordfish-, or mixed- (tuna and swordfish) target. In 2002, all trips were tuna-target trips.

The annual number of trips for the Hawaii-based longline fishery has remained relatively stable, but there has been a shift from mixed-target and swordfish-target trips to tuna-target trips from the early 1990s up to 2002 (Figure 2. 2).

The proposed action would allow 2,120 shallow sets to be made each year, which is equivalent to approximately 166 trips given the historical average of 13 sets per swordfish trip. It is predicted that there would be about 9, 759 annual deep sets targeting tuna, which is equivalent to approximately 813 tuna-target trips given the historical average of 12 sets per tuna trip.

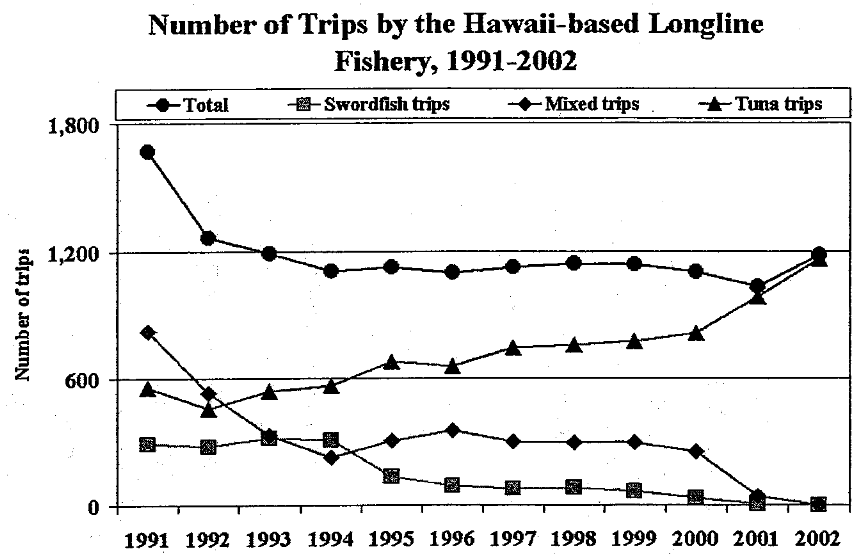
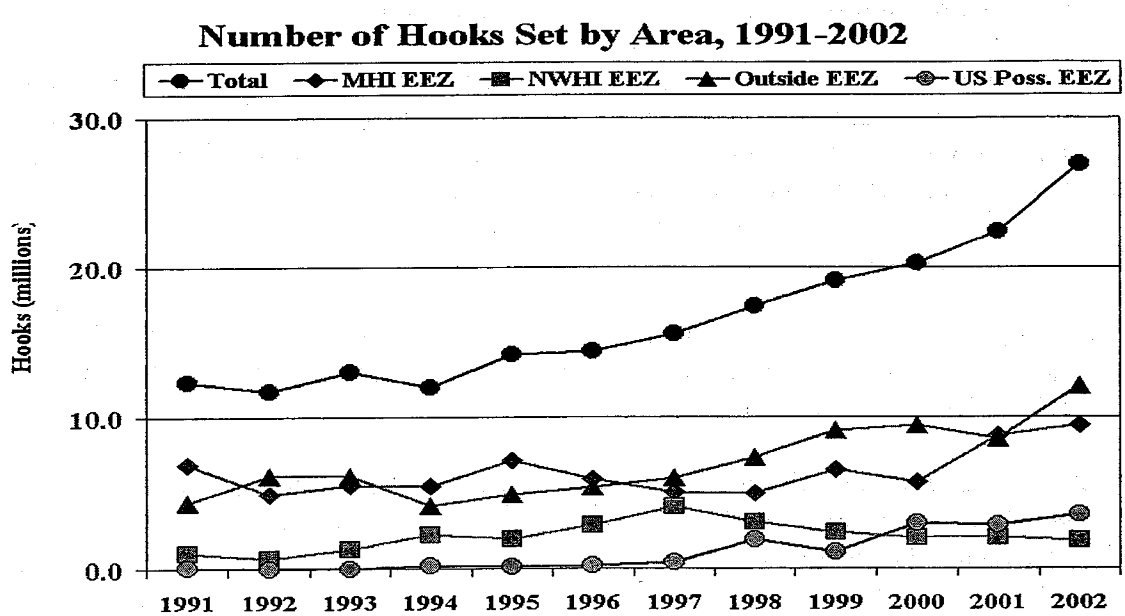


Figure 2.2. Number of trips in the Hawaii-based longline fishery, 1991-2002.
Source: Ito and Machado, 2004, NMFS unpublished data.



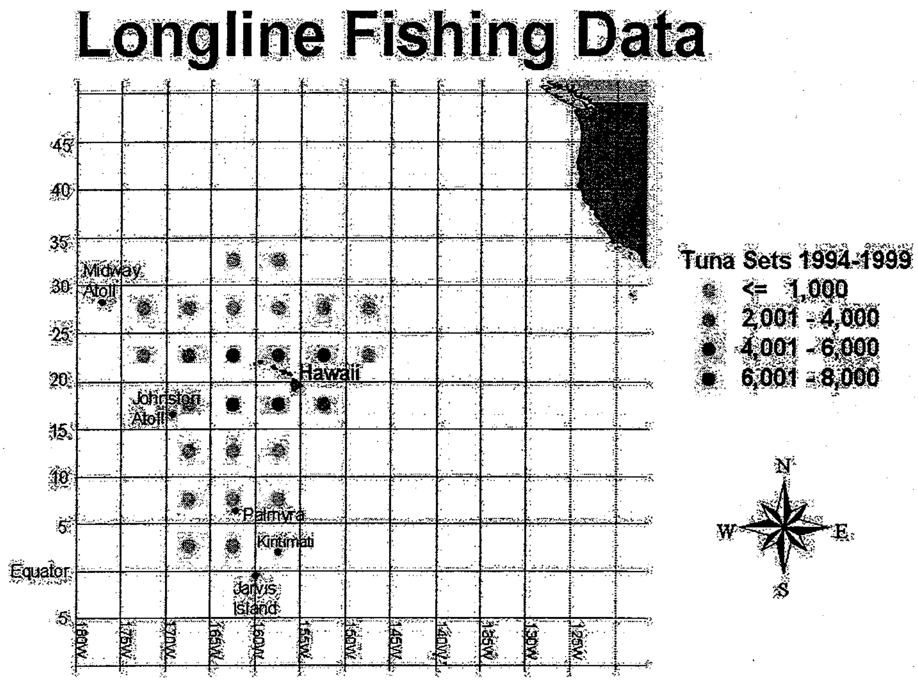


Figure 2.4. Fishing effort by the tuna component of the Hawaii-based longline fishery 1994-1999. Source: NMFS Annual Report

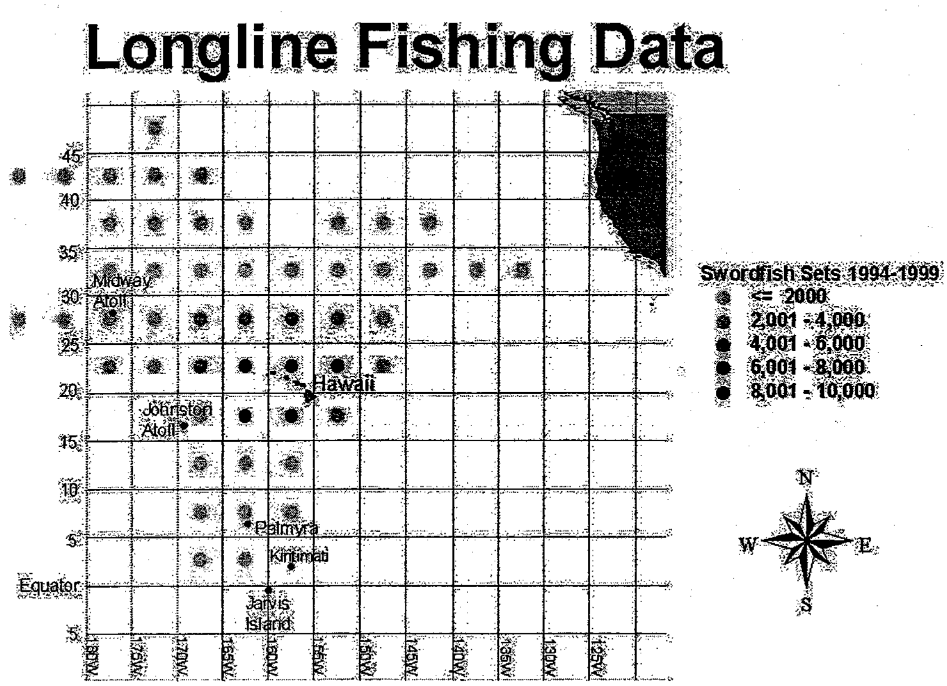


Figure 2.5. Fishing effort by the swordfish component of the Hawaii-based longline fishery 1994-1999. Source: NMFS Annual Report

2.1.1.5. *Number of Hooks Set*

A record number of 27 million hooks were set in 2002 (NMFS unpublished data, 2004) (Figure 2.3). This increase in number of hooks is a result of the shift in effort to tuna, which typically includes more than twice as many hooks per day fished than swordfish or mixed-target trips.

The spatial distribution of effort in the tuna and swordfish components of the fishery during the 1994-1999 period is shown in Figures 2.4 and 2.5, respectively.

As indicated in Figure 2.5, the swordfish component of the fishery operates well north of the Hawaiian Island chain, outside the EEZ. The proposed action, which would allow a limited amount of shallow-set effort, is therefore expected to result in an increase in longline effort in this northern area relative to 2001 and 2002. The proposed action will also eliminate the seasonal longline closure in waters south of the Hawaiian Islands. The closure currently applies to the waters from the equator to 15° N lat. and between 145° W long. and 180° W long. from April 1 to May 31. Tuna-directed effort is consequently expected to increase in those waters under the proposed action.

2.1.1.6. *Catches*

Between 1994 and 1999, before the imposition of measures to protect sea turtles, the fishery resulted in average annual catches of 6.5 million pounds of swordfish, 5.2 million pounds of bigeye, 2.5 million pounds of albacore, and 1.7 million pounds of yellowfin (Table 2.2). The 1994-1999 period provides a convenient baseline because the longline fishery was not yet subject to the sea turtle conservation measures. Data from 2002, which are included in Table 2.3, are indicative of fishery characteristics under the current management regime.

The proposed action is predicted to result in a decline of 45% in the swordfish catches relative to the 1994-1999 baseline. Catches are expected to increase by about 13% for bigeye tuna, 19% for albacore tuna, and 12% for yellowfin tuna. Ex-vessel revenues are expected to decrease by about 4.4% relative to the 1994-1999 period.

Table 2.2. Catch and revenues: estimates for 1994-1999 and 2002, and projections under action. Source: NOAA-Fisheries Pacific Islands Fisheries Science Center

	Swordfish catch (million lb)	Bigeye catch (million lb)	Albacore catch (million lb)	Yellowfin catch (million lb)	Ex-vessel revenue ($ million)
1994-1999 annual average	6.5	5.2	2.5	1.7	45.4
2002	0.5	5.2	2.8	2.2	33.1
Proposed action	3.3	5.9	3.0	1.9	43.5

2.1.1.7. *Observer program for the Hawaii-based longline fishery*

The NMFS observer program for the Hawaii-based longline fishery began in 1990, with the voluntary sampling of fishing operations because of unconfirmed reports of interactions between swordfish vessels and protected species, such as Hawaiian monk seals, sea turtles, and seabirds (Dollar, 1991).

Subsequently, a mandatory NMFS observer program was established in April 1994, to better characterize and understand the effects of the Hawaii-based longline fishery on the incidental take of sea turtle, sea bird, and marine mammal populations.

Initially, observers were placed aboard Hawaii-based longline vessels according to the Statistical Guidelines for a Pilot Observer Program to Estimate Turtle Takes in the Hawaii Longline Fishery (DiNardo, 1993). Using this approach, observer placements were distributed evenly across different strata based on target species and time. During each quarter, a pre-determined number of swordfish, tuna, mixed, or switcher vessels were randomly sampled by observers. Overall observer coverage between 1994 and 1996 was between 4.5 and 5.3%.

In April 1997, the observer placement strategy changed to reflect the guidelines established in the NOAA Administrative Report, "Recommendations for Scoping the Sea Turtle Observer Program for the Hawaii-Based Longline Fishery" (Skillman et al., 1996). These guidelines recommended that observer coverage be increased to at least 20% overall to obtain more reliable estimates of sea turtle take. However, because of a lack of funding, the Southwest Region began sampling approximately 5% of the overall fleet effort while focusing on the larger vessels, which were determined to account for 87% of the sea turtle takes. Monitoring a percentage of the small boat sector allowed the potential for detecting large changes in the turtle take rate in that portion of the fishery. The observer data are used to estimate the incidental take of sea turtles, marine mammals, and seabirds and to verify logbook data which are considered reliable for calculating fishing effort and target species, but not for estimating incidental take of sea turtles or other protected species. Observer coverage between 1997 and 1999 was 3.3 to 4.1%.

In August 2000, NMFS modified the observer program sampling design to comply with the terms and conditions of a Court Order. Vessel selections during this time period were based on observer availability and the percent observer coverage goals stipulated by the Court. In late 2000, observer services were contracted out on a permanent basis through a private contractor, Saltwater, Inc. Since January, 2001, 102 observers have been trained. An experienced corps of observers has emerged from this group enabling the NMFS observer program, administered by NMFS-PIRO, to maintain an observer staff ranging from 25 to 40 persons at a given time.

The sampling design for the program changed in 2001. Unstratified random sampling of vessels for observer placement was initiated when the entire fleet converted to targeting tuna in 2001. In May, 2002, a formal systematic sampling scheme, developed by the NMFS Honolulu Laboratory, was implemented to facilitate data analysis.

The observer program maintained observer coverage levels for the Hawaii-based longline fleet above 20% in 2001 and 2002. In the early part of 2002, coverage rates over 30% were attained when monies and personnel became available to the program. NMFS' practice is to maintain observer coverage rates slightly above 20% at any given time. The NMFS observer program completed four to five times the number of observed trips per year in 2001 and 2002 than in years prior to 2000 (see Table 2.3 for summary).

Table 2.3. Selected performance measures for the Hawaii-based longline vessel observer program, 1994-2003. (NMFS unpublished data)

Year	Number of trips[3]	Number of trips observed[4]	Percent Coverage[5] (%)
1994[6]	1031	55	5.3
1995[7]	937	42	4.5
1996	1062	52	4.9
1997	1123	40	3.6
1998	1180	48	4.1
1999	1136	38	3.3
2000	1134	118	10.4
2001	1035	233	22.5
2002	1129	278	24.6
2003 (9 months)[8]	875	187	21.4

For the purpose of monitoring with respect to the turtle interaction limits under the proposed action, NOAA-Fisheries will restructure the observer program by separating the shallow and deep set components of the fishery for the purpose of sampling design.

2.1.2. Hawaii-based Troll Fishery

The Hawaii troll fishery is a hook and-line fishery that typically uses rods and reels as well as hydraulic haulers, outriggers, and other gear to drag lures or baited hooks from moving vessels.

[3]Based on dockside information obtained by NMFS

[4]Completed number of trips

[5]Observer coverage based on number of observed trips and dock-side information.

[6] Data from March 1994 through February 1995.

[7] Data from February through December 1995.

[8] Data from January through September 2003.

Up to six lines rigged with artificial lures or live bait may be trolled when outrigger poles are used to keep gear from tangling. When using live bait, trollers move at slower speeds to permit the bait to swim naturally (WPRFMC 1995). This fishery has three major sectors: commercial troll, charter, and recreational/subsistence. A detailed description of this fishery is presented in the March 2001 FEIS (Section 3.10.3.2, pages 257 to 287).

The Hawaii-based troll fishery operates mainly within the EEZ of the Main Hawaiian Islands (Table 2.4), usually well within the 50 nautical mile protected species zone closed to longliners. The fishery operates year round but activity is usually highest during the summer months. There were 1,490 active fishermen in the commercial Hawaii based troll fishery that made 25,372 trips and landed 2.1 million pounds of fish worth 3.0 million in 2002 (HDAR,2002 preliminary).

Under the current management regime, all vessels fishing with hook and line are required to employ sea turtle handling measures and to carry certain equipment to remove hooks and line from accidentally hooked or entangled sea turtles. The proposed action does not reinstate this requirement for the pelagic handline, troll, and pole-and-line vessels.

Table 2.4. Fishery Information on the Commercial Hawaii Troll Fishery, 2002. Source: Hawaii Division of Aquatic Resources, DLNR, State of Hawaii

Area Fished	Predominantly Main Hawaiian Island's EEZ
Total Landings (in pounds)	2,170,897
Target Species	Yellowfin tuna, Mahimahi, Blue Marlin, Ono, Skipjack Tuna
Catch Composition	31.7% Tuna, 24.3% Billfish, 27.5% mahimahi, 15.9% ono
Season	All year but highest during summer months
Active Vessels	1,490
Total Permits	NA
Total Trips	25,372
Total Ex-vessel Value	US$3,004,160

2.1.3. Hawaii-based Handline Fishery

The pelagic handline fishery is predominantly a tuna fishery conducted by small boats using relatively simple hook-and-line fishing methods. In Hawaii, three types of handline fishing methods are practiced: nighttime *ika-shibi* (squid-tuna) method, daytime *palu-ahi* (chum-tuna), and seamount fishing and weather buoy method (using both handline and troll methods). The Hawaii-based handline fishery operates within the EEZ of the Main Hawaiian Islands and outside the EEZ (Table 2.5). The fishery operates year round but activity is usually highest during the summer months. The Hawaii-based handline fishery made a total of 4,433 trips in 2002 (HDAR, 2002, preliminary). A detailed description of the Hawaii-based handline fishery is covered in the March 2001 FEIS (Section 3.10.3.3, pages 287 to 305).

Handline gear is set below the surface to catch relatively small quantities of large, deep-swimming tuna that are suitable for *sashimi* markets. The Hawaii handline fishery has nearshore and offshore components. The nearshore fishery targets large yellowfin and bigeye tunas. Nearshore areas have a public sector supported FAD system. The offshore fishery targets juvenile bigeye and yellowfin tuna around seamounts and weather buoys that are 50 to 320 km (35 to 200 nm) from shore (WPRFMC 1995). Some of the larger vessels are able to fish near seamounts and weather buoys located 100 to 200 nm from shore.

In the nighttime *ika-shibi* fishery, three to four handlines are set, each consisting of a long nylon rope connected to a dacron or polypropylene mainline attached to a monofilament nylon leader. The hooks are usually baited with mackerel scad, and the lines are lowered with lead weights. To attract baitfish and tuna, a low-wattage light bulb is placed in the water, and the surface is chummed with chopped squid and/or chopped anchovies (WPRFMC 1995).

The daytime *palu-ahi* technique adds a weighted, retrievable bag stuffed with chum that is opened at a depth of 120 to 140 meters (400 to 650 ft), releasing the bait to attract tuna to the baited hooks. When a fish is hooked, it is manually hauled in, gaffed and then killed with a bullet or wooden bat.

Under the current management regime, all vessels fishing with hook and line are required to employ sea turtle handling measures and to carry certain equipment to remove hooks and line from accidentally hooked or entangled sea turtles (65 FR 16346, March 28, 2000; 66 FR 67495 December 31, 2001; 67 FR 40232, June 12, 2002). The proposed action does not reinstate this requirement for the pelagic handline, troll, and pole-and-line vessels.

Table 2.5. Summary information on the Commercial Hawaii-based Handline Fishery, 2002. Source: Hawaii Division of Aquatic Resources, 2002, preliminary

Area Fished	**Predominantly EEZ Main Hawaiian Island and seamounts outside the EEZ**
Total Landings	2,102,150
Target Species	Yellowfin tuna, Bigeye tuna
Catch Composition	37.7% yellowfin tuna, 39.2% bigeye tuna, 16.7% albacore tuna
Season	Year round
Active Vessels	421
Total Permits	NA
Total Trips	
Total Ex-vessel Value	US$2,918,704

2.1.4. Hawaii-based Pole-and-Line Fishery

The Hawaii-based pole-and-line fishery is referred to as the *aku* (skipjack tuna) fishery. This fishery uses live-bait as chum to catch skipjack tuna and juvenile yellowfin tuna. A description of the pole-and- line fishery is included in the March 2001 FEIS (Section 3.10.3.4, pages 305 - 312). Hawaii's *aku* fishery began to decline in the mid-1970s prior to closure of the tuna cannery in Honolulu.

Skipjack tuna caught by this fishery are now sold to the local fresh fish market. The Hawaii-based pole-and-line fishery operates primarily within the EEZ around the Main Hawaiian Islands (Table 2.6). Seven pole-and-line vessels actively fished in 2002. These vessels operated year round but their activity was highest during the summer months. The Hawaii-based pole-and-line fishery made a total of 239 trips in 2002. The landings by the pole-and line fishery was 550 thousand pounds which consisted almost exclusively of skipjack tuna (HDAR, 2002, preliminary)

Under the current management regime, all vessels fishing with hook and line are required to employ sea turtle handling measures and to carry certain equipment to remove hooks and line from accidentally hooked or entangled sea turtles. The proposed action does not reinstate this requirement for the pelagic handline, troll, and pole-and-line vessels.

Table 2.6. Fishery Information on the Commercial Hawaii Pole-and Line Fishery, 2002. Source: Hawaii Division of Aquatic Resources, 2002, preliminary

Area Fished	Main Hawaiian Islands EEZ
Total Landings (in poiunds)	550,737
Target Species	Skipjack Tuna
Catch Composition	93% skipjack tuna
Season	All year
Active Vessels	7
Total Permits	NA
Total Trips	239
Total Ex-vessel Value	US$746,036

2.1.5. Pacific Remote Island Areas (PRIA) Pelagic Troll/Handline Fishery

The PRIA or "U.S. island possessions in the Pacific" include Howland Island, Baker Island, Jarvis Island, Wake Island, Kingman Reef, Johnston Atoll, Palmyra Atoll, and Midway Atoll. Midway Atoll, located in the Northwestern Hawaiian Islands, is not part of the State of Hawaii and is treated as one of the PRIA. A few years ago (1998-1999), there was interest in the potential development of a pelagic troll/handline fishery around Palmyra in the central Pacific. This was spurred by two or three Hawaii-based trollers journeying to Palmyra on fishing expeditions. Also there was indication that a charter troll fishery would expand at Midway Atoll as part of an ecotourism program administered by the U.S. Fish and Wildlife Service (USFWS) (March 2001 FEIS, Section 3.10.3.5, pages 312 - 313). Today, the fishery is dormant; there is no commercial troll/handline fishing activity in EEZ waters around the PRIA in the central Pacific, which is likely due to the lack of an infrastructure at Palmyra Atoll to support a fishery. At Midway Atoll, the U.S. Fish and Wildlife Service is currently engaged in securing a private contractor to reestablish an economically viable ecotourism program. At this time it is unclear if the program will have a troll charter fishing component as part of its program. Nonetheless, current Pelagics FMP management measures include permit and reporting requirements for any U.S. fishing vessel using troll/handline fishing gear to harvest PMUS in waters of the EEZ around the PRIA (67 FR 56500, September 4, 2002). The reporting requirements enable NMFS to monitor the fishery through the collection of catch and effort data , including fishery interactions with protected species.

2.2. Pelagic Fisheries in American Samoa

The American Samoa-based pelagic fleet includes the generally small twin-hulled *alia* longline vessels, a number of mid-sized and larger monohull longliners, and a relatively small number of vessels used for trolling. In addition, the U.S. distant-water tuna purse seine fleet delivers much of its catch to the canneries in Pago Pago, the capital of American Samoa, and U.S. distant-water albacore trollers occasionally do, as well. Substantial offloading at the canneries is done by foreign purse seine and longline vessels. A detailed description of the pelagic fisheries in American Samoa is presented in the March 2001 FEIS (Section 3.10.4, pages 313 - 335). The longline and troll fishing has been described earlier under the title *Pelagic Fisheries in Hawaii.*

American Samoa's domestic longline and troll fisheries are described further below. Relatively small amounts of pelagic species are also landed from methods not generally used to target pelagic species, including bottomfishing and spearfishing. For example, in 2001 these other methods resulted in about 6,000 pounds of pelagic species landings (WPRFMC 2002c).

2.2.1. American Samoa-based Pelagic Longline Fishery

Table 2.7 summarizes the recent status of the American Samoa-based longline fishery managed under the Pelagics FMP. In 2002, the longline fleet, composed of 60 active vessels, landed 423,046 fish (primarily tunas). Landings of the longline fleet have been dominated by albacore tuna, which comprised about 79% of the landings in 2002. The ex-vessel value of longline landings in 2001 was about $8 million.

Small-scale pelagic longlining was introduced into American Samoa in 1995 by fishermen from neighboring independent Samoa (former Western Samoa), where a longline fishery was already established. The longline fleet based on the island of Tutuila, American Samoa, has been, until recently, dominated by twin-hulled boats of aluminum or wood/fiberglass, called *alia*, most of which are about 30 feet long and powered by 40 horsepower outboard engines. These vessels, on which navigation is generally limited to visual methods, typically make only single-day trips, so most of their fishing effort occurs within 25 nautical miles of shore. The longline fishery grew fairly steadily through the late 1990s, but after 2000, it expanded rapidly with the entry of a number of large vessels. In 2002, the fleet was composed of about 27 of the relatively small (< 40 feet) *alia*, about five mid-sized (40-50 feet) monohull vessels, and about 28 large (> 50 feet) monohull vessels (WestPacFin, 2003). These large vessels, which have hydraulically powered reels and electronic navigation equipment and substantially greater gear and storage capacities than the small *alia*, tend to conduct multi-day fishing trips and can range throughout the EEZ (WPRFMC 2002b and WPRFMC 2002c). The rapid influx of the large domestic longliners during just the last three years has resulted in both a dramatic increase in longline fishing effort in the EEZ around American Samoa and a shift in the spatial distribution of longline effort towards waters more distant from shore. The large-vessel closed area that went into effect early in 2002, which prohibits vessels longer than 50 feet from fishing for PMUS within approximately 50 nautical miles of the islands of American Samoa, has presumably contributed to the shift.

Table 2.7. Summary information on the American Samoa-based Pelagic Longline Fishery, 2002. Source: HDAR, 2002, preliminary

Gear	Longline
Area Fished	Inshore and EEZ
Season	All year
Active Vessels	70
Total Permits	75 (open access)
Total Sets	6,861
Total Landings (total number of fish)	423,023
Catch Composition	79% Albacore, 11% Skipjack, 4% Yellowfin, <4% all others
Total ex-vessel value	US$13.7 million

The domestic longline fleet in American Samoa expanded with the development of the *alia* longline fleet in 1996. A four-fold increase in landings between 2000 and 2001 reflects the near-doubling of the longline fleet size in that one-year period, including the entry of a number of relatively large vessels.

According to the Daily Effort Census, a dockside monitoring program, 70 vessels were engaged in longline fishing in 2002 (Western Pacific Regional Fisheries Management Council 2003). Of these 60 vessels turned in longline logs for sets made during the year. The logbooks submitted by the 60 vessels indicated that they made 6,861 sets (Figure 2.6) and set about 13 million hooks. Even though the number of vessels turning in logbooks was down from the 67 of 2001, the number of sets increased by 43% and the number of hooks set increased by 125% due to the increasing proportion of large vessels in the fleet.

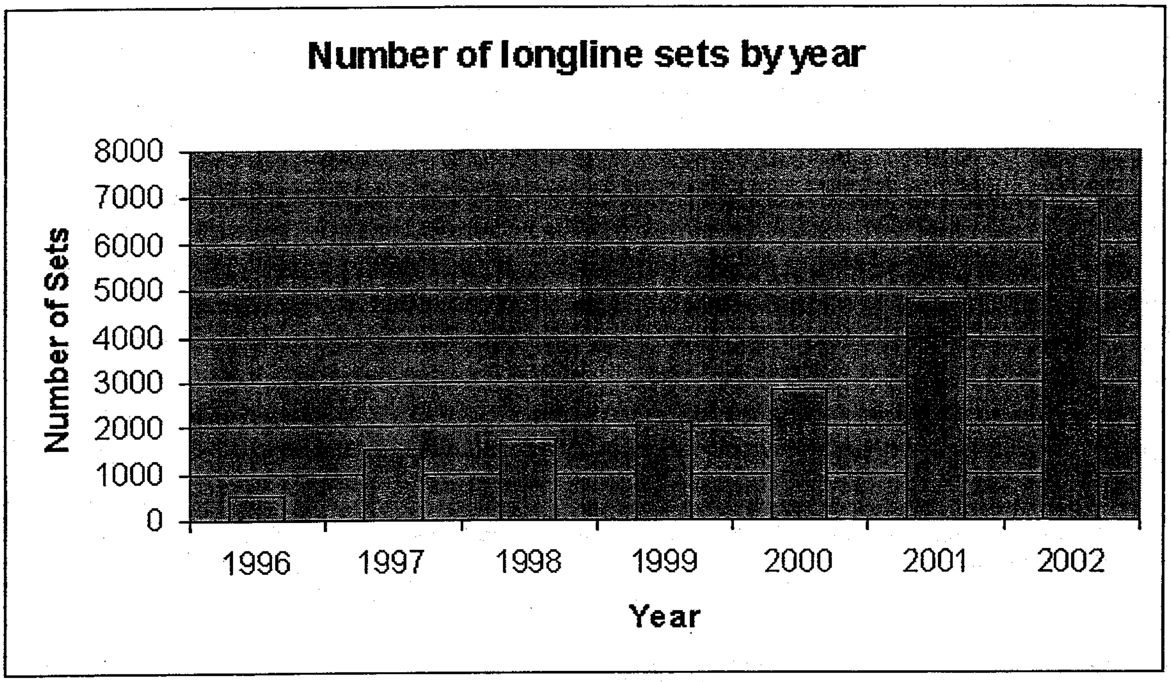


Figure 2.6. Number of sets in American Samoa longline fishery, 1996-2002. Source: WestPacFin, 2003

A record number of 478,855 fish were caught by the American Samoa longline fishery in 2002. Albacore continued to dominate the catch with 333,196 fish caught in 2002. This is a 77% increase over the record catch of 2001. Catches of skipjack tuna experienced almost a five-fold increase from 2001, while catches of yellowfin tuna increased by 107% and bigeye tuna increased by 119%.

The large increase in the number of longline vessels in 2001 and 2002 was due primarily to the entry of large (> 50 ft) vessels from outside American Samoa. O'Malley and Pooley (2002) reported that among recent new entrants in the fishery, three came from Hawaii, six came from the U.S. west coast, three came from the Gulf of Mexico, and four were U.S.-owned longliners that were foreign-built.

A Western Pacific general longline permit or Hawaii longline permit is required to longline in the EEZ around American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, or the PRIA. With the exception of the troll/handline permit requirement for the PRIA (67 FR 56500, September 4, 2002), access by U.S. vessels to the pelagic fishery in these waters is not otherwise restricted. In addition to the permit requirement, longline operators must record certain information about their fishing activity, including catch by set and species, as well as interactions with protected species, in daily logbooks. Pelagics FMP management measures also prohibit large fishing vessels (greater than 50 feet in length), except as exempted, from fishing for PMUS within approximately 50 nm of the islands of American Samoa, including Tutuila, Manua, and Swains Islands, and Rose Atoll. Pelagics FMP sea turtle measures require operators of vessels that fish for pelagic fish with hook-and-line gear to carry line clippers and bolt or wire cutters and to employ specific sea turtle handling and resuscitation methods in the event that sea turtles are accidentally hooked or entangled during fishing operations. In addition, the operators of longline vessels must annually attend a protected species workshop conducted by NMFS. Under the proposed action, vessels based in American Samoa would continue to be prohibited to fish in the EEZ around Hawaii or land longline-caught fish in Hawaii. These vessels would be allowed to engage in shallow setting north of the Equator without any of the restrictions to which the Hawaii-based longline vessels would be subject. Although this represents new fishing opportunities for these vessels, the restrictions of fishing in the EEZ around Hawaii and on landing fish in Hawaii make it unlikely to be a cost-effective option, and it is unlikely to be taken advantage of by the vessels based out of Hawaii and American Samoa.

In response to the unrestricted expansion of the pelagic longline fishery in American Samoa, the Council developed an amendment to the Pelagics FMP (Amendment 11, incorporated by reference in this Opinion), which identifies nine alternatives to control longline effort around American Samoa (WPRFMC 2002b). The preferred alternative adopted by the Council would establish a limited access program in which eligibility to participate in the fishery is limited to owners of vessels that legally harvested PMUS with longline gear in the EEZ around American Samoa on or prior to March 21, 2002. Once the initial permits are issued to eligible participants, the number of available permits would be limited to that number. The limits would be broken down into each of four vessel size classes, although there would be limited opportunities for permit upgrades (by vessel size class) during the first four years of the program.

It has been estimated that a maximum of 138 individuals would likely to be eligible for initial permits, although not all eligible individuals would necessarily obtain a permit (WPRFMC 2002b). This is almost twice the number of currently permitted longline vessels, with most of the difference in the smallest of the four vessel size classes (≤ 40 ft), as indicated in Table 2.8.

Table 2.8. Current number of Permitted Longline Vessels based in American Samoa and likely number of permits available under the preferred alternative of proposed Amendment 11. Source: WPRFMC, 2002b.

Vessel Size	Current Number of Permits	Potential Number of Permits in 2003
< 40 ft.	40	93
40-50 ft.	5	9
50-70 ft.	15	15
> 70 ft.	15	21
All	75	138

The wide range of longline vessel types and associated fishing power in the American Samoa-based longline fleet is highlighted in data from two sources. Table 2.9 lists some of the typical characteristics of three vessel types used in American Samoa and neighboring Samoa, including the most common *alia* design (28 ft), the less common 40-foot *alia*, and the typical monohull longliner greater than 50 feet in length. Table 2.9 shows, for 2001, some of the same characteristics for three vessel types, as measured for the American Samoa fleet from logbook data. The estimates from the logbook data of sets per boat-year and hooks per boat-year are substantially less than the estimates for comparable vessel types given in Table 2.9. One possible explanation for the difference is that some of the vessels monitored in American Samoa in 2001 arrived in 2001 and did not fish the full year.

Table 2.9. Profiles of Longline Vessels based in American Samoa and Samoa (formerly Western Samoa). Source: Mulipola, 2000, pers. comm. cited in WPRFMC 2000.

Vessel Size and Type	28 ft. alia	40 ft. alia	50 + ft Monohull
Purchase Price (USD)	$25,000	$60,000	$250,000
Miles of mainline set	7-10	20-25	35-50
Sets per trip	1-2	up to 4	6-8
Hooks/set	250-350	500-900	1,200-1,600
Trips/year	100-200 (wester dependent)	50	40
Hooks/year	30,000-60,000	160,000	400,000

Amendment 11 includes an assessment of the likely effects of the management alternatives. In order to estimate the likely total fleet-wide fishing effort that would occur under the preferred alternative, certain assumptions were made about likely levels of participation and per-vessel fishing effort, by size class. Using the assumptions made in the first three rows of Table 2.10, the estimate of total likely effort in the EEZ around American Samoa was about 17 million hooks per year assuming no permit upgrades and about 25 million hooks per year assuming all available permit upgrades are taken. It was estimated that about 85 to 90 percent of total effort would occur beyond 50 nm from shore (WPRFMC 2002b). The estimates were based on the assumption that 75 vessels (the number permitted as of the control date, March 21, 2002) would obtain permits and actually fish. In comparison, the Hawaii-based longline fleet included 100 vessels in 2002 and set a record of 27 million hooks.

2.2.2. American Samoa-based Troll Fishery

Table 2.11 contains a summary of the recent status of the American Samoa-based troll fishery managed under the Pelagics FMP. In 2001, the troll fleet, composed of about 18 active vessels, landed about 24,000 pounds of pelagic species (Figure 2.9), dominated by skipjack and yellowfin tuna, with an ex-vessel value of about $24,000. In 2002, longlining constituted approximately 99.8 % of the total landings whereas trolling constituted 0.2% of landings recorded.

While the longline fishery has grown rapidly during the last few years, the troll fishery has diminished (although not as dramatically as the longline fishery has grown) due to troll fishermen switching to longlining. Trolling catches decreased fairly steadily from 1982 through 2001. This trend may reflect the increase in effort of longline fishing method used by local fishermen during this period. In 2002, landings by the troll fishery comprised only about 0.2% of total pelagic species landings in American Samoa by the locally based fleets. Recently there have been anecdotal reports of *alia* fishermen returning to trolling, but data are not available to indicate the extent of the shift.

Table 2.10. Estimates of Likely Fishing Effort in American Samoa's Longline Fishery under Amendment 11. Source: WPRFMC 2002b.

	< 40 ft.	40-50 ft.	50-70 ft.	>70 ft.	Total
Average sets/boat year	125	175	225	225	
Average hooks/boat year	43, 750	218,750	472,550	472,550	
Boats	40	5	15	15	75
Total sets/year	5,000	900	3,400	3,400	13,000
Total hooks/year	1,750,000	1,094,000	7,087,000	7,087,000	17,000,000

Table 2.11. Summary information on the American Samoa-based Troll Fishery, 2002. Source: NMFS unpublished data

Gear	**Troll**
Area Fished	Nearshore and EEZ
Total Landings	24,000 lb.
Landings Composition (by weight)	50% skipjack, 20% yellowfin, 9% pomfret
Season	All year
Active vessels	18
Total Permits	n/a
Total trips	343
Total ex-vessel value	$24,000

Values were estimated as the product of total landings and average prices by species group reported in WPRFMC 2002c.

2.3. Pelagic Fisheries in the Territory of Guam

U.S. domestic fishing vessels based in Guam that target PMUS are the distant-water tuna purse seiners, longliners, and smaller recreational trollers. The larger purse seiners fish outside the EEZ around Guam and transship their catch through Guam. The smaller recreational fishing vessels, which are either towed to boat launch sites or berthed in marinas, and domestic longliners, fish within the EEZ around Guam or the adjacent EEZ around the Northern Mariana Islands. There is no active domestic longline fishery in Guam at this time. Background information on the pelagic fisheries in Guam is contained in the March 2001 FEIS (Section 3.10.5, pages 335 - 352), which is incorporated in this Opinion by reference.

Guam's domestic pelagic fishery consists mostly of small trolling vessels that are recreational, subsistence and/or commercial (part-time). There is also a small, but significant charter troll fleet that are full-time commercial. Table 2.12 profiles the pelagic fishery as it existed in 2002. The number of troll fishing vessels active in the Guam pelagic fishery in 2002 remained constant with 375 active vessels (Figure 2.12). In 2002, the total pelagic landings were about 533,855 pounds, a decrease of 42% from 2001.

Table 2.12. Summary Information on the Pelagic Fishery in Guam, 2001. Source: NMFS unpublished data.

Gear	**Troll/Charter**
Area Fished	Nearshore and EEZ
Total Landings (in pounds)	533,855
Targets and Catch Composition	33% skipjack tuna, 32% mahimahi, 13% wahoo, 8% yellowfin tuna, 10% Pacific blue marlin
Season	All year
Active Vessels (est.)	375
Total Permits	NA
Total Trips	8,933
Total Ex-vessel (Commercial) Value*	US$486,946

*Data (inflation-unadjusted) are available for commercial value, and unavailable for noncommercial values.

2.4 Pelagic Fisheries in the Commonwealth of the Northern Mariana Islands

The CNMI-based pelagic fleet is composed primarily of vessels less than 24 feet in length that are used for trolling and that tend to range no more than about 20 miles from shore (WPRFMC 2002a). The charter component of the fleet includes larger vessels. Most of the fleet is based on Saipan, with smaller numbers of boats on Rota and Tinian. No longlining or purse seining currently occurs in the EEZ around the CNMI. Background information on the pelagic fisheries of the CNMI is presented in the March 2001 FEIS (Section 3.10.6, pages 352 - 362), which is incorporated by reference in this Opinion.

Table 2.13 contains a summary of the recent status of the CNMI-based troll fisheries managed under the Pelagics FMP. These estimates of landings, fishing effort, and revenues are derived from records of fish sales only on the island of Saipan, and not all fish sales on Saipan are recorded. It was estimated in WPRFMC (2002c:4-1) that "the commercial purchase database landings include more than 90% of all commercial landings on Saipan."

Table 2.13. Summary Information on the Pelagic Fisheries of the Commonwealth of the Northern Mariana Islands, 2002. Source: draft WPRFMC 2003

Gear	Troll/Charter
Area Fished	Nearshore and EEZ
Total Landings (in pounds)	253,274
Landings Composition (by weight)	70 % skipjack tuna, 7% mahimahi, 12% yellowfin tuna
Season	All year
Active Vessels	86
Total Permits	NA
Total Trips	1,803
Total Ex-vessel Value	US$499,730

Note: These estimates are only for commercial activity that resulted in fish sales on Saipan. The estimates of CNMI-based fishing activity that are provided in Table 2.13 and throughout this section have not been adjusted to account for the unreported components of the fisheries, so unless otherwise noted, the estimates provided here under-represent total pelagic fishing activity in the CNMI

Figure 2.13 shows the numbers of fishermen that were active in Saipan's commercial pelagic fisheries from 1984 through 2002. Each year's estimate is the number of individuals that were recorded as having sold any pelagic species during the year. Based on the WPRFMC draft report (draft WPRFMC,2003) about 55 vessels were identifed as involved in full time commercial fishing and 41 vessels were classified as part-time. No fishing and/or recreational usage included 312 vessels. Twenty-six vessels were registered as charter vessels for 2002.

3.0 APPROACH TO THE ASSESSMENT

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. §1536), requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat that has been designated for those species. Regulations that implement section 7(b)(2) of the ESA define *jeopardize the continued existence of* as engaging in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). With respect to threatened and endangered species, then, federal actions are required to ensure that their actions would not be reasonably expected to appreciably reduce the species' likelihood of both surviving and recovering in the wild, by reducing the species' reproduction, numbers, or distribution.

The regulations that defined destruction or adverse modification were vacated by the Court in *Sierra Club* v *U.S. Fish and Wildlife Service and National Marine Fisheries Service* (Fifth Circuit Court of Appeals; CA No. 98-3788-K-2 E.D. La). Until the Services promulgate a new regulatory definition, the Services apply the statutory definition of critical habitat: "(i) the specific areas within the geographical area occupied by the species, at the time it is listed ,..., on which are found those physical or biological features (ii) essential to the conservation of the species and (ii) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed,..., upon a determination by the Secretary that such areas are essential for the conservation of the species" (16 U.S.C. 1533(5)(A)).

By law, the National Marine Fisheries Service (NOAA-Fisheries) issues biological opinions to help federal agencies comply with the requirements of section 7 of the Endangered Species Act. This biological opinion is designed to help the Sustainable Fisheries Division of NOAA-Fisheries' Pacific Islands Regional Office ensure that the proposed management regime of the pelagics fisheries of the western Pacific region is not likely to jeopardize the continued existence of threatened or endangered species. Because the proposed fisheries are not likely to adversely affect critical habitat that has been designated in the action area for this consultation, this Opinion will focus only on jeopardy analyses.

3.1 Method

After receiving a complete description of the proposed management regime for the fisheries from Pacific Islands Regional Office's Sustainable Fisheries Division, we conducted our assessment of the effects of the proposed fisheries and fishery management regime using four discrete steps:

1. Our first step of our assessment deconstructed the proposed fisheries management plans into their constituent parts (using our agency's prior experience with the fisheries and published information, and) to allow us to distinguish the effects of different fisheries and different fishing strategies on listed resources.

2. The second step of our assessment consisted of exposure analyses which identify the listed species and designated critical habitat that are likely to co-occur with different components of those fisheries in space and time and any important attributes of that co-occurrence that might help explain the potential risks the fisheries pose to the species.

3. The third step of our assessment consisted of response analyses which identify how listed resources are likely to respond once exposed to the Action's stressors. These analyses distinguished between turtles that are captured and released, unharmed; captured and released with injuries that prove fatal later, and sub-lethal effects. As part of these analyses, we considered new information on sea turtle mortalities following their release after having been captured by longline gear.

4. The final step of our assessment used the analyses from the previous two steps identify the number of individuals of each species that are likely to be exposed to the proposed fisheries (as well as other information like their age or life history stage) and what is likely to happen to those individuals given exposure. In the final step of our assessment we ask (1) what is likely to happen to different nesting aggregations given the exposure and responses of individual members of those aggregations and (2) what is likely to happen to the populations or species those nesting aggregations comprise (Table X provides the details of the risk analyses we have conducted for these consultations).

In this consultation, our analyses focused on four specific measures of a species' extinction risk: (a) estimated times to quasi-extinction; (b) probabilities of quasi-extinction in 25, 50, and 100-year time intervals to capture the short-term, mid-term, and long-term risks the fisheries may pose to listed resources; (c) mean times to quasi-extinction; and (d) median times to quasi-extinction. To assess the probability of regional extinction (for example, the probability of leatherback turtles becoming extinct in the Pacific Ocean), we consider a regional probability of ultimate extinction. We consider probabilities of extinction over multiple time horizons because the results of most population models have a log-normal or right-skewed distribution, species have higher short-term risks of extinction and lower long-term extinction risks. At the same time, the long-lives of species like turtles can often mask their extinction risks over time so long-term projections allow us to detect the dampening influence of their long lives.

As the preceding paragraph suggests, our analyses focused on the risks of species falling below quasi-extinction thresholds rather than declining to zero. We used quasi-extinction thresholds instead of true extinction for several reasons. First, most populations or species that have become extinct since the passage of the Endangered Species Act became extinct because their populations had declined to levels were demographic stochasticity — or variation in the number of births and the number of deaths in a population — dominated their population dynamics. Quasi-extinction thresholds can help prevent species from declining to levels where demographic stochasticity makes their extinction almost certain. For these reasons, recent literature on conservation biology and population modeling recommends using quasi-extinction thresholds instead of true extinction for population viability analyses (for example, see Burgman et al. 1993, Morris and Doak 2002).

Finally, jeopardy analyses must look into the future to encompass any delays between the effects of an action and the population responses of threatened and endangered species. Some human activities appear to have "delayed" effects on plant and animal populations, which can occur for two primary reasons. First, a disease, toxic chemical, or other stressor may take time to accumulate and individuals animals may respond only after they receive particular threshold doses. Second, a human stressor may have immediate effects on individuals or populations, but the ecology of the species may mask our ability to detect the effect. In the previous example, the bald eagle populations had declined for several years before humans were able to detect it. This kind of "delayed" effect probably reflects limitations in our ability to detect effects below certain thresholds or our inability to identify abnormal population declines given background rates of population variability.

With sea turtles, we expect the second kind of "delayed" effect. Because of these delayed effects, assessments in the Services' biological opinions must look far enough into the future to (1) be certain of detecting a population's response to an effect, (2) be certain of detecting changes in a species' reproduction, numbers, and distribution, and (3) be certain of detecting changes in a species' likelihood of surviving and recovering in the wild (Crouse 1999). If we do not look far enough into the future, we increase the risk of failing to detect a population's response to a human activity and we are more likely to falsely conclude there was no effect when, in fact, an effect occurred (which, in the case of fisheries, means that adult, subadult, and juvenile turtles will have been captured and killed for a period of years). If we look too far into the future, the passage of time can mask short-term collapses in a population and, again, we increase our likelihood of falsely concluding there was no effect when, in fact, an effect occurred.

3.2 Relationship Between these Analyses and Jeopardy Determinations

We begin our analyses with an implicit understanding that the sea turtles considered in this Opinion are threatened with global extinction by a wide array of human activities and natural phenomena; we have outlined many of those activities in the *Status of the Species* section of this Opinion. We also recognize that some of these other human activities and natural phenomena pose a much larger and more serious threat to the survival and recovery of threatened and endangered species than the U.S. Pacific pelagics fisheries. For example, many foreign fishing fleets have substantially larger, adverse effects on threatened and endangered sea turtle populations in the Pacific Ocean than U.S. fishing fleets. We recognize that we will not be able to recover threatened and endangered species without addressing the full range of human activities and natural phenomena that have caused these species to decline or could cause these species to become extinct in the foreseeable future (USFWS and NMFS 1997). Recovering threatened and endangered sea turtles, as with other imperilled marine species, will require an international, cooperative effort that addresses the full suite of threats to those species.

Nevertheless, our task in this consultation is not to identify the various risks contributing to the endangerment of listed marine species, rank them according to their relative significance, and address them according to their ranked order. Our task in a consultation is simpler: identify the direct and indirect effects of the U.S. Pacific pelagics fisheries managed under the Western Pacific Pelagics Fisheries Management Plan to determine if the proposed management regime is likely to *contribute* to the endangerment of threatened and endangered species by appreciably reducing their likelihood of both surviving and recovering in the wild. We reach our conclusions by adding the fisheries' effects to the effects of other human activities and natural phenomena on the species' status and trend as described in the *Status* and *Environmental Baseline* section of this Opinion.

For this assessment, we consider several scenarios that represent various assumptions about which nesting aggregations of the different species of sea turtles are likely to be exposed to the proposed fisheries and their responses upon exposure. We use these scenarios as the starting point of our risk assessment (see Table 2). Using those scenarios as reference points, we evaluate the evidence we have assembled to determination if reductions in reproduction, numbers, or distribution of threatened or endangered species, if there are any, would reasonably be expected to reduce a species' likelihood of surviving and recovering in the wild.. Our conclusions about whether the proposed fisheries are or are not likely to jeopardize the continued existence of listed species relies on the strength of the assembled evidence using our general understanding of population dynamics and the processes by which other populations and species have already become extinct.

3.3 Evidence Available for the Assessment

Detailed background information on the status of these species and critical habitat has been published in a number of documents including recent status reviews of sea turtles (NMFS and USFWS, 1995; USFWS, 1997); recovery plans for the eastern Pacific green turtle (NMFS and USFWS, 1998a), U.S. Pacific populations of hawksbill sea turtles (NMFS and USFWS, 1998b), loggerhead sea turtle (NMFS and USFWS, 1991), leatherback sea turtle (NMFS and USFWS, 1992), and U.S. Pacific populations of olive-ridley sea turtles (NMFS and USFWS, 1998c); and reports on interactions between sea turtles and gear used in pelagic fisheries (Bolten *et al.*, 1996). In addition, Crouse *et al.* (1987), Crowder *et al.* (1994), Heppell (1998), Heppell *et al.* (1996, 1999, and 2000) published results from population models, sensitivity analyses, and elasticity analyses for various species of marine turtles, although most models are based on data on loggerhead sea turtles in the Atlantic Ocean.

In the past two years, significant new information on the biology and ecology has become available and has begun to answer some of the major questions that remain about the biology and ecology of sea turtles. For example, combining the information provided by Kamezaki et al. (2003) on the structure, status, and trends of the loggerhead sea turtle nesting aggregation in Japan with earlier work on the geography of a rare haplotype in Japanese loggerhead sea turtles and the incidence of that haplotype in the area fished by the Hawaii-based longline fisheries allows us to distinguish between the nesting aggregations on Yakushima Island and other nesting aggregations in Japan. Polovina et al. (2004) provides substantial new information on the migratory patterns of loggerhead and olive ridley sea turtles in the Pacific Ocean and their relationships with oceanographic phenomena like eddies and currents.

Lutz et al. (2001) edited a volume on the biology of sea turtles that integrated and synthesized substantial amounts of new information on the general ecology and biology of sea turtles generally, including their reproductive ecology, population dynamics, biogeography, and threats.

Bolten and Witherington (2003) edited a volume that further integrated the state of scientific knowledge on the biology and ecology of loggerhead sea turtles, including their biology, distribution, population structure, and population dynamics

Despite the availability of this new information, our knowledge of the biogeography, migratory patterns, life history and population dynamics, and their response to environmental and other variation remains rudimentary and limits the precision of our assessments. The National Research Council (1990) identified many of these limits and recommended research on a wide array of variables, including age at reproductive maturity, age-specific rates of survivorship and fecundity, distribution, and migration.

To conduct this assessment, we relied on three kinds of evidence: (1) empirical information, that is data, studies, other observations of species and populations that have become extinct; (2) quantitative analyses using data that had been gathered from other threatened, endangered, or extinct species or populations; and (3) the results of computer simulations and similar analyses. From the perspective of the evidence available for this consultation, we must distinguish between the data that are available, the various methods that are available to analyze those data, the theoretical foundations for our current understanding of population ecology, and computer simulations and similar analyses that are conducted to gain insights into population ecologies, but are often based on a series of assumptions rather than data collected through empirical study.

Truly quantitative models require large amounts of data on the survival, growth, and fecundity of the different life stages of species and populations and the effects of environmental variability on these parameters (Feiberg and Ellner 2000, Groom and Pascual 1998). Without robust, long-term data, "quantitative" models can lead to highly-biased estimates of the extinction risks facing populations and species (Beissinger and Westphal 1998, Feiberg and Ellner 2000, Heppell et al. 2003, Ludwig 1996, Ludwig 1998, Taylor 1995). With the exception of long-term datasets for loggerhead sea turtles in Australia, the kind of information these models require is not available for this consultation and are not likely to become available in the near future.

Absent the robust, long-term demographic data required by the more complex computer simulation models, we have to rely on simpler analytical methods whose results require qualitative interpretation because of the uncertainty and assumptions underlying these methods. Bolten *et al.* (1996) and Heppell et al. (2003) concluded that developing analytical tools to support assessments like the one we must conduct in this Opinion requires much more information than is currently available. Pritchard (1996) concluded that we do not currently have enough life history data on sea turtles to construct models that can be used for predictive purposes. Until we have more robust demographic data, we must interpret the products of any "quantitative" analyses with sufficient caution and reason to blur any distinction between qualitative and quantitative analyses (Beissinger and Westphal 1998, Feiberg and Ellner 2000, Heppell et al. 2003, Ludwig 1998). To do otherwise with the limited data available would give the appearance of numerical precision without the reality of it Burgman et al. 1993, Caughley 1994, Cortes 1999, Morris and Doak 2002, Reed et al. 1998). As a result of these limits, we cannot quantify the effects of changes in abundance, reproductive success, and other vital rates on a sea turtle population's likelihood of surviving and recovering in the wild.

4.0 DESCRIPTION OF THE ACTION AREA

The action area is all the areas that will be affected directly or indirectly by the Western Pacific Pelagics Fisheries. These fisheries occur throughout the central, western, and northern Pacific Ocean, including inside the EEZ around U.S. islands in the Pacific. These are the islands of American Samoa (Tutuila, Rose Atoll, Swain's Island, and Manua group islands); Commonwealth of the Northern Mariana Islands (Saipan, Rota, Tinian, Farallon de Medinilla, Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Farallon de Pajaros); Hawaii (main and Northwestern Hawaiian Islands), Guam, and the largely uninhabited U.S. Pacific remote island areas comprised of Johnston Atoll, Kingman Reef, and Palmyra, Jarvis, Howland, Baker, Midway, and Wake Islands (see Figure II-15). Thus the action area, for purposes of this opinion, is the EEZs around the U.S. Pacific islands and the high sea waters where U.S. fishing vessels that target Pacific pelagic management unit species using longline, troll, and handline gear are managed under the Pelagics FMP.

4.1. Pelagic Fisheries in Hawaii

4.1.1. Hawaii Longline Fishery

The Hawaii longline fishery operates inside and outside the EEZ around the main Hawaiian islands and Northwestern Hawaiian Islands (NWHI). Longline fishing is prohibited inside the protected species zone surrounding the NWHI (50 nautical miles from the center geographical positions of Nihoa Island, Necker Island, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Island, and Kure Island) to protect monk seals (see Figure II-16). The area closed around the main Hawaiian Islands varies from 25 to 75 nautical miles seaward of the shore depending on the season, island, and direction of the facing shore. These closures are in place to alleviate potential gear conflicts among small boat handline/troll fishers, charter boat operators, recreational fishers, and longline fishers. From

Figure 4.1. Exclusive Economic Zones (EEZs) of the Pacific Islands. Western Pacific Regional Fishery Management Council managed areas are shaded. Source: NMFS, Pacific Islands Area Office.

February 1 through September 30 each year, longline fishing is prohibited up to 75 nautical miles around the main Hawaiian Islands in the portion of the EEZ seaward of Hawaii bounded by straight lines. From October 1 through the following January 31 each year, longline fishing is prohibited further inshore around the main Hawaiian Islands in the portion of the EEZ seaward of Hawaii (see Figure 4.3).

Hawaii-based longline vessels vary their fishing grounds depending on their target species. Most effort is to the north and south of the Hawaiian Islands between the equator and 40 ^{O} N and longitudes 140 ^{o} and 180 ^{o} W.

4.1.2. Hawaii-based Troll Fishery

The Hawaii troll fishery, composed of commercial, troll, charter, and recreational/subsistence sectors, generally operates within the EEZ around the main Hawaiian Islands, between 4.9 miles to 53.5 miles offshore. Most of the trips occur within 25 miles from shore (NMFS, 2000). The charter trolling fleet typically operates about 7.5 miles from shore.

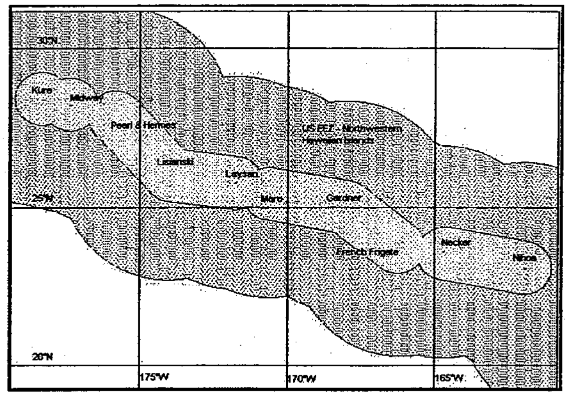


Figure 4-2. Protected species zone around the Northwestern Hawaiian Islands closed to longline fishing.

4.1.3. Hawaii-based Handline Fishery

The offshore handline fisheries occur between 35 to 200 nautical miles from shore, whereas the inshore handline fisheries occur between 5 and 14 miles from shore.

4.1.4. Hawaii-based Pole-and-line Fishery

The pole-and-line fishery operates within 25 miles offshore in the EEZ around the main Hawaiian Islands.

4.1.5. Troll/Handline fishery in the U.S. Pacific remote island areas (PRIA)

At present, there is no pelagic troll/handline fishery in the EEZ around the PRIA. It is expected that an active fishery would occur within 25 miles from shore.

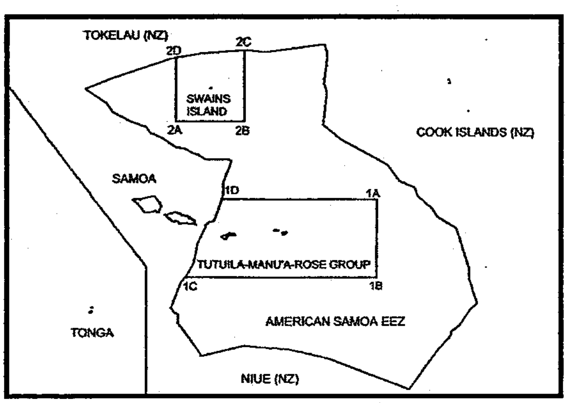


Figure 4.5. Areas around American Samoa closed to vessels greater than 50 feet in length.

4.2. Pelagic Fisheries in American Samoa

Most of the pelagic hook-and-line fishery based in American Samoa occurs within the EEZ, although vessels greater than 50 feet in length targeting PMUS are prohibited from fishing within approximately 50 nautical miles of the islands of American Samoa, including Tutuila, Manua group and Swains Islands, and Rose Atoll (see Figure II-19). The local, small (<40 ft in length) *alia* longline fleet and charter trolling vessels typically operate within 50 nm from the islands.

The American Samoa-based pelagic longline fleet, which until recently was comprised exclusively of *alia* less than 30 feet in length, generally fished within 25 nautical miles from shore. The recent entry of numerous large (>50 ft) longline vessels, most of which can range throughout the EEZ, has resulted in not only a dramatic increase in longline fishing effort but also a shift of fishing effort in waters between 50 and 200 nm from shore.

4.2.1. American Samoa Troll Fishery

The majority of the American Samoa troll fleet, which is composed of relatively small boats, fishes within 50 nautical miles from shore, although some vessels may fish as far out as 100 nautical miles.

4.3. Pelagic Fisheries in Guam

4.3.1. Guam-based troll (recreational, commercial, and charter) Fishery

The troll vessels in Guam are small, primarily recreational trolling boats that are either trailered to launch sites or berthed in marinas. The vessels generally fish inshore (within 25 nautical miles of

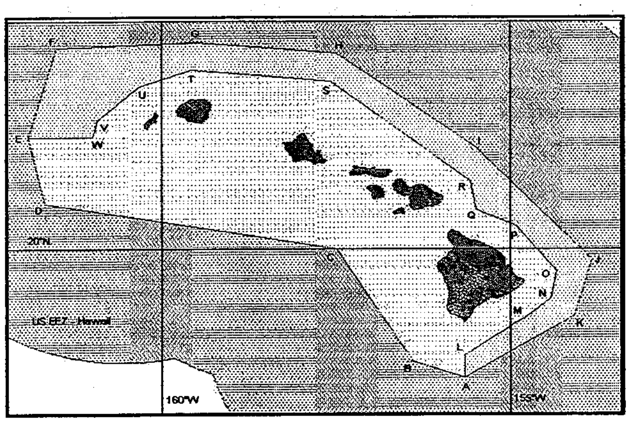


Figure 4.3. Closed areas to longline fishing around the main Hawaiian Islands. Distance from shore varies from 25 to 75 nautical miles. Vessels are required to fish further away from shore on the windward side (Northwest) of the islands from February 1 through September 30 each year.

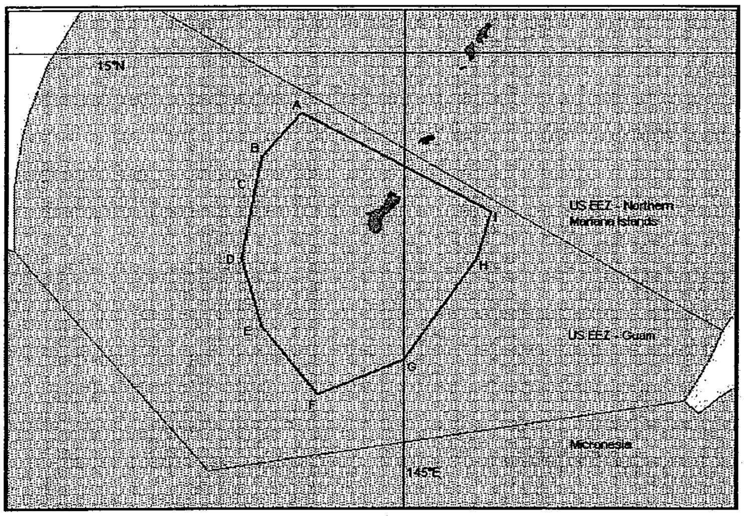


Figure 4.5. Closed area to longline fishing around the island of Guam.

shore) because of their small size. The larger vessels may fish further out within the EEZ.

4.3.2. Guam-based Longline Fishery

Figure II-20 depicts the 50-nm area around Guam that is closed to longline fishing. Vessels registered with longline general permits fish outside this closed area. There is no domestic longline fishery off Guam at this time.

4.4. Pelagic Fisheries of Commonwealth of Northern Mariana Islands

4.4.1. Commonwealth of Northern Mariana Islands Troll Fishery

The troll fishery occurs primarily between the island of Farallon de Medinilla and the island of Rota to the south. Most of the pelagic troll vessels are based on Saipan. They are small (generally <24 feet) and operate primarily within 20 nautical miles from shore. Larger vessels may fish further offshore within the EEZ. There is no domestic longline fishery in the Commonwealth of the Northern Mariana Islands at this time.

4.5. Western Pacific Tuna Purse Seine Fishery

The U.S. tuna purse seine fishery is managed under the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (the South Pacific Tuna Treaty). Although the fishery occurs in the action area and subject to management under the Magnuson-Stevens Fishery Conservation and Management Act, for the most part this fishery is not regulated under the Pelagics FMP. [Note: Pelagics FMP regulations prohibit domestic purse seine vessels from fishing within the 50-nm area closure around American Samoa].

5.0 STATUS OF LISTED RESOURCES AND ENVIRONMENTAL BASELINE

The following endangered and threatened species occur in the action area, as defined above, and may be affected by the proposed action:

Marine Mammals	**Status**
Blue whale (*Balaenoptera musculus*)	Endangered
Fin whale (*Balaenoptera physalus*)	Endangered
Hawaiian monk seal (*Monachus schauinslandi*)	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
Pacific right whale (*Eubalaena japonica*)	Endangered
Sei whale (*Balaenoptera borealis*)	Endangered
Sperm whale (*Physeter macrocephalus*)	Endangered
Sea turtles	
Green turtle (*Chelonia mydas*)	Endangered/Threatened
Hawksbill turtle (*Eretmochelys imbricata*)	Endangered
Leatherback turtle (*Dermochelys coriacea*)	Endangered
Loggerhead turtle (*Caretta caretta*)	Threatened
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered/Threatened

Except for the Hawaiian monk seal, no critical habitat has been designated for any of these threatened or endangered species in the Pacific Ocean. In May 1988, NMFS designated critical habitat for the Hawaiian monk seal out from shore to 20 fathoms in 10 areas of the Northwestern Hawaiian Islands. Critical habitat for these species includes "all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms around the following: Kure Atoll, Midway Islands, except Sand Island and its harbor, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island" (50 CFR § 226.201). Some U.S. fisheries regulated under the Pelagics FMP fish in critical habitat areas of the Hawaiian monk seal (i.e., ocean waters out to 20 fathoms depth), although they do not adversely affect physical features identified as critical habitat. In addition, these fisheries do not target or incidentally catch prey species of the Hawaiian monk seals. Therefore, although the action area for the proposed fisheries includes the critical habitat for the endangered Hawaiian monk seals, the proposed action is not likely to adversely affect critical habitat that has been designated for the Hawaiian monk seal.

Although blue whales, fin whales, northern right whales, and sei whales are found within the action area and could potentially interact with the U.S. fisheries under the Pelagics FMP, there have been no reported or observed incidental takes of these species in these fisheries. Therefore, although the action area for the proposed fisheries includes the distribution of endangered blue whales, fin whales, Pacific right whales, and sei whales, the proposed action is not likely to adversely affect these species, which will not be considered further in this Opinion.

The endangered Hawaiian monk seal is currently found throughout the northwest Hawaiian Islands, specifically: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianki Island, Laysan Island, French Frigate Shoals, Gardner Pinnacles, Necker Island and Nihoa Island. These islands form a chain approximately 1,840 km long. Hawaiian monk seals are also occasionally found in the main Hawaiian Islands. The longline area closure around the northwest Hawaiian Islands that was instituted in 1991 (longline fishing prohibited within 50 nm of the northwest Hawaiian Islands and in 100 nm closed corridors connecting the non-contiguous closed circles) appears to have eliminated monk seal interactions with the Hawaii-based longline fleet, as there have been no observed or reported interactions with this fishery since then. In addition, there have been no reported interactions between Hawaiian monk seals and other fisheries under the Pelagics FMP. Therefore, although the action area for the proposed fisheries includes the distribution of the endangered Hawaiian monk seals, NOAA-Fisheries has determined that the proposed action is not likely to adversely affect the Hawaiian monk seal.

In 1991, one humpback was reported by an observer entangled in the mainline of a Hawaii-based longline vessel. The animal was released with trailing gear (Dollar 1991). The interaction occurred inside what is now the protected species zone (50 nautical miles) of the islands and atolls of the Northwestern Hawaiian Islands (Bob Harman, NMFS, personal communication, November, 2000). Another humpback whale was reported entangled in longline gear off Lanai (Nitta and Henderson 1993) and by whalewatch operators off Maui in 1993 (Hill and DeMaster 1999). Although the reports did not identify the gear as pelagic longline gear, both observations are believed to have been of the same whale.

Humpback whales favor waters less than 100 fathoms (183 meters) around the main Hawaiian Islands. The highest densities of humpback whales occur in the shallow-water, inter-island channels of the four-island region (Maui, Lāna'i, Moloka'i, and Kaho'olawe) and Penguin Bank (Hudnall 1978, Baker and Herman 1981, Mobley and Bauer 1991 *in* Mazzuca *et al.* 1998). Because humpback whales prefer shallower waters and the 1991 interaction occurred inside the 50 nautical mile area now closed to longline fishing, NOAA-Fisheries believes there is almost no likelihood of another interaction between the Hawaii-based longline fishery and a humpback whale.

NMFS has observed one sperm whale interaction by the Hawaii-based longline fishery. The event occurred in May 1999 inside the Northwestern Hawaiian Islands exclusive economic zone or EEZ (about 140 nautical miles north of Raita Bank) and the vessel was targeting swordfish (gear was set at night, lightsticks were used, and no line shooter was used). According to the observer report, the sperm whale's pectoral fin was entangled in the mainline. The captain stopped the boat, let out more mainline, and then backed up until he could reach the other end of the mainline. At this point, both ends of the mainline, on each side of the sperm whale, were secured on the vessel. During this time, the whale broke the mainline and swam away without trailing gear. This is the first reported interaction by the observer program since the Hawaii-based longline fleet has been monitored (1991). No other interactions between sperm whales and other fisheries have been reported under the Pelagics FMP.

Based on observer reports in the Hawaii-based longline fishery, vessels using longline gear to target highly migratory species have on rare occasions interacted with sperm whales. These species interacted with longliners based out of Hawaii in areas of the north Pacific Ocean where longliners based out of the west coast also fish. Therefore, the possibility exists that longliners based out of the west coast could interact with these marine mammal species, although there have been no reports from observers or fishermen in their logbooks. NOAA-Fisheries acknowledges the possibility of interactions between the proposed fisheries (particularly the Hawaii-based longline fishery) and sperm whales but interprets the available data to conclude that future interactions are improbable. Therefore, NOAA-Fisheries does not anticipate another sperm whale interaction in the foreseeable future by the Hawaii-based longline fishery. As a result, although the action area for the proposed fisheries includes the distribution of endangered humpback whales and sperm whales, NOAA-Fisheries has determined that the proposed fisheries are not likely to adversely affect these whale species.

Based on observed and reported interactions between the Hawaii-based longline fishery and four species of sea turtles, NOAA-Fisheries has determined that the proposed action is likely to adversely affect green, leatherback, loggerhead, and olive ridley turtles. Therefore, formal consultation is required in order to analyze the effects of the proposed action on these listed species.

The following narratives summarize the current state of knowledge on the life history, distribution, and population trends of these sea turtle species and that NOAA-Fisheries expects may be incidentally taken as a result of the proposed action. These narratives focus primarily on the Pacific Ocean populations of these species as these are the populations directly affected by the proposed action. However, NOAA-Fisheries recognizes that many of these species are listed as global populations (e.g. leatherback and loggerhead turtles and large whales), and the global status and trends of these species are included as well in order to provide a basis for our final determination of the effects of the proposed action on the species as listed under the ESA. Although the *Status of the Species* and the *Environmental Baseline* are typically two separate sections in Biological Opinions, they are combined here because the status of the species in the Pacific Basin and the factors affecting them in the action area are similar to those throughout their range in the Pacific Ocean.

5.1 Status of Listed Sea Turtles

For the purposes of this consultation, this Opinion focuses on the effects of the Pelagics FMP fisheries on sea turtle populations in the Pacific Ocean as distinct from their, as listed, global distribution. This approach is allowable based on interagency policy on the recognition of distinct vertebrate populations (Federal Register 61: 4722-4725). To address specific criteria outlined in that policy, sea turtle populations in the Pacific Ocean are geographically discrete from their populations in the Atlantic Ocean , for example, with limited genetic exchange (see NMFS and USFWS 1998a-e). The loss of sea turtle populations in the Pacific Ocean would result in a significant gap in the distribution of each turtle species, thus making these populations biologically significant. Finally, the loss of these sea turtle populations in the Pacific Ocean would dramatically reduce the distributions and population abundances of these species and would, by itself, appreciably reduce all species' likelihood of surviving and recovering in the wild. However, despite primarily focusing on the Pacific Ocean populations, NMFS must make its final determination of the effect of the Pelagics FMP fisheries on the species as they are listed, or their global populations. To that end, the following discussions include information on the global status and trends of the sea turtles as well as more detailed information on the Pacific Ocean populations. In addition, green turtles and olive ridley turtles on the Pacific coast of Mexico are listed separately as endangered species, rather than the threatened status assigned to the remainder of their global populations. These two populations, which have been listed separately as endangered species, will receive separate final determinations from their threatened counterparts.

Populations persist as individuals survive from eggs to adults that successfully reproduce. Populations increase as survivorship rates consistently exceed mortality rates over time; mortality rates that consistently exceed survivorship rates result in declines in population abundance and may result in a population's eventual extirpation (Mangel and Tier 1994). As summarized in the *Global Status* and *Factors Affecting Sea Turtles in the Pacific Ocean* sections that follow, both natural and anthropogenic (human-caused) activities affect the abundance and survivorship rates of each life-stage. Turtles that survive from one stage to the next life-stage must survive the rigors of that stage and subsequent stages before they can reach sexual maturity and reproduce. In general, most anthropogenic activities have negatively affected each life stage, resulting in the observed declines in abundance of most sea turtle populations.

Except for nesting aggregations of olive ridley sea turtles and the threatened Hawaiian green sea turtles, nesting aggregations of the other sea turtle species that interact with the Pelagics FMP fisheries are declining. These population declines are primarily the result of a wide variety of human activities, including legal harvests and illegal poaching of adults, immatures, and eggs; incidental capture in fisheries (coastal and high-seas); and loss and degradation of nesting and foraging habitat as a result of coastal development, including predation by domestic dogs and pigs foraging on nesting beaches associated with human settlement and commercial development of coastal areas (Heppell et al. 2003a, Lutcavage et al. 1997). Increased environmental contaminants (e.g. sewage, industrial discharge) and marine debris, which adversely impact nearshore ecosystems that turtles depend on for food and shelter, including sea grass and coral reef communities, also contribute to the overall decline. While turtle biologists and others generally accept that these factors are the primary cause of turtle population declines, the limited amount of quantitative data on the risks posed by these different activities makes it difficult to rank the absolute risks these different activities pose to listed turtles.

Green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles are highly migratory or have a highly migratory phase in their life history, which makes them susceptible to being incidentally caught by fisheries operating throughout the Pacific Ocean. The collective fisheries proposed to be managed under the Pelagics FMP are known to interact with all of these species, although varying in degree. In addition to anthropogenic factors, natural threats to nesting beaches and marine habitats such as coastal erosion, seasonal storms, predators, temperature variations, and phenomena such as El Niño also affect the survival and recovery of sea turtle populations.

More information on the status of these species along with an assessment of overall impacts are found in this section as well as the Pacific Sea Turtle Recovery Plans (NMFS and USFWS, 1998a-e) and are reviewed extensively in Eckert (1993).

Status Assessments Using the Dennis Model

To help assess the status of the various species of sea turtles, we evaluated census data for different nesting aggregations, when those data were available, using the density-independent form of the "Dennis" model (Dennis et al. 1991, see Appendix A for details of these analyses) to assess the probable trend for the different populations. We had chosen the Dennis model because the available data allows us to meet most, if not all, of the model's data requirements, while the data required to conduct more complex models (for example, population matrices) are not available for all but a few species of sea turtles or nesting aggregations (for example, stage- or age-specific survival rates, growth rates, and any variance associated with these parameters).

Truly quantitative models require large amounts of data on the survival, growth, and fecundity of the different life stages of species and populations and the effects of environmental variability on these parameters (Feiberg and Ellner 2000, Groom and Pascual 1998). Without robust, long-term data, "quantitative" models can lead to highly-biased estimates of the extinction risks facing populations and species (Beissinger and Westphal 1998, Feiberg and Ellner 2000, Heppell et al. 2003, Ludwig 1996, Ludwig 1998, Taylor 1995). With the exception of long-term datasets for loggerhead sea turtles in Australia, the kind of information these models require is not available for this consultation and are not likely to become available in the near future. Absent robust, long-term data, we have to rely on simpler population models whose results require qualitative interpretation because of the uncertainty and assumptions underlying these models.

The "Dennis" model is a relatively simple model that relies on time series of census counts to estimate several demographic variables that provide important insights into a population's (or subpopulation's) status and future trend. Despite its simplicity, this model allows us to make full use of the data in hand: time series of census counts of the number of nests or nesting females of different species. When the only data available were estimates of the number of nests, we converted those estimates into estimates of the number of adult females in a particular nesting aggregation (which we treat as a equivalent to a subpopulation) using published conversion methods (see Appendix A for details of these conversions). When the only data available were estimates of the number of females that nested in a particular year, we converted those estimates into estimates of the number of adult females in a particular nesting aggregation using published estimates of remigration intervals for the different species (see Appendix A).

Table 3.1 lists the products of our analyses using the Dennis model, which are described in narrative form below. Anyone interested in more detailed discussion of this method, the interpretation of model results, and the application of this method to endangered species should refer to Dennis et al. (1991) and Morris and Doak (2002). In the narratives that follow, we provide a summary table of the results with supporting narrative when the available census data allowed us to conduct more detailed assessments. Although these assessments provide numerical estimates of different demographic variables, it is important to note that simple models like the Dennis model produce qualitative rather than quantitative predictions. Although the results of these analyses require qualitative interpretations, they provide important insights into the probable status and future trend of the different sea turtle species.

