III. CONDITION OF PACIFIC PELAGIC MANAGEMENT UNIT SPECIES AND FISHERIES

III.A Species in the management unit.

The Pacific pelagic management unit species (PPMUS) include tuna, billfish, sharks, mahimahi, wahoo and other related species. The common and scientific names of the PPMUS of the FMP are shown in Table III-1.

Table III-1. Pacific Pelagic Management Unit Species[1]

Common Name	Scientific Name
Mahimahi (dolphin fish)	*Coryphaena* spp.
Marlin and Spearfish	*Makaira* spp. *Terapturus* spp.
Oceanic Sharks	family Alopiidae family Carcharinidae family Lamnidae family Sphyrindae
Sailfish	*Istiophorus* spp.
Swordfish	*Xiphias* sp.
Tuna and Related Species	*Allothunnus* sp. *Auxis* spp. *Euthynnus* spp. *Gymnosarda* sp. *Katsuwonus* sp. *Scomber* spp. *Thunnus* spp.
Wahoo (ono)	*Acanthocybium* sp.

1 Amendment 7 proposes to add several other important species which are harvested by pelagic fisheries but which are currently not included as management unit species. These are moonfish or opah (Lampris sp.), pomfret (pelagic spp. of family Bramidae) and oilfish or walu (family Gempylidae)

III. B. Status of Stocks

Hawaii pelagic fisheries are under the management jurisdiction of the Western Pacific Regional Fishery Management Council (Council). However, many or all of the pelagic species exploited by Hawaii's fisheries belong to wide-ranging stocks fished by much larger fisheries throughout the Pacific. These fisheries include the longline, purse-seine, pole-and-line, and troll fisheries of Japan, the USA, Korea, Taiwan and other nations. Until recently (1993) they also included the drift gillnet fisheries of Japan, Korea, and Taiwan. The available information on status of the stocks of the six species most important to the Hawaii longline fishery (swordfish, blue and striped marlin, yellowfin and bigeye tuna, and albacore) is summarized below. Available information on other species harvested by Hawaii's pelagic fisheries is reviewed briefly. Little is known regarding the stock status of many other species (e.g., sharks).

The most common method to assess stocks of Pacific tuna and billfish is "production modeling", whereby the total fishery yield (catch) of the stock is modeled as a function of total fishing effort (Skillman 1989a). Production models are used to estimate maximum sustainable yield (MSY) as the highest average level of catch that can be sustained at the most productive (on average) level of fishing effort. When fishing effort increases above this level, yield subsequently declines. Unless data exists for high levels of effort with reduced yield, MSY cannot be estimated accurately. When fishing effort is below, at or above MSY level, the stock is said to be under-, fully-, or over-utilized, respectively (NOAA 1991b, NOAA uses "long-term potential yield [LTPY]" to refer to MSY). Over-utilization is synonymous with "growth overfishing" (Amendments 1 and 6). A stock that is over-utilized in this context is not overfished as defined by the Pelagic FMP (i.e., recruitment overfished). For most of the stocks discussed below, yields appear to level out at the highest levels of fishing effort rather than decline. In such cases, the best-fit MSY estimate is close to the highest level of catch seen in the fishery to date (Table III-2). Higher levels of effort may result in increased catch, and subsequent production modeling may result in higher estimates of MSY. Although categorizing a stock as fully-utilized in these circumstances is common (NOAA 1991b), it is not particularly meaningful.

The status of a stock as categorized by production modelling (e.g., fully-utilized) may contradict other indicators, such as spawning potential ratio (SPR). Overfishing is defined as an SPR below 0.20 for billfishes and tunas (Amendments 1 and 6). The SPR is a measure of the current reproductive capacity of the stock or stock complex relative to its unexploited capacity. There are no good estimates of SPR for the six important species covered below, but rough estimates of SPR (Table III-2) were made using the ratio between current CPUE and CPUE observed in the earliest period of exploitation. Where several fisheries exploit different sizes of fish, CPUE for the fishery that exploits mostly mature fish (i.e., the longline fishery) is the better indicator of SPR. This method is fourth in the ranked list of preferred methods for estimating

Table III-2. Various indicators of the status of stocks of six major species exploited by the Hawaii longline fishery. Catch and MSY are in metric tons (t). Areas as defined for MSY estimates and shown in Fig. III-1. The SPR indicators were estimated for this amendment from information discussed in the text.

Species	Area (Stock?)	MSY (t)	Source[a]	SPR	Utilization	Catch[b] (t)	Source[c]
Swordfish	Pacific	25,000	1	1.00	Unknown	29,000	8
Blue Marlin	Pacific	24,000	2	0.25	Over	22,000	8
Striped Marlin	North Pacific	Unknown	3	1.00	Under	10,000	9
Yellowfin tuna	Eastern Pacific	300,000	4	1.00[d]	Full	290,000	4
	Western & Central Pacific	Unknown	5	0.50	Under	375,000	5
Bigeye tuna	Pacific	160,000	6	0.35	Full	152,000	8
Albacore	North Pacific	Unknown	7	0.25	Over	59,000	1

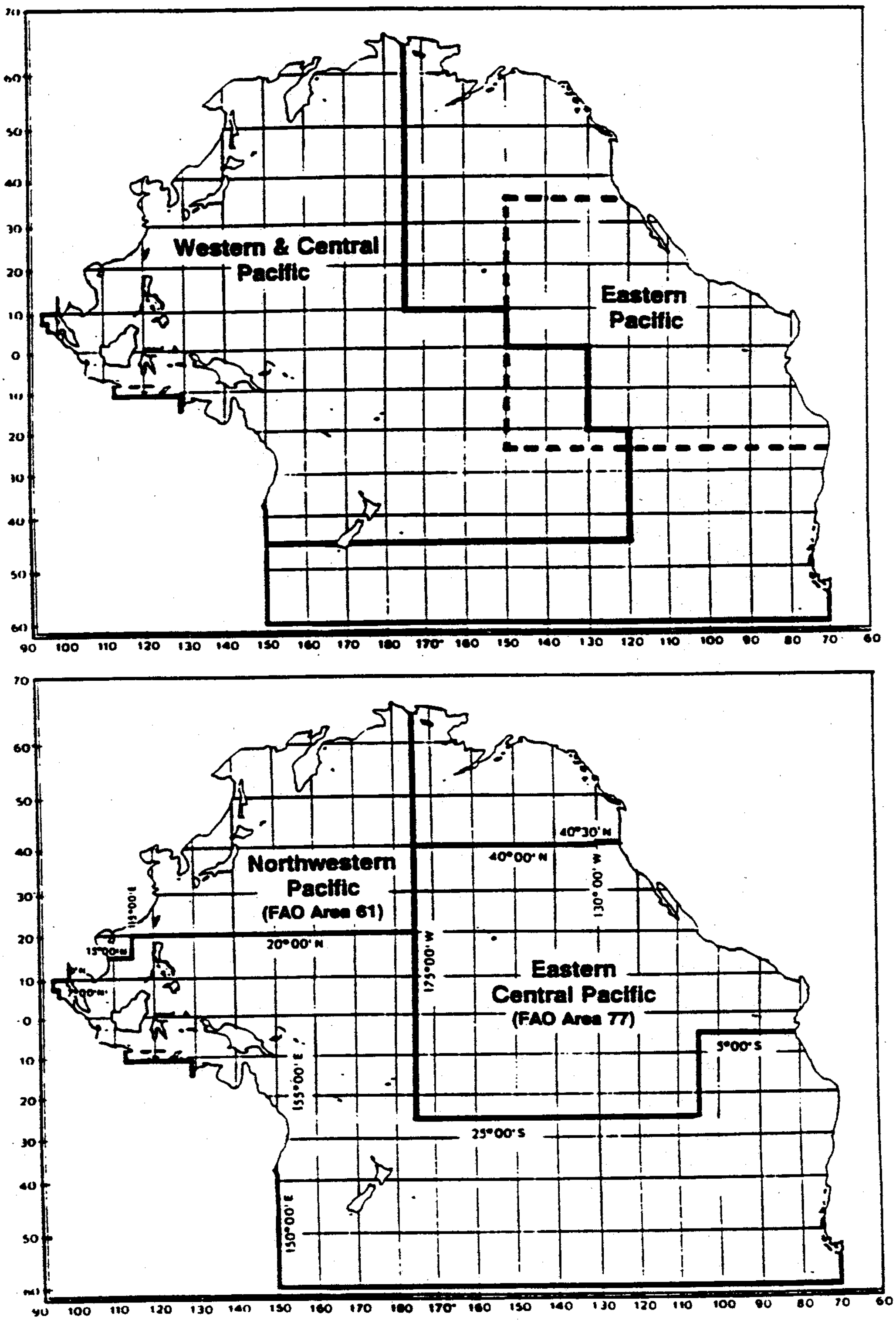
[a] Sources of MSY estimates = 1-NOAA(1991b), 2-Skillman(1989a), 3-Suzuki(1989), 4-Wild (1993), 5-Suzuki (1993b), 6-Miyabe (1991), 7- Bartoo and Foreman (1993)

[b] Catch for 1990 except for source 4 (1986 - 1989 average)

[c] Sources of catch data are the same as for MSY (footnote 1) plus: 8 - FAO (unpublished data), 9 - approximation based on the FAO statistics for FAO areas 61 (Northwest Pacific) and 71 (Eastern Central Pacific)

[d] Inconsistent with utilization status

Figure III-1. Areas used in reference to the status of stocks (Tables III-2 and III-3) as described by Suzuki (1993b), Wild (1993), and FAO (1990). The North Pacific area (not shown) is the area north of the equator. These areas may not be related to the true boundaries of any stocks.



SPR (see alternative d in Amendment 1). Longline CPUE from the earliest period of exploitation may be biased by several factors and may provide a poor index of unexploited reproductive capacity. Such biases could include initial fishing in small areas where density was atypical, and improvements in fishing methods and efficiency over time.

The fisheries and the data needed to assess the stocks belong to many nations. Presently, there is no single organizations or network of organizations with the responsibility to monitor the Pacific-wide tuna fisheries; thus, the data needed for stock assessment are far from adequate.

III.B.1 Swordfish

Swordfish occur mainly from California to Chile in the eastern Pacific, throughout the central Pacific and from Japan to Australia and New Zealand in the far western Pacific. The stock structure of swordfish in the Pacific is uncertain. Several studies indicate there is more than one stock. One hypothesis envisions three separate stocks: one in the northwestern Pacific, one in the southwestern Pacific, and one in the eastern Pacific, as evidenced by areas of apparent high abundance (Bartoo and Coan 1989). Data on the seasonal concentrations of sexually mature swordfish examined by Sosa-Nishizaki and Shimizu (1990) suggest the possible occurrence of four subpopulations of swordfish in different areas of the Pacific. These are the central North Pacific (waters around Hawaii), the Coral Sea, the area between 10° and 30° S and west of 110° W, and the equatorial Pacific.

Most of the total Pacific-wide swordfish catch is taken by the Japanese longline fishery directed at tunas, with the remainder taken by surface gear such as harpoons, drift gillnets, and handlines (Sakagawa 1989). Only the Japanese longline fishery catch-per-unit-effort (CPUE) data are suitable for estimating trends in abundance of Pacific swordfish stock(s), and these data present major problems in interpretation. The data reflect changes in fishing methods and species targeting that appear to account for major changes in CPUE which are unrelated to real abundance. These problems were considered, but not resolved by the most recent attempts to determine the status of swordfish stocks. Based on data through 1980, the tentative conclusion reached by the most recent assessments was that the stock(s) had not been exploited heavily enough to cause either an over-utilized condition (Skillman 1989a), or a noticeable decline in CPUE (Bartoo and Coan 1989). Although the data through 1980 are not recent, they contain useful information on the dynamics of the stock(s) through a period in which yields varied over a wide range, including yields higher than current yields.

No decline in CPUE would imply a high SPR (i.e., 1.0, Table III-2) but the CPUE data are questionable since there are indications that changes in fishing method and species targeting have influenced catchability. Evidence that the swordfish resource is at least maintaining a high SPR is indicated by the fact that only a slight decline in fish size was found by Skillman (1989a).

Estimates of MSY (assuming a single stock) have increased as catch and effort have increased. Thus, despite the catch being near the most recent estimate of MSY, the stock may be under-utilized NOAA (1991b) which would be consistent with a high SPR (Table III-2). Skillman (1989a) estimated MSY at about 18,000 t (metric tons) using data through 1980. NOAA (1991a) reported MSY at 19,000 t and NOAA (1991b) reported MSY at 25,000 t (Table III-2). The total Pacific swordfish catch (FAO 1990, FAO, Viadell Terme di Caracalla, 00100, Rome, Italy, unpublished data) increased from <17,000 t to about 29,000 t from 1980-90 (Table III-2) with the catch in the eastern central Pacific increasing from 4,300 to 8,900 t (Table III-3). Less change occurred in the northwestern Pacific where the 1990 catch of 9,200 t (FAO 1990, FAO, unpublished data) was about average for the decade (1980-90). From 1990-1992 the Hawaii longline fishery directed at swordfish increased its catch from 1,500 t to almost 5,000 t, making it quite large in relation to eastern central Pacific or northwestern Pacific fisheries (Table III-3). This new fishery will be important to the future status of the stock(s), particularly if there is a central North Pacific subpopulation, as the data of Sosa-Nishizaki and Shimizu (1990) suggest.

Whether the recent increases in yield can be sustained at the present level of fishing effort is unknown, but the severe growth-overfishing of the Atlantic stock(s) (ICCAT 1992a, 1992b; NCMC 1993) suggests that close attention should be paid to the possibility of over-utilization of the swordfish stock exploited by the Hawaii longline fishery (see statement of problems). Although a recently completed production model analysis for North Atlantic swordfish suggest that the stock is recovering under a regime of reduced fishing effort (ICCAT 1992b), western North Atlantic swordfish may still be over-utilized (NCMC 1993). Age-structured assessments for Atlantic swordfish continue to show that the adult stock remains at about 50% of its 1978 level (ICCAT 1992b).

No indication of decreasing swordfish size has been found in the Hawaii fishery (Ito 1992), also suggesting no recent decline in the SPR of the stock. Swordfish gillnet fisheries off California and Mexico have declined in recent years (NOAA 1991a, Oscar Sosa-Nishizaki, Centro de Investigacion Cientifica y de Education Superior de Ensenada, pers. comm.) but the causes of the decline appear to be mostly economic and environmental. The recent agreement by the major driftnet fishing nations to abide by a United Nations General Assembly resolution to suspend large-scale, pelagic drift gillnetting in December 1992, may not have much impact on swordfish in the North Pacific, since the fishery appears to harvest only a few thousand metric tons in that region (Ueyanagi et al. 1989).

Table III-3. Catch (in metric tons) of tuna, billfish, and other pelagic species by areas of interest compared with Hawaiii catch (t). Areas as shown in Fig. III-1.

Species	Area Stock (?)	Catch[1] (t)	Hawaii[2] (t)	Hawaii (%)[3]
Swordfish	Pacific	29,000		15%
	Northwest Pacific (FAO)	9,200		
	Eastern Central Pacific (FAO)	8,900	5,000	42%
Blue Marlin	Pacific	22,000	630	3%
Striped Marlin	North Pacific	10,000	430	4%
Yellowfin tuna	Eastern Pacific	290,000		0.04%
	Central & Western Pacific	375,000	1,220	0.03%
Bigeye tuna	Pacific	152,000	1,770	1.2%
Albacore	North Pacific	59,000	420	0.7%
Mahimahi (Dolphin fish)	Pacific	27,900		N/A
	Eastern Central Pacific (FAO)	N/A[4]	540	N/A[4]
Wahoo (Ono)	Pacific	720		N/A
	Eastern Central Pacific (FAO)	N/A[4]	170	N/A[4]

1 Mostly 1990 FAO statistics unless noted otherwise in Table 2.
2 Hawaii data for 1992 (preliminary)
3 Hawaii 1992 catch as a percentage of the total for each area or stock. Percentage based on the assumption that total catch stayed relatively stable over the last several years, except for swordfish. The large 1990-92 increase in the Hawaii swordfish catch (3,100t) was added to the area or stock totals before calculating Hawaii's percentage of the swordfish catch.
4 N/A FAO Statistics do not routinely contain reports on wahoo or mahimahi catch.

III.B.2 Blue Marlin

Pacific Blue Marlin appear to consist of a single stock centered about the equator, with the northern and southern extent of its distribution varying seasonally within water temperatures above about 24°C. The single-stock hypothesis is based on the continuous distribution of larvae and adult fish, a few long-distance tag returns, and the similarity of CPUE trends across a broad area (Skillman 1989b). Most blue marlin are caught by foreign, distant-water longline fisheries targeting tuna; the species is also taken as a bycatch of the tuna purse-seine fishery (Sakagawa 1987). The relatively low price commanded by blue marlin as a food fish places this species low on the species priority list of the longline fisheries. The blue marlin's greatest value is to charter and recreational troll fisheries throughout the Pacific."

A production model for blue marlin based on data through 1980 showed that the fishing effort required to produce an MSY of about 19,000-24,000 t (Table III-2) was exceeded in the mid-1960s and that during the 1970s the blue marlin resource was over-utilized (Skillman 1989a). Effective longline effort for blue marlin declined in the mid-1980s as the longline fisheries changed fishing methods to target deep-swimming bigeye tuna. "Effective" effort refers to longline effort corrected to account for longline depth changes over time. Longline catch and effective effort data through 1985 showed that, even though fishing effort declined after 1981, yield did not change (Suzuki 1989). The lack of relationship between catch and effort suggested that effort had little effect on the stock (Suzuki 1989). Another interpretation is that since longline CPUE (corrected for targeting) during the late 1970s declined to about 19% of the level during the earliest years of exploitation (SPR=0.19), the blue marlin stock was overfished (by Amendment 1 definition). This may have interfered with recruitment for some time, slowing the recovery of the stock when fishing effort declined after 1981. By 1985, CPUE had recovered a little, suggesting a SPR of about 0.25 (Table III-2). Effective longline effort for blue marlin in more recent years is unknown, but increased purse seine activity and blue marlin bycatch in the tropical western Pacific may have added to the pressure on the stock.

The total annual Pacific catch of blue marlin has increased in recent years to about 22,000 t in 1990 (Table III-2) and the resource is still tentatively categorized as over-utilized (NOAA 1991a, 1991b). Even at MSY, this resource might not be at OY because of its much greater value to recreational fisheries, which benefit from higher CPUE and lower yield.

III.B.3 Striped Marlin

Striped marlin occupy more temperate waters than blue marlin, ranging to latitudes as high as 45° N and 45°S in the western Pacific. The abundance of adults is low near the equator in the western Pacific, with high concentrations of larvae north and south of the equator. Thus, the species may be comprised of separate North and South Pacific stocks with a possible spawning aggregation in the western Pacific. This North and South Pacific stock structure is the working hypothesis for stock assessments (Skillman 1989a, 1989b; Suzuki 1989). High catch rate areas are found in the northern central Pacific (near Hawaii), in the southern central Pacific and in the eastern tropical Pacific on both sides of the equator (Skillman, 1989b). Striped marlin tagged off California and Mexico have been recovered in Hawaii.

Foreign, distant-water longline fisheries, directed mostly at tunas catch most of the striped marlin harvested in the North Pacific, with a peak of about 21,000 t in 1968 (Suzuki 1989a) and annual catches of about 7,000-14,000 t in the 1980s. Longliners sometimes target striped marlin in the eastern tropical Pacific. Striped marlin are also important to recreational and charterboat fisheries, especially in the eastern Pacific. In the north Pacific the foreign large-mesh drift gillnet fishery also harvested about 2,000-4,000 t per year of striped marlin during the 1980s (Ueyanagi et al. 1989).

The two most recent attempts to assess the North Pacific striped marlin stock using longline catch and effort data were unsuccessful in fitting reasonable production curves to the data (Suzuki 1989, Skillman 1989a). Neither assessment found a decline in yield under increased fishing effort. Based on some area adjustments to FAO statistics, the total North Pacific harvest in 1990 was about 10,000 t (Table III-2). Japanese longline data indicated wide fluctuations in CPUE without clear trends during the 1952-1985 period (Suzuki 1989) suggesting that these fisheries have had little or no impact on either the stock or SPR (i.e., SPR = 1.0, Table III-2).

III.B.4 Yellowfin Tuna

Yellowfin tuna are widely distributed in the Pacific, and are most abundant between 20°N and 20°S latitude, where the distribution of adults and larvae is continuous across the Pacific. Despite much study, definitive information on the stock structure, movements, and population dynamics of yellowfin tuna is scarce. Yellowfin tuna caught by Hawaii fisheries may belong to a central Pacific stock which is separate from eastern and western Pacific stocks (Suzuki et al. 1978), but no conclusive evidence supports this hypothesis (Suzuki 1993a). No stock assessments exist for this possibly distinct central Pacific stock. Morphometric studies and some genetic studies suggest even more localized stocks, but other genetic work is contradictory (Wild 1993). Evidence from tagging programs suggests that most yellowfin tuna remain within a few hundred miles of their tagging location, but about 10% of long-term (>180 days) tag recoveries are at distances of over 1,000 nm (Lewis 1992). One recent study suggests that large (>100 cm) yellowfin tuna are much more mobile than small ones (Bard and Scott, 1992).

