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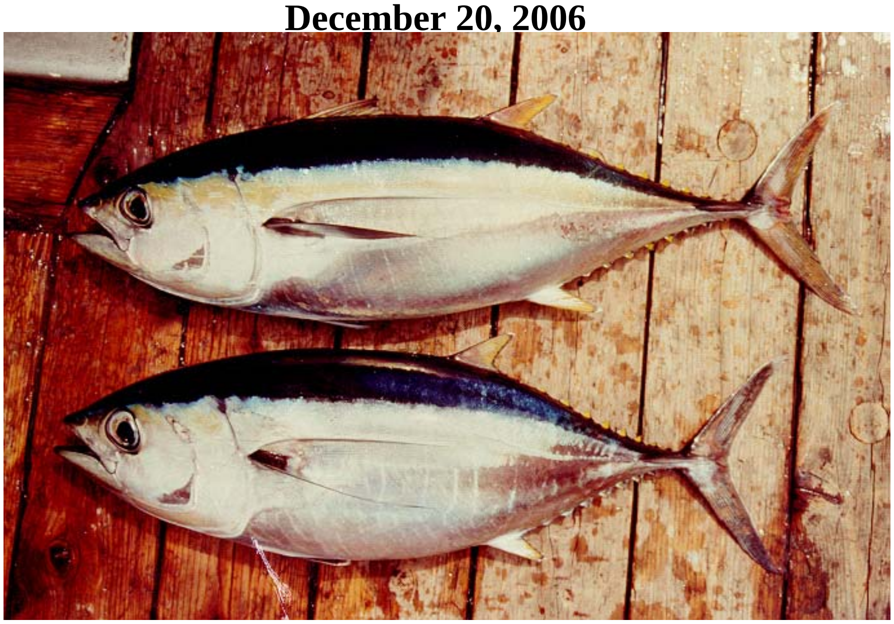
Management Measures for Pacific Bigeye Tuna and Western and Central PacificYellowfin Tuna

Amendment 14 to the Fishery Management Plan for Pelagics Fisheries of the Western Pacific Region including an Environmental Assessment

December 20, 2006



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Amendment 14 to the Fisheries Management Plan for Pelagics Fisheries of the Western Pacific Region

Including an Environmental Assessment

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2.0 Summary

The purpose of the recommendations of the Western Pacific Regional Fishery Management Council (Council) discussed in this document is to address overfishing of Pacific bigeye and Western and Central Pacific (WCPO) yellowfin tuna. The Council was notified by letter on December, 15, 2004, that the Secretary of Commerce (Secretary) had determined that overfishing of bigeye tuna (*Thunnus obesus*) was occurring Pacific-wide. As indicated in the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act or MSA), and required by the implementing regulations for National Standard 1 (50 CFR 600.310(e)(3), the Council was requested by the Secretary to take remedial action (i.e. recommend to NMFS an amendment to its Pelagics Fishery Management Plan) within one year of the identification by the Secretary. More recently in August 2005, the Scientific Committee of the Western and Central Pacific Fisheries Commission reviewed a stock assessment that indicated that yellowfin tuna in the Western and Central Pacific Ocean (WCPO) also appears to being subjected to overfishing. An official communication to this effect was received by the Council from the Secretary on March 16, 2006.

Pacific bigeye and yellowfin tunas occur in the waters of multiple nations and the high seas and are fished by the fleets of other nations in addition to those of the U.S.. The capacity for unilateral action by the U.S. to prevent overfishing is limited, as is the capacity for actions taken by the Councils to end overfishing (National Standard 1, 16 U.S.C. § 1851(a)(1); 50 CFR 600.310(e)(4)(i)) (69 FR 78397). Bigeye tuna catches by commercial fisheries under the Council's jurisdiction in 2004 amounted to 5,163 metric tons (mt), or 2.3% of the 2004 total Pacific-wide bigeye catch. Similarly, 2004 yellowfin tuna catches by commercial fisheries under the Council's jurisdiction amounted to 2,383 mt or about 0.35% of the 2004 total Pacific-wide yellowfin catches, and 0.58% of the yellowfin caught in the WCPO.

The stock structure of bigeye tuna in the Pacific Ocean is unresolved. Bigeye tuna in the Pacific has been assessed using two different approaches, one that treats it as a single Pacific-wide stock and the other that treats it as two stocks, one in the WCPO, corresponding to the area of Western and Central Pacific Fisheries Commission, and the other in the Eastern Pacific Ocean (EPO) corresponding to the area of authority of the Inter-American Tropical Tuna Commission (IATTC). The 2004 overfishing determination relied on assessment results from both of these approaches, but it does not rely on any assumptions or conclusions about stock structure. The most recent stock assessments continued the separate stock approach used by IATTC and SPC. An assessment for the western and central Pacific was completed in July 2004 (Hampton et al. 2004a) and an assessment for the eastern Pacific was completed in May 2004 (Harley and Maunder 2004). A Pacific-wide stock assessment, including comparisons with results from separate stock assessments, was completed in July 2003 (Hampton et al. 2003). The July 2004 assessment for the western and central Pacific indicates that there is a probability of at least 67 % that the recent fishing mortality rate exceeded the fishing mortality rate associated with MSY. The May 2004 assessment results for the eastern Pacific indicate that in all scenarios considered, the recent fishing mortality rate exceeded the rate associated with average MSY. The results of the collaborative July 2003 assessment for the western and central Pacific and for the Pacific Ocean as a whole were similar in that the recent fishing mortality rate in both cases exceeded the fishing mortality rate associated with MSY. The results suggest that for bigeye tuna fishing

mortality, $F_{current,}$ is at or above the fishing mortality at MSY (F_{MSY}) i.e. $F_{MSY}/F_{current} = 0.90 – 1.30$. While the results with respect to fishing mortality were uncertain for both stock assumptions, there was a high degree of correspondence between the estimates of stock trends for the western and central Pacific and those for the Pacific as a whole. Based on these assessment results for bigeye tuna in the Pacific Ocean, NMFS, relying on the expertise and advice of its regional Fisheries Science Centers, has determined that overfishing is occurring Pacific-wide on bigeye tuna.

The most recent stock assessment (August, 2005) on WCPO yellowfin tuna by the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, indicates that the then-current rate of fishing mortality ($F_{current}$) is likely to be in excess of the rate associated with MSY (F_{MSY}). For the base case analysis, the assessment results indicate an $F_{current}/F_{MSY}$ ratio of 1.22 with a range from 1.0 to 2.33 for the four analyses using alternative sets of assumptions (Hampton et al. 2005). The latest estimate of $F_{current}/F_{MSY}$ (1.22) for WCPO yellowfin tuna in 2005 was substantially higher than in the 2004 assessment (0.63) (Hampton et al. 2004b). Scientists at the NMFS Pacific Islands Fisheries Science Center (PIFSC) consider the 2005 assessment model to be an improvement over the 2004 model, and the results to be more reliable. Based on these assessment results and relying on the expertise and advice of the PIFSC Director (October 28, 2005), NMFS has determined that overfishing of the WCPO yellowfin tuna stock is occurring.

Any unilateral management action on the 2.3% of the total Pacific bigeye catch represented by the Council managed pelagic fisheries would not alter the status of bigeye. Such action would not be expected to end overfishing, since the maximum potential reduction in fishing mortality (roughly 2%) is less than the amount required to end overfishing (roughly 20%). This situation is even more acute for WCPO yellowfin tuna, where commercial fisheries under Council jurisdiction account for only 0.58% of WCPO catches. Multilateral internationally coordinated management action is essential to ensure that overfishing on bigeye and yellowfin tunas in the Pacific Ocean ends (69 FR 78397).

In the EPO, the Inter-American Tropical Tuna Commission (IATTC) implemented management measures in 2004 for purse seine and longline fisheries in response to concerns about the condition of EPO bigeye tuna. The longline fleets of member nations of the IATTC were allocated a bigeye quota equivalent to their 2001 catches. The U.S. longline fleet-wide bigeye quota was set at 150 metric tons (mt), the majority of which was taken by Hawaii-based longline vessels in 2004. Other U.S. fisheries based on the West Coast in 2004 caught 488 t of yellowfin and 22 t of bigeye tuna in 2004.

In the WCPO the U.S. has yet to become a party to the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean. The U.S. Senate ratified the treaty in November 2005, but the implementing legislation has yet to be passed by Congress and signed by the President, and in the interim the U.S. remains a cooperating non-member of the Convention. The second meeting of the Western and Central Pacific Fisheries Commission (WCPFC) established under this Convention was held in Pohnpei, during which conservation and management measures for yellowfin and bigeye tuna were adopted (WCPFC 2006). These included a cap on bigeye catches by longline fisheries, based either on their average 2001-2004 catches for most members of the Convention, or based on their 2004 catches for China and U.S.A. These limits will remain in effect between 2006 and 2008. The WCPFC also instructed members, cooperating non-members and participating territories (together abbreviated as CCMs) that caught less than 2,000 mt in 2004, that their catches should not exceed 2,000 mt each year from 2006 to 2008.

For yellowfin tuna, where the main source of fishing mortality is purse seine fishing, the WCPFC established measures within the area of the Convention bounded by 20° N and 20° S. CCMs were instructed to take necessary measures to ensure beginning in 2006, purse seine effort levels do not exceed either 2004 levels, or the average of 2001 to 2004 levels, in waters under their national jurisdiction,. The WCPFC also undertook to implement, at some future date, compatible measures as required under Article 8 of the Convention, to ensure that purse seine effort levels do not exceed 2004 levels on the high seas in the Convention Area or the total fishing capacity will not increase in the Convention Area. Further, a limit on the number of days fished by purse seiners belonging to the countries which are Parties to the Nauru Agreement (PNA) was also implemented, with 2004 set as the base year for this effort cap. Other non-PNA member countries were required to implement similar measures to limit purse seine effort in waters under their jurisdiction to no greater than 2004 levels, or to the average of 2001 to 2004 levels.

The WCPFC also took some initial steps to limit the use of Fish Aggregation Device (FADs) by purse seine vessels, and required CCMs to develop management plans for the use of FADs (anchored and drifting) within waters under national jurisdiction, and submit these to the Commission.

With respect to Council action to conserve yellowfin and bigeye tunas, the Council held a series of public meetings prior to its 127th Council meeting (Honolulu, May 31- June 2, 2005) At its 127th meeting, the Council reviewed available information and comments from each of the public meetings and held a public hearing. The Council then took final action to recommend a suite of non-regulatory measures for the international management of fisheries which harvest bigeye or yellowfin tuna. The Council also reviewed and recommended a range of regulatory and non-regulatory measures for fisheries managed under the Pelagics FMP. In August 2005, the Scientific Committee of the Western and Central Pacific Fisheries Commission reviewed stock assessments for Western and Central Pacific bigeye, yellowfin and skipjack tunas, and South Pacific albacore tuna. The conclusion for bigeye tuna remained more or less unchanged, but yellowfin was found to be likely being subjected to overfishing, although the biomass of the stock was still well above the biomass at maximum sustainable yield (MSY). Subsequently, National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) advised the NMFS Pacific Islands Regional Office (PIRO) that yellowfin tuna was being subjected to unsustainably high levels of fishing mortality in the Western and Central Pacific Ocean (WCPO). In light of this information and anticipating that NMFS would soon determine that overfishing of yellowfin tuna was occurring, at its 129th Council meeting in Guam in November 2005, the Council recommended applying to fishing for yellowfin tuna the management measures in draft Amendment 14 to the Pelagics FMP that the Council recommended for bigeye tuna and directed staff to edit and transmit the amendment accordingly.

Following transmission of Amendment 14 to NMFS on March 22, 2006, comments and recommendations were received from NOAA regarding the need for the action's objectives to be quantified, for its measures to be grouped as alternatives, and for it to include a specific recommendation for EPO purse seine fisheries. In response to these comments, the Council considered the above issues at its 133rd meeting in June, 2006. At that meeting, the Council took action and finalized the recommendations contained in this document.

Together these recommendations and measures constitute a comprehensive foundation plan for the active international and domestic participation of the Western Pacific Regional Fishery Management Council to end overfishing of Pacific bigeye and WCPO yellowfin tuna. Although concerned primarily with Pacific bigeye tuna and WCPO yellowfin tuna, its scope and principles apply to all tunas, billfish and other pelagic fishes managed by this Council. It includes specific recommendations for an immediate end to overfishing in the WCPO and the EPO, focuses on fisheries with the greatest impact on Pacific bigeye and WCPO yellowfin tunas (i.e. longline and purse seines), and recommends a long-term reduction of surplus capacity and restrictions on FAD use by purse seiners. It also includes a mechanism by which the Council will be meaningfully involved in international negotiations that involve fisheries managed by the Council.

Although Council managed vessels in the Pacific are responsible for a very small fraction of total Pacific-wide bigeye and WCPO yellowfin tuna catches, the implementation of the Council's recommended control date (June 2, 2005) for entry into Hawaii-based small boat pelagic fisheries addresses the potential need to constrain expansion of domestic bigeye and yellowfin fishing mortality. This control date does not require the Council to implement limited entry programs or other management measures but they serve to alert participants that such actions could occur.

The Council has already implemented limited entry programs for its Hawaii and American Samoa-based longline fisheries, but recognizes the potential for the expansion of longline fishing into the Mariana Islands. The implementation of the Council's recommended control date (June 2, 2005) for entry into these fisheries again does not require the Council to implement limited entry programs or other management measures but does provide the Council with a mechanism to limit fishing for bigeye and yellowfin tunas by these emerging fisheries if necessary.

The Council's recommendations regarding data collection from Hawaii-based small pelagic fishing boats (i.e. troll, handline, offshore handline, and pole-and-line vessels), including new requirements for Federal permits and logbooks for commercial vessels and increased voluntary surveys of all fishery participants, will improve the accuracy and timeliness of information on the volume of bigeye and yellowfin tunas caught by these vessels. This information is essential to understanding and managing the impacts of bigeye and yellowfin fishing mortality so as to address overfishing and achieve long-term sustainable yields.

3.0 Table of Contents

3.1 List of Tables

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3.3 List of Acronyms

AMSY	Average Maximum Sustainable Yield
CCM	Commission Members, Cooperating Non-Members and Participating Territories of the Western and Central Pacific Fisheries Commission
CFR	Code of Federal Regulations
CML	Commercial Marine License
CNMI	Commonwealth of the Northern Mariana Islands
DWFN	Distant Water Fishing Nation
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPO	Eastern Pacific Ocean
ESA	Endangered Species Act
EU	European Union
FAD	Fish Aggregating Device
FEIS	Final Environmental Impact Statement
FFA	Fisheries Forum Agency
FMP	Fishery Management Plan
FR	Federal Register
FSM	Federated States of Micronesia
GT	Gross Tonnage
HAPC	Habitat Areas of Particular Concern
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Committee for the Conservation of Atlantic Tunas
LL	Longline
MRFSS	Marine Recreational Fisheries Statistical Survey
MHI	Main Hawaiian Islands
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum Sustainable Yield
MUS	Management Unit Species
NAO	NOAA Administrative Order
NEPA	National Environment Policy Act
NGO	Non Government Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OFP	Oceanic Fisheries Program (of the SPC)
PA	Palau Arrangement
PIC	Pacific Island Countries
PL	Pole-and Line fishing
PMUS	Pelagic Management Unit Species
PNA	Parties to the Nauru Agreement
PNG	Papua New Guinea

PFRP	Pelagic Fisheries Research Program (of the University of Hawaii)
PRA	Paperwork Reduction Act
PRIA	Pacific Remote Island Areas
PS	Purse seine fishing
RFA	Regulatory Flexibility Act
RFMO	Regional Fishery Management Organization
RR	Regional Register (of FFA)
RSW	Refrigerated Seawater Systems
SARS	Severe Acute Respiratory Syndrome
SBR	Spawning Biomass Ratio
SBRAMSY	Spawning Biomass Ratio-Average Maximum Sustainable Yield
SCTB	Standing Committee on Tuna and Billfish
SPC	Secretariat of the Pacific Community
SPTT	South Pacific Tuna Treaty
SSTF	South Subtropical Front
STF	Subtropical Front
TAC	Total Allowable Catch
TLL	Tuna Longline Vessel
USAID	United States Agency for International Development
USMLT	United States Multi-Lateral Treaty = SPTT
VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Commission
WCPFC-SA	WCPFC Statistical Area
WCPO	Western and Central Pacific Ocean
WPRFMC	Western Pacific Regional Fishery Management Council

4.0 Introduction

4.1 Responsible Agencies

The Council was established by the Magnuson-Stevens Fishery and Conservation Management Act (MSA) to develop Fishery Management Plans (FMPs) for fisheries operating in the offshore waters around American Samoa, Guam, Hawaii and Commonwealth of the Northern Mariana Islands and the U.S. possessions in the Pacific.[1] Once an FMP is approved by the Secretary of Commerce, it is implemented by federal regulations which are enforced by the National Marine Fisheries Service and the U.S. Coast Guard, in cooperation with state, territorial and commonwealth agencies. For further information contact:

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4.2 Public Review Process and Schedule

In response to the identification of overfishing by the Secretary of Commerce, at its 126th meeting held March 14-17, 2005 in Honolulu the Council reviewed a background document on Pacific bigeye fisheries, listened to public comments and took initial action to direct its staff to continue its development of an amendment to the Pelagics FMP containing comprehensive background information and analyses as well as recommendations for international management and a range of alternatives for the management of domestic fisheries.

The Council's Pelagics Plan Team reviewed and commented on the draft analyses and recommendations at a public meeting held May 3-5, 2005 in Honolulu. This was followed by additional reviews and discussion at public meetings of the Council's Science and Statistical Committee (Honolulu, May 17-19, 2005) and Advisory Panels (Honolulu, May 20, 2005). A summary document of the measures considered to date and their anticipated impacts was then mailed to over 1,500 holders of Hawaii Commercial Marine Licenses as well as other interested parties on the Council's mailing list, to solicit their comments. Included in this mailing was an agenda for the Council's 127th meeting, as well as an announcement of upcoming public meetings to be held in the major ports for those fishery participants most likely to be affected by new requirements, namely the pelagic handline port in Hilo, Hawaii (May 13, 2005) and in Honolulu (May 19, 2005) which includes a major port for offshore handliners and is the urban center of Oahu where approximately 80% of Hawaii's population is located. All of these meetings were also advertised in Hawaii newspapers. At its 127th meeting (Honolulu, May 31-June 2, 2005) the Council reviewed a background paper containing the information presented in

[1] Howland, Baker, Jarvis, Wake and Johnston Islands, Palmyra and Midway Atolls and Kingman Reef.

this amendment and comments from each of the above meetings, and held a public hearing. The Council then took final action to recommend a suite of non-regulatory measures for the international management of fisheries which harvest bigeye tuna. The Council also reviewed and recommended a range of regulatory and non-regulatory measures for fisheries managed under the Pelagics FMP.

In August 2005, the Scientific Committee of the Western and Central Pacific Fisheries Commission reviewed stock assessments for Western and Central Pacific bigeye, yellowfin and skipjack tunas, and South Pacific albacore tuna. The conclusion for bigeye tuna remained more or less unchanged, but yellowfin was found to be likely being subjected to overfishing, although the biomass of the stock was still well above the biomass at maximum sustainable yield (MSY). Subsequently, National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) advised the NMFS Pacific Islands Regional Office (PIRO) that yellowfin tuna was being subjected to unsustainably high levels of fishing mortality in the Western and Central Pacific Ocean (WCPO). In light of this information and anticipating that NMFS would soon determine that overfishing of yellowfin tuna was occurring, at its 129th Council meeting in Guam in November 2005, the Council recommended applying to fishing for yellowfin tuna the existing management measures in draft Amendment 14 to the Pelagics FMP that the Council recommended for bigeye tuna and directed staff to edit and transmit the amendment accordingly.

Following transmission of Amendment 14 to NMFS on March 22, 2006, comments and recommendations were received from NOAA regarding the need for the action's objectives to be quantified, for its measures to be grouped as alternatives, and for it to include a specific recommendation for EPO purse seine fisheries. In response to these comments, the Council considered the above issues at its 133rd meeting in June, 2006. At that meeting, the Council took action and finalized the recommendations contained in this document.

4.3 List of Preparers

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5.0 Purpose and Need for Action

The purpose of this amendment to the Pelagics Fishery Management Plan is to address overfishing of Pacific bigeye tuna, and yellowfin tunas in the WCPO.

The Council was notified by letter on December, 15, 2004, that the Secretary of Commerce (Secretary) had determined that overfishing of bigeye tuna (*Thunnus obesus*) was occurring Pacific-wide. A stock is considered to be subject to overfishing whenever it is subjected to a rate of fishing mortality that jeopardizes its capacity to produce MSY on a continuing basis (50 CFR 600.310(d)(1)(ii)). The reference point for assessing overfishing of a stock is the Maximum Fishing Mortality Threshold (MFMT) which is the ratio of current fishing mortality (F_t) to the fishing mortality at MSY (F_{msy}), or F_t / F_{msy}. The MFMT should not exceed unity or F_t =Fmsy for more than one year or the stock is considered to be subject to overfishing (50 CFR 600.310(d)(2)(i)).

In August 2005, the Scientific Committee of the Western and Central Pacific Fisheries Commission reviewed stock assessments for both the Eastern and Western-Central Pacific that indicated that yellowfin tuna across the Pacific also appears to being subjected to overfishing (Hoyle and Maunder 2005; Hampton et al. 2005). Pacific bigeye tuna (bigeye) are caught by a suite of domestic and foreign purse seiners and longliners, with small amounts also taken by handline and troll vessels. Until recently, the majority of the bigeye catch was taken by longliners, primarily for the Japanese sashimi market. However, during the past 10 years catches of bigeye by purse seiners have increased considerably. This is not due to deliberate targeting of bigeye tuna by purse seiners, but as an incidental catch when purse seiners are targeting skipjack (*Katsuwonus pelamis*) and juvenile yellowfin tuna (*Thunnus albacares*) around fish aggregating devices (FADs) with larger and deeper purse seine nets. Not surprisingly, the stock of bigeye tuna in the Pacific has shown signs of over-exploitation, with declining biomass, and fishing mortalities at unsustainably high levels. Stock assessments for bigeye tuna in the Eastern and Western Pacific, conducted in 2003 and 2004, showed that the level of fishing mortality had exceeded the fishing mortality associated with maximum sustainable yields (F_{msy}). This level of fishing mortality is one of the limit reference points of the Council's overfishing control rule for bigeye tuna and other pelagic fishes. The Pacific-wide stock itself is not yet overfished, but could become so if levels of fishing mortality are not reduced. Recent estimates of total annual take (domestically and internationally) of Pacific bigeye tuna (SPC 2004) approach 200,000 mt, which based on recent stock assessments for Western and Central Pacific (Hampton et al. 2004) and Eastern Pacific bigeye stocks (Maunder and Hoyle 2005), appears to greatly exceed the unquantified long-term Pacific-wide bigeye MSY.

As with bigeye tuna, an official communication to this effect was received from the Secretary in March 2006 requiring the Council take action to address this situation. Yellowfin tuna are caught primarily by purse seine type nets in both the Western and Central and Eastern Pacific Ocean. Substantial volumes of yellowfin tuna are also caught by pole-and-line fleets in Indonesia and by handliners in the Philippines. Yellowfin catches by longlines comprise a significant catch of yellowfin tuna, but longlining is a much smaller component of the fishing mortality on this species compared to bigeye tuna. Recent landings of yellowfin in the Western and Central Pacific have ranged from 400,000 to 450,000 mt. The MSY estimates for these analyses range from about 209,200 t to 313,400 t per year (Hampton et al. 2005). These MSY estimates are substantially lower than recent catches indicating catches have been sustained by the removal of the accumulated biomass, as is evident from the recent accelerated fishery impacts on the stock.

As indicated in the MSA and required by the implementing regulations for National Standard 1 (50 CFR 600.310(e)(3), the Council was requested by the Secretary to take remedial action within one year of the identification by the Secretary, to end overfishing. Although unilateral action by the Council will not end overfishing of Pacific bigeye and yellowfin tunas, the actions described in this document are consistent with the MSA which states at 304(e)(3):

> Within one year of an identification under paragraph (1) or notification under paragraphs (2) or (7), the appropriate Council (or the Secretary, for fisheries under section 302(a)(3)) shall prepare a fishery management plan, plan amendment, or proposed regulations for the fishery to which the identification or notice applies
> (A) to end overfishing in the fishery and to rebuild affected stocks of fish; or
> (B) to prevent overfishing from occurring in the fishery whenever such fishery is identified as approaching an overfished condition.

Moreover, this amendment is also consistent with NMFS' Atlantic Highly Migratory Species FMP which includes a 'foundation plan' as its response to overfishing of highly migratory species including bluefin tuna and swordfish.

Pacific bigeye and yellowfin tunas occur in the waters of multiple nations and the high seas and are fished by the fleets of other nations in addition to those of the U.S.. The capacity for unilateral action by the U.S. to prevent overfishing, as required under National Standard 1 of the Magnuson-Stevens Act (16 U.S.C. 1851(a)(1), is limited as is the capacity for actions taken by the Councils to end overfishing, as required under 50 CFR 600.310(e)(4)(i)) (69 FR 78397). Bigeye tuna catches by fisheries under the Council's jurisdiction in 2003 amounted to 4,449 t, or 2.3% of the total Pacific-wide catch (see Table 21). Similarly, 2003 yellowfin catches by fisheries under the Council's jurisdiction amounted to 2,319 mt, or 0.34% of Pacific-wide landings. Consequently, any unilateral action by these U.S. fisheries to end overfishing will have little effect on the stock. Such action would not be expected to end overfishing, since the maximum potential reduction in fishing mortality is less than the amount required to end overfishing. Multilateral management action is essential to ensure that overfishing on Pacific bigeye and WCPO yellowfin tunas ends (69 FR 78397).

In the Eastern Pacific Ocean (EPO), the Inter-American Tropical Tuna Commission (IATTC) has already implemented management measures for purse seine and longline fisheries in response to concerns about the condition of EPO bigeye tuna. The longline fleets of member nations of the IATTC were allocated a bigeye tuna quota equivalent to the 2001 level of catch. Based on this level of fishing, the U.S. fleet-wide bigeye tuna quota was set at 150 mt. The Council subsequently expressed its concerns regarding the basis and method for the selection of the base year for the quota allocations. The Council also expressed its concern that the quota was implemented by NMFS with virtually no input from either the Western Pacific or Pacific Fishery Management Councils which manage U.S. longline fisheries in the Pacific (WPRFMC 2004a).

Given that further management actions for U.S. Pacific fisheries are likely to be considered by the IATTC and the newly emergent Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (more commonly referred to as the Western and Central Pacific Fisheries Commission or WCPFC), the Council determined that it was necessary to also amend the Pelagics FMP to include a protocol regarding the Council's role in the development and implementation of measures stemming from Regional Fishery Management Organizations (RFMOs) such as the IATTC and WCPFC. The Council also recognized the need to implement measures for domestic fisheries in the Western Pacific in response to the overfishing of bigeye and yellowfin tunas. These international and domestic fishery management measures for Pacific bigeye and yellowfin tunas are the major focus of this amendment.

The Secretary, through NMFS, approves, disapproves, or partially approves the Council's recommendations for fishery management plans and amendments (Section 304(a)(3)) of the MSA). While this entire amendment addresses the overfishing requirements under the MSA for the Pelagics FMP, the only regulatory actions concern Hawaii-based small (i.e., non-longline) boats catching bigeye and yellowfin tunas. However, the international management measures proposed to be implemented through RFMOs, are a fundamental component of the Council's plan to end overfishing on the subject tuna stocks, and as such, they are required to be contained in the FMP. Additionally, the actions clarify the context in which overfishing is occurring, and help to explain the Council's recommendations. Given the lack of jurisdiction over international harvest, the Council's recommendations for international fisheries do not include regulations subject to approval and implementation by the Secretary. However, as part of the FMP, and the Council's plan to end overfishing, the approach is subject to Secretarial review and approval under the MSA.

6.0 Management Objectives

The objectives of the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region (Pelagics FMP), as amended in Amendment 1, are as follows:

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.

3. To diminish gear conflicts in the EEZ, particularly in areas of concentrated domestic fishing.

4. To improve the statistical base for conducting better stock assessments and fishery evaluations, thus supporting fishery management and resource conservation in the EEZ and throughout the range of the MUS.

5. To promote the formation of a regional or international arrangement for assessing and conserving the MUS and tunas throughout their range.

6. To preclude waste of MUS associated with longline, purse seine, pole-and-line or other fishing operations.

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

The specific objective of this management action is to make appropriate recommendations for research, monitoring and management of international and domestic fisheries that address the management and end overfishing of Pacific bigeye and WCPO yellowfin tunas in a cost-effective and equitable manner, as required under the Magnuson-Stevens Act. Current stock assessments suggest that for bigeye tuna fishing mortality, $F_{current,}$ is at or above the fishing mortality at MSY (F_{MSY}) i.e. $F_{MSY}/F_{current} = 0.90 – 1.30$, while for yellowfin, the $F_{current}$ is slightly higher than fishing mortality at MSY, i.e. $F_{MSY}/F_{current}$ =1.20-1.30 (Hampton et al. 2003; Hampton et al. 2004a; Harley and Maunder 2004; Hampton et al. 2005). Unilateral management action on the 2.3% of the total Pacific bigeye catch represented by the Council managed pelagic fisheries could reduce the fishing mortality (F) but clearly, this would be insufficient to reduce it below the level of the MFMT. The situation is even more acute for yellowfin tuna, where fisheries under Council jurisdiction account for only 0.24% of reported Pacific-wide catches. Multilateral management action is therefore essential to ensure that overfishing on bigeye and yellowfin tunas in the Pacific Ocean ends (69 FR 78397).

The status of Pacific bigeye, WCPO yellowfin and skipjack and South Pacific albacore tunas, with respect to the MFMT and other reference points as specified in the FMP is shown in Figure 1. Based on stock assessments conducted in 2005 (WCPFC 2005) and 2006 (IATTC 2006a), fishing mortality on Pacific bigeye and WCPO yellowfin stocks by both longlines and purse seines needs to be reduced in the WCPO by 20% from 2001-2003 levels for each gear type. In the Eastern Pacific Ocean (EPO) fishing mortality on Pacific bigeye by longline vessels needs to be reduced by 30% and purse seine fishing mortality by 38% as compared to 2003-2004 fishing levels (IATTC 2006a). A summary of the required actions is shown in Table 1, while the reference points for Pelagic MUS adopted by the Council in Amendment 8 to the Pelagics FMP are shown in Table 2.

The measures recommended in this amendment are based on the 2005 stock assessments. There are differences between the stocks' status as indicated by the 2005 versus the 2006 stock assessments, but they are not substantial. In terms of fishing mortality levels, the 2006 assessments were slightly more optimistic for yellowfin tuna and slightly more pessimistic for bigeye tuna than the 2005 assessments. It is understood that the international scope of the overfishing situation, and measures to meaningfully address the problem, must be addressed via international institutions. Furthermore, the minor differences in the baseline stock status do not undermine the general approach in the Pelagics FMP’s proposed plan to end overfishing immediately, nor will such differences hamper the benefits gained from the recommended measures, if implemented via the relevant RFMOs.

Given the time it takes to develop and implement regulatory measures via the international management processes, and the fairly high degree of uncertainty associated with stock assessment results, stock status will likely undergo additional changes prior to implementation of the recommended measures or alternative measures. Some of these changes are likely to be attributable to uncertainty in the estimates, and some to actual changes in status. However, the RFMOs are expected to base their decisions on the most recent and best scientific information available at the time the specific measures are approved, and proposed measures can always be revisited by the Council, NMFS, and relevant RFMOs as new information becomes available suggesting that different courses of action are necessary.

Table 1. Summary of the required reductions in fishing mortality required to end overfishing on WCPO yellowfin tuna and Pacific bigeye tuna.

Stock	Reduction in fishing mortality required to end overfishing			
	WCPO		EPO	
	Purse seine	Longline	Purse seine	Longline
WCPO Yellowfin	20%	20%	NA	NA
Pacific Bigeye	20%	20%	38%	30%

Table 2. Recent estimates of stock status of Pelagic Management Unit Species (PMUS) in relation to PMUS reference points established by the WPRFMC.

Stock	Overfishing reference point (F/Fmsy)	Is overfishing occurring?	Approaching Overfishing (2 yr)	Overfished reference point (B/Bmsy)	Is the stock overfished?	Approaching Overfished (2 yr)	Assessment results	Natural mortality[1]	MSST
Skipjack Tuna (WCPO)	F/F_{MSY}=0.17	No	No	B/B_{MSY}=3.0	No	No	Langley et al. 2005	>0.5 yr^{-1}	0.5 B_{MSY}
Yellowfin Tuna (WCPO)	F/F_{MSY}=1.22	Yes	Not applicable	B/B_{MSY}=1.32	No	No	Hampton et al. 2005a	0.8-1.6 yr^{-1}	0.5 B_{MSY}
Yellowfin Tuna (EPO)	F/F_{MSY}=1.20	Yes	Not applicable	B/B_{MSY}=0.89	No	No	Hoyle & Maunder 2005	0.8-1.6 yr^{-1}	0.5 B_{MSY}
Albacore Tuna (S. Pacific)	F/F_{MSY}=0.05	No	No	B/B_{MSY}=1.69	No	No	Langley & Hampton 2005	0.3 yr^{-1}	0.7 B_{MSY}
Albacore Tuna (N. Pacific)		Unknown			Unknown			0.3 yr^{-1}	0.7 B_{MSY}
Bigeye Tuna (WCPO)	F/F_{MSY}=1.23	Yes	Not applicable	B/B_{MSY}=1.25	No	No	Hampton et al. 2005b	0.4 yr^{-1}	0.6 B_{MSY}
Blue Marlin (Pacific)	F/F_{MSY}=0.50	No	Unknown	B/B_{MSY}=1.4	No	Unknown	Kleiber et al. 2002	0.2 yr^{-1}	0.8 B_{MSY}
Bigeye Tuna (EPO)	F/F_{MSY}=1.75	Yes	Not applicable	B/B_{MSY}=0.76	No	No	Maunder & Hoyle 2005	0.4 yr^{-1}	0.6 B_{MSY}
Swordfish (N. Pacific)	F/F_{MSY}=0.33	No	Unknown	B/B_{MSY}=1.75	No	Unknown	Kleiber & Yokawa 2004	0.3 yr^{-1}	0.7 B_{MSY}
Blue Shark (N. Pacific)	F/F_{MSY}=0.01	No	Unknown	B/B_{MSY}=1.9	No	Unknown	Kleiber et al. 2001	Unknown	
Other Billfishes		Unknown			Unknown			Unknown	
Other Pelagic Sharks		Unknown			Unknown			Unknown	
Other PMUS		Unknown			Unknown			Unknown	

[1] Estimates based on Boggs et al. 2000

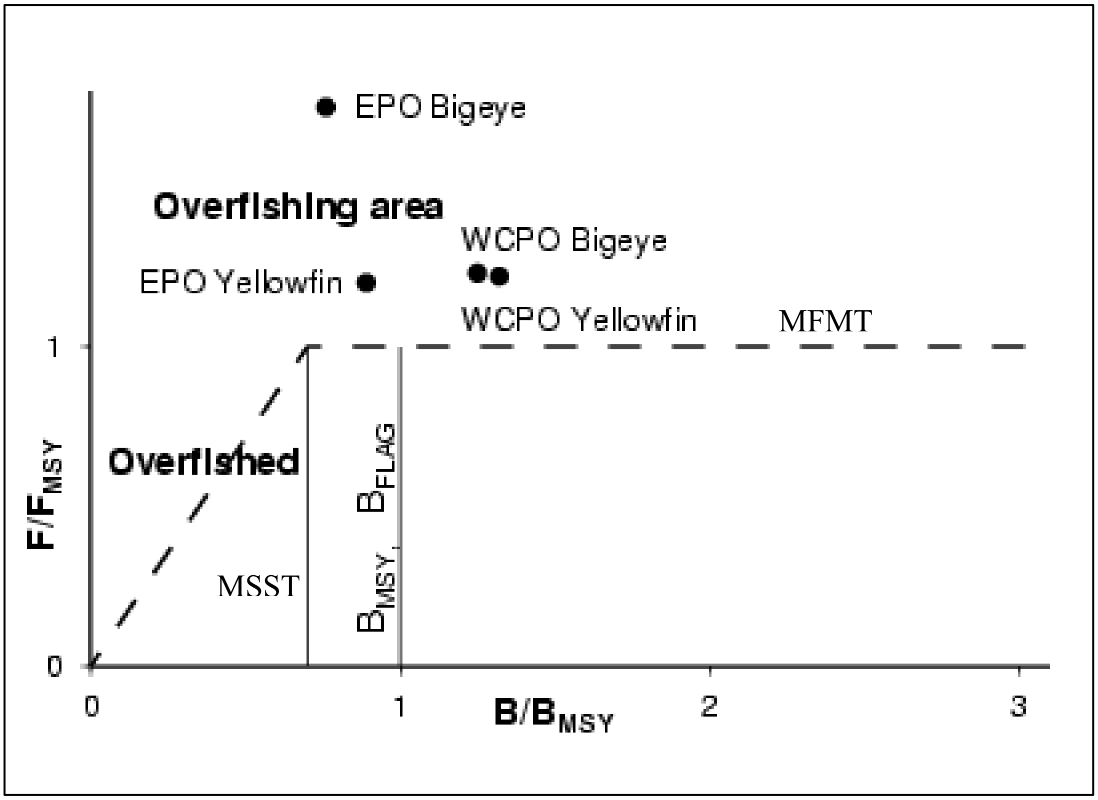


Figure 1. Western Pacific Council's MSY control rule and reference points showing status of WCPO and EPO bigeye tuna, and WCPO and EPO yellowfin. (The MSST, and thus the inflection point in the MFMT is set at the greater of 0.5and 1-M. For WCPO bigeye tuna M was last estimated to be 0.4 and for the WCPO yellowfin as 0.8-1.6, so the positions of the MSST are 0.6 for Pacific bigeye tuna and 0.5 for WCPO yellowfin tuna.)

Based on this information, this management action seeks to reduce WCPO international longline and purse seine bigeye mortality by 20% as compared to 2001-2003 fishing levels; to reduce WCPO international longline and purse seine yellowfin mortality by 20% as compared to 2001-2003 fishing levels; and to reduce EPO international longline and purse seine bigeye mortality by 30% and 38% respectively as compared to 2003-2004 fishing levels. While other gears such as handlines and trolling may also catch Pacific bigeye and WCPO yellowfin tunas, most of the fishing mortality on these two stocks is generated by purse seine and longline fisheries. It is also intended to address tuna fishing by domestic small vessels by increasing data collection and availability, and implementing mechanisms to cap effort if necessary.

The measures proposed in Amendment 14 do not regulate the harvest of every component of the fisheries that take Pacific bigeye tuna and WCPO yellowfin tuna, i.e., they do not address all recreational fisheries and all commercial fisheries using other gear types. However, the longline and purse seine fisheries, for which restrictions are proposed, account for the vast majority of the harvest and fishing mortality of bigeye and yellowfin tuna, so the measures as proposed should be sufficient to end overfishing, if implemented. Additionally, proposed measures can always be revisited as new information becomes available that indicates that such measures do not address as large a proportion of total fishing mortality as is currently understood to be the case.

7.0 Initial Actions

The Council has taken a series of management actions to conserve pelagic species caught by fisheries in the Western Pacific Region. The Pelagics FMP (published in 1986) banned the use of drift gill nets in the U.S. EEZ waters of the U.S. Flag Pacific Islands. Although this gear was primarily used to catch albacore, the ban eliminated the potential for this gear to incidentally catch bigeye and yellowfin tunas which make diurnal feeding migrations between the epilimnion and the deeper waters of the epi-pelagic zone.

Amendment 1 became effective on March 1, 1991 (56 FR 9686, March 7, 1991) and defined recruitment overfishing for each Pelagic MUS (PMUS). It also defined the optimum yield for PMUS as the amount of fish, including bigeye and yellowfin tunas that can be harvested by domestic and foreign vessels in the EEZ without causing local overfishing or economic overfishing.

Amendment 2 became effective on May 26, 1991 (56 FR 24731, May 31, 1991). It implemented requirements for domestic pelagic longline fishing and transshipment vessel operators to have Federal permits, to maintain Federal fishing logbooks, and, if fishing within 50 nm of the Northwestern Hawaiian Islands (NWHI), to have observers placed on board if directed by NMFS. The logbook program, in conjunction with the observer program, has permitted the accurate reporting of yellowfin and bigeye catches of yellowfin and bigeye tuna by longline fisheries under the Council's jurisdiction. Amendment 2 also required longline gear to be marked with the official number of the permitted vessel, and incorporated the waters of the EEZ around the Commonwealth of the Northern Mariana Islands into the area managed under the FMP.

Amendment 3, which became effective on October 14, 1991 (56 FR 52214, October 18, 1991), created a 50 nm longline exclusion zone around the NWHI to protect endangered Hawaiian monk seals. This is a contiguous area extending 50 nm from named features in the NWHI and connected by corridors between those areas where the 50-nm-radius circles do not intersect. Both longline exclusion zones have a conservation benefit for bigeye tuna by placing them beyond the reach of Hawaii-based longliners operating in the U.S. EEZ around Hawaii. Amendment 3 also implemented framework provisions for establishing a mandatory observer program to collect information on interactions between longline fishing and sea turtles. Although not specifically aimed at bigeye and yellowfin tunas, the area closure had a conservation effect by placing those fish within the 50 nm zone out of the reach of longline gear, which is the domestic fishery with the highest bigeye catches in the Western Pacific region.

Amendment 4 was effective October 10, 1991 through April 22, 1994 (56 FR 14866, October 16, 1991). It established a three-year moratorium on new entry into the Hawaii-based domestic longline fishery. The amendment also included provisions for establishing a mandatory vessel monitoring system for domestic longline vessels fishing in the Western Pacific Region. This amendment, through limiting vessel numbers, limited the volume of bigeye and yellowfin tuna that could be caught and landed by the Hawaii-based longline fleet.

A final rule effective December 15, 1994 (59 FR 58789, November 15, 1994) under Amendment 4 required Hawaii-based longline vessels to carry and use a NMFS-owned vessel monitoring system (VMS) transmitter to ensure that they do not fish within prohibited areas.

Amendment 5 became effective on March 2, 1992 (57 FR 7661, March 4, 1992) and created a domestic longline vessel exclusion zone around the Main Hawaiian Islands ranging from 50 to 75 nm, and a similar 50 nm exclusion zone around Guam and its offshore banks. The zones were designed primarily to prevent gear conflicts and vessel safety issues arising from interactions between longline vessels and smaller fishing boats. A seasonal reduction in the size of the closure was implemented in October 1992; between October and January longline fishing is prohibited within 25 nm of the windward shores of all Main Hawaiian Islands except Oahu, where it is prohibited within 50 nm from the shore. As above, although not specifically aimed at bigeye tuna, the area closure had a conservation effect by placing those bigeye and yellowfin tunas within the closed areas out of the reach of longline gear, which is the domestic fishery with the highest bigeye catches in the Western Pacific region, and a yellowfin catch equal in size to Western Pacific troll and handline catches.

Amendment 6, which became effective on November 27, 1992 (57 FR 48564, October 27, 1992) specified that all tuna species are designated as fish under U.S. management authority and included tunas and related species as PMUS under the FMP. This amendment allowed bigeye and yellowfin tuna to be subject to specific management and conservation measures developed by the Council. It also applied the longline exclusion zones of 50 nm around the island of Guam and the 25-75 nm zone around the MHI to foreign vessels.

Amendment 7 became effective on June 24, 1994 (59 FR 26979, May 25, 1994). It instituted a limited entry program for the Hawaii-based longline fishery with no more than 164 vessels allowed in the fishery and a maximum vessel size of 101' in length overall. This amendment constrained the expansion of the Hawaii-based longline fishery, which has the largest domestic catches of Pacific bigeye and yellowfin tunas under the Council's jurisdiction.

Amendment 8 addressed new requirements under the 1996 Sustainable Fisheries Act (SFA). This amendment implemented new definitions for overfishing stemming from the 1996 reauthorization of the MSA, based on the biomass at MSY and the fishing mortality that generates MSY. Portions of the amendment that were immediately approved included designations of essential fish habitat and descriptions of some fishing communities. Those provisions became effective on February 3, 1999 (64 FR 19067, April 19, 1999). Remaining portions that were approved in 2003 were provisions regarding fishing communities, overfishing definitions, and bycatch (68 FR 46112, August 5, 2003).

Amendment 9 will address the management of sharks in the Western Pacific Region and is currently under development

Framework Measure 1 closed waters within 3-50 nm around American Samoa to pelagic fishing by vessels greater than 50ft in length (67 FR 4369, January 30, 2002). Although not specifically aimed at bigeye and yellowfin tuna, the area closure may have a conservation effect by placing those fish out of the reach of large scale American Samoa based-longline vessels as well domestic purse seiners.

Amendment 11 was recently approved (70 FR 29646, May 24, 2005) to implement a limited entry program for the American Samoa-based domestic longline fishery, with an expected fleet size of less than 140 longline vessels, with 93 of those anticipated to be equal to or less than 40' in length. This action constrained the potential expansion of the American Samoa-based longline fishery, which has the largest domestic catches of Pacific bigeye tuna in the U.S. EEZ around American Samoa, and a yellowfin catch equal in size to Western Pacific troll and handline catches.

Regulatory Amendment 2 required vessel operators using troll or handline gear to target PMUS around the PRIA to obtain Federal permits and to submit Federal logbooks documenting their catch and effort (67 FR 56500, September 4, 2004). Although not specifically developed for bigeye tuna, this regulatory amendment to the FMP provides information on all pelagic catches (including bigeye and yellowfin tunas) from these vessels.

Regulatory Amendment 3 allowed 2,120 shallow sets annually (targeting swordfish) by the Hawaii-based longline line fleet, provided that circle hooks and mackerel type bait are used to prevent and mitigate interactions with sea turtles. Although not directly intended to conserve bigeye and yellowfin tuna, this action provided an alternative target species for the Hawaii-based longline fleet (69 FR 17329, April 2, 2004).

The Western Pacific Council has also taken steps to coordinate pelagic fisheries management with the Pacific Fisheries Management Council (PFMC), which promulgated its Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species in 2004. The Western Pacific Council and the PFMC are currently planning to hold a joint Council meeting to review pelagic fisheries management issues, and Pacific Council staff participated in a recent Western Pacific Council's Pelagics Plan Team meeting to discuss the issues and recommendations contained in this document.

The management measures in this amendment would be added to existing management actions under the Pelagics FMP, and are expected to lead to conservation benefits for bigeye and yellowfin tunas.

8.0 Management Recommendations for International Fisheries to Address Overfishing of Pacific-wide Bigeye Tuna and WCPO Yellowfin Tuna

Sections 8 through 11 have been prepared as an Environmental Assessment in accordance with the requirements of the National Environmental Policy Act (NEPA) of 1969, to assess the impacts on the human environment that may result from the proposed Federal action. This Environmental Assessment examines a range of alternatives designed to address issues related to overfishing of Pacific-wide bigeye and WCPO yellowfin tuna. It also incorporates by reference the cover sheet (page ii), table of contents (page vii), list of agencies (page 1), public review process and schedule (page 1), list of preparers (page 2), discussion of the purpose and need for action (page 2), list of references (page 183), and additional text from other sections of this document as indicated.

The goal of the Council is to take appropriate action to address its statutory requirement under the Magnuson-Stevens Act to end overfishing of Pacific bigeye and WCPO yellowfin tunas in a cost-effective and equitable manner. Following general management, research and monitoring recommendations for Pacific bigeye and WCPO yellowfin tunas, management alternatives to end overfishing of both species are presented. How these alternatives would address the reduction of fishing mortality in the WCPO and the EPO are discussed separately, however, as each are subject to different management authorities (the WCPFC in the Western and Central Pacific and the IATTC in the Eastern Pacific). Recommendations for domestic fisheries are discussed in Section 9.0.

The Council recommends that the United States promote the following measures in the international arena.

8.1 General Recommendations for the Management, Monitoring and Research of Bigeye and Yellowfin Tunas in the Pacific Ocean

These recommendations are consistent with requirements of the MSA and its National Standards. For example, providing consistency between the WCPO and EPO is appropriate under National Standards 3, 5, and 7. Further it is essential to avoid confusion and potential conflict between the WCPFC and the IATTC with respect to management measures regarding bigeye and yellowfin tunas. Moreover, the areas of competence of these two RFMOs overlap in the South Pacific so it is essential that management measures are harmonized as far as possible.

Recommendations such as focusing on the fisheries with the greatest impacts and on the regions of highest catches and spawning areas, reducing surplus capacity and restricting the use of purse seine FADs are designed to identify those measures that will have a measurable impact on bigeye and yellowfin tuna conservation. Similarly, an exemption for those fleets that catch less than 1% of the total from some or all measures recognizes the need to avoid overly burdening those fleets and countries which are peripheral in generating fishing mortality for bigeye tuna

Reduction of fishing capacity is a recognized goal and NMFS has stated that its target is to eliminate or significantly reduce overcapacity in 25% of federally managed fisheries by the end of 2009 and in a substantial majority of fisheries in the following decade (NMFS 2004)[2]. There is known to be an excess of purse seine capacity for skipjack tuna, as recognized by a 2001 resolution by the World Tuna Purse Seine Organization to achieve a 35% reduction in fishing effort by member countries. Although the purse seine vessels are targeting skipjack rather than bigeye tuna, they are a major contributor to fishing mortality through catches of bigeye and yellowfin juveniles around FADs. Consequently reduction of purse seine fishing capacity overall would likely have a marked conservation benefit for bigeye and yellowfin tuna. In this regard, the IATTC promulgated resolutions in 2000 and 2003 to limit fishing capacity of purse seine vessels operating in the Eastern Pacific. The IATTC established a target of 158,000 m^3 (well

[2] United States National Plan Of Action for the Management of Fishing Capacity August 2004 Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service

volume) for the total purse seine fleet in the Eastern Pacific, but which took into account stock status and the rights of coastal States and other States with a longstanding and significant interest in the tuna fisheries of the Eastern Pacific to develop and maintain their own tuna fishing industries.

Restricting the use of FADs by purse seine vessels in the Pacific, to aggregate skipjack tuna, will reduce the overall catch of bigeye and yellowfin tunas, and specifically the catches of juvenile bigeye and yellowfin tunas, which also aggregate beneath FADs. It is expected that this reduction in juvenile bigeye catch will likely improve recruitment of bigeye tuna to the longline fishery, where fish are caught at larger sizes and at higher value. It is also likely that a reduction in FAD-associated harvests of juvenile and sub-adult yellowfin tuna will improve recruitment of yellowfin to longline fisheries and purse seine landings of larger, higher value yellowfin. Improvements to spawning stock biomass for both species would also result. Similarly, any measure designed to develop time/area closures in spawning grounds or areas of high juvenile bigeye and yellowfin tuna densities would reduce fishing mortality on spawning fish and reduce the catch of juvenile fish before they had a chance to recruit to the longline fishery. The area of the southern Philippines, Indonesia and Papua New Guinea (PNG) are highly relevant as they have large-scale longline and FAD-based surface fisheries and are situated in the core area of WCPO spawning and juvenile development for both species. While fishery data collection and reporting mechanisms are well developed in PNG, significant improvements to species specific catch and effort data in the Philippines and Indonesia are urgently required.

The MSA's National Standard 1 established a process for the use of biomass based reference points and fishing mortality limits to determine whether fisheries are overfished or subject to overfishing. In the absence of existing reference points from the RFMOs, the Council's reference points for bigeye and yellowfin tunas should be advanced for consideration by the WCPFMC and the IATTC. This will be useful to the Council as, at this time, outputs from these stock assessments generate the estimates of indicators used in the Council's overfishing control rule. In addition, the Pacific Council also has similar status reference points for highly migratory species such as bigeye and yellowfin tunas in the Eastern Pacific Ocean. Moreover, the United States as a member of regional fishery management organizations should establish and adhere to general principles to guide the U.S. in developing and promoting conservation and management programs and associated monitoring and compliance, The Council recommends the following:

General recommendations for management and monitoring:

- **i. Use science-based measures that consider historical participation, and provide for sustained participation by local communities.**
- **ii. Strive for consistent measures (e.g. WCPO and EPO) where possible.**
- **iii. Focus on fisheries with greatest impacts.**
- **iv. Focus on regions of highest catches and spawning areas.**
- **v. Reduce surplus capacity.**
- **vi. Restrict the use of purse seine FADs.**
- **vii. Consider exempting fleets that catch less than 1% of the total from some or all measures.**
- **viii. Improve species specific fishery monitoring.**
- **ix. Establish standardized vessel registry system for the WCPO.**

x. **To the extent practicable the U.S. should seek RFMO decisions that are consistent with National Standard 1 of the MSA and its guidelines as codified.**

Half of the elements in this list, (ii-vi) are concerned with minimizing fishing mortality of bigeye and yellowfin tunas in the WCPO, while the remainder are concerned with participation, monitoring and management of pelagic fishing. With respect to principles and priorities for research and data collection, the Council recommends that the U.S. should also promote the following:

General recommendations for research:

i. **Determine consistent science-based reference points that are appropriate for management use. In the absence of international reference points, promote the establishment and application of MSY based reference points and associated control rules with respect to preventing and ending overfishing.**
ii. **Improve stock assessments that provide region specific information and understanding of recruitment.**
iii. **Promote pan-Pacific assessments that provide region specific information.**
iv. **Improve understanding of responses to FADs.**
v. **Investigate gear and fishing characteristics of vessels with above-average CPUE.**
vi. **Collect and define vessel and gear attributes useful for effort standardization for all fleets.**
vii. **Define total costs of management on governments and participants.**

8.2 Council Management Protocol for Pacific Bigeye and Yellowfin Tunas

The role of Pacific-based domestic fishery management Councils has become particularly important with the advent of the Western and Central Pacific Fisheries Commission in 2004, as the entire Western Pacific Region's EEZ waters are contained within the boundaries of the WCPFC area of management competence, although some longline fishing by Hawaii-based longline vessels does occur in the EPO. The Inter-American Tropical Tuna Commission has already begun to implement management measures for bigeye tuna, commencing with seasonal closures of purse seine fishing and bigeye tuna quotas for U.S. longline vessels (both Hawaii-based and California-based) for the years 2004-2006. The IATTC may at some point in the future introduce management measures for yellowfin tuna. Moreover, the measures adopted by the IATTC for Pacific bigeye tuna could also have a limiting effect on WCPO yellowfin landings. A formal Council management protocol for the development of input and recommendations that will be provided to the U.S. delegations and U.S. representatives to the RFMOs is needed to ensure that both the WPRFMC and PFMC are informed and afforded the opportunity to substantively participate in all of the activities leading up to the development and implementation of U.S. proposals for international management[3].

The adoption of a formal management protocol creates a mechanism and a timetable for the Council to review the status of stocks, to consider and advise on impending RFMO actions, to

3 . During the drafting of this amendment, staff from the Western Pacific Regional Fishery Management Council were included in the delegations to the June 2005 and June 2006 meetings of the IATTC and the Western and Central Pacific Fishery Commission's second meeting in December 2005.

deliberate on the Council's own proposals for conservation and management, to inform NMFS and the Department of State about the Council's positions and concerns, to participate in international meetings, and to apply their expertise in the subsequent implementation of any resultant agreements. The amendment is intended to provide a solid basis for collaboration of the Council with its partners (NMFS, DOS) to ensure

- effective involvement of the Council on behalf of its constituents and members in the development of U.S. positions in RFMOs;

- a good track record for the Council's use in generating inputs to the U.S. positions and for the Council's subsequent use in determining what if any conservation and management measures are needed; and

- a process that NMFS and DOS can point to as having obtained solid advice from constituents in carrying out U.S. obligations under international treaties.

This management protocol must be synchronized with both RFMO and Council meetings to ensure adequate review prior to and following RFMO meetings. Without such a process, the Council would have to continue to respond in an *ad hoc* manner to fishery management requirements stemming from RFMOs in the Pacific. The Council would still seek the opportunity to review and comment on management proposals and to advance its own recommendations for U.S. proposals to RFMOs, but an *ad hoc* process is inefficient and untimely, and runs the risk of marginalizing the Councils' role in developing proposals for international management. Moreover, an *ad hoc* process does not provide a framework for collaboration between the Department of State, NMFS and the Councils that is necessary to ensure that the Councils' views are fully considered.

The following issues and criteria were considered in the development of the protocol

- Likelihood of effectiveness in RFMOs
- Timeliness
- Completeness of inputs
- Transparency of decision making
- Linkage of international and MSA authorities
- Credibility with stakeholders

Council recommended protocol for international management of Pacific highly migratory pelagic species:

a. The Council participates in U.S. delegations to Regional Fishery Management Organizations (RFMOs e.g. IATTC and WCPFC) in the Pacific Ocean and is included in all pre and post meetings and negotiations.

b. The Council and NMFS monitor RFMO meetings and actions and relevant fisheries, Council becomes aware of a need for management action or receives notice from

NMFS or the RFMO directly of a need for such action, with supporting documentation.

c. The Council reviews information from RFMO, NMFS, and other sources concerning stock assessment, area of consideration, fishery issues and data supporting determinations, and the role of U.S. fisheries in causing or contributing to overfishing.

d. NMFS provides formal notice of overfishing determination or other management concerns and the time frame for Council action within MSA and RFMO frameworks.

e. The Council refers information to its Pelagics Plan Team, Advisory Panel(s), SSC and other advisors for review and advice with focus on:

- **Definition and condition of the stock or other fishery management unit, and the issue of concern (e.g., overfishing, bycatch, allocation, etc.),**
- **Possible reasons for the situation including fishery and environmental conditions that may be relevant to the stock condition or other management concern,**
- **Relative role of U.S. fisheries in overall stock harvests and management situation,**
- **Existing conservation and management measures of the RFMO with jurisdiction over the stock or fishery involved,**
- **Possible multi-lateral measures to avoid or end overfishing, rebuild the stock, or resolve other management concerns.**

f. The Council's PPT, AP, SSC and other advisory bodies recommend possible domestic and international fishery conservation and management measures, including a comparison and evaluation of alternative measures including distinctions between Pacific-wide, regional, and local measure's effects and effectiveness.

g. The Council makes initial decision on how to address problem (initial action).

h. The Council distributes a draft background and action document for public review and advice.

i. The Council makes formal recommendations to NMFS and the Department of State on:

- **domestic regulations,**
- **international actions.**

j. The Council drafts a position paper on how RFMOs should address the situation (the position paper should clearly and forcefully state the Council's recommendation on every substantial issue).

k. The Council presents its position within the U.S. delegation to the RFMO.

l. The RFMO meets and acts on fishery conservation and management needs in the international arena.

m. The Council considers the RFMO’s actions, U.S. government positions and requirements under applicable treaties and the MSA.

n. The Council determines its appropriate regulatory response for domestic fisheries consistent with international agreements and the MSA.

o. The Council takes final action (if any) to recommend regulations for NMFS’ approval and implementation.

p. NMFS implements approved recommendations.

8.3 Recommendations to Address International Overfishing of Pacific-wide Bigeye and WCPO Yellowfin Tuna

Three alternatives were developed to address international overfishing of Pacific bigeye and WCPO yellowfin tuna as follows:

International Alternative 1. No action

Under International Alternative 1 (No action), the Council would not take any action to address the international overfishing of Pacific-wide bigeye tuna and WCPO yellowfin tuna, and WCPO and EPO tuna fishing would continue to operate under current conditions as described in Section 10.8.

International Alternative 2. End overfishing immediately (Preferred)

Under International Alternative 2 (preferred), the Council would transmit a recommendation for the immediate specified reductions in fishing mortality to NMFS, the Department of State, and the U.S delegations to the Pacific tuna RFMOs. Based on stock assessments conducted in 2005 (WCPFC 2005) and 2006 (IATTC 2006a), fishing mortality on Pacific bigeye and WCPO yellowfin stocks by both longlines and purse seines needs to be reduced in the WCPO by 20% from 2001-2003 levels for each gear type. In the Eastern Pacific Ocean (EPO) fishing mortality on Pacific bigeye by longline vessels needs to be reduced by 30% and purse seine fishing mortality by 38% as compared to 2003-2004 fishing levels (IATTC 2006a). All measures must consider traditional participation and emerging island fisheries. These measures are cumulative across the two regions since although Pacific bigeye tuna is thought to be a single population, it is managed as two segments of the same population, fished by different fisheries and managed by two separate RFMOs

International Alternative 3. Phase out overfishing over a maximum of 10 years

Under International Alternative 3, the Council would transmit a recommendation for a phased approach for achieving this action’s objectives for reductions in fishing mortality (as described above and in Section 6) to NMFS, the Department of State, and the U.S delegations to the Pacific tuna RFMOs. Actions included to achieve this phased approach are described below. All measures must consider traditional participation and emerging island fisheries.

A. Output controls

WCPO (for Pacific-wide bigeye and WCPO yellowfin)

- If required, implement quotas on a country level basis with domestic allocation left to each country
- Gradually (over a maximum of 10 years) reduce quotas to achieve objectives

EPO (for Pacific-wide bigeye)

- Implement an EPO bigeye longline quota equal to 1999 harvests
- Provide the U.S. longline fleet with EPO bigeye quota of 250 mt
- Exempt fleets that take less than 1% or 550 mt of EPO annual bigeye catch
- Exempt U.S. longline vessels not targeting bigeye tuna from the annual EPO quota
- Gradually (over a maximum of 10 years) reduce quotas to achieve objectives

B. Input controls

WCPO (for Pacific-wide bigeye and yellowfin)

- Gradually decrease longline fishing effort (number of vessels), starting with rollback to 1999 levels
- Register and limit the use of purse seine FADs
- Gradually (over a maximum of 10 years) increase input controls to achieve objectives

EPO (for Pacific-wide bigeye)

- Gradually reduce EPO purse seining on bigeye by 38%
- Gradually (over a maximum of 10 years) increase input controls to achieve objectives

9.0 Recommendations to Address Overfishing of Pacific Bigeye and WCPO Yellowfin Tuna in Domestic WPRFMC Fisheries

9.1 Recommendations for WPRFMC Pelagic Longline and Purse Seine Fisheries

Existing longline vessels managed by the Council (those based in Hawaii and American Samoa) caught only 2.3% of total reported Pacific bigeye landings in 2003 and 0.22% of total reported Pacific yellowfin landings (see Table 22). This is largely because both of these fleets are managed under limited entry programs that include caps on the numbers of vessels as well as on vessel lengths. No foreign fishing is allowed in EEZ waters under the Council's jurisdiction and portions of EEZ waters around Hawaii and Guam are closed to domestic longliners. Given these regulatory controls in place for these fisheries (and associated low bigeye and yellowfin catch levels), and the fact that the necessary international actions required to end Pacific-wide overfishing are underway, the Council has determined that it should continue to seek substantive participation (see Section 8) in the international management fora that are necessary to develop effective solutions to the Pacific-wide overfishing of bigeye and yellowfin tunas. The Council also determined that further unilateral management actions for these domestic fisheries would be premature and would not have a meaningful effect on the Pacific-wide overfishing problem. Moreover, it would also be inconsistent with MSA Section 304(e)(4)(C), which states that actions to address overfishing in fisheries managed under international agreements shall "reflect traditional participation in the fishery, relative to other nations, by fishermen of the United States". The Council intends to manage overfishing by these fisheries through its international management protocol described in Section 8.2. However, given the potential for the development of domestic longline fisheries based in Guam or CNMI, as well as the potential for domestic purse seiners to fish in WPRFMC EEZ waters, the Council made the following recommendation:

Establish a control date of June 2, 2005 for domestic longline and purse seiners fishing under open access programs in U.S. EEZ waters in the Western Pacific region, including developing longline fisheries in Guam and CNMI.[4]

This control date would apply to vessels that are or may begin fishing under open-access programs and would not bind the Council to establishing limited access or other management programs for these fisheries, but it would notify current and prospective fishery participants that additional management measures may be taken by the Council for these fisheries. The implementation of a control date is in recognition of the fact that unlimited expansion of purse seining and longline fishing is untenable with the conservation of bigeye and yellowfin tuna.

9.2 Recommendations for Other WPRFMC Pelagic Fisheries

Regarding commercial small boat pelagic fisheries (i.e. non-longline and non-purse seine) managed by the Council in the Western Pacific region, based on their low catches of bigeye (0.13% of Pacific-wide 2004 catches) and yellowfin (0.13% of Pacific-wide catches, see Table 22), the Council made no new recommendations regarding the activities of these fisheries. However, although reported and estimated bigeye and yellowfin tuna catches by Hawaii-based small boats are low; data for some sectors is believed to be incomplete due to non-reporting and is certainly often many months behind in collection, inputting, processing and availability to fishery scientists and managers. Recreational landings are unknown as there are no reporting requirements for these vessels. Preliminary data from NMFS' Marine Recreational Fishing Statistics Survey (MRFSS) is currently under review by NMFS following the release of an external review of this program by the National Research Council which questioned the sampling and extrapolations methodologies used by NMFS (NRC 2006). As such the Council has recommended that MRFSS catch estimates should not be used for management purposes until these problems have been resolved. Thus the Council considered a range of regulatory and non-regulatory measures designed to improve the availability of data regarding bigeye and yellowfin catch and effort by these fisheries. In sum, the Council considered the following alternatives for the management of the region's pelagic small boat commercial and recreational fisheries:

Small boat Alternative 1. No action

[4] Notification of this control date was published August 15, 2005 in the Federal Register, Vol. 70, No. 156

Under this alternative the Council would not take any action to address the role of small boat domestic pelagic fisheries in the overfishing of Pacific-wide bigeye and WCPO yellowfin tunas, and these fisheries would continue to operate under current conditions as described in Section 10.9.