Table 3.1. Results of analyses using the discrete-time, density-independent diffusion estimation model described by Dennis et al. (1991)

Demographic Parameter
Mean log growth rate (μ)
Upper 95% confidence interval
Lower 95% confidence interval
Variance in mean log growth rate (σ^2)
Upper 95% confidence interval
Lower 95% confidence interval

A population's mean log growth rate, which is equal to the natural logarithm of the population's geometric mean growth rate, is a measure of a population's stochastic growth over time (Dennis et al. 1991, Lande and Orzack 1988, Morris and Doak 2002). If someone forecast a population's stochastic growth over time, some trajectories would increase, some would remain somewhat stable, while others would decrease. The mean log growth rate is a measure of the population's "average" growth rate assuming that some trajectories will increase, some will remain stable, and others will decrease (here, "average" is a geometric mean rather than an arithmetic mean because forecasts of population growth multiply a starting value by a rate; averages of multiplicative processes are best represented by geometric means). If a population's mean log growth rate, $\mu > 0$, then most population trajectories will increase; if $\mu < 0$, then most population trajectories will decline (Morris and Doak 2002).

The variance in a population's mean log growth rate (σ^2) captures the rate at which the variance around the distribution of the population's growth rate changes over time (Lande and Orzack 1988, Morris and Doak 2002). This parameter is important because even populations that are growing have some risk of falling to low levels or becoming extinct simply because of variation in growth rates. As a population's growth rate varies from year to year as a result of environmental variation, the population's variance will increase accompanied by an increase in the range of population sizes in the future.

These two statistics can be used to estimates other statistics that population biologists commonly use to characterize a population's status and trend: finite rates of population increase (or decrease) and intrinsic or continuous rates of increase (or decrease). A population's finite rate of increase (λ) captures a population's growth rate or the amount by which a population size multiplies from year to year. In the face of stable environmental conditions, this growth rate would be constant and a population would increase geometrically ($\lambda > 1$), decrease geometrically ($\lambda < 1$), or remain the same ($\lambda = 1$). The continuous or intrinsic rate of population increase is another statistic that is important to population biology; it is the natural logarithm of the finite rate of increase and represents rates of population growth over short intervals of time. However, in changing environments, a population's birth and death rates will vary and the population's growth rate will vary as well. Where the appropriate census data were available, we used the Dennis model to assess the status of the different species of sea turtles and report the results of our analyses in the following narratives for the species.

Green Turtles

Global status

Green turtles are listed as threatened under the ESA, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. Using a precautionary approach, Seminoff (2002) estimates that the global green turtle population has declined by 34% to 58% over the last three generations (approximately 150 years) although actual declines may be closer to 70% to 80%. Causes for this decline include harvest of eggs, subadults and adults, incidental capture by fisheries, loss of habitat, and disease.

Taxonomy

The genus *Chelonia* is composed of two taxonomic units at the subspecies/subspecific level: the east Pacific green turtle (also known as the "black turtle," *C. mydas agassizii*), which ranges (including nesting) from Baja California south to Peru and west to the Galapagos Islands, and the nominate *C. m. mydas* in the rest of the range (insular Pacific, including Hawaii).

Physical Description

Green turtles are distinguished from other sea turtles by their smooth carapace with four pairs of lateral scutes, a single pair of prefrontal scales, four post-orbital scales, and a serrated upper and lower jaw. Adult green turtles have a light to dark brown carapace, sometimes shaded with olive, and can exceed one meter in carapace length and 200 kilograms (kg) in body mass. Females nesting in Hawaii averaged 92 cm in straight carapace length (SCL), while at the Olimarao Atoll in Yap, females averaged 104 cm in curved carapace length (CCL) and approximately 140 kg. Eastern Pacific green turtles are conspicuously smaller and lighter than their counterparts in the central and western Pacific. At the rookeries of Michoacán, Mexico, females averaged 82 cm in CCL, while males averaged 77 cm CCL (*in* NMFS and USFWS, 1998a). Nesting females at the Bramble Cay rookery in Queensland, Australia averaged 105.9 cm CCL (Limpus *et al.*, 2001).

General Distribution

Green turtles are found throughout the world, occurring primarily in tropical, and to a lesser extent, subtropical waters. The species occurs in five major regions: the Pacific Ocean, Atlantic Ocean, Indian Ocean, Carribean Sea, and Mediterranean Sea. These regions can be further divided into nesting aggregations within the eastern, central, and western Pacific Ocean; the western, northern, and eastern Indian Ocean; Mediterranean Sea; and eastern, southern, and western Atlantic Ocean, including the Carribean Sea. Primary nesting aggregations of green turtles (i.e. sites with greater than 500 nesting females per year) include: Ascension Island (south Atlantic Ocean), Australia, Brazil, Comoros Islands, Costa Rica, Ecuador (Galapagos Archipelago), Equatorial Guinea (Bioko Island), Guinea-Gissau (Bijagos Archipelago), Iles Eparses Islands (Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida) (Seminoff, 2002).

Smaller nesting aggregations include: Angola, Bangladesh, Bikar Atoll, Brazil, Chagos Archipelago, China, Costa Rica, Cuba, Cyprus, Democratic Republic of Yemen, Dominican Republic, d'Entrecasteaux Reef, French Guiana, Ghana, Guyana, India, Iran, Japan, Kenya, Madagascar, Maldives Islands, Mayotte Archipelago, Mexico, Micronesia, Pakistan, Palmerston Atoll, Papua New Guinea, Primieras Islands, Sao Tome é Principe, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Taiwan, Tanzania, Thailand, Turkey, Scilly Atoll, United States (Hawaii), Venezuela, and Vietnam (Seminoff, 2002).

Green turtles appear to prefer waters that usually remain around 20°C in the coldest month. During warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C. An east Pacific green turtle equipped with a satellite transmitter was tracked along the California coast and showed a distinct preference for waters with temperatures above 20°C (Eckert, unpublished data).

Additionally, it is presumed that drift lines or surface current convergences are preferential zones due to increased densities of likely food items. In the western Atlantic, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS, 1998a). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS, 2000e).

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green turtles. Throughout the Pacific, nesting assemblages group into two distinct regional clades: 1) western Pacific and South Pacific islands, and 2) eastern Pacific and central Pacific, including the rookery at French Frigate Shoals, Hawaii. In the eastern Pacific, greens forage coastally from San Diego Bay, California in the north to Mejillones, Chile in the South. Based on mtDNA analyses, green turtles found on foraging grounds along Chile's coast originate from the Galapagos nesting beaches, while those greens foraging in the Gulf of California originate primarily from the Michoacan nesting stock. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton, 2003).

Life Cycle and Population Dynamics

Figure 3.1 illustrates the basic life cycle of green turtles (based on Chaloupka, 2002). This cycle is broken into six life stages: (1) egg/neonate; (2) pelagic juvenile; (3) benthic juvenile; (4) sub-adult; (5) maturing adult; and (6) adult, each with their own expected survival rate (Table 3.1). Arrows along the bottom represent the probability of each ageclass surviving and remaining in the ageclass. Arrows between each ageclass represent the probability of the ageclass surviving and growing to the next ageclass, and the arrows along the top represent the ageclass-specific fertility. The thickness or length of the lines do not indicate a level of probability or fecundity. Available information on the behavior, physiology, and biological requirements of these stages is summarized below.

Figure 3.1. Life-cycle graph of the green turtle

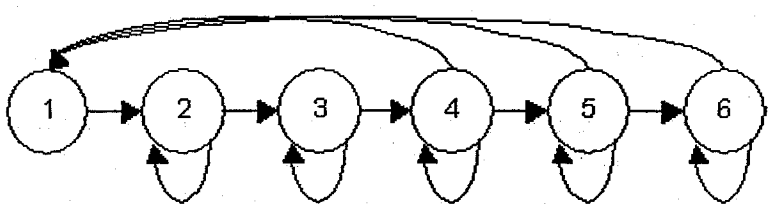


Table 3.1: Stage specific demographic information for the southern Great Barrier Reef green turtle (Chaloupka 2002)

Life Stage	Name	Mean Stage Duration (# years)	Stable Stage Structure	Survival Probability (lx)	Fecundity (eggs/female)
1	Egg-neonate	1	38.0%	0.4394	0
2	Pelagic Juvenile	4	38.8%	0.6445	0
3	Benthic Juvenile	11	18.1%	0.8804	0
4	Subadult	19	4.4%	0.8474	.2488
5	Maturing Adult	5	0.1%	0.9482	40.59
6	Adult	19	0.45%	0.9482	68.84

Numerical analyses of the survival rates, transition rates, and fecundities in Table 3.1 indicated that the southern Great Barrier Reef green turtle population has a finite population growth rate (λ) of approximately 1, which suggests a population that is stationary – neither increasing nor declining. This nesting aggregation has not been seriously exposed to incidental capture in fisheries or direct harvest and has shown no evidence of a population decline (Chaloupka, 2002) and therefore may be viewed as a surrogate example of green turtle population dynamics in the

absence of anthropogenic activities. The stable stage structure for this nesting aggregation of green turtles is typical of long-lived species with delayed maturity – a life history with large numbers of early stage individuals (as a result of high fecundity in the adult life stages) of which relatively few survive through the rigors of natural mortality from predation, environmental variation, and individual fitness to older reproductive stages (Crouse, 1999). The earliest life stages (Stages 1 and 2) have the highest proportion of individuals but the lowest survival probabilities. Despite low abundances in these life stages, mature individuals have more chances to reproduce and replace themselves. Consequently, changes in the survival rates of adult would be expected to have significant effect on the growth and persistence of this population.
A review of the elasticity, or proportional effect of a change in the vital rates of a stage on λ, of this stage structure confirms the general relationships in this life cycle. Table 3.2 includes the elasticities of the vital rates of each life stage in the green turtle life cycle.

Table 3.2. Stage elasticities (Chaloupka, 2002)

Life Stage	Survival Rate	Transition Rate	Fecundity
1	0	0.0277	0
2	0.0367	0.0277	0
3	0.1466	0.0277	0
4	0.1457	0.0268	0.0008
5	0.0942	0.0227	0.0041
6	0.4166	0	0.0228

Based on these data, a change in the survival rate of an adult green turtle (or the proportion of the stage population that survives as a reproductive adult another year) will have the highest proportional change on the population's finite growth rate (λ). Changes in the survival rates of the 3rd, 4th, and 5th life stages have the next highest proportional effect on λ, followed by smaller proportional effects due to changes in the survival of pelagic juveniles (Stage 2), transition rates between all stages, or fecundity. The growth, decline, or persistence of the population is determined by the survival rate of reproductive adults, sub-adults, and benthic juveniles. This is not particularly surprising given that these are the longest duration stages for this species. Persistence of long-lived species with delayed maturity would be most vulnerable to impacts that preclude individuals from attaining age and sexual maturity.

The observed declines in the green turtle populations attest to the effect of changing these survival rates on species' persistence. Green turtles have long survived natural fluctuations in environmental conditions (environmental stochasticity) such as changes in climate, coastal erosion, or destruction of nesting beaches by hurricanes and typhoons. Green turtles have survived these phenomena by evolving a life history strategy that allows their populations to withstand periodic, and often significant, losses in the life stages that would be most vulnerable to environmental change (that is, eggs, hatchlings, and juveniles) while buffering the adult life stages from these environmental changes through ocean dispersal. Although adult females on nesting beaches are also vulnerable to phenomena like beach erosion, hurricanes, and typhoons, the reproductive pattern in which adult females only nest every two or more years exposes only a small portion of the breeding population to these risks. Conversely, most anthropogenic activities such as harvest and poaching of eggs and adults, incidental capture in fisheries, or human destruction or encroachment of nesting habitat place these populations under constant pressure, can affect entire regions in short periods of time, and can affect all life stages simultaneously.

For example, green turtle eggs and hatchlings are vulnerable to many of the same factors affecting other sea turtle populations: beach erosion, human or wildlife poaching and predation, and widely fluctuating beach temperatures. Once the green turtles transition into the oceanic environment, however, individual life stages are vulnerable to different impacts based on the habitats they inhabit. Pelagic individuals are incidentally captured in pelagic fisheries such as longline. Benthic life stages are injured or killed by coastal fisheries and other hazards associated with the nearshore environment. While relatively few green turtles are taken by Pelagics fisheries, based on past observations in the Hawaii-based longline fishery, sub-adult and adult green turtles are the life stage most commonly captured and injured or killed. Because changes in the survival rates of these stages have the highest proportional effect on a population's finite growth rate (λ), the consequences of these fisheries on the survival and recovery of green turtle populations would be significant, particularly when these losses are added to losses in other life stages. The combined effect of these activities, which affect most or all life stages of most green turtle populations, would cause these populations to have λs significantly lower than the southern Great Barrier Reef green turtle population, meaning that these populations would be declining.

Biological Characteristics

Diet

Although most green turtles appear to have a nearly exclusive herbivorous diet, consisting primarily of sea grass and algae (Wetherall *et al.*, 1993; Hirth, 1997), those along some areas of the east Pacific coast seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of molluscs and polychaetes, while fish and fish eggs, and jellyfish and commensal amphipods comprised a lesser percentage (Bjorndal, 1997). Black turtles studied in the Magdalena Bay region of the Baja California Peninsula were found to feed predominantly on red algae, *Gracilariopsis*, and to a lesser extent, sea lettuce (*Ulva lactuca*) (Hilbert *et al.*, 2002). These turtles locate algae in the rocky coasts and marine grasses plentiful in the shallow waters of the coastal areas, including lagoons and bays (Millan and Carrasco, 2003). Black turtles foraging in areas adjacent to Magdalena Bay fed primarily on sea grass. The stomach contents of one turtle in this area contained more than 82% red crabs (*Plueroncodes planipes*), perhaps the first record of this species feeding predominantly on crustaceans (Mendilaharsu *et al.*, 2003). In the Hawaiian Islands, green turtles are site-specific and consistently feed in the same areas on preferred substrates, which vary by location and between islands (*in* Landsberg, *et al.*, 1999).

Diving Behavior

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS, 1998a). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson, 1967, *in* Lutcavage and Lutz, 1997), while subadults routinely dive 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill, *et al.*, 1995, *in* Lutcavage and Lutz, 1997).

Life History/ Reproduction

Compared to all other sea turtles, green turtles exhibit particularly slow growth rate, and age to maturity appears to be the longest. Based on age-specific growth rates, green turtles are estimated to attain sexual maturity beginning at age 25 to 50 years (Limpus and Chaloupka, 1997, Bjorndal *et al.*, 2000, Chaloupka *et al.*, in press, *all in* Seminoff, 2002, Zug *et al.*, 2002). Dobbs (2002) estimated the age at first breeding of green turtles in Australia to be 46 years of age. The length of reproductivity has been estimated to range from 17 to 23 years (Carr *et al.*, 1978, Fitzsimmons *et al.*, 1995 *in* Seminoff, 2002).

In Hawaii, green turtles lay up to six clutches of eggs per year (mean of 3.7), and clutches consist of about 100 eggs each. Females migrate to breed only once every two or possibly many more years. On the Hawaiian Archipelago, females nest every 3 to 4 years (Balazs and Chaloupka, in press). Eastern Pacific green turtles have reported nesting between two and six times during a season, laying a mean of between 65 and 86 eggs per clutch, depending on the area studied (Michoacán, Mexico and Playa Naranjo, Costa Rica) (*in* Eckert, 1993 and NMFS and USFWS, 1998a). Mean observed and estimated clutch frequency for green turtles nesting at Colola beach (Michoacan, Mexico) was 2.5 and 3.2, respectively (Arias-Coyotl *et al.*, 2003). At the Bramble Cay rookery in Queensland, Australia, green turtles laid an estimated 6.2 clutches per season, with an average clutch containing 102.2 eggs. The renesting interval was 12.4 days (Limpus *et al.*, 2001).

Migration

The nonbreeding range of green turtles is generally tropical, and can extend thousands of miles from shore in certain regions. Hawaiian green turtles monitored through satellite transmitters were found to travel more than 1,100 km from their nesting beach in the French Frigate Shoals, south and southwest against prevailing currents to numerous distant foraging grounds within the 2,400 kilometer span of the archipelago (Balazs, 1994; Balazs, *et al.*, 1994; Balazs and Ellis, 1996). Three green turtles outfitted with satellite tags on the Rose Atoll (the easternmost island at the Samoan Archipelago) traveled on a southwesterly course to Fiji, approximately 1,500 km distance (Balazs *et al.*, 1994; Craig et al. 2004).

Tag returns of eastern Pacific green turtles establish that these turtles travel long distances between foraging and nesting grounds. In fact, 75 percent of tag recoveries from 1982-90 were from turtles that had traveled more than 1,000 kilometers from Michoacán, Mexico. Even though these turtles were found in coastal waters, the species is not confined to these areas, as indicated by 1990 sightings records from a NOAA research ship. Observers documented green turtles

1,000-2,000 statute miles from shore (Eckert, 1993). The east Pacific green is also the second-most sighted turtle in the east Pacific during tuna fishing cruises; they are frequent along a north-south band from 15°N to 5°S along 90°W, and between the Galapagos Islands and Central American Coast (NMFS and USFWS, 1998a). In a review of sea turtle sighting records from northern Baja California to Alaska, Stinson (1984) determined that the green turtle was the most commonly observed sea turtle on the U.S. Pacific Coast, with 62% reported in a band from southern California and southward. The results of genetic studies and satellite telemetry of black turtles off Baja California suggest a strong connection to rookeries on Michoacan, and to a lesser extent rookeries on Isla Revillagigedo (Nichols, 2003).

The northernmost reported resident population of green turtles occurs in San Diego Bay, where about 50-60 mature and immature turtles concentrate in the warm water effluent discharged by a power plant (McDonald, *et al.*, 1994). These turtles appear to have originated from east Pacific nesting beaches and the Revillagigedo Islands (west of Baja California), based on morphology, genetic analyses, and tagging data (*in* NMFS and USFWS, 1998a; P. Dutton, NMFS, personal communication, March, 2002); however, the possibility exists that some are from Hawaii (P. Dutton, NMFS, personal communication, January, 2001). In order to reach nesting beaches in late fall and winter, sea turtles in this area must depart these feeding areas by late summer, returning to the area again in early spring (Nichols, 2003).

Population Status and Trends

While some nesting populations of green turtles appear to be stable and/or increasing in the Atlantic Ocean (e.g. Bujigos Archipelago (Guinea-Bissau), Ascension Island, Tortuguero (Costa Rica), Yucatan Peninsula (Mexico), and Florida), declines of over 50% have been documented in the eastern (Bioko Island, Equatorial Guinea) and western Atlantic (Aves Island, Venezuela). Nesting populations in Turkey (Mediterranean Sea) have declined between 42% and 88% since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50% have been documented at Sharma (Republic of Yemen) and Assumption and Aldabra (Seychelles), while no changes have occurred at Karan Island (Saudi Arabia) or at Ras al Hadd (Oman). The number of females nesting annually in the Indian Ocean has increased at the Comoros Islands, Tromelin and maybe Europa Island (Iles Esparses) (*in* Seminoff, 2002).

Despite international conservation efforts to protect green turtles in all areas of the world, threats to their survival continue. In the Atlantic and Indian Oceans and the Mediterranean Sea, intentional harvest continues. Egg collection is ongoing at nesting beaches in the eastern Atlantic, western Atlantic and in the Caribbean, while nesting females continue to be killed in the Caribbean, eastern Atlantic and Indian Ocean. High numbers of juveniles and adults are intentionally captured at foraging habitats in the eastern Atlantic, Caribbean, Indian Ocean, and in the Mediterranean (*in* Seminoff, 2002).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, as a direct consequence of a historical combination of overexploitation and habitat loss

(Eckert, 1993; Seminoff, 2002). A more detailed description of the abundance, distribution, and population trends for green turtles in the Pacific Ocean is presented in the following subsections.

Pacific Ocean

Western Pacific - Distribution and Abundance of Green Turtles, including Nesting Females

In the western Pacific, the only major (> 2,000 nesting females) populations of green turtles occur in Australia and Malaysia.

Australia

In Queensland, Australia there are four distinct subpopulations of green turtles. The southern Great Barrier Reef subpopulation (located at the Capricorn/ Bunker group of islands) has an average annual nesting population of 8,000 females; the northern Great Barrier Reef subpopulation (Raine Island and Moulter Cay) consists of an average of 30,000 nesting females; the Gulf of Carpenteria (nesting concentrated around Wellesley) averages 5,000 nesting females; and the Coral Sea Islands Territory averages around 1,000 nesting females (Dobbs, 2002).

Threats to green turtles in this area include boat strikes, indigenous harvest of adults and eggs, increased incidence of disease, ingestion of synthetic materials, incidental catch in a shark control program and by commercial fisheries, predation of eggs at nesting beaches, and tourism (*in* Dobbs, 2001). In a study conducted between 1985 and 1992 on foraging greens near southern Great Barrier Reef waters, researchers documented an 11% per year increase in the resident green turtle population, while the female nesting population increased at 3% per year. In 1992, the resident green turtle population was estimated to be comprised of 1,300 individuals (Chaloupka and Limpus, 2001).

Malaysia

In Malaysia, green turtles are widely distributed. Major rookeries are located in Sabah, in the Turtle Islands, where there are about 10,000 nests (increasing trend); in the Sipadan Islands - 800 nests (decreasing trend); in the Sarawak Turtle Islands, about 2,500 nests (stabilized since 1970); in Terengganu, with 2,500 nests (stabilized since 1984); and minor rookeries in Pahang (250 nests) and Perak (200 nests) (Liew, 2002).

Although there are no current estimates available, Pulau Redang, a coral fringed island located approximately 45 kilometers off the coast of Terengganu, Malaysia contains one of the largest green turtle rookeries in peninsular Malaysia, and a 1 nautical mile no-fishing zone has been established around the island to prevent interactions between fishing gear and internesting females (Liew and Chan, 1994).

French Polynesia

Smaller colonies of green turtles occur in the islands of French Polynesia. Although green turtles used to nest in large numbers at Scilly, Motu-one, and Mopelia, located in the western limits of French Polynesia, their populations have declined in recent decades due mainly to commercial exploitation for markets in Tahiti (Balazs, *et al.*, 1995). Currently, Scilly is the only known sea turtle nesting site of any magnitude throughout the 130 islands and atolls that comprise French Polynesia. Although residents of Scilly are allowed to harvest 50 adult turtles annually, Balazs *et al.* (1995) estimates that the number of green turtles nesting annually in 1991 is approximately 300-400 turtles, similar to what Lebeau (1985 *in* Balazs, *et al.*, 1995) estimated several years earlier.

Indonesia

In Indonesia, green turtles are widely distributed throughout the archipelago; however, many of the largest rookeries have decreased over the last 50 years, primarily due to over-harvest of eggs. Since the Indonesian Government Legislation No. 7/1999 was formally promulgated, all sea turtles in Indonesia, including green turtles, are listed as a protected species. Green turtles reportedly nest in high numbers in the Berau district of East Kalimantan province, the Aru and Kei islands in the Malukkas, and other smaller and more remote islands throughout the country (Dermawan, 2002).

Throughout the Barau district, there are five major nesting sites for green turtles, including the islands of Sangalaki, Mataha, Belambangan, Bilang-bilangan, Balikukup, and Sambit. During 2000, over 1.5 million green turtle eggs were collected in this district, according to the Berau Fisheries Department. Once collected for subsistence, green turtle eggs are now sold to local businessmen, who sell the eggs to distant markets throughout the country as well as illegally export them to Singapore, Brunei, and Sarawak, Malaysia (Dermawan, 2002). Sangalaki Island in the Berau region of East Kalimantan, Indonesia contained one of the largest known nesting populations of green turtles in the Sulawesi Sea. During the post-World War II period, nearly 200 turtles reportedly nested per night. In 1993-94, 20-50 turtles nested per night, while during 2000-2001, 10 turtles on average nested nightly. In the past, egg collectors collected 100% of the eggs. In February, 2001, the Turtle Foundation instituted measures to protect approximately 20% of the eggs laid by female green turtles (approximately 2000 eggs saved per week), and the latest information from the Foundation is that as of January 1, 2002, Bupati and the government of Berau stopped granting licenses to collect turtle eggs on Sangalaki (Turtle Foundation, 2002). At Pulau Banyak (Sumatra, Indonesia), green turtle nesting has been monitored since 1997. The main nesting site is at Amandangan beach. Several thousand clutches are laid annually by several hundred nesting females (Stringell, *et al.*, 2000).

Thailand

In Thailand, green turtles nest at the Khram Islands, in the Gulf of Thailand. Here, the nesting areas have been protected and controlled since 1950, so nesting populations have not declined significantly. While peak nesting years for greens showed almost 1,000 nests (late 1980s), since 1994, there has been a steady trend of approximately 200 nests per year at the Khram Islands.

Fiji

In a recent study of migratory patterns of green turtles in the central South Pacific, Craig *et al.* (2004) concluded that about half of the turtle migrations they studied were specifically headed to Fiji and that the seagrass and algae beds associated with Fiji are a regionally-significant food resource for green turtles in that region. However, in Fiji, there is very little information on population trends of green turtles. Although 4,000-5,000 green turtles are found foraging or migrating in Fijian waters, only 30-40 green turtles nest in Fiji. The only nesting sites are located on the islands of Heemskereq Reef and Ringgold reefs. Threats to green turtles in this country are not well known, although green turtles are the most prized food of the Fijians, and they are used as important ceremonial gifts (Rupeni, *et al.*, 2002).

Commonwealth of the Northern Mariana Islands

Greens and hawksbills make up most of the composition of sea turtle species in the Pacific island groups under U.S. jurisdiction. Unfortunately, there is a serious shortage of information on the population sizes, distribution, and migration patterns of these turtles, which can hamper recovery efforts. Recently, an assessment of resident sea turtles and their nearshore habitats on two islands of the Commonwealth of the Northern Mariana Islands (CNMI) was conducted. The study took place from March 12-21, 2001 on the islands of Tinian and Aguijan. An estimated 351 individual green turtles were observed in surveys covering approximately 59% of Tinian's total shore and outer reef perimeter, while only 14 greens were observed during tow surveys covering 95% of Aguijan's shore and reef perimeter. Most of the turtles sighted were juveniles, suggesting recent and continuing recruitment at both islands. Based on data from surveys of four of the five CNMI southern arc islands, Kolinski (2001) also projected sea turtle densities and abundance in these areas and concluded that "the small uninhabited islands of Farallon de Medinilla and Aguijan sustain tens of turtles, turtle numbers around the larger inhabited islands of Saipan and Tinian range in the hundreds, while the CNMI portion of the southern arc (which includes Rota) likely supports between 1,000 and 2,000 resident green turtles." The Division of Fish and Wildlife (2002) report that sea turtles in the Northern Marianas still face problems such as poaching, disturbance of nesting habitat, and the Carolinian and Chamorros (natives) have put in a request to take a limited number of turtles for culture practices.

Guam

In Guam, nesting surveys have been conducted since 1973, more consistently since 1990, and most reliably for the 2000 and 2001 nesting seasons. Trend data since 1990 show that the number of nesting females range between a few to approximately 60 annually, with a general increasing trend over the last 12 years. Aerial surveys from 1990-2000 also show an increasing trend in the number of green turtles sighted around Guam (Cummings, 2002).

Based on limited data, green turtle populations in the Pacific islands have declined dramatically, due foremost to harvest of eggs and adults by humans. In the green turtle recovery plans, directed take of eggs and turtles was identified as a "major problem" in American Samoa, Guam, Palau, CNMI, Federated States of Micronesia, Republic of the Marshall Islands, Wake, Jarvis, Howland, Baker, and Midway Islands, Kingman Reef, Johnston and Palmyra Atoll. Severe overharvests have resulted in modern times from a number of factors: 1) the loss of traditional restrictions limiting the number of turtles taken by island residents; 2) modernized hunting gear; 3) easier boat access to remote islands; 4) extensive commercial exploitation for turtle products in both domestic markets and international trade; 5) loss of the spiritual significance of turtles; 6) inadequate regulations; and 7) lack of enforcement (NMFS and USFWS, 1998a). Confirming this, Cummings (2002) reports that in Guam, there is still a high level of illegal take for cultural reasons, particularly during fiestas for the patron saints of villages. Based on anecdotal information, nesting females and eggs are also likely harvested.

Taiwan
Scattered low density nesting of green turtles occur on beaches in Taiwan. Here, Cheng and Chen (1996) report that between 1992 and 1994, green turtles were found nesting on 9 of 11 beaches on Wan-An Island (Peng-Hu Archipelago). The numbers, however, were small, between 8 and 14 females nested during each of these 3 years. Cheng (2002) recently reported similar numbers of nesting greens for those areas: 2-19 nesters on Wan-An Island and 4 to 11 nesters on Lanyu Island.

Vietnam
In Vietnam, researchers have only recently been documenting green turtle nesting populations on their beaches; however, anecdotal reports are that the population has declined sharply, due in part to the harvest of turtles, egg collection for food and wildlife trade, and coastal development. Sea turtles were considered an economic resource until the mid-1990s, when the World Wildlife Fund helped educate the government in the importance of protecting sea turtles and their habitat. Presently, Con Dao National Park is the most important sea turtle nesting site in Vietnam. Data from 1995 through October, 2001 show that for all years except one (1996) over 200 green turtles nested on 14 beaches. Limited numbers of green turtles (23 nests in 2001) have also been documented nesting in Nui Chua Nature Preserve (Hien, 2002).

Japan
In Japan, the Ogasawara Islands, located approximately 1,000 km south of Tokyo, serve as the northern edge of green turtles rookeries in the western Pacific. In the late 1800s, when Japan first colonized the islands, the government encouraged a sea turtle fishery. Declines in catch were steady from 1880-1890s (1,000-1,800 adults taken annually) through the mid-1920s (250 taken annually). Data from 1945-1972 (American occupation) indicate that 20-80 turtles were taken annually, and since then, annual harvests have fluctuated from 45-225 turtles per year (Horikoshi, *et al.*, 1994). Suganuma, *et al.* (1996) estimates 100 mating adults are speared by fishermen annually. Beach census data from 1985-93 indicate that 170-649 clutches were deposited each year (43 to 162 nesting females, assuming a female deposited 4 clutches during a nesting season). The Ogasawara population has declined in part due to past commercial exploitation, and it is likely to continue if fishery effort continues (Horikoshi, *et al.*, 1994).

Central Pacific - Hawaii

Green turtles in Hawaii are considered genetically distinct and geographically isolated although a nesting population at Islas Revillagigedos in Mexico appears to share the mtDNA haplotype that commonly occurs in Hawaii. In Hawaii, green turtles nest on six small sand islands at French Frigate Shoals, a crescent-shaped atoll situated in the middle of the Hawaiian Archipelago (Northwestern Hawaiian Islands) (Balazs, 1995). Ninety to 95% percent of the nesting and breeding activity occurs at the French Frigate Shoals, and at least 50% of that nesting takes place on East Island, a 12-acre island. Long-term monitoring of the population shows that there is strong island fidelity within the regional rookery.

Researchers have monitored East Island since 1973 and have collected information on numbers of females nesting annually, and have conducted tagging studies (Balazs, 2002). Since the establishment of the ESA in 1973, and following years of exploitation, the nesting population of Hawaiian green turtles has shown a gradual but definite increase (Balazs, 1996; Balazs and Chaloupka, in press). In three decades the number of nesting females at East Island increased from 67 nesting females in 1973 to 467 nesting females in 2002 (Figure 3.2). At this rookery, "... nester abundance increased rapidly during the early 1980s, leveled off during the early 1990s before again increasing rapidly during the late 1990s and up to the present. This trend is very similar to the underlying trend in the recovery of the much larger green turtle population that nests at Tortuguero, Costa Rica (Bjorndal *et al.*, 1999). The stepwise increase of the long-term nester trend since the mid-1980s is suggestive, but not conclusive, of a density-dependent adjustment process affecting sea turtle abundance at the foraging grounds (Bjorndal *et al.*, 2000)" (Balazs and Chaloupka, in press). This increase can be attributed to increased female survivorship since harvesting of turtles in the foraging grounds was prohibited in the mid-1970s, and cessation of habitat damage at the nesting beaches since the early 1950s (Balazs and Chaloupka, in press). Low level nesting also occurs at Laysan Island, Lisianki Island and on Pearl and Hermes Reef (NMFS and USFWS, 1998a).

Important resident areas of green turtles have been identified and are being monitored along the coastlines of Oahu, Molokai, Maui, Lanai, Hawaii, and at nesting areas in the reefs surrounding the French Frigate Shoals, Lisianski Island, and Pearl and Hermes Reef (Balazs, 1982; Balazs *et al.*, 1987).

Unfortunately, the green turtle population in the Hawaiian Islands area is afflicted with a tumor disease, fibropapilloma, which is of an unknown etiology and often fatal, as well as spirochidiasis, both of which are the major causes of stranding of this species (G. Balazs, NMFS, personal communication, 2000). The presence of fibropapillomatosis among stranded turtles has increased significantly over the past 17 years, ranging from 47-69 percent during the past decade (Murakawa, *et al.*, 2000). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs, *et al.*, 1998). Preliminary evidence suggests that there is an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg, *et al.*, 1999). Fibropapillomatosis is considered an inhibiting factor to the full recovery of the Hawaiian green turtle populations, and the incidence of decreased growth rates in afflicted turtles is a minimum estimate of the impact of the disease (Balazs, *et al.*, 1998). Stranding reports from the Hawaiian Islands from 1982-1999 indicate that the green turtle is the most commonly stranded sea turtle (96.5 percent, compared to other species), averaging around 150 per year (2,689 total/18 years). Despite recent increases in this disease, increases in nester abundance in the Hawaiian Archipelago has continued to occur (Aguirre *et al.*, 1998 *in* Balazs and Chaloupka, in press).

Eastern Pacific - Distribution and Abundance of Nesting Females

Analysis using mitochondrial DNA (mtDNA) sequences from three key nesting green turtle populations in the eastern Pacific indicate that they may be considered distinct management units: Michoacán, Mexico; Galapagos Islands, Ecuador, and Islas Revillagigedos, Mexico (Dutton, 2003).

The primary green turtle nesting grounds in the eastern Pacific are located in Michoacán, Mexico, and the Galapagos Islands, Ecuador (NMFS and USFWS, 1998a). Here, green turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. Sporadic nesting occurs on the Pacific coast of Costa Rica.

Mexico

In the Mexican Pacific, the two main nesting beaches for female green turtles occur in Michoacán and include Colola, which is responsible for 70% of total green turtle nesting in Michoacán (Delgado and Alverado, 1999), and Maruata. These nesting beaches have showed a dramatic decline, particularly in the early 1980s, decreasing from 5,585 females in 1982 to 940 in 1984, which represents about a 90% decline in two years. On Colola, an estimated 500-1,000 females nested nightly in the late 1960s. In the 1990s, that number dropped to 60-100 per night, or about 800-1,000 turtles per year (Eckert, 1993).

Since their decline in the 1980s from about 5,500 nesting females per year, the number of nesting females arriving at Colola Beach in Mexico has fluctuated widely between lows of 171 and highs of 880, until recently when about 2,100 female turtles returned to nest in 2001 (see Figure 3.3)..

Table 3.11. Results of an assessment of the Colola, Mexico, nesting aggregation of green sea turtles using a discrete-time, density-independent diffusion estimation model

Demographic Parameter	Estimate
Mean log growth rate (μ)	-0.026078
Upper 95% confidence interval	0.321947
Lower 95% confidence interval	-0.374102
Variance in mean log growth rate (σ^2)	0.584556
Upper 95% confidence interval	0.637932
Lower 95% confidence interval	0.342150

Our analyses of estimates of the number of female green turtles that nest at Colola Beach suggest that most trajectories of this population would be expected to decline slightly (μ = -0.261), although the population seems to be capable of growth (λ = 1.30, which is greater than 1) and may experience short periods of growth. The wide fluctuations in the number of nesting females that return from year-to-year could present a more serious problem for this population as those fluctuations bring the population to very low levels that, over time, would be expected to create weak year-classes of recruits into the adult, female population. Although the increases in nesting

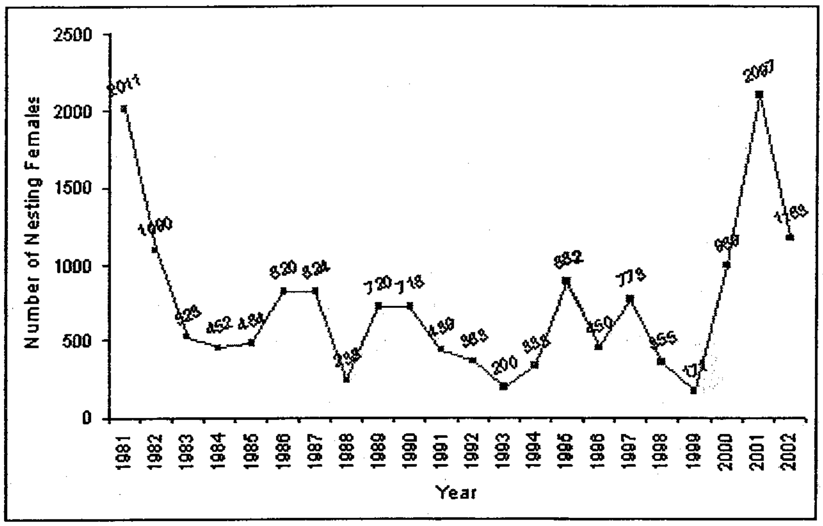


Figure 3.3. Number of Nesting Female Green Turtles at Colola beach, Michoacan, Mexico (from Alvarado-Diaz, personal communication, October, 2003).

females in 2000 and 2001 provide cause for optimism, historical numbers of this species nesting during the 1960s show that the population is still below its natural level (Alvarado-Diaz and Trejo, 2003; Alvarado-Diaz, personal communication, October, 2003). The small size of this nesting population, relative to its historic levels, leaves this population with a moderate risk of extinction: projecting over 25-, 50-, and 100-year intervals suggest that this population has a low risk of declining to extinction in any interval of time, but has a moderate risk of declining to 100 or 500 individuals in about 50 years.

Historically in the Mexican Pacific, more than 165,000 turtles were harvested from 1965 to 1977. In the early 1970s nearly 100,000 eggs per night were collected from these nesting beaches (*in* NMFS and USFWS, 1998a). Despite long-term protection of females and their eggs at these sites since 1990, the population continues to decline, and it is believed that adverse impacts (including incidental take in various coastal fisheries as well as illegal directed take at forage areas) continue to prevent recovery of endangered populations (P. Dutton, NMFS, personal communication, 1999; Nichols, 2002). In addition, the black market for sea turtle eggs in Mexico has remained as brisk as before the ban (Delgado and Alvarado, 1999). Although about 5% of the nests were poached at Colola during this season, about 50% of the nests at Maruata were poached (Delgado and Alvarado, 1999).

The Archipelago of Revillagigedo, an isolated group of islands offshore from the Pacific Mexican coast also hosts a nesting and foraging population of green turtles. Monitoring studies from 1999-2001 on three beaches on Clarión Island and five beaches on Socorro showed a small but productive population of nesting greens. Nesting occurs year-round but peaks during October and November. Genetic analyses on these turtles show the Revillagigedo population to be a genetically distinct stock distributed throughout Baja California and the western United States (Juarez-Ceron, *et al.*, 2003).

Ecuador

There are few historical records of abundance of green turtles from the Galapagos. Investigators documented nesting females during the period 1976-1982 and recorded an annual average of 1,400 nesting females. At this time, only residents were allowed to harvest turtles for subsistence, and egg poaching occurs only occasionally (NMFS and USFWS, 1998a) The main documented threats that were registered in the past was the presence of feral pigs (*Sus scrofa*), an introduced species to the islands, and the beetle (*Omorgus suberosus*), a native species. Both of these combined to reduce turtle hatchling success during earlier monitoring years (Zárate *et al.*, 2003). After nearly twenty years of limited data, a field study commenced in 2002 to assess the status of green turtles nesting in the main nesting sites of the Galapagos Archipelago. The most important nesting beaches are Quinta Playa and Bahía Barahona, both on Isabela Island, Las Bachas, Santa Cruz Island, Las Salinas, Seymour Island, and Espumilla, Santiago Island. All are protected as either national parks, tourist sites, or are under military jurisdiction (e.g. Seymour Island). Monitoring sites included all of the above-listed nesting beaches except Espumilla. Nesting activity was monitored for nearly 4 months in Las Bachas and approximately 3 months on the remaining sites. During the season, a total of 2,756 females were tagged, with the highest numbers in Las Bachas (925 females). This total outnumbers the highest values recorded in previous studies (1,961 females tagged in 1982) (Table 3.3). Researchers observed few feral pigs and they were only observed in Qunita Playa. There were few documented beetle observations, although feral cats were observed predating on hatchlings as they emerged from the nest (Zàrate *et al.* 2003).

Table 3.3. Historic data of turtles tagged in Galapagos between 1975-1983 and 2002.

Year	Total Number of Tagged Females
1975	102
1976	478
1977	526
1978	1,087
1979	827
1980	1,411
1981	1,639
1982	1,961
1983	89
2002	2,756

Source: Data from 1979-1983 from Hurtado (1984); Data from 1975 from Cifuentes (1975); data from 1976-79 from Green (1984); data from 1980-83 in Hurtado (1984) *all in* Zàrate *et. al.* (2003).

Costa Rica
Green turtles also nest sporadically on the south Pacific coast of Costa Rica, and have been monitored in Caña Blanca and Punta Banco. The total number of nests recorded in Caña Blanca from 1998-2001 ranged from 47 to 106 annually, while the total nests recorded in Punta Banco from 1996 to 2001 ranged from 73 to 233 nests (Lopez and Arauz, 2003). At Playa Naranjo, the population of nesting green turtles was estimated to be between 125 and 175 (Cornelius, 1976 *in* NMFS and USFWS, 1998a).

Green turtles encountered by U.S. vessels managed under the Pelagics FMP may originate from a number of known proximal, or even distant, breeding colonies in the Pacific Ocean. No green turtles have been observed taken in the longline fishery based off the west coast. Genetic analyses revealed that the one green turtle observed taken in the CA/OR drift gillnet fishery originated from the eastern Pacific stock, most likely a Mexican nesting beach (P. Dutton, personal communication, January, 2000). Green turtles taken in the eastern tropical Pacific purse seine fishery likely originate from eastern Pacific nesting beaches; however, genetic sampling has not been conducted.

Genetic sampling of green turtles taken by the Hawaii-based longline fishery on observer trips indicates representation from nesting beaches on Hawaii (French Frigate Shoals) and the eastern Pacific (Mexico - both Revillagigedos and Michoacan and Galapagos). Preliminary genetic analysis has revealed that of 14 green turtles sampled by observers in the Hawaii-based longline fishery from 1994 to 2001, six were of eastern Pacific (Mexico) stock origin, five were of eastern Pacific or Hawaiian nesting stock origin, three were of Hawaii stock origin, and one was of unknown origin, although it is most likely to be of eastern Pacific stock due to similarities in mtDNA sequence. (P. Dutton, NMFS, personal communication, December, 2003).

Hawksbill Turtles

Global Status

The hawksbill turtle is listed as endangered under the ESA. Under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the hawksbill is identified as "most endangered." Anecdotal reports throughout the Pacific indicate that the current population is well below historical levels. In the Pacific, this species is rapidly approaching extinction primarily due to the harvesting of the species for its meat, eggs, and shell, as well as the destruction of nesting habitat by human occupation and disruption (NMFS, 2001).

Physical Description

The following characteristics distinguish the hawksbill from other sea turtles: two pairs of prefrontal scales; thick, posteriorly overlapping scutes on the carapace; four pairs of costal scutes; two claws on each flipper; and a beak-like mouth. The carapace is heart-shaped in very young turtles, and becomes more elongate or subovate with maturity. Its lateral and posterior margins are sharply serrated in all but very old individuals. The epidermal scutes that overlay the bones of the shell are the tortoiseshell of commerce. They are unusually thick, and overlap posteriorly on the carapace in all but hatchlings and very old individuals. Carpacial scutes are often richly patterned with irregularly radiating streaks of brown or black on an amber background. The scutes of the plastron of Atlantic hawksbills are usually clear yellow, with little or no dark pigmentation. The soft skin on the ventral side is cream or yellow, and may be pinkish-orange in mature individuals. The scales of the head and forelimbs are dark brown or black with sharply defined yellow borders. There are typically four pairs of inframarginal scutes. The head is elongate and tapers sharply to a point. The lower jaw is V-shaped.

The hawksbill is a small to medium-sized sea turtle. In the U.S. Caribbean, nesting females average about 62-94 cm in straight carapace length. Weight is typically to 80 kg in the wider Caribbean, with a record weight of 127 kg. Hatchlings average about 42 mm straight carapace length and range in weight from 13.5-19.5 g.

General Distribution

The hawksbill occurs in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with representatives of at least some life history stages regularly occurring in southern Florida and the northern Gulf of Mexico (especially Texas); in the Greater and Lesser Antilles; and along the Central American mainland south to Brazil. Within the United States, hawksbills are most common in Puerto Rico and its associated islands, and in the U.S. Virgin Islands. In the continental U.S., the species is recorded from all the gulf states and from along the eastern seaboard as far north as Massachusetts, with the exception of Connecticut, but sightings north of Florida are rare. Hawksbills are observed in Florida with some regularity on the reefs off Palm Beach County, where the warm Gulf Stream current passes close to shore, and in the Florida Keys. Texas is the only other state where hawksbills are sighted with any regularity. Most sightings involve post-hatchlings and juveniles. These small turtles are believed to originate from nesting beaches in Mexico.

Nesting within the Caribbean dependent areas of the United States occurs principally in Puerto Rico and the U.S. Virgin Islands, the most important sites being Mona Island and Buck Island. Nesting also occurs on other beaches of St. Croix, and on Culebra Island, Vieques Island, mainland Puerto Rico, St. John and St. Thomas. Within the continental United States, nesting is restricted to the southeast coast of Florida and Florida Keys.

In the U.S. Pacific Ocean, there have been no hawksbill sightings off the west coast. Hawksbills have been observed in the Gulf of California as far north as 29°N, throughout the northwestern states of Mexico, and south along the Central and South American coasts to Columbia and Ecuador. In the Hawaiian Islands, nesting occurs in the main islands, primarily on several small sand beaches on the Islands of Hawaii and Molokai. Two of these sites are at a remote location in the Hawaii Volcanos National Park.

Along the far western and southeastern Pacific, hawksbill turtles nest on the islands and mainland of southeast Asia, from China to Japan, and throughout the Philippines, Malaysia, Indonesia, Papua New Guinea, the Solomon Islands (McKeown, 1977) and Australia (Limpus, 1982). Along the eastern Pacific rim, hawksbill turtles were common to abundant in the 1930s (Cliffton *et al.*, 1982). By the 1990s, the hawksbill turtle was rare to absent in most localities where it was once abundant (Cliffton *et al.*, 1982; Cornelius, 1982).

Hawksbills utilize different habitats at different stages of their life cycle. Posthatchling hawksbills occupy the pelagic environment, taking shelter in weedlines that accumulate at convergence points. Hawksbills reenter coastal waters when they reach approximately 20-25 cm carapace length. Coral reefs are widely recognized as the resident foraging habitat of juveniles, subadults and adults. This habitat association is undoubtedly related to their diet of sponges, which need solid substrate for attachment. The ledges and caves of the reef provide shelter for resting both during the day and night. Hawksbills are also found around rocky outcrops and high energy shoals, which are also optimum sites for sponge growth. Hawksbills are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent. In Texas, juvenile hawksbills are associated with stone jetties (Hidebrand 1987, Amos 1989).

Tag return data (Pritchard and Trebbau 1984) and recent genetic studies (Bowen *et al.*, 1996) suggest that individual foraging areas support hawksbills from distant breeding populations rather than just from nearby rookeries. They are found in all tropical seas between about 30°N and 30°S latitudes (NMFS and USFWS, 1998b). They are generally associated with coral reefs or other hard substrate structures close to shore where they feed on sponges and small crustaceans.

Life Cycle and Population Dynamics

The best estimate of age at sexual maturity for hawksbill turtles is about 20 to 40 years (Chaloupka and Limpus, 1997; Crouse, 1999a). Boulon (1994) estimated that juvenile hawksbills from the U.S. Virgin Islands would require between 16.5 and 19.3 additional years to reach maturity after entering nearshore habitats at several years of age at 21.4 cm straight carapace length.

Growth rates within benthic stage (juvenile turtles which have returned from pelagic developmental habitats) Australian hawksbill turtles are sex dependent with the female growing faster. Maximal growth rates for both males and females occurred at 60 cm curved carapace length (CCL) and then declined to minimal rates of growth as the turtles neared maturity at 80 cm CCL (Chaloupka and Limpus, 1997). The growth rates of Australian hawksbills appear to be less than those of Caribbean turtles, indicating geographic variation in growth.

Data on the transition rates between life stages are unavailable for hawksbill turtles. As a result, we were unable to analyze the stage structure of this species to estimate its finite population growth rate (λ) or the elasticities of the various life stages. The typical population structure for long-lived, late-maturing species like hawksbill turtles would be expected to have the largest proportion of individuals and the highest mortality rates in the earliest stages; proportions and mortality decline through successive stages with the smallest proportion of the total population in the adult stages, which also have the lowest mortality rates.

Biological Characteristics

There is little information available on the biology of hawksbills most likely because they are sparsely distributed throughout their range and they nest in very isolated locations (Eckert, 1993).

Diet
Hawksbills have a relatively unique diet of sponges (Meylan, 1985; 1988). While data are somewhat limited on diet in the Pacific, it is well documented in the Caribbean where hawksbill turtles are selective spongivores, preferring particular sponge species over others (Dam and Diez, 1997b).

Diving Behavior
Foraging dive durations are often a function of turtle size with larger turtles diving deeper and longer. At a study site also in the northern Caribbean, foraging dives were made only during the day and dive durations ranged from 19-26 minutes in duration at depths of 8-10 m. At night, resting dives ranged from 35-47 minutes in duration (Dam and Diez, 1997a).

Life History/Reproduction
As hawksbill turtle grow from juveniles to adults, data suggest that the turtle switches foraging behaviors from pelagic surface feeding to benthic reef feeding (Limpus, 1992). Within the Great Barrier Reef of Australia, hawksbills move from a pelagic existence to a "neritic" life on the reef at minimum CCL of 35 cm. The maturing turtle establishes foraging territory and will remain in this territory until it is displaced (Limpus, 1992). As with other sea turtles, hawksbills will make long reproductive migrations between foraging and nesting areas (Meylan, 1999), but otherwise they remain within coastal reef habitats. In Australia, juvenile turtles outnumber adults 100:1. These populations are also sex biased with females outnumbering males 2.57:1 (Limpus, 1992).

Although hawksbill nesting is broadly distributed, at no one place do hawksbills nest in large numbers, and many areas have experienced notable declines. Hawksbills utilize both low- and high-energy nesting beaches in tropical oceans of the world. Both insular and mainland nesting sites are known. Hawksbills will nest on small pocket beaches, and, because of their small body size and great agility, can traverse fringing reefs that limit access by other species. They exhibit a wide tolerance for nesting substrate type. Nests are typically placed under vegetation.

There is much variation in clutch size from site to site and among sizes of turtles, with the larger turtles laying the largest clutches. Known clutch size in the Pacific averages 130 eggs per clutch, around 3 clutches per year, and anecdotal reports indicate that hawksbill remigration intervals average around two years (Eckert, 1993; NMFS and USFWS, 1998b). Hawksbills nest throughout the insular tropical Pacific, though only in low density colonies. In the Campbell Island colony of northeastern Australia, nesting females average 83.2 cm CCL, weigh 51.6 kg and lay three clutches of eggs 14 days apart. Average clutch size was 132 eggs (Limpus *et al.*, 1983). In Samoa, hawksbill nests averaged 149.5 eggs.

Mrosovsky *et al.* (1995) evaluated the effect of incubation temperature on sex determination in hawksbill hatchlings. Incubation temperatures warmer than approximately 29.2°C produced females, while cooler temperatures produced males.

Migration
Like other sea turtles, hawksbills are highly migratory, although they may be less of a long-distant migrant. An adult female tagged in its foraging ground in the Torres Strait was observed nesting 322 days later in the Solomon Islands, a distance of over 1,650 km (Pritchard and Trebbau 1984). Another female traveled 1,400 km from the Solomon Islands to its foraging grounds in Papua New Guinea (Parmenter 1983).

Population Status and Trends

The hawksbill is a solitary nester, and thus, population trends or estimates are difficult to determine. There are no world population estimates for hawksbill turtles, but a minimum of 15,000 to 25,000 females are thought to nest annually in more than 60 geopolitical entities (Groombridge and Luxmoore 1989). Moderate population levels appear to persist around the Solomons, northern Australia, Palau, Persian Gule islands, Oman, and parts of the Seychelles (Groombridge 1982). In a more recent review, Groombridge and Luxmoore (1989) list Papua New Guinea, Queensland, and Western Australia as likely to host 500-1,000 nesting females per year, while Indonesia and the Seychelles may support >1,000 nesting females. The largest known nesting colony in the world is located on Milman Island, Queensland, Australia where Loop (1995) tagged 365 hawksbills nesting within an 11 week period. With the exception of Mexico, and possibly Cuba, nearly all Wider Caribbean countries are estimated to receive <100 nesting females per year (Meylan 1989).

Hawksbills appear to be declining throughout their range. By far the most serious problem hawksbill turtles face is the harvest by humans, while a less significant threat, but no less important, is loss of habitat due to expansion of resident human populations and/or increased tourism development. Dramatic reductions in the numbers of nesting and foraging hawksbills have occurred in Micronesia and the Mexican Pacific coast, probably due largely to technological advances in fishing gear, which facilitate legal and illegal harvest. In addition, the hawksbill tortoiseshell trade probably remains an important contributing factor in the decline of the hawksbill. Although the Japanese market was closed in 1994, southeast Asia and Indonesia markets remain lucrative (NMFS and USFWS, 1998b). In addition to the demand for the hawksbill's shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Prior to being certified under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles. A negotiated settlement was reached regarding this trade on June 19, 1992. The hawksbill shell commands high prices (currently $225/kilogram), a major factor preventing effective protection[9].

Distribution and Abundance of Nesting Females in the Pacific Ocean
Generally, in the Pacific, the largest nesting concentrations of hawksbills occur on remote oceanic islands off Australia (Torres Strait), while remote beaches in the Solomon Islands, Papua New Guinea, Indonesia, and Malaysia serve as less significant sites. Otherwise, hawksbill nesting does not occur in abundance in the Pacific. Throughout Micronesia, hawksbill nesting is in decline, with Palau representing the highest activity, with conceivably as few as 20 nesting females per year (NMFS and USFWS, 1998b). In Japan, nesting is very rare and is confined to the southern islands. Hawksbill nesting also occurs in Vietnam and China, although the status in these areas is unknown. Nesting is widespread throughout the Philippines, although the sites are relatively poorly known, and population abundance has not been quantified (Eckert, 1993).

Australia
In Queensland, Australia, there are two genetic stocks of hawksbills, with about 4,000 females nesting annually in the area. A study began at Milman Island to look at hawksbill nesting trends; researchers have documented a three percent per annum decline in the number of females nesting and a four percent decline in the clutches laid over the past ten years. Anthropogenic threats include hunting, ingestion and entanglement in marine debris, and disease (Dobbs, 2002).

Palau
The Palau nesting population of hawksbills is the largest in Oceania north of the equator; nesting is concentrated on small beaches of the Rock Islands between Koror and Peleliu islands (Maragos 1991). This population is severely stressed by chronic egg poaching and the hunting of turtles for jewelry and crafts (Maragos 1991). Residents are nearly unanimous in their opinion that nesting numbers are down significantly during their lifetimes. Maragos (1991) reported an average of 58 nests found per year (1982-1990), of which 76% were identified as "nests without eggs" or nests that were illegally poached. The annual number of nests in the Rock Islands might approach one hundred under the most favorable of circumstances. This would represent 20-25 nesting females per season, assuming 4-5 nests per turtle per season. If 40% of adult female hawksbills return to nest each year, given an average remigration interval of 2.5 years for the population, then approximately 50-60 adult females might remain in the Rock Island nesting population today.

Fiji
In Fiji, hawksbill nesting is widely dispersed and populations are small. In addition, the nesting populations at most sites have been reduced to 10-20% during the last five years (Batibasaga, 2002). Most nesting takes place on the eastern and southern parts of the Fiji Islands, particularly Namena Island, which used to have over 100 nests per season in the early 1970s. Currently, it is the main nesting site for hawksbills in Fiji, with approximately 40 nests per season between 1995 and 1999 (Batibasaga, 2002). The breeding population of hawksbills in Fiji is estimated to be

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[9]http://www.nmfs.noaa.gov/prot_res/species/turtles/hawksbill.html

approximately 120-150 turtles (*in* Rupeni *et al.*, 2002). While there was a moratorium on killing sea turtles instituted in Fiji in 1997, this ban ended after December, 2000, so harvesting of turtles remains a significant threat to hawksbills.

Malaysia
In Malaysia, hawksbills do not nest in large numbers, and likely decades of excessive egg collection and exploitation is the primary cause of the decimation of sea turtle populations in this country. Liew (2002) reports that there are approximately 500 hawksbill nests per year in the Sabah Turtle Islands and the trend appears to be stabilized. Basintal (2002), however, notes a decline in hawksbill nesting in this region since 1995, with less than 300 nests in 2001. At Gulisaan Island, where 87% of the hawksbill nesting takes place in the Turtle Islands, severe erosion is taking place, so this decreasing trend will likely continue. In Malacca, there are approximately 250 nests per year, and appears to be stable. In Terengganu, there has been a significant decrease in the number of hawksbill nestings in the last 20 years: from a high of 120 nests in 1986 to an average of around 20 nests per years from 1994 through 2000 (Liew, 2002).

Indonesia
In Indonesia, although hawksbill populations have been declining, they can still be found nesting throughout the country in significant numbers. Important hawksbill rookeries include the Anambas and Natuna-Riau islands; Lima Momperang; Pesemut-Belitung, Segamat Islands, Lampung; South of Ujungpandang; Bira-Birahan, and the Derawan Islands, East Kalimantan (*in* Dermawan, 2002). Nesting trends of hawksbills have been monitored since the early 1980s at three sites: Alas Purwo National Park, East Java, Jamursba-Medi beach, Papua; and Sukamade beach, Meru Betiri, East Java. At Meru Betiri, hawksbill nestings have declined significantly since 1980, with very low numbers nesting in the last decade, while the trends for the other two sites appear to fluctuate over the past two decades, but appear stable (Dermawan, 2002).

Thailand
In Thailand, hawksbills nest on the Khram Islands, in the Gulf of Thailand, and since their nesting areas have been protected and controlled since 1950, the population of nesting females has remained stable. Since 1973, there are approximately 100 hawksbill nests per year at the Khram Islands (Charuchinda *et al.*, 2002).

American Samoa
For American Samoa, based on interviews, Tuato'o-Bartley *et al.* (1993) estimated 50 nesting female hawksbills per year on Tutuila and 30 nesting females per year on the Manu'a island group of Ofu, Olosega and Ta'u, using an average 2.8 nesting turtles per active beach. A total of 120 nesting females were estimated throughout American Samoa. However, since local people almost always seem to underestimate individual fecundity (numbers of clutches per female), the actual number of turtles nesting at Tutuila and Manu'a could be significantly lower than Tuato'o-Bartley's estimates. Given an estimate of 120 nesting females, recent records indicate that there is a decline in the number of females nesting annually, based on confirmed nests and clutches of hatchlings. (Utzurrum, 2002).

CNMI

There are no reports of hawksbills nesting in the Commonwealth of the Northern Mariana Islands (CNMI) (Pritchard, 1982a). This is partly because there is a long history of occupation on the more southern islands of Saipan, Rota, and Tinian, and partly because almost no hawksbill nesting surveys of small pocket beaches have ever been done in remote areas of the CNMI. However, lack of evidences does not rule out the possibility of hawksbills nesting at low levels at unknown locations.

Hawaii

Within the State of Hawaii, hawksbill turtles are known to nest on the Hawaiian Islands of Maui, Molokai, and Hawaii. Two nesting sites are located in the Hawaii Volcanoes National Park (Balazs *et al.*, 1992; Katahira *et al.*, 1994). In surveys conducted between 1989 and 1993, 18 hawksbill turtles were tagged and 98 nests documented (NMFS and USFWS, 1998b). Although total population numbers and trends in abundance are not known for the Hawaiian population of hawksbill turtles, probably no more than 35 females nest annually on all beaches combined (J. Wetherall, NMFS, personal communication, 1999). The peak nesting occurs from late July to early September (Katahira *et al.*, 1994). Recent nesting activity has occurred at Kealia Beach on Maui. There are no records of nesting hawksbill turtles or reported observations of their occurrence near the Main Hawaiian Islands, although they may have occupied the region in the past. Hawksbill turtles appear to prefer nesting sites with steep beaches and coarse sand, and this may explain, in part, their presence in the main Hawaiian Islands.

Only the ETP purse seine fishery has observed the take of hawksbills. Unfortunately, turtles in this fishery are not sampled to determine nesting origin. Nonetheless, because of the location of fishing effort, hawksbills taken in this fishery likely originate from eastern Pacific nesting beaches.

Leatherback Turtles

Global Status

The leatherback turtle is listed as endangered under the ESA throughout its global range. Increases in the number of nesting females have been noted at some sites *in the Atlantic*, but these are far outweighed by local extinctions, especially of island populations, and the demise of once large populations *throughout the Pacific*, such as in Malaysia and Mexico. Spotila *et al.* (1996) estimated the *global* population of female leatherback turtles to be only 34,500 (confidence limits: 26,200 to 42,900) nesting females; however, the eastern Pacific population has continued to decline since that estimate, leading some researchers to conclude that the leatherback is now on the verge of extinction in the Pacific Ocean (e.g. Spotila, *et al.*, 1996; Spotila, *et al.*, 2000).

Physical Description

Leatherback turtles are the largest of the marine turtles, with a CCL often exceeding 150 cm and front flippers that are proportionately larger than in other sea turtles and may span 270 cm in an adult (NMFS and USFWS, 1998c). In view of its unusual ecology, the leatherback is morphologically and physiologically distinct from other sea turtles. Its streamlined body, with a smooth, dermis-sheathed carapace and dorso-longitudinal ridges may improve laminar flow of this highly pelagic species. Leatherbacks nesting in the western Pacific are considerably larger than those nesting in the eastern Pacific. Adult females nesting in Michoacán, Mexico averaged 145 cm CCL (Sarti, unpublished data, *in* NMFS and USFWS, 1998c), while adult female leatherback turtles nesting in eastern Australia averaged 162 cm CCL (Limpus, *et al.*, 1984, *in* NMFS and USFWS, 1998c). Leatherbacks in Papua, Indonesia and Papua New Guinea averaged 161 cm CCL (Starbird and Suárez, 1994; Hirth *et al.*, 1993, respectively).

General Distribution

Leatherback turtles are widely distributed throughout the oceans of the world. The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main regional areas may further be divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India and Sri Lanka.

Leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific Ocean between 71°N and 47°S latitude and in all other major pelagic ocean habitats (NMFS and USFWS, 1998c). For this reason, however, studies of their abundance, life history and ecology, and pelagic distribution are exceedingly difficult. Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been proposed that mating most likely takes place outside of the tropical waters, before females move to their nesting beaches (Eckert and Eckert, 1988). Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale, *et al.*, 1994; Eckert, 1998; Eckert, 1999a). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert, 1998).

The distribution of juvenile leatherback turtles has long been a mystery. However, a recent compilation and analysis of sighting and stranding data for the species has provided some insight into the developmental habitats of this species at earlier life stages. It appears that young leatherback turtles (carapace length <100 cm) reside only in waters warmer than 26°C, which should generally place them outside of areas in which longline swordfish fleets operate (Eckert, 1999b; Eckert, 2002).

Life Cycle and Population Dynamics

Figure 3.4 illustrates the basic life cycle of the leatherback turtle (based on estimates provided by Chaloupka (2001) for western Pacific leatherback nesting aggregations). This cycle is broken into seven life stages based on age: (1) egg/hatchling; (2) neonate; (3) warm water juvenile, (4) cool water juvenile, (5) immature, (6) sub-adult, and (7) adult, each with their own expected survival rate (Table 3.4). Arrows along the bottom represent the probability of each ageclass surviving and remaining in the ageclass. Arrows between each ageclass represent the probability of the ageclass surviving and growing to the next ageclass, and the arrows along the top represent the ageclass-specific fertility. The thickness or length of the lines do not indicate a level of probability or fecundity. Available information on the behavior, physiology, and biological requirements of these stages is summarized below.

Figure 3.4. Life-cycle graph of the leatherback turtle (based on Chaloupka 2001)

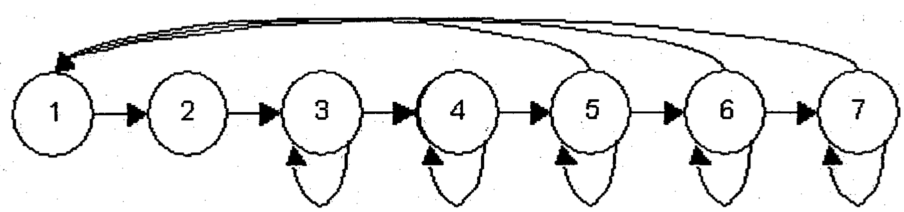

Table 3.4: Stage structure and vital rates for leatherback turtles (Chaloupka, 2001; 2002)

Stage	Name	Age	Stable Stage Structure[1]	Survival Probability (lx)	Fecundity[2]
1	Egg-hatchling	0	not estimated	various	0
2	Neonate	1	65.12%	0.25	0
3	Warm Water Juvenile	2-4	21.38%	0.75	0
4	Cool Water Juvenile	4-5	4.02%	0.75	0
5	Immature	5-9	5.99%	0.85	79-90
6	Sub-adult	10-14	1.46%	0.9	79-90
7	Adult	15+	1.97%	0.9	79-90

[1] Stable age structure proportions estimated from Chaloupka (2002) leatherback simulation model parameters for initial abundance of western Pacific population in 1900.
[2] Eckert (2000).

Because leatherback turtles spend most of their lives in pelagic environments, it is very difficult to gather the basic information on their abundance, life history and ecology, and pelagic distribution difficult. In the absence of these data, several investigators have constructed conceptual models, simulations, or thought experiments to estimate possible stable age structures and stage-specific survival probabilities for leatherback turtles (Chaloupka 2001, 2002; Spotila et al. 1996, 2000).

The results of these efforts help frame the direction of future research, but the degree to which they reliably describe the actual vital rates of different leatherback turtle populations is unknown.

However, the data that are available suggest that leatherback turtles follow patterns that are similar to other long-lived species that delay the age at which they become mature (Chaloupka 2001, 2002; Crouse 1999; Heppell et al. 1999, 2003a; Meylen and Ehrenfeld 2000; Spotila et al. 1996, 2000). That is, leatherback turtles can be expected to have low and variable survival in the egg and hatchling stages and high and relatively constant annual survival in the subadult and adult life stages (Heppell et al. 2003). An undisturbed population of leatherback sea turtles is likely to have rates of increase that are fairly stable. For example, green turtles in the southern Great Barrier Reef have a finite rate of increase (λ) of approximately 1, indicating a stationary population, or one that is neither increasing nor decreasing over time intervals covering several years.

In addition, growth rates of leatherback turtle populations are probably more sensitive to changes in the survival rate of juvenile, sub-adult, and adult turtles than other stages. As a result, the survival rate of reproductive adults, sub-adults, and juvenile leatherback turtles will largely determine the growth, decline, or maintenance of the population (Crouse 1999; Heppell et al. 1999, 2003a; Meylen and Ehrenfeld 2000; Spotila et al. 1996, 2000). Conversely, the population's rates of increase or decrease would be relatively insensitive to changes in the survival rates of eggs or hatchlings; this does not imply that other life stages can be disregarded, but does imply that the species has evolved to withstand low survival rates at these stages as well as large amounts of year-to-year variation (Heppell et al. 2003a). Persistence of long-lived species with delayed maturity would be most vulnerable to impacts that preclude individuals from (1) attaining age and sexual maturity, or (2) surviving to produce sufficient offspring to replace themselves.

Finally, like other sea turtles, high site fidelity in nesting females implies that once a nesting aggregation declines to a few individuals or becomes extinct, it will not be "rescued" by adult females from other nesting aggregations. As a result, the loss of a nesting aggregation is a final and irreversible.

The dynamics of most leatherback turtle populations today, however, are certain to reflect the effects of numerous anthropogenic activities which have caused or exacerbated the declines in abundance noted in many leatherback nesting aggregations, such as those documented in Malaysia. As a result, the rates of population increase or decrease, and life stage elasticities of these populations are likely indicative of declining populations (that is rates of increase or λs less than 1, and changed proportional importance of different life stage elasticities on a population's rate of growth). For an example of the changed dynamics of a declining sea turtle population, see the *Life Cycle and Population Dynamics* discussion for loggerhead turtles below. In a disturbed population, the survival rates of adult turtles may still have the highest elasticities, typical for long-lived species with delayed maturity. However, the survival rates of life stages relatively undisturbed by chronic or significant sources of mortality increase in importance as the population relies upon these stages to supply enough individuals to survive the rigors of subsequent life stages and reach sexual maturity. In the case of a population where the survival of all life stages has been decreased by anthropogenic activities, stage elasticities may change such that the proportional effect of a change in survival rate in any stage can have significant effect on the rates at which their populations grow over time.

Leatherback populations currently face high probabilities of extinction as a result of both environmental and demographic stochasticity. Demographic stochasticity, or chance variation in the birth or death of an individual of the population, is facilitated by the increases in mortality rates of leatherback populations due in part to harvest of individuals (either eggs or reproductive females on nesting beaches) or incidental capture and mortality of individuals in various fisheries. Environmental stochasticity, or random environmental changes that deteriorate or degrade environmental quality, is facilitated by destruction of nesting beach habitat or changes in nest temperature from loss of shade on nesting beaches. Loss of habitat or deterioration in habitat quality can reduce egg survival or even change the sex ratios of produced hatchlings. In both cases, the variation in rate or ratio due to environmental stochasticity exacerbate demographic stochasticity through increased mortality, or decreased breeding probability as individuals in a sex-skewed population have more difficulty finding members of the opposite sex. Increases in demographic stochasticity tend to increase the variance in the population growth rate (Gilpin and Soule, 1986). As this variance increases, a population's probability of extinction due to chance events increases. As a result, declines in a species' abundance due to increased mortality or the loss of some resource (nesting habitat, prey, etc.,) that might otherwise lead to extinction through deterministic processes also increase a species' chance of extinction via other random occurrences (Gilpin and Soule, 1986).

Based on past observations, the leatherback turtles that are captured and killed in U.S. fisheries operating in the Pacific are primarily sub-adult and adult leatherback turtles (see the discussion in the *Effects of the Action* section). Over the history of these fisheries, the effect of these annual deaths would significantly reduce the survival rates of individuals in these life stages in the nesting aggregations that interact with these fisheries. From our analyses, these reductions would be expected to have a significant, adverse affect on the trend of those nesting aggregations, particularly if these losses are added to losses in other life stages. The combined effect of these activities, which affect most or all life stages of most leatherback turtle populations, would significantly reduce the population growth rates of the nesting aggregations that interact with these fisheries.

Biological Characteristics

Diet

Satellite telemetry studies indicate that adult leatherback turtles follow bathymetric contours over their long pelagic migrations and typically feed on cnidarians (jellyfish and siphonophores) and tunicates (pyrosomas and salps), and their commensals, parasites and prey (NMFS and USFWS, 1998c). Because of the low nutritive value of jellyfish and tunicates, it has been estimated that an adult leatherback would need to eat about 50 large jellyfish (equivalent to approximately 200 liters) per day to maintain its nutritional needs (Duron, 1978, *in* Bjorndal, 1997). Compared to greens and loggerheads, which consume approximately 3-5% of their body weight per day, leatherback turtles may consume perhaps 20-30% of their body weight per day (Davenport and Balazs, 1991).

Surface feeding by leatherbacks has been reported in U.S. waters, especially off the west coast (Eisenberg and Frazier, 1983), but foraging may also occur at depth. Based on offshore studies of diving by adult females nesting on St. Croix, U.S. Virgin Islands, Eckert *et al.* (1989) proposed that observed internesting[10] dive behavior reflected nocturnal feeding within the deep scattering layer (strata comprised primarily of vertically migrating zooplankton, chiefly siphonophore and salp colonies, as well as medusae). Hartog (1980, *in* NMFS and USFWS, 1998c) also speculated that foraging may occur at depth, when nematocysts from deep water siphonophores were found in leatherback stomach samples. Davenport (1988, *in* Davenport and Balazs, 1991) speculated that leatherback turtles may locate pyrosomas at night due to their bioluminescence; however direct evidence is lacking.

Diving Behavior

The maximum dive depths for post-nesting female leatherbacks in the Carribean have been recorded at 475 meters and over 1,000 meters, with routine dives recorded at between 50 and 84 meters. The maximum dive length recorded for such female leatherback turtles was 37.4 minutes, while routine dives ranged from 4-14.5 minutes (*in* Lutcavage and Lutz, 1997). Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert, *et al.*, 1989).

A total of six adult female leatherback turtles from Playa Grande, Costa Rica were monitored at sea during their internesting intervals and during the 1995 through 1998 nesting seasons. The turtles dived continuously for the majority of their time at sea, spending 57-68% of their time submerged. Mean dive depth was 19 ± 1 meters and the mean dive duration was 7.4 ± 0.6 minutes (Southwood, *et al.*, 1999). Similarly, Eckert (1999a) placed transmitters on nine leatherback females nesting at Mexiquillo Beach and recorded dive behavior during the nesting season. The majority of the dives were less than 150 meters depth, although maximum depths ranged from 132 meters to over 750 meters. Although the dive durations varied between individuals, the majority of them made a large proportion of very short dives (less than two minutes), although Eckert (1999a) speculates that these short duration dives most likely represent just surfacing activity after each dive. Excluding these short dives, five of the turtles had dive durations greater than 24 minutes, while three others had dive durations between 12-16 minutes.

Migrating leatherback turtles also spend a majority of time at sea submerged, and they display a pattern of continual diving (Standora, *et al.*, 1984, *in* Southwood, *et al.*, 1999). Based on depth profiles of four leatherbacks tagged and tracked from Monterey Bay, California in 2000 and 2001, using satellite-linked dive recorders, most of the dives were to depths of less than 100 meters and most of the time was spent shallower than 80 meters. Based on preliminary data analysis, 75-90%

[10]Internesting – time spent between laying clutches of eggs during a single nesting season.

of the time the leatherback turtles were at depths less than 80 meters (Peter Dutton, NOAA Fisheries, personal communication, January 2004).

Life History/Reproduction

Using a small sample size of leatherback sclerotic ossicles, analysis by Zug and Parham (1996) suggested that mean age at sexual maturity for leatherback turtles is around 13 to 14 years, giving them the highest juvenile growth rate of all sea turtle species. Zug and Parham (1996) concluded that for conservation and management purposes, 9 years is a likely minimum age for maturity of leatherback turtles, based on the youngest adult in their sample. The natural longevity of leatherback turtles has not been determined (NMFS and USFWS, 1998c), although there are recorded documentations of post-maturation survival on the order of about 20 years (Pritchard, 1996).

On the Pacific coast of Mexico, female leatherback turtles lay an average of 4 clutches per season, with clutch size averaging 64 yolked eggs per clutch (García and Sarti, 2000) (each clutch contains a complement of yolkless eggs[11], sometimes comprising as much as 50 percent of total clutch size, a unique phenomenon among leatherback turtles and some hawksbills (Hirth and Ogren, 1987)). Each clutch is laid within a 9.3 day interval (García and Sarti, 2000). In Las Baulas, Costa Rica, the average clutch size is also 64.7 ± 1.4 yolked eggs. Reproductive output ranged from 4.3 ±0.2 to 7.9 ±0.3 clutches per female per nesting season (Reina *et al.*, 2002). Clutch sizes in Terengganu, Malaysia, and in Pacific Australia were larger, averaging around 85-95 yolked eggs and 83 yolked eggs, respectively (*in* Eckert, 1993).

Females are believed to migrate long distances between foraging and breeding grounds, at intervals of typically two or four years (García and Sarti, 2000). Spotila *et al.* (2000), found the mean re-nesting interval of females on Playa Grande, Costa Rica to be 3.7 years, while in Mexico, 3 years was the typical reported interval (L. Sarti, Universidad Naçional Autonoma de Mexico (UNAM), personal communication, 2000). In Mexico, the nesting season generally extends from November to February, although some females arrive as early as August (Sarti *et al.*, 1989). Most of the nesting on Las Baulas takes place from the beginning of October to the end of February (Reina *et al.*, 2002). In the western Pacific, nesting peaks on Jamursba-Medi Beach (Papua, Indonesia) from May to August, on War-Mon Beach (Papua) from November to January (Starbird and Suarez, 1994), in peninsular Malaysia in June and July (Chan and Liew, 1989), and in Queensland, Australia in December and January (Limpus and Riemer, 1984).