Eastern Pacific purse-seine and longline fishing effort increased from the early 1960s to the early 1980s. Longline CPUE and purse-seine CPUE for large fish declined over this period to reach an average of about 1/3 of that experienced in the early years of exploitation (SPR = 0.33). Purse-seine harvests of small fish appeared to have reduced the subsequent abundance of older fish (Wild 1993). After a temporary reduction in fishing pressure, and several El Niño events in the mid-1980s, the productive capacity of the stock as indicated by the MSY, increased above the previous MSY level by about 60% after 1985. Improved recruitment and fishing methods that target larger fish (i.e., targeting schools associated with porpoises, as opposed to free-swimming schools or schools associated with floating objects) may have contributed to the increase in productive capacity. Both longline and purse-seine CPUE increased to levels similar to those seen in the early period of exploitation. Thus SPR could be estimated at around 1.0 (Table III-2) although the change in productive capacity may invalidate this SPR index. The SPR calculation assumes that the unexploited spawning potential is a fixed point of reference, whereas the change in the stock productivity suggests a change in unexploited spawning potential, and in the carrying capacity of the environment. Currently, MSY for the eastern Pacific is estimated at about 300,000 t with recent annual catches (1986-89) averaging about 290,000 t (Table III-2) at an effort level slightly below that required for MSY (Wild, in press). The eastern Pacific stock appears to be fully utilized at the current levels of fishing effort and productive capacity.

Japanese longline CPUE statistics from the western Pacific (west of 180° W longitude) were used by Suzuki et al. (1989b) to estimate MSY at about 70,000-112,000 t for the longline fisheries of Japan, Korea, and Taiwan (combined). The highest level of effort was in 1980-81 with catch at 70,000-90,000 t. Longline catch and effective fishing effort for yellowfin tuna have since declined due to reduction of fleets and changes in fishing methods to target bigeye tuna for the Japanese sashimi market. Yellowfin tuna CPUE (corrected for targeting) remained low throughout the 1980s, with a record low level in 1989 (Suzuki 1993). Overall, western Pacific longline CPUE has declined to an average of about half the level seen in earlier years (SPR = 0.5, Table III-2).

Purse-seine fisheries (mostly by Japan and the USA) caught most of the yellowfin tuna harvested in the central and western Pacific since the early 1980s. Purse-seine caught yellowfin tuna include a much higher proportion of juveniles than the longline catch. Also, since the mid-1970s, growing numbers of small yellowfin were caught by developing multi-gear tuna fisheries in the Philippines and Indonesia. Increased mortality of small yellowfin tuna may have a negative impact on the longline fishery, with fewer juveniles surviving and growing to enter the longline fishery, which takes larger fish. The record low longline CPUE observed in 1989 could have resulted from the major (50%) increase in purse-seine catch that occurred in 1987 (Suzuki 1993b). This fishery interaction appears to have been localized, with longline yellowfin CPUE decreasing mostly in the area of heavy purse-seine fishing.

Purse-seine fishing methods are diverse, and problems with the availability and interpretation of purse-seine data have so far prevented estimation of MSY for the central and western Pacific. Suzuki et al. (1989) found that purse-seine catch continued to increase with effort and suggested that the 1984-86 catch level of 200,000-210,000 t (all gears) in the western central Pacific (FAO area 71) appeared to be sustainable at the concurrent level of effort. Subsequent (1987-90) catches in this area ranged from 200,000-280,000 t (FAO 1990, FAO, unpublished data). The total catch in the western and central Pacific (Fig III-1) as described by Suzuki (in press b), has doubled since 1980 to reach a total of about 370,000-380,000 t in 1990. CPUE has been highly variable due to changes in targeting and environmental effects (Suzuki, in press a, b).

Fishing effort and yellowfin tuna catch are expected to increase to unprecedented levels in the central and western Pacific. A comprehensive stock assessment of western Pacific yellowfin is needed. The Western Pacific Yellowfin Research Group (WPYRG) was established in 1990 to facilitate collaborative research on western Pacific yellowfin tuna for management advice. The participants are scientist and fishery officers of south Pacific island nations, distant-water fishing nations, the South Pacific Commission (SPC) and the Forum Fisheries Agency (FFA). All of these participants have an interest in research and management of the tropical tunas of the western and central Pacific Ocean. At its first meeting (Port Vila, Vanuatu, June 1991), the WPYRG took note of the limited progress made in reducing the uncertainty about the status of the yellowfin stock and of the urgent need for developing scientific advice for fishery management. The WPYRG, therefore, agreed on the goal of assessing the condition of the yellowfin tuna stock(s) of the central-western Pacific region in order to provide scientific advice for informed fishery management decisions. Their second meeting was held in Honolulu, in June 1992, to create a comprehensive catch and size-frequency database. Preliminary results of the SPC yellowfin tuna tagging study presented at the meeting suggest that the purse-seine harvest of yellowfin in the central and western Pacific could increase without harm to the stock (Hampton 1992).

III.B.5 Bigeye Tuna

Bigeye tuna are distributed throughout the Pacific to higher latitudes than yellowfin tuna (45° N - 40° S in the western Pacific and 40° N - 30° S in the eastern Pacific). Catch rates in the Japanese longline fishery indicate several east-west zonal bands of high abundance. These bands are in temperate waters around 35° N and in the tropics around 10°N, with a similar pattern in the southeastern Pacific.

Reproduction occurs at lower latitudes, suggesting migratory behavior between feeding and spawning grounds. Of 12 long-term (0.7-4.2 yr) tag recoveries summarized by Miyabe (in press a), six were within 400 nm and three were beyond 1,000 nm from the point of release. Although the stock structure of bigeye tuna is not well understood, the continuous distribution of adults, widespread spawning across the tropics, and the concurrence of size-class modes across broad areas suggest that there is a single Pacific stock (Miyabe, in press a).

Bigeye tuna are the primary target of Japanese, Korean and Taiwanese longline fleets which harvest most of the total catch. Effective fishing effort for bigeye tuna continued to increase, even after the reduction in size of the foreign longline fleets in the early

1980s, due to increased numbers of hooks set per vessel and the greater fishing depth which improved the fishing effectiveness for bigeye tuna. Since 1975, the total annual catch of bigeye tuna in the Pacific has fluctuated between 105,000-152,000 t (152,000 t in 1990, Table III-2). These totals do not include significant quantities of small bigeye tuna caught by purse seine and diverse Philippine and Indonesian fisheries. In addition, Perhaps 10% of the small tunas identified by purse-seine fishermen as "yellowfin tuna" are actually bigeye tuna. Increased catches of small bigeye tuna appear to be detrimental to the subsequent abundance of the large fish caught by the longline fishery (Miyabe, in press b).

Average longline CPUE (corrected for gear depth changes) in the 1980s was 45% as high as the average CPUE in the early period of exploitation (Miyabe, in press a). CPUE reached a record low in 1988 (about 35% of the initial average CPUE, i.e., SPR = 0.35). CPUE continued to be poor in 1989-1992. The bigeye stock may be near full exploitation (Table III-2) since MSY is estimated at about 160,000 t (Miyabe 1991), and effort appears to be nearing the MSY level.

III.B.6 Albacore

Albacore are found in temperate and tropical waters throughout the Pacific. The widely-accepted hypothesis for the stock structure of albacore is that there are at least two stocks, North and South Pacific, with separate spawning areas in the tropics north and south of the equator. Troll, drift gillnets and baitboat fisheries (pole-and-line) exploit the younger surface-dwelling fish in temperate waters, whereas longline fisheries harvest older, larger fish inhabiting deeper and more tropical waters.

The annual estimated catch of albacore in the North Pacific (Table III-2) in 1988-90 was 59,000 t (NOAA 1991a), down from levels exceeding 100,000 t during the 1970s. MSY has been estimated at 90,000-200,000 t, but none of the estimates is reliable due to problems with troll and baitboat CPUE indices (Bartoo and Foreman, in press). Catches declined mostly in the Japanese baitboat fishery and the A mainland-based troll fishery. Baitboat and troll catches (combined) declined from 75,000-105,000 t in the mid-1970's to about 15,000 t in 1990 (NOAA 1991a); effort by both these fisheries also declined. The abundance of young, surface-caught fish declined by about one-third after 1977 (Bartoo and Foreman, in press). Environmental changes could have affected the productivity of the stock, as they have with yellowfin tuna (see above).

The expansion of the drift gillnet fishery in recent years has made this the dominant fishery for albacore in the North Pacific and raised concerns that the stock may be over-utilized or over-fished. In 1989, the drift gillnet catch was estimated at 20,000 t. More recent estimates that include estimates of the rate at which dead fish drop out of nets (killed but not harvested) suggest the catch may be 30,000 t or more (Holts et al. 1992). The US trolling fleet recently noted that over 7% of their albacore catch showed fresh net markings, suggesting encounters with drift gillnets (Bartoo et al., in press). The suspension of large-scale, pelagic drift gillnetting in December 1992 has considerably reduced fears of long-term damage to the stock.

During the 1980s the annual longline catch of albacore has averaged around 15,000 t, about the same as in the preceding decade (NOAA 1991a). The Japanese fleets harvested approximately 95% of this catch. Although overall Japanese longline CPUE declines suggest a SPR of about 0.25 (Table III-2), Japanese longline CPUE for two index areas presented at the 12th Albacore Workshop (fide Bartoo and Foreman, in press) suggested that although "feeding area" CPUE has declined to about one-fourth of the level seen in the early years of exploitation, "spawning area" CPUE was stable. Hence, the workshop concluded that the abundance of the adult stock was stable (Bartoo and Foreman, in press). Other sources (NOAA 1991a, 1991b) list the stock as over-utilized (Table III-2).

III.B.7 Other species

Other pelagic species harvested by Hawaii's pelagic fisheries include skipjack tuna, kawakawa, frigate tuna, bluefin tuna, dolphin fish (mahimahi), wahoo (ono), shortbill spearfish, black marlin, sailfish, pomfrets (manchong), moonfish (opah), gempylids (walu), mako sharks, thresher sharks, and others. Species that are discarded include blue sharks, other sharks, pelagic stingrays, lancetfish, ocean sunfish (mola mola), snake mackerel, and others. Very little is known regarding the stock structure or status of most of these species. Skipjack tuna are considered to be under-utilized (Boggs and Kikkawa 1993, Hampton 1992). Skipjack and other small tuna species are not important to this amendment since the longline catch of these tuna is negligible compared with other Hawaii fisheries. Mahimahi and wahoo are of particular concern because the longline catch is sizable in comparison to the catch by other Hawaii fisheries that place a greater value on these species. Commercial troll fishermen target mahimahi and wahoo because these small-vessel fishermen make short, frequent trips and can land a fresher, higher-priced product than longline fishermen. The reported magnitude of the Pacific catch of mahimahi and wahoo (Table III-3) may be unreliable because the catch of these species is often not reported to the FAO. In particular, US catches in the eastern central Pacific are not reported. Thus, the data on these species are often inadequate to show the catch, let alone the status of stocks.

III.C. Description of Fishery Sectors

III.C.1. Harvesters

Hawaii's pelagic fisheries catch more tons of fish than all other fisheries in the state. The Hawaii catch is far greater than the catch by fisheries in the other areas under Council jurisdiction (i.e., Guam, American Samoa, and the Northern Marianas). However, Hawaii's pelagic fisheries are small by Pacific standards (Table III-3). Hawaii's pelagic fisheries supply the bulk of fresh fish consumed in Hawaii, and the catch is exported to Japan, the mainland USA, and Europe. The fisheries are also important to Hawaii's cultural heritage, and include popular recreational fisheries.

III.C.1.a Gear types

The gear types, size of vessels, and target species in Hawaii's domestic pelagic fisheries are diverse (Boggs and Ito 1993). Commercial pole-and-line and longline fisheries utilize large (>12 m) vessels. Commercial, recreational, and subsistence troll and handline fisheries use smaller vessels. The pole-and-line fishery targets skipjack tuna and lands very little of any other species.[2] The longline fishery targets swordfish, bigeye tuna, and yellowfin tuna. The troll and pelagic handline fleets primarily target yellowfin tuna, mahimahi, and blue marlin. The charter and recreational troll fisheries may target blue marlin more than the commercial troll fishery but these sectors are difficult to distinguish in the existing data since they often sell at least part of their catch.

The longline fishery

Longline gear catches fish using baited hooks on hundreds of branch lines attached to a single long main line set horizontally across 1-60 (usually 20-30) miles of ocean. The main line is buoyed at regular intervals by float lines connected to surface floats. Longliners fish at a variety of depths depending on the target species. Fishing depth is determined by the length of the floatlines and branchlines, and the amount of sag in the main line between floats. The depth of the hooks affect their efficiency at catching different species (Hanamoto 1976, 1987, Suzuki et al. 1977, Boggs 1992). Each longline "set" from gear deployment to retrieval, requires most of a day to accomplish. Each fishing trip by a Hawaii longline vessel entails many sets, and a trip often lasts several weeks. A typical longliner carries a crew of six, including the captain, although some of the smaller vessels operated with a four-man crew.

Traditionally, longline gear was set to fish primarily during daylight and targeted yellowfin and bigeye tuna using scad (opelu), squid, sardines, herring, or saury for bait. During the 1970s, longline fisheries in Hawaii and elsewhere began to set deeper gear to catch more valuable bigeye tuna.

The tuna longline fishery adopted new monofilament gear in the late 1980s, replacing older-style rope "basket" gear with a more flexible system of line throwers and snap-on branch lines and floatlines that allowed much greater flexibility in fishing depth (Kawamoto et al 1989, Boggs and Ito, in press). This flexibility contributed to the development of the swordfish longline fishery in the 1990s. Shallow-set longline gear

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2 Although the troll, handline, and longline fisheries also catch skipjack tuna it is a minor component of those fisheries. Further description of the pole-and-line fishery for skipjack tuna (Boggs and Kikkawa 1993) would be irrelevant to this amendment.

is used at night, with luminescent "light sticks" that attract swordfish and bigeye tuna. Large "hard" squid (*Illex* sp.) are the preferred bait.

In the late 1980s, vessels began joining the Hawaii longline fishery after leaving US east coast tuna and swordfish fisheries. The expanded fishery became the largest fishery in the state in terms of landings and revenue. The new vessels were mostly steel-hulled, up to 33 m (107 ft) in length, and equipped with modern electronics (radar, Global Positioning System [GPS], radio beacons, radio-facsimile [FAX] and electronic thermometers) for use in navigation, gear location, and finding fish associated with temperature fronts.

Hawaii longliners range much farther from shore than the smaller vessels used in the troll and handline fisheries. In the fishery's early years, most of the catch was reported to come from areas 2-20 nm off Waianae, Oahu and off Kona, Hilo, and Hamakua, Hawaii (June 1950). Bigeye tuna catch rates were found to be higher off the windward coasts (i.e., Hilo and Hamakua) in winter than they were off sheltered leeward coasts (i.e., Waianae, Kona) where yellowfin tuna were abundant in summer (Shomura 1959). During the 1960s, a growing number of longliners extended their range 100-400 nm south of Oahu, where CPUE was found to be higher than average (Hida 1966). In the early 1980s Hawaii longliners told researchers that they had to travel progressively farther from the islands to locate good fishing grounds (Hawaii Opinion 1984). Ten vessels fished exclusively outside the Hawaiian EEZ in 1992 while 104 vessels fished both inside and outside the EEZ. Only 9 vessels fished exclusively within the main Hawaiian islands EEZ. Over half of the trips taken in 1992 made at least one set outside the EEZ surrounding Hawaii (Table III-4).

With the advent of the swordfish longline fishery in the 1990s, a segment of the fishery began to routinely make trips beyond the EEZ to swordfish grounds 400-1,000 miles away, predominantly to the north of the Hawaiian islands. In 1991, there were approximately 23 vessels, about 16% of the longline fleet, in this distant water fishery, which targeted swordfish year-round. In 1992, 66 vessels targeted swordfish sometime during the year, while 27 vessels fished for swordfish full-time. Trips targeting swordfish accounted for 23% of the total number of longline trips taken in 1992.

At present, most of the Hawaii-based longline vessels do not have the fuel or ice carrying capacity, or are not large enough to safely participate full-time in the swordfish fishery. Swordfish longliners average 30-40 days at sea per trip and fish up to 1500 miles from Hawaii, compared to tuna longliners that average 7-10 days per trip and fish closer to the islands (Dollar 1991). The majority of the swordfish catch is made well beyond the 200 mile EEZ. For other species, the proportion caught outside varies depending on the species (Table III-5). Tables III-6 and III-7 present quarterly catch information through June 1993 for inside and outside the EEZ, respectively.

Table III-4. Fishing effort outside the Hawaii EEZ and inside the EEZ of the eight main Hawaiian islands (MHI) by Hawaii longliners and inside the EEZ by other Hawaii pelagic fisheries. Virtually all of the catch by other gears was within the MHI EEZ.

	Longline		Other Gears
	Outside HI EEZ	Inside MHI EEZ	Inside MHI EEZ
Active Vessels	113[1]	114	1,585
Trips	771[2]	775	26,600[2]
Hooks (thousands)	6,803	4,864	Unknown

[1] Vessels and trips that made at least one set outside the US EEZ. Also, 63 vessels made 133 trips that made at least one set in the EEZ of the northwestern Hawaiian Islands (NWHI). The number of vessels and trips for all areas is not additive, since a trip may include several areas. Nine vessels operated exclusively inside the MHI EEZ while 10 vessels operated exclusively outside the Hawaii EEZ. The fleet as a whole made 544 trips exclusively outside the MHI EEZ. A total of 1,299 trips were taken (all areas) in 1992.

[2] Troll and handline trips (total) in 1991. Estimate of number of vessels based on HDAR license records. Commercial vessels only, number of recreational troll-handline vessels is unknown.

Table III-5. Proportions of the total 1992 catch caught outside and inside the EEZ of the eight main Hawaiian islands (MHI) by Hawaii longliners and inside the EEZ by other Hawaii pelagic fisheries. Virtually all of the catch by other gears was within the MHI EEZ. Proportions are given as percent by weight of the total catch of each species by all gears. Longline CPUE (number caught/1,000 hooks), by area is also presented

	Longline				Other Gears
	Outside MHI EEZ		Inside MHI EEZ		Inside MHI EEZ
Species Caught	Percent total	CPUE	Percent Total	CPUE	Percent Total
Swordfish	90%	9.9	10%	1.5	<1%
Yellowfin Tuna	13%	0.6	13%	0.8	74%
Bigeye Tuna	45%	3.1	50%	4.7	5%
Albacore	70%	2.3	17%	0.8	13%
Blue Marlin	22%	0.3	34%	0.6	44%
Striped Marlin	35%	0.9	58%	2.0	7%
Mahimahi (Dolphin Fish)	43%	6.4	13%	2.7	44%

Table III-6a. Longline Catch and Effort Information From NMFS Logbook Program (Inside the EEZ, 1991-1992, By Quarter)

	1991								1992							
	January - March		April - June[2,3]		July - September		October - December		January - March		April - June		July - September		October-December[4]	
	MHI	NWHI	MHI	NWHI	MHI	NWHI	MHI	NWHI	MHI	NWHI	MHI	NWHI	MHI	NWHI	MHI	NWHI
Effort Information																
# Vessels	112	61	108	50	87	33	82	22	73	39	89	31	60	17	70	20
# Sets	2,005	406	1,831	486	928	213	1,359	149	1,045	268	781	213	666	129	1,633	120
Number of Fish Caught																
Swordfish	2,986	3,293	8,226	4,521	1,546	1,361	764	265	1,107	1,865	3,450	1,604	581	1,147	1,907	495
Bigeye Tuna	10,693	2,033	2,712	983	1,911	568	6,807	870	5,445	1,210	2,061	304	1,549	203	13,823	832
Yellowfin Tuna	1,800	437	2,293	572	2,187	211	828	153	699	178	403	84	1,519	42	1,207	80
Blue Marlin[1]	2,686	195	2,007	378	368	68	985	80	905	93	670	78	322	47	850	25
Striped Marlin	4,851	989	3,569	1,083	542	159	2,320	213	2,814	787	1,305	356	693	197	4,996	338
Mahimahi	6,405	513	3,748	1,194	2,016	103	5,189	193	2,103	91	1,104	1,335	2,542	680	7,540	200
Shark	3,557	3,322	3,960	3,744	2,568	2,668	3,036	925	2,427	3,423	2,567	2,300	2,738	2,095	3,940	1,052
Albacore	736	254	2,231	124	1,424	55	1,255	48	323	201	575	43	1,207	14	1,862	50

1 Blue Marlin catch may be overstated and striped marlin catch may be understated due to species identification problems.
2 NWHI closures went into effect 4/15/91
3 MHI closures went into effect 6/14/91
4 MHI seasonal closure adjustment went into effect 10/1/92

Table III-6.b. Longline catch and effort information from NMFS logbook program (Inside the EEZ, Jan-June 1993)

	1993			
	January - March		April - June	
	MHI	NWHI	MHI	NWHI
Effort Information				
# Vessels	58	51	79	45
# Sets	1,057	465	1,089	377
Number of Fish Caught				
Swordfish	798	2,754	2,572	4,110
Bigeye Tuna	8,436	3,759	3,970	1,392
Yellowfin Tuna	2,677	1,106	1,447	296
Blue Marlin	457	97	743	193
Striped Marlin	2,460	681	2,335	1,141
Mahimahi	3,819	537	1,312	1,029
Shark	2,420	4,847	2,696	6,919
Albacore	593	691	2,699	203

Table III-7. Longline catch and effort information from NMFS logbook program (Outside the EEZ, 1991-June 1993, by quarter).