Small boat Alternative 2. Implement fishery controls

Under this alternative the Council would implement limits to fishing for Pacific bigeye and WCPO yellowfin tuna by small boat domestic pelagic fisheries. These could include measures such as fleet-wide quotas, trip limits, or time and area closures.

Small boat Alternative 3. 3 Establish control date[5] (Preferred)

Under this alternative, the Council would implement a June 2, 2005 control date for entry into small boat commercial pelagic fisheries (i.e. non-longline and non-purse seine) in U.S. EEZ waters around Hawaii. This control date does not bind the Council to establishing limited access or other management programs for these fisheries, but it does notify current and prospective fishery participants that additional management measures may be taken by the Council for these fisheries.

Small boat Alternative 4. Increase data collection (Preferred)

Under this alternative, the Council would a) require federal permits and logbooks for all Hawaii-based small boat commercial pelagic fishermen; b) implement a voluntary reporting system for Hawaii-based small boat recreational pelagic fishermen; c) implement a targeted survey of all Hawii-based small boat pelagic owners and operators to obtain information on their fishing effort and catches. Although the Council considered these measures in a comprehensive context (i.e. wherever such vessels operate) legal counsel has stated that the Council's authority does not extend into state waters and thus any resultant regulations would not apply in those areas.

9.3 Alternatives Considered but not Analyzed in Detail

Closure of all Council fisheries that catch bigeye or yellowfin tunas in the Pacific Ocean

Closing all fisheries under the Council's jurisdiction that catch bigeye or yellowfin tunas in the Pacific Ocean would appear to address the contribution to overfishing by U.S. vessels. However, as discussed above this unilateral action would place an unfair burden on U.S. fishermen and would not result in any significant impact on reducing bigeye and yellowfin fishing mortality. This is not consistent with the Council's objective of addressing overfishing in a cost-effective and equitable manner, or with the MSA Section 304(e)(4)(C) as described above. For these reasons this alternative was not analyzed in detail.

Time area closures of spawning areas or areas with high concentrations of juvenile bigeye or yellowfin tunas

[5] Notification of this control date was published August 15, 2005 in the Federal Register, Vol. 70, No. 156

The major fishing mortality impact on bigeye is generated by longline vessels; although the impact of purse seine caught juvenile bigeye has greatly exacerbated the overfishing problem on this species. By contrast, purse seine and other surface fisheries (pole-and-line etc.) are the main source of mortality for yellowfin tuna. One possible management approach might therefore be to look at areas of the ocean where juvenile bigeye and yellowfin tuna are caught in substantial quantities and develop tine/area closures to minimize catches. However, a preliminary analysis investigating the catch of juvenile bigeye and yellowfin tunas by different purse seine fleets for the years 1989 through 2003 (SPC 2005), failed to identify any such juvenile 'hot spots' in the Western and Central Pacific. The IATTC has also analyzed time area closures for the Eastern Pacific for reducing purse seine catches of bigeye tuna. The IATTC has also tried to manage purse seine fishing around FADs in the Eastern Pacific since 1998, however, this was found to be difficult to implement due to disputes over when a purse seine set was actually a FAD set. Accordingly, the IATTC decided to simply close all purse seine fishing for two six week periods in 2004, 2005 and 2006. Similarly, the WCPFC has opted to follow the example of the IATTC to limit purse seine fishing effort by a combination of Vessel Day Scheme for PNA member countries, limitation of effort to either 2004 levels or the average of 2001 to 2004 for other CCMs and to develop a proposal for temporary purse seine closures at the third session of the WCPFC in December 2006.

Moratorium on the expansion of longline fisheries in other parts of the Western Pacific Region (i.e. open access fisheries in Guam and CNMI)

Longline fishing is not currently conducted by fishermen based in other parts of the Council's jurisdiction. A blanket moratorium on future expansion of longlining in these areas was not analyzed in detail as it would be inequitable and discriminatory to allow longline fishing only in some parts of the Western Pacific. It would also be inconsistent with Section 2 (a)(10) which states that "Pacific Insular Areas [including Guam and CNMI] contain unique historical, cultural, legal, political, and geographical circumstances which make fisheries resources important in sustaining their economic growth". However, the control date recommended by the Council can be used to check unconstrained expansion of longline fishing in these areas.

10.0 Physical and Biological Environment

10.1 Oceanographic Environment

The following summary of the oceanography of the tropical and sub-tropical Pacific Ocean is taken from a Final Environmental Impact Statement (FEIS) for the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region published by NMFS in 2001 (NMFS, 2001), which is believed to be a complete and accurate account of that ecosystem.

The Hawaiian Archipelago and the Marianas Archipelago, which includes Guam and CNMI, lie in the North Pacific subtropical gyre while American Samoa lies in the South Pacific subtropical gyre. These subtropical gyres rotate clockwise in the Northern Hemisphere and counter clockwise in the Southern Hemisphere in response to tradewind and westerly wind forcing. Hence the Main Hawaiian Islands (MHI), Guam and CNMI, and American Samoa experience weak mean currents flowing from east to west, while the northern portion of the Hawaiian

Archipelago experiences a weak mean current flowing from west to east. Imbedded in this mean flow are an abundance of mesoscale eddies created from wind and current interactions with bathymetry. These eddies, which can rotate either clockwise or counter clockwise, have important biological impacts. Eddies create vertical fluxes, with regions of divergence (upwelling) where the thermocline shoals and deep nutrients are pumped into surface waters enhancing phytoplankton production, and also regions of convergence (downwelling) where the thermocline deepens. North and south of the islands are frontal zones that also provide important habitat for pelagic fish and thus are targeted by fishers. To the north of the Hawaiian and Marianas Archipelagoes, and also to the south of American Samoa, lie the subtropical frontal zones consisting of several convergent fronts located along latitudes 25°-40° N. and S. often referred to as the Transition Zones. To the south of the Hawaiian and Marianas Archipelagoes, and to the north of American Samoa, spanning latitudes 15° N.-15° S. lies the equatorial current system consisting of alternating east and west zonal flows with adjacent fronts.

A significant source of interannual physical and biological variation is the El Niño and La Niña events. During an El Niño the normal easterly trade winds weaken, resulting in a weakening of the westward equatorial surface current and a deepening of the thermocline in the central and eastern equatorial Pacific. Water in the central and eastern equatorial Pacific becomes warmer and more vertically stratified with a substantial drop in surface chlorophyll. A La Niña event exhibits the opposite conditions. During an El Niño the purse seine fishery for skipjack tuna shifts over 1,000 km from the western to the central equatorial Pacific in response to physical and biological impacts (Lehodey et al. 1997).

Physical and biological oceanographic changes have also been observed on decadal time scales. These low frequency changes, termed regime shifts, can impact the entire ocean basin. Recent regime shifts in the North Pacific have occurred in 1976 and 1989, with both physical and biological (including fishery) impacts (Polovina 1996; Polovina et al. 1995).

Pelagic species are closely associated with their physical and chemical environment. Suitable physical environment for these species depends on gradients in temperature, oxygen or salinity, all of which are influenced by oceanic conditions on various scales. In the pelagic environment, physical conditions such as isotherm and isohaline boundaries often determine whether or not the surrounding water mass is suitable for pelagic fish, and many of the species are associated with specific isothermic regions. Additionally, areas of high trophic transfer as found in fronts and eddies are important habitat for foraging, migration, and reproduction for many species (Bakun 1996).

Oceanic pelagic fish such as skipjack and yellowfin tuna, and blue marlin prefer warm surface layers, where the water is well mixed by surface winds and is relatively uniform in temperature and salinity. Other fish such as albacore, bigeye tuna, striped marlin and swordfish, prefer cooler, more temperate waters, often meaning higher latitudes or greater depths. Preferred water temperature often varies with the size and maturity of pelagic fish, and adults usually have a wider temperature tolerance than sub-adults. Thus, during spawning, adults of many pelagic species usually move to warmer waters, the preferred habitat of their larval and juvenile stages. Large-scale oceanographic events (such as El Niño) change the characteristics of water temperature and productivity across the Pacific, and these events have a significant effect on the habitat range and movements of pelagic species. Tuna are commonly most concentrated near islands and seamounts that create divergences and convergences which concentrate forage species, also near upwelling zones along ocean current boundaries, and along gradients in temperature, oxygen and salinity. Swordfish and numerous other pelagic species tend to concentrate along food-rich temperature fronts between cold, upwelled water and warmer oceanic water masses.

These fronts represent sharp boundaries in a variety of physical parameters including temperature, salinity, chlorophyll, and sea surface height (geostrophic flow) (Niiler and Reynolds 1984; Roden 1980; Seki et al. in press). Biologically, these convergent fronts appear to represent zones of enhanced trophic transfer (Bakun 1996; Olsen et al. 1994). The dense cooler phytoplankton-rich water sinks below the warmer water creating a convergence of phytoplankton (Roden 1980; Polovina et al. in review). Buoyant organisms, such as jellyfish as well as vertically swimming zooplankton, can maintain their vertical position in the weak down-welling, and aggregate in the front to graze on the down-welled phytoplankton (Bakun 1996; Olsen et al. 1994). The increased level of biological productivity in these zones attracts higher trophic-level predators such as swordfish, tunas, seabirds, and sea turtles, and ultimately a complete pelagic food web is assembled.

Near Hawaii, there are two prominent frontal zones. These frontal zones are associated with two isotherms (17° C and 20° C), and they are climatologically located at latitudes 32°-34° N. (the Subtropical Front or STF) and latitudes 28°-30° N. (the South Subtropical Front or SSTF) (Seki et al. in press). Both the STF and SSTF represent important habitats for swordfish, tunas, seabirds and sea turtles. Variations in their position play a key role in catch rates of swordfish and albacore tuna, and distribution patterns of Pacific pomfret, flying squid, loggerhead turtles (Seki et al., in press), and seabirds. Hawaii-based longline vessels targeting swordfish set their lines where the fish are believed to be moving south through the fronts following squid, the primary prey of swordfish (Seki et al., in press). Squid is also the primary prey item for albatross (Harrison et al.1983), hence the albatross and longline vessels targeting swordfish are often present at the same time in the same area of biological productivity.

These frontal zones have also been found to be likely migratory pathways across the Pacific for loggerhead turtles (Polovina et al. 2000). Loggerhead turtles are opportunistic omnivores that feed on floating prey such as the pelagic cnidarian Vellela vellela ("by the wind sailor"), and the pelagic gastropod Janthia sp., both of which are likely to be concentrated by the weak downwelling associated with frontal zones (Polovina et al. 2000). Data from on-board observers in the Hawaii-based longline fishery indicate that incidental catch of loggerheads occurs along the 17° C front (STF) during the first quarter of the year and along the 20° C front (SSTF) in the second quarter of the year. The interaction rate, however is substantially greater along the 17° C front (Polovina et al. 2000).

Since the publication of the 2001 FEIS there has been an increasing awareness within the scientific community of the occurrence and importance of long-term (decadal-scale) oceanographic cycles (Chavez et al. 2003; SCBT 15, inter alia) and of their relationship to cycles in the population sizes of some species of fish such as California sardines and North Atlantic bluefin tuna. These naturally occurring cycles can either mitigate or accentuate the impact of fishing mortality on target species and, in general, the scientific community is becoming more aware of the need to recognize the possibility of large natural swings in the populations of exploited species and to incorporate this dynamism into management models. Meso-scale events such as El Nino and shorter term phenomena such as cyclonic eddies near the Hawaiian Islands (PFRP Newsletter 8(1) 2003) also impact the recruitment and fishing vulnerability of species managed under the Pelagics FMP.

10.2 Pelagic Management Unit Species

The Pelagics FMP manages a suite of "pelagic management unit species" (PMUS, see Table 3). These species have been assigned to species assemblages based upon the ecological relationships between 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 tuna, bluefin tuna, albacore tuna, striped marlin and pomfret. The tropical species complex includes all other tunas and billfish as well as *mahimahi*, wahoo and *opah*.

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.

Table 3. Pelagic Management Unit Species.

English or Common Name	Scientific Name
Mahimahi (dolphinfishes)	*Coryphaena* spp.
Wahoo	*Acanthocybium solandri*
Indo-Pacific blue marlin: Black marlin	*Makaira mazara: M. indica*
Striped marlin	*Tetrapturus audax*
Shortbill spearfish	*T. angustirostris*
Swordfish	*Xiphias gladius*
Sailfish	*Istiophorus platypterus*
Pelagic thresher shark	*Alopias pelagicus*
Bigeye thresher shark	*Alopias superciliosus*
Common thresher shark	*Alopias vulpinus*
Silky shark	*Charcharinus falciformis*
Oceanic whitetip shark	*Carcharhinus longimanus*
Blue shark	*Prionace glauca*

English or Common Name	Scientific Name
Shortfin mako shark	*Isurus oxyrinchus*
Longfin mako shark	*Isurus paucus*
Salmon shark	*Lamna ditropis*
Albacore	*Thunnus alalunga*
Bigeye tuna	*T. obesus*
Yellowfin tuna	*T. albacares*
Pacific bluefin tuna	*T. orientalis*
Skipjack tuna	*Katsuwonus pelamis*
Kawakawa	*Euthynnus affinis*
Dogtooth tuna	*Gymnosarda unicolor*
Moonfish	*Lampris* spp
Oilfish and snake mackerel family	*Gempylidae*
Pomfret	*family Bramidae*
Other tuna relatives	*Auxis* spp, *Scomber* spp; *Allothunus* spp

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. Concise definitions of the various criteria used in the Pelagics FMP to analyze current levels of harvest exploitation and the status of PMUS stocks can be found in a publication by Boggs et al. (2000). That document and the NMFS Report to the U.S. Congress both contain estimates of the status of PMUS stocks. Those two publications and the most Report of the 17th Standing Committee on Tuna and Billfish (SCTB17) and the Report of the First Regular Session of the Scientific Committee (SC1) to the WCPFC are the main sources for the following sections regarding the current status of PMUS stocks.

As this amendment is concerned with measures to address overfishing of bigeye and yellowfin tuna, a detailed account of bigeye and yellowfin tuna life history and stock assessments is presented in the following sections. The status of other pelagic species potentially affected by this amendment, including stock assessments, as well as fishery and non-fishery related impacts to those species are addressed in the 2001 EIS (NMFS 2001), as supplemented in 2004 (WPRFMC 2004). Those discussions are hereby incorporated by reference.

10.3 Bigeye Tuna (*Thunnus obesus*)

Several studies on the taxonomy, biology, population dynamics and exploitation of bigeye tuna (*Thunnus obesus*) have been carried out, which include comprehensive reviews by Alverson and Peterson (1963), Collette and Nauen (1983), Mimura and Staff (1963) and Whitelaw and Unnithan (1997). Calkins (1980), Martinez and Bohm (1983) and Miyabe (1994) provide descriptions of bigeye tuna biology and fisheries specific to the Pacific or Indo-Pacific region. Hampton et al. (1998), provide a summary of information on the biology, fisheries and stock assessment of Pacific Ocean bigeye tuna. A great deal of information on the physiology and ecology of all tuna species, including bigeye is compiled by Block and Stevens [eds] (2001).

In November 1996, the Inter-American Tropical Tuna Commission (IATTC) hosted the First World Meeting on Bigeye Tuna at their headquarters in La Jolla, California. The objectives of the meeting were to review and compare the extant knowledge of the species and associated fisheries between ocean basins and to make recommendations for necessary areas of research. Review papers on the biology and fisheries for bigeye tuna in the Atlantic, Indian and Pacific Oceans were tabled by Pallarés et al. (1998), Stobberup et al. (1998) and Miyabe and Bayliff (1998) and published in the proceedings to the meeting (IATTC 1998).

The Second World Meeting on Bigeye Tuna was convened in March 2004 by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in Madrid, Spain and is summarized in ICCAT (2005). This meeting served as a forum to gather scientists from around the world to discuss advances in bigeye related research since the first World Meeting on Bigeye Tuna and to plan future research objectives.

Specific information on the status of bigeye fisheries and stocks in the Pacific Ocean are contained in the collective research and publications of the IATTC and in seventeen years of annual meetings of the Standing Committee on Tuna and Billfish (SCTB) for the Eastern Pacific Ocean (EPO) and the Western/Central Pacific Ocean (WCPO) respectively. The information contained in this review relies heavily on these sources that represent the most recent information available on the biology, ecology, physiology and fisheries for bigeye tuna in the Pacific Ocean.

10.3.1 Bigeye Tuna - Life History and Habitat Selection

Bigeye tuna are believed to have recently evolved from a common parent stock of yellowfin tuna (*Thunnus albacares*), remaining in a close phylogenetic position to yellowfin with similar larval form and development. Although the species shares a similar latitudinal distribution with yellowfin tuna worldwide, bigeye have evolved to exploit cooler, deeper and more oxygen poor waters when compared to yellowfin in a classic example of adaptive niche partitioning. Several investigators have demonstrated that this has been accomplished through a combination of physiological and behavioral thermoregulation and other anatomical adaptations for foraging at depth, e.g. respiratory adaptations, eye and brain heaters (Holland and Sibert 1994; Lowe et al. 2000; Fritsches and Warrant 2001). In this way, the species is considered to be intermediate between a tropical tuna (e.g. yellowfin, blackfin <*T. atlanticus*>, longtail tuna <*T. tonggol*>) and the temperate water tunas (e.g. albacore <*T. alalunga*>, the bluefin tunas). This combination of traits can be characterized by rapid growth during the juvenile stage, movements between temperate and tropical waters to feed and spawn, equatorial spawning with high fecundity -- combined with a preference for cool water foraging and a protracted maturity schedule, an extended life span and the potential for broad spatial movements. It is believed that bigeye tuna are relatively long lived in comparison to yellowfin tuna but not as long lived as the three bluefin tuna species.

Feeding is opportunistic at all life stages, with prey items consisting of crustaceans, cephalopods and fish (Calkins 1980). There is significant evidence that bigeye feed at greater depths than yellowfin tuna, utilizing higher proportions of cephalopods, and mesopelagic fishes and crustaceans in their diet thus reducing niche competition (Whitelaw and Unnithan 1997).

Spawning spans broad areas of the Pacific and occurs throughout the year in tropical waters and seasonally at higher latitudes at water temperatures above 24°C (Kume 1967; Miyabe 1994). Hisada (1979) reported that bigeye tuna require a mixed layer depth of at least 50 m with a sea surface temperature (SST) of at least 24°C. While spawning of bigeye tuna occurs across the Pacific, the highest reproductive potential was considered to be in the EPO based on size frequencies and catch per unit of effort inferred abundance (Kikawa 1966).

Basic environmental conditions favorable for survival include clean, clear oceanic waters between 13°C and 29°C. However, recent evidence from archival tags indicates that bigeye can make short excursions to depths in excess of 1000 m and to ambient sea temperatures of less than 3°C (Schaefer and Fuller 2002). Juvenile bigeye tuna in the smaller length classes occupy surface mixed layer waters with similar sized juvenile yellowfin tuna. Larger bigeye frequent greater depths, cooler waters and areas of lower dissolved oxygen compared to skipjack and yellowfin. Hanamoto (1987) estimated optimum bigeye habitat to exist in water temperatures between 10° to 15°C at salinities ranging between 34.5‰ to 35.5‰ where dissolved oxygen concentrations remain above 1 ml/l. Recent data from archival tagging has largely corroborated these earlier findings while extending the actual habitat range of the species.

The determination of age, growth and maturity schedules for bigeye tuna are only now becoming better defined. There is no doubt that bigeye tuna are considerably longer lived, slower growing and therefore more vulnerable than the yellowfin. It is now considered that bigeye mature at 3 – 4 years of age after which growth slows considerably with fish capable of living well past ten years. Critical to the understanding of bigeye biology and management are better estimates of maturity schedules by area which are just now beginning to become available. Preliminary results indicate that earlier assessments may have been utilized unrealistically low estimates of size at "maturity" for the species. For the purposes of this review paper, the following categories of bigeye life stage will be used:

1) egg/larval//early juvenile;	< 20 cm
2) juvenile;	20 – 75 cm
3) sub-adult;	76 – 110 cm
4) adult.	> 110 cm

Bigeye tuna - egg, larval and early juvenile development

The eggs of bigeye tuna resemble those of several scombrid species and can not be differentiated by visual means. Therefore, the distribution of bigeye eggs has not been determined in the Pacific Ocean. However, the duration of the fertilized egg phase is very short, approximately one day, meaning egg distributions are roughly coincident with documented larval distributions. Eggs are epipelagic and buoyed at the surface by a single oil droplet until hatching occurs.

Kume (1962) examined artificially fertilized bigeye eggs in the Indian Ocean, noting egg diameters ranging from 1.03 to 1.08 mm with oil droplets measuring 0.23 to 0.24 mm. Hatching began 21 hours post-fertilization, and larvae measured 1.5 mm in length. Larval development soon after hatching has been described by Kume (1962) and Yasutake et al. (1973). Descriptions of bigeye larvae and keys to their differentiation from other *Thunnus* species are given by Matsumoto et al. (1972) and Nishikawa and Rimmer (1987). However, the early larval stages of bigeye and yellowfin are difficult or impossible to differentiate without allozyme or mitochondrial DNA analyses (Graves et al. 1988). An indexed bibliography of references on the eggs and early life stages of tuna is provided by Richards and Klawe (1972).

The distribution or areas of collection of larval bigeye in the Pacific has been described or estimated by Nishikawa et al. (1978), Strasburg (1960) and Ueyanagi (1969). Data compiled by Nishikawa et al. (1978) indicates that bigeye larvae are relatively abundant in the western and eastern Pacific compared to central Pacific areas and are most common in the western Pacific between 10°N and 15°S. The basic environment of bigeye larvae can be characterized as warm, oceanic surface waters at the upper range of temperatures utilized by the species, which is basically a consequence of preferred spawning habitat.

Bigeye larvae appear to be restricted to surface waters of the mixed layer well above the thermocline and at depths less than 50 to 60 m, with no clear consensus on diurnal preference by depth or patterns of vertical migration (Matsumoto 1961, Strasburg 1960, Ueyanagi 1969). Prey species inhabit this zone, consisting of crustacean zooplankton at early stages, shifting to fish larvae at the end of the larval phase and beginning of early juvenile stages. The diet of larval and juvenile bigeye tuna is similar to that of yellowfin tuna, consisting of a mix of crustaceans, cephalopods and fish (Uotani et al. 1981).

The age and growth of larval, post-larval and early juvenile bigeye is not well known or studied. Yasutake et al. (1973) recorded newly hatched larvae at 2.5 mm in total length, growing to 3.0 and 3.1 mm at 24 and 48 hours. The early post-larval stage was achieved at 86 hours after hatching. However, it is likely that the early development of bigeye tuna is similar to that of yellowfin tuna which is the subject of current land based tank studies by the IATTC (IATTC 1997). The larval stages of bigeye tuna likely extend for approximately two to three weeks after hatching. The short duration of the larval stage suggests that the distribution of bigeye larvae is nearly coincident with the distribution of bigeye spawning and eggs. It has been suggested that areas of elevated productivity are necessary to support broad spawning events that are characteristic of skipjack, yellowfin and bigeye tuna whose larvae would subsequently benefit from being in areas of high forage densities (Sund et al. 1981, Miller 1979, Boehlert and Mundy 1994; Itano 2000).

Bigeye tuna - juvenile and sub-adult stages (20 – 110 cm)

The juvenile phase of bigeye is not clearly defined in the literature. Technically, the term "juvenile" should refer to all sexually immature fish. Calkins (1980) suggests grouping bigeye into larval, juvenile, adolescent, immature adult and adult stages. For the purposes of this management related review, length/age classes were selected in relation to their landings in major fisheries coupled with their size-related vulnerability to various gear types and fishing methods and what is known of bigeye maturity schedules.

Defined this way, the "Juvenile" category will refer to bigeye tuna of 20 – 75 cm fork length which closely corresponds to their size at first recruitment to surface fisheries and includes the majority of surface catches, e.g. purse seine, pole and line, troll. The "Sub-Adult" category of 76 – 110 cm includes the interesting middle size class of bigeye that first enter longline fisheries, are also taken by surface fisheries but are generally not sexually mature or contributing to the spawning biomass.

Bigeye tuna - juvenile and sub-adult – habitat and feeding

It is well known that juvenile tunas, including bigeye aggregate strongly to floating objects or to large, slow-moving marine animals, such as whale sharks and manta rays (Calkins 1980, Hampton and Bailey 1993). This behavior has been exploited by surface fisheries to aggregate juvenile yellowfin and bigeye tuna to anchored or drifting FADs (Sharp 1978; Hampton and Bailey 1993). Juvenile, sub-adult and adult bigeye tuna are also known to aggregate near seamounts and submarine ridge features where they are exploited by pole-and-line, handline and purse-seine fisheries (Fonteneau 1991, Itano 1998a; Hallier and Delgado de Molina 2000; Itano and Holland 2000).

Juvenile bigeye form mono-specific schools at or near the surface with similar-sized tuna or may form mixed aggregations with skipjack and/or juvenile yellowfin tuna (Calkins 1980). Yuen (1963) has suggested that these mixed-species schools are actually separate single-species schools that temporarily aggregate to a common element such as food. Echo sounder, sonar data and test fishing strongly suggest a vertical separation of bigeye, yellowfin and skipjack schools that are aggregated to the same floating object. A great deal of circumstantial evidence supports species specific vertical stratification of tuna on drifting objects, with bigeye being the deepest, yellowfin intermediate and skipjack closest the surface. Several studies have come very close to defining these issues using sophisticated sonar and echo sounder equipment capable of measuring target strength readings of individual fish (Josse et al. 2000; Josse and Bertrand 2000). However, species specific remote sensing of tuna needs further study. An added complication is that normal daytime deep diving behavior of bigeye tuna appears to break down when in association with drifting and anchored FADs where the fish tend to remain within the mixed layer (Schaefer and Fuller 2002; Musyl et al. 2003).

The majority of feeding studies on bigeye tuna have sampled gut contents of large longline-caught fish. Very few studies have specifically examined the feeding behavior of juvenile bigeye tuna. Collette and Nauen (1983) state that juvenile bigeye have been noted to feed opportunistically during day and night on a wide variety of crustaceans, cephalopods and fish in a manner similar to yellowfin of a similar size. Prey items include epipelagic or mesopelagic members of the oceanic community or pelagic post-larval or pre-juvenile stages of island-, reef- or benthic-associated fish and crustaceans. Alverson and Peterson (1963) state that juvenile bigeye less than 100 cm generally feed at the surface during daylight, usually near continental land masses, islands, seamounts, banks or floating objects. Much of this information should be considered dated or incomplete in nature.

Recent and ongoing work in Hawaiian waters may significantly alter the perception that juvenile bigeye feed on epipelagic fauna in a similar manner to similar sized yellowfin tuna. Grubbs et al. (2002) found that small and medium sized juvenile yellowfin and bigeye tuna in a size range of 40 – 80 cm exploited similar broad groups of prey but significantly different species. Yellowfin were noted to feed almost exclusively on epipelagic fish or crustaceans or mesopelagic organisms that vertically migrate into the shallow mixed layer at night. Bigeye tuna of the same size and in the same aggregations fed primarily on a deeper dwelling complex of mesopelagic crustaceans, cephalopods and fish, and fed more successfully near seamounts compared to yellowfin. Interestingly, neither species appears to feed well on anchored FADs but continue to exploit different species that are apparently advected past the FAD by currents or exist in the surrounding waters: yellowfin eating epipelagic organisms and bigeye concentrating on mesopelagic organisms of the sound scattering layer.

Schaefer and Fuller (2002) characterized vertical behavior by association type for bigeye archivally tagged in association with drifting FADs in the equatorial EPO. An interesting behavioral pattern was evident during 27.7% of the time (pooled data) with fish remaining shallow during the night and most of the day as is characteristic of FAD associated bigeye tuna. However, extended deep diving activity took place during afternoon which may have represented a temporary break in the association to forage at depth. Additional archival data in conjunction with acoustic surveys and gut analysis is necessary to resolve these issues.

Bigeye tuna - juvenile and sub-adult importance to fisheries

Juvenile bigeye are regularly taken as an incidental in surface fisheries, and occasionally as targeted catch, such as in the seamount and FAD associated offshore handline fishery of Hawaii (Adam et al. 2003). Juvenile bigeye tuna of very small sizes are taken in the equatorial Philippine ringnet and small purse seine fishery, but are poorly documented due to mixing in the statistics with yellowfin tuna and other tuna species (Lawson 2004). These fisheries are based on anchored FADs, taking advantage of the strong tendency of juvenile tuna to aggregate to floating objects.

Juvenile bigeye are regularly taken as an incidental in pole and line fisheries, especially when floating objects or FADs are utilized. Tsukagoe (1981) describes interesting techniques used by distant water Japanese pole and line skipjack vessels to target juvenile and sub-adult bigeye tuna on drifting logs in the tropical western Pacific. However, bigeye as small as 32 cm are taken in the Japanese coastal pole-and-line fishery (Honma et al. 1973). Bigeye tuna have also been recorded from a seamount-associated handline fishery and FAD-based pole-and-line and handline fisheries in Hawaii as small as approximately 40 cm FL (Boggs and Ito 1993, Itano 1998). Smaller sized fish are apparently available but not retained due to marketing preferences. The smallest bigeye tuna of 7957 bigeye tag releases achieved during the Hawaii Tuna Tagging Project was 29.0 cm captured by handline gear (Itano and Holland 2000).

Both juvenile and sub-adult bigeye are taken as an incidental catch in floating object sets in western Pacific purse seine fisheries. In the eastern Pacific Ocean, purse seine catches of sub-adult bigeye have been quite high in some years and should be considered as a retained component of the catch in the skipjack floating object fishery. Schaefer and Fuller (2002) from archival tag data noted that bigeye less than 110 cm spent a greater percentage of their time in association with drifting FADs in the EPO but that the larger bigeye still had an affinity for aggregating to floating objects. Very small bigeye tuna are also taken in equatorial purse seine fisheries though may be discarded or poorly enumerated due to market demands and mixed reporting with juvenile yellowfin tuna.

Juvenile and sub-adult bigeye of increasing size appear in higher latitude fisheries, suggesting portions of the population move away from equatorial spawning/nursery grounds to feed and grow, only to return later to spawn. The distribution of these juvenile and sub-adult tuna becomes better understood as they begin to enter catch statistics of temperate water fisheries. The sub-adult size bigeye figure significantly in several handline and longline fisheries. For example, the Hawaii based longline fishery takes primarily sub-adult bigeye tuna. During the 16 year period 1987-2002, annual average size of bigeye ranged from 111 – 120 cm (WPRFMC 2004b).

Bigeye tuna - adult distribution and habitat preference

Adult bigeye are distributed across the tropical and temperate waters of the Pacific, between northern Japan and the North Island of New Zealand in the western Pacific, and from 40°N to 30°S in the eastern Pacific (Calkins 1980). Numerous references exist on the distribution of Pacific bigeye tuna in relation to general distribution and migration (Hanamoto 1986; Kume 1963, 1967, 1969a, 1969b; Kume and Shiohama 1965; Laevastu and Rosa 1963); the oceanic environment (Blackburn 1965, 1969; Hanamoto 1975, 1976, 1983, 1987; Nakamura and Yamanaka 1959; Suda et al. 1969; Sund et al. 1981; Yamanaka et al. 1969); the physiology of tunas (Magnuson 1963; Sharp and Dizon 1978; Stretta and Petit 1989); and fish aggregation devices (Holland et al. 1990).

There is some consensus that the primary determinants of adult bigeye distribution are water temperature and dissolved oxygen levels. Salinity does not appear to play an important role in tuna distribution in comparison to water temperature, dissolved oxygen levels and water clarity. Hanamoto (1987) reasons that optimum salinity for bigeye tuna ranges from 34.5‰ to 35.5‰ given the existence of a 1:1 relationship between temperature and salinity within the optimum temperature range for the species. Alverson and Peterson (1963) state that bigeye tuna are found within SST ranges of 13° to 29°C with an optimum temperature range of 17° to 22°C. However, the distribution of bigeye tuna cannot be accurately described by SST data since the fish spend a great deal of time at depth in cooler waters. Hanamoto (1987) analyzes longline catch and gear configurations in relation to vertical water temperature profiles to estimate preferred bigeye habitat. He notes that bigeye are taken by longline gear at ambient temperatures ranging from 9° to 28°C and concludes from relative catch rates within this range that the optimum temperature for large bigeye lies between 10° and 15°C if available dissolved oxygen levels remain above 1ml/l. In a similar study in the Indian Ocean, the optimum temperature for bigeye tuna was estimated to lie between 10° and 16°C (Mohri et al. 1996).

According to several authors, bigeye can tolerate dissolved oxygen levels as low as 1 ml/l, which is significantly lower than the dissolved oxygen requirements of skipjack and yellowfin tuna (Sund et al. 1981). Brill (1994) has proposed a physiological basis to explain how bigeye are able to utilize oxygen in a highly efficient manner, thereby allowing them to forage in areas that are not utilized by other tuna species. He theorizes that bigeye tuna spend the majority of their time at depth, making short excursions to the surface to warm up. Lowe et al. (2000) demonstrate that the blood of bigeye tuna has a significantly higher affinity for O2 compared to other tunas, thus explaining their ability to exploit O2 poor regions and depths.

This vertical movement pattern, which has been clearly demonstrated by sonic tracking experiments of bigeye tuna, is exactly the opposite pattern demonstrated by skipjack and juvenile yellowfin tuna (Holland et al. 1992). Sonic tracking and archival tagging of bigeye tuna consistently indicate deep foraging during the daytime near or below the thermocline and shallow swimming behavior at night.

The use of sonic and archival tagging technologies has greatly expanded our knowledge of bigeye behavior and habitat selection. Schaefer and Fuller (2002) noted that bigeye in the EPO spend most of the day at depths of 200 – 300 m and ambient temperatures of 13 - 14°C, although dives to below 1500 m and ambient temperatures of < 3°C were noted.

Bigeye tuna - size at maturity and the classification "sub-adult" and "adult" bigeye

Estimates of size at maturity for Pacific bigeye vary widely between authors (Whitelaw and Unnithan 1997). This is likely due to a mixing between estimates and/or observations of "*size at first spawning*"; "*size of fish observed in running ripe condition*" or some estimate or guess of "*size at sexual maturity for the stock*" as determined by a variety of methods using vastly different temporal and spatial sampling protocols. Maturity of bigeye is most accurately indicated by the presence of hydrated oocytes in the ovarian lumen or microscopically observed post-ovulatory follicles of recent age or for the male, by a variety of visual observations of the testis (Nikaidoet al. 1991). Large-scale stratified sampling over multi-year periods may be necessary to adequately address area effects and inter-annual variation in oceanographic conditions, e.g. ENSO effects.

Kikawa (1957, 1961) estimated size at first maturity for males at 101–105 cm and 91–95 cm for female bigeye and selected 100 cm as a general size for "potential maturity" for Pacific bigeye. Kume (1962) recorded a running ripe female bigeye of 93 cm, and McPherson (1988) recorded mature bigeye of 100 cm using histological methods. The study by Yuen (1955) agreed with Kikawa (1953) with an estimated size at first spawning for central Pacific bigeye at roughly 90 – 100 cm. In a later study, Kikawa (1962) reported finding very few sexually mature female bigeye less than 100 cm in fork length. Sun (1999) reported on a year of bigeye port sampling of Taiwanese longline vessel catch from the far western Pacific and noted the smallest mature female sampled measured 99.7 cm. Nikaido et al. (1991) reported that most of the bigeye over 100 cm were "sexually very active" from taken near Java and from waters south of Johnston Atoll. These observations are incomplete and clearly unsuitable for stock assessment purposes.

The IATTC is in the process of concluding and publishing results of a two-year investigation on the reproductive biology of bigeye tuna from the Eastern Pacific Ocean that evaluated 1869 gonad samples from male and female bigeye ranging between 80 and 163 cm FL to determine spawning habitat, maturity, fecundity and sex ratios. Histological methods were used to evaluate sexual maturity, spawning periodicity and spawning time. The smallest female bigeye tuna histologically classified as mature was 120 cm FL and only 4 per cent of fish 120.0-124.0 cm FL (n=70) were mature (IATTC 2004). Approximately 54 per cent of samples 140.0-144.9 and 78 per cent of fish 150.9-154.9 were classified sexually mature.

These initial findings suggest considerably larger sizes at maturity for bigeye tuna in the EPO in comparison to observations made in the central and western Pacific. However, it should be noted that spawning of bigeye has been linked with sea surface temperatures above 24°C. It has been suggested that sexual maturity, or more accurately, the development into active spawning condition appears to be linked to mixed layer water temperatures above 26° C (Mohri 1998). Kume (1967) noted a correlation between mature but sexually inactive bigeye at SSTs below 23° to 24°C, which appears to represent a lower limit to bigeye spawning activity

Sea surface temperatures are considerably lower in the equatorial EPO compared to the WCPO which could depress and lengthen maturity schedules of bigeye tuna in the EPO if they remained in that area for extended periods. For example, mean annual SSTs measured at oceanographic buoys in the area of the EPO study at 0°, 95°W and at 0°, 180° during 2000 (the time period of the sampling by Schaefer) were 23.1 and 27.5°C respectively[6].

In other words, bigeye maturity schedules and spawning patterns need to be examined on a regional basis. A broad scale investigation of bigeye maturity and reproductive parameters using histological methodology is clearly indicated.

In review of the available information, the categorization of 100 cm bigeye tuna as "generally mature" may be inaccurate and potentially dangerous for stock assessment purposes. The selection of 100 cm to describe mature bigeye would be similar to selecting a size of ~ 60 cm to describe mature yellowfin when this actually represents the size when a few yellowfin first enter maturity. Estimates of L50 for WCPO and EPO yellowfin are 105 cm and 92 cm respectively (Itano 2000; Schaefer 1998).

For the purposes of this review, a conservative value of 110 cm has been selected to differentiate sub-adult populations from adult bigeye.

Bigeye tuna - reproduction

Sex ratios

Information on sex ratios of bigeye by area are incomplete and somewhat inconsistent though there is general agreement that males are more abundant, particularly in the larger size classes. Most studies agree that sex ratios of bigeye tuna are close to the expected 1:1 up to a fork length of approximately 140 cm after which several authors have noted an increase in the proportion of males in the population (Miyabe and Bayliff 1998; Miyabe 2001; Sun et al. 2004). Bigeye larger than 160 cm are predominantly males, and females appear to be completely absent from the largest size classes.

The cline in sex ratios after 140 cm may be related to a slowing of growth, increased natural mortality, increased catchability or some factor related to courtship and spawning. The cline in

[6] http://www.pmel.noaa.gov/tao/data_deliv/deliv-nojava.html

sex ratios toward males near the size of maturity for females has lead many investigators to speculate that the energetic costs of maturation and spawning may slow somatic growth in females, eventually leading to higher natural mortality. Estimates of differential cost of spawning on the basis of gonadal production, bioenergetics modeling (locomotion, metabolism, energy loss and growth) or some combination of both have been made for yellowfin tuna (Olson and Boggs 1986; Schaefer 1996: 1998). Although several energetic factors may not be fully addressed in these studies, they do agree that energetic costs for females and the massive cytoplasmic investment of females in daily expenditures of ova far outweigh that expended by the males. In short, it appears that female tuna, particularly the tropical tunas simply burn out and stop growing or die young as a consequence of massive reproductive output.

Reproductive parameters

Bigeye tuna spawn throughout the year in equatorial regions, engaging in night time mass spawning events in oceanic waters above approximately 24°C, but ideally closer to 26°C. Kume (1967) noted a correlation between mature but sexually inactive bigeye at SSTs below 23° to 24°C, which appears to represent a lower limit to bigeye spawning activity. Bigeye tuna are serial spawners, capable of repeated spawning events at daily or near daily intervals during extended spawning periods of unknown length (Nikaido et al. 1991). Spawning takes place during the late afternoon or evening hours at or near the surface (McPherson 1991a). Spawning peaks in the evening from about 1900 to 2400 hours, with batch fecundities of millions of ova per spawning event. Batch fecundity, as with many fishes, increased dramatically with body length with estimates of bigeye batch fecundities ranging from around one to five million eggs per spawn for fish ranging from 120 to 180 cm FL (Nikaido, et al. 1991). Sun et al. (1999) estimated an average batch fecundity for western Pacific bigeye of 3.47 million oocytes, or 59.5 oocytes per gram of body weight for samples.

Additional information on the maturity and spawning of western and central Pacific bigeye is provided by Kikawa (1953, 1957, 1961, 1962, and 1966). However, none of these older studies applied histological techniques that are necessary to accurately define maturity stages and reproductive parameters of tuna populations (Schaefer 2001). Goldberg and Herring-Dyal (1981) provide one of the few accessible studies on bigeye maturity using histological techniques.

Spawning areas and seasons

In a general sense, bigeye tuna are believed to spawn throughout the year in tropical regions (10°N - 10°S) and during summer months at higher latitudes (Collette and Nauen 1983). A study by McPherson (1991a) in eastern Australian waters supports this concept of equatorial spawning of bigeye throughout the year with seasonal spawning of bigeye in the north Australian zone, e.g. higher latitudes. Hisada (1979) noted from a study in the central and eastern Pacific that a temperature of 24°C to a depth of 50 m were necessary for maturity and spawning, suggesting a similar seasonal pattern of spawning in the western Pacific. It can be assumed that bigeye spawning and larval development are common at SSTs above 26°C, but may occur in some regions with surface mixed layers of 23°-24°C and above.

Yuen (1955) found fully mature, spawning condition bigeye in samples collected in the western Pacific, Caroline and Marshall Islands (1° - 7° N latitude) throughout the period of his sampling (April – October). Sampling at similar latitudes among the central Pacific, Line Islands of

Kiribati suggested two peak spawning periods in Jan-Feb and July-Oct. However, these results were considered preliminary due to restricted sample sizes and periods. A large data set from the Hawaiian Islands revealed no bigeye tuna in spawning condition with the nearest spawning condition bigeye sampled 400 miles southeast of Hawaii.

Two years of ovary sampling of Hawaiian bigeye revealed a definite increase in relative ovary weight from winter to summer, peaking in June, but no fully mature or spawning-condition bigeye were ever sampled (Yuen 1955). June also coincides with the annual low in the landings of large bigeye in Hawaiian waters. Yuen (1955) suggested that large bigeye in maturing stages leave Hawaii in spring and summer to spawn, presumably to the south. Gear selectivity was not considered a plausible explanation for the reduced summertime catches, as the same gear takes large, spawning condition bigeye at that time of year near Palmyra Atoll, 800 nmi south of Hawaii. This would also concur with a central equatorial spawning season of Jul-Oct, peaking in Aug-Sept as was inferred by the Line Islands samples examined in the same study.

Nikaido et al., (1991) noted bigeye in active spawning condition in waters described as "south-western offshore of Hawaii". Several tables and graphs in the paper are labeled as "Hawaii samples", which has lead to some confusion of the status of bigeye spawning in Hawaiian waters. His "Hawaii" samples were actually taken from locations 11°- 13°N, and 163°- 176°W which are well south of Johnston Atoll and over 700 miles from the closest Hawaiian island. Nevertheless, the sampling occurred from May 27 – July 10.

Boehlert and Mundy (1994), in larval fish tows around the Hawaiian island of Oahu tentatively identified five bigeye tuna larvae collected in June using visual criteria. However, these identifications are now considered suspect due to more recent work defining visual characters of tuna larvae using DNA techniques (Graves et al. 1988; Mundy, pers. comm.).

Sun et al. (1999), examined bigeye tuna gonads taken in the western Pacific longline fishery over a one year period. Based on monthly variation in gonad size and oocyte stage he proposed that the spawning season of western Pacific bigeye extended from February to September with peaks from March to June. These samples were taken primary from areas east and west of the Philippines; therefore around 10°N. 120-130°E.

Bigeye tuna - age and growth

Whitelaw and Unnithan (1997) provide a summary of early studies on the age and growth of bigeye tuna in the Pacific and Indian Oceans using primarily analyses of modal progression in size frequencies. Pertinent references include Iverson (1955), Kume and Joseph (1966), Marcille and Stequert (1976), Peterson and Bayliff (1985), Tankevich (1982) and Talbot and Penrith (1960). Yukinawa and Yabuta (1963) examined scale increments. Lehodey et al. (1999) and Sun et al. (2001) provide summarized tables of growth parameters derived by bigeye studies in the Pacific and Atlantic Oceans.

Significantly, the IATTC has completed an otolith age validation study on central Pacific bigeye tuna in collaboration with the University of Hawaii, Pelagic Fisheries Research Program (IATTC 2002). Saggital otoliths from recaptured bigeye tuna previously marked with oxytetracycline

(OTC) from Hawaiian waters and the Eastern Pacific Ocean were evaluated. The study concluded that daily microincrements were deposited on bigeye otoliths within the range of sampling (38-135 cm FL), but that expanded sampling and evaluation was necessary to expand the significance of the work.

In more recent studies, Hampton and Leroy (1998) developed a von Bertelanffy growth curve fitted to tag recapture data and otolith readings for western and central Pacific bigeye tuna, resulting in the growth curve as depicted in Figure 10 of Hampton et al. (1998b). Lehodey et al. (1999) refit the composite model, excluding otolith readings from fish >110 cm FL due to difficulties in reading daily increments beyond three years. Figure 6 in Lehodey et al. (1999) was felt to provide a reasonably good fit to both tagging and otolith data, with the tagging data providing estimated $L\infty$ within a more realistic framework.

Within the past few years, CSIRO has developed techniques to age bigeye tuna using seasonal annuli on otoliths (Farley et al. 2003). Annuli are not clearly defined during the first two years of life due to rapid growth but become easily discernable after two or three years of life. Leroy (1991) concludes that the second and third annuli can be accurately determined by visual enumeration of daily microincrements in prepared saggital otoliths. Therefore, a combination of daily and annular readings of otoliths should provide accurate estimates of bigeye growth.

In an independent study, Sun et al. (2001) used presumed annular marks on the first dorsal spine of western Pacific bigeye tuna to develop estimates of age and growth. Spines from 1149 specimens ranging between 45.6 – 189.2 cm FL were examined. Age estimates of mean and back calculated fork lengths of bigeye up to ten year estimates are provided.

Stequert and Conand (2004) examined the age and growth of bigeye tuna sampled from the western Indian Ocean. Presumed daily microincrements on saggital otoliths were interpreted using scanning electron microscope for 164 samples. A growth curve was derived indicating bigeye in this region measure 59 cm at year 1, 111 cm at year 3 and 147 cm at 6 years. Marks on the first dorsal spines of 140 bigeye tunas were also interpreted. Comparable results were reached using otoliths and spines up to estimated ages of three years, but they did not feel that spines were suitable for ageing larger fish.

These studies in combination with tag recapture data suggest that bigeye growth is rapid and parallels yellowfin growth for the first two years, after which it slows down significantly prior to the onset of sexual maturity. The disparity in results by area also suggests that studies need to be carried out on a regional basis and results from one area should be used with caution in other areas if at all. Maximum age of bigeye is not known, but tag recapture data provides empirical evidence that bigeye tuna grow to at least 12+ years of age which is considerably longer than yellowfin. Recently, large bigeye tuna have been aged using a combination of daily and annular marks at 13 to 15 years of age (Leroy pers. comm.).

Bigeye tuna - adult diet and feeding

Several investigators have proposed that the greater depth distribution of bigeye is a foraging strategy to exploit regions less utilized by yellowfin or skipjack tuna, thus reducing niche competition. Bigeye tuna are opportunistic feeders like yellowfin, relying on a mix of crustaceans, fish and cephalopods with feeding taking place during the day and night (Calkins 1980; Collette and Nauen 1983). However, the composition of adult bigeye diet differs significantly from that of similar-sized yellowfin (Watanabe 1958, Talbot and Penrith 1963, Kornilova 1980). Adult bigeye tuna prefer to forage at significant depths, utilizing a higher proportion of squid and mesopelagic fishes compared to yellowfin. Solov'yev (1970) suggests that the preferred feeding depth of large bigeye is 218–265 m, which is the most productive depth for longline catches. Miyabe and Bayliff (1998) summarize diet items of bigeye in the Pacific in tabular form from studies by Alverson and Peterson (1963), Blunt (1960), Juhl (1955), King and Ikehara (1956) and Watanabe (1958).

Any discussion of preferred bigeye habitat must address the vertical temperature structure, thermocline depth and local characteristics of the sound scattering layer (SSL) of the region in discussion. Josse et al. (1998) used tracking of bigeye and yellowfin marked with depth transmitting tags with simultaneous recording of biotic elements of the water column to examine tuna behavior during the day and night. The study clearly illustrated the importance of the SSL and prey to tuna movements and presumed feeding behavior. Sonic tracking and the use of archival data loggers have clearly shown the ability of adult bigeye to exploit prey and forage in a much deeper environment when compared to yellowfin (Dagorn et al. 2000; Musyl et al. 2003).

Bigeye tuna are also known to aggregate to large near surface concentrations of forage, such as the spawning aggregations of lanternfish (*Diaphus sp*.) that occur seasonally in the Australian Coral Sea (Hisada 1973; McPherson 1991b).

Bigeye tuna - adult importance to fisheries

Large, mature-sized bigeye tuna are sought by high value sub-surface fisheries, primarily longline fleets landing sashimi grade product. Adult bigeye tuna aggregate to drifting flotsam and anchored buoys, though to a lesser degree than juvenile fish. Large bigeye also aggregate over deep seamount and ridge features where they are targeted by some longline and handline fisheries.

Regions of elevated primary productivity and high zooplankton density—such as near regions of upwelling and convergence of surface waters of different densities that are very important to the distribution of skipjack and yellowfin tuna—are less important to the distribution of adult bigeye. This is logical if one assumes skipjack and yellowfin are inhabitants of the upper mixed layer while adult bigeye are sub-surface in nature, more closely tied to the thermocline and organisms of the deep scattering layer. Water temperature, thermocline depth and season appear to have much stronger influences on the distribution of large bigeye (Calkins 1980). The fact that large bigeye take longline hooks at greater depths than yellowfin coupled with a rising demand for sashimi-grade tuna and improved storage techniques prompted a shift to deep longline gear to target bigeye tuna during the late 1970s and early 1980s (Sakagawa et al. 1987; Suzuki et al. 1977). This development promoted numerous studies on differential catch rates and gear configurations to define productive hooking depths for bigeye given different oceanographic conditions (Bahar 1985, 1987; Boggs 1992; Gong et al. 1987, 1989; Hanamoto 1974; Nishi

1990; Saito 1975; Shimamura and Soeda 1981; Suzuki and Kume 1981, 1982; Suzuki et al. 1979).

Hanamoto (1987) proposed that productive longline fishing grounds for bigeye do not necessarily equate to regions of higher abundance, but "are nothing more than areas where the hook depths happened to coincide with the optimum temperature layer and where the amount of dissolved oxygen happened to be greater than the minimum required for bigeye tuna (1ml/l)." Nakamura (1969) suggests that bigeye tuna are closely associated with particular water masses or current systems during different life stages. Fish taken in the higher latitude longline fishing grounds tend to be large sub-adults, reproductively inactive young adults, or spent (mature but reproductively inactive) adults, while the fish taken in the equatorial longline fishery are actively spawning adults (Calkins 1980).

10.3.2 Bigeye Tuna Movement

Bigeye tuna - horizontal movements

There have been relatively few bigeye tagged in the Pacific in comparison to skipjack and yellowfin due to the difficulty in capturing quantities of bigeye in suitable condition for tagging. The South Pacific Commission tagged and released approximately 147,000 tuna between 1989 – 1992, of which only 5.5% were bigeye. As a result, horizontal movement data from conventional tagging programs is not conclusive.

Miyabe and Bayliff (1998) present summary information of some long distance movements of tagged bigeye in the Pacific. Hampton and Williams (2005) describes 8,074 bigeye releases made in the western Pacific by the South Pacific Commission (SPC) Regional Tuna Tagging Project (RTTP) during 1989–1992. An overall recapture rate of 12.5% of bigeye releases was reported.

For large release data sets in the Philippines and from the Coral Sea of Australia, more than 80% of recaptures were reported within 200 nmi of release. In contrast, about 50% of equatorial releases occurred beyond 200 nmi from their point of release and 10% beyond 1,000 nmi. The authors suggest the difference may be due to a greater tendency for bigeye to remain close to large land masses, FADs or tightly packed island groups. The equatorial releases were made in high seas areas or near isolated, oceanic islands and atolls.

Approximately 63 per cent of all SPC/RTTP bigeye tag releases were made in the northeastern Australian EEZ, most of which were captured in large feeding aggregations in the Coral Sea at approximately 17-18° S latitude (Itano and Bailey 1991). Hampton and Gunn (1998) examined a release dataset of 4,277 bigeye using a tag-attrition model with seasonally variable catchability and targeting options. Tag recaptures supported some linkage of Australian bigeye to the broader western and central Pacific and as far east as 130°-140° W longitude. However, the majority of recaptures came from the general area of release with a significant seasonal pulse during mid-year. Various explanations are given but some degree of localization of bigeye cannot be discounted.

The Hawaii Tuna Tagging Project (HTTP) conventionally tagged and released 7,440 yellowfin and 7,957 bigeye tuna throughout the Hawaiian archipelago, primarily from 1996 – 1999. Most of the bigeye releases were juvenile fish (mean 59.8 cm) tagged and released near a large seamount feature in the Hawaii EEZ or on offshore buoys that were acting as fish aggregation devices (Itano and Holland 2000). Bigeye recaptures reached 15% overall, which were primarily short term recaptures at or near their point of release, reinforcing the importance of aggregation and schooling to juvenile bigeye tuna behavior. Recaptured bigeye apparently remained within the Hawaii zone for at least two or three years, repeatedly aggregating to the same seamount or FADs where recaptures continued to be reported. Adam et al. (2003) supported some degree of regional fidelity or island association of these juvenile and sub-adult phase bigeye with a low level of mixing with the broader WCPO. In this respect, the results were somewhat similar to those reported by Hampton and Gunn (1998) for bigeye tuna in the Australian Coral Sea.

Sibert et al. (2003) applied a Kalman filter statistical model to refine horizontal movement data from geolocating archival tags recovered from Hawaiian bigeye tuna. Juvenile and sub-adult bigeye recoveries showed little real movement and a strong tendency to remain at the seamount and FADs where they had been tagged. The only large bigeye (131 cm) apparently remained associated with the coastal features and nearshore bathymetry of the island of Hawaii during 84 days at liberty. The authors suggest that large features, such as islands may also act as points of attraction and aggregation for bigeye tuna. This is a commonly held belief of traditional handline fishermen in Polynesia who target deep swimming tunas at specific locations close to atolls and high islands. There are several of these traditional handline areas along the south shore of the island of Hawaii that are known to hold bigeye and yellowfin tunas (Rizutto 1983).

However, over time, increasing numbers of HTTP recaptures have been reported radiating out from the Hawaiian islands in all directions, but primarily to the south of Hawaii toward Johnston and Palmyra Atolls. This recapture pattern may reflect different life stages of bigeye tuna, with semi-resident juveniles and sub-adults strongly aggregated to island and seamount features, expanding out into oceanic environments and tropical spawning grounds with their development to maturity. It should be noted that higher recapture rates to the south of Hawaii are undoubtedly influenced by differential fishing effort, but effort and abundance are often closely related.

Horizontal movements of bigeye in relation to FADs and drifting objects are not well described, although a great deal of anecdotal information is available from the fishing industry. Schaefer and Fuller (2005) noted that bigeye tended to remain tightly aggregated and upcurrent of anchored FADs and downcurrent from the drifting research vessel during the day. At night, the bigeye aggregations became more diffuse when it was presumed that individuals were foraging on organisms of the SSL. Bigeye returned to their daytime positions at dawn, often forming monospecific schools at the surface, usually termed a “breezer”.

Bigeye tuna can move freely throughout broad regions of favorable water temperature and dissolved oxygen values; and are capable of large, basin-scale movements as documented by tag recoveries. However, most bigeye recaptures have occurred within 200 miles of their point of release. However, these results may be confounded by the preponderance of juvenile fish in tag release cohorts, a protracted time to reach adult stages, reporting problems for recaptures of large fish from high seas fleets and a general paucity of adequate tag release data.

If the majority of spawning takes place in equatorial waters, then this infers mass movements of juvenile and sub-adult fish to higher latitudes, and presumably some return movements of mature or maturing fish to spawn. However, the extent to which these are directed movements is unknown and the extent of bigeye movement between the western, central and eastern Pacific remains unclear. An increase in tag releases of medium and large bigeye tuna throughout their range, incorporating fishery independent technologies where possible is needed.

Bigeye tuna - vertical movements

A great deal of information on the vertical behavior of bigeye tuna has been inferred from commercial or research derived longline data. However, this indirect source of information has been largely superseded by fisheries independent depth data either transmitted or recorded *in situ* and at fine time scales using sonic and archival (data logging) tags. Holland et al. (1990) tracked FAD associated bigeye tuna (72.0, 74.5 cm) fitted with pressure-sensitive (= depth recording) ultrasonic transmitters in Hawaiian waters. The fish exhibited a deep daytime (220 – 240 m) vs shallow night-time (70 – 90 m) behavior. This pattern broke down when FAD-associated, when average on-FAD daytime depths of 50 – 60 m. were noted. Daytime behavior was characterized by large, regular, but brief vertical excursions between the thermocline and the bottom of surface mixed layer, oscillating between the 14° and 17°C isotherms.

Holland and Sibert (1994) examined thermoregulation in Hawaiian bigeye tuna with data produced by depth and temperature transmitters and simultaneous use of expendable bathythermographs for vertical temperature profiling. Juvenile and sub-adult bigeye tuna (65 – 80 cm) exhibited regular vertical daytime movements as described in Holland et al. (1990). These excursions consistently began when internal body temperatures declined to 17.5 to 18°C, suggesting this may represent a lower body temperature limit for this medium size bigeye tuna.

Dagorn et al. (2000) tracked large bigeye in open ocean environments in French Polynesia, noting the same shallow night-time vs deep daytime behavior. The largest adult bigeye tuna (estimated 50 kg body weight) rose from daytime base depths of 400 – 460 m to mixed layer depths of 74 – 119 m moving through a temperature gradient of 11.5 – 25.6°C. This fish made only four upward excursions, one every 2.5 hours compared to eleven upward excursions per day recorded by Holland et al. (1990) for a much smaller bigeye tuna in Hawaii (74.5 cm). The authors attribute the difference to differences in body size, thermal inertia and the more frequent need for smaller bigeye to rise to the surface to warm core temperatures. A comparison of day and night swimming depth and simultaneous recording of the prey-rich sound scattering layer (SSL) indicated that bigeye tuna appear to maximize their time within the SSL; deep in the daytime and shallow at night. Vertical movements through the SSL were noted, possibly indicative of hunting/feeding behavior (Josse et al. 1998).

Schaefer and Fuller (2002) report on the largest documented archival dataset for bigeye: 27 sub-adult or potentially adult size fish (88 – 124 cm) tagged and released in drifting FAD aggregations in the equatorial Eastern Pacific Ocean. Vertical behavior was characterized into unassociated, drifting object associated, intermediate, or deep diving. Classic unassociated behavior was characterized as remaining at mostly < 50 m during the night and spending most of the day at 200 – 300 m within ambient sea temperatures of 13 - 14°C. Fish associated with a drifting FAD generally remained within the shallow mixed layer throughout the day and night above 50 m, although the daytime depth was slightly deeper. An intermediate behavior was noted in the data characterized by remaining shallow at night and day coupled with some deeper diving periods in the afternoon. The authors speculated that this behavior may have been representative of a fish associated with a drifting FAD that broke that association to feed at depth, or a fish feeding on forage aggregated unusually shallow during the daytime as sometimes occurs with some mesopelagic fishes. Sporadic, deep diving behavior was noted when bigeye tuna quickly dove to below 1000 m and ambient temperatures of < 3°C. The archival tags employed were only capable of reading to 1000 m, but it was inferred from ambient sea temperatures that some fish may have reached depths of 1500 m. It is not known why bigeye would dive so deep, but predator avoidance (i.e. marine mammals) or feeding was proposed.

Pooled data characterized the behavior of tagged bigeye as 54.3% unassociated, 27.7% intermediate-type behavior and only 18.7% of the time associated with a floating object, e.g. FAD as natural logs are very rare in this region of the EPO. Daytime diving depths were noted to be significantly shallower than those recorded in the central/western Pacific. The authors suggested that the main determinant of bigeye depth preferences at night and day had to do with their prey and feeding within the vertically migrating sound scattering layer. FAD associations were noted to be of short duration (mean residence time 3.1 days) but were though to contribute significantly to fishing mortality and vulnerability as evidenced by the high recapture rate of this tag release cohort (30 per cent overall).

Musyl et al. (2003) report on the vertical movements of bigeye tuna equipped with similar archival tags that had been released and recaptured from different types of aggregations in Hawaiian waters. Bigeye frequenting open-water areas exhibited the classic deep-daytime vs shallow-night time behavior observed by Schaefer and Fuller (2002). Bigeye periodically rose from daytime depths of ~300 – 500 m to spend short periods in the upper mixed layer, presumably to warm up after foraging at depth. All fish rose to very shallow depths at dusk only to sink down again at dawn. A strong positive correlation was found between body size and daytime depth as Dagorn et al. (2000) had suggested. Bigeye tuna tagged and later recaptured in association with an offshore anchored FAD spent the majority of their time in the upper mixed layer around 50 - 100 m. It is not known if the fish remained in association with the FAD during their entire time at liberty, but they exhibited this shallow "abnormal" behavior after release and when recaptured on the FAD. Bigeye tagged and recaptured on an offshore seamount feature exhibited vertical behavior similar to but not as regular as the vertical behavior of unassociated bigeye. In agreement with previous studies, bigeye in open water areas and on the seamount appeared to maximize their time within the SSL, presumably to maximize foraging success. In contrast to the observations of Holland et al. (1990) from brief sonic tracking data, internal temperatures of juvenile and sub-adult bigeye (52 – 86 cm) were recorded to fall to a minimum of ~ 12 - 13°C. The deepest recorded depth was 817 m and the coldest ambient temperature visited was 4.7°C, but fish spent very little time at these extremes.

By using a combination of archival tags and ultrasonic telemetry, Schaefer and Fuller (2005) report on the vertical behavior of bigeye tuna in mixes species aggregations on an anchored FAD. A larger bigeye (108 cm) occupied significantly deeper waters, day and night, compared to a smaller fish (59 cm). For the large fish, mean depths were significantly deeper during the day vs night. However, this pattern was curiously reversed for the smaller bigeye. Generally, the presence of FADs or drifting objects appears to significantly influence the vertical behavior of bigeye tuna.

Archival tag data is essential to characterize the habitat and behavior of tuna and billfish to refine habitat based models and to estimate the impact of fisheries. Currently, the SPC is attempting to obtain data on the vertical behavior of principal tuna species across a wide expanse of the WCPO that covers a wide range of oceanic environments.

10.3.3 Bigeye Tuna Stock Structure

The geographic distribution of bigeye tuna is pan-Pacific with no physical or oceanographic barriers to movement within temperature extremes. Analyses of genetic variation in mitochondria1 DNA and nuclear microsatellite loci have been conducted on bigeye otoliths from nine geographically scattered regions of the Pacific (Grewe and Hampton 1998). The study noted some evidence for restricted gene-flow between the most geographically distinct samples (Ecuador and the Philippines). However, the data otherwise failed to reject the null hypothesis of a single Pacific-wide population of bigeye tuna. In other words, the study supported the possibility of some degree of population mixing throughout the basin; results that may be termed inconclusive. It should be noted that in a separate study, Grewe et al, (2000) found no evidence to suggest that bigeye from the Indian Ocean were genetically different from the Pacific Ocean samples examined in the earlier study. This suggests that the methodology currently used may be an inappropriate tool for determining the issue of stock structure.

Miyabe and Bayliff (1998) suggest that there is insufficient information currently available to definitively determine the stock structure of bigeye in the Pacific, and therefore, a single stock hypothesis is usually adopted for Pacific bigeye tuna. However, consistent areas of low catch separate principal fishing grounds in the eastern and central/western regions (around 165 - 170°W) and there appears to be little mixing of tagged populations: although the tagging data is quite limited. Due to these considerations and the existence of two major, geographically separated fishing grounds and fisheries coupled with the possibility of ocean basin movements of Pacific bigeye tuna, stock assessments have been carried out on both a Pacific-wide basis and a two-stock hypothesis: separating the central and western Pacific from the Eastern Pacific Ocean. The two-stock hypothesis conforms to the definition of a stock proposed by Suzuki et al. (1978) as *"...an exploitable subset of the population existing in a particular area and having some uniqueness relative to exploitation*."