Migration

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known. However, satellite tracking of post-nesting females and genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the west coast of the U.S. present some strong insight into at least a portion of their routes and the importance of

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[11] Bell *et al.* (2003) note that "yolkless eggs" is an incorrect nomenclature, since they do not contain a 1 N nucleous with an associated yolk that together make up a gamete or oöcyte.

particular foraging areas. Aerial surveys conducted during the late summer and fall months of 1990-2001 reveal that leatherbacks forage off central California, generally at the end of the summer, when upwelling relaxes and sea surface temperatures increase. Leatherbacks were most often spotted off Point Reyes, south of Point Arena, in the Gulf of the Farallones, and in Monterey Bay. These areas are upwelling "shadows," regions where larval fish, crabs, and jellyfish are retained in the upper water column during relaxation of upwelling. Researchers estimated an average of 170 leatherbacks (95% CI = 130-222) were present between the coast and roughly the 50 fathom isobath off California. Abundance over the study period was variable between years, ranging from an estimated 20 leatherbacks (1995) to 366 leatherbacks (1990) (Benson *et al.*, 2003).

Current data from genetic research suggest that Pacific leatherback stock structure (natal origins) may vary by region. Due to the fact that leatherback turtles are highly migratory and stocks mix in high seas foraging areas, and based on genetic analyses of samples collected by both Hawaii-based and west coast-based longline observers, leatherback turtles inhabiting the northern and central Pacific Ocean are comprised of individuals originating from nesting assemblages located south of the equator in the western Pacific (e.g. Indonesia, Solomon Islands) and in the eastern Pacific along the Americas (e.g., Mexico, Costa Rica) (Dutton, *et al.*, 2000).

For female leatherback turtles nesting at Mexiquillo Beach, Mexico, the eastern Pacific region has been shown to be a critical migratory route. Nine females outfitted with satellite transmitters in 1997 traveled along almost identical pathways away from the nesting beach. These individuals moved south and, upon encountering the North Equatorial Current at about 8°N, diverted west for approximately 800 km and then moved east/southeast towards the waters off Peru and Chile (Eckert, 1999a). In addition, four leatherback turtles recovered from Chilean fishing vessels from 1988-91 had been tagged on nesting beaches in Costa Rica and Mexico (Brito-Montero, 1995, *in* Donoso, 2000). A leatherback tagged at Agua Blanca in Baja California in 2000 began migrating south to approximately 370 kilometers from where it was tagged (Pinal *et al.*, 2002).

Morreale *et al.* (1994) demonstrated that satellite tagged, post-nesting leatherback turtles leaving Costa Rica followed precisely defined, long-distance migratory pathways after nesting. Despite differences in dates of departure from the nesting areas, nesting cohorts followed along nearly identical pathways. All 6 leatherback turtles' (from the Pacific and Caribbean coasts of Costa Rica) movements paralleled deepwater bathymetric contours ranging from 200-3,500 meters. When a turtle's path intersected an abyssal plain, it veered along the outer slope, and when an abyssal plain was unavoidable, the turtle crossed it at its narrowest point. These studies underscore the importance of this offshore habitat and migratory corridors and the likelihood that sea turtles are present on fishing grounds, particularly for large commercial fishing fleets south of the equator (Eckert, 1997). Eckert (1999a) speculates that leatherback turtles leaving the nesting areas of Mexico and Costa Rica may be resource-stressed by a long reproductive season with limited food and the high energetic requirements brought about by the demands of reproduction, elevated water temperatures, or both. When they leave, their greatest need is to replenish energy stores (e.g. fat) and they must move to areas where food is concentrated (e.g. upwelling areas). Most of these eastern Pacific nesting stocks migrate south, although one genetic sample from a leatherback turtle caught south of the main Hawaiian Islands by the Hawaii-based longline fishery indicated representation from eastern Pacific nesting beaches (P. Dutton, NMFS, personal communication, October 2002).

In the last three years, researchers have discovered two important migratory corridors of leatherback turtles originating from western Pacific nesting beaches. Initially, genetic analyses of stranded leatherbacks found along the western U.S. mainland determined that the turtles had originated from western Pacific nesting beaches. Furthermore, genetic analysis of samples from leatherback turtles taken off California and Oregon by the CA/OR drift gillnet fishery and in the northern Pacific, taken by the California-based longline fishery, revealed that all originated from western Pacific nesting beaches (i.e. Indonesia/Solomon Islands/Malaysia) (P. Dutton, NMFS, personal communication, December, 2003).

Observations of tracked leatherbacks captured and tagged off the west coast of the United States have revealed an important migratory corridor from central California, to south of the Hawaiian Islands, leading to western Pacific nesting beaches. In September, 2000, researchers captured their first two leatherbacks off Monterey, California. Of two females, one was of a size normally associated with the western Pacific nesting stock, which are, on average, 10-20 centimeters larger than eastern Pacific nesting stocks (Zug and Parham, 1996). Both headed on a southwest migratory path, appearing to be heading to the western Pacific nesting beaches (Dutton and Eckert in press). In 2001, a male and female leatherback were captured and tagged. The male headed north of the "migratory corridor" taken by the two females the year before and stopped transmitting on 12/17/01, while the female traveled north to the Farallon Islands and then headed west, where transmissions stopped on 10/11/01 (D. Parker and P. Dutton, NMFS, personal communication, June, 2002). Genetic analysis confirmed that all four of these leatherbacks tagged and outfitted with transmitters were from the western Pacific stock (P. Dutton, NMFS, personal communication, October 2002). Since then, eight leatherbacks (6 females, 2 males) were captured in 2002, and six (5 females, 1 male) were captured in 2003. All were outfitted with satellite tags and tracked. Most followed the southwest migratory corridor, heading towards western Pacific nesting beaches. Two that have been tracked for an extended period of time did not arrive on the nesting beaches, instead heading north and east, back towards the northen part of Hawaii. One leatherback did not follow a southwest track out of Monterey and instead headed southeast, along Baja California, Mexico, and into the Gulf of California. All leatherbacks captured off central California have been found to originate from western Pacific nesting beaches (P. Dutton, NMFS, personal communication, December, 2003).

Researchers have also begun to track female leatherbacks tagged on western Pacific nesting beaches, both from Jamursba-Medi, Papua, and from the Morobe coast of Papua New Guinea. Most of the females that have been tagged in Papua have been tracked heading on an easterly pathway, towards the western U.S. coast. One female headed north and is currently meandering in the East China Sea and the Sea of Japan, generally between Japan and South Korea. Another female headed north and then west of the Philippines. Meanwhile, all the leatherbacks tagged off Papua New Guinea have traveled on a southeasterly direction, in the south Pacific Ocean (P. Dutton, NMFS, personal communication, December, 2003).

Genetic markers in 16 of 17 leatherback turtles sampled to date from the central North Pacific (captured in the Hawaii-based longline fishery) have identified those turtles as originating from nesting populations in the southwestern Pacific; the other specimen, taken in the southern range of the Hawaii fishery, was from nesting beaches in the eastern Pacific (Dutton and Eckert, in press). All 3 leatherbacks taken in the California-based longline fishery were found to originate from western Pacific nesting beaches, based on genetic analyses.

Population Status and Trends

Leatherback turtles are widely distributed throughout the oceans of the world, and are found in waters of the Atlantic, Pacific, and Indian Oceans, the Caribbean Sea, and the Gulf of Mexico (Ernst and Barbour, 1972). Globally, leatherback turtle populations have been decimated worldwide. In 1980, the leatherback population was estimated at approximately 115,000 (adult females) globally (Pritchard, 1982b). By 1995, this global population of adult females had declined to 34,500 (Spotila *et al.* 1996). Populations have declined in Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. Throughout the Pacific, leatherbacks are seriously declining at all major nesting beaches. The decline can be attributed to many factors, including fisheries interactions, direct harvest, egg collection, and degradation of habitat. On some beaches, nearly 100% of the eggs laid have been harvested. Eckert (1996) and Spotila *et al.* (1996) note that adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries.

Atlantic Ocean/Caribbean Sea

In the Atlantic and Caribbean, the largest nesting assemblages of leatherbacks are found in the U.S. Virgin Islands, Puerto Rico, and Florida. Since the early 1980s, nesting data has been collected at these locations. Populations in the eastern Atlantic (*i.e.* off Africa) and Caribbean appear to be stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking and it is certain that some nesting populations (*e.g.*, St. John and St. Thomas, U.S. Virgin Islands) have been extirpated (NMFS and USFWS, 1995). Data collected in southeast Florida clearly indicate increasing numbers of nests for the past twenty years (9.1-11.5% increase), although it is critical to note that there was also an increase in the survey area in Florida over time (NMFS SEFSC, 2001). However, the largest leatherback rookery in the western North Atlantic remains along the northern coast of South America in French Guiana and Suriname. Recent information suggests that Western Atlantic populations declined from 18,800 nesting females in 1996 (Spotila *et al.*, 1996) to 15,000 nesting females by 2000 (Spotila, personal communication *in* NMFS SEFSC, 2001). The nesting population of leatherback turtles in the Suriname-French Guiana trans-boundary region has been declining since 1992 (Chevalier and Girondot, 1998). Poaching and fishing gear interactions are, once again, believed to be the major contributors to the decline of leatherbacks in the area (Chevalier *et al.* in press; Swinkels *et al.* in press). While Spotila *et al.* (1996) indicated that turtles may have been shifting their nesting from French Guiana to Suriname due to beach erosion, analyses show that the overall area trend in number of nests has been negative since 1987 at a rate of 15.0 -17.3 % per year (NMFS SEFSC, 2001). If turtles are not nesting elsewhere, it appears that the Western Atlantic portion of the population is being subjected to mortality beyond sustainable levels, resulting in a continued decline in numbers of nesting females.

Leatherbacks are exposed to commercial fisheries in many areas of the Atlantic Ocean. For example, leatherback entanglements in fishing gear are common in Canadian waters where Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland/ Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line and crab pot line. Leatherbacks are reported taken by the many other nations that participate in Atlantic pelagic longline fisheries (see NMFS SEFSC 2001, for a complete description of take records), including Taiwan, Brazil, Trinidad, Morocco, Cyprus, Venezuela, Korea, Mexico, Cuba, U.K., Bermuda, People's Republic of China, Grenada, Canada, Belize, France, and Ireland. Leatherbacks are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Castroviejo *et al.,* 1994; Graff, 1995). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier *et al.,*1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux *et al.,* 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio, 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95% (Eckert and Lien, 1999). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS SEFSC 2001). There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

Pacific Ocean - general
Based on published estimates of nesting female abundance, leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (Spotila *et al.*, 1996; NMFS and USFWS, 1998c; Spotila, *et al.*, 2000). Declines in nesting populations have been documented through systematic beach counts or surveys in Malaysia (Rantau Abang, Terengganu), Mexico and Costa Rica. In other leatherback nesting areas, such as Papua New Guinea, Indonesia, and the Solomon Islands, there have been no systematic consistent nesting surveys, so it is difficult to assess the status and trends of leatherback turtles at these beaches. In all areas where leatherback nesting has been documented, however, current nesting populations are reported by scientists, government officials, and local observers to be well below abundance levels of several decades ago. The collapse of these nesting populations was most likely precipitated by a tremendous overharvest of eggs coupled with incidental mortality from fishing (Sarti *et al.*, 1996; Eckert, 1997).

Eastern Pacific Nesting Populations of Leatherbacks

Leatherback nesting populations are declining at a rapid rate along the Pacific coast of Mexico and Costa Rica. Three countries which are important to leatherbacks nesting in the eastern Pacific include Costa Rica, which has the highest abundance and density in this area, Mexico, with

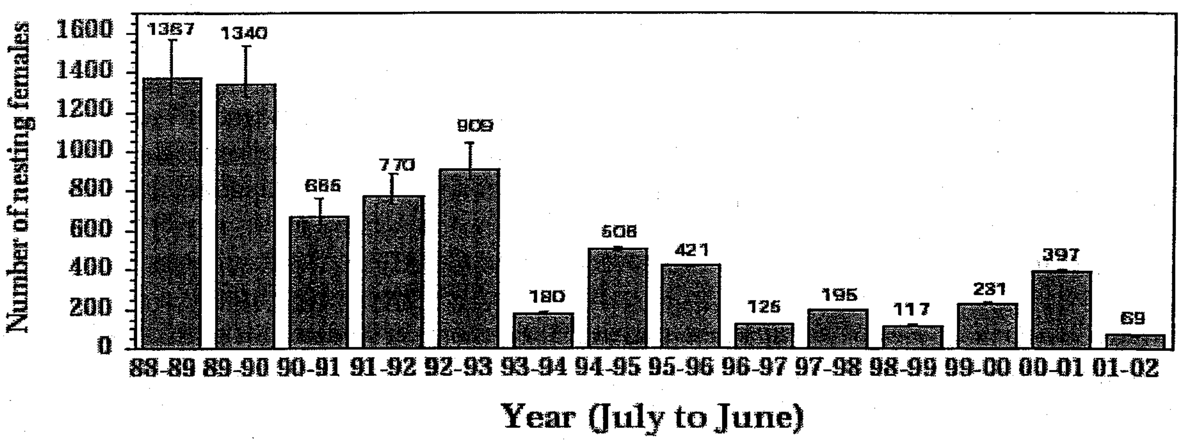

Figure 3.5. Number of female leatherbacks nesting at Playa Grande (Las Baulas, Costa Rica) from 1988-2002. (Source: R. Reina, Drexel University, personal communication, September, 2003).

several important nesting beaches, and Nicaragua, with two important nesting areas. Leatherbacks have been documented nesting as far north as Baja California Sur and as far south as Panama, with few areas of high nesting (Sarti, 2002).

Costa Rica. During the 1980s researchers realized that the beaches of Playa Grande, Playa Ventanas and Playa Langosta collectively hosted the largest remaining Pacific leatherback populations in Costa Rica. Since 1988, leatherback turtles have been studied at Playa Grande (in Las Baulas), the fourth largest leatherback nesting colony in the world. As shown in Figure III-5, during the 1988-89 season (July-June), 1,367 leatherback turtles nested on this beach, and by the 1998-99 season, only 117 leatherback turtles nested (Spotila, 2000). The 1999-2000 and 2000-01 season showed increases in the number of adult females nesting here, with 224 and 397 leatherbacks nesting, respectively. The last two nesting seasons have shown major declines, with only 69 nesting females during the 2001-02 season, and only 55 nesting females during the 2002-03 season. Scientists speculate that the low turnout during 2002-03 may be due to the "better than expected season in 2000-01 which temporarily depleted the reproductive pool of adult females in reproductive condition following the El Niño/La Niña transition" (R. Reina, Drexel University, personal communication, September, 2003).

Researchers began tagging females at Playa Grande in 1994. Since then, tagged leatherbacks have had a low return rate - 16% and 25% in the five or six years following tagging. Spotila *et al.* (2000) calculated a mean annual mortality rate of 35% for leatherbacks nesting at Las Baulas. At St. Croix, US Virgin Islands nesting grounds, female leatherbacks returned approximately 60% over the same period (McDonald and Dutton, 1996 *in* Reina *et al.*, 2002) and annual mortality rates ranged from 4-10% (Dutton *et al.*, 1999 *in* Reina *et al.*, 2002). Thus, comparatively few leatherback turtles are returning to nest on east Pacific nesting beaches and it is likely that leatherback turtles are experiencing abnormally high mortalities during non-nesting years. Since 1993, environmental education and conservation efforts through active law enforcement has greatly reduced egg poaching in Costa Rica (Chaves, *et al.*, 1996). For example, during the 1993-

94 nesting season, poaching accounted for only 1.3 percent of the loss of nests on Playa Grande. Other losses were due to predation, tidal effects and failure in egg development or infestation by maggots (Schwandt, *et al.*, 1996). Bell *et al.* (2003) found that while leatherbacks at Playa Grande had a high rate of fertility (mean = 93.3% ± 2.5%), embryonic death was the main cause of low hatchling success in this population. Researchers at Playa Grande have also found that temperature of the sand surrounding the egg will determine the sex of the hatchlings during a critical phase of their embryonic development. At this beach, temperatures above 29.5°C produce female hatchlings, while below 29.5°C, the hatchlings are male.

Since the late 1980s, the number of leatherback turtles nesting on the beaches of Playa Grande has declined from about 1,300 nesters per year to less than 400. The nesting aggregation appears to have fluctuated between about 400 and 70 individuals throughout most of the 1990s and early 2000s which suggests an instability in the population. This is consistent with the reports on the infertility of females in this population, high female mortalities between breeding intervals, and changing beach temperatures, all of which increase the variance in a population.

Table 3.11. Results of an assessment of the Playa Grande nesting aggregation of leatherback sea turtles using a discrete-time, density-independent diffusion estimation model

Demographic Parameter	Lower Census Estimate	Upper Census Estimate
Mean log growth rate (μ)	-0.048485	-0.048439
Upper 95% confidence interval	0.174896	0.194803
Lower 95% confidence interval	-0.271865	-0.291680
Variance in mean log growth rate (σ^2)	0.226610	0.268697
Upper 95% confidence interval	0.653270	0.774597
Lower 95% confidence interval	0.113718	0.134839

The results of our analyses of the lower and upper estimates of the number of female leatherback turtles that nest at Playa Grande suggest that most trajectories of this population would be expected to decline (μ = -0.229501) although the population is capable of growth (λ = 1.17, which is greater than 1) and may grow in some years. Projecting these results over 25-, 50-, and 100-year intervals suggest that this population has a high risk of extinction (declining to 1 or 0 females) in the one human generation (about 20 years) if no action is taken.

There have been anecdotal reports of leatherbacks nesting at Playa Caletas and Playa Coyote. Playa Caletas is an 8 km beach on the Nicoya Peninsula on the Pacific Coast of Costa Rica. It is separated from Playa Coyote to the north. Locals report that in the mid-1990s, approximately 20 leatherbacks emerged to nest each night, while during the 1997-98 nesting season, 30-40 leatherback nesting incidences were observed. A monitoring study in this area during October 1 through December 11, 1999 noted only five leatherback body pits and one possible leatherback body pit on Playa Caletas (Squires, 1999).

Mexico

The decline of leatherback subpopulations is even more dramatic off the Pacific coast of Mexico. Surveys indicate that the eastern Pacific Mexican population of adult female leatherback turtles has declined from 70,000[12] in 1980 (Pritchard, 1982b, *in* Spotila *et al.*, 1996) to approximately 60 nesting females during the 2002-03 nesting season, the lowest seen in 20 years (L. Sarti, UNAM, personal communication, June, 2003).

Leatherbacks nesting in Mexico nest from October through March. According to reports from the late 1970s and early 1980s, three beaches located on the Pacific coast of Mexico (Bahiá de Chacahua, Oaxaca, Tierra Colorada, Guerrero and Mexiquillo, Michoacán) sustained a large portion of all global nesting of leatherback turtles, perhaps as much as one-half. Because nearly 100% of the clutches in these areas were poached by local people, a monitoring plan was implemented to evaluate the nesting population and establish measures for the protection of eggs. From aerial surveys, daily beach surveys, and nightly patrols, the following information has been determined for nesting leatherbacks on the Pacific coast of Mexico:

1. Four main nesting beaches: Mexiquillo, Michoacán; Tierra Colorada, Guerrero; and Cahuitan and Barra de la Cruz, in Oaxaca, comprise from 40-50% of total nests along the Mexican Pacific;
2. Four secondary nesting beaches: Chacahua, Oaxaca; La Tuza, Oaxaca; Playa Ventura, Guerrero, and Agua Blanca, Baja California Sur;
3. All eight beaches comprise approximately 75-80% of the total annual nests of the Mexican Pacific (Sarti, personal communication, December, 2003).

Monitoring of the nesting assemblage at Mexiquillo, Mexico has been continuous since 1982. During the mid-1980s, more than 5,000 nests per season were documented along 4 kilometers of this nesting beach. By the early 1990s (specifically 1993), less than 100 nests were counted along the entire beach (18 kilometers) (Sarti, 2002). According to Sarti *et al.* (1996), nesting declined at this location at an annual rate of over 22 percent from 1984 to 1995. Sarti *et al.* (1998) reports:

> "While reporting the results for the 1995-96 nesting season (Sarti *et al.*, 1996), we regarded beaches having densities higher than 50 nests per kilometer as the most important. In the present season [1997-98] no beach reached such density values: the main beaches had 5 or more nests per kilometer, and none were higher than 25. This is evidence of the large decrement witnessed from the start of the aerial surveys, and may indicate that the nesting population still has a declining trend despite the protection efforts in the major beaches."

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[12]This estimate of 70,000 adult female leatherback turtles comes from a brief aerial survey of beaches by Pritchard (1982), who has commented: "I probably chanced to hit an unusually good nesting year during my 1980 flight along the Mexican Pacific coast, the population estimates derived from which (Pritchard, 1982b) have possibly been used as baseline data for subsequent estimates to a greater degree than the quality of the data would justify" (Pritchard, 1996).

Censuses of four index beaches in Mexico during the 2000-2001 nesting season showed a slight increase in the numbers of females nesting compared to the all-time lows observed from 1996 through 1999 (Sarti *et al.* in prep). However, the number of nestings during the last two nesting seasons (2001-02 and 2002-03) is the lowest ever recorded, as shown in Table 3.5.

Table 3.5. Annual number of leatherback nestings from 2000-2003 on primary and secondary nesting beaches.

Index beach	2000-2001	2001-2002[1]	2002-2003[2]
Primary Nesting Beaches (40-50% of total nesting activity)			
Mexiquillo	624	20	36
Tierra Colorada	535	49	8
Cahuitan	539	52	73
Barra de la Cruz	146	67	3
Secondary Nesting Beaches			
Agua Blanca	113	no data	no data
Total - all index beaches	**1,957**	**188**	**120**
Total - Mexican Pacific	**4,513**	**658**	**not available yet**

[1] **Source: Sarti, pers. comm, March, 2002 – index beaches; Sarti *et al.*, 2002 for totals;**
[2] **Source: Sarti, pers. comm, December, 2003 – index beaches, totals.**

A summary of total leatherback nestings counted and total females estimated to have nested along the Mexican coast from 1995 through 2003 is shown in Table 3.6. Sarti, *et al.* (2000) notes that during the 1980s, 30% of the nesting females per season were remigrants, but since the mid-1990s, there has been very little evidence of remigration, even with more efficient tagging methods. Sarti (2002) reported that during the 1999-2000 and 2000-01 nesting seasons, only a small increment in the number of remigrant turtles was observed.

Although the causes of the decline in the eastern Pacific nesting populations are not entirely clear, Sarti *et al.* (1998) surmises that the decline could be a result of intensive egg poaching on the nesting beaches, incidental capture of adults or juveniles in high seas fisheries, and natural fluctuations due to changing environmental conditions. Although leatherback turtles are not generally captured for their meat or skin in Mexico, the slaughter of female leatherback turtles has been detected on beaches such as Piedra de Tiacoyunque, Guerrero (Sarti, *et al.*, 2000). Nichols (2002) notes that leatherbacks were once harvested off Baja California but their meat is now considered inferior for human consumption. In addition, there is little information on incidental capture of adults due to coastal fisheries off Mexico, but entanglement in longlines and driftnets probably account for some mortality of leatherback turtles. Eckert (1997) speculates that the swordfish gillnet fisheries in Peru and Chile have contributed to the decline of the leatherback in the eastern Pacific. The decline in the nesting population at Mexiquillo, Mexico occurred at the same time that effort doubled in the Chilean driftnet fishery.

Table 3.6. Total leatherback nestings counted and total number of females estimated to nest along the Mexican Pacific coast per season.

Season	Nestings	Females
1995-1996	5,354	1,093
1996-1997	1,097	236
1997-1998	1,596	250
1998-1999[1]	799[1]	67[2]
1999-2000	1,125	225
2000-2001	4,513	991
2001-2002	658	109-120
2002-2003	not available yet	not available yet

1 Value corrected for E1 (error due to track and bodypit aging) and E2 (error due to difficulty of observation from the air) only.

2 Number of females only includes tagged females at the key beaches.

Source - Sarti *et al.*, 2000 (1995-1999 data), Sarti *et al.*, 2002 (2001-02 data), Sarti, personal communication, June, 2003 (2002-03 data).

Most conservation programs aimed at protecting nesting sea turtles in Mexico have continued since the early 1980s, and there is little information on the degree of poaching prior to the establishment of these programs. However, Sarti *et al.* (1998) estimates that as much as 100% of the clutches were taken from the Mexican beaches. Since protective measures have been in place, particularly emergency measures recommended by a joint U.S./Mexico leatherback working group meeting in 1999, there has been greater nest protection and nest success (Table 3.7). Mexican military personnel were present during the 1999-2000 season at three of the primary nesting beaches in Mexico (Llano Grande, Mexiquillo, and Tierra Colorado), responsible for approximately 34% of all nesting activity in Mexico. Of 1,294 nests documented, 736 were protected (57%), resulting in a total of 25,802 hatchlings. Monitoring and protection measures at two secondary nesting beaches resulted in the protection of 67% and 10% at Barra de la Cruz and Playa Ventura, respectively. Beginning in 2000, the primary management objective has been to protect over 95% of nests laid at the three index beaches (includes protecting nesting females, eliminating illegal egg harvest, and relocating nests to protected hatcheries) and to maximize protection of all the secondary nesting beaches over the next three years. NMFS has committed funding for three years to help implement these objectives (Dutton *et al.*, 2002).

The most recent results for 2000-01 indicate that nearly 58% of clutches laid in key beaches in Mexico were relocated to hatcheries. This is a significant increase since 1996, when only 12% of nests were relocated. Although data are not available, most of the nests that were not moved are believed to have survived in situ in 2000-01, unlike previous years when it is assumed that all nests that are not relocated are taken by poachers. This has been due to successful involvement of community leaders in Cahuitan, the most important leatherback nesting beach in the nest protection program. At this beach 24,797 eggs representing 80% of the nests laid were protected, producing a total of 12,275 hatchlings (L. Sarti, INP Preliminary Report).

Table 3.7. Nest protection at index beaches on the Pacific coast of Mexico (Source: Sarti *et al.*, personal communication, December, 2003)

Nesting Season	Number of clutches laid	Number of clutches protected	Percentage of clutches protected
1996-97	445	86	19.3
1997-98	508	101	19.9
1998-99	442	150	33.9
1999-00	1590	943	58.7
2000-01	1,732	933	57.04
2001-02	171	116	67.9

Nicaragua

In Nicaragua, small numbers of leatherbacks nest on Playa El Mogote, and Playa Chacocente, both beaches within 5 kilometers of one another and located in the Rio Escalante Chacocente Wildlife Refuge. From October through December,1980, 108 leatherbacks were sighted nesting on Playa Chacocente, while during January, 1981, 100 leatherbacks reportedly nested in a single night on Playa El Mogote (*in* Arauz, 2002). Similar to many of the leatherback nesting beaches along the eastern Pacific, the abundance of nesting females has decreased. An aerial survey conducted during the 1998-1999 season estimated a nesting density in Playa El Mogote of only 0.72 turtles per kilometer (Sarti *et al.*, 1999 *in* Arauz, 2002). During the 2000-01 nesting season, community members near Playa El Mogote noted that 210 leatherback nests had been deposited. Of these, 31 nests produced hatchlings, while the rest were poached (85% poaching rate). During the 2001-02 nesting season (monitored from October through March), leatherbacks successfully nested 29 times. Of these, 6 nests were protected in a hatchery and 23 were poached (79.3% poaching rate) (Arauz, 2002).

Guatemala

On the Pacific coast of Guatemala, leatherbacks nest in limited numbers (2-3 nests per night from November to December), primarily on the beach at Hawaii. Since an average nest can bring in one quarter of the monthly income of a typical agricultural worker or fishermen, most leatherback eggs are collected (Juarez and Muccio, 1997), and in the Hawaii area, "it is very rare that a nest is laid without being detected by an egg collector" (Muccio, 1998).

Estimates of the Total Abundance of Nesting Females in the Eastern Pacific

From tagging and aerial surveys, Spotila *et al.* (2000) have estimated that there are currently 687 adult females and 518 subadults comprising the Central American population of leatherback turtles. With an estimated Mexican population of 1,000 adults and 750 subadults (by Spotila *et al.*, 2000), the entire east Pacific leatherback population has been estimated by Spotila *et al.* (2000) to contain approximately 2,955 females (1,687 adults and 1,268 subadults); however, insufficient foundation was given for these estimates (i.e. derivation of estimates are unclear, and models rely on theoretical assumptions that need further evaluation and testing).

Based on aerial surveys and ground censuses during the 2000-2001 season and using an estimated clutch frequency of 5.8, Sarti *et al.* (in preparation) estimated the total number of female leatherbacks (*nesters only*) in the eastern Pacific:

1. primary beaches in Mexico - 396 females;
2. total Mexico (without primary beaches) - 452 females;
3. Central America (including data from Costa Rica) - 751 females; and (d) grand total - 1,599 females.

Western Pacific Nesting Populations of Leatherbacks

Similar to their eastern Pacific counterparts, leatherback turtles originating from the western Pacific are also threatened by poaching of eggs, killing of nesting females, human encroachment on nesting beaches, incidental capture in fishing gear, beach erosion, and egg predation by animals. Little is known about the status of the western Pacific leatherback nesting populations but once major leatherback nesting assemblages are declining along the coasts of Malaysia, Indonesia and the Solomon Islands. Low density and scattered nesting of leatherback turtles occurs in Fiji, Thailand, and Australia (primarily western and to a lesser extent, eastern).

Malaysia

The decline of leatherback turtles is severe at one of the most significant nesting sites in the western Pacific region - Terengganu, Malaysia, with current nesting representing less than 2 percent of the levels recorded in the 1950s, and the decline is continuing. The nesting population at this location has declined from 3,103 females estimated nesting in 1968 to 2 nesting females in 1994 (Chan and Liew, 1996) (Table 3.8). With one or two females reportedly nesting each year, this population has essentially been eradicated (P. Dutton, personal communication, 2000). Years of excessive egg harvest, egg poaching, the direct harvest of adults in this area, as well as incidental capture in various fisheries in territorial and international waters, have impacted the Malaysian population of leatherback turtles. There were two periods in which there were sharp declines in nesting leatherback turtles at this location: 1972-74 and 1978-80. Between 1972 and 1974, the number of females nesting declined 21% and coincided with a period of rapid development in the fishing industry, particularly trawling, in Terengganu (Chan *et al.*, 1988 *in* Chan and Liew, 1996). Between 1978 and 1980, nestings dropped an average of 31% annually, and coincided directly with the introduction of the Japanese high seas squid fishery of the North

Pacific in 1978 (Yatsu *et al.*, 1991, *in* Chan and Liew, 1996). Because tagged individuals from Rantau Abang have been recovered from as far away as Taiwan, Japan and Hawaii, this fishery, as well as fisheries operating within the South China Sea, may have impacted the Malaysian leatherback population (Chan and Liew, 1996). After 1980, rates of decline averaged 16% annually, suggesting continuing threats from fisheries (Chan and Liew, 1996).

Table 3.8. Number of nesting females per year in Terengganu, Malaysia (summarized in Spotilla, *et al.*, 1996)

1968	1970	1972	1974	1976	1978	1980	1984	1987	1988	1993	1994
3,103	1,760	2,926	1,377	1,067	600	200	100	84	62	20	2

In the 1960s, the leatherback turtles nesting on the beaches in Terengganu represented one of the larger remaining nesting aggregations for this species in the Pacific Ocean. Since then, the population has declined to a handful of individual, nesting females. Although the implications of such a decline are readily apparent and should require no further analyses, we evaluated the census data for this population using the density-independent form of the Dennis model (Dennis et al. 1991, see Appendix A for details of these analyses) to assess the probable trend for this population (see Table 3.9 for results).

Table 3.9. Results of an assessment of the Terengganu nesting aggregation of leatherback sea turtles using a discrete-time, density-independent diffusion estimation model

Demographic Parameter	Estimate
Mean log growth rate (μ)	-0.229501
Upper 95% confidence interval	0.302985
Lower 95% confidence interval	-0.761988
Variance in mean log growth rate (σ^2)	0.776462
Upper 95% confidence interval	2.115806
Lower 95% confidence interval	0.399266

The results of our analyses of the number of female leatherback turtles that nest at the Terengganu supports the conclusion that the population's growth rate has been, on average, negative ($\lambda = 0.97$, which is less than 1, and $\mu = -0.282579$), a conclusion that is supported by a casual observation of the counts. Projecting these results over 25-, 50-, and 100-year intervals suggest that this population has a very high risk of extinction (declining to 1 or 0 females) in the short-term (less than a decade) if no action is taken.

Indonesia

In Indonesia, leatherback turtles have been protected since 1978 and low density nesting occurs along western Sumatra (200 females nesting annually) and in southeastern Java (50 females nesting annually), although the last known information is from the early 1980s (*in* Suarez and Starbird, 1996a; Dermawan, 2002). However the largest leatherback rookery can be found on the north coast of Papua, and information on population status and trends are reviewed extensively below.

Leatherback nesting generally takes place on two major beaches, located 30 km apart, on the north Vogelkop coast of the State of Papua: Jamursba-Medi (18 km) and War-Mon beach (4.5 km) (Starbird and Suarez, 1994). In 1984, the World Wildlife Fund (WWF) began a preliminary study to assess the status of the leatherback nesting population and found at least an estimated 13,000 nests on Jamursba Medi. A subsequent survey undertaken in 1992 reported a decline of nesting levels to 25% of the 1984 levels (Table 3.9). A near total collection of eggs during this time period may have contributed to this decline. Commercial exploitation of turtle eggs on this beach was intense for a long time; for example, during 1984-1985, four to five fishermen boats were observed visiting the beach weekly and returning with 10,000 - 15,000 eggs per boat (Hitipeuw, 2003a). Out of concern for the rapid declines in nestings, the WWF proposed the designation of five beaches as protected areas - Sauapor (14 km), Wewe-Kwoor (20 km), Jamursba-Medi (28 km), Sidei-Wibain (18 km) and Mubrani-Kaironi (20 km). These beaches are monitored for leatherback nesting activities and patrolled for potential poaching activities (Hitipeuw and Maturbongs, 2002).

Leatherbacks nest on Jamursba-Medi during April through September, with a peak in July and August (Suarez *et al.*, in press). A summary of data collected from leatherback nesting surveys from 1981 to 2003 for Jamursba-Medi has been compiled, re-analyzed, and standardized and is shown in Table 3.9 (Hitipeuw and Maturbongs, 2002; Hitipeuw, 2003b). The number of nests were adjusted to correct for the days or months of the survey missed during the nesting season, and the average number of nests per female is assumed to range between 4.4 to 5.8 (see footnotes in Table 3.9). Gaps in the data for the year 1998 and 2000 were due to lack of financial support and transition of management changes of WWF Indonesia, which has been helping to monitor the leatherback nesting populations at these beaches since the early 1980s.

Suarez *et al.* (in press) has also compiled information on the estimated number of nests lost due to both natural and anthropogenic causes. For example, during 1984 and 1985, on Jamursba-Medi, 40-60% of nests were lost to inundation and erosion, while 90% of those nests not taken by poachers[13] or by the sea were destroyed by feral pigs (*Sus scrofa*). Eggs from poached nests were commercially harvested for sale in the Sarong markets until 1993, when the beaches first received protection by the Indonesian government (J. Bakarbessy, personal communication, *in* Suarez and Starbird, 1996a). During the 1993-96 seasons, environmental education activities in nearby villages and protection measures on this same beach were put into place, with unreported results. Again, approximately 90% of those nests not taken by poachers or the sea[14] were destroyed by pigs (Suarez *et al.* in press). In addition to natural erosion, logging activity in the area also threatens the nesting beach habitat. Current nearby logging activities include lumber harvest and transportation and the construction of a log pond and base camp. Such activities may remove

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[13]Suarez, *et al.* (in press) provided no information on the estimated percentage of nests lost to poachers.

[14]No information on percentage of nests lost to poachers or the sea were given, except that it was "noted."

vegetation, change drainage patterns and increase human presence, which may also increase poaching of eggs. Logs washed up on the beach may impair females coming ashore to nest and hatchlings from reaching the ocean (Hitipeuw, 2003a).

Table 3.9. **Estimated numbers of female leatherback turtles nesting on Jamursba-Medi Beach, along the north coast of the State of Papua (Summarized by Hitipeuw and Maturbongs, 2002 and Hitipeuw, 2003b)**

Survey Period	# of Nests	Adjusted # Nests	Estimated # of Females[3]
Jamursba-Medi Beach:			
September, 1981	4,000+	7,143[1]	1,232 - 1,623
April - Oct. 1984	13,360	13,360	2,303 - 3,036
April - Oct. 1985	3,000	3,000	658 - 731
June - Sept. 1993	3,247	4,091[2]	705 - 930
June - Sept. 1994	3,298	4,155[2]	716 - 944
June - Sept. 1995	3,382	4,228[2]	729 - 961
June - Sept., 1996	5,058	6,373[2]	1,099 - 1,448
May - Aug., 1997	4,001	4,481[4]	773 - 1,018
May - Sept. 1999	2,983	3,251	560 - 739
April - Dec., 2000	2,264	No	390 - 514
March - Oct., 2001	3,056	No	527 - 695
March - Aug., 2002	1,865	1,921	331 - 437
March - July, 2003 (ongoing)	2,109	2,459	424 - 559

[1]The total number of nests reported during aerial surveys were adjusted to account for loss of nests prior to the survey. Based on data from other surveys on Jamursba-Medi, on average 44% of all nests are lost by the end of August.

[2]The total number of nests have been adjusted based on data from Bhaskar's surveys from 1984-85 from which it was determined that 26% of the total number of nests laid during the season (4/1-10/1) are laid between April and May.

[3]Based on Bhaskar's tagging data, an average number of nests laid by leatherback turtles on Jamursba-Medi in 1985 was 4.4 nests per female. This is consistent with estimates for the average number of nests by leatherback turtles during a season on beaches in Pacific Mexico, which range from 4.4 to 5.8 nests per female (Sarti *et al.*, unpub. report). The range of the number of females is estimated using these data.

[4]Number adjusted from Bhaskar (1984), where percentage of nests laid in April and September is 9% and 3%, respectively, of the total nests laid during the season.

Nesting of leatherbacks on War-Mon beach takes place during October through February, with a peak in December (Suárez *et al.*, in press). Recently, the beach was monitored during the nesting season and documented 1,442 nests (Hitipeuw, 2003b), which may equate to several hundred females (249-328 females, given 4.4 to 5.8 nests per female). Given shorter monitoring periods in past studies, it is difficult to analyze any trends for this nesting beach (see Table 3.10).

Egg poaching for subsistence on War-Mon beach accounted for over 60% of total nest loss during 1993-94, and total loss of nests due to pig predation was 40% (because there are more people in this region, there is more pig hunting; hence less pig predation of leatherback eggs (Starbird and Suárez, 1994)). In 2001 and 2002, conservation measures have reduced predation of eggs by pigs (P. Dutton, NMFS, personal communication, October 2002), and coastal patrols are currently being conducted to prevent disturbance and exploitation of the beach (Hitipeuw, 2003b).

Table 3.10. Number of leatherback turtle nests observed along War-Mon Beach

Monitoring Period	# nests	Source
Nov. 23-Dec. 20, 1984 and Jan. 1-24, 1985	1,012	Starbird and Suárez, 1994; Suárez *et al.*, in press
Dec. 6-22, 1993	406	Starbird and Suárez, 1994; Suárez *et al.*, in press
Dec. 2002 - May, 2003	1,442	Hitipeuw, 2003b

The leatherback turtles nesting on the beaches in the State of Papua represent one of the largest remaining nesting aggregations for this species in the Pacific Ocean. The nesting aggregation appears to be relatively large and has fluctuated between 400 and 1,000 individuals throughout most of the 1990s and early 2000s and could suggest that the population is stable or slightly increasing. However, we evaluated the census data for this population using the density-independent form of the Dennis model (Dennis et al. 1991, see Appendix A for details of these analyses) to better assess the probable trend for this population (see Table 3.11 for results).

Table 3.11. Results of an assessment of the Jamursba-Medi nesting aggregation of leatherback sea turtles using a discrete-time, density-independent diffusion estimation model

Demographic Parameter	Lower Census Estimate	Upper Census Estimate
Mean log growth rate (μ)	-0.048485	-0.048439
Upper 95% confidence interval	0.174896	0.194803
Lower 95% confidence interval	-0.271865	-0.291680
Variance in mean log growth rate (σ^2)	0.226610	0.268697
Upper 95% confidence interval	0.653270	0.774597
Lower 95% confidence interval	0.113718	0.134839

The results of our analyses of the lower and upper estimates of the number of female leatherback turtles that nest at the Jamursba-Medi suggest that most population trajectories are declining slightly (μ = -0.0484). Projecting these results over 25-, 50-, and 100-year intervals suggest that this population has a low risk of extinction (declining to 1 or 0 females), but the population has a high risk of declining to 100 or 50 females. Our assessment suggests that this population has a 50 percent probability of declining to 100 females in about 30 ears or 50 females within 40 years. At these smaller population sizes, this nesting aggregation would have an increased risk of extinction from stochastic events like changes in the ratio of males to females, the probability of an adult female dying before giving birth, or difficulties in finding mates.

Given the current, serious threats to all life stages of the Indonesian leatherback populations, these forecasts are not surprising. As human populations in Indonesia increase, the need for meat and competition between the expanding human population and turtles for space increases, all leading to more direct takes of leatherback turtles or incidental take by local fisheries. There is no evidence to indicate that the threats discussed earlier in this narrative are not continuing today, as problems with nest destruction by feral pigs, beach erosion, and harvest of adults in local waters have been reported (Suarez et al., unpublished report). This forecast is also consistent with the observations of local Indonesian villagers who have reported dramatic declines in local sea turtle populations (Suarez, 1999) and agrees with Suarez *et al.* (in press) who, when writing about the Papuan population of nesting leatherback turtles, concluded that "Given the high nest loss which has occurred along this coast for over thirty years it is not unlikely that this population may also suddenly collapse. Nesting activity must also continue to be monitored along this coast, and nest mortality must be minimized in order to prevent this population of leatherback turtles from declining in the future." Without adequate protection of nesting beaches, emerging hatchlings, and adults, this population will continue to decline.

Papua New Guinea

In Papua New Guinea, leatherbacks nest primarily along the coast of the Morobe Province, mostly between November and March, with a peak of nesting in December. There are no current estimates of the number of nesting females in this area, but researchers are analyzing all known data to determine status and trends[15]. Based on data from surveys conducted during the 1980s, researchers estimated that between 200-300 females were estimated to nest annually in an area between the two villages of Labu Tali and Busama (approximately 19 kilometers along the Morobe Province) (Quinn and Kojis (1985) and Bedding and Lockhart (1989), both *in* Hirth *et al.*, 1993). While leatherback meat is not consumed in this area, leatherback eggs are an important source of protein for the local people, and eggs are also sold in towns such as Lae. In addition, when rivers break through a berm in the area, leatherback eggs are exposed and destroyed by inundation (Hirth *et al.*, 1993). Egg collection continues in this country, although the extent is unknown (P. Dutton, NMFS, personal communication, March, 2002) but "significant" (M. Philip, Office of Environment and Conservation, Papua New Guinea, personal communication, December, 2003). The Kamiali nesting beach (also in the Morobe Province and within the Kamiali Wildlife Management Area) is approximately 11 km long and is an important nesting area for leatherbacks. Currently, Kamiali contains approximately 150 nesting females producing 500-600 clutches per season. Due to increasing awareness and concern about the local declines in nesting leatherbacks, the Kamiali community agreed to a 100 meter no-take zone in 1999, increased to a 1 km no-take zone in 2000, and 0.5 km was added in 2001 (1.5 km total). The no-take zone is effective from December to February (nesting season). Although very few adults are killed, 99% of the eggs are collected outside of the no-take zone (Philip, 2002).

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[15]Philip (2002) reports an estimated 1,000 to 1,500 females nesting (very approximate) along the Morobe coast between Labu Butu and Busama beach, but without an ongoing monitoring project in place, these numbers are very speculative and probably should not be used until a full study and analysis has been conducted. Researchers are currently analyzing the data to determine a trend, but so far there has not been a comprehensive analysis.

In January, 2004, NMFS plans to conduct aerial surveys to locate nesting areas and assess the significance of this area for leatherback nesting females (S. Benson, NMFS-SWFSC, personal communication, December, 2003).

Solomon Islands

In the Solomon Islands, the rookery size is estimated to be less than 100 females nesting per year (D. Broderick, personal communication, *in* Dutton, *et al.*, 1999). Past studies have identified four important nesting beaches in Isabel Province: Sasakolo, Lithoghahira, Lilika, and Katova. While Leary and Laumani (1989 *in* Ramohia *et al.*, 2001) reported that leatherback nesting throughout Isabel Province doubled since 1980, there have been few monitoring studies to substantiate this reported trend. From November 28, 2000 through January 21, 2001, a monitoring study was conducted on one of the nesting beaches, located on Sasakolo Beach. This period represented approximately two-thirds of the known peak-breeding season. During this time, leatherbacks appeared 192 times, with 132 clutches laid. A total of 27 nesting turtles were encountered: 26 were new nesting individuals and 1 had been tagged in 1995. Egg harvest by humans has been reported in the past. In addition, lizards and iguanas have been documented predating on leatherback eggs (Rahomia, *et al.*, 2001).

Fiji

In Fiji, leatherbacks are uncommon, although there are recorded sightings and 4 documented nesting attempts on Fijian beaches. They have been seen in the Savusavu region, Qoma, Yaro passage, Vatulele and Tailevu, and researchers estimate approximately 20-30 individual leatherbacks in Fijian waters (Rupeni, *et al.*, 2002).

Australia

In Australia, leatherback nesting is sporadic, less than 5 per year, generally outside of Great Barrier Reef in southeast Queensland. Human related threats are listed as: incidental capture in fisheries and ingestion and entanglement in marine debris (Dobbs, 2002).

Conclusion on Status of Eastern and Western Pacific leatherback turtles

Although quantitative data on human-caused mortality are scarce, the available information suggests that leatherback mortality on many nesting beaches remains at unsustainable levels (Tillman, 2000). Published assessments of the extinction risks of leatherback turtles in the Pacific Ocean have concluded that these turtles have a very high risk of disappearing from the Pacific Ocean within one or two human generations (Spotila et al. 1996, 2002). Our assessments of three nesting aggregations support this conclusion: if no action is taken to reverse their decline, leatherback turtles nesting in the Pacific Ocean either have high risks of extinction in a single human generation (for example, nesting aggregations at Terrenganu and Costa Rica) or they have a high risk of declining to levels where more precipitous declines become almost certain (for example Jamursba-Medi). As we have discussed previously, different nesting aggregations of sea turtles are effectively isolated from one another, the female leatherback turtles nesting at this different beaches will not be "rescued" by migrants from other nesting beaches. If a nesting aggregation becomes extinct, it will remain extinct.

Although these assessments have focused on adult, female leatherback turtles, as the extinction of the Dusky seaside sparrow (*Ammodramus maritimus nigrescens*) demonstrated, no animal population will survive for more than a generation without adult females. That species became functionally extinct when the last female in the population produced only male young, then died. The species' final extinction occurred when the last male died in 1987.

Except for elimination of fishing mortality in the now-defunct high-seas driftnet fisheries in the North and South Pacific, and reductions of effort in a few other fisheries (e.g. the Hawaii-based longline fishery and the CA/OR drift gillnet fishery), many of the risks that caused these populations to decline remain. Leatherback turtles still experience harvests of their eggs, they are still killed for subsistence purposes, their beaches continue to erode, and adult and sub-adult leatherback turtles are still captured and killed in fisheries interactions. The dire predictions of sea level rise and associated increases in beach erosion and subsidence present new risks to this declining species. Finally, the small sizes of leatherback turtle populations places this species at high risk of extinction in the Pacific; with such small population sizes, each pre-mature death of an adult or sub-adult turtles reduces the number of breeding adults in the population over time. As the number of breeding adults declines, the number of eggs each generation produces declines and reduces the population's ability to recover.

Conservation efforts during the last few years at nesting beaches in Mexico and Costa Rica have led to increased survival of eggs, and therefore greater hatchling production per nesting female. This has the potential for increasing future recruitment if post-hatchling survival is not further reduced; however, since numbers of nests are so low, and post-hatchling and juvenile natural mortality are assumed to be high, this increase in hatchling production may only result in the addition of a few adults annually. In western Pacific populations, particularly Papua, nest destruction by beach erosion and feral pig predation is widespread, and hatchling production is likely to be low relative to the numbers of nests laid. Overall, both eastern and western Pacific populations appear to have low female abundance as a result of legal harvest of eggs and nesting females, poaching, and incidental take in fisheries. Representation in the various age classes of female leatherback turtles is most likely unbalanced as a result of losses of adult females, juveniles and eggs and sub-adults and adults as a result of on-going fisheries and the now-defunct high seas driftnet fisheries. Gaps in age structure may cause sudden collapse of nesting populations when age classes with few individuals recruit into the reproductive population as older individuals die or are removed.

Genetic analysis of samples taken from two leatherbacks incidentally captured in the CA/OR drift gillnet fishery revealed that they both originated from western Pacific nesting beaches (i.e. Indonesia/Solomon Islands, Malaysia). Similarly, all three leatherbacks taken in the California-based longline fishery were found to originate from western Pacific nesting beaches (P. Dutton, personal communication, 2003). Because a leatherback taken in the Hawaii-based longline fishery was found to originate from an eastern Pacific nesting beach, the north Pacific Ocean is a foraging area for leatherbacks from both sides of the Pacific. As Dutton *et al.* (2000) note, the predominance of western Pacific turtles may be an artifact of small sample size or may reflect the relative abundance of the two subpopulations. Leatherbacks have been observed taken by the ETP purse seine fishery; however, genetic data was not collected from any turtles in this fishery.

Loggerhead Turtles

Global Status

The loggerhead turtle is listed as threatened under the ESA throughout its range, primarily due to direct take, incidental capture in various fisheries, and the alteration and destruction of its habitat.

Physical Description

The loggerhead is characterized by a reddish brown, bony carapace, with a comparatively large head, up to 25 cm wide in some adults. They usually have five pairs of costal scutes, and three inframarginals without pores. Adult males have comparatively narrow shells, gradually tapering posteriorly, and long thick tales, extending well beyond the edge of the carapace. Adults typically weigh between 80 and 150 kg, with average CCL measurements for adult females worldwide between 95-100 cm CCL (*in* Dodd, 1988) and adult males in Australia averaging around 97 cm CCL (Limpus, 1985, *in* Eckert, 1993). Juveniles found off California and Mexico measured between 20 and 80 cm (average 60 cm) in length (Bartlett, 1989, *in* Eckert, 1993). Skeletochronological age estimates and growth rates were derived from small loggerheads caught in the Pacific high-seas driftnet fishery. Loggerheads less than 20 cm were estimated to be 3 years or less, while those greater than 36 cm were estimated to be 6 years or more. Age-specific growth rates for the first 10 years were estimated to be 4.2 cm/year (Zug, *et al.*, 1995).

General Distribution

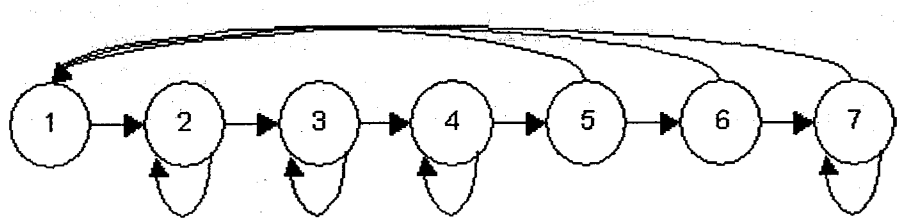
Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (*in* NMFS and USFWS, 1998d).

Loggerheads can be divided into five regions: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. These regions may be further divided into nesting aggregations. In the Pacific Ocean, loggerhead turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) which may be comprised of separate nesting groups (Hatase, *et al.*, 2002) and a smaller southwestern nesting aggregation that occurs in Australia (Great Barrier Reef and Queensland), New Caledonia, New Zealand, Indonesia, and Papua New Guinea. In the western Atlantic Ocean, NMFS recognizes five major nesting aggregations: (1) a northern nesting aggregation that occurs from North Carolina to northeast Florida, about 29° N; (2) a south Florida nesting aggregation, occurring from 29° N on the east coast to Sarasota on the west coast; (3) a Florida panhandle nesting aggregation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán nesting aggregation, occurring on the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas nesting subpopulation, occurring in the islands of the Dry Tortugas, near Key West, Florida (NMFS SEFSC, 2001). In addition, Atlantic and Caribbean nesting aggregations are found in Honduras, Colombia, Panama, the Bahamas, and Cuba. In the Mediterranean Sea, nesting aggregations in Greece, Turkey, Israel, Italy, and several other sites have been recorded. One of the largest loggerhead nesting aggregations in the world is found in Oman, in the Indian Ocean.

Life Cycle and Population Dynamics

Figure 3.6 illustrates the basic life cycle of the loggerhead turtle (based on data presented by Crouse, *et. al.* (1987) for females of the western Atlantic nesting aggregations). This cycle is broken into seven life stages based on age: (1) egg/hatchling; (2) small juveniles (pelagic); (3) large juveniles (benthic); (4) subadults; (5) novice breeders; (6) first year remigrants; (7) and mature breeders, each with their own expected survival rate (Table 3.11). Arrows along the bottom represent the probability of each ageclass surviving and remaining in the ageclass. Arrows between each ageclass represent the probability of the ageclass surviving and growing to the next ageclass, and the arrows along the top represent the ageclass-specific fertility. The thickness or length of the lines do not indicate the level of probability or fecundity. Available information on the behavior, physiology, and biological requirements of these stages is summarized below.

Figure 3.6. Life-cycle graph of the loggerhead turtle (Crouse *et. al.*, 1987)



Numerical analyses of the survival rates, transition rates, and fecundities in Table 3.11 indicated that the modeled loggerhead turtle population has a finite population growth rate (λ) of approximately 0.95, which suggests a population that is declining at a rate of approximately 5 percent per year. The stage structure of this population is atypical for long-lived species with delayed maturity[16] and may reflect the effects of various human activities. For example, the survival rates of stage 1 individuals (eggs and hatchlings) probably reflect the combined effects of habitat degradation, feral and wild predators, and beach erosion (NRC 1990). The survival rates of the benthic stages, including adults returning to breed, probably reflect the effects of incidental capture in coastal fisheries and habitat degradation (NRC 1990). By contrast, the survival rate of pelagic juveniles (stage 2) would not have been affected by human activities on land or in coastal waters, which is why a higher proportion of individuals are in that stage. However, this population

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16 The typical population structure for these species has the largest proportion of individuals and the highest mortality rates in the earliest stages; with proportions and mortality declining through successive stages and the smallest proportion of the total population in the adult stages, which also have the lowest mortality rates. For further discussion of these population structures, see Stearns (1992) and Crouse (1999).

structure is probably an appropriate surrogate of other declining loggerhead populations because of its atypical structure.

Table 3.11: Stage Structure and Vital Rates for Loggerhead Turtles (Crouse, *et. al.*, 1987 as modified by Bolten 2003 and Heppell et al. 2003)

Stage	Name	Size	Stable Stage Structure	Survival Probability (lx)	Fecundity (eggs/female)
1	Egg-Hatchling	0	20.66%	0.6747	0
2	Oceanic Juvenile	5-45 cm	66.97%	0.745 (0.875)	0
3	Small Neritic Juvenile	45-72 cm	11.46%	0.6758 (0.7)	0
4	Large Neritic Juvenile	72-92 cm	0.66%	0.7425 (0.8)	0
5	Breeding Adult	>92 cm	0.04%	0.8091 (0.85)	127
6	Non-nesting Females	-	0.03%	0.8091 (0.85)	4
7	(Mature Breeder)	-	0.18%	0.8091	80

[1] Bjorndal, *et al.* (2001) indicate that the pelagic stage may last from 6.5 to 11.5 years.

Elasticity analyses for the stage matrix of this population support these general conclusions (Table 3.12). The survival rates of adult loggerhead turtles have the highest elasticities, which is typical for long-lived species with delayed maturity. However, the survival rates of pelagic juveniles had the second highest elasticities, which is atypical but, as we discussed previously, may be an artifact of a population whose structure has been modified by various human activities and natural phenomena. These results suggest that changes in the survival rates of mature, reproductive, adults and pelagic juveniles would have the largest proportional effect on this population's trend; increasing those survival rates would help the population recover from its decline, while decreasing those survival rates would exacerbate the population's rate of decline.

In contrast to the rates provided in Crouse, *et al.* (1987; Table 3.11), Chaloupka and Limpus (2002) reported higher survival rates for immature (benthic juvenile and sub-adult) and adult loggerhead turtles at one large coral reef in the southern Great Barrier Reef (Table 3.13). Although this population is exposed to a high risk of incidental capture in coastal Australia otter-trawl fisheries (Chaloupka and Limpus 2002), these higher survival rates are more representative of the expected dynamics of a long-lived, delayed maturity species.

Table 3.12. Stage elasticities

Stage	Survival Rate	Transition Rate	Fecundity
1	0	0.051	0
2	0.1851	0.051	0
3	0.1186	0.051	0
4	0.1384	0.051	0
5	0	0.039	0.0120
6	0	0.039	0.0003
7	0.2298	0	0.0386

Table 3.13. Expected age-class-specific survival probability estimates for southern Great Barrier Reef loggerhead turtles (Chaloupka and Limpus 2002)

Age Class	Survival (Mean)	Survival (95% CI)
Immature[1]	0.8588	0.828-0.885
Adult	0.8749	0.835-.0906

[1] Immature turtles in Chaloupka and Limpus (2001) correspond to stages 3 and 4 of the Crouse model (benthic juveniles and sub-adults)

Based on past observations, the loggerhead turtles that are captured and killed in Hawaii-based longline fisheries are primarily pelagic, juvenile loggerhead turtles (see the discussion in the *Effects of the Action* section). Over the history of these fisheries, the effect of these annual deaths would significantly reduce the survival rates of individuals in this stage in the nesting aggregations that interact with these fisheries. From our analyses, these reductions would be expected to have a significant, adverse affect on the trend of those nesting aggregations, particularly if these losses are added to losses in other life stages. The combined effect of these activities, which affect most or all life stages of most loggerhead turtle populations, would significantly reduce the growth rates of the nesting aggregations that interact with these fisheries.

Biological Characteristics

Diet

For their first years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. The large aggregations of juveniles off Baja California have been observed foraging on dense concentrations of the pelagic red crab, *Pleuronocodes planipes* (Pitman, 1990; Nichols, *et al.*, 2000). A high percentage of loggerheads sampled off Baja California Sur have had exclusively pelagic red crab in their stomachs, revealing the importance of this area and this prey species for loggerheads (Peckham and Nichols, 2003). Similarly, examinations of the gut contents of 70 loggerheads stranded off North Africa revealed a large presence of bentho-pelagic crab, *Polybius henslowii* during all seasons. Loggerheads in this area are found coincident with the high abundance of crabs during spring and summer (Ocaña and García, 2003).

Data collected from stomach samples of turtles captured in North Pacific driftnets indicate a diet of gastropods (*Janthina* sp.), heteropods (*Carinaria* sp.), gooseneck barnacles (*Lepas* sp.), pelagic purple snails (*Janthina* sp.), medusae (*Vellela* sp.), and pyrosomas (tunicate zooids). Other common components include fish eggs, amphipods, and plastics (Parker, *et al.*, in press). These loggerheads in the north Pacific are opportunistic feeders that target items floating at or near the surface, and if high densities of prey are present, they will actively forage at depth (Parker, *et al.*, 2002). As they age, some loggerheads begin to move into shallower waters, where, as adults, they forage over a variety of benthic hard- and soft-bottom habitats (reviewed *in* Dodd, 1988).

Diving Behavior

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). The maximum recorded dive depth for a post-nesting female was 211-233 meters, while mean dive depths for both a post-nesting female and a subadult were 9-22 meters. Routine dive times for a post-nesting female were between 15 and 30 minutes, and for a subadult, between 19 and 30 minutes (Sakamoto, *et al.*, 1990 *in* Lutcavage and Lutz, 1997). Two loggerheads tagged by Hawaii-based longline observers in the North Pacific and attached with satellite-linked dive recorders were tracked for about 5 months. Analysis of the dive data indicate that most of the dives were very shallow - 70% of the dives were no deeper than 5 meters. In addition, the loggerheads spent approximately 40% of their time in the top meter and nearly all of their time in waters shallower than 100 meters. For only 5% of the days, the turtles dove deeper than 100 meters; the deepest daily dive recorded was 178 meters (Polovina *et al.*, 2003).

A recent study (Polovina *et al.*, 2004) found that tagged turtles spent 40 percent of their time at the surface and 90 percent of their time at depths shallower than 40 meters. On only five percent of recorded dive days loggerheads dove to depths greater than 100 meters at least once. In the areas that the loggerheads were diving, there was a shallow thermocline at 50 meters. There were also several strong surface temperature fronts the turtles were associated with, one of 20°C at 28°N and another of 17°C at 32°N.

Life History/Reproduction

For loggerheads, the transition from hatchling to young juvenile occurs in the open sea, and evidence from genetic analyses and tracking studies show that this part of the loggerhead life cycle involves trans-Pacific developmental migration. The size structure of loggerheads in coastal and nearshore waters of the eastern and western Pacific suggest that Pacific loggerheads have a pelagic stage similar to the Atlantic. This is supported by the fact that the high seas driftnet fishery, which operated in the Central North Pacific in the 1980s and early 1990s, incidentally caught juvenile loggerheads (mostly 40-70 cm in length) (Wetherall, *et al.*, 1993). In addition, large aggregations (numbering in the thousands) of mainly juveniles and subadult loggerheads are found off the southwestern coast of Baja California, over 10,000 km from the nearest significant nesting beaches (Pitman, 1990; Nichols, *et al.*, 2000). Genetic studies have shown these animals originate from Japanese nesting subpopulation (Bowen *et al.*, 1995), and their presence reflects a migration pattern probably related to their feeding habits (Cruz, *et al.*, 1991, *in* Eckert, 1993). While these loggerheads are primarily juveniles, carapace length measurements indicate that some of them are 10 years old or older. Dobbs (2002) reports that loggerheads off Australia recruit from the open ocean pelagic habitat at around 10 to 15 years of age, or approximately 78 cm in carapace length.

Based on skeletochronological and mark-recapture studies, mean age at sexual maturity for loggerheads ranges between 25 to 35 years of age, depending on the subpopulation (*in* Chaloupka and Musick, 1997). Dobbs (2002) reports that loggerheads originating from Australian beaches mature at around age 25, although Frazer *et al.* (1994 *in* NMFS and USFWS, 1998d) determined that maturity of loggerheads in Australia occurs between 34.3 and 37.4 years of age.

Upon reaching maturity, adult female loggerheads migrate long distances from resident foraging grounds to their preferred nesting beaches. Clutch size averages 110 to 130 eggs, and one to six clutches of eggs are deposited during the nesting season (Dodd, 1988). The mean number of clutches deposited are 1.1 for females at Miyazaki, Japan, 2.06 for females at Yakushima Island, Japan (both *in* Schroeder *et al.*, 2003), and 3.4 clutches per season estimated for loggerheads in eastern Australia (Limpus and Limpus, 2003). The average renesting interval for eastern Australian loggerheads is 14 days (Limpus and Limpus, 2003). The average re-migration interval is between 2.6 and 3.5 years (*in* NMFS and USFWS, 1998d) (average 3.8 years for eastern Australian loggerheads (Limpus and Limpus, 2003)), and adults can breed up to 28 years (Dobbs, 2002). Nesting is preceded by offshore courting, and individuals return faithfully to the same nesting area over many years.

Migration

Loggerhead hatchlings on nesting beaches in Japan undertake developmental migrations in the North Pacific, using the Kuroshio and North Pacific Currents. Tagging programs to study migration and movement of sea turtles and genetic analyses provide evidence that loggerhead turtles undergo trans-Pacific migrations and have been found foraging off Baja California. For example, loggerheads tagged in Mexico and California with flipper and/or satellite transmitters have been monitored returning to Japanese waters (Resendiz, *et al.*, 1998a-b). In addition, genetic analyses of all loggerheads caught and sampled in the Hawaii-based and the west coast-based longline fishery indicated that all originated from Japanese nesting stock (P. Dutton, NMFS, personal communication, December, 2003). Most loggerheads taken in the Hawaii-based longline fishery are non-adults, suggesting that loggerheads in the Pacific are pelagic until they become sexually mature, returning to nesting beaches and subsequently begin a benthic existence (Parker *et al.*, 2003).

After reaching sexual maturity, female loggerheads exhibit precise natal homing and nearly all return to their nesting beach. Following nesting, females undertake seasonal breeding migrations between foraging grounds and the same nesting beach every few years (*in* Hatase, *et al.*, 2002).[17]

Loggerheads originating from south Pacific nesting stocks have been documented foraging in the waters off southern Peru and northern Chile. Genetic analyses conducted on three specimens incidentally taken by Peruvian artisanal fisheries confirmed them to be loggerheads originating from Australian nesting stocks (Alfaro-Shigueto, *et al.*, in press). In eastern Australia, nesting females have been documented migrating to feeding areas spread over a 2,600 kilometer radius throughout eastern and northern Australia, eastern Indonesia, Papua New Guinea, the Solomon Islands, and New Caledonia (Limpus and Limpus, 2003).

In the north Pacific Ocean, satellite telemetry studies show that loggerhead turtles tend to follow 17° and 20°C sea surface isotherms north of the Hawaiian Islands (Polovina, *et al.*, 2000; Eckert, unpublished data). Relationships between other turtle species and sea surface temperatures have also been demonstrated, with most species preferring distinct thermal regimes (Stinson, 1984). After capture in the Hawaii-based longline fishery, six satellite transmitter-equipped loggerheads traveled westward along two convergent oceanic fronts, against prevailing currents and associated with a "cool" front characterized by sea surface temperature (17°C), surface chlorophyll and an eastward geostrophic current of about 4 centimeters/second (cm/sec). Three others were associated with a warmer front (20°C), lower chlorophyll levels, and an eastward geostrophic flow of about 7 cm/sec. This study supports a theory that fronts are important juvenile habitat (Polovina, *et al.*, 2000).

Recent telemetry studies have described the oceanic habitat of loggerheads in more detail. Polovina *et al.* (2004) tagged 26 loggerheads captured in Hawaii-based longline fishery. All of these turtles came from Japanese nesting beaches. Three of the 26 loggerhead turtles tagged may have been sexually mature based on straight carapace lengths, the remainder with immature turtles. These turtles tended to migrate west following interactions. The turtles also shifted seasonally north and south between 28°N and 40°N. During January through June the loggerheads were found in the southern portion of this range, shifting to the northern end during July though December. The turtles also associated with areas with sea surface temperatures (SSTs) between 15° and 25° C. The loggerhead turtles were found in cooler waters during winter and spring, warmer waters in summertime.

Loggerhead turtles appear to utilize surface convergent forage habitat to capture their primary prey organisms which float along currents and congregate at fronts. Based on oceanographic conditions, the loggerheads were associated with fronts, eddies, and geostrophic currents (Polovina *et al.* 2004). The turtles moved with the seasonal movements of the Transition Zone Chlorophyll Front (TZCF), although they tended to remain south of the front itself, and were

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[17]For example, of 2,219 tagged nesting females, only 5 females relocated their nesting sites (0.2 percent) (Kamezaki, *et al.*, 1997 *in* Hatase *et al.*, 2002).

found along the southeastern edge of the Kuroshio Extension Current (KEC) and the northern edge of the Subtropical Gyre. The TZCF and KEC appear to be important forage habitat for loggerhead turtles as these areas contain colder, plankton-rich waters. The study indicates that loggerheads may spend months at the edge of eddies in these areas. As this area has also been found to be an important foraging habitat for juvenile bluefin tuna (Ingake *et al.* 2001 *in* Polovina *et al.* 2004), overlaps between fisheries targeting these fish and others with similar habitat associations are likely to also encounter loggerhead sea turtles.

Population status and trends

Based on genetic analyses conducted at nesting sites, there are five distinct subpopulations of loggerheads in the western Atlantic: (1) a northern nesting subpopulation that occurs from North Carolina to northeast Florida, about 29° N (approximately 7,500 nests in 1998); (2) a south Florida nesting subpopulation, occurring from 29° N on the east coast to Sarasota, Florida on the west coast (approximately 83,400 nests in 1998); (3) a Florida panhandle nesting subpopulation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida (approximately 1,200 nests in 1998); (4) a Yucatán nesting subpopulation, occurring on the eastern Yucatán Peninsula, Mexico (TEWG, 2000); and (5) a Dry Tortugas nesting subpopulation, occurring in the islands of the Dry Tortugas, near Key West, Florida (approximately 200 nests per year) (NMFS SEFSC, 2001). The status of the northern population based on the number of loggerhead nests has been classified as stable or declining (TEWG, 2000). Although nesting data from 1990 to the present for the northern loggerhead subpopulation suggests that nests have been increasing annually (2.8 - 2.9%) (NMFS SEFSC, 2001), there are confidence intervals about these estimates that include no growth[18]. Adding to concerns for the long-term stability of the northern subpopulation, genetics data has shown that, unlike the much larger south Florida subpopulation which produces predominantly females (80%), the northern subpopulation produces predominantly males (65%; NMFS SEFSC 2001).

The diversity of the loggerheads' life history renders them susceptible to many natural and human impacts, including impacts while they are on land and in the ocean, including both the benthic and the pelagic environment. Hurricanes are particularly destructive to sea turtle nests. Sand accretion and rainfall that result from these storms as well as wave action can appreciably reduce hatchling success. For example, in 1992, all of the eggs over a 90-mile length of coastal Florida were destroyed by storm surges on beaches that were closest to the eye of Hurricane Andrew (Milton *et al.*, 1994). Other sources of natural mortality include cold stunning and biotoxin exposure.

Anthropogenic factors that impact hatchlings and adult female turtles on land, or the success of nesting and hatching include: beach erosion, beach armoring and nourishment; artificial lighting; beach cleaning; increased human presence; recreational beach equipment; beach driving; coastal

[18] Meta-analyses conducted by NMFS' Southeast Fisheries Science Center to produce these estimates were unweighted analyses and did not consider a beach's relative contribution to the total nesting activity of a subpopulation. Consequently, the results of these analyses must be interpreted with caution.

construction and fishing piers; exotic dune and beach vegetation; and poaching. An increased human presence at some nesting beaches or close to nesting beaches has led to secondary threats such as the introduction of exotic fire ants, feral hogs, dogs, and an increased presence of native species (*e.g.*, raccoons, armadillos, and opossums), which raid and feed on turtle eggs. Although sea turtle nesting beaches are protected along large expanses of the northwest Atlantic coast, other areas along these coasts have limited or no protection. Sea turtle nesting and hatching success on unprotected high density east Florida nesting beaches from Indian River to Broward County are affected by all of the above threats (NMFS SEFSC, 2001).

Loggerhead turtles are affected by a completely different set of anthropogenic threats in the marine environment. These include oil and gas exploration, coastal development, and transportation; marine pollution; underwater explosions; hopper dredging, offshore artificial lighting; power plant entrainment and/or impingement; entanglement in debris; ingestion of marine debris; marina and dock construction and operation; boat collisions; poaching, and fishery interactions. In the pelagic environment, loggerheads are exposed to a series of longline fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various fleets in the Mediterranean Sea (Aguilar *et al.*, 1995, Bolten *et al.,* 1994, Crouse, 1999). In the benthic environment in waters off the coastal U.S., loggerheads are exposed to a suite of fisheries in federal and state waters including trawl, purse seine, hook and line, gillnet, pound net, longline, dredge, and trap fisheries.

Distribution and Abundance of Nesting Females in the Pacific Ocean

In the Pacific Ocean, loggerhead turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) and a smaller southwestern nesting aggregation that occurs in eastern Australia (Great Barrier Reef and Queensland) and New Caledonia (NMFS SEFSC, 2001). There are no reported loggerhead nesting sites in the eastern or central Pacific Ocean basin.

Japan

In the western Pacific, the only major nesting beaches are in the southern part of Japan (Dodd, 1988). Balazs and Wetherall (1991) speculated that 2,000 to 3,000 female loggerheads nested annually in all of Japan. From nesting data collected by the Sea Turtle Association of Japan since 1990, the latest estimates of nesting females on almost all of the rookeries are as follows: 1998 - 2,479 nests; 1999 - 2,255 nests; 2000 - 2,589 nests. Considering multiple nesting estimates, Kamezaki *et al.* (2003) estimates that approximately less than 1,000 female loggerheads return to Japanese beaches per nesting season.

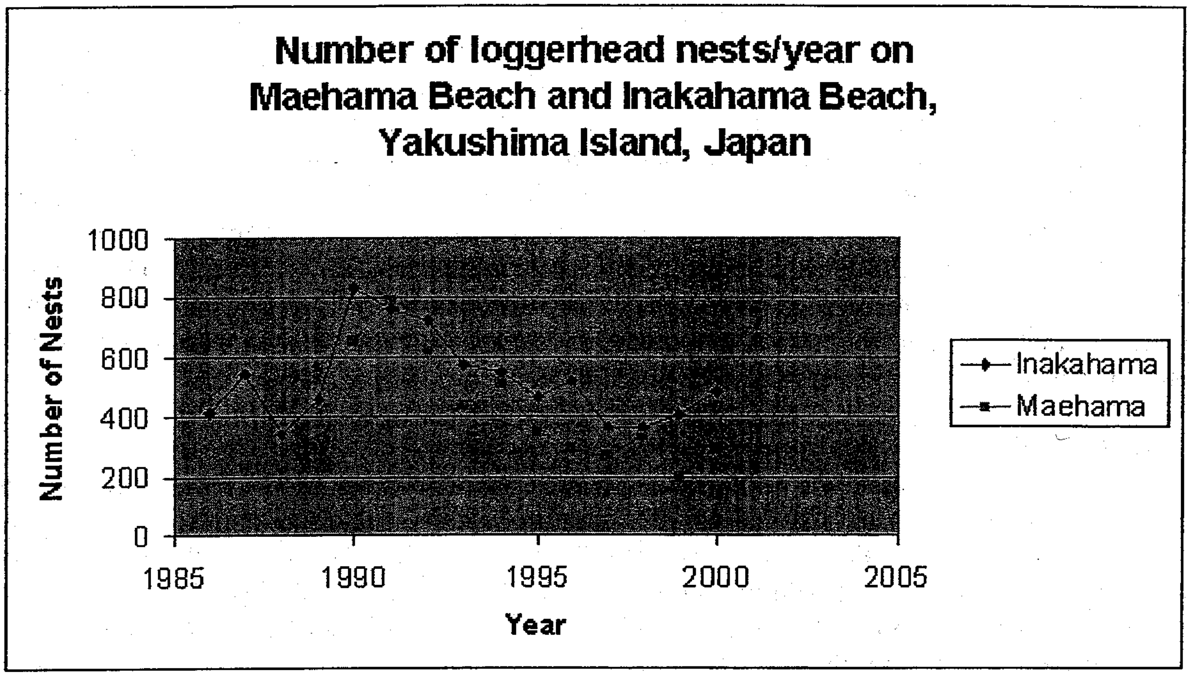
In Japan, loggerheads nest on beaches across 13 degrees of latitude (24°N to 37°N), from the mainland island of Honshu south to the Yaeyama Islands, which appear to be the southernmost extent of loggerhead nesting in the western North Pacific. Researchers have separated 42 beaches into five geographic areas: (1) the Nansei Shoto Archipelago (Satsunan Islands and Ryukyu Islands); (2) Kyushu; (3) Shikoku; (4) the Kii Peninsula (Honshu); and (5) east-central Honshu and nearby islands. There are nine "major nesting beaches" (defined as beaches having at least 100 nests in one season within the last decade) and six "submajor nesting beaches" (defined as beaches having 10-100 nests in at least one season within the last decade), which contain approximately 75% of the total clutches deposited by loggerheads in Japan (Kamezaki *et al.*, 2003).

Two of the most important beaches in Japan, Inakahama Beach and Maehama Beach, located on Yakushima Island in the Nansei Shoto Archipelago, account for approximately 30% of all loggerhead nesting in Japan. Monitoring on Inakahama Beach has taken place since 1985. Figure 3.7 shows the abundance and trend of loggerhead nests on these two beaches. Monitoring on some other nesting beaches has been ongoing since the 1950s, while other more remote beaches have been only recently monitored, since the 1990s. Sea turtle conservation and research is growing in Japan, resulting in more widespread beach summaries; however, there are limited reports describing the trends and status of loggerheads in this country (Kamezaki *et al.*, 2003).

According to the latest status and trend information, as reviewed in Kamezaki *et al.* (2003):

> "In the 1990s, there has been a consistent decline in annual nesting, especially in Hiwasa Beach (89% decline) and Minabe (74% decline) [both of these are 2 of 9 major nesting beaches]. For most beaches, the lowest nesting numbers recorded have been during the recent period of 1997-1999.
>
> In the 1980s, there were increases in nesting numbers. However, nesting at the beginning of the 1980s was in most instances greater than nesting at the same beach some 20 years later at the end of the 1990s.
>
> There are indications that the 1970s was a period of approximate population stability with respect to breeding numbers.
>
> For the one population with census data extending back to the 1950s (Kamouda Beach) [one of 6 submajor nesting beaches], there is a clear indication that the population has greatly declined."

In general, during the last 50 years, loggerhead nesting populations have declined 50-90%. (Also see Table 2 in Appendix B) (N. Kamezaki, Sea Turtle Association of Japan, personal communication, August, 2001). Recent genetic analyses on female loggerheads nesting in Japan suggest that this "subpopulation" is comprised of genetically distinct nesting colonies (Hatase, *et al.*, 2002) with precise natal homing of individual females. As a result, Hatase, *et al.* (2002) indicate that loss of one of these colonies would decrease the genetic diversity of Japanese loggerheads; recolonization of the site would not be expected on an ecological time scale.