	1991				1992				1993	
	Jan-Mar	Apr[1]-June[2]	July-Sept	Oct-Dec	Jan-Mar	Apr-June	July-Sept	Oct-Dec[3]	Jan-Mar	Apr-June
Effort Information										
# Vessels	87	103	73	88	100	108	70	74	96	105
# Sets	947	1,560	1,216	1,335	1,883	2,441	1,148	1,134	1,845	283
Number of Fish Caught										
Swordfish	12,687	13,953	7,395	8,694	19,131	18,259	10,769	13,526	22,209	19,746
Bigeye Tuna	2,805	2,280	3,064	5,302	5,375	6,264	3,721	2,845	8,446	6,732
Yellowfin Tuna	745	1,574	1,927	1,066	1,713	1,313	296	267	2,008	1,762
Blue Marlin[4]	201	587	645	711	204	701	461	138	144	901
Striped Marlin	507	1,628	1,023	1,131	939	2,101	950	405	462	2,525
Mahimahi	1,500	6,670	8,286	3,236	2,631	13,368	20,719	4,278	1,690	7,575
Shark	7,025	8,847	20,939	10,472	16,093	11,639	15,746	30,053	25,082	13,070
Albacore	1,252	1,592	330	4,405	2,938	2.861	338	9,296	2,862	2,978

[1] NWHI closures went into effect 4/15/91
[2] MHI closures went into effect 6/14/91
[3] MHI seasonal closure adjustment went into effect 10/1/92
[4] Blue marlin catch may be overstated and striped marlin catch may be understated due to species identification problems.

The troll fishery

There is little documentation of the gear and methods used in Hawaii's small-vessel troll fisheries, particularly in recent years. Trolling is conducted by towing lures or baited hooks from a moving vessel, using rods and reels typical of big-game fishing, as well as power gurdies, outriggers, and other gear. Troll vessels are mostly small (5-8 m, 15-25 ft long) but some are as large as 18 m (59 ft). Troll vessels are typically operated with a 1-2 man crew. Some larger (20-26 m, 65-85 ft) troll vessels from the North Pacific albacore fishery participated briefly in the Hawaii troll fishery in the mid-1980s. Vessels from the lobster and bottomfish fisheries troll sometimes for pelagic species, as well. Troll vessels generally fish within 20 nm of shore throughout the main Hawaiian islands, although trips to 50 nm are common in the summer.

The troll fishery is composed of several poorly-differentiated sectors including full-time and part-time commercial trollers, commercial charterboats, and recreational and subsistence fishing. The commercial charter sector is often referred to as recreational because its patrons are sport fishermen, but the charter catch is often retained by the vessel and sold. Recreational and subsistence fishermen sometimes operate commercially as well, in that they sell some of their catch.

The pelagic handline fishery

Several types of pelagic handline fishing are practiced in Hawaii, but only the night-handline method is well-described (Yuen 1979, Ikehara 1981). Night-handline or "ika-shibi" fishing developed from a squid (ika) fishery which switched to target the incidental catch of tuna (shibi). Ika-shibi fishermen use lights and chum to attract small prey species and tuna to handlines baited with squid. Handline fishing during the day is called "palu-ahi" or "drop stone" fishing. It differs from the ika-shibi method; the handline is wound around a stone with a baited hook and chum wrapped in the line with the stone (Rizzuto, 1983). The line is tied in a slip knot, and the bundle is dropped to about 20-30 m (depth may vary more widely) and then jerked to untie the knot. This releases the baited hook and chum at the target depth.

The ika-shibi fishery was started by Japanese immigrants to Hawaii and the palu-ahi fishery has prehistoric origins. Both these methods are steeped in tradition and are a treasured part of Hawaii's cultural heritage. Handline fishing is still a source of subsistence for vanishing Hawaiian fishing villages such as Milolii on the island of Hawaii, and is popular among recreational fishermen as well, who often use the method around state-funded fish aggregating devices (FAD) buoys.

Handline vessels are mostly 6-9 m in length with a crew of 1-2 persons. Handline fisheries primarily operated along the coast of the Island of Hawaii until the 1980s when they were revitalized on the other islands in response to an increasing market and better air shipment facilities for fresh fish. Longline and troll vessels will occasionally use handlines if they locate suitable aggregations of fish.

Fishing is often conducted within a few miles of shore at natural "ahi koa", or artificial FAD buoys where yellowfin and bigeye tuna aggregate. In the late 1980s and 1990s, several of the largest handline vessels began fishing around seamounts and weather buoys 100-200 miles from shore. Other variations of handline fishing are not well documented, and only in the last few years do commercial handline catch reports identify what type of handline fishing method was used. For this reason, handline catch and effort data for palu-ahi, ika-shibi, and other types of handline gear are combined in the discussion below.

Some handline fishermen worry that too many new handline fishermen may be impacting the locally-available resource. There is also concern that the new, offshore fishery harvests too many small fish. The WPRFMC has instituted a control date for this fishery with regard to possible limited-entry management.

Other fisheries

Foreign fisheries are currently not authorized to operate in the Hawaii EEZ. Legal foreign longline and pole-and line fishing ceased in 1980 and 1993, respectively, as foreign operators declined to apply for permits and carry US observers as required by the FMP (WPRFMC 1986, Amendment 6). No concerted purse-seine fishing, other than government-sponsored trials, has taken place in the Hawaii EEZ, largely because large surface schools of yellowfin tuna are uncommon and skipjack tuna schools proved difficult to target. Purse-seine methods are improving, however, allowing seiners to effectively fish new areas. In 1990, US purse seiners were reported to be fishing in the US EEZ around Howland and Baker Islands. The possible use of purse-seine gear in Hawaii concerns Hawaii fishermen because in other areas a single set may harvest as much as 200 t of tuna. This is about half of the annual tuna harvest of the entire Hawaii commercial troll fishery.

III.C.1.b. Trends in catch and effort, by gear type

Hawaii longline landings time series (Fig. III-2 and Fig. III-3) are based on four data sources and a correction to account for under-reporting. Hawaii Department of Aquatic Resources (HDAR) longline data are believed to be relatively complete through 1978. NMFS estimates based on market sampling are used for 1987-90 and market sampling combined with logbook data are used to estimate landings for 1991-1992 (Ito 1992, Pooley 1993b). Because of under-reporting discovered in the mid-1980s, total longline catch estimates for 1979-86 are values interpolated between HDAR reported landings in 1978 and NMFS estimates for 1987 (Pooley 1993b). HDAR troll and handline landings reported to HDAR through 1992 (Fig. III-2 through III-4) are similar to NMFS estimates (Pooley 1993b) and are used uncorrected. However, troll and handline landings may also be vastly under-reported and these "best available data" are inadequate to properly monitor Hawaii's pelagic fisheries.

Catch by gear type

Early growth of Hawaii's longline fishery peaked in the mid 1950s and then declined during the 1960s and 1970s when foreign longline catches within the EEZ became greater than domestic landings (Boggs and Ito 1993). A desire to regulate this foreign fishery provided the original impetus for the FMP. Foreign longline catch in the EEZ reached a peak of about 11.2 million lbs in 1970 (Yong and Wetherall 1980). The domestic fishery expanded in the 1980s, surpassing its 1954 record catch of 4.4 million lb by 1988 and surpassing the foreign catch record for the EEZ in 1990. By 1992, landings reached 21.2 million lb (Fig. III-2A).

The longline catch has been was 19.6 million lb and 21.2 million lb in 1991 and 1992, respectively. About half of the catch is swordfish, a species unimportant to any other fishery sector. The non-swordfish component of the longline catch in 1991 was about 9.7 million lbs, exceeding all previous levels (Table III-8). In 1993, non-swordfish catch was 8.6 million lb.

The commercial troll and handline fisheries experienced rapid growth in the 1970s, and declined in the late 1980s (Fig. III-2B). The domestic longline fishery on the other hand was growing rapidly in the late 1980s. This raised concerns regarding catch competition and fishery interactions (Boggs 1991; Ito 1991; Boggs 1993). Reported commercial troll catches (all species) were less than 0.4 million lb/yr until 1974. From 1975-84 commercial troll catches ranged between 1.2-1.7 million lb/yr and then rose to a record peak of almost 3.7 million lb in 1987, declining thereafter (Fig.III-2A,B). Annual commercial handline landings reported to HDAR increased from 0.1 million lb to almost 2.2 million lb between 1970 and 1981. Since 1981 commercial handline landings have ranged between 1.1-2.2 million pounds with major peaks in 1981, 1983, 1986, and 1991 (Fig.III-2B).

The recently expanded Hawaii longline fishery (Fig. III-3A,B) now accounts for the bulk of Hawaii's pelagic catch including most of the swordfish (12.6 million lb, >99%), bigeye tuna (3.2 million lb, 95%), albacore (0.8 million lb, 87%), striped marlin (1.1 million lb, 93%), blue marlin (0.7 million lb, 56%), and mahimahi (0.6 million lb, 53%) caught in 1992 (Table III-8). The longline fishery also catches substantial amounts of yellowfin tuna (0.8 million lb). The longline catch of yellowfin tuna, blue marlin, and mahimahi creates a potential for fishery interaction between the longline fishery and the small-vessel troll and handline fisheries that target these species. Until the early 1970s and for a brief period (1989-91) before the enactment of the moratorium on entry and area closures, Hawaii's longline fleet accounted for the majority of the reported yellowfin tuna catch. Since then, Hawaii longline catches of yellowfin tuna have declined (Fig.III-3B), and now account for 26% of the total Hawaii catch (Table III-5).

Yellowfin tuna is a secondary target species for longline fishermen, and blue marlin and mahimahi are incidental catches, but the species composition of longline landings has changed over time. During 1951- 64, more than half of longline landings (by

Table III-8. Hawaii longline fishery landings (1000 lb) and Revenue ($1000).[1]

Species	Landings (1000 lb)		Revenue ($1000 lb)	
	1991	1992	1991	1992
Tunas				
Albacore	700	780	$ 900	$ 970
Bigeye	3,500	3,280	12,500	11,910
Yellowfin	1,600	770	4,300	2,310
Other tuna	100	102	100	680
Billfish				
Blue Marlin	700	730	500	870
Swordfish	9,900	12,640	22,000	24,270
Striped Marlin	1,400	1,060	1,400	1,360
Other billfish	400	280	300	300
Other Pelagics				
Mahimahi	500	590	700	830
Wahoo (ono)	100	80	200	200
Sharks	200	560	100	350
Misc.	500	370	700	600
TOTAL	19,600	21,240	$43,700	$44,650
Total less swordfish	9,700	8,600	$21,700	$20,380

[1] 1991 data from Dollar (1992) and Ito (1992). 1992 data from Dollar (1993) and NMFS shoreside monitoring program.

Figure III-2A. Hawaii pelagic commerical landings, by gear type, 1970-1992. HDAR summary and NMFS Estimates.

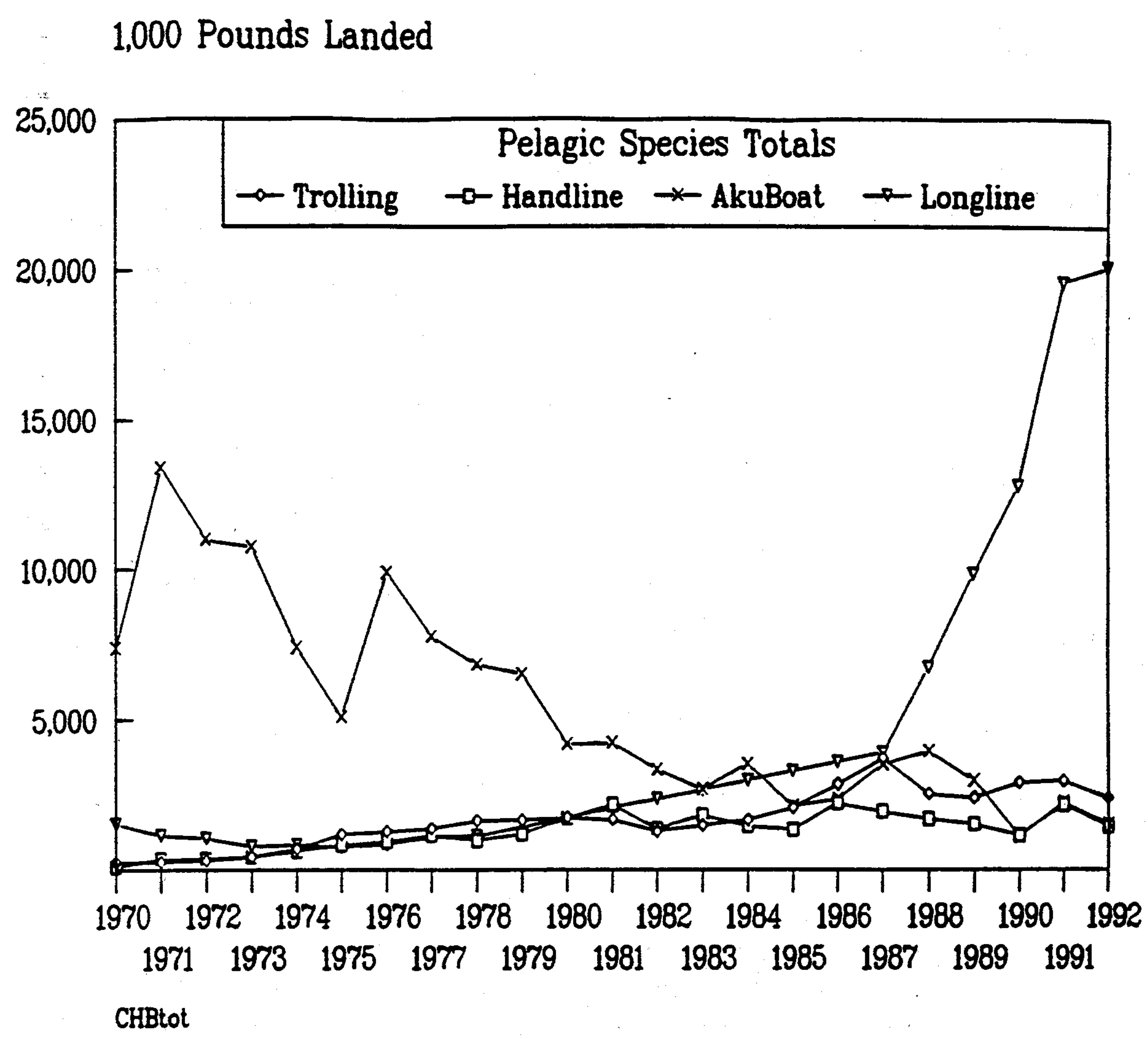


Figure III-2b. Hawaii troll and handline pelagic commercial landings, 1990-1992 (Longline and aku boat excluded to show annual variation).

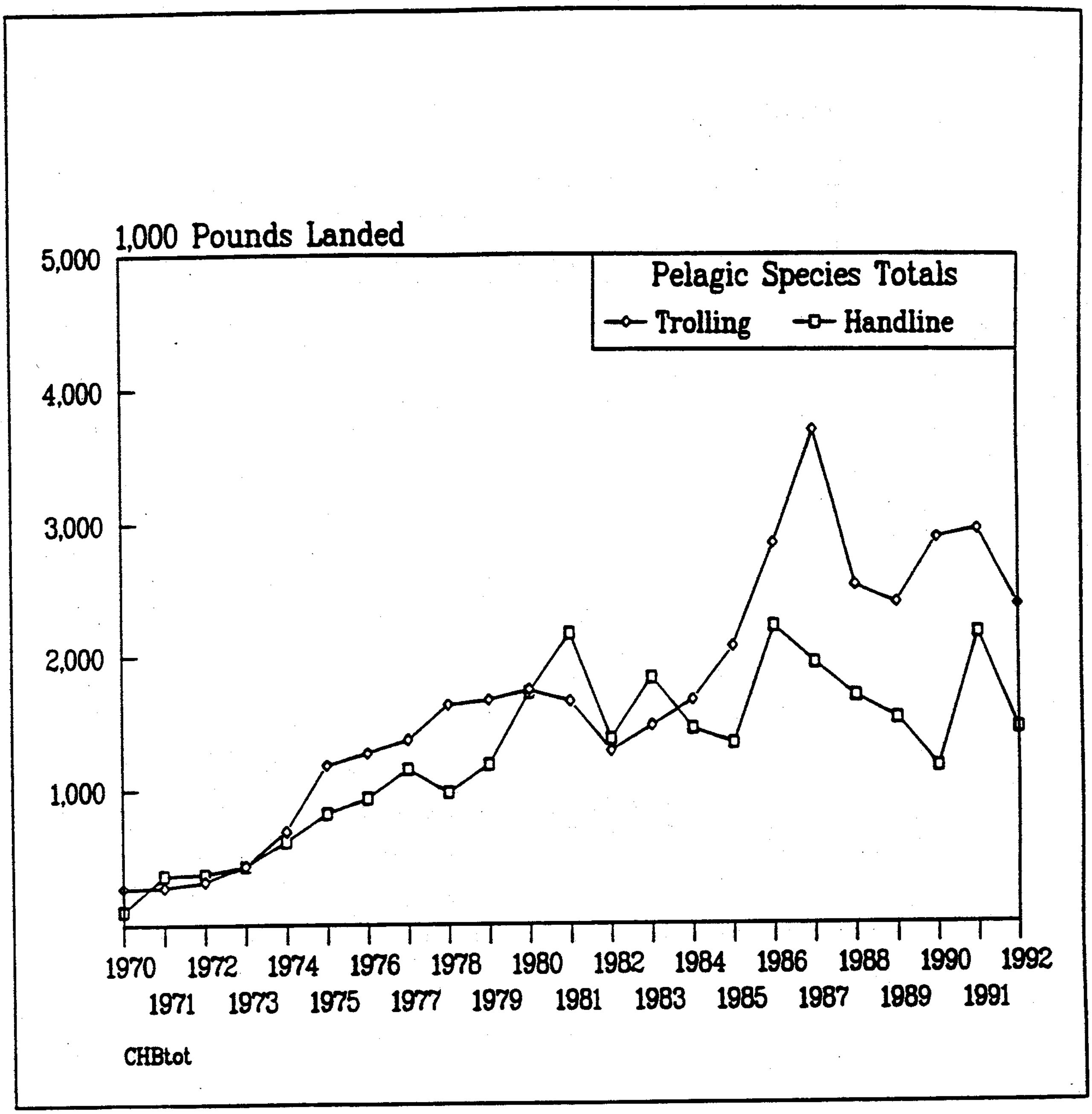


Figure III-3a. Hawaii longline landings, by species, 1970-1992. NMFS estimates.