The results of the genetic analyses are broadly consistent with SPC tagging experiments on bigeye tuna; most stay close but some go far. Bigeye tagged in locations throughout the western tropical Pacific have displayed eastward movements of up to 4,000 nmi over periods of one to several years. The widespread distribution of bigeye spawning throughout the tropical Pacific and the greater longevity of bigeye relative to other tropical tunas, such as yellowfin (Hampton et al. 1998), are also consistent with a high *potential* for basin-scale gene flow. However, large-scale movements of bigeye > 1,000 nmi have accounted for only a small percentage of returns, with most recaptures occurring within 200 nmi of release (see Section 1.4.1). In addition, a significant degree of site fidelity of bigeye tuna in some locations has been suggested, such as near large land masses, island-rich archipelagos and possibly areas of high FAD densities.

Sibert and Hampton (2003) estimated median lifetime displacements of skipjack and yellowfin tuna in the order of some hundreds of nautical miles, rejecting the notion that these tropical tuna species are widely ranging by nature and "highly migratory". These findings are consistent with the concept of "semi-discrete stocks" of yellowfin in the Pacific as proposed by Suzuki et al. (1978). Bigeye tuna, representing a unique blend of traits between a tropical and temperate tuna species with a protracted life span, may be expected to remain in a general area for extended periods of time and to also range further and have a higher potential for broader displacements throughout their extended life span. Stock assessments are currently carried out for 1) the entire Pacific bigeye stock; 2) the western and central Pacific regional stock and 3) the eastern Pacific regional stock. Due to the importance of fisheries in both regions and their differential characteristics, the different methodologies used in each stock assessment, and the fact that the each region is managed under a different authority, only the two separate regional stock assessments will be discussed in detail at this time. These regions are illustrated in Figure 2 and discussed below.

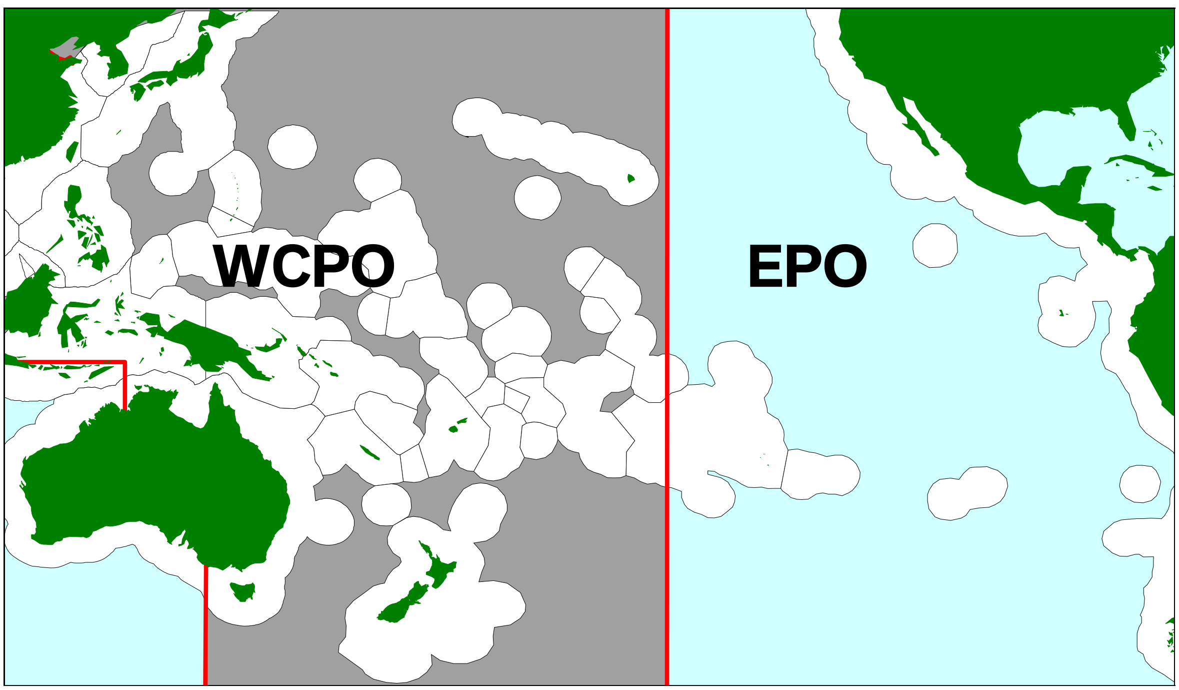


Figure 2. Geographic delineation of the WCPO and EPO for statistical purposes

10.3.4 Bigeye Tuna Stock Assessment[7]

Western and Central Pacific Ocean

The most recent stock assessments for WCPO bigeye were presented at the 17th Meeting of the Standing Committee on Tuna and Billfish (Hampton et al. 2004) and the first regular session of the Scientific Committee to the WCPFC. The assessments use the stock assessment model and computer software known as MULTIFAN-CL (Fournier et al. 1998). The Pacific-wide distribution of bigeye catch by gear and the statistical areas used in the MULTIFAN-CL analyses are shown in Figure 3. The bigeye tuna model is both age (40 age-classes) and spatially structured (5 regions) and the catch, effort, size composition and tagging data used in the model are classified by 17 fisheries and quarterly time periods from 1950 through 2007. The last 4-5 years (depending on the fishery) constitute a projection period in which the last year's fishing effort for each fishery is assumed to continue into the future. The data used in the assessment were the same as those used in 2003, with the exception that pre-1965 Japanese longline size composition data became available recently and were used in the assessment, and an additional year of fishery data (2002 for longline, 2002 for Philippines and Indonesia, 2003 for purse seine) was included.

Five independent analyses were conducted to the impact of using different standardizations of fishing effort in the main longline fisheries (LL1-LL5), using estimated or assumed values of natural mortality-at-age, and assuming fixed or variable catchability for the main longline fisheries. These analyses are listed below:

- SHBS-MEST Statistical habitat-based standardized effort for LL1−LL5, constant catchability for LL1−LL5.
- SHBS-MEST-LLq Statistical habitat-based standardized effort for LL1−LL5, catchability for LL1−LL5 allowed to vary independently.
- SHBS-MFIX Statistical habitat-based standardized effort for LL1−LL5, *M*-fixed levels, constant catchability for LL1−LL5.
- GLM-MEST General linear model standardized effort for LL1−LL5, constant catchability for LL1−LL5.
- GLM-MFIX General linear model standardized effort for LL1−LL5, *M*-fixed levels, constant catchability for LL1−LL5.

Recruitment showed an increasing trend from the 1970s onward, while biomass declined through the 1960s and 1970s after which it was relatively stable or declining slightly (Figures 4 and 5). The fisheries are estimated to have reduced overall biomass to around 40% of unfished levels by 2003, with impacts more severe in the equatorial region of the WCPO, particularly in the west.

[7] The drafting of this amendment began in 2004 and has meant that several stock assessments have been conducted in the interim. The latest assessment for bigeye tuna in the WCPO, conducted in 2006 and presented to the second regular session of the WCPFC's Scientific Committee (Hampton et al. 2006a), estimated, in the base case model, that FCURRENT/FMSY was 1.32 (FCURRENT was taken to be the 2001-04 average fishing mortality-at-age). The probability of FCURRENT being greater than FMSY was estimated to be 100%. BCURRENT/BMSY (where "current" meant the 2001-04 period) in the base case model was estimated to be 1.27, with a 0.8% probability of being less than 1.

On the other hand, the current level of biomass is estimated to be high, around 1.7-2.3 times the equilibrium biomass expected at MSY. Current biomass has remained high because of above average estimated recruitment since about 1980.

The assessment suggested a high probability that current fishing mortality on bigeye tuna in the WCPO is above MSY levels, but that current biomass remains above the MSY level, hence overfishing is occurring but the stock is not yet in an overfished condition.

On the basis of all of the results presented in the assessment, it was concluded that maintenance of current levels of fishing mortality carries a high risk of overfishing. Should recruitment fall to average levels, or if recruitment was over-estimated in the models, current catch levels would result in stock reductions to near and possibly below MSY-based reference points. Reduction of juvenile fishing mortality in the equatorial regions would have significant benefits for both the bigeye tuna stock and the longline fishery.

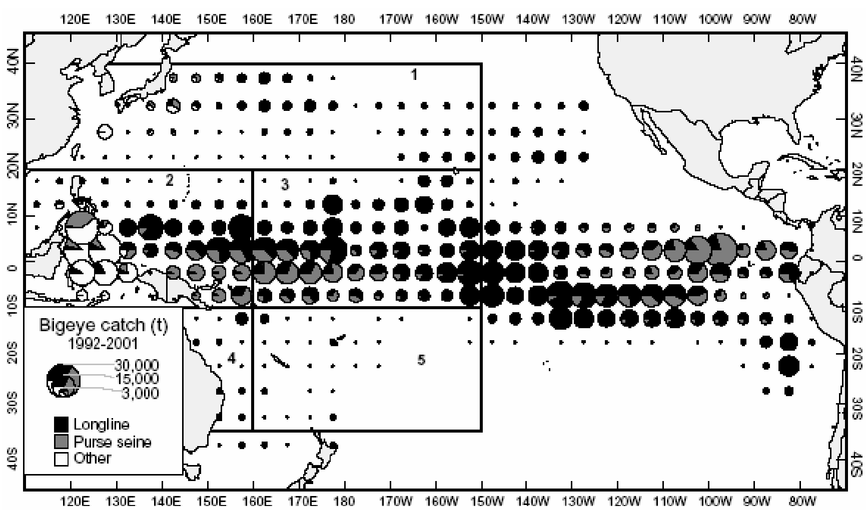


Figure 3. Distribution of bigeye catch (1992-2001) with spatial stratification used in the WCPO MULTIFAN-CL analyses.

(Source: Hampton et al. 2004)

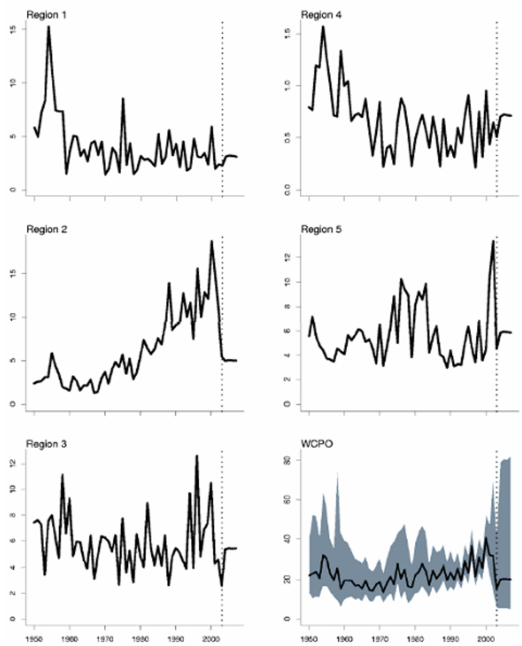


Figure 4. Estimated annual recruitment (millions) by region and for the WCPO (SHBS-MEST model).

(Source: Hampton et al. 2004)

The shaded area for the WCPO indicates the approximate 95% confidence intervals. The dotted vertical line delineates data-supported model estimates from projections. The vertical dotted lines indicate the point at which population projections are made with levels of effort assumed to remain constant at recent (2002-2003) levels.

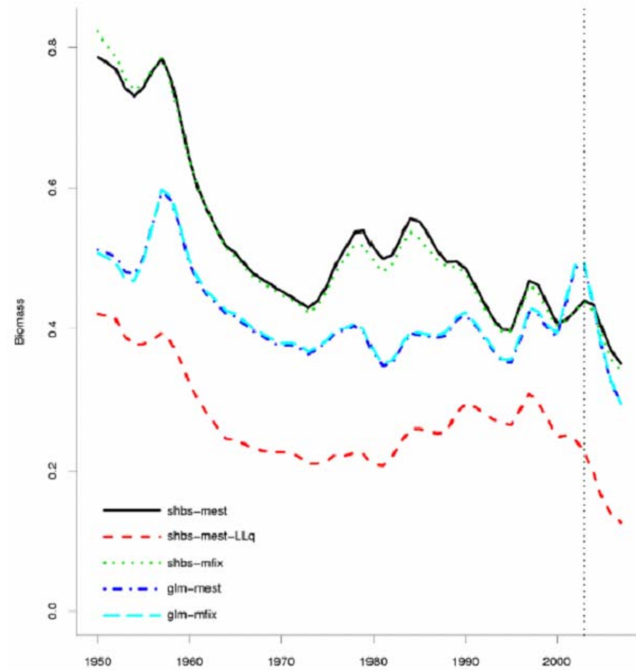


Figure 5. Estimated annual average total biomass (million t) for the WCPO, from three separate analyses.

(Source: Hampton et al. 2004)

Figure 5's vertical dotted line again indicates the point at which population projections are made with levels of effort assumed to remain constant at recent (2002-2003) levels.

In summary, the assessment suggests a high probability that current fishing mortality on bigeye tuna is above MSY levels, but that current biomass remains above the MSY level. The results are somewhat more optimistic than those of the 2003 assessment for comparable analyses, although the LLq model produced a more pessimistic result. On the basis of all of the results presented in the assessment, it appears that maintenance of current levels of fishing mortality carries a high risk of overfishing. Should recruitment fall to average levels, current catch levels would result in stock reductions to near and possibly below MSY-based reference points. Reduction of juvenile fishing mortality in the equatorial regions would have significant benefits for both the bigeye tuna stock and the longline fishery.

The latest MULTIFAN-CL stock assessment for WCPO bigeye tuna concluded that maintenance of current levels of bigeye fishing mortality carries a high risk of overfishing, particularly if predicted recruitment levels fall to average levels. The model predicts an approximate halving of virgin biomass by 1970 followed by a relatively stable or slightly declining condition. The model predicts increasing recruitment since 1980 and above average recruitment in recent years. Overall, depletion was estimated to have been rapid, particularly since the mid-1980s. However, the predicted stability of total biomass since the 1970s appears to have only been sustained by concurrent above average predicted recruitment. If recruitment levels were to decline to average or below average levels, total biomass would be predicted to decline rapidly. The importance of accurate estimates of recruitment for bigeye and yellowfin can not be over-emphasized.

When examining the impact of various fisheries or groups of fisheries on stock depletion, the model indicated that longline fishing had the greatest impact throughout the entire region. However, the purse seine fishery and the combined Philippines/Indonesian fisheries had the largest impact in Regions 2 and to a lesser extent in Region 3 (Figure 6). Regions 2 and 3 are the most important and resource rich areas of the WCPO tropical tuna fishery and account for 90% of estimated bigeye catch in the MULTIFAN-CL model area (Molony 2004a). These areas also comprise the primary bigeye and yellowfin spawning grounds in the WCPO as indicated by SST data and studies on the reproductive biology of the species. All studies are in agreement that the floating object sector of the purse seine fishery is the main contributor to bigeye mortality in the purse seine category. In other words, longline, drifting object purse seine and the Philippine/Indonesian fisheries are the major components of predicted bigeye depletion in the WCPO.

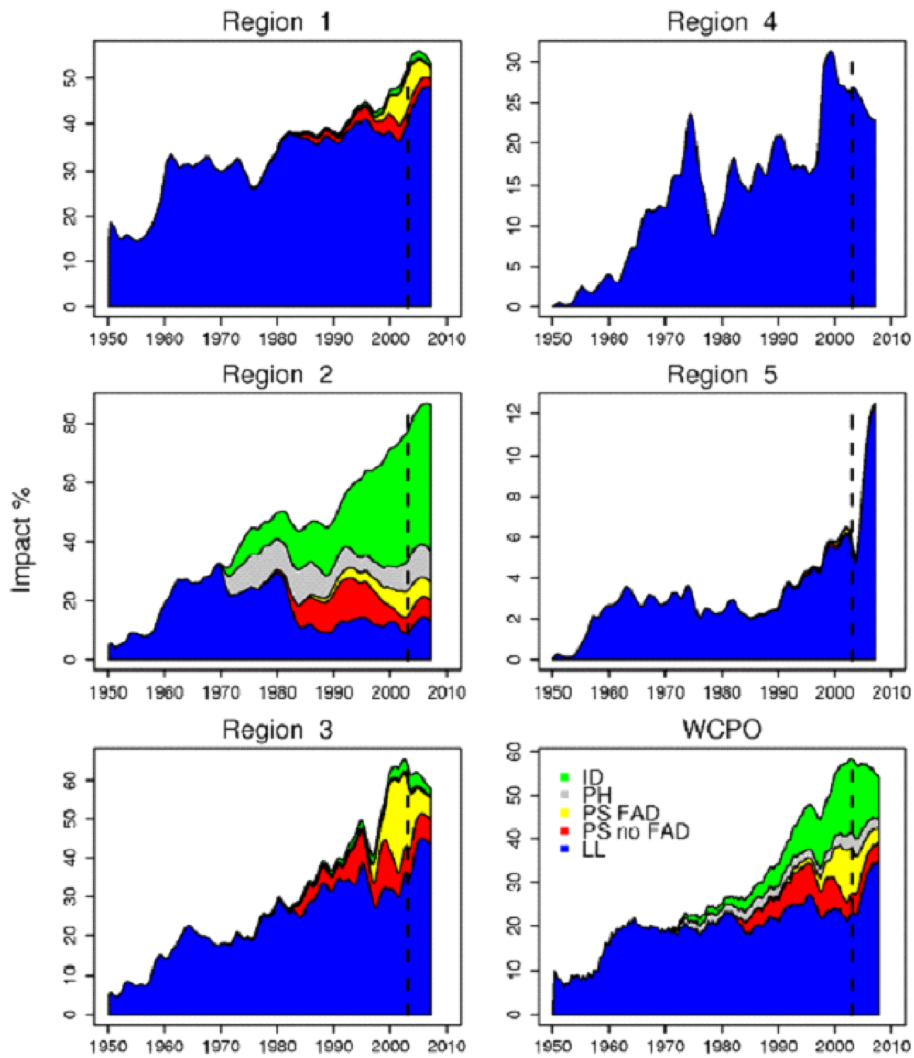


Figure 6. Estimates of reduction in total biomass due to fishing by region and for the WCPO attributed to various fishery groups (SHBS-MEST model).

Note: LL = all longline fisheries; ID = Indonesian domestic fishery; PH = Philippines domestic fisheries; PS FAD = purse seine FAD sets; PS non-FAD = purse seine log and school sets (Source: Hampton et al. 2004)

Table 4 provides estimates of critical reference points based on the 2004 and 2005 WCPO bigeye stock assessments.

Table 4. Estimates of stock reference points resulting from 2004 and 2005 stock assessments for WCPO bigeye tuna.

Management Quantity	2005 Assessment	2004 Assessment
Most recent catch	125,940 (2004) 2001-2003 range 102,000-115,000 mt	96,000 mt
Maximum yield under recent recruitment (1994-2003)	93,300 mt	NA
MSY	66,000~76,000 mt	56,000~62,000 mt
$\mathbf{Y_{Fcurrent}/MSY}$	0.9~1.00	1.00
$\mathbf{B_{current}/B_{current,\ F=0}}$	0.31~0.51	0.41~0.43
$\mathbf{F_{current}/FMSY}$	Base case: 1.23 Range: 0.90~1.45	Base case: 0.98 Range: 0.89~1.02
$\mathbf{B_{current}/\ BMSY}$	Base case: 1.25 Range: 1.06~1.48	Base case: 1.75 Range: 1.75~2.28

WCPO Purse seine fisheries

Purse seine catches of bigeye in the most recent period have been lead by Japan, PNG and the Philippines. This is most surely a consequence of the relative proportion of floating object sets or for PNG and the Philippine fleets, their reliance on sets made on anchored FADs. The U.S. had very high rates of bigeye catch in the late 1990s coinciding with their increased use of drifting FADs during those years, which peaked in 1999. This also may also be a consequence of better reporting relative to other fleets. However, their bigeye catch has dropped off considerably in recent years as the fleet has widely abandoned the use of drifting FADs, primarily due to the low price for small skipjack associated with FAD sets, versus those for large free swimming skipjack.

The distribution of purse seine catches of bigeye by set type are shown in Figure 7. The increase in use of drifting FADs in the late 1990s and subsequent decline is clearly indicated as is the increase in anchored FAD sets during the same time period.

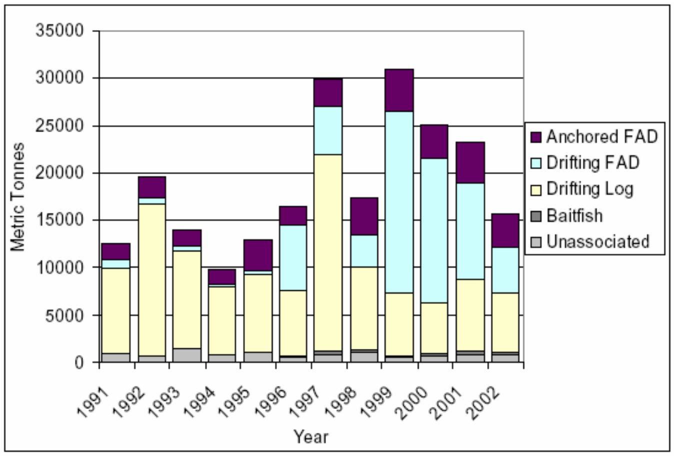


Figure 7. Distribution of purse seine bigeye catch by set type for the WCPO, 2001-2002. (Source: Molony 2004a).

The CPUE (t/set) of bigeye tuna by set type is shown in Figure 8. Drifting FAD, natural log and anchored FAD sets clearly have the highest bigeye CPUE values. However, the range of values varies somewhat, which is likely a consequence of differential reporting rates between fleets.

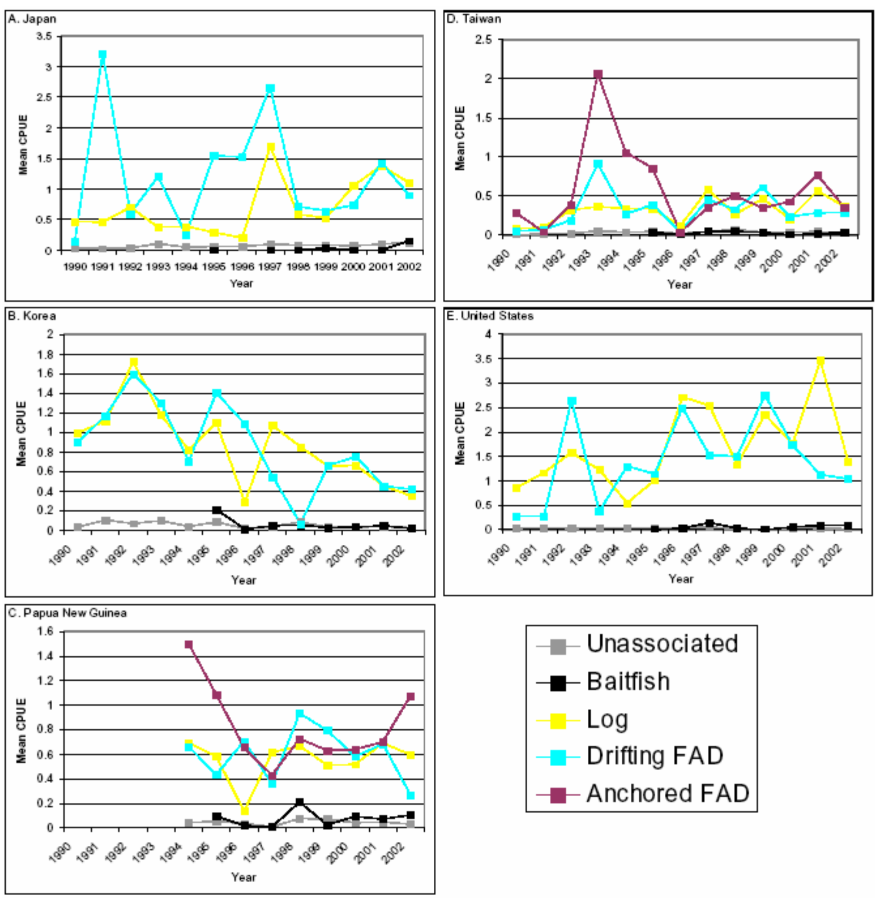


Figure 8. CPUE (t/set) of bigeye tuna by set type in the WCPO.

The spatial distribution of bigeye catches by purse seine in the WCPO confirms the importance of the MULTIFAN-CL Regions (also known as Areas) 2 and 3. These areas are depicted in Figure 9. More than 90% of all bigeye catches made from 1990 – 2002 were made in Areas 2 and 3 (Figure 10). This is simply a reflection of the spatial distribution of purse seine effort in the area.

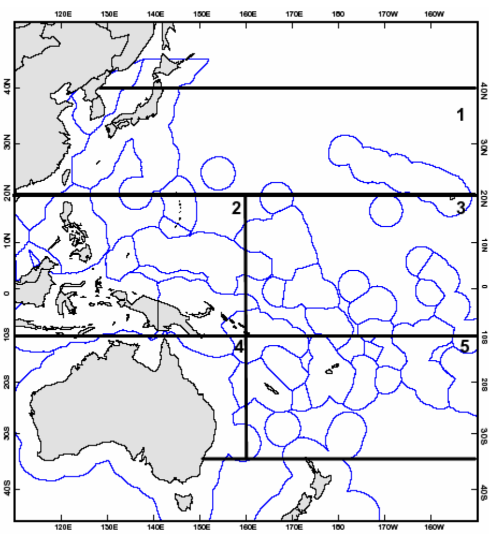


Figure 9. Approximate boundaries of the MULTIFAN-CL areas used in the model analyses.

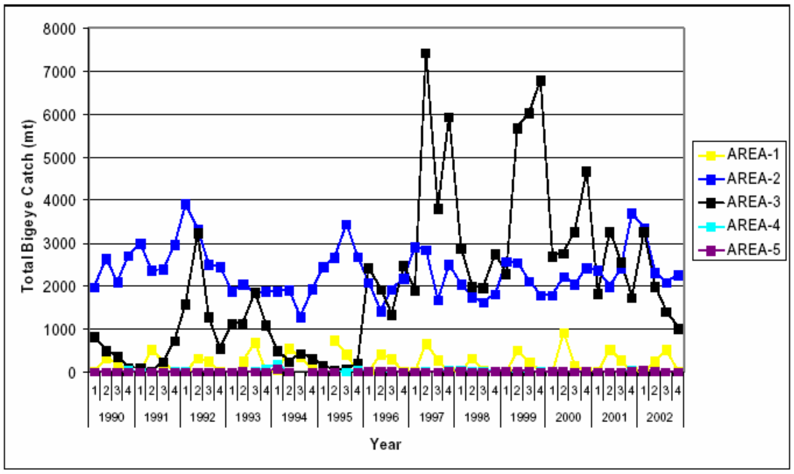


Figure 10. Total purse seine bigeye catch by MULTIFAN-CL region, 1990 – 2002.

The size of bigeye by set type was examined. Generally, the modal size of bigeye taken in all set types was around 50 cm, but bimodal and even trimodal distributions were evident in some years. Smaller bigeye were more common in Area 2 on logs and FADs while slightly larger bigeye were more available in Area 3 on drifting FADs. Bigeye larger than 100 cm were rare in all set types.

In response to the recommendations of the second meeting of the Scientific Coordinating Group (SCG2) on Sustainable Fisheries Management, the fifth meeting of the Preparatory Conference (PrepCon) requested the Interim Secretariat to prepare a document on management options on how the Commission could respond to sustainability concerns in respect to bigeye and yellowfin tuna. The resulting paper, *Management Options for Bigeye and Yellow Tuna in the Western and Central Pacific Ocean* (Anonymous 2004) was available for discussion during PrepCon VI. Due to a lack of time for substantive discussion, PrepCon VI requested that SCG 3 "advise on the further analyses to support the consideration by PrepCon VII and the first session of the Commission of management options and how these analyses can carried out in a timely and effective manner." (see Appendix I for summary).

In order to assist SCG 3, the Oceanic Fisheries Programme (OFP) undertook to compile available information from the OFP Regional Tuna Fishery Database relevant to bigeye and yellowfin conservation for WCPO purse seine and longline fisheries. The resulting paper, *Summarized fishery information for evaluating options for bigeye and yellowfin tuna. 1. Review of fleet capacity, catch, and effort of the purse seine fishery in the western and central Pacific Ocean, with emphasis on the use of fish aggregation devices (FADs)*, is summarized here (Molony 2004a).

Information was compiled as follows:

- Time series purse seine capacity classified by flag state and national/high seas zones, expressed in terms of number of vessels and/or GT and/or carrying capacity;

- Time series of purse seine fishing effort (days and sets for purse seine, hooks and sets for longline) classified by flag state and national/high seas zones;

- Time series of bigeye and yellowfin catch for purse seine fisheries classified by flag state and national/high seas zones;

- Estimates of bigeye and yellowfin purse seine catch classified by set type (log, anchored FAD, drifting FAD, free school) by flag state for recent years;

- Estimates of bigeye and yellowfin purse seine catch by area/time strata to identify areas and times of consistently higher catches, if they exist;

- Estimates of recent purse seine effort (in days and number of sets) classified by set type (log, anchored FAD, drifting FAD, free school) by flag state;

- Distribution of bigeye and yellowfin catches by size, classified by area and flag state;

The study examined data back to 1975 referencing the FFA Regional Register of Fishing Vessels for capacity measurements. The U.S., South Korean and Japanese vessels have been relatively stable in size since the early 1980s, while the Taiwanese, Philippine and FSM vessels have nearly doubled in GT within a five to ten year period from the mid-1980s. Total purse seine capacity estimated for 2002 for all fleets has near quadrupled since the mid-1980s and vessel numbers have also increased. The Taiwanese and South Korean fleets in particular have increased significantly while the U.S. fleet has declined.

Langley (2004) examined the main factors that influence bigeye tuna catches in comparison between drifting FADs and natural logs. This study examined detailed observer data resulting from the United States Multi-lateral Treaty (USMLT) Observer Program for U.S. purse seine vessels in the WCPO. This data is considered far more detailed and reliable than unverified logsheet data. The observers routinely collect catch and effort data by set type and are trained in the differentiation between juvenile bigeye and yellowfin and coached in the importance of species specific reporting. Data was filtered to eliminate observers whose species identification skills were judged to be "unreliable". Also, observers are trained to classify logs that have been modified by the addition of man-made materials as a drifting FAD thus standardizing a source of ambiguity in logsheet data. The comparative analysis concentrated on the main area where U.S. vessels make drifting FAD sets and logs sets also occur: from the equator to 10°S and 170°E – 170°W.

Overall, bigeye accounted for a slightly higher proportion of the total tuna catch from drifting FAD sets compared to log sets. The probability of catching bigeye within the area did not vary by latitude or longitude, but the area was relatively small. Virtually all bigeye catches were made in the early morning hours which is expected as this is when floating object and anchored FAD sets normally take place. Of significant interest, there was considerable variability in the probability of catching bigeye between individual vessels. In particular, two vessels had a significantly higher catch rate of bigeye in relation to the rest of the fleet.

There was a strong seasonal trend in bigeye catches note in the data. Bigeye catches were highest in the austral summer (Nov – Feb) and lowest in winter (May – Oct). During the 1996 – 2002 period, when 92% of the bigeye catch was taken. However, the summer period also accounted for 87% of the annual skipjack catch.

Bigeye catch and moon phase were found to be positively correlated around the new moon, with catch rates lowest during full moon. The converse relationship was noted for skipjack CPUE on drifting FADs with low CPUE during the new moon and high CPUE during full moon. Langly (2004) suggests this may be a means to reduce bigeye catch on drifting object sets without reducing skipjack catch during peak periods. Langly (2004) concluded that skipjack, yellowfin and bigeye all favor the same oceanographic conditions when near a FAD, thus making it impossible to completely avoid bigeye bycatch when landing significant amounts of the other two species. However, restricting fishing on the new moon may be worth investigating. Also, he suggested that gear and vessel attributes and particulars of FAD construction by high bigeye-catching vessels should be investigated to look for common fishing techniques or gear configurations. The most significant hindrance and limitation on this and similar studies was felt to be the lack of accurate, species and set specific data for all fleets and over wide spatial and temporal strata.

WCPO longline fisheries

Total effort in numbers of hooks set increased rapidly in the early years of industrialized fishing, and experienced a four-fold increase between 1952 – 2002 when 680 million hooks were recorded. Effort in numbers of hooks and sets has been increasing slightly or been relatively stable since 1980 (Figure 11). However, there have been significant changes in gear and targeting during the same time period.

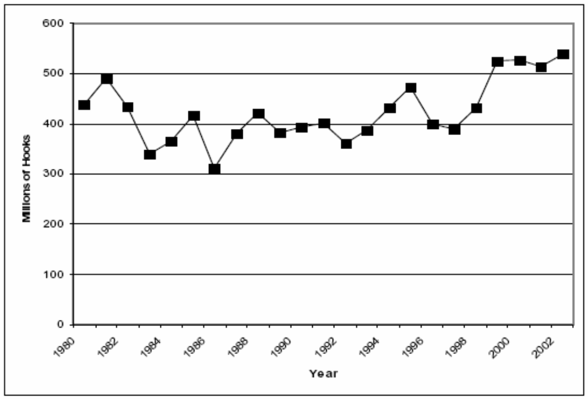


Figure 11. Total number of hooks set by combined WCPO longline fleets.

(Source: Molony 2004b)

The distant water fleets of Japan, Taiwan and South Korea currently account for the majority of longline sets and hooks deployed despite considerable reductions in effort by the Japanese fleet. The FSM received most of the longline effort in recent years while high seas zones recorded increasing effort.

Total longline bigeye catches have increased steadily since the beginning of the fishery and were the highest on record in 2002. However, significant inter-annual fluctuations are apparent with higher catches recorded every 2 – 4 years. The catches are dominated by the Japanese and South Korean fleets that target sashimi grade bigeye tuna. Bigeye landings by Japanese vessels represent a five-fold level compared to those of Taiwan, China and the U.S..

Bigeye CPUE (kgs/100 hooks) has stabilized since the early 1990s. Not surprisingly, the highest CPUEs were recorded from the major bigeye targeting fleets of Japan, South Korea and the U.S.. The Marshall Islands EEZ has recorded the highest CPUE for bigeye in the WCPO.

Most of the WCPO bigeye catch is taken from MULTIFAN-CL Area 3 with smaller amounts harvested from Areas 2 and 1 and minor catches from Areas 4 and 5. The total bigeye longline catch from Areas 2 and 3 fluctuate over time but show an increasing trend (Figure 12).

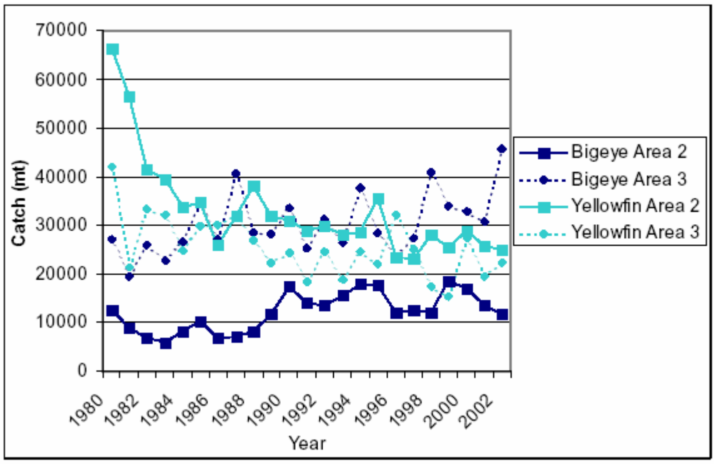


Figure 12. Total catch of bigeye and yellowfin from MULTIFAN-CL Areas 2 and 3.

(Source: Molony 2004b)

The data examined indicate that most of the bigeye taken by longline in Area 2 are > 110 cm with few fish recorded < 90 cm. Area 3 shows a higher proportion of both smaller and larger fish taken in comparison to Area 3 (Figure 13). It should be noted that these data come from observer programs so should more accurately reflect total catch in comparison to logsheet data that normally does not reflect rejection or highgrading by the fishermen (in general highgrading refers to the discarding of low value fish in favor of higher valued fish).

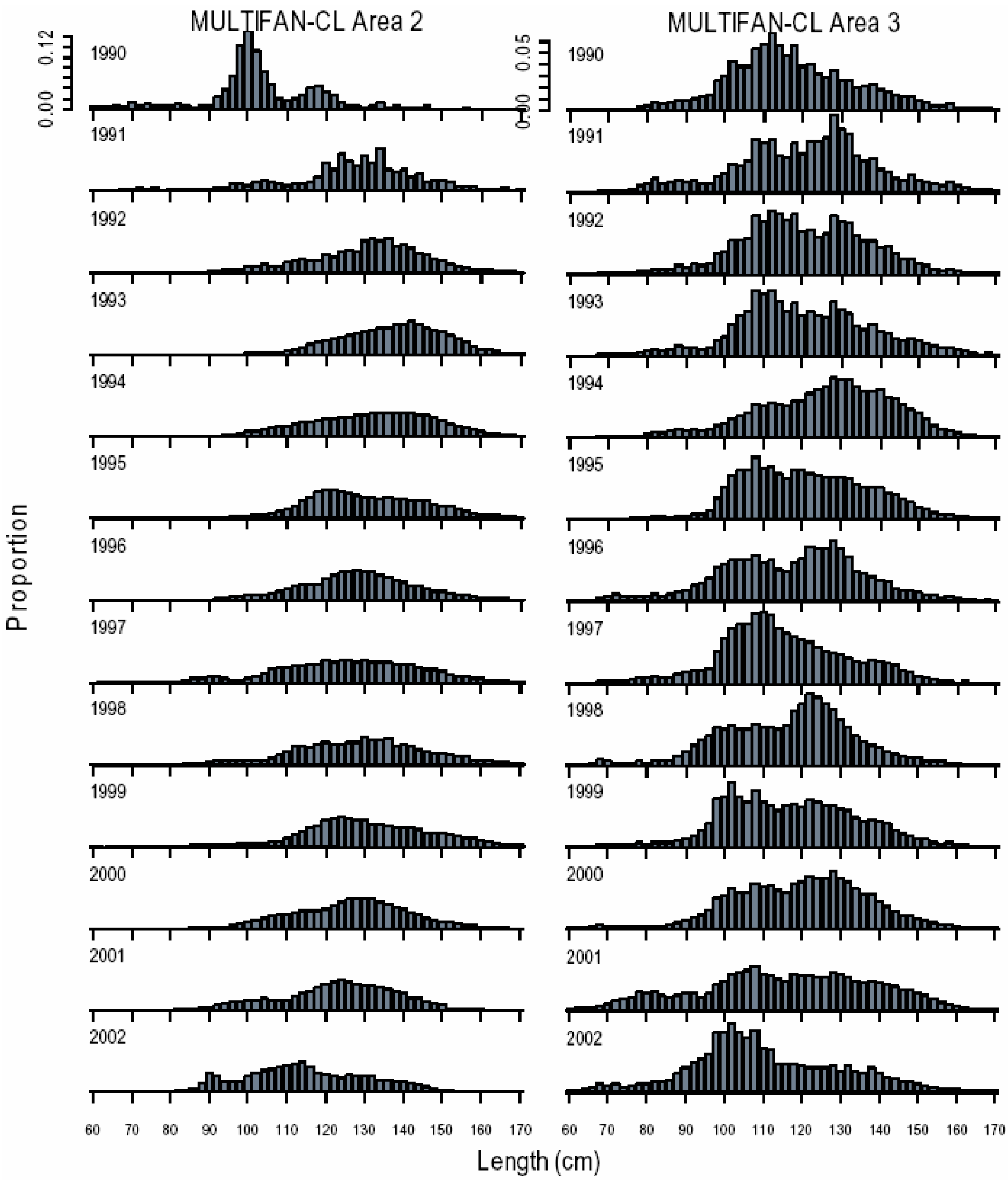


Figure 13. Length frequency of longline caught bigeye in MULTIFAN-CL Areas 2 and 3 from observer data.

(Source: Molony 2004b)

Following PrepCon VI, the SCG was tasked with defining analyses necessary to address concerns over bigeye and yellowfin stock condition in the WCPO. In order to assist SCG3, the Oceanic Fisheries Programme (OFP) undertook to compile available information from the OFP Regional Tuna Fishery Database relevant to bigeye and yellowfin conservation for WCPO purse seine and longline fisheries. The first paper summarizing information on purse seine fisheries was described in the previous section. The second paper: *Summarized fishery information for evaluating options for bigeye and yellowfin tuna. 2. Review of fleet capacity, catch, and effort of the longline fishery in the western and central Pacific Ocean*, is summarized here (Molony 2004b).

Information was compiled as follows:

- Time series of longline capacity classified by flag state and national/high seas zones, expressed in terms of number of vessels and/or GT and/or carrying capacity;

- Time series of longline fishing effort (days and sets for purse seine, hooks and sets for longline) classified by flag state and national/high seas zones;

- Time series of bigeye and yellowfin catch for longline and purse seine fisheries classified by flag state and national/high seas zones;

- Distribution of bigeye and yellowfin catches by size, classified by area and flag state;

Information on vessel capacity was obtained from the FFA Regional Register of Fishing Vessels (RR). Unfortunately, the RR generally does not record information on domestic fleets and may not record data for foreign vessels classified as domestic under some joint venture scheme. As a result, Molony (2004b) states, "*the FFA longline register greatly under-estimates the number of longline vessels currently operating in western and central Pacific Oceans (WCPO)*", representing only 23% of the total number of longline vessels operating in the region. Information in the paper is representative mainly of the larger Distant Water Fishing Nation (DWFN) longline vessels and does not reflect information from many domestic situations.

Also, the RR data for GT was used to estimate capacity, which is an inconsistent and unverified statistic between fleets due to different ways in which GT is calculated in different countries. Data on hold capacity was not yet available or has not been collected from enough vessels to utilize. Another significant problem of the RR that is not mentioned is that it may contain a number of entries of the same vessel under different names and registries or for vessels no longer active in the fishery.

Longline data was examined back to 1978, but 27% of RR records had no entry for GT. Using available and estimated values, it appears that the number of longline vessels rose in the early 1980s, declined in the mid-1980s and have risen since to record highs. Mean GT values for all fleets have remained relatively stable since the 1980s except for the Chinese fleet whose GT values have been gradually increasing over time. Most fleets record GT in the range of 50 – 150 GT with the exception of the South Korean longline fleet that consists of larger vessels to 400 GT, presumably the large sashimi freezer boats. Total longline capacity in GT examined doubled between 1980 and the mid-1990s before stabilizing at a lower level around 1998. Japanese distant water effort has declined, primarily due to exclusion from the Australian and New Zealand EEZs while South Korean effort has increased significantly.

Eastern Pacific Ocean

The IATTC Working Group on Stock Assessment (Maunder and Hoyle 2005) found that their analysis suggests that by the beginning of 2004, the spawning stock biomass of bigeye in the EPO dropped below levels required to produce the average maximum sustainable yield (AMSY), and was predicted to drop to historic lows by 2007 – 2008 due to recent weak recruitments and high fishing mortality. The average weight of fish in the catch of all fisheries combined has been below the critical weight (about 49.8 kg) since 1993, suggesting that the recent age-specific pattern of fishing mortality is not satisfactory from a yield-per-recruit perspective.

The EPO assessment assumes no stock recruitment relationship and estimates below average recruitment in recent years. The researchers agree that recruitment is highly variable and difficult to predict, strengthening the importance of gaining increased understanding of recruitment processes.

The impact of purse seine and longline fisheries on the stock is considered to be highly significant. The analysis suggests that the initial decline in stock biomass was caused by longline fishing but accelerated declines since 2000 are mainly attributable to floating object based purse seine fishing. Under the current model, Spawning Biomass Ratio (SBR) levels are predicted to remain at very low levels for many years unless fishing mortality is significantly reduced or recruitment increases for several years.

Available information has shown that FADs substantially increase catchability of bigeye in offshore waters where they were formerly unexploited and that the floating object purse seine fishery has caused significant increases in fishing mortality of juvenile bigeye. A significant and more concerning matter is that that the EPO floating object FAD fishery takes a far higher proportion of sub-adult size bigeye compared to the WCPO fishery that harvests mainly smaller juvenile size bigeye. It might be expected that impacts on sub-adults would have a greater impact on potential spawning stock biomass and stock condition.

The authors conclude that the purse-seine fishery on floating objects has the greatest impact on the EPO bigeye tuna stock. Restrictions applied only to a single fishery (e.g. longline or purse-seine), particularly restrictions on longline fisheries, are predicted to be insufficient to allow the stock to rebuild to levels that will support the AMSY. Large (50%) reductions in effort (on bigeye tuna) from the purse-seine fishery will allow the stock to rebuild towards the AMSY level, but restrictions on both longline and purse-seine fisheries are necessary to rebuild the stock to the AMSY level in ten years. Simulations suggest that the restrictions imposed by the 2003 Resolution on the Conservation of Tuna in the EPO will not be sufficient to rebuild the stock.

There have been important changes in the amount of fishing mortality caused by the fisheries that catch bigeye tuna in the EPO. On average, the fishing mortality for bigeye with an age of less than about 20 quarters old has increased substantially since 1993, and that on fish with an age of more than about 24 quarters old has increased slightly. The increase in average fishing mortality on the younger fish was caused by the expansion of the fisheries that catch bigeye in association with floating objects. The base case assessment suggests that:

- the use of FADs has substantially increased the catchability of bigeye by fisheries that catch tunas associated with floating objects, and

- bigeye are substantially more catchable when they are associated with floating objects in offshore areas.

Recruitment of bigeye tuna to the fisheries in the EPO is variable, and the mechanisms that explain variation in recruitment have not been identified. Nevertheless, the abundance of bigeye tuna being recruited to the fisheries in the EPO appears to be related to zonal-velocity anomalies at 240 m during the time that these fish are assumed to have hatched. Over the range of spawning biomasses estimated by the base case assessment, the abundance of bigeye recruits appears to be unrelated to the spawning potential of adult females at the time of hatching.

There are two important features in the estimated time series of bigeye recruitment. First, greater-than average recruitments occurred in 1977, 1979, 1982-1983, 1992, 1994, 1995-1997, and during the second quarters of 2001 and 2002. The lower confidence bounds of these estimates were greater than the estimate of virgin recruitment only for 1994, 1997, and the recruitment in 2001 and 2002. Second, aside from these two recruitment pulses in 2001 and 2002, recruitment has been much less than average from the second quarter of 1998 to the end of 2003, and the upper confidence bounds of many of these recruitment estimates are below the virgin recruitment. Evidence for these low recruitments comes from the decreased CPUEs achieved by some of the floating-object fisheries, discard records collected by observers, length-frequency data, and poor environmental conditions for recruitment. The extended sequence of low recruitments is important because, in concert with high levels of fishing mortality, they are likely to produce a sequence of years in which the spawning biomass ratio (the ratio of spawning biomass to that for the unfished stock; SBR) will be considerably below the level that would support the average maximum sustainable yield (AMSY).

The biomass of 1+-year-old bigeye increased during 1980-1984, and reached its peak level of about 586,000 t in 1986. After reaching this peak, the biomass of 1+-year-olds decreased to an historic low of about 156,000 t at the start of 2004. Spawning biomass has generally followed a trend similar to that for the biomass of 1+-year-olds, but lagged by 1-2 years. There is uncertainty in the estimated biomasses of both 1+-year-old bigeye and spawners. Nevertheless, it is apparent that fishing has reduced the total biomass of bigeye present in the EPO. Both are predicted to be at their lowest levels by the end of 2004. There has been an accelerated decline in biomass since the small peak in 2000. Analysis of the impacts attributed to each fishery indicates that the initial decline can be attributed to longline fishing but the most recent declines are mainly attributed to purse-seine fishing. The estimates of recruitment and biomass were not sensitive to the range of alternative parameterizations of the assessment model considered or to the alternative data source included in the assessment. However, in the current assessment, a narrower range of alternative analyses were considered.

At the beginning of January 2004, the spawning biomass of bigeye tuna in the EPO was declining from a recent high level. At that time the SBR was about 0.14, about 32% less than the level that would be expected to produce the AMSY, with lower and upper confidence limits (± 2 standard deviations) of about 0.07 and 0.21. The estimate of the upper confidence bound is only slightly greater than the estimate of Spawning Biomass Ratio-Average Maximum Sustainable Yield (SBRAMSY, 0.20), suggesting that, at the start of January 2004, the spawning biomass of bigeye in the EPO was less than the level that is required to produce the AMSY. The dramatic change from being above the SBRAMSY level to below it has been predicted by the past three assessments. Estimates of the average SBR projected to occur during 2004-2014 indicate that the SBR is likely to reach an historic low level in 2007-2008, and remain below the level required to produce the AMSY for many years unless fishing mortality is greatly reduced or recruitment is greater than average levels for a number of years. This decline is likely to occur because of the recent weak cohorts and the high estimated levels of fishing mortality.

The average weight of fish in the catch of all fisheries combined has been below the critical weight (about 49.8 kg) since 1993, suggesting that the recent age-specific pattern of fishing mortality is not satisfactory from a yield-per-recruit perspective. The average weight of purse-seine-caught fish is currently about 10 kg, while the average weight of longline fish is about 60 kg. Recent catches are estimated to have been about 26% above the AMSY level. If fishing mortality is proportional to fishing effort, and the current patterns of age-specific selectivity are maintained, the level of fishing effort that is estimated to produce AMSY is about 62% of the current level of effort. Decreasing the effort to 62% of its present level would increase the long-term average yield by 8% and would increase the spawning potential of the stock by about 156%.

The AMSY of bigeye in the EPO could be maximized if the age-specific selectivity pattern were similar to that for the longline fishery that operates south of 15°N because it catches individuals close to the critical size. All analyses considered suggest that at the start of 2004 the spawning biomass was below the level that would be present if the stock were producing the AMSY. AMSY and the fishing mortality (F) multiplier are sensitive to how the assessment model is parameterized, the data that are included in the assessment, and the periods assumed to represent average fishing mortality, but under all scenarios considered, fishing mortality is well above the level that will produce the AMSY. Presently the purse-seine fishery on floating objects has the greatest impact on the bigeye tuna stock. Restrictions that apply only to a single fishery (e.g. longline or purse-seine), particularly restrictions on longline fisheries, are predicted to be insufficient to allow the stock to rebuild to levels that will support the AMSY. Large (50%) reductions in effort (on bigeye tuna) from the purse-seine fishery will allow the stock to rebuild towards the AMSY level, but restrictions on both longline and purse-seine fisheries are necessary to rebuild the stock to the AMSY level in ten years. Simulations suggest that the restrictions imposed by the 2003 Resolution on the Conservation of Tuna in the EPO will not be sufficient to rebuild the stock. Projections indicate that, if fishing mortality rates continue at their recent (2002 and 2003) levels, longline catches and SBR will decrease to extremely low levels. As the base case does not include a stock recruitment relationship, recruitment will not decline, so purse-seine catches are predicted to decline only slightly from recent levels under this model.

10.4 Yellowfin Tuna (*Thunnus albacares*)

A detailed account of yellowfin tuna life history, habitat and stock status is presented in the following sections. These descriptive sections provide the background and context within which the management measures discussed in this amendment are based.

Several studies on the taxonomy, biology, population dynamics and exploitation of yellowfin tuna *(Thunnus albacares*) have been carried out. However, directed research and management attention has tended to concentrate on bigeye tuna in recent years, limiting to some extent the amount of recent information available for yellowfin tuna. Cole (1980) and Collette and Nauen (1983) provide general descriptions of the species and fisheries that were updated in fourteen years later by Wild (1994), for eastern Pacific yellowfin tuna and Suzuki (1994) for western and central Pacific yellowfin.

Specific information on the status of yellowfin fisheries and stocks in the Pacific Ocean are contained in the collective research and publications of the IATTC for the Eastern Pacific Ocean (EPO). Information on yellowfin tuna of the Western and Central Pacific Ocean (WCPO) can be found in the proceedings of seventeen years of annual meetings of the Standing Committee on Tuna and Billfish (SCTB) and the Scientific Committee (SC) of the Western and Central Pacific Fisheries Commission (WCPFC). The information contained in this review relies heavily on these sources that represent the most recent information available on the biology, ecology, physiology and fisheries for yellowfin tuna in the Pacific Ocean.

10.4.1 Yellowfin Tuna - Life History and Habitat Selection

Yellowfin tuna have been placed in the subgenera *Neothunnus* with the Atlantic blackfin tuna (*Thunnus atlanticus*) and Indo-Pacific longtail tuna (*T. tonggol*) by Collett (1979, 1999) based on various morphological adaptations to endothermy, e.g. heat exchanger and liver morphology. This separation characterizes yellowfin tuna as "tropical" tuna vs the "cold-water" subgenera *Thunnus* that consists of the bluefins, albacore and to some extent the bigeye tuna. However, yellowfin and bigeye tuna continue to share important morphological characters and bigeye tuna appears to cluster weakly with the tropical tunas based on some genetic evidence (Chow and Kishino 1995; Alvarado Bremer et al. 1996).

While these observations suggest the bigeye is somehow intermediate between the tropical and "cold water" tunas, the yellowfin tuna is clearly a tropical species, occupying the surface waters of all warm oceans. Yellowfin and bigeye tuna share a great deal of latitudinal distribution across the world oceans with yellowfin tending to occupy shallower and warmer depth strata within the upper mixed layer, i.e. the epipelagic zone.

Within the Pacific, yellowfin tuna are widely distributed from around 35°N - 33°S in the EPO and 40°N - 35°S in the WCPO (Blackburn 1965). Basic environmental conditions favorable for survival include clean oceanic waters between 18°C and 31°C within salinity ranges normal for the pelagic environment with dissolved oxygen concentrations greater than 1.4 to 2.0 ml/l; higher than those required by bigeye tuna (Blackburn 1965; Sund et al. 1981). Larval and juvenile yellowfin occupy surface waters with adults increasingly utilizing greater depth strata while remaining within the mixed layer, i.e. generally above the thermocline (Suzuki et al. 1978). However, these habitat preferences are not strict or exclusive as juveniles of both species occupy surface waters, and recent evidence suggests adult yellowfin may spend some time at significant depths below the thermocline.

Feeding is opportunistic at all life stages, with prey items consisting of crustaceans, cephalopods and fish (Reintjes and King 1953; Cole 1980). A large number of age and growth studies have been carried out for yellowfin and for Pacific yellowfin tuna in particular as reviewed by Suzuki (1994). Studies have examined length or weight frequencies, tagging data, scales, otoliths or other hard parts such as dorsal spines. Results have been inconsistent with some suggestion that the examination of hard parts yields superior results to length or weight frequency analyses or tagging data. Growth is considered very rapid, with individuals reaching approximately 55 cm in fork length at age one and over 90 cm at age two. Yellowfin tuna are not considered long-lived in comparison to the bluefin tunas or albacore with tagging data suggesting a maximum age of around 6 - 7 years.

Spawning occurs over broad areas of the Pacific, occurring throughout the year in tropical waters and seasonally at higher latitudes at water temperatures above 24°C (Suzuki 1994; Schaefer 1998; Itano 2000). Yellowfin are serial spawners, capable of repeated spawning at near daily intervals with batch fecundities of millions of ova per spawning event (June 1953; Nikaido 1988; McPherson 1991; Schaefer 1996, Itano 2000). It is believed maturity is reached very quickly at around two years of age with some regional variability.

Yellowfin tuna appear to move freely within broad regions of favorable water temperature and are known to make annual excursions to higher latitudes as water temperatures increase with season. However, the extent to which these are directed movements is unknown and the nature or existence of yellowfin "migration" in the central and western Pacific remains unclear (Suzuki 1994). Yellowfin are clearly capable of large-scale movements which have been documented by tag and recapture programs, but many tag recaptures occur within a relatively short distance of release.

Yellowfin tuna are known to aggregate to drifting flotsam, large marine animals and in regions of elevated productivity, such as near seamounts and regions of localzed upwelling (Blackburn 1969; Wild 1994; Suzuki, 1994). As for bigeye tuna, aggregation to floating objects is particularly pronounced for juvenile stages. Major surface fisheries for yellowfin exploit these behaviors either by utilizing artificial fish aggregation devices or by targeting productive areas with vulnerable concentrations of tuna (Sharp 1978; Hampton and Bailey 1993).

The combination of these biological and behavioral traits identify yellowfin tuna as a classic "tropical" tuna species with rapid growth and maturity, high fecundity, relatively short life span and inhabiting broad expanses of warm, surface waters. In a simplified way, yellowfin and bigeye tuna may be considered as shallow and deeper-dwelling cousins with similar worldwide (horizontal) distributions but adapted to exploit different, vertically stratified food sources.

Like bigeye, the juvenile phase of yellowfin is not clearly defined in the literature. Technically, the term “juvenile” should refer to all sexually immature fish. This definition is impractical as sexual maturity of yellowfin appears to vary significantly between regions and even within the same area. For the purposes of this management related review, yellowfin size (age) classes were chosen in relation to what is known of their maturity schedules in the WCPO in relation to their size-related vulnerability to different gear types and fisheries.

Defined this way, the “Juvenile/sub-adult” category will refer to bigeye tuna of 20 – 99 cm fork length which closely corresponds to their size at first recruitment to surface fisheries and includes the majority of surface catches, e.g. purse seine, ringnet, pole and line, troll, handline. This category also includes the interesting middle size class of yellowfin that first enter longline fisheries, are also taken by surface fisheries but are generally not sexually mature in the WCPO.

For the purposes of this review paper, the following categories of bigeye life stage will be described:

1) egg/larval//early juvenile;	< 20 cm
2) juvenile and sub-adult	20 – 99 cm
3) adult.	≥100 cm

Yellowfin tuna - egg, larval and early juvenile development

The eggs of yellowfin tuna resemble those of several scombrid species, and can not be differentiated by visual means (Cole 1980). Therefore, the distribution of yellowfin eggs has not been absolutely determined in the Pacific. However, the duration of the fertilized egg phase is very short (approximately 24 hours): therefore egg distributions can be assumed to be roughly coincident with documented yellowfin larval distributions. The eggs are epipelagic, suspended at the surface by a single oil droplet until hatching. The observation of yellowfin spawning and the development of yellowfin egg and early larval stages is now possible at shore based facilities where yellowfin spawning was first observed during late 1996 (IATTC 1997). Egg diameters ranged from 0.90 to 0.95 mm and the duration of the egg stage was approximately 24 hours. The notochord lengths of larvae at hatching ranged from 2.2 to 2.5 mm. The duration of the larval stage has been variable in laboratory reared specimens. Research on yellowfin larvae collected at sea and identified as yellowfin tuna by mitochondrial DNA analysis indicated that wild larvae grew at a rate approximately twice that of laboratory reared larvae and average sizes were 1.5 to 2.5 larger than laboratory reared specimens of a similar age (Wexler 1997).

The larval development from artificially fertilized eggs has been described by Harada et al. (1971), Mori et al. (1971) and Harada et al. (1980). A review of research on the development, internal anatomy and identification yellowfin larvae and early life stages is available in Wild (1994). The early larval stages of yellowfin and bigeye are difficult or impossible to differentiate without allozyme or mitochondrial DNA analyses. The distribution of larval yellowfin in different regions of the Pacific has been described by several authors (Matsumoto, 1958; Strasburg 1960; Sun 1960). Studies on the larval distribution of yellowfin by Yabe et al. 1963, Matsumoto, 1966, Ueyanagi (1969) and Nishikawa et al. (1985) encompass broad areas of the Pacific.

Yellowfin larvae are trans-Pacific in distribution and found throughout the year in tropical waters but are restricted to summer months in sub-tropical regions. For example, peak larval abundance occurs in the Kuroshio Current during May and June and in the East Australian Current during the austral fall and summer (November to December). Yellowfin larvae have been reported close to the main Hawaiian Islands in June and September but were not found in December and April (Beohlert and Mundy 1994).

The basic environment of yellowfin larvae can be characterized by warm, oceanic surface waters with a preference toward the upper range of temperatures utilized by the species, which may be a reflection of preferred spawning habitat. It can be assumed that yellowfin larvae are common at sea surface temperatures above 26° C (Ueyanagi 1969) but may occur in some regions with sea surface temperatures of approximately 24° C and above in consideration of what is known of yellowfin spawning distributions. Harada et al. (1980) found the highest occurrence of normally hatched larvae at water temperatures between 26.4° C to 27.8° C with no normal larvae found in water less than 18.7° C or greater than 31.9° C from laboratory observations. Laboratory trials at the IATTC tuna holding facility in Achotines, Panama found yellowfin eggs appeared to develop and hatch normally at temperatures between 32° - 35°C but resulting yolk-sac larvae appeared malformed when hatched at temperatures ≥34°C (IATTC 2006b).

Yellowfin larvae appear to be restricted to surface waters of the mixed layer well above the thermocline and at depths less than 50 to 60 meters, with no clear consensus on diurnal preference by depth or patterns of vertical migration (Matsumoto 1958; Strasburg 1960; Ueyanagi 1969). Prey species inhabit this zone, consisting of crustacean zooplankton at early stages with some fish larvae at the end of the larval phase. A great deal of work on the diet of larval stage yellowfin tuna has been carried out in recent years by the IATTC at their Panama laboratory (Maugulies et al. 2005).

The distribution of yellowfin larvae has been linked to areas of high productivity and islands, but how essential these areas are to the life history of the species is not known. Grimes and Lang (1991) noted high concentrations of yellowfin larvae in productive waters on the edge of the Mississippi River discharge plume and *Thunnus* larvae (most likely yellowfin due to spawning distributions) have been noted to be relatively abundant near the Hawaiian Islands compared to offshore areas (Miller 1979; Boehlert and Mundy 1994).

Yellowfin tuna - juvenile and sub-adult stages

The distribution of juvenile tuna less than 35 cm fork length has not been well documented but is assumed to be similar to that of larval yellowfin. These small juvenile stage yellowfin occupy warm oceanic surface waters above the thermocline and are found throughout the year in tropical waters. Published accounts on the capture of juvenile tuna have been summarized by Higgins (1967). Juveniles have been reported in the western Pacific between 31°N near the east coast of Japan to 23°S and 23°N near the Hawaiian Islands to 23°S in the central Pacific region. Juvenile yellowfin form mono-specific schools at or near the surface of similar sized fish or may be mixed with other tuna species such as skipjack or juvenile bigeye tuna. Yuen (1963) has suggested that the mixed-species schools are actually separate single-species schools that temporarily aggregate to a common factor such as food. Juvenile fish will aggregate beneath drifting objects or with large, slow moving animals such as whale sharks and manta rays (Hampton and Bailey 1993). This characteristic has been exploited by surface fisheries to aggregate and exploit yellowfin tuna, most of which are juvenile fish, to anchored or drifting artificial fish aggregation devices (FADs). Juvenile yellowfin tuna are also known to aggregate near seamounts and submarine ridge features and areas of elevated productivity (Fonteneau 1991; Itano and Holland 2000).

Juvenile yellowfin feed primarily during the day and are opportunistic feeders on a wide variety of forage organisms, including various species of crustaceans, cephalopods and fish (Reintjes and King 1953; Watanabe 1958). Prey items include epipelagic or mesopelagic members of the oceanic community or pelagic post-larval or pre-juvenile stages of island, reef or benthic associated organisms. Significant differences in the composition of prey species of FAD and non-FAD associated yellowfin have been noted in Hawaii (Brock 1985), American Samoa (Buckley and Miller 1994) and the southern Philippines (Yesaki 1983).

Recent work in Hawaiian waters found that juvenile yellowfin and bigeye tuna in a size range of 40 – 80 cm exploited similar broad groups of prey but significantly different species (Grubbs et al. 2002). Yellowfin were noted to feed almost exclusively on epipelagic crustaceans and fish or mesopelagic speciess that vertically migrate into the shallow mixed layer at night. Bigeye tuna of the same size and in the same aggregations fed primarily on a deeper dwelling complex of mesopelagic crustaceans, cephalopods and fish. Preliminary results suggest that yellowfin gain no trophic advantage in association with anchored FADs, but apparently are able to exploit epipelagic prey organisms that are advected past the FAD by currents or exist in the surrounding waters. The most dominant prey items for yellowfin were sergestid shrimp, brachyuran crab megalopae, cephalopods and vertically migrating oplophorid shrimp species. The same patterns were noted for fish prey with juvenile bigeye feeding primarily on mesopelagic fish groups while epilelagic fish were more common in yellowfin, i.e. flyingfish and surgeonfishes.

Yellowfin tuna - adult stage

The habitat of adult yellowfin can be characterized as warm oceanic waters of low turbidity with a chemical and saline composition typical of tropical and sub-tropical oceanic environments. Within the Pacific, Blackburn (1965) noted that yellowfin tuna are widely distributed from around 35°N - 33°S in the EPO and 40°N - 35°S in the WCPO. Suzuki et al. (1978) suggested the adult distribution of yellowfin in the Pacific is even broader, lying roughly within latitudes 40°N to 40°S as indicated by catch records of the Japanese purse seine and longline fisheries. Adult yellowfin are clearly trans-Pacific in distribution and range to higher latitudes compared to juvenile fish. Sea surface temperatures play a primary role in the horizontal and vertical distribution of yellowfin, particularly at higher latitudes. Blackburn (1965) suggested the range of yellowfin distribution was bounded water temperatures between 18°C and 31°C with commercial concentrations occurring between 20°C and 30°C. Salinity does not appear to play as important a role in yellowfin tuna distribution in comparison to water temperature and clarity.