While loggerhead meat is generally not consumed by Japanese, except in some local communities, there has been a black market for sea turtle eggs. However, egg poaching has nearly disappeared due to conservation efforts and research throughout the country. As mentioned in the "Threats" section, coastal fisheries off Japan, particularly gillnets, poundnets, and intensive trawl fisheries for anchovies operating offshore of the major rookeries, may be impacting loggerhead populations. The Sea Turtle Association (2002) reports that approximately 80 mature loggerheads strand every year. This may be significant if they are pre- or post-nesting females. The most serious problem, however, may be a lack of nesting habitat due to beach erosion from upstream dams and dredging, and obstruction by sea walls. The extent of this impact has not been quantitatively studied to evaluate the impact to the loggerhead population (Kamezaki *et al.*, 2003).

Australia

In eastern Australia, Limpus and Riemer (1994) reported an estimated 3,500 loggerheads nesting annually during the late 1970s. Since that time, there has been a substantial decline in nesting populations at all sites. Currently, less than 500 female loggerheads nest annually in eastern Australia, representing an 86% reduction within less than one generation (Limpus and Limpus, 2003).

Loggerheads originating from eastern Australia nest on nearly all beaches along the mainland and large barrier sand islands from South Stradbroke Island (27.6°S) northwards to Bustard Head (24.0°S) and islands of the Capricorn Bunker Group and Swain reefs in the southern Great Barrier Reef and on Bushy Island in the central Great Barrier Reef. Within this area, there are five major rookeries which account for approximately 70% of nesting loggerheads in eastern Australia.

Long-term census data has been collected at some rookeries since the late 1960s and early 1970s, and nearly all the data show marked declines in nesting populations since the mid-1980s (Limpus and Limpus, 2003). For example, in southern Great Barrier Reef waters, nesting loggerheads have declined approximately 8% per year since the mid-1980s (Heron Island), while the foraging ground population has declined 3% and were comprised of less than 40 adults by 1992. Researchers attribute the declines to perhaps recruitment failure due to fox predation of eggs in the 1960s and mortality of pelagic juveniles from incidental capture in longline fisheries since the 1970s (Chaloupka and Limpus, 2001). Wreck Island has seen a 70 to 90% decline over the last few decades. The decline of loggerheads in Australia can generally be attributed to incidental catch in trawl, net and drumline fisheries, boat strikes, ingestion/ entanglement of marine debris, and fox predation of mainland nests (Dobbs, 2002).

New Caledonia

Although loggerheads are the most common nesting sea turtle in the Île de Pins area of southern New Caledonia, there is no quantitative information available, and surveys in the late 1990s failed to locate regular nesting. However, anecdotal information from locals indicate that there may be more substantial loggerhead nesting occurring on peripheral small coral cays offshore of the main island. Limpus and Limpus (2003) estimate that the annual nesting population in the Île de Pins area may be in the "tens or the low hundreds."

Other Countries

Scattered loggerhead nesting has also been reported on Papua New Guinea, New Zealand, Indonesia (NMFS and USFWS, 1998d); however, Limpus and Limpus (2003) state that reports have not been confirmed, and in some cases, sea turtles species have been misidentified. The authors state that it is very unlikely for one to encounter nesting loggerheads north of Australia.

There are no records of nesting loggerheads in the Hawaiian Islands (Balazs, 1982), or in any of the islands of Guam, Palau, the Northern Mariana Islands (Thomas, 1989), the Federated States of Micronesia (Pritchard, 1982b), Fiji (Rupeni *et al.*, 2002), or American Samoa (Tuato'o-Bartley, *et al.*, 1993). In addition, loggerheads are not commonly found in U.S. Pacific coastal waters, and there has only been one documented stranding of a loggerhead in the Hawaiian Islands in the past 20 years (1982-2002 stranding data, G. Balazs, NMFS, personal communication, 2002). There are very few records of loggerheads nesting on any of the many islands of the central Pacific, and the species is considered rare or vagrant on islands in this region (NMFS and USFWS, 1998d).

Loggerhead mortality from human activities in the Pacific Ocean is not well-documented except for estimates based on NMFS observer data in the Hawaii-based longline fishery, CA/OR drift gillnet fishery, and recent ongoing studies in Baja California, Mexico (Nichols, *et al.*, 2000; Nichols, 2002). A high mortality in the North Pacific high-seas driftnet fisheries of Japan, Republic of Korea, and Taiwan was estimated in the 1980s and 1990s, but those fisheries no longer operate (Wetherall, *et al.*, 1993). Mortality of loggerheads in the East China Sea and other benthic habitats of this population are a concern and thought to be "high," but have not been quantified (Kamezaki, personal communication, *in* Tillman, 2000).

Of the loggerheads taken in the California-based longline fishery and the CA/OR drift gillnet fishery, all were determined to have originated from Japanese nesting beaches, based on genetic analyses (P. Dutton, NMFS, personal communication, December, 2003). Therefore, this fishery is impacting a subpopulation that consists of approximately 1,000 females nesting annually. Loggerheads taken in the ETP purse seine fishery have not been sampled for genetic data; however, because loggerheads originating from Japanese nesting beaches have been tracked to foraging areas off Baja California, Mexico, it is likely that any loggerheads taken in this area by purse seiners originated from Japan.

Olive Ridley Turtle

Global Status

Although the olive ridley is regarded as the most abundant sea turtle in the world, olive ridley nesting populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened.

Physical Description

Olive ridleys are the smallest living sea turtle, with an adult carapace length between 60 and 70 cm, and rarely weighing over 50 kg. They are olive or grayish green above, with a greenish white underpart, and adults are moderately sexually dimorphic (NMFS and USFWS, 1998e). They have an unusually broad carapace, a medium-sized head that is triangular in planar view, five to nine pairs of costal scutes and four inframarginals with pores.

General Distribution

Olive ridley turtles occur throughout the world, primarily in tropical and sub-tropical waters. The species is divided into three main populations, with distributions in the Pacific Ocean, Indian Ocean, and Atlantic Ocean. Nesting aggregations in the Pacific Ocean are found in the Marianas Islands, Australia, Indonesia, Malaysia, and Japan (western Pacific), and Mexico, Costa Rica, Guatemala, and South America (eastern Pacific). In the Indian Ocean, nesting aggregations have been documented in Sri Lanka, east Africa, Madagascar, and there are very large aggregations in Orissa, India. In the Atlantic Ocean, nesting aggregations occur from Senegal to Zaire, Brazil, French Guiana, Suriname, Guyana, Trinidad, and Venezuela.

Life Cycle and Population Dynamics

Figure 3.8 illustrates the basic life cycle of the olive ridley turtle (based on general life history information presented by Marquez (1994) for the Kemp's ridley sea turtle, a surrogate species for the lesser known olive ridley turtle). This cycle is broken into six life stages: (1) egg/hatchling; (2) pelagic juvenile; (3) sub-adult; (4) neophyte breeder; (5) remigrant; and (6) adult. Arrows along the bottom represent the probability of each ageclass surviving and remaining in the ageclass. Arrows between each ageclass represent the probability of the ageclass surviving and growing to the next ageclass, and the arrows along the top represent the ageclass-specific fertility. The thickness or length of the lines do not indicate the level of probability or fecundity. Information on the life stage survival rates and fecundities of olive ridley turtles is sparse. Table 3.14 includes the available information on the Kemp's ridley turtle (*Lepidochelys kempi*). Available information on the behavior, physiology, and biological requirements of the olive ridley turtle is summarized below.

Figure 3.8. Life-cycle graph of the olive ridley sea turtle

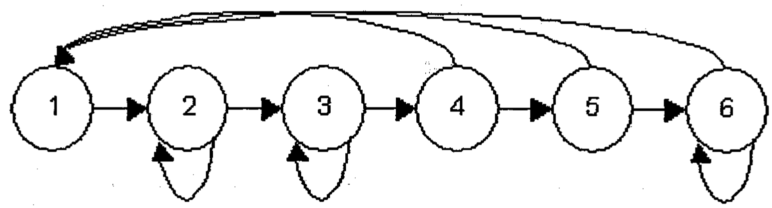


Table 3.14: Stage structure and vital rates for olive ridleys (based on Marquez (1981, 1994) data for Kemp's ridley turtles)

Stage	Name	Age	Survival Probability (lx)	Fecundity
1	Egg-hatchling	0	0.609	0
2	Pelagic juvenile	1	0.565	0
3	Sub-adult	-na	0.445	0
4	Neophyte	8	0.421	80
5	Remigrant	9	0.421	84
6	Mature breeder	10-	0.421 (0.48)[1]	81

1 Marquez *et al.* (1982a, *in* Chaloupka and Limpus 2002) report a survival rate of 0.48 for adult female olive ridley turtles.

Data on the transition rates between life stages are unavailable; olive ridleys spend most of their life in the pelagic environment which makes studies of their abundance, life history and ecology, and pelagic distribution difficult. As a result, we were unable to analyze the stage structure of this population to estimate its finite population growth rate (λ) or the elasticities of the various life stages. The typical population structure for long-lived, late-maturing species like olive ridley turtles has the largest proportion of individuals and the highest mortality rates in the earliest stages; proportions and mortality decline through successive stages with the smallest proportion of the total population in the adult stages, which also have the lowest mortality rates. For further discussion of these population structures, see Crouse (1999) and Stearns (1992).

The dynamics of some olive ridley turtle populations today are certain to reflect the effects of the various anthropogenic activities which have caused or exacerbated the declines in abundance noted in some olive ridley nesting aggregations, such as those in areas of India, Malaysia, Costa Rica, and Guatemala. As a result, the λ and life stage elasticities of these populations are likely indicative of declining populations (λs less than 1, and changed proportional importance of different life stage elasticities on λ). For an example of the changed dynamics of a declining sea turtle population, see the *Life Cycle and Population Dynamics* discussion for loggerhead turtles above. In a disturbed population the survival rates of adult turtles may still have the highest elasticities, typical for long-lived species with delayed maturity. However, the survival rates of life stages relatively undisturbed by chronic or significant sources of mortality increase in importance as the population relies upon these stages to supply enough individuals to survive the rigors of subsequent life stages and reach sexual maturity. In the case of a population where the survival of all life stages has been decreased by anthropogenic activities, stage elasticities may change such that the proportional effect of a change in survival rate in any stage can have significant effect on the population's growth rate.

Based on past observations, the olive ridley turtles that are captured and killed in Pacific Ocean longline fisheries are primarily sub-adults and adults (see the discussion in the *Effects of the Action* section). As a result, olive ridley nesting aggregations affected by the HMS FMP fisheries could experience declines in adult and sub-adult life stage survival rates, with a corresponding proportional effect on the growth rate of that aggregation. Depending on the magnitude of the change in survival rates and λ, some of these aggregations could slow their rate of increase, begin to decline, or increase the rate of their decline.

Biological Characteristics

Diet

Olive ridleys feed on tunicates, salps, crustaceans, other invertebrates and small fish. Montenegro *et al.* 1986 (*in* NMFS and USFWS, 1998e) found a wide variety of prey in olive ridleys from the eastern Pacific. Adult males fed primarily on fishes (57%), salps (38%), crustaceans (2%) and molluscs (2%), while adult females fed primarily on salps (58%), and a lesser degree on fishes (13%), molluscs (11%), algae (6%), crustaceans (6%), bryozoans, sea squirts, sipunculid worms and fish eggs (all individually less than 1%). Similar to loggerheads, olive ridleys off western Baja California may feed exclusively on pelagic red crabs (Marquez, 1990 *in* NMFS and USFWS, 1998e).

Dive Behavior

Olive ridleys have been caught in trawls at depths of 80-110 meters (NMFS and USFWS, 1998e), and a post-nesting female reportedly dove to a maximum depth of 290 meters. The average dive length for an adult female and adult male is reported to be 54.3 and 28.5 minutes, respectively (Plotkin, 1994, *in* Lutcavage and Lutz, 1997).

The most common prey of olive ridley turtles are salps and pyrosomes, similar to leatherback turtles. These prey organisms occur sub-surface and migrate within the water column as part of the deep scattering layer. As a result, olive ridley turtles tend to dive deeper, spending 20 percent of the time at the surface and 40 percent of their time at depths greater than 40 meters. On 25 percent of the recorded dive days, olive ridley turtles dove to depths greater than 150 meters at least once (Polovina *et al.*, 2004). Daily dives of 200 meters have been observed, and one dive was recorded at 254 meters (Polovina *et al.*, 2003). The dive habitat of the tagged olive ridley turtles had a deep thermocline at 100 meters and minimal horizontal surface temperature fronts (Polovina *et al.*, 2004).

In 1999 eight olive ridley turtles (4 adult females, 3 adult males, and 1 juvenile) were tagged using satellite-linked dive recorders during a research survey in the eastern tropical Pacific Ocean. Sixty percent of the dives were of two minutes or less in duration. The average of the longest dive time for females was 120-180 minutes, 75 minutes for males, and 45-60 minutes for the one juvenile. A diurnal dive behavior was seen where most turtles spent more time near the surface during daylight hours, which were between 9 a.m. to 2 p.m., between 22-56% (mean of 37%) of the total dive time was spent near the surface during this 6-hour period. Female olive ridleys in this study spent significantly more time at 40 to 80 meters than did the males, and the thermocline is an important foraging area for the olive ridley as both male and female turtles spent a significant amount of time in the region of the thermocline. Mated females and males did not make dives greater than 150 meters, while a non-mated pelagic male and female both made dives greater than 150 meters, with a number of dives over 250 meters (Parker *et al.*, 2003).

Life History/Reproduction

Olive ridleys are famous for their synchronized mass nesting emergences, a phenomenon commonly known as "arribadas." While arribadas occur only on a few beaches world-wide, the olive ridley's nesting range is far-reaching and is also comprised of solitary nesters. Thus, there are two clearly distinct reproductive behaviors within the species - some females are solitary nesters, while others are arribada nesters (Plotkin and Bernardo, 2003).

Olive ridley turtles begin to aggregate near the nesting beach two months before the nesting season, and most mating is generally assumed to occur in the vicinity of the nesting beaches, although copulating pairs have been reported over 100 km from the nearest nesting beach. Olive ridleys are considered to reach sexual maturity between 8 and 10 years of age, and approximately 3 percent of the number of hatchlings recruit to the reproductive population (Marquez, 1982 *in* Salazar, *et al.*, 1998). The mean clutch size for females nesting on Mexican beaches is 105.3 eggs, in Costa Rica, clutch size averages between 100 and 107 eggs (*in* NMFS and USFWS, 1998e). Research shows that arribada nesters produced larger clutches than solitary nesters, perhaps to offset the large number of predators near the arribada sites (Plotkin and Bernardo, 2003). Females generally lay 1.6 clutches of eggs per season in Mexico (Salazar, *et al.*, 1998) and two clutches of eggs per season in Costa Rica (Eckert, 1993). Arribada nesters have high site fidelity and remain near the nesting beach during the internesting period and are relatively inactive (Plotkin and Bernardo, 2003). Solitary nesters appear to have low site fidelity (Kalb, 1999 *in* Plotkin and Bernardo, 2003). Data on the remigration intervals of olive ridleys in the eastern Pacific are scarce; however, in the western Pacific (Orissa, India), females showed an annual mean remigration interval of 1.1 years. Reproductive span in females of this area was shown to be up to 21 years (Pandav and Kar, 2000).

Migration

Like leatherback turtles, most olive ridley turtles lead a primarily pelagic existence (Plotkin *et al.*, 1993), migrating throughout the Pacific, from their nesting grounds in Mexico and Central America to the north Pacific. While olive ridleys generally have a tropical to subtropical range, with a distribution from Baja California, Mexico to Chile (Silva-Batiz, *et al.*, 1996), individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing, 2000). Surprisingly little is known of their oceanic distribution and critical foraging areas, despite being the most populous of north Pacific sea turtles. They appear to occupy a series of foraging areas geographically distributed over a very broad range within their oceanic habitat (Plotkin, *et al.*, 1994).

Little is also known about the habitat of the juvenile olive ridleys, primarily because there have been few observations. While adult olive ridleys are the most abundant and widely distributed in the eastern tropical Pacific, no juveniles were seen during several years of observations (Pitman, 1990 *in* Juárez-Cerón and Sarti-Martínez, 2003). It has been hypothesized that depending on food sources, the distribution of juveniles may be similar to that of adults. Young olive ridleys may move offshore and occupy areas of surface current convergences to find food and shelter among aggregated floating objects until they are large enough to recruit to benthic feeding grounds of the adults. During four surveys carried out between Socorro Island of the Revillagigedo Archipelago and Bahia de Manzanillo between November 1999 and December 2000, researchers observed a number of juvenile olive ridleys (11), measuring around 29 cm CCL. All were found close together, and almost always in pairs. All were in a pelagic environment, characterized by deep water (land was not visible and there was no algae accumulation; Juárez-Cerón and Sarti-Martínez, 2003).

In the eastern Pacific Ocean, adult olive ridleys are found in warm, tropical waters, bounded on the north by the California Current and on the south by the Humboldt Current. There are few observations of olive ridleys west of 140°W. Olive ridleys appear to forage throughout the eastern tropical Pacific Ocean, often in large groups, or flotillas, and are occasionally found entangled in scraps of net or other floating debris. In a three year study of communities associated with floating objects in the eastern tropical Pacific, Arenas and Hall (1992) found sea turtles present in 15 percent of observations and suggested that flotsam may provide the turtles with food, shelter, and/or orientation cues in an otherwise featureless landscape. Olive ridleys comprised the vast majority (75%) of these sea turtle sightings. Small crabs, barnacles and other marine life often reside on the debris and likely serve as food attractants to turtles.

During seven research cruises conducted in the eastern tropical Pacific from 1989 to 2000, researchers opportunistically captured olive ridleys and recorded environmental information surrounding the capture location. This included distance to land, water depth, sea surface temperature and currents. Analyses of the data revealed high numbers of adults distributed on the continental shelf and slope (near major nesting beaches), next to the Pacific trench in upwelling regions. Adults were frequently found in shallow waters, with peak numbers between 0 and 1,000 meters. Juveniles were more often found in deeper waters (off the continental shelf; Kopitsky *et al.* 2003).

The post-nesting migration routes of olive ridleys tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters, ranging from Mexico to Peru, and more than 3,000 kilometers out into the central Pacific (Plotkin, *et al.*, 1993).

Tagging data from Orissa, India shows that olive ridleys that nest there migrate to southern Tamil Nadu and Sri Lanka during the non-breeding season. Four olive ridleys nesting in Orissa were outfitted with satellite transmitters and tracked. Three turtles moved in large circles off the coast and northern Andhra Pradesh, while one turtle swam south towards Sri Lanka, swimming 1,000 kilometers in 18 days. All turtles averaged about 25 to 30 kilometers per day (Shanker *et al.*, 2003a).

Olive ridley turtles from both eastern and western Pacific nesting beaches were tagged in the Hawaii-based longline fishery (Polovina *et al.*, 2004). Two of the 10 olive ridleys may have been sexually mature based on straight carapace lengths, the remainder were immature turtles. These turtles migrated in areas between 8 and 31°N, with SSTs of 23° to 28°C (primarily in areas with SSTs of 24° or 27°C). Throughout the year, the olive ridley turtles had a less distinct pattern of distribution than loggerhead turtles tagged in this fishery. For example, olive ridley turtles were seen in the southern portion of their preferred range between October and December. Between April and September, the turtles were found between 14° and 28°N, but not in the area between 20° and 24° N. This middle area is where olive ridley turtles were most frequently found during January through March. The data was not separated by nesting beach origin, however, so some of these patterns may also be attributable to the different habitat associations between eastern and western Pacific olive ridley turtles.

Interestingly, olive ridley turtles from the east and west Pacific had different habitat associations. Western Pacific olive ridley turtles associated with major ocean currents, such as the southern edge of the KEC, the North Equatorial Current (NEC) and the Equatorial Countercurrent (ECC). Olive ridley turtles from the eastern Pacific were not associated with strong current systems, most of these turtles remained within the center of the Subtropical Gyre. These waters are warm, vertically stratified with deep thermoclines, and do not have strong surface temperature or chlorophyll gradients. Olive ridley turtles of either nesting aggregation origin were not associated with strong surface chlorophyll fronts. However, olive ridleys from the western Pacific were found in habitat characterized by wind-induced upwelling and shoaling of the thermocline, which may allow olive ridley turtles to forage more shallowly in these areas. Polovina *et al.* (2004) theorize that these conditions may provide an energetic advantage to turtles migrating across the Pacific to nesting beaches.

Population status and trends

As mentioned, the Mexican nesting population of olive ridley is listed as endangered, while all other populations of olive ridleys are listed as threatened. Since its listing in 1978, there has been a decline in abundance of this species, and it has been recommended that the olive ridley for the western Atlantic be reclassified as endangered. This is based on continued direct and incidental take of olive ridleys, particularly in shrimp trawl nets. Since 1967, the western North Atlantic (Surinam and adjacent areas) nesting population has declined more than 80 percent. In general, anthropogenic activities have negatively affected each life stage of the olive ridley turtle populations, resulting in the observed declines in abundance of some olive ridley turtle nesting aggregations. Other aggregations, however, have experienced significant increases in abundance in recent years, often as a result of decreased adult and egg harvest pressure, indicating populations in which the birth rates are now exceeding death rates.

Declines in olive ridley populations have been documented in Playa Nancite, Costa Rica; however, other nesting populations along the Pacific coast of Mexico and Costa Rica appear to be stable or increasing, after an initial large decline due to harvesting of adults. Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton, *et al.*, 1982 *in* NMFS and USFWS, 1998e). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan. (NMFS and USFWS, 1998e). Although olive ridley meat is palatable, it was not widely sought after; its eggs, however, are considered a delicacy, and egg harvest can certainly be considered one of the major causes for its decline. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo, 1982).

In the Indian Ocean, Gahirmatha supports perhaps the largest nesting population; however, this population continues to be threatened by nearshore trawl fisheries. Direct harvest of adults and eggs, incidental capture in commercial fisheries, and loss of nesting habits are the main threats to the olive ridley's recovery.

Distribution and Abundance of Nesting Females in the Pacific Ocean

Eastern Pacific Ocean

In the eastern Pacific Ocean, nesting occurs all along the Mexican and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. Few turtles nest as far north as southern Baja California, Mexico (Fritts, *et al.*, 1982) or as far south as Peru (Brown and Brown, 1982). As mentioned previously, where population densities are high enough, nesting takes place in synchronized aggregations known as arribadas. The largest known arriba*das* in the eastern Pacific are off the coast of Costa Rica (~475,000 - 650,000 females estimated nesting annually) and in southern Mexico (~800,000+ nests/year at La Escobilla, in Oaxaca (Millán, 2000).

Mexico

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, has improved the situation for the olive ridley. Surveys of important olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Marquez, *et al.*, 1995; Arenas, *et al.*, 2000). Annual nesting at the principal beach, Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests (Salazar, *et al.*, in press). At a smaller olive ridley nesting beach in central Mexico, Playon de Mismalayo, nest and egg protection efforts have resulted in more hatchlings, but the population is still "seriously decremented and is threatened with extinction" (Silva-Batiz, *et al.*, 1996). Still, there is some discussion in Mexico that the species should be considered recovered (Arenas, *et al.*, 2000).

Costa Rica

In Costa Rica, 25,000 to 50,000 olive ridleys nest at Playa Nancite and 450,000 to 600,000 turtles nest at Playa Ostional each year (NMFS and USFWS, 1998e). In an 11-year review of the nesting at Playa Ostional, (Ballestero, *et al.*, 2000) report that the data on numbers of nests deposited is too limited for a statistically valid determination of a trend; however, there does appear to be a six-year decrease in the number of nesting turtles. Under a management plan, the community of Ostional is allowed to harvest a portion of eggs. Between 1988 and 1997, the average egg harvest from January to May ranged between 6.7 and 36%, and from June through December, the average harvest ranged from 5.4 to 20.9% (Ballestero, *et al.*, 2000). At Playa Nancite, concern has been raised about the vulnerability of offshore aggregations of reproductive individuals to "trawlers, longliners, turtle fishermen, collisions with boats, and the rapidly developing tourist industry" (Kalb, *et al.*, 1996). The greatest single cause of olive ridley egg loss comes from the nesting activity of conspecifics on *arribada* beaches, where nesting turtles destroy eggs by inadvertently digging up previously laid nests or causing them to become contaminated by bacteria and other pathogens from rotting nests nearby. At a nesting site in Costa Rica, an estimated 0.2 percent of 11.5 million eggs laid during a single *arribada* produced hatchlings (*in* NMFS and USFWS, 1998e). In addition, some female olive ridleys nesting in Costa Rica have been found afflicted with the fibropapilloma disease (Aguirre, *et al.*, 1999).

Guatemala

In Guatemala, the number of nesting olive ridleys nesting along their Pacific coast has declined by 34% between 1981 and 1997. This is only based on two studies conducted 16 years apart, however: in 1981, the estimated production of olive ridley eggs was 6,320,000, while in 1997, only 4,300,000 eggs were estimated laid (*in* Muccio, 1998). Villagers also report a decline in sea turtles; where collectors used to collect 2-3 nests per night during the nesting season 15 years prior, now collectors may find only 2-4 nests per year due to fewer turtles and more competition. This decline most certainly can be attributed to the collection of nearly 95% of eggs laid, and the incidental capture of adults in commercial fisheries (Muccio, 1998).

Nicaragua

In Nicaragua, there are two primary *arribada* beaches: Playa La Flor and Playa Chacocente, both in the southern Department of Rivas. At Playa La Flor, the second most important nesting beach for olive ridleys on Nicaragua, Ruiz (1994) documented 6 *arribadas* (defined as 50 or more females nesting simultaneously). The main egg predators were domestic dogs and vultures (*Coragyps atratus* and *Cathartes aura*). During the largest *arribada*, 12,960 females nested from October 13-18, 1994 at Playa La Flor (*in* NMFS and USFWS, 1998e). Von Mutius and Berghe (2002) reported that management of this beach includes a six-month open season for egg collection, during a time when the *arribadas* is small. During this time, all eggs are taken by locals, and during the "closed period," approximately 10-20% of eggs are given to the locals to consume or sell. At Playa Chacocente, approximately 5,000 to 20,000 females may nest over the course of five days (Camacho y Cáceres, 1994, *in* Arauz, 2002). Here, the harvest and commercialization of sea turtle eggs is allowed and somewhat controlled. During a monitoring project conducted on nearby Playa El Mogote from October, 2001 through March, 2002, researchers documented olive ridleys nesting 327 times. Of these, 99.7% of the nests were poached (Arauz, 2002).

Indian Ocean

In the eastern Indian Ocean, olive ridleys nest on the east coast of India, Sri Lanka, and Bangladesh.

India

In India, a few thousand olive ridleys nest in northern Tamil Nadu, Andhra Pradesh, and the Andaman and Nicobar Islands (*in* Shanker *et al.*, 2003b). However, the largest nesting aggregation of olive ridleys in the world occurs in the Indian Ocean along the northeast coast of India (Orissa). Not surprisingly then, olive ridleys are the most common sea turtle species found along the east coast of India, migrating every winter to nest en-masse at three major rookeries in the state of Orissa: Gahirmatha, Devi River mouth, and Rushikulya (Shanker *et al.*, 2003b). Sporadic nesting occurs between these mass nesting beaches.

The Gahirmatha rookery, located along the northern coast of Orissa, hosts the largest known nesting concentration of olive ridleys. Shanker *et al.* (2003b) provide a comprehensive report on the status and trends of olive ridleys nesting in Orissa since monitoring began in 1975. Table 3.15 shows the estimated number of olive ridleys nesting at Gahirmatha in the largest arribada during a season. No estimates are available for arribadas at the Devi River mouth and Rushikulya. Current population sizes are estimated to be between 150-200,000 nesting females per year. Based on analyses of the data, while there has been no drastic decline in the nesting population at Gahirmatha in the last 25 years, there are differences in trends between decades. For example, trend analyses suggest stability or increase in the size of the 1980s arribadas, which may be due to enforcement of legislation in the late 1970s, stopping the directed take of turtles. However, the 1990s data show that the population is declining or on the verge of a decline, which may be consistent with the recent increase in fishery related mortality and other threats (see below). No arribadas occurred on this nesting beach in 1997, 1998, and 2002, which is the highest documented incidence of failure since this rookery has been monitored (Shanker *et al.*, 2003b).

Table 3.15. Consensus estimates for nesting populations in Gahirmatha, derived from multiple sources (Source: Shanker *et al.*, 2003b)

Year	Consensus estimate[1]	Comments	Year	Consensus estimate[1]	Comments
1975-1976	158,000		1989-1990	200,000	1 arribada
1976-1977	150,000		1990-1991	350,000	2 arribadas
1977-1978	150,000	1 arribada	1991-1992	320,000	2 arribadas
1978-1979	133,000	1 arribada	1992-1993	350,000	?
1979-1980	218,000	1 arribada	1993-1994	350,000	2 arribadas
1980-1981	191,000	1 arribada	1994-1995	340,000	?
1981-1982	0	no arribada	1995-1996	200,000	1 arribada
1982-1983	200,000	2 arribadas	1996-1997	0	no arribada
1983-1984	300,000	2 arribadas	1997-1998	0	no arribada
1984-1985	280,000	2 arribadas	1998-1999	180,000	1 arribada
1985-1986	50,000	1 arribada	1999-2000	?	1 arribada
1986-1987	386,000	2 arribadas	2000-2001	?	1 arribada
1987-1988	0	no arribada	2001-2002	0	no arribada
1988-1989	300,000	1 arribada			

[1] Estimates refer to the largest arribada during a nesting season, usually the first.

Uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large scale mortality of adults during the last two decades. Records of stranded sea turtles have been kept since 1993. Since that time, over 90,000 strandings (mortalities) of olive ridleys have been documented (*in* Shanker *et al.*, 2003b), and much of it is believed to be due to illegal gillnet and shrimp trawl fishing in the offshore waters. Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. Marine turtles in Orissa are protected by a prohibition of all mechanized fishing within 5 km of the coast and within 20 km of the Gahirmatha coast (~35 km). Despite these rules, mortality due to shrimp trawling reached a record high of 13,575 ridleys during the 1997-98 season, and none of the approximately 3,000 trawlers operating off the Orissa coast use turtle excluder devices in their nets (Pandav and Choudhury, 1999), despite mandatory requirements passed in 1997. "Operation Kachhapa" was developed in the late 1990s to protect sea turtles and their habitat by enabling strict enforcement of the 5 km non-mechanized fishing zone limit, as well as putting forward efforts to monitor nestings and educate local inhabitants and fishermen (Shanker and Mohanty, 1999). However, shrimp boats continue to fish close to shore within this protected zone and continue to not use turtle excluder devices. Current mortality rates are estimated to be ~15,000 turtles per year (B. Mohanty, personal communication, *in* Shanker *et al.*, 2003b). Threats to these sea turtles also include artificial illumination from coastal development and unsuitable beach conditions, including reduction in beach width due to erosion (Pandav and Choudhury, 1999).

Genetic studies indicate that olive ridleys originating from the east coast of India are distinct from other ridleys worldwide, increasing the conservation importance of this particular population (Shanker *et al.*, 2000 *in* Shanker *et al.*, 2003b).

Western Pacific Ocean
In the western Pacific, olive ridleys are not as well documented as in the eastern Pacific, nor do they appear to be recovering as well. There are a few sightings of olive ridleys from Japan, but no report of egg-laying. Similarly, there are no nesting records from China, Korea, the Philippines, or Taiwan. No information is available from Vietnam or Kampuchea (*in* Eckert, 1993).

Indonesia
Indonesia and its associated waters also provides habitat for olive ridleys, and there are some recently documented nesting sites. The main nesting areas are located in Sumatra, Alas Purwo in East Java, Paloh-West Kalimantan and Nusa Tenggara. On Jamursba-Medi beach, on the northern coast of Papua, 77 olive ridley nests were documented from May to October, 1999 (Teguh, 2000 *in* Putrawidjaja, 2000). However, as mentioned in the leatherback subsection, extensive hunting and egg collection, in addition to rapid rural and urban development, have reduced nesting activities in this area. In Jayapura Bay, olive ridleys were often seen feeding, and in June, 1999, an estimated several hundred ridleys were observed nesting on Hamadi beach, despite heavy human population in the nearby area. Locals report daily trading and selling of sea turtles and their eggs in the local fish markets (Putrawidjaja, 2000). At Alas Purwo National Park, located at the eastern-most tip of East Java, olive ridley nesting was documented from 1992-96. Recorded nests were as follows: from September, 1993 to August, 1993, 101 nests; between March and October, 1995, 162 nests; and between April and June, 1996, 169 nests. From this limited data, no conclusions could be reached regarding population trends (Suwelo, 1999); however, recently, Dermawan (2002) reports that there were up to 250 females nesting at this site in 1996, with an increasing trend.

Malaysia
Olive ridleys nest on the eastern and western coasts of peninsular Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 *eggs* (2,400 nests, with approximately 100 eggs per nest) (Siow and Moll, 1982, *in* Eckert, 1993)), while only 187 *nests* were reported from the area in 1990 (Eckert, 1993). In eastern Malaysia, olive ridleys nest very rarely in Sabah and in low numbers (Basintal, 2002), and only a few records are available from Sarak (*in* Eckert, 1993).

Thailand
In Thailand, olive ridleys occur along the southwest coast, on the Surin and Similan islands, and in the Andaman Sea. On Phra Thong Island, on the west coast of Thailand, the number of nesting turtles have declined markedly from 1979 to 1990. During a 1996-97 survey, only six olive ridley nests were recorded, and of these, half were poached, and one was predated by feral dogs. During

the 1997-98 survey, only three nests were recorded. The main threats to turtles in Thailand include egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e. carapace), indirect capture in fishing gear, and loss of nesting beaches through development (Aureggi, *et al.*, 1999).

Central Pacific Ocean

There are no records of nesting on the unincorporated U.S. territories in the North Pacific. In the central Pacific, a single nesting was reported in September, 1985 on the island of Maui, Hawaii but the eggs did not hatch and the event was most likely an anomaly (Balazs and Hau, 1986 *in* NMFS and USFWS, 1998e). In October 2002, an olive ridley turtle was reported to have nested on the shores of Hilo Bay, on the Island of Hawaii. If confirmed upon hatching, this nesting event marks the second recorded nesting of an olive ridley in the main Hawaiian Islands.

Based on genetic analyses, an olive ridley taken in the CA/OR drift gillnet fishery originated from an eastern Pacific stock (i.e. Costa Rica or Mexico) (P. Dutton, NMFS, personal communication, October 2002). The one olive ridley observed taken in the California-based longline fishery was found to originate from the eastern Pacific (P. Dutton, NMFS personal communication, December, 2003). Although genetic analyses are not executed on olive ridleys taken in the ETP purse seine fishery, captured olive ridleys likely originate from eastern Pacific nesting beaches. Research cruises in the ETP collected information on sighted olive ridleys and genetic analyses determined those turtles originated from eastern Pacific nesting beaches.

Recent genetic information analyzed from 39 olive ridleys taken in the Hawaii-based longline fishery indicate that 74% of the turtles (n=29) originated from the eastern Pacific (Mexico and Costa Rica) and 26% of the turtles (n=10) were from the Indian and western Pacific rookeries (P. Dutton, NMFS, personal communication, January, 2001), indicating the animals from both sides of the Pacific converge in the north Pacific pelagic environment.

Factors Affecting Sea Turtles in the Pacific Ocean

Because impacts to sea turtles in the Pacific Ocean are generally non-discriminatory insofar as the different species are concerned, the following is a description of known fisheries and non-fisheries-related threats to all sea turtles in the Pacific Ocean.

Fisheries impacts

Very few fisheries in the Pacific Ocean are observed or monitored for bycatch. Rough estimates can be made of the impacts of coastal, offshore, and distant water fisheries on sea turtle populations in the Pacific Ocean by extrapolating data collected on fisheries with known effort that have been observed to incidentally take sea turtles. However, it is important to note that a straight extrapolation of this data contains a large degree of uncertainty and variability. Sea turtles are not uniformly distributed, either by area, or by time of year. In addition, observer coverage of a fishery may be very low, observers may not always be randomly assigned to vessels, or they may be placed on vessels that use fishing strategy that may be uncharacteristic of the fleet. Also, surveys and logbooks may contain biased or incomplete information. Lastly, any take estimates are hampered by a lack of data on pelagic distribution of sea turtles.

This section will summarize known fisheries that have been observed or reported to incidentally or intentionally take sea turtles in the Pacific Ocean. The past effects of the fisheries of the Pelagics FMP are summarized in Section IV, the Effects of the Action section of this Opinion.

Appendix A provides a summary of current trends in fishing effort in the eastern and western Pacific Ocean, by year, and country. Estimates of total fishing effort are complicated by the fact that not all active vessels fish equivalent number of days per trip or annually, or use the same number of hooks, length of net, or mesh size, or have the same carrying capacity. However, even with minimum effort estimates, it is apparent that there is significant fishing effort in the Pacific Ocean for which NMFS has no bycatch information for sea turtles.

North Pacific Driftnet Fisheries (before December 1992)

Because the effects of high seas driftnet fisheries operating prior to 1992 may still be evident in sea turtle population trends, it is important to summarize what little is known about the impact of the fisheries on sea turtles in the North Pacific Ocean. Foreign high-seas driftnet fishing in the north Pacific Ocean for squid, tuna and billfish ended with a United Nations moratorium in December, 1992.

Except for observer data collected in 1990-1991, there is virtually no information on the incidental take of sea turtle species by the driftnet fisheries prior to the moratorium. The high seas squid driftnet fishery in the North Pacific was observed in Japan, Korea, and Taiwan, while the large-mesh fisheries targeting tuna and billfish were observed in the Japanese fleet (1990-91) and the Taiwanese fleet (1990). A combination of observer data and fleet effort statistics indicate that 4,366 turtles, mostly loggerheads and leatherback turtles, were entangled by the combined fleets of Japan, Korea and Taiwan during June, 1990 through May, 1991, when all fleets were monitored (Table 3.16). Of these incidental entanglements, an estimated 1,009 turtles were killed (77 percent survival rate).

Table 3.16. Estimated annual bycatch and mortality of sea turtles in the North Pacific high-seas driftnet fishery for squid, tuna & billfish in 1990-91 (Wetherall, 1997).

Species	Estimated Annual Take	Estimated Annual Mortality
green	378	93
leatherback	1,002	111
loggerhead	2,986	805
TOTAL	4,366	1,009

Data on size composition of the turtles caught in the high-seas driftnet fisheries were also collected by observers. Green turtles and the majority of loggerheads measured by observers were immature, and most of the actual measured leatherback turtles were immature, although the size of leatherback turtles that were too large to bring on board were only estimated, and are therefore unreliable (Wetherall, 1997).

These rough mortality estimates for a single fishing season provide only a narrow glimpse of the past impacts of the driftnet fishery on sea turtles. A full assessment of impacts would consider the turtle mortality generated by the driftnet fleets over their entire history and geographical range. Unfortunately, comprehensive data are lacking, but the observer data does indicate the possible magnitude of past turtle mortality, given the best information available. Wetherall *et al.* (1993) speculate that "the minimum total turtle mortality in the North Pacific high-seas driftnet fisheries may have been on the order of 2,500 turtles per year during the late 1980s. The actual mortality was probably greater than this, but less than the estimated total driftnet bycatch of perhaps 9,000 turtles per year. Based on 1990 observer data, most of the mortalities would have been loggerheads taken in the Japanese and Taiwanese large-mesh fisheries."

While a comprehensive, quantitative assessment of the past impacts of the North Pacific driftnet fishery on turtles is impossible without a better understanding of turtle population abundance, stock origins, exploitation history and population dynamics, it is likely that the mortality inflicted by the driftnet fisheries in 1990 and in prior years was significant (Wetherall *et al.* 1993), and the effects may still be evident in sea turtle populations today. The high mortality of juvenile, pre-reproductive adults, and reproductive adults in the high-seas driftnet fishery has probably altered the current age structure (especially if certain age groups were more vulnerable to driftnet fisheries) and therefore diminished or limited the reproductive potential of affected sea turtle populations.

Japan

Japanese tuna longliners in the Western Pacific Ocean and South China Sea - in the year 1978

Based on turtle sightings and capture rates reported in a survey of fisheries research and training vessels and extrapolated to total longline fleet effort by the Japanese fleet in 1978, Nishimura and Nakahigashi (1990) estimated that 21,200 turtles, including greens, leatherback turtles, loggerheads, olive ridleys and hawksbills, were captured annually by Japanese tuna longliners in the Western Pacific and South China Sea, with a reported mortality of approximately 12,300 turtles per year. Using commercial tuna longline logbooks, research vessel data and questionnaires, Nishimura and Nakahigashi (1990) estimated that for every 10,000 hooks in the Western Pacific and South China Sea, one turtle is captured, with a mortality rate of 42 percent. Although species-specific information is not available, vessels reported sightings of turtles in locations which overlap with commercial fishing grounds in the following proportions: loggerhead - 36 percent; green turtle - 19 percent; leatherback - 13.7 percent; hawksbill - 10.3 percent; olive ridley - 1.7 percent; and unknown - 19 percent.

Caution should be used in interpreting the results of Nishimura and Nakahigashi (1990), including estimates of sea turtle take rate (per number of hooks) and resultant mortality rate, and estimates of annual take by the fishery, for the following reasons: (1) the data collected was based on observations by training and research vessels, logbooks and a questionnaire (i.e. hypothetical), and do not represent actual, substantiated logged or observed catch of sea turtles by the fishery; (2) the authors assumed that turtles were distributed homogeneously; and (3) the authors used only one year (1978) to estimate total effort and distribution of the Japanese tuna longline fleet. Although the data and analyses provided by Nishimura and Nakahigashi (1990) are conjectural, longliners fishing in the Pacific have had, and (with the current level of effort) probably continue to have significant impacts on sea turtle populations.

Japanese tuna longliners - in the year 2000

The most recent bycatch information for Japanese tuna longliners is based on data collected during 2000. At a recent bycatch working group meeting of the IATTC, held in Kobe, Japan on January 14-16, a member of the Japanese delegation stated that based on preliminary data from 2000, the Japanese tuna longline fleet was estimated to take approximately 6,000 turtles, with 50 percent mortality. Little information on species composition was given; however, all species of Pacific sea turtles were taken, and of an estimated 160 leatherbacks taken, 25 were dead. The Japanese are currently analyzing the data and plan to provide more information to the Secretariat of the IATTC at a later date (K. Hanafusa, Fisheries Agency of Japan, personal communication, January, 2004).

Recently, the Japanese have tested the use of circle hooks and mackerel bait to determine effectiveness of reducing sea turtle interaction and mortality rates. Preliminary analyses show that circle hooks and mackerel bait significantly reduced the catch rate of sea turtles, without affecting the catch rate of the target species (tuna). The experiments were conducted off Japan, between 30°N and 40°N. At the bycatch working group meeting, the Japanese proposed that longline fisheries in the eastern tropical Pacific should be required to use circle hooks and not use squid bait on gear set at depths less than 120 meters from the surface. Unfortunately, several countries would not agree to the proposal, generally stating that more research needed to take place before such proposals were implemented (T. Fahy, NMFS, personal communication, January, 2004).

Table 1 in Appendix A provides a summary of the number of active Japanese longline vessels fishing mainly for tuna in the Central Western Pacific Ocean from 1990-2002. Okamoto *et al.* (1999) estimated the number of hooks deployed by Japan's offshore and distant water longline fleet in the western Pacific Ocean to average around 154 million hooks per year, based on effort data from 1990 to 1997.

Japanese coastal fisheries

Off the coast of Japan, gillnets and pound nets are very common. In addition, there is an intense trawl fishery for anchovy operated off-shore of some major loggerhead rookeries during the nesting season. According to the Sea Turtle Association of Japan (2002), approximately 80 mature loggerheads strand every year in Japan - "these coastal fisheries might be strongly related with stranding." With less than 1,000 female loggerheads nesting annually in Japan, this number of strandings is not insignificant.

Taiwan

Coastal setnet and gillnet fishery
Taiwanese have harvested sea turtles for many years for their meat, their bones for use in Chinese medicine, and eggs for profit. In Taiwan, sea turtle bycatch in fisheries occurs, although little quantitative information is available for fisheries operating in the Pacific Ocean (Cheng, 2002).

Researchers investigated the incidental capture of sea turtles by the coastal setnet and gillnet fisheries in the eastern waters of Taiwan from 1991 through 1995. Setnets used in the coastal waters off Taiwan are near-shore sedentary trap nets, and rarely extend below 20 meters. During the time of the study, there were 107 setnets in Taiwan, and they provided the second largest total fish yields, after gillnets. According to interviews with fishermen, incidentally caught sea turtles are either sold to dealers in the market or are butchered for meat (subsistence). Fishing grounds including set nets and gillnets were observed from 1991 through 1992, and the fish market was visited once or twice per month from 1991 through 1995 to corroborate bycatch data (Cheng and Chen, 1997).

Of the sea turtles caught, 82% were caught in setnets, and of these, all were alive. As shown in Table 3.17, green turtles accounted for 70% of the sea turtles taken, and captured turtles represented all age classes (large juvenile, subadult and adults). Most captured loggerheads were either subadults or adult females (only one male was unidentified), and most of the captured olive ridleys were subadults. The one captured leatherback was released alive. Not surprisingly, bycatch rate also increased with fishing effort, and most of the turtles taken were sold to temples for "religious release"[19] later. Of all captured turtles, 88% were sold to temples for Chinese religious ceremonies, 8% were stuffed or butchered, and 3% were released at the site (Cheng and Chen, 1997).

Table 3.17. Sea turtles incidentally caught in fishing gear off Taiwan from 1991-1995.

Year/Species	1991	1992	1993	1994	1995	Total
green	6	17	28	23	42	116
leatherback	1	0	0	0	0	1
loggerhead	1	4	5	15	1	26
olive ridley	9	0	1	0	4	14

[19]"Religious release" refers to the practice by which fishermen would sell live turtles to a temple. The temple master would then sell the turtles to believers for release back into the ocean several months later. Many turtles were kept in an unhealthy environment during captivity and died following release. This practice is not done anymore because any landing of live turtles is forbidden and violators will be reported to the police (I.J. Cheng, Institute of Marine Biology, Keelung, Taiwan, personal communication, November, 2003).

Source: Cheng and Chen, 1997

Philippines

Near the Turtle Islands, a variety of fisheries interact with sea turtles, and Cruz (2002) reports and an increasing number of floating dead turtles have been observed in this area in the since 1999, most likely attributable to an increasing number of fishing vessels operating in the area, including purse seiners, shrimp trawlers, and hulbot-hulbot (demersal drive-in net). These vessels originate primarily from Sabah, Malaysia, and Manila, Philippines. There are also an increasing number of fishing vessels operating in Philippine waters that have originated from China. Aside from fishing illegally, the Chinese vessels are also catching sea turtles. In January, 2002, more than 58 sea turtles, primarily green turtles were discovered on four Chinese vessels in Tabbataha Marine Park, a UNESCO Natural Heritage Park, located in the Sulu Sea (Cruz, 2002).

Malaysia

Sea turtles are caught an a variety of fisheries in Malaysia, ranging from driftnets, lift nets, ray nets (similar to sunken driftnets with a large mesh to target rays and sharks), trawl nets, and purse seines. In 1994-95, a survey was conducted of fisherman to determine the percentage of them that had past experience incidentally capturing sea turtles. The results are presented in Table 3.18.

Table 3.18. Summary of 1994-95 sample survey of fishermen for incidental catch of sea turtles in Terengganu, Malaysia.

Gear Type	No. Fishermen Inteviewed	No. Of Fishermen with past experience incidentally capturing sea turtles (%)
Hook and Line	77	0
Fish Traps	35	4 (11%)
Purse Seine	27	6 (22%)
Drift/Trammel Nets	23	3 (13%)
Longlines	20	0
Trawls	20	11 (55%)
Ray Nets	9	6 (67%)
Lift Nets	7	2 (27%)
Beach Seine	4	4 (100%)

Source: Liew (2002).

India

As summarized in the prior section on status of the olive ridley, thousands of these turtles nest in Orissa, India each year. With an increase in fishing intensity off Orissa's coast, there has been an increase in the mortality of olive ridleys, primarily due to illegal gillnet and trawl fishing in the offshore waters. While turtle excluder devices are mandatory in Orissa, the trawler community opposes their use and thus many trawlers do not use them. In addition, the Orissa Marine Fisheries

Act (1982) and Rules (1983) prohibit all mechanized fishing within 5 kilometers of the coast and within 20 kilometers of the Gahirmatha coast (~35 km).

During the 1980s, a few hundred ridleys per year were reported killed incidentally in Orissa. By the 1990s, mortality increased from 5,000 per year in 1994 to 13,000 per year in 1999, a total of approximately 46,000 dead turtles along the coast of Orissa in six years (*in* Shanker *et al.*, 2003b). The number of dead turtles counted during a survey correlated strongly with the number of mechanized fishing vessels operating in their respective coastal waters (Pandav, 2001). Since the late 1980s, there has been an increase in fishing intensity, from less than 1,000 mechanized boats to greater than 4,000 boats by 1996. Since 1994, an estimated 90,000 olive ridleys have been documented stranding, and current annual estimates of mortality are approximately 15,000 per year (Shanker *et al.*, 2003b).

Distant Water Fishing Nations Longline Fishing in the EEZ around the Federated States of Micronesia

Heberer (1997) summarized the results of 51 distant-water fishing nation (DWFN) longline trips observed by Micronesian Maritime Authority fisheries observers from 1993 through 1995. Vessels from China, Taiwan, and Japan captured a total of 34 sea turtles. These turtles were reported as 15 olive ridleys, 8 green turtles, and 11 unidentified sea turtles. Thirty of the 34 turtles were released alive and the remainder were dead when landed (11.8% mortality rate). Data on hooking location or entanglement was not reported, nor was the condition of each turtle by species.

The Micronesia Fisheries Authority (previously Micronesian Maritime Authority) places observers aboard distant water fishing vessels fishing by longline in their EEZ. Table 3.19 shows the observed catch of sea turtles by these vessels from January 1, 1990 through December, 2000. While the overall data set represents a significant amount of effort - 971 sets and 1,272,000 hooks observed over a 10 year period, the rate of observer coverage is extremely low. From 1990 through 1997, observer coverage ranged from 1 to 3%.

Table 3.19. Observed captures of sea turtles aboard distant water longline vessels, January 1990 through December 2000. Source: Micronesian Fisheries Authority

Species	Number	Condition	
		% Alive	% Dead
Green	4	100	0
Hawksbill	1	100	0
Loggerhead	1	100	0
Olive ridley	8	100	0
Unidentified turtle	33	79	21
Total	47		

The information presented above is from two separate data sets, which may not have been coordinated. The study conducted by Heberer (1997) utilized observers specifically trained and directed to record bycatch information, whereas observers in this fishery typically prioritize the collection of target catch data over bycatch information. This information represents the best available information on bycatch in this fishery.

Foreign tuna fisheries in the western and central Pacific Ocean

As described above, the western and central Pacific Ocean (area west of 150°W longitude, and between 10°N and 45°S) contains the largest industrial tuna fishery in the world. Much of the effort takes place in the EEZs of Pacific-Island counties, in the western tropical Pacific area (10°N - 10°S). Annual tuna catches in this area have averaged around 1.5 million metric tons, with around 60% of the catch taken by purse seine vessels, and the rest taken by longline vessels and other fisheries (e.g. pole-and-line, troll, ring-net). About five thousand longliners operate throughout the western and central Pacific (45°N to 45°S), using up to 3,000 baited hooks per line to catch tuna. As shown in Table 2 in Appendix A, there are nearly 400 active purse seine vessels originating from a variety of countries and operating nearly exclusively in tropical waters.

Observers have been placed on both purse seiners and longliners in this area, and operate and report to the Oceanic Fisheries Programme of the Secretariat of the Pacific Community (SPC). While observers have covered most of the fleets, three fleets have not been observed: the Japanese and Korean distant-water longline fleets operating in the eastern areas and a recently established Australian swordfish fishery operating off eastern Australia.

Given the low observer coverage (<1%) for the longline fishery, patterns of sea turtle observed interactions show that sea turtles are more likely to encounter gear in tropical waters and that they are much more likely to encounter gear that is shallow-set (by an order of magnitude) verses deep-set (for longline fishery). When encountered on deep-set gear, sea turtles were likely to be taken on the shallowest hooks. From available observer data, the longline fishery operating in the western and central Pacific is estimated to take 2,182 sea turtles per year, with 500-600 expected to die as a result of the encounter. From observer data, 1,490 are estimated taken by offshore/fresh tuna vessels using shallow-night sets, 129 are estimated taken by offshore/fresh tuna vessels on deep-day sets, and 564 are estimated taken by distant water freezer vessels on deep-day sets. The composition of species observed taken include (ranked by highest occurrence first): olive ridley, green, leatherback, loggerhead and hawksbill. Given the low observer coverage, this estimate has very wide confidence intervals.

For the purse seine fishery operating in this area, an estimated 105 sea turtles are taken per year, with approximately 17% mortality rate (less than 20 sea turtles dead per year). The composition of species included green turtles, hawksbills and most often olive ridleys. Animal-associated, drifting log and anchored-FAD sets had the highest incidence of sea turtle encounter (1.115, 0.807, and 0.615 encounters per 100 sets, respectively). In contrast, drifting FAD sets were observed to have only 0.07 encounters per 100 sets. With less than 5% observer coverage, confidence intervals for these estimates are also very wide (Oceanic Fisheries Programme, SPC (draft report), 2001).

Chile

Although data on the incidental take of sea turtles in the Chilean swordfish fisheries are sparse, both green and leatherback turtles have been confirmed taken and killed, and olive ridleys and loggerheads may also be taken incidentally by the fishery (Weidner and Serrano, 1997). As described further in Appendix A, the Chilean swordfish fishery is comprised primarily of artisanal fishermen, averaging 500 boats (mainly driftnetters) from 1989 to 1991, and decreasing in numbers after 1991. Since 1991, approximately 20 large industrial (i.e. commercial) boats have fished swordfish in Chile, the effort is comprised of gillnets (27%), pelagic longliners (72%) and boats that switch gear. Effort by the artisanal fishery (including the driftnet fleet) increased from 5,265 days-at-sea in 1987 to 41,315 days-at-sea in 1994 (Barbieri, *et al.*, 1998).

Adult female leatherback turtles tagged in Mexico have been taken in Chilean waters by gillnet *and* purse seine fisheries (Marquez and Villanueva, 1993). In addition, data were recorded opportunistically from the artisanal swordfish fishery (driftnetters primarily) for a single port (San Antonio) over a two year period. This partial record documented leatherback captures and sightings totaling 9 in 1988 and 21 in 1989. A rough estimate of 250 leatherback takes per year without differentiating between kills and total takes for vessels operating out of San Antonio was provided (Frazier and Brito Montero, 1990). A more recent estimated annual take of 500 leatherback turtles was provided by Montero (personal communication, 1997, *in* Eckert, 1997) which was not unreasonable, given the nearly ten-fold increase in fishing effort from 1987 to 1994[20]. As shown in Table 3.20, the take of sea turtles by the artisanal driftnet fishery in the late 1980s appeared to be comprised primarily of leatherback turtles.

Table 3.20. Chile – turtle bycatch of artisanal driftnet fishermen, 1988-89.

Species	Number	Percentage of Total
Green turtle	42	28%
Leatherback	82	55%
Loggerhead	5	3%
Olive ridley	21	14%
Total	150	100%

Source: José Brito-Montero, personal communication, 3/3/97, *in* Weidner and Serrano, 1997

[20]Based on all information from Chile and Peru, Eckert (1997) estimated that a minimum of 2,000 leatherback turtles are killed annually by Peruvian and Chilean swordfish operations, representing a major source of mortality for leatherback turtles originating from and returning to nesting beaches in Costa Rica and Mexico. Because swordfish fishing effort has declined significantly since the early 1990s, incidental take has most likely declined as well, although the current estimate is unknown.

Effort by the artisanal driftnet fishery for swordfish appears to be relatively constant through 1996, as shown in Table 3.21. Given the total sea turtle take estimate from the 1988-89 season, and combining it with the total effort (days-at-sea) data from 1988-1996, and assuming effort was constant and in the same general area during all years, a simple calculation can be made to estimate the incidental take of turtles by the Chilean artisanal driftnet fishery for swordfish during subsequent years (third column in Table 3.21). Turtles reportedly began appearing in Chilean markets in 1987, just as the swordfish driftnet fishery was expanding, and Chilean observers have reported occasional individual sets with leatherback mortalities from 3-13 (*in* Weidner and Serrano, 1997). Assuming the current artisanal driftnet fishing effort is equivalent to 1996 and assuming the proportion of species taken is equivalent to data collected from the 1988-89 fishing season, this fishery would currently take an estimated 39 greens, 76 leatherback turtles, 4 loggerheads, and 29 olive ridleys annually. However, Donoso (personal communication, September 2002) reports that the artisanal fleet has declined to maybe a third of its size in recent years.

Table 3.21. Chile - artisanal (driftnet) swordfish effort, by year, from 1989-1996 and calculated (not actual or known) turtle take [note assumptions used in this Opinion].

Year	Effort (Days-at-sea)	Calculated Turtle Take*
1989	7,579	150*
1990	6,226	123
1991	11,450	227
1992	11,209	222
1993	10,755	213
1994	8,393	166
1995	8,152	161
1996	7,041	139

*Calculated turtle take was estimated by comparing effort for 1989 (7,579 days-at-sea) and a known turtle take of 150 (1988-89 season) with subsequent years for which effort was known, but turtle take is not known.

**Estimated take of turtles by Brito-Montero, for the 1988-89 season, and assuming 1989 data is equivalent in effort to 1988-89 effort, for the purpose of comparing year-to-year calculations of estimated turtle take. Source: Weidner and Serrano, 1997.

During 1996, there was a substantial expansion of Chilean longline fishing in offshore areas, but as there has been no collection of data on this fishery as of 1997 (Weidner and Serrano, 1997), the anticipated effects on sea turtle stocks as a result in this change in fishing strategy are not known. Since effort for swordfish in the Chilean fishery or throughout the Pacific has declined significantly overall since 1994 (as a result of concerns about overfishing swordfish stocks), and populations of turtles have declined, the bycatch of sea turtles in this fishery has likely declined as well, although the extent of this decrease is currently unknown. There is very little information on lethal and non-lethal incidental catch per unit effort although new studies are underway to quantify bycatch. In addition to the swordfish fishery, Chile also has a substantial purse seine fleet, which has recently shifted from a reliance on coastal anchovy and sardines to a substantial take of jack mackerel further offshore, where turtle interactions may be more common (Weidner and Serrano, 1997). The extent of the impact of the Chilean purse seine fishery on sea turtles is unknown.

Peru
Since 1995, Peruvian law has prohibited the capture, trade, and consumption of sea turtles. Despite the law, sea turtles continue to be caught alive in artisanal fisheries as bycatch and are nearly always killed for "bushmeat."

Appendix A contains a description of known domestic and foreign fisheries in Peru. Peruvian commercial longline fleets have had limited success in fishing for swordfish, so there is probably very little incidental catch of sea turtles in this fishery. Peruvian artisanal fishermen, however, also target fish species normally taken in commercial longline fisheries (especially shark) and have been more successful than the commercial longline fleet, so more turtles may be caught incidental to these artisanal fisheries (Weidner and Serrano, 1997).

From 1997-1999, the government agency IMARPE estimated that 8.02 tons of turtles were captured (Alfaro-Shigueto, in press). Kelez *et al.* (2003) report that sea turtles are commonly caught incidentally by artisanal fisherman, entangled by gillnets and hook-and-line. In general, fishermen from the smaller villages may release a turtle that is alive; however, if it is dying or dead, they will kill it. In the larger towns, fishermen will nearly always kill an incidentally caught turtle because of the demand for its meat. The carapaces of sea turtles are also sold in the department of Tumbes and in the northern part of the department of Piura, due to the tourist industry (Kelez *et al.*, 2003). From January, 2001 through February, 2003, observers sampled eight ports in Peru to document sea turtle bycatch. During this time, observed turtle bycatch was 1,630 individuals, with total estimated bycatch to be 2,025 turtles (after extrapolation for days not observed). Ports sampled included Mancora (272 turtles), Constante (231 turtles), Parachique (337 turtles), San Jose (153 turtles), Salaverry (167 turtles), Chimbote (168 turtles), Pisco (77 turtles), and Morro Sama (620 turtles). Table 3.22 shows a breakdown of turtle bycatch by species.

Foreign longline fleets are also active and extensive off Peru and the bycatch of sea turtles in these foreign fisheries has been considered significant (Weidner and Serrano, 1997).

Ecuador
Currently, the artisanal fleet is composed of roughly an estimated 5,000 vessels, while the industrial longline fleet is composed of approximately 181 vessels (E. Everett, IATTC, personal communication, November, 2003).

Table 3.22. Estimated number of sea turtles captured in artisanal fisheries in Peru from January, 2001 - February, 2003.

Species	Estimated # captured
Green turtle	1,509
Loggerhead	354
Leatherback	103
Olive Ridley	51
Hawksbill	8
Total	2,025

Source: Alfaro-Shigueto, In press.

Unfortunately, the composition of turtle species incidentally taken by Ecuadoran commercial and artisanal fisheries is unavailable. Prior to a ban on the commercial harvest for olive ridleys in 1986, artisanal fishermen prosecuted a directed turtle fishery as well as taking them incidentally. During 1985 and 1986, 124 and 715 metric tons of turtles, respectively, were reportedly taken (Table 3.21). In 1990, the Ecuadoran government permanently ended the directed fishery, prohibiting the catch as well as domestic and export marketing. Incidental catches of sea turtles by tuna and swordfish longliners are reportedly very rare, but they do occur, and Ecuadoran authorities have seized turtle skins from Japanese longliners (*in* Weidner and Serrano, 1997).

Colombia

A description of known Colombian commercial fisheries is provided in Appendix A and summarized in Table 5 of the Appendix. No information is available on the sea turtle bycatch levels in the shrimp trawl fisheries and other fisheries operating out of Colombia. However, a turtle excluder device program has been initiated in the shrimp trawl fishery to reduce incidental catch. Artisanal fisheries in the past targeted turtles (Weidner and Serrano, 1997); however, no recent information on directed take is available.

Central American shrimp fishery

Shrimp fishery operations were initiated throughout Central America during the mid 1950s. On the Pacific, vessels pull one standard 50 to 75 foot headrope length two seam balloon trawl or one standard flat net from each outrigger. Target species include white and small shrimp in shallow waters (9-20 meters deep), pink and brown shrimp in water depths ranging from 55 to 85 meters, and deep shrimp "fidel" or "camello" in deeper waters (150-225 meters depth). A description of the shrimp fisheries on the Pacific coast of Central America is contained in Appendix A.

Arauz (1995) estimated that over 60,000 sea turtles were taken by shrimp trawlers on the Pacific coast of Central America. Mortality rates were not estimated. Olive ridleys were the species most commonly taken, and foraging grounds for these turtles overlap with shrimp trawling grounds. Table 3.23 shows the estimated turtle catch by shrimp trawlers in Central America, by country, for 1993.

Table 3.23. Estimated turtle catch by shrimp trawlers for the Pacific coast of central America, 1993

Country	# Vessels	Total CPUE turtles/hr	Turtles/year
Guatemala	58	?	(10,000)
El Salvador	70	0.0511	21,280
Nicaragua	21	?	(8,000)
Costa Rica	55	0.0899	20,762
Total	**204**		**60,042**

Note: figures in parenthesis are estimated. Source: Arauz, 1995.

Observers have also been deployed on shrimp trawling operations off the Pacific coast of Costa Rica. During 2,556.5 hours of observation, 281 sea turtles were incidentally captured. Of those captured, 90% were olive ridleys (253 observed taken), 9.6% were Pacific greens (27 observed taken) and 0.4% were hawksbills (1 observed taken). The observed mortality rate for this species captured by this fishery was around 40%. Researchers estimate that approximately 15,000 sea turtles are captured by Costa Rican shrimpers per year without TEDs. (Arauz, *et al.*, 1998; López and Arauz, 2003).

Arauz (personal communication, December, 2003) reports that few countries in Central America use turtle excluder devices, despite Section 609 of Public Law 101-162. Section 609 states that the "importation of shrimp or products from shrimp which have been harvested with commercial fishing technology which may affect adversely such species of sea turtles shall be prohibited" unless the President certifies to the U.S. Congress by May 1 of each year, that any nation which intends to export shrimp to the U.S. conforms with certain conditions. With few exceptions, "certification" requires that shrimpers from other nations use Trawling Efficiency Devices (also known as "Turtle Excluder Devices," or "TEDs" Arauz, 2000). Costa Rica and Honduras are currently embargoed (R. Arauz, personal communication, December, 2003).

Costa Rica

Sea turtles are impacted by Costa Rican fisheries and by interaction with human activities. Several studies have been undertaken in recent years in order to document the incidental capture of sea turtles in Costa Rican longline fisheries. The longline fleet consists of a "medium" artisanal fishery, which targets mahi mahi and tunas within the country's EEZ, and an "advanced" fleet, which targets billfish and tunas within and outside the EEZ. In 1999, the fleet was comprised of 678 registered vessels, with lengths varying between 6 and 29.9 meters. Two studies in 1997 and 1998 on two longline fishing cruises (one experimental) documented a high incidental take of sea turtles. On one cruise, a total of 34 turtles (55% olive ridleys and 45% east Pacific green turtles) were taken on two sets containing 1,750 hooks (1.42 turtles per 100 hooks). One additional set caught two leatherbacks. The second cruise documented the incidental take of 26 olive ridleys, with 1,804 hooks deployed (Arauz *et al.*, 2000).

An observer program was put in place from August, 1999 through February, 2000. Seventy seven longline sets were observed on 9 cruises. Of the nearly 40,000 hooks deployed, turtles represented

7.6% of the total catch, with a catch per unit effort of 6.364 turtles/1,000 hooks. The results are shown in Table 3.24. Immediate sea turtle mortality was 0%, and most of the hooks were removed prior to release (Arauz, 2001).

Table 3.24. Costa Rican longline fleet - observed number and condition of sea turtles taken on nine cruises, August, 1999 - February, 2000

Species and Condition	Number of Individuals
Olive ridley	
Hooked in mouth	216
Hooked in flipper	26
Hooked in neck	1
Entangled	4
Total	**247**
Green turtle	
Hooked in mouth	8
Hooked in flipper	4
Total	**12**

Source: Arauz, 2001.

From September to December of 2000, the Sea Turtle Restoration Project documented more than 400 dead turtles washed up along the north and central Pacific coast of Costa Rica. Of 423 dead turtles observed, 84 turtles showed "clear interaction with human activities, such as cracked skulls or carapaces due to collisions with boats, hooks imbedded in the mouth and throat, incisions in the groin to collect eggs, and digital fractures due to entanglement in gillnets. As of 2001, more than 130 dead turtles have been observed." The Costa Rican Fishery Institute (INCOPESCA) has "declared itself incompetent to enforce sea turtle protection laws, and proposes that [the authorities of the Environment] MINAE should be responsible and apply the Wildlife Conservation Law (PESJ-1451-2000). However, while MINAE eludes responsibility, hundreds of dead sea turtles continue to wash up along the coast..." (Sea Turtle Restoration Project press release, 8/6/01[21]).

During a survey of three Costa Rican beaches (Nancite, Ostional and Grande or Baulas) from August 2000 and January 2001, stranded sea turtles were collected and assessed. Ninety three dead turtles were assessed, and of these, 78.5% were attributed to anthropogenic causes, including: "capture and forced immersion by shrimp nets, entanglement in nylon lines, cranial traumas, boat strikes that may cause injuries, and slaughter to harvest eggs and meat for

[21]http://www.seaturtles.org/press_release2.cfm?pressID=107

consumption by humans." Hooks were also found in the mouths and esophagus of sea turtles, primarily in olive ridleys (Vasquez and Morales, 2003).

Nicaragua
Incidental capture of sea turtles in Nicaraguan fisheries occurs; however, there has been little documentation. The primary concern is with the artisanal fleet, which is comprised of nearly 5,000 vessels. Every year, hundreds of dead olive ridleys are reported throughout the Pacific coast of Nicaragua. During 2001, over 100 olive ridleys and one juvenile leatherback were documented stranded in the Chacocente Wildlife Refuge. Of stranded turtles that were examined during a monitoring project in 2001-2002, 100% (12/12, all females) had been cut in the groin area (common practice by fishermen in search of eggs). Artisanal gillnetters and industrial shrimp trawlers routinely operate within the limits of the "no fishing zone" established around the nesting beaches (Arauz, 2002).

Mexican (Baja California) fisheries and direct harvest
Sea turtles have been protected in Mexico since 1990, when a federal law decreed the prohibition of the "extraction, capture and pursuit of all species of sea turtle in federal waters or from beaches within national territory ... [and a requirement that] ... any species of sea turtle incidentally captured during the operations of any commercial fishery shall be returned to the sea, independently of its physical state, dead or alive" (*in* Garcia-Martinez and Nichols, 2000). Despite the ban, studies have shown that sea turtles continue to be caught, both indirectly in fisheries and by a directed harvest of eggs, immatures, and adults. Turtles are principally hunted using nets, longlines and harpoons. While some killed immediately, others are kept alive in pens and transported in trucks, pick-ups, or cars. The market for sea turtles consists of two types: the local market (consumed locally) and the export market (sold to restaurants in cities such as Tijuana, Ensenada, Mexicali, and U.S. cities such as San Diego and Tuscon). Consumption is highest during holidays such as Easter and Christmas (Wildcoast, *et al.* 2003).

As discussed earlier, green turtle populations in the Mexican Pacific continue to decline. Based on a combination of analyses of stranding data, beach and sea surveys, tag-recapture studies and extensive interviews, all carried out between June, 1994 and January, 1999, Nichols (2002) conservatively estimated the annual take of sea turtles by various fisheries and through direct harvest in the Baja California, Mexico region.

Although there are no solid estimates of fisheries-related sea turtle mortality rates for the region, sea turtles are known to interact with (and be killed by) several fisheries in the area. As in other parts of the world, shrimp trawling off Baja California is a source of sea turtle mortality, although since 1996, shrimp fishermen are required to use turtle excluder devices. Prior to this requirement, Figueroa *et al.* (1992 *in* Nichols, 2002) reported that nearly 40% of known mortality of post-nesting green turtles tagged in Michoacán was due to shrimp trawlers. Based on stranding patterns, Nichols, *et al.* (2000) speculate that mortality of loggerheads due to local fishing in Baja California may primarily be due to a net-based fishery. None of the stranded turtles showed signs of hooking; therefore the halibut (*Paralichthys californicus*) gillnet fishery, which reports regular loggerhead bycatch and coincides with the movement of pelagic red crab into the shallower continental shelf, may interact with loggerheads as they enter coastal waters in the spring and summer. Fishermen also report the incidental capture of sea turtles, primarily loggerheads, by pelagic longlines and hook sets used to catch sharks and pelagic fish. Lastly, sea turtles have occasionally been found by fishermen entangled in buoy and trap lines, although this is apparently a rare occurrence (Nichols, 2002). Although fishermen may release sea turtles alive after being entangled in or hooked by their gear, based on information on the directed harvest and estimated human consumption of sea turtles in this region, incidentally caught sea turtles are likely retained for later consumption.

Sea turtle mortality data collected between 1994 and 1999 indicate that 90% of sea turtles recorded dead were either green turtles or loggerheads (Table 3.25), and signs of human consumption were evident in over half of the specimens. Most of the loggerheads were immature, while size ranges for both green and olive ridleys indicated representation from both immature and mature life stages (Nichols, 2002).

Table 3.25.. Recorded sea turtle mortality by species during 1994-1999 on the Gulf of California coast and the Pacific coast of Baja California, Mexico.

Species	Gulf of California	Pacific	Totals
green turtle	30	276	**306**
leatherback	1	0	**1**
loggerhead	3	617	**620**
olive ridley	1	35	**36**
unidentified	0	57	**57**
Total	**35**	**985**	**1,020**

Source: Nichols (2002).

A more focused study was conducted from June to December, 1999 in Bahia Magdalena, a coastal lagoon to determine the extent of sea turtle mortality. Researchers searched for sea turtle carapaces in local towns and dumps as well as coastal beaches. The majority (78%) of the carapaces were found in towns and dumps and green and loggerhead turtles most frequently observed. Both species found were generally smaller than the average size of nesting adults. Researchers estimated that the minimum sea turtle mortality rate for the Bahía Magdalena region was 47 turtles per month, or 564 turtles per year. Based on observations, approximately 52% were green turtles, 35% were loggerheads, 2% olive ridleys, and 1% hawksbills (10% unidentified) (Gardner and Nichols, 2002). A study conducted from 1995 to 2002 in Bahía de los Angeles, a large bay that was once the site of the greatest sea turtle harvest in the Gulf of California, revealed that the populations of green turtles in the area had decreased significantly since the early 1960s. Despite the 1990 ban, sea turtle carcasses were found at dumpsites, so human activities continue to impact green turtles in this important foraging site (Seminoff, *et al.*, 2003).

Based on surveys conducted in coastal communities of Baja California, extrapolated to include the entire coastal peninsula, Nichols (2002) estimated the annual mortality of *green* turtles in this region to be *greater* than 7,800 turtles, impacting both immature and adult turtles. Results from a region-wide socioeconomic study conducted with The Universidad Autonoma de Baja California Sur preliminarily suggest that the actual annual harvest of green turtles may be three to four times higher than this estimate (i.e. approximately 23,000 - 31,000 green turtles taken per year). Mortality of loggerhead turtles, based on stranding and harvest rates, is estimated at 1,950 annually, and affects primarily immature size classes. The primary causes for mortality are the incidental take in a variety of fishing gears and direct harvest for consumption and [illegal] trade. With the local declines of green turtles, a market for loggerhead meat has developed in several Pacific communities. Olive ridleys are not found as commonly in Baja California waters as loggerheads and greens; however, they are consumed locally, occasionally strand on beaches, and have been found entangled in plastic debris. No annual mortality estimates of olive ridleys in the area were presented. Lastly, anecdotal reports of leatherbacks caught in fishing gear or consumed exist for the region; however, these instances are rare, and no annual mortality estimates of leatherbacks were presented (Nichols, 2002). A recent estimate by Wildcoast *et al.* (2003) reiterates that there is likely high mortality of turtles in the Californias[22], estimating 15,600 to 31,200 sea turtles consumed annually (no differentiation between species).

Foreign tuna purse seine fishery in the eastern tropical Pacific
The international fleet represents the majority of the fishing effort and carrying capacity in the ETP tuna fishery, with much of the total capacity consisting of purse seiners greater than 400 st. These large vessels comprised nearly 70 percent of the total fishing capacity operating in the ETP in 1996 (IATTC, 2002). An average of 122 foreign vessels with a carrying capacity greater than 400 st fished each year in the ETP during 1996 to 2001. In addition to these larger vessels, the foreign fleet contains smaller vessels less than 400 st that target tuna in the ETP. From 1996 to 2001, an average of 59 foreign vessels ranging from 45 to 400 st carrying capacity fished in the ETP each year (IATTC, 1999, 2001, 2002a-b).

Since 1999, seminars have been given by the IATTC to skippers and their crews to educate them on, among other items, status of sea turtles, and handling and recovery of turtles taken by purse seine. In addition, during their 70th meeting held in Antigua, Guatemala on June 24-27, 2003, the IATTC passed Resolution C-03-08. Under the resolution, purse seine fishermen are required to promptly release unharmed, to the extent practicable, all sea turtles. Crews are required to be trained in techniques for handling turtles to improve survival after release. Vessels are to encourage the release of sea turtles entangled in FADs and recover FADs when they are not being used in the fishery. Specific to the purse seine fishery operation, whenever a sea turtle is sighted in the net, all reasonable efforts should be made to rescue the turtle before it becomes entangled, including, if necessary, the deployment of a speedboat. If a sea turtle is entangled in the net, net roll should stop as the turtle comes out of the water and should not start again until the turtle has

[22]"California" as defined here is the region encompassing the Gulf of California (including the coast of Sonora and Sinaloa, Mexico); Baja California and Baja California Sur, Mexico, and California, USA.

been disentangled and released. If a turtle is brought aboard the vessel, all appropriate efforts to assist in the recovery of the turtle should be made before returning it to see (IATTC Resolution C-03-08, Action #3).

Data from observers on both U.S. and foreign tuna purse seine vessels have been gathered collectively by the IATTC since the early 1990s. The most recent data from the IATTC indicate that an average of 136 sea turtles per year were killed by vessels over 400 st in the foreign ETP purse seine fishery (non-U.S.) from 1993-2002 ((Table 3.26) M. Hall, IATTC, personal communication, December, 2003). The numbers of sea turtles killed by the fishery dropped significantly in 2002, likely as a result of increased awareness by fishermen through educational seminars given by the IATTC. Given the passing of the latest IATTC Resolution on Bycatch, the mortalities should continue to decrease.