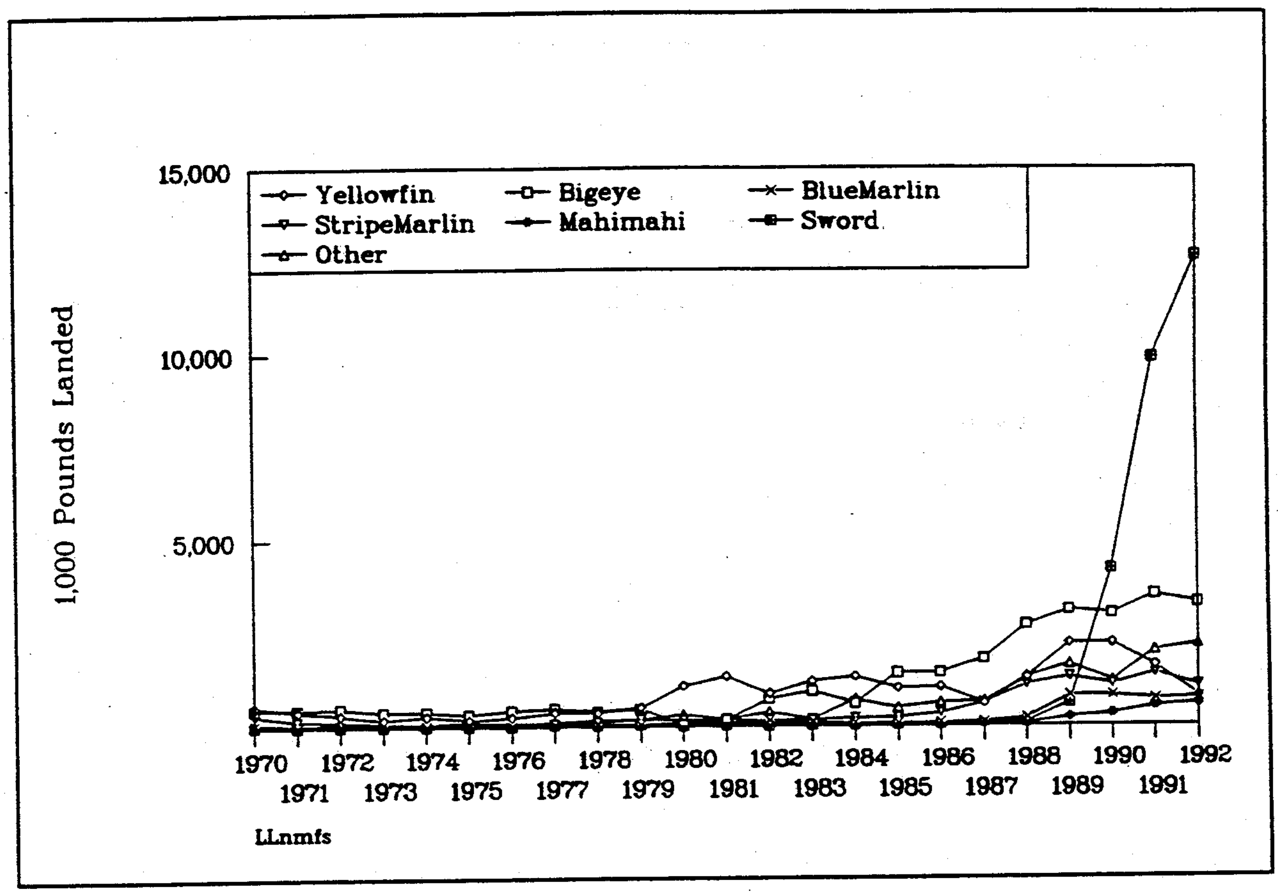
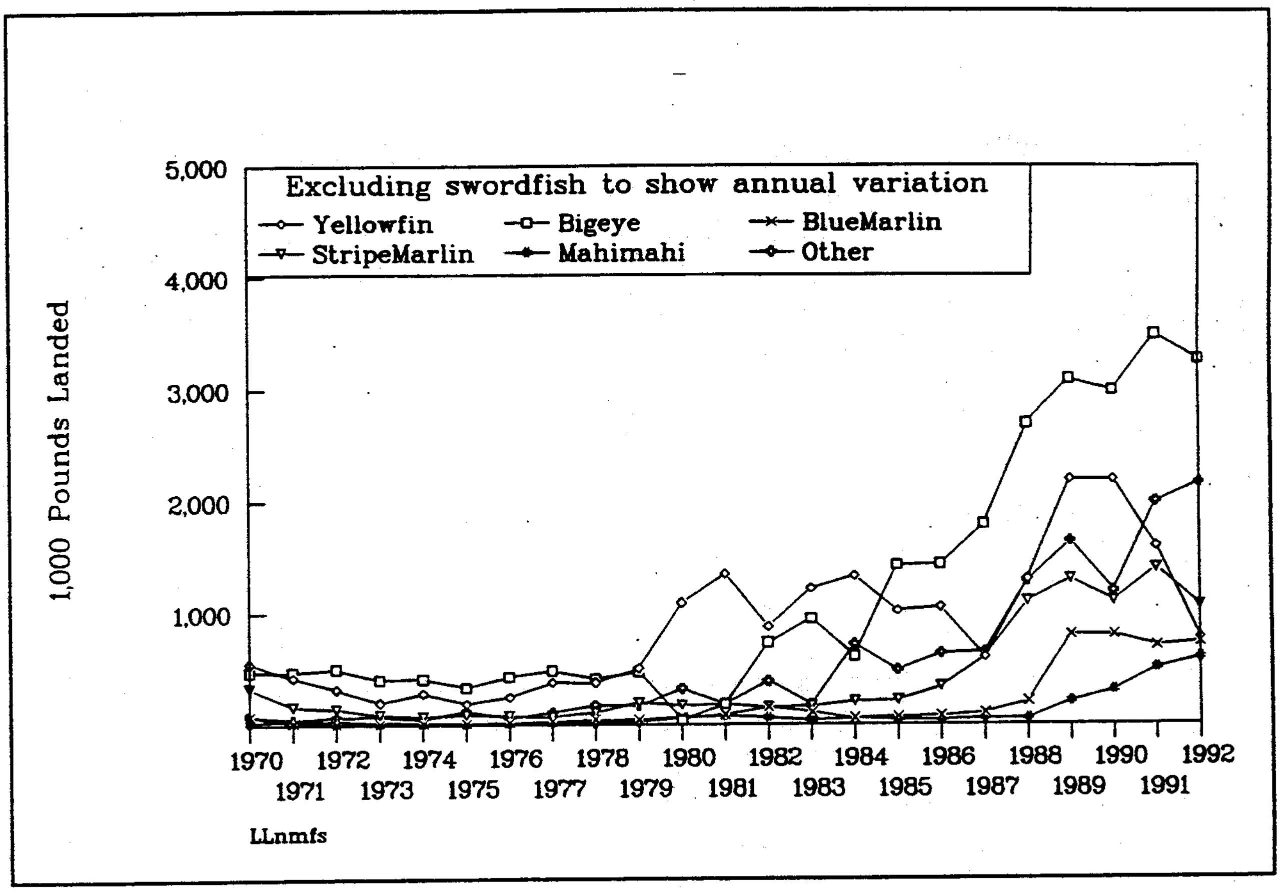


Figure III-3b. Hawaii longline landings, 1970-1992. Swordfish excluded to show annual variation. NMFS estimates.



weight) were bigeye tuna, but before 1950 and in the 1970s, yellowfin tuna made up roughly equal proportions of the catch. The proportion of blue marlin was higher than striped marlin in the early 1950s, but striped marlin became more predominant from the early 1960s to the present (Boggs and Ito, in press). These trends, and the switch to swordfish in the 1990s, illustrate the potential for the longline fishery to impact different resources as markets and fishing methods change.

Yellowfin tuna are the primary target of the commercial troll and handline fleets which landed 0.6 million and 1.5 million lb, respectively, of yellowfin tuna in 1992 (Figs III-4A and III-4B). The 1987-1989 decline by the troll fishery (Fig. III-4A) and the 1986-90 decline in yellowfin tuna catch by the handline fishery (Fig. III-4B) coincided roughly with the rapid expansion of the longline fishery, and many people perceived the longline expansion as a cause for the decline (Boggs 1991). The subsequent pattern of yellowfin tuna catches in these fisheries has been variable. The troll catch of yellowfin tuna increased somewhat in 1990 and was lower again in 1991-1992. The handline rebounded in 1991 through 1992.

The commercial troll/handline fishery caught a substantial fraction of the blue marlin (0.6 million lb 41%), and most of the wahoo (79%) caught in 1992 (Table III-9). Commercial troll landings of species other than yellowfin tuna have remained relatively constant (compared with yellowfin tuna) since 1987 (Fig III-4A), except for mahimahi which increased through 1991 and dropped in 1992. The commercial handline catches of species other than yellowfin tuna appear minor (Fig.III-4B), but the handline catch described as yellowfin tuna includes an unknown amount of bigeye tuna mis-categorized as yellowfin tuna during the reporting and processing of the data. The confusion is partially due to the common name "ahi" which can mean either yellowfin or bigeye tuna. The handline catch of bigeye tuna would be among the most likely to be affected by catch competition with the longline fishery. However, there are currently no good estimates of handline catch or CPUE for bigeye tuna. Catch competition for bigeye tuna will remain unquantified unless data collection procedures are improved.

State of Hawaii (HDAR) commercial catch reports used for this summary do not identify types of troll or handline fishing (i.e., charter, part-time commercial) and there are no current estimates of the magnitude of recreational or subsistence harvest. In 1976, the troll catch by sector was estimated at 21% charter, 44% part-time commercial and recreational-subsistence (combined), and 35% full-time commercial (Cooper and Adams 1978). However, changes in troll fisheries make it unlikely that these proportions represent the current situation. The catch of these unquantified sectors is probably significant with regard to catch competition and fishery interaction.

Figure III-4a. Hawaii troll pelagic landings, by species, 1970-1992. HDAR summary files.

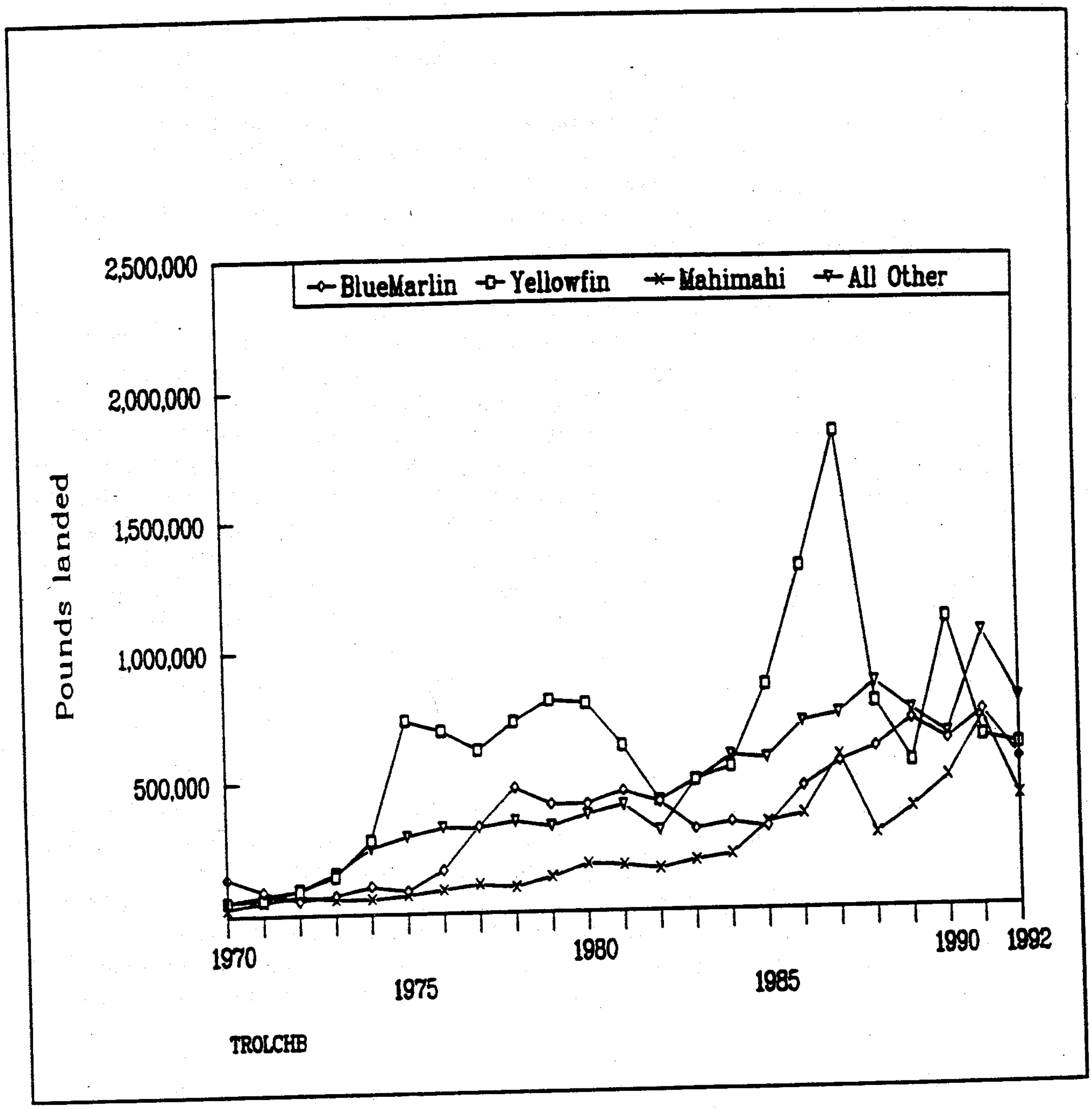


Figure III-4b. Handline pelagic landings, by species, 1970-1992. HDAR summary files.

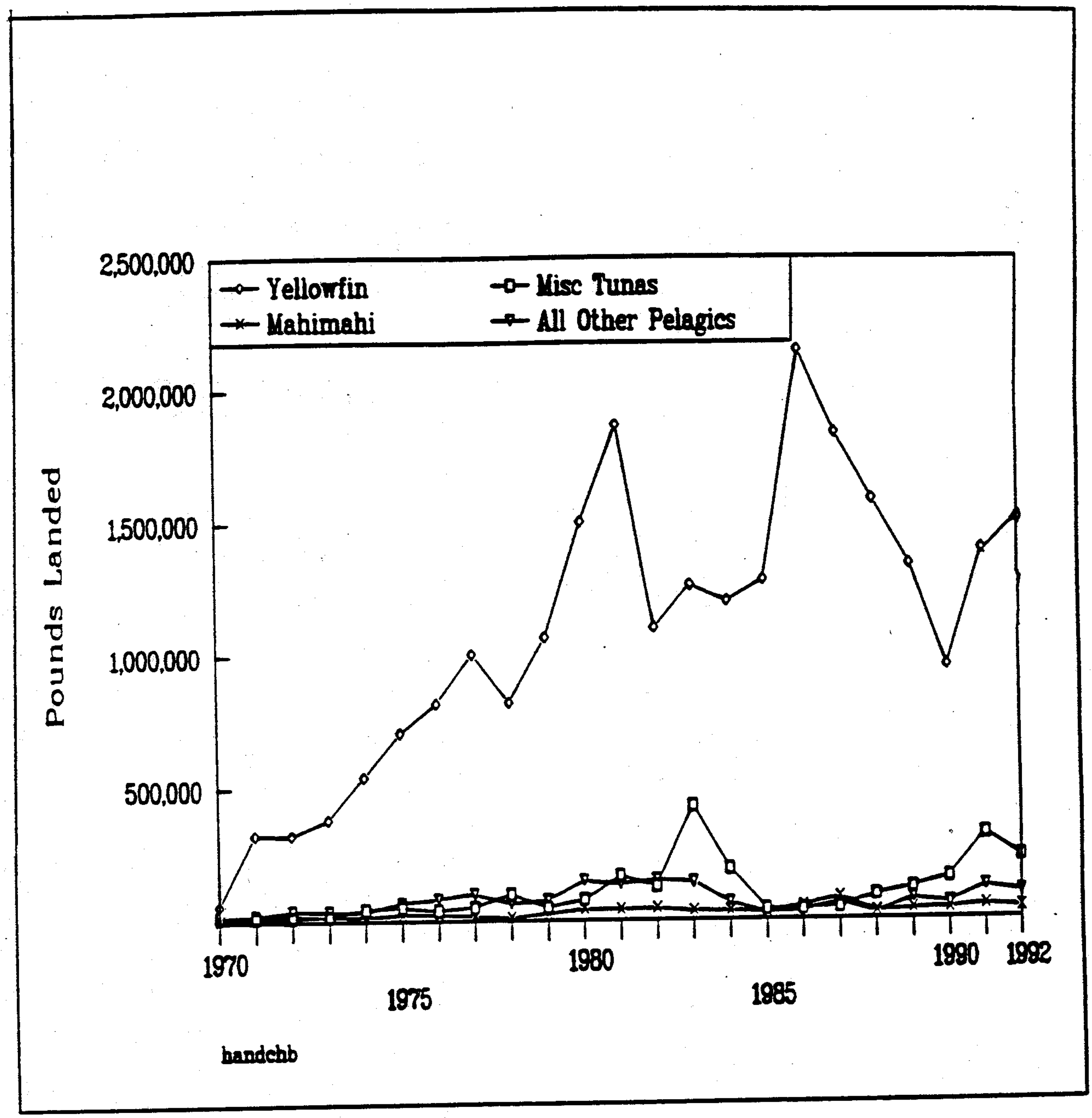


Table III-9. Non-longline pelagic commercial landings & revenue 1991-1992. HDAR commercial fisheries data for pelagic species only, excluding longline-caught fish.

Species	1991				1992			
	Pounds	Lb Sold	Revenue	Price/lb	Pounds	Lb Sold	Revenue	Price/lb
Skipjack Tuna	2,711,577	2,585,473	$3,408,314	$1.32	2,052,926	1,938,538	$2,737,147	$1.41
Yellowfin Tuna	2,113,378	2,008,873	3,803,129	1.89	2,219,498	2,112,449	3,912,901	1.85
Bigeye Tuna	178,362	166,948	298,626	1.79	183,482	176,207	279,947	1.59
Albacore	158,362	154,099	142,864	.93	115,889	113,963	111,947	.98
Other Tunas	20,968	13,911	19,061	1.37	28,508	21,823	29,516	1.42
Billfish	51,605	39,789	40,936	1.03	36,362	29,559	38,913	1.32
Swordfish	13,627	13,529	28,909	2.14	3,238	3,179	9,107	2.86
Blue Marlin	769,051	642,878	524,040	.81	574,532	489,022	441,330	.90
Sailfish	2,762	1,597	1,795	1.12	1,001	689	681	.99
Striped Marlin	90,440	67,640	80,624	1.19	84,844	65,176	87,916	1.35
Mahimahi	781,045	712,466	1,387,276	1.95	529,438	485,446	1,138,659	2.35
Wahoo	381,891	346,662	861,486	2.49	299,609	268,157	785,000	2.85
Sharks	22,154	5,338	4,003	.75	13,849	4,218	3,645	1.35
Other Pelagics	7,825	7,037	11,101	1.58	9,953	9,270	13,145	1.42
All Species	7,304,531	6,768,200	$10,614,165	$1.57	6,151,129	5,717,696	$9,569,386	$1.67

Fishing effort by gear type

Documenting the number of vessels that participated historically in the Hawaii longline fishery is difficult. Reported participation declined from 42 vessels in 1952 to 20 in 1970 (Yoshida 1974), and to 15 in 1977 (Yuen 1977). By 1983, HDAR records showed only 13 registered longline vessels, more longliners were actually fishing. During the 1980s, many longliners did not submit their state commercial catch reports. The federal logbook and permit system was implemented in the 1990s which led to much better documentation of longline activity. The NMFS Market Monitoring Program found that participation in the Hawaii longline fishery more than doubled from 37 vessels in 1987 to 80 in 1989, and then increased by an additional 73% to 138 vessels in 1990. The first full year of the moratorium was 1991. During that year, 72% of the permits issued (111 out of a total of 154) actively fished in the Hawaii longline fishery. In 1992, 123 permits (74% of the total 166 issued) actively fished.

Deployment of increasing numbers of hooks per set and per trip has characterized the history of the Hawaii longline fishery (Boggs and Hawn, unpublished manuscript). The number of hooks deployed during an average trip nearly doubled between the 1950s (Shomura 1959) and the early 1980s (Hawaii Opinion 1984). Longline vessels deployed over three times as much gear on an average trip in 1988 as in 1982, and users of the new monofilament longline systems tended to deploy over four times as much gear per trip in 1988 (Kawamoto et al. 1989) as was typical of the fleet in 1982 (Hawaii Opinion 1984).

The amount of gear deployed per set and per trip varies depending on the type of longline trip. When fishing for swordfish longliners use between 35-45% fewer hooks per set than when fishing for tuna in 1992 (Table III-10). For a given target fishery, size of vessel does not appear to affect the number of hooks which can be deployed per set. The amount of effort expended per trip (hooks per trip) does not vary much with the size of the vessel when fishing closer to the islands for tuna (Table III-10), but the larger boats (over 74 ft.) targeting distant water swordfish deployed 11,249 hooks/trip, while mid-size vessels (56 to 74 ft in length) deployed 8, 164 hooks/trip on average during 1992.[3]

To estimate longline fishing effort, published data on the changes in the amount of gear deployed per longline trip are combined with estimates of the number of longline fishing trips[4] (Boggs and Hawn, unpubl.) to derive the annual number of total hooks deployed (Fig III-5). Longline fishing effort increased throughout the 1980s until the

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3 Information from longline logbook reports for the period 1 October 1991 through 30 September 1992.