Adult yellowfin tuna opportunistic feeders, relying primarily on crustaceans, cephalopods and fish as has been described for juvenile fish. However, the larger size of adult fish allows the exploitation of larger prey items, with large squid and fish species becoming more important diet items. For example, Yesaki (1983) noted a high degree of cannibalism of large FAD associated yellowfin on juvenile tunas in the southern Philippines. The baiting of longlines with saury, mackerel and large squid also implies that mature fish will take large prey items if available.

Yellowfin tuna are also known to aggregate to large near surface concentrations of forage, such as the spawning aggregations of lanternfish (*Diaphus sp*.) that occur seasonally in the Australian Coral Sea (Hisada 1973; McPherson 1991b).

Juvenile and adult yellowfin tuna aggregate to drifting flotsam, anchored buoys and large marine animals, while adult yellowfin are known to associate with herds of porpoise (Hampton and Bailey 1993). Adult yellowfin also aggregate in regions of elevated productivity and high zooplankton density, such as near seamounts and regions of upwelling and convergence of surface waters of different densities, presumably to capitalize on the elevated forage available (Blackburn 1969; Cole 1980; Wild 1994; Suzuki 1994).

The use of sonic and archival tagging technologies have greatly expanded our knowledge of tuna behavior and habitat selection. Electronic evidence supports the belief that yellowfin tuna spend most of their time in the mixed layer above 100 m depth, above or just below the thermocline. A more thorough description of yellowfin tuna vertical distribution is given later in this document.

Yellowfin tuna - age and growth

Age and growth of yellowfin larvae has been investigated under a variety of laboratory conditions and from field collections. Observations from both laboratory-raised and wild specimens indicate highly variable growth rates, with wild fish consistently exhibiting higher growth rates compared to laboratory reared specimens (IATTC, 1997). It was suggested the differences in growth rates and size at age were due to less than optimal growth conditions in the laboratory environment. Two critical periods of larval mortality have been identified at 4 - 5 days and another at about 11 days after hatching which corresponds to the time period when the diet of yellowfin larvae is proposed to shift from crustaceans to fish larvae (FSFRL 1973).

Suzuki (1994) and Stequert et al. (1996) provide summaries of studies on the age and growth of yellowfin tuna using length or weight frequencies, tagging data, scales, otoliths or other hard parts such as dorsal spines. Results have been inconsistent with some suggestion that the examination of hard parts yields superior results to length or weight frequency analyses or tagging data. Growth curves developed from length and weigh frequency analyses can be negatively influenced by a suite of factors, such as uncertainties in time of recruitment, mortality and size dependent gear selectivity of the datasets.

The deposition of daily growth increments on the saggital otoliths of yellowfin tuna have been validated in the eastern Pacific and the WCPO through oxytetracycline (OTC) marking and recapture experiments (Wild and Foreman 1980; Lehodey and Leroy 1999). In independent studies enumerating daily growth increments on saggital otoliths, Yamanaka (1990), Uchiyama and Struhsaker (1981) and Wild (1986) estimated age 1 yellowfin to be 57, 53 and 49 cm respectively from Philippine, Hawaii and eastern Pacific yellowfin. Length vs age estimates become more wide-ranging with age, with most estimates suggesting year 2 and year 3 yellowfin to be approximately 90 – 100 cm and 120 – 130 cm respectively.

In a more recent study, Lehodey and Leroy (1999) examined WCPO yellowfin age and growth using daily microincrement counts from otoliths and data from large-scale tagging experiments. Their findings support a "two-stanza" growth model for WCPO yellowfin with a period of slower juvenile growth between ages 0.5 to 1 year followed by more rapid growth that gradually slows with age. These findings that are counter to the von Bertalanffy growth model were supported by independent estimates of growth derived from fishing statistics, length frequency and tagging data. The authors therefore propose the use of a classic von Bertalanffy model with growth parameter modified to describe the observed two phase growth pattern. The resulting difference predicts larger sizes in general for yellowfin tuna between ages 1 and 3 when compared to other studies.

Longevity for the species has not been defined but a maximum age of 6 to 7 years appears likely based on growth estimates and tag recapture data. Maximum size exceeds 200 cm. The current International Game Fish Association all tackle record was caught in the eastern Pacific in 1977 for a yellowfin tuna of 176.4 kg that measured 208 cm (Collette and Nauen 1983).

Yellowfin tuna – reproduction

Sex ratios

Sex ratios of yellowfin tuna in the WCPO are believed to be close to 1:1 until about 120 cm FL after which males become dominant (Suzuki 1994). Orange (1961) reported sex ratios of suface caught yellowfin in the EPO to be close to 1:1 up to around 130 cm after which the ratio of males was reported to increase rapidly. This is a common observation among tuna populations, such as for bigeye (Kume and Joseph 1966; Sun et al. 2004), albacore (Otsu and Sumida 1968) and skipjack (Brock 1954). Elevated natural mortality of females at mature sizes possibly due to the higher energetic costs of spawning compared to males (Schaefer 1996) or possibly aggressive spawning behavior of males (Schaefer 1998) is believed to be responsible for the skewed sex ratios of larger yellowfin rather than differential growth. Yellowfin tuna larger than about 150 cm are predominantly males.

Length at maturity

Estimates of length at maturity for central and western Pacific yellowfin vary widely. The variation in maturity estimates is most likely due to a mixing of estimates and/or observations of "size at first spawning"; "size of fish observed in running ripe condition" or some estimate or guess of "size at sexual maturity for the stock" as determined by a variety of methods using vastly different temporal and spatial sampling protocols. However, variation in maturity estimates for yellowfin using similar methodology may be real differences caused by spatial differences in productivity, growth and maturation. For example, some studies support an advanced maturity schedule for yellowfin in more productive coastal or archipelagic waters (Cole 1980). Maturity of yellowfin tuna is most accurately indicated by the presence of hydrated oocytes in the ovarian lumen or microscopically observed post-ovulatory follicles of recent age or for the male, by a variety of visual and histological observations of the testis and testicular tissue (Schaefer 1998).

Most estimates suggest that the majority of yellowfin reach maturity between 2 and 3 years of age on the basis of length-age estimates for the species (Ueyanagi 1966). Observations of length at first maturity (first spawning) for female yellowfin range widely from 56.7 cm in the Philippines (Buñag 1956) to 112.0 cm for western Pacific yellowfin (Sun and Yang 1983). However, most of these studies were based on macroscopic staging techniques that are far less accurate compared to histological methods for determining reproductive parameters in serial spawning fishes. Histological studies are required to accurately define maturity, spawning frequency and periodicity and to provide meaningful estimates of length at 50% maturity (length at which 50% of the population is considered reproductively mature) which is a more meaningful parameter compared to benchmarks such as length at first spawning.

Histological studies that examine carefully prepared yellowfin ovarian tissue are uncommon and only a few have been completed in the WCPO (McPherson 1991; Itano 2000; Sun et al. 2005). McPherson (1991) estimated the length at 50% maturity for female yellowfin in the Australian Coral Sea at 107.9 cm in the inshore handline fishery and 120.0 cm for fish taken by the offshore longline fishery. These results were similar to Kikawa (1962) who noted from the tropical WCPO that a few longline caught yellowfin were reproductive at 80 - 110 cm and estimated a length at 50% maturity between 110 and 120 cm from GI analysis.

Itano (2000) estimated length at 50% maturity of female yellowfin sampled from the tropical WCPO (10°N - 10°S) from purse seine, longline and handline fisheries at 104.6 cm (n=7565) with a lower estimate from Philippine/Indonesian handline samples (98.2 cm) compared to high seas purse seine and longline sampling (107.9 cm). Sun et al. (2005) using histological methods obtained similar results when examining longline caught yellowfin collected in northern Philippine/Taiwanese waters, estimating length at 50% maturity to be 107.8 cm. Sun et al. (2005) suggested the higher estimate from his study compared to samples collected in the southern Philippines by Itano (2000) may be due to lower productivity and protracted maturity schedules at higher latitudes. For example, the highest length at maturity estimate in the study by Itano (2000) was 112.5 cm for yellowfin from the Hawaii region, the northern-most area examined. Schaefer (1998) using the same methodology estimated the length at 50% maturity for yellowfin in the Eastern Pacific Ocean at 92.1 cm, considerably lower than WCPO estimates. This significantly lower estimate may reflect the higher productivity of the EPO resulting in shortened maturity schedules.

Spawning time, frequency and fecundity

Yellowfin tuna spawn in sea surface temperatures above 24 - 25°C in pelagic environments across the Pacific with some evidence suggesting some preference for leeward coasts of oceanic islands and archipelagos. Spawning of yellowfin takes place at night, peaking between 2200 – 0300 and is believed to take place close to the surface although wild spawning has not been witnessed (Schaefer 1998; Itano 2000). A great deal of what we know of the spawning behavior and early life history of yellowfin tuna comes from the live tuna holding facilities of the IATTC in Achotines, Panama.

Yellowfin tuna are serial spawners, releasing millions of eggs during each spawning event and capable of repeated spawning at daily or near daily intervals during extended spawning. The spawning frequency estimates for yellowfin are based on the fraction of actively spawning females (as evidenced by the presence of post-ovulatory follicles in the ovary) in relation to (A) the total number of reproductively active females in the sample, or (B) the total number of females that were histologically classified as sexually mature which includes mature but reproductively inactive fish. Tuna in category (A) have fully yolked oocytes (eggs) in their ovaries. Tuna in category (B) are often large tuna that had spawned in the past but have reabsorbed yolked oocytes and are no longer in spawning condition.

Schaefer (1998) sampled purse seine catches in the EPO and found reproductively active females (category A) to be spawning at an average frequency of 1.52 days while reproductively active female yellowfin had an average spawning frequency of 1.19 days. Itano (2000) found very similar values in equatorial WCPO yellowfin, with spawning frequencies of purse seine caught yellowfin in categories A and B of 1.71 and 1.18 days respectively. For samples combined from purse seine, longline and handline fisheries, spawning frequency estimates were 1.99 d and 1.19 days. Yellowfin sampled from deep-set longline gear were the least reproductively active. Sun (1995) for longline caught fish estimated a spawning frequency of female yellowfin of 1.97 days. These figures are mean values and do not imply that they actually spawn at these exact rates but do so over the year, i.e. an estimate of 1.5 d would mean on average the fish spawned 21 days a month. Therefore, it is estimated that reproductively active yellowfin spawn at near daily intervals. These estimates have been verified by observations of captive yellowfin held in land-based facilities (IATTC 1997).

An examination of spawning frequencies in an area with a definite seasonal spawning period is illustrative. Mature yellowfin in Hawaii were sampled during the spawning season (April – September) and the non-spawning season (October – March) and analyzed for spawning frequency and fecundity (Itano 2002). During the Hawaii spawning season, the spawning rates were very high from all surface fisheries, ranging from 1.02 d to 1.07 d indicating a near-daily spawning pattern. Yellowfin taken by deep-set longline gear during this time indicated a lower average spawning frequency resulting from a higher percentage of mature, non spawning fish. Spawning activity ceased completely in the fall season, resuming in early spring.

Yellowfin tuna are highly fecund, releasing hundreds of thousands to some millions of eggs during each spawning event. Batch fecundity increases significantly with weight but can be highly variable between fish of similar sizes (Schaefer 1998). In the EPO, Schaefer (1998) from a very large sample (n=345) estimated batch fecundities ranging from 0.163 – 8.026 million with an average batch fecundity across all samples of 2.502 million ova and a mean relative fecundity of 67.3 oocytes per gram of body weight. Itano (2000) estimated batch fecundity of WCPO yellowfin ranging in size from 87 – 149 cm at 0.550 – 4.061 million ova (mean 2.160 M) with a mean relative fecundity of 54.7 oocytes per gram of body weight. Sun et al. (2005) estimated a mean batch fecundity of 2.71 million ova (range 0.97 – 4.69 million).

Spawning areas and seasons

Yellowfin spawning occurs throughout the year in tropical waters at least within 10 degrees of the equator and seasonally at higher latitudes when sea surface temperatures rise above 24° C (Suzuki 1994). Several different areas and seasons of peak spawning for yellowfin have been proposed for the central and western equatorial Pacific. Koido and Suzuki (1989) proposed a peak spawning period for yellowfin in the western tropical Pacific from April to November. Kikawa (1966) reported the peak spawning potential of yellowfin in the western tropical Pacific (120°E - 180°) to occur in December - January and in April to May east of the date line (180°-140°W). Sun et al. (2005), using GSI analyses, oocyte diameters and histological evidence found that yellowfin spawn all year in the northern Philippines/southern Taiwanese waters with a peak season from February to June.

Yellowfin spawning along the equator takes place throughout the year but apparently not at a uniform rate nor does it appear to follow a seasonally repeated pattern in the sense of temperate seasons, i.e. summer, fall, etc. However, a positive relationship between reproductive condition, spawning activity and areas of high forage abundance along the equator has been noted (Itano 2000). In a related fashion, it has been noted that fish taken by purse seine and surface gear are more reproductively active with a higher spawning frequency than longline caught fish in the same areas. Areas with marked monsoonal weather patterns may prove an exception to the lack of seasonality to equatorial spawning. Yamanaka (1990) and Itano (2000) suggest that the monsoon season experienced by the Philippines and Indonesia may significantly affect spawning, growth and recruitment of yellowfin in these regions.

Hawaii and eastern Australia are a good examples of higher latitude, seasonal spawning situations for yellowfin tuna. Yellowfin spawn in Hawaiian waters during the spring to fall period. June (1953) noted well developed ovaries in yellowfin caught by longline gear close the main Hawaiian Islands from mid-May to the end of October. Spawning in Hawaiian waters has been histologically confirmed from April to October, peaking in the June – August season when daily or near-daily spawning rates occur, and ceases completely between the November to April period. Spawning was noted to cease very soon after water temperatures first began to drop from the seasonal high that occurs in September or October of every year. It is noteworthy that spawning ceased during all three years of sampling at SSTs well above the minimum temperatures required for yellowfin spawning (24°-25°C) suggesting that a sudden drop in SST triggers a physiological shutdown of spawning and not absolute water temperatures.

Yellowfin tuna - importance to fisheries – juvenile and adult yellowfin

The total catch of yellowfin tuna has increased steadily since 1980 in the Pacific Ocean, driven for the most part by increases in purse seine landings (Williams and Reid 2005). Pole and line catches have remained relatively stable during this time period in the WCPO while declining significantly in the EPO in recent years. Longline catches in both areas has been generally stable while there have been significant increases in yellowfin landings in the WCPO Mixed gear types that primarily consist of unclassified gear types of Indonesia and Philippine handline catches (WCPFC 2005).

Juvenile yellowfin tuna form a major component of surface landings in the WCPO and form an economically and socially important component of domestic, artisanal and subsistence fisheries in the Pacific, particularly in small island and coastal states. In particular, small scale troll and surface handline fisheries generally take juvenile yellowfin less than 100 cm. Juvenile yellowfin are also regularly taken as an incidental byproduct in skipjack pole and line fisheries, especially when floating objects or FADs are utilized. Juvenile yellowfin tuna of very small sizes are taken in the Philippine ringnet, gillnet and small purse seine fisheries or by a mixture of hook and line gears. These fisheries are based on anchored FADs, taking advantage of the strong tendency of juvenile tuna to aggregate to floating objects. The same can be said for the capture of juvenile yellowfin by the pole-and-line, small purse seine and mixed hook and line fisheries of Indonesia.

Large, mature-sized yellowfin tuna are caught by higher value sub-surface fisheries, primarily longline fleets landing sashimi grade product. Adult yellowfin tuna aggregate to drifting flotsam and anchored buoys, though to a lesser degree than juvenile fish. Large yellowfin also aggregate over deep seamount and ridge features where they are targeted by some longline and handline fisheries.

A general perception suggests that adult yellowfin are taken by longline gear and in unassociated purse seine sets while juvenile yellowfin are taken during purse seine sets on floating objects, i.e. logs, and anchored or drifting FADs. In reality, considerable overlap exists in longline and purse seine fisheries. It appears that juvenile yellowfin tuna recruit to and are potentially vulnerable to longline gear from around 55 cm and may be retained or discarded depending on the market characteristics of the fishery. Purse seine sets on floating objects definitely harvest mainly juvenile sized yellowfin but a small proportion of mature yellowfin are also taken. Examples of fishing gears or methods that really concentrate on mature sized yellowfin include dolphin-associated purse seine fishing in the EPO and deep handline fisheries of the Philippines and Indonesia.

10.4.2 Yellowfin Tuna Movement

Yellowfin tuna - horizontal movements

The migration or movement of yellowfin tuna has been inferred from seasonal displacements to higher latitudes with warming SST and returning to lower latitudes during the cooler seasons (Suzuki et al. 1978). Examples of these situations can be seen off Japan with yellowfin in the Kuroshio Current, movements of yellowfin in the East Australian Current, or the seasonal appearance of yellowfin tuna in California and New Zealand coastal waters. However, the extent to which these are migrations or simply habitat extensions with warming water is unknown.

Yellowfin tuna appear to be free to move throughout broad regions of favorable water temperature (18 - 31°C), salinity and dissolved oxygen values; and are capable of large, basin-scale movements as documented by tag recoveries. However, large, basin-scale movements that are typical for bluefin and albacore tuna appear to be very rare for yellowfin, with most tag recaptures occurring within 200 miles of release. Movement parameters for yellowfin tuna may also be influenced by geography or bathymetry, with greater retention around islands, seamounts and banks.

The South Pacific Commission - SPC (currently the Secretariat of the Pacific Community) has conducted two large-scale conventional tagging experiments in the WCPO: the Skipjack Survey and Assessment Programme - SSAP (1977 – 1981) and the Regional Tuna Tagging Programme-SSAP (1989 – 1992). The SSAP concentrated on defining the distribution and stock abundance of skipjack and tuna baitfish resources of the WCPO during a time when pole and line fisheries were the dominant gear type (Kearney 1983). During the SSAP, 9464 yellowfin tuna were also tagged and released with 264 (2.8%) recaptured. Most recaptures occurred within four months and close to the point of release. However, restricted movement noted in this study may have been a consequence of the patchy distribution of fishing effort and the island-associated nature of the pole and line fisheries of the time. For those recaptures that were recorded greater than 200 nmi from their point of release, a west – east movement within the 10°N - 10°S equatorial corridor was most evident (Itano and Williams 1992). The longest displacement recorded was for a yellowfin released in Fiji and recovered in the EPO by a U.S. purse seiner 3800 nm to the east. The longest time at liberty for this dataset was for a 34 cm yellowfin released in Palau and recaptured seven years later, also in the Palau EEZ (Itano and Williams 1992).

The SPC Regional Tuna Tagging Project concentrated on the assessment of yellowfin tuna; releasing 40,075 yellowfin in the WCPO with 4,950 (12.4%) recaptured (Kaltongga 1998). Again, most recaptures were made within a few hundred miles of release. Tagging concentrated within the equatorial regions of the WCPO. Longer-distance yellowfin movements > 1000 nm documented by recaptures were generally in an east – west or west – east direction within 10° of the equator. A few higher latitude movements were recorded from equatorial releases, including: two off Japan, thee off eastern Australia and one northeast of the Hawaiian Islands.

The Hawaii Tuna Tagging Project – HTTP (1998 – 2000) conventionally tagged and released 7,440 yellowfin and 7,957 bigeye tuna throughout the Hawaiian archipelago, primarily to examine within-zone movement and fishery interaction issues (Adam et al., 2003). More than half of the yellowfin releases were caught in association with a shallow seamount or deep-water FADs in the outer Hawaii EEZ. However, 11% of yellowfin releases were made around FADs anchored close to the main Hawaiian Islands (MHI) and 29% of releases were made in the Northwest Hawaiian Islands (NWHI), as far as 28.5°N and 178°W. Yellowfin were recaptured at a rate of 10.8% (807 fish) (Itano and Holland 2000). Most of the fish were recaptured within a short time and distance of release.

An interesting observation relates to the difference between yellowfin tagged within the main Hawaiian Island group (5,264 fish) vs those tagged in the Northwest Hawaiian Islands (2176 fish). Virtually all of the recaptures resulting from yellowfin tagged in the MHI area were caught within the MHI areas. Only one recapture was reported from outside the zone for the only recapture reported from the Eastern Pacific Ocean. However, yellowfin tagged and released in the Northwest Hawaiian Islands recorded long-distance movements in all directions; into the main Hawaiian Islands, south to Johnston Atoll or west to Japan. Ten yellowfin recaptures have been reported west of the Date Line from NWHI releases all the way to the coastal waters of Japan and Okinawa. None of the releases made near the MHI were recaptured at any distance westward (PFRP unpublished data). This behavior suggests and island-associated tendency for yellowfin tuna, particularly in a situation of isolated high islands such as the main Hawaiian

Islands, but further research is needed. Kleiber and Hampton (1994) have modeled tagging data and suggested that the retention and residency rates of skipjack can be positively influenced by the presensce of island archipelagos and anchored FADs.

Sibert and Hampton (2003) applied an advection-diffustion reaction model to the large SPC tagging datasets to examine the notion of migration or movement in tropical tunas. Their findings, based on empirical tag recapture data suggest that skipjack and yellowfin tuna are not "highly migratory" at all and may live out their lifespan within some hundreds of miles. Their estimate of the median lifetime displacement of yellowfin tuna from RTTP data was 337 nm in the presence of large-scale fishing as in the current situation.

Fine scale horizontal movements of yellowfin tuna have also been examined through the use of ultrasonic tracking experiments and the use of ultrasonic receivers mounted at fixed locations. Many of these studies have been designed to examine yellowfin behavior in relation to FADs and natural aggregation points. Holland et al. (1990) showed that juvenile yellowfin tuna in Hawaii oriented to anchored FADs during the daytime, move away at night sometimes orienting to shelf contours, and return to the same or nearby FADs in the morning. The tuna appeared to move directly toward FADs some tens of km away, suggesting they have the ability to navigate to or orient toward the FAD. Similar behaviors have been reported for Hawaiian and Japanese yellowfin using sonic receivers on FADs (Ohta and Kakuma 2005) and a shelf contour (Klimley and Holloway 1999) and for sonic tracking from the Indian Ocean (Cayre 1991). Dagorn et al. (2000) used active sonic tracking of yellowfin tuna in French Polynesia noting tight and lengthy associations with FADs, foraging movements asuggested by simultaneous acoustic monitoring of prey items, movements along shelf contours and apparent directed movements between or toward FADs.

Very few studies have been able to examine the fine scale behavior of adult yellowfin tuna. Brill et al. (1999) used sonic tracking to record horizontal and vertical behavior of five adult yellowfin tuna (148 – 167 cm) near the island of Hawaii. The fish tended to move parallel to the coastline, often very close to shore and were tracked to associations with FADs, drifting objects and the tracking vessel itself. The adult yellowfin moved repeatedly and directly between FADs up to 18 km apart but without the repeated daily pattern noted for juvenile yellowfin tuna by previous authors.

Yellowfin tuna - vertical movements

A relatively large body of literature exists on the sonic tracking of yellowfin tuna in comparison to other tuna species (Block et al. 1997; Brill et al. 1999; Cayré 1991; Holland et al. 1990; Marsac and Cayré 1998). These studies generally support the assumption that yellowfin tuna spend most of their time in the surface mixed layer of the ocean or near the thermocline. Juvenile yellowfin in Hawaii were observed to remain in the mixed layer or just above the thermocline (Holland et al. 1990) while large, adult size yellowfin in the same region were observed by sonic tracking to spend ~60 to 80% of their time in or immediately below the mixed layer and above 100 m (Brill et al. 1999). On the basis of these observations, Brill et al. (1999) proposed that yellowfin depth range was determined by a temperature differential based on the ambient surface temperature rather than any absolute temperature *per se*. In the case of Hawaiian yellowfin, they hypothesized that vertical diving was limited to water temperatures 8°C colder than surface waters due to the impact of cold water on heart function.

However, yellowfin have been observed (via acoustic telemetry) to make deeper dives to very cold water temperatures, generally for brief periods. Carey and Olsen (1982) report a yellowfin tuna diving to 464 m, the deepest diving record for a yellowfin yet published. Block et al. (1997) monitored juvenile and sub-adult yellowfin at the northern extreme of their range off the California coast. One yellowfin was recorded to spike dive to almost 300 m to an ambient sea temperature of 7°C but the dive only lasted one minute. Unpublished reports suggest that yellowfin are capable of much deeper dives for extended periods, but further evidence across many geographic areas is needed. Recent data from archival tags suggest that yellowfin tuna are capable of diving to extreme depths below 1000 m and into temperatures formerly thought to be beyond their range (Dagorn pers. comm.).

Research is being conducted in Hawaii to examine the vertical behavior of yellowfin and bigeye tuna found in association with anchored FADs (Itano et al. 2005). Anchored FADs have been equipped with underwater sonic receivers while tuna, billfish and oceanic sharks have been equipped with sonic transmitters that send presence/absence and depth data to the FAD receivers at a fine temporal scale. This work is ongoing but will document diurnal vertical behavior of these species in the presence of FADs.

10.4.3 Yellowfin Tuna Stock Structure

Yellowfin tuna is an epipelagic species with worldwide distribution and are distributed across the Pacific from around 35°N - 33°S in the EPO and 40°N - 35°S in the WCPO (Blackburn 1965). The species thrives in clean oceanic waters with sea surface temperatures between 18°C and 31°C with dissolved oxygen concentrations greater than 1.4 to 2.0 ml/l. Within these basic limits, there appear to be no physical or physiological barriers that prevent yellowfin tuna from mixing throughout the Pacific basin. However, the question of stock structure of yellowfin in the Pacific continues to confront management and several theories on stock heterogeneity exist.

Wild (1994) and Suzuki (1994) review the body of research on the stock structure of yellowfin tuna in the EPO and WCPO. Several indirect stock identification procedures or methodologies have been employed that include morphometric and meristic variability, length frequency and catch-and-effort analyses, analyses of tagging data and spawning/reproductive studies (Cole 1980). Recently, genetic studies and the analyses of microconstituents in hard parts have attempted to develop more direct methods to discriminate yellowfin subpopulations. Results from indirect and direct methods have not always been complementary and the existence of sub-populations of yellowfin in the Pacific has yet to be proven (Wild 1994).

Tagging data suggests that yellowfin can move throughout the western and central Pacific Ocean, at least within the equatorial latitudes, but generally do not move more than a few hundred miles (Sibert and Hampton 2003). Movement to higher latitudes may be more restricted in nature, but further research and tagging is needed. However, tagging data strongly suggests that movement between the Eastern Pacific Ocean and the WCPO is fairly restricted for the species. Morphometric studies also support the possibility of restricted gene flow between the EPO and

WCPO and even between northern and southern groups of yellowfin within the EPO (Schaefer 1989, 1991). The existence of semi-discrete equatorial populations of yellowfin in the eastern, central and western Pacific have also been supported by length frequency and catch composition data (Kamimura and Honma 1963; Suzuki et al. 1978). Analyses of otolith microchemistry has also suggested some geographic variation between central and western Pacific yellowfin (Gunn and Ward 1994).

Genetic studies for the most part have not been able to demonstrate population structure within the Pacific. Studies based on mitochondrial DNA (mtDNA) showed no evidence for population structure in Pacific yellowfin (Scoles and Graves 1993; Ward et al. 1994) but a larger scale study showed barely significant heterogeneity (Ward et al. 1997). The use of genetic microsatellite analyses may be a more promising technique. Appleyard et al. (2001) examined five microsatellite loci from EPO and WCPO yellowfin and found very limited, but significant differentiation between some areas. However, he concluded that population structure of a species like yellowfin tuna that have the ability to mix genes across wide areas needs to be examined using a mixture of genetic and other data, i.e. tagging, morphology and analyses of otolith microchemistry.

More than 25 years ago, Suzuki (1978) defined a stock as *"... an exploitable subset of the population existing in a particular area and having some uniqueness relative to exploitation*.". On the basis of existing data and fisheries, he proposed three semi-discrete stocks of yellowfin in the Pacific as: 1) western Pacific from about 120°E - 170°W; 2) an eastern Pacific stock roughly within the IATTC – Commission Yellowfin Regulatory Area that roughly follows offshore from the Central and South American coast encompassing the EPO fishery and 3) a central Pacific stock in the middle. For the purpose of stock assessment and management, two stocks are generally recognized; 1) an Eastern Pacific stock and 2) a Western and Central Pacific stock, separated at 150°W longitude.

10.4.4 Yellowfin Tuna Stock Assessment[8]

Western and Central Pacific Ocean

The most recent stock assessment for WCPO yellowfin was presented at the 1st Meeting of the Scientific Committee of the WCPFC (WCPFC-SC1), Noumea, New Caledonia, 8 – 19 August 2005 (Hampton, et al. 2005). The assessment uses the stock assessment model and computer software MULTIFAN-CL (Fournier et al. 1998) as described in the section on bigeye stock structure. Direct text from the study follows:

Six independent analyses (were) conducted to test the impact of using different methods of standardising fishing effort in the main longline fisheries, using estimated or assumed values of

[8] The drafting of this amendment began in 2004 and has meant that several stock assessments have been conducted in the interim. The latest assessment for yellowfin tuna in the WCPO, conducted in 2006 and presented to the second regular session of the WCPFC's Scientific Committee (Hampton et al. 2006b), estimated, in the base case model, that FCURRENT/FMSY was 1.11 (FCURRENT was taken to be the 2001-04 average fishing mortality-at-age). The probability of FCURRENT being greater than FMSY was estimated to be 73%. BCURRENT/ BMSY (where "current" meant the 2001-04 period) in the base case model was estimated to be 1.17, with a 5% probability of being less than 1.

natural mortality-at-age, and examining the effect of applying an incremental increase in effective fishing effort to mimic increased fishing efficiency (Hampton et al. 2005). Direct text from the study follows:

The analyses conducted are:

SHBS-MEST Statistical habitat-based standardised effort for "main" longline fisheries, *M* (assumed constant across age-class) estimated.

SHBS-MFIX Statistical habitat-based standardised effort for "main" longline fisheries, *M*-atage assumed at fixed levels.

GLM-MEST General linear model standardised effort for "main" longline fisheries, *M* (assumed constant across age-class) estimated.

GLM-MFIX General linear model standardised effort for "main" longline fisheries, *M*-at-age assumed at fixed levels.

FPOW-MEST General linear model standardised effort for "main" longline fisheries, *M* (assumed constant across age-class) estimated. Fishing power expansions incorporated into longline (1% per year) and purse seine (4 % per year) effort. No temporal trend in purse-seine catchability.

FPOW-MFIX General linear model standardised effort for "main" longline fisheries, *M*-at-age assumed at fixed levels. Fishing power expansions incorporated into longline (1% per year) and purse seine (4 % per year) effort. No temporal trend in purse seine catchability.

The estimates for *Fcurrent F~MSY* suggested that overfishing of yellowfin in the WCPO was likely to be occurring although the stock was not judged to be in an overfished state for most of the models examined. This assessment was considerably more pessimistic than the 2004 stock assessment. The assessment concluded that maintaining fishing mortality at current levels would likely push the WCPO stock into an overfished state.

The main conclusions directly from the assessment were:

1. For all analyses, there was a strong temporal trend in recruitment. Initial recruitment was relatively high but declined to a lower level during the 1960s and early-1970s. Recruitment subsequently increased during the late-1970s and remained relatively high during the 1980s and 1990s. This is similar to the pattern obtained in previous assessments and is largely attributable to the trends in the principal longline CPUE indices, particularly from regions 3 and 4.

2. For all analyses, the trends in biomass were generally comparable prior to the mid-1980s and were consistent with the underlying trends in recruitment, with biomass declining during the initial period to a low level in the 1960s and early-1970s, before increasing in the mid-1970s. Biomass levels remained relatively stable during the 1980s. For all model options, biomass is

predicted to have declined sharply since 1990, largely due to the decline in the biomass within region 3 but also evident in most other regions.

3. The FPOW analyses are an attempt to account for systematic trends in increasing fishing efficiency over the history of the fishery — trends that are not already captured in the standardisation of longline CPUE data. Undoubtedly, such increases in fishing efficiency have occurred, although it is very difficult to quantify these effects and even a small annual incremental increase, such as applied to the longline fishery, has a very large effect on fishing power when applied over the complete history of the fishery; i.e. the 1% annual increase represents a 67% increase in effective fishing power over the history of the fishery. The model explained this increased efficiency largely through a substantial increase in recruitment during the earlier period of the fishery, and correspondingly higher initial biomass levels. Consequently, compared to the corresponding GLM models, current biomass is substantially lower than initial biomass. However, this resulted in temporal trends in both recruitment and spawning biomass that in turn resulted in low estimated SRR steepness. In fact, the FPOW-MEST model predicts that under equilibrium conditions, spawning biomass is driven to almost nil at current levels of exploitation. Consequently, while the FPOW models may provide a useful comparison of current vs. historical stock size the resulting management quantities based on equilibrium measures may not be realistic.

4. Fishing mortality for adult and juvenile yellowfin tuna is estimated to have increased continuously since the beginning of industrial tuna fishing. A significant component of the increase in juvenile fishing mortality is attributable to the Philippines and Indonesian fisheries, which have the weakest catch, effort and size data. There has been recent progress made in the acquisition of a large amount of historical length frequency data from the Philippines and these data were incorporated in the assessment for the first time. However, there is an ongoing need to improve estimates of recent and historical catch from these fisheries and maintain the current fishery monitoring programme within the Philippines.

5. The ratios $B_t \; B_{t,F=0}$ provide a time-series index of population depletion by the fisheries. Depletion has increased steadily over time, reaching a recent level of 30% of unexploited biomass (a fishery impact of 70%) in 2004. This represents a high level of stock-wide depletion that is close to or exceeds the equivalent equilibrium-based limit reference point (0 $\tilde{B}_{MSY}$ $\tilde{B}$ = 0.37−0.41). Further, depletion is somewhat greater for some individual model regions, notably in the equatorial regions 3 and 4 where recent depletion levels are approximately 0.2 and 0.3, respectively. Other regions are less depleted, with indices of 0.8 or greater for most other regions. If stock-wide over-fishing criteria were applied at the level of our model regions, we would conclude that regions 3 and 4 are over-exploited and the remaining regions are under-exploited.

6. The attribution of depletion to various fisheries or groups of fisheries indicates that the Indonesian fishery has the greatest impact, particularly in its home region (3) and is contributing significantly to the impact in adjacent regions 1, 4 and 5. The purse seine fishery also has high impact in regions 3 and 4 and accounts for a significant component of the impact in region 1. It is notable that the composite longline fishery is responsible for biomass depletion of about 5% in the WCPO during recent years, although higher longline impacts are evident in regions 4 and 5.

7. The reference points that predict the status of the stock under equilibrium conditions are *BF BMSY current* ~ ~ (0.69−1.00) and *SBF SBMSY current* ~ ~ (0.62−1.00), which indicate that the long-term average biomass would approximate or fall substantially below that capable of producing *MSY* at 2001−2003 average fishing mortality. Overall, current biomass exceeds the biomass yielding *MSY* (*Bcurrent B~MSY* > 1.0) due to sustained high recent recruitment. It is also important to note that the definition of *Fcurrent* is derived from a period when exploitation rates were rapidly increasing and choosing a more recent period (for example, 2003 only) would result in a more pessimistic interpretation of the stock status.

8. In conclusion, the estimate of *Fcurrent F~MSY* reveals that overfishing of yellowfin is now likely to be occurring in the WCPO. While the stock is not yet in an overfished state (*Bcurrent B~MSY* > 1), further biomass decline is likely to occur at 2001−2003 levels of fishing mortality.

Table 5 provides estimates of critical reference points based on the 2004 and 2005 WCPO yellowfin stock assessments.

Table 5. Estimates of stock reference points resulting from 2004 and 2005 stock assessments for WCPO yellowfin tuna.

Management Quantity	2005 Assessment	2004 Assessment
Most recent catch	413,201 mt (2004) 2001-2003 range 376,000-443,000 mt	456,947 mt (2003)
Maximum yield under recent recruitment (1994-2003)	312,200 mt	-N/A-
MSY	236,000~313,000 mt	248,000~310,000 mt
$Y_{Fcurrent}$/MSY	0.66~1.0	0.90~1.00
$B_{current}/B_{current, F=0}$	0.33~0.52	0.51~0.67
$F_{current}$/FMSY	Base case: 1.22 Range: 1.0~1.89	Base case: 0.63 Range: 0.63~1.11
$B_{current}$/ BMSY	Base case: 1.32 Range: 0.93~1.55	Base case: 2.46 Range: 1.75~2.46

Eastern Pacific Ocean

The most recent stock assessment for EPO yellowfin tuna was conducted by Hoyle and Maunder (2005), utilizing an age-structured, catch-at-length ananysis (A-SCALA) assuming a single stock of yellowfin tuna in the EPO. The Executive Summary from the study is reproduced here in full.

An age-structured, catch-at-length analysis (A-SCALA) was used to assess yellowfin tuna in the eastern Pacific Ocean (EPO). The methods of analysis are described in IATTC Bulletin, Vol. 22, No. 5, and readers are referred to that report for technical details.

The assessment reported here is based on the assumption that there is a single stock of yellowfin tuna in the EPO. Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the east and west. The purse-seine catches of yellowfin tuna are less in the vicinity of the western boundary of the EPO. The movements of tagged yellowfin tuna are generally over hundreds, rather than thousands, of kilometers, and exchange between the eastern and western Pacific Ocean appears to be limited. This is consistent with the fact that longline catch-per-unit-of-effort (CPUE) trends differ among areas. It is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at a local level, although there is some genetic evidence for local isolation. Movement rates between the EPO and the western Pacific cannot be estimated with currently available tagging data.

The stock assessment requires substantial amounts of information, including data on retained catches, discards, fishing effort, and the size compositions of the catches of the various fisheries. Assumptions have been made about processes such as growth, recruitment, movement, natural mortality, fishing mortality, and stock structure. The assessment for 2005 differs from that of 2004 in the following ways. The catch and length-frequency data for the purse-seine and pole-and-line fisheries have been updated to include new data for 2004 and revised data for 2000-2003. The effort data for these fisheries have been updated to include new data for 2004 and revised data for 1975-2003. The catch data for the Japanese longline fisheries have been updated for 1999-2002, and new data for 2003 have been added. The catch data for the longline fisheries of Chinese Taipei have been updated to include new data for 2002. The catch data for the longline fisheries of the People's Republic of China have been updated to include new data for 2003 and revised data for 2001 and 2002. The longline catch-at-length data for 2001-2002 have been updated, and new data for 2003 have been added. The longline effort data have been standardized by means of a generalized linear model standardization of the CPUE, using data for 1975-2003, rather than the neural network that was used previously. The growth model likelihood has been adjusted to account for sampling at length, rather than assuming random sampling.

Significant levels of fishing mortality have been observed in the yellowfin tuna fishery in the EPO. These levels are highest for middle-aged yellowfin. Both recruitment and exploitation have had substantial impacts on the yellowfin biomass trajectory. Most of the yellowfin catch is taken in schools associated with dolphins, and, accordingly, this method has the greatest impact on the yellowfin tuna population, although it has almost the least impact per unit of weight captured of all fishing methods. It appears that the yellowfin population has experienced two different productivity regimes (1975-1983 and 1984-2004), with greater recruitment during the second regime. The two recruitment regimes correspond to two regimes in biomass, the high-recruitment regime corresponding to greater biomasses. The spawning biomass ratio (the ratio of the current spawning biomass to that for the unfished stock; SBR) of yellowfin in the EPO was below the level corresponding to the average maximum sustainable yields (AMSYs) during the low-recruitment regime, but close to that level during the high-recruitment regime. The two different productivity regimes may support two different levels of AMSY and associated SBRs, and theAMSY reported here is an average for the 1975-2004 period. The current SBR is below the SBR level corresponding to the AMSY. However, there is substantial uncertainty in the most recent estimate of SBR, and there is a moderate probability that the current SBR is above the level corresponding to the AMSY. The effort levels are estimated to be greater than those corresponding to the AMSY (based on the recent (2002-2003) distribution of effort among the different fisheries). Because of the flat yield curve, however, the recent effort levels are estimated to be capable of producing, under average conditions, catch that is only slightly less than the AMSY. Future projections under the current effort levels and average recruitment indicate that the population is likely to remain at approximately the same level over the next 5 years. These simulations were carried out using the average recruitment for the 1975-2004 period. If they had been carried out using the average recruitment for the 1984-2004 period, the projected trend in SBR and catches would have been more positive. Both the purse-seine and longline catches are expected to remain close to 2004 levels.

The AMSY has been stable during the assessment period, which suggests that the overall pattern of selectivity has not varied a great deal through time. However, the overall level of fishing effort has varied with respect to the AMSY multiplier.

The analysis indicates that strong cohorts entered the fishery during 1998-2000, and that these cohorts increased the biomass during 1999-2000. However, these cohorts have now moved through the population, so the biomass decreased during 2002-2004.

The overall average weights of yellowfin tuna that are caught have consistently been much less than those that would maximize the AMSY, indicating that, from the yield-per-recruit standpoint, the yellowfin in the EPO are not harvested at the optimal size. There is substantial variability in the average weights of the yellowfin taken by the different fisheries, however. In general, the floating-object, unassociated, and pole-and-line fisheries capture younger, smaller fish than do the dolphin-associated and longline fisheries.

The longline fisheries and the purse-seine sets in the southern area on yellowfin associated with dolphins capture older, larger yellowfin than do the coastal and northern dolphin-associated fisheries. The AMSY calculations indicate that the yield levels could be increased if the fishing effort were diverted to the fisheries that catch larger yellowfin, and would be diminished if the fishing effort were diverted to catching smaller fish. Any such changes would also affect the SBR levels in a similar way.

The conservation measures imposed in 2004 under IATTC Resolution C-04-09 are predicted to result in slightly greater biomasses and SBRs than would otherwise have been the case. However, it is likely that the stock is below the AMSY level.

A sensitivity analysis was carried out to estimate the effect of a stock-recruitment relationship. The results suggest that the model with a stock-recruitment relationship fits the data slightly better than the base case, but this result could also be explained by the regime shift, since the spawning biomass is relatively low during the period of low recruitment and relatively high during that of high recruitment.

The results from the analysis with a stock-recruitment relationship suggest that the effort level is five times greater than that corresponding to the AMSY; however, the yield at this effort level is still only 6% less than the AMSY. The biomass is estimated to have been less than the biomass that would produce the AMSY for most of the modeling period, except for most of 2000-2002. The assessment results are similar to those from the previous assessments. The major differences occur, as expected, in the most recent years. The current assessment, and those for 2002, 2003, and 2004, indicates that the biomass increased in 2000, whereas the earlier assessments indicated a decline. In addition, SBR and the SBR corresponding to the AMSY have increased compared to the 2004 assessment because of changes in estimates of growth and recent age-specific fishing mortality.

Summary

1. The results are similar to those of the previous five assessments, except that the SBR corresponding to AMSY is greater than in those assessments.

2. The biomass is estimated to have declined very slightly in 2004.

3. There is uncertainty about recent and future recruitment and biomass levels.

4. The estimate of the current SBR is less than that corresponding to the AMSY, but its confidence intervals encompass the AMSY.

5. The recent fishing mortality rates are 20% above those corresponding to the AMSY.

6. Increasing the average weight of the yellowfin caught could substantially increase the AMSY.

7. There have been two different productivity regimes, and the levels of AMSY and the biomasses corresponding to the AMSY may differ between the regimes.

8. The results are more pessimistic if a stock-recruitment relationship is assumed.

10.5 Sea Turtles

All sea turtles are designated under the Endangered Species Act (ESA) as either threatened or endangered. The breeding populations of the Mexico olive ridley turtles (*Lepidochelys olivacea*) are currently listed as endangered. Also listed as endangered are the leatherback turtles (*Dermochelys coriacea*) and hawksbill turtles (*Eretmochelys imbricata*). Green sea turtles (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*) are listed as threatened, but are afforded the same protection as endangered sea turtles. 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.

The populations of several species of sea turtles have declined in the Pacific as the result of nesting habitat loss and excessive and widespread harvesting for commercial and subsistence purposes (Eckert 1993). There are only two populations of loggerhead turtles in the Pacific, one originating in Australia where serious declines are occurring, and the other in southern Japan (Eckert 1993). Leatherback turtles inhabiting the Pacific mainly originate from nesting beaches in Mexico and Costa Rica where significant declines have been documented; from Indonesia where their status is uncertain but possibly stable; and from Malaysia where the nesting colony appears nearly extinct (Eckert 1993).

The diet of the leatherback turtle generally consists of cnidarians (i.e., medusae and siphonophores) in the pelagic environment. Leatherback turtles have the most extensive range of any living reptile and have been reported circumglobally from latitudes 71° N. to 42° S. in the Pacific and in all other major oceans. In a single year a leatherback may swim more than 10,000 km. They lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to beaches to lay eggs. Typically leatherback turtles are found in convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters.

The loggerhead turtle is listed as a threatened species throughout its range, primarily due to incidental mortality associated with commercial fishing operations and the alteration and destruction of its habitat. It is a cosmopolitan species found in temperate and subtropical waters and inhabiting continental shelves, bays, estuaries and lagoons. Major nesting grounds are generally located in warm temperate and subtropical regions, generally north of 25° N. or south of 25° S. latitude in the Pacific Ocean. For their first several years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. As they age, 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). Satellite telemetry studies show that loggerhead turtles tend to follow 17° and 20° C sea surface isotherms north of the Hawaiian islands.

The olive ridley turtle is listed as threatened in the Pacific, except for the Mexican nesting population, which is listed as endangered, primarily because of over-harvesting of females and eggs. The olive ridley is one of the smallest living sea turtles (carapace length usually between 60 and 70 cm) and is regarded as the most abundant sea turtle in the world. Since the directed take of sea turtles was stopped in the early 1990s, the nesting populations in Mexico appear to be recovering, with females nesting in record numbers in recent years. In 1996, the primary nesting beach at La Escobilla in Oaxaca sustained over 800,000 nests. There is some discussion in Mexico that the species should be considered recovered. The olive ridley turtle is omnivorous and identified prey include a variety of benthic and pelagic items such as shrimp, jellyfish, crabs, snails, and fish, as well as algae and sea grass (Marquez 1990).

Green turtles in Hawaii are genetically distinct and geographically isolated which is uncharacteristic of other regional sea turtle populations. Both the nesting population and foraging populations of green turtles in Hawaii appear to have increased over the last 30 years. Balazs and Chaloupka (2004) document a substantial long-term increase in abundance of the once seriously depleted green sea turtle stock in Hawaii. This population increase has occurred in a far shorter period of time than previously thought possible. Green turtles are found throughout the Pacific Ocean, including the Eastern Pacific Ocean, where they are dark green to black in color and are known colloquially as 'black turtles'. Although EPO green turtles are listed as endangered, green turtle populations in other parts of the world have shown similar recovery trends to the Hawaiian population (Chaloupka et al. in press). In all cases population recovery has been due to limiting harvests of adults and eggs, however, there may be some population benefits if longline effort was reduced leading to a decrease in fishery interactions.

The hawksbill turtle is listed as endangered throughout its range. In the Pacific, this species is apparently declining 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. Hawksbill turtles have a relatively unique diet of sponges.

10.6 Marine Mammals

Based on research, observer, and logbook data, the following marine mammals occur in the region and may be affected by the fisheries managed under the Pelagics FMP:

Marine mammals listed as threatened or endangered:

Humpback whale (*Megaptera novaeangliae*)
Sperm whale (*Physeter macrocephalus*)
Hawaiian monk seal (*Monachus schauinslandi*)
Blue whale (*Balaenoptera musculus*)
Fin whale (*Balaenoptera physalus*)
Northern right whale (*Eubalaena glacialis*)
Sei whale (*Balaenoptera borealis*)

Other marine mammals:

Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
Rough-toothed dolphin (*Steno bredanensis*)
Risso’s dolphin (*Grampus griseus*)
Bottlenose dolphin (*Tursiops truncatus*)
Pantropical spotted dolphin (*Stenella attenuata*)
Spinner dolphin (*Stenella longirostris*)
Striped dolphin (*Stenella coeruleoalba*)
Melon-headed whale (*Peponocephala electra*)
Pygmy killer whale (*Feresa attenuata*)
False killer whale (*Pseudorca crassidens*)
Killer whale (*Orcinus orca*)
Pilot whale, short-finned (*Globicephala melas*)
Blainville’s beaked whale (*Mesoplodon densirostris*)
Cuvier’s beached whale (*Ziphius cavirostris*)
Pygmy sperm whale (*Kogia breviceps*)
Dwarf sperm whale (*Kogia simus*)
Bryde’s whale (*Balaenoptera edeni*)

Although blue whales, fin whales, northern right whales, and sei whales are found within the area and could potentially interact with the Pelagics FMP fisheries, there have been no reported or observed incidental takes of these species in these fisheries. Therefore, these species are not discussed in this document.

Humpback whales
The International Whaling Commission first protected humpback whales in the North Pacific in 1965. Humpback whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and the Marine Mammal Protection Act (MMPA). Critical habitat has not been designated for this species.

Humpback whales typically migrate between tropical/sub-tropical and temperate/polar latitudes. Humpback whales feed on krill and small schooling fish on their summer grounds. The whales occupy tropical areas during winter months when they are breeding and calving, and polar areas during the spring, summer, and fall, when they are feeding, primarily on small schooling fish and krill (Caldwell and Caldwell 1983).

Humpback whales occur off all eight Hawaiian Islands during the winter breeding season, but particularly within the shallow waters of the "four-island" region (Kaho'olawe, Molokai, Lanai, Maui), the northwestern coast of the island of Hawaii (Big Island), and the waters around Niihau, Kauai and Oahu (Wolman and Jurasz,1977; Herman et al. 1980; Baker and Herman 1981).

Estimates of the number of individuals in the Northern Pacific stock have recently risen. Estimates in the 1980s ranged from 1,407 to 2,100 (Baker 1985; Darling and Morowitz 1986; Baker and Herman 1981), while recent estimates of abundances were approximately 6,000 (Calambokidis et al. 1997; Mobley et al. 1999).

Studies based on resighting individuals through photographs resulted in an estimate of 6,010 animals (S.E. = 474) for the entire North Pacific (Calambokidis et al. 1997). The central North Pacific stock of humpback whales winters in the waters of the main Hawaiian Islands and feeds on the summer grounds of Southeast Alaska and Prince William Sound. A population estimate of 1,407 whales was derived using capture-recapture methodology (95% CI 1,113 - 1,701) for data collected in 1980-83 (Baker and Herman 1987).

Cerchio (1998) estimated that about 4,000 animals visit Hawaii annually. Aerial surveys conducted between 1976 and 1990 found a significant increase in sighting rates of humpbacks over that time (Mobley et al. 1999), consistent with the increase in photographic estimates. Finally, aerial surveys using line-transect methodologies were conducted in 1993, 1995 and 1998. Hawaii population estimates for nearshore waters derived from the sighting data show an increase from 2,717 (+/- 608) in 1993, to 3,284 (+/- 646) in 1995 and 3,852 (+/- 777) in 1998 (Mobley et al. 1999).

Sperm whales
Sperm whales have been protected from commercial harvest by the IWC since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and

Whitehead 1997). Sperm whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for sperm whales.

Sperm whales are distributed in all of the world's oceans. Several authors have recommended three or more stocks of sperm whales in the North Pacific for management purposes (Kasuya 1991; Bannister and Mitchell 1980). However, the IWC's Scientific Committee designated two sperm whale stocks in the North Pacific: a western and an eastern stock (Donovan 1991). The line separating these stocks has been debated since their acceptance by the IWC's Scientific Committee. For stock assessment purposes, NMFS recognizes three discrete population "centers" of sperm whales: (1) Alaska, (2) California/Oregon/Washington, and (3) Hawaii.

A 1997 survey to investigate sperm whale stock structure and abundance in the eastern temperate North Pacific area did not detect a seasonal distribution pattern between the U. S. EEZ waters off California and areas farther west, out to Hawaii (Forney et al. 2000). A 1997 survey, which combined visual and acoustic line-transect methods, resulted in estimates of 24,000 (CV=0.46) sperm whales based on visual sightings, and 39,200 sperm whales (CV=0.60) based on acoustic detections and visual group size estimates (Forney et al. 2000). An analysis for the eastern tropical Pacific estimates abundance at 22,700 sperm whales (95% C. I. = 14,800-34,000; Forney et al. 2000).

Sperm whales have been sighted in the Kauai Channel, the Alenuihaha Channel between Maui and the island of Hawaii, and off the island of Hawaii (Mobley et al.1999; Forney et al. 2000). Additionally, the sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Twenty-one sperm whales were sighted during aerial surveys conducted in nearshore Hawaiian waters conducted from 1993 through 1998. Sperm whales sighted during the survey tended to be on the outer edge of a 50 - 70 km distance from the Hawaiian Islands, indicating that presence may increase with distance from shore (Mobley, pers. comm.2000). However, from the results of these surveys, NMFS has calculated a minimum abundance of sperm whales within 46 km of Hawaii to be 43 individuals (Forney et al. 2000).

Hawaiian monk seals

The Hawaiian monk seal was listed as endangered under the ESA in 1976. The species is endemic to the Hawaiian Archipelago and Johnston Atoll, and is one of the most endangered marine mammals in the United States. It is also the only endangered marine mammal that exists wholly within the jurisdiction of the United States.

Monks seals are one of the most primitive genera of seals. They are nonmigratory, but recent studies show that their home ranges may be extensive (Abernathy and Sniff 1998). Counts of individuals or shore compared with enumerated subpopulations at some of the NWHI indicate that monk seals spend about one-third of their time on land and about two thirds in the water. (Forney et al. 2000)

Before human habitation of the Hawaiian Archipelago, the monk seal population may have measured in the tens of thousands as opposed to the hundreds of thousands or millions typical of some pinniped species. When population measurements were first taken in the 1950s, the population was already considered to be in a state of decline. In 1998, minimum population estimate for monk seals was 1,436 individuals (based on enumeration of individuals of all age classes at each of the subpopulations in the NWHI, derived estimates based on beach counts for Nihoa and Necker, and estimates for the MHI) (Forney et al. 2001). Taking into account the first year survival rates, NMFS Southwest Fisheries Science Center - Honolulu Laboratory estimated the species population size to be between 1,300 and 1,400 individuals (Laurs 2000). Monk seals are found at six main reproductive sites in the NWHI: Kure Atoll, Midway Island, Pearl and Hermes Reef, Lisianski Island, Laysan Island and French Frigate Shoals. Smaller populations also occur on Necker Island, and Nihoa Island. NMFS researchers have also observed monk seals at Gardner Pinnacles and Maro Reef. Monk seals are also increasingly found in the MHI (including Niihau), where preliminary surveys have counted more than 50 individuals. Additional sightings and at least one birth have occurred at Johnston Atoll, excluding eleven adult males that were translocated to Johnston Atoll (nine from Laysan Island and two from French Frigate Shoals) over the past 30 years.

Population trends for monk seals are determined by the highly variable dynamics of the six main reproductive subpopulations. At the species level, demographic trends over the past decade have been driven primarily by the dynamics of the French Frigate Shoals subpopulation, where the largest monk seal population is experiencing an unstable age distribution resulting in an inverted age structure. This age structure indicates that recruitment of females and pup production may soon decrease. In the near future, total population trends for the species will likely depend on the balance between continued losses at French Frigate Shoals and gains at other breeding locations including the Main Hawaiian Islands.

There was some evidence in the early 1990s that longline operations were adversely affecting the Hawaiian monk seals, as indicated by the sighting of a few animals with hooks and other non-natural injuries. In 1991, Amendment 3 established a permanent 50-mile Protected Species Zone around the NWHI that is closed to longline fishing. Since 1993, no interactions with Hawaiian monk seals in the pelagic longline fishery have been reported.

Delphinids

The Pacific white-sided dolphin is found throughout the temperate North Pacific (Hill and DeMaster 1999). Two stocks of this species are recognized, but the stock structure throughout the North Pacific is poorly defined. Population trends and status of the Central North Pacific stock of Pacific white-sided dolphins relative to the optimum sustainable population are currently unknown (Hill and DeMaster 1999).

The rough-toothed dolphin’s distribution is worldwide in oceanic tropical and warm temperate waters (Miyazaki and Perrin 1994). They have been sighted northeast of the Northern Mariana Islands during winter (Reeves et al. 1999). Rough-toothed dolphins are also found in the waters off the Main Hawaiian islands (Shallenberger 1981) and have been observed at least as far north as French Frigate Shoals in the Northwestern Hawaiian Islands (Nitta and Henderson 1993). The stock structure for this species in the North Pacific is unknown (Forney et al. 2000). The status of rough-toothed dolphins in Hawaii’s waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Risso's dolphins are found in tropical to warm-temperate waters worldwide (Kruse et al. 1999) but appear to be rare in the waters around Hawaii. There have been four reported strandings of Risso's dolphins on the Main Hawaiian Islands (Nitta 1991). Risso's dolphins have also been sighted near Guam and the Northern Mariana Islands (Reeves et al. 1999). Nothing is known about stock structure for this species in the North Pacific (Forney et al. 2000). The status of Risso's dolphins in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Bottlenose dolphins are widely distributed throughout the world in tropical and warm-temperate waters (Reeves et al. 1999). The species is primarily coastal, but there are also populations in offshore waters. Bottlenose dolphins are common throughout the Hawaiian Islands (Shallenberger 1981). Data suggest that the bottlenose dolphins in Hawaii belong to a separate stock from those in the eastern tropical Pacific (Scott and Chivers 1990). The status of bottlenose dolphins in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000). Elsewhere, the Indo-Pacific Bottlenose *T. aduncus* is found in the coastal waters Southeast Asia and extends into the larger Melanesian islands of Papua New Guinea and the Solomon Islands. These waters are typically not fished by U.S. longline boats but are part of the fishing grounds for the U.S. purse seine fleet.

As its name implies, the pantropical spotted dolphin has a pantropical distribution in both coastal and oceanic waters (Perris and Hohn 1994). Pantropical spotted dolphins are common in Hawaii, primarily on the lee sides of the islands and in the inter-island channels (Shallenberger 1981). They are also considered common in American Samoa (Reeves et al. 1999). Morphological differences and distribution patterns have been used to establish that the spotted dolphins around Hawaii belong to a stock that is distinct from those in the eastern tropical Pacific (Dizon et al. 1994). The status of pantropical dolphins in Hawaii waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Spinner dolphins are the cetaceans most likely to be seen around oceanic islands throughout the Pacific and are also seen in pelagic areas far from land (Perrin and Gilpatrick 1994). This species is common around American Samoa (Reeves et al. 1999). There is some suggestion of a large, relatively stable resident population surrounding the island of Hawaii (Norris et al. 1994). Spinner dolphins are among the most abundant cetaceans in Hawaii's waters. However, the status of spinner dolphins in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

The striped dolphin occurs in tropical and warm temperate waters worldwide (Perrin et al. 1994). Several sightings were made in winter to the north and west of the Northern Mariana Islands (Reeves et al. 1999). In Hawaii, striped dolphins have been reported stranded 13 times between the years of 1936-1996 (Nitta 1991), yet there have been only two at-sea sightings of this species (Shallenberger 1981). Striped dolphin population estimates are available for the waters around Japan and in the eastern tropical Pacific, but it is not known whether any of these animals are part of the same population that occurs in Hawaii (Forney et al. 2000). The status of striped dolphins in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

The pygmy killer whale has a circumglobal distribution in tropical and subtropical waters (Ross and Leatherwood 1994). They have been observed several times off the lee shore of Oahu (Pryor et al. 1965), and Nitta (1991) documented five strandings on Maui and the island of Hawaii. According to the MMPA stock assessment reports, there is a single Pacific management stock (Forney et al. 2000). The status of pygmy killer whales in Hawaii waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

False killer whales occur in tropical, subtropical and warm temperate seas worldwide (Stacey et al. 1994). This species occurs around the Main Hawaiian Islands, but its presence around the Northwestern Hawaiian Islands has not yet been established (Nitta and Henderson 1993). For the MMPA stock assessment reports, there is a single Pacific management stock (Forney et al. 2000). The status of false killer whales in Hawaii waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

The killer whale has a cosmopolitan distribution (Reeves et al. 1999). Observations from Japanese whaling or whale sighting vessels indicate large concentrations of these whales north of the Northern Mariana Islands and near Samoa (Reeves et al. 1999). Killer whales are rare in Hawaii's waters. There have been two reported sightings of killer whales, one off the Waianae coast of Oahu, and the other near Kauai (Shallenberger 1981). Except in the northeastern Pacific, little is known about stock structure of killer whales in the North Pacific (Forney et al. 2000). The status of killer whales in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

The melon-headed whale has a circumglobal, tropical to subtropical distribution (Perryman et al. 1994). Large herds of this species are seen regularly in Hawaii's waters (Shallenberger 1981). Strandings of melon-headed whales have been reported in Guam (Reeves et al. 1999). For the MMPA stock assessment reports, there is a single Pacific management stock (Forney et al. 2000). The status of melon-headed whales in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Whales

The short-finned pilot whale ranges throughout tropical and warm temperate waters in all the oceans, often in sizable herds (Reeves et al. 1999). It is one of the most frequently observed cetaceans around Guam (Reeves et al. 1999). Short-finned pilot whales are commonly observed around the Main Hawaiian Islands, and are probably present around the Northwestern Hawaiian Islands (Shallenberger 1981). Stock structure of short-finned pilot whales has not been adequately studied in the North Pacific, except in the waters around Japan (Forney et al. 2000). The status of short-finned whales in Hawaii's waters relative to their optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Bryde's whales have a pantropical distribution and are common in much of the tropical Pacific (Reeves et al. 1999). Shallenberger (1981) reported a sighting of a Bryde's whale southeast of Nihoa in 1977. Available evidence provides no biological basis for defining separate stocks of Bryde's whales in the central North Pacific (Forney et al. 2000). The status of Bryde's whales in Hawaii waters relative to their optimum sustainable populations is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

The Blainsville's beaked whale has a cosmopolitan distribution in tropical and temperate waters (Mead, 1989). Sixteen sightings of this species were reported from the Main Hawaiian Islands by Shallenberger (1981). Cuvier's beaked whale probably occurs in deep waters throughout much of the tropical and subtropical Pacific (Heyning 1989). Strandings of this species have been reported in the Main and Northwestern Hawaiian Islands (Nitta 1991; Shallenberger 1981). There is no information on stock structure of the Blainsville's beaked whale or Cuvier's beaked whale. The status of Blainsville's beaked whales and Cuvier's beaked whales in Hawaii's waters relative to their optimum sustainable populations is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

The pygmy sperm whale is likely to occur all year in many parts of the tropical and subtropical Pacific (Caldwell and Caldwell 1989). There have been at least nine reported strandings of this species in the Hawaiian Islands (Nitta 1991). The dwarf sperm whale is rarely observed at sea in most areas, but is apparently abundant in some (Nagorsen 1985). Its distribution, as inferred mainly from strandings, is worldwide in tropical and temperate waters. There have been two strandings of this species in the Hawaiian Islands (Nitta 1991). The status of pygmy sperm whales and dwarf sperm whales in Hawaii's waters relative to their optimum sustainable populations is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

Pinnipeds

Northern fur seals and northern elephant seals commonly migrate into the northeastern portion of the historic Hawaii-based fishing zone (Bigg 1990; Stewart and DeLong 1995). Both species may occur in this region anytime of the year, but there are periods when the probability of their presence is greatest, especially for certain age and sex groups. Juvenile northern fur seals of both sexes are believed primarily to occur in the region during the fall, early winter and early summer (Bigg 1990). Northern elephant seal adult females also migrate into the area twice a year, returning briefly to land to breed in the winter and molt in the spring (Stewart and Delong 1995). The eastern Pacific stock of the northern fur seal is classified as a strategic stock because it is designated as depleted under the MMPA (Hill and DeMaster 1999). A review of elephant seal population dynamics through 1991 concluded that the status of this species could not be determined with certainty, but that these animals might be within their optimal sustainable population range (Barlow et al. 1993).

10.7 Seabirds

Fishery interactions with seabirds under the Pelagics FMP appear to be largely confined to Hawaii-based vessels fishing for swordfish to the north of the Hawaiian Islands. Little information exists on interactions with other fishery sectors, however none of the other fishing methods or geographic fishing areas are believed or known to have other than minor to non-existent seabird impacts. Although rare, there are some interactions between small boats employing troll gear and seabirds. Nitta (1993) reports that during 26 trips by mixed handline fishing (bottomfish and troll) vessels to the Northwestern Hawaiian Islands (NWHI) between 1990 and 1993 carrying NMFS observers, interactions were recorded with Laysan and blackfooted albatrosses, where the birds dived on and stole trolling bait. One Laysan albatross was hooked and released alive during this period. More recently, NMFS deployed observers on 26 bottomfish trips to the NWHI between 2004 and 2005, with eight reported seabird interactions, of which three were between trolling gear and various species of boobies.

10.8 Fisheries – General Overview

Global catches of bigeye and yellowfin in 2004 by all gears were estimated at 449,604 and 1,212,532 t (WCPFC 2005). The Pacific Ocean accounted for an estimated 56.1% (680,746 t) of the yellowfin and 50.3% (226,151 t) of the global bigeye landings. Several figures, tables and data extractions in this section refer to the WCPFC-SA, which stands for the Western and Central Pacific Fisheries Commission, statistical area. This is the area in which the WCPFC is responsible to manage fisheries and collect, compile and disseminate fisheries data. Figure 14 shows the limit of this area within the WCPO.