Table 3.26. **Estimated sea turtle mortality by species for the foreign ETP tuna purse seine fishery (non-U.S.) from 1993-2002[1]**

Species/Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Green/black	15	16	13	13	20	9	11	6.1	7.6	2
Hawksbill	0	1.8	0	1	0	3	2	1	1.3	0
Leatherback	0	1	0	0	0	0	0	0	0	0
Loggerhead	3.6	1.8	2	0	4.6	1	4	1.8	1.3	0
Olive ridley	75.8	80	91.3	72.8	93.8	106.6	108.8	91.6	68.9	30.1
Unidentified	21	45.2	43	48.6	51	41	46	29.2	55.4	13.8
TOTAL	115.4	145.8	149.3	135.4	169.4	160.6	171.7	129.8	134.6	45.9

[1] (M. Hall, IATTC, personal communication, December, 2003)

The 1993-2002 data indicate that turtles killed by the entire tuna purse seine fishery were "unidentified," although the reasons for this were not given. Assuming that these unidentified turtle mortalities occurred in the same proportions as the identified turtle mortalities, 85% would be olive ridleys, 12% would be green turtles, 2% would be loggerheads, 1% would be a hawksbill, and 0% would be leatherbacks.

United States (Fisheries Other Than the Pelagic Fisheries of the Western Pacific Region)

U.S. tuna purse seine fishery in the central and western Pacific Ocean

The vast majority of the U.S. western and central Pacific purse seine activity occurs in the highly productive fishing grounds of the equatorial western Pacific (principally in the EEZs surrounding Papua New Guinea, the Federated States of Micronesia and Kiribati) under a multilateral agreement entitled *Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America* or the South Pacific Tuna Treaty. The treaty was signed by the United States and 16 Pacific Island Parties belonging to the Forum Fisheries Agency, and provides U.S. tuna purse seiners access to tunas in a 25.9 million km^2 area of the central-western Pacific Ocean in exchange for fishing fees and adherence to rules related to closed area, etc (Coan, *et al.*, 1997). The treaty was renegotiated in 1992 for an additional 10 years.

Between 1988 and 1999, the number of licensed U.S. tuna purse seiners ranged from 35 to 51, although only between 31 and 49 vessels fished during those years. Between 71 and 241 trips were made during each calendar year (Coan, *et al.*, 2000), and most of the fishing was conducted in the equatorial belt, extending from around 155°W to 140°E longitude, the traditional fishing zone for the U.S. fleet (Coan, *et al.*, 1997). The U.S. fleet primarily lands their catch in American Samoa (Coan, *et al*, 1997, 2000). From 1988 to 1995, the fleet primarily set on free-swimming school sets and less on log sets; however, beginning in 1996, sets were increasingly made on floating aggregation devices (FADs), and in 1999, nearly 100 % of sets were on FADs (Coan, *et al.*, 2000). Because turtles tend to congregate around floating objects in the open ocean, this change in fishing strategy may increase the likelihood of sea turtle interactions.

The U.S. fleet is required to take Fisheries Forum Agency observers on a minimum of 20 percent of their fishing trips, and captains are responsible for recording catch and bycatch data in logbooks. Logbooks are verified by observers, if possible, and are sent to the Fisheries Forum Agency no later than 14 days after returning to port (K. Staisch, FFA, personal communication, February, 2001). Between 1997 and 1999, there was approximately 20-23% observer coverage (Forum Fisheries Agency, 1998; A. Coan, personal communication, February, 2001). Collecting data on target species (i.e. tuna) is a priority for observers; however, if possible, and when time permits, observers do collect bycatch data. Observers receive limited training on sea turtle identification and are trained to look for tags, but they do not collect information on length or take biopsies, as the turtles are generally released immediately from the net. The incidental catch of sea turtles is a "rare occurrence," and any turtles observed taken have been released alive. Purse seine techniques normally allow turtles to surface for air during the pursing period, and based on observer reports, any turtles caught in nets are usually released as soon as possible. In addition, there have been no reports of turtles caught in the power block (K. Staisch, FFA, personal communication, February, 2001).

American Samoa-based longline fishery

For the American Samoa-based longline fishery, the federal logbooks from 1992 through 1999 indicate six interactions with sea turtles (i.e. hooking/entanglement). In 1992, one vessel interacted with a green turtle. In 1998, one vessel interacted with an unidentified sea turtle; it was released alive. In 1999, one vessel reported interactions with four sea turtles. Three turtles released alive were recorded as a hawksbill, a leatherback, and an olive ridley. One turtle, identified as a green, was reported to have died from its interaction with this vessel. None of the species' identification were validated by NOAA-Fisheries' Southwest Fisheries Science Center; and NOAA-Fisheries cannot attest to the local knowledge of fishermen regarding the identity of various turtle species, particularly hard-shelled turtles. However, all four species of sea turtles reportedly caught by the fishery do occur in the fishing grounds of this longline fishery. In addition, as discussed below, logbook data may not be a reliable method to measure sea turtle interaction in the fisheries. From 2000 through October 2002, there have been no reported interactions with sea turtles in this fishery (S. Pooley, NMFS, personal communication, October 2002).

Hawaii-based longline fishery (Since 2000)

The Hawaii-based longline fishery now operates under management measures, described in the *preferred alternative* of the final Environmental Impact Statement (FEIS) completed on March 30, 2001, which were implemented to mitigate adverse impacts on sea turtles (67 FR 40232, June 12, 2002)[23]. These measures were promulgated as a regulatory amendment to the Pelagics FMP, under the authority of the Magnuson-Stevens Act. The final rule, approved by the Secretary of Commerce, was implemented by NOAA Fisheries on June 12, 2002 (67 FR 40232). They prohibit swordfish-targeted longline fishing, impose a seasonal closure in waters south of Hawaii (from the equator to 15°N and 145°W to 180°) during April and May, ban the possession of light sticks, and limit the possession of 10 swordfish per trip by any Hawaii-based longline vessel. The definition of swordfish-target or shallow-set longline gear is described in the March 2001 FEIS.

The Hawaii-based longline fishery is a limited access fishery, with a total of 164 permits that are transferable. Vessels active in this fishery are limited to 101 feet in length. The area fished ranges as close as 25 miles from Hawaii to thousands of miles from port. These Hawaii-based longline vessels compete with foreign distant water fishing fleets operating on the high seas. In 2001, 101 Hawaii–based longline vessels made 1,034 trips, almost all of which targeted tunas. Swordfish was a major target species of this fishery prior to 2001, but due to conservation measures to protect sea turtles this segment of the Hawaii-based longline fishery was phased out completely by the end of 2001.

[23]Sea turtle mitigation measures for the Hawaii-based longline fishery were initially promulgated as an emergency interim rule on June 12, 2001 (66 FR 31561).

Vessels based out of Hawaii targeting tuna deploy about 34 horizontal miles of main line in the water. Vessels targeting tuna typically use a line shooter. The line shooter increases the speed at which the main line is set which causes the main line to sag in the middle (more line between floats), allowing the middle hooks to fish deeper. The average speed of the shooter is 9 knots. The vessel speed is about 6.8 knots. No light sticks are used as the gear soaks. The float line length is about 22 meters (72 feet) and the branch line lengths are about 13 meters (43 feet). The average number of hooks deployed is about 1,690 hooks per set with about 27 hooks set between each float. There are approximately 66 floats used during each set. Deep set vessels use saury (sanma) as bait and the hook type used are "tuna" hooks. The average target depth is 167 meters. The gear is allowed to soak during the day and the total fishing time typically lasts about 19 hours, including setting and hauling of gear. This type of set is referred to below as "deep set."

Table 3.27 contains rough estimates of the annual capture and mortality of sea turtles in the Hawaii-based longline fishery, based on past interactions between July 1, 2001 and June 30, 2002.

Table 3.27. Annual sea turtle capture and mortality estimates in the Hawaii-based longline fishery.

Species	Incidental Take	Incidental Mortalities
Green	8	7
Leatherback	8	3
Loggerhead	14	8
Olive Ridley	26	24

[1] The estimated incidental mortality is a subset of the estimated incidental take by hooking or entanglement.

Direct harvest

Solomon Islands

Between 1993 and 1996, Broderick (1997) investigated the subsistence harvest of green (and hawksbill) turtles by people from three different communities, Kia, Wagina, and Katupika on the Solomon Islands. At Kia, the majority of turtles are consumed for feasts, and the meat of the green turtle is more highly valued than that of the hawksbill. Broderick (1997) estimated that a minimum of 1,068 green turtles were harvested per year, and most were immature turtles.

Indonesia

In the Kai Islands (also spelled "Kei Islands"), located approximately 1,000 kilometers southwest of the Papua nesting beaches, adult leatherback turtles are traditionally hunted and captured at sea by local people. Villagers hunt leatherback turtles only for ritual and subsistence purposes, and, according to their beliefs (known as *adat*), they are forbidden to sell or trade the meat. However, due to population increase and deforestation of the area which has lead to the loss of forest resources such as deer, pigs, and birds, villagers are taking leatherback turtles more for their increased need for meat for subsistence than for traditional purposes (Suarez and Starbird, 1996b). The carapace is rendered for oil, and the meat from the plastron is shared among villagers

(Starbird and Suarez, 1994). Based on a study conducted during October-November, 1994, Suarez and Starbird (1996a) estimated that approximately 87 leatherback turtles were taken annually by villagers in the Kai Islands, and this estimate did not include incidental take by local gill and shark nets. Locals report that sea turtle populations in the area have declined dramatically (Suarez, 1999). Overall, approximately 200 leatherback turtles, both adult males and females, were estimated killed per year in these traditional fisheries southwest of Kai Kecil during October-April (*in* Chan and Liew, 1996) (the Kai Islands take is assumed included in this estimate).

While takes of adult leatherbacks are continuing, approximately 20 leatherback turtles are currently taken per year, as villagers are reportedly too busy in village activities and local economy to be hunting (Hitipeuw, WWF, personal communication, December, 2003). In addition, a specialist from a local non-governmental organization is currently working with the eight villages of the Kai Islands to explore the potential for a community-based harvest monitoring as well as alternative substitutes for the traditional harvest of leatherbacks. The main strategy is to gain community support for sea turtle conservation. Harvest monitoring and research initiatives are scheduled to be implemented during the next hunting period (November, 2003-February, 2004) (Hitipeuw, 2003b).

Mexico
Because studies of sea turtle mortality in Mexico focused on both fisheries bycatch and directed harvest, a summary of estimated mortality due to harvest is contained above in section 1(p) (above).

Peru and Ecuador
The Ministerio de Pesqueria (MIPE), which is the Peruvian agency responsible for fisheries, prohibited the taking of all leatherback turtles and green turtles less than or equal to 80 cm in length through a resolution in January, 1977 (Weidner and Serrano, 1997). In 1995, the Peruvian government prohibited the capture, trade, and consumption of green turtles, leatherbacks, olive ridleys, and hawksbills. However, in many ports of Peru, this decree was and is poorly enforced, and sea turtles were widely caught for human consumption. Noted Peruvian ports included Pisco, Chincha, Pucusana, Callao, and Chimbote (Alfaro-Shigueto, *et al.*, 2002).

Peru conducted directed commercial turtle harvests throughout the 1980s, and, as recently as 1990, over 100 metric tons of turtles were taken (Table 3.28) (FAO, Yearbook of Fishery Statistics, 1994, *in* Weidner and Serrano, 1997). Species-specific information was not available. Based on a sighting of 167 leatherback carapaces in a canyon near the port of Pucusana in 1978, Brown and Brown (1982) estimated a minimum of 200 leatherback turtles killed per year at that time. Furthermore, central Peru was known to have had the largest leatherback fishery in the world, taking what appeared to be adults and subadults, thus representing a considerable number of reproductive and near reproductive individuals (*in* Brown and Brown, 1982).

Researchers from the Peruvian Centre for Coastal Research also opportunistically collected data on sea turtle captures while collecting data on dolphin mortality. They present data on sea turtle mortality in two ports, Cerro Azul and Chimbote in 1993 and 1994, and compile data on leatherback capture along the Peruvian coast from 1984-1999. Sea turtles, particularly olive ridleys and green turtles, are commonly taken with "animaleros," which are large mesh drift gillnets targetting sharks and rays, but take dolphins and sea turtles as bycatch. Researchers provided a minimum estimate of 77 turtles taken in 11 months (1993) and 45 turtles taken in 8 months (1994) in Cerro Azul. In Chimbote, researchers estimated a minimum of 133 turtles taken in approximately 7 months (1993). Species composition of observed turtles taken included both olive ridleys and greens (83.2%) and leatherbacks (16.18%) (Alfaro-Shigueto, *et al.*, 2002).

Table 3.28. Ecuador and Peru - turtle catch in metric tons, 1985-95.

Year	Catch - Ecuador (metric tons)	Catch - Peru (metric tons)
1985	124	36
1986	715	9
1987	–	305
1988	–	32
1989	–	79
1990	–	101
1991	–	9
1992	–	30
1993	–	28
1994	–	6
1995	10*	4*

Source: FAO, Yearbook of Fishery Statistics, 1994, *in* Weidner and Serrano (1997)
*1995 data would not be found in the above source, yet Weidner and Serrano (1997) provide data for this year.

During 1985-1999, researchers observed at least 33 leatherbacks, alive and dead, along Peruvian beaches, in fishmarkets, or in dumps located in Pisco, Cerro Azul, Pucusana, Ancón, Chancay, Huacho, Chimbote and Salaverry. In addition, remains of at least two dozen leatherbacks were found in fish offal dumps in Pucusana in 1984, the same area where a large number of leatherback carapaces were found in 1978 (see above) (Alfaro-Shigueto, *et al.*, 2002).

Vietnam

In Vietnam, there is a high demand for sea turtle products in the market, and as a result, green turtles and hawksbills have been harvested heavily to supply this demand. Direct harvest of sea turtles is common among the coastal communities, where turtles forage and breed. In addition, sea turtle eggs are collected for food. Poverty in the country and a lack of awareness of the conservation of resources are partially to blame for this exploitation; in addition, there are no regulations and little government support for sea turtle research and conservation efforts (Hien, 2002). Unfortunately, no quantitative estimates are available on the level of sea turtle mortality or the number of eggs taken.

Australasia (Bali, Torres Strait)

Bali appears to have the largest trade in live green turtles. Reports from World Wildlife Fund/International Union for the Conservation of Nature (1984 *in* Dermawan, 2002) indicate that green turtles have been collected from all over Indonesia in order to supply Bali with up to 30,000 turtles. Turtles have been used as a standard source of food and in religious festivities in southern Bali (within the Balinese-Hindu culture) for many years, and the demand is increasing (Dermawan, 2002). While traditional religious ceremonies require the use of sea turtle meat, Hindu high priests have estimated that only 300 to 500 turtles annually should serve that purpose (*in* Dethmers and Broderick, 2003). The average demand for sea turtles in Bali alone is approximately 17,000 per year, although the government only permitted the harvest and slaughter of up to 3,000 turtles per year. With green turtles foraging near and nesting on Bali decreasing, the sea turtle fishery out of Bali has had to expand to more distant foraging and nesting populations throughout the Indonesian archipelago. This has required larger vessels and a network of hunters, traders, and shippers (Dethmers and Broderick, 2003).

In the Torres Strait, both a commercial fishery and a subsistence fishery operates, taking substantially fewer turtles than the Balinese fishery. In the subsistence fishery, Islanders use small aluminum dinghies and deploy small nets or use traditional gear, typically within a day's journey from their village. Sea turtles are consumed for subsistence or used in traditional feasts. In the late 1980s, the commercial fishery was estimated to take 5,000 and 10,000 sea turtles annually and is marketed through Daru in Papua New Guinea (Limpus and Parmenter, 1986 and Groombridge and Luxmoore, 1989, both *in* Dethmers and Broderick, 2003).

Based on analysis of genetic data collected from green turtles from the Bali and Torres Strait region as well as a feeding aggregation in Aru, researchers analyzed the extent of the fisheries' impact on genetic stocks. There are 17 genetic stocks throughout the Australasian region. Researchers found that the Bali fishery is impacting several green turtle stocks throughout the region, with few stocks unaffected, while the Torres Strait fishery, having a more local focus, affects the NGBR almost exclusively (Dethmers and Broderick, 2003).

Turtle meat is reportedly sold at several restaurants in Indonesia and has been exported to Japan, Hong Kong, South Korea, and Europe. In 2001, the Indonesian government began to more strictly implement the existing laws and confiscated several shiploads of live turtles and temporarily closed turtle slaughterhouses on the island (Dermawan, 2002).

Fiji

Of the main threats to sea turtle populations around Fiji, mortalities due to the traditional harvesting of adults for ceremonial purposes, and subsistence and commercial harvesting of adults, eggs, and shells are significant. Traditionally, sea turtles were consumed for special occasions; however, eggs were not used for such feasts. As the tradition has weakened, sea turtles have been considered more common property and have been harvested for general consumption as well as for sale in local markets and exports. For example, approximately 30,000 hawksbill shells were exported during the 1980s, with approximately 2,000 kilograms of shells exported in just 1989. In addition, eggs have also been harvested for subsistence and commercial purposes. Hunting for sea turtles in Fiji is relatively easy because it is generally unregulated and uncoordinated. Currently, Fijians are prohibited from taking turtles and their eggs during the breeding season (December through March), and there was a moratorium on the killing of turtles and poaching of eggs (including trade of turtle meat and eggs) through December, 2000. The Department of Fisheries is hoping to extend this moratorium (Rupeni *et al.* 2002).

Australia
Anecdotal information indicates that from 100 to up to 1,000 southern Great Barrier Reef sea turtles are taken by hunters for traditional purposes (K. Dobbs, 2002). It is unclear as to whether this number is "per year" or over what period, or what species are taken.

Philippines
In the Philippines, despite a significant increase in conservation awareness in the past decade, turtles are still killed and sold for their meat and eggs are also taken and sold. This primarily occurs in remote areas of the country and the reasons are the following: (1) lack of law-enforcement personnel in the area; (2) lack of implementation of existing local and national laws/ordinances/orders; (3) penalties are not enough to deter violators; (4) traditional use of turtles, especially during celebration of town fiestas and weddings; and (5) poverty. Each year, an estimated 1,000 nesters are being killed (Cruz, 2002), and given that greens primarily nesting in the Philippines, they are the likely species being killed.

Hawksbill Tortoiseshell Trade
By far the most serious problem hawksbill turtles face is the harvest by humans (NMFS and USFWS, 1998b). Turtles have been harvested for centuries by native inhabitants of the Pacific region. Many adults are taken for the shell, which has a commercial value, rather than food. Hawksbill generally are considered to taste poor, and infrequently are toxic to humans (NMFS and USFWS, 1998b). Until recently, tens of thousands of hawksbills were sacrificed each year to meet the demand for jewelry, ornamentation, and whole stuffed turtles (Milliken and Tokunaga *1987 in* Eckert, 1993). In 1988, Japan's imports from Jamaica, Haiti and Cuba represented some 13,383 hawksbills: it is extremely unlikely that this volume could have originated solely from local waters (Greenpeace 1989 *in* Eckert, 1993). Japan ceased the importation of turtle shell in 1992. Today the illegal domestic harvest of eggs and turtles continues in the United States, especially in Caribbean and Pacific island territories. Law enforcement, as well as conservation and management efforts, are hindered by diffuse nesting distributions and the remoteness of some rookeries. It is not easy to determine whether remaining populations are stable, increasing, or declining (Eckert, 1993).

Scientific Research Permits

Scientific Research Permit #1277

Scientific Research Permit #1277 was issued under an ESA Section 10, to the Southwest Fisheries Science Center, NMFS, in part to study habitat use, home range, stock structure, and migration patterns of the leatherback turtle in the Pacific Ocean. During a routine capture of a 150 cm male leatherback in Monterey, California in August, 2003, the turtle died. Subsequent necropsy revealed that this animal had several chronic conditions believed to have compromised its health. Although this is an extremely rare event, it has prompted the need to collect baseline data on the health and physiology of leatherbacks (P. Dutton, NMFS-SWFSC, personal communication, January, 2004).

Other Risk Factors

Threats to sea turtles vary among the species, depending on their distribution and behavior. The value of their meat, eggs, shell or other parts plays an important role in the extent of directed harvest. All sea turtle life stages are vulnerable to human-induced mortality. On nesting beaches, direct exploitation of turtles for meat, eggs, skin or shell, and other products takes place for both commercial markets and local utilization, and to a much lesser degree for traditional ceremonies. Nesting beach and in-water habitat degradation and destruction have occurred due to many factors, including coastal development, dredging, vessel traffic, erosion control, sand mining, vehicular traffic on beaches, and artificial lighting, which repels the adults and disorients the hatchlings. In areas where recreational boating and ship traffic is intense, propeller and collision injuries are not uncommon. Human alteration of terrestrial habitats can also change the feeding patterns of natural predators, thereby increasing predation on marine turtle nests and eggs. In addition, the hawksbill's dependence on coral reefs for shelter and food link its well-being to the condition of the reefs. Destruction of reefs from vessels anchoring, striking or grounding is a growing problem.

Petroleum and other forms of chemical pollution (pesticides, heavy metals, and PCB's) affect turtles throughout their marine and terrestrial habitats and have been detected in turtles and eggs. Poisoning, as well as blockage of the gastrointestinal tract by ingested tar balls, has been reported. Low level chemical pollution, possibly causing immunosuppression has been suggested as one factor in the epidemic outbreak of a tumor disease (fibropapilloma) in green turtles. Plastics and other persistent debris discharged into the ocean are also recognized as harmful pollutants in the pelagic environment. Marine turtles such as leatherback turtles actively feed on jellyfish, and plastic bags floating in the water potentially resemble such prey in form, color and texture. Hawksbills also eat a wide variety of debris such as plastic bags, plastic and styrofoam pieces, tar balls, balloons and plastic pellets. Ingested plastics can occlude the gut, preventing or hampering feeding, and causing malnutrition or starvation. Both the entanglement in, and ingestion of, this synthetic debris have been documented (*in* NMFS and USFWS, 1998a-e).

5.3 Summary of the Status of Sea Turtles

All listed sea turtle populations affected by the proposed action have been impacted by human-induced factors such as commercial fisheries, direct harvest of turtles and eggs, and modification or degradation of the turtle's terrestrial and marine habitats. Nesting beach habitat impacts have resulted in the loss of eggs and hatchlings as well as the deterrence of nesting females, resulting in decreased nesting success. In the marine environment, a significant anthropogenic impact is the incidental capture and mortality of subadult and adult sea turtles in various commercial fisheries. Generally, mortality resulting from the effects of marine pollution are important but less significant (NMFS and USFWS, 1998a-e). Increased mortality from these anthropogenic sources at the egg and early life history stages has impacted the species' ability to maintain or increase their numbers by limiting the number of individuals that survive to sexual maturity. In addition, the human-induced mortality of adult females results in the loss of their future reproductive output. The age at sexual maturity of loggerheads may be as high as 35 years, while green turtles may not reach maturity until 30-60 years (*in* Crouse, 1999). Upon reaching maturity, female sea turtles generally lay between 100-130 eggs per clutch, minimally 2-3 clutches per year, every 2-4 years. Thus, in general, a female sea turtle will lay between 200-390 eggs per season over an average of 2-4 years.

The potential for an egg to develop into a hatchling, into a juvenile, and finally into a sexually mature adult sea turtle varies among species and populations, as well as the degree of threats faced during each life stage. Females killed prior to their first successful nesting will have contributed nothing to the overall maintenance or improvement of the species' status. Anthropogenic mortality to females (or males, for that matter) prior to the end of their reproductive life results in a serious loss of reproductive potential to the population. While quantitative data do not yet exist to provide a precise understanding of the effects of this loss of reproductive potential, the status and trends of the turtles themselves are the best evidence that sea turtle populations cannot withstand current mortality rates. In the face of current levels of mortality and extent of habitat degradation, nesting aggregations of green, leatherback, and loggerhead turtles have declined to levels that place them at a very high risk of extinction within the foreseeable future. Of the sea turtles considered in this Opinion, Hawaii green turtles are increasing, and olive ridley turtle nesting aggregations in the western Pacific appear to be somewhat stable or increasing slightly.

Efforts to Conserve Threatened and Endangered Sea Turtles in the Pacific

The Western Pacific Regional Fisheries Management Council, NOAA-Fisheries' Pacific Islands Regional Office and Southwest Fisheries Science Center are continuing to collaborate with regional and local governments around the Pacific rim, conservation and wildlife groups internationally, and the fishing industry both nationally and internationally. Over the past year, these parties have started to implement five specific projects to conserve leatherback and loggerhead sea turtles in the Pacific in cooperation with experienced non-governmental organizations (NGOs) such as World Wildlife Fund - Indonesia (WWF-Indo), Kamiali Integrated Conservation Development Group (KICDG) of Papua New Guinea, the Sea Turtle Association of Japan, and Wildcoast in Baja, Mexico.

Papua (formerly Irian Jaya), War-mon Beach:
Under this contract, World Wildlife Fund-Indonesia (WWF-Indo) would hire villagers to protect the War-mon nesting beach at Jamursba-Medi, Bird's Head Peninsula in Papua (formerly Irian Jaya). This effort is designed to monitor and protect about 33% of the known leatherback nesting beach habitat along the north coast of Papua and protect between 90% and 100% of the currently

unprotected War-mon beach at Jamursba-Medi (the largest known leatherback nesting site in Indonesia). This effort is expected to protect about 1,000 leatherback nests per year (TAC 2003, P. Dutton, NMFS SWFSC) from predation by feral pigs, beach erosion and egg collectors. Protection may be achieved through the use of an electric fence to keep pigs off beaches, by relocating eggs to more secure areas, and deter poachers through monitoring presence. In addition, through monitoring presence, measures are expected to conserve an additional 10 adult nesting females per year from poachers.

Western Papua coastal foraging grounds:
Under this contract, WWF-Indo would work with villagers in western Papua's Kei Kecil Islands to reduce or eliminate the harpooning of about 100 adult leatherback turtles per year in the coastal foraging grounds (TAC 2003, P. Dutton, NMFS SWFSC). In addition, effort will be made to explore and identify alternative food resources for these villagers.

Papua New Guinea nesting beaches:
Under this contract, the Kamiali Integrated Conservation Development Group (KICDG), would work with up to three villages of the Kamiali community in Papua New Guinea to eliminate egg harvesting and nest predation of leatherback eggs, and move those eggs laid in areas likely to be lost to beach erosion. Current practices have a two km section of beach marked off as a "no take" area. This effort is expected to protect about 90% of the nesting beach, and save about 1,000 to 1,500 nests per year (TAC 2003, P. Dutton, NMFS SWFSC).

In addition to establishing nesting beach management measures in Papua New Guinea, this effort will conduct aerial surveys of the coastal areas of northern Papua New Guinea, Solomon Islands and Vanuatu over the next four years to establish a comprehensive inventory of leatherback nesting beaches for which further conservation projects might be established. An initial feasibility study to conduct the initial surveys has been funded for late 2003 (WPRFMC in prep.).

Baja, Mexico halibut gillnet fishery:
Under this contract, Wildcoast would conduct mortality reduction workshops with fishermen and place observers on local boats to insure that all the live loggerheads that comprise the estimated 3,000 loggerhead juveniles per year caught in the halibut gillnets are returned to the ocean (TAC 2003, P. Dutton, NMFS SWFSC). Without observers, these loggerheads become part of the catch.

Japan nesting beaches:
As part of this effort, the Sea Turtle Association of Japan (STAJ) would moving loggerhead eggs from locations prone to washing out and provide shading to nests that experience extreme temperatures at two nesting beaches. A contract has been developed with STAJ for this work to begin during the May 2004 nesting season. The goal of this effort is to save 53 loggerhead nests (TAC 2003, G. Balazs, NMFS PIFSC).

In addition, a contract has been developed with the Ostional National Wildlife Refuge in Costa Rica to help refuge managers to convene workshops to reduce sea turtle mortalities in longline fisheries based in Costa Rica.

Although these conservation measures would benefit leatherback and loggerhead sea turtles, it is not clear whether and how they will improve the status of leatherback sea turtles in the Pacific. Based on our understanding of the measures and their intended benefits, NOAA-Fisheries hopes they are as effective as proposed because these projects should improve the status of leatherback and loggerhead sea turtles.

6.0 EFFECTS OF THE PROPOSED ACTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. §1536), requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat.

The ESA defines "species" to include any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." This biological opinion assesses the effects of NOAA-Fisheries' proposal to modify the management regime for the Hawaii-based longline fisheries managed under the Pelagics FMP while continuing the management regime for the other fisheries managed under that FMP on threatened and endangered species and critical habitat that has been designated for these species. NOAA-Fisheries has previously concluded that the fisheries authorized under the Pelagics FMP are likely to adversely affect listed species through gear interactions that are known to injure or kill individuals of these species.

In the *Description of the Action* section of this Opinion, NOAA-Fisheries provided an overview of the fisheries, particularly the distribution of timing of fisheries that use gear that has been a problem for threatened and endangered species. In the *Status of the Species* (which is also the *Environmental Baseline* for this biological opinion) section of this Opinion, NOAA-Fisheries provided an overview of the threatened and endangered species that are likely to be adversely affected by fisheries authorized under the Pelagics FMP.

In this section of a biological opinion, NOAA-Fisheries assesses the probable direct and indirect effects of the fisheries authorized under the Pelagics FMP on threatened and endangered species and designated critical habitat. The purpose of this assessment is to determine if it is reasonable to expect that the fisheries can be expected to have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild or appreciably diminish the value of designated critical habitat for both the survival and recovery of threatened and endangered species in the wild. Before beginning our analyses, we will discuss our approach to the assessment, the evidence available for our assessment, and assumptions we had to make to overcome limits in our knowledge.

6.1 Effects of Fisheries Authorized Under the Pelagics FMP

As discussed in the Action Area, the fisheries authorized under the Pelagics FMP occur throughout the central, western, eastern and northern Pacific Ocean, including the western Pacific islands of the Northwestern Hawaiian Islands, the main Hawaiian Islands, American Samoa, Guam, Commonwealth of the Northern Mariana Islands (Saipan, Rota, and Tinian), and the U.S. possessions of Johnston Atoll, Kingman Reef, and the islands: Palmyra, Jarvis, Howland, Baker, Midway, and Wake.

The Hawaii-based longline fishery generally operates around the main and northwestern Hawaiian islands except for prohibited areas (a) that extend 50 nautical miles from the center geographical positions of Nihoa Island, Necker Island, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Island, and Kure Island, which were established to protect Hawaiian monk seals; (b) around the main Hawaiian Islands that seasonally and geographically range from 25 to 75 nautical miles seaward of the shore of particular islands that were established to reduce potential gear conflicts among small boat fishers; and (c) an area that can extend up to 75 nautical miles around the main Hawaiian Islands in the portion of the EEZ seaward of Hawaii; from February 1 through September 30 each year, longline fishing is prohibited up to 75 nautical miles from these islands; from October 1 through the following January 31 each year, longline fishing is prohibited further inshore.

Hawaii-based longline vessels vary their fishing grounds depending on their target species. Most of the effort is north and south of the Hawaiian Islands between latitudes 5° and 40° N and longitudes 140° and 180° W.

The other fisheries authorized under the Pelagics FMP generally occur closer to shore. Most of the vessels associated with the pelagic longline fishery based out of American Samoa occur with 25 nautical miles of shore, although newer, larger vessels are capable of fishing out to and beyond 50 nautical miles. Similarly, the pole-and-line fishery based in Hawaii; the recreational fisheries that target pelagic species around Hawaii; the Hawaiian charter boat fishery; and troll fisheries based out of American Samoa, Guam; Hawaii, and the Commonwealth of Northern Mariana Island all generally occur within 25 miles of shore (NMFS, 2000). In all of these fisheries some fishing vessels range as far as 100 nautical miles from land.

The primary effects of the fisheries on threatened and endangered species results from interactions with the fishing gear, resulting in the capture, injury, or death of the species. In addition to these direct effects of the fisheries, the Western Pacific Regional Fisheries Management Council and the Hawaii Longline Association considered the potential effects of closing the Hawaii-based longline fisheries, which they called "transferred effects." These analyses concluded that imports replaced the fresh swordfish that had been produced by the U.S. swordfish fleet. From that displacement, the analyses asserted that more sea turtles were killed in the fisheries of the foreign suppliers of fresh swordfish. That conclusion seemed predicated on an assumption that effort in those foreign fisheries actually increased to supply the U.S. market rather than that swordfish that would have been caught anyway was redirected from foreign markets to U.S. markets. From this chain of reasoning, the Council and Hawaii Longline Association suggest that prosecuting the Hawaii-based longline fisheries for swordfish would benefit threatened and endangered sea turtles. NOAA-Fisheries recognizes the possibility of "transferred effects" but cannot evaluate the potential adverse or beneficial indirect effects of these transfers on threatened and endangered sea turtles without additional information on the market relationships between shifts in swordfish landings in the Hawaii-based longline fisheries and changes in fishing effort of specific foreign fleets.

6.2 Exposure Analysis

This section of the Opinion evaluates the available information to determine the likelihood of a listed sea turtle co-occurring and interacting with one or more of the fisheries authorized by the Pelagics FMP. As part of our exposure analyses, we consider the probable duration, frequency, and severity of these interactions. This analysis assumes that sea turtles are not likely to be adversely affected by a fishery if they do not interact with the fishery; these analyses also assume that the potential effects of the fisheries would be proportional to the number of interactions between the fisheries and sea turtles.

The only source of information available for this analysis are reports of actual interactions between the fisheries and sea turtles that have been derived from observer programs and logbooks. These sources do not allow us to determine the abundance of sea turtles from different nesting aggregations that *could* interact with the Pelagic fisheries (that is, the number of turtles that are susceptible to interactions with the fisheries). As a result, we cannot analyze potential interactions or the probability of interactions that remain unreported. Therefore, this interaction analysis assumes that the spatial and temporal patterns derived from reported interactions between the fisheries and turtles represents the actual spatial and temporal distribution of the sea turtle populations in the action area. However, given the distribution of their nesting aggregations, turtles probably occur throughout the entire fishing area.

In addition to sea turtles, humpback whales, sperm whales, and Hawaiian monk seals have been exposed to have been known to be exposed to the pelagic fisheries of the western Pacific region. Humpback and sperm whales have been entangled in longline fishing gear and monk seals have been both entangled and hooked in longline fishing gear. On December 29, 2003, a small sperm whale surfaced near a longline vessel and, when it swam away, was reported to have been entangled in longline gear (hooks, line, and floats). Unfortunately, the information available is insufficient to determine whether the whale was harassed or harmed in the incident.

6.2.1 Exposure Probabilities By Gear Type

In general, five different fishing gear types are used under the western Pacific Pelagics Fishery Management Plan: troll, handline, pole-and-line, and longline gear. The type of fishing gear used and the area fished will affect the likelihood of an interaction with a sea turtle. The following section discusses the likelihood of interactions between these gear types and sea turtles.

6.2.1.1 Troll fishing gear

Trolling is conducted by towing lures or baited hooks from a moving vessel, using big-game-type rods and reels as well as hydraulic haulers, outriggers, and other gear. Up to six lines rigged with artificial lures or live bait may be trolled when outrigger poles are used to keep gear from tangling. When using live bait, trollers move at slower speeds to permit the bait to swim naturally (WPRFMC, 1995). Freshly caught small yellowfin tuna or skipjack tuna may be used as live bait to attract marlin. Once a fish is hooked, the gear is immediately retrieved.

Although the distribution of trolling overlaps with the distribution of sea turtles, there have been no reported interactions by vessel operators. In addition, sea turtles are not likely to captured by troll fishing gear because the gear is towed through the water faster than sea turtles may be traveling. Furthermore, sea turtles do not prey on the same type of prey as used by the troll fisheries. A small potential exists that the fishing gear may incidentally hook or entangle a sea turtle when the gear is towed through the water. However, this type of interaction has been extremely rare and NOAA-Fisheries expects interactions to remain rare n the future. Furthermore, because the gear in these fisheries are retrieved almost immediately, interactions are not likely to injure or killed turtles that are captured. Therefore, NOAA-Fisheries does not believe trolling gear is likely to adversely affect sea turtle populations.

6.2.1.2 Pole-and-line

A small pole-and-line fishery operates from Hawai'i that targets skipjack tuna. It is sometimes referred to as the aku (skipjack tuna) fishery or baitboat fishery. The pole-and-line fishery uses live bait thrown from a fishing vessel (ranging from 65 - 80 feet) to stimulate a surface tuna school into a feeding frenzy. The pole and line used are of equal length (3 meters). Fishing is conducted using a barbless hook with feather skirts slapped against the water until a fish strikes. The hooked fish is then yanked into the vessel in one motion. The fish unhooks when the line is slacked so that the process can be repeated. The bait most often used is anchovy.

Although the distribution of the pole-and-line fishery overlaps with the distribution of sea turtles, there is a very low likelihood of an interaction with a sea turtle because the turtle would need to be in the vicinity and the fisher would need to hook the turtle or the turtle would need to strike the hook. This type of an event is unlikely to occur because sea turtles are not likely to prey on anchovy, and the activity of the fish feeding frenzy would deter turtles from remaining in the area. For these reasons, NOAA-Fisheries concludes that the pole-and-line fishery is not likely to adversely affect sea turtle populations.

6.2.1.3 Handline fishery

Two types of pelagic handline fishing methods are practiced in Hawai'i, the *ika-shibi* method, and the *palu-ahi* method. The *ika-shibi* or night handline fishery developed from a squid (*ika*) fishery which switched to target the incidental catch of tuna (*shibi*). Lights and chum are used to attract small prey species and larger target tunas to handlines baited with squid. The vessels typically fish between 5 - 6.5 nm from shore. The night-time fishery is mostly conducted off Hilo and off Keahou, both of the island of Hawaii (Hamilton, 1996 *in* NOAA-Fisheries, 2000a).

The *palu-ahi* or day-handline fishery also targets tuna but fishing occurs during the day. A baited hook on the end of a handline is laid against a stone and the line wound around it. Additional pieces of chum are wound into the bundle which is then tied in a slip knot (Rizzuto, 1983 *in* NOAA-Fisheries, 2000a). The bundle is lowered to the preferred depth (commonly 20-30 meters) where the line is jerked to untie the knot so the baited hook and chum are released at the target depth. Fishing usually takes place by smaller vessels within 6.5 nm from shore and by larger vessels around fish aggregating device or around sea mounts and weather buoys (100 - 200 nm from shore). As soon as a fish is caught, the gear is brought back on board.

There have been no reported interactions between gear used in the handline fishery and sea turtles. Although there is the risk that sea turtles may become hooked or entangled in the fishing gear, any caught animal can be immediately dehooked or disentangled and released. Moreover, most turtles found in the area of the handline fisheries are not likely to prey on the baited hooks. For these reasons, NOAA-Fisheries concludes the handline fishery, as managed under the Pelagics FMP is not likely to adversely affect listed sea turtle populations.

6.2.1.4 Longline fisheries

Longline fishing is a passive fishing method that consists of suspending a monofilament line (main line) in the water column, by using floats, and attaching baited hooks along the line to attract fish. While the main line is deployed over the stern of the vessel, floats and hooks are attached to the main line using clips. Each float is attached to a float line and each hook is attached to a "branch line." The branch line is sometimes called a "gangion" or "dropper" line. For the most part, the branch lines are evenly spaced along the main line, except between floats where the placement of the float on the main line may lengthen the distance between the branch lines. The lengths of the branch lines and the float lines affect how deep the gear (hook) will fish and the type of species that might be caught. The depth that hooks actually fish is also determined by the vessel speed, drum speed, and shooter speed. The faster the main line is set (more line set in a shorter distance), the deeper the line will sink because of the line sag between the floats. In addition to the speed that the main line is set, the number of hooks and the size of the weight on each branch line can affect the depth and rate that the gear will sink. The type of species that are caught are also affected by the time of day the gear is set and the type of bait that is used.

American Samoa longline fishery.
Apart from a few larger (> 40 ft) inboards, longlining out of American Samoa generally takes place on *alias*, twin-hulled (wood with fiberglass or aluminum) boats about 30 feet long, and powered by small gasoline outboard engines. The gear is stored on deck attached to a hand crank reel which can hold as much as 10 miles of monofilament mainline. Participants set between 100 and 300 hooks on a typical eight-hour trip. The gear is set by spooling the mainline off the reel and retrieved by hand cranking back onto the reel. Currently most fishing is done within 25 miles of shore, but with better equipped vessels, fishing activity may extend further. Generally, gear setting begins in early morning; with retrieval in the mid-morning to afternoon.

6.2.1.5 Past sea turtle take in the American Samoa-based longline fishery

For the American Samoa-based longline fishery, the federal logbooks from 1992 to 1999 indicate a range of interactions with sea turtles (i.e. hooking/entanglement). In 1992, one vessel interacted with a green turtle. In 1998, one vessel interacted with an unidentified sea turtle; it was released alive. In 1999, one vessel reported interactions with four sea turtles. Three turtles released alive were recorded as a hawksbill, a leatherback, and an olive ridley. One turtle, identified as a green, was reported to have died from its interaction with this vessel. None of the species' identification were validated by NOAA-Fisheries' Southwest Fisheries Science Center; and NOAA-Fisheries cannot attest to the local knowledge of fishermen regarding the identity of various turtle species, particularly hard-shelled turtles. However, all five species of sea turtles reportedly caught by the fishery do occur in the fishing grounds of this longline fishery. In addition, as discussed immediately below, logbook data may not be a reliable method to measure sea turtle interaction in the fisheries. Therefore, for the purposes of this Opinion, from 1992-1999, the take of sea turtles by the American Samoa-based longline fishery included at least 4 hardshelled turtles (with 3 released alive, 1 mortality), 1 leatherback, and 1 unidentified sea turtle.

6.2.1.6 Hawaii-based longline fishery

SWORDFISH OR MIXED TARGET (SHALLOW SET) LONGLINE FISHERY. Pacific Ocean longline vessels targeting swordfish or a mixture of tuna and swordfish, typically deploy about 42 horizontal miles of main line in the water. Most branch lines are about 17 meters (56 feet) in length and float lines are about 8 meters (26 feet) in length. For bait, fishers use squid (either large or small) and a number 9 Mustad (J-shaped) hook or, more rarely, an offset J-shaped hook. In addition, fishers use lightsticks on almost half of the hooks (every other hook). A typical set uses about 820 hooks and 189 floats which means there are approximately 4 or 5 hooks between each float. Assuming the branch lines and the float lines are evenly spaced, the distance between them is approximately 67 meters (220 feet). On average, fishers try to set their gear at about 28 meters (92 feet) below the water surface. The gear is allowed to soak during the night and soak times of the gear typically last about 20 hours, including setting and hauling of gear. This type of set is referred to below as "shallow set."

TUNA (DEEP SET) LONGLINE FISHERY. Vessels targeting tuna in the Pacific Ocean deploy about 34 horizontal miles of main line in the water. Vessels targeting tuna typically use a line shooter. The line shooter increases the speed at which the main line is set which causes the main line to sag in the middle (more line between floats), allowing the middle hooks to fish deeper. The average speed of the shooter is 9 knots. The vessel speed is about 6.8 knots. No light sticks are used as the gear soaks. The float line length is about 22 meters (72 feet) and the branch line lengths are about 13 meters (43 feet). The average number of hooks deployed is about 1,690 hooks per set with about 27 hooks set between each float. There are approximately 66 floats used during each set. Instead of squid, deep set vessels use saury (sanma) as bait and the hook type used are "tuna" hooks. The average target depth is 167 meters. The gear is allowed to soak during the day and the total soak time typically lasts about 19 hours, including setting and hauling of gear. This type of set is referred to below as "deep set."

DIFFERENCES BETWEEN THE SHALLOW SET AND DEEP SET LONGLINE FISHERIES. Shallow set fishing effort rarely occurs below 20°N throughout the year (see Figures 1 through 5 in Appendix B), although there has been some concentration of effort between 18° and 20° N in the third quarter. Deep set fishing effort rarely occurs north of 25°N. Shallow set vessels fish shallower using fewer hooks per float than vessels targeting tuna. For practical purposes, vessels using fewer than 10 hooks per float are targeting swordfish, or a mix of swordfish and tuna, and vessels using more than 10 hooks per float are targeting tuna (D. Kobayashi, NOAA-Fisheries, personal communication, January, 2001). Shallow set vessels set about 42 horizontal miles of gear whereas deep set vessels set only 34 horizontal miles of gear. The shorter horizontal distance is because deep set vessels put more sag in their gear and the gear is fishing deeper even though the mainline itself may be the same length between the two types of sets. To increase the amount of sag in the main line on deep sets, fewer floats are used with more mainline between each float, which will increase the amount of sag. In addition, shallow sets are made during the night, while deep sets are soaked during the day.

6.2.2 Exposure Probabilities By Turtle Species

The narratives that follow describe the co-occurrence between the fisheries and sea turtles using three variables.

:

a. *Demographic patterns of exposure.* Interaction between fishing gear and marine species can be described using a wide variety of demographic variables, but three variables are particularly important for section 7 assessments : the number of individuals, the age or gender of those individuals, and the populations to which those individuals belong. gear can interact with individuals from all populations of threatened and endangered species or they can interact with particular populations.

b. *Behavioral patterns of exposure.* Interaction between fishing gear and marine species may be influenced by the behaviors of the sea turtles in the action area. Fishing gear under the FMP can interact with individuals that are foraging within or migrating through the action area. The turtles may have a specific behavioral response to the gear (presence of attractants such as light sticks, floats, or bait for example) or the course of normal behaviors may bring the animal into contact with the fishery. There are spatial and temporal components to these interactions as well, therefore, behavioral and spatial or temporal components sometimes overlap in the discussions below.

c. *Spatial patterns of exposure.* The spatial patterns of interactions between fishing gear and marine species can be described by three dimensions: degrees of latitude, degrees of longitude, and vertically within the water column. The first two dimensions describe the patterns as seen from the surface. The third dimension, however, describes the interaction from the eyes of the turtle.

d. *Temporal patterns of exposure.* Interactions between fishing gear and marine species through time can be described by three dimensions: annual patterns, time of year, and time of day. These dimensions describe the patterns as they interact with changes in fishing effort, changes in oceanographic conditions, and changes in behavior of target species as well as listed species that are incidentally captured in a fishery. To the extent that information was available, we described these patterns using all three dimensions.

6.2.2.1 Green Sea Turtle

DEMOGRAPHIC PATTERNS OF EXPOSURE. Green turtles are exposed to the Hawaii-based longline fisheries and have been reported being exposed to the longline fisheries based out of American Samoa. The turtles that interact with longline vessels based in American Samoa are likely to be individuals from western Pacific nesting beaches, although we cannot assign probabilities to any particular nesting aggregations.

Those green turtles that are captured by the Hawaii-based longline fisheries will be members of the endangered Mexican (Pacific coast) or threatened Hawaiian (French Frigate Shoals) nesting aggregations. Out of eight green turtles caught by the Hawaii-based longline fishery, genetic analyses concluded that four of the eight turtles (50%) represented nesting aggregations from the eastern Pacific (Mexico), one turtle (12.5%) represented the Hawaiian nesting aggregations, the remaining three turtles (37.5%) could have been from either of these two nesting aggregations (P. Dutton, NOAA-Fisheries, personal communication, January, 2001) but may also have represented other nesting aggregations in the Pacific Ocean.

Life history information collected by observers suggests that the Hawaii-based longline fisheries are likely to capture sub-adult and adult green turtles (straight carapace lengths ranged from 28.5 cm to 73.5 cm with an average of 51.5 cm).

BEHAVIORAL PATTERNS OF EXPOSURE. Although most green turtles appear to have a nearly exclusive herbivorous diet, consisting primarily of sea grass and algae (Wetherall et al., 1993; Hirth, 1997), those along some areas of the east Pacific coast seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of molluscs and polychaetes, while fish and fish eggs, and jellyfish and commensal amphipods comprised a lesser percentage (Bjorndal, 1997). Exclusively herbivorous green turtles may be less likely to be attracted to bait set on fishing gear reducing their chances of hooking.

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, wild green turtles in pelagic habitats probably live and feed at or near the ocean surface, and their routine dives probably do not exceed several meters in depth (NOAA Fisheries and USFWS, 1998a). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson, 1967, *in* Lutcavage and Lutz, 1997), while subadults routinely dive 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill, *et al.*, 1995, *in* Lutcavage and Lutz, 1997). These dive depths are within the range of fishing gear such as longlines and drift gillnets that are set and left to fish for long periods. Green turtles may interact with nets or lines as they descend or ascend through the water column. Turtles resting or foraging at or near the surface could be accidentally hooked by trolling gear or encircled by nets.

SPATIAL PATTERNS OF EXPOSURE. The existing data on these interactions revealed clear spatial patterns between the Hawaii-based longline fisheries and green turtles. Green turtles have been caught in the area bounded by 155°W and approximately 180°E longitude and between 5°N and 30°N latitude. Ten out of the 18 turtles were caught in an area around the Hawaiian island chain between 155°W and 165°W longitude and between 15°N and 30°N latitude. Of the remaining turtles, four were captured far to the south of the Hawaiian islands and four were captured to the northwest of the main Hawaiian Islands.

Within the water column, more green turtles were captured in shallow sets compared to deep sets. Thirteen of 18 turtles caught were captured in sets with less than 10 hooks per float, indicative of shallow-set gear. The only mortalities (n = 4) observed were on deep sets; therefore, it is likely that the turtles died as a result of their inability to reach the surface. Because sub-adult green turtles reportedly perform routine dives of 20 meters (Brill, *et al.*, 1995, *in* Lutcavage and Lutz, 1997)routinely dive to depths of 20 meters (Brill, *et al.*, 1995, *in* Lutcavage and Lutz, 1997), they are more likely to encounter shallow-set longline gear than deep-set longline gear (which is often set at depths greater than 100 meters).

TEMPORAL PATTERNS OF EXPOSURE. The existing data also revealed that green turtles have been captured in all months of the year except January and September. From observer data, and using a model-based predictor, McCracken (2000) estimated that between 37 and 45 green turtles (mean = 40) were captured each year by the Hawaii-based longline fishery.

EXPOSURE TO THE PROPOSED FISHERIES. Assuming that patterns observed in the past represent future patterns, green sea turtles will be exposed primarily to the longline fisheries; the number of green turtles that have been captured by other fisheries included in the Pelagics FMP are expected to be minimal. One green turtle was reported to have been captured and killed by the longline fisheries based in American Samoa in 1999, but no interactions have been reported since then (it is important to note that these fisheries are not observed, so the absence of reports may only reflect the absence of sampling rather than the absence of interactions). With the proposed fishery management regime, about 7 (95% confidence interval = 2 - 17) green turtles are expected to be captured by the Hawaii-based longline fisheries each year. Unlike the past, most of these turtles (86%) would be exposed to deep-set gear: about 6 green sea turtles (95% confidence interval = 1 - 13) are expected to be captured by deep-set gear, while 1 turtle (95% confidence interval = 1 to 5) is expected to be captured by shallow-set gear.

Based on genetic sampling of the green sea turtles captured in these fisheries in the past, the turtles that are exposed to the Hawaii-based longline fleets will represent nesting beaches both the eastern Pacific Ocean or Hawaii, although most of the green turtles will be endangered turtles that will have migrated from the east (P. Dutton *et al.*, 2000; P. Dutton, NOAA-Fisheries, personal communication, January, 2001). If the longline fisheries affect green turtle populations proportional to their relative abundance in the action area, about 4 to 6 of the 7 green turtles that are expected to be captured in the Hawaii-based longline fisheries each year would represent endangered green turtles from the eastern tropical Pacific , while 1 or 2 of the 7 turtles would represent turtles from the Hawaiian nesting aggregations.

6.2.2.2 Hawksbill Sea Turtle

DEMOGRAPHIC PATTERNS OF EXPOSURE. Hawksbill turtles are exposed to the Hawaii-based longline fisheries and have been reported being exposed to the longline fisheries based out of American Samoa. The turtles that are captured by longline vessels based in American Samoa are likely to be individuals from western Pacific nesting beaches, although we cannot assign probabilities to any particular nesting aggregations.

SPATIAL AND TEMPORAL PATTERNS OF EXPOSURE. It is impossible to identify any patterns from the single report, particularly since that report had not been observed.

6.2.2.3 Leatherback Sea Turtle

DEMOGRAPHIC PATTERNS OF EXPOSURE. Leatherback turtles are exposed to the Hawaii-based longline fisheries and have been reported being exposed to the longline fisheries based out of American Samoa. Genetic analyses of leatherback turtles captured previously in the Hawaii-based longline fishery, identified 12 of the 14 leatherback turtles captured in the fishery from nesting aggregations in the southwestern Pacific; the remaining 2 turtles, which were captured in the southern range of the fishery, were from nesting aggregations in the eastern Pacific (P. Dutton, *et al.*, in press, and P. Dutton, NOAA-Fisheries, personal communication, May, 2000). Based on these data we assume that most of the leatherback turtles that are exposed to the Hawaii-based longline fisheries are from two nesting aggregations: the eastern Pacific region (Mexico and Costa Rica), and the western Pacific region (Indonesia, Malaysia, Papua New Guinea, Fiji, and the Solomon Islands). Leatherback turtles that are captured by the longline fisheries based out of American Samoa are most likely to represent one or more of the western Pacific nesting aggregations, although we cannot assign probabilities to any particular nesting aggregations.

Observers collected life history records for 34 leatherback turtles, but only five of the turtles captured in the fishery had been measured (the unmeasured turtles may have been too large to be safely brought on board; therefore they may have been adults). The straight carapace lengths for the five turtles were 71, 80, 87.5, 110, and 130 centimeters, the smallest four of these turtles were probably early pelagic juveniles (n = 1) and late pelagic sub-adults (n = 3) based on growth rates that have been assumed for Malaysian turtles (see Bolten, *et al.* 1996). If the larger (>130 cm) leatherback turtle was from the western Pacific, it would have been a sub-adult turtle, if it was from the eastern Pacific nesting aggregations, it could have been an adult (P. Dutton, NOAA-Fisheries, personal communication, January, 2001). In either case, we assume that the leatherback turtles that are exposed to the Hawaii-based longline fisheries are either sub-adult or adult turtles.

BEHAVIORAL PATTERNS OF EXPOSURE. Their long pectoral flippers and extremely active behavior make Leatherback sea turtles particularly vulnerable to fishing gear and ocean debris. Observed leatherback sea turtle entanglements have primarily involved the front flippers and/or the neck and head region. Leatherback hatchlings studied in captivity for almost 2 years swam persistently without ever recognizing the tank sides as a barrier (Deraniyagala, 1939, *in* Wyneken, 1997). A leatherback entangled in a net can be expected to continue trying to swim, expending valuable amounts of energy and oxygen. As the turtle's available oxygen diminishes, anaerobic glycolysis will take over, producing high levels of lactic acid in the blood. Unlike the hard-shelled sea turtles, leatherback turtles lack calcium, which helps to neutralize the lactic acid build-up by building up bicarbonate levels. In addition, leatherback turtles store an enormous amount of oxygen in their tissues, similar to marine mammals, and have comparatively high hematocrits, which is efficient for such a deep-diving turtle but means that they have relatively less oxygen available for submergence. Maximum dive duration for the species is substantially less than half that of other turtles. The disadvantage of this is that they are not able to hold their breath as long and are probably more vulnerable to drowning in long gear sets.

Leatherback turtles within the action area of the Hawaii-based longline fishery are probably foraging (at the surface or at depth, including the deep scattering layer – strata comprised primarily of vertically migrating zooplankton, chiefly siphonophore and salp colonies, as well as medusae) or migrating between their nesting, mating, and foraging areas. Davenport (1988, *in* Davenport and Balazs, 1991) speculated that leatherback turtles may locate pyrosomas at night due to their bioluminescence; however direct evidence is lacking. If they are tracking these prey via bioluminescence, fishing gear that uses lighsticks or other similar devices may attract leatherback sea turtles. Additionally, if gillnet gear collects medusae or pyrosomas during their sets, leatherback sea turtles may become entangled while foraging on this "catch."

Leatherback sea turtles are able to dive quite deep, but appear to spend most of their time (up to 90%) diving to depths shallower than 80 meters. Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert, *et al.*, 1989). Migrating leatherback turtles also spend a majority of time at sea submerged, and they display a pattern of continual diving (Standora, *et al.*, 1984, *in* Southwood, *et al.*, 1999). They are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale, *et al.*, 1994; Eckert, 1998; Eckert, 1999a).

Recent information on leatherback sea turtles tagged off the west coast of the United States has revealed an important migratory corridor from central California, to south of the Hawaiian islands, leading to western Pacific nesting beaches (P. Dutton, NOAA Fisheries, personal communication, December 2003). This corridor runs through the areas typically fished by HMS fleets and supports genetic findings that most of the leatherback turtles caught in the fishery originate from western Pacific beaches. Most of the western Pacific leatherback sea turtles followed the southwest migratory corridor, heading towards western Pacific nesting beaches. Two that have been tracked for an extended period of time did not arrive on the nesting beaches, instead heading north and east, back towards the northen part of Hawaii where shallow-set longline fleets operate. One leatherback did not follow a southwest track out of Monterey and instead headed southeast, along Baja California, Mexico, and into the Gulf of California. Eastern Pacific leatherback turtles appear to migrate primarily to the south, into the fishing grounds of South American fishing nations, supporting the low observed interaction rate between the Hawaii-based longline fishery, west-coast based longline fishery, CA/OR drift gillnet fishery, and eastern Pacific leatherback turtles.

Researchers have also begun to track female leatherbacks tagged on western Pacific nesting beaches, both from Jamursba-Medi, Papua, and from the Morobe coast of Papua New Guinea. Most of the females that have been tagged in Papua have been tracked heading on an easterly pathway, towards the western U.S. coast. One female headed north and is currently meandering in the East China Sea and the Sea of Japan, generally between Japan and South Korea. Another female headed north and then west of the Philippines. Meanwhile, all the leatherbacks tagged off Papua New Guinea have traveled on a southeasterly direction, in the south Pacific Ocean (P. Dutton, NOAA Fisheries, personal communication, December, 2003).

These observations further support findings that the Hawaii-based longline fisheries are more likely to interact with leatherback sea turtles from western Pacific nesting aggregations than those from the eastern Pacific. Within the western Pacific aggregations, turtles from the Indonesian beaches may be more likely to be exposed to these fisheries because of their relative abundance

SPATIAL PATTERNS OF EXPOSURE. There appears to be consistent spatial patterns to the existing data on the interactions between the Pelagics fisheries and leatherback turtles. Vessels fishing off Hawaii generally observe leatherback turtles beyond the 100-fathom curve but within sight of land. Two areas where observations have been reported are off the north coast of Oahu and the west coast of the Island of Hawaii, and in the area of the seamounts above the Northwestern Hawaiian Islands (Skillman and Balazs 1992). Leatherback turtles apparently use the pelagic zone surrounding the Hawaiian Islands as foraging habitat and migratory pathways. Further to the north of the Hawaiian Islands, leatherback turtles are known to aggregate at 35°N latitude, between 175°W and 180°W longitudes (NOAA-Fisheries 1991).

In the past, leatherback turtles have been captured in longline gear in the area bounded by 170°E and 133°W longitude and between 5°N and 41°N latitude. Leatherback turtles caught in sets above 20°N latitude (43 out of 52 leatherback turtles observed) were caught in sets with less than 10 hooks per float, indicative of shallow-set gear and also indicative of the general area in which shallow-set fishing methods are used. Leatherback turtles were primarily captured in these sets between 165°W and 130°W longitude and 20°N and 40°N latitude.

The remaining leatherback turtles captured in the fisheries (9 out of 52), were associated with in sets with more than 10 hooks per float, suggesting deep-set gear. These interactions occurred between 153°W and 167°W longitude and 5°N and 26°N latitude. Sea surface temperatures, latitude, and the distance to the approximate 17°C and 19°C isotherms were associated with these interactions, but these variables were highly correlated (McCracken, 2000). When McCracken

(2000) examined four latitude predictor categories for leatherback turtles[24], she found that the proportion of sets associated with leatherback captured was higher in the northernmost and southernmost categories, even though these areas had lower proportions of the observed sets than the middle two categories, which had high observed sets but fewer observed takes. These observations suggest that the risk of an interaction increases toward the northern and southern boundaries of the action area.

TEMPORAL PATTERNS OF EXPOSURE. There have been no obvious temporal patterns to interactions between leatherback turtles and longline gear: leatherback turtles have been captured in every month of the year, except August.

EXPOSURE TO THE PROPOSED FISHERIES. Assuming that patterns observed in the past represent future patterns, leatherback sea turtles will be exposed primarily to the Hawaii-based longline fisheries. The number of leatherback turtles that have been captured by other fisheries included in the Pelagics FMP are expected to be minimal: one leatherback turtles was reported to have been captured but not killed by the longline fisheries based in American Samoa in 1999, no interactions have been reported since then but it is important to note that these fisheries are not observed, so the absence of reports may only reflect the absence of sampling rather than the absence of interactions).

As proposed, the Hawaii-based longline fisheries would be modified to require longline vessels to use management measures that have proven effective at reducing the number and rate of interactions between leatherback and loggerhead sea turtles: the use of 18.0 10° offset circle hook with squid bait. Fishing experiments conducted in the North Atlantic Ocean, demonstrated that interaction rates between leatherback turtles and the fisheries were significantly reduced with the18/0 10° offset circle hook with squid bait compared with J-hooks with squid bait that have been used historically. On average, the interaction rate of leatherback turtles declined by 50% in these experiments. Interaction rates between leatherback turtle were also significantly reduced by using mackerel as bait rather than squid on J-hooks. On average, the interaction rate of leatherback turtles declined by 67% using mackerel bait.

Using mackerel bait on hooks appeared to have some influence on turtle interactions. About one third of the vessels used a "single hooking" technique, which involved passing the hook point a single time through the bait's eye, back or tail. The remaining vessels employed a threading technique which involved passing the entire hook through the bait multiple times starting through the eyes, back or tail. This technique was used to better secure the bait to the hook and minimize bait loss. Interactions with loggerhead turtles were 74 % greater with this threading technique as compared to the single hooked mackerel. This may be due to the ease with which single hooked baits are torn away from the hooks during the feeding process. The single hooked baits also had the highest catch rates of swordfish. However, the single hooked baits had a 107% higher leatherback interaction rate than the threaded bait. This is likely due to the shielding effect offered

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[24] These four categories were: less than 14.95°N, between 14.95°N and 24.84°N, between 24.84°N and 33.82°N, and greater than 33.82°N (McCracken 2000).

by the threading of the baits, as leatherback turtles are known to be frequently flipper hooked, presumably because they tend to run into the longline gear accidentally rather than biting it.

With the proposed management regime for the Hawaii-based longline fisheries, which include these gear modifications, about 34 (95% confidence interval = 18 - 60) leatherback turtles are expected to be captured by the Hawaii-based longline fisheries each year. Interactions between the different types of gear and leatherback turtles is split almost equally. About 16 leatherback turtles (95% confidence interval = 9 - 30) are expected to be captured by the shallow-set gear, while about 18 turtles (95% confidence interval = 9 to 30) are expected to be captured by the deep set gear.

Based on the limited genetic sampling from the action area, about 86% of the leatherback turtle sample (12 out of 14 genetic samples) originated from western Pacific nesting beaches (P. Dutton *et al.*, 2000; P. Dutton, NOAA-Fisheries, personal communication, January, 2001). If the longline fisheries affect leatherback turtle populations proportional to their relative abundance in the action area, about 29 of the 34 leatherback turtles that are expected to be captured in the Hawaii-based longline fisheries each year would come from nesting aggregations in the western Pacific Ocean. These turtles could represent individuals from Indonesia (Jamursba-Medi or War-Mon), Papua New Guinea (Kamiali), Malaysia (Terengganu), the Solomon Islands, or Fiji, although satellite tracks from leatherback turtles tagged in Papua New Guinea suggest that these turtles tend to migrate south instead of north, which would take them away from Hawaiian waters. Further, the abundance of the nesting aggregations in Indonesia relative to the small size of the other nesting aggregations suggests that the interactions between Indonesian leatherback turtles and the Hawaii-based longline fisheries are most likely.

The remaining 14 percent of the interactions, or about 5 leatherback turtles per year, would represent turtles from the eastern Pacific Ocean. These turtles could represent individuals from nesting aggregations along the coast of Mexico, Costa Rica, or Panama, although turtles from these nesting aggregations may only migrate into Hawaiian waters when oceanic phenomena like El Nino events prevent them from migrating south to the coasts of Peru and Chile. Several investigators who have followed leatherback turtles equipped with satellite tags have reported that leatherback turtles from the beaches of Mexico and Costa Rica migrate through the equatorial current towards the coasts of Peru and Chile (Chandler 1991, Eckert 1997, Marquez and Vellanueva 1993, Morreale et al. 1996). Eckert (1997) suggested that these turtles migrate toward the coast of South America where upwelling water masses provide an abundance of prey.

Although these data suggest that the Hawaii-based longline fisheries are more likely to capture leatherback turtles from Indonesia, over a period of several years, we would expect these fisheries to capture turtles from the other, smaller nesting aggregations.

6.2.2.4 Loggerhead Sea Turtle

DEMOGRAPHIC PATTERNS OF EXPOSURE. Most interactions between the Hawaii-based longline fishery and sea turtles involve loggerhead sea turtles. Based on genetic analyses of 124 loggerheads captured previously in this fishery, almost all of the loggerhead turtles that are exposed to the fishery are from the Japanese nesting aggregations (Dutton, *et al.*, 1998). The majority of these turtles represent the 40 different nesting beaches in southern Japan while a small percentage (about 5 percent of the turtles sampled) represent a rare genetic type that is unique to two nesting beaches on Yakushima Island off southern Japan (Kamezaki et al. 2003, P. Dutton, NOAA-Fisheries, personal communication, December, 2003).

The proposed fisheries would primarily capture or interact with loggerhead sea turtles in the oceanic juvenile[25] stage of development(Bolten 2003).

BEHAVIORAL PATTERNS OF EXPOSURE. For their first years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. Large aggregations of juveniles off Baja California have been observed foraging on dense concentrations of the pelagic red crab. Loggerheads in the north Pacific are opportunistic feeders that target items floating at or near the surface, including gastropods, medusae, and pyrosomas. If high densities of prey are present, they will actively forage at depth (Parker, *et al.*, in press). Based on their foraging pattern, loggerhead turtles may be attracted to bait or lightsticks on longline gear. If gillnet gear collects medusae or pyrosomas during their sets, loggerhead sea turtles may become entangled while foraging on this “catch.”

A recent study (Polovina *et al.*, 2004) found that tagged turtles spent 40 percent of their time at the surface and 90 percent of their time at depths shallower than 40 meters. On only five percent of recorded dive days loggerheads dove to depths greater than 100 meters at least once. In the areas that the loggerheads were diving, there was a shallow thermocline at 50 meters. There were also several strong surface temperature fronts the turtles were associated with, one of 20°C at 28°N and another of 17°C at 32°N. These patterns suggest that loggerhead turtles are more likely to interact with fishing gear that fishes at the surface or shallow depths. This is borne out by patterns that have been observed in longline and drift gillnet fisheries. In addition, two loggerheads were incidentally caught in the albacore surface hook and line fishery which fishes at the surface or very shallow depths.

Loggerhead hatchlings on nesting beaches in Japan undertake developmental migrations in the North Pacific, using the Kuroshio and North Pacific Currents. Loggerheads tagged in Mexico and California with flipper and/or satellite transmitters have been monitored returning to Japanese waters (Resendiz, et al., 1998a-b). Loggerheads appear to utilize surface convergent forage habitat to capture their primary prey organisms which float along currents and congregate at fronts.

Based on oceanographic conditions, the loggerheads were associated with fronts, eddies, and geostrophic currents. The turtles moved with the seasonal movements of the Transition Zone Chlorophyll Front (TZCF), although they tended to remain south of the front itself, and were

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[25] In previous biological opinions on the Pelagic fisheries, , this stage had been termed “pelagic juvenile” stage.

found along the southeastern edge of the Kuroshio Extension Current (KEC) and the northern edge of the Subtropical Gyre (Polovina *et al.* 2004). The TZCF and KEC appear to be important forage habitat for loggerhead turtles as these areas contain colder, plankton-rich waters. The tagging studies indicate that loggerheads may spend months at the edge of eddies in these areas. As this area has also been found to be an important foraging habitat for juvenile bluefin tuna (Ingake *et al.* 2001 *in* Polovina *et al.* 2004), overlaps between fisheries targeting these fish and others with similar habitat associations are likely to also encounter loggerhead sea turtles.

SPATIAL PATTERNS OF EXPOSURE. From 1994 to 2003, observers recorded the capture of 147 loggerhead sea turtles by the Hawaii-based longline fisheries. The existing data on these interactions revealed clear spatial patterns between the Hawaii-based longline fisheries and loggerhead turtles. For example, McCracken (2000) reported that none of 1,263 sets that were observed south of 22°N captured loggerhead turtles. Kleiber (1998) also found latitude seemed to determine the chances of interactions between the fisheries and loggerhead turtles.

Statistical analyses of these captures to determine possible associations with several different variables like sea surface temperature, latitude, and the distance to the approximate 17°C and 19°C isotherms was highly correlated with these variables. Degree of latitude appeared to be a primary determinant of the probability of loggerhead captures in the fisheries. Of 55 trips in which loggerheads were captured, 29 had captured loggerheads in more than one set, suggesting that loggerhead turtles forage or migrate in groups, that longline vessels target swordfish and tuna in areas of high loggerhead concentration, or both.

Other data suggest that loggerhead turtles forage or migrate in groups. Off Baja California, thousands of loggerhead turtles have been observed feeding on pelagic crabs. In the Atlantic Ocean, 68.1% of the loggerhead turtles captured in longline gear were caught in sets with other loggerheads compared with 31.9% that were caught singly (Hoey, 1998). Recent satellite tracking by Polovina *et al.* (2000, 2003, 2004) indicates that all life states of loggerhead turtles actively migrate, swimming against weak geostrophic currents along two convergent fronts as they travel from east to west across the Pacific. Of nine juvenile loggerheads tracked in the central North Pacific, six associated with a front characterized by 17°C sea surface temperature (termed "cool group") and the other three associated with a front with a sea surface temperature of 20°C ("warm group"). Seasonally, these 17°C and 20°C isotherms move north and south over 10 degrees of latitude, and as the turtles moved westward, they also appeared to move north and south coincident with these isotherms. During the first quarter, the distribution of shallow longline sets is largely between the 17°C and 20°C sea surface temperature fronts used by loggerheads.

Swordfish are believed to move south through these fronts, perhaps following squid. For example, during the second quarter, the fishery tends to locate well south of the front formed along the 17°C isotherm but overlapping with the front formed along the 20°C isotherm. Sea turtles tracked during the first quarter of the years (1997 and 1998) occupied waters with a mean of 17°C sea surface temperature (SST), with considerable overlap with the SST associated with the fishery in the northern portion of the fishing grounds. As the fishery moves south in the second quarter, those "warm group" turtles following the 20°C front may be well within the fishing ground, while the "cool group" will likely be well north of the fishing ground (Polovina, *et al.*, 2000). Observer data shows that the interaction rate (or the number of turtles captured per longline set) is substantially greater at 17°C SST than at 20°C SST (P. Kleiber, NOAA-Fisheries, personal communication *in* Polovina, *et al.*, 2000).

Finally, all of the 147 loggerheads observed taken by the Hawaii-based longline fishery from 1994-1999 were captured by longline vessels using shallow sets (i.e. target depth less than 100 meters, using less than 10 hooks per float, fishing at night, using lightsticks). The mean dive depth for loggerhead turtles (post-nesting female and subadult) is between 9 and 22 meters; therefore, loggerhead turtles are more likely to be captured by shallow sets than deep sets (which generally target depths greater than 100 meters).

TEMPORAL PATTERS OF EXPOSURE. The interactions between the Hawaii-based longline fisheries and loggerhead sea turtles had a temporal pattern. There are no reports of loggerhead turtle being captured by the fishery during May or June. In the past, most loggerhead turtles were captured during the fall and winter months, especially January and February.

EXPOSURE TO THE PROPOSED FISHERIES. Assuming that patterns observed in the past represent future patterns, loggerhead sea turtles will be exposed to the Hawaii-based longline fisheries. As proposed, the Hawaii-based longline fisheries would be modified to require longline vessels to use management measures that have proven effective at reducing the number and rate of interactions between leatherback and loggerhead sea turtles: the use of 18/0 10° offset circle hook with squid bait. Like the leatherback turtles that were discussed previously, fishing experiments conducted in the North Atlantic Ocean demonstrated that interaction rates of loggerhead turtles were significantly reduced with the18/0 10° offset circle hook with squid bait compared with J-hooks with squid bait that have been used historically. On average, the interaction rate of loggerhead turtles declined by 85% in these experiments. Interaction rates between leatherback turtle were also significantly reduced by using mackerel as bait rather than squid on J-hooks. On average, the interaction rate of leatherback turtles declined by 75% using mackerel bait. The greatest reduction in loggerhead interactions was achieved using a combination of mackerel bait with an 18/0 circle hook with a 10° offset. On average, the interaction rate of loggerhead turtles declined by 92% with these modifications.

With the proposed management regime for the Hawaii-based longline fisheries, including these gear modifications, about 21 (95% confidence interval = 8 - 64) loggerhead turtles are expected to be captured by the Hawaii-based longline fisheries each year. As in the past, most of these turtles (81%) will be exposed to shallow-set gear: about 17 loggerhead turtles (95% confidence interval = 7 - 55) are expected to be captured by the shallow-set gear, while about 18 turtles (95% confidence interval = 4 to 9) are expected to be captured by deep set gear.

Based on genetic sampling of the loggerhead turtles captured in these fisheries in the past, these loggerhead turtles will represent nesting beaches from southern Japan (P. Dutton *et al.*, 2000; P. Dutton, NOAA-Fisheries, personal communication, January, 2001). If the longline fisheries affect leatherback turtle populations proportional to their relative abundance in the action area, about 1 of the 21 loggerhead turtles that are expected to be captured in the Hawaii-based longline fisheries each year would represent the turtles that nest on two beaches on Yakushima Islands in southern Japan, while the remaining 20 of the 21 loggerhead turtles would represent turtles that nest elsewhere in southern Japan.

6.2.2.5 Olive Ridley Sea Turtle

DEMOGRAPHIC PATTERNS OF EXPOSURE. Olive ridley sea turtles are exposed to the Hawaii-based longline fisheries and have been reported being exposed to the longline fisheries based out of American Samoa. The turtles that interact with longline vessels based in American Samoa are likely to be individuals from western Pacific nesting beaches, although we cannot assign probabilities to any particular nesting aggregations.

Genetic analyses of olive ridley sea turtles captured previously in the Hawaii-based longline fisheries identified olive ridley turtles from nesting aggregations in the eastern, western, and Indian Pacific Ocean. Of 20 olive ridleys captured by the Hawaii-based longline fishery, 8 (40 %) were from the Indian Ocean or western Pacific Ocean and 12 (60%) were from the eastern Pacific (P. Dutton, NOAA-Fisheries, personal communication, January, 2001). Based on these data we assume that the olive ridley turtles that are exposed to the Hawaii-based longline fisheries represent the threatened western Pacific population and the endangered eastern Pacific population. Most of these sea turtles will be sub-adults or adults.

BEHAVIORAL PATTERNS OF EXPOSURE. Recent observations of the diving behavior of olive ridley sea turtles in the Pacific by the NMFS Pacific Islands Science Center (Jeffery Polovina, NMFS PIFSC, pers. comm.) suggest that they spend over 90% of their time at depths of less than 100 m. Swimming at these depths in the Pacific places olive ridley sea turtles in the zone where shallow-set swordfish targeting longline gear, or the shallowest of hooks on deeper tuna targeting gear would be deployed by the Hawaii longline fleet This information suggests that the Hawaii-based longline fishing fleet targeting tuna can reduce the exposure of olive ridley turtles to their gear by setting the line below the dive depths of these turtles.

SPATIAL PATTERNS OF EXPOSURE. The existing data on these interactions revealed clear spatial patterns between the Pelagics fisheries and olive ridley turtles. In addition, the fishery interacted with olive ridleys throughout the fishing area, with captures reported from as far north as 33°N to as far south as 7°N latitude, and from longitudes 143°W, west to 175°W. Sea surface temperatures, latitude, and the distance to the approximate 17°C and 19°C isotherms were associated with the takes, but there was a high degree of collinearity between these variables. There was a clear distinction between the proportion of takes between the two categories of sea surface temperature, but over latitude, the pattern was less clear (McCracken, 2000).

TEMPORAL PATTERNS OF EXPOSURE. In the past, interactions between olive ridley sea turtles and longline vessels had a weak temporal pattern: olive ridley turtles have been captured in every month of the year, except February, with most of the captures occurring between May and August.

EXPOSURE TO THE PROPOSED FISHERIES. Assuming that patterns observed in the past represent future patterns, olive ridley sea turtles will be exposed to longline fisheries based out of Hawaii and American Samoa. The number of olive ridley turtles that have been captured by other fisheries included in the Pelagics FMP are expected to be minimal one olive ridley turtle was reported to have been captured but not killed by the longline fisheries based in American Samoa in 1999. No interactions have been reported since then, but it is important to note that these fisheries are not observed, so the absence of reports may only reflect the absence of sampling rather than the absence of interactions.

The degree to which the proposed management measures (circle hooks and mackerel style bait) will benefit olive ridley sea turtles remains unknown since they were not (and could not have been) included in the experiments that were conducted in the North Atlantic. However, because of similarities between the diving behavior and dive depths of leatherback turtles and olive ridley turtles, we would expect the measures would benefit olive ridley turtles that interact with shallow-set gear like they benefit leatherback turtles. With the proposed management regime for the Hawaii-based longline fisheries, about 42 (95% confidence interval = 23 - 76) olive ridley turtles are expected to be captured by the Hawaii-based longline fisheries each year. As in the past, and because of their diving habit, most of these turtles (60%) will be exposed to deep-set gear: about 37 olive ridley sea turtles (95% confidence interval = 21 - 60) are expected to be captured by deep-set gear, while about 5 turtles (95% confidence interval = 2 to 16) are expected to be captured by shallow-set gear.