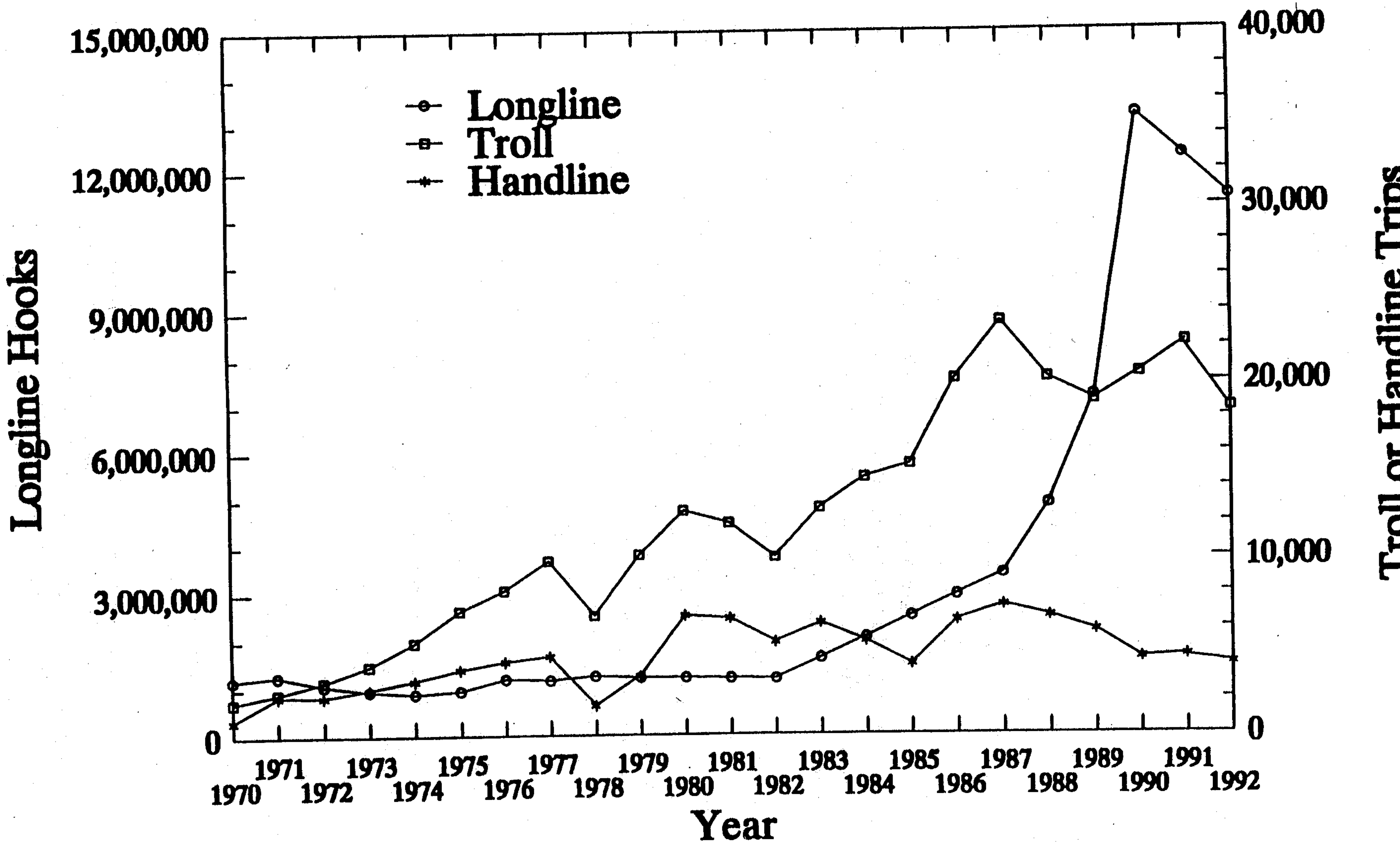
4 Longline trips from 1979-86 were estimated by interpolation between HDAR data for 1978 and NMFS estimate for 1987.

Table III-10. Average number of hooks deployed (per set, per trip) by vessel size category.

Type of Trip	Vessel Size Category	Average Hooks/Set		Average Hooks/Trip	
		1991	1992	1991	1992
All trips combined	Large[1]	871	886	7,550	9,721
	Medium[2]	986	1,017	7,028	8,218
	Small[3]	1,149	1,248	7,541	9,827
Swordfish Target	Large	774	831	8,948	11,249
	Medium	725	759	6,926	8,164
	Small	657	*	5,911	*
Tuna Target	Large	1,060	1,285	7,896	11,706
	Medium	1,213	1,371	9,918	11,595
	Small	1,282	1,345	9,339	10,878
Mixed	Large	902	893	6,734	8,237
	Medium	924	894	5,432	5,932
	Small	928	875	3,823	4,666

[1] >74 ft in length
[2] 56-74 ft
[3] <56 ft
* confidential data, less than 3 vessels reporting

Figure III-5. Hawaii pelagic fishing effort, 1970-1992. NMFS and HDAR data.



moratorium on new participants in the fishery was established; longline effort then declined in 1991-92. Longline fishing effort that is known to be directed at swordfish[5] accounted for about 24% of total hooks in 1992, with 45% directed at tuna and the remainder directed at mixed or unknown targets. In 1991 hooks were 19% swordfish-directed, and 43% tuna-directed. About 30% of the effort categorized as directed at mixed or unknown targets used lightsticks, presumably to target swordfish (NMFS longline logbook summaries).

There were 102 and 119 charter vessels in the Hawaii troll fishery in 1976 and 1982, respectively (Cooper and Adams 1978, Samples et al. 1984), compared to an estimated 160 full-time commercial, and 1,544 part-time and recreational-subsistence trollers (combined) in 1976 (Cooper and Adams 1978). More recent counts of participation by sector are not available, but it is likely that all sectors have changed.

The only estimates of fishing effort for the commercial troll and handline fisheries are based on counts of records for unique landing dates by vessels (Boggs and Ito, in press). Fishing effort in the Hawaii commercial troll fishery showed an increasing trend from 1970-87, dipped in 1988-90, and then rose again in 1991 to the record high level set in 1987 (Fig III-5).

Surveys of the ika-shibi fishery showed participation growing from 30-40 boats in 1976 to at least 230 boats by 1980 (Yuen 1979, Ikehara 1981). A similar number of handline fishermen (palu-ahi and ika-shibi combined) are currently active in the fishery, but there is now a larger component of the handline fishery that does not report their effort or catch. Estimates of total trips by handline vessels (all types) increased from 1970-77 with a notable dip in 1978-79. Peaks of about 7,000 trips annually were reached in 1980-81 and 1986-88 with a subsequent decline to about 4,000 trips annually in 1990-92.

The total effective effort by all fishing gears combined would be a very useful statistic for describing the fishing pressure on the locally available resource, but no such estimate is available given the present data collection environment in Hawaii. The three major gear categories have very different efficiencies for each species, and these efficiencies change with time. It may be possible to approximate some measure of total fishing effort through a thorough analysis of the historical data as proposed for the Western Pacific Pelagic Fisheries Research Program. Meanwhile, the only available index of fishing pressure is the total catch of each species (Boggs 1991, in press), which is given below[6].

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5 Hooks deployed on trips defined as swordfish, mixed, or tuna-directed, as defined by fishermen in terms of target species.

6 Total catch data for Hawaii fisheries are only valid as a fishing pressure index after 1980, since they do not include the foreign catch in the EEZ for earlier years. This index also lacks the non-commercial component, which if substantial and independent of the trend in commercial effort would invalidate the index. Information on the magnitude of non-commercial (recreational and subsistence harvests which are not sold) catch and effort is needed for rational management.

III.C.1.c. Trends in commercial revenue, by gear type

The Hawaii pelagic fisheries land approximately 70% of total commercial fishery revenue (ex vessel) in Hawaii and also account for a large proportion of total recreational and sports fishing income. Figure III-6 provides inflation-adjusted (1992 dollars) ex-vessel revenue for the four main pelagic gear types from 1970 to 1992.[7] Pelagic fishery revenue has grown from $3 million in 1970 ($12 million in inflation-adjusted 1992 dollars) to $54 million in 1992. The pelagic fishery has been dominated by two gear types: in the early 1970s the aku boat (skipjack tuna) fishery provided 52% of the revenue (declining to 4% in 1992), while in 1992 the longline fishery provided 82% of the pelagic fishery value (rising from just 17% in 1976). However in the interim, the troll and handline fisheries have also played an important part.

Aku boat landings have declined primarily because of the closure of the Honolulu cannery in 1984, problems in catching live bait, and the aging of the vessels in the 50 plus year old fleet. Troll and handline revenue rose from 5% of total pelagic value in 1970 to 41% in 1986. Actual revenues in the troll and handline pelagic fisheries remained stable from the mid-1970s through the mid-1980s, peaking at $12.6 million in 1987 (inflation-adjusted to 1992 dollars) and declining to $7.1 million in 1992. Most of the growth in the longline fishery is attributable to the increase in swordfish landings (54% of longline revenue in 1992, up from less than 1% in 1987).

III.D. 1.d Trends in catch and CPUE by species

In this section catch and CPUE are examined for evidence of declines in CPUE caused by increased local fishing pressure. As noted above (Section III.D.1.b) the only available measure of local fishing pressure is the total estimated catch of each species (by all fisheries combined).

When catch competition occurs CPUE should decline as total catch increases (Boggs 1993). However, other factors that affect CPUE may tend to obscure catch competition, and many other factors affect the estimates of CPUE for Hawaii's pelagic fisheries (Boggs, in press; Boggs and Ito, in press).

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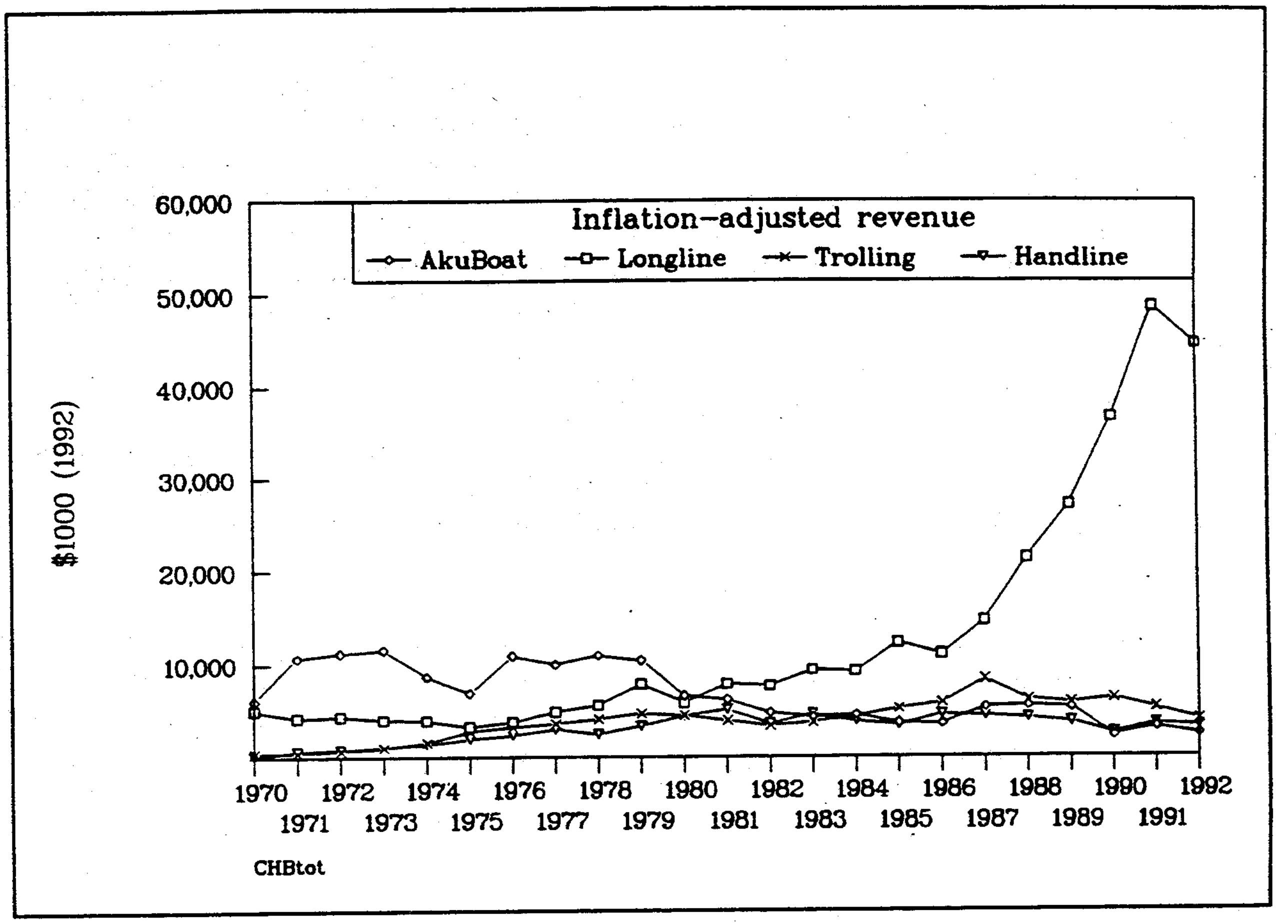
[7] Revenue was estimated by applying Hawaii Division of Aquatic Resources (HDAR) commercial fish catch reports average prices to HDAR figures for aku (bait) boat, troll and handline landings and NMFS estimates of longline landings.

Figure III-6. Hawaii pelagic fishery ex-vessel revenue by gear type, 1970-1992 (1992 dollars). HDAR summary files and NMFS estimates.



The "best available" estimates of total catch and CPUE[8] for important species are presented here despite major problems with the estimates and their interpretation (Boggs 1991, 1993, Boggs and Ito 1993). The types of research needed to improve these estimates and to estimate the optimal level of fishing effort is described in Appendix 2. Funds to initiate these analyses recently became available.

Swordfish

The total swordfish catch increased to the current level of 12.6 million lb from almost nil before 1989. Between 1991 and 1992 swordfish CPUE increased slightly from 2,300 to 2,600 lb/1,000 hooks. The average size of longline-caught swordfish ranged from a low of 119.2 lb in 1988, to a high of 177.9 lb in 1992 (Table III-11). No clear trend can be seen over such a short time[9]

Yellowfin tuna

The catch of yellowfin tuna by all Hawaii commercial fisheries increased 5-fold from 1970 to 1981, declined by 40% in 1982, increased to a record high of about 4.5 million lbs in 1986, remained at a relatively high level through 1990, and then declined by about 30% from 1990-1992 (Fig. III-7).

Yellowfin tuna CPUE[10] in the Hawaii longline fishery peaked in 1970, 1980 and 1989 and declined to near record-low levels in 1991 and 1992 (Fig. III-8). The decline in longline CPUE for yellowfin tuna in 1991-92 may reflect the effect of area closures that kept longliners farther from the islands. The 1991-92 decline in CPUE is not

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8 Longline catch rates after 1989 have not been estimated previously (Boggs and Ito 1993) because the shift in longline effort to target swordfish drastically altered the efficiency of the gear. To calculate CPUE for recent years, 1991-92 logbook data was summarized for three trip categories: 1) trips known to be targeted at swordfish, 2) trips known to be targeted at tuna, and 3) trips targeted at both or with the target unknown. Effort (hooks) from swordfish trips was used to estimate CPUE for swordfish and effort from tuna trips was used to calculate CPUE for the other species. Mixed/unknown trips were not used to calculate CPUE.

9 The lack of logbook data before 1991 and the absence of any directed fishery for swordfish prior to 1987 prevents calculating swordfish CPUE for earlier years.

10 Longline CPUE data from Boggs and Ito (1993) were updated to include 1991-92 longline CPUE calculated as catch per 1,000 hooks for tuna-directed trips. Data through 1989 contain relatively little effort for swordfish and these CPUE were calculated from data on all trips. No longline CPUE was estimated for 1990 due to lack of data on substantial effort directed at swordfish. NMFS longline CPUE data for 1987-1989 are based on NMFS market monitoring data on catch and trips as described in Boggs and Ito (1993). Prior and overlapping CPUE estimates are based on HDAR catch reports. The lack of agreement between overlapping HDAR and NMFS estimates of longline CPUE from 1987-89 is due to differences between in fishery coverage provided by the two data sources. Although NMFS data has almost complete coverage HDAR data are included because of they include a much longer time series.

Table III-11. Average size of fish (lb), by gear type, 1987-1992.

Year	Non-Tuna PPMUS					Tunas			
	Swordfish	Blue Marlin	Striped Marlin	Mahimahi	Wahoo (Ono)	Bigeye Tuna	Yellowfin Tuna	Albacore	Skipjack Tuna
Longline									
1987	129.3	161.4	66.2	21.1	33.3	76.3	81.9	62.3	--
1988	119.2	157.3	56.9	20.0	31.9	83.9	102.5	59.7	--
1989	131.1	164.7	61.5	23.0	34.6	77.0	103.7	62.0	--
1990	147.6	198.4	61.5	18.7	36.0	79.8	121.9	61.2	--
1991	142.4	172.0	55.8	14.5	31.6	85.5	117.2	53.3	--
1992	177.9	166.9	69.1	11.0	35.0	76.7	100.5	48.0	--
Troll and Handline									
1987	--	212.1	67.3	18.8	19.5	19.6	27.6	--	8.9
1988	--	181.6	60.3	17.2	21.1	58.9	31.5	--	11.1
1989	--	185.7	67.9	19.9	20.9	34.0	35.4	--	13.6
1990	--	243.3	74.8	19.1	21.9	25.3	51.6	--	10.6
1991	--	179.2	60.6	13.5	18.8	20.4	26.0	--	14.5

Source: NMFS and HDAR shoreside monitoring program. Average weights are the averages of shoreside monitoring samples. 1992 weights are preliminary estimates; 1992 weights for troll and handline fisheries are not available.

Figure III-7. Hawaii commercial yellowfin and bigeye tuna landings; longline,troll and handline combined, 1970-1992.