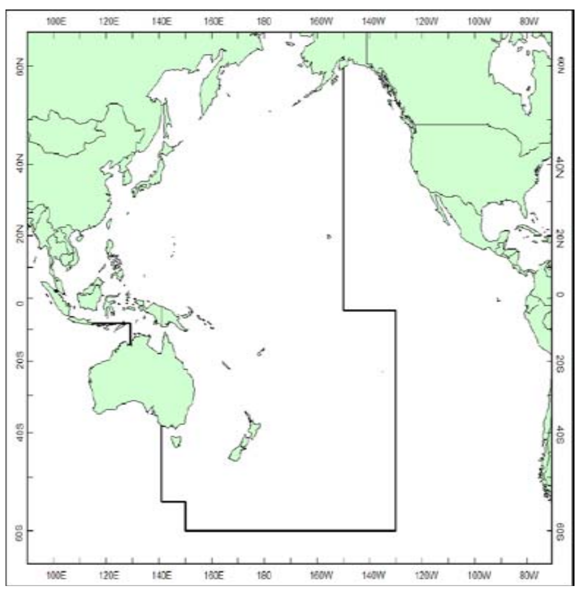


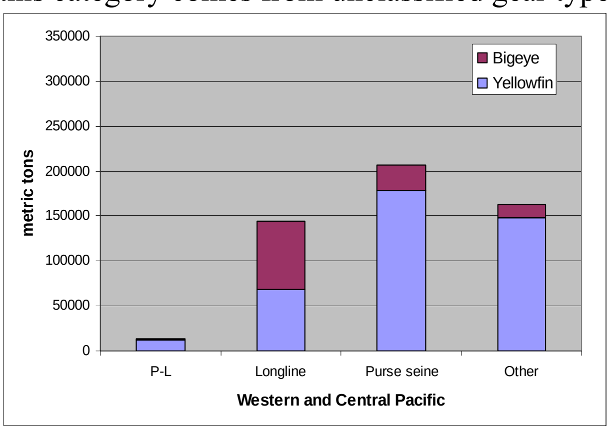
Figure 14. Western and Central Pacific Fisheries Commission statistical area.

Within the Pacific Ocean, the WCPO accounted for 59.8% of the yellowfin (407,002 t) and 52.8% (119,472 t) of the bigeye landed (Table 6). Combined yellowfin and bigeye catches in the WCPO are greater (526,474 t) compared to 380,432 t from the EPO. An etimated 906,897 t of both species were taken in the Pacific during 2004.

Table 6. 2004 total reported Pacific bigeye and yellowfin catches by gear type and region.

2004		Purse seine	Longline	Pole-and-line	Other	Species subtotal	
WCPO	Bigeye	27,786	75,231	1,809	14,646	119,472	WCPO total 526,474
	Yellowfin	178,475	69,075	11,855	147,597	407,002	
Gear-type subtotal		206,261	144,306	13,664	162,243	526,474	
EPO	Bigeye	66,944	39,729	0	6	106,679	EPO total 380,423
	Yellowfin	268,356	2,041	1,905	1,442	273,744	
Gear-type subtotal		335,300	41,770	1,905	1,448		
						Pacific-wide total	906,897

The distribution of catches across gear types is very different depending on area (Figure 15**)**. The WCPO has a slightly higher overall catch by pole and line gear due to greater overall effort from Japanese and Indonesian fleets that are actually targeting skipjack. The EPO pole and line fishery for yellowfin tuna is a small fishery with very low effort. Annual longline catches of yellowfin and bigeye in the WCPO are nearly equal at around 70,000 t while the majority of the EPO longline catch consists of bigeye. EPO yellowfin and bigeye catch in the EPO during 2004 significantly exceeded WCPO landings. The WCPO "Other" category of mixed, gear types (handline, troll, gillnet, etc) reports a huge catch of nearly 150,000 tons per year from the WCPO while almost no catch is reported for these gear types in the EPO. Most of the yellowfin catch in this category comes from unclassified gear types from Indonesia .



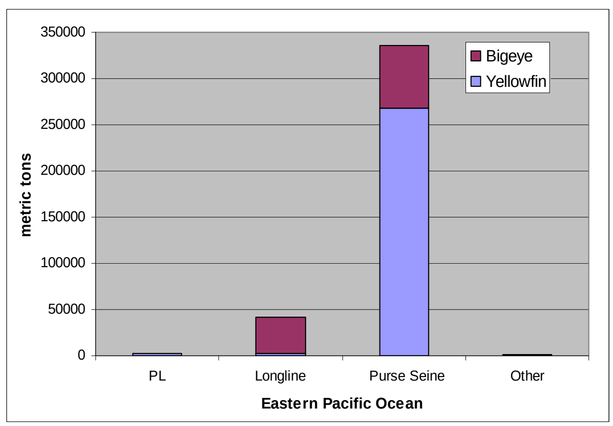


Figure 15. 2004 catches of bigeye and yellowfin tuna in the WCPO and EPO by gear type.

The estimated catch of bigeye in the Pacific for 2004 by purse seine and longline vessels was almost equal between WCPO and EPO (Table 7). However, the relative amounts taken by gear type were reversed, i.e. purse seine vs. longline percent landings in the WCPO were 13% vs 36% compared to 32% vs. 19% in the EPO. In other words, significant amounts of bigeye are taken in the EPO purse seine fishery, primarily in the southern water drifting FAD fishery. Yellowfin are taken in significant quantities by both gear types in the WCPO but mainly by purse seine gear in the EPO.

Table 7. 2004 reported Pacific bigeye and yellowfin catches by purse seine and longline and vessels.

Area	Gear type	Bigeye landings (t)	Percent of Pacific-wide purse seine and longline total bigeye landings	Yellowfin landings (t)	Percent of Pacific-wide purse seine and longline total yellowfin landings
WCPO	Purse seine	27,786	13%	178,475	34%
	Longline	75,231	36%	69,075	13%
	Total	103,017	49%	247,550	47%
EPO	Purse seine	66,944	32%	268,356	52%
	Longline	39,729	19%	2,041	1%
	Total	106,673	51%	270,397	53%
PACIFIC-WIDE	GRAND TOTAL	209,690	100%	517,947	100%

The following sections describe the fishing fleets that impact bigeye tuna in the Pacific Ocean. WCPO fisheries are described first, followed by EPO fisheries. Additional details on the domestic fleets managed under the Pelagics FMP are presented in Section 10.9.

10.8.1 Tuna Fisheries: Bigeye and Yellowfin Landings

10.8.1.1 Pacific-wide Landings

Since 1980, Pacific-wide catch of bigeye by all gears has fluctuated between 119,000 to a peak of 254,000 t in 2002 (Figure 16). The WCPO longline catch has ranged between 40,000-80,000 t for over thirty years and has remained relatively stable in recent years. Catches by WCPO surface gears have increased significantly in the last ten years, believed to be mainly indicative of expanding mixed gear fisheries in the Philippines and Indonesia. Since about 1994, there has been an increase in purse-seine catches of juvenile bigeye tuna, first in the EPO and since 1996, though to a lesser extent, in the WCPO. Reductions in the EPO longline take of bigeye have occurred in recent years.

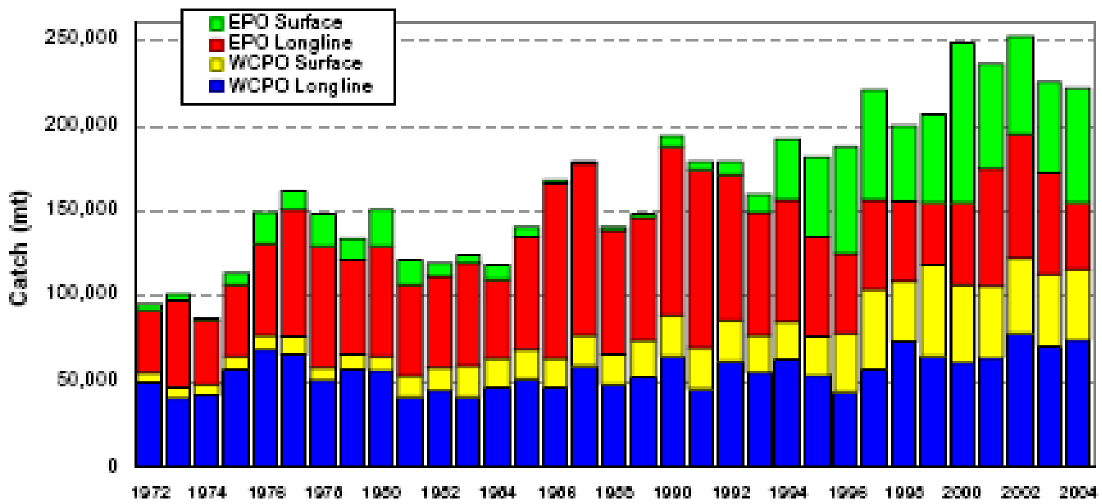


Figure 16. Pacific-wide bigeye catch by surface and longline gears by area.

(Source: Williams and Reid 2005)

The spatial distribution of bigeye catch in the Pacific for 1990 – 2003) is shown in Figure 17. Most of the catch is taken across the Pacific by longline gear (in red), although significant purse seine landings are concentrated in the western Pacific and eastern Pacific Oceans (in green). Another important source of bigeye mortality comes from the handline, ringnet and mixed gear fisheries of the Philippines and Indonesia (in blue). Some sub-tropical longline fisheries for bigeye exist, e.g. east of Japan, east of Australia, around Hawaii and off South America.

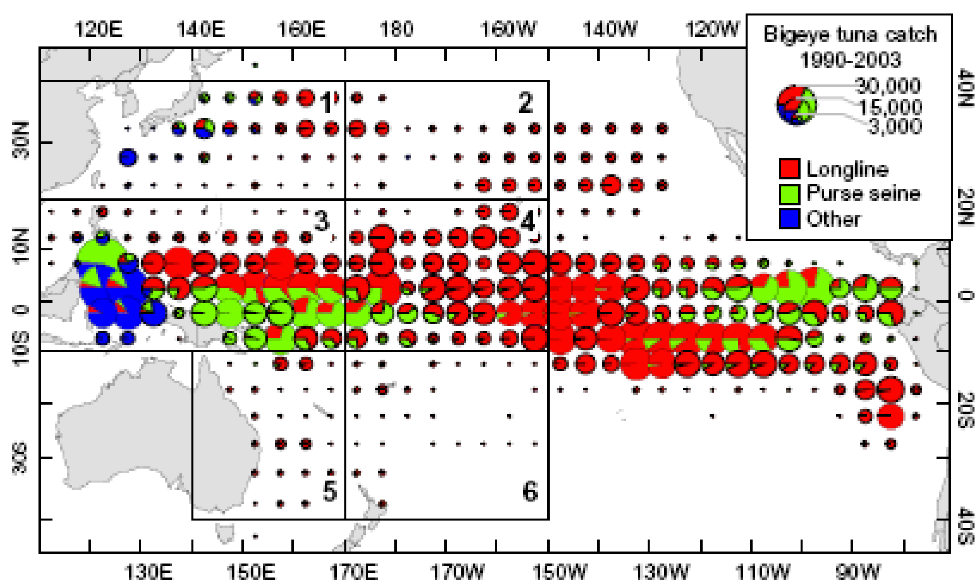


Figure 17. Spatial distribution of bigeye catch in the Pacific by gear.

(Source: Williams and Reid 2005)

Since 1980, Pacific-wide catch of yellowfin tuna by all gears has ranged from a low of 348,000 t in 1982 to a record high of 847,796 t in 2002 (WCPFC 2005). Pacific yellowfin catches have remained above 600,000 t since 1990. The spatial distribution of yellowfin catch is shown in Figure 18 with Multifan CL regions overlayed on the plot.

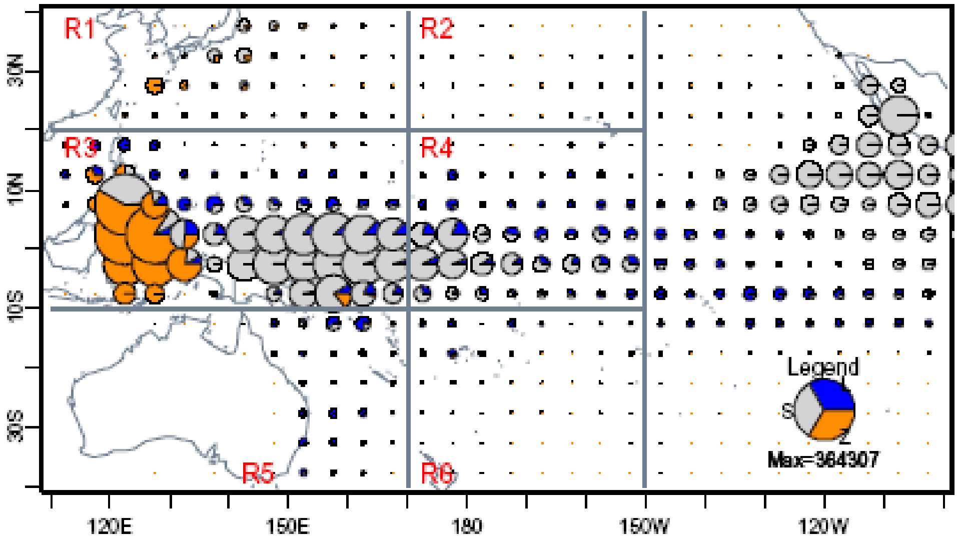


Figure 18. Distribution of cumulative yellowfin catch from 1990 – 2004 by 5 degree square and gear.

Note: Longline (blue-L), purse seine (grey, S), other (dark orange-Z).

(Source: Hampton et al. 2005, SC-1: SA WP-1)

In contrast to bigeye tuna, yellowfin are taken in greater proportions by purse seine gear in the equatorial western and central Pacific and the eastern Pacific tropical and sub-tropical areas (in grey). However, yellowfin contribute significantly to equatorial and sub-tropical longline fisheries (in blue). One of the most significant sources of fishing mortality for yellowfin comes from the mixed gear fisheries of the Philippines and Indonesia (in dark orange)

10.8.1.2 WCPO DWFN Fleets and Landings

Bigeye catch

Since about 1994, there has been a significant increase in purse-seine catches of juvenile bigeye tuna, first in the eastern Pacific Ocean (EPO) and since 1996, though to a lesser extent, in the WCPO. A temporally coincident reduction in the EPO longline take of bigeye is also apparent. In the WCPO, purse-seine catches of bigeye tuna are estimated to have been less than 20,000 t per year up to 1996, mostly from sets on natural floating objects (Hampton et al. 1998). In 1997, the catch increased to 35,000 t, primarily as a result of increased used of drifting fish aggregation devices (FADs). High purse seine catches were also recorded in 1999 (38,000 t) and 2000 (33,000 t). The total WCPO bigeye tuna catch in 2002 was a record 124,000 t. (Hampton et al.

2004). These trends followed those in the EPO, where FAD based purse seining significantly increased landings of bigeye tuna since 1994. A slight and continued reduction in bigeye landings by WCPO purse seine gear since 2000 is easier to discern in Figure 19, caused by continued reductions in the use of drifting FADs to support purse seine operations.

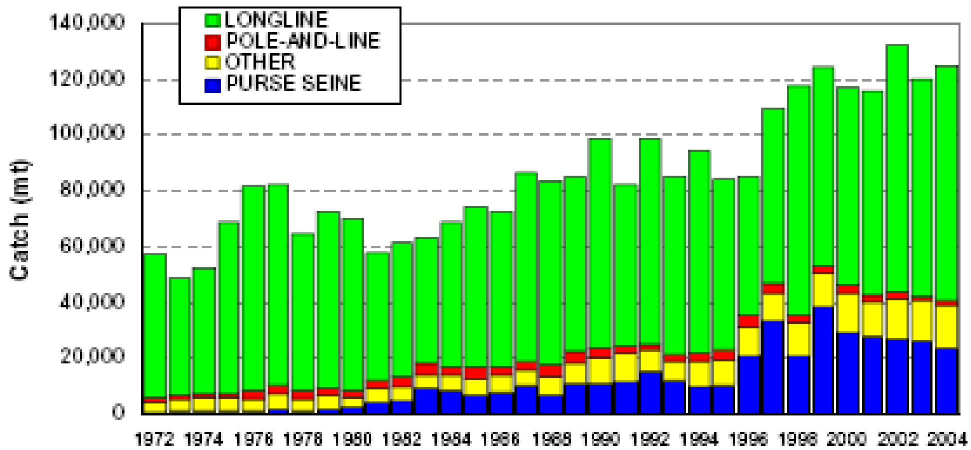


Figure 19. Bigeye catch by gear in the WCP-CA .

(Source: Williams and Reid 2005)

Figure 20 shows yearly catch of bigeye tuna in the WCPO by size and gear types or fishing mode. Longline gear takes the majority of large, mature size bigeye in the region. Purse seine gear captures primarily juvenile or sub-adult fish in the 50 – 70 cm size class from associated sets, primarily logs, drifting FADs and anchored FADs. Virtually no bigeye tuna are captured in the WCPO from unassociated sets. The Philippine and Indonesian fisheries are responsible for high volumes of juvenile bigeye.

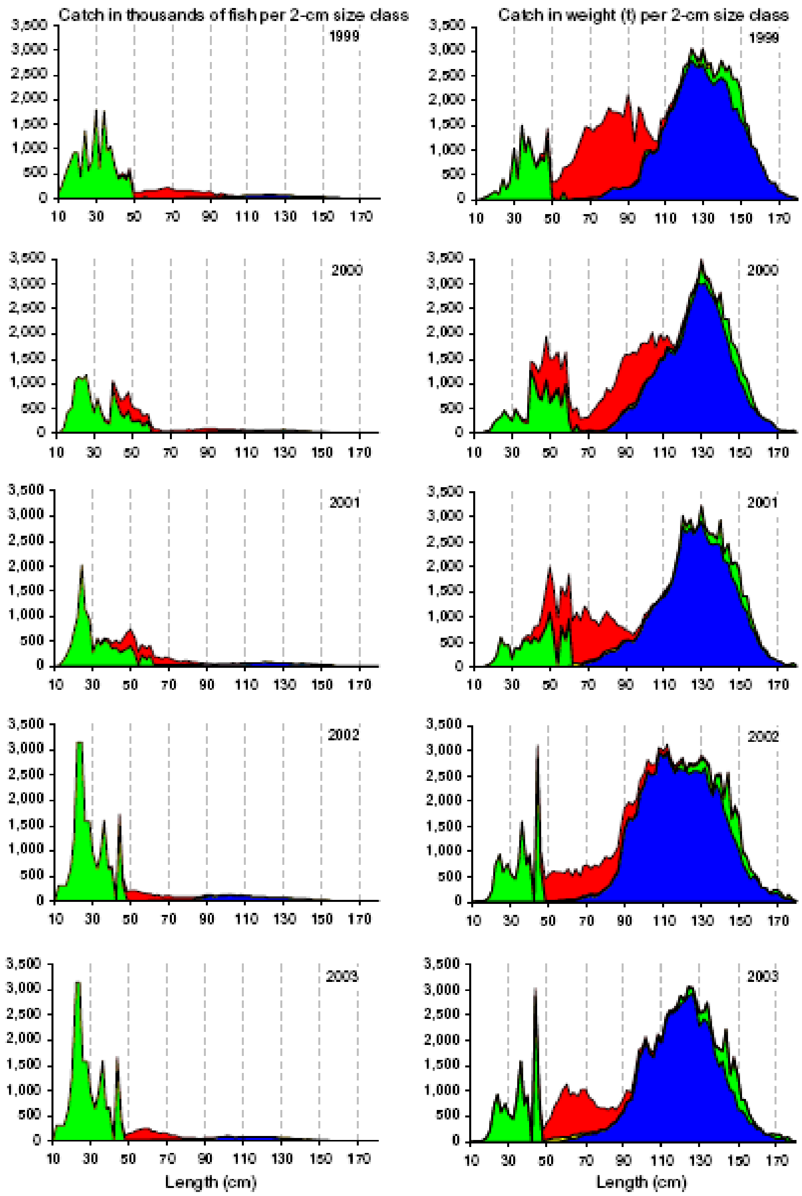


Figure 20. Annual catches of bigeye tuna in the WCPO by size and gear.

Note: Longline-blue; Philippines/Indonesia mixed-green; Purse seine associated sets-red; Purse seine unassociated-yellow levels of fishing mortality on small juvenile bigeye in the size range of 20 – 60 cm and smaller amounts of large, mature size bigeye taken on handline gear.

Yellowfin catch

Recorded catches of yellowfin from the WCPO increased from a low of 22,000 t in 1950 to a record high of 459,000 t in 1998. Figure 21 shows WCPO yellowfin catches since 1950 by gear type. What began as exploitation by longline gear only has changed significantly since the beginning of purse seine and mixed gear exploitation in the 1970s. Total annual catches in the WCPO since 1990 have been relatively stable around 350,000 – 420,000 t with a significant dip in 1996 to 308,000 and a record high of 459,000 in 1998, both caused by apparent variability in purse seine catchability for the stocks. In 1990, purse seine gear was responsible for 50% of yellowfin landings with longline, pole-and-line and other mixed gears taking 20%, 5% and 25% respectively. In 2004, the picture shifted slightly with a significant increase in fishing effort by the Philippine/Indonesian mixed gear fisheries taking 36% of WCPO yellowfin tuna (WCPFC 2005). Purse seine landings now account for only 44% while longline and pole-and-line take 17% and 3% respectively. The increase in mixed gear (other) take of yellowfin since around 2000 is easier to see in Figure 22.

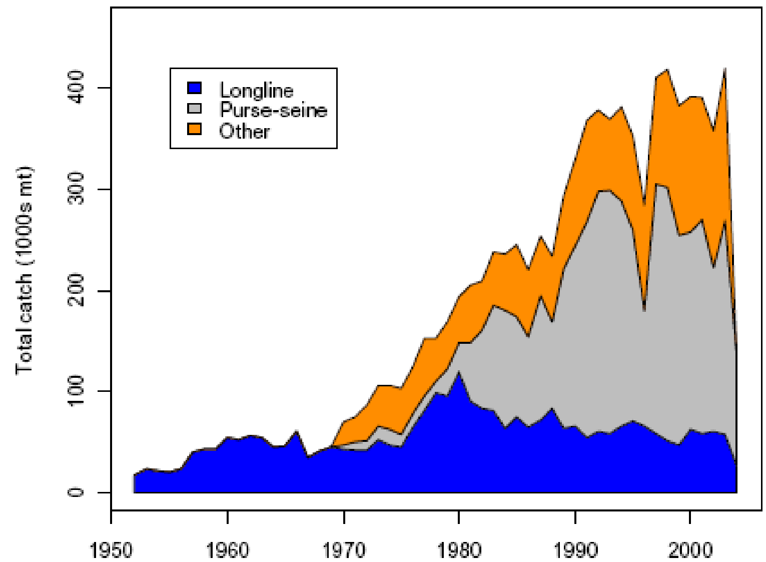


Figure 21. Total WCPO yellowfin catch by gear from 1952-2004.

(Source: Hampton et al. 2005, SC-1 : SA WP-1)

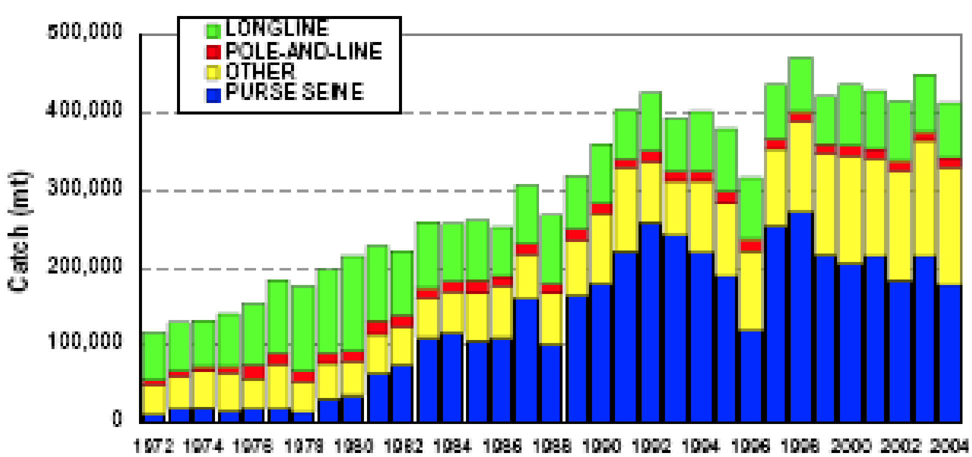


Figure 22. WCP-CA yellowfin catch by gear.

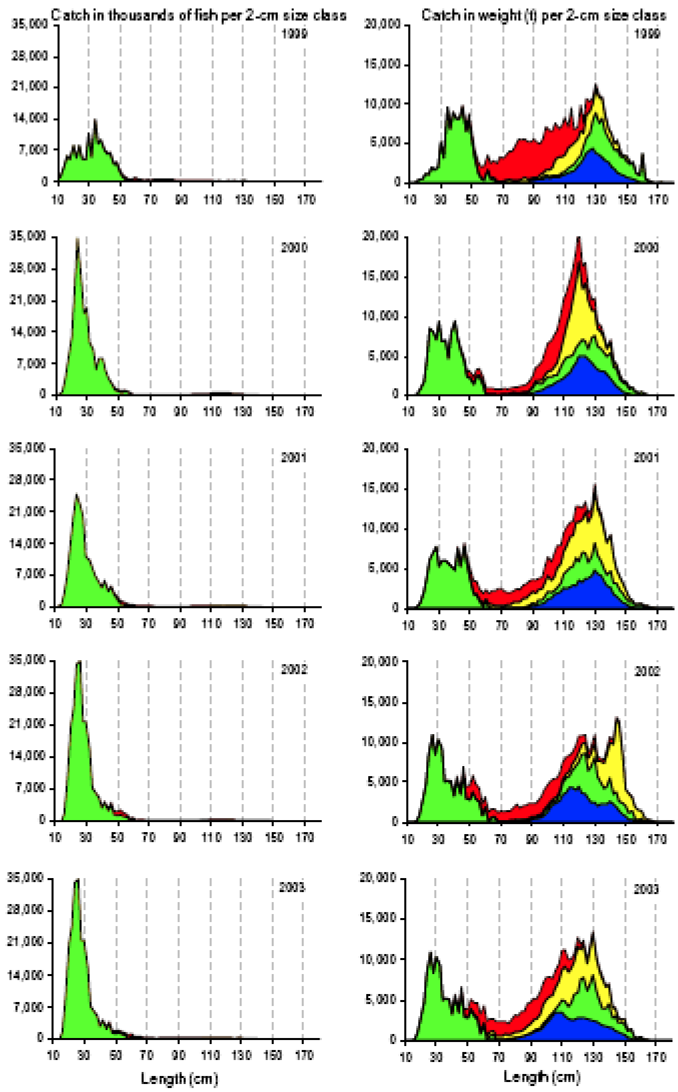


Figure 23. Annual catches of yellowfin tuna in the WCPO by size and gear.

Note: Longline-blue; Philippines/Indonesia mixed-green; Purse seine associated sets-red; Purse seine unassociated-yellow

As for bigeye tuna, the size distribution of yellowfin catch varies widely and predictably by region and gear type (Figure 23). The Philippine and Indonesian fisheries make large catches of very small yellowfin (20-50 cm) and also significant quantities of adult yellowfin by handline gear (in green). Purse seine sets on drifting objects like logs and FADs take primarily juvenile and sub-adult fish less than 110 cm (in red) while longline fisheries take primarily adult fish greater than 90 cm (in blue). Unlike bigeye tuna, a significant proportion of adult yellowfin are taken by purse seine gear on unassociated sets. In combination with associated sets, purse seine gear is normally responsible for a greater take of adult yellowfin than longline gear. This is in strong contrast to adult bigeye landings that are dominated by longline catches. Strong recruitments of WCPO yellowfin can cause significant inter-annular variability in landings. For example, an apparent strong recruitment pulse of WCPO yellowfin is apparent in the time series from 1999 that appear as large mature fish in surface and subsurface gears in 2002.

Active vessels – longline

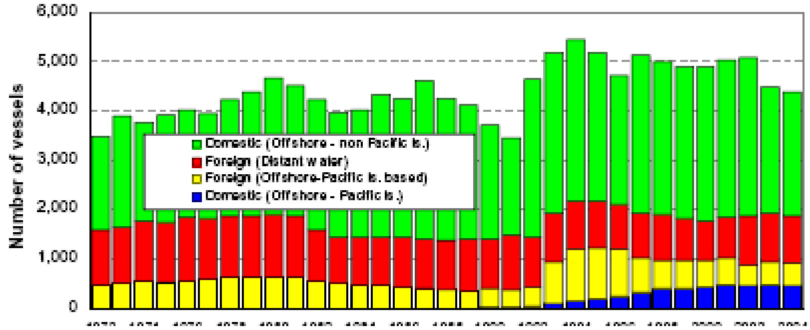


Figure 24. Number of longline vessels operating in the WCP-CA 1972-2004.

(Source: Williams and Reid 2005)

The numbers of active vessels and catches of major species by longline vessels of the major distant water fishing operating in the WCPO for 2004 are shown in Figure 24. Longline vessels number in the thousands while purse seine activity is limited to 205 large-scale purse seiners in the WCPO by conditions of the Palau Arrangement. Longline vessels generally fall into two categories: large freezer boats > 250 GT from distant water fishing nations like Japan, Kora and Chinese Taipei; or smaller ice boats <100 GT fishing for fresh, sashimi grade tuna. Although the longline fisheries only take about 15% of total WCPO catch, the value of these larger fish rival total landings from the larger purse seine fisheries. In 2004, the delivered value of the longline fleets operating in the WCPFC was U.S. $ 1,059 million vs. 1,158 million for purse seine landings (Williams and Reid 2005).

The longline fishery of the WCPO has experienced several changes in targeting and operations since the beginning of the fishery. Significant changes include:

1. a directed increase in the depth of deployed gear from the 1980s onward for daytime sets to target higher-value bigeye tuna rather than yellowfin tuna in tropical regions;
2. the development of ultra-low temperature freezer boats supplying frozen tuna at sashimi grade;
3. a significant entry into the fishery of smaller ice boats from Chinese Taipei and China during the 1990s targeting bigeye for fresh export from regional ports and subsequent decline of this activity;
4. a dramatic increase in the number of domestic Pacific Island freezer and ice boats targeting albacore for regional canneries;
5. a shift of larger albacore vessels of Chinese Taipei retrofitted to ultra low temperature freezing, to target bigeye and yellowfin in the eastern equatorial areas of the WCPO;
6. an increase in the number of large Chinese longliners targeting albacore in southern water high seas zones and also tropical tunas; and

7. the rapid development of other longline fleets, notably Vietnam to supply yellowfin sashimi markets.

Table 8 indicates numbers and landings of active WCPO longline vessels in 2004 with reported numbers of hooks used where data is available (Japan, Korea, Chinese Taipei). Percentages of catch by country and species are also given. Leading bigeye catching countries by longline include Japan, Korea and Chinese Taipei and China. U.S. longline vessels account for only 5% of the bigeye landings. Chinese Taipei, through their distant water, offshore and domestic fleets are responsible for 45% of all yellowfin landings. Japan and Korea are also major harvesters of yellowfin tuna in the region.

Table 8. Number of 2004 active vessels and estimated landings (t) by distant water longline fishing fleets of the WCPO.

(Source: WCPFC 2005)

Country or territory	Vessels Active (year)	# of hooks (thousands) and notes	Bigeye	Yellow-fin	Alba-core	Other	Total catch
Japan - distant water	484 (2002)	118,000 catch data '04	9,400 18%	21,910 28%	8,658 30%	9,657 16%	49,625
Chinese Taipei domestic	1060 (2003)	catch data '03	10,567 20%	2,299 3%	712 2%	33,484 57%	47,062
Chinese Taipei distant water	137	850,634 (2003) vessel and catch data 2004	9,018 17%	16,888 21%	11,819 41%	4,980 8%	42,705
Korea	165 (2003)	1,383,112 (2003) catch data '04	10,058 19%	17,941 23%	1,163 4%	3,904 7%	33,066
China	179 (2003)	catch data '03	8,965 11%	3,358 6%	6,223 22%	3,353 6%	21,899
Japan coastal	784? (2003)	catch data '03	4,434 9%	4,942 6%	?	?	9,376
USA- Hawaii and California	125	all data '04	694 1%	4,181 5%	356 1%	3,795 6%	9,026
Chinese Taipei offshore E of 130°	284 (2000)	catch data '04	4,245 8%	2,228 3%	?	?	6,473
USA - other PIN EEZ	3	all data '04	58 0%	30 0%	0	28 0%	116
Totals			51,832 100%	79,384 100%	28,930 100%	59,201 100%	219,347

The proportion of bigeye and yellowfin by country and fleet type is shown in Figures 25 and 26.

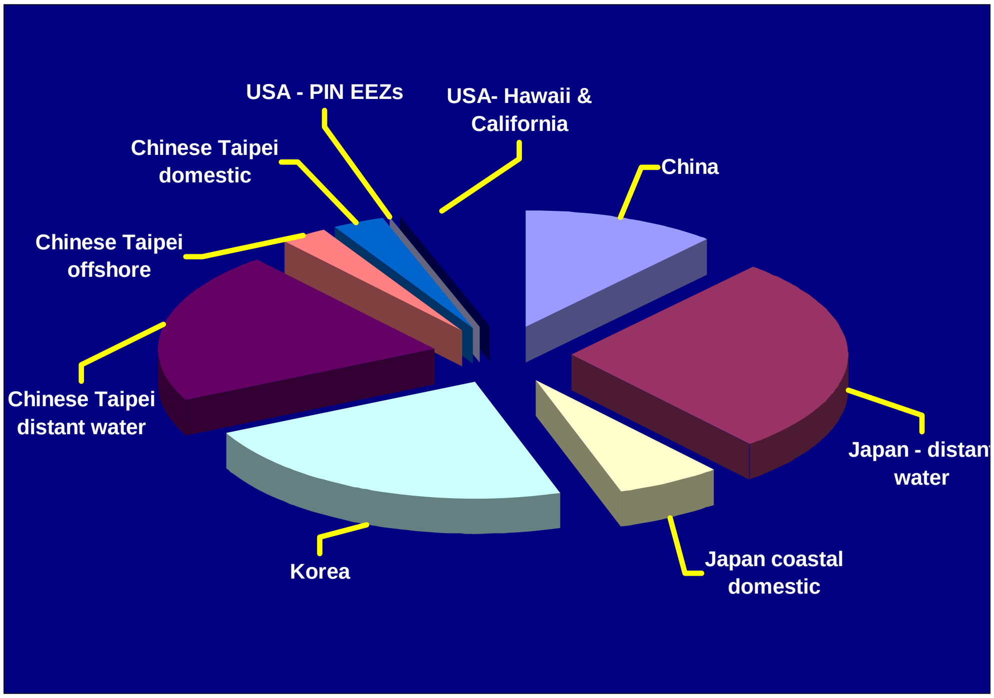


Figure 25. Proportions of 2004 WCPO bigeye tuna catch by DWFN longline fleets.
(Source: WCPFC 2005)

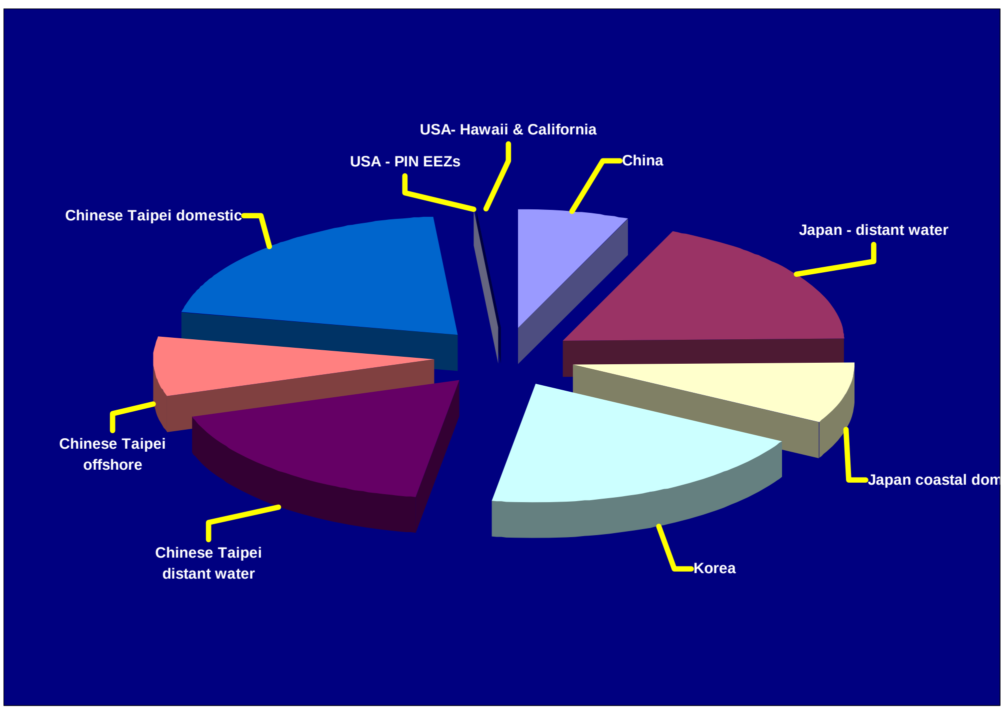


Figure 26. Proportions of 2004 WCPO yellowfin tuna catch by DWFN longline fleets.
(Source: WCPFC 2005)

Table 9 and Figures 28 and 29 provide similar information regarding WCPO catches by DWFN purse seine fleets.

Active vessels – purse sine

The WCPO purse seine fishery accounts for about half the total WCPO tuna catch by volume and had an estimated delivered value of U.S. $1,159 million in 2004 consisting primarily of canning grade skipjack (Williams and Reid 2005). The majority of the catch is taken by the DWFN fleets of Japan, Korea, Chinese Taipei and the U.S. which account for about 120 vessels annually (Figure 27). In recent years, increasing numbers of Pacific Island domestic or joint venture vessels have joined the fishery as well as some new distant water entrants, i.e. Australia, New Zealand and China.

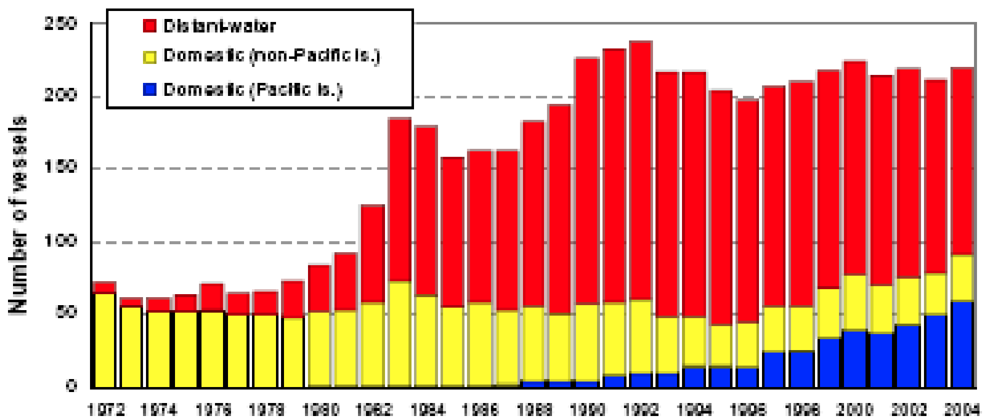


Figure 27. Number of purse seine vessels operating in the WCP-CA, 1972-2004.

(Source: Williams and Reid 2005)

The numbers and landings of active purse seine vessels in the WCPO during 2004 are listed in Table 9 in descending order of total catch. The largest number of vessels is the combination of Philippine domestic purse seine and ringnet vessels that harvested more than 150,000 t of tropical tuna in 2004. Although they register many more vessels than the other countries, they are generally of very small size and work almost exclusively on tuna schools aggregated to anchored FADs. A large number of small purse seine vessels operate in a similar fashion in the Indonesia EEZ, but data on the exact number of these vessels was not available. Papua New Guinea lists the next highest number of purse seiners (37) and the highest overall catch. The vessels are a mix of sizes and generally operate on anchored FADs within the northern EEZ. The large vessels of the major DWFN fleets (Japan, Chinese Taipei, Korea and the U.S.) had 35, 34, 28 and 21 purse seine vessels respectively that operated in the region during 2004.

PNG, Japan DW, Chinese Taipei and Korea landed close to 200,000 t of tropical tunas during 2004 with the U.S. landing 67,000 t. The fleets with the highest reported bigeye catch in decreasing order were the Philippines (combined), U.S., Japan and PNG. It is possible that these figures are influenced by better reporting and dock sampling procedures for some of these fleets compared to others. It is likewise probably that fleets that depend heavily on associated purse seining like Chinese Taipei, Indonesia domestic, Philippine ringnet and Philippine distant water have higher bigeye catches than are reported here. This is related to the common problem of juvenile bigeye landings being mixed with and reported as yellowfin tuna.

The Korean fleet recorded the highest yellowfin catch for 2004. This fleet is unique in the region having preferred to engage in unassociated setting on large yellowfin and skipjack whenever possible. The Philippine domestic fleet recorded the second highest yellowfin catch by purse seine gear which consisted of small juvenile yellowfin. The Papua New Guinea and Japanese distant water fleets recorded relatively high catches of yellowfin tuna.

Table 9. Numbers and estimated landings of active purse seine vessels of the 2004 distant water fishing fleets in the WCPO.
(Source: WCPFC 2005)

Country or territory	Vessels active	Bigeye		Yellowfin		Skipjack		Total catch
		Catch	%	Catch	%	Catch	%	
PNG	37	3,749	13%	23,166	13%	175,201	17%	202,116
Japan distant water	35	4,577	16%	22,626	13%	172,563	17%	199,766
Chinese Taipei	34	730	3%	15,968	9%	181,524	18%	198,222
Korea	28	1,892	7%	29,472	17%	152,126	15%	183,490
Philippines domestic purse seine	(164) split with PH ringnet	3,165	11%	28,483	16%	79,540	8%	111,188
USA	21	5,031	18%	14,492	8%	47,896	5%	67,419
Philippines domestic ringnet	(164) split with PH purse seine	811	3%	7,377	4%	40,516	4%	48,704
Marshall Islands	6	962	3%	3,632	2%	42,078	4%	46,672
Philippines distant-water	10	1,375	5%	5,153	3%	27,288	3%	33,816
FSM	6	683	2%	3,276	2%	22,998	2%	26,957
China	4	177	1%	3,200	2%	20,248	2%	23,625
New Zealand	11	558	2%	1,997	1%	20,289	2%	22,844
Indonesia domestic	no data	794	3%	7,143	4%	13,620	1%	21,557
Solomon Islands	14	2,069	7%	7,208	4%	6,817	1%	16,094
Spain	no data	842	3%	1,196	1%	3,479	0%	5,517
Kiribati	1	140	1%	644	0%	3,816	0%	4,600
Vanuatu	7	229	1%	3,334	2%		0%	3,563
Japan coastal	18	2	0%	87	0%	1,024	0%	1,113
Australia	3	0	0%	21	0%	165	0%	186
Totals		**27,786**		**178,475**		**1,011,188**		**1,217,449**

The relative amounts of bigeye and yellowfin tuna taken by WCPO purse seine fleets are shown in Figure 28 and 29.

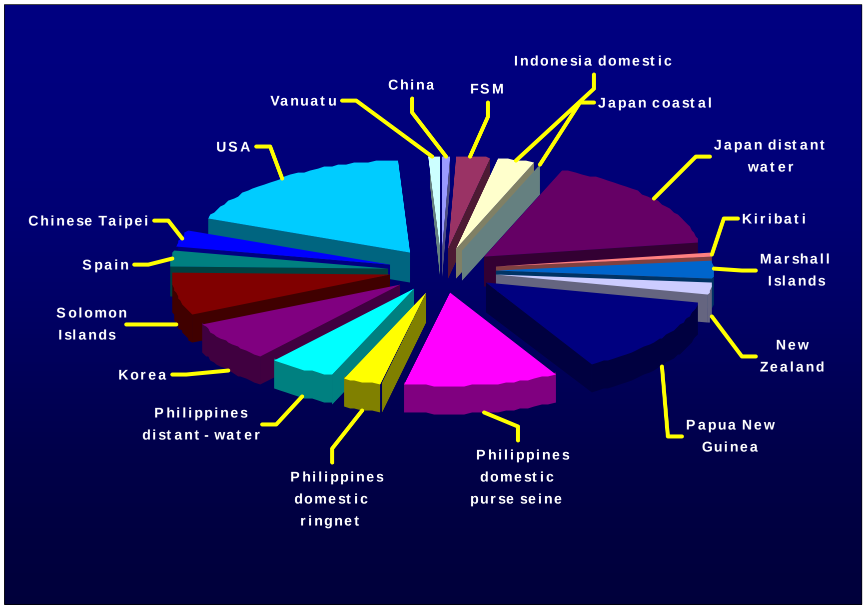


Figure 28. Proportions of 2004 WCPO bigeye tuna catch by DWFN purse seine fleets.
(Source: WCPFC 2005)

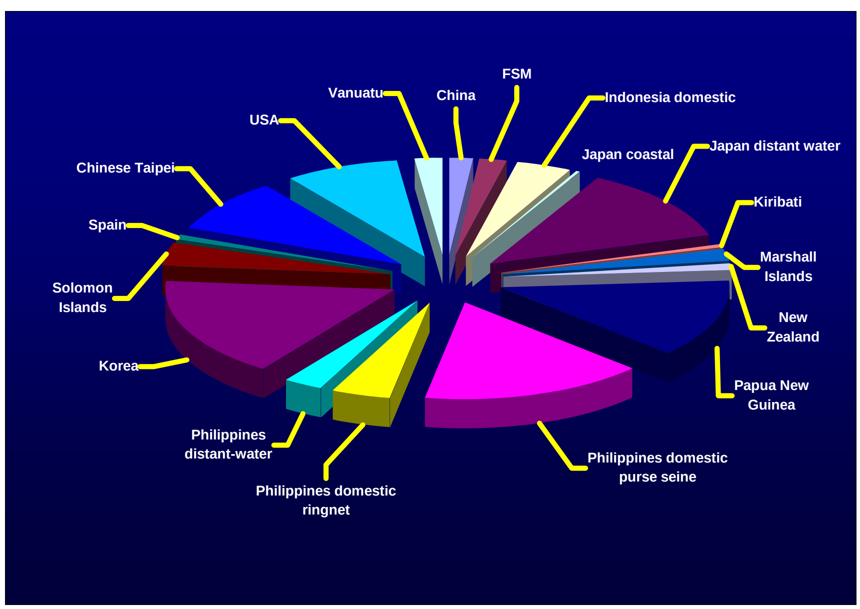


Figure 29. Proportions of 2004 WCPO yellowfin tuna catch by DWFN purse seine fleets.
(Source: WCPFC 2005)

Combining information from Table 8 for total longline catches and Table 9 for purse seine landings gives each nation's WCPO 2004 totals and percent of total landings. Table 10 compiles this information for those countries with the highest combined landings of bigeye and yellowfin tuna, shown in decreasing order of bigeye catches. The countries with highest reported bigeye catched during 2004 were Japan, Chinese Taipei and Korea.

Table 10. Reported WCPO bigeye and yellowfin longline and purse seining landings for top ten countries.
(Source: WCPFC 2005)

Country	Bigeye landings (t)	Percent of Bigeye total	Yellowfin landings (t)	Percent of Yellowfin total
Japan	31,431	29%	36,547	15%
Chinese Taipei	22,145	21%	39,798	17%
Korea	19,833	18%	39,530	17%
USA	9,242	9%	15,244	6%
China	9,142	8%	6,558	3%
Philippines	5,594	5%	43,592	18%
PNG	4,145	4%	25,692	11%
Solomon Islands	2,426	2%	7,746	3%
Indonesia	1,435	1%	13,953	6%
Fiji LL	1,254	1%	4,164	2%
All others	1,255	1%	5,000	2%
Totals	**107,902**	**100%**	**237,824**	**100%**

The major distant water longline and purse seine fleets of the WCPO are described in the following section with specific references to landings of bigeye and yellowfin tuna. A brief description of the fisheries, recent catches by major categories, areas fished, seasonality, fleet descriptions, targeting and any available details on fishing mode or strategy are provided for: China (PRC), Japan, Korea, Chinese Taipei and the U.S..

Peoples Republic of China (PRC)

PRC longline fishery

Chinese longline vessels first arrived in the WCPO in 1988, rapidly increasing in numbers to a peak level of 457 vessels in 1994 (Song et al. 2004). Most of these vessels were converted inshore trawlers of 50 – 149 GT and poorly fitted for pelagic tuna longlining. Due to low CPUE and profitability, the fleet declined to a low of 66 vessels in 1999. Accumulated experience and the introduction of larger, better equipped vessels have stabilized the number of vessels at 110 – 120 in recent years. A further development has been the introduction of Chinese flag purse seiners to the region in 2002. Four Chinese purse seiners were active in the region in 2003 and six in 2004. It is anticipated that significant increases in purse seine activity by Chinese vessels will develop if regional access can be secured.

The smaller size classes of Chinese longliners maintain catch on ice and run limited range trips generally within the EEZ of a single Pacific Island country. After 2002, larger vessels of ~30 m equipped with refrigerated sea water systems (RSW) for conservation of catch and monofilament mainline gear were introduced, primarily to the Fiji fishery. Song et al. (2004) notes the recent introduction of larger-scale deep freezer boats that have significantly increased landings. However, there has always been a strong influence of Taiwanese involvement in Chinese flagged longline vessels in the region through Taiwanese companies using PRC longliners and Taiwanese fishing masters on PRC vessels. The separation between Chinese, Taiwanese, or Chinese longline vessels flying a flag of convenience (FOC) in the region continues to pose a problem to statistics and monitoring of catch.

These vessels mainly target bigeye and yellowfin tuna in the EEZs of the Marshall Islands, FSM, Palau, Tonga and Fiji. Medium-size RSW equipped vessels target albacore in the Fiji EEZ and adjacent high seas areas while the large-scale freezer boats operate throughout the region and in high seas pockets. Some of the larger boats have shifted targeting to albacore, making seasonal shifts between the WCPO and the north Pacific (Song et al. 2004).

Detailed fishing characteristics of Chinese RSW albacore boats operating at higher latitudes and deep freezer boats could not be found. However, it is assumed they operate in a manner similar to Taiwanese and Japanese vessels of similar class.

Reported catch by 179 Chinese longline vessels operating in the WCPO during 2003 totaled 21,899 t consisting of 8,965 t bigeye (42%), 6223 t albacore (28%), 3358 t yellowfin (15), 1,168 t swordfish (5%), 1,043 t marlins (5%), and 1,142 t of other species (5%) (see Table 8). The high rate of bigeye targeting by this fleet is impressive at >41% and may represent highgrading and sorting at sea to discard less desirable species such as yellowfin. This level of catch represented a huge increase in traditional catch levels, with significant increases in bigeye and albacore landings (Figure 30).

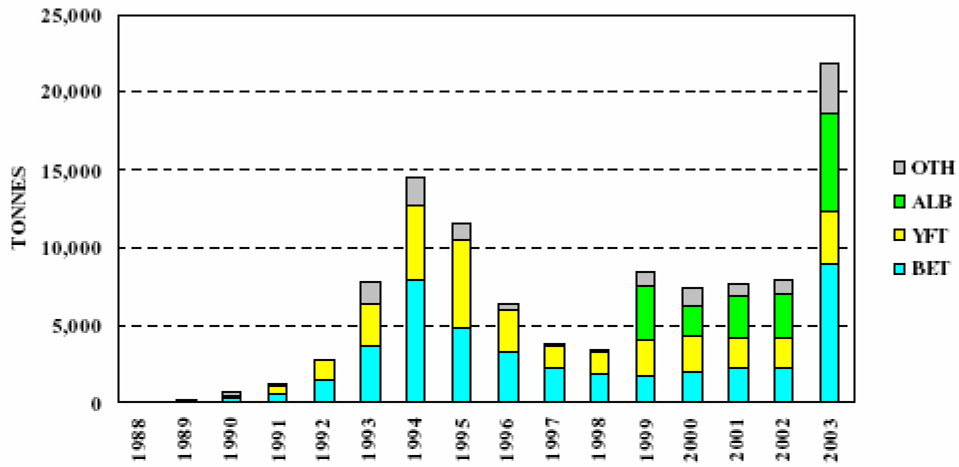


Figure 30. Landings of bigeye (BET), yellowfin (YFT), albacore (ALB), and other species (OTH) by Chinese longliners in 2003. (Source: Lawson 2004)

Traditionally, Chinese vessels in the WCPO have used simple fishing technology to target large bigeye at night around the full moon period. The technique involves the use of traditional basket gear deploying around 5 – 7 hooks per basket in the evening without the use of a line shooter with squid bait. This takes advantage of the vertical movement of large bigeye to surface waters at night to feed. Some of the newer vessels are equipped with monofilament mainline gear and line shooters, making it possible to set deep gear to target bigeye tuna during the day.

Park (2001) examined the vessel characteristics of vessels operating in the FSM zone. For the smaller Chinese ice boats, he noted the lowest power to length ratios of any fleet. The boats also separate out from other fleets in that they normally fish their gear at night and haulback in the day. Chinese longliners normally set their gear at 1600 and began the haul at 0600. The boats set at a slow speed, presumably due to the manual nature of the process and set 600 – 900 hooks per set. Setting took between 2 – 4 hours and haulback averaged 5 – 7 hours. Chinese longline activity peaked during mid-year and was lowest in February during the Chinese New Year period. Some vessels time return visits to China or refits for this period. Fishing activity always peaked during the week surrounding the full moon period and trips normally lasted two weeks and maintained a 4 week activity cycle timed to the full moon period.

Chinese longliners are required to submit logsheet data while operating within the WCPO and report monthly fishing activities to a technical working group of the Shanghai Fisheries University that compiles data for regional fisheries management organizations. A national observer program is just beginning with a few trips conducted on Chinese longline and six purse seine vessels in the WCPO during 2003 – 2004. Due to the limited nature of the program, length frequency data is not yet available. However, port sampling programs throughout the region coordinated by the SPC and past scientific observer trips have compiled data for several fleets.

Japan

Japan longline fishery

Miyabe et al. (2004) describe the major tuna fisheries of Japan in the Pacific Ocean to 2004, concentrating on the WCPO west of 150°W longitude. Total catches of tropical tuna species for longline, purse seine, pole-and-line and other small gears during 2002 were 371,571 t consisting of 35,973 t of bigeye, 42,171 t yellowfin and 293,463 t of skipjack. These data appear to represent the effort of 1,442 longline, 403 pole-and-line, 53 purse seine and a large number of small coastal vessels.

Fishing effort within the WCPO for the Japanese distant-water and offshore fleets > 20 GT is listed at 126 m hooks in 2003. The main vessel size class in this region is 50 – 199 GT, hence annual trends in fishing effort tend to track the number of vessels in this category over time. There has been a declining trend in overall catch since 1980 when yellowfin catch began to decline. Bigeye catches began to decline since the early 1990s (Figure 31). The catch reported from the 126 m hook effort totaled 49,220 t consisting of 20,573 t of bigeye, 7,258 t of albacore, 12,501 t of yellowfin and 8,888 t of other species, primarily swordfish and marlins.

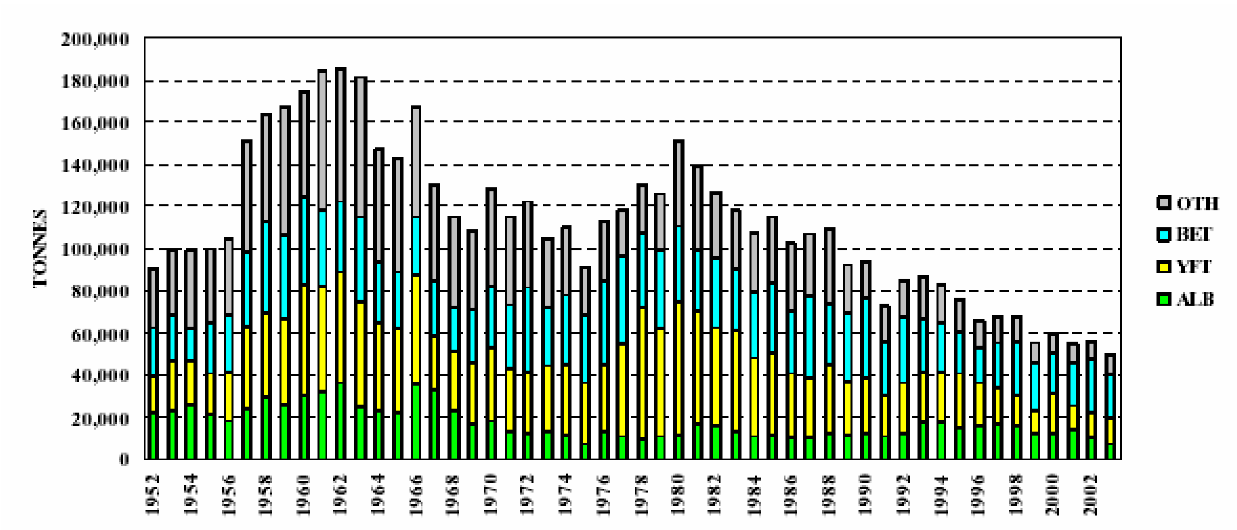


Figure 31. Species composition of the WCPO Japanese longline fleet, 1952 – 2003

(Source: Lawson 2004)

The Japanese longline fisheries are broadly categorized into:

- northern latitude fishery (albacore, bigeye, swordfish) (Coastal longline);
- a mid-latitude fishery near the CNMI (large albacore) (Distant water longline) ;
- an equatorial fishery concentrated near Nauru/Marshall Islands/Kiribati (bigeye and yellowfin) (Distant water longline);
- the Johnston Island and Hawaii region (bigeye) (Distant water longline); and
- the Eastern Pacific fishery (large bigeye) (Distant water longline) .

The longline vessels which fish for albacore, bigeye and swordfish in the northern hemisphere are classed by the Japanese as coastal longliners, although they do fish at considerable distances beyond the Japanese EEZ. The other longline fleets are classed by the Japanese as distant water longliners.

Figure 32 indicates the Japanese Pacific-wide longline catch for major species during the 2001 – 2002 period. The importance of bigeye to their longline fisheries is clearly indicated in all regions.

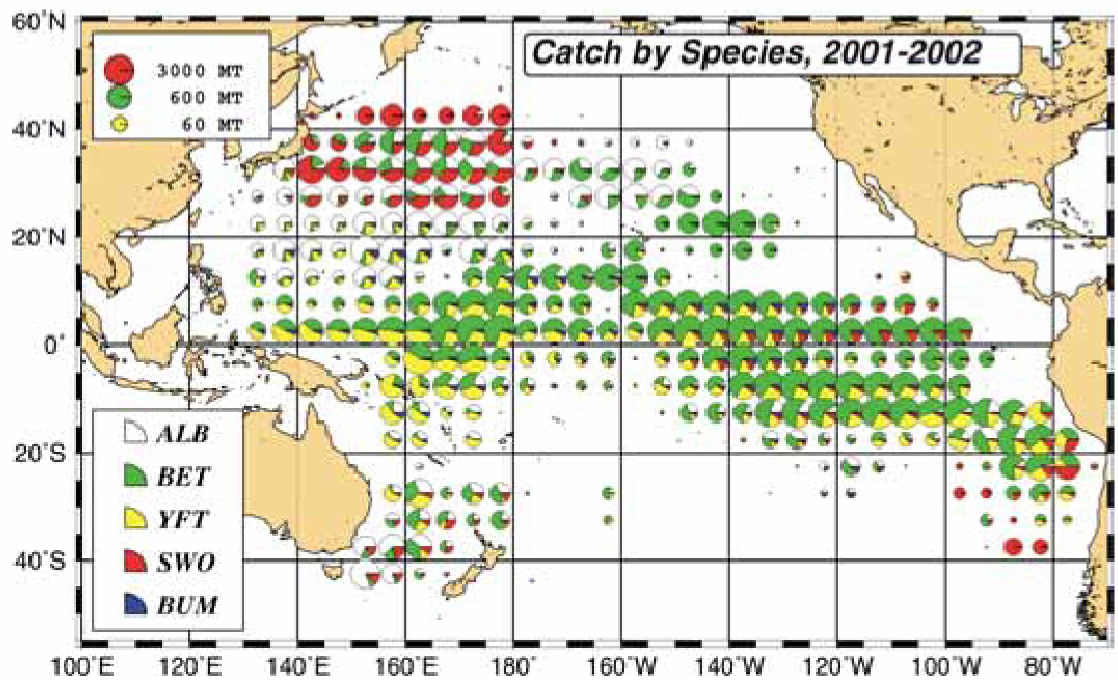


Figure 32. Japanese offshore and distant-water longline catch (weight) by species for 2001-2002 for the five main species. Note: ALB:albacore, BET:bigeye tuna, YFT: yellowfin tuna, SWO: swordfish, BUM: blue marlin (Source: Miyabe et al. 2004).

The Japanese distant-water and domestic pole-and-line fishery has been contracting steadily since the advent of large-scale tuna purse seining in the region. The fleet of 279 vessels in 1975 has shrunk to only 48 vessels in 2004. The most recent catch reported for Japanese WCPO pole-and-line vessels (2002) totaled 144,637 t consisting of 1,714 t of bigeye, 49,443 t of albacore, 2,501 t of yellowfin, 90,446 t of skipjack and 514 t of other species. The fishery targets equatorial skipjack for dried product and higher latitude fatty albacore and skipjack. However, some targeting of log associated bigeye tuna has been documented in equatorial waters (Tsukagoe 1981).

Japan purse seine fishery

Japanese purse seine effort in the WCPO has been stable at 35 vessels since the early 1980s as regulated by their industry. The distribution of effort is generally distributed between 10°N - 5°S and from 140°E to the Date Line. Fishing effort during 2002 was heavily concentrated in the Nauru and Gilbert Islands portion of Kiribati. Effort in 2003 was spread throughout the region with some concentration of activity in the far western area of the FSM EEZ. Total catch for 2003 was reported at 159,610 t consisting of 3,822 t of bigeye, 125,834 t of skipjack and 29,955 t of yellowfin. Length frequency data collected by the National Research Institute of Far Seas

Fisheries indicated most of the bigeye catch by purse seine was less than 70 cm as is typical of the fishery. Strong modes were evident at ~38 and 58-60 cm.

The amount of reported bigeye in purse seine landings is believed to be under-reported due to mixing of juvenile bigeye with yellowfin landings. The Japanese have gone to the trouble to critically examine this issue by comparing recorded landing data against species specific dock sampling (see Table 11). Results of these investigations indicate that bigeye catches in their fishery were under-estimated by 10 – 27% during the 1996 – 2002 period (Miyabe et al. 2004).

Table 11. Comparison of species composition between landing and corrected statistics for the Japanese western Pacific equatorial purse seine fishery, 1996-2003 (t).

(Source: Miyabe et al. 2004)

	Landings				Estimated by port sampling			
Year	**Bigeye**	**Yellowfin**	**Skipjack**	**Total**	**Bigeye**	**Yellowfin**	**Skipjack**	**Total**
1996	1,947	26,889	137,047	165,883	2,665	25,424	137,278	165,367
1997	11,638	49,665	84,805	146,109	13,082	49,745	84,732	147,559
1998	4,217	37,723	132,378	174,318	4,813	35,793	129,693	170,299
1999	4,882	43,304	116,017	164,203	5,667	42,520	115,600	163,787
2000	6,336	37,960	139,087	183,382	8,660	35,438	138,553	182,651
2001	8,657	43,074	113,030	164,761	9,567	42,080	113,004	164,652
2002	4,497	22,585	148,287	175,370	5,784	21,297	148,287	175,368
2003	3,822	29,955	125,834	159,610				

Several small-scale and coastal Japanese fisheries using vessels less than 20 GT take tropical tuna species. A total of 5,148 t of bigeye is reported by Miyabe et al. (2004) in 2002, taken primarily by coastal Japanese longline vessels.

Park (2001) examined the vessel characteristics of vessels operating in the FSM zone during the 1995 – 2001 period as documented by at-sea observers. Japanese vessels had the widest range in lengths of all fleets examined but had a consistently low power to length ratio, possibly due to lighter construction. Japanese vessels soaked gear in the daytime deep and hauled back in the afternoon and evening. Average setting times were 0500 – 0700 with hauling starting 1500 – 1600 hours. The Japanese longliners were smaller class vessels, setting their gear in 4 – 6 hours and hauling back in 9 – 13 hours. The boats made 1,400 – 2,700 hook sets, averaging 2,400 hooks per set. Larger vessels set more hooks. For the smaller ice boats delivering fresh sashimi grade product, trip lengths were about 3-4 weeks long. Effort was not clearly timed to moon phase, but there was some indication of increased activity during new moon phases, in contrast to the night-setting/night fishing activity of Chinese boats.