Based on genetic sampling of the olive ridley sea turtles captured in these fisheries in the past, these turtles will represent nesting beaches both the eastern and western Pacific Ocean as well as the Indian Ocean (P. Dutton *et al.*, 2000; P. Dutton, NOAA-Fisheries, personal communication, January, 2001). If the longline fisheries affect olive ridley turtle populations proportional to their relative abundance in the action area, about 31 of the 41 olive ridley turtles that are expected to be captured in the Hawaii-based longline fisheries each year would represent endangered olive ridley turtles from the eastern tropical Pacific , while 11 of the 41 olive ridley turtles would represent turtles from the western Pacific or Indian Oceans.

6.2.3. Factors contributing to the likelihood of an interaction with the longline fishery

6.2.3.1 Gear

FLOATS. Sea turtles may be attracted to the floats used on longline gear. Sea turtles have been observed associating with manmade floating objects significantly more frequently than with natural objects, perhaps related to turtles' affinity for three-dimensional objects. Turtles also show a preference for objects floating horizontally and nearly submerged and are strongly attracted to brightly colored objects (Arenas and Hall, 1992). Floats typically used during swordfish-style sets are bright orange, bullet-shaped, and slightly submerged. Tuna-style sets generally use larger cylindrical inflatable or rigid spherical buoys and floats, and these also are typically orange in color (L. Enriquez, NOAA-Fisheries, personal communication, January, 2001; e.g. www.lindgren-pitman.com/floats.htm).

BAIT. Sea turtles may also be attracted to the bait used on longline gear. Four olive ridleys necropsied after being taken dead by Hawaii-based longliners were found with bait in their stomachs (Work, 2000). In addition, a leatherback has been documented ingesting squid bait on swordfish longline gear. The authors speculate that the lightsticks may initially have attracted the turtle, by simulating natural prey (Skillman and Balazs, 1992).

6.2.3.2 Environmental conditions

Environmental conditions may also play a large part in whether or not a sea turtle interacts with longline gear. Sea turtles in the open ocean are often found associated with oceanographic discontinuities such as fronts and driftlines, areas often indicating high productivity. In addition, sea turtles also appear to associate with particular sea surface temperatures . As mentioned in more detail later, species such as the loggerheads have been tracked moving along convergent ocean fronts, in waters with sea surface temperatures of 17° C and 20° C (Polovina, *et al.*, 2000). Swordfish are caught by longliners in association with frontal zones where ocean currents or water masses meet to create turbulence and sharp gradients of temperature and salinity. Swordfish also make vertical migrations through the water column, rising near to the surface at night from deep waters. Thus, while searching for concentrations of swordfish, longliners set their gear across these temperature gradients ("breaks") indicative of intersecting water masses, and when sea turtles are associated with these fronts, interactions are more likely.

6.3 Response of Sea Turtles Given Exposure

As discussed in the Assessment Approach, once we have identified which listed resources are likely to be exposed to the proposed fisheries, we conduct response analyses to identify how listed resources are likely to respond once exposed to the fisheries.

The most significant hazard the pelagics fisheries present to sea turtles results from potential entanglement in or hooking by gear used in the fisheries which can injure or kill turtles. Turtles that are entangled in or hooked by gear can drown after being prevented from surfacing for air; alternatively, turtles that are hooked, but do not die from their wounds, can suffer impaired swimming or foraging abilities, altered migratory behavior, and altered breeding or reproductive patterns. Although survivability studies have been conducted on sea turtles captured in longline fisheries, such long-term effects are nearly impossible to monitor; therefore a quantitative measure of the effect of longlining on sea turtle populations is very difficult. Even if turtles are not injured or killed after being entangled or hooked, these interactions can be expected to elicit stress-responses in the turtles that can have longer-term physiological or behavioral effects. The following discussion summarizes the information on how sea turtles are likely to respond to these interactions with fishing gear.

6.3.1. Entanglement in Longline Gear

Sea turtles are particularly prone to being entangled in fishing gear because of their body configuration and behavior. Records of stranded or entangled sea turtles reveal that fishing debris can wrap around the neck or flipper, or body of a sea turtle and severely restrict swimming or feeding. Over time, if the sea turtle is entangled when young, the fishing line will become tighter and more constricting as the sea turtle grows, cutting off blood flow, causing deep gashes, some severe enough to remove an appendage. Sea turtles have also been found trailing gear that has been snagged on the bottom, thus causing them to be anchored in place (Balazs, 1985).

Sea turtles have been found entangled in branchlines (gangions), mainlines and float lines. Longline gear is fluid and can move according to oceanographic conditions determined by wind and waves, surface and subsurface currents, etc.; therefore, depending on both sea turtle behavior, environmental conditions, and location of the set, turtles could be entangled in longline gear. Entanglement in monofilament line (mainline or gangion) or polypropylene (float line) could result in substantial wounds, including cuts, constriction, or bleeding on any body part. In addition entanglement could directly or indirectly interfere with mobility, causing impairment in feeding, breeding, or migration. Sea turtles entangled by longline gear are most often entangled around their neck and foreflippers, and, often in the case of leatherback entanglements, turtles have been found snarled in the mainline, floatline, and the branchline (e.g. Hoey, 2000).

6.3.2. Hooking (Longline Gear)

In addition to being entangled in a longline, sea turtles are also injured and killed by being hooked. Hooking can occur as a result of a variety of scenarios, some of which will depend on foraging strategies and diving and swimming behavior of the various species of sea turtles. For example, necropsied olive ridleys have been found with bait in their stomachs after being hooked; therefore, they most likely were attracted to the bait and attacked the hook. In addition, leatherbacks, loggerheads and olive ridleys have all been found foraging on pyrosomas which are illuminated at night. If lightsticks are used on a shallow set at night to attract the target species, the turtles could mistake the lightsticks for their preferred prey and get hooked externally or internally by a nearby hook. Similarly, a turtle could concurrently be foraging in or migrating through an area where the longline is set and could be hooked at any time during the setting, hauling, or soaking process.

Sea turtles are either hooked externally - generally in the flippers, head, beak, or mouth - or internally, where the animal has attempted to forage on the bait, and the hook is ingested into the gastro-intestinal tract, often a major site of hooking (E. Jacobson, *in* Balazs, *et al.*, 1995). Even if the hook is removed, which is often possible with a lightly hooked (i.e. externally hooked) turtle, the hooking interaction is believed to be a significant event. Like most vertebrates, the digestive tract of the sea turtle begins in the mouth, through the esophagus, and then dilates into the stomach. The esophagus is lined by strong conical papillae, which are directed caudally towards the stomach (White, 1994). The existence of these papillae, coupled with the fact that the esophagus snakes into an s-shaped bend further towards the tail make it difficult to see hooks, especially when deeply ingested. Not surprisingly, and for those same reasons, a deeply ingested hook is also very difficult to remove from a turtle's mouth without significant injury to the animal. The esophagus is attached fairly firmly to underlying tissue; therefore, when a hook is ingested, the process of movement, either by the turtle's attempt to get free of the hook or by being hauled in by the vessel, can traumatize the internal organs of the turtle, either by piercing the esophagus, stomach, or other organs, or by pulling the organs from their connective tissue. Once the hook is set and pierces an organ, infection may ensue, which may result in the death of the animal.

If a hook does not become lodged or pierce an organ, it can pass through to the colon, or even be expelled through the turtle (E. Jacobson *in* Balazs, *et al.*, 1995). In such cases, sea turtles are able to pass hooks through the digestive track with little damage (Work, 2000). Of 38 loggerheads deeply hooked by the Spanish Mediterranean longline fleet and subsequently held in captivity, six loggerheads expelled hooks after 53 to 285 days (average 118 days)Aguilar, *et al.* (1995) . If a hook passes through a turtle's digestive tract without getting lodged, the chances are good that less damage has been done. Tissue necrosis that may have developed around the hook may also get passed along through the turtle as a foreign body (E. Jacobson, *in* Balazs, *et al.*, 1995).

6.3.3. Trailing Gear

Trailing line is line that is left on a turtle after it has been captured and released, particularly line trailing from an ingested hook. Turtles are likely to swallow line trailing from an ingested hook, which may occlude their gastrointestinal tract, preventing or hampering the turtle when it feeds. As a result, trailing line can eventually kill a turtle shortly after the turtle is released or it may take a while for the turtle to die.

Trailing line can also become snagged on a floating or fixed object, further entangling sea turtles or the drag from the float can cause the line to constrict around a turtle's appendages until the line cuts through the appendage. With the loss of a flipper a turtle's mobility is reduced, as is its ability to feed, evade predators, and reproduce. Observers on longliners that have captured (hooked) a turtle are directed to clip the line as close to the hook as possible in order to minimize the amount of trailing gear. This is difficult with larger turtles, such as the leatherback, which often cannot practicably be brought on board the vessel, or in inclement weather, when such action might place the observer or the vessel and its crew at risk. Turtles captured by vessels without observers may not have the line cut as close to the hook as possible because this is not required under the proposed action.

6.3.4. Post-hooking Survival

Research has been conducted in both the Atlantic and the Pacific to estimate post-hooking survival and behavior of sea turtles captured by longline. In the Pacific, from 1997 to late 2000, a total of 54 pelagic turtles hooked by the Hawaii-based longline fishery have had satellite transmitters attached to them in order to track their location and distance traveled following the interaction. Of these 54 turtles, 15 produced no transmissions, or their transmissions lasted less than a month - 11 had deeply ingested hooks (turtles had swallowed the hook, and it was not removed) and 4 were lightly hooked.(turtles had the hook lodged externally (beak or flipper), permitting easy removal) (D. Parker and G. Balazs, NMFS, personal communication, April, 2002). The researchers made no assumptions about the fate of the turtles that failed to transmit or only transmitted for a short period of time. Assuming that the satellite transmitter was working correctly, there are a number of possible explanations for few or no transmissions, any of which could be correct.

Following hooking incidents — including forced submergence, hauling of the longline and subsequent capture on the vessel — turtles that had been released may not have had time to recover from their experience. As discussed earlier, turtles that expend energy as a result of increased activity, need time at the surface to process lactic acid loads. Sea turtles often appear to be moving fairly well and then just collapse, while they rebuild their energy stores or repay their oxygen debt (E. Jacobsen, *in* Balazs, *et al.*, 1995). If a turtle does not have enough energy to remain afloat, it could submerge and die. In addition, injuries sustained as a result of the hooking incident, especially in incidents where the hook may have perforated an organ, may also result in death to the turtle. In both instances, the turtle sinks with the transmitter, and no signal is received. Whether or not these turtles remained submerged and therefore died, or the transmitters failed to transmit is a matter of speculation.

For the 34 turtles that did produce successful tracks for periods lasting more than a month, there were no significant differences ($P>0.05$) found for the duration of tracking (days) and the distance traveled between lightly hooked turtles ($n=15$) and turtles with deeply ingested hooks ($n=19$). Even when the 15 turtles that did not produce successful tracks were taken into account, no significant differences were found in terms of distance traveled and duration between the two groups (19 total lightly hooked, and 30 total deeply ingested). Furthermore, when species were analyzed individually for the two categories, no significant differences were found.

Polovina (NMFS, personal communication, September, 2000) used a contingency table approach to analyze the transmission duration in intervals of 1 month for 34 loggerheads (including those w/ few or no transmissions), comparing lightly hooked versus deeply hooked turtles. While 43% of the deeply hooked turtles transmitted less than one month compared to 27% of the lightly hooked turtles, the chi-squared test found no significant difference between the transmission distributions for these two categories. When the data for all hard shell turtles are combined ($n=48$), 22% ($n=4$) lightly hooked and 37% ($n=11$) deeply hooked turtles transmitted less than one month. Again, the difference between hooking categories was not statistically significant based on a chi-square test.

Data were also analyzed to determine whether the length of the turtle (in straight carapace length) played any role in determining differences between deeply hooked turtles and those that were lightly hooked. Only all satellite tagged loggerheads (both with successful tracks and without ($n=35$)) showed a significant difference ($P=0.02$) in size between deeply ingested (mean size = 62.0 ± 10.9 cm) and lightly hooked (mean size = 53.0 ± 6.6 cm) (D. Parker and G. Balazs, NMFS, personal communication, November, 2000).

In the eastern Atlantic, in the waters around the Azores, three juvenile loggerheads that had been lightly hooked by swordfish longline gear were instrumented with satellite-linked time-depth recorders in 1998. The number of dives performed by these hooked turtles was compared to five juvenile loggerheads that had been captured by dipnet and also instrumented. Turtles caught on longline fishing gear had significantly lower dive counts than turtle caught with dipnets during the normal (observed) period of most intense diving activity (from 9:00 am to 3:00 pm) (Bjorndal, *et al.*, 1999). During a similar study in the summer of 2000, in the same area of the Atlantic, 10 pelagic juvenile loggerheads were instrumented - four were captured with dipnets (control), and six had been deeply hooked. In all periods of the 24-hour day (separated by 6-hour increments), the hooked turtles appeared to make longer and shallower dives than control turtles, but overall, dive behavior appeared similar between hooked and non-hooked turtles, having a diurnal component (shallowest dives occurring during 21:00 and 03:00) and a seasonal component (dive depth generally increased for most turtles from summer into fall) (Riewald, *et al.*, 2000). Caution was given in interpreting both sets of data, as the studies were ongoing at the time of writing. However, as we will discuss below, NOAA-Fisheries recently convened a workshop to review post-hooking mortality estimates.

6.3.4.1. Forcible Submergence

Sea turtles can be forcibly submerged by drift gillnet or longline gear, or in the FADs deployed by purse seiners. Forcible submergence may occur through a hooking or entanglement event, where the turtle is unable to reach the surface to breathe. This can occur at any time during the set, including the setting and hauling of the gear, and generally occurs when the sea turtle encounters a net or line that is too deep below the surface, or is too heavy to be brought up to the surface by a swimming sea turtle. For example, a sea turtle that is hooked on a 3 meter branchline attached to a mainline set at depth by a 6 meter floatline will generally not be able to swim to the surface unless it has the strength to drag the mainline approximately 3 more meters (discussed further below).

When interacting with longline gear, hooked sea turtles will sometimes drag the clip, attached to the branch line, along the main line. If this happens, the potential exists for a turtle to become entangled in an adjacent branch line which may have another species hooked such as a shark, swordfish, or tuna. According to observer reports, most of the sharks and some of the larger tuna such as bigeye are still alive when they are retrieved aboard the vessel, whereas most of the swordfish are dead. If a turtle were to drag the branch line up against a branch line with a live shark or bigeye tuna attached, the likelihood of the turtle becoming entangled in the branch line is greater. If the turtle becomes entangled in the gear, then the turtle may be prevented from reaching the surface. The potential also exists, that if a turtle drags the dropper line next to a float line, the turtle may wrap itself around the float line and become entangled.

During drift gillnet operations, a sea turtle may encounter a net when swimming or foraging at depth. The net is suspended below the sea surface by the ball buoys to a depth equal to the length of the buoylines. This depth has historically ranged from 18 ft to as much as 90 ft, but is currently limited by regulations enacted under the Marine Mammal Protection Act (MMPA) to a minimum depth of 36 feet below the sea surface. Since the CA/OR drift gillnet fishery is required to fish at this minimum depth, a sea turtle would have to either be swimming at or below this depth to encounter the net. On the other hand, a sea turtle could be entangled when swimming shallower than 36 feet during the hauling or setting of the gear.

Sea turtles have been observed entangled in FADs. Such entanglement has lead to mortality, likely through drowning. Sea turtles can become entangled in any part of the FAD, including the webbing or lines associated with it.

RESPONSE OF SEA TURTLES TO BEING SUBMERGED. Sea turtles forcibly submerged for extended periods of time show marked, even severe, metabolic acidosis as a result of high blood lactate levels. With such increased lactate levels, lactate recovery times are long (even as much as 20 hours), indicating that turtles are probably more susceptible to lethal metabolic acidosis if they experience multiple captures in a short period of time, because they would not have had time to process lactic acid loads (*in* Lutcavage and Lutz, 1997). Kemp's ridley turtles that were stressed from capture in an experimental trawl (≤ 7.3 minute forcible submergence) experienced significant blood acidosis, which originated primarily from non-repiratory (metabolic) sources. Visual observations indicated that the average breathing frequency increased from approximately 1-2 breaths/minute pre-trawl to 11 breaths/minute post-trawl (a 9 to 10-fold increase). Given the magnitude of the observed imbalance, complete recovery of acid-base homeostasis may have required 7 to 9 hours (Stabenau *et al.*, 1991). Similar results were reported for Kemp's ridleys captured in entanglement nets - turtles showed significant physiological disturbance, and post-capture recovery depended greatly on holding protocol (Hoopes *et al.*, 2000).

Presumably, however, a sea turtle recovering from a forced submergence would most likely remain resting on the surface (given that it had the energy stores to do so), which would reduce the likelihood of being recaptured by a submerged longline. Recapture would also depend on the condition of the turtle and the intensity of fishing pressure in the area. NMFS has no information on the likelihood of recapture of sea turtles by HMS fisheries. However, in the Atlantic Ocean, turtles have been reported as captured more than once by longliners (on subsequent days), as observers reported clean hooks already in the jaw of captured turtles. Such multiple captures were thought to be most likely on three or four trips that had the highest number of interactions (Hoey, 1998).

Stabenau and Vietti (2003) studied the physiological effects of multiple forced submergences in loggerhead turtles. The initial submergence produced severe and pronounced metabolic and respiratory acidosis in all turtles. As the number of submergences increased, the acid-base imbalances was substantially reduced; although successive submergences produced significant changes in blood pH, P_{CO_2}, and lactate. Increasing the time interval between successive submergences resulted in greater recovery of blood homeostatis. The authors conclude that as long as sea turtles have an adequate rest interval at the surface between submergences, their survival potential should not change with repetitive submergences.

Respiratory and metabolic stress due to forcible submergence is also correlated with additional factors such as size and activity of the sea turtle (including dive limits), water temperature, and biological and behavioral differences between species and will therefore also affect the survivability. For example, larger sea turtles are capable of longer voluntary dives than small turtles, so juveniles may be more vulnerable to the stress of forced submergence than adults. Gregory *et al.* (1996) found that corticosterone concentrations of small loggerheads captured were higher than those of large loggerheads captured during the same season. During the warmer months, routine metabolic rates are higher, so the impacts of the stress due to entanglement or hooking may be magnified (e.g. Gregory *et al.*, 1996). In addition, disease factors and hormonal status may also play a role in anoxic survival during forced submergence. Any disease that causes a reduction in the blood oxygen transport capacity could severely reduce a sea turtle's endurance on a longline, and since thyroid hormones appear to have a role in setting metabolic rate, they may also play a role in increasing or reducing the survival rate of an entangled sea turtle (*in* Lutz and Lutcavage, 1997). Turtles necropsied following capture (and subsequent death) by longliners in this fishery were found to have pathologic lesions. Two of the seven turtles (both leatherbacks) had lesions severe enough to cause probable organ dysfunction, although whether or not the lesions predisposed these turtles to being hooked could not be determined (Work, 2000). As discussed further in the leatherback and loggerhead subsections below, some sea turtle species are better equipped to deal with forced submergence.

Sea turtles also exhibit dynamic endocrine responses to stress. In male vertebrates, androgen and glucocorticoid hormones (corticosterone (CORT) in reptiles) can mediate physiological and behavioral responses to various stimuli that influence both the success and costs of reproduction. Typically, the glucocorticoid hormones increase in response to a stressor in the environment, including interaction with fishing gear. "During reproduction, elevated circulating CORT levels in response to a stressor can inhibit synthesis of testosterone or other hormones mediating reproduction, thus leading to a disruption in the physiology or behavior underlying male reproductive success" (Jessop *et al.*, 2002). A study in Australia examined whether adult male green turtles decreased either CORT or androgen responsiveness to a capture/restraint stressor to maintain reproduction. Researchers found that migrant breeders, which typically had overall poor body condition because they were relying on stored energy to maintain reproduction, had decreased adrenocortical activity in response to a capture/restraint stressor. Smaller males in poor condition exhibited a pronounced and classic endocrine stress response compared to the larger males with good body condition. The authors state: "We speculate that the stress-induced decrease in plasma androgen may function to reduce the temporary expression of reproductive behaviors until the stressor has abated. Decreased androgen levels, particularly during stress, are known to reduce the expression of reproductive behavior in other vertebrates, including reptiles." Small males with poor body condition that are exposed to stressors during reproduction and experience shifting hormonal levels may abandon their breeding behavior (Jessop *et al.*, 2002).

Female green turtles have also been studied to evaluate their stress response to capture/restraint. Studies showed that female green turtles during the breeding season exhibited a limited adrenocortical stress response when exposed to ecological stressors and when captured and restrained. Researchers speculate that the apparent adrenocortical modulation could function as a hormonal tactic to maximize maternal investment in reproductive behavior such as breeding and nesting (*in* Jessop, *et al.*, 2002).

Although a low percentage of turtles that are captured by longliners actually are reported dead, sea turtles can drown from being forcibly submerged. Such drowning may be either "wet" or "dry." In the case of dry drowning, a reflex spasm seals the lungs from both air and water. With wet drowning, water enters the lungs, causing damage to the organs and/or causing asphyxiation, leading to death. Before death due to drowning occurs, sea turtles may become comatose or unconscious. Studies have shown that sea turtles that are allowed time to stabilize after being forcibly submerged have a higher survival rate. This of course depends on the physiological condition of the turtle (e.g. overall health, age, size), time of last breath, time of submergence, environmental conditions (e.g. sea surface temperature, wave action, etc.), and the nature of any sustained injuries at the time of submergence (NRC, 1990).

6.3.4.2. Survival of Sea Turtles that Interact With Longline Gear

Between 1994 and 1999 observers recorded data on 239 interactions between turtles and longline fisheries that provide insights into the relative effects of the different longline sets on the survival of sea turtles. During this period, none of the turtles that had been captured in deep-set longline gear were released alive or uninjured from deep sets, compared to 6 of 225 turtles taken by shallow sets (2.7%). Although the number of interactions between the turtles and shallow-set longline gear represent a small sample size, these data still suggest that sea turtles caught in the two different gear types experience different rates of "immediate" mortality.

Eight of the 14 turtles (57%), or 0.0056 turtles per set, caught by deep sets were dead upon retrieval of the gear compared to three turtles (1.33%, or up to 4.9% if all unknown condition turtles are treated as dead) dead out of 225 turtles , or 0.0017 turtles per set, caught in shallow sets. Differences in species-specific "immediate" mortality between gear types are also apparent. Based on past observer data for 1,440 tuna-style sets, 50% of the green turtles, 33% of the leatherback turtles, and 83% of the olive ridley turtles died per set. Loggerhead turtles were not observed captured in this segment of the fishery. In 1,811 shallow sets, 11.8% of the leatherback turtles, 1.36% of the loggerhead turtles, 3.85% of the olive ridley turtles, and 40% of the unidentified sea turtles died per set (assuming that the 4 out of 10 turtles captured in "unknown" condition were mortalities). This difference between "immediate" death rates could have several explanations, although one possible explanation is that the turtles captured in deep sets could not reach the surface to breathe or rest, but turtles caught in shallow sets may be able to reach the surface. For example, on a shallow set, the length of the branch line is 17 meters. This length is more than half the distance between the hook and the surface (average target depth is 28 meters). With a float line length of 8 meters, the main line sag between floats would be about 3 meters or about 11 meters below the water surface. This means that a hooked turtle could swim to the surface and breathe because the branch line length is greater than the depth of the main line from the surface.

Overall mortality rates, or the combined, immediate and delayed mortality rates, are also notably different between the two fishing styles. In deep sets, five turtles were lightly hooked and one was entangled. These injuries were assigned a 0% post-interaction mortality rate (McCracken, 2000). In shallow sets, 108 turtles were lightly hooked, 103 were deeply hooked, and two were entangled. Deeply hooked turtles were assigned a post-interaction mortality rate of 29% (McCracken, 2000).

Given the assigned mortality rates for dead and deeply hooked sea turtles, the deep sets had a sea turtle mortality rate per take of 57% and the shallow sets had an overall sea turtle mortality rate per take of 14.7% (30 turtles killed by deep hook injuries [29% of 103 deep hooked turtles] and 3 turtles dead upon gear retrieval [100% mortality] = 33 turtles/225 turtles = 14.7%). This appears to be a considerable difference in overall mortality rates between the two types of fishing, however when overall mortality rates are calculated per set, it becomes apparent that shallow sets kill more turtles per set (0.0182 turtles per set versus 0.0056 turtles per set in deep sets) due to higher interaction rates and the higher incidence of deep hooking shallow sets have with turtles compared to deep sets. Revision of the kills per set data using more recent information on post-hooking delayed mortality (discussed below) which assigns a 27% mortality rate to externally hooked turtles with minor or moderate injuries and a 42% mortality rate to turtles with more serious injuries, including deep hooks, still indicates that shallow sets kill more turtles per set with 0.042 turtles killed per set compared to deep sets which kill 0.0081 turtles per set.

6.3.4.3. Post-Hooking Survival and Mortality

In February 2001, NOAA-Fisheries established a policy and criteria for estimating sea turtle survival and mortalities following interactions with longline fishing gear (Table 6.5 in NMFS 2001b). These criteria were based on the information that was available on the survival of leatherback sea turtles after they were captured and released from longline gear and were expected to be refined or revised once more information became available.

Table 6.1. Sea turtle mortality rates based on level and type of interaction with longline fishing gear. Source: NMFS, 2001b

Interaction	Response	Injury	Mortality Rate
Entangled / no hook	Disentangled	No injury	0%
Entangled / external hook	Disentangled, no gear	Minor	27%
	Disentangled, trailing gear	Moderate	27%
	Dehooked, no gear	Minor	27%
Hooked in beak or mouth	Hook left, no gear	Moderate	27%
	Hook left, trailing gear	Serious	42%
	Dehooked, no gear	Moderate	27%
Hook swallowed	Hook left, no gear	Serious	42%
	Hook left, trailing gear	Serious	42%
Turtle Retrieved Dead	---	Lethal	100%

In 2003, NOAA-Fisheries' Office of Protected Resources was charged with conducting a review of NOAA-Fisheries' February 2001 post-hooking mortality criteria and recommending if and how the earlier criteria should be modified. As part of that review, the Office of Protected Resources convened a Workshop on Marine Turtle Longline Post-Interaction Mortality on 15-16 January 2004, during which seventeen experts in the areas of biology, anatomy/physiology, veterinary medicine, satellite telemetry and longline gear deployment presented and discussed the more recent data available on the survival and mortality of sea turtles subsequent to being hooked by fishing gear. Based on the information presented and discussed at the workshop and a comprehensive review of all of the information available on the issue, the Office of Protected Resources proposed the following changes to the earlier criteria (see Table 6.2 for the criteria):

CATEGORIES. The February 2001 injury categories were expanded to better describe the specific nature of the interaction. The February 2001 criteria described two categories for mouth hooking: (1) hook does not penetrate internal mouth structure; and (2) mouth hooked (penetrates) or ingested hook. The new criteria divides the mouth hooking event into three components to reflect the severity of the injury and to account for the probable improvement in survivorship resulting from removal of gear, where appropriate, for each injury. The three components consist of: (1) hooked in esophagus at or below the heart (insertion point of the hook is not visible when viewed through the open mouth; (2) hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa[26] (insertion point of the hook is visible when viewed through the open mouth); and (3) hooked in lower jaw (not adnexa). The new criteria, also, separates external hooking from mouth hooking, eliminates the 'no injury' category, and adds a new category for comatose/resuscitated.

PROBABLE IMPROVEMENT IN SURVIVORSHIP WHEN GEAR IS REMOVED: The new criteria recognize that in most cases removal of some or all of the gear (except deeply-ingested hooks) is likely to improve the probability of survival. The categories for gear removal are: released with hook and with line that is greater than or equal to half the length of the carapace; released with hook and with line that is less than or equal to half the length of the carapace; and released with all gear removed. Turtles that have all or most of the gear removed are expected to have, on average, a higher probability of survival.

SPECIES DIFFERENCE: Species differences between hard-shelled turtles and leatherback turtles appears to play a role in post-interaction survival. The new criteria takes these differences into consideration and assign slightly higher rates of post-interaction mortality for leatherback turtles.

Mortality estimates for turtles taken by the Hawaii-based longline fishery were based on limited data from Aguilar, *et al.* (1995) and from information recorded by observers on the condition of the turtles when released (Kleiber, 1998). Aguilar, *et al.* (1995) estimated a 29% mortality rate for loggerheads ingesting a longline hook; therefore all turtles (hard-shelled and leatherback) that had been hooked internally were assigned a mortality rate of 29%. Turtles recorded as dead had a 100% mortality rate, and turtles recorded as okay (released uninjured) were assigned a 0% mortality rate. All species of turtles hooked externally were also assigned a 0% mortality rate (McCracken, 2000).

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[26] Subordinate part such as tongue, extraembryonic membranes

Table 6.2. Criteria for assessing marine turtle post-interaction mortality after release from longline gear. Percentages are shown for hardshelled turtles, followed by percentages for leatherbacks (in parentheses).

Nature of Interaction	Released with hook and with line greater than or equal to half the length of the carapace	Release with hook and with line less than half the length of the carapace	Released with all gear removed
	Hardshell (Leatherback)	Hardshell (Leatherback)	Hardshell (Leatherback)
Hooked externally with or without entanglement	20 (30)	10 (15)	5 (10)
Hooked in lower jaw (not adnexa[27]) with or without entanglement	30 (40)	20 (30)	10 (15)
Hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa (and the insertion point of the hook is visible when viewed through the mouth) with or without entanglement	45 (55)	35 (45)	25 (35)
Hooked in esophagus at or below level of the heart (includes all hooks where the insertion point of the hook is not visible when viewed through the mouth) with or without entanglement	60 (70)	50 (60)	n/a[28]
Entangled Only	Released Entangled 50 (60)		Fully Disentangled 1 (2)
Comatose/resuscitated	n/a[29]	70 (80)	60 (70)

[27] Subordinate part such as tongue, extraembryonic membranes

[28] Per veterinary recommendation hooks would not be removed if the insertion point of the hook is not visible when viewed through the open mouth.

[29] Assumes that a resuscitated turtle will always have the line cut to a length less than half the length of the carapace, even if the hook cannot be removed.

Observers occasionally could not gather all of the information necessary to use these criteria (for example, they could not identify the species of some of the sea turtles that had been captured or assess their condition accurately). Turtles in this category, which are considered "hooked in an unknown location," were assigned the average mortality of the turtles of their species with a known hook location. Turtles with an unknown condition (i.e. not recorded) were assigned the average within species of turtles with condition "okay," internally hooked, or externally hooked. For hardshell turtles that were hooked in an unknown location or unknown condition, the averaging was conducted over all turtles except leatherback turtles (Kleiber, 1998) and adjusted to consider the temperature or latitude of the interaction (McCracken, 2000). For example, there were 10 unidentified hardshell turtles observed taken from 1994 to 1999. The identity of these turtles was apportioned to loggerhead, olive ridley, or green turtle takes in the same proportion as observed takes of these species, and, except for green turtles, using the prediction models for each species. Based on the prediction models, the number of olive ridley turtles captured by the fishery were higher at temperatures greater than 24.22°C, whereas the number of loggerhead turtles captured by the fishery were higher at temperatures less than 23.77°C. If the sea surface temperature was not a clear indicator, the observed latitude was used to determine the species, since loggerhead takes were higher in the northern latitudes. In the two instances where the choice between the two species was completely unknown, the turtles were divided proportionally between the three hardshelled turtles (McCracken, 2000).

Because the abundance and distribution, migration and foraging patterns, and physiology vary so significantly between the four species of sea turtles that may be encountered by longliners fishing in the Pacific Ocean, their vulnerability to the Hawaii-based longline fishing operations also varies. The following sections review the past impacts that the Hawaii-based longline fishery has had on each of the sea turtle species.

6.3.5 Summary of Sea Turtle Responses to Interactions with the Fisheries

Green Sea Turtle. Assuming that patterns observed in the past represent future patterns, green sea turtles will be exposed primarily to longline fisheries based out of Hawaii and American Samoa. With the management regime proposed for the Hawaii-based fisheries, about 7 (95% confidence interval = 2 - 17) green turtles are expected to be captured by the fisheries each year. Unlike the past, most of these turtles (86%) would be captured by deep-set gear: about 6 green sea turtles (95% confidence interval = 1 - 13) are expected to be captured by deep-set gear, while 1 turtle (95% confidence interval = 1 to 5) is expected to be captured by shallow-set gear. We assume that another green turtle is likely to be captured by the longline fisheries based out of American Samoa in a single year or over any 5-year period.

Of the turtles that interact with the Hawaii-based longline fisheries, 5 (95% confidence interval = 1 - 11) are expected to die as a result of the exposure. Two to 4 of these 5 might be endangered green turtles from nesting beaches in Mexico while the remaining 1 or 2 green turtles killed in an interaction with longline gear would have originated in the Hawaiian nesting beaches. We assume that green turtles captured in the longline fisheries based out of American Samoan fisheries will be released unharmed.

Hawksbill Sea Turtle. Assuming that patterns observed in the past represent future patterns, we assume that individual hawksbill turtles will be exposed to the longline fisheries based out of American Samoa. The turtles that are captured by longline vessels based in American Samoa are likely to be individuals from western Pacific nesting beaches, although we cannot assign probabilities to any particular nesting aggregations.

Leatherback Sea Turtle. Assuming that patterns observed in the past represent future patterns, leatherback sea turtles will be exposed primarily to the Hawaii-based longline fisheries, although individual leatherback turtles are likely to be captured by longline fisheries based out of American Samoa. With the management regime proposed for the Hawaii-based longline fisheries, about 34 (95% confidence interval = 18 - 60) leatherback turtles are expected to be captured by the Hawaii-based longline fisheries each year. Interactions between the different types of gear and leatherback turtles is split almost equally. About 16 leatherback turtles (95% confidence interval = 9 - 30) are expected to be captured by the shallow-set gear, while about 18 turtles (95% confidence interval = 9 to 30) are expected to be captured by the deep set gear.

Of these turtles, 9 (95% confidence interval = 5 - 16) are expected to die as a result of the exposure. One of these 9 might be leatherback turtles from the eastern Tropical Pacific while the remaining 8 leatherback turtles killed in an interaction with longline gear would have originated in the western Pacific Ocean. Based on abundance patterns, we assume that most of the turtles that die as a result of exposure to longline gear would have originated in Indonesia, although leatherback turtles from any of the smaller nesting aggregations in the western Pacific Ocean have a risk of being captured, injured, or killed by these fisheries in some years.

Loggerhead Sea Turtle. With the proposed fishery management regime, about 21 (95% confidence interval = 8 - 64) loggerhead turtles are expected to be captured by the Hawaii-based longline fisheries each year. As in the past, most of these turtles (81%) will be exposed to shallow-set gear: about 17 loggerhead turtles (95% confidence interval = 7 - 55) are expected to be captured by the shallow-set gear, while about 4 turtles (95% confidence interval = 4 to 9) are expected to be captured by deep set gear.

Of these turtles, 4 (95% confidence interval = 2 - 13) are expected to die as a result of the exposure. Most of these loggerhead turtles would be oceanic juveniles originated from nesting beaches in southern Japan while oceanic juveniles from the two nesting beaches on Yakushima Island have a low risk of being killed in an interaction with longline gear in any particular year, but a small risk of being killed in those interactions over several years.

Olive Ridley Sea Turtle. Assuming that patterns observed in the past represent future patterns, olive ridley sea turtles will be exposed primarily to the longline fisheries; the number of olive ridley turtles that have been captured by other fisheries included in the Pelagics FMP are expected to be minimal – if any exposure occurs at all. With the proposed fishery management regime, about 42 (95% confidence interval = 23 - 76) olive ridley turtles are expected to be captured by the Hawaii-based longline fisheries each year. As in the past, and because of their diving habit, most of these turtles (60%) will be exposed to deep-set gear: about 37 olive ridley sea turtles (95% confidence interval = 21 - 60) are expected to be captured by deep-set gear, while about 5 turtles (95% confidence interval = 2 to 16) are expected to be captured by shallow-set gear.

Of these turtles, 36 (95% confidence interval = 20 - 56) are expected to die as a result of that exposure. Twenty-seven of these 36 olive ridley turtles would be endangered turtles that have migrated from the eastern Tropical Pacific while the remaining 9 killed in an interaction with longline gear would have originated in the western Pacific or Indian Oceans.

6.4 Risk Analyses

As discussed in the Approach to the Assessment, the final step of our assessment uses the results from our exposure and response analyses to ask (1) what is likely to happen to different nesting aggregations given the exposure and responses of individual members of those aggregations and (2) what is likely to happen to the populations or species those nesting aggregations comprise. These analyses form the foundation for our jeopardy determinations, which are designed to determine if we would reasonably expect threatened or endangered species to experience reductions in reproduction, numbers, or distribution that would appreciably reduce the species' likelihood of surviving and recovering in the wild (since the proposed fisheries are not likely to adversely affect designated critical habitat, this Opinion did not conduct "destruction and adverse modification analyses).

In the *Status of the Species and Environmental Baseline* sections of this Opinion, we discussed the various natural and human-related phenomena that caused the various sea turtle species to become threatened or endangered and continue to keep their populations suppressed. This section of the Opinion examines the physical, chemical, and biotic effects of the fisheries associated with the Pelagics FMP to determine (a) if those effects can be expected to reduce the reproduction, numbers, or distribution of threatened or endangered species in the action area, (b) determine if any reductions in reproduction, numbers, or distribution would be expected to appreciably reduce the Pacific Ocean population's likelihood of surviving and recovering in the wild, and (c) if appreciable reductions in the Pacific Ocean population's likelihood of surviving and recovering in the wild would cause appreciable reductions in the species (as listed) likelihood of surviving and recovering in the wild.

For the purposes of this analysis, we will assume that anything that places sea turtle populations in the Pacific Ocean at greater risk of extinction, also places the entire species at a greater risk of extinction; or, in other words, reduces the species' likelihood of survival and recovery. Although leatherback sea turtles appear to be faring better in the Atlantic, the species remains at risk in the Atlantic. This assumption is reasonable based on the relationship between local and regional persistence in species (Gotelli, 2001). Based on this relationship, the risk of regional extinction is lower than the risk of local extinction; however, as local probabilities change, the probability of regional persistence changes correspondingly.

Table 6.3. Annual estimates of the number of different species of sea turtles captured and killed by the Hawaii-based longline fisheries

Species and Scenario	Exposure Mean	Exposure Lower 95% CI	Exposure Upper 95% CI	Mortalities Mean	Mortalities Lower 95% CI	Mortalities Upper 95% CI
Green Sea Turtles	**7.0005**	**2.1948**	**17.3292**	**4.9246**	**1.4492**	**11.3654**
Scenario 1						
Eastern Tropical Pacific	3.50025	1.0974	8.6646	2.4623	0.7246	5.6827
Hawaiian population	0.84006	0.263376	2.079504	0.590952	0.173904	1.363848
Mixture	2.66019	0.834024	6.585096	1.871348	0.550696	4.318852
Rounded Values*						
Eastern Tropical Pacific	4.0	1.0	9.0	2.0	1.0	6.0
Hawaiian population	1.0	0.0	2.0	1.0	0.0	1.0
Mixture	3.0	1.0	7.0	2.0	1.0	4.0
Leatherback Sea Turtle	**34.2201**	**18.3357**	**60.4231**	**9.4051**	**4.8839**	**16.0657**
Scenario 1						
Eastern Tropical Pacific	4.790814	2.566998	8.459234	1.316714	0.683746	2.249198
Western Pacific nesting aggregations	29.429286	15.768702	51.963866	8.088386	4.200154	13.816502
Rounded Values*						
Eastern Tropical Pacific	5.0	3.0	8.0	1.0	1.0	2.0
Western Pacific nesting aggregations	29.0	16.0	52.0	8.0	4.0	14.0
Loggerhead Sea Turtle	**20.6438**	**8.2839**	**63.6645**	**4.4639**	**1.6061**	**12.8839**
Scenario 1						
Yakushima nesting aggregation	1.03219	0.414195	3.183225	0.223195	0.080305	0.644195
Other Japanese nesting aggregations	19.61161	7.869705	60.481275	4.240705	1.525795	12.239705
Rounded Values*						
Yakushima nesting aggregation	1.0	0.0	3.0	0.0	0.0	1.0
Other Japanese nesting aggregations	20.0	8.0	60.0	4.0	2.0	12.0
Olive Ridley Sea Turtle	**41.9963**	**23.0448**	**76.0295**	**35.8665**	**20.1617**	**59.2033**
Scenario 1						
Eastern Tropical Pacific	31.077262	17.053152	56.26183	26.54121	14.919658	43.810442
Western Pacific and Indian Ocean	10.919038	5.991648	19.76767	9.32529	5.242042	15.392858
Rounded Values*						
Eastern Tropical Pacific	31.0	17.0	56.0	27.0	15.0	44.0
Western Pacific and Indian Ocean	11.0	6.0	20.0	9.0	5.0	15.0

* Because of rounding, these values may produce estimates that, when summed, are higher than the initial total

6.4.1 Humpback Whale

Based on the available information on interactions between humpback whales and the longline fisheries, humpback whales have been entangled in longline fishing gear. However, based on the information available on these previous interactions, the interactions appear to be rare occurrences and, when they have occurred, the humpback whales do not appear to have been injured or killed by the interaction. Because the Western Pacific Pelagic Fisheries have a small probability of interacting with endangered humpback whales and, when they occur, they do not appear to kill or injure the whales, those interactions are not likely to reduce the reproduction, numbers, or distribution of humpback whales. As a result, they are not likely to reduce the humpback whales' likelihood of surviving and recovering in the wild.

6.4.2 Hawaiian Monk Seal

Based on unconfirmed logbook data, monk seals may become entangled or hooked in longline fishing gear. However, no interactions between monk seals and the fisheries have been observed (by personnel in NMFS' Observer Program), which we interpret to indicate that the likelihood of interactions between the fisheries and monk seals is small. Further, the single report of an interaction indicated that the seal was entangled in a shallow set which are now prohibited under the Pelagics FMP. Based on these data, NMFS does not anticipate future interactions between monk seals and longline gear.

As a result, the Western Pacific Pelagic Fisheries are not likely to reduce the reproduction, numbers, or distribution of monk seals. As a result, they are not likely to reduce the monk seals' likelihood of surviving and recovering in the wild.

6.4.3 Sperm Whale

Based on the available information on interactions between sperm whales and the longline fisheries, sperm whales have been entangled in longline fishing gear. However, based on the information available on these previous interactions, the interactions appear to be rare occurrences and, when they have occurred, the sperm whales did not appear to have been injured or killed by the interaction. Because the Western Pacific Pelagic Fisheries have a small probability of interacting with endangered sperm whales and, when they occur, they do not appear to kill or injure the whales, those interactions are not likely to reduce the reproduction, numbers, or distribution of sperm whales. As a result, they are not likely to reduce the sperm whales' likelihood of surviving and recovering in the wild.

6.4.4 Green Turtles

Assuming that patterns observed in the past represent future patterns, green sea turtles will be exposed primarily to longline fisheries based out of Hawaii and American Samoa. With the management regime proposed for the Hawaii-based fisheries, about 7 (95% confidence interval =

2 - 17) green turtles are expected to be captured by the fisheries each year. Unlike the past, most of these turtles (86%) would be captured by deep-set gear: about 6 green sea turtles (95% confidence interval = 1 - 13) are expected to be captured by deep-set gear, while 1 turtle (95% confidence interval = 1 to 5) is expected to be captured by shallow-set gear. We assume that another green turtle is likely to be captured by the longline fisheries based out of American Samoa in a single year or over any 5-year period.

Of the turtles that interact with the Hawaii-based longline fisheries, 5 (95% confidence interval = 1 - 11) are expected to die as a result of the exposure. Two to 4 of these 5 might be endangered green turtles from nesting beaches in Mexico while the remaining 1 or 2 green turtles killed in an interaction with longline gear would have originated in the Hawaiian nesting beaches. We assume that green turtles captured in the longline fisheries based out of American Samoan fisheries will be released unharmed.

These green turtles that interact with the Hawaii-based longline fisheries will be members of the endangered Mexican (Pacific coast) or threatened Hawaiian (French Frigate Shoals) nesting aggregations. Out of eight green turtles caught by the Hawaii-based longline fishery, genetic analyses concluded that four of the eight turtles (50%) represented nesting aggregations from the eastern Pacific (Mexico), one turtle (12.5%) represented the Hawaiian nesting aggregations, the remaining three turtles (37.5%) could have been from either of these two nesting aggregations (P. Dutton, NOAA-Fisheries, personal communication, January, 2001) but may also have represented other nesting aggregations in the Pacific Ocean.

Life history information collected by observers suggests that the Hawaii-based longline fisheries are likely to capture sub-adult and adult green turtles (straight carapace lengths ranged from 28.5 cm to 73.5 cm with an average of 51.5 cm).

Historically, the longline fishery has been more likely to hook green turtles externally than to entangle them or hook them internally. The tendency to be hooked externally seemed to result from their diet: because green turtles primarily feed on benthic, marine algae, they seemed less likely to be attracted to the baited hooks used in the longline fishery. As a result they were less likely to swallow baited hooks, which would reduce their likelihood of being hooked internally. Further, because of their diet and foraging strategy (green turtles usually forage in water less than 10 meters deep), green turtles were more likely to interact with shallow-set gear than deep-set gear.

Several authors have demonstrated that long-lived species that have evolved low, adult mortality rates, and delayed maturity cannot sustain high adult or juvenile mortalities without having increased extinction risk. For example, Crouse (1999) discussed the importance of high adult and juvenile survival in long-lived species with delayed maturity; after examining the population ecology of a large number of these species (including leatherback and loggerhead sea turtles, and several species of sharks, rockfish, groundfish, albatross, and whales), she concluded that seemingly small numbers of deaths in these species, particularly of adults and juveniles, could have catastrophic effects on the health of population of these long-lived species. Crouse (1999), Heppell (1999), and Caswell (2001) demonstrated that changes in the survival of adult and sub-adult stages of loggerhead turtles can have significant, short-term effects on the status and trend of these turtle populations. Heppell *et al.* (1999) reached similar conclusions based on demographic evaluations of several species of sea turtles and sharks. Congdon *et al.* (1999) and Congdon and Dunham (1984) reached the same conclusions after conducting demographic simulations of several species of long-lived freshwater turtles and sea turtles. Caswell *et al.* (1999) concluded that the loss of small numbers of adult females would be sufficient to critically endanger the western Atlantic population of northern right whales (*Eubalaena glacialis*), which is another long-lived species with delayed maturity.

Because of the similarities between these life history patterns and those of green turtles (they are long-lived, have high adult survival rates, and delayed maturity), we assume that changes in the survival of adult and sub-adult stages of green turtles would have significant, short-term effects on the status and trend of these turtle populations. Because of their life history pattern, the long lives and high, adult survival rates of sea turtles would mask changes in the survival rates of non-adult age classes. Nevertheless, we do not believe these mortalities (the annual loss of about 5 adult or sub- adult green turtles) would be expected to appreciably reduce the threatened or endangered green turtle's likelihood of surviving and recovering in the wild. This conclusion is based on the number of green turtles that are likely to be killed during interactions with the fishery relative to the size of the subpopulation to which those turtles probably belong and the changed conditions of the Environmental Baseline. We will discuss the status and trend of the two aggregations separately, then summarize our conclusions for both.

Eastern Pacific Green Turtle Population. As discussed in the *Status of the Species* section of this opinion, the primary green turtle nesting grounds in the eastern Pacific are located in Michoacán, Mexico, and the Galapagos Islands, Ecuador (NMFS and USFWS, 1998a). The nesting aggregation at the two main nesting beaches in Michoacán, (Colola — which represents about 70% of the total green turtle nesting in Michoacán — and Maruata; Delgado and Alverado, 1999), decreased from 5,585 females in 1982 to 940 in 1984. On Colola, an estimated 500-1,000 females nested nightly in the late 1960s. In the 1990s, that number dropped to 60-100 per night, or about 800-1,000 turtles per year (Eckert, 1993). During the 1998-99 season, based on a comparison of nest counts and egg collection data, an estimated 600 green turtles nested at Colola.

In 1990, the government provided female, green turtles and their eggs with long-term protection from poaching and other activities. During the 1998-99 season, only about 5% of the nests were poached at Colola, although about 50% of the nests at Maruata were poached because political infighting made it difficult to protect the turtles on this beach (Delgado and Alvarado, 1999). Nevertheless, despite the long-term protections, the nesting aggregation continues to decline, and investigators believe that human activities (including incidental take in various coastal fisheries as well as illegal directed take at forage areas) continue to prevent the aggregations from recovering (P. Dutton, NMFS, personal communication, 1999; Nichols, 2002).

There are few historical records of abundance of green turtles from the Galapagos - only residents are allowed to harvest turtles for subsistence, and egg poaching occurs only occasionally. An annual average of 1,400 nesting females was estimated for the period 1976- 1982 in the Galapagos Islands (NMFS and USFWS, 1998a). More current estimates of the status and trend of this population are not available.

Clearly, the additional loss of between 1 and 3 adult or sub-adult, green turtles from these nesting aggregations each year would reduce the number of animals in the sub-population. If we assume that some of the adult or sub-adult turtles that are killed during interactions with the fishery are female, this reduction in numbers would also reduce the number of adult turtles that reproduce each year.

Hawaiian Green Turtle Population. The green turtles in Hawaii are genetically-distinct and geographically isolated from other green turtle populations; therefore, we treat them as a discrete subpopulation. Ninety percent of the nesting and breeding activity of the Hawaiian green turtle occurs at French Frigate Shoals, where 200-700 females were estimated to nest annually (NMFS and USFWS, 1998a). The incidence of diseases such as fibropapilloma, and spirochidiasis, which are major causes of strandings of green turtles suggests that future declines in this population could reverse or eliminate the increases of recent decades (Murakawa *et al.*, 2000). Nevertheless, since the green turtles in Hawaii were first protected in the early 1970s, ending years of exploitation, the nesting population of green turtles in Hawaii has shown a definite increase (Balazs, 1996, Chaloupka and Balazs in press). For example, the number of green turtles nesting at an index study site at East Island has tripled since systematic monitoring began in 1973 (NMFS and USFWS, 1998a).

Killing 1 to 3 of these green turtles each year would reduce the abundance of this nesting aggregation. If we assume that some of the adult turtles that are killed in interactions with the Hawaii-based longline fisheries are females, then the fishery would also reduce the reproduction of this nesting aggregation.

Synthesis: Almost all of the green turtles that interact with the Hawaii-based longline fisheries are probably members of the eastern Pacific and Hawaiian nesting aggregations. If we assume that some of the adult turtles that are killed in interactions with the Hawaii-based longline fisheries are females, then the fishery would also reduce the reproduction of these nesting aggregations, although, the consequences of losing a female turtle on the dynamics of a turtle's population will vary depending on whether the adult female dies before or after she lays her eggs (if the turtle dies before laying her eggs, the potential effect on the population would be larger).

In the *Environmental Baseline* section of this opinion, we noted that green turtles are captured, injured, or killed in numerous Pacific fisheries including Japanese longline fisheries in the western Pacific Ocean and South China Seas; longline fisheries off the Federated States of Micronesia; commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru; purse seine fisheries for tuna in the eastern tropical Pacific Ocean, and California/Oregon drift gillnet fisheries. Because of limited available data, we cannot accurately estimate the number of green turtles captured, injured, or killed through interactions with these fisheries. However, an estimated 85 green turtles were estimated to have died between 1993 and 1997 in interactions with the tuna purse seine fishery in the eastern tropical Pacific Ocean; approximately 7,800 green turtles are estimated to die annually in fisheries and direct harvest off of Baja, California; and before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 378 green turtles each year, killing about 93 of them each year. Little data on the life stage or sex of captured animals are available; however, we expect that both incidental and intentional takes affect the larger turtle life stages, sub-adults and adults. Given the population ecology of sea turtles in general, and green turtles in particular, these mortalities would be expected to reduce the numbers of these green turtles.

Although the mortalities associated with the Western Pacific Pelagic Fisheries would reduce the numbers and may reduce the reproduction of both the eastern Pacific and Hawaiian nesting aggregations, the "jeopardy" standard requires us to consider those effects on a species' survival and recovery in the wild. Specifically, as discussed in the introduction to the *Effects of the Action* section, the "jeopardy" standard requires us to determine that reductions in a species' reproduction, numbers, or distribution would be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild. We identify reductions in a species' likelihood of surviving and recovering in the wild by quantitatively or qualitatively analyzing the probable effect of changes in a reproduction, numbers, and distribution based on our understanding of relationships between vital rates (for example, age- or stage-specific rates of survival or fecundity), variance in those rates over time and among different populations, a species' rates of increase (lambda), and a species' probability of quasi-extinction or persistence over time.

In the past, we have concluded that the additional mortalities caused by the Hawaii-based longline fishery appreciably contributed to the green turtle's risk of extinction. In the past, the Hawaii-based longline fishery interacted with an average of 40 green turtles each year; we estimated that as many as 23 of these turtles died as a result of these interactions (McCracken, 2000). In the past, most of those interactions and deaths were associated with the shallow-set component of the Hawaii-based longline fisheries, which as now been modified to reduce the number of sea turtles that are likely to be captured by the fisheries and to reduce the consequences of those interactions to the turtles that are captured.[30]

Nevertheless, we estimate that about 5 green turtles could still be killed in the proposed fisheries. Of these turtles, 2 to 4 (95% confidence interval = 1 - 6) are likely to be adult or sub-adult female green turtles from the eastern Pacific nesting aggregations and 1 to 3 (95% confidence interval = 0 - 5) are likely to be from the Hawaiian nesting aggregations (because our estimates for green sea turtles resulted in three categories — eastern tropical Pacific, Hawaiian, and a mixture of the two

[30] As discussed previously, green turtles on the Pacific coast of Mexico are listed separately as endangered species, rather than the threatened status assigned to the remainder of their global populations. Under normal circumstances, we would analyze the effects of the proposed fisheries on the endangered populations separately from their threatened counterparts; however, using the information available, we cannot distinguish the effects of the fisheries on the different populations (because our data on interactions between the fisheries and these turtles cannot distinguish between the endangered turtles and the threatened turtles of these turtles). As a result, our analyses group the endangered populations and the threatened populations and treat them both as endangered to make certain that we afford the endangered turtles the additional protection warranted by their classification.

— the ranges in these estimates overlap because the "mixture" could consist of turtles from the eastern tropical Pacific, Hawaii, or both. Because of this overlap, these numbers, as presented, do not sum to 5). Killing this number of green turtles would represent a small, proportional change in the survival rates of female turtles in those life history stages. The quantitative analyses we conducted to assess the potential risks these mortalities might pose to the different nesting aggregations could not detect the effect of these mortalities on the extinction risk of either the endangered or threatened green sea turtles, although these results may say more about the power of the models than they says about the effect of these mortalities on the different nesting aggregations. With such small sample sizes, moderate amounts of observer bias, and wide confidence intervals, the ability of these quantitative methods to detect these small effects is very limited.

To approach the assessment qualitatively, we need to ask if the deaths associated with the proposed fisheries are likely to be exceeded by the number of younger turtles recruiting into the adult of sub-adult population. Although most populations are designed to withstand some level of mortality without increases in their risk of extinction, threatened and endangered species will often be incapable of recovering from even small numbers of deaths. Further, most populations fluctuate over time, if a population is experiencing an increasing trend in a longer cycle, it is more likely to be able to withstand mortalities than if the population is experiencing a decreasing trend. The important consideration is whether the population appears to have a growth rate that would allow it to recover from small numbers of deaths.

The Hawaii nesting aggregation of green turtles has been increasing for several years and has the demographic characteristics of a population that is slowly recovering from historic declines (see the detailed assessment in Status). Similarly, our assessment of the female green turtles that nest at Colola Beach suggest that this nesting beach is also growing, on average, despite a lower confidence interval suggesting that the population may, in fact, be declining. The wide fluctuations in the number of nesting females that return from year-to-year could present a more serious problem for this population as those fluctuations bring the population to very low levels that, over time, would be expected to create weak year-classes of recruits into the adult, female population. Although the increases in nesting females in 2000 and 2001 provide cause for optimism, historical numbers of this species nesting during the 1960s show that the population is still below its natural level (Alvarado-Diaz and Trejo, 2003; Alvarado-Diaz, personal communication, October, 2003).

If the variance in the vital rates of green turtles in the eastern tropical Pacific Ocean or Hawaii are roughly the same order of magnitude as those of green turtles from the southern Great Barrier Reef, we would not be able to detect the effect of the remaining mortalities associated with the current fisheries on the survival rates of adult and sub-adult green turtles from the eastern tropical Pacific Ocean or Hawaiian (assuming that we had the data necessary to reliably estimate survival rates). We believe the number of green turtles that would be expected to interact with the current pelagic fisheries and die as a result of those interactions is so small that it would be masked by background variance, even considering the effects of the other sources of mortality that were discussed in the *Environmental Baseline*.

6.4.5 Hawksbill Sea Turtle

Hawksbill turtles occur in the water around the Hawaiian Islands (on Molokai, Maui and Hawaii), but they are not known to interact with the Hawaii-based longline fishery (there have been no reported or observed interactions between these pelagic longliners and hawksbill turtles). Based on an unconfirmed logbook report of an interaction between a hawksbill turtle and longline gear in American Samoa, there is a possibility of hawksbill turtles becoming incidentally entangled or hooked in longline fishing gear. However, no hawksbill turtles have been observed to interact with the longline fisheries, which indicates that the likelihood of an interaction is small. Moreover, the single report in vessel logbooks of an interaction indicated that the animal was taken in a shallow set and shallow sets are now prohibited under the Pelagics FMP. Based on the available data and the distribution of hawksbill turtles relative to the distribution of the pelagic fisheries, NMFS does not anticipate future interactions between hawksbill turtles and longline gear. Consequently, the Western Pacific Pelagic Fisheries are not likely to reduce the reproduction, numbers, or distribution of hawksbill turtles. As a result, they are not likely to reduce the turtles' likelihood of surviving and recovering in the wild.

6.4.6 Leatherback Turtles

Assuming that patterns observed in the past represent future patterns, leatherback sea turtles will be exposed primarily to the Hawaii-based longline fisheries. The number of leatherback turtles that have been captured by other fisheries included in the Pelagics FMP are expected to be minimal one leatherback turtle was reported to have been captured but not killed by the longline fisheries based in American Samoa in 1999, no interactions have been reported since then, but it is important to note that these fisheries are not observed, so the absence of reports may only reflect the absence of sampling rather than the absence of interactions).

As proposed, the Hawaii-based longline fisheries would be modified to require longline vessels to use management measures that have proven effective at reducing the number and rate of interactions between leatherback and loggerhead sea turtles: the use of 18.0 10° offset circle hook with squid bait. Under the proposed management regime for the Hawaii-based longline fisheries, which include these gear modifications, about 34 (95% confidence interval = 18 - 60) leatherback turtles are expected to be captured by the Hawaii-based longline fisheries each year. Interactions between the different types of gear and leatherback turtles is split almost equally. About 16 leatherback turtles (95% confidence interval = 9 - 30) are expected to be captured by the shallow-set gear, while about 18 turtles (95% confidence interval = 9 to 30) are expected to be captured by the deep set gear.

Based on the limited genetic sampling from the action area, about 86% of the leatherback turtle sample (12 out of 14 genetic samples) originated from western Pacific nesting beaches (P. Dutton *et al.*, 2000; P. Dutton, NOAA-Fisheries, personal communication, January, 2001). If the longline fisheries affect leatherback turtle populations proportional to their relative abundance in the action area, about 29 of the 34 leatherback turtles that are expected to be captured in the Hawaii-based longline fisheries each year would come from nesting aggregations in the western Pacific Ocean. These turtles could represent individuals from Indonesia (Jamursba-Medi or War-Mon), Papua New Guinea (Kamiali), Malaysia (Terengganu), the Solomon Islands, or Fiji, although satellite tracks from leatherback turtles tagged in Papua New Guinea suggest that these turtles tend to migrate south instead of north, which would take them away from Hawaiian waters. Further, the abundance of the nesting aggregations in Indonesia relative to the small size of the other nesting aggregations suggests that the interactions between Indonesian leatherback turtles and the Hawaii-based longline fisheries are most likely.

The remaining 14 percent of the interactions, or about 5 of the leatherback turtles captured in a year, would represent turtles from the eastern Pacific Ocean. These turtles could represent individuals from nesting aggregations along the coast of Mexico, Costa Rica, or Panama, although turtles from these nesting aggregations may only migrate into Hawaiian waters when oceanic phenomena like El Nino events prevent them from migrating south to the coasts of Peru and Chile. Several investigators who have followed leatherback turtles equipped with satellite tags have reported that leatherback turtles from the beaches of Mexico and Costa Rica migrate through the equatorial current towards the coasts of Peru and Chile (Chandler 1991, Eckert 1997, Marquez and Vellanueva 1993, Morreale et al. 1996). Eckert (1997) suggested that these turtles migrate toward the coast of South America where upwelling water masses provide an abundance of prey. Although these data suggest that the Hawaii-based longline fisheries are more likely to interact with leatherback turtles from Indonesia, over a period of several years, we would expect these fisheries to interact with turtles from the other, smaller nesting aggregations.

Published estimates of the abundance of nesting female leatherbacks in the Pacific Ocean have established that leatherback populations have collapsed or have been declining at all major Pacific basin nesting beaches over the past two decades (Spotila *et al.*, 1996; NMFS and USFWS 1998b; Sarti, *et al.* 2000; Spotila, *et al.* 2000). Leatherback turtles had disappeared from India before 1930, have been virtually extinct in Sri Lanka since 1994, and appear to be approaching extinction in Malaysia (Spotila *et al.* 2000). Leatherback turtle colonies throughout the eastern and western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females and reduced the reproductive success of females that manage to nest (for example, egg poaching). At current rates of decline, leatherback turtles in the Pacific basin are a critically endangered species with a low probability of surviving and recovering in the wild (see Section III,. *Status of the Species and Environmental Baseline*).

Leatherback turtles, like green turtles discussed previously, are long-lived, have high adult survival rates, and delayed maturity; as a result, we assume that changes in the survival of adult and sub-adult stages of leatherback turtles can have significant, short-term effects on the status and trend of these turtle populations. Because of their life history pattern, the long lives and high, adult survival rates of sea turtles would mask changes in the survival rates of non-adult age classes. Nevertheless, we do not believe these mortalities (the annual loss of about 9 adult or sub-adult leatherback turtles) would be expected to appreciably reduce the leatherback sea turtle's likelihood of surviving and recovering in the wild. This conclusion is based on the number of leatherback turtles that are likely to be killed during interactions with the fishery relative to the size of the subpopulation to which those turtles probably belong and the changed conditions of the *Environmental Baseline.*

As discussed previously, almost all of the leatherback turtles that interact with the Hawaii-based longline fisheries are probably members of the western Pacific nesting aggregation, which consists of nesting aggregations located in Indonesia, Papua New Guinea, and the Solomon Islands. In the *Environmental Baseline* section of this Opinion, we established that in the western Pacific Ocean and South China Seas, leatherback turtles are captured, injured, or killed in numerous fisheries including Japanese longline fisheries. Leatherback turtles in the western Pacific are also threatened by poaching of eggs, killing of nesting females, human encroachment on nesting beaches, incidental capture in fishing gear, beach erosion, and egg predation by animals. As a result of these threats, the nesting assemblage Terengganu - which was one of the most significant nesting sites in the western Pacific Ocean - has declined severely from an estimated 3,103 females in 1968 to 2 nesting females in 1994 (Chan and Liew, 1996). The size of the current nesting assemblage represents less than 2 percent of the size of the assemblage reported from the 1950s; with one or two females nesting in this area each year (P. Dutton, personal communication, 2000). Nesting assemblages of leatherback turtles along the coasts of the Solomon Islands, which supported important nesting assemblages historically, are also reported to be declining (D. Broderick, personal communication, *in* Dutton *et al.* 1999). In Fiji, Thailand, Australia, and Papua-New Guinea (East Papua), leatherback turtles have only been known to nest in low densities and scattered colonies.

The leatherback turtles nesting on the beaches in the State of Papua represent one of the largest remaining nesting aggregations for this species in the Pacific Ocean. The nesting aggregation appears to be relatively large and has fluctuated between 400 and 1,000 individuals throughout most of the 1990s and early 2000s and could suggest that the population is stable or slightly increasing. Our assessment of this population also suggest that this population is stable or increasing, on average. However, the confidence intervals around our estimates suggest that the population may, in fact, be declining and that most population trajectories would show slight declines.

The western Pacific nesting aggregation consists of about 1,000 adult females (about 500 in Indonesia, about 150 in the Solomon Islands, about 400 in Papua New Guinea, and a handful in Malaysia). Killing three of these adult leatherback turtles each year would reduce the abundance of this nesting aggregation. If we assume that all of the 4 to 14 adult turtles that are killed in interactions with the Hawaii-based longline fisheries are females (an incorrect assumption since at least some of the turtles captured in the fishery have been male), then the fishery would reduce the reproduction of this nesting aggregation, although, the consequences of losing a female turtle on the dynamics of the turtle's population will vary depending on whether the adult female dies before or after she lays her eggs.

If we assume that, in most years, all of these turtles migrate into the action area from Indonesia or Papua New Guinea, then the higher mortality estimate would represent about 1.0 percent of the number of nesting females. If we assume that, in all or some years, leatherback turtles from Papua New Guinea, the Solomon Islands, or Malaysia may also be captured and killed by the fisheries, then the risks to the Indonesian nesting aggregation would be smaller. As with the green sea turtles, the quantitative analyses we conducted to assess the potential risks these mortalities might pose to the different nesting aggregations could not detect the effect of these mortalities on the extinction risk of leatherback sea turtles, although these results may say more about the power of the models than they says about the effect of these mortalities on the different nesting aggregations.

To approach the assessment qualitatively, we asked if the deaths associated with the proposed fisheries are likely to be exceeded by the number of younger turtles recruiting into the adult of sub-adult population. Although most populations are designed to withstand some level of mortality without increases in their risk of extinction, threatened and endangered species will often be incapable of recovering from even small numbers of deaths. Further, most populations fluctuate over time, if a population is experiencing an increasing trend in a longer cycle, it is more likely to be able to withstand mortalities than if the population is experiencing a decreasing trend. The important consideration is whether the population appears to have a growth rate that would allow it to recover from small numbers of deaths.

If the leatherback turtles originating in the western Pacific are a random mix of individuals from Indonesia or Papua New Guinea, we would expect their combined populations, given their size, to be able to withstand the small mortality levels associated with the fisheries without measurable effect on the population's extinction risks. If, the leatherback turtles killed in the fisheries were exclusively from Indonesia, the effect of these mortalities would be small and might appear to be trivial, but those mortalities might have longer-term consequences for this population because of accumulating effects. If the leatherback turtles killed in the fisheries were exclusively from Papua New Guinea, the effect of these mortalities would be small, but those mortalities are less likely to be trivial for this nesting aggregation in any particular year or over several years. Although stronger cohorts in this nesting aggregation might be able to withstand these mortalities, these mortalities would be more significant to weaker cohorts and could cause those cohorts to decline. If the leatherback turtles killed in the fisheries were exclusively or primarily from the Malaysian nesting aggregation, they would be certain to drive that nesting aggregation closer to extinction.

Nesting populations of leatherback turtles in the eastern Pacific Ocean are declining along the Pacific coast of Mexico and Costa Rica. According to reports from the late 1970s and early 1980s, three beaches located on the Pacific coast of Mexico support as many as half of all leatherback turtle nests. Since the early 1980s, the eastern Pacific Mexican population of adult female leatherback turtles has declined to slightly more than 200 during 1998-99 and 1999-2000 (Sarti *et al.* 2000). Spotila *et al.* (2000) reported the decline of the leatherback turtle population at Playa Grande, Costa Rica, which had been the fourth largest nesting colony in the world. Between 1988 and 1999, the nesting colony declined from 1,367 to 117 female leatherback turtles. Based on their models, Spotila *et al.* (2000) estimated that the colony could fall to less than 50 females by 2003-2004. Although these predictions have not proved true, our assessment suggests that this population has a high risk of extinction (declining to 1 or 0 females) in the one human generation (about 20 years) if its trajectory does not change.

In the past, NMFS has concluded that the additional mortalities caused by the Hawaii-based longline fisheries and other domestic fisheries appreciably contributed to the leatherback turtle's risk of extinction. Although the number of leatherback turtles killed in these fisheries were "small" relative to other fisheries in the Pacific Ocean, they were not "small" in terms of their impacts on the survival and recovery of leatherback turtles.

Common perceptions to the contrary, several, published studies have demonstrated that the death of "small" numbers of individuals can substantially-increase a species' risk of extinction. For example, Walters (1992) chronicled how the incremental loss of small numbers of individuals contributed to the extinction of the endangered dusky seaside sparrow (*Ammodramus maritimus nigrescens*). Spotila et al. (1996, 2001) used population models to demonstrate that leatherback sea turtles in the eastern tropical Pacific could not withstand low levels of adult mortalities. Fujiwara and Caswell (2001) used population models to demonstrate that preventing just two adult, female North Atlantic right whales (*Eubalaena glacialis*) would be sufficient to change the declining trend of this endangered species. Wiegand et al. (1998) used population models to demonstrate that annual anthropogenic mortalities ranging between 0 and 10 individuals per year over a 15-year interval increased the extinction risk of endangered brown bears (*Ursus arctos*) in Spain. Saether et al. (1998) used demographic models to reach similar conclusions for Scandinavian brown bears. Studies of species like the endangered Sonoran pronghorn antelope (*Antillocarpa americana sonoriensis*), Iberian lynx (*Lynx pardinus*), Mediterranean monk seal (*Monachus monachus*), Florida panther (*Felis concolor coryi*), Hawaiian crow (*Corvus hawaiiensis*), California condor (*Gymnogyps californicus*), Puerto Rican parrot (*Amazona vittata*), among others, have also demonstrated that small mortalities — a handful or individuals — would increase these species' risk of extinction.

At the same time, almost every species has evolved to withstand the loss of some of their numbers, even when they are experiencing declines; otherwise any species that experienced any decline would begin a decline to extinction with any additional death within its population. Species and populations persist because, above certain population levels, there usually isn't a one-to-one (or several-to-one) relationship between the species' risk of extinction and the death of individual plants or animals. That is, the death of each individual usually does not result in a corresponding increase in the species' risk of extinction. Species like the North Atlantic right whale and others we identified in the previous paragraph are endangered because they have declined to a point where we can draw a direct relationship between the loss of individual adults and increases in the species' risk of final extinction.

Other species are endangered because they appear likely to decline to the condition of these species in the foreseeable future. For these species, the consequences of the death of small numbers of individuals in different populations will usually depend on which populations those individuals represent and the population's size, growth rates over time (which reflect differences in the numbers of individuals that die in the population compared with the number that are born into the population over the same time interval), birth rates, gender ratios, age structure, and how these rates vary with time. These characteristics of populations will determine the relationship between the loss of individuals and the population's or species' extinction risk.

In the past, the U.S. Pacific pelagic fisheries interacted with an average of 112 (95% confidence interval 75-157) leatherback turtles and caused the death of between 24 to 49 of these turtles each year. In the past, we concluded that these mortality levels would be expected to appreciably reduce the leatherback turtle's chances of surviving and recovering in the wild. That is, we concluded that these mortality levels would combine to increase the species' extinction risk. The proposed management regime is expected to result in the death of about 8 (95% confidence interval = 4 to 14) adult or sub-adult leatherback turtles from the western Pacific nesting aggregations and 1 (95% confidence interval = 1 to 2) from the would represent a small proportional change in the survival rates of female turtles in those life history stages (0.003 percent).

Given the size of leatherback sea turtles populations in the western Pacific region, particularly the nesting aggregations in Indonesia and Papua-New Guinea these leatherback turtles probably represent and the growth rates of this population, we do not expect the death of about 8 adult or sub-adult sea turtles to measurably increase this population's extinction risk. Given the size of leatherback sea turtles populations in the eastern tropical Pacific, we do not expect the death of 1 adult or sub-adult sea turtles to measurably increase this population's extinction risk. We believe this statement remains true despite the declining trend of the leatherback turtle populations in both the eastern and western Pacific.

We also expect the variance in the survival and fecundity rates of the western Pacific leatherback sea turtle populations to make it more difficult to detect increases in the population's extinction risks from these small number of deaths. Chaloupka and Limpus (2002) reported survival rates for adult green turtles in the southern Great Barrier reef region of Australia averaged 0.875 percent (with 95% confidence interval 0.84-0.91). Doak et al (1994) and Wisdom et al (2000) reported that the vital rates of adult and sub-adult desert tortoises (*Gopherus agassizii*) varied by about 8 to 15 percent. Woolfenden and Fitzpatrick (1984) reported that the estimated annual survival rates of adult Florida scrub jays (a threatened species) varied by about 11 percent (mean of 0.820 ±0.091). If the variance in the vital rates of leatherback turtles in the Pacific Ocean are roughly the same order of magnitude as those of green turtles from the southern Great Barrier Reef, we would not be able to detect the effect of the remaining mortalities associated with the current fisheries on the survival rates of adult and sub-adult leatherback turtles in the western Pacific (assuming that we had the data necessary to reliably estimate survival rates).

Because of the size of leatherback turtle populations in the eastern and western Pacific, relative to the small number of individual leatherback sea turtles that are expected to be captured and killed in the proposed fisheries in any particular year, we do not expect these mortalities to appreciably reduce the population's likelihood of surviving and recovering in the wild. Because these mortalities are not likely to reduce the population's likelihood of surviving and recovering in the wild, we do not expect these mortalities to reduce the species' likelihood of surviving and recovering in the wild.

6.4.7 Loggerhead Turtles

With the proposed fishery management regime, about 21 (95% confidence interval = 8 - 64) loggerhead turtles are expected to be captured by the Hawaii-based longline fisheries each year. As in the past, most of these turtles (81%) will be exposed to shallow-set gear: about 17 loggerhead turtles (95% confidence interval = 7 - 55) are expected to be captured by the shallow-set gear, while about 4 turtles (95% confidence interval = 4 to 9) are expected to be captured by deep set gear.

Of these turtles, 4 (95% confidence interval = 2 - 13) are expected to die as a result of the exposure. Most of these loggerhead turtles would be oceanic juveniles originated from nesting beaches in southern Japan while oceanic juveniles from the two nesting beaches on Yakushima Island have a low risk of being killed in an interaction with longline gear in any particular year, but a small risk of being killed in those interactions over several years.

Historically, most of the loggerhead turtles that interact with the fishery were either hooked internally or externally. The tendency to be hooked internally probably resulted from their diet: Loggerhead turtles in north Pacific pelagic habitats are opportunistic, omnivorous predators of the surface layer, feeding both by swallowing floating prey whole, biting off prey items from larger floating objects, or both. Based on past patterns of the condition of sea turtles that have been observed in the fishery and expected mortality rates for turtles given their condition when they were observed, we have estimated that about 8 of the 14 loggerhead turtles would be expected to die each year as a result of their interactions with the fisheries.

However, it is important to place these numbers into perspective: between July 2001 and June 2002 (when the fishery was modified to eliminate the targeted swordfish fishery and the shallow sets associated with it), three loggerhead turtles were captured in the fishery, two of those three turtles were captured by vessels that are believed to have been illegally using shallow sets to target swordfish. All of the 175 loggerheads that interacted with the Hawaii-based longline fishery from 1994 through March, 2001, were captured by longliners using shallow sets (i.e. target depths less than 100 meters, using less than 10 hooks per float, fishing at night, using lightsticks). Loggerheads in the north Pacific are opportunistic feeders that target items floating at or near the surface, and if high densities of prey are present, they will actively forage at depth (Parker, *et al.*, in press). Although loggerhead turtles have been reported to dive to depths of 128 meters, they spend most of their time (90%) at the surface or at depths less than 40 meters; therefore, loggerheads were more likely to interact with shallow sets than deep sets, which generally target depths greater than 100 meters. Eliminating the targeted swordfish fishery is expected to virtually eliminate the likelihood of interactions between the current fishery and loggerhead turtles.

Placed in this perspective, the estimated number of interactions between the current fishery and loggerhead turtles was biased by vessels that were allegedly fishing illegally; the Council and NOAA-Fisheries have taken further action to reduce the likelihood of such illegal activity in the future. As a result, although we estimated that 14 loggerhead turtles would be captured by the fishery and 8 of those turtles would die as a result of their capture, those estimates may overestimate the risk by more than 66%. In July 2002, a loggerhead turtle was caught in a deep set fishing at 13%N latitude, an interaction than diverged from NOAA-Fisheries' past observations of the overlap between this species' pelagic distribution and behavior and the deep-set portion of the longline fishery; this recent observation is evidence that the current fishery poses a risk to loggerhead turtles even if that risk is much smaller than our current estimates.

Killing about 4 (95% confidence interval = 2 - 13) pelagic juvenile loggerhead turtles each year would reduce the numbers of individuals in the species, particularly since population estimates for this species are based on estimated numbers of adult, female turtles. Assuming that some of the loggerhead turtles captured and killed in the fishery would be females, we would also conclude that these deaths would reduce the number of female loggerhead turtles that recruit into the adult, breeding population, with future effects on the species' reproduction.