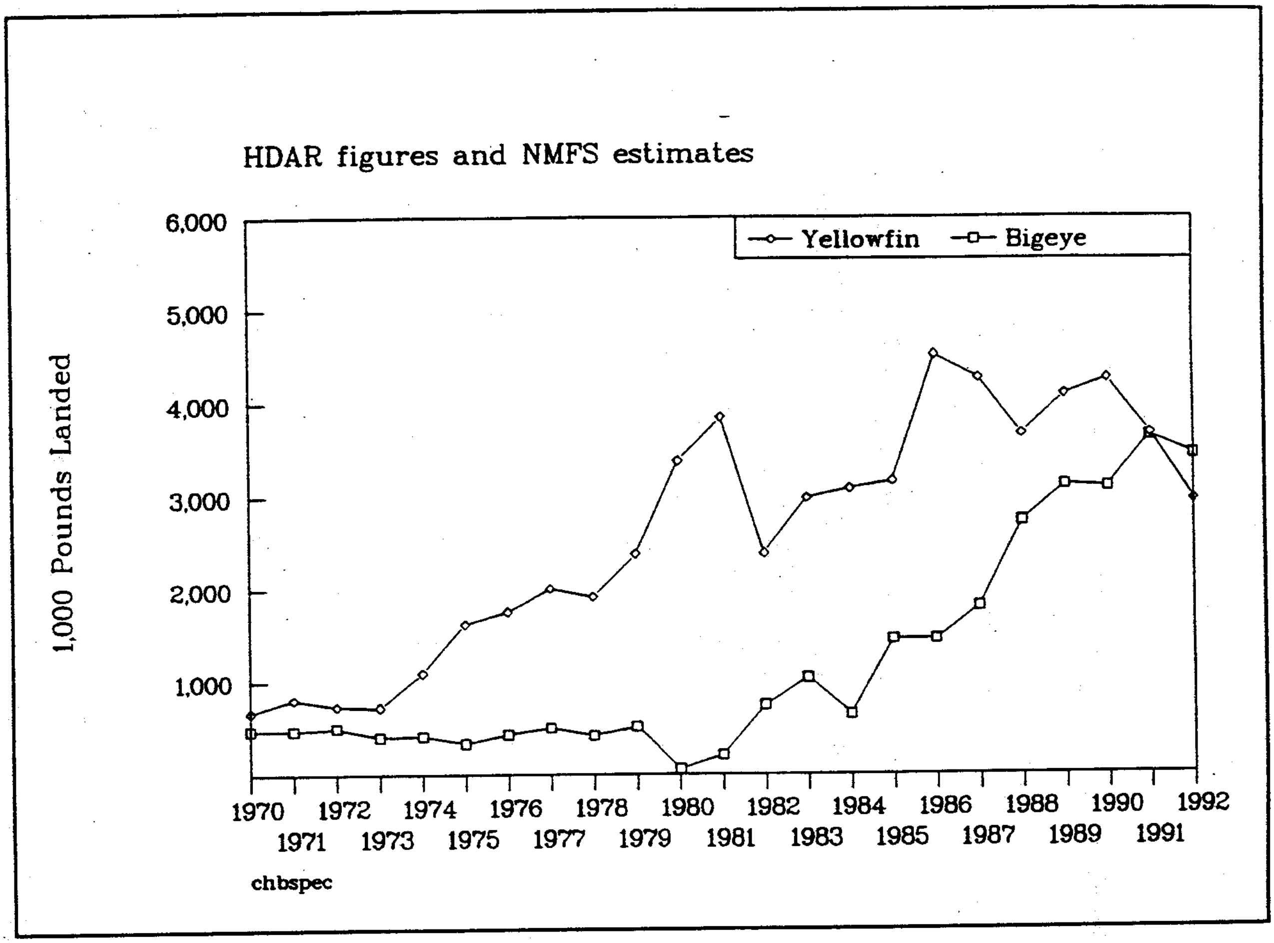
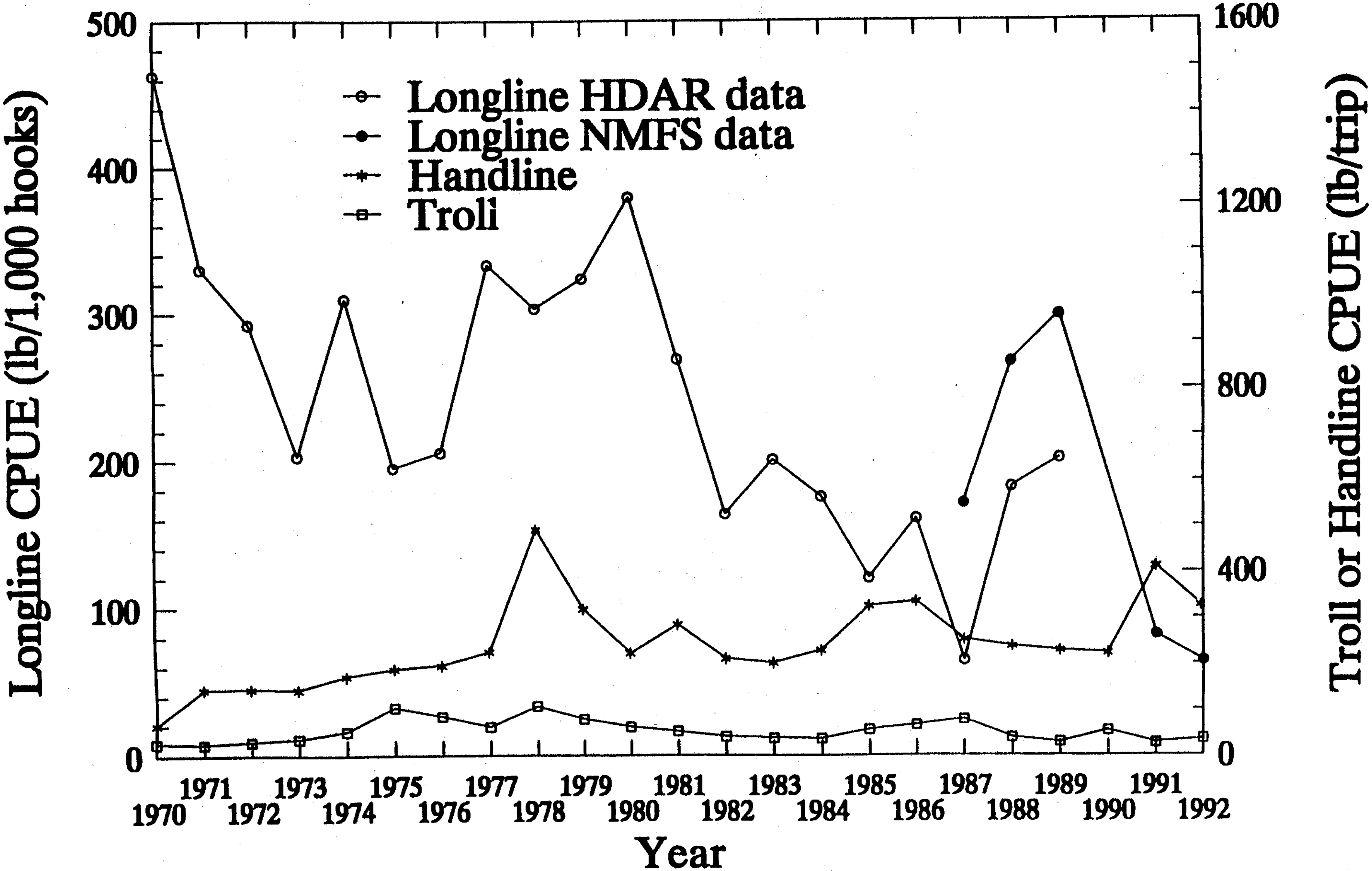


Figure III-8. Hawaii yellowfin tuna CPUE, by gear type. 1970-1992.



associated with an increase in fishing pressure (estimated as total catch rather than effort) on yellowfin (Fig.III-7). Yellowfin tuna appear to be more abundant near the islands than in the surrounding ocean (Murphy and Shomura 1972).

A previous decline in longline CPUE occurred in the early- to mid-1980s and may have reflected a change to deeper gear configuration, reducing the efficiency of the gear for yellowfin tuna. The decline was also associated with the increase in total landings of yellowfin during this period, suggesting catch competition. However, if the local abundance of yellowfin tuna decreased from 1980-1987 due to fishing pressure, one would expect to see that decline in CPUE indices for other gear types, but that was not the case (Fig. III-8). Troll CPUE peaked in 1975, 1978 and 1987, while handline CPUE peaked in 1978 and 1985-86. The declines in troll and handline CPUE in the late 1980s occurred while fishing pressure (total catch) was relatively stable. Variation in troll CPUE appears to be related to the abundance or catchability of surface-caught yellowfin tuna over a wider geographic scale perhaps in relation to such environmental anomalies as "El Niño" (Sukuzi, in press a; Boggs, in press).

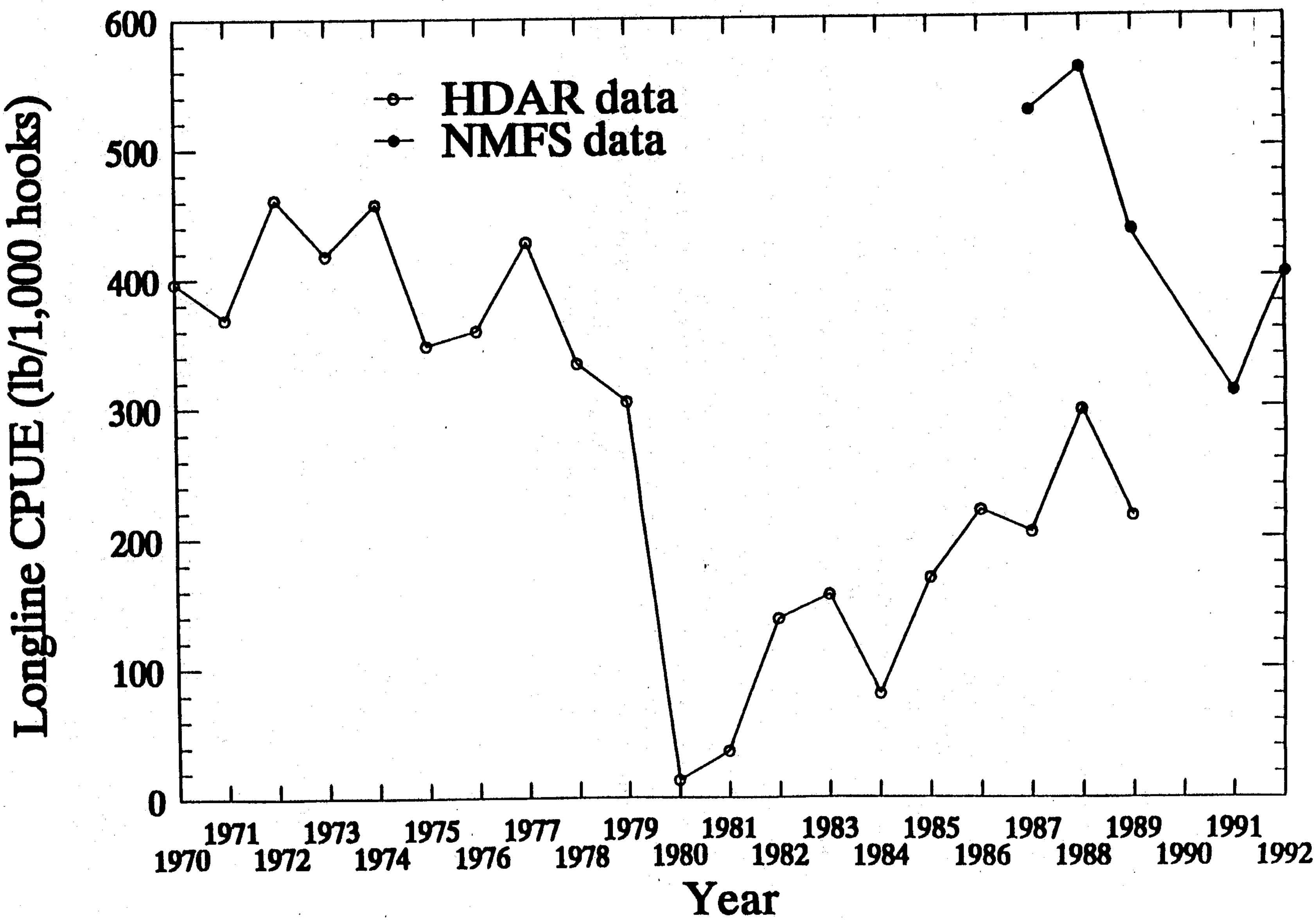
The increase in longline CPUE in the late-1980s, despite continued high levels of fishing pressure (total catch), may have reflected a reverse trend towards more shallow gear configuration. Many new entrants to the fishery in 1989-91 did not invest in the equipment required to set monofilament longline gear deep to target bigeye tuna. This equipment was not as important in the US east coast yellowfin and swordfish longline fisheries from which the new entrants had arrived. Many new entrants fished shallow even when targeting tuna (daytime fishing), which contributed to the increases in CPUE for all species associated with the upper layer of the ocean (i.e., yellowfin tuna, marlins, mahimahi, etc.)

Bigeye tuna

The total bigeye tuna catch (Fig. III-7, virtually the same as the longline bigeye tuna catch) and longline CPUE for bigeye tuna (Fig. III-9) appeared relatively stable in the 1970s, dropped precipitously in 1980 to almost zero, and increased again in the mid-1980s through 1991, and declined slightly in 1992 (Fig. III-7). Longline CPUE peaked in 1988, declined moderately in 1989-91, and increased slightly in 1992 (Fig.III-9).

The 1980-81 decline is hard to believe (Fig.III-9), and may reflect some error in the data. Bigeye tuna CPUE for the entire Pacific (Miyabe 1993) also reached a minimum in 1981, but the Pacific-wide drop was relatively small compared with the Hawaii drop. Generally, there was similarity between Pacific-wide CPUE data and Hawaii CPUE data through 1985, suggesting that local pelagic fish availability is linked to the abundance or catchability of a widespread population, although Pacific-wide CPUE declined to record low levels after 1985, whereas Hawaii CPUE remained relatively stable.

Figure III-9. Hawaii longline bigeye tuna CPUE, 1970-1992.



The increase in Hawaii CPUE in the 1980s (Fig. III-9) is probably a result of increased fishing depth to target bigeye tuna (Boggs 1992). The Pacific-wide data were corrected to account for changes in fishing depth (Miyabe 1993), and show less of an increase during the same period. It is possible that the decline in average 1989-92 CPUE, compared with 1987-88 NMFS data, is a result of continued increases in fishing pressure (total catch), but the evidence is weak considering the background variability in CPUE (Fig. III-9).

Blue marlin

The total blue marlin catch (by all gears) increased from 1975-78, remained relatively the same (0.4-0.6 million lb) through 1986, and then tripled to 1.5 million lb by 1989. The catch remains at this higher level (Fig. III-10).

Longline CPUE for blue marlin in the Hawaii longline fishery showed peaks and dips that correspond closely to those seen in Hawaii troll CPUE (Fig. III-11). The similarity of pattern suggests that both CPUE time-series reflected true changes in local abundance or catchability, despite the limitations of the available statistics (Boggs 1991, Boggs and Ito, in press). Both suggest declines in CPUE in the early- to mid-1980s (like yellowfin) when fishing pressure (total catch) was stable. The longline decline was greater than the troll decline, which would fit with the explanation of a trend towards setting deeper longline gear during this period because yellowfin tuna are caught at shallower depths. Similarly, the greater increase in longline CPUE from 1987-1989 would fit with the explanation of a new, shallow-fishing component of the longline fleet (see yellowfin tuna, above). There is no evidence of declining troll CPUE (Fig. III-11) associated with increased fishing pressure (total catch by all gears) from 1986-89 (Fig. III-10).

Blue marlin CPUE in the Hawaii fishery followed the same declining trend in the 1960s and 1970s as Pacific-wide blue marlin CPUE (Wetherall and Yong 1983, Skillman and Kamer 1992, Boggs and Ito, in press), suggesting that CPUE in Hawaii is related to the abundance or catchability of the stock over a wide-scale area.

Striped marlin

The striped marlin catch (by all gears) remained below 0.4 million lb/year until 1987, increased to about 1.3 million lb in 1988, and fluctuated between 1.0-1.5 million lb thereafter (Fig. III-10). CPUE showed a pattern of decline in the early- to mid-1980s, and an increase in the late 1980s (Fig. III-12). These trends were qualitatively similar to those seen for the other surface-oriented species, again suggesting changes in longline catch by all gears for surface-oriented species due to fishing at greater depths (Boggs 1992). CPUE declined from 1988-1991 although the decline did not correspond with an increase in fishing pressure (total catch by all gears). Again, over the long term, there has been a correspondence in trends between Hawaii CPUE and North Pacific longline CPUE (Skillman and Kamer 1992, Boggs and Ito 1993).

Figure III-10. Commercial landings of blue marlin, striped marlin, mahimahi and wahoo (ono), 1970-1992. Longline, troll and handline combined.

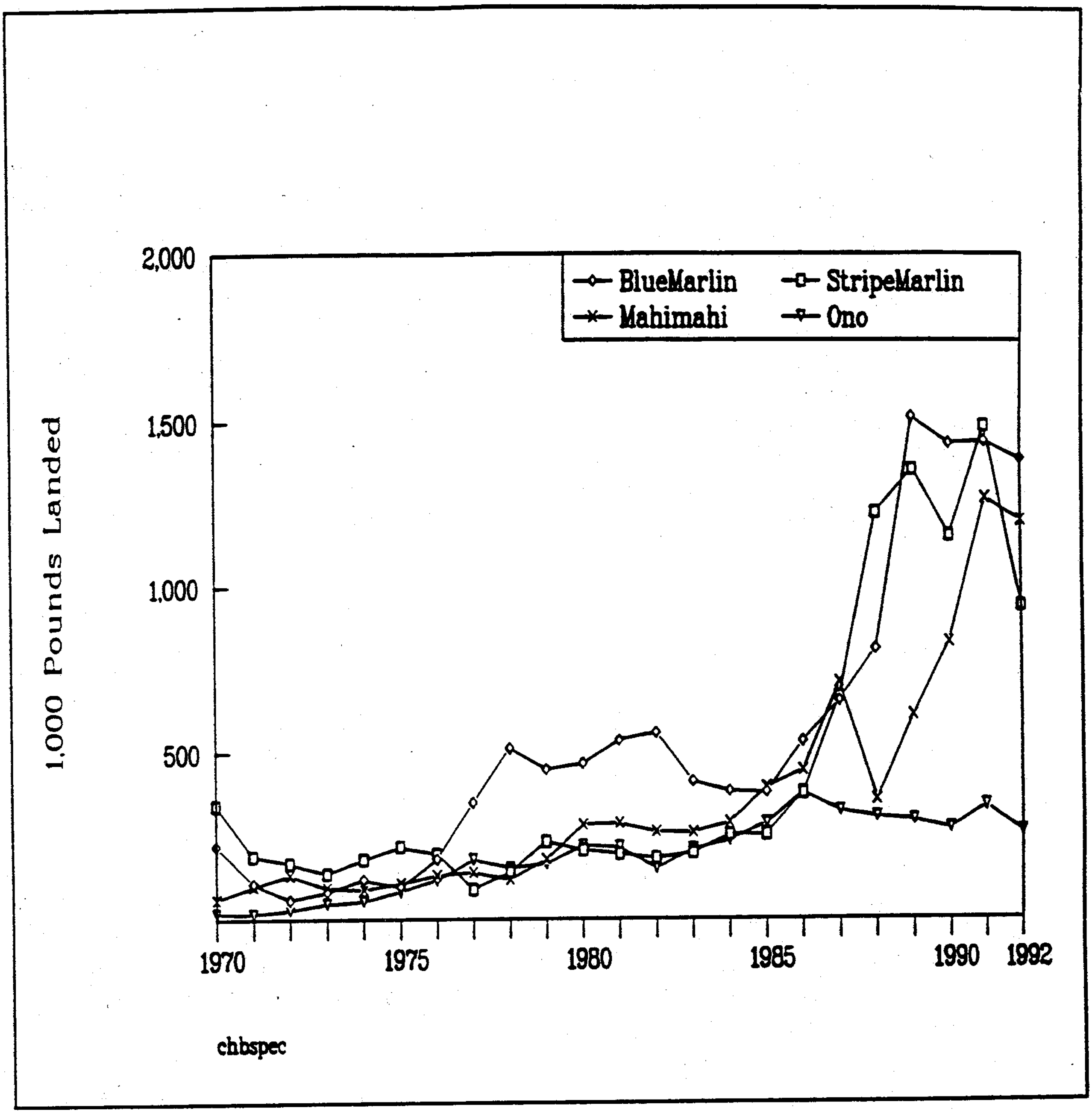


Figure III-11. Hawaii blue marlin CPUE, by gear type 1970-1992.