Republic of Korea

Republic of Korea longline fishery

More than 95% of South Korean tuna catch is taken from the Pacific Ocean, and the majority of that from the WCPO. All South Korean purse seine vessels and more than 98% of active longline vessels operate in the Pacific Ocean. A total Pacific catch of 225,581 t was realized from 20,575 t of bigeye, 153,328 t of skipjack, 49,883 t of yellowfin and 1,795 t of albacore (Yang et al. 2004)

A total of 183 South Korean longline vessels operated in the Pacific in 2003 taking 44,552 t of pelagics. Longliners operating in the WCPO took 24,142 t of tuna consisting of 9658 t of bigeye, 8,477 t of yellowfin, 1,452 t of albacore and 4,555 t of other species. These landings represented a significant decline in catch, most notably for bigeye (see Figure 33). Most of these vessels were relatively large and fell into the following size categories: 201-300 GT (1); 301-400 GT (75) and 401-500 GT (107 vessels). Vessel participation ranged around 170 in the 1998-2002 period when bigeye catches ranged from 16,000 - >21,000 t. In 2003, vessel numbers increased to 183 but catches of all species dropped significantly. The South Korean distant-water longline fleet, consisting mostly of large deep freezer boats operated in the central Pacific targeting bigeye tuna around the Line Islands of Kiribati (see Figure 34).

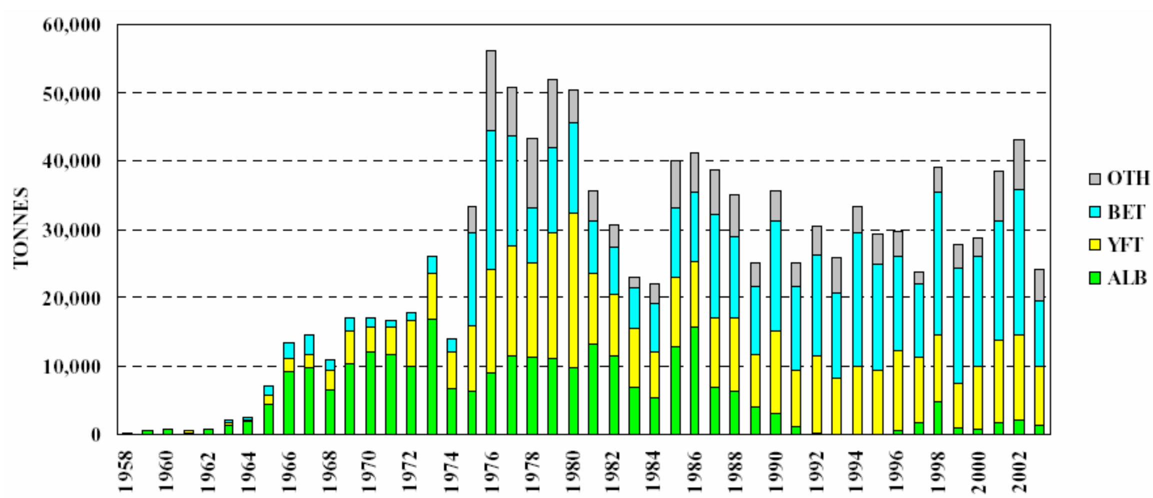


Figure 33. Landings(t) of bigeye (BET), yellowfin (YFT), albacore (ALB), and other species (OTH) by South Korean distant-water longliners in the WCPO during 2003 (Source: Lawson 2004)

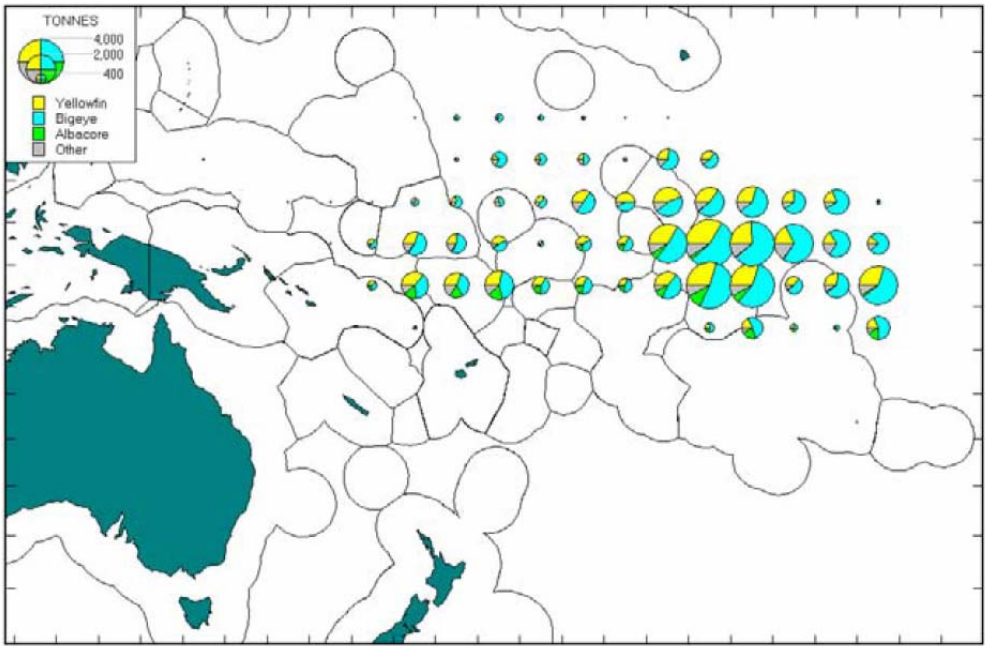


Figure 34. South Korean distant-water longline catch and effort by species. (Source: Lawson 2004)

Republic of Korea purse seine fishery

Purse seine effort in 2003 recorded 190,452 t consisting of 645 t of bigeye, 36,495 t of yellowfin and 153,312 t of skipjack. It is likely that the amount of bigeye in the catch is under-reported. However, the South Korean purse seine fleet prefers to set on free schools and has not adopted the drifting FAD technology commonly used by other fleets. Therefore, their bycatch of juvenile bigeye may actually be relatively low. The vessels are about evenly split between those above 1,001 GT and smaller vessels. Vessel numbers have been stable over the past five years and actually increased by one in 2003.

The South Korea Deep-Sea Fisheries Association (KODEFA) collects catch by gear type from the major fisheries. The National Fisheries Research and Development Institute (NFRDI) collects and compiles logsheet data which is used to determine species composition and area of catch.

A government observer program was initiated in 2002 and is expected to expand in the future to monitor all major fisheries.

Chinese Taipei

Chinese Taipei longline fishery

Chinese Taipei operates large longline and purse seine fleets in the WCPO. The total catches by major species over time and the spatial distribution of catches in 2003 are shown in Figures 35 and 36. Fisheries statistics are separated into distant-water purse seine (DWPS), fresh and/or chilled tuna longline (CTLL) and frozen tuna longline (FTLL) fisheries (OFDC/FA 2004). The

FTLL category corresponds to the "Taiwan Distant-Water Longline" category in Lawson (2004) while the CTLL category corresponds to the "Taiwan Offshore Domestic" and "Taiwan Offshore Foreign" categories combined. The fresh or chilled longline vessels operate near Taiwan and throughout the WCPO. Total catch of bigeye landed in Taiwan was 2,299 t in 2003 while landings of the CTLL fleet in other countries was 3,506 t (Lawson 2004, OFDC/FA 2004). Most of these vessels are less than 1,000 GT and use ice to store fresh product for export or direct consumption. The number of registered CTLL vessels in the Pacific was estimated at approximately 1,180 in 2003. The actual number and registry of this class of vessel is difficult to determine as they often shift between EEZs and target.

The FTLL vessels are larger, generally greater than 100 GT and operate beyond Taiwan waters in the EEZs of other countries or on the high seas. An estimated 142 TLL class vessels were active in 2003. These boats historically targeted albacore in mid and high latitudes for the canning industry. In recent years, more of these boats have equipped with lower temperature freezing systems to target tropical tuna for the Japanese frozen sashimi market. In 2003, FTLL vessels landed 4,332 t of bigeye from a total catch of 21,924 t.

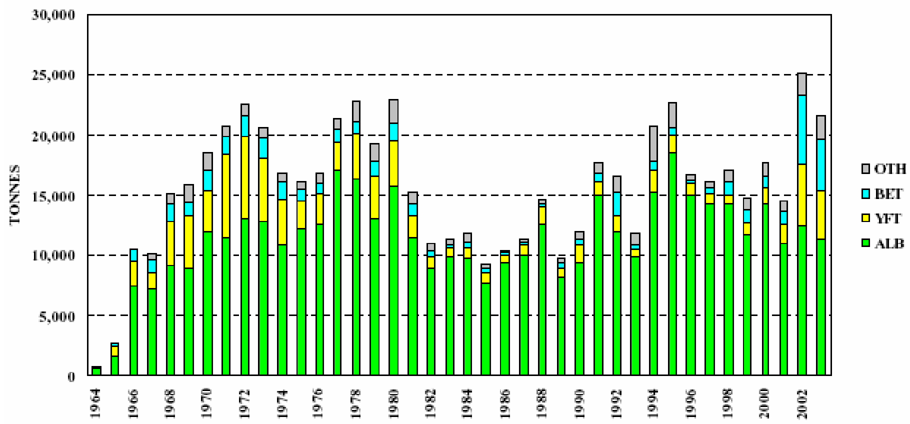


Figure 35. Species composition of the Chinese Taipei WCPO longline catch . (Source: Lawson 2004)

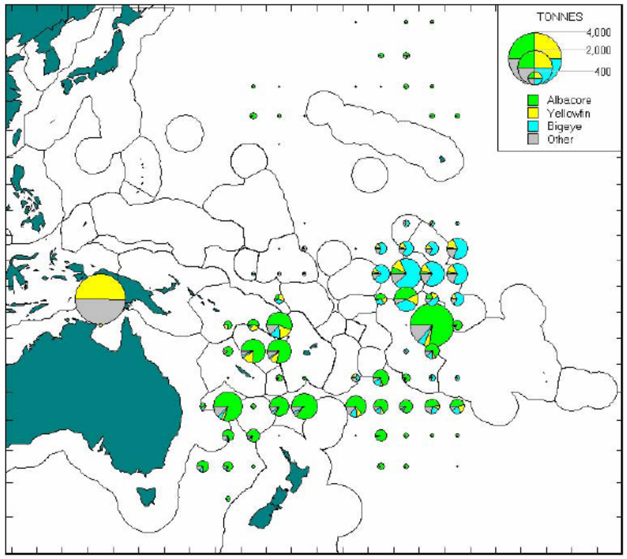


Figure 36. Chinese Taipei distant-water longline catch and effort by species. (Source: Lawson 2004)

Chinese Taipei purse seine fishery

The distant-water purse seine fishery has grown rapidly in the WCPO since its start in 1982 to be the largest purse seine fleet in the region. Currently, 42 vessels operate with 36 active in the WCPO during 2003. Total catch for the year was recorded at 201,317 t consisting of 2,767 t of bigeye, 29,058 t of yellowfin and 169,492 t of skipjack. The level of reporting of bigeye catch in the fishery (1.4%) is likely under reported due to a mixing of juvenile bigeye with yellowfin.

The fleet operates throughout the equatorial WCPO, apparently shifting eastward during El Niño conditions and contracting westward during La Niña years. During 2003, the fishery operated over a wide range between 140E to the Date Line but concentrating in the western portion of the fishery.

The government encourages the installation of VMS systems on distant-water freezer longline boats and virtually all distant-water purse seine vessels are so equipped. An experimental observer program was initiated in 2001 and is expanding gradually. During the 2002 – 2004 period, observers boarded distant-water freezer longline and purse seine vessels to collect detailed fishery data.

United States

U.S. longline fishery

The only significant domestic longline fishery targeting Pacific bigeye tuna at this time is based in Hawaii, while the Hawaii and American Samoa longline fleets both catch similar volumes of WCPO yellowfin tuna. Approximately 95% of Hawaii-based longline landings are from the WCPO and in 2003 a total of 3,653 t of bigeye, were reported harvested from this area, along with a total of 1,479 t of WCPO yellowfin tuna.

The Hawaii-based longline fishery began around 1917 and was based on fishing techniques brought to Hawaii by Japanese immigrants. During the 1980s, tuna longline effort began to expand to supply developing domestic and export markets for high quality fresh and sashimi grade tuna. In the late 1980s and early 1990s, the nature of the fishery changed completely with the arrival of swordfish and tuna targeting fishermen from longline fisheries of the Atlantic and Gulf states. Longline effort increased rapidly from 37 vessels in 1987 to 138 vessels in 1990 (Ito and Machado 2001). In 1985, the longline fishery surpassed landings of the skipjack pole-and-line fleet and has remained the largest Hawaii-based fishery to date. The influx of large, modern longline vessels promoted a revitalization of the fishery, and the fleet quickly adopted new technology to better target bigeye tuna at depth. The near-full adoption of monofilament mainline longline reels further modernized the fleet and improved profitability.

An emergency moratorium was placed on the rapidly expanding fishery in 1991. A limited access program was established in 1994 allowing for a maximum of 164 transferable longline permits for vessels ≤101 feet in overall length.

The relative importance of swordfish to the fishery declined during the mid 1990s following a 47% decrease in landings in 1994. The latter part of 1992 saw a stabilization of swordfish landings at close to 6.5 million pounds/year, a significant increase in shark take, primarily blue shark fins, and a gradual increase in tuna fishing effort and landings. Effort continued to shift away from swordfish and back to tuna targeted trips throughout the latter 1990s (WPRFMC 1997; 1998). In fact, most of the fishery always simply continued to fish tuna and bigeye remains the primary target species and mainstay of the fishery.

Vessels carry mandatory vessel monitoring systems monitored by the NMFS, must carry federal observers if requested, and must submit federal logsheets at the completion of every trip. The limited access program allows for 164 vessels in the fishery, but active vessel participation has been closer to 115 during the past decade. In 2003, 110 vessels participated in the fishery. Vessel sizes range up to nearly the maximum 100 foot limit, but the average size is closer to 65 – 70 ft. Almost all of the vessels are of steel construction and use flake ice to hold catch in fresh/chilled condition. A few older wooden boats persist in the fishery. Some of the boats have mechanical refrigeration that is used to conserve ice, but catch is not frozen in this fishery.

Tuna vessels may range out to 1,000 nmi but generally make trips within 500 nmi from the home port of Honolulu. Prime tuna fishing grounds lie to the south of the main Hawaiian Islands and towards Johnston Atoll. The swordfish grounds center around the sub-tropical convergence zone that forms north of the Hawaiian archipelago near 35°N.

Figure 37 provides a visual representation of the development of the Hawaii longline fishery since 1987. The dramatic spike in swordfish landings in the early 1990s is followed by a leveling off of catch throughout the decade. Swordfish landings dropped to near zero following the temporary shutdown of the swordfish sector due to interactions with sea turtles. During the entire period, tuna landings have increased steadily, likely due to increased effort resulting from increasing numbers of tuna targeting vessels and increasing number of hooks deployed per trip. When swordfishing stopped in 2001, a noticeable rise in bigeye landings and total tuna landings is clearly evident. Albacore and yellowfin landings have been generally stable throughout the period.

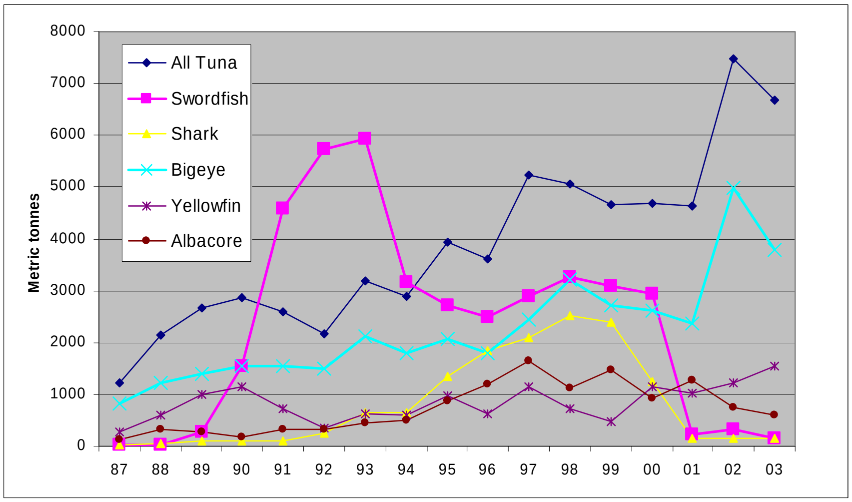


Figure 37. Total landings of the main species taken by the Hawaii-based pelagic longline fishery. (Source: WPRFMC, 2004b)

U.S. purse seine fishery

U.S. flag vessels operate throughout the central and western Pacific under conditions of the Treaty on Fisheries between the Governments of Certain Pacific Islands States and the Government of the United States of America; otherwise knows as the South Pacific Tuna Treaty (SPTT) or Tuna Treaty. This multi-lateral agreement provides the U.S. fleet with widespread access to the waters of 16 Pacific Island countries from Palau in the west to the Cook Islands and the Line Islands of Kiribati to the east. The fleet is monitored by the Forum Fisheries Agency (FFA) that administers the compliance related issues and the NMFS in conjunction with the Secretariat of the Pacific Community for catch, effort and economic data. Vessel activity is monitored via detailed logbooks, cannery landing receipts, national surveillance activities, observers and port sampling. Gillett et al. (2002) provides a detailed description of the development and status of the U.S. western Pacific purse seine fleet.

Purse seine vessels must also be entered into the FFA, Regional Register of Foreign Fishing Vessels and the FFA Vessel Monitoring System (VMS) Register, which implies that they have operational VMS equipment. The vessel must be a member in good standing on both registers to obtain fishery access to any FFA member states, which includes all Pacific Island Countries (PICs) or the central and western Pacific. Total access numbers to the FFA region are controlled by the Palau Arrangement for the Management of the Purse Seine Fishery in the Western and Central Pacific (Palau Arrangement or PA) which was developed by the Parties to the Nauru Agreement (PNA), made effective in November 1995. The Palau Arrangement set a total limit of 205 purse seine licenses for operation in the region and allocated these by national fleet. The current PA was re-negotiated in May 2004 which allocated the U.S. fleet 40 possible licenses. During 2004, 21 U.S. purse seine vessels were active in the WCPO.

The fleet size has been contracting steadily since a Treaty high of 49 active vessels in 1994 to 26 vessels reported as active in 2003 (Ito et al. 2004). Total catch by the fleet during 2003 was 87,994 t of which 2,628 t was bigeye tuna representing only 3 % of the catch. Skipjack and yellowfin made up 72% (65,995 t) and 25% (21,998 t) of the total catch in a ratio that is typical of the WCPO fishery. Port sampling of catch in Pago Pago, American Samoa measured 8,537 bigeye tuna sampled during the unloading process. A single mode was evident, at approximately 58 cm which is a typical size of bigeye taken by purse seine gear on floating object sets. Almost all bigeye catch by purse seine in the WCPO is taken from floating object sets. Fishing effort shifted to the west during 2003 as is typical of a non-El Niño year, closer to New Guinea and the Solomon Islands, resulting in an increase in sets in sets on natural drift logs. As a result, combined floating object sets increased in overall, with 24% of effort on logs and 32% on drifting FADs. FAD use peaked in the U.S. fishery in 1999, an El Niña year. When other purse seine fleets were fishing in the Western Pacific, the U.S. fleet fished the Central Pacific using FADs, and minimized their steaming times to their home port of Pago Pago in American Samoa. Since that time FAD use has declined to less than 20% of sets in 2003 (Coan et al. 2004). The decline in FAD use after 1999 was concomitant with a shift in fishing to the West, where sets on free schools of skipjack predominated (53%) in 2003), although this has also been matched by an increase in log sets (29%). Any sets around floating objects such as logs (washed down rivers from the Asian mainland or the large Southeast Asian and Pacific Island archipelagos) or FADs will catch juvenile bigeye and yellowfin tuna, thus measures to curb such fishing by limiting FADs will reduce catches of the juveniles of these species.

Although domestic purse seine vessels at times fish in EEZ waters around the PRIA, and are prohibited from fishing within 50 miles of American Samoa under the Pelagics FMP, in general they are not currently regarded as being managed under the FMP.

U.S. distant-water pelagic troll fishery

U.S. troll vessels based primarily in California, Oregon and Washington engage in a surface troll fishery for juvenile albacore in the north and south central Pacific Ocean. Fourteen vessels operated in the southern fishery during the 2002-2003 season, taking 1,205 t of albacore (Ito et al. 2004). These vessels are monitored by mandatory NMFS logbook reporting, cannery receipts, port sampling programs and occasional observers. The fishery is characterized by little or no bycatch and bigeye tuna are not normally taken by the fisheries.

10.8.1.3 Coastal Fisheries and Landings

Pacific Islands and Territories Bigeye and Yellowfin fisheries (including American Samoa and Hawaii domestic)

Several Pacific Island countries and territories have developing longline fisheries that either target or take bigeye tuna and yellowfin tuna are also taken. Some of these are extremely small test fisheries while others represent significant sources of income, employment and export revenue. Indonesia also has a large domestic pole-and-line fishery that harvests some bigeye and yellowfin from FAD associated schools and some countries have domestic or joint venture purse seine fisheries. Table 12 summarizes the fleet or effort levels of these countries and territories with recent estimates of tropical tuna longline landings from WCPFC (2005) and National Fishery Reports from individual countries submitted to the First Regular Session of the Scientific Committee of the WCPFC held in Noumea, New Caledonia, August 2005. Total estimated landings of bigeye in 2004 from this group come to 5,863 t and range from a high of 1254 t taken by Fiji to one t harvested in Kiribati. Total estimated landings of yellowfin in 2004 from this group come to 22,899 t and range from a high of 4,164 t taken by Fiji to one t harvested by Nauru. Percentages of each species or species group are provided by country.

Figures 38 and 39 provide the same information in a graphical format for bigeye and yellowfin tuna to quickly highlight which are the main fishers of these species in the region. Australia, Fiji and Indonesia each harvested over over 600 t of bigeye during 2004. Yellowfin harvests are higher with Indonesia and Fiji harvesting 6,810 t and 4,164 t in 2004. However, in general landings are very low compared to DWFN activity. Each country's fishery is discussed in the following sections.

Table 12. Numbers of 2004 active vessels and estimated landings (t) of bigeye, yellowfin, albacore and other pelagics by Pacific island countries and territories of the WCPO
(Source: WCPFC 2005)

Country or territory	Vessels active	Data notes	Albacore Catch	Albacore %	Bigeye Catch	Bigeye %	Yellowfin Catch	Yellowfin %	Other Catch	Other %	Total catch
American Samoa	40	all data '04	2,462	10%	227	4%	888	4%	496	4%	4,073
Australia	124	all data '04	658	3%	784	13%	1,948	9%	2,125	17%	5,515
Cook Islands	33	all data '04	1,630	6%	343	6%	458	2%	573	5%	3,004
FSM	18	all data '04	0	0%	520	9%	207	1%	122	1%	849
Fiji	84	all data '04	11,290	45%	1,254	21%	4,164	18%	2,909	24%	19,617
French Polynesia	75	all data '04	2,164	9%	495	8%	1,042	5%	1,458	12%	5,159
Indonesia	293 (*1994)	*catch data '04	?	NA	641	11%	6,810	30%	?	NA	7,451
Kiribati	2 (*2003)	*catch data '03	0	0%	1	0%	2	0%	5	0%	8

Country or territory	Vessels active	Data notes	Albacore Catch	%	Bigeye Catch	%	Yellowfin Catch	%	Other Catch	%	Total catch
Nauru	2	all data '04	0	0%	0	0%	1	0%	0	0%	1
New Caledonia	27	all data '04	1,468	6%	90	2%	631	3%	427	4%	2,616
New Zealand	99	all data '04	1,360	5%	177	3%	0	0%	982	8%	2,519
Palau	1	all data '04	0	0%	7	0%	28	0%	2	0%	37
Papua New Guinea	50	all data '04	1,640	7%	396	7%	2,526	11%	1602	13%	6,164
Philippines	14 (*2000)	*catch data '04	0	0%	243	4%	2,579	11%	982	8%	3,804
Samoa	17	all data '04	1,232	5%	104	2%	444	2%	155	1%	1,935
Solomon Islands	9	all data '04	267	1%	357	6%	538	2%	12	0%	1,174
Tonga	22	all data '04	182	1%	40	1%	163	1%	137	1%	522
Vanuatu	31	all data '04	820	3%	184	3%	470	2%	181	1%	1,655
Totals			**25,173**		**5,863**		**22,899**		**12,168**		

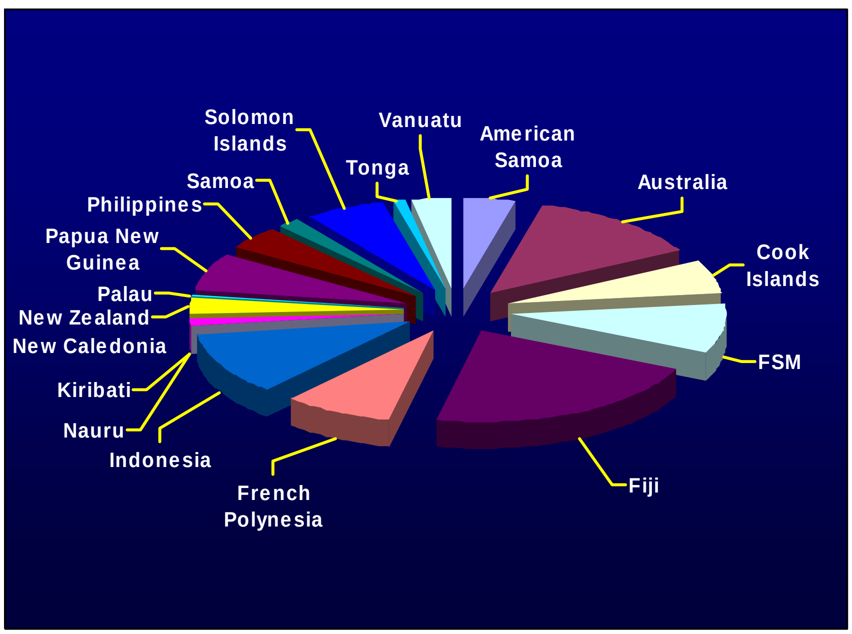


Figure 38. Proportions of 2004 bigeye catch by Pacific Island countries and territories.
(Source: WCPFC 2005)

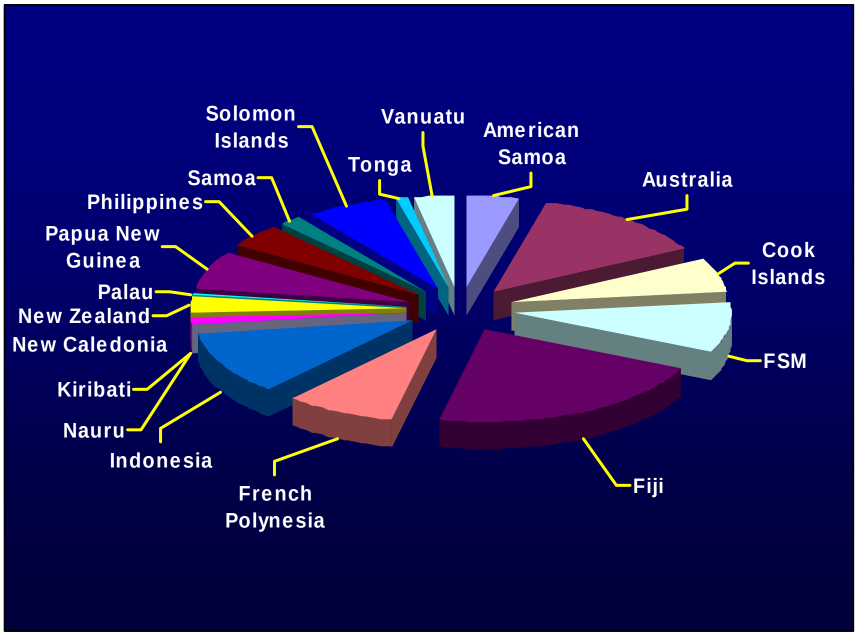


Figure 39. Proportions of 2004 yellowfin catch by Pacific Island countries and territories. (Source: WCPFC 2005)

The domestic fisheries of the Pacific island nations and territories with specific reference to landings of bigeye and yellowfin are described in this section[9]. A brief description of the fisheries, recent catches by major categories, areas fished, seasonality, fleet descriptions, targeting and any available details on fishing mode or strategy are provided for: Australia, the Cook Islands, the Federated States of Micronesia, Fiji, French Polynesia, Indonesia, Kiribati, Nauru, New Caledonia, New Zealand, Palau, Papua New Guinea, the Philippines, Samoa, the Solomon Islands, Tonga and Vanuatu. In some cases, fishery harvests are taken by local domestic vessels, in others harvesting rights are leased to other nations, and in many cases there is a combination of harvesters.

Australia

The Australian east coast was at one time heavily exploited by Japanese longline vessels operating under bilateral access arrangements. Access to the zone was closed to foreign fishing in 1997 followed by a significant expansion of domestic longline activity. Currently, three major longline fishing grounds are recognized: at 1) south of 34° S. in cool water for high grade yellowfin and bigeye; 2) off Cairns in the Coral Sea around 16 - 17° S. for seasonally abundant bigeye and yellowfin resources; and 3) offshore from Mooloolaba around 24-28° S. for swordfish but also taking yellowfin and bigeye tunas (Ward and Bromhead 2004). The number of active Australian tuna longline vessels has increased steadily in recent years and is in the range of 134 – 146 vessels depending on information source. Catch figures also vary slightly but not significantly. Lawson (2004) lists a total catch of 8,197 t consisting of 901 t of bigeye, 3,110 t of yellowfin, 487 t of albacore and 3,699 t of other pelagics, significantly swordfish.

[9] American Samoa is included in the table but is described in detail in a previous section on U.S. Pacific fisheries.

Tuna fishing trips normally last one week with the catch stored on ice, ice brine or refrigerated sea water. A typical Australian tuna longline vessel will set 900 hooks in a daytime deep set to target large bigeye and yellowfin. Continuous, monofilament longline gear on one or two hydraulic spools are common and used in conjunction with a line shooter to deepen the set. Swordfish boats make longer trips and make the typical shallow night sets with chemical light sticks or artificial lights to attract swordfish. High quality tuna is air freighted to Japan for the fresh sashimi market while lesser grade fish is sold on the domestic sashimi market. Most swordfish is air freighted to west coast U.S. markets but is also sent to Japan. Domestic consumption of tuna and swordfish continues to grow.

The fishery is now monitored by a government observer program targeting 5% coverage and all vessels are required to submit set level logsheet data. The Australian Fisheries Management Authority manages the domestic longline fishery operating within the Australian EEZ. Various management mechanisms are in place including limited entry by areas, VMS requirements, seabird mitigation measures and limits on the take of some bycatch. For example, the commercial sale of marlin species is forbidden. A new management plan will come into effect in the near future that will set limits on the number of hooks set by the fishery. Computer VMS with integrated real-time monitoring of mainline drum activity will be an integral part of the monitoring and enforcement.

Cook Islands

Marurai (2004) provides recent information on the Cook Islands domestic longline fishery. The industry was initiated through the licensing of foreign fishing vessels based in Pago Pago, American Samoa. Foreign licensing was suspended in 2000 aside from joint venture charter arrangements with domestic interests. The domestic fishery expanded rapidly from 19 to 46 vessels during the 2002 – 2004 period. The northern fishery targets frozen albacore for the Pago Pago canneries while the southern water fishery concentrates on fresh iced bigeye, yellowfin and swordfish for export. The fleet consists of vessels ranging from 10 to 34 m or six to 281 GT. Catches of bigeye dropped from 200 t in 2003 to 124.5 t in 2004.

Federated States of Micronesia

Retalmai (2004) reported 25 FSM domestic longline boats operating in 2003 with a total catch of 574 t, 402 t of which was bigeye from logsheet data. This is a significant difference from that reported by Lawson (2004) for 26 FSM longline vessels landing 620 t of bigeye out of a total catch of 1,018 t. It is assumed the SPC dataset of Lawson is more complete.

Fiji

Domestic longline effort has increased significantly in recent years, with 101 vessels licensed and operating in 2003. The fleet size is regulated to a maximum of domestic 110 vessels. Most of the effort took place within the Fiji EEZ although fishing also took place in the neighboring EEZ of Vanuatu and the Solomon Islands and high seas area to the south. Catch and effort logsheets are submitted to the Fiji Fisheries Department as required by the fishing license. The fishery is also monitored by a domestic observer program. The fishery is primarily based on albacore with significant landings of yellowfin, bigeye, blue marlin and swordfish. Total landings reported by Amoe (2004) were 12,205 t, of which 886 t was bigeye tuna.

French Polynesia

In 2003, the domestic longline fleet consisted of converted skipjack pole boats (5), 37 ice boats and 22 larger steel boats capable of freezing (Ponsonnet 2004). The converted skipjack boats have very limited range and deploy only 610 hook/set on average. The number of these boats is declining due to limited profitability. Ice boats can operate up to about 350 nmi from the main port of Papeete. The freezer vessels can stat at sea for 1 to 2 months and process albacore onboard by cleaning and freezing loins. The primary target species is albacore, with bigeye and yellowfin tuna making up 7% and 10% of landings in 2003. Total catch during this year was 6530 t, of which 439 t was bigeye tuna. Bigeye tuna are not generally targeted by the fishery but are more often caught near seamounts and at latitudes of 12 - 14°S. Bigeye appear to be more abundant in the Marquesas area between May – August.

Indonesia

The tuna resources of Indonesia are immense and currently exploited by a well developed domestic pole-and-line fleet targeting skipjack, extensive handline fisheries for small and large tunas, longline fleets targeting large tuna and purse seine vessels taking mainly skipjack and yellowfin. Reporting and documentation of the catch is rudimentary at best and a subject of great concern considering the magnitude of harvest and potential impact on yellowfin and bigeye resources. Estimates of total landings for tropical tunas have been close to 300,000 t in recent years (Figure 40).

Lawson (2004) provides estimates of bigeye catches from all sectors of the domestic fisheries of Indonesia, suggesting a total catch of 11,221 t in 2003 from the pole-and-line (1,135 t), handline (1,030 t), longline (770 t), purse seine (954 t) and other gears (7,332 t). These estimates were derived by allocating a proportion of estimates of total yellowfin catch for the inclusion of bigeye at 8.6 % of yellowfin longline landings, and 10% of pole-and-line and purse seine yellowfin landings (Hampton et al. 1998a).

Indonesian tuna fisheries are monitored by the Research Institute for Marine Fisheries which was the source for catch estimates provided by Lawson (2004).

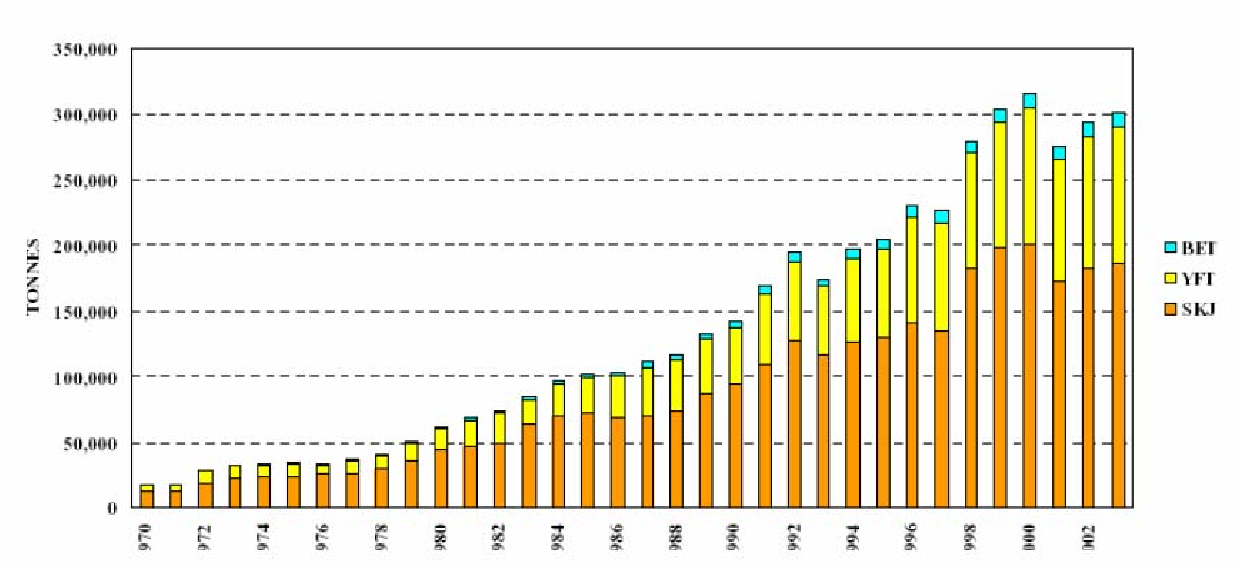


Figure 40. Estimated catches (t) of bigeye, yellowfin and skipjack by Indonesian domestic fisheries . (Source: Lawson 2004)

Kiribati

Since gaining independence in 1979, Kiribati has been heavily dependent on the licensing of DWFN fleets to gain benefit from her living marine resources. Approximately 250 – 350 foreign vessels have been licensed to operate in the huge EEZ that straddles some of the richest tuna habitat in the central Pacific. Revenues from fishing access agreements totaled A$31.4 million in 2003 (Awira 2004). DWFN purse seine activity concentrates in the Gilbert and Phoenix Island groups while longline fishing is more concentrated around the Line Islands. However, purse seine activity is known to shift eastward to the Line Islands in strong El Niño years. The estimated DWFN bigeye catch in the Kiribati EEZ was 6,000 t in 2003.

The primary domestic pelagic fishery involves an artisanal scale pole-and-line fishery for skipjack for local consumption. One joint venture purse seine vessel operated in 2003 and one or two small scale longline vessels operated on a trial basis. Landings of bigeye by the Kiribati domestic fleet were negligible during 2003.

Republic of the Marshall Islands

The Republic of the Marshall Islands (RMI) maintains fishery access agreements with several DWFN entities for all main gear types. During 2003, multilateral purse seine agreements were in effect with the U.S. and the FSM Arrangement. Purse seine and longline agreements were in place with China, Japan, South Korea, and Chinese Taipei with additional purse seine access brokered with Vanuatu and New Zealand flag vessels (Joseph 2004). Limited pole-and-line activity by Japanese vessels also took place during 2003. Purse seine production within the EEZ was down in 2003 while longline activity was stable with some increase in yellowfin and bigeye landings.

Combined longline activity in 2003 landed a total of 3,367 t consisting of 2,104 t of bigeye, 832 t of yellowfin and 430 t of other species (Joseph 2004). Most of the longline effort was concentrated in the southern region of the zone between the FSM and Kiribati EEZs. Combined bigeye landings by all purse seine fleets operating in the zone during 2003 are listed at only 32 t of a total catch of 3,643 t. Purse seine effort was strongly concentrated in the southern EEZ and close to Majuro Atoll.

Six purse seine vessels are flagged to the RMI and operate throughout the WCPO under the Palau Arrangement. These vessels fished between 145°E - 170°W during 2003 landing 37,875 t of tuna (35,272 t skipjack: 2,603 t yellowfin). No bigeye landings were reported by these vessels, which likely represents an issue with landings of bigeye being reported as yellowfin.

The RMI has a well developed domestic observer and port sampling program maintained by the Marshall Islands Marine Resources Authority (MIMRA) and supported by the SPC/OFP. All fleets are monitored by these activities as well as via submission of logsheet data. MIMRA is currently developing a National Tuna Management Plan in line with the newly established Western and Central Pacific Fishery Convention.

New Caledonia

The New Caledonia domestic longline fishery has been expanding steadily in recent years, with 29 vessels (28 active) in 2003 comprised of 18 <50 GT and 18 larger vessels to 200 GT (Etaix-Bonin 2004). Originally, it was hoped that the fishery would be able to target bigeye tuna, but albacore has become the main portion of the catch. Albacore catches also declined in 2002 when a total of 2,466 t was landed. Bigeye tuna made up only 142 t (6%) of the catch. The vessels are monitored by logsheets that are compiled by the SPC Oceanic Fisheries Programme. The local government also plans to implement VMS on domestic vessels in 2005.

New Zealand

Domestic tuna fisheries within the New Zealand EEZ concentrate on albacore, bigeye tuna, Pacific bluefin (*Thunnus orientalis*) and southern bluefin tuna (*T. maccoyii*) and skipjack. Small landings of yellowfin tuna are also taken seasonally. Tuna and swordfish landings peaked in 2000, declining to around 11,000 t/year since 2001 (Kendrick et al. 2004). Purse seine, longline and troll gear take about one third each of the total pelagic catch with skipjack and albacore accounting for almost all of purse seine and troll landings respectively.

Longline effort targets bigeye and southern bluefin tuna due to their high value on the sashimi market but albacore make up the bulk of the longline catch. Bigeye tuna are taken mainly by longline gear but may be least available in May and June. A small amount (0.4 t) of bigeye tuna were reported taken by troll gear in 2003. Longline bigeye landings peaked in 2001 at 480 t but decreased to 157 t in 2003. A significant factor in reduced landings was a near halving of the number of dedicated NZ flag longline vessels operating in the EEZ during 2003; from 83 vessels in 2002 to 48 vessels in 2003.

A small number of New Zealand flag purse seiners have operated within the equatorial western Pacific fishery under the FSM Arrangement within EEZs of PICs or in high seas areas. Four New Zealand purse seiners took 18,000 t in the fishery during 2003 of which ~80% was skipjack and ~20 % yellowfin tuna. It was estimated that approximately 10 t of bigeye tuna were taken by these purse seiners during 2003 in the equatorial fishery.

Palau

Tuna fisheries in Palau mainly refers to the licensing of DWFN longline and purse seine effort through the Fishing Agreements between Palau and the Four Fishing Associations of Japan, the U.S. South Pacific Tuna Treaty, and the Uniform Fishing Agreement that exists between three locally based foreign fishing companies (Sisior 2004). However, Palauan-owned companies have obtained fishery agreements with the government but have not begun operations as of 2004.

Domestic companies have licensed Chinese longline activity in the EEZ since the late 1980s. However, their participation has declined in recent years due to competition with Taiwanese longline vessels. The Japanese are licensed to operate pole-and-line, longline and purse seine gear within the EEZ through bilateral agreements.

Longline activity by the main fleets (China and Chinese Taipei) peaks in the second half of the year with Chinese effort peaking during the full moon period of each month. Catch is monitored by logsheets and port sampling that also cross-checks logsheet data. Yellowfin is the main catch (~50%) followed by bigeye tuna (~20%). Best estimates from logsheet and port sampling data of bigeye landings by Taiwanese, Chinese, Japanese and Palau joint venture fleets for 2003 were 560 t, 47 t, 5 t and 1 t respectively (Sisior 2004). Fluctuations in fishing effort due to fleets moving between PIC EEZs and the general decline in Chinese participation appear to most strongly influence fluctuating inter-annual catches. Size frequency data of port sampled bigeye landings in 2003 have a bi-modal distribution around 135 and 158 cm.

Papua New Guinea

The diverse pelagic fisheries of Papua New Guinea (PNG) are guided by a domestic National Tuna Fishery Management Plan that establishes a management structure for large-scale fisheries that includes license limits and total allowable catch levels (TACs) for some species. Currently, a longline TAC of 10,000 t of yellowfin and bigeye has been established.

Currently, tuna fishing effort in the PNG EEZ (2004) consists of domestic longline vessels (42 licenses), domestic purse seine (16 licenses) locally-based foreign purse seine (16 licenses), bilateral foreign purse seine (76 licenses), U.S. Multilateral purse seine (25 active) and 8 additional non-PNG flag purse seiners operating under the FSM Arrangement. A trial project is investigating the use of Philippine style handline gear to land large yellowfin and bigeye tuna on anchored FADs. There is no foreign longline activity permitted in the zone following the institution of a national policy to in 1995 to domesticate the longline industry.

Raised estimates of tuna longline catch for 2003 were 1,686 t of yellowfin, 366 t of bigeye and 857 t of albacore from a total catch of 4,389 t (Kumoru 2004). Most of the catch comes from the

Coral and Solomon Seas in the central and southern areas. However, higher catch rates and proportion of bigeye in the catch are found in the northern EEZ around the Bismarck Archipelago. The longline bigeye catch in 2003 was the highest on record, but this may be influenced by recent improvements in reporting.

Total purse seine catches (domestic and otherwise) in the PNG EEZ reached a historical high in 2003 of 370,153 t. Purse seine landings within the PNG EEZ by the different domestic and foreign sectors of the fishery are listed in Table 13. Purse seine effort and landings of tropical tunas are high during non-El Niño years such as during 2003. Skipjack makes up more than 70% of reported purse seine catches with most of the remainder reported as yellowfin. Reported landings of bigeye by purse seiners operating in PNG are very low and likely to be under-reported. For example, bigeye landings from logsheet data during 2003 totaled only 76 t from a total catch of 107,001 t, or only 0.07% of the catch.

Table 13. 2003 bigeye catch by domestic and foreign sectors of the PNG purse seine fishery.

Sector	Bigeye catch (t)
Domestic and locally based foreign	107,001
Taiwan	104,742
Philippine foreign access	31,926
USA	29,389
FSM arrangement	16,330
China	6,292
Total	370,153

A significant proportion of purse seine effort in PNG waters takes place on drifting logs, FADs and anchored FADs that are known to have the highest proportion of bigeye for any purse seine set type (Bailey and Hampton 1991). Specifically, the PNG domestic, locally based foreign and licensed Philippine flag purse seiners work almost exclusively on large arrays of anchored FADs in the Bismarck Archipelago. These fleets, particularly those that work in conjunction with transshipment operations to motherships are targeted for 100% observer coverage. Results from the PNG domestic observer program indicate that the percentage of bigeye in the catch is highest in log and FAD sets and particularly high in anchored FAD sets by PNG domestic and Philippine flag fleets (Kumoru 2003). The combined yellowfin plus bigeye landings by these fleets exceeded 60% for FAD associated sets. Observed bigeye catches in 2002 for FAD sets were 15% and 20% for the PNG and Philippine fleets as compared to ~zero and 1 % for unassociated sets. This suggests that actual landings of bigeye in the fishery may be significantly under-reported.

As noted, the fisheries of PNG are monitored by an active observer and port sampling program and the collection and compilation of logsheet and landing data through the coordination of the SPC Oceanic Fisheries Programme. Fisheries management and development are guided by the Fisheries Management Act of 1999 that established the National Tuna Fishery Management Plan. A National Fish Aggregating Device Management Policy monitors the number, design, reporting and related data collection on anchored FADs set within the PNG EEZ. Currently, the maximum number of FADs is set at 1,000 with a limit of three tender/support vessels per catcher vessel (Kumoru 2003).

Philippines

The fishery situation in the Philippines is similar to Indonesia having a huge tuna resource with large and diverse fisheries whose catch and effort parameters are poorly and recorded and reported. However, the fisheries of the Philippines have been described in detail making more accurate catch estimates possible (see de Jesus 1982). Barut (2003) provides a description of Philippine domestic fisheries production, market flow and fleets as of 2002. Unlike Indonesia, there is no domestic pole-and-line fishery in the Philippines, but handline fisheries for large tuna and a mix of small purse seine fisheries are well developed. The estimated landings of bigeye, yellowfin and skipjack by Philippine domestic fisheries over time are represented in Figure 41.

Lawson (2004) provides estimates for Philippine bigeye take in 2003 at 11,634 t consisting of landings by gillnet (346 t), hook and line (6,402 t), longline (238 t), purse seine (3,108 t), ringnet (796 t) and unclassified gears (744 t). Hook and line fisheries target large yellowfin and bigeye, generally found in association with anchored FADs. Barut (2003) estimated approximately 10,000 domestic tuna handline vessels were active throughout the country. Handline vessels are of a characteristic double outrigger monohull design with small gasoline or diesel inboard engines. Crew sizes of about six make 6 to 10 day trips often in the Moro Gulf or northern Celebes Sea. Fishermen deploy single hook handlines baited with small tunas or scads at depth during the daytime. The catch is held on ice and graded on return to port. Better grade fish may be exported to Japan for the sashimi market. Lower grade fish goes to domestic canneries or enters domestic fresh markets or may be processed with carbon monoxide in the production of "tasteless smoke" tuna for export. The production of carbon monoxide treated tuna is a rapidly expanding sector of the fishery.

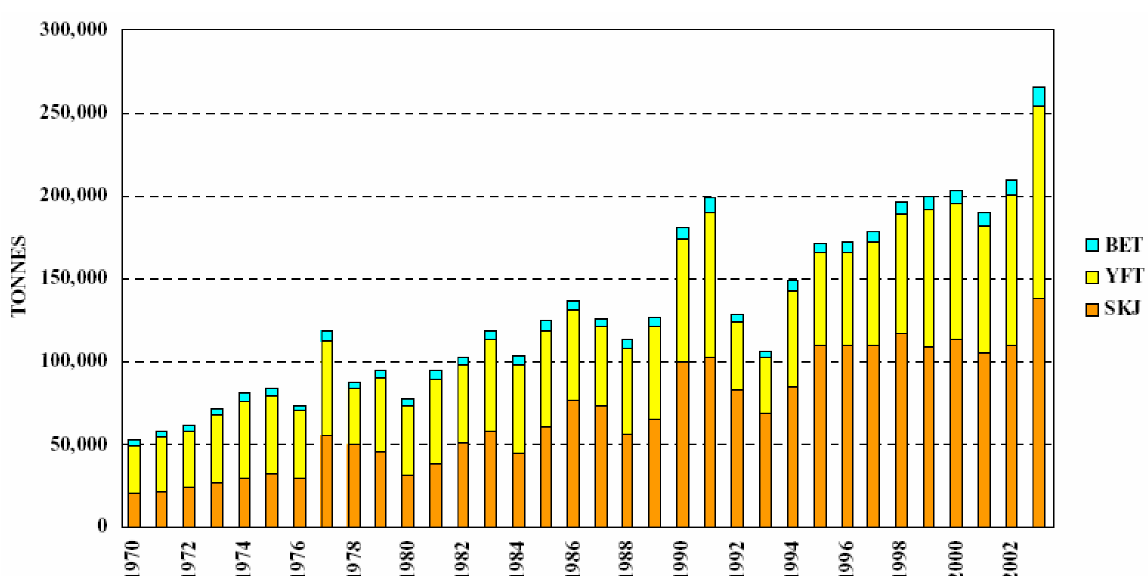


Figure 41. Estimated catches (t) of bigeye, yellowfin and skipjack by Philippine domestic fisheries. (Source: Lawson 2004)

Skipjack, small yellowfin and bigeye are taken by purse seine and ringnet gears and supply domestic canneries. Major markets for Philippine canned tuna were listed in order of importance (2002) as Canada, Germany and Singapore. Aside from canned product, tuna is exported as smoked/dried product primarily to Japan and as fresh/chilled or frozen product to Japan, Thailand, U.S.A, Hong Kong and other countries (Barut 2003).

Fisheries catch and efforts are ongoing but have experienced significant disruptions in the past due to funding constraints. Fisheries data is collected and compiled by the Bureau of Fisheries and Aquatic Resources.

Samoa

In Samoa, a domestic longline fishery has developed rapidly, targeting albacore for export to canneries in neighboring American Samoa. Landings consist of approximately 79% albacore, 8.6% yellowfin, 3% bigeye and 9.4% miscellaneous species (Imo et al. 2004). The fishery was originally established with small outboard catamaran vessels that have largely exited the fishery due to low profitability and catches in recent years. Recent data indicates only 3 vessels <12.5 m and 14 larger vessels were active in the fishery during 2004.

Total landings declined sharply in 2003 from around 5,000/year to 2,846 t due mainly to a sharp decrease in albacore landings. Bigeye landings appear to be relatively stable, with 110 t landed in 2003 representing 3.9% of total catch. Detailed length frequency data is available for the fishery in recent years, but clear patterns are not evident supporting strong inter-annual and possibly seasonal shifts in local availability. In 2003, the larger size classes of both yellowfin and bigeye were not taken by the fishery, with bigeye length modes closer to 70 and 90 cm. In 2003, it was reported that 42.9 t of bigeye was exported valued at 591,324 S$.
Longline vessel activity is monitored by a port sampling program combined with a visual census of boats in port and supported by logsheet data from the larger vessels.

Solomon Islands

Tuna fisheries in the Solomon Islands are split between a diverse domestic fleet accounting for 46% of landings and foreign fleets that land 54% of the total (Oreihaka 2004). The domestic fisheries are still recovering extensive civil unrest in recent, particularly for the domestic pole-and-line and purse seine fisheries. Domestic arrangements currently license purse seine, pole-and-line and longline operations. Japanese (PL, LL, PS), Taiwanese (LL, PS) and South Korean (LL, PS) operate under bilateral agreements while U.S. purse seiners utilize part of the EEZ under conditions of the U.S.MLT. Tuna fishing negotiations are also underway with the European Union (EU) and New Zealand.

A total catch of 27,462 t was reported by Solomon Islands domestic tuna fisheries (all gears) lead by purse seine caught skipjack and yellowfin. A total domestic catch of 980 t of bigeye was reported from single purse seine (13 t) and longline vessels (967 t). The longline catch was reported from 12 active vessels during 2003. Bigeye tuna represented the majority of longline landings (65.6%) followed by yellowfin (362 t) and albacore (122 t) from a total longline catch of 1,474 t (Oreihaka 2004).

A domestic observer program monitors all domestic fleets (PS, LL, PL) but the port sampling program has been suspended due to lack of funding. Catch and effort data for domestic and foreign fleets are collected and processed by Solomon Islands Fisheries and the SPC/OFP.

Tonga

Tonga was one of the first Pacific island countries to develop a domestic longline fishery. In 2003, 33 domestic longline vessels were registered consisting of 17 domestic, 14 foreign joint venture and 2 government-owned vessels (Matoto 2004). These vessels landed 287 t of pelagics in 2003 consisting of 660 t of albacore, 227 t of yellowfin, 80 t of bigeye, 40 t of marlin and 14 t of swordfish. The fleet size contracted to 22 vessels due to reductions in participation by domestic and joint venture vessels. The fleet ranges in size from 18 – 39 m with an average size of 24 m.

The fishery is monitored by logsheet data and a national observer program. Domestic vessels are required to carry national VMS systems and locally based joint venture vessels are required to carry FFA VMS systems. An effort cap of 50 longline vessels has been recommended by the government that is actively developing a Tuna Management Plan with assistance from U.S.AID.

United States

American Samoa longline fleet

In 1995, small-scale longline fishing began in American Samoa following training initiated by the Secretariat of the Pacific Community (Chapman 1998). Both the American Samoa and Samoa fisheries are based on supplying fresh or frozen albacore directly to the two large tuna canneries in Pago Pago. The American Samoa albacore longline fleet was originally based on 9.0 m aluminum hulled alia-style catamarans fitted with manual longline reels setting around 300 hooks per day on 3 to 4 miles of monofilament mainline. Single day trips were the rule. Larger alia style vessels and monohull vessels of various styles and sizes (generally > 12 m) have since entered the fishery.

In 1997, a larger vessel began making multiple day trips for the first time in the fishery. In 2001, 25 large monohull vessels greater than 15 m in length entered the fishery. These vessels were equipped with large, hydraulically driven longline reels, modern marine electronics for communication and fish finding and mechanical refrigeration (O'Malley and Pooley 2002). Albacore landings expanded in response to increasing effort from 29 t in 1995 to 6,559 t during 2002 (WPRFMC 2004b).

Total landings peaked in 2002 and have been declining since. Effort in numbers of hooks continued to rise through 2003 when 14.3 million hooks were set. In 2003, 51 longline boats were active, landing a total of 5,691 t of all species combined. The decrease in total catch is attributable to a 33% decrease in albacore landings, the primary target species. A noted decrease in CPUE of albacore was evident while there was a slight increase in bigeye and yellowfin CPUE (WPRFMC 2004b).

Bigeye tuna are not targeted by the fishery and represented only 279 t of the 2003 total catch. This is in part because the canneries will not purchase large bigeye tuna due to the darkening of the meat resulting from the canning process. However, almost all of the albacore is sold to the cannery as well as some quantities of wahoo, yellowfin tuna and small bigeye tuna. The rest is sold on the domestic market as fresh fish or consumed directly. The average size of bigeye has ranged from 25.9 – 37.6 kg but dropped to 16.9 kg in 2003. Yellowfin tuna landings have increased along with fleet size, with 569 t landed in 2003, a 6% increase over the previous year. Attempts have been made to export the larger bigeye and yellowfin tuna from the fishery but it is not believed to be widespread at this time due to a lack of air freight services. In 1999, some longline boats began to land albacore gilled and gutted at a higher price (WPRFMC 2004b).

In 2003, the fleet consisted of 15 small alia-style catamarans, four monohull vessels less than 50 feet in length and 32 larger monohull vessels over 50 feet in length. Fishing power is clearly distinct between the different size classes of vessel and separate catch statistics are compiled. The alias use manually powered mainline drums that hold about four miles of monofilament line. The boats make single day trips wit a crew of three, setting around 300 – 350 hooks per set and keep their catch on ice. The large monohull vessels are similar and in some cases the same vessels that have engaged in the Hawaii longline fishery. These boats are typically steel hulled vessels of around 20 – 22 m operating hydraulically driven mainline reels holding 40 – 50 miles of monofilament, setting around 2000 hooks per day with crews of 5 – 6. They are also likely to be well equipped with marine electronics and may have refrigeration systems to keep ice or semi-freeze catch onboard for extended trips. Therefore, the larger vessels can range out to the outer portions of the EEZ and some have in the past negotiated fishing access with neighboring states.

The fishery is now transitioning to a limited access program developed by the Western Pacific Regional Management Council and implemented by NMFS. Under this program vessel operators must submit federal longline logbooks and must carry VMS systems and observers if requested by NMFS.

American Samoa small boat pelagic fisheries

Prior to 1995, pelagic fishing in American Samoa essentially meant trolling from small outboard powered vessels and a few monohull inboard powered craft. Trolling accounted for 15.5 t of pelagic fish in 2003, most of which consisted of yellowfin (3.5 t) and skipjack (9.7 t) tuna. Bigeye tuna are not taken in the American Samoa troll fishery (WPRFMC 2004b).

CNMI-based fisheries

Small troll vessels less than 7.3 m in length characterize the CNMI pelagic fishery which takes place close to the inhabited islands. Total reported landings of all pelagics in 2003 were 113.6 t and consisted primarily of skipjack tuna, yellowfin tuna, dolphinfish, dogtooth tuna and wahoo (WPRFMC 2004b). Similar to Guam, the CNMI pelagic fishery is made up of a mixture of overlapping recreational, subsistence, charter and commercial interests that are poorly defined. Currently, commercial catches are only documented on the main island of Saipan where the data coverage rate is estimated at ~80%. Vessels larger than five net tons are required to hold a commercial marine license issued by the government. Bigeye tuna do not appear in the landing statistics for the CNMI fishery and are not believed to be taken by the troll fishery. In 2003 the CNMI commercial fishery was estimated to have landed 12.8 t of yellowfin tuna (WPRFMC 2004b).

Guam-based fisheries

Guam hosts a number of distant-water purse seine and longline fleets, but does not currently engage in any large-scale pelagic fisheries. The domestic pelagic fishery is made up of a mixture of recreational or charter vessels that conduct single-day trolling trips within the EEZ of Guam or occasionally in the waters of the neighboring Northern Marianas Islands. An estimated 375 small boats were active in the fishery in 2003. Landings in 2003, in declining order by weight were mainly comprised of skipjack tuna and dolphinfish with lesser amounts of wahoo, blue marlin and yellowfin tuna (WPRFMC 2004b). The long term average pelagic catch (1982 – 2003) was 295 t, of which about 40 – 45 % consisted of tuna species. Bigeye tuna do not appear in the landing statistics and are essentially not taken by the Guam based domestic pelagic fishery. In 2003 Guam's domestic fishery was estimated to have landed 33.8 t of yellowfin tuna.

Hawaii-based fisheries

Hawaii's coastal pelagic fisheries are divided into the aku boat (pole and line), troll and handline, and the offshore handline fisheries (WPRFMC, 2004b).

In 2003 there were 3,219 licensed pelagic fishermen in Hawaii. Of these licensed fishermen most indicated that their primary interest was to catch pelagic fish (67%). Most of these pelagic targeting fishermen indicated that their primary fishing method was trolling (73%) or longline fishing (17%). Mixed handline fishing gears (8%) and skipjack pole and line fishing (2%) accounted for the rest of the licensed fishermen (WPRFMC, 2004b).

Hawaii aku boat – pole and line fishery

The Hawaiian pole and line fishery has had a long development from traditional Hawaiian canoes in the 1800s to the unique "Hawaiian sampan" still in use today. These vessels evolved from designs introduced to Hawaii by Japanese immigrants and employed live bait assisted poling techniques from Okinawa.

The skipjack, or aku boat fishery was formerly the most important domestic Hawaiian pelagic fishery, supplying fresh and dried skipjack to domestic markets and a locally-based cannery. The fleet size peaked in 1948 at 32 vessels while maximum production reached 7,400 t in 1965. The fishery has been in steady decline since the mid-1970s reflecting a decline in total effort as well as declining CPUE (Boggs and Kikkawa 1991). Landings have declined to around 500 – 1,000 t during the 1990s to only 265 t in 2002 (WPRFMC, 2004b). Currently, only two vessels are active in the fishery and supply fresh skipjack for local markets.

Hawaii troll and handline fisheries

The troll and handline fisheries of the main Hawaiian Islands (MHI) consist of a poorly differentiated mix of recreational, subsistence and commercial fishers running primarily single day trips from small vessels. Information on commercial landings is available from state catch reports, there are no permitting or reporting requirements for recreational boats.

The long term average reported commercial tuna catch by MHI troll gear (1982 – 2003) was 552 t, with 566 t reported in 2003 (WPRFMC 2004b). The most important species by weight in the fishery (1982 - 2003 means) in declining order were yellowfin, blue marlin, dolphinfish, wahoo and skipjack. Bigeye tuna make up a very minor proportion of total reported troll catch, ranking eighth in importance (by weight) behind albacore and striped marlin. In 2003, only 6.4 t of bigeye were recorded. An additional 402.5 t of yellowfin tuna were reported landed in 2003 (WPRFMC 2004b).

Several different methods and styles of handline fishing are used in Hawaii to take pelagic species; primarily yellowfin tuna, bigeye tuna, and albacore. The long term average tuna catch by the MHI handline fishery (1982 – 2003) was 745 t with 529 t of tunas reported in 2003. The reported MHI handline catch consists primarily of yellowfin tuna, followed by bigeye and albacore.Reported 2003 MHI handline catches were 343.5 t, 90 t and 89.5 t respectively (WPRFMC 2004b).

Hawaii offshore handline fishery

Larger handline vessels moved offshore to exploit tuna aggregations found on an offshore submarine feature (Cross Seamount) and anchored weather buoys 100 – 200 nmi from the main Hawaiian Islands (Boggs and Ito 1993).

The fishery targets juvenile and sub-adult bigeye and yellowfin tuna in structure-associated aggregations that are highly vulnerable to simple hook and line gear types (Itano and Holland 2000). Available data indicate that the fishery targets bigeye tuna in the size range of 6.8 – 18 kgs, although larger fish to 30+ kgs contribute significantly to the value of landings. Yellowfin tuna make up a smaller proportion of the catch. The same sources of data indicate that total tuna landings from the fishery consist of 75 – 80% bigeye and ~20% juvenile yellowfin (Itano 1998a). Smaller quantities of dolphinfish, wahoo and billfish are also taken. Reported total landings by the fishery peaked in 1994 at 587 t with a long term average (1990 – 2003) of 383 t/year (WPRFMC 2004b). In 2003 the fishery reported landing 122 t of bigeye and 18 t of yellowfin.

Vanuatu

Vanuatu has had a long history of longline fishery development since the establishment of a longline transshipment base on Espiritu Santo Island in the late 1950s. In 2003, eleven domestic vessels based in Fiji landing an estimated 2240 t in 2003 (Naviti 2004). The domestic catch consisted of 1,823 t of albacore (81%), 134 t of yellowfin (6%), 102 t of bigeye (5%) and 181 t of other species. Bilateral access agreements are also in place for Taiwanese distant-water, South Korean and Chinese longline vessels. Unraised logsheet data held by SPC indicates a total bigeye longline catch of 211 t by Vanuatu, Fiji and Taiwanese fleets.

Naviti (2004) summarizes the Vanuatu longline fleet (2001 – 2003) as consisting of Vanuatu flag vessels (11), Fiji domestic and joint venture vessels (30), Chinese Taipei distant-water (29), South Korean (29) and Chinese (42). It is unclear which of these vessels are considered domestic, joint venture, Fiji flag or bilateral DWFN longliners, particularly for those vessels based in Fiji but fishing in Vanuatu waters. It is believed that many of the Fiji based vessels are larger Chinese longline boats operating under a mixture of access agreements with either Fiji and/or Vanuatu.

Vanuatu does not have a domestic observer program but is negotiating with Fiji to have Fiji national observers board Vanuatu flag longliners and Fiji-based Vanuatu vessels. A Vanuatu Tuna Management Plan is also in development. Through the analysis of historical catches by the Santo-based transshipment operations, a MSY for bigeye has been estimated at 2000 t/year with a recommended total allowable effort (TAE) of 100 vessels (Naviti 2004).