Within the Pacific Ocean, loggerhead sea turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) and a smaller southwestern nesting aggregation that occurs in Australia (Great Barrier Reef and Queensland), New Caledonia, New Zealand, Indonesia, and Papua New Guinea. Based on available information, the Japanese nesting aggregation is significantly larger than the southwest Pacific nesting aggregation. Data from 1995 estimated the Japanese nesting aggregation at 1,000 female loggerhead turtles (Bolten *et al.*, 1996; Sea Turtle Association of Japan, 2002). Recent data reflect a continuing decline (see Table 2 in Appendix C; N. Kamezaki, Sea Turtle Association of Japan, personal communication, August, 2001). We have no recent, quantitative estimates of the size of the nesting aggregation in the southwest Pacific, but currently, approximately 300 females nest annually in Queensland, mainly on offshore islands (Capricorn-Bunker Islands, Sandy Cape, Swains Head; Dobbs, 2001).

In the *Environmental Baseline* section of this Opinion, we established that loggerhead turtles are captured, injured, or killed in numerous Pacific fisheries including Japanese longline fisheries in the western Pacific Ocean and South China Seas; direct harvest and commercial fisheries off Baja California, Mexico, commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru; purse seine fisheries for tuna in the eastern tropical Pacific Ocean, and California/Oregon drift gillnet fisheries. In addition, the abundance of loggerhead turtles on nesting colonies throughout the Pacific basin has declined dramatically over the past 10 to 20 years. Loggerhead turtle colonies in the western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females and reduced the reproductive success of females that manage to nest (for example, egg poaching). Despite limited quantitative data on the effects of these fisheries and other natural and anthropogenic phenomena on the Japanese nesting population, the effects of the mortalities associated with the Pelagic FMP fisheries added to the current status and trend of the Japanese loggerhead population would increase the Japanese loggerhead population's rate of decline.

Although the mortalities associated with the Western Pacific Pelagic Fisheries would clearly reduce the numbers and may reduce the reproduction of both the eastern Pacific and Hawaiian nesting aggregations, the "jeopardy" standard requires us to consider those effects on a species' survival and recovery in the wild. Specifically, as discussed in the introduction to the Effects of the Action section, the "jeopardy" standard requires us to determine that reductions in a species' reproduction, numbers, or distribution would be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild. As we discussed in the previous turtle narratives, we generally identify reductions in a listed species' likelihood of surviving and recovering in the wild by quantitatively or qualitatively analyzing the probable effect of changes in a reproduction, numbers, and distribution based on our understanding of relationships between vital rates (for example, age- or stage-specific rates of survival or fecundity), variance in those rates over time and among different populations, a species' rates of increase (lambda), and a species' probability of quasi-extinction or persistence over time.

In the past, we have concluded that the additional mortalities caused by the Hawaii-based longline fishery appreciably contributed to the green turtle's risk of extinction. In the past, the Hawaii-based longline fishery interacted with an average of 418 loggerhead turtles each year; we estimated that as many as 73 of these turtles died as a result of these interactions (McCracken 2000). The proposed management measures will dramatically reduce the number of these interactions and the consequences of those interactions for loggerhead sea turtles. Nevertheless, we estimate that between about 4 pelagic juvenile loggerhead turtles from the 40 nesting aggregations in southern Japan and perhaps 1 loggerhead turtle from the 2 nesting aggregations on Yakushima Island could still be killed in the proposed fishery.

As with the green and leatherback sea turtles, the quantitative analyses we conducted to assess the potential risks these mortalities might pose to the different nesting aggregations could not detect the effect of these mortalities on the extinction risk of leatherback sea turtles, although these results may say more about the power of the models than they say about the effect of these mortalities on the different nesting aggregations.

To approach the assessment qualitatively, we asked if the deaths associated with the proposed fisheries are likely to be exceeded by the number of younger turtles recruiting into the adult of sub-adult population. Although most populations are designed to withstand some level of mortality without increases in their risk of extinction, threatened and endangered species will often be incapable of recovering from even small numbers of deaths. Further, most populations fluctuate over time, if a population is experiencing an increasing trend in a longer cycle, it is more likely to be able to withstand mortalities than if the population is experiencing a decreasing trend. The important consideration is whether the population appears to have a growth rate that would allow it to recover from small numbers of deaths.

Balazs and Wetherall (1991) speculated that 2,000 to 3,000 female loggerheads nested annually in all of Japan. From nesting data collected by the Sea Turtle Association of Japan since 1990, the latest estimates of nesting females on almost all of the rookeries are as follows: 1998 - 2,479 nests; 1999 - 2,255 nests; 2000 - 2,589 nests. Considering multiple nesting estimates, Kamezaki *et al.* (2003) estimates that approximately fewer than 1,000 female loggerheads return to Japanese beaches per nesting season. Two of the most important beaches in Japan, Inakahama Beach and Maehama Beach, located on Yakushima Island in the Nansei Shoto Archipelago, account for approximately 30% of all loggerhead nesting in Japan. Monitoring on Inakahama Beach has taken place since 1985, with about 300 to 400 nesters in 2000.

Given the size of loggerhead sea turtles populations in Japan, we do not expect the death of about 5 oceanic, juvenile loggerhead sea turtles to measurably increase the extinction risk of one or more of the Japanese nesting aggregations. We believe this statement remains true despite the declining trend of the leatherback turtle populations in both the eastern and western Pacific. We also expect the variance in the survival and fecundity rates of the Japanese loggerhead sea turtle populations to make it more difficult to detect increases in the population's extinction risks from these small number of deaths of juvenile turtles. Chaloupka and Limpus (2002) reported survival rates for adult green turtles in the southern Great Barrier reef region of Australia averaged 0.875 percent (with 95% confidence interval 0.84-0.91). Doak et al (1994) and Wisdom et al (2000) reported that the vital rates of adult and sub-adult desert tortoises (*Gopherus agassizii*) varied by about 8 to 15 percent. Woolfenden and Fitzpatrick (1984) reported that the estimated annual survival rates of adult Florida scrub jays (a threatened species) varied by about 11 percent (mean of 0.820 ±0.091). If the variance in the vital rates of leatherback turtles in the Pacific Ocean are roughly the same order of magnitude as those of green turtles from the southern Great Barrier Reef, we would not be able to detect the effect of the remaining mortalities associated with the current fisheries on the survival rates of adult and sub-adult leatherback turtles in the western Pacific (assuming that we had the data necessary to reliably estimate survival rates).

Because of the size of loggerhead turtle populations in the Pacific, relative to the small number of individual loggerhead sea turtles that are expected to be captured and killed in the proposed fisheries in any particular year, we do not expect these mortalities to appreciably reduce the likelihood of loggerhead sea turtle's surviving and recovering in the wild in the Pacific Ocean. Because these mortalities are not likely to reduce the turtles likelihood of surviving and recovering in the wild in the Pacific Ocean, we do not expect these mortalities to reduce the species' likelihood of surviving and recovering in the wild.

6.4.8 Olive Ridley Turtle

Assuming that patterns observed in the past represent future patterns, olive ridley sea turtles will be exposed to longline fisheries based out of Hawaii and American Samoa. The number of olive ridley turtles that have been captured by other fisheries included in the Pelagics FMP are expected to be minimal one: olive ridley turtle was reported to have been captured but not killed by the longline fisheries based in American Samoa in 1999. No interactions have been reported since then, but it is important to note that these fisheries are not observed, so the absence of reports may only reflect the absence of sampling rather than the absence of interactions.

With the proposed management regime for the Hawaii-based longline fisheries, about 42 (95% confidence interval = 23 - 76) olive ridley turtles are expected to interact with the Hawaii-based longline fisheries each year. As in the past, and because of their diving habit, most of these turtles (60%) will be exposed to deep-set gear: about 37 olive ridley sea turtles (95% confidence interval = 21 - 60) are expected to interact with deep-set gear, while about 5 turtles (95% confidence interval = 2 to 16) are expected to interact with shallow-set gear.

Based on genetic sampling of the olive ridley sea turtles captured in these fisheries in the past, these turtles will represent nesting beaches both the eastern and western Pacific Ocean as well as the Indian Ocean (P. Dutton *et al.*, 2000; P. Dutton, NOAA-Fisheries, personal communication, January, 2001). If the longline fisheries affect olive ridley turtle populations proportional to their relative abundance in the action area, about 31 of the 41 olive ridley turtles that are expected to be captured in the Hawaii-based longline fisheries each year would represent endangered olive ridley turtles from the eastern tropical Pacific , while 11 of the 41 olive ridley turtles would represent turtles from the western Pacific or Indian Oceans.

We do not believe these mortalities will appreciably reduce the olive ridley sea turtles' likelihood of surviving and recovering in the wild, because of the status and trend of olive ridley turtle populations in the Pacific basin. Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton, *et al.*, 1982 *in* NMFS and USFWS, 1998d). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan. (NMFS and USFWS, 1998d). Although olive ridley meat is palatable, it was not widely sought after; its eggs, however, are considered a delicacy. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo, 1982).

In the eastern Pacific, nesting occurs all along the Mexico and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. The largest known *arribadas* in the eastern Pacific are off the coast of Costa Rica (about 475,000 to 650,000 females estimated nesting annually) and in southern Mexico (about 800,000 or more nests per year at La Escobilla, in Oaxaca; Millán, 2000). The greatest single cause of olive ridley egg loss comes from the nesting activity of conspecifics on *arribada* beaches, where nesting turtles destroy eggs by inadvertently digging up previously laid nests or causing them to become contaminated by bacteria and other pathogens from rotting nests nearby.

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, appears to have improved the situation for the olive ridley. Surveys of important olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Marquez, *et al.*, 1995; Arenas, *et al.*, 2000). Annual nesting at the principal beach, Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests (Salazar, *et al.*, in press).

Olive ridleys are not as well documented in the western Pacific as in the eastern Pacific, nor do they appear to be recovering as well (with the exception of Orissa, India in recent years). There are a few sightings of olive ridleys from Japan, but no report of egg-laying. Nesting information from Thailand indicates a marked decline in olive ridley numbers primarily due to egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e. carapace), indirect capture in fishing gear, and loss of nesting beaches through development (Aureggi, *et al.*, 1999).

Extensive hunting and egg collection, in addition to rapid rural and urban development, have reduced nesting activities in Indonesia as well.

Olive ridley nesting is known to occur on the eastern and western coasts of Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 eggs (2,400 nests, with approximately 100 eggs per nest) (Siow and Moll, 1982, *in* Eckert, 1993)), while only 187 nests were reported from the area in 1990 (Eckert, 1993).

In contrast, olive ridleys are the most common species found along the east coast of India, migrating every winter to nest en-masse at three major rookeries in the state of Orissa, Gahirmatha, Robert Island, and Rushikulya (*in* Pandav and Choudhury, 1999). The Gahirmatha rookery, located along the northern coast of Orissa, hosts the largest known nesting concentration of olive ridleys. Unfortunately, uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large scale mortality of adults during the last two decades. Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. Threats to these sea turtles also include artificial illumination and unsuitable beach conditions, including reduction in beach width due to erosion (Pandav and Choudhury, 1999). According to Pandav and Choudhury (1999), the number of nesting females at Gahirmatha has declined in recent years, although after three years of low nestings, the 1998-99 season showed an increasing trend, and the 1999-2000 season had the largest recorded number of olive ridleys nesting in 15 years when over 700,000 olive ridleys nested at Nasi islands and Babubali island, on the Gahirmatha coast.

Given initial population sizes and increases in the Mexican and Costa Rican populations in recent year, the mortalities associated with the U.S. pelagics fisheries are not likely to halt or reverse the increasing trend of those populations. Removing adult or sub-adult turtles from the eastern Pacific population could slow the recovery of the population that is occurring, although it is not clear if that reduction would be measurable given the size of the nesting population.

Population trends in the western Pacific are more difficult to discern, although it is clear that there are still large populations of olive ridleys nesting in India. Killing adult and sub-adult turtles in the western Pacific population could have more serious consequences, since this population continues to be affected by ongoing factors such as incidental take in fisheries, the harvest of eggs on nesting beaches, and inundation and erosion of beaches. By removing reproductive adults and pre-reproductive sub-adults from this declining population, the Hawaii- based longline fisheries could adversely affect this population's persistence, although it is unknown how much, or to what degree, this might impact the population's survival in light of the other factors currently affecting this population.

Nevertheless, the major populations of olive ridley turtles in the Pacific Ocean appear to be increasing, despite some residual, adverse effects of fishery-related mortalities and harvest of adults and eggs. Because of the population size, number of reproductive females, and the rates at which sub-adults are probably recruiting into the adult population, we believe nesting aggregations of this species can withstand the mortalities and reduced reproductive rates associated with the current fisheries without appreciable reductions in the olive ridley turtle's likelihood of the surviving and recovering in the wild.[31]

7.0 CUMULATIVE EFFECTS

Cumulative effects[32] include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Most of the fisheries described as occurring within the action area (Section III. *Status of the Species* and *Environmental Baseline*), are expected to continue as described into the foreseeable future. Therefore, NMFS is not aware of any proposed or anticipated changes in most of these fisheries that would substantially change the impacts each fishery has on the sea turtles covered by this Opinion.

In addition to fisheries, NMFS is not aware of any proposed or anticipated changes in other human-related actions (e.g. poaching, habitat degradation) or natural conditions (e.g. over-abundance of land or sea predators, changes in oceanic conditions, etc.) that would substantially change the impacts that each threat has on the sea turtles or marine mammals covered by this Opinion. Therefore, NMFS expects that the levels of take of sea turtles described for each of the fisheries, except the California longline fishery, which will take fewer sea turtles if the proposed regulatory regime is made final, and non-fisheries will continue at similar levels into the foreseeable future.

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31 Olive ridley turtles on the Pacific coast of Mexico are listed separately as endangered species, rather than the threatened status assigned to the remainder of their global populations. Under normal circumstances, we would analyze the effects of the proposed fisheries on the endangered populations separately from their threatened counterparts; however, using the information available, we cannot distinguish the effects of the fisheries on the different populations (because our data on interactions between the fisheries and these turtles cannot distinguish between the endangered turtles and the threatened turtles of these turtles). As a result, our analyses group the endangered populations and the threatened populations and treat them both as endangered to make certain that we afford the endangered turtles the additional protection warranted by their classification.

32 "Cumulative effects," as defined for the purposes of the Endangered Species Act in 50 CFR 402.14, should not be confused with the term "cumulative impact" as defined for the purposes of the National Environmental Policy Act of 1969 (42 U.S.C. 4321). "Cumulative effects" are limited to the effects of future, non-federal actions in an action area while "cumulative impacts" are "the impacts on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR 1508.7).

8.0 CONCLUSION

After reviewing the available scientific and commercial data, current status of green turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NOAA-Fisheries' biological opinion that the continued authorization of pelagic fisheries in the Western Pacific Region under the Pelagics FMP is not likely to jeopardize the continued existence of green turtles.

After reviewing the available scientific and commercial data, current status of leatherback turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NOAA-Fisheries' biological opinion that the continued authorization of pelagic fisheries in the Western Pacific Region under the Pelagics FMP is not likely to jeopardize the continued existence of leatherback turtles.

After reviewing the available scientific and commercial data, current status of loggerhead turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NOAA-Fisheries' biological opinion that the continued authorization of pelagic fisheries in the Western Pacific Region under the Pelagics FMP is not likely to jeopardize the continued existence of loggerhead turtles.

After reviewing the available scientific and commercial data, current status of olive ridley turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NOAA-Fisheries' biological opinion that the continued authorization of pelagic fisheries in the Western Pacific Region under the Pelagics FMP is not likely to jeopardize the continued existence of olive ridley turtles.

8.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and protective regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the reasonable and prudent measures and terms and conditions of the Incidental Take Statement.

Section 7(b)(4)(c) of the ESA specifies that in order to provide an incidental take statement for an endangered or threatened species of marine mammal, the taking must be authorized under section 101(a)(5) of the MMPA. Since no incidental take of listed marine mammals is expected or has been authorized under section 101(a)(5) of the MMPA, no statement on incidental take of endangered whales is provided and no take is authorized. Nevertheless, NOAA-Fisheries' Office of Sustainable Fisheries (F/SF) must immediately (within 24 hours, if communication is possible) notify the NOAA-Fisheries' Office of Protected Resources if an endangered marine mammal is "taken" in any of the fisheries authorized under the Pelagics FMP. Following issuance of such regulations or authorizations, NOAA-Fisheries may amend this biological opinion to include an incidental take statement for humpback whales, sperm whales, or Hawaiian monk seals, as appropriate.

8.1 Amount or extent of take

NOAA-Fisheries believes that the following levels of incidental take may be expected to occur associated with the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded in any of the three groups of fisheries for which individual incidental take level are given in the tables that follow, the Pacific Islands Region's Sustainable Fisheries Division must immediately reinitiate formal consultation with the Office of Protected Resources pursuant to Criterion 2 of the section 7 regulations (50 CFR 402.16).

8.1.1. Pelagic Longline Fisheries for Swordfish, Tuna, and Shark

The tables that follow identify the annual number of sea turtles that are expected to be captured, injured, or killed by one or more of the proposed fisheries managed by the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. These tables are based on the estimates discussed in the Exposure Analysis, Response Analysis, and Risk Analysis sections of this biological opinion and are organized as follows: Hawaii-based longline fisheries using shallow-set gear (Table 8.1), Hawaii-based longline fisheries using deep-set gear (Table 8.2), other fisheries managed under the Pelagics Fishery Management Plan (Table 8.3).[33]

Table 8.1 The annual number of turtles expected to be captured or killed in the shallow-set, longline fisheries based out of Hawaii

	number captured	number killed
green sea turtles	1	1
hawksbill sea turtles	0	0
leatherback sea turtles	16	2
loggerhead sea turtle	17	3
olive ridley sea turtles	5	1

As discussed elsewhere in this Opinion, the estimates contained in Table 8.1 (above) assume that the new management measures (circle hooks, mackerel-style bait, and de-hooking methods) will

33 The number of individual sea turtles that are anticipated to be "taken" incidental to the fisheries was derived from our prior experience with the fisheries (that is, past interactions). These numbers are anticipated (because they are expectations that have yet to occur) but they are also estimates (because these expectations are based on data we collected in the past).

be as effective in the Pacific Ocean as they have been in the Atlantic Ocean. Currently, these methods will only apply to the longline fisheries based out of Hawaii using gear configured for shallow-sets that operate north of the equator and not to the shallow-set longline fisheries operating south of the equator or longline fisheries based out of Hawaii using gear configured for deep-sets. These shallow-set longline fisheries will have exceeded this level of incidental take if and when estimates from observer reports exceed these estimates of the number of turtles (in Table 8.1) captured in the fisheries, the number of turtles killed in the fisheries, or both.

The annual estimates of the incidental take associated with those fisheries are described in the following table. These fisheries will have exceeded the levels of incidental take outlined in Table 8.2 if and when the fishery is estimated to have exceeded these estimated values:

Table 8.2 The annual number of turtles expected to be captured or killed in the deep-set, longline fisheries based out of Hawaii

	number captured	number killed
green sea turtles	6	5
hawksbill sea turtles	0	0
leatherback sea turtles	18	7
loggerhead sea turtle	4	2
olive ridley sea turtles	37	35

All five species of sea turtles may be taken in the other fisheries authorized by the Pelagics FMP. These fisheries include all of the handline fisheries, troll fisheries, pole and line fisheries managed under the Pelagics Fisheries Management Plan as well as the longline fisheries based out of American Samoa. The known level of effort and the selectivity of the gear used in most of these fisheries has led NOAA-Fisheries to conclude that few sea turtles, if any, are captured, injured, or killed by these fisheries. Because NOAA-Fisheries observers have not worked with these fisheries, most of the sea turtles that have been reported to have been captured in these fisheries have not been identified to species, therefore we identify the species as hardshell (green, hawksbill, loggerhead, and olive ridley sea turtles) or leatherback sea turtles. In the former case, any interaction with one of these species would be considered a "take" for the purposes of Table 8.3.

Table 8.3 The annual number of turtles expected to be captured or killed in the handline fisheries, troll fisheries, pole and line fisheries managed under the Pelagics Fisheries Management Plan as well as the longline fisheries based out of American Samoa

	number captured	number killed
hardshell sea turtle	6	1
leatherback sea turtle	1	0

8.2 Impact of the Take

In the accompanying Opinion, NOAA-Fisheries determined that these levels of anticipated take are not likely to result in jeopardy to the green turtle, hawksbill, humpback whale, leatherback turtle, loggerhead turtle, monk seal, olive ridley turtle, or sperm whale when the reasonable and prudent measures are implemented.

8.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when an agency action is found to comply with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of listed species, NOAA-Fisheries will issue a statement specifying the impact of any incidental taking. It also states that reasonable and prudent measures necessary to minimize impacts, and terms and conditions to implement those measures be provided and must be followed to minimize those impacts. Only incidental taking by the federal agency or applicant that complies with the specified terms and conditions is authorized.

NOAA-Fisheries believes the following reasonable and prudent measures, as implemented by the terms and conditions, are necessary and appropriate to minimize impacts to sea turtles and monitor levels of incidental take. The measures described below are non-discretionary, and must be undertaken by NOAA-Fisheries for the exemption in section 7(o)(2) to apply. If NOAA-Fisheries fails to adhere to the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. Thus, the following reasonable and prudent measures must be implemented to allow activities of the Pelagic Fisheries to continue.

1. NOAA-Fisheries shall collect data on capture, injury and mortality of sea turtles in addition to life history information on longline fishing vessels.

2. NOAA-Fisheries shall develop a system that will enable NOAA-Fisheries to collect basic listed species bycatch data in the troll, handline, and purse seine fisheries under the Pelagics FMP and assign these interactions into the categories developed through the February 2004 post-hooking mortality guidelines (either as drafted or amended by NOAA-Fisheries).

3. Sea turtles captured alive shall be released from fishing gear in a manner that minimizes injury and the likelihood of further gear entanglement or entrapment.

4. Comatose and lethargic sea turtles shall be retained on board, handled, resuscitated, and released according to established procedures.

5. Sea turtles that are dead when brought aboard a vessel or that die while on-board shall be disposed of at sea unless NOAA-Fisheries requests retention of the carcass for sea turtle research.

Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the ESA, NOAA-Fisheries must comply or ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. The following terms and conditions implement reasonable and prudent measure No. 1.

1A. NOAA-Fisheries shall continue the observer program aboard Hawaii-based limited access permit longline vessels to collect data on the incidental take of marine mammals, sea turtles, and other protected species. No vessel using shallow-set gear in the Hawaii-based fisheries shall be permitted to fish without observer coverage. Observer coverage in the deep-set longline fisheries generally shall be maintained at an annual average level of at least 20 percent.

1B. NOAA-Fisheries shall establish an observer program, where feasible, aboard longline vessels fishing under a Pelagics FMP general permit or a limited access permit for the American Samoa-based longline fishery, should such a permit program be established. The purpose of the observer program is to provide NOAA-Fisheries with information necessary to determine if these fisheries interact with listed species and what level of impact the fisheries might have on those species. The feasibility of establishing an observer program aboard these vessels may depend upon the space available on the vessel to house and maintain an observer to carry out their duties.

1C. Observer programs shall collect information regarding the incidental capture, injury, and mortality of sea turtles by species, gear and set information in which each interaction occurred, and life history information.

1D. NOAA-Fisheries shall also collect life history information on sea turtles captured by longline fisheries, including species identification; measurements, including direct measure or visual estimates of tail length; condition; skin biopsy samples; and estimated length of gear left on the turtle at release. To the extent practicable, these data should allow NOAA-Fisheries to assign these interactions into the categories developed through the February 2004 post-hooking mortality guidelines (either as drafted or amended by NOAA-Fisheries).

1E. NOAA-Fisheries observers shall record the presence or absence of tags on all sea turtles captured by longline fisheries.

1F. Data collected by observers shall be made available on a quarterly basis. "Quarterly Status Reports" shall be sent to the Assistant Regional Directors of Protected Resources and Sustainable Fisheries in NOAA-Fisheries' Pacific Islands Regional

Office and distributed to NOAA-Fisheries' Sea Turtle Coordinators in Honolulu, Hawaii (when established); Long Beach, California, and Silver Spring, Maryland.

2. The following terms and conditions implement reasonable and prudent measure No. 2.

2A. NOAA-Fisheries shall coordinate with the Forum Fisheries Agency observer program to collect life history information on sea turtles, such as species identification, measurements, condition, skin biopsy samples, the presence or absence of tags, and the application of flipper tags if none are present.

2B NOAA-Fisheries, in collaboration with the Western Pacific Fishery Management Council, shall develop a system to collect basic listed species bycatch data associated with non-longline pelagic fishing vessels fishing with hook-and-line within EEZ waters of the western Pacific region.

3. The following term and condition implements reasonable and prudent measure No. 3.

3A. NOAA-Fisheries shall continue to conduct protected species workshops for skippers of vessels registered for use with longline fishing permits issued under the Pelagics FMP to facilitate proficiency on mitigation, handling, and release techniques for turtles, as outlined in 50 CFR 223.206(d)(1).

3B. NOAA-Fisheries shall include information on sea turtle biology and ways to avoid and minimize sea turtle impacts to promote sea turtle protection and conservation in the protected species workshops for skippers of longline vessels registered for use with permits issued under the Pelagics FMP.

3C. NOAA-Fisheries shall continue to include sea turtle resuscitation techniques and sea turtle biology information during observer training.

3D. All sea turtles shall be removed from fishing gear or brought on deck prior to continuing with gear retrieval.

3E. Personnel aboard a vessel registered for use with a longline permit issued under the Pelagics FMP must remove the hook from a turtle, if feasible, as quickly and carefully as possible to avoid injuring or killing the turtle. Each vessel must carry a line clipper. If a hook cannot be removed (e.g., the hook is deeply ingested or the animal is too large to bring aboard), the line clipper must be used to cut the line as close to the hook as practicable and remove as much line as possible prior to releasing the turtle.

3F. Each longline vessel registered for use with a longline permit issued for use under the Pelagics FMP must carry a sea turtle dip net to hoist a sea turtle onto the deck, if practicable, to facilitate the removal of the hook. If the vessel is too small to carry a dipnet, sea turtles must be eased onto the deck by grasping its carapace or flippers, if practicable, to facilitate the removal of the hook. Any sea turtle brought on board must not be dropped on to the deck

3G. Each longline vessel registered for use with a longline permit issued under the Pelagics FMP must have a wire or bolt cutter aboard the vessel capable of cutting through a hook that may be imbedded externally, including the head/beak area of a turtle.

3H. NOAA-Fisheries shall make available and disseminate information on sea turtle biology and ways to avoid and minimize sea turtle impacts for promoting sea turtle protection and conservation at appropriate Regional forums (such as the Heads of Fisheries Meetings of the Pacific Community) in the western Pacific region.

3I. In the event of an interaction with a sea turtle, an operator of a vessel not using longlines but using hooks (i.e, handline, troll, and pole-and-line vessels) to target Pacific pelagic management unit species in waters of U.S. western Pacific EEZ, must handle the sea turtle in a manner to minimize injury and promote post-hooking survival. If a sea turtle is too large or hooked in such a manner as to preclude safe boarding without causing further damage/injury to the turtle, the fishing line must be severed and as much line removed prior to releasing the turtle.

4. The following term and condition implements reasonable and prudent measure No. 4.

4A. Operators of vessels registered for use with longline permits issued under the Pelagics FMP shall bring comatose sea turtles aboard, if feasible, and perform resuscitation techniques according to the procedures described at 50 CFR 223.206 (d)(1) and 660.32(b),(c), and (d).

4B. If an observer is aboard the vessel, the observer shall perform resuscitation techniques on comatose sea turtles.

4C. In the event of an interaction with a sea turtle, an operator of a vessel not using longlines but using hooks (i.e, handline, troll, and pole-and-line vessels) to target Pacific pelagic management unit species in waters of U.S. western Pacific EEZ, must handle the sea turtle in a manner to minimize injury and promote post-hooking survival as outlined in 50 CFR 660.32 (c) and (d).

5. The following term and condition implements reasonable and prudent measure No. 5.

5A. Dead sea turtles may not be consumed, sold, landed, offloaded, transhipped or kept below deck, but must be returned to the ocean after identification unless NOAA-Fisheries requests the turtle be kept for further study.

9.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or develop information.

The following conservation recommendations are provided pursuant to section 7(a)(1) of the ESA for developing management policies and regulations, and to encourage multilateral research efforts which would help in reducing adverse impacts to listed species in the Pacific Ocean.

1. NOAA-Fisheries should research modifications to existing gear that (1) reduce the likelihood of interactions between sea turtles and longline fishing gear and (2) reduce the immediate or delayed mortality rates of captured turtles. In particular, NOAA-Fisheries should develop circle hooks that are suitable for use in deep-set longline gear. Any research funded or implemented by NOAA-Fisheries that is likely to increase the number of turtles captured or killed in these fisheries beyond the levels considered in this Opinion or that involve fishing in a manner not considered in this biological opinion must be covered by a research and enhancement permit pursuant to section 10(a)(1)(a) of the ESA. The goal of any research should be to develop a technology or method, through robust experimental designs, that would achieve these goals while remaining economically and technically feasible for fishermen to implement.

2. NOAA-Fisheries should research development or modifications of existing technologies, such as sonar, to detect and alert fishers if sea turtles or marine mammals become entangled in their gear.

3. NOAA-Fisheries should explore the feasibility of developing a system for fishermen to collect life history information on sea turtles.

4. NOAA-Fisheries should continue efforts to gather international support for the Inter-American Convention for the Protection and Conservation of Sea Turtles.

5. NOAA-Fisheries should support the development of a trans-Pacific international agreement that would include Pacific island and Pacific rim nations for the protection and conservation of sea turtle populations.

6. NOAA-Fisheries should continue and expand on existing efforts to implement measures and management actions that protect nesting sea turtles in their ocean environments and increase hatchling production at nesting beaches in the eastern and western Pacific. NOAA-Fisheries should continue to work with the Western Pacific Regional Fisheries Management Council and the relevant non-governmental organizations (such as World Wildlife Fund - Indonesia, Kamiali Integrated Conservation Development Group of Papua

New Guinea, the Sea Turtle Association of Japan, and Wildcoast in Baja, Mexico) to develop and implement long-term conservation programs for sea turtles in the Pacific that (1) protect the War-mon nesting beach at Jamursba-Medi, Bird's Head Peninsula in the State of Papua, Indonesia; (2) work with villagers in western Papua's Kei Kecil Islands to limit subsistence harvests of leatherback turtles to levels that would be sustainable by the population of leatherback turtles that uses those coastal foraging grounds; (3) work with villages of the Kamiali community in Papua New Guinea to eliminate nest predation of leatherback eggs, relocate leatherback nests from areas that are likely to be lost to beach erosion, and conduct subsistence harvests of leatherback turtle eggs that sustainable by this nesting aggregation of leatherback turtles; (4) conduct mortality reduction workshops with fishermen along the coast of Baja Mexico and place observers on local boats to reduce or eliminate the number of loggerhead turtles captured and killed in these fisheries; (5) conduct programs to relocate loggerhead sea turtle nests in Japan that are likely to be lost to beach erosion and provide shading to nests that experience extreme temperatures.

7. NOAA-Fisheries should provide technical and financial assistance necessary to export advances in knowledge of techniques and gear modifications that reduce interactions with sea turtles and/or dramatically reduce the immediate and/or delayed mortality rates of captured turtles with other nations engaged in similar fishing practices to reduce fishery impacts to sea turtle populations worldwide.

8. NOAA Fisheries should continue to work with the Forum Fisheries Agency to ensure that Forum Fisheries Agency observers who are deployed on U.S. purse seine vessels continue to collect and summarize data on the number of sea turtles captured, injured, and killed associated with interactions with the fishery (as an alternative, NOAA-Fisheries should continue to work with key member countries of the Forum Fisheries Agency to achieve the same outcomes discussed in this recommendation). NOAA Fisheries should request that Forum Fisheries Agency work with the Pacific Community's Oceanic Fisheries Program to ensure that relevant sea turtle information is provided in fishery summaries disseminated at annual consultations on the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (recognizing that these data are considered highly confidential by the 16 Pacific Island member countries and the release of these data must be authorized by these countries before any data can be released). NOAA-Fisheries should request that the collection of sea turtle information becomes a high priority for Forum Fisheries Agency observers and that sea-going observers have enough time to collect essential sea turtle life history and disposition information on any captured sea turtles and that VMS data be provided to NOAA-Fisheries for use in estimating the effects of U.S. vessels on sea turtles. This bycatch and fleet operation information is needed in an effort to obtain more representative data on sea turtle interactions. NOAA-Fisheries should ask the Forum Fisheries Agency to provide sea turtle data collected by observers aboard U.S. tuna purse seine vessels fishing under the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America on a quarterly and annual basis. The report should include, at a minimum, the number of sea turtles incidentally captured,

injured, and killed by species, type of set in which each interaction occurred, and life history information on the turtles (size, gender, condition). Whenever possible, photographs should be taken.

10.0 REINITIATION NOTICE

This concludes formal consultation on the proposed regulatory amendments to the Fisheries Management Plan for pelagic fisheries of the Western Pacific Region. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of the incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. If the amount or extent of incidental take identified in the incidental take statement that is enclosed in this biological opinion is exceeded, NOAA-Fisheries' Pacific Islands Region's Sustainable Fisheries Division should immediately request initiation of formal consultation.

This biological opinion has been predicated on several assumptions, which were necessary to overcome gaps in our knowledge. First, the exposure analyses in this biological opinion assumed that different nesting aggregations of green, leatherback, and loggerhead sea turtles were likely to be exposed to these fisheries proportional to their representation in genetics data collected in the area fished by the Hawaii-based longline fisheries. If new data reveals that these assumptions are incorrect, particularly if the eastern tropical Pacific population of green sea turtles, the Malaysian population of leatherback sea turtles, populations of leatherback sea turtles from New Caledonia or the Solomon Islands, or loggerhead sea turtle nesting aggregations on Maehama Beach on Yakushima Island in Japan are exposed in greater proportions than assumed in this opinion, then this new information is likely to satisfy the second requirement for reinitiating consultation.

Second, the response analyses of this biological opinion made assumptions about acute and chronic (post-hooking) mortality rates that were based on the information available from sea turtle experts. If new data, including data collected through the observer program, reveals that those assumptions substantially underestimated the number of sea turtles the would die from acute or chronic exposure to the fisheries, then this new information is likely to satisfy the second requirement for reinitiating consultation.

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APPENDIX A: TECHNICAL DISCUSSION OF ASSESSMENT APPROACH

As summarized in the *Approach to the Assessment* section of this biological opinion, section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. §1536), requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat that has been designated for those species. Regulations that implement section 7(b)(2) of the ESA define *jeopardize the continued existence of* as engaging in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). With respect to threatened and endangered species, then, federal actions are required to ensure that their actions would not be reasonably expected to appreciably reduce the species' likelihood of both surviving and recovering in the wild, by reducing the species' reproduction, numbers, or distribution.

This appendix provides more detailed descriptions of the specific approaches the Office of Protected Resources used to conduct its assessment of the effects of the proposed Fisheries Management Plan for the pelagic fisheries of the Western Pacific Region.

A.1 Method

We conducted our assessment of the effects of the proposed fisheries and fishery management regime using four discrete steps: deconstruct the action, exposure analyses, response analyses, and risk analyses.

Deconstruct the Action

Our first step of our assessment deconstructed the proposed fisheries management plans into their constituent parts (using our agency's prior experience with the fisheries and published information, and) to allow us to distinguish the effects of different fisheries and different fishing strategies on listed resources.

Exposure Analyses

The second step of our assessment consisted of exposure analyses which identified the listed species and designated critical habitat that are likely to co-occur with different components of those fisheries in space and time and any important attributes of that co-occurrence that might help explain the potential risks the fisheries pose to the species. Our exposure analyses used the following scenarios for the different sea turtles:

Green sea turtles: Green sea turtles in the Action Area seem to represent a mix of the threatened Hawaiian turtles and endangered eastern Tropical Pacific turtles, although a majority of the green turtles captured by the Hawaii-based fisheries seem to be ETP. For these risk analyses, exposure to the proposed fisheries and the response of nesting aggregations to that exposure will be evaluated using the following scenarios:

a. green turtles occurring in the Action Area are dominated by the endangered species with individual turtles from Hawaiian nesting aggregations (50% from eastern tropical Pacific; 35% random combination of ETP and Hawaiian turtles; 12% Hawaiian turtles);

b. green turtles in the Action Area are a random mix of these nesting aggregations

Hawksbill sea turtles: hawksbill sea turtles in the Action Area all seem to originate from local nesting aggregations. Exposure to the proposed fisheries and the response of nesting aggregations to that exposure assumed that hawksbill turtles in the Action Area are a random mix of the Pacific nesting aggregations

Leatherback sea turtles: the affiliation between leatherback turtles exposed to the longline fisheries and the different nesting aggregations of leatherback turtles in the Pacific remains uncertain, although the evidence available suggests that at least turtles from the eastern Pacific, Indonesia, Malaysia, and Papua New Guinea are exposed to the Hawaii-based longline.fisheries. We do not know the proportional representation of turtles from these and other aggregations in the Action Area. We also remain uncertain about the size of these nesting aggregations, although the nesting aggregations in the eastern tropical Pacific and Malaysia have been represented by less than handfuls of nesting females for the past several years. Our exposure analyses considered the following scenarios:

a. leatherback turtles occur in the Action Area proportional to the limited genetics information available

b. leatherback turtles occurring in the Action Area are dominated by the Papua nesting aggregation with individual turtles from other nesting aggregations occurring periodically

Loggerhead sea turtles loggerhead sea turtles in the Action Area all seem to originate from the Japanese nesting aggregations. Our exposure analyses considered the following scenarios:

a. loggerhead turtles in the Action Area are a single nesting population

b. loggerhead turtles in the Action Area represent two groups: a random mix of all nesting aggregations except for the Yakushima Island nesting aggregations (which have a rare haplotype and represent about 5 percent of the sample taken in Hawaiian waters) and a random mix of turtles from the Yakushima Island nesting aggregations

Olive ridley sea turtles: olive sea turtles in the Action Area seem to represent a mix of turtles from the eastern tropical Pacific, western tropical Pacific, and Indian Oceans, although a majority of the olive ridley turtles captured by the Hawaii-based fisheries seem to be ETP. Our exposure analyses considered the following scenarios:

a. olive turtles occurring in the Action Area are dominated by the endangered species with individual turtles from ETP nesting aggregations (74% from eastern tropical Pacific; 26% from the western Pacific and Indian Oceans);

b. olive ridley turtles in the Action Area are a random mix of these nesting aggregations

Additional scenarios had appeared in the analysis plans we had presented earlier in the consultation we had developed; however, we merged several of those scenarios because they were mathematically identical to other scenarios or because we did not have sufficient data to support them.

Response Analyses
The third step of our assessment consisted of response analyses which identify how listed resources are likely to respond once exposed to the Action's stressors. These analyses distinguished between turtles that are captured and released, unharmed; captured and released with injuries that prove fatal later, and sub-lethal effects. As part of these analyses, we considered new information on sea turtle mortalities following their release after having been captured by longline gear.

In 2003, NOAA-Fisheries' Office of Protected Resources was charged with conducting a review of NOAA-Fisheries' February 2001 post-hooking mortality criteria and recommending if and how the earlier criteria should be modified. As part of that review, the Office of Protected Resources convened a Workshop on Marine Turtle Longline Post-Interaction Mortality on 15-16 January 2004, during which seventeen experts in the areas of biology, anatomy/physiology, veterinary medicine, satellite telemetry and longline gear deployment presented and discussed the more recent data available on the survival and mortality of sea turtles subsequent to being hooked by fishing gear. Based on the information presented and discussed at the workshop and a comprehensive review of all of the information available on the issue, the Office of Protected Resources proposed the following changes to the earlier criteria (see Table A.1 for the criteria):

Categories. The February 2001 injury categories were expanded to better describe the specific nature of the interaction. The February 2001 criteria described two categories for mouth hooking: (1) hook does not penetrate internal mouth structure; and (2) mouth hooked (penetrates) or ingested hook. The new criteria divides the mouth hooking event into three components to reflect the severity of the injury and to account for the probable improvement in survivorship resulting from removal of gear, where appropriate, for each injury. The three components consist of: (1) hooked in esophagus at or below the heart (insertion point of the hook is not visible when viewed through the open mouth; (2) hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa[1] (insertion point of the hook is visible when viewed through the open mouth); and (3) hooked in lower jaw (not adnexa). The new criteria, also, separates external hooking from mouth hooking, eliminates the 'no injury' category, and adds a new category for comatose/resuscitated.

[1] Subordinate part such as tongue, extraembryonic membranes

Risk Analyses
The final step of our assessment used the analyses from the previous two steps identify the number of individuals of each species that are likely to be exposed to the proposed fisheries (as well as other information like their age or life history stage) and what is likely to happen to those individuals given exposure. This step of our assessment asked (1) what is likely to happen to different nesting aggregations given the exposure and responses of individual members of those aggregations and (2) what is likely to happen to the populations or species those nesting aggregations comprise.

To assess the probability of regional extinction (for example, the probability of leatherback turtles becoming extinct in the Pacific Ocean), we considered regional probabilities of extinction over multiple time horizons because the results of most population models have a log-normal or right-skewed distribution, species have higher short-term risks of extinction and lower long-term extinction risks.

A.2 Simulations Using the Dennis Model

To help assess the status of the various species of sea turtles, we evaluated census data for different nesting aggregations, when those data were available, using the density-independent form of the Dennis model (Dennis et al. 1991, Morris and Doak 2002). This model uses a diffusion estimation equation to estimate demographic variables for a population and probable population trends. We chose the Dennis model because the available data allows us to meet most, if not all, of the model's data requirements, while the data required to conduct more complex models (for example, population matrices) are not available for all but a few species of sea turtles or nesting aggregations (for example, stage- or age-specific survival rates, growth rates, and any variance associated with these parameters).

The Dennis model, however, uses time series of census counts to estimate several demographic variables that provide important insights into a population's (or subpopulation's) status and future trend. Despite its simplicity, this model allows us to make full use of the data in hand: time series of census counts of the number of nests or nesting females of different species. When the only data available were estimates of the number of nests, we converted those estimates into estimates of the number of adult females in a particular nesting aggregation (which we treat as a equivalent to a subpopulation) using published conversion methods.

To apply the procedures described by Dennis et al. (1991) and Morris and Doak (2002), we first had to estimate two population metrics: (a) population's mean logarithmic growth rate and (b) variance in a population's mean logarithmic growth rate

Table X. Criteria for assessing marine turtle post-interaction mortality after release from longline gear. Percentages are shown for hardshelled turtles, followed by percentages for leatherbacks (in parentheses).

Nature of Interaction	Released with hook and with line greater than or equal to half the length of the carapace	Release with hook and with line less than half the length of the carapace	Released with all gear removed
	Hardshell (Leatherback)	Hardshell (Leatherback)	Hardshell (Leatherback)
Hooked externally with or without entanglement	20 (30)	10 (15)	5 (10)
Hooked in lower jaw (not adnexa[2]) with or without entanglement	30 (40)	20 (30)	10 (15)
Hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa (and the insertion point of the hook is visible when viewed through the mouth) with or without entanglement	45 (55)	35 (45)	25 (35)
Hooked in esophagus at or below level of the heart (includes all hooks where the insertion point of the hook is not visible when viewed through the mouth) with or without entanglement	60 (70)	50 (60)	n/a[3]
Entangled Only	Released Entangled 50 (60)		Fully Disentangled 1 (2)
Comatose/resuscitated	n/a[4]	70 (80)	60 (70)

2 Subordinate part such as tongue, extraembryonic membranes

3 Per veterinary recommendation hooks would not be removed if the insertion point of the hook is not visible when viewed through the open mouth.

4 Assumes that a resuscitated turtle will always have the line cut to a length less than half the length of the carapace, even if the hook cannot be removed.

Population's Mean Logarithmic Growth Rate
A population's mean logarithmic growth rate (or μ), which is equal to the natural logarithm of the population's geometric mean growth rate, measures the mean of the change in a population's growth rate and is a measure of a population's stochastic growth over time (Dennis et al. 1991, Lande and Orzack 1988, Morris and Doak 2002). Forecasts of a population's stochastic growth over time would produce some trajectories that increase, some that remain somewhat stable, while others decrease. The mean logarithmic growth rate is a measure of a population's "average" growth rate assuming that some trajectories will increase, some will remain stable, and others will decrease (here, "average" is a geometric mean rather than an arithmetic mean because forecasts of population growth multiply a starting value by a rate; averages of multiplicative processes are best represented by geometric means).

To estimate population mean logarithmic growth rates, we used counts of sea turtle nests in a particular year (or time interval) or counts of nesting adult females in a particular year (or time interval) to estimate the number of adult females in a nesting aggregation or colony at a particular time (see *Conversions* section below). We then converted these estimates of the number of adult females in a nesting aggregation into their logarithmic equivalents, the converting the result using the equation

$$(\log N_{t+1} - \log N_t)/(t+1-t)^{0.5} \qquad \text{equation A1.}$$

where $(t+1-t)^{0.5}$ is a transformation of the length of the time intervals between censuses or counts. ~~Using these transformations as *x-variables* and the results of equation A.1 as *y*~~ *variables*, we then performed a linear regression of the *y*s against the *x*s while forcing the regression intercept to be zero.

The slope of the regression is an estimate of μ and the regression's error mean square is an estimate of σ^2 (see further discussion of this parameter in the next section). We used the 95% confidence limits for the regression slope to estimate 95% confidence intervals around our estimates of the population's mean log growth rate.

Variance in a Population's Mean Logarithmic Growth Rate
The variance in a population's mean log growth rate (σ^2) captures the rate at which the variance around the distribution of the population's growth rate changes over time (Lande and Orzack 1988, Morris and Doak 2002). This parameter is important because even populations that are growing have some risk of falling to low levels or becoming extinct simply because of variation in growth rates. As a population's growth rate varies from year to year as a result of environmental variation, the population's variance will increase accompanied by an increase in the range of population sizes in the future.

As discussed in the previous section, we used the slope of the regression to estimate μ and the regression's error mean square to estimate σ^2. To calculate 95% confidence limits for our estimates of variance of population mean log growth rates, we obtained the 2.5th and 97.5th percentiles of the chi-square distribution with q-1 degrees of freedom (where q

is the number of transitions in a census) and substituting the result into the following equation

$$((q-1)\hat{\sigma}^2 / \chi^2_{0.025,q-1}, (q-1)\hat{\sigma}^2 / \chi^2_{0.0975,q-1}) \qquad \text{Equation A.2}$$

Using these estimates of μ and σ^2, we first constructed a probability density function which is given by the inverse Gaussian distribution for hitting a quasi-extinction threshold in a small time interval

$$g(t|u,\sigma^2,d) = \frac{d}{\sqrt{2\pi\sigma^2 t^3}} \exp\left[\frac{-(d+\mu t)^2}{2\sigma^2 t}\right] \qquad \text{Equation A.3}$$

then a cumulative distribution function of extinction time using the equation:

$$G(T \mid d,\mu,\sigma^2) = \phi\left(\frac{-d-\mu T}{\sqrt{\sigma^2 T}}\right) + \exp(-2\mu d/\sigma^2)\phi\left(\frac{-d+\mu T}{\sqrt{\sigma^2 T}}\right) \qquad \text{Equation A.4}$$

Where $G(T\|d, \mu, \sigma^2)$	=	the cumulative probability of reaching a quasi-extinction threshold at time T, given d, μ, and σ^2
φ	=	is the standard normal cumulative distribution function (produced by the NORMDIST function in Excel)
d	=	log N_c - Log N_x or the difference between the log of the current population size (N_c) and the log of the quasi-extinction threshold (N_x)
μ	=	the mean of the log population growth rate
σ^2	=	the variance of the log population growth rate

The cumulative distribution function integrates the inverse Gaussian distribution from t = 0 to t = T to calculate the probability of reaching a quasi-extinction threshold at any time between the present (t = 0) and a future time (t = T). Anyone interested in more detailed discussion of this method, the interpretation of model results, and the application of this method to endangered species should refer to Dennis et al. (1991) and Morris and Doak (2002).

A.2.2. Conversions and Scenarios

Leatherback Sea Turtles

We conducted our analyses by started with published counts of the number of leatherback turtle nesters or nests from Las Baulas, Costa Rica; Jamursba-Medi, Indonesia; and Terengganu, Malaysia. We converted these counts to estimates of the number of adult females in the two nesting aggregations by multiplying these estimates by 2.5 to estimate the number of nesting females in the aggregation (the same value used by Spotila et al. 1996) and is an average of re-migration intervals reported for several nesting beaches

Table A.1 Additional parameters, definitions of the parameters, and equations used in Dennis model calculations

Parameter	Definition and Equation
q	The number transitions in a data set (count of transitions)
t_q	Length of time population has been observed (in years)
$\pi(x_d, \mu, \sigma^2)$	The probability of reaching a threshold population size
	$= \begin{cases} 1, \mu \le 0 \\ \exp(-2\mu x_d / \sigma^2) \mu > 0 \end{cases}$
E[T]	mean time until threshold (x_e) is reached
	$\equiv \theta(x_d, \mu) = x_d/\lvert\mu\rvert$
Var(T)	variance in mean time to extinction
	$= x_d/\lvert\mu\rvert^3$
$t^*(x_d, \mu, \sigma^2)$	Maximum likelihood estimate of most likely (mode) time to extinction
	$= \frac{x_d}{\lvert\mu\rvert}\left[\left(1+\frac{9}{4v^2}\right)^{0.5} - \frac{3}{2v}\right]$, where $v = x_d\lvert\mu\rvert/\sigma^2$
r	Continuous rate of population increase (a revision of "intrinsic" rate of increase)
	$= \mu + (\sigma^2/2)$
Var (r) ~	$= (\sigma^2/t_q)+\{\sigma^4/[2(q-1)]\}$
θ	$\theta(x_d, \mu\text{-cap}) = x_d/\lvert\mu\text{-cap}\rvert$
Var(θ)	$x_d^2\sigma^2/(\mu^4 t_q)$
	Lambda or the finite rate of population increase
	= exp (r)

We then applied the procedures prescribed by Dennis et al. (1991) and Morris and Doak (2002) to these estimates of the adult population size to estimate several demographic variables for each of these nesting aggregations of leatherback sea turtles:

a. the population's mean log growth rate,
b. the variance in the population's mean log growth rate,
c. continuous rate of increase (r), and
d. finite rate of population increase (lambda).

Using these parameters, we then calculated the nesting aggregation's risk of quasi-extinction (probability of threshold), mean time to threshold, median time to threshold, and modal time to threshold. In all instances, we used quasi-extinction thresholds of 50 adult females. We also applied the procedures Dennis et al. (1991) and Morris and Doak (2002) to estimate the upper and lower 95% confidence intervals for all of these parameters.

To estimate the risks the mortalities associated with the proposed fisheries might pose to leatherback sea turtles, we asked the question: how would these additional deaths of large adult or sub-adult females affect the demographic variables and extinction risks of a nesting aggregation of leatherback sea turtles? In asking that question, we were interested in incremental changes in demographic variables or extinction risks, rather than an absolute increase in risk.

To answer that question, we used the converted census estimates for the three nesting aggregations, treating the time series of these counts as a "simulated" population of leatherback sea turtles with appropriate levels of year-to-year variation. We then subtracted the number of adult females identified in our exposure analyses from this "population" (we considered using a stochastic mortality rate, but decided that a constant rate would bracket the upper boundary of any stochastic estimate) and re-calculated the demographic variables for the "population" that had been affected by these mortalities.

Using the mean log growth rate and variance in mean log growth rate from this "population" we then compared the "population's" risk of quasi-extinction (probability of threshold), mean time to threshold, median time to threshold, and modal time to threshold with those of "populations" that had not experienced these mortalities.

Loggerhead Sea Turtles. Japanese investigators had provided us with counts of the number of loggerhead turtle nests on Inakahama and Maehama Beaches on Yakushima Island, Japan (data we had received from Japanese investigators). We converted these counts to estimates of the number of adult females in the two nesting aggregations using two methods: Method 1 assumed 4.1 nests per nesting female per year based on estimates from Heppell et al. (2002). Method 2 assumed 2.06 nests per nesting female per year based on estimated from Schroeder et al. (2003). Both methods assumed remigrations intervals of 2.59 years from Miller et al. (2002)

Method 1: (number of nests/4.1)*2.59
Method 2: (no. nests/2.06)*2.59

Once we had completed these conversion, we applied the procedures described in the preceding sections and by Dennis et al. (1991) and Morris and Doak (2002) to these estimates

To estimate the risks the mortalities associated with the proposed fisheries might pose to loggerhead sea turtles, we asked the question: how would these additional deaths (of large oceanic or small neritic juveniles) affect the demographic variables and extinction risks of a population of loggerhead sea turtles with demographic rates similar to those of Inakahama and Maehama nesting beaches? In asking that question, we were interested in incremental changes in demographic variables or extinction risks, rather than an absolute increase in risk.

To answer this question, we used the converted census estimates for Inakahama and Maehama Beaches, treating the time series of these counts as a "simulated" population of loggerhead sea turtles with appropriate levels of year-to-year variation. We then subtracted a constant level of mortality from this "population" (we considered using a stochastic mortality rate, but decided that a constant rate would bracket the upper boundary of any stochastic estimate) and re-calculated the demographic variables for the "population" that had been affected by these mortalities.

Using the mean log growth rate and variance in mean log growth rate from this "population" we then compared the population's risk of quasi-extinction (probability of threshold), mean time to threshold, median time to threshold, and modal time to threshold with those of the population that had not experienced these mortalities.

To assess the risks these mortalities might pose to the remaining Japanese nesting aggregations, we assumed that these aggregations were equivalent in size to Yakushima and that, by assigning the mortalities to the total number of adult females, we were approximating the consequences of randomly distributing the mortalities among the various nesting aggregations (since we did not have counts for the other nesting aggregations, we used this approach to approximate the risks).

We identified life stages using the new life history pattern presented by Bolten[1]: oceanic immatures (5 - 45 cm CCL); small neritic juveniles (45 - 72 cm), large neritic juveniles (72-92 cm), and adults (>92 cm). These growth intervals had been developed using data on sea turtles in the Atlantic rather than the Pacific, in the absence of stage intervals for Pacific loggerheads, we used the Atlantic life stages without conversion. Since most of the loggerhead turtles that have been captured in interactions with the longline fisheries in the Pacific ranged from 41 to 83 cm (straight carapace lengths) with a mean of 58 cm. This would place them in the upper size range of oceanic or the mid-range of small neritic juveniles.

As a result, we assumed that most of the loggerhead turtles that would interact with the fisheries would be small, neritic juveniles. Using the survival values between this stage and the adult stage (from Heppell et al. 2003; once again for Atlantic loggerheads) we converted estimates of the number of small neritic juveniles sea turtles to adult sea turtles: using two steps: multiplying by 0.6758 (the survival rate from small neritic to large neritic) and then by 0.8 and 0.7425 (the survival rate from large neritic to adult).

Matrix Models

We used published stage-based population structures for loggerhead sea turtles and stage-based survival rates, transition rates, and fecundity rates to build population matrices for loggerhead sea turtles (Crouse et al. 1987, Heppell et al. 2003). Using these matrices and operating with the Poptools software plug-in for Microsoft Excel©, we calculated dominant eigenvalues to estimate finite rates of population increase, stable stage structure, stage-elasticities and stage-sensitivities using to procedures described in Caswell (2002) and Morris and Doak (2002)

$$\begin{aligned} \mathbf{Mn}_0 &= n_1 \\ \mathbf{Mn}_1 &= n_2 \\ \mathbf{Mn}_2 &= n_3 \end{aligned} \qquad \text{or generalized as } \mathbf{Mn}_{t-1} = n_t$$

Where

[1] A.B. Bolten. 2003. Active swimmer-passive drifters: the oceanic juvenile stages of loggerheads in the Atlantic system, Pages 63-78, in A.B. Bolten and B.E. Witherington (eds.). Loggerhead sea turtles. Smithsonian Institution Press; Washington, D.C.

$$\begin{pmatrix} F_0 & F_1 & F_2 & F_3 \\ P_0 & 0 & 0 & 0 \\ 0 & P_1 & 0 & 0 \\ 0 & 0 & P_2 & 0 \end{pmatrix} = M \qquad \begin{pmatrix} n_{00} \\ n_{10} \\ n_{20} \\ n_{30} \end{pmatrix} = n_o \qquad \begin{pmatrix} n_{01} \\ n_{11} \\ n_{21} \\ n_{31} \end{pmatrix} = n_1$$

To assess the relative effect of loggerhead mortalities associated with the proposed fisheries on the trajectory of loggerhead sea turtles, we created a "population"-vector with stage abundances consistent with a stable-stage structure, increased the mortality rates of the oceanic juveniles and, separately, small neritic juveniles consistent with the mortalities associated with the proposed fisheries, and projected this "population" matrix for 25, 50, and 100-years. We ran both deterministic (fixed rates) and stochastic (variable rates) projections of these matrices. We compared the results of these projections against an identical "population" that had not been subjected to these stage-specific mortalities.

APPENDIX A: TECHNICAL DISCUSSION OF ASSESSMENT APPROACH

As summarized in the *Approach to the Assessment* section of this biological opinion, section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. §1536), requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat that has been designated for those species. Regulations that implement section 7(b)(2) of the ESA define *jeopardize the continued existence of* as engaging in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). With respect to threatened and endangered species, then, federal actions are required to ensure that their actions would not be reasonably expected to appreciably reduce the species' likelihood of both surviving and recovering in the wild, by reducing the species' reproduction, numbers, or distribution.

This appendix provides more detailed descriptions of the specific approaches the Office of Protected Resources used to conduct its assessment of the effects of the proposed Fisheries Management Plan for the pelagic fisheries of the Western Pacific Region.

A.1 Method

We conducted our assessment of the effects of the proposed fisheries and fishery management regime using four discrete steps: deconstruct the action, exposure analyses, response analyses, and risk analyses.

Deconstruct the Action
Our first step of our assessment deconstructed the proposed fisheries management plans into their constituent parts (using our agency's prior experience with the fisheries and published information, and) to allow us to distinguish the effects of different fisheries and different fishing strategies on listed resources.

Exposure Analyses
The second step of our assessment consisted of exposure analyses which identified the listed species and designated critical habitat that are likely to co-occur with different components of those fisheries in space and time and any important attributes of that co-occurrence that might help explain the potential risks the fisheries pose to the species. Our exposure analyses used the following scenarios for the different sea turtles:

Green sea turtles: Green sea turtles in the Action Area seem to represent a mix of the threatened Hawaiian turtles and endangered eastern Tropical Pacific turtles, although a majority of the green turtles captured by the Hawaii-based fisheries seem to be ETP. For these risk analyses, exposure to the proposed fisheries and the response of nesting aggregations to that exposure will be evaluated using the following scenarios:

a. green turtles occurring in the Action Area are dominated by the endangered species with individual turtles from Hawaiian nesting aggregations (50% from eastern tropical Pacific; 35% random combination of ETP and Hawaiian turtles; 12% Hawaiian turtles);

b. green turtles in the Action Area are a random mix of these nesting aggregations

Hawksbill sea turtles: hawksbill sea turtles in the Action Area all seem to originate from local nesting aggregations. Exposure to the proposed fisheries and the response of nesting aggregations to that exposure assumed that hawksbill turtles in the Action Area are a random mix of the Pacific nesting aggregations

Leatherback sea turtles: the affiliation between leatherback turtles exposed to the longline fisheries and the different nesting aggregations of leatherback turtles in the Pacific remains uncertain, although the evidence available suggests that at least turtles from the eastern Pacific, Indonesia, Malaysia, and Papua New Guinea are exposed to the Hawaii-based longline.fisheries. We do not know the proportional representation of turtles from these and other aggregations in the Action Area. We also remain uncertain about the size of these nesting aggregations, although the nesting aggregations in the eastern tropical Pacific and Malaysia have been represented by less than handfuls of nesting females for the past several years. Our exposure analyses considered the following scenarios:

a. leatherback turtles occur in the Action Area proportional to the limited genetics information available

b. leatherback turtles occurring in the Action Area are dominated by the Papua nesting aggregation with individual turtles from other nesting aggregations occurring periodically

Loggerhead sea turtles loggerhead sea turtles in the Action Area all seem to originate from the Japanese nesting aggregations. Our exposure analyses considered the following scenarios:

a. loggerhead turtles in the Action Area are a single nesting population

b. loggerhead turtles in the Action Area represent two groups: a random mix of all nesting aggregations except for the Yakushima Island nesting aggregations (which have a rare haplotype and represent about 5 percent of the sample taken in Hawaiian waters) and a random mix of turtles from the Yakushima Island nesting aggregations

Olive ridley sea turtles: olive sea turtles in the Action Area seem to represent a mix of turtles from the eastern tropical Pacific, western tropical Pacific, and Indian Oceans, although a majority of the olive ridley turtles captured by the Hawaii-based fisheries seem to be ETP. Our exposure analyses considered the following scenarios:

a. olive turtles occurring in the Action Area are dominated by the endangered species with individual turtles from ETP nesting aggregations (74% from eastern tropical Pacific; 26% from the western Pacific and Indian Oceans);

b. olive ridley turtles in the Action Area are a random mix of these nesting aggregations

Additional scenarios had appeared in the analysis plans we had presented earlier in the consultation we had developed; however, we merged several of those scenarios because they were mathematically identical to other scenarios or because we did not have sufficient data to support them.

Response Analyses
The third step of our assessment consisted of response analyses which identify how listed resources are likely to respond once exposed to the Action's stressors. These analyses distinguished between turtles that are captured and released, unharmed; captured and released with injuries that prove fatal later, and sub-lethal effects. As part of these analyses, we considered new information on sea turtle mortalities following their release after having been captured by longline gear.

In 2003, NOAA-Fisheries' Office of Protected Resources was charged with conducting a review of NOAA-Fisheries' February 2001 post-hooking mortality criteria and recommending if and how the earlier criteria should be modified. As part of that review, the Office of Protected Resources convened a Workshop on Marine Turtle Longline Post-Interaction Mortality on 15-16 January 2004, during which seventeen experts in the areas of biology, anatomy/physiology, veterinary medicine, satellite telemetry and longline gear deployment presented and discussed the more recent data available on the survival and mortality of sea turtles subsequent to being hooked by fishing gear. Based on the information presented and discussed at the workshop and a comprehensive review of all of the information available on the issue, the Office of Protected Resources proposed the following changes to the earlier criteria (see Table A.1 for the criteria):

Categories. The February 2001 injury categories were expanded to better describe the specific nature of the interaction. The February 2001 criteria described two categories for mouth hooking: (1) hook does not penetrate internal mouth structure; and (2) mouth hooked (penetrates) or ingested hook. The new criteria divides the mouth hooking event into three components to reflect the severity of the injury and to account for the probable improvement in survivorship resulting from removal of gear, where appropriate, for each injury. The three components consist of: (1) hooked in esophagus at or below the heart (insertion point of the hook is not visible when viewed through the open mouth; (2) hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa[1] (insertion point of the hook is visible when viewed through the open mouth); and (3) hooked in lower jaw (not adnexa). The new criteria, also, separates external hooking from mouth hooking, eliminates the 'no injury' category, and adds a new category for comatose/resuscitated.

[1] Subordinate part such as tongue, extraembryonic membranes

Risk Analyses

The final step of our assessment used the analyses from the previous two steps identify the number of individuals of each species that are likely to be exposed to the proposed fisheries (as well as other information like their age or life history stage) and what is likely to happen to those individuals given exposure. This step of our assessment asked (1) what is likely to happen to different nesting aggregations given the exposure and responses of individual members of those aggregations and (2) what is likely to happen to the populations or species those nesting aggregations comprise.

To assess the probability of regional extinction (for example, the probability of leatherback turtles becoming extinct in the Pacific Ocean), we considered regional probabilities of extinction over multiple time horizons because the results of most population models have a log-normal or right-skewed distribution, species have higher short-term risks of extinction and lower long-term extinction risks.

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The Dennis model, however, uses time series of census counts to estimate several demographic variables that provide important insights into a population's (or subpopulation's) status and future trend. Despite its simplicity, this model allows us to make full use of the data in hand: time series of census counts of the number of nests or nesting females of different species. When the only data available were estimates of the number of nests, we converted those estimates into estimates of the number of adult females in a particular nesting aggregation (which we treat as a equivalent to a subpopulation) using published conversion methods.

To apply the procedures described by Dennis et al. (1991) and Morris and Doak (2002), we first had to estimate two population metrics: (a) population's mean logarithmic growth rate and (b) variance in a population's mean logarithmic growth rate

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Nature of Interaction	Released with hook and with line greater than or equal to half the length of the carapace	Release with hook and with line less than half the length of the carapace	Released with all gear removed
	Hardshell (Leatherback)	Hardshell (Leatherback)	Hardshell (Leatherback)
Hooked externally with or without entanglement	20 (30)	10 (15)	5 (10)
Hooked in lower jaw (not adnexa[2]) with or without entanglement	30 (40)	20 (30)	10 (15)
Hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa (and the insertion point of the hook is visible when viewed through the mouth) with or without entanglement	45 (55)	35 (45)	25 (35)
Hooked in esophagus at or below level of the heart (includes all hooks where the insertion point of the hook is not visible when viewed through the mouth) with or without entanglement	60 (70)	50 (60)	n/a[3]
Entangled Only	Released Entangled 50 (60)		Fully Disentangled 1 (2)
Comatose/resuscitated	n/a[4]	70 (80)	60 (70)

2 Subordinate part such as tongue, extraembryonic membranes

3 Per veterinary recommendation hooks would not be removed if the insertion point of the hook is not visible when viewed through the open mouth.

4 Assumes that a resuscitated turtle will always have the line cut to a length less than half the length of the carapace, even if the hook cannot be removed.

Population's Mean Logarithmic Growth Rate
A population's mean logarithmic growth rate (or μ), which is equal to the natural logarithm of the population's geometric mean growth rate, measures the mean of the change in a population's growth rate and is a measure of a population's stochastic growth over time (Dennis et al. 1991, Lande and Orzack 1988, Morris and Doak 2002). Forecasts of a population's stochastic growth over time would produce some trajectories that increase, some that remain somewhat stable, while others decrease. The mean logarithmic growth rate is a measure of a population's "average" growth rate assuming that some trajectories will increase, some will remain stable, and others will decrease (here, "average" is a geometric mean rather than an arithmetic mean because forecasts of population growth multiply a starting value by a rate; averages of multiplicative processes are best represented by geometric means).

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$$(\log N_{t+1} - \log N_t)/(t+1-t)^{0.5} \qquad \text{equation A1.}$$

where $(t+1-t)^{0.5}$ is a transformation of the length of the time intervals between censuses or counts. Using these transformations as *x-variables* and the results of equation A.1 as *y variables*, we then performed a linear regression of the *y*s against the *x*s while forcing the regression intercept to be zero.

The slope of the regression is an estimate of μ and the regression's error mean square is an estimate of σ^2 (see further discussion of this parameter in the next section). We used the 95% confidence limits for the regression slope to estimate 95% confidence intervals around our estimates of the population's mean log growth rate.

Variance in a Population's Mean Logarithmic Growth Rate
The variance in a population's mean log growth rate (σ^2) captures the rate at which the variance around the distribution of the population's growth rate changes over time (Lande and Orzack 1988, Morris and Doak 2002). This parameter is important because even populations that are growing have some risk of falling to low levels or becoming extinct simply because of variation in growth rates. As a population's growth rate varies from year to year as a result of environmental variation, the population's variance will increase accompanied by an increase in the range of population sizes in the future.

As discussed in the previous section, we used the slope of the regression to estimate μ and the regression's error mean square to estimate σ^2. To calculate 95% confidence limits for our estimates of variance of population mean log growth rates, we obtained the 2.5th and 97.5th percentiles of the chi-square distribution with q-1 degrees of freedom (where q

is the number of transitions in a census) and substituting the result into the following equation

$$((q-1)\hat{\sigma}^2 / \chi^2_{0.025,q-1}, (q-1)\hat{\sigma}^2 / \chi^2_{0.097.5,q-1}) \quad \text{Equation A.2}$$

Using these estimates of μ and σ^2, we first constructed a probability density function which is given by the inverse Gaussian distribution for hitting a quasi-extinction threshold in a small time interval

$$g(t \mid u, \sigma^2, d) = \frac{d}{\sqrt{2\pi\sigma^2 t^3}} \exp\left[\frac{-(d+\mu t)^2}{2\sigma^2 t}\right] \quad \text{Equation A.3}$$

then a cumulative distribution function of extinction time using the equation:

$$G(T \mid d, \mu, \sigma^2) = \phi\left(\frac{-d-\mu T}{\sqrt{\sigma^2 T}}\right) + \exp(-2\mu d / \sigma^2)\phi\left(\frac{-d+\mu T}{\sqrt{\sigma^2 T}}\right) \quad \text{Equation A.4}$$

Where $G(T \mid d, \mu, \sigma^2)$	=	the cumulative probability of reaching a quasi-extinction threshold at time T, given d, μ, and σ^2
φ	=	is the standard normal cumulative distribution function (produced by the NORMDIST function in Excel)
d	=	log N_c - Log N_x or the difference between the log of the current population size (N_c) and the log of the quasi-extinction threshold (N_x)
μ	=	the mean of the log population growth rate
σ^2	=	the variance of the log population growth rate

The cumulative distribution function integrates the inverse Gaussian distribution from $t =$ 0 to $t =$ T to calculate the probability of reaching a quasi-extinction threshold at any time between the present (t = 0) and a future time (t = T). Anyone interested in more detailed discussion of this method, the interpretation of model results, and the application of this method to endangered species should refer to Dennis et al. (1991) and Morris and Doak (2002).

A.2.2. Conversions and Scenarios

Leatherback Sea Turtles

We conducted our analyses by started with published counts of the number of leatherback turtle nesters or nests from Las Baulas, Costa Rica; Jamursba-Medi, Indonesia; and Terengganu, Malaysia. We converted these counts to estimates of the number of adult females in the two nesting aggregations by multiplying these estimates by 2.5 to estimate the number of nesting females in the aggregation (the same value used by Spotila et al. 1996) and is an average of re-migration intervals reported for several nesting beaches

Table A.1 Additional parameters, definitions of the parameters, and equations used in Dennis model calculations

Parameter	Definition and Equation
q	The number transitions in a data set (count of transitions)
t_q	Length of time population has been observed (in years)
$\pi(x_d, \mu, \sigma^2)$	The probability of reaching a threshold population size
	$= \begin{cases} 1, \mu \le 0 \\ \exp(-2\mu x_d / \sigma^2) \mu > 0 \end{cases}$
E[T]	mean time until threshold (x_e) is reached
	$\equiv \theta(x_d, \mu) = x_d/\lvert\mu\rvert$
Var(T)	variance in mean time to extinction
	$= x_d/\lvert\mu\rvert^3$
$t^*(x_d, \mu, \sigma^2)$	Maximum likelihood estimate of most likely (mode) time to extinction
	$= \frac{x_d}{\lvert\mu\rvert}\left[\left(1+\frac{9}{4v^2}\right)^{0.5} - \frac{3}{2v}\right]$, where $v = x_d\lvert\mu\rvert/\sigma^2$
r	Continuous rate of population increase (a revision of "intrinsic" rate of increase)
	$= \mu + (\sigma^2/2)$
Var (r) ~	$= (\sigma^2/t_q)+\{\sigma^4/[2(q-1)]\}$
θ	$\theta(x_d, \mu\text{-cap}) = x_d/\lvert\mu\text{-cap}\rvert$
Var(θ)	$x_d^2\sigma^2/(\mu^4 t_q)$
	Lambda or the finite rate of population increase
	= exp (r)

We then applied the procedures prescribed by Dennis et al. (1991) and Morris and Doak (2002) to these estimates of the adult population size to estimate several demographic variables for each of these nesting aggregations of leatherback sea turtles:

a. the population's mean log growth rate,
b. the variance in the population's mean log growth rate,
c. continuous rate of increase (r), and
d. finite rate of population increase (lambda).

Using these parameters, we then calculated the nesting aggregation's risk of quasi-extinction (probability of threshold), mean time to threshold, median time to threshold, and modal time to threshold. In all instances, we used quasi-extinction thresholds of 50 adult females. We also applied the procedures Dennis et al. (1991) and Morris and Doak (2002) to estimate the upper and lower 95% confidence intervals for all of these parameters.

To estimate the risks the mortalities associated with the proposed fisheries might pose to leatherback sea turtles, we asked the question: how would these additional deaths of large adult or sub-adult females affect the demographic variables and extinction risks of a nesting aggregation of leatherback sea turtles? In asking that question, we were interested in incremental changes in demographic variables or extinction risks, rather than an absolute increase in risk.

To answer that question, we used the converted census estimates for the three nesting aggregations, treating the time series of these counts as a "simulated" population of leatherback sea turtles with appropriate levels of year-to-year variation. We then subtracted the number of adult females identified in our exposure analyses from this "population" (we considered using a stochastic mortality rate, but decided that a constant rate would bracket the upper boundary of any stochastic estimate) and re-calculated the demographic variables for the "population" that had been affected by these mortalities.

Using the mean log growth rate and variance in mean log growth rate from this "population" we then compared the "population's" risk of quasi-extinction (probability of threshold), mean time to threshold, median time to threshold, and modal time to threshold with those of "populations" that had not experienced these mortalities.

Loggerhead Sea Turtles. Japanese investigators had provided us with counts of the number of loggerhead turtle nests on Inakahama and Maehama Beaches on Yakushima Island, Japan (data we had received from Japanese investigators). We converted these counts to estimates of the number of adult females in the two nesting aggregations using two methods: Method 1 assumed 4.1 nests per nesting female per year based on estimates from Heppell et al. (2002). Method 2 assumed 2.06 nests per nesting female per year based on estimated from Schroeder et al. (2003). Both methods assumed remigrations intervals of 2.59 years from Miller et al. (2002)

Method 1: (number of nests/4.1)*2.59
Method 2: (no. nests/2.06)*2.59

Once we had completed these conversion, we applied the procedures described in the preceding sections and by Dennis et al. (1991) and Morris and Doak (2002) to these estimates

To estimate the risks the mortalities associated with the proposed fisheries might pose to loggerhead sea turtles, we asked the question: how would these additional deaths (of large oceanic or small neritic juveniles) affect the demographic variables and extinction risks of a population of loggerhead sea turtles with demographic rates similar to those of Inakahama and Maehama nesting beaches? In asking that question, we were interested in incremental changes in demographic variables or extinction risks, rather than an absolute increase in risk.

To answer this question, we used the converted census estimates for Inakahama and Maehama Beaches, treating the time series of these counts as a "simulated" population of loggerhead sea turtles with appropriate levels of year-to-year variation. We then subtracted a constant level of mortality from this "population" (we considered using a stochastic mortality rate, but decided that a constant rate would bracket the upper boundary of any stochastic estimate) and re-calculated the demographic variables for the "population" that had been affected by these mortalities.

Using the mean log growth rate and variance in mean log growth rate from this "population" we then compared the population's risk of quasi-extinction (probability of threshold), mean time to threshold, median time to threshold, and modal time to threshold with those of the population that had not experienced these mortalities.

To assess the risks these mortalities might pose to the remaining Japanese nesting aggregations, we assumed that these aggregations were equivalent in size to Yakushima and that, by assigning the mortalities to the total number of adult females, we were approximating the consequences of randomly distributing the mortalities among the various nesting aggregations (since we did not have counts for the other nesting aggregations, we used this approach to approximate the risks).

We identified life stages using the new life history pattern presented by Bolten[1]: oceanic immatures (5 - 45 cm CCL); small neritic juveniles (45 - 72 cm), large neritic juveniles (72-92 cm), and adults (>92 cm). These growth intervals had been developed using data on sea turtles in the Atlantic rather than the Pacific, in the absence of stage intervals for Pacific loggerheads, we used the Atlantic life stages without conversion. Since most of the loggerhead turtles that have been captured in interactions with the longline fisheries in the Pacific ranged from 41 to 83 cm (straight carapace lengths) with a mean of 58 cm. This would place them in the upper size range of oceanic or the mid-range of small neritic juveniles.

As a result, we assumed that most of the loggerhead turtles that would interact with the fisheries would be small, neritic juveniles. Using the survival values between this stage and the adult stage (from Heppell et al. 2003; once again for Atlantic loggerheads) we converted estimates of the number of small neritic juveniles sea turtles to adult sea turtles: using two steps: multiplying by 0.6758 (the survival rate from small neritic to large neritic) and then by 0.8 and 0.7425 (the survival rate from large neritic to adult).