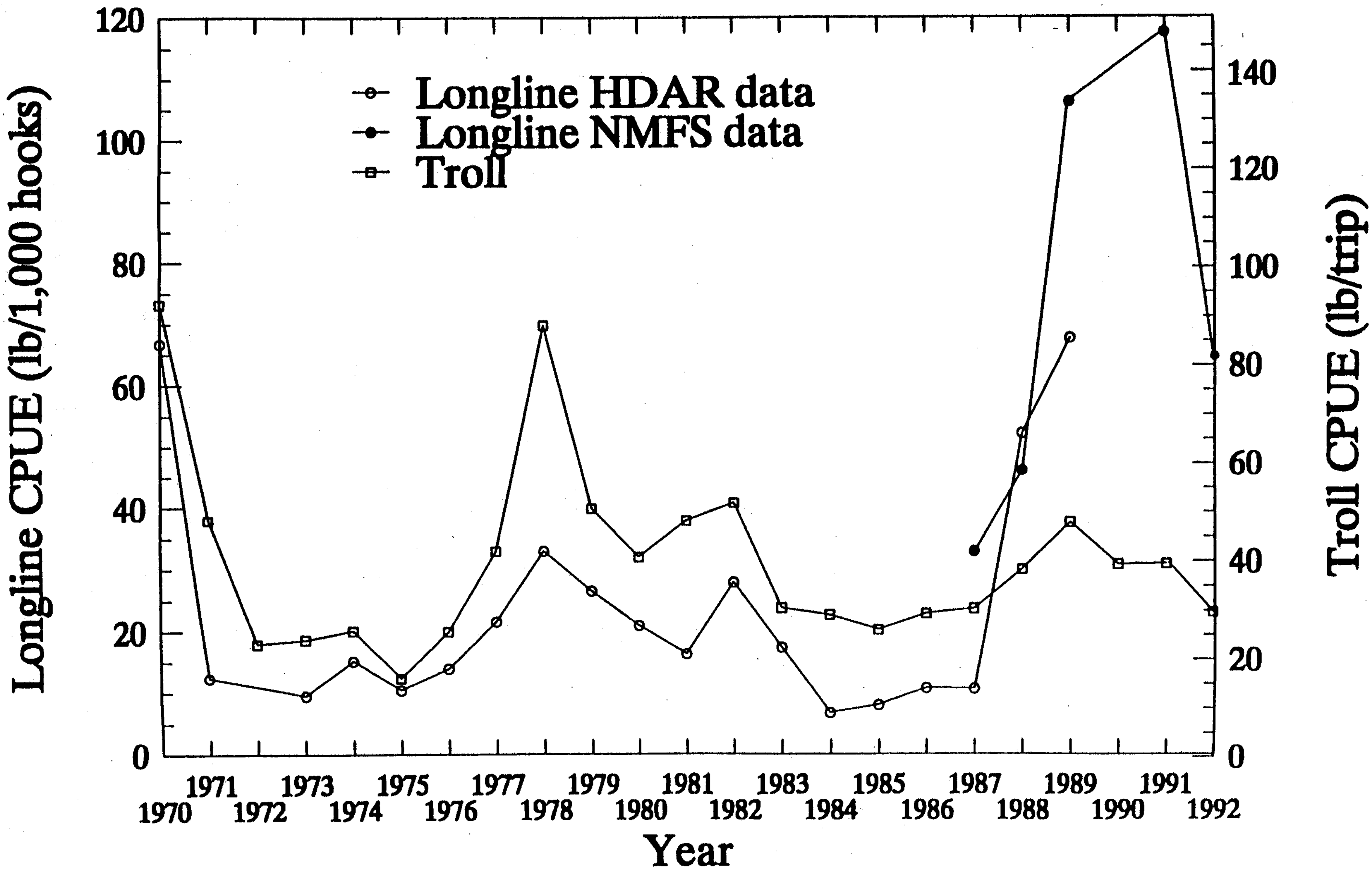
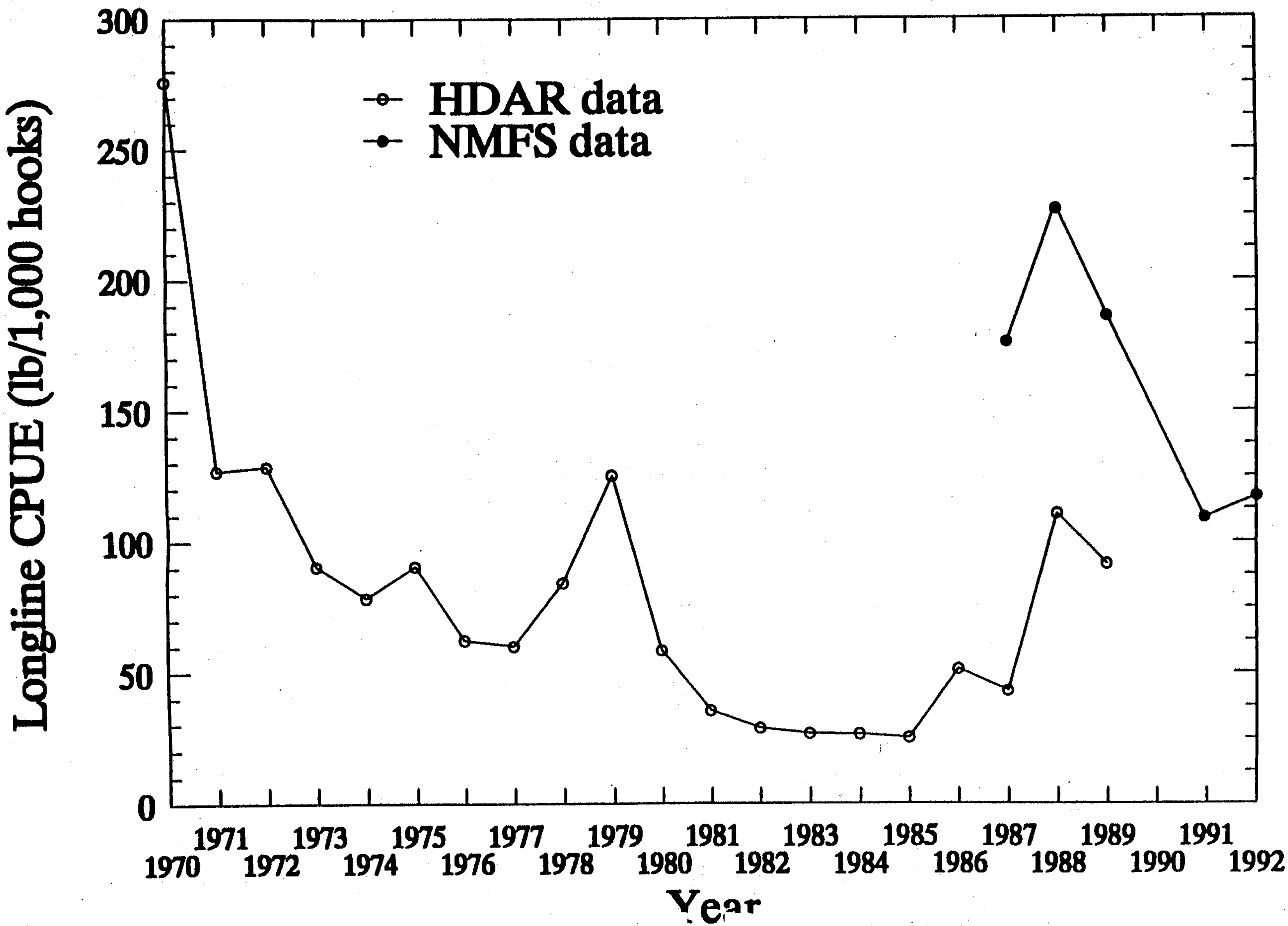


Figure III-12. Hawaii longline striped marlin CPUE, 1970-1992.



Mahimahi (Dolphin fish)

Mahimahi CPUE in the Hawaii longline fishery reached a peak in 1972, dropped in 1988, and then rose from 1989-92. This pattern was mirrored in the Hawaii troll and handline CPUE data (Fig. III-13). Troll and handline CPUE data corresponded with each other even more closely. The increase in CPUE by all three gear types since 1988, during the greatest increase in fishing pressure (total catch) on record (Fig. III-10) indicates no evidence of catch competition.

Summary

Patterns in CPUE of Hawaii's pelagic fisheries over the last two decades (1970-92) were variable, showing little net change associated with increases in local fishing pressure (estimated as total catch). This observation must be tempered by the acknowledgement that the available statistical basis for estimates of CPUE and total catch is weak[11]. For many species CPUE declined dramatically during the 1950s and 1960s following the pattern of declining CPUE seen in much larger foreign fisheries on the same stocks (Skillman and Kamer 1992; Boggs and Ito 1993). This correspondence suggests a close relationship between the availability of fish to Hawaii fishermen and the more widespread abundance of the stock. The pre-1970s decline in CPUE was typical for stocks moving from unexploited status to fully exploited status.

III.C.2. Processors.

Landings from the Hawaii-based pelagic fishery are primarily a fresh product (as discussed in Section III-D below). In addition to fresh fish retailers and wholesalers (as many as 100 dealers buy direct from the commercial fleet), approximately five businesses act as brokers for the export of longline-caught fish to the mainland US, Europe, and Japan. No estimates are available on the volume of their business.

Some pelagic landings are also processed locally into dried fish products and fish cake. Five to ten businesses are thought to be in this segment of the industry, but no estimates are available on their volume.

III.D Description of Markets and Products.

The Hawaii-based commercial pelagic fishery sells primarily to a fresh product market. Figure III-14 illustrates the major market channels for Hawaii's pelagic fish marketing. Although there was substantial research conducted on the Hawaii market in the early

[11] See footnotes 9 and 13, Boggs (1991, in press) and Boggs and Ito (in press) for a discussion of the inadequacies of the data.

Figure III-13. Hawaii mahimahi CPUE, by gear type, 1970-1992.

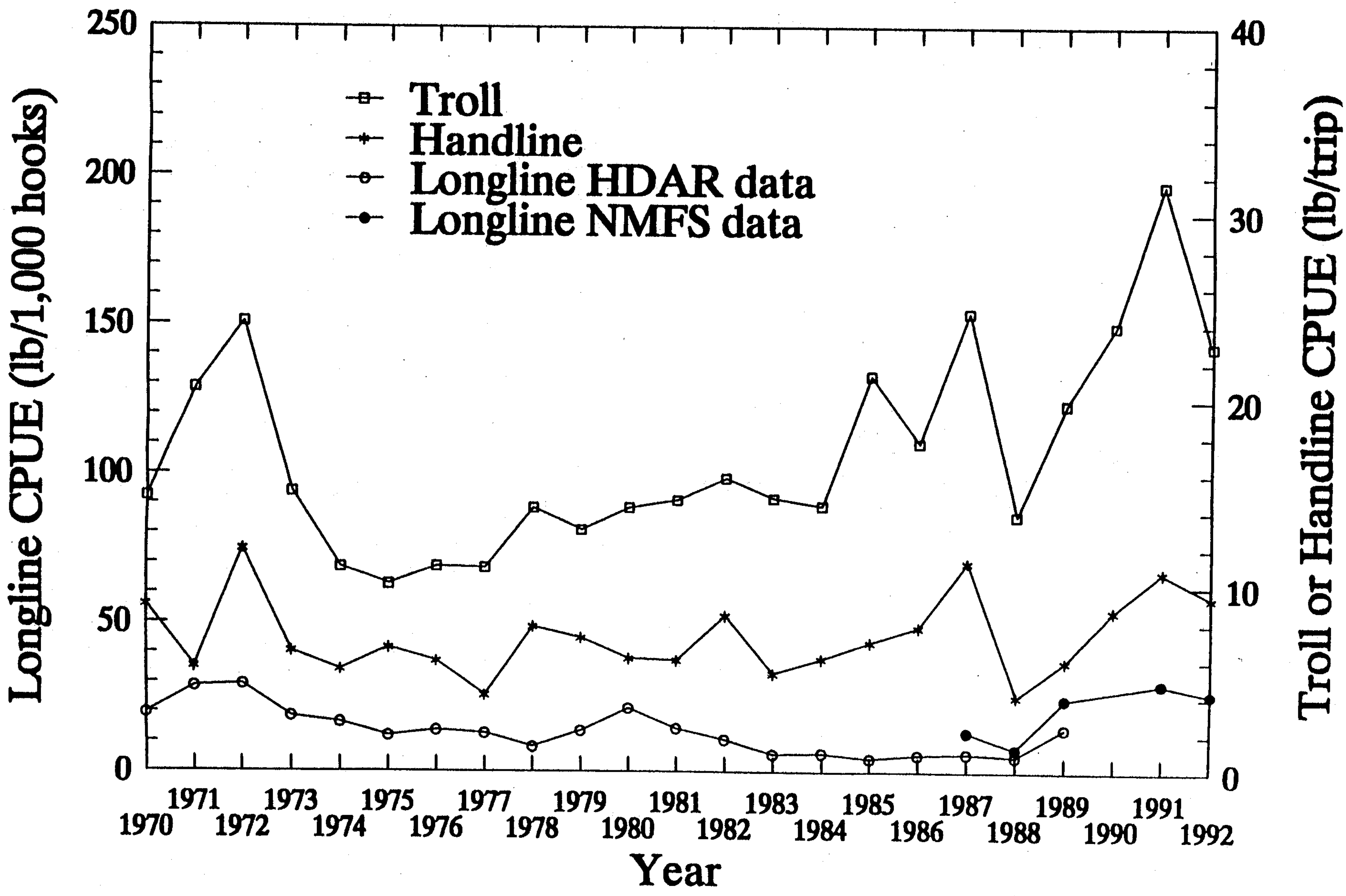
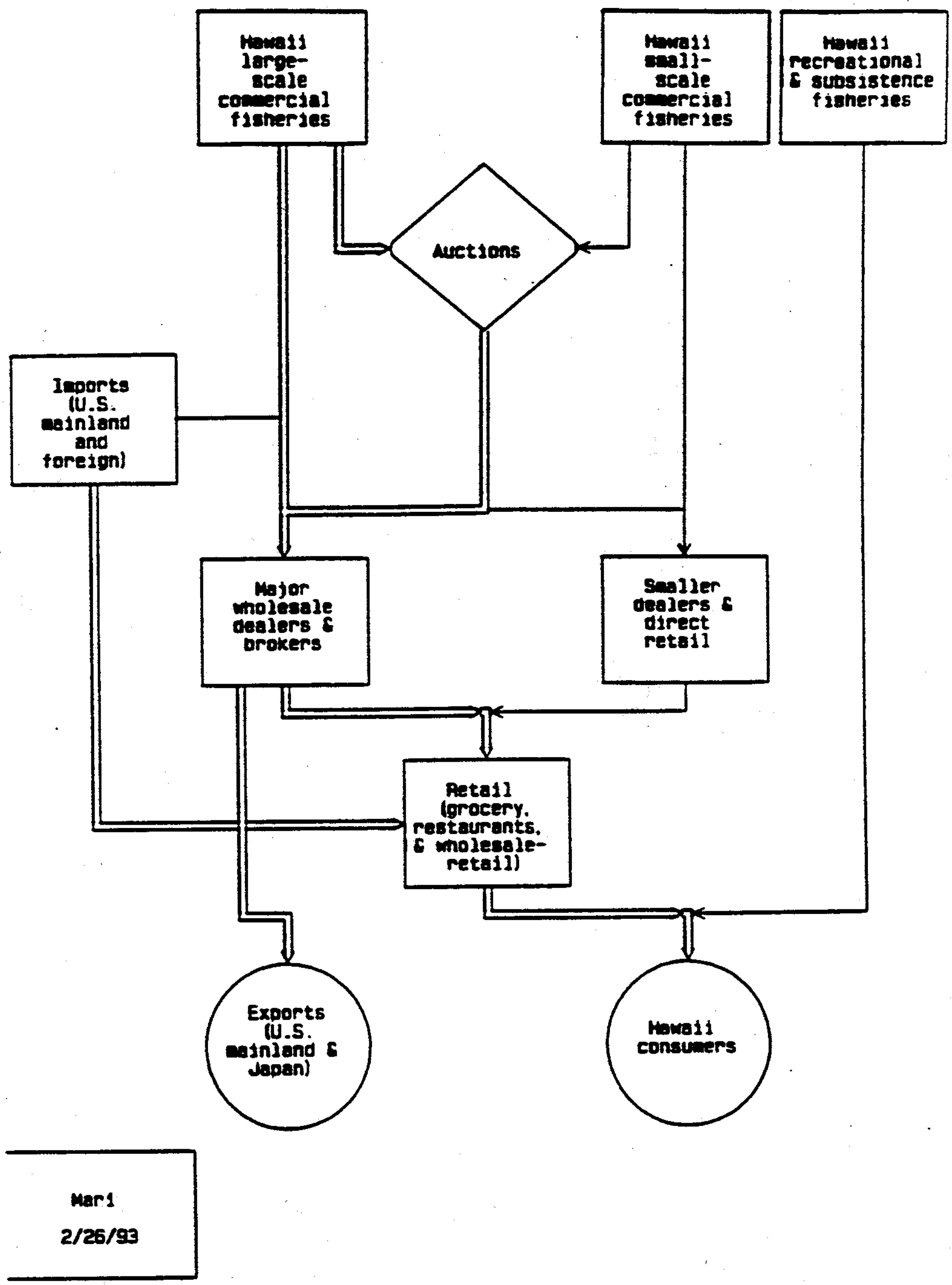


Figure III-14.- Hawaii Seafood Market Channels.



to mid-1980s (Cooper and Pooley 1983, Higuchi and Pooley 1985a, and Pooley 1986), little market research has been conducted in the past five years. Therefore, it is impossible to produce accurate estimates of volume through particular market channels.

Ito (1992) provides the most recent detailed estimates of the overall volume of Hawaii's commercial pelagic fishery. The following information uses that provided by Ito (1992) as well as a summary of longline logbook information for 1991 (Dollar 1992), and unpublished preliminary estimates of 1992 market volume prepared by the Fishery Monitoring & Economics Program of the NMFS Honolulu Laboratory. Pooley (1993b) provides an overview of recent trends in Hawaii's commercial fisheries, including markets.

Table III-12 provides estimates of 1992 pelagic species landings and revenue in comparison to 1991 landings and revenue (not adjusted for inflation)[12], and Table III-13 and III-14 provide an overview of the Hawaii market in general for 1991 (all species). Tables III-8 and III-9 give longline and non-longline landings and revenue (by species) for 1991 and estimates for 1992, while Table III-15 gives total landings (all species) by gear type. Figures III-2 through III-4 provide estimates of recent trends in Hawaii pelagic landings by the major gear types. The following is a brief qualitative description of the pelagic commercial fishery market channels:

Longline landings can be divided into three main components:

- swordfish
- general tuna and other pelagics
- high-quality bigeye tuna

Almost all swordfish are gilled and gutted prior to landing in Hawaii and transhipped by wholesalers and brokers to the east coast of the USA where it competes with Atlantic and Pacific swordfish from both domestic and foreign sources. Local landings of swordfish in 1992 were approximately 12.6 million lb ($24.2 million), up 28% in weight from 1991. In 1991 Hawaii landings (9.9 million lb) represented 56% of total reported US swordfish landings (18.0 million lb)[13] (Dept.of Commerce, 1992).

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[12] 1992 landings and revenue figures in this amendment were prepared by the NMFS Honolulu Laboratory, Fishery Monitoring & Economics Program. The figures are preliminary estimates based on year-to-date information. Longline logbook data are approximately 97% complete; Hawaii Division of Aquatic Resources (HDAR) troll and handline data are approximately 84% complete (i.e, 84% of the expected data for the year have been received. The extent to which these data accurately cover the full volume of catch is unknown.).

[13] Fisheries of the United States, 1991. Current Fishery Statistics No. 9100. US Department of Commerce, 1992.

Table III-12. Hawaii pelagic landings (1000 lb) and revenue ($1000), 1991 and 1992 (preliminary). NMFS logbook summary and HDAR commercial landings data.

Species	Landings (1,000 lb)		Revenue ($1,000)	
	1991	1992	1991	1992
Swordfish	9,914	12,643	$ 22,029	$ 24,279
Blue Marlin	1,469	1,305	1,024	1,311
Striped Marlin	1,490	1,145	1,481	1,448
Other Billfish	454	317	343	340
Mahimahi	1,281	1,199	2,087	1,969
Ono (wahoo)	483	380	1,061	965
Sharks	222	574	104	354
Bigeye tuna	3,678	3,463	12,799	12,190
Yellowfin tuna	3,713	2,989	8,103	6,223
Albacore	859	896	1,043	1,081
Other tuna	2,833	2,179	3,529	3,447
Other pelagics	508	380	711	613
TOTAL	26,904	26,390	$ 54,314	$ 54,220
(minus swordfish)	-9,914	-12,643	-22,029	-24,279
TOTAL (except swordfish	16,990	13,747	$ 32,285	$ 29,941

Table III-13. Hawaii seafood supply and market, 1991 Wholesale Purchase Level Preliminary NMFS estimates[1]

	All Species	
Source of Supply	Pounds 1,000s	Revenue $1,000s
Commercial Fishing[2]	29,400	$61,200
Recreational Fishing[3]	10,200	
= Hawaii Fishery	39,600	61,200
+ Foreign Imports[4]	17,000	38,100
+ US Mainland "imports"[5]	26,500	59,400
- Export (foreign and U.S. Mainland)[6]	11,200	23,300
= Hawaii Consumption (inc. recreational)[7]	71,900	
= Hawaii Market (commercial only)[8]	61,700	135,400

1 Honolulu Laboratory, National Marine Fisheries Service Fishery Monitoring & Economics Program

2 Hawaii Commercial fishing: domestic landings estimated by detailed NMFS logbooks and shoreside sampling, augmented by available State of Hawaii data for non-sampled fisheries

3 Recreational: volume estimated in 1981 by NMFS Marine Recreational Fishing Statistical Survey

4 Foreign imports: volume (pounds) recorded by US Food & Drug Administration monitoring; revenue estimated by Honolulu market price by NMFS (not adjusted for product form).

5 US mainland "imports": volume and revenue estimated as proportion of Foreign imports using raising factors calculated from 1981 NMFS seafood market survey in Hawaii.

6 Exports: estimated form domestic landings of lobster, bottomfish, swordfish, bigeye and yellowfin tuna.

7 Hawaii consumption: Hawaii fishery + Imports - Exports

8 Hawaii market: Hawaii consumption - Recreational

Table III-14. Hawaii commercial fisheries, 1991 NMFS estimates based on logbooks and shoreside monitoring

Fleet	Pounds Landed (1000s)	Revenue ($1000s)
Longline	19,500	$43,750
Troll-Hand Pelagics	5,030	7,785
Aku Boat (HDAR)	2,240	2,790
MHI[1] Bottomfish	715	2,320
NWHI[2] Bottomfish	390	1,040
NWHI Lobster	185	1,025
Other (Gas)[3]	1,310	$2,465
TOTAL	29,370	$61,175

1 MHI = Main Hawaiian Islands

2 NWHI = Norhtwestern Hawaiian Islands

3 Information on other non-specified fisheries derived from NMFS compilation program (Gas), applied to HDAR data.

Table III-15. Commercial landings of pelagic species, revenues, and average prices. NMFS and HDAR data.