10.8.1.4 Importance of Coastal Tuna Fisheries to Pacific Island Economies

The importance of fresh tuna to the food security, health and culture of the Pacific Islands cannot be estimated in monetary terms. The value of seafood to the people and cultures of the region is clearly priceless. Attempts to calculate a dollar value on seafood are equally difficult as the economic benefits of a healthy tuna resource are equally priceless. However, to address the issue, consider the ongoing work of the Forum Fisheries Agency. Reid (2003) estimated the delivered value of the purse seine fishery to the FFA region in 2002 at U.S. $925 million. He notes that the figures are to be taken with caution due to the need to make various assumptions and the ever present data gaps and other constraints. No attempt was made to calculate the value of the longline fisheries in the region. However, the value no doubt runs to several million, with bigeye tuna contributing significantly if not the majority of revenues.

Gillett and Lightfoot (2001) calculated the value of various fishing sectors for the Pacific Island countries, as summarized in Table 14. The Offshore Locally Based (domestic longline and purse seine) and Offshore Foreign Based (DWFN longline and purse seine) categories are 100% tuna aside from a minor amount of prawn trawling in PNG. The contribution of bigeye to these categories has not been differentiated, but no doubt makes a significant contribution to some countries, i.e. Fiji, Samoa. Combining these two categories suggests a value of U.S. $657 million from all tuna species, not even considering the value of subsistence and coastal fisheries.

Table 14. Economic value of fisheries to the Pacific Island countries (in U.S. $000).

(Source: Gillett and Lightfoot 2001)

	Subsistence Fishing	Coastal Commercial Fishing	Offshore Locally Based	Offshore Foreign Based	Total $000
FSM	$10,000	$14,500	$12,495	$144,000	$180,995.00
PNG	$20,227	$21,394	$44,344	$75,074	$161,039.00
Kiribati	$7,890	$6,310	$0	$132,258	$146,458.00
Solomon	$8,061	$1,902	$69,242	$827	$80,032.00
Fiji	$24,675	$15,232	$25,640	$555	$66,102.00
Marshall	$3,836	$973	$0	$50,000	$54,809.00
Tuvalu	$931	$284	$0	$38,000	$39,215.00

	Subsistence Fishing	Coastal Commercial Fishing	Offshore Locally Based	Offshore Foreign Based	Total $000
Nauru	$331	$1,118	$250	$36,774	$38,473.00
Samoa	$7,143	$6,583	$9,840	$99	$23,665.00
Tonga	$3,992	$10,856	$3,676	$104	$18,628.00
Palau	$2,500	$2,595	$12,500	$270	$17,865.00
Cook Is	$1,164	$10,320	$397	$407	$12,288.00
Vanuatu	$3,975	$682	$0	$253	$4,910.00
Niue	$167	$51	$0	$4	$222.00
Total	$94,892.00	$92,800.00	$178,384.00	$478,625.00	$844,701.00

10.8.1.5 EPO Tuna Fisheries with Bigeye and Yellowfin Landings

Catches of the principal tuna market species (albacore, bigeye, skipjack, yellowfin) in the Eastern Pacific Ocean rose slowly between 300,000 – 475,000 t during the 1970 – 1989 period in response to gradual increases in longline and purse seine landings. Strong ENSO conditions are known to significantly reduce catches in the EPO, particularly by purse seine gear as was evident in 1983 when only 237,000 t by all gear types was landed (WCPFC 2005). Overall landings of all species remained relatively stable around 450,000 t/year until 1995 when total landings began to increase steadily to a record high in 2003 of 821,485 t which represented 19% of global tuna landings.

Table 15 indicates EPO time series of landings for the tropical species by main gear types. Longline catches of yellowfin are very minor in comparison to purse seine landings during all years. The prime longline grounds for large bigeye in the Pacific has traditionally been east of 150°W in the EPO and heavily fished by the Japanese distant-water longline fleet. Longline landings have ranged between 36,000−105,000 mt since 1980, surpassing 100,000 mt three times (1986, 1987 and 1991), but with an historical low in 1999 (Williams and Reid 2005). Korean, Chinese Taipei and recently China have been active in the EPO bigeye fishery with large ultra low temperature freezer boats. Since 1990 EPO bigeye landings by longline gear have generally been on a declining trend with catches below ~ 70,000 t/yr.

Table 15. Bigeye, yellowfin and skipjack landings (mt) in the Eastern Pacficic Ocean by selected gear.
(Source: WCPFC 2005).

Year	Bigeye Longline	Bigeye Purse seine	Total EPO Bigeye	Yellowfin Longline	Yellowfin Purse seine	Total EPO Yellowfin	Skipjack Purse seine
1990	98,871	5,920	104,806	34,634	263,251	302,284	74,370
1991	104,194	4,870	109,116	39,729	231,257	266,089	62,229
1992	84,800	7,179	92,000	18,526	228,121	253,712	84,283
1993	72,473	9,657	82,189	23,808	219,494	254,952	83,829

Year	Bigeye Longline	Bigeye Purse seine	Total EPO Bigeye	Yellowfin Longline	Yellowfin Purse seine	Total EPO Yellowfin	Skipjack Purse seine
1994	71,359	34,900	107,067	29,545	208,409	243,557	70,127
1995	58,256	45,319	104,956	20,054	215,434	239,326	127,045
1996	46,957	61,312	109,015	16,426	238,606	260,149	103,976
1997	52,571	64,270	116,864	21,448	244,878	272,748	153,456
1998	46,347	44,128	91,092	12,196	253,959	275,422	140,631
1999	36,405	51,158	88,104	10,642	281,920	297,962	261,564
2000	47,511	94,083	141,863	22,766	254,988	282,169	205,240
2001	68,697	61,259	130,003	28,482	382,402	415,874	143,948
2002	72,778	57,412	130,220	22,437	412,285	436,449	153,633
2003	58,892	54,103	113,016	22,192	380,523	405,264	275,089
2004	39,729	66,944	106,679	2,041	268,356	273,744	196,911

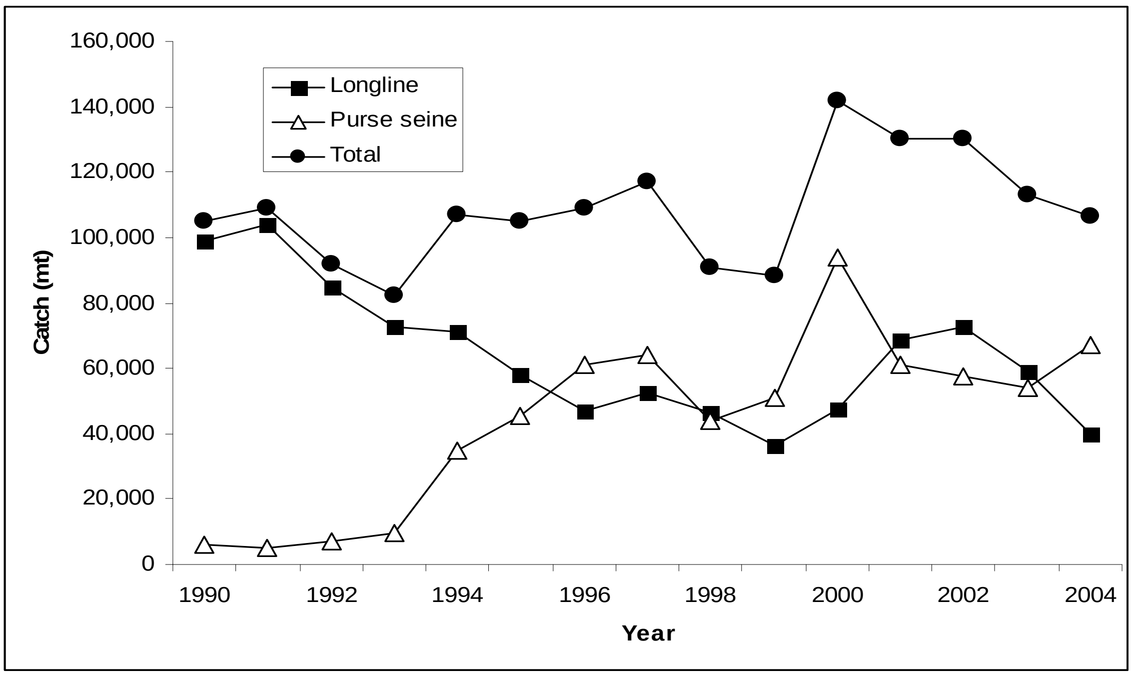


Figure 42. EPO bigeye landings by longline and purse seine gear 1990 – 2004. (Source: WCPFC 2005)

The most significant change to impact EPO tuna fisheries in recent years has been rapidly increasing fishing mortality on juvenile bigeye tuna by purse seine gear. Figure 42 shows a 15 year time series of longline and purse seine catch of bigeye tuna. Prior to 1990, the situation was essentially a longline-only fishery targeting large, mature size bigeye tuna for high value sashimi markets. In 1994, landings of bigeye tuna by purse seine gear rose sharply in response to a newly developed fishery west of Ecuador targeting skipjack on drifting FADs. The fishery is concentrated between 5°N - 10°S and 95° - 140° W. Significant quantities of juvenile/sub adult size bigeye are taken incidentally in this fishery. Prior to 1994, the average annual catch of bigeye by EPO purse seiners was about 9,000 t. After the development of the FAD fishery, catches rose to 64,000 t in 1997 to reach a record high of 94,000 t in 2000. The 2004 estimate of total bigeye catch is 67,000 t. The average amount of bigeye discarded at sea during 1993 – 2004 period is approximately 5% of the total annual purse seine catch of bigeye (IATTC 2005). Small amounts of bigeye are caught by pole-and-line gear also. Longline landings of bigeye have decreased during the same time period while overall bigeye landings have remained relatively constant.

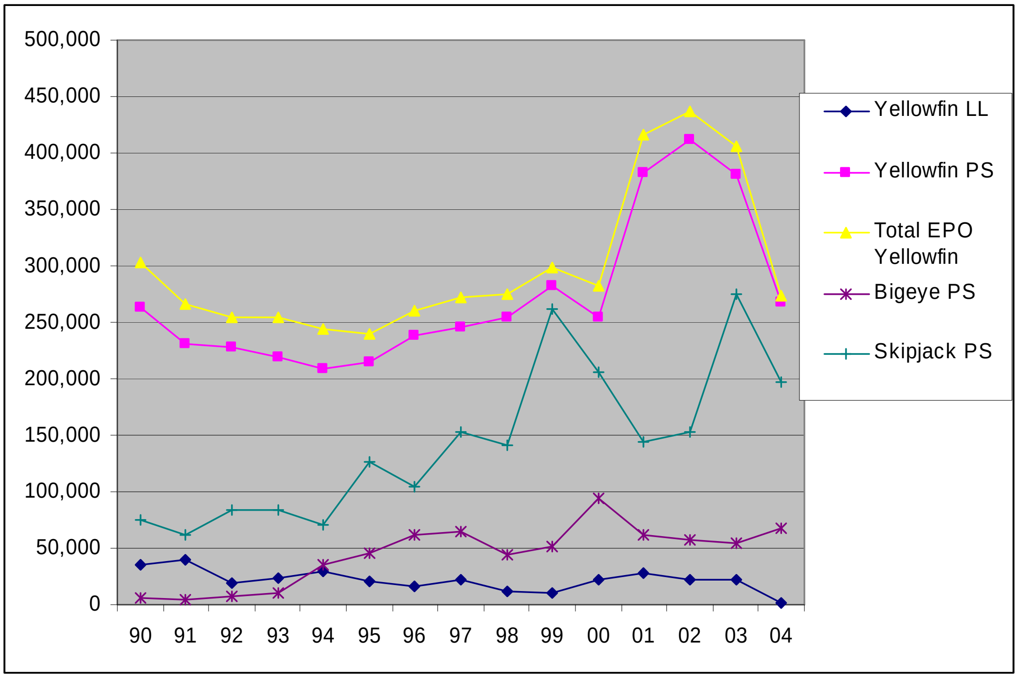


Figure 43. EPO skipjack, yellowfin and bigeye landings by gear 1990 – 2004. (Source: WCPFC 2005)

Figure 43 clearly shows the dominant influence of purse seine effort on total yellowfin landings in the EPO. The rapid rise in skipjack landings due to the developing drifting FAD fishery is also apparent after 1994. The increasing bigeye catch mirrors the skipjack landings but is not as easy to discern due to scaling.

<u>Fisheries and fleets</u>

As noted above, longline effort in the EPO does not significantly impact yellowfin stocks as they are most commonly harvested by purse seine gear. The main countries involved in the EPO longline bigeye fisheries include Japan, Chinese Taipei, Korea and China. Total catches for the period 1999 – 2004 are listed in Table 16. Data for 2004 are not complete.

Table 16. EPO longline catches (mt) of bigeye tuna (IATTC).

Year	Japan	Chinese Taipei	South Korea	China	USA	Other fleets	Total
1999	22,224	910	9,431	660	228	961	34,414
2000	27,929	5,214	13,280	1,320	162	3,719	51,624
2001	37,493	7,953	12,576	2,639	147	4,169	64,977
2002	33,794	16,692	10,358	7,351	132	3,597	71,924
2003	20,517	12,501	10,272	10,065	232	1,292	54,879
2004	18,458	7,384	10,729	2,602	NA	NA	NA

Concern over the impact of the purse seine impact on juvenile bigeye stocks has lead to a number of management measures by the IATTC, including annual bigeye quotas and restrictions on the use of FAD tender vessels. Resolution C-04-09 on the Conservation of Tuna in the eastern Pacfiic Ocean in 2004-2006 now requires that the main bigeye harvesting countries of the EPO should reduce their landings to those reported in 2001. The resolution states: “China, Japan, Korea and Chinese Taipei, shall take the measures necessary to ensure that their total annual longline catch of bigeye tuna in the EPO during 204, 2005 and 2006 will not exceed the following catch levels: China – 2,639 t; Japan – 34,076 t; Korea – 12,576 t; and Chinese Taipei – 7,953 t.

As Table 16 illustrates, Japan has the highest bigeye landings, followed by Chinese Taipei, South Korea and China. 2003 landings were the highest to date. Preliminary estimates for 2004 suggest that catch levels have declined slightly. Approximately 5% of Hawaii-based longline bigeye landings are estimated to come from the EPO, as well as 100% of longline bigeye landings from domestic vessels ported on the west coast (i.e. in California). The IATTC also lists 2004 longline catches of vessels from Vanuatu and Belize at 431 t and 120 t respectively.

EPO purse seine fisheries account for approximately 40% of the EPO bigeye catch, (Figure 44) and in 2003 reported catching 40,122 t of bigeye tuna.

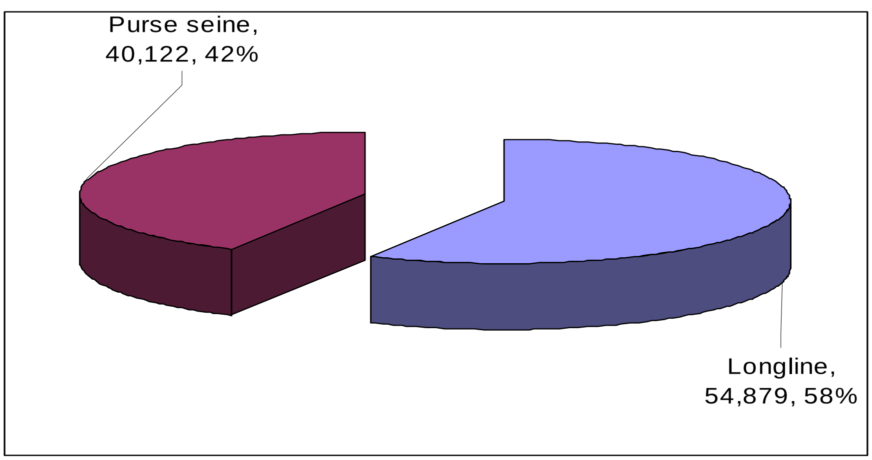


Figure 44. Proportion of bigeye tuna caught by purse seine and longline vessels in the EPO in 2003

The countries that currently harvest the highest levels of bigeye and yellowfin tuna in the EPO are listed in Table 17. Bigeye catch is directly linked to setting mode and countries that engage primarily in the drifting FAD fishery catch most of the bigeye tuna such as Ecuador, Panama and Spain. The highest yellowfin harvesting nations are Mexico, Venezuela, Ecuador and Panama.

Table 17. Main fleets catching bigeye tuna by non-longline gears in the EPO.
(Source: IATTC 2005)

Country	Gear	Catch (mt)		
		Yellowfin	Bigeye	Total
Ecuador	Purse seine	40,542	30,852	71,394
Panama	Purse seine	30,904	13,202	44,106
Spain	Purse seine	3,913	6,577	10,490
Others	Purse seine	45,797	6,066	51,863
Vanuatu	Purse seine	1,760	5,137	6,897
USA	Purse seine	1,977	4,027	6,004
Venezuela	Purse seine	56,128	986	57,114
Mexico	Purse seine	87,334	98	87,432
USA	Recreational	1,052	4	1,056
Mexico	Pole and line	1,905	0	1,905

Three U.S. flag purse seiners > 1,001 gross ton were active in the Eastern Tropical Pacific fleet during 2004. These vessels operate within the jurisdiction of the Inter-American Tropical Tuna Commission and are also monitored by NMFS. The vessels are monitored by mandatory logbooks, the IATTC observer and port sampling programs, national surveillance activities and cannery records. Vessels operate under the Agreement on the International Dolphin Conservation Program (AIDCP) which is a multi-lateral agreement aimed at continually reducing and minimizing the incidental take of dolphins and undersize tuna during fishing operations. If offloading to a U.S. facility, the vessel must be able to document their catch within the applicable criteria set for “Dolphin Safe” tuna.

10.8.2 International Management Authorities and Agreements

10.8.2.1 WCPO Management Authorities

Western and Central Pacific Fisheries Commission

The international **Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean** was opened for signature on September 5, 2000. The objective of the Convention is to assure the long-term conservation and sustainability of pelagic resources in the FFA/SPC region. The Convention entered into force on April 19, 2004 and the first session of the Commission was held in Pohnpei, Federated States of

Micronesia December 9-10, 2004. The Convention also provides for participation of fishing entities and Territories situated within the Convention area. Notably, Taiwan has signed the Arrangement for the Participation of Fishing Entities and agreed to be bound by the requirements stipulated by the Convention and participate as a Commission member. The Convention establishes a **Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**, now more commonly referred to as the **Western and Central Pacific Fisheries Commission (WCPFC)**. Initial staffing for the Commission is in progress at its site in Pohnpei, FSM. Although not yet completely defined, the boundaries of the Convention are indicated in Figure 45. A noteworthy aspect of the Convention is the fact that it will exercise management control into the high seas zones outside national EEZs in contrast to some other regional fishery management organizations. However whether EEZ waters will be included in management agreements remains unclear.

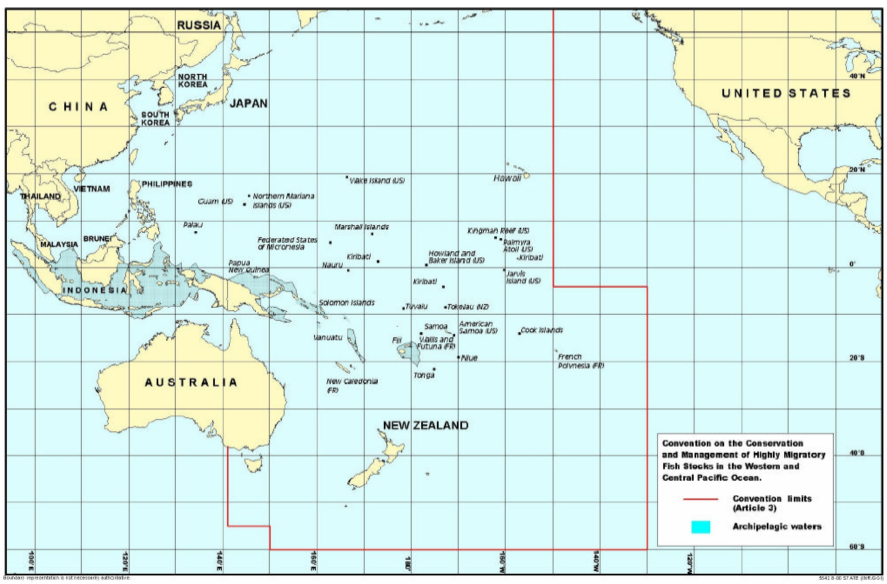


Figure 45. The Palau Arrangement for the Management of the Purse Seine Fishery in the Western and Central Pacific

The Palau Arrangement (PA) entered into force in November 1995, and was developed by the Parties to the Nauru Agreement as a means to place a limit on purse seine effort within the FFA. The Arrangement set a limit of 205 tuna purse seine vessels that could be licensed by the Parties and set up a system for allocating these licenses by fleet. Table 18, from Rodwell (2004) indicates recent allocations under the Arrangement.

Two allocation categories introduced in 2004 are explained further by Rodwell (2004). The **New Bilateral Access** category was created by the Parties to provide for access of new entrants into the WCPO fishery, taking in to account the decline in bilateral access numbers by some Taiwanese flag vessels. The decline occurred due to the reflagging of a number of Taiwanese vessels to Marshall Islands and Vanuatu registry that currently operate under the conditions of the FSM Arrangement. Some of these vessels have also been sold to Chinese interests. An allocation of four vessels was granted to China and four to the European Union.

Under **Special Arrangements**, 13 additional allocations were granted to EU, Chinese and Domestic/Locally based vessels. This category was created on a temporary basis when the number of actual vessels allocated under the Agreement falls below the maximum of 205. This situation has occurred because the U.S. fleet is operating well below their maximum allocation of 40 vessels.

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Table 18. Purse seine allocations under the Palau Arrangement in 2004.

(Source: Rodwell 2004)

Category	Agreed, April 1997	Agreed, April 1999	Agreed, April 2002	Agreed, April 2003	Agreed, May 2004
1. Multilateral Access					
U.S. Treaty	50	50	29	40	40
2. Bilateral Foreign Access					
Japan	35	35	35	35	35
Taiwan	40	40 (+2)	41	41	33
South Korea	29	29	27	27	27
Philippines	10	10	10	10	10
Sub-total (1+2)	164	166	142	153	145
3. Domestic / Locally-based					
All parties	41	41 (-2)	40	45	52
4. New Bilateral Access					
China	0	0	1	3	4
European Union	0	0	0	4	4
Total ((1+2) + 3+ 4)	**205**	**205**	**183**	**205**	**205**

Note: Fleets that fail to fully utilise their allocation will be liable to forfeit their unused allocation.

Special Arrangements[1]

Category	Agreed, May 2004
1. EU vessels part-time in Kiribati waters only	2
2. Domestic/Locally Based	9
3. China	2

Pacific Islands Forum Fisheries Agency

The **Pacific Islands Forum Fisheries Agency (FFA)**, formerly known as the South Pacific Forum Fisheries Agency), based in Honiara, Solomon Islands, was established in 1979 to assist independent Pacific Island countries to effectively manage and utilize the living marine resources that lie within their 200 mile exclusive economic zones. The FFA comprises 17 member governments from the central and western Pacific region. The organization consists of the Forum Fisheries Committee as governing body and the Secretariat based in Honiara. The Secretariat is composed of 52 positions and organized into six divisions coordinated by an executive management unit under the control of the Director. The divisions within the FFA Secretariat include: Economics and Marketing; Legal Services; Monitoring, Control and Surveillance; Information Technology and Communication; Corporate Services; and Treaties Administration. Although the FFA is not technically a management body, as it has no regulatory functions, the

Agency has nevertheless contributed significantly to fisheries management and development in the region.

An extremely important role of FFA is to assist Island States to negotiate fishing access agreements with distant water fishing nations or between FFA member states. The FFA fulfils a critical role in the administration of the U.S. multilateral tuna treaty. The organization facilitates the collection, analysis, evaluation and dissemination of relevant statistical scientific and economic information about the resources covered by the South Pacific FFA Convention. In this regard, the FFA forms a critical link between management and the management oriented research conducted by the Secretariat of the Pacific Community, Oceanic Fisheries Programme. states include Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. Although the FFA is not technically a management body as it has no regulatory functions, the Agency has nevertheless contributed significantly to fisheries management and development in the region.

Secretariat of the Pacific Community, Oceanic Fisheries Programme

The Secretariat **of the Pacific Community (SPC)**, formerly known as the South Pacific Commission, is a non-political, technical assistance research based organization that fills a consultative and advisory role to Pacific Island countries and territories. The organization was founded in 1947 to assist island governments toward economic and social stability in the wake of the Pacific war. The SPC currently consists of 22 island governments, both independent states and territories. The work program focuses on: Agriculture and Forestry; Marine Resources (coastal, oceanic, and maritime); and Social Resources including education, culture, women and youth, demography, public health and training. The region served by the SPC and the SPC Statistical Area is shown in Figure 46

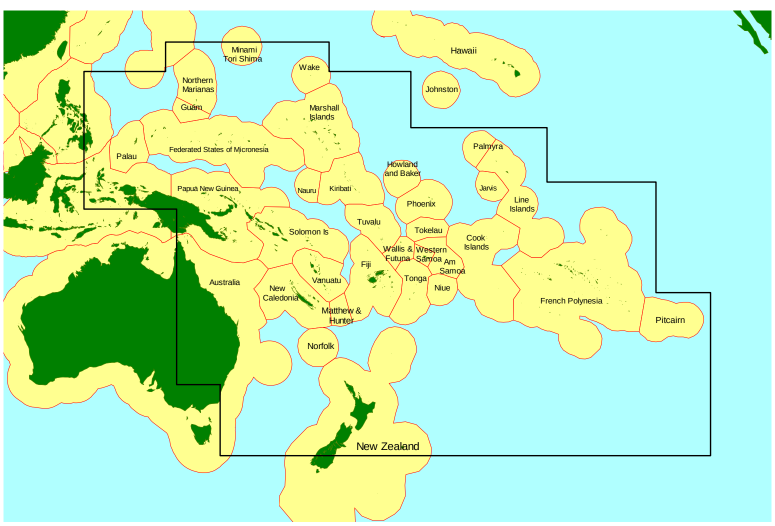

Figure 46. Secretariat of the Pacific Commission area.

The largest sector within the SPC is the **Oceanic Fisheries Programme (OFP),** formerly the Tuna and Billfish Assessment Programme. The mission statement of the OFP is "*to provide member countries with the scientific information and advice necessary to rationally manage* *fisheries exploiting the region's resources of tuna, billfish and related species*". The OFP is composed of research sections on Statistics and Monitoring, Tuna Ecology and Biology, and Stock Assessment and Modeling. Catch and effort data was formerly reported from the boxed area indicated in Figure 40, which encompasses the area of influence of the Forum Fisheries Agency and most of the area included in the U.S. Multilateral Tuna Treaty. In 1998, reporting of regional fisheries statistics were modified to present catch statistics for the Western and Central Pacific Ocean (WCPO) and summary statistics for the Eastern Pacific Ocean (EPO) as in Figure 1. This WCPO Area was established for statistical purposes at the Twelfth Meeting of the Standing Committee on Tuna and Billfish, 16–23 June 1999, Tahiti, French Polynesia.

Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest

This agreement entered into force 4 December 1982 as a means for Pacific Island countries rich in tuna resources to consolidate and work together to better manage and conserve their shared pelagic resources. The agreement, commonly referred to as the **Parties to the Nauru Agreement**, or PNA was established:

> *… to coordinate and harmonize the management of fisheries with regard to common stocks within the Fisheries Zones of the contracting Parties, for the benefit of their people. To this end, the parties undertake to establish a coordinated approach to the fishing of the common stocks in the Fisheries Zones by foreign fishing vessels, and in particular: (a) to establish principles for the granting of priority to applications by fishing vessels of the Parties to fish within the Fisheries Zones over other foreign fishing vessels; (b) to establish, as a minimum, uniform terms and conditions under which the Parties may license foreign fishing vessels to fish within the Fisheries Zones; and (c) to establish other uniform terms and conditions under which the Parties may license foreign fishing vessels to fish within the Fisheries Zones.*

The Forum Fisheries Agency contributes significant advisory and administrative support. The PNA countries include: FSM, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu.

Federated States of Micronesia Arrangement for Regional Fisheries Access

This arrangement entered into force on September 23, 1995 as a mechanism by which Pacific Island states could engage in large-scale fisheries within the heart of the WCPO tuna fishing grounds on in a similar manner in which distant water fishing nations gain access to this (their) resource. This contract, commonly referred to as the **FSM Arrangement** was established:

… to cooperate to secure, for the mutual benefit of the Parties, the maximum sustainable economic benefits from the exploitation of the tuna resources of the Central and Western Pacific; to promote greater participation by nationals of the Parties in fisheries and assist in the development of national fisheries industries of the Parties; to establish a licensing regime under which fishing vessels of the Parties may gain access to the waters within the Arrangement Area on terms and conditions no less favorable than those granted by the Parties to foreign fishing vessels under bilateral and multilateral access arrangements; to establish and enforce agreed criteria to ensure that only those fishing operations which are capable of providing genuine and quantifiable economic benefits to the Parties, are eligible for licenses pursuant to this Arrangement; to allow access to the exclusive economic and fisheries zones of the Parties by purse seine fishing vessels on terms and conditions which are consistent with the provisions of the Palau **Arrangement for the Management of the Western Pacific Purse Seine Fishery**; and to further the objectives of the **Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest**.

The Parties to the FSM Arrangement are the FSM, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea and the Solomon Islands.

Treaty on Fisheries between the Governments of Certain Pacific Islands States and the Government of the United States of America

In June 1988, the Treaty on Fisheries between the Governments of Certain Pacific Islands States and the Government of the United States of America entered into force. This multilateral agreement is more commonly referred to as the U.S. **Multilateral Treaty (USMLT), the South Pacific Tuna Treaty (SPTT) or simply, the Treaty**. The U.S.MLT was recently renegotiated for another 10 years period, extending the agreement to June 14, 2013. The Treaty provides U.S. purse seiners with nearly free roaming access to most of the waters of the 16 Pacific Island parties to the agreement. This provides the U.S. fleet with a considerable advantage over fleets of other countries that remain geographically limited by domestic policies and/or limited bilateral access agreements that must be re-negotiated on an annual basis. Gillett et al. (2002) provides a detailed description of the historical development of the U.S. tuna industry in the CWPO with projections on possible scenarios of future involvement. The area of the U.S.MLT is represented in Figure 47

The Treaty provides considerable economic benefit to the Parties, the U.S. tuna industry and to the status of U.S. diplomacy in the region. The Treaty has generated U.S. $273 million to the Parties since it came into force in mid-1988 (as of 2004) thus generating about U.S. $17.5 million per year. The Parties received a total of U.S. $21,931,698 during the 16th licensing period (June 15, 2003 – June 14, 2004). Treaty payments are distributed in accordance with an agreed formula with 15% allocated on an equal basis and 85% on the basis of catch derived from member EEZs. A sum of U.S. $1.78 million is also allocated for Project Development Funds which are distributed equally to the Parties. In return, the U.S. western Pacific tuna fleet has received approximately U.S. $100 – $200 million annually with almost all of the fish landed and processed in American Samoa providing a great deal of economic development and security.

Formerly, the U.S. tuna industry paid U.S. $4 million annually to the Treaty while the U.S. government paid the remaining U.S. $14 million. Under re-negotiated terms of the current licensing period, the U.S. government contribution increased to U.S. $18 million per year while the tuna industry contribution was reduced to U.S. $3 million, reflecting the continued decrease in the number of U.S. vessels participating in the fishery. The Parties to the U.S.MLT are Australia, Cook Islands, Federated States of Micronesia, Fiji, Republic of Kiribati, Republic of the Marshall Islands, Republic of Nauru, New Zealand, Niue, Republic of Palau, Papua New Guinea, Samoa, Solomon Islands, Kingdom of Tonga, Tuvalu and the Republic of Vanuatu.

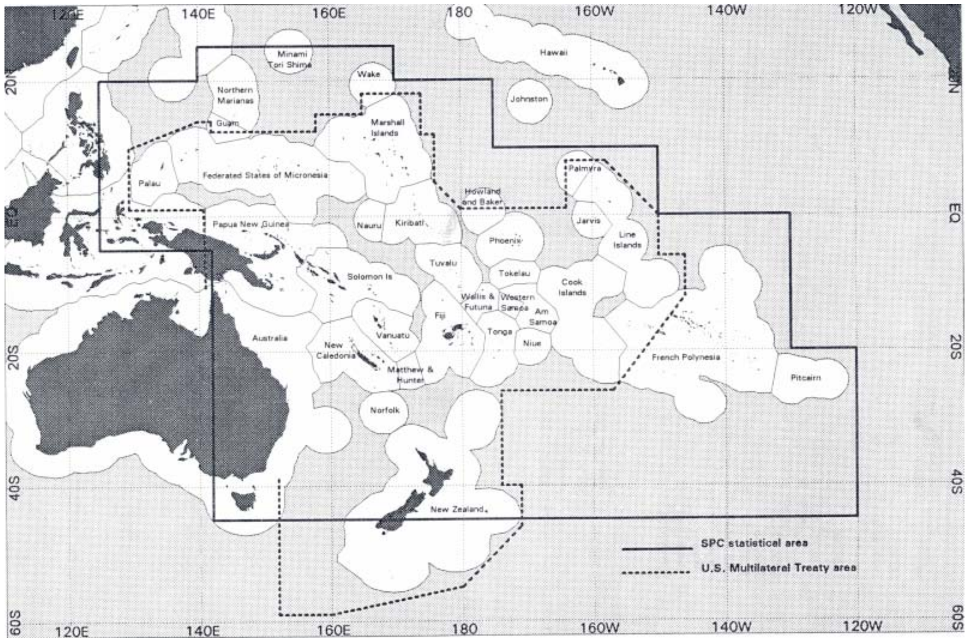

Figure 47. Boundaries of the U.S. Multilateral Tuna Treaty.

10.8.2.2 EPO Management Authorities

__Inter-American Tropical Tuna Commission__

The **IATTC** was established by international convention in 1950 and is responsible for the conservation and management of tuna fisheries and other species taken by tuna fishing activity in the eastern Pacific Ocean. The area of competence of the IATTC is bounded by the coasts of the Americas to longitude 150° W., and to the 40° N and S lines of latitude. These boundaries were established in the Antigua Convention in 2003, which modified the original area of competence of the IATTC established in 1949. The organization consists of a Commission where each member country may be represented by up to four commissioners and a Director of Investigations, or the Director who is responsible for drafting research programs, budgets, administrative support, directing technical staff, coordination with other organizations and preparing reports to the Commission. The IATTC maintains a core staff of fishery scientists that coordinate and conduct research, observer programs and the collection, compilation, analysis and dissemination of fishery data and scientific findings. The work of the IATTC research staff is divided into two main groups. The work of these programs are as follows:

IATTC Tuna-Billfish Program

- to study the biology of the tunas and related species of the eastern Pacific Ocean with a view to determining the effects that fishing and natural factors have on their abundance;
- to recommend appropriate conservation measures so that the stocks of fish can be maintained at levels which afford maximum sustainable catches;

- to collect information on compliance with Commission resolutions.

IATTC Tuna-Dolphin Program

- to monitor the abundance of dolphins and their mortality incidental to purse-seine fishing in the eastern Pacific Ocean;
- to study the causes of mortality of dolphins during fishing operations and promote the use of fishing techniques and equipment which minimize these mortalities;
- to study the effects of different modes of fishing on the various fish and other animals of the pelagic ecosystem;
- to provide a secretariat for the International Dolphin Conservation Program

The IATTC also coordinates a number of working groups on particular issues of concern, such as the Permanent Working Group on Fleet Capacity and the Bycatch Working Group.

Current membership of the IATTC includes Costa Rica, Ecuador, El Salvador, France, Guatemala, Japan, Mexico, Nicaragua, Panama, Peru, Spain, U.S.A, Vanuatu and Venezuela. Canada, China, the European Union, Honduras, South Korea and Taiwan are Cooperating Non Parties or Cooperating Fishing Entities.

Pacific Fishery Management Council

The **Pacific Fishery Management Council (PFMC**), based in Portland Oregon, is one of eight regional fishery management councils established by the Magnuson-Stevens Act of 1976. The Council works interactively with the fishing community to manage fisheries in the federal waters of their jurisdiction. The Pacific Council is responsible for fisheries that lie off the coasts of California, Oregon, and Washington. The PFMC promulgated a pelagic fisheries management plan in 2004. Within the realm of pelagic species, the PFMC is involved in the management of north Pacific albacore, yellowfin, bigeye, skipjack, Pacific bluefin, common thresher shark, pelagic thresher, bigeye thresher, shortfin mako, blue shark, striped marlin, Pacific swordfish and dolphinfish.

Western Pacific Regional Fishery Management Council

The **Western Pacific Regional Fishery Management Council** is based in Honolulu, Hawaii and is another of the eight regional fishery management councils established by the MSA. The Council works interactively with fishing communities to manage fisheries in the waters of their jurisdiction. The Council manages domestic fisheries that occur in offshore waters around American Samoa, the Northern Mariana Islands, Guam, Hawaii and the Pacific Remote Island Areas (Palmyra, Johnston and Midway Atolls, Wake, Jarvis, Howland and Baker Islands, and Kingman Reef), as shown in Figure 48 This area includes nearly 1.5 million square miles of U.S. EEZ waters and managed vessels fish in waters of both the EPO and the WCPO. 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 others are designated state, territorial and federal officials with fishery management responsibilities.

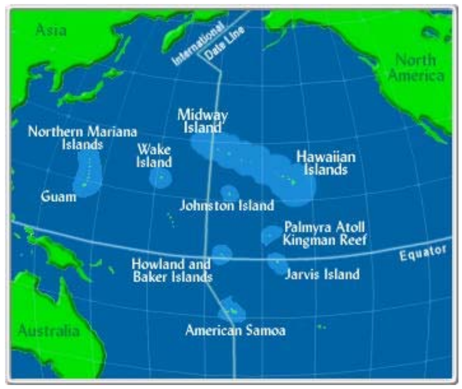

Figure 48. Area of jurisdiction of the WPRFMC.

10.9 WPRFMC Pelagic Fisheries and Landings

The WPRFMC manages bigeye and yellowfin tunas through its Pelagics FMP which includes a range of unique and diverse fisheries. Although fisheries in American Samoa, the Northern Mariana Islands, Guam and the Pacific Remote Island Areas are managed under the Pelagics FMP, this document focuses primarily on Hawaii's fisheries as they are the only ones affected by most of the alternatives considered here. Not discussed in this section are U.S. purse seine and distant water albacore trolling fleets. Although these vessels may occasionally fish in EEZ waters under the Council's jurisdiction, they are not generally considered to be managed by the Council.

Hawaii's pelagic fisheries are small in comparison with other Pacific pelagic fisheries such as distant-water purse seine fisheries and other foreign pelagic longline fisheries, but they comprise the largest fishery sector in the State of Hawaii. Tuna, billfish and other tropical pelagic species supply most of the fresh pelagic fish consumed by Hawaii residents and support popular recreational 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 occur within 25 miles of land, with trips lasting only one day.

Hawaii-based longline fishery

Of all Pelagics FMP fisheries, the Hawaii-based limited access longline fishery is the largest. This fishery accounted for the majority of Hawaii's commercial pelagic landings (8,700 t or 18.9 million lb) in 2003 (Table 19). As discussed in Section 10.9, 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 limited entry program. 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. 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 nine knots with an average vessel speed of about 6.8 knots. No light sticks are used and float line lengths average 22 m (72 feet) with branch line lengths averaging 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.

This fishery began around 1917 and was based on fishing techniques brought to Hawaii by Japanese immigrants. The early Hawaiian sampan-style flagline boats targeted large yellowfin and bigeye tuna using traditional basket gear with tarred rope mainline. This early phase of Hawaii longline fishing declined steadily into the 1970s due to low profitability and lack of investment in an ageing fleet (Boggs and Ito 1993).

During the 1980s, tuna longline effort began to expand to supply developing domestic and export markets for high quality fresh and sashimi grade tuna. In the late 1980s and early 1990s, the nature of the fishery changed completely with the arrival of swordfish and tuna targeting fishermen from longline fisheries of the Atlantic and Gulf states. Longline effort increased rapidly from 37 vessels in 1987 to 138 vessels in 1990 (Ito and Machado 2001). In 1985, the longline fishery surpassed landings of the skipjack pole-and-line fleet and has remained the largest Hawaii-based fishery to date. Swordfish landings rose rapidly from 600,000 lbs in 1989 to 13.1 million pounds in 1993 (WPRFMC 2003). The influx of large, modern longline vessels promoted a revitalization of the fishery, and the fleet quickly adopted new technology to better target bigeye tuna at depth. The near-full adoption of monofilament mainline longline reels further modernized the fleet and improved profitability.

An emergency moratorium was placed on the rapidly expanding fishery in 1991. Pelagic longline fishing was also restricted from use within a buffer zone surrounding the main Hawaiian Islands to reduce gear interaction between small and large scale fishing methods. Further buffer zones were established within a 50 nmi radius of the Northwest Hawaiian Islands to minimize interactions with the endangered Hawaiian monk seals. A limited access program was established in 1994 allowing for a maximum of 164 transferable longline permits for vessels ≤101 feet in overall length that is administered by NMFS. During the same year, the Hawaii Longline Observer Program was initiated, primarily to monitor interactions with protected species.

The relative importance of swordfish to the fishery declined during the mid 1990s following a 47% decrease in landings in 1994. The latter part of 1994 saw a stabilization of swordfish landings at close to 6.5 million pounds/year, a significant increase in shark take, primarily blue shark fins, and a gradual increase in tuna fishing effort and landings. Effort continued to shift away from swordfish and back to tuna targeted trips throughout the latter 1990s (WPRFMC 2004b). In fact, most of the fishery always simply continued to fish tuna and bigeye remains a primary target species and mainstay of the fishery.

During this period, the fishery was often described as consisting of three components; a core tuna group, a swordfish targeting sector and vessels that were classified as "mixed"; switching between swordfish and tuna throughout the year or even within a single trip. Generally speaking, tuna vessels set deep gear with more than 15 hooks between floats in the morning, began hauling gear in the late afternoon or dusk, usually used a line shooter to deepen the set, preferred saury or sardine bait and made relatively short trips within 500 miles of home port. Swordfish boats were generally larger than tuna boats, set shallow gear at dusk with an average of 4 hooks between floats, used chemical light sticks, hauled gear at dawn, never used a line shooter, preferred large squid bait and made much longer trips beyond 700 miles from port. The primary swordfish grounds lie far to the north of the Hawaiian Islands.

Beginning in 1999, a series of events related to protected species interactions and litigation with environmental NGOs have had a profound effect on the Hawaii longline fishery. Issues related to the incidental take, interaction or threat of interaction of longline gear with sea turtles, seabirds, oceanic sharks and marine mammals have lead to a number of changes in the fishery. In 2000, state legislation was passed that was later supported by federal action to prohibit the possession or landing of shark fin without the corresponding shark carcass, virtually eliminating the practice of finning sharks at sea. During the period 2000 – 2005, the fishery has experienced periodic time/area closures, retention limits on swordfish and been required to adopt various gear and operational changes to fishing related activities.

Regulations imposed in 2001 temporarily prohibited swordfish targeted longline fishing for Hawaii-based vessels due to concerns of interactions with sea turtles. Subsequently a suite of regulations were adopted to minimize interactions and facilitate the safe release of accidentally hooked sea turtles and seabirds.

As a result of restrictions on swordfish-targeted longline fishing by Hawaii-based boats, a number of vessels left Hawaii to exploit the same swordfish stocks from bases in California. Other swordfish boats converted gear to remain in Hawaii and target bigeye tuna. In April 2005, the Hawaii-based swordfishery re-opened in Hawaii under a quota system for both the number of swordfish sets and the maximum number of sea turtle interactions allowed. Integral to this program has been the requirement for 100% observer coverage. Additional operational requirements also apply including the use of large circle hooks and mackerel-type bait instead of squid. Many of the swordfish boats that had moved to California have now returned, but tuna directed effort remains high.

All vessels carry mandatory VMS monitored by the NMFS and must submit mandatory logsheet data at the completion of every trip.

The limited access program allows for 164 vessels in the fishery, but active vessel participation has been closer to 115 during the past decade. In 2003, 110 vessels actively participated in the fishery (WPRFMC 2004b). Vessel sizes range up to nearly the maximum 100 foot limit, but the average size is closer to 65 – 70 ft. Almost all of the vessels are of steel construction and use flake ice to hold catch in fresh/chilled condition. A few older wooden boats persist in the fishery. Some of the boats have mechanical refrigeration that is used to conserve ice, but catch is not frozen in this fishery.

The physical and operational characteristics of Hawaii-based longliners were summarized from interviews and NMFS data by O'Malley and Pooley (2003) during the 2000 season. Based on their interviews, swordfish vessels were newer than tuna boats on average (14 vs 23 years), were slightly larger (average 74 vs 65 feet), had larger fish hold capacities (mean 37,765 vs 33,967 pounds), carried more fuel and had more powerful engines compared to tuna targeting vessels. Swordfish vessels made fewer, longer trips, set more times per trip and traveled much further than tuna vessels. Tuna targeting vessels averaged 11 trips per year, made 11 sets per trip, set gear that averaged 29 hooks per basket and set an average of 2069 hooks per set on 33 miles of monofilament mainline. Swordfish targeting boats set only 4 or 5 hooks per basket at night. Based on interview data, Hamilton et al. (1996) found that tuna vessels operated with an average of 3.7 – 4 crewmen, while swordfish vessels required a larger crew of 4 – 5 persons (both figures excluding the captain).

Tuna vessels may range out to 1,000 nmi but generally make trips within 500 nmi from the home port of Honolulu. Prime tuna fishing grounds lie to the south of the main Hawaiian Islands and towards Johnston Atoll. The swordfish grounds center around the sub-tropical convergence zone that forms north of the Hawaiian archipelago near 35°N.

Almost all of the Hawaii-based longline catch is sold at the United Fishing Agency auction in Honolulu. It is believed that very little of the longline catch is directly marketed to retailers or exported by the fishermen.

Table 19. Hawaii-based longline fishery landings 1999-2003.

(Source: (WPRFMC 2004b).

Item	1999	2000	2001	2002	2003
Area Fished	EEZ and high seas	EEZ and high seas	EEZ and high seas	EEZ and high seas	EEZ and high seas
Total Landings (t)	14,150	11,900	7,800	8,750	8,700
Bigeye Landings (t)	2,998	2,894	2,609	4,840	3,885
Yellowfin Landings (t)	521	1,253	1,117	629	910
Catch Composition*					
Tuna	41%	41%	52%	52%	65%
Swordfish	9%	9%	1%	1%	2%
Miscellaneous	32%	32%	36%	37%	31%
Sharks	18%	18%	11%	10%	2%

Season	All year	All year	All year	All year	All year
Active Vessels	119	125	101	100	110
Total Permits	164	164	164	164	164
Total Trips	1,138	1,103	1,034	1,165	1,215
Total Ex-vessel Value (adjusted) ($millions)	$50.5	$52.5	$34.1	$38.4	$38.6

* Number of fish

<u>Hawaii-based non-longline pelagic fisheries</u>

Hawaii's coastal pelagic fisheries are divided into the aku boat (pole and line), troll, handline, and the offshore handline fisheries (WPRFMC 2004b). All fishery participants who fish, or land at least one fish with an intent to sell, within 3 miles of the shoreline (i.e. within the state) are required to have an annually renewable Commercial Marine License (CML), and vessel operators are required to file state catch reports reporting the fishing effort, catch, discards, and landings and of all those onboard during each fishing trip. These data are reported below. There are no mandatory reporting requirements for recreational participants (those who do not sell one fish during the year). However in 2001 NMFS resumed its voluntary Marine Recreational Fishing Statistics Survey (MRFSS) in Hawaii. This is a random phone survey of all Hawaii households to determine statewide fishing participation rates. Also newly instituted are associated voluntary creel surveys (the Hawaii Marine Recreational Fishing Survey or HMRFS) conducted by State of Hawaii Division of Aquatic Resources' personnel to determine catch rates and species composition. The results from these two surveys are then combined to yield estimates of recreational catch and effort by both shore and land based fishermen. No final species specific estimates of purely recreational fishing for any year have yet been released, however interim reports indicate an extremely low number of interviews to date (less than five) with recreational fishermen who caught bigeye tuna. This may well be because such landings are indeed extremely rare by recreational fishermen, as Table 20 illustrates bigeye tuna are not commonly caught on trolling gear which is the most popular pelagic recreational fishing gear.

Hawaii's seafood dealers are required to report to the Hawaii Division of Aquatic Resources the provenance (i.e. the CML number of the seller), weight and price of each fish which they buy. This provides a means to verify reported catches, to detect unreported catches, and to collect additional information regarding the weight and price of each fish. This relatively new requirement has yet to be fully implemented, however it is believed that Hawaii's major fish dealers are now in compliance.

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.

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.

In 2003 there were 3,219 licensed commercial pelagic fishermen in Hawaii. Of these licensed fishermen most indicated that their primary interest was to catch pelagic fish (67%). Most of these pelagic targeting fishermen indicated that their primary fishing method was trolling (73%) or longline fishing (17%). Mixed handline fishing gears (8%) and skipjack pole and line fishing (2%) accounted for the rest of the licensed fishermen (WPRFMC, 2004b).

Though somewhat dated, Boggs and Ito (1993) provide an excellent overview of the development and status of Hawaii's pelagic fisheries circa 1990. Generally, the aku boat fishery has contracted steadily to where it now exists as minor remnant of former times while the longline fishery has expanded steadily and is by far the leading producer of pelagic landings and bigeye tuna in Hawaii. The fishery is based upon and targets sub-adult and adult sized bigeye tuna. The MHI troll and handline fisheries take a variety of pelagic species of which bigeye tuna is a relatively minor component. The inshore *ika shibi* handline fishery for large tunas, which did at one time take significant quantities of bigeye tuna, has contracted steadily over the last decade for a variety of reasons. In its place, the “offshore handline fishery” has evolved steadily and undergone a number of changes. This fishery originally centered on handline and troll fishing on tuna found in aggregations around the Cross Seamount and four offshore moored NOAA weather buoys. Although, the FADs moored around the coast of Hawaii by the State government have not been used extensively by the offshore handline fishery, the fishery has, in recent years, expanded to include fishing operations on privately set FADs, some of which are very close to the MHI thus blurring the distinction between “offshore handline” and “MHI handline” fisheries. The private FAD fishery is included here with the offshore handline fishery due to similar fishing techniques, operational and catch characteristics. The offshore handline fishery targets juvenile and sub-adult bigeye tuna with a considerable catch of juvenile, sub-adult and adult size yellowfin.

Hawaii aku boat pole-and-line fishery

The Hawaiian pole and line fishery has had a long development from traditional Hawaiian canoes in the 1800s to the unique “Hawaiian sampan” still in use today. These vessels evolved from designs introduced to Hawaii by Japanese immigrants and employed live bait assisted poling techniques from Okinawa. Boggs and Kikkawa (1991) provide a summary of the development and status if the fishery.

The skipjack, or aku boat fishery was formerly the most important domestic Hawaiian pelagic fishery, supplying fresh and dried skipjack to domestic markets and a locally-based cannery. The fleet size peaked in 1948 at 32 vessels while maximum production reached 7,400 t in 1965. The fishery has been in steady decline since the mid-1970s reflecting a decline in total effort as well as declining CPUE (Boggs and Kikkawa 1991). Constraints to the fishery have included limitations on live baitfish supplies, increased competition and reduced profitability due to the developing skipjack purse seine fisheries, the closure of the local cannery in 1984, increased fixed costs and general ageing of the fleet. There has also been a significant and ongoing decline in the CPUE of large sized skipjack by the fishery that have a higher value and marketability compared to the smaller fish.

Landings have declined from around 1000 – 2,000 t/year during the 1980s and 1990s, to 509 t in 2002 (WPRFMC 2004b). During the history of the fishery, the catch has been predominantly skipjack with small quantities of juvenile yellowfin and bigeye tuna. Catches of juvenile yellowfin and bigeye tuna occur primarily during times of low skipjack abundance when the boats operate on anchored FADs set by the State of Hawaii. Generally, landings of juvenile bigeye are considered insignificant by this fishery and do not appear in published sources. However, it is known that some juvenile bigeye tuna are taken by the fishery, particularly when operating on FADs. During tagging cruises of the Hawaii Tuna Tagging Project on a Hawaii-based pole and line vessel Itano and Holland (2000) recorded 81 bigeye tuna tagged and released on Hawaii State FADs. These fish were all of juvenile size (40 – 64 cm) averaging 47 cm FL and are believed to be representative of the size range typically encountered by the fishery. In 2003 this fishery reported landing 25 t of yellowfin tuna.

Hawaii troll and handline fisheries

The troll and handline fisheries of the main Hawaiian Islands (MHI) consist of a poorly differentiated mix of recreational, subsistence and commercial fishers running primarily single day trips from small vessels. The long term average reported commercial tuna catch by MHI troll gear (1982 – 2003) was 552 t, with 566 t reported in 2003 (WPRFMC 2004b). The most important species by weight in the fishery (1982 - 2003 means) in declining order were yellowfin, blue marlin, dolphinfish, wahoo and skipjack. Bigeye tuna make up a very minor proportion of total reported troll catch, ranking eighth in importance (by weight) behind albacore and striped marlin. In 2003, only 6.4 t of bigeye were recorded. An additional 403 t of yellowfin tuna were reported landed in 2003 (WPRFMC 2004b).

Several different methods and styles of handline fishing are used in Hawaii to take pelagic species; primarily yellowfin tuna, bigeye tuna, and albacore. Boggs and Ito (1993) categorize the primary handline methods into: 1) daytime *palu ahi* fishing; and 2) the night time *ika shibi* style of fishing. These fishing methods are described in detail by Yuen (1979) and Rizzuto (1983). *Palu ahi* fishing is a modern evolution of the traditional Polynesian *drop stone* technique to target chum and a baited, single hook handline on sub-surface concentrations of tuna. The method usually concentrates on medium-sized tuna found in natural aggregations near the main islands or near fish aggregation devices (FADs). The *ika shibi* fishery targets medium and large sized tuna attracted to drifting vessels using underwater bait-attracting lights and additional chum supplied by the fishermen.

The long term average tuna catch by the MHI handline fishery (1982 – 2003) was 745 t with 529 t of tunas reported in 2003. The reported MHI handline catch consists primarily of yellowfin tuna, followed by bigeye and albacore. However, bigeye tuna were once an important component of the *ika shibi* handline fishery, accounting for the highest proportion of catch and value landed by the fishery in 1973 – 1974 (Yuen 1979). During the same time period, catch records of the Hawaii Division of Aquatic Resources (HDAR) recorded only minor landings of bigeye tuna by the fishery (Boggs and Ito 1993), highlighting a reporting problem that exists to this day. Significant mixing of bigeye with yellowfin catch statistics has apparently plagued handline and troll catches for decades. Reported 2003 MHI handline catches were 343.5 t, 90 t and 89.5 t respectively (WPRFMC 2004b).

Landings by the MHI handline fisheries peaked in 1986 followed by a decline in catches apparently led by a general decline in effort by the *ika shibi* fishery. The increase in reported bigeye catch in recent years may reflect better species specific reporting by the fisheries and recording by HDAR. However, further investigation is required to clarify these issues.

The total number of recreational fishers in Hawaii is unknown but there are about 14,300 small vessels in Hawaii, of which about 90% are registered as ‘pleasure craft’. McConnell and Haab (2001) estimated that 6,600 of these vessels might be used for recreational fishing. Out of a sample of 1008 respondents from these 6,600 vessel owners in a phone survey, 17% indicated that their vessel was either not being used or was not used for fishing. Based on these data it is estimated that Hawaii’s recreational small boat fleet numbers about 5,500 vessels. As mentioned above, NMFS' MRFSS program has been sampling recreational catches since 2001. The preliminary data indicate that little to no bigeye tuna is caught by recreational fishers, while yellowfin landings have been estimated to range between 2,270 and 5050 t, with a three year mean of 3,295 t. However, caution must be exercised in interpreting the figures from the MFRSS program, which are generated through the product of catch per trip from intercept surveys at landing sites, and a random digit dialing phone survey to estimate effort in trips. The recent NRC review of the entire MRFSS was highly critical of the sampling methods and statistical algorithms employed to develop recreational catch totals. As such the Council has recommended that MRFSS catch estimates should not be used for management purposes until these problems have been resolved.

Hawaii offshore handline fishery

Larger handline vessels moved offshore to exploit tuna aggregations found on an offshore submarine feature (Cross Seamount) and anchored weather buoys 100 – 200 nmi from the main Hawaiian Islands (Boggs and Ito 1993). This fishery is considered to be distinct from the MHI handline fisheries due to significant differences in fishing grounds, trip characteristics, fishing methods, and landings. Separate catch and effort statistics have been reported by HDAR and NMFS since 1990.

The development and fishery characteristics of the offshore handline fishery are described in detail by Itano (1998a). Hamilton and Huffman (1997) provide economic and some operational details on the fishery. Offshore handline boats are generally larger and better equipped than typical MHI handline boats that use a variety of handline and troll methods. Crew sizes range from 2 – 5 persons taking part in multiple day trips that were reported to average 4.9 days (Hamilton and Huffman 1997).

The fishery targets juvenile and sub-adult bigeye and yellowfin tuna in structure-associated aggregations that are highly vulnerable to simple hook and line gear types (Itano and Holland 2000). The WPRFMC initiated the Hawaii Handline Project to examine catch and effort data on the fishery. A control date of July 2, 1992 for participation in the fishery was established by the Council and later updated to July 15, 2000, but has not been applied to date. Data from the Hawaii Handline Project, NMFS dock sampling, and the Hawaii Tuna Tagging Project determined that the fishery targets bigeye tuna in the size range of 6.8 – 18 kgs, although larger fish to 30+ kgs contribute significantly to the value of landings. Yellowfin tuna make up a smaller proportion of the catch. The same sources of data indicate that total tuna landings from the fishery consist of 75 – 80% bigeye and ~20% juvenile yellowfin (Itano 1998a). Smaller quantities of dolphinfish, wahoo and billfish are also taken.

Reported landings by the fishery peaked in 1994 at 533 t with a long term average (1990 – 2003) of 383 t/year. HDAR catch statistics reported ~ 75 - 80% yellowfin in the catch during the pre-1995 period after which the proportion of reported bigeye has gradually increased. This situation is likely due to the standard practice of HDAR to record any catches reported under the Hawaiian name of "*ahi*" as yellowfin tuna despite the fact that the fishery takes mainly bigeye tuna. Therefore, species specific landing data for the earlier years should be viewed with caution. In recent years, species specific catch report forms and efforts by HDAR to educate fishermen on the importance of correct species identification and reporting procedures may have improved the situation significantly. In 2003, total landings of 148 t were recorded of which 122 t was bigeye and 18 t yellowfin (WPRFMC 2004b).

Although current information is difficult to obtain, it appears that total effort and catch by the offshore handline fishery has declined in recent years. At the same time, there has been increasing effort by Hawaii handline fishermen directed to the setting of privately funded FADs. The so called "Private FAD" fishery (PFAD) is centered off the east coast of the island of Hawaii, but PFADs currently surround the island at distances of approximately 15 – 50 nmi (HDAR pers. comm.). These buoys appear to aggregate juvenile and sub-adult bigeye and yellowfin tuna in a similar manner to which they aggregate to the weather buoys fished by the offshore handline fishery. Fishing methods, gears and catch composition are believed to be very similar to the offshore handline fishery. However, there is a marked lack of documented information on the PFAD fishery. The Pelagic Fisheries Research Program is currently funding a study on Hawaii handline fisheries that may provide additional information on the current status of PFADs and related fisheries[10]

Another recent development in Hawaii pelagic fisheries has been the adoption of short longline-type gear less than one nmi in length on the Cross Seamount to target bigeye tuna and the lustrous pomfret (*Eumegistus illustris*). This type of gear has been referred to as "short-line gear" in Council documents though it is not yet defined as a separate gear type within the Pelagics FMP. The gear type lands bigeye tuna of a larger size and higher value than handline vessels operating in the time/area strata. The use of and catch characteristics short-line gear on the Cross Seamount has been documented by Beverly et al. (2004) and Itano (2005). The method improves targeting of baited branchlines at depth and has been proposed as a means to reduce shallow-water bycatch within the upper mixed-layer.

Table 20 summarizes the 2003 catches from each of these fisheries, and their relative importance to each fishery.

Table 20. Hawaii-based non-longline commercial pelagic fishery 2003 landings (t).

(Source: WPRFMC 2004b)

Fleet	Total landings (t)	Skipjack landings (t)	Bigeye landings (t)	Bigeye as percent of total fleet landings	Yellowfin landings (t)	Yellowfin as percent of total fleet landings
Aku boats	510	480	0	0%	25	4.9%
Troll	1,345	85	73	5.4%	403	29.9%
Handline	575	6	90	15.7%	344	59.8%
Offshore handline	150	0	122	83.0%	18	12.0%
Total landings	2,580	571	285	11.1%	790	30.6%

[10] Human Dimensions Analysis of Hawaii's *Ika-Shibi* Fishery, E. Glazier and J. Petterson

American Samoa-based longline fishery

In 1995, small-scale longline fishing began in American Samoa following training initiated by the Secretariat of the Pacific Community (Chapman 1998). Both the American Samoa and Samoa fisheries are based on supplying fresh or frozen albacore directly to the two large tuna canneries in Pago Pago. The American Samoa albacore longline fleet was originally based on 9.0 m aluminum hulled alia-style catamarans fitted with manual longline reels setting around 300 hooks per day on 3 to 4 miles of monofilament mainline. Single day trips were the rule. Larger alia style vessels and monohull vessels of various styles and sizes (generally > 12 m) have since entered the fishery.

In 1997, a larger vessel began making multiple day trips for the first time in the fishery. In 2001, 25 large monohull vessels greater than 15 m in length entered the fishery. These vessels were equipped with large, hydraulically driven longline reels, modern marine electronics for communication and fish finding and mechanical refrigeration (O'Malley and Pooley 2002). Albacore landings expanded in response to increasing effort from 29 t in 1995 to 6,559 t during 2002 (WPRFMC 2004b).

Total landings peaked in 2002 and have been declining since. Effort in numbers of hooks continued to rise through 2003 when 14.3 million hooks were set. In 2003, 51 longline boats were active, landing a total of 5,691 t of all species combined. The decrease in total catch is attributable to a 33% decrease in albacore landings, the primary target species. A noted decrease in CPUE of albacore was evident while there was a slight increase in bigeye and yellowfin CPUE (WPRFMC 2004b).

Bigeye tuna are not targeted by the fishery and represented only 279 t of the 2003 total catch. This is in part because the canneries will not purchase large bigeye tuna due to the darkening of the meat resulting from the canning process. However, almost all of the albacore is sold to the cannery as well as some quantities of wahoo, yellowfin tuna and small bigeye tuna. The rest is sold on the domestic market as fresh fish or consumed directly. The average size of bigeye has ranged from 25.9 – 37.6 kg but dropped to 16.9 kg in 2003. Yellowfin tuna landings have increased along with fleet size, with 569 t landed in 2003, a 6% increase over the previous year. Attempts have been made to export the larger bigeye and yellowfin tuna from the fishery but it is not believed to be widespread at this time due to a lack of air freight services. In 1999, some longline boats began to land albacore gilled and gutted at a higher price (WPRFMC 2004b).

In 2003, the fleet consisted of 15 small alia-style catamarans, four monohull vessels less than 50 feet in length and 32 larger monohull vessels over 50 feet in length. Fishing power is clearly distinct between the different size classes of vessel and separate catch statistics are compiled. The alias use manually powered mainline drums that hold about four miles of monofilament line. The boats make single day trips wit a crew of three, setting around 300 – 350 hooks per set and keep their catch on ice. The large monohull vessels are similar and in some cases the same vessels that have engaged in the Hawaii longline fishery. These boats are typically steel hulled vessels of around 20 – 22 m operating hydraulically driven mainline reels holding 40 – 50 miles of monofilament, setting around 2000 hooks per day with crews of 5 – 6. They are also likely to be well equipped with marine electronics and may have refrigeration systems to keep ice or semi-freeze catch onboard for extended trips. Therefore, the larger vessels can range out to the outer portions of the EEZ and some have in the past negotiated fishing access with neighboring states.

The fishery is now transitioning to a limited access program developed by the Western Pacific Regional Management Council and implemented by NMFS. Under this program vessel operators must submit federal longline logbooks and must carry VMS systems and observers if requested by NMFS.

In 2002, domestic longline vessels greater than 50 feet in overall length were prohibited from operating within an area of 50 nm surrounding the islands of American Samoa, including Tutuila, the Manua group, Swains Island and Rose Atoll. These measures were enacted to reduce gear interaction and competition with the smaller alia-style catamarans. American Samoa longline vessel operators must also carry gear and be trained to facilitate the health and release of protected species that may become accidentally hooked or entangled. A NMFS observer program is being implemented to document the rate of protected species interactions. The 2003 total catch and bigeye and yellowfin catches from the American Samoa longline fleet are given in Table 21.