Matrix Models

We used published stage-based population structures for loggerhead sea turtles and stage-based survival rates, transition rates, and fecundity rates to build population matrices for loggerhead sea turtles (Crouse et al. 1987, Heppell et al. 2003). Using these matrices and operating with the Poptools software plug-in for Microsoft Excel©, we calculated dominant eigenvalues to estimate finite rates of population increase, stable stage structure, stage-elasticities and stage-sensitivities using to procedures described in Caswell (2002) and Morris and Doak (2002)

$$\mathbf{Mn}_0 = n_1$$
$$\mathbf{Mn}_1 = n_2 \qquad \text{or generalized as } \mathbf{Mn}_{t-1} = n_t$$
$$\mathbf{Mn}_2 = n_3$$

Where

[1] A.B. Bolten. 2003. Active swimmer-passive drifters: the oceanic juvenile stages of loggerheads in the Atlantic system, Pages 63-78, in A.B. Bolten and B.E. Witherington (eds.). Loggerhead sea turtles. Smithsonian Institution Press; Washington, D.C.

$$\begin{pmatrix} F_0 & F_1 & F_2 & F_3 \\ P_0 & 0 & 0 & 0 \\ 0 & P_1 & 0 & 0 \\ 0 & 0 & P_2 & 0 \end{pmatrix} = M \qquad \begin{pmatrix} n_{00} \\ n_{10} \\ n_{20} \\ n_{30} \end{pmatrix} = n_o \qquad \begin{pmatrix} n_{01} \\ n_{11} \\ n_{21} \\ n_{31} \end{pmatrix} = n_1$$

To assess the relative effect of loggerhead mortalities associated with the proposed fisheries on the trajectory of loggerhead sea turtles, we created a "population"-vector with stage abundances consistent with a stable-stage structure, increased the mortality rates of the oceanic juveniles and, separately, small neritic juveniles consistent with the mortalities associated with the proposed fisheries, and projected this "population" matrix for 25, 50, and 100-years. We ran both deterministic (fixed rates) and stochastic (variable rates) projections of these matrices. We compared the results of these projections against an identical "population" that had not been subjected to these stage-specific mortalities.

APPENDIX W

Distribution List for the Final Supplemental Impact Statement on Management Measures to Implement New Technologies for the Western Pacific Pelagic Longline Fisheries

FSEIS Distribution List

* Submitted written comments on DSEIS
** Commented at DSEIS Public Hearing (2/18/04)

Last name	First name	Afflliation
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*Abramson	Sarah	Bren School of Environmental Science and Management
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Administrator		Department of Land & Natural Resources
Administrator		Division of Aquatic Resources, DLNR
Administrator		Office of Hawaiian Affairs
Agard	Louis	
Agcioe	Joseph	
Aguiar	Dennis	
Aila	William	
*Aish	Annabelle	Environmental Justice Foundation
Aitaoto, Site Coordinator	Fini	American Samoa On-site Coordinator
*Aldom	Terence	
*Alexander	Charles	Bay Area Amphibian and Reptile Society
Alig	Frank	
Allen	Stewart	NMFS Pacific Islands Fisheries Science Center
Allen	Laurie K.	NOAA Fisheries, Office of Protected Resources
Alofaituli	Letalitonu	
*Althouse	Sherry	
Alvarez	Dale	Civil Service
*Amarillas	Cristina	
*Amerson	Debra	Plantris
Amesbury	Judith	Micronesian Archeological Research Services
Anderson	James	
Andrews	Russel	Univ. of British Columbia Dept. of Zoology
Anjo	Anthony	
April	Victoriano	
Arakaki	Edward	
Arboleda	Juliana	
*Arrieta	Diane	
Arrow Inc.		
Artero	Victor	
Atichoff	Paul	Earthjustic Legal Defense Fund, Mid-Pacific Office
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Barefoot	Jordon	
Barja	James	
Barrows	Scott	
Bartram	Paul	Hawaii Seafood Distributors
Basargin	Natalia/Kiril	
Bass	Jamie	
Bator	Bommie	
Bauer	Jennifer	
*Baumoel	Jeffrey	
*Bayer	Evan	
Beals	Gary	
Becker	Elizabeth	TEC
Beebe	Bill	
Bell	Eric	
*Benton	Andrew	
*Bettess	Petra	
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*Bradford	Patricia	
Brandt	G	Lyons, Brandt, Cook, & Hiramatsu
*Braude	Michael	
*Bray	Jeanine	
*Breslin	Nancy and Bob	
Bright	Jody	Tropidilla Productions
Broadway	Megan	
Brock	Richard	University of Hawaii Sea Grant
*Broussard	Kelle	
Brown	Steve	
Bucehard	John	
Buck	Mike	
*Bural	Brenda	
*Burdi	Jackie	
Burgess	Puanani	
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*Carroll	Philip	
Carroll Muffet	William	Defenders of Wildlife
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*Catt	Maggie	STRP
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*DeWit	Kim	Monterey Bay Aquarium
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Director		Waikiki Aquarium
Director State Department of Health		
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Holland	Kim	
Hollister	William	
*Holtz	Barbara	
*Holz	Rudolph	
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James Fee	James	TEC
Janchez	Joe	
Janisse	Chuck	
Jessop	Aaron	
*Johansen	Claudia	
Johnson	Bruce	Fresh Island Fish
Johnson	Dane	Island Girl
*Johnson	Vicki	
Johnson	Damon	
Jones	Andrew	
*Jutz	Deborah	
K.	Sharane	
Kajihiro	Kule	
Kalthoff	David	Aikane 49
Kamezaki	Naoki	Sea Turtle Assoc. of Japan Dept. of Ecosystem Studies Ur
Kamikawa	Dennis	
Kaneko	John	Pacific Management Resources, Inc
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Kanuha	Clement	Reef Advisory Board
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*Keil	Bryan	
*Kelly	Matt	
Kelly	Marion	
*Kelner	Marian	
*Kemmerling	Deb	
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Kim	Hwa Deong	
Kim	James Chan Song	

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Last name	First name	Afflliation
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*Walker	Jim	Chicago Turtle Club
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		Aiga Ma Uo LLC
		Amak River Legacy
		Amanda K Inc.
		Amko Fishing Co. Inc.
		Aquanut Co. Inc.
		Aukai Fishing Co.Ltd.
		Awahnee Oceanics Inc.
		B-52 Inc.
		Barbara H Inc.
		Bayshore Mgmt. Inc.
		Bethel Inc.
		Black Magic LLC
		Blue Sky Fishing Producer
		Capt. Millions III, Inc.
		Capt. Washington I Inc.
		Carleta LLC
		Clay Howenstine Inc.
		Coldwater Fisheries Inc.
		Crivello Fishing LLC
		Dang Fishery Inc.
		Davis B Inc.
		Dongwon Marine Inc.
		DukSung Fishing Inc.
		Edward G. Co. Inc.
		Faivaimoana Fishing Co Lt
		Feli Fisheries Inc.
		Firebird Fishing Corp.
		Fishrite Inc.
		Gail Ann Co. Inc.
		Golden Sable Fisheries Inc.
		Grunn Sea Venture LLC
		Gunn Pacific Reflection
		H & Lee Inc.
		H and M Fishery Inc.
		Hanson/Hanson Fishing Co.
		Harbor Refuse & Environmental Services
		Hawaii Fishing Co.

Last name	First name	Affliliation
		Heola Inc.
		Highliner Inc.
		H-N Fishery Inc.
		Independence Inc.
		Intl. Quality Fishery Inc
		Island Tuna Mgmt. Inc.
		Jackson Bay Co.
		Ji Hyun Inc.
		Jong Ik Fishing Co. Inc.
		K.A. Fishing Co. Inc.
		K.R. Fishing Inc.
		Katherine VII LLC
		Ka'upu Ltd.
		Kelly Ann Corp.
		Kim Fishing Co.
		KMC & PCC Inc.
		Konam Fishing
		Kuku Fishing Inc.
		Kwang Myong Co. Inc.
		KYL Inc.
		L.S. Fishing Inc.
		Lady Alice Co. Inc.
		Lady Ann Margaret Inc.
		Letalitonu Alofaituli
		Lindgren-Pitman Inc.
		Longline Services Inc.
		M.S. Honolulu Inc.
		M/V Piky Inc.
		Maria J Fishing Inc
		Martin Noel Inc.
		Mee Won Inc.
		Mid Pac Fisheries
		Mini Corp.
		Miss Lisa Inc.
		N. Pac. Fishery Inc.
		Natali Fishing Inc.
		Native Resources Develop
		Nguyen Fishery Inc.
		Ocean Associates Corp.
		Offshore Adventures Inc.
		Ohana Fishing LLC
		Pacboat LLC
		Pacific Fishing & Supply
		Pacific Jennings Inc.
		Pacific Seafoods Inc.
		Paik Fishing Inc.
		Palmer Pedersen Fisheries
		Port Lynch Inc.
		Princess K Fishing Corp.

Last name	First name	Afflilиation
		Quality Tuna Co.
		Queen Diamond Inc.
		Samoa Enterprises Inc.
		Sea Diamond II Inc.
		Sea Dragon II Inc.
		Sea Flower Inc.
		Sea Moon II Inc.
		Seeker Fisheries Inc.
		Sierra Fisheries Inc.
		Silva Fishing Inc.
		Song Fishing Corp.
		Sylvan Seafoods Inc.
		THK Fishing Inc.
		Trans World Marine Inc.
		Tuna Ventures Inc.
		Twin N Fishery Inc.
		Two Bulls Inc.
		Ulheelani Corp.
		Universal Fishing Co.
		Vessel Management Assoc.
		Viking V Inc.
		Vui Vui II Inc.
		Wearefish Inc.
		White Inc.
		Wynne Inc.
		Young S Fishing Inc.
		Zephyr Fisheries LLC

APPENDIX X

Public Comments on the Draft Supplemental Impact Statement on Management Measures to Implement New Technologies for the Western Pacific Pelagic Longline Fisheries with Responses

Summary of Public Comments on the Draft Supplemental Environmental Impact Statement with Responses

Source	Cite	Comment	Response
Identical Form Letters (204 exactly the same; 8 minor, non-substantive changes to wording)	Paragraph 1	Oppose renewed swordfishing east of 150°W	The SEIS does not require revision based on this comment. The proposed regulatory amendment does not distinguish between waters east and west of 150°W longitude as the best available scientific information does not warrant such an action. Vessels operating under Hawaii longline limited access permits would be allowed to target swordfish (make shallow longline sets) north of the equator at any longitude. This issue about making distinctions by longitude arose in development of regulations for the west coast-based longline fishery in the Pacific Fishery Management Council's Highly Migratory Species (HMS) Fishery Management Plan (FMP) for vessels operating primarily out of California and the Biological Opinion (BiOp) for that action. The Pacific Council's FMP reviewed the available evidence and concluded that there was insufficient evidence that turtle takes were significantly higher east 150°W. A recent study of this issue (Carretta, 2003) concluded that, while there is some evidence that shallow sets east of 150°W have higher interaction rates with loggerhead and leatherback sea turtles, the difference is not statistically significant at the 0.05 level. Conversely, the interaction rate of shallow sets with olive ridley sea turtles was significantly higher west of 150°W. Regulation of the fishery conducted under the HMS FMP is independent of this proposed action for the Western Pacific. The HMS fishery would still be prohibited from shallow-sets west of 150°W by the FMP and its implementing regulations and from shallow sets east of 150°W by rules proposed pursuant to the ESA. The HMS FMP and its BiOp assumed that any shallow set longlining would be done using the same techniques historically used in both the Hawaii-based and the West Coast-based fisheries, specifically, J hooks and squid bait. This proposed regulatory amendment requires the use of circle hooks and mackerel type bait for Hawaii-based vessels making shallow sets north of the equator, which have been shown in the Atlantic to significantly reduce interactions with loggerhead and leatherback turtles. Waters east of 150°W have historically represented a relatively minor portion of the Hawaii-based longline effort and that could be expected to continue under any new regulations.

Summary of Public Comments on the Draft Supplemental Environmental Impact Statement with Responses

Source	Cite	Comment	Response
	Paragraph 2	Keeping the area east of 150°W closed to longline fishing for swordfish is the only measure that will help prevent extinction of the leatherback	The SEIS does not require revision based on this comment because there are a number of measures that will help reduce the risk of extinction of the leatherback including elimination or reduction of direct harvesting, nesting beach management, and egg protection and the alternatives described in the DSEIS include five such measures (Conservation Projects) designed to help prevent the extinction of leatherback and loggerhead turtles. As indicated in the response to Paragraph 1 of this comment, the best available scientific information does not warrant a longitudinal separation of regulations for the Hawaii-based longline fleet. In either case, there is relatively little fishing east of 150°W by this fleet. Further, the NMFS Office of Protected Resources concluded in the 2004 Biological Opinion for this action that fishing in the manner identified by the proposed regulatory amendment i.e., without longitudinal regulations, would not jeopardize the continued existence of sea turtles.
	Paragraph 3	Since the area east of 150°W was closed to shallow sets, the number of sea turtles killed has dropped significantly.	The SEIS does not require revision based on this comment because although it is historically true that shallow-set longlines have higher turtle interaction rates than do deep set longlines, and if there were no shallow-sets these interactions would not occur, the Hawaii-based fleet only represents approximately 3% of Pacific pelagic longline effort. When U.S. vessels are restricted from fishing, foreign fleets may fill all or part of the void in market supply. As described in DSEIS section 10.11.1, these fleets may have many times the interaction and mortality rates per unit catch as the Hawaii-based fleet ever did. The proposed regulatory amendment includes a model swordfish fishery employing methods shown in the Atlantic (circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. If these techniques prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term effects of exporting these techniques may far outweigh any short-term gains resulting from closing areas to Hawaii-based vessels.

Source	Cite	Comment	Response
	Paragraph 4	The WPRFMC should take a stronger role in advocating international agreements that would close these waters to swordfish fishers from other countries.	The SEIS does not require revision based on this comment because the WPRFMC (Council) is already on the forefront of efforts to encourage international cooperation in these efforts and to this end has sponsored a number of symposia, workshops, meetings and conferences. NMFS and the Council are cooperating with the U.S. Department of State to implement international or multinational agreements affecting fishing on the high seas. In a pragmatic sense, the most effective action the WPRFMC can take is to support the proposed regulatory amendment's model swordfish fishery, with its potential to demonstrate to foreign fleets that different fishing techniques will increase their catch rates of swordfish, while decreasing their turtle interaction rates.
The following 27 letters contain additional comments. The additions are responded to below.			
Heather Ferguson	Paragraph 2	All species of sea turtles are at an equal risk of devastation by using these poor fishing practices.	The SEIS does not require revision based on this comment because shallow-set longline fishing under the preferred alternative would provide a substantially reduced risk of interaction with sea turtles. There are differences in interaction rates of longlines with different species of sea turtles due to turtle distributions, migratory pathways, foraging habits, food preferences, fishing effort distributions, and other factors. Leatherback and loggerhead turtles are the species of greatest concern in the Hawaii-based fishery, not because they are most frequently caught, but because their stocks are in the most critical condition of the listed sea turtle species. The preferred alternative's model swordfish fishery, through its potential positive influence on international longline fishing practices, would have positive effects on leatherback and loggerhead turtle populations. In addition, as described in the DSEIS, the sea turtle conservation projects being pursued by the Council are expected to have positive effects on the same leatherback and loggerhead turtle populations by protecting them in their nesting and coastal habitats.

Summary of Public Comments on the Draft Supplemental Environmental Impact Statement with Responses

Source	Cite	Comment	Response
Charles Fox	Paragraph 1	Several species of sea turtles are in dire threat of extinction due to massive mortality by longline fishing. Survival of these turtles will depend on curtailment of longline fishing.	The SEIS does not require revision based on this comment because there have been historically and are now many factors contributing to the declines of sea turtle populations and it is an oversimplification to attribute the current plight of sea turtles exclusively to longline fishing. Curtailment of longline fishing by U.S. vessels will have little positive effect on sea turtle populations, and cumulatively may have a negative effect to the extent U.S. effort is replaced by foreign effort with higher interaction rates per unit catch (see section 10.11.1 of the SEIS). The proposed model swordfish fishery and its potential influence on international longline fishing practices, and the conservation projects, are expected to have positive effects on leatherback and loggerhead turtle populations
	Paragraph 6	We shouldn't just restrict American fishermen, but level the playing field and restrict foreign longline fleets from these waters as well.	The SEIS does not require revision based on this comment because the U.S. government does not control foreign fishing efforts on the high seas. The most effective way we can influence foreign fishing is to provide them a cost-effective means to improve their catch while decreasing their turtle interaction rates. The expected results of the proposed model swordfish fishery would assist in this regard.

Summary of Public Comments on the Draft Supplemental Environmental Impact Statement with Responses

Source	Cite	Comment	Response
Melanie Gates	Paragraph 1	If you continue to kill these precious animals you will be responsible for the potential extinction of one of the most rare and beautiful creatures on this earth. The economic value of swordfish can never replace a species.	The SEIS does not require revision based on this comment because the Hawaii-based longline fleet under the preferred alternative has been evaluated by the NMFS Office of Protected Species not to jeopardize the recovery of these species. The Hawaii longline fishery represents only 3% of Pacific pelagic longline effort. When U.S. vessels are restricted from fishing, foreign fleets may fill all or part of the void in market supply. As described in DSEIS section 10.11.1, these fleets may have many times the interaction and mortality rates per unit catch as the Hawaii-based fleet ever did. The preferred alternative includes a model swordfish fishery employing methods shown in the Atlantic (circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. If these techniques prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term cumulative effects of exporting these techniques may far outweigh any short-term gains resulting from closing areas to U.S. vessels. Additionally, one of the objectives of the FMP is to achieve optimum yield. The preferred alternative was selected to provide the greatest economic benefits at the least cost, including the non-market costs associated with sea turtle interactions.

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Source	Cite	Comment	Response
Ann Hallowell	Paragraph 2	Keeping the area east of 150°W closed to longlining for swordfishing is essential to protect leatherbacks, whose slow maturity means that even a small decrease in their numbers would seriously impact the species' survival.	The SEIS does not require revision based on this comment because the Hawaii-based longline fleet has been evaluated by the NMFS Office of Protected Species not to jeopardize the recovery of these species. The Hawaii longline fishery only represents 3% of Pacific pelagic longline effort. When U.S. vessels are restricted from fishing, fleets may fill all or part of the void in market supply. As described in DSEIS section 10.11.1, these fleets may have many times the interaction and mortality rates per unit catch as the Hawaii-based fleet ever did. The preferred alternative includes a model swordfish fishery employing methods shown in the Atlantic(circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. If these techniques prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term cumulative effects of exporting these techniques may far outweigh any short-term gains resulting from simply closing areas to Hawaii-based vessels.
Janet Hitt	Paragraph 5	The proposed action is unnecessary and irresponsible.	The SEIS does not require revision based on this comment because one of the objectives of the FMP is to achieve optimum yield in the utilization of U.S. fishery resources as required by the Magnuson-Stevens Fishery Conservation and Management Act of 1996. The preferred alternative was selected to provide the greatest economic benefits at the least cost, including the cost to sea turtle populations associated with interactions. The model swordfish fishery should reduce turtle takes in both U.S. and ultimately foreign longline fleets. The conservation projects being undertaken by the Council and NMFS are intended to address other factors contributing to the decline of loggerhead and leatherback populations. Complete elimination of longline fishing in the Pacific would not necessarily save these species from extinction. Action on a number of fronts is needed and the proposed actions constitute a responsible initiative to conserve turtle populations.

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Source	Cite	Comment	Response
David Katzman	Paragraph 2	You must arrest the extinction of the leatherback by closing the area to swordfishing.	The SEIS does not require revision based on this comment because there have been historically and are now many factors contributing to the declines of sea turtle populations and it is an oversimplification to attribute the current plight of sea turtles exclusively to swordfish fishing east of 150°W. Curtailment of longline fishing by U.S. vessels will have little positive effect on sea turtle populations, and cumulatively may have a negative effect to the extent U.S. effort is replaced by foreign effort with higher interaction rates per unit of catch (see section 10.11.1 of the DSEIS). The proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations.
	Paragraph 3	Please help save this amazing, million-year-old species.	The SEIS does not require revision based on this comment because the proposed model swordfish fishery and its potential influence on international longline fishing practices, and the conservation projects, are expected to have positive effects on leatherback and loggerhead turtle populations.
Ellis and Cheryl Levinson	Paragraph 1	Renewed swordfishing east of 150°W could mean the end of the species.	The SEIS does not require revision based on this comment because there have been historically and are now many factors contributing to the declines of sea turtle populations and it is an oversimplification to attribute the current plight of sea turtles exclusively to swordfish fishing east of 150°W. Curtailment of longline fishing by U.S. vessels will have little positive effect on sea turtle populations, and cumulatively may have a negative effect to the extent U.S. effort is replaced by foreign effort with higher interaction rates per unit of catch (see section 10.11.1 of the DSEIS). The proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations.

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Source	Cite	Comment	Response
Mark Nicholas	Paragraph 3	Longline fishing kills turtles. Until swordfishing can be done without killing turtles, do what is right and not allow this to occur.	The SEIS does not require revision based on this comment because there have been historically and are now many factors contributing to the declines of sea turtle populations and it is an oversimplification to attribute the current plight of sea turtles exclusively to swordfish fishing. We cannot prohibit foreign fishing efforts on the high seas and prohibition of longline fishing by U.S. vessels will have little positive effect on sea turtle populations, and cumulatively may have a negative effect to the extent U.S. effort is replaced by foreign effort with higher interaction rates per unit catch (see section 10.11.1 of the DSEIS). The proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations. This is a more proactive approach to resolution of the problem than simply stopping U.S. longlining which would do nothing substantive for the long-term recovery of the turtle populations.
Jaclyn Rolph	Paragraph 5	I urge you to make the right choices in keeping turtles around. They are an essential part of the diversity of our planet. They have a right to life. We have the power to ensure they enjoy that right.	The SEIS does not require revision based on this comment because the proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations.
Elizabeth Szabo	Paragraph 5	You should be doing all you can to protect what little there is left of our precious natural heritage.	The SEIS does not require revision based on this comment because the proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations.

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Read Vanderbilt	Paragraph 2	Leatherbacks can withstand no additional human captures or kills and are likely to be killed at an increased rate if shallow sets are allowed.	The SEIS does not require revision based on this comment because the NMFS Office of Protected Resources 2004 Biological Opinion prepared for the proposed action concluded that the action is not likely to jeopardize the continued existence of any turtle species. The proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations. Those alternatives that would eliminate or sharply curtail the model swordfish fishery would provide little incentive for foreign fishing vessels to change their fishing patterns.
		Of captured and released turtles, it is unknown if they were able to survive the injury and trauma.	The SEIS does not require revision based on this comment. Post-release mortality is an area of active research and quite a bit is known. In 2001, NMFS established a policy and criteria for estimating survival and mortalities following interactions with longline gear. In 2004 (since publication of the DSEIS and described in new section 14.0 of the Final SEIS), these criteria were reviewed and modified on the basis of new information. Six categories of interaction and three categories of release were defined to give a matrix of post release mortality estimates for both leatherback and hard shell turtles. These percentages currently are used in estimating post-release mortalities. It is likely that these criteria will continue to be refined as new data become available.

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	Paragraph 3	Indiscriminate use of long soak times, shallow depths and light sticks poses a terrible threat to our oceans. It simply is too wasteful a fishing technique.	The SEIS does not require revision based on this comment because the preferred alternative includes a variety a measures to regulate and monitor the Hawaii-based domestic longline fishery. This includes a model swordfish fishery employing methods shown in the Atlantic (circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. Discarding of light sticks is prohibited under U.S. law and international convention. If these new gear technologies prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term cumulative effects of exporting these techniques to foreign fisheries are expected to far outweigh any short-term gains resulting from unilaterally closing the U.S. fisheries. The U.S. longline fisheries in the Pacific only represent approximately 3% of Pacific pelagic longline effort. What is needed is further development and international implementation of fishing methods that catch fewer turtles.
	Paragraph 4	Harpooning would be preferable to longline fishing in terms of economics, jobs, product quality and ecosystem impact.	The SEIS does not require revision based on this comment because there are only certain places where the oceanographic conditions favor concentration of swordfish at the sea surface where they can be harpooned. These conditions do not exist in the area fished by the Hawaii-based fleet, and this method is impractical for them to use.

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Source	Cite	Comment	Response
Joseph Vincent	Paragraph 5	Let common sense prevail, and the sense of Bush be crushed.	The SEIS does not require revision based on this comment because the proposed action and the analyses that underpin it are based on the best available information. The preferred alternative includes a model swordfish fishery employing methods shown in the Atlantic (circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. If these techniques prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term cumulative effects of exporting these techniques may far outweigh any short-term gains resulting from unilaterally closing U.S. fisheries.
Lori-Anne Williams	Paragraph 1	Sea turtles are essential to the lure and lore of the Western Pacific cultures and communities.	The SEIS does not require revision based on this comment. It is true that Pacific cultures used turtles and their shells for a variety of consumptive and ceremonial purposes. Several of these cultures desire to resume a cultural take of these animals. If programs such as that proposed in the regulatory amendment are ultimately successful in restoring these populations to sizes allowing their removal from the list of threatened and endangered species, then perhaps limited cultural takes will be possible.

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Source	Cite	Comment	Response
Anon.	Paragraph 3	Clearly, the “incidental take” associated with the swordfish fishery will lead to the ultimate demise of the leatherback.	The SEIS does not require revision based on this comment because there have been historically and are now many factors contributing to the declines of sea turtle populations and it is an oversimplification to attribute the current plight of sea turtles exclusively to longline fishing. Curtailment of longline fishing by U.S. vessels will have little positive effect on sea turtle populations, and cumulatively may have a negative effect to the extent U.S. effort is replaced by foreign effort with higher interaction rates (see Section 10.11.1 of the DSEIS). The proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations. The NMFS Office of Protected Resources 2004 Biological Opinion prepared for the proposed action concluded that the action is not likely to jeopardize the continued existence of any turtle species.
	Paragraph 4	If the general public knew of the sea turtle mortality associated with harvesting seafood they would demand turtle-safe products.	The SEIS does not require revision based on this comment. NMFS and the Council are committed to public education and outreach, both domestically and internationally and have been engaged such activities for many years. Better education of the general public is indeed necessary, but this is not an issue that can be addressed by unilateral U.S. action. International education, adoption of fishing practices that catch fewer turtles, and conservation programs to improve conditions at nesting beaches are all necessary.

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		Disheartened and outraged because by catch accounts for far more of the take than the actual desired species do.	The SEIS does not require revision based on this comment. By catch does not account for more of the catch than target species and the by catch of protected species such as turtles is a minute percentage of the total catch of fish species. The largest component of by catch is shark, most of which are released alive. However, by catch reduction is mandated by the Sustainable Fisheries Act, and NMFS and the Council are actively researching how this can be accomplished in all domestic fisheries. In addition, a possible result of implementing the modified fishing techniques described in the preferred alternative would be to reduce the catch of turtles by not only U.S. longline fisheries, but also some foreign longline fisheries affecting turtle stocks throughout the Pacific Ocean.
	Paragraph 8	We must protect those species that cannot advocate for themselves.	The SEIS does not require revision based on this comment. Because the proposed model swordfish fishery and its potential influence on international longline fishing practices and the conservation projects are expected to have positive effects on leatherback and loggerhead turtle populations.
Barbara Sachau	Page 1, Paragraph 1	Stop giving commercial fishermen optimum yields, which means no fish left in our oceans for our children's world.	The SEIS does not require revision based on this comment. Optimum yield (OY) is the yield from a fishery which provides the greatest overall benefit to the nation with particular reference to food production and recreational opportunities; it is based on maximum sustainable yield (MSY) as modified by economic, social or ecological factors. MSY is a conservative, sustainable, biological management benchmark and OY further reduces that benchmark to account for other relevant factors including interactions with protected species.

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	Page 1, Paragraph 2	Eliminate all longlining. Swordfish are endangered.	The SEIS does not require revision based on this comment because swordfish are not overfished, endangered, or listed as endangered under the Endangered Species Act, and the stock historically fished by the Hawaii-based fishery appears to be in good condition.. As reviewed in section 9.1.4.6 of the DSEIS, "The stock assessment for North Pacific swordfish by Kleiber and Yokawa (2002) suggests that the population in recent years is well above 50% of the unexploited biomass, implying that swordfish are not over-exploited and relatively stable at current levels of longline fishing effort in the North Pacific."
	Page 1, Paragraph 3	I oppose eliminating the requirement that operators of general longline vessels take an annual protected species course.	The SEIS does not require revision based on this comment. The removal of this requirement will occur as a result of a court order vacating the June 12, 2002 regulations. The Council is expected to consider whether this requirement should be reimplemented at their March 2004 meeting.
	Page 1, Paragraph 4	Does the fact that the regional council is so heavily infested with commercial fishing profiteers influence the biological opinions we get? Do the council biologists have to produce biological opinions to suit commercial fishers?	The SEIS does not require revision based on this comment. The Western Pacific Council has 13 voting and 3 non-voting members. Half of the members are appointed by the U.S. Secretary of Commerce to represent fishing and related community interests in the region. The other Council members are designated state, territorial and federal officials with fishery management responsibilities. Only one of the four Hawaii members of the Council represents commercial fishing interests. Biological Opinions are produced by staff of NMFS' Office of Protected Resources, not the Council or its staff.
	Page 1, Paragraph 5	There is a federal law called FACA which calls for all Federal councils to be balanced. I question whether this council is balanced.	The SEIS does not require revision based on this comment as FACA does not apply to Fishery Management Councils established under Magnuson-Stevens Act.

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Source	Cite	Comment	Response
	Page 2, Paragraph 1	Results from the Atlantic may not work in the Pacific. There is too little food and too few turtles in the Atlantic.	The SEIS does not require revision based on this comment. The reduction of turtle takes in the Atlantic were highly significant for loggerheads and leatherbacks and it is hoped that they will be similarly successful in the Pacific. However the 100% observer coverage for the shallow-setting required by the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action, and the hard limits for leatherback and loggerhead interactions, will ensure that turtle interactions and mortalities are strictly limited regardless of the success of the hook and bait requirements.
	Page 2, Paragraph 2	Suggest all quotas be cut by 50% this year and 10% each subsequent year.	The SEIS does not require revision based on this comment. Because swordfish stocks in the North Pacific are not over-exploited and the population is relatively stable, there are no quotas on swordfish landings. The proposed action would limit the number of shallow sets targeting swordfish to about one half their historical average and strictly limit the number of leatherback and loggerhead turtles incidentally caught to avoid jeopardizing turtle species. The limit on shallow sets would also serve as a de facto quota on other species.
	Page 2, Paragraph 3	Suggest any fishing violator lose his vessel.	The SEIS does not require revision based on this comment. The appropriate vehicles for establishing penalties are the enabling statute and penalty schedules issued by the NOAA Office of Law Enforcement and NOAA General Counsel.

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	Page 2, Paragraph 4	Would like marine sanctuaries established where nobody can fish.	The SEIS does not require revision based on this comment. Marine sanctuaries, including “no take” areas are being established throughout the Western Pacific by local and federal agencies. The Council has implemented such areas through its Coral Reef Ecosystems Fishery Management Plan, and is considering implementing more such areas in draft EISs for its bottomfish, crustaceans and precious corals FMPs. Establishing no-take marine sanctuaries in international waters is not feasible as we cannot prohibit foreign fishing on the high seas, however the DSEIS does examine alternatives which would prohibit longlining in certain areas by vessels managed by the Council.
	Page 2, Paragraph 5	Does the Council want to fish out the area and decimate the stocks?	The SEIS does not require revision based on this comment. The main task of the Council is to protect fishery resources while maintaining opportunities for domestic fishing at sustainable levels of effort and yield consistent with conservation of protected species. Towards this end, there is a limited entry program in place for the Hawaii-based longline fleet, and the preferred alternative would implement effort limits for the shallow-set sector of this fishery. The effect of both is to restrict the catch of fish, of which no stocks targeted by the Hawaii longline fleet are over-fished.
	Page 2, Paragraph 6	If there is a “possibility” that greater effort per set could increase relative to the no action scenario then any such plan allowing such increase is wrong.	The SEIS does not require revision based on this comment. There are physical constraints to how many hooks can be set in a day by a shallow-setting longline vessel. However the effort limits, incidental take statement, hard limits on interactions with leatherback and loggerhead turtles, and the 100% observer coverage mandated by the 2004 Biological Opinion prepared by NMFS’ Office of Protected Resources for this action combine to ensure that fishery managers will be fully informed and able to take appropriate action to further limit effort and avoid jeopardizing sea turtles even if fishing effort per set does increase.

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	Page 2, Paragraph 7	Assessing for multi years is worrisome as a plan could be set in stone and meanwhile every fish in the ocean could have disappeared.	The SEIS does not require revision based on this comment. The FMP and implementing regulations for this fishery are reviewed annually. Due to the considerable inter-annual variability in climatic and oceanographic conditions across the Western Pacific, results obtained in a single year may not represent typical conditions. Valid, representative results are necessary to formulate appropriate long-term management measures, and this typically requires data from more than a single year. The status of each stock is regularly assessed and adjustments to the respective management regime are required if a stock is found to be overfished.
	Page 2, Paragraph 8	Hooking is a guaranteed killer of fish. You cannot unhook successfully and mortality is said to be about 70% or more. So dehooking is wasted effort. The fish is killed by the initial hooking.	The SEIS does not require revision based on this comment. Post-release mortality percentage depends upon a number of variables, but is not 100%. Tag and release programs have recovered many hooked and tagged fish from both commercial trolling and longline and sports fishing vessels.
	Page 2, Paragraph 9	We don't need an abbreviated comment period, but instead more time.	The SEIS does not require revision based on this comment. The abbreviated comment period was necessitated by the Court order that will remove important protective measures for sea turtles on April 1, 2004, and was approved by the EPA.
	Page 2, Paragraph 10	A business should not hold more than one permit.	The SEIS does not require revision based on this comment. At the present time there is not an excessive concentration of permits by any one entity. There does not seem to be any reason at this time to restrict the number of permits that can be held by one entity.
	Page 3, Paragraph 1	All the catch of all vessels should be posted on the internet so the public can see what is being done to a resource that belongs to all Americans.	The SEIS does not require revision based on this comment. NMFS and the Council provide this information in the form of annual reports which are available on their websites. (www.nmfs.hawaii.edu and www.wpcouncil.org).

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	Page 3, Paragraph 2	I do not think any swordfish should be allowed to be caught.	The SEIS does not require revision based on this comment because swordfish are not overfished, endangered, or listed as endangered under the Endangered Species Act, and the stock historically fished by the Hawaii-based fishery appears to be in good condition.. As reviewed in section 9.1.4.6 of the DSEIS, "The stock assessment for North Pacific swordfish by Kleiber and Yokawa (2002) suggests that the population in recent years is well above 50% of the unexploited biomass, implying that swordfish are not over-exploited and relatively stable at current levels of longline fishing effort in the North Pacific." One of the objectives of the FMP is to achieve optimum yield. The preferred alternative was selected to provide the greatest economic benefits at the least cost, including the non-market costs associated with sea turtle interactions.
	Page 3, Paragraph 3	The limit on shallow setting certificates should be 500, not 2120.	The SEIS does not require revision based on this comment. The DSEIS considered a range of numbers of shallow sets from 0 to 3,179. Several considerations factored into the choice of the number of sets for the preferred alternative, including potential effects on turtle populations, adequacy of resultant data to document the effects of the model swordfish fishery, the costs of outfitting a vessel for this type of fishing and the potential annual returns for participants. One of the objectives of the FMP is to achieve optimum yield. The preferred alternative was selected to provide the greatest economic benefits at the least cost, including the non-market costs associated with sea turtle interactions.

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Source	Cite	Comment	Response
Jill Cresko	Paragraph 1	Strongly oppose re-opening to shallow longlining high seas west of 150°W.	The SEIS does not require revision based on this comment. The proposed regulatory amendment does not distinguish between waters east and west of 150°W longitude as the best available scientific information does not warrant such an action. Vessels operating under Hawaii longline limited access permits would be allowed to target swordfish (make shallow longline sets) north of the equator at any longitude. This issue about making distinctions by longitude arose in development of regulations for the west coast-based longline fishery in the Pacific Fishery Management Council's Highly Migratory Species (HMS) Fishery Management Plan (FMP) for vessels operating primarily out of California and the Biological Opinion (BiOp) for that action. The Pacific Council's FMP reviewed the available evidence and concluded that there was insufficient evidence that turtle takes were significantly higher east 150°W. A recent study of this issue (Carretta, 2003) concluded that, while there is some evidence that shallow sets east of 150°W have higher interaction rates with loggerhead and leatherback sea turtles, the difference is not statistically significant at the 0.05 level. Conversely, the interaction rate of shallow sets with olive ridley sea turtles was significantly higher west of 150°W. Regulation of the fishery conducted under the HMS FMP is independent of this proposed action for the Western Pacific. The HMS fishery would still be prohibited from shallow-sets west of 150°W by the FMP and its implementing regulations and from shallow sets east of 150°W by rules proposed pursuant to the ESA. The HMS FMP and its BiOp assumed that any shallow set longlining would be done using the same techniques historically used in both the Hawaii-based and the West Coast-based fisheries, specifically, J hooks and squid bait. The preferred alternative requires the use of circle hooks and mackerel type bait for Hawaii-based vessels making shallow sets north of the equator, which have been shown in the Atlantic to significantly reduce interactions with loggerhead and leatherback turtles.

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	Paragraph 2	If these waters are re-opened, 52 leatherbacks and 174 loggerheads would be taken every year.	The SEIS does not require revision based on this comment. The results of modeling of the outcomes of the preferred alternative as analyzed in (Table 6.3 of the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action) indicate that the level of permitted shallow setting would result in 34 leatherback and 21 loggerhead interactions per year with 9 and 4 mortalities, respectively. While some turtles would be injured or killed, the preferred alternative is expected to benefit turtle populations in the long-term through its potential influence on international longline fishing practices, and the conservation projects.
	Paragraph 3	The viability of the leatherback cannot withstand the killing of even a small number of its members.	The SEIS does not require revision based on this comment. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action concluded that it is not likely to jeopardize the continued existence of any turtle species. If we simply do nothing, the global circumstances driving the species to extinction will continue. The proposed model swordfish fishery and its potential influence on international longline fishing practices, and the conservation projects, are expected to have positive effects on leatherback and loggerhead turtle populations.
Richard Y. Shiroma	Page 1, Paragraph 2	Disagree strongly with the piece-meal approach of splitting the issues into two EISs. Remaining issues of seabird interactions, billfish, FADs and squid fishing are all related to opening the swordfish fishery and should be addressed together.	The SEIS does not require revision based on this comment. Separation of the issues was necessitated by the Court order that will vacate important measures to conserve sea turtles on April 1, 2004. All available resources were dedicated to this effort and two emergency Council meetings were held to discuss potential alternatives and select a preferred alternative. NMFS and the Council have not yet begun the process of evaluating potential alternatives for the other, less pressing, issues. The results of the joint scoping process for both EISs will be reviewed by the Council at its March 2004 meeting, and development of alternatives for other issues will proceed thereafter. Interrelationships among the issues will be explored fully in subsequent NEPA documents. To the extent that the proposed action has an effect on seabirds and fish stocks the DSEIS provides information on likely impacts and cumulative effects.

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	Page 1, Paragraph 3	The DSEIS was developed to back into a pre-determined alternative. There is not enough discussion of the impacts of each alternative.	The SEIS does not require revision based on this comment. The alternatives were developed by NMFS and Council staff based on public comments, and consultation with scientists, fishermen and environmentalists. The alternatives and their impacts were discussed in open Council meetings and a vote was conducted to select a preferred alternative. The most contentious issue is sea turtle interactions and the primary focus of the DSEIS is that issue. PIFSC staff completed modeling efforts to assess impacts of the alternatives on sea turtle populations, and those results are presented in the DSEIS. Also included in the DSEIS are discussions of indirect and cumulative impacts of the alternatives.
	Page 1, Paragraph 3	Lack of specifics on how the fishery will be monitored to provide notification on a real time basis when hard limits are reached.	The SEIS does not require revision based on this comment. Several options for the monitoring and control of model swordfishing effort and turtle interactions are discussed in the DSEIS (see section 8.0). With the 100% observer coverage required by the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action, collecting real time data will not be difficult. The preferred alternative includes a provision for the closures of the shallow-set fishery if and when the leatherback and loggerhead interaction limits for this segment of the fishery are reached. The SEIS does not address how the closure would be implemented, if necessary, because this is at a level of administrative detail and discretion that is beyond the scope of NEPA review.
	Page 1, Paragraph 4	During the winter, the longline fishing closure around some parts of the MHI is less than 50-75 nm.	The closure is lessened from October 1 through January 30, when the longline closed areas decrease on the windward sides to approximately 25 nm off Hawaii, Maui, Kahoolawe, Lanai, Molokai, Kauai, Niihau, and Kaula, and approximately 50 nm off Oahu. This is to allow increased access to these waters by longline vessels when bad weather normally keeps other small boats closer to shore. The SEIS will be supplemented to clarify the closure.

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	Page 1, Paragraph 5	If leatherbacks are typically flipper hooked why not reduce the length of the hook leader to reduce hookings?	The SEIS does not require revision based on this comment. Encounters by leatherbacks with longline gear are not completely random, but may to some extent be related to the turtles being attracted to the gear. Experiments in the Atlantic showed that hooks nearer to floats have a higher incidence of turtle interactions, however this has not been consistently observed for Pacific turtles. It would be premature to regulate this parameter without a better understanding of why leatherbacks are hooked.
	Page 2, Paragraph 1	Participation option should not be a means to achieve personal enrichment. Trading, selling or giving shares should not be allowed. Fish it or lose it.	The SEIS does not require revision based on this comment. Depending on the number of interested permit holders, individual permit holders may receive so few shallow-set certificates that prohibiting transfers of these certificates could have the effect of making participation uneconomical due to the start-up costs. It would also result in unused effort, meaning the FMP objective of attaining optimum yield would not be furthered nor would the efficacy of the Atlantic measures be tested and demonstrated to foreign fishing fleets.
	Page 2, Paragraph 2	Hard limits should be set for interaction with all endangered species, including olive ridley and green turtles.	The SEIS does not require revision based on this comment. Authorized take levels for all species are included in the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action. If authorized takes of any species are exceeded, NMFS' Office of Protected Resources would determine what the appropriate management action would be. The fact that a hard limit under the model swordfish fishery is not established for these species does not mean their protection is lessened.

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	Page 2, Paragraph 3	Blue marlin may be nearly fully exploited. More study is required before opening up a fishery that could further diminish this stock.	The SEIS does not require revision based on this comment. The referenced paragraph goes on to state: "It appears that the stock has been in this condition for the past 30 years, while the level of longline fishing has increased in the Pacific." In 1997, the Hawaii-based longline fishery was estimated to have caught 3.7% of the Pacific-wide catch of blue marlin (Boggs et. al., 2000). That includes both deep and shallow set catches. Limitations inherent in the preferred alternative would allow Hawaii-based shallow-set effort, with its greater rate of blue marlin catch as compared to the deep-set fishery, to 50% of the average annual effort seen during the 1994-1999 period.
	Page 2, Paragraph 4	Development and maintenance of seafood markets should not overshadow doing what is right to protect endangered species and fully exploited stocks.	The SEIS does not require revision based on this comment. The proposed model swordfish fishery and its potential influence on international longline fishing practices, and the conservation projects, are expected to have positive effects on leatherback and loggerhead turtle populations. Allowing carefully regulated fishing will allow decreased domestic consumption of fish imported from less regulated foreign fleets.
James R. Spotila	Paragraphs 1 and 2	Implementation of these measures will continue to threaten the leatherback with extinction in the Pacific. Reduction of interactions will only be 67%. Mortality of the breeding population at Playa Grande Costa Rica is 25-30%. Longline mortality could be projected at 8-12%, but needs to be reduced to 5%.	The SEIS does not require revision based on this comment. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action concluded that it is not likely to jeopardize the continued existence of any turtle species. The proposed model swordfish fishery and its potential influence on international longline fishing practices, and the conservation projects, are expected to have positive effects on leatherback and loggerhead turtle populations.

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Source	Cite	Comment	Response
Donald M. Schug	Page 1, Paragraph 2	Concern is lack of transparency in the process by which the alternative allocation methods were developed and evaluated. Economic and social impact analysis is sketchy and sometimes contradictory. This lack of depth and precision is inconsistent with NEPA and MSA National Standard 2.	The participation options were discussed, and a preliminarily preferred option selected, at the Council's 121st meeting. In trying to determine the fairest alternative the preferences of those most affected (permit holders) were of primary importance in selecting the preferred alternative. The option contained in the preferred alternative has been endorsed by the Hawaii Longline Association which represents the fishermen. This statement will be added to the SEIS. Analysis will be expanded and contradictions addressed. Further, the FEIS provides a full socio-economic analysis which remains pertinent today and remains the best available information on the topic.
	Page 1 Paragraph 4	No description of the scoping process used to identify alternative ways of allocating fishing privileges.	The SEIS does not require revision based on this comment. A discussion of alternative participation options was included in documents provided on the Council's website and at the Council's 120th and 121st meetings. As discussed in section 4.2 of the DSEIS, public comments on all aspects of this action were solicited at a series of public meetings.
	Page 2, Paragraph 1	The DSEIS states that Participation Option 1 could result in derby-style fishing with compromised safety. Impacts analysis says Hawaii longliners fish in all weather up to hurricanes so potential impacts are minor. Unclear if compromised safety is a valid reason for rejecting Option 1.	Discussions of the impacts of the participation options have been expanded and contradictory statements in the DSEIS and the Regulatory Flexibility Analysis have been addressed.

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	Page 2, Paragraph 2	Contention that Option 1 would result in market gluts and shortages is not substantiated, and information provided seems to indicate otherwise.	Although Hawaii caught swordfish has been a small part of the world market, interruptions or fluctuating availability of any product make the necessary establishment of market channels difficult. This is especially for producers in relatively remote areas such as Hawaii who do not have easy access to the world market. These statements have been qualified to indicate that these results could happen, not that they necessarily would.
	Page 2, Paragraph 3	The DSEIS says Option 1 would be relatively easy to implement, but the IRFA says it would be difficult to monitor and administer.	Discussions of the impacts of the participation options have been expanded and contradictory statements in the DSEIS and the Regulatory Flexibility Analysis have been addressed.
	Page 2, Paragraph 4	The DSEIS states that a negative effect of Option 2 could be contentious, but no mention that preferred alternative (Option 5) may also be contentious. Potential for controversy and dissension should be examined in a balanced, objective and comprehensive manner. Who may receive windfall gains should be carefully considered.	Text explaining that restriction of allowable effort to those with historical experience in the swordfish fishery (Option 2) would represent the uncompensated removal of a previous right from vessels that historically targeted tuna will be added to the discussion of impacts. In trying to determine the fairest alternative the preferences of those most affected (permit holders) were of primary importance in selecting the preferred alternative. The method contained in the preferred alternative has been endorsed by the Hawaii Longline Association. This statement will be added to the SEIS.
	Page 3, Paragraph 1	One reason Option 2 was rejected is because it would exclude those who target tuna but participated in developing this measure. The fact that someone who has engaged in “rent-seeking” behavior is not rewarded does not justify rejecting the alternative.	Text explaining that restriction of allowable effort to those with historical experience in the swordfish fishery (Option 2) would represent the uncompensated removal of a previous privilege and economic option from vessels that historically targeted tuna will be added to the discussion of impacts. In trying to determine the fairest alternative the preferences of those most affected (permit holders) were of primary importance in selecting the preferred alternative. The method contained in the preferred alternative has been endorsed by the Hawaii Longline Association. This statement will be added to the SEIS.

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	Page 3, Paragraph 2	Administrative expediency should not justify rejection of Option 2. A time extension or an interim rule could allow a sound analysis of allocation alternatives. It is unclear why certificate transferability could not be added to Option 2.	Option 2, with our without transferable certificates, would represent the uncompensated removal of a previous privilege and important economic option from vessels that historically targeted tuna. Administrative efficiency was one consideration but the refinement of the Council's preliminarily preferred option was also based partly on input from the interested involved parties. The method contained in the preferred alternative has been endorsed by the Hawaii Longline Association. This statement will be added to the SEIS.
	Page 4, Paragraph 3	No comprehensive analysis of consistency with National Standard 4. No estimate of the distributional differences among alternatives.	The SEIS does not require revision based on this comment as the discussion of National Standard 4 is not part of the DSEIS. However, National Standard 4 focuses on the allocation of fishing privileges based on the residency of potential participants (discrimination between residents of different states). Because the Hawaii-based longline fishery is open to residents of all states, the preferred alternative will not discriminate among them. Because the preferred alternative would allow equal access by all interested permit holders (including those residing in other states) to shallow-set certificates, it does not create distributional differences.
	Page 4, Paragraph 4	Recommend more explicit analysis of costs and benefits of annual allocation of certificates versus long-term allocation of shares.	The SEIS does not require revision based on this comment. Given the shortened time frame to implement these actions, long-term allocation options could not be analyzed or considered. However, as with any management measure, the preferred alternative's approach to participation may be modified in future years and long-term allocation options may be considered at that time.

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Source	Cite	Comment	Response
	Page 4, Paragraph 5	No examination of environmental justice implications of the allocation alternatives.	In trying to determine the fairest alternative the preferences of those most affected (permit holders) were of primary importance in selecting the preferred alternative. Because the proposed regulatory amendment would allow equal access by all interested permit holders (including those residing in other states) to shallow-set certificates, it does not create distributional differences. This statement will be added to the SEIS. Furthermore, the preferred alternative does not disposess any current permit holder. Those fishers who targeted swordfish prior to the closure in 2001 also received preferential compensation under the Hawaii economic assistance program.
	Page 5, Paragraph 1	Preferred participation option may or may not be the approach that maximizes net benefits. Insufficient information is disclosed to make that determination.	The SEIS does not require revision based on this comment. As discussed in section 10.1 of the DSEIS, the preferred alternative was selected because it was viewed as the most equitable. It is most likely to result in the use of all allowable effort by those most able to exercise that effort.
	Page 5, Paragraph 2	Economic and social impacts should be given as much attention as biological and physical impacts.	In trying to determine the fairest alternative the preferences of those most affected (permit holders) were of primary importance in selecting the proposed regulatory amendment. The method contained in the proposed regulatory amendment has been endorsed by the Hawaii Longline Association. This statement will be added to the SEIS.
Jeffrey W. Leppo (Stoel Rives LLP)	Page 3, A. NEPA Process	Support Acceleration of SEIS process. Appreciate consideration of transferred effects.	Comment acknowledged.
Sierra Weaver, Marydele Donnelly, The Ocean Conservancy	Page 1, I. Background and General Comments	Concerned about general tone of the DEIS and missing background information.	The SEIS does not require revision based on this comment. The comment on tone lacks sufficient specificity to respond to. The DSEIS provides over 300 pages of background and impact information and the SEIS which it supplements provides more than 400 pages of additional information and analyses.

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Source	Cite	Comment	Response
	Page 1	The current action is being undertaken in response to the August 31, 2003 decision of Judge Kollar-Kotelly in HLA v. NMFS. and the basis for that decision was explicitly procedural.	The SEIS does not require revision based on this comment The relationship between the HLA v. NMFS litigation and the proposed regulatory amendment is different and more complex than suggested. The litigation focused on section 7 consultation under the ESA. As discussed in the DSEIS, the Council and NMFS were engaged in activities relating to this proposed regulatory amendment before the August 31, 2003 decision in this case. The identification of new data, technologies, and information regarding modified fishing methods and gear that substantially reduce incidental sea turtle interactions, and the development of conservation projects, specifically prompted the Council and NMFS to consider their use. As discussed in section 7 of the DSEIS, the new technologies were the result of a two-year study collaboratively conducted in the Atlantic by NMFS and the longline fishery. As discussed in section 8.2 of the DSEIS, the conservation measures were collaboratively developed in mid-2003 under the auspices of the Council's Turtle Advisory Committee. Moreover, the current NEPA process is entirely independent of Judge Kollar-Kotelly's decision, which did not address the existing FEIS issued by NMFS, or the NEPA process. In any event, the DSEIS explicitly acknowledges the relevance of Judge Kollar-Kotelly's decision invalidating the then-existing biological opinion and the related fishery regulations. It is not necessary or appropriate for the DSEIS to attempt to characterize the basis for that decision. In all likelihood, the parties to that litigation are not in agreement regarding the characterization of the basis for the court's ruling.

Source	Cite	Comment	Response
	Page 2, I. Background and General Comments (continued)	Object to the process surrounding the Turtle Conservation Special Advisory Committee formation and deliberation. It excluded important stakeholders. Notices of meetings, agenda and public comment periods were inadequate. The Ocean Conservancy had insufficient notice of the first meeting and agenda changes. Unaware of notices in Federal Register or local media. That caused The Ocean Conservancy to miss first meeting where 4 of 7 alternatives were selected with only 1 conservation organization in attendance.	The SEIS does not require revision based on this comment. The tripartite membership on the Turtle Conservation Special Advisory Committee by scientists, managers, industry members, and non-governmental conservation organizations was recommended by NMFS. Both the head of The Ocean Conservancy and its Pacific Fish Conservation Manager were contacted and invited to attend to the Committee's first and subsequent meetings. Two other conservation organizations were also invited to participate, one of which did so. Attendance at the meetings was open to the public with no one excluded from attending or giving comments as members of the public. Notices for the Committee's first and last meetings were advertised in the Honolulu Advertiser (the second meeting was a follow-up to the first and was held in Washington D.C., it was not advertised). The Ocean Conservancy was invited to participate in this process and did so (including calling into, and commenting at, the first meeting but declining to be identified as an official participant in that meeting). In addition, their suggested alternative was included in the analyses and in the report to the Council. Every attempt was made to keep The Ocean Conservancy informed and to accommodate their schedules. Call- in numbers were provided for those unable to attend a meeting in person, and informational documents were made available via email and on the Council's web site. No public comment periods were required or provided for the Committee's report presented at the Council's 121st meeting, although public comments were accepted at that meeting. Comment periods have also been provided for both the DSEIS and the proposed rule for this action.

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Source	Cite	Comment	Response
		The agency is under no legal obligation to take the drastic action in the Proposed Rule to undo regulations intended to prevent the longline fishery from jeopardizing the continued existence of threatened and endangered sea turtles.	The SEIS does not require revision based on this comment. The comment is acknowledged, however not to take action would be inconsistent with the objective of the FMP to achieve OY and to demonstrate the effectiveness of the Atlantic gear modifications to foreign fishing nations in the Pacific, thus enhancing the possibility of reducing sea turtle by catch throughout the Pacific.
	Page 2, II NEPA and Substantive Comments, First Paragraph	The DEIS fails to provide a full and fair discussion of significant impacts and inform of alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment.	The SEIS does not require revision based on this comment. The DSEIS is supplemental to the 2001 FEIS which provides additional background and analyses useful in further understanding the alternatives and impacts of the present proposal. The DSEIS is focused on changes to the management regime for the shallow-set component of the Hawaii-based longline fishery and consequent impacts to listed species of sea turtles. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action concluded that it is not likely to jeopardize the continued existence of any turtle species. However, i would clearly lessen social and economic impacts of the prior management regime thereby improving the quality of the human environment while minimizing adverse impacts.

Source	Cite	Comment	Response
	Page 3, A. Purpose and Need	Statement of purpose and need is artificially circumscribed and has inappropriately limited the range of alternatives.	The SEIS does not require revision based on this comment as it seems to confuse the purpose of section 7 consultation with the purpose of the underlying proposed action. The purpose of a section 7 ESA consultation is to determine whether a proposed action will jeopardize, or not jeopardize, listed ESA species. However, section 7 consultation does not define the nature of, purpose for or need of the management action. In this instance, it would not be accurate to state that the purpose of the proposed amendment – the management, or proposed, action – is to correct a procedural defect in the section 7 ESA consultation that occurred over a different proposed action. Moreover, while the NMFS and the Council did, through the FEIS and the DSEIS, investigate a wide range of alternative actions, the management action's purpose is more focused than to merely "reevaluate the environmental baseline" and to "consider a wide range of alternatives." As stated in the DSEIS (section 5.2), the objective of the management action is to achieve optimum yield and promote domestic marketing of MUS on a long-term basis from the region's pelagic fishery, without jeopardizing the continued existence of any threatened or endangered species. The preferred alternative also serves to model the implementation of Atlantic gear measures for foreign fishing fleets in the Pacific. This objective is consistent with the requirements of the MSA and the FMP into to which the proposed regulatory amendment relates. This objective, and the purpose and need for this action are also consistent with the ESA as demonstrated by the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action's conclusion that it is not likely to jeopardize the continued existence of any turtle species.

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Source	Cite	Comment	Response
	Page 3, B. Alternatives Analysis	A "reasonable range of alternatives" was not "rigorously explored."	The SEIS does not require revision based on this comment. The process that led the Council and NMFS to its alternatives analysis is detailed in section 8 of the DSEIS. As explained there, the FEIS, which this DSEIS supplements, analyzed a range of ten alternative actions. In the Council's proposed emergency rule package of October 9, 2003, eighteen additional alternatives were analyzed, plus a no action alternative. These alternatives consisted of a series of variations on five themes – (1) tuna fishery only, (2) tuna fishery (with time and area closure) and with various levels of a swordfish fishery, (3) tuna fishery (with time and area closures, except for EEZ water around Palmyra) and with various levels of a swordfish fishery, (4) tuna fishery (without time and area closures) and with various levels of a swordfish fishery and (5) no action. Following information scoping and information consultation with NMFS' Office of Protected Resources, these 19 alternatives were narrowed to a set of 7 new alternatives analyzed in detail in the DSEIS. Three of these alternatives involve a tuna fishery with time and area closures and with varying levels of a swordfish fishery, one alternative involves a tuna fishery only with time and area closures, two alternatives involve a tuna fishery without time and area closures with varying levels of a swordfish fishery and one alternative is the no action option. Section 8 of the DSEIS also explains which alternatives from the FEIS were carried forward and which were not, and why. In addition, the U.S. EPA, which has the responsibility to review all EIS documents for quality and completeness, found the DSEIS to adequately address the proposed regulatory amendment and a reasonable set of alternatives.
		Alternatives analysis is wholly inadequate.	The SEIS does not require revision based on this comment. The most advanced modeling techniques available were used in the DSEIS to rigorously explore the impacts to turtle populations of the current alternatives. The results of those analyses are clearly presented in the DSEIS as a basis for choice among the alternatives. The expected numbers of turtle interactions and mortalities by species and alternative are presented in Tables 44 through 53 (pages 157-165) of the DSEIS.

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Source	Cite	Comment	Response
	Page 4, 1. More Protective Measures	An alternative more protective of turtle species should be considered.	The SEIS does not require revision based on this comment. The alternatives analyzed in the DSEIS and the FEIS address a wide range of actions that are both more and less restrictive of the fishery for purposes of sea turtle conservation. Alternatives 1-3 and 6 each include more restrictive time and area closures. In fact Alternative 6 provides for both time and area closures in the tuna fishery and a complete closure of the swordfish fishery. Moreover, as addressed DSEIS (section 8), Alternative 9 of the FEIS analyzed, in detail, a regional closure of the entire Hawaii-based longline fishery. However, as also explained in section 8, this alternative was eliminated from further consideration beyond its detailed analysis in the FEIS because it conflicts with the objectives of the MSA and the FMP, and because the best available information does not demonstrate a need to close the entire fishery to avoid jeopardizing listed species. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action concluded that it is not likely to jeopardize the continued existence of any turtle species. The MSA and the FMP for the Western Pacific Region provides for actions that ensure maximum yield from and that promote domestic marketing of managed species on a long-term basis. These objectives are the starting point for the proposed action. Adoption of a fishery management regime more restrictive than otherwise would meet these objectives is only authorized to the extent compelled by other laws (i.e., the ESA). Because the proposed action has been found not to jeopardize listed species, there is no requirement to close the swordfish fishery or to maintain additional restrictions that further conflict with the objectives of the MSA and the FMP. Moveover, as addressed in the FEIS and the DSEIS closure of the swordfish fishery could reasonably be expected to have adverse implications for sea turtle populations from the resulting transferred effects.

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Source	Cite	Comment	Response
	Page 4, 2. Use of Circle Hooks in Tuna Fishery	A demonstration tuna fishery using the hook and bait combinations tested in the Atlantic should be implemented rather than the model swordfish fishery.	The SEIS does not require revision based on this comment. There is insufficient information available at this time on the impacts of circle hooks in a deep-set tuna longline fishery such as that around Hawaii to move forward with this measure. Although some work has been done on Atlantic tuna sets, these are shallow-sets and those results are not directly transferrable to the Hawaii deep-set tuna fishery. The conduct of a Pacific demonstration tuna fishery using new hook and bait combinations is being considered by NMFS and research into such modifications is a discretionary recommendation of the 2004 Biological Opinion. However, at this time there is no data on the effectiveness of various alternative hook and bait combinations in the Pacific deep-set fishery and, accordingly, it is unknown whether and to what degree such methods would decrease or increase sea turtle interactions, or to what degree such methods would be effective methods of harvesting target fish. However, Alternative 6 in the DSEIS did analyze not reopening the swordfish fishery. As previously explained, this level of restriction conflicts with the objectives of the MSA and FMP. Because such restrictions were not found to be necessary to avoid jeopardizing listed species, a closure of the swordfish fishery has not been found to be appropriate or necessary.
	Page 5, 3. Time and Area Closures	Time and area closures were implemented to avoid the jeopardy conclusion of the March 2001 BiOp. The same sort of analysis that led to the closure must be used to analyze consequences of potentially modifying or rescinding it.	The SEIS does not require revision based on this comment. Of the seven alternatives considered in the DSEIS, four (Alternatives 1-3 and 6) included time and area closures for the tuna fishery in the interest of sea turtle conservation. Ultimately, these types of restrictions were not demonstrated to be necessary to ensure that the action undertaken does not jeopardize listed species. Accordingly, because such restrictions conflict with the objectives of the MSA and the FMP, the proposed regulatory amendment does not impose time and area closures.

Source	Cite	Comment	Response
		Recommend additional protections for the tuna fleet including at least 20% observer coverage in that area in April and May and a trigger for closing the area if take levels are exceeded.	The SEIS does not require revision based on this comment. Maintenance of 20% observer coverage in the tuna fleet throughout the year and 100% observer coverage of the swordfish fleet is required by the the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action. That Biological Opinion (released since the distribution of the DSEIS) concluded that the proposed action is not likely to jeopardize the continued existence of any sea turtle species. It also established separate take levels for the swordfish and tuna sectors of the fishery. Should the tuna sector exceed its authorized take levels, NMFS' Office of Protected Resources would determine the appropriate course of action.
	Page 6, 4. Sea Turtle Measures for General Longline Permitted Vessels	The proposed rule [and proposed regulatory amendment] would remove all controls from General Longline permits and the Am. Samoa longline fleet. This was not discussed in meetings of the Sea Turtle Special Advisory Committee. It reverses course from the 2001 BiOp. All fleets should have 20% observer coverage. NMFS should take immediate steps to export guidelines and gear to foreign fleets.	The SEIS does not require revision based on this comment. The removal of the existing relevant requirements for general longline permit holders will occur as a result of a court order vacating the June 12, 2002 regulations. The Council is expected to consider their reimplementation at their March 2004 meeting. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action directs NMFS to establish an observer program, where feasible, aboard longline vessels fishing under a Pelagics FMP general permit or a limited access permit for the American Samoa-based longline fishery, should such a permit program be established. In addition, the 2004 Biological Opinion includes several recommendations aimed at increasing NMFS' exportation of new technologies and information to reduce fishery impacts to sea turtle populations worldwide.

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Source	Cite	Comment	Response
	Page 6, 5. Options for Closing Fisheries.	The one week advance notice of closure of the fishery upon reaching the hard cap is unnecessary and very harmful to the sea turtles. The “yellow-light concept” and observer reports should provide ample warning. Similar mechanisms should also be put into place if rate of capture or mortality per set is much higher than estimated, and that should trigger reinitiation of consultation.	The SEIS does not require revision based on this comment. The proposed regulatory amendment includes a provision for the closures of the shallow-set fishery if and when the take limit for this segment of the fishery is reached. The purpose of this is to address the uncertainty that exists in implementing hook and bait modifications that have proven very effective in the Atlantic longline fishery but are, as yet, untested in the Pacific. Should interaction rates be unexpectedly high, NMFS’ Office of Protected Resources would determine the appropriate response. The DSEIS does not address how the closure would be implemented, if necessary, because this is at a level of administrative detail and discretion that is beyond the reasonable scope of NEPA review, however given the anticipated low rates of sea turtle interactions, it is unlikely that there will be an additional interaction during this week.
		Recommend a similar analysis for closure of the tuna fishery. Support use of circle hooks and squid bait in the tuna fishery. Both measures should be considered in the alternatives analysis.	The SEIS does not require revision based on this comment. The proposed regulatory amendment does not include a hard limit for the deep-set fishery because there is a higher level of confidence in the reliability of the projected take levels. The tuna sector of the fishery has its own incidental take statement and if those limits are exceeded, NMFS’ office Of Protected Resources would determine the appropriate course of action. Experimentation with alternative gear, bait and tactics in the tuna sector of the fishery are could be undertaken within the existing management framework and are recommended under the 2004 Biological Opinion prepared by NMFS’ Office of Protected Resources for this action.

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Source	Cite	Comment	Response
	Page 7, C. Indirect and Cumulative Effects	Because of the precipitous decline of some leatherback populations, it is especially important to consider indirect and cumulative effects and avoid speculative analysis. Controls on general longline permitted vessels and those operating out of American Samoa should be included in the Proposed Rule and analyzed in the DSEIS.	The SEIS does not require revision based on this comment. Potential impacts of the American Samoa-based longline fleet are discussed in section 10.5 of the DSEIS. Implementation of the proposed regulatory amendment will be done through a final rule, which will incorporate measures specified in the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action including a requirement to establish an observer program in the American Samoa fishery. This will provide the data necessary for a more accurate assessment of the cumulative impacts of fisheries conducted under the FMP. Although the 2004 Biological Opinion concluded that this action is not likely to jeopardize the continued existence of any turtle species, the Council will consider further measures for the American Samoa-based longline fishery at its March, 2004 meeting (see new section 14.0 of the SEIS).
		It is important to avoid speculative analysis concerning transferred affects.	It is agreed that it is important to avoid speculative analysis, but the fact that our understanding of foreign fleet operations is incomplete does not invalidate the conclusions. We know, for example, that some Hawaii-based longliners relocated to California when shallow-setting was banned in Hawaii. We know that some swordfish exporters and importers turned to other sources when the supply from Hawaii stopped. We know that some fleets in other parts of the world have a much higher interaction rate with turtles than the Hawaii fleet did. The "unpublished report" on market transferred effects referred to was produced under a grant from the Pelagics Fisheries Research Program at the University of Hawaii. A powerpoint presentation of that study is available on the PFRP web site at http://www.soest.hawaii.edu/PFRP/dec03mtg/dec03mtg.html and copies of the report are available through that organization. A second draft report that contains updated domestic and import swordfish data provided by NMFS has been added section 10.7 of the SEIS.

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	Page 8, III. Other Environmental Concerns, A. Continued Work Needed in Atlantic	The Atlantic results don't "minimize" turtle bycatch and more work needs to be done. The limit of 2,120 sets per year is too much. We support additional work in the Atlantic and Azores with larger hooks and urge NMFS to promote the use of promising gear by foreign fleets.	The SEIS does not require revision based on this comment. It may be that further reductions in turtle takes and mortalities can be achieved with further experimentation on gear and fishing tactics and we agree that more work needs to be done.However, according to the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action, the proposed number of sets are not likely to jeopardize the continued existence of any turtle species. Adaptation of the Atlantic results to the Pacific is necessary because of the different oceanographic conditions and fishing practices, and will be essential in transferring new methods to foreign fleets in the Pacific. It is likely that work in both the Atlantic and Pacific will contribute to reductions of turtle takes. The 2004 Biological Opinion includes several conservation recommendations aimed at increasing the exportation of knowledge of techniques and gear to reduce turtle interactions and mortalities.
	Page 8, B. Bycatch of Other Non-Target Species must be Dealt With.	NMFS should carefully review the bycatch of other non-target species, such as seabirds and sharks. Seabird interactions were seasonal with peaks in April-June.	The SEIS does not require revision based on this comment. The proposed regulatory amendment includes the necessary seabird mitigation measure to maintain compliance with the latest Biological Opinion issued by the US Fish and Wildlife Service on this fishery. However a new section 7 consultation on this action will be conducted if determined necessary by that agency. NMFS and the Council are currently formulating alternatives to implement new seabird deterrent methods (including underwater setting chutes and side-setting) that essentially eliminate seabird interactions. That issue will be addressed in a separate NEPA document now under preparation (see new section 14.0 of the DSEIS). It should be noted that the April-June peak observed in seabird interactions coincided with the bulk of the southern area closure which had the indirect effect of pushing longline effort closer to the major seabird breeding colonies in the NWHI.

Source	Cite	Comment	Response
		The DSEIS notes extremely high levels of interactions of shallow sets with pelagic sharks. Reopening the shallow set fishery will increase shark bycatch. More information is needed on post-hooking mortality. These interactions could have ecosystem wide impacts.	The SEIS does not require revision based on this comment. With the ban on shark finning, few sharks are retained and most are released alive. While better post-release mortality data will be valuable, as noted in the DSEIS, current modeling conservatively indicates that the stocks of blue sharks (the most frequently caught shark) are being fished at about half of MSY.
	Page 9, C. Post-Hooking Mortality Considerations	Discussion of the latest NMFS post-hooking estimates should be included in the FSEIS.	The SEIS does not require revision based on this comment. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources will be appended to the DEIS and section 10.4.2 will be expanded to include an explanation of NMFS' most current post-hooking mortality estimates.
	Page 9, D. Conservation Efforts	Concerned that confusion exists about "offsets." The conservation projects cannot serve to mitigate the fishery impacts or justify larger incidental take levels.	The SEIS does not require revision based on this comment. Although the Council regards the conservation measures as potentially offsetting fishery impacts, a contrary position is taken in the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action. Nevertheless, that Opinion concluded that the regulatory component of the proposed action is not likely to jeopardize the continued existence of sea turtles.
Linda Paul, Hawaii Audubon Society	Page 1, Paragraphs 1 and 2	The alternatives are insufficient and do not comply with NEPA. Only one alternative retains existing time and area closures.	The SEIS does not require revision based on this comment. Of the seven alternatives considered in the DSEIS, four (Alternatives 1-3 and 6) include a variety of time and area closures.

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	Page 1, Paragraph 3	There are no limits on the length of a set.	The SEIS does not require revision based on this comment. There are physical constraints to how many hooks can be set in a day by a shallow-setting longline vessel. However the effort limits, incidental take statement, hard limits on interactions with leatherback and loggerhead turtles, and the 100% observer coverage mandated by the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action combine to ensure that fishery managers will be fully informed and able to take appropriate action to further limit effort and avoid jeopardizing sea turtles even if fishing effort per set does increase.
	Page 1, Paragraph 4	No alternatives mention the need for 100% observer coverage.	The SEIS does not require revision based on this comment. As discussed in section 8.1 of the DSEIS, The Sea Turtle Conservation Special Advisory Committee recommended that NMFS consider providing 100% observer coverage for the shallow-set fishery. However, the proposed regulatory amendment ultimately leaves that decision up to NMFS. One of the non-discretionary terms and conditions of the the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action specifies that no vessel using shallow-set gear in the Hawaii-based fisheries shall be permitted to fish without observer coverage.
	Page 1, Paragraph 5	The one week lag between the time the hard cap is reached and stop fishing is an unacceptable risk for the leatherback.	The SEIS does not require revision based on this comment. The proposed regulatory amendment includes a provision for the closures of the shallow-set fishery if and when the take limit for this segment of the fishery is reached. The purpose of this is to address the uncertainty that exists in implementing hook and bait modifications that have proven very effective in the Atlantic longline fishery but are, as yet, untested in the Pacific. Should interaction rates be unexpectedly high, NMFS' Office of Protected Resources would determine the appropriate response. The DSEIS does not address how the closure would be implemented, if necessary, because this is at a level of administrative detail and discretion that is beyond the reasonable scope of NEPA review, however given the historical and anticipated low rates of sea turtle interactions, it is unlikely that there will be a significant number of interactions during this week.

Summary of Public Comments on the Draft Supplemental Environmental Impact Statement with Responses

Source	Cite	Comment	Response
	Page 2, Paragraph 1	There are no seabird mitigation alternatives. No prohibition of lightsticks which cause chick mortality due to ingestion.	The SEIS does not require revision based on this comment. NMFS and the Council are currently formulating alternatives to implement new seabird deterrent methods (including underwater setting chutes and side-setting) that essentially eliminate seabird interactions. That issue will be addressed in a separate NEPA document now under preparation (see new section 14.0 of the DSEIS). However, discarding of light sticks is prohibited under U.S. law and international convention.
	Page 2, Paragraphs 2 and 3	The loss of even one leatherback could push this species to extinction.	The SEIS does not require revision based on this comment. All turtle population models applied to assess the impacts of the Hawaii-based longline fishery on the population trajectories of the four species affected by the fishery arrive at the same conclusion, which is that this fishery has an insignificant effect on those trajectories. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action concluded that it is not likely to jeopardize the continued existence of any turtle species.
Craig J. Severance	Paragraph 3	Major concern is with preferred allocation strategy. Do we know what those who left the Hawaii fishery favor? They have historical participation.	The SEIS does not require revision based on this comment. Interested permit holders now based in California or elsewhere will receive shares equal to those received by Hawaii-based interested permit holders.
	Paragraph 4	If amendment is only partially approved, it might be worth mining logbook data to establish preferential access to the quota on swords.	Comment acknowledged.

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Source	Cite	Comment	Response
Shihoko Uemura	Paragraph 1	Human actions disturb living creatures and habitats.	The SEIS does not require revision based on this comment. The proposed regulatory amendment includes a model swordfish fishery employing methods shown in the Atlantic (circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. If these techniques prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term cumulative effects of exporting these techniques may far outweigh any short-term gains resulting from keeping the Hawaii-based swordfish fishery closed.
Mihoko Uemura	Paragraphs 1-3	Respect for all creatures will bring a more promising future to our children.	The SEIS does not require revision based on this comment The proposed regulatory amendment includes a model swordfish fishery employing methods shown in the Atlantic (circle hooks and mackerel bait) to dramatically reduce turtle interactions and at the same time, increase swordfish catches. If these techniques prove as effective in the Pacific as in the Atlantic, foreign fleets may adopt these methods to increase their swordfish landings while also reducing their turtle interaction rates. The long-term cumulative effects of exporting these techniques may far outweigh any short-term gains resulting from simply closing areas to Hawaii-based vessels.
The following comments were received at the February 18, 2004 Public Hearing			
Sean Martin, Hawaii Longline Association	Oral Comments	HLA believes the proposed amendment uses the best available scientific and commercial data to identify a fishery action that will avoid jeopardizing listed turtles.	Comment acknowledged.

Source	Cite	Comment	Response
		Capture of turtles by longlines is a rare event and the numbers are small. If a turtle is hooked externally or entangled it usually does not die. Satellite tagging data suggests that they live for at least several months after release. Recent reviews of mortality estimates indicate that previous estimates are not based on best available scientific and commercial data and overestimate impacts of the Hawaii longline fishery on listed turtle species.	In 2001, NMFS established a policy and criteria for estimating survival and mortalities following interactions with longline gear. In 2004 (since publication of the DSEIS), the criteria were reviewed and modified on the basis of new information. Six categories of interaction and three categories of release were defined to give a matrix of post-release mortality estimates for both leatherback and hardshell turtles. These percentages currently are used in estimating post-release mortalities, and were used in the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action. Text on these new criteria will be added to section 10.4.2.
		The proposed amendment reflects dramatic progress toward a collaborative, science-based, integrated and lawful regulatory regime for the fishery. HLA endorses the action.	Comment acknowledged.

Source	Cite	Comment	Response
		Continued efforts to develop and employ the best scientific methodologies and data must be vigorously pursued by the Council and NMFS. The challenge of exporting sea turtle-safe fishing gear and methods to the foreign fisheries, which can cause tens if not humdreds of times greater impacts on sea turtles than the Hawaii-based fishery, is a work in progress.	The SEIS does not require revision based on this comment. The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action includes several recommendations aimed at increasing the exportation of knowledge of techniques and gear to reduce turtle interactions and mortalities.
		The swordfish component of the fishery is severely limited to 50% of its historic levels and the take limitations imposed are stricter than the fishery feels is warranted by the best available science.	The SEIS does not require revision based on this comment. The effort levels expressed in the alternatives analyzed in the DSEIS were developed by the Council and its Sea Turtle Conservation Special Advisory Committee, of which HLA was a part. There were compromises made by all parties, with the proposed regulatory amendment believed to reflect a level of effort appropriate to a model swordfish fishery. Authorized take levels were established in the 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action which uses NMFS' updated (2004) estimates of post-capture mortality and information on expected capture rates from Atlantic experiments.
		HLA supports the conservation measures and believes protection of habitat will provide substantial benefits for these species.	Comment acknowledged.

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Source	Cite	Comment	Response
		ESA consultation process continues to be a concern. HLA's applicant status has not been fully recognized, but hopes that over time NMFS will recognize that it is in its interest to work closely with the regulated parties that possess the expertise and ability to devise workable environmental solutions to complex management issues.	Comment acknowledged although the comment is not particularly pertinent to the NEPA analysis or process.
Lisa Hanf, EPA	Page 1, Paragraph 2	The EPA supports the objectives of the amendment and has rated the document LO (Lack of Objections).	Comment acknowledged.
	Page 2, Recommendation	Should include a brief description of future management issues that will be addressed soon.	A new section 14.0 will be added to the DSEIS which will include a description of future management measures and how they are being addressed.
	Page 3, Recommendation	The FSEIS should discuss the status of the section 7 consultation or include a copy of the BiOp.	The 2004 Biological Opinion prepared by NMFS' Office of Protected Resources for this action is now available and will be discussed in a new section 14.0 to be added to the SEIS and the entire Biological Opinion will be added as an Appendix.