Table 21. American Samoa-based longline landings for 2003 (t).

(Source: WPRFMC 2004b)

Total landings	Bigeye landings	Bigeye as percent of total fishery landings	Yellowfin landings	Yellowfin as percent of total fishery landings
5,691	279	4.9%	569	10.0%

American Samoa small boat pelagic fisheries

Prior to 1995, pelagic fishing in American Samoa essentially meant trolling from small outboard powered vessels and a few monohull inboard powered craft. Trolling accounted for 15.5 t of pelagic fish in 2003, most of which consisted of yellowfin (3.5 t) and skipjack (9.7 t) tuna (see Table 22). Bigeye tuna are not taken in the American Samoa troll fishery (WPRFMC 2004b).

CNMI small boat pelagic fisheries

Small troll vessels less than 7.3 m in length characterize the CNMI pelagic fishery which takes place close to the inhabited islands. Total reported landings of all pelagics in 2003 were 113.6 t and consisted primarily of skipjack tuna, yellowfin tuna, dolphinfish, dogtooth tuna and wahoo (WPRFMC 2004b). Similar to Guam, the CNMI pelagic fishery is made up of a mixture of overlapping recreational, subsistence, charter and commercial interests that are poorly defined. Currently, commercial catches are only documented on the main island of Saipan where the data coverage rate is estimated at ~80%. Vessels larger than five net tons are required to hold a commercial marine license issued by the government. Bigeye tuna do not appear in the landing statistics for the CNMI fishery and are not believed to be taken by the troll fishery. In 2003 the CNMI commercial fishery was estimated to have landed 12.8 t of yellowfin tuna (WPRFMC 2004b).

Guam small boat pelagic fisheries

Guam hosts a number of distant-water purse seine and longline fleets, but does not currently engage in any large-scale pelagic fisheries. The domestic pelagic fishery is made up of a mixture of recreational or charter vessels that conduct single-day trolling trips within the EEZ of Guam or occasionally in the waters of the neighboring Northern Marianas Islands. An estimated 375 small boats were active in the fishery in 2003. Pelagic landings in 2003 totaled 253 t, and in declining order by weight were mainly comprised of skipjack tuna and dolphinfish with lesser amounts of wahoo, blue marlin and yellowfin tuna (WPRFMC 2004b). The long term average pelagic catch (1982 – 2003) was 295 t, of which about 40 – 45 % consisted of tuna species. Bigeye tuna do not appear in the landing statistics and are essentially not taken by the Guam based domestic pelagic fishery. In 2003 Guam's domestic fishery was estimated to have landed 33.8 t of yellowfin tuna.

Table 22. Summary of 2003 bigeye and yellowfin catches by vessels managed under the Pelagics FMP.

(Source: WPRFMC 2004b)

Fishery	Total landings (t)	Bigeye landings (t)	Bigeye as percent of 2004 Pacific-wide landings (226,151 t, WCPFC 2005)	Yellowfin landings (t)	Yellowfin as percent of 2004 Pacific-wide landings (680,746 t, WCPFC 2005)
Hawaii-based longline	8,700	3,885	1.72%	910	0.13%
Hawaii-based small commercial boat	2,580	285	0.13%	790	0.12%
American Samoa-based longline	5,691	279	0.12%	569	0.08%
American Samoa-based small boat	15.5	0	0%	3.5	0.0005%
CNMI-based small boat	113.6	0	0%	12.8	0.002%
Guam-based small boat	253	0	0%	33.8	0.005%
Total	17,353	4,449	1.97%	2,319	0.34%

10.10 WPRFMC Fishing Communities

The Magnuson-Stevens Act defines a "fishing community" as "...a community that is substantially dependent upon or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew, and fish processors that are based in such communities" (Sec. 3 (16)). NMFS further specifies in the National Standard guidelines that a fishing community is "...a social or economic group whose members reside in a specific location and share a common dependency on commercial, recreational, or subsistence fishing or on directly related fisheries dependent services and industries (for example, boatyards, ice suppliers, tackle shops)".

In 1998, the Council identified the islands of American Samoa, the Northern Mariana Islands and Guam as fishing communities for the purposes of assessing the effects of fishery conservation and management measures on fishing communities, providing for the sustained participation of such communities, minimizing adverse economic impacts on such communities, and for other purposes under the MSA (64 FR 19067). In 2002, the Council identified each of the islands of Kauai, Ni'ihau, Oahu, Maui, Molokai, Lanai and Hawaii as a fishing community (68 FR 46112).

The city of Honolulu on the island of Oahu is the base of the longline and other industrial-scale fleets and the center of the state's fish marketing/distribution network (NMFS 2001a). However, the total number of pelagic fisheries-related jobs in the Honolulu metropolitan area compared to the overall number of jobs in the area is very small. Oahu contains approximately three-quarters of the state's total population, and over one-half of Oahu's residents live in the "primary urban center," which includes greater Honolulu. Thus, although Oahu has a high level of engagement in fishing and especially longline fishing relative to the other islands in Hawaii, the island's level of dependence on it is lower due to the size and scope of Oahu's population and economy.

The nature and magnitude of Hawaii communities' dependence on and engagement in pelagic fisheries have also been affected by the overall condition of the state's economy. As described in NMFS' 2001 and 2004 Final Environmental Impact Statements (NMFS 2001 and 2004a), tourism is by far the leading industry in Hawaii in terms of generating jobs and contributing to gross state product. In the first years of the new century Hawaii's tourism industry suffered major external shocks, including the September 11 terrorist attacks and SARS (severe acute respiratory syndrome) epidemic (Brewbaker 2003). The market for tuna weakened due to the decline in tourists arriving from Japan and elsewhere and due to a weak export demand. More recently, the decline in the value of the U.S. dollar compared with other currencies such as the Euro and the Japanese yen has made it more expensive for Americans to travel overseas and cheaper for foreign visitors to visit Hawaii. The weak U.S. dollar, combined with moderate growth in the national economy, is expected to help boost the state's tourism industry. Both domestic and international visitor counts have shown a general increasing trend (Brewbaker 2003). These improvements in Hawaii's tourist industry will likely have a positive economic effect on local businesses engaged in the harvesting, processing and marketing of pelagic fishery resources.

11.0 Environmental Impacts of the Alternatives

The alternatives considered by the Council are described in Sections 8 and 9 and are summarized below in Table 23.

Table 23. Alternatives considered to end overfishing of Pacific-wide bigeye and WCPO yellowfin tuna.

Alternative	Measures
International Alternative 1	No action
International Alternative 2	End overfishing immediately (preferred)
International Alternative 3	Phase out overfishing over a maximum of 10 years
Small Boat Alternative 1	No action
Small Boat Alternative 2	Implement fishery controls
Small Boat Alternative 3	Establish control date (preferred)
Small Boat Alternative 4	Increase data collection (preferred) a) require federal permits and logbooks for all Hawaii-based small boat commercial pelagic fishermen; b) implement a voluntary reporting system for Hawaii-based small boat recreational pelagic fishermen; c) implement a targeted survey of all Hawaii-based small boat pelagic owners and operators to obtain information on their fishing effort and catches.

11.1 Impacts of International Alternatives

The NEPA analyses of the International Alternatives are necessarily general, because of the international scope of the overfishing. As such no actual regulatory measures can be implemented via Council action to effectively address the situation. Also, any future domestic actions taken to implement measures proposed by the associated RFMOs will be subject to NEPA analysis, as necessary, prior to implementation.

11.1.1 Impacts on Target Stocks

Under the no-action alternative (International Alternative 1) the Council would make no recommendations to be advanced by the U.S. through the IATTC and WCPFC. While these organizations may independently take action to recover Pacific-wide bigeye tuna and WCPO yellowfin stocks there is no guarantee that this would happen. Indeed, actions to date by both RFMOs have been at best only sufficient to maintain international effort levels rather than resulting in wholesale reduction in fishing effort and hence fishing mortality. In particular, the WCPFC has yet to implement any restrictions on purse seine effort and purse seining around FADs. Without Council action it is likely that, at best, overfishing of both Pacific-wide bigeye tuna and WCPO yellowfin stocks would not increase but fishing mortality levels would remain too high and both stocks would ultimately become overfished. At worst, the reduction of stock levels would occur at a more accelerated rate as evinced by various scenarios from population modeling and stock assessments (WCPFC 2006). Moreover, Council inaction may also be contributory to expansion of purse seine and longline fishing such that other target stocks such as albacore and skipjack, or important incidental catches such as mahimahi, marlins, wahoo etc. also become subjected to overfishing. The no action alternative would not be consistent with National Standard 1 of the MSA, which requires Councils to take action when stocks are overfished or overfishing is occurring. Although unilateral action by the Council will not recover Pacific-wide bigeye tuna and WCPO yellowfin stocks, this does not imply that Council inaction would be an appropriate response.

Under International Alternative 2 (end overfishing immediately), the Council would recommend that the delegations to the Pacific RFMOs immediately reduce international fishing mortality as recommended by the WCPFC Science Committee and the Scientific Staff of the IATTC to result in the most immediate reduction of international overfishing on Pacific-wide bigeye tuna and WCPO yellowfin stocks. Based on stock assessments conducted in 2005 (WCPFC 2005) and 2006 (IATTC 2006a), fishing mortality on Pacific bigeye and WCPO yellowfin stocks by both longlines and purse seines needs to be reduced in the WCPO by 20% from 2001-2003 levels for each gear type. In the Eastern Pacific Ocean (EPO) fishing mortality on Pacific bigeye by longline vessels needs to be reduced by 30% and purse seine fishing mortality by 38% as compared to 2003-2004 fishing levels (IATTC 2006a).This is the strongest of the three alternatives considered. The Council recognizes that even if both RFMOs adopted the recommended measures immediately, they would be difficult to implement and it would take several years to fully implement all the required actions to sufficiently reduce purse seine and longline fishing effort and catches. In addition, resource conditions and stock status can change relatively quickly and committing to this action may turn out to be overly cautious. However reductions in the specified amounts in fishing mortality on the two stocks, if successfully implemented would likely end overfishing of the two stocks and thus achieving this action's objective, with the most rapid recovery of the two tuna stocks. It may also ensure that other target stocks do not become overfished. If resource conditions change significantly, the Council and RFMOs may make additional recommendations in response.

International Alternative 3 would recommend a phased approach over 10 years to reducing international overfishing by the Pacific RFMOs. This would achieve this action's objective; however stocks may continue to be subject to overfishing during this period thus making their recovery less certain. While the impacts of environmental parameters are beyond the control of fishery managers, the adoption of a phased approach to ending overfishing of Pacific-wide bigeye tuna and WCPO yellowfin stocks may exacerbate negative impacts by maintaining stocks at low levels during periods of low recruitment.

11.1.2 Impacts on Non-target Stocks

Under the no action alternative, international purse seine and longline fishing impacts on non-target stocks would continue as described in Section 10.8. These stocks do not appear to be in danger of overfishing. International Alternatives 2 and 3 would both be expected to lead to reductions in fishing mortality across the entire range of non-target species caught by purse seines and longlines, with reductions occurring more rapidly under Alternative 2. These reductions in both incidental catches and bycatch (i.e. discards) are expected to be proportionate to reductions in bigeye and yellowfin catches as vessel operators do not desire to catch non-target species due to their relatively low value. Should bigeye and yellowfin tuna prices rise significantly due to reduced landings, there is potential for the prices of some non-target species to rise to the point that they become target species. If this should happen, the Council and RFMOs may make additional recommendations in response.

11.1.3 Impacts on Other Species

Under the no action alternative, international purse seine and longline fishing impacts on other species would continue as described in Section 10.8. International Alternatives 2 and 3 would both be expected to lead to reductions in fishery interactions and mortalities with seabirds, sea turtles, and marine mammals, with reductions occurring more rapidly under Alternative 2.

Reductions in longline fishing would be expected to decrease the number of interactions between longlines and sea turtles in the tropical and sub-tropical Pacific. Similarly, reductions in purse seine fishing would decrease interactions between purse seines and sea turtles, especially in the EPO, where such interactions are more frequent. Moreover, reductions in purse seine fishing on FADs (due to reductions of the number of FAD used) should result in proportionately less encounters and entangling of turtles in the materials used to construct FADs.

Seabird-longline interactions are essentially confined to sub-tropical latitudes, however, International Alternatives 2 and 3 would be expected to somewhat reduce such interactions if they include reductions in longlining directed at bigeye tuna in higher latitudes. However, because deep-set longline fishing for tuna tends to have far lower seabird interaction rates than shallow-set longlining for swordfish, these reductions may be small. Purse seine gear is not generally believed to interact with seabirds.

Marine mammal interactions in tuna fisheries are most frequent between purse seiners and dolphins in the EPO, where purse seiners have traditionally targeted yellowfin tuna schools associated with dolphin pods. Indeed, the development of the FAD-associated purse seine fishery in the EPO was part of the strategy adopted to reduce dolphin mortalities from purse seine fishing. In the WCPO purse seine sets have been traditionally made on free swimming skipjack schools and skipjack schools associated with logs or other floating objects, which minimizes dolphin interactions. Reductions in international purse seining under International Alternatives 2 and 3 should decrease purse seine-dolphin interactions, especially in the EPO, but this could be offset with the reduction of sets on FADs to minimize juvenile bigeye and yellowfin fishing mortality. Longline interactions with marine mammals include both depredation of catches by small toothed whales such as false killer whales and pilot whales, and the occasional capture thereof. Reductions in international longline fishing across the Pacific would be expected to proportionately reduce these interactions.

11.1.4 Impacts on Marine Habitat

Because the affected fisheries use purse seine nets and hook-and-line gear which do not contact the seabed, and because none of the international alternatives considered here would be expected to significantly alter these fishing operations, no impacts on marine habitat are anticipated under any of the alternatives. However loose FADS, both un-tethered or tethered which have slipped their moorings, are known to wash ashore on Pacific coasts and reduction of FAD associated sets would reduce the number of FADs being deployed in the Pacific and hence the frequency of groundings and associated impacts on Pacific coastlines.

11.1.5 Impacts on Biodiversity and Ecosystem Functions

The impacts of pelagic fisheries in the Pacific and other oceans have been the topic of a substantial research effort over the last 50 years, and more recently the topic of debate within the scientific community. Myers and Worm (2003) argue that long-term trends in Japanese longline spatially aggregated CPUE could be interpreted to indicate that the community (species-aggregated) biomass of large pelagic fish, mainly tunas, was reduced by 80% during the first 15 years of exploitation and is now at 10% of pre-industrial levels. Similar claims have been advanced for declines of shark populations in the Northwest Atlantic Ocean and Gulf of Mexico based on U.S. longline fishery data (Baum et al. 2003, Baum and Myers 2004).

However, these claims have been challenged by several additional studies by Walters (2003), Burgess et al. (2005), Hampton et al. (2005) and Polachek (2006). These authors suggest that spatial CPUE data can provide useful indices of population trends provided that they are averaged so as to correct for effects of changes in the distribution of fishing activity. If such analyses ignore unfished strata (averaging only over the areas that were fished), it amounts to assuming that these strata behave in the same way as the fished strata, and can lead to severe hyper-depletion in abundance indices for fisheries that developed progressively over large regions. Moreover, as Hampton et al. (2005) have noted, the conclusions of Myers and Worm

(2003) are not supported by stock assessments of Pacific tunas, which rely on a range of data in addition to CPUE, including catch, size composition, tagging and biological data. When stock-assessment models that consider all the available data are applied to Pacific tunas, fishery-induced declines in abundance during the 1950s and 1960s of the magnitude proposed by Myers and Worm are found to be extremely unlikely. Moreover, where declines do occur, they are not, as claimed by Myers and Worm, due exclusively to fishing.

Other studies have attempted to build trophic models of the Pacific to estimate the impacts of removals or changes in abundance of species or groups of species on the assemblage of pelagic species within this ecosystem. Kitchell et al. (1999, 2002) used the ECOPATH family of models to evaluate the impact of fishing on keystone predators such as sharks, tunas and billfish. The authors conclude that no single fish species of the highest trophic levels appears to have a profound or uniquely important role in the organization and structure of the Central Pacific ecosystem. The most important components among the guild of apex predators appear to be species such as yellowfin and skipjack tunas which have greater biomass than other apex predators, highly diverse diets and rapid turnover rates. Moreover, the authors note that other sources of mortality such as cannibalism, particularly among sharks, may have a strong influence on ecosystem assemblages and abundance.

Under International Alternative 1 (no action), WCPO yellowfin tuna and Pacific bigeye tuna would continue to be subject to international overfishing and ultimately the stocks would likely become overfished, with biomasses reduced to below the minimum stock size thresholds. Kitchell et al. (2002) reported that their model of the Central Pacific demonstrated strong predator-removal effects when yellowfin or bigeye tunas are heavily harvested. When either one is fished intensively reciprocal changes are evident among many of the competitors and prey pools including skipjack, mahimahi and flying fishes. Kitchell et al. (2002) note that increases in mahimahi in catch records have been widely reported from many of the world's tropical seas. Moreover, skipjack, although extremely heavily fished in the WCPO has shown no indication of a major decline in biomass, indeed a positive trend is evident for the WCPO between 1975 and 2005 (Langley et al. 2005).

Under International Alternative 2, international fishing effort and mortality would be significantly reduced for Pacific bigeye and WCPO yellowfin. In contrast to Alternative 1, where fishing mortality is likely to increase and biomasses of the two tunas to decline, Alternative 2's reduction in international fishing mortality on Pacific bigeye and WCPO yellowfin would be expected to result in increases in these populations, with concomitant reciprocal effects on their competitors and prey. A similar result would be expected under International Alternative 3, but over a longer time period. Both International Alternatives 2 and 3 would include reductions in purse seining around FADs, resulting in reductions in bycatch and associated impacts on a wide range of target and non-target species.

11.1.6 Impacts on Public Health and Safety

None of the international alternatives considered here are expected to require participants to fish in ways significantly outside of historical patterns, and thus no impacts on public health and safety are anticipated under any of the alternatives.

11.1.7 Impacts on Fishery Participants and Fishing Communities

Under International Alternative 1 (no action), impacts to fishery participants would initially be minimal to non-existent. However, should Pacific-wide bigeye tuna and WCPO yellowfin stocks decline in the absence of increased controls on fishing effort, fishery participants will experience progressively worsening catch rates, which will affect economic returns from fishing and result in adverse impacts to fishing communities. Moreover, if stock biomasses are reduced to levels where Pacific-wide bigeye tuna and WCPO yellowfin stocks are categorized as overfished, participants (especially those in the U.S. fishing industries) may be even more constrained from targeting these stocks. Impacts of the action alternatives will vary significantly depending on the specific measures implemented.

Even though an instantaneous reduction in fishing effort is not expected, International Alternative 2 would be expected to have the largest adverse impacts on fishery participants in the relative near-term. The most widespread impacts would be felt by those nations with the largest longline and purse seine fishing fleets, especially Japan and Taiwan. These nations have a combined total of around 5,000 longline vessels, which represents a considerable investment and labor force and a substantial reduction in longline fishing would have large impacts in these two countries. Several nations have large purse seine fleets, including Japan, Taiwan, Korea, Mexico and Ecuador. Given Alternative 2's recommendations for reducing purse seine fishing effort, impacts are likely to be the greatest on nations with large purse seine fleets (e.g. Japan, Taiwan and Papua New Guinea). However Alternative 2 has the greatest potential for allowing the sustained participation of fishing communities by helping to ensure the long-term availability of bigeye and yellowfin tuna.

The phased approach contemplated under International Alternative 3 would provide opportunities to minimize the negative impacts associated with the required reductions of both international longline and purse seine fishing by allowing time for nations and fleets to shift into other fisheries and industries. This would provide fishery participants and communities with alternative employment, income, and protein sources.

11.1.8 Impacts on Data Collection and Monitoring

Under Alternative 1 (no action), no immediate impacts to data collection and monitoring would be anticipated. As described in Sections 10.8.2.1 and 10.8.2.2, the international management of tunas in the WCPO and the EPO are the responsibilities of the WCPFC and the IATTC, including data collection activities. In the WCPO about 80% of all tuna catches can be accounted for, but there are notable data gaps and believed wide-scale under-reporting by tuna fisheries in Indonesia and the Philippines.

Currently, the longline fleets in both the EPO and WCPO are operating under quotas for Pacific bigeye tuna. Restrictions on EPO purse seiners are currently limited to fishing effort limitations as opposed to catch quotas. Reductions in fishing mortality through the implementation of additional catch quotas in both parts of the Pacific Ocean would likely lead to more timely catch monitoring to ensure that quotas are not exceeded. Under Alternative 2, such measures would be implemented more rapidly than under Alternative 3, thus providing quicker access to improved catch and effort information.

11.2 Impacts of Small Boat Alternatives

11.2.1 Impacts on Target Stocks

As described in Section 10.9, the small boat pelagic fisheries managed under the Council's Pelagics FMP are multi-target fisheries in which fishermen catch a range of PMUS, with the majority of catches consisting of yellowfin and skipjack. With the exception of Hawaii's offshore handline fishery, bigeye tuna is probably not a main target species for many of these vessels, however it is a welcome and valuable catch. Under Small Boat Alternative 1 (no action) these fisheries would continue to operate as described in Section 10.9

Under Small Boat Alternative 2, fishing mortality on target species would be directly (in the case of the bigeye and yellowfin tuna fisheries) or indirectly (in the case of skipjack fisheries) reduced through regulatory controls designed to reduce bigeye and yellowfin mortality.

Small Boat Alternative 3 (preferred, and already implemented) provides a mechanism to limit future participation in Hawaii's small boat commercial pelagic fisheries. Due to the small sizes of these fisheries (about 0.14% of Pacific-wide totals for both yellowfin and bigeye), such controls would not be anticipated to result in significant impacts to bigeye and yellowfin stocks. Limitations on catch or under Alternatives 2 and 3 would not be expected to significantly affect WCPO yellowfin tuna and Pacific bigeye tuna stocks.

Small Boat Alternative 4 (preferred), which would require operators of Hawaii small commercial pelagic vessels to obtain federal permits and to maintain federal logbooks of their catches could indirectly result in small reductions in fishing effort and mortality as there may be some current or potential fishery participants who would be unwilling to observe these conditions. Small Boat Alternative 4 would be expected to also improve information on recreational catches of Pacific bigeye and yellowfin tuna through voluntary reporting and targeted surveys.

None of the alternatives are expected to increase catches of target stocks in any significant manner and therefore none are anticipated to result in adverse impacts to these stocks. As described above, alternatives that would reduce catches of target stocks would reduce fishing impacts on these species.

11.2.2 Impacts on Non-target Stocks

Under the no action alternative (Small Boat Alternative 1) current impacts to non-target stocks would be expected to continue as described in Section 10.9 with no changes to management measures, no control dates and no changes to data collection.

Under Small Boat Alternative 2, catches of non-target species would be indirectly reduced through regulatory controls directed at bigeye and yellowfin tuna. Because current landings are so small, this would not be expected to significantly affect the stocks of any non-target species that are often caught incidentally on the same gear types used by small boats to catch bigeye and yellowfin tuna.

Small Boat Alternative 3 (preferred, and already implemented) provides a mechanism to limit future participation in Hawaii's small boat commercial pelagic fisheries, which may also indirectly reduce impacts on non-target stocks by a small amount due to constrained effort and harvests of these species that are often caught incidentally on the same gear types used by small boats to catch bigeye and yellowfin tuna.

Similarly, Small Boat Alternative 4 (preferred) may slightly reduce impacts to non-target stocks if some current or future participants leave or do not enter pelagic fisheries due to these requirements. As under Alternative 3, this could also reduce harvests of non-target species. Alternative 4 would be expected to improve information on the recreational catches of non-target stocks through voluntary reporting and targeted surveys.

None of the alternatives are expected to increase catches of non-target stocks in any significant manner and therefore none are anticipated to result in adverse impacts to these stocks. As discussed above, alternatives that would reduce bigeye and yellowfin tuna catch and effort may also slightly decrease catches of non-target species.

11.2.3 Impacts on Other Species

As discussed in Sections 10.5 -10.7 and 12.4-12.5, based on available research, analyses, catch reports, observer, and anecdotal information, the Council's small boat pelagic fisheries are believed to have minimal interactions with seabirds, sea turtles and marine mammals. Trolling vessels may occasionally hook seabirds but this is believed to be rare and birds are thought to generally be released alive. Interactions with sea turtles by small boat pelagic vessels are believed to be few, based on the effort levels and the selectivity of the gear used in these fisheries (NMFS 2004b). Dolphins are known to strip fish and bait from fishing lines, but hookings or entanglements are rare. Under Small Boat Alternative 1 (no action) these low level impacts would continue as described.

Under Small Boat Alternative 2 regulatory controls would be expected to reduce Hawaii small boat catches of bigeye and yellowfin tuna and presumably their effort would be reduced proportionately. This reduction in effort would reduce the potential for pelagic fishery interactions with seabirds, sea turtles and marine mammals.

Small Boat Alternative 3 (preferred and already implemented) provides a mechanism to limit future participation in Hawaii's small boat commercial pelagic fisheries, which may also indirectly reduce potential impacts on these species.

Similarly, Small Boat Alternative 4 (preferred) may slightly reduce potential impacts to seabirds, sea turtles and marine mammals if some current or future participants leave or do not enter pelagic fisheries due to these requirements. Although rare, there are some interactions between small boats employing troll gear and seabirds. Nitta (1993) reports that during 26 trips by mixed handline fishing (bottomfish and troll) vessels to the Northwestern Hawaiian Islands (NWHI) between 1990 and 1993 carrying NMFS observers, interactions were recorded with Laysan and blackfooted albatrosses, where the birds dived on and stole trolling bait. One Laysan albatross was hooked and released alive during this period. More recently, NMFS deployed observers on 26 bottomfish trips to the NWHI between 2004 and 2005, with eight reported seabird interactions, of which three were between trolling gear and various species of boobies. Alternative 4 would be expected to improve information on interactions with recreational fisheries through voluntary reporting and targeted surveys.

None of the alternatives are expected to increase catches of these species and therefore none are anticipated to result in adverse impacts to these species. As described above, alternatives that would reduce bigeye and yellowfin tuna fishing effort may reduce fishery interactions with marine mammals, sea turtles and seabirds.

11.2.4 Impacts on Marine Habitat

Because the affected fisheries use hook-and-line gear which does not contact the seabed, and because none of the small boat alternatives considered here would be expected to significantly alter these fishing operations, no impacts on marine habitat are anticipated under any of the alternatives.

11.2.5 Impacts on Biodiversity and Ecosystem Functions

In 2003 the region's small pelagic commercial fishing boats landed 2,957 t (see Table 22) of fish, which is a very small fraction of the topical and subtropical pelagic ecosystem biomass. Because none of the small boat alternatives considered here is expected to significantly affect the fishing operations or increase effort or catches by these vessels, no impacts on biodiversity or ecosystem functions are anticipated under any of the alternatives.

11.2.6 Impacts on Public Health and Safety

None of the small boat alternatives considered here is expected to require participants to fish in ways significantly outside of historical patterns, and thus no impacts on public health and safety are anticipated under any of the alternatives.

11.2.7 Impacts on Fishery Participants and Fishing Communities

Under Small Boat Alternative 1, fishery participants and communities would continue to operate as described in Section 10.10.

Under Small Boat Alternative 2, some or all Hawaii small boat pelagic fishery participants would experience reduced bigeye and yellowfin landings due to new quotas, bag limits, minimum size limits or gear restrictions. Such measures would only be applied to those sectors that have bigeye and yellowfin catches and anticipated impacts would vary widely according to the severity of the reductions and each fishery's proportion of bigeye tuna and yellowfin relative to their total catches. For bigeye this amounts to approximately 5% of landings for Hawaii troll vessels, 16% for Hawaii handline vessels, and 83% for Hawaii offshore handline vessels (Table 20). Yellowfin tuna is caught by small boats throughout the region and represents from 0.13% to

23% of each fleet's reported total pelagic landings. Some participants could potentially offset these losses over time with increased landings of other species however others (e.g. handliners and offshore handliners) would likely have to switch to other fisheries or find other employment as they are highly dependent on yellowfin and bigeye tuna and these species can represent the majority of their landings.

Small Boat Alternative 3 (which was implemented in August 2005) established a June 2, 2005 control date for entry into small boat commercial pelagic fisheries (i.e. non-longline and non-purse seine) in U.S. EEZ waters around Hawaii. This control date does not bind the Council to establishing limited access or other management programs for these fisheries, but it does notify current and prospective fishery participants that additional management measures may be taken by the Council for these fisheries. Fishermen entering the non-longline pelagic fishery after June 2, 2005 could be at a distinct disadvantage in the future should the Council decide to implement a limited entry program.

Under Small Boat Alternative 4 (preferred), the Council would require federal permits and logbooks for the operators of all Hawaii-based small boat commercial pelagic vessels. Impacts to these fishery participants would consist of the time and cost required to obtain and renew Federal permits, as well as the time required to fill out Federal logbooks. It is anticipated that initial permit applications would require 0.5 hours per applicant, with renewals requiring an additional 0.5 hour annually. The cost for Federal permits has not been determined but would represent only the administrative cost and is anticipated to be less than $80 per permit. Based on experience in other fisheries, the time requirement for filling out Federal catch reports is anticipated to be approximately 20 minutes per fishing day. Depending on how it was implemented, Alternative 4 could result in duplicative reporting requirements as all Hawaii-based commercial fishermen are currently subject to state permitting and reporting requirements as described in Section 10.9. These state requirements would need to be waived in order to avoid duplicative measures and in that case, the impacts of Alternative 4 would be largely offset by the elimination of the state requirements.

The recreational fishery components of Small Boat Alternative 4 would involve voluntary reporting by Hawaii-based small boat pelagic fishery participants either through targeted phone surveys, or through creel surveys or other voluntary catch reports. The total number of recreational fishers in Hawaii is unknown but there are about 14,300 small vessels in Hawaii, of which about 90% are registered as 'pleasure craft'. McConnell and Haab (2001) estimated that 6,600 of these vessels might be used for recreational fishing. Out of a sample of 1008 respondents from these 6,600 vessel owners in a phone survey, 17% indicated that their vessel was either not being used or was not used for fishing. Based on these data it is estimated that Hawaii's recreational small boat fleet numbers about 5,500 vessels. Given their voluntary nature it is not anticipated that the measures described under Alternative 4 would have adverse impacts on fishery participants or communities. To the extent that Alternative 4 successfully documents recreational fishery participants' historical participation and catches, it would provide a basis for allocation of future national or local recreational fishing quotas. Although not a measure under consideration at this time, recreational fisheries in the Atlantic have been subjected to quotas and it is not unreasonable to believe that recreational quotas could someday be implemented in the Pacific. Without documented participation it may be hard for the recreational sector or individual participants to claim their share. Recreational fishing data would also improve the information available to fishery scientists and managers and result in improved fishery management.

In summary the preferred alternatives will provide for the sustained participation of fishing communities by helping to ensure the long-term availability of bigeye and yellowfin tuna.

11.2.8 Impacts on Data Collection and Monitoring

Under Small Boat Alternatives 1 and 2, the Council would not recommend any new actions concerning data collection or monitoring of its fisheries. Because the majority (87%, see Table 22) of WPRFMC pelagic fishery commercial bigeye landings are caught by longline vessels which are currently subject to Federal logbook requirements, available information on bigeye catches across the Council's fisheries is fairly robust. As discussed in Section 10.9, the remaining 13% of Hawaii's commercial bigeye landings are reported through Hawaii state catch reports. Although required under state law, there has been a relatively high rate of late and non-reporting by these participants. Limited resources for data processing have also resulted in significant delays in the release of catch statistics to fishery scientists and managers. Under these alternatives, this situation would remain unchanged. In addition, the unknown recreational landings of bigeye tuna would remain undocumented. The majority of commercial yellowfin tuna landings (60%) are taken by Hawaii and American Samoa longliners, but there is also a non-trivial small vessel yellowfin tuna catch. These landings are reported either on written catch reports in Hawaii, or through creel surveys in Guam, American Samoa and the CNMI. In addition, there is believed to be some additional yellowfin catch taken by primarily recreational vessels in Hawaii.

Small Boat Alternative 3, (which was implemented in August 2005) established a June 2, 2005 control date for entry into small boat commercial pelagic fisheries (i.e. non-longline and non-purse seine) in U.S. EEZ waters around Hawaii. This control date does not bind the Council to establishing limited access or other management programs for these fisheries, but it does notify current and prospective fishery participants that additional management measures may be taken by the Council for these fisheries. Such additional measures could include increased data collection requirements.

The recreational fishery components of Small Boat Alternative 4 (preferred) include both voluntary reporting and targeted surveys to augment the current HMRFS creel and MRFSS random digit dialing survey described in Section 10.7.4 which collects phone and creel data from Hawaii-based boat and shoreline fishermen. A targeted survey would use available participation information on primary gear types to narrow the sample frame to those recreational participants who are engaged in Hawaii-based small boat pelagic fishing. This group could then be sampled or surveyed comprehensively to gather information on their catch and effort in a more focused manner than random digit dialing allows. Although yellowfin is a principal target of the Hawaii recreational fishery, there are many uncertainties about the volume of this catch which, according to the MRFSS survey, can change by as much as 100% per year and has a relatively wide coefficient of variation (>30%) around the annual estimates. Alternative 4's data collection measures would be expected to lead to better estimates of both bigeye and yellowfin catches. Alternative 4 would also establish a system for Hawaii-based small boat recreational pelagic fishery participants to voluntarily submit their catch and effort information. This system could consist of drop-boxes at boat ramps, a website for remote data entry, or voluntary catch reports that are mailed into a central office. Experience to date in Hawaii has found high response rates by fishery participants to phone and creel surveys, with less success resulting from methods that do not involve direct personal contact. Low response rates can lead to biased estimates, as it is likely that those choosing to participate would not be completely representative of the entire sector. The higher the response rate the lower the chances of reporting bias significantly affecting catch estimates.

Other impacts of Small Boat Alternative 4 could include duplicative (and useful) commercial reporting, a reduction in delinquent reporting and improved fishery monitoring. Alternative 4 would be anticipated to reduce reporting delinquency rates as fishery participants generally regard Federal regulations more seriously than they do those of the state. In addition, under Alternative 4 a Federal agency (NMFS) would incur the responsibility for data collecting and processing, and which generally has more staff and resources than does the Hawaii Division of Aquatic Resources and would thus be anticipated to produce fishery statistics in a timelier manner. However, it should be noted that any permit and log book requirements, and survey of all Hawaii-based small boat pelagic owners would be bound to have a dramatic impact on the financial and staffing capacity of the NMFS Pacific Islands Region.

NMFS Office of Law Enforcement (OLE) has noted that Alternative 2 would require dockside and at sea inspections to ensure compliance of the management measure imposed. Additional enforcement personnel would be required to carry out this function.

NMFS OLE noted that the preferred alternative would require additional enforcement personnel to carry out the management measures requiring permits and federal catch reports. An estimated total of $1,023,000 for additional personnel, vehicles and other equipment would be needed. Alternative 4 would require dockside and at sea inspections to ensure compliance of the management measures imposed. Additional enforcement personnel would be required to carry out this function. See first comment for estimated cost. To assure compliance, air patrols utilizing USCG aircraft would also be necessary to observe those offshore vessels not required to carry VMS. OLE believes the preferred alternative would require USCG air patrols to identify those Hawaii-based offshore vessels not required to carry VMS units.If Federal permits and reporting requirements are to be mandatory, the permit program must include accurate identification of permit applicants including all pertinent biographical data and must be enforced.

11.3 Reasons for Choosing the Preferred Alternatives

The Council's preferred alternative for international Pacific bigeye and WCPO yellowfin tuna fishing calls for an immediate end to international overfishing. This is preferred to a phased approach because the realties of international fishery management are that even implementing an "immediate" end to overfishing will have a substantial lag time while the two Pacific tuna RFMOs adopt and operationalize the necessary resolutions. In addition, a phased approach carries with it the danger that, without immediate action, the Pacific bigeye and WCPO yellowfin stocks could become overfished, i.e. their biomasses be reduced to below the MSSTs adopted in the Council's Pelagic FMP.

Because the potentially affected pelagic fisheries under the Council's jurisdiction constitute such a small percentage of Pacific-wide bigeye and WCPO yellowfin landings (about 2.3% and 0.58% respectively), measures that would unilaterally restrict their operations were rejected as overly burdensome given their insignificant value in addressing Pacific-wide overfishing of this species. Small Boat Alternatives 3 and 4 (preferred) would instead provide both a mechanism to limit future participation in federally managed pelagic fisheries and increase data regarding those sectors that are known to harvest higher proportions of bigeye and yellowfin tuna (i.e. Hawaii-based small pelagic fishing boats) in a targeted manner. Potential conflicts with state law regarding recreational permits would be avoided through the use of voluntary survey and targeted reporting methods. The resultant increases in available data would be anticipated to result in improved monitoring of bigeye landings by WPRFMC fisheries. In addition, this would create the necessary institutional basis for further regulatory measures should they become necessary.

In summary implementation of the preferred alternatives will address overfishing by recommending that the Pacific RFMOs take immediate action to end international overfishing of bigeye and yellowfin tunas, and thus ensure the long-term availability of bigeye and yellowfin tuna. As described above these measures are also consistent with MSA Sections 304(e)(4)(C) and 2(a)(10). In addition, they will provide increased documentation of catches of bigeye and yellowfin tuna by Hawaii-based small boat fishery participants.

12.0 Consistency with other Laws and Statutes

12.1 National Standards for Fishery Conservation and Management

National Standard 1 states that conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

The non-regulatory recommendations discussed here relating to international fisheries, as well as the indicated preferred alternatives for domestic fisheries, are consistent with National Standard 1 as they together constitute a foundation plan for the active international and domestic participation of the Western Pacific Regional Fishery Management Council to end overfishing of Pacific-wide bigeye and WCPO yellowfin tuna. Although concerned primarily with bigeye and yellowfin tuna, its scope and principles apply to all tunas, billfish and other pelagic fishes managed by this Council. This foundation plan is similar to those contained within the Pacific Council's Pelagics FMP, and NMFS' Highly Migratory Species FMP for the Atlantic Ocean. With respect to National Standard 1, it addresses the need for consistency between measures adopted for the WCPO and the EPO, focuses on fisheries with the greatest impact on bigeye and yellowfin tunas, focuses on regions with highest catches and spawning of bigeye and yellowfin tunas, and recommends a reduction of surplus capacity, and restrictions on FAD use by purse seiners. It also includes a mechanism by which the Council will be meaningfully involved in international negotiations that involve fisheries managed by the Council. All these recommendations are intended to address overfishing of bigeye and yellowfin tunas by reducing the current level of fishing mortality on the population to below the maximum fishing mortality threshold.

Although Council managed vessels in the Pacific are only responsible for approximately 2.3% of total Pacific-wide bigeye tuna catches and 0.34% of yellowfin catches, the implementation of control dates for entry into domestic pelagic fisheries catching bigeye or yellowfin tunas in the Western Pacific addresses the potential need to constrain expansion of domestic bigeye and yellowfin fishing mortality. The Council has already implemented limited entry programs for its Hawaii and American Samoa-based longline fisheries, but recognizes the potential for the expansion of longline fishing into the Mariana Islands as well as small boat fishing around Hawaii. The implementation of these control dates provides the Council with a mechanism to limit fishing for bigeye and yellowfin tunas by these domestic fisheries should this become necessary.

Implementation of a Federal permit and reporting system for Hawaii-based commercial small pelagic fishing vessels is consistent with National Standard 1 as it will improve the accuracy and timeliness of information on the volume of bigeye and yellowfin tunas caught by these vessels. Other data collection measures in this amendment such as the targeted and voluntary surveys of Hawaii pelagic fishery participants will address the data gap regarding the volume of bigeye and yellowfin tunas landed by recreational participants. Increasing the availability of catch and effort data does not directly address National Standard 1, however it is essential to understanding the impacts of Pelagics FMP fisheries on bigeye and yellowfin tuna fishing mortality. Federalizing the commercial small boat pelagic fishery will also establish the institutional framework necessary to directly regulate bigeye and yellowfin catches by these vessels should this become necessary.

National Standard 2 states that conservation and management measures shall be based upon the best scientific information available.

The recommendations and preferred alternatives in this amendment are consistent with National Standard 2 because they are based on the best scientific information available. The stock assessments for bigeye and yellowfin tunas discussed here are developed annually by the IATTC and the SPC-OFP, based on peer reviewed integrated stock assessment models which incorporate contemporary information on catches and fishing effort by different fishing fleets, size frequencies, fishing and natural mortality rates, and the age and growth of bigeye and yellowfin tunas. These models are supported by intensive data gathering programs run by the SPC-OFP and the IATTC in their member countries, including at-sea observer programs and shore-side sampling.

Both organizations are also world centers of excellence in the biology and ecology of tuna and tuna-like species, and collaborate with colleagues in member country premier scientific research organizations on a diverse range of research. These include the Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO), the National Research Institute of Far Seas Fisheries of Japan, National Taiwan University Institute of Oceanography, and the French Institute de recherché pour le development. The Council initiated Pelagics Fisheries Research Program (PFRP) at the University of Hawaii continues to fund tuna and tuna-like species research in these and other institutions, and much of the substance of this document concerned with bigeye biology, stock assessment and fisheries were drafted by staff of the PFRP, and represents the most up-to-date review of bigeye and yellowfin biology.

The implementation of Federal permit and reporting requirements for Hawaii-based commercial small pelagic fishing vessels, and the voluntary data collection schemes included here will improve the accuracy and timeliness of information on commercial participants as well as addressing the data gap regarding the volume of bigeye tuna landed by recreational participants and the precision of yellowfin landings by recreational fishing. This will improve both the quality and the quantity of information available to fishery scientists and managers.

<u>National Standard 3</u> *states that, to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.*

The recommendations and preferred alternatives in this amendment were developed with full consideration that bigeye tuna is a pan-Pacific stock subject to differing levels and types of fishing mortality across its range. This is illustrated by the inclusion of general (pan-Pacific) recommendations as well as separate recommendations for WCPO and EPO fisheries that are tailored to the management, fishery and environmental conditions that exist in each region. Thus this foundation plan directly addresses the need for conservation measures across the entire Pacific, with an appropriate emphasis on those fleets which are responsible for significant amounts of bigeye fishing mortality. With respect to WCPO yellowfin tuna, while there might be arguments in favor of some stock separation between the eastern and western Pacific, there is also mixing across the Pacific as evinced by tagging data. Like bigeye tuna, the eastern and western 'stocks' are managed under two international management arrangements which conduct stock assessments for their areas of competency and which collaborate on stock assessments, research and management measures.

<u>National Standard 4</u> *states that conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.*

The recommendations and preferred alternatives in this amendment are consistent with National Standard 4 because the actions do not discriminate between residents of different States or allocate fishing privileges among any fishermen based upon their residence.

<u>National Standard 5</u> *states that conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.*

The recommendations and preferred alternatives in this amendment are consistent with National Standard 5 because they promote cost-efficiency by focusing on those fleets which are responsible for significant amounts of Pacific-wide bigeye and WCPO yellowfin tuna fishing mortality and do not impose onerous requirements on sectors with minimal landings. The implementation of voluntary reporting systems and surveys for bigeye and yellowfin catches in addition to a Federal permit and logbook program for all Hawaii-based commercial small pelagic fishing vessels may seem duplicative and inefficient with its potential for overlap. However a feature of successful data collection in U.S. fisheries has been the availability of multiple data streams on individual fisheries, (e.g. logbooks, observers and dealer reports for Hawaii longliners, logbooks and creel surveys for American Samoa longliners, and dealer and catch reports commercial vessels in Hawaii). Such overlapping data streams permit cross referencing and validation of different data sources (Walsh et al. 2002).

National Standard 6 states that conservation and management action shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources and catches.

The recommendations and preferred alternatives in this amendment are consistent with National Standard 6 because they include separate recommendations for WCPO and EPO fisheries that are tailored to the management, fishery and environmental conditions that exist in each region. Similarly, the preferred alternatives for domestic fisheries focus on those Council managed fisheries that are not part of international negotiations and that catch Pacific-wide bigeye and WCPO yellowfin tunas, thus avoiding the imposition of onerous or premature requirements on sectors with minimal landings.

National Standard 7 states that conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

The recommendations and preferred alternatives in this amendment are consistent with National Standard 7 because they achieve their objectives in a manner that minimizes costs and avoids unnecessary duplication. The implementation of voluntary reporting systems and surveys for bigeye and yellowfin catches in addition to a Federal permit and logbook program for all Hawaii-based commercial small pelagic fishing vessels may seem duplicative and costly with its potential for overlap. However a feature of successful data collection in U.S. fisheries has been the availability of multiple data streams on individual fisheries, (e.g. logbooks, observers and dealer reports for Hawaii longliners, logbooks and creel surveys for American Samoa longliners, and dealer and catch reports commercial vessels in Hawaii). Such overlapping data streams permit cross referencing and validation of different data sources (Walsh et al. 2002).

National Standard 8 states that conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.

The recommendations and preferred alternatives in this amendment are consistent with National Standard 8 because they will have minimal impacts on fishing communities and will provide for their sustained participation by helping to ensure the long-term availability of bigeye and yellowfin tunas. In addition, the preferred alternatives for Hawaii-based small pelagic fishing vessels will provide documentation of the recreational catches of bigeye and yellowfin tunas by Hawaii-based fishery participants. Such information will provide a basis for allocation of future national or local recreational fishing quotas. Although not a measure under consideration at this time, recreational fisheries in the Atlantic have been subjected to quotas and it is not unreasonable to believe that recreational quotas could someday be implemented in the Pacific. Without documented participation it may be hard for the recreational sector or individual participants to claim their share.

National Standard 9 states that conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided minimize the mortality of such bycatch.

The recommendations and preferred alternatives in this amendment are consistent with National Standard 9 because they do not increase regulatory bycatch by prohibiting the retention of incidentally caught bigeye tuna by longliners targeting swordfish in the EPO. In addition, the data collection measures recommended for Hawaii-based small boats will provide information on bycatch in these fisheries.

National Standard 10 states that conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

The recommendations and preferred alternatives in this amendment are consistent with National Standard 10 because they do not promote any changes to current fishing practices or increase risks to fishery participants.

12.2 Essential Fish Habitat

None of the alternatives are expected to have adverse impacts on essential fish habitat (EFH) or habitat areas of particular concern (HAPC) for species managed under the Pelagics, Bottomfish and Seamount Groundfish, Precious Corals, Crustaceans, or Coral Reef Ecosystems Western Pacific Fishery Management Plans (Table 24) because they are not expected to significantly affect the fishing operations or catches of any fisheries, and thus they are not likely to lead to substantial physical, chemical, or biological alterations to the habitat, or result in loss of, or injury to, these species or their prey. None of the alternatives will result in a change in fishing gear or strategy that will impact EFH. They all maintain the same level of protection to EFH as the current Pelagics FMP. For the same reason, the preferred alternatives are not anticipated to cause substantial damage to the ocean and coastal habitat.

Table 24. Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for species managed under the Pelagics, Crustaceans, Bottomfish and Seamount Groundfish, Precious Corals, Crustaceans, and Coral Reef Ecosystems, Western Pacific Fishery Management Plans.

All areas are bounded by the shoreline, and the seaward boundary of the EEZ, unless otherwise indicated.

SPECIES GROUP (FMP)	EFH (juveniles and adults)	EFH (eggs and larvae)	HAPC
Pelagics	Water column down to 1,000 m	Water column down to 200 m	Water column down to 1,000 m that lies above seamounts and banks.
Bottomfish	Water column and bottom habitat out to a depth of 400 m	Water column down to 400 m	All escarpments and slopes between 40-280 m, and three known areas of juvenile opakapaka habitat
Seamount Groundfish	Water column and bottom from 80 to 600 m, bounded by 29°-35°N and 171°E - 179°W (adults only)	Epipelagic zone (0-200 nm) bounded by 29°-35°N and 171°E -179°W (includes juveniles)	Not identified
Precious Corals	Keahole, Makapuu, Kaena, Wespac, Brooks, and 180 Fathom gold/red coral beds, and Milolii, S. Kauai and Auau Channel black coral beds	Not applicable	Makapuu, Wespac, and Brooks Bank beds, and the Auau Channel
Crustaceans	Bottom habitat from shoreline to a depth of 100 m	Water column down to 150 m	All banks within the Northwestern Hawaiian Islands with summits less than 30 m
Coral Reef Ecosystems	Water column and benthic substrate to a depth of 100 m	Water column and benthic substrate to a depth of 100 m	All Marine Protected Areas identified in the FMP, all PRIAs, many specific areas of coral reef habitat (see FMP)

12.3 Coastal Zone Management Act

The Coastal Zone Management Act requires a determination that a recommended management measure has no effect on the land or water uses or natural resources of the coastal zone or is consistent to the maximum extent practicable with the enforceable policies of an affected state's approved coastal zone management program. A copy of this document will be submitted to the appropriate state government agency in Hawaii for review and concurrence with a determination that the recommended measures are consistent, to the maximum extent practicable, with the enforceable policies of an affected state's coastal zone management program.

12.4 Endangered Species Act

Species listed as endangered or threatened under the Endangered Species Act (ESA) that have been observed in the area where fishing vessels managed under the Pelagics FMP operate are as follows:

Species listed as endangered
Short-tailed albatross (*Phoebastria albatrus*)
Hawaiian monk seal (*Monachus schauinslandi*)
Pacific olive ridley turtle *(Lepidochelys olivacea*) –Mexico nesting population
Leatherback turtle (*Dermochelys coriacea*)
Hawksbill turtle (*Eretmochelys imbricata*)
Green turtle (*Chelonia mydas*) - Florida and Pacific coast of Mexico breeding populations only
Humpback whale (*Megaptera novaeangliae*)
North Pacific Right Whale (*Eubalaena japonica*)
Sperm whale (*Physeter macrocephalus*)
Blue whale (*Balaenoptera musculus*)
Fin whale (*B. Physalus*)
Sei whale (*B. Borealis*)

Species listed as threatened
Loggerhead turtle (*Caretta caretta*)
Asian stocks of Pacific olive ridley (*Lepidochelys olivacea*) and green turtles (*Chelonia mydas*)

Although blue whales, fin whales, northern right whales, and sei whales are found within the area and could potentially interact with the Pelagics FMP fisheries, there have been no reported or observed incidental takes of these species in these fisheries. Therefore, these species are not discussed in this document.

The only listed species of seabirds that may interact with the fisheries managed under the Pelagics FMP is the short-tailed albatross, however, no interactions have been observed for any fishery sectors. Other listed species known to interact with the Hawaii longline fishery and which may potentially interact with other fisheries managed under the Pelagics FMP are the leatherback turtle, loggerhead turtle, green turtle, olive ridley turtles, and hawksbill turtles. In addition, several Hawaii-based small troll vessels have reportedly collided with humpback whales. A Biological Opinion completed in February 2004 by NMFS (NMFS 2004b) concluded that the fisheries managed under the Pelagics Fishery Management Plan are unlikely to jeopardize the continued existence of threatened and endangered species in the Western Pacific.

<u>Troll fisheries:</u> Although the spatial distribution of FMP troll fisheries overlaps with the distribution of sea turtles and listed marine mammals, there have been no reported fishing interactions with turtles within the EEZ by vessel operators. In addition, sea turtles are not likely to interact with troll fishing gear because the gear is towed through the water faster than sea turtles may be traveling Furthermore, sea turtles and listed marine mammals do not prey on the bait species used by the troll fisheries. Several Hawaii-based small troll vessels have reportedly collided with humpback whales. However, this type of interaction is extremely rare, and there

are no confirmed gear interactions with marine mammals or sea turtles in this fishery, although a lack of reported information does not necessarily equate to a lack of interactions. In general, incidental capture of sea turtles or marine mammals in these fisheries is expected to be rare and, due to the immediate retrieval of the gear, not believed likely to result in serious injury or mortality of the captured animal. No listed seabird species are known to interact with this fishery. Under the preferred alternatives, Hawaii-based small boat commercial fishery participants will be required to report any interactions with listed species; this will provide researchers and managers with improved data and understanding of the type and frequency of such interactions.

Handline fisheries: There have been no reported interactions between gear used in the Pelagics FMP handline fisheries and sea turtles or listed marine mammals within the EEZ. Although there is the risk that sea turtles or listed marine mammals may become hooked or entangled in the fishing gear, any caught animal can be immediately dehooked or disentangled and released. Moreover, most turtles or listed marine mammals found in the area of the handline fisheries are not likely to prey on the baited hooks. No listed seabird species are known to interact with this fishery. Under the preferred alternatives, Hawaii-based small boat commercial fishery participants will be required to report any interactions with listed species; this will provide researchers and managers with improved data and understanding of the type and frequency of such interactions.

Pole-and-line fishery: Although the distribution of the FMP pole-and-line fishery overlaps with the distribution of sea turtles and listed marine mammals, the likelihood of an interaction with a sea turtle or listed marine mammal within the EEZ is very low because sea turtles and listed marine mammals are not likely to prey on the anchovy bait typically used, and the fish feeding frenzies produced by these fishing operations would deter turtles from remaining in the area. No listed seabird species are known to interact with this fishery. Under the preferred alternatives, Hawaii-based small boat commercial fishery participants will be required to report any interactions with listed species; this will provide researchers and managers with improved data and understanding of the type and frequency of such interactions.

12.5 Marine Mammal Protection Act

With the exception of the Hawaii-based longline fishery (Category I), all other fisheries managed under the Pelagics FMP are listed as Category III fisheries under Section 118 of the Marine Mammal Protection Act of 1972 (62 FR 28657, May 27, 1997) effective September 9, 2004 (69 FR 48407, August 10, 2004). This means that interactions between marine mammals and the region's small boat pelagic fisheries are believed to be rare.

Marine mammals not listed as endangered or threatened under the Endangered Species Act that have been observed in the area where fisheries managed under the Pelagics FMP operate are as follows:

Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
Rough-toothed dolphin (*Steno bredanensis*)
Risso's dolphin (*Grampus griseus*)
Bottlenose dolphin (*Tursiops truncatus*)

Pantropical spotted dolphin (*Stenella attenuata*)
Spinner dolphin (*Stenella longirostris*)
Striped dolphin (*Stenella coeruleoalba*)
Melon-headed whale (*Peponocephala electra*)
Pygmy killer whale (*Feresa attenuata*)
False killer whale (*Pseudorca crassidens*)
Killer whale (*Orcinus orca*)
Pilot whale, short-finned (*Globicephala melas*)
Blainville's beaked whale (*Mesoplodon densirostris*)
Cuvier's beached whale (*Ziphius cavirostris*)
Pygmy sperm whale (*Kogia breviceps*)
Dwarf sperm whale (*Kogia simus*)
Bryde's whale (*Balaenoptera edeni*)

Because the preferred alternatives focus on data collection (including data on interactions with protected species) and are not anticipated to alter historical fishing operations or patterns, they are anticipated to have neutral to potentially beneficial impacts on marine mammals that occur in the Western Pacific region.

12.6 National Environmental Policy Act

Sections 8 through 11 of this document were prepared as an Environmental Assessment to assess the impacts on the human environment that may result from the proposed action in accordance with the requirements of the National Environmental Policy Act of 1969. This Environmental Assessment examines a range of alternatives designed to address issues related to overfishing of Pacific-wide bigeye and WCPO yellowfin tuna. It also incorporates by reference the cover sheet (page ii), table of contents (page vii), list of agencies (page 1), public review process and schedule (page 1), list of preparers (page 2), discussion of the purpose and need for action (page 2), list of references (page 182), and additional text from other sections of this document as indicated.

12.7 Paperwork Reduction Act

The purpose of the PRA is to minimize the burden on the public. The Act is intended to ensure that the information collected under the proposed action is needed and is collected in an efficient manner (44 U.S.C. 3501(1)).

The only preferred alternative considered here that contains any regulatory compliance requirements is the action to require all Hawaii-based commercial pelagic small boat (i.e. non-longline) vessel operators to obtain Federal permits and to submit Federal catch reports. The Council anticipates that initial permit applications would require 0.5 hours per applicant, with renewals requiring an additional 0.5 hours annually. The cost for Federal permits has not been determined but would represent only the administrative cost and is anticipated to be less than $80 per permit. Based on experience in other fisheries, the time requirement for filling out Federal catch reports, the Council anticipates this to be approximately 20 minutes per fishing day.

12.8 Regulatory Flexibility Act

In order to meet the requirements of 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 entities via the preparation of Regulatory Flexibility Analyses.

The Regulatory Flexibility Act, 5 U.S.C. 601 et seq. (RFA) requires government agencies to assess the impact of significant regulatory actions on small businesses and other small organizations. The basis and purpose of this rule are described in Section 5 and the regulatory alternatives considered are presented in Section 9.2. The only preferred alternative considered here that contains any regulatory compliance requirements is the action to require all Hawaii-based commercial pelagic small boat (i.e. troll, handline, offshore handline and pole-and-line) vessel operators to obtain Federal permits and to submit Federal catch reports. Given this sector's aggregate annual ex-vessel revenues of $9,102,000 (Table 25) this yields an average annual revenue per vessel of $5,496 and results in all affected operations being classified as "small entities" as their annual revenues are below the $4 million threshold set for this determination.

Table 25. Number and annual revenue of Hawaii-based commercial small boats, 2003.

(Source: WPRFMC 2004b)

Gear type	Number of vessels	Aggregate annual ex-vessel revenue	Average annual ex-vessel revenue per vessel
Pole and line (aku boats)	6	$1,005,000	$167,500
Offshore handline	4 (estimate)	$427,000	$106,750
Handline	152	$2,195,000	$14,441
Troll	1,494	$5,475,000	$3,664
Total	1,646	$9,102,000	$5,496

Given that each permit is anticipated to cost less than $80 annually (representing from 2% to less than 1% of annual per vessel revenues by gear type, with an overall average of 1.5%), the Council believes that this action is not significant (i.e. it will not have a significant impact on a substantial number of small entities) for the purposes of the Regulatory Flexibility Act and no Initial Regulatory Flexibility Analysis has been prepared.

12.9 Executive Order 12866

12.9 Executive Order 12866

In order to meet the requirements of Executive Order 12866 (E.O. 12866), a Regulatory Impact Review (RIR) must 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 the proposed action, 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.

A description of management objectives is found at Section 6.0 of this document, a description of the fishery is found at Section 10.0, and a description of alternatives are found in Section 9.2.

The no action alternative for this action represents no change to the economy since the status quo would be maintained.

For the preferred alternative, the net economic benefits to the economy are indeterminate since data obtained from a permitting and reporting program could have many applications for management purposes and produce different aggregate economic benefits depending upon their use. However, the Council believes that future economic benefits from enhanced permitting, reporting, and recordkeeping will produce benefits per annum greater than total annual costs of $131,680 ($ 80 x 1646), the amount required to obtain small vessel permits. This takes into account that recordkeeping and reporting associated with this rulemaking would be voluntary for recreational vessels only.

Net economic benefits derived from alternative 2 would be indeterminate without specific details for management measures proposed, and net benefits of reaffirmation of a control date would also be indeterminate without a specific limited entry program identified.

The Council believes that this rule is anticipated to yield net economic benefits to the nation by addressing overfishing of Pacific-wide bigeye and WCPO yellowfin tunas and by improving the accuracy and timeliness of available data on bigeye and yellowfin catch and effort by Hawaii-based small pelagic fishing vessels.

In accordance with E.O. 12866, the following is set forth: (1) This rule is not expected to have an annual effect on the economy of more than $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 actions 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; (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.

Based on these findings, the Council has determined that this action is not significant under E.O. 12866.

12.10 Information Quality Act

To the extent possible, the Council believes that this information complies with the Information Quality Act and NOAA standards (NOAA Information Quality Guidelines, September 30, 2002) that recognize information quality is composed of three elements - utility, integrity and objectivity. Central to the preparation of this regulatory amendment is objectivity which consists of two distinct elements: presentation and substance. The presentation element includes whether disseminated information is presented in an accurate, clear, complete, and unbiased manner and in a proper context. The substance element involves a focus on ensuring accurate, reliable, and unbiased information. In a scientific, financial, or statistical context, the original and supporting data shall be generated, and the analytic results shall be developed, using sound statistical and research methods.

At the same time, however, the Federal government has recognized, "information quality comes at a cost. In this context, agencies are required to weigh the costs and the benefits of higher information quality in the development of information, and the level of quality to which the information disseminated will be held." (OMB Guidelines, pp. 8452-8453).

This document has used the best available information and made a broad presentation thereof. The process of public review of this document provides an opportunity for comment and challenge to this information, as well as for the provision of additional information. The stock assessments for bigeye and yellowfin tunas tuna discussed here are developed annually by the IATTC and the SPC-OFP, based on peer reviewed integrated stock assessment models which incorporate contemporary information on catches and fishing effort by different fishing fleets, size frequencies, fishing and natural mortality rates, and the age and growth of bigeye and yellowfin tunas. These models are supported by intensive data gathering programs run by the SPC-OFP and the IATTC in their member countries, including at-sea observer programs and shore side sampling.

Both organizations are also world centers of excellence in the biology and ecology of tuna and tuna-like species, and collaborate with colleagues in member country premier scientific research organizations on a diverse range of research. These include the Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO), the National Research Institute of Far Seas Fisheries of Japan, National Taiwan University Institute of Oceanography, and the French Institute de recherché pour le development. The Council initiated Pelagics Fisheries Research Program (PFRP) at the University of Hawaii continues to fund tuna and tuna-like species research in these and other institutions, and much of the substance of this document concerned with bigeye biology, stock assessment and fisheries were drafted by staff of the PFRP, and represents the most up-to-date review of bigeye and yellowfin biology..

12.11 Agencies and Organizations Consulted

The following agencies and organizations were consulted in the drafting of this document

National Marine Fisheries Service Pacific Islands Regional Office

National Marine Fisheries Service Pacific Islands Fisheries Science Center

Pacific Fishery Management Council

Hawaii Longline Association

University of Hawaii Pelagic Fisheries Research Program

Secretariat of the Pacific Community's Ocean Fisheries Program

Inter-American Tropical Tuna Commission.

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14.0 Draft Regulations

§ 660.12 Definitions

Hawaii non-longline pelagic permit means the permit required by § 665.21 to use non-longline fishing gear to fish for Pacific pelagic management unit species in EEZ waters around Hawaii with the intent for some or all of the harvest to enter commerce through sale, barter or trade.

§ 665.15 Prohibitions

Engage in fishing using non-longline gear for Pacific pelagic management unit species in EEZ waters around Hawaii with the intent for some or all of the harvest to enter commerce through sale, barter or trade, without a valid Hawaii pelagic permit as required under § 665.21 (m).

§ 665.21 Permits

(m) The owner of any vessel used to fish for Pacific pelagic management unit species using non-longline gear in EEZ waters around Hawaii with the intent for some or all of the harvest to enter commerce through sale, barter or trade, must have a valid permit issued for the vessel.

Appendix I. Determination of the Feasibility of Analysis of WCPO Tuna Management Options (Anon 2004)

Control Type	Management Option	Feasibility Statement
NO CONTROLS	Status-quo: No attempt is made to control fishing mortality	Analysis is feasible in the immediate term and could represent an analysis against which other analyses are compared.
OUTPUT CONTROLS	Catch limits (a): Competitive overall or regional catch limits.	Analysis is feasible in the immediate term contingent on management advice: overall or regional catch limits.
	Catch limits (b): Allocated overall or regional catch limits.	Analysis is feasible in the immediate term contingent on management advice: overall or regional catch limits.
	Catch limits (c): Vessel Limits	Analysis is feasible in the immediate term contingent on management advice: vessel catch limits.
INPUT CONTROLS	Capacity (a): Limit/restriction on the number of vessels. This could be general reductions or directed at those fleets catching most bigeye and yellowfin.	Analysis is feasible in the immediate term contingent on the provision of information on: number and type of vessels.
	Capacity (b): Limit size or power of vessels	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	Capacity (c): Limit size of fish hold.	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	Total effort limits: Setting overall or regional limits for some measure of effort (e.g. sets, hooks, days fished).	Analysis is feasible in the immediate term contingent on management advice: overall or regional effort limits.
	Area/seasonal closures: Restricting fishing effort in particular area/seasonal strata	Analysis is feasible in the immediate term contingent on management advice: the area/seasonal closures.
TECHNICAL MEASURES	Gear restrictions (a): Restrictions on various gear configurations (e.g. net size/depth, longline length)	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	Gear restrictions (b): Method restrictions (e.g. time of set, soak time)	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	Size restrictions:	Analysis is feasible in the immediate term

	Limits on the sizes of fish that can be retained. Compulsory retention (no discards allowed).	contingent on management advice: size limits and species and fleets to which they apply.
	Restrictions on operational efficiency (a): Banning or limiting power of vessel electronics.	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	Restrictions on operational efficiency (b): Restrictions on auxiliary vessels, e.g. tender vessels or light vessels. Regulations on transshipment.	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	FAD restrictions (a): Prohibition of FAD sets on a time and/or area basis. Restrictions of the number of sets allowed on FADs.	Analysis is feasible in the immediate term contingent on management advice: areas/seasons where FAD sets will be restricted and the specific FAD types.
	FAD restrictions (b): Limit number of FADs deployed	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.
	FAD restrictions (c): Regulations on the design of FADs	Analysis is not feasible in the immediate term due to data limitation, but maybe feasible in the long term.