Year	Fishery	Pounds	Lb Sold	Revenue	Price
1991	Aku Boat	2,232,330	2,226,434	$2,815,872	$1.26
	Handline	1,862,890	1,811,287	3,139,119	1.73
	Trolling	3,203,074	2,728,239	4,656,671	1.71
	Longline	19,600,000	19,600,000	43,700,000	2.23
	Other	6,237	2,240	3,502	1.56
	TOTAL	26,904,531	26,368,200	$54,314,164	$2.06
	Excluding longline	7,304,531	6,768,200	10,614,164	1.57
	Troll & Handline	5,065,964	4,439,526	7,795,790	1.72
1992	Aku Boat	1,734,958	1,725,387	2,415,408	1.40
	Handline	1,939,085	1,897,077	3,229,033	1.70
	Trolling	2,472,975	2,092,934	3,920,218	1.87
	Longline	21,240,000	21,240,000	44,650,000	2.10
	Other	4,100	2,298	4,727	2.06
	TOTAL	27,391,129	26,957,696	$54,219,386	$2.01
	Excluding longline	6,151,129	5,717,696	9,569,386	1.67
	Troll & Handline	4,412,060	3,990,011	7,149.251	1.79

Most tuna (yellowfin, some bigeye, and skipjack) and other pelagics (mahimahi, wahoo [*ono*], moonfish [*opah*], and sharks) are landed whole in Hawaii and marketed by local (Hawaii) wholesalers. The local restaurant market is the primary destination for higher-priced tuna and other pelagics. The Honolulu seafood market is comprised of a wide range of firms, from those specializing in *sashimi*-quality tuna to those emphasizing fillets or steaks for grilling. A very small proportion of the swordfish landed enters the local market. The total volume of pelagic species, including the longline catch except for swordfish, was approximately 13.7 million pounds in 1992 ($27.7 million), down 20% in weight from 1991.

The gear composition of landings is important in determining marketability. Longline tuna is generally considered to be the highest value, while troll mahimahi is considered high value. In 1991, longline prices exceeded those obtained by troll and handline vessels (combined average) for bigeye and yellowfin tuna, the primary target species, while troll and handline operators got slightly better prices for mahimahi and wahoo.

The extent to which there is market competition between the two fisheries is debatable. On the one hand, the two fisheries land similar products so it seems that there are particular market segments which relate to species caught by each gear. Pooley (1990 and 1991a) undertook a brief examination of market interactions, but determined that the evidence concerning the relationship of longline to troll/handline sales was inconclusive due to limited information on exports.

Longline vessels are able to ice their catch more thoroughly, thus preserving product quality in a warm climate. Furthermore, longline vessels do not experience the phenomenon called *Burnt Tuna Syndrome (BTS)* which affects yellowfin tuna caught by troll and handline methods. *BTS* reduces the sightliness, texture and taste of the yellowfin tuna's flesh making it unsuitable for sashimi (raw fish), the highest priced use. Thus, longline-caught tuna tends to be exported (more often than troll or handline tuna) to Japan's sashimi market and sold to better white table cloth restaurants in Hawaii and on the US Mainland. On the other hand, troll and handline boats take shorter trips, making it possible for them to land a fresher product when BTS has not been a problem. This seems to pay off for their landings of mahimahi and wahoo, which are frequently destined for better restaurants. But, most of their tuna landings are believed sold for the lower-value grill market, due to the lower quality of the tuna relative to longline tuna. Table III-16 gives ex-vessel revenue by species and gear type for 1991 (Ito 1992).

Information on exports of tuna and other pelagics was unavailable until recently. The NMFS Honolulu Laboratory used a factor of 10% of longline bigeye landings and 10% of troll/handline yellowfin landings to provide a rough estimate of order-of-magnitude volume of Hawaii "exports" (not differentiating foreign exports from shipments to the mainland USA). However, these figures were based on information obtained in the early to mid-1980s, after which conditions in Hawaii's pelagic fisheries and pelagic

Table III-16. Hawaii's pelagic ex-vessel revenue (x $1,000) by gear type, 1987-91. Estimates are based on the wholesale marketing monitoring program of the National Marine Fisheries Service and Hawaii Division of Aquatic Resources.

Year	Swordfish	Blue Marlin	Striped marlin	Other billfish	mahi-mahi	Ono	Sharks	Bigeye tuna	Yellowfin tuna	Albacore	Skipjack tuna	Other pelagics
						Longline						
1987	200	100	800	200	100	200	100	6,500	1,500	500	<50	300
1988	200	200	1,200	300	100	200	100	9,200	3,300	900	<50	300
1989	1,100	600	1,400	300	400	400	100	10,600	5,100	700	<50	400
1990	9,700	700	1,500	200	600	200	100	10,900	5,800	600	<50	600
1991	22,000	500	1,400	300	700	200	100	12,500	4,300	900	100	700
						Troll and Handline						
1987	<50	800	100	100	2,100	600	<50	200	4,300	<50	200	<50
1988	100	600	200	100	1,300	600	<50	600	3,200	<50	200	<50
1989	100	800	200	100	1,900	500	<50	1,000	1,500	<50	300	<50
1990	<50	500	100	<50	2,300	500	<50	1,200	1,900	<50	200	<50
1991	<50	600	200	<50	2,800	700	<50	1,000	2,000	100	400	0
						Other Gear Types						
1987	<50	<50	<50	<50	<50	300	<50	<50	400	0	4,300	<50
1988	<50	<50	<50	<50	<50	300	<50	<50	600	<50	4,400	<50
1989	0	<50	<50	<50	<50	100	0	0	<50	0	4,300	<50
1990	0	<50	<50	<50	<50	<50	<50	<50	100	0	1,800	<50
1991	0	<50	<50	0	<50	<50	<50	<50	100	0	2,700	<50

Source: Ito (1992)

markets changed substantially. Recently US Customs data on exports were obtained by the NMFS Southwest Region which indicated that foreign exports of tuna from Hawaii were 1 million lb ($4.5 million) in 1991 (P. Donley, NMFS Southwest Region, Long Beach, pers. comm.).[14] Japan was the primary destination for these exports. Exports of other pelagic species were not noted in the export data but do occur. Table III-17 summarizes NMFS Southwest Region information on Hawaii pelagic exports. These figures are substantially higher than previously estimated by the Honolulu Laboratory, and may represent an important market breakthrough for the Hawaii pelagic fishery. While information on "exports" to the mainland US are not available, knowledgeable industry sources indicate that the volume is at least as large as for foreign exports, indicating that at least 33% and perhaps as much as 50% of longline tuna landings leave Hawaii. Handline tuna exports (foreign and US mainland) are believed to have declined to almost zero in the early 1990s, but an export market may still exist. Exports, at least to the US mainland, of other pelagics, primarily mahimahi, are also believed to be important.

Tuna and other pelagics are also imported into Hawaii, some directly through the Honolulu Customs District, and some indirectly through other US ports of entry. Table III-18 identifies the primary sources of supply and their volume, as recorded by the NMFS Market News Service from US Food & Drug Administration monitoring at the Honolulu Customs District. Total pelagic imports in 1991 were 5.6 million pounds, valued at approximately $10.5 million. Of this, frozen mahimahi is the largest component (3.6 million lb). Some of the imported tuna is re-exported to the mainland USA and to foreign countries.

High-quality bigeye tuna is frequently exported directly from Hawaii to Japan's fresh fish markets. This product is landed whole and is usually exported whole, on consignment. The Japanese market for Hawaii bigeye tuna is highly dependent on two central factors: the yen-dollar exchange rate and the supply of fresh bluefin and bigeye from alternative sources (e.g., Australia).

III.E Description of Support Industries.

Little is known in detail of the industries supporting Hawaii's commercial, recreational, and subsistence fisheries. The most recent detailed study examined the volume of business generated by foreign longline fishing boats and refrigerated transshipment boats which use Hawaii as a re-supply port (Hudgins and Iversen 1990). The support industries include suppliers to fishing vessels (fuel, bait, ice, provisions, equipment, etc.), shoreside infrastructure (harbors, transportation, shipyard and marine repair,

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[14] Although the exports are identified as yellowfin tuna, knowledgeable industry sources indicate that most, if not all, is actually bigeye tuna. Much of the bluefin tuna exports may also be bigeye since bluefin is a common name for bigeye tuna in Hawaii [only 100,000 lb of 'other tuna' was caught by longliners in 1991 (Table 5) versus 177,000 lb of "bluefin" exported. Export prices are also thought to be under-reported.

Table III-17. Hawaii fresh/frozen tuna exports in 1991. (NMFS Market News) no information available on other pelagic exports.

	Pounds Exported	Estimated (US $)	
		Price/lb	Value
Total Tunas	1,028,491	$4.33	$4,458,391
Bluefin	177,992	$5.47	$973,632
Unclassified	48,501	$3.22	$156,148
Yellowfin	801,998	$4.15	$3,328,611

Source: NMFS Market News

Table III-18. Hawaii fresh/frozen seafood imports, 1991.

	Pounds		
	Round	Fillet	Total
Pelagics	315,065	3,638,956	3,954,021
Billfish	9,557		9,557
Swordfish	425		425
Mahimahi	157,531	3,638,956	3,796,487
Wahoo	134,779		134,779
Other	12,773		12,773
Tunas	1,323,401	328,769	1,652,170
Albacore	129,124	2,132	131,256
Bigeye	361,653	2,500	364,153
Bluefin	646		646
Bonito	6,006		6,006
Skipjack	230,698	109,943	340,641
Yellowfin	595,274	214,194	809,468

Source: NMFS Southwest Region Market News etc.), managerial services (insurance, administration, financing), market services (auctions, brokers, wholesalers, cold storage, processing, etc.), labor (fishing vessel captains and crews, market personnel, electronics and hydraulic technicians), and government services (fisheries research, monitoring and management, dockside security, etc.). For the recreational and charter fishing components of the pelagic fisheries, additional support is required, including fishing tackle and supplies, marketing to clients, arrangements with hotels, tournament administration, etc.

For this amendment, estimates of direct income to the support industries are based on a limited sample of cost-earnings information from commercial pelagic fishing vessels. Value-added components at the support industry level have not been calculated. Thus direct income roughly equates to ex-vessel or wholesale market value.

Table III-19 identifies the total industry direct income to industries which support Hawaii's commercial pelagic fishery (calculated as direct costs of each component of the commercial pelagic fleet). These figures were obtained by merging 1991 landings information (Ito 1992) with cost per pound information derived from cost-earnings samples (Pooley 1991b). Figure III-15 illustrates the breakdown of direct costs into capital, labor and other physical services. Figure III-16 indicates the direct income to support industries for the three components of Hawaii's commercial pelagic fishery. Figures III-17 and III-18 indicate the financial and operating cost components of direct support industry income created by Hawaii's commercial pelagic fishery.

The income generated by recreational fishing and by sports fishing tournaments is also poorly quantified, as is the total volume of participation in those segments of the fishery. In Hawaii, the differentiation between small-scale commercial and recreational fishing is difficult to determine. Skillman and Louie (1984) reported that 27% of small-boat owners sold at least a portion of their catch during the year, and Meyer (1987) found that 35% of small boat catches were sold on the market and 13% were sold "off" the market (i.e., not in established retail/wholesale outlets).

The only comprehensive survey of recreational fishing participation and catch was the Marine Recreational Fishing Statistical Survey (MRFSS) conducted under contract to NMFS in the western Pacific for 1979-81. The MRFSS estimated total recreational landings were 10 million pounds, of which over 50% were pelagic species.[15] There were 206,900 participants, of whom 77% were local residents and the remainder were visitors (i.e., tourists). There were 512,000 private recreational fishing trips taken, and 43,700 charter fishing boat trips taken in 1981. These were not broken down by type of fishing, but pelagic fishing (primarily trolling) probably represented a high percentage of these trips.

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[15] The survey results were not published by NMFS headquarters at the time. A brief summary of the survey and of other research on recreational fishing in Hawaii is contained in Pooley (1993a). Although the survey was designed to count only fish caught for recreational purposes (i.e., not to be sold), it is not clear that the results represent only un-sold fish.

Table III-19A. Hawaii commercial pelagic fishery: Estimated total and net revenue, costs and income in 1992 (Longline, troll-handlined and charterboat segments combined)

Pelagic Fishery Total ($1000s)		
Revenue		$71,016
Costs	Financial Sector Costs[1]	$24,213
	Fuel & Oil	8,024
	Repair Services	3,777
	Supplies	10,725
	Equipment	5,308
	Handling Service	10,653
	Other	3,835
	Labor & Mgmt	11,898
	Total Cost	$78,432
Net Revenue		$7,416

[1] Excluding annual repairs

Table III-19B. Hawaii commercial fishing support. Estimated direct income in 1992.

	Industry Cost Components ($1,000s)
Longline	
Total	$61,498
Capital	18,447
Operating	33,405
Labor & Mgmt	9,646
Troll-handline	
Total	8,123
Capital	2,309
Operating	5,073
Labor & Mgmt	714
Charterboat	
Total	9,566
Capital	3,457
Operating	4,599
Labor & Mgmt	1,511
Total	
Total	79,188
Capital	24,213
Operating	43,077
Labor & Mgmt	11,898

Figure III-15. Breakdown of direct costs into capital, labor and other physical services. Expressed in 1992 dollars.

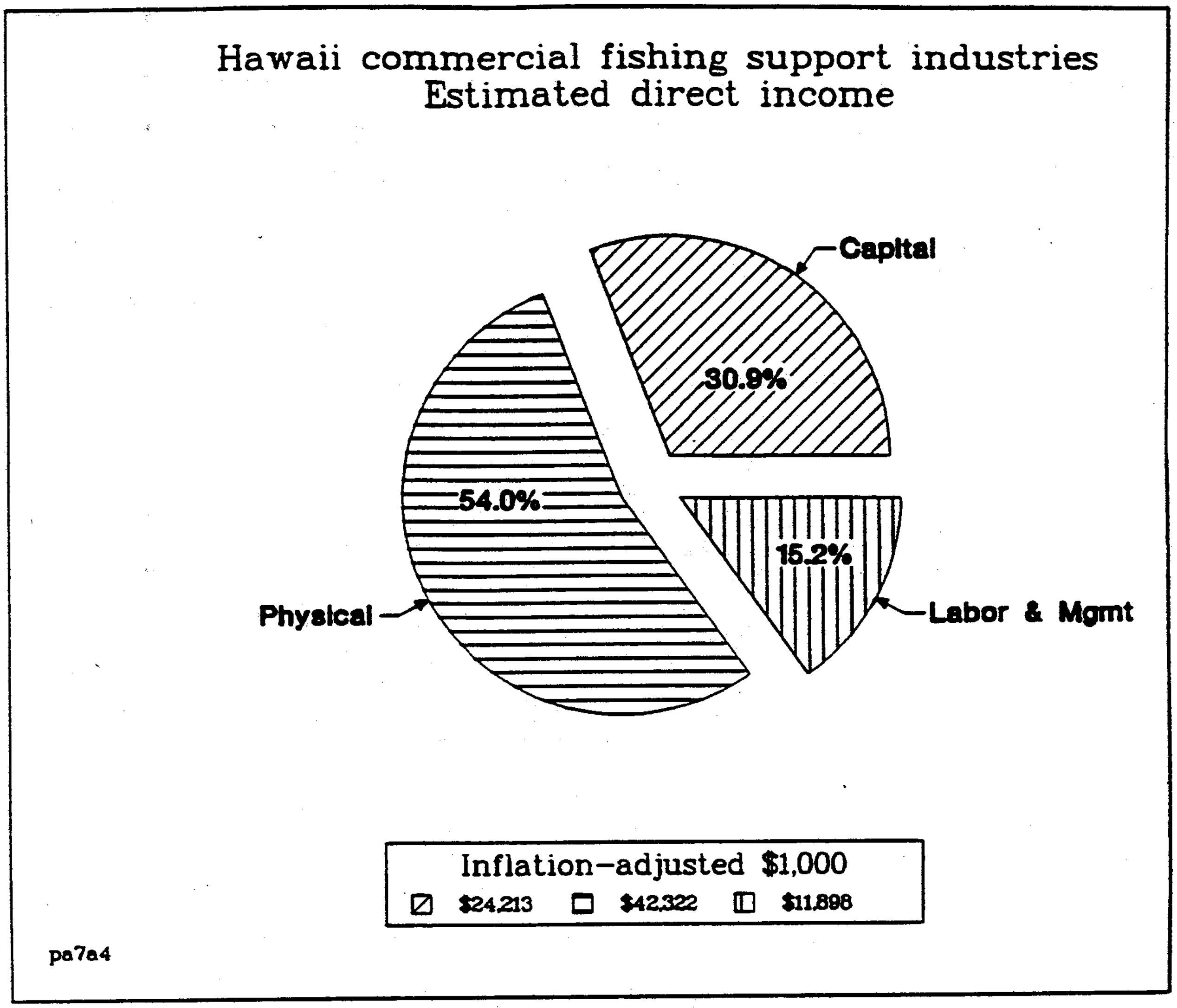


Figure III-16. Direct income to support industries derived from longline, troll-handline and charterboat commercial fisheries. (1992 dollars).

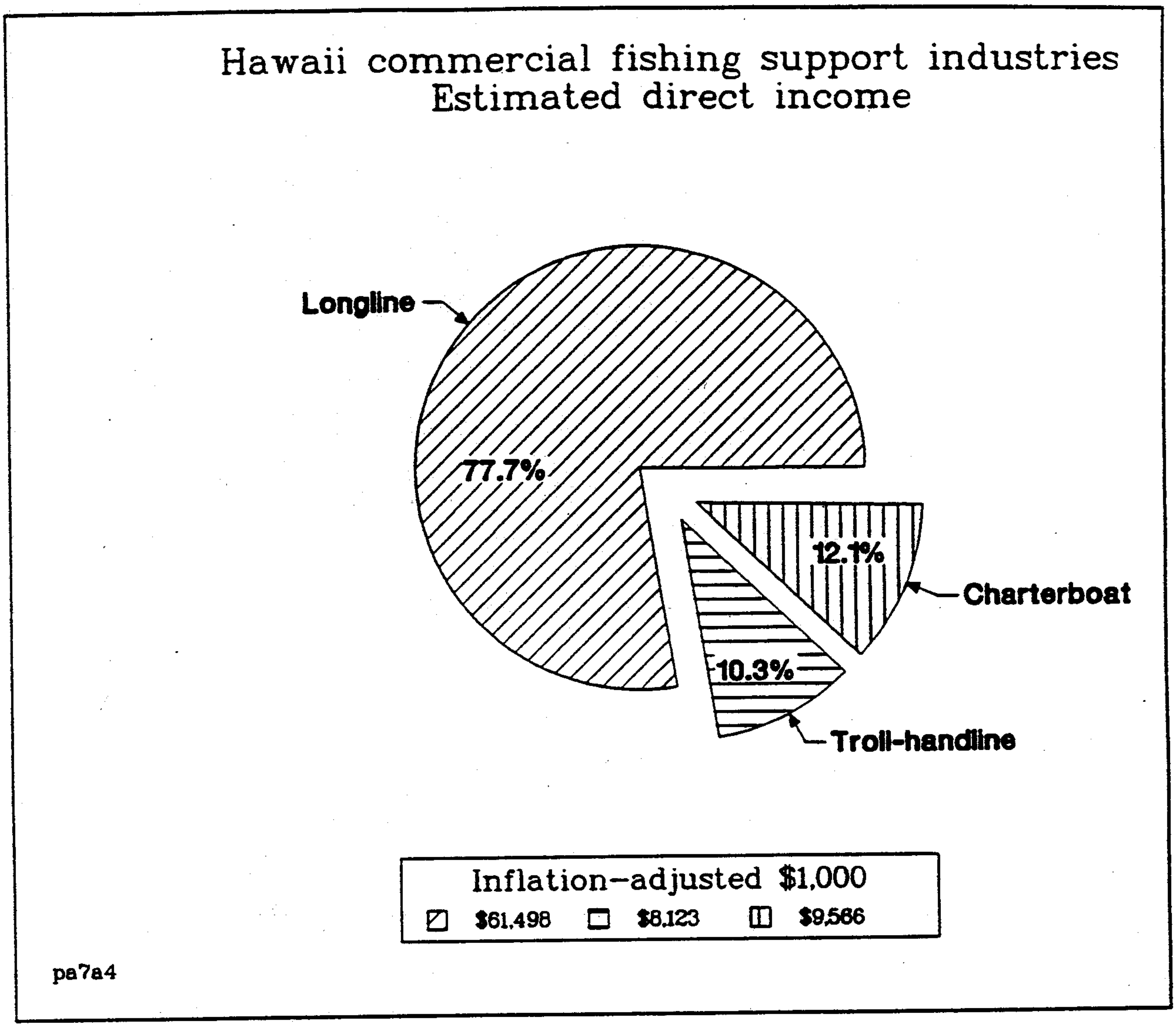


Figure III-17. Financial services components of direct support industry income created by Hawaii's commercial pelagic fishery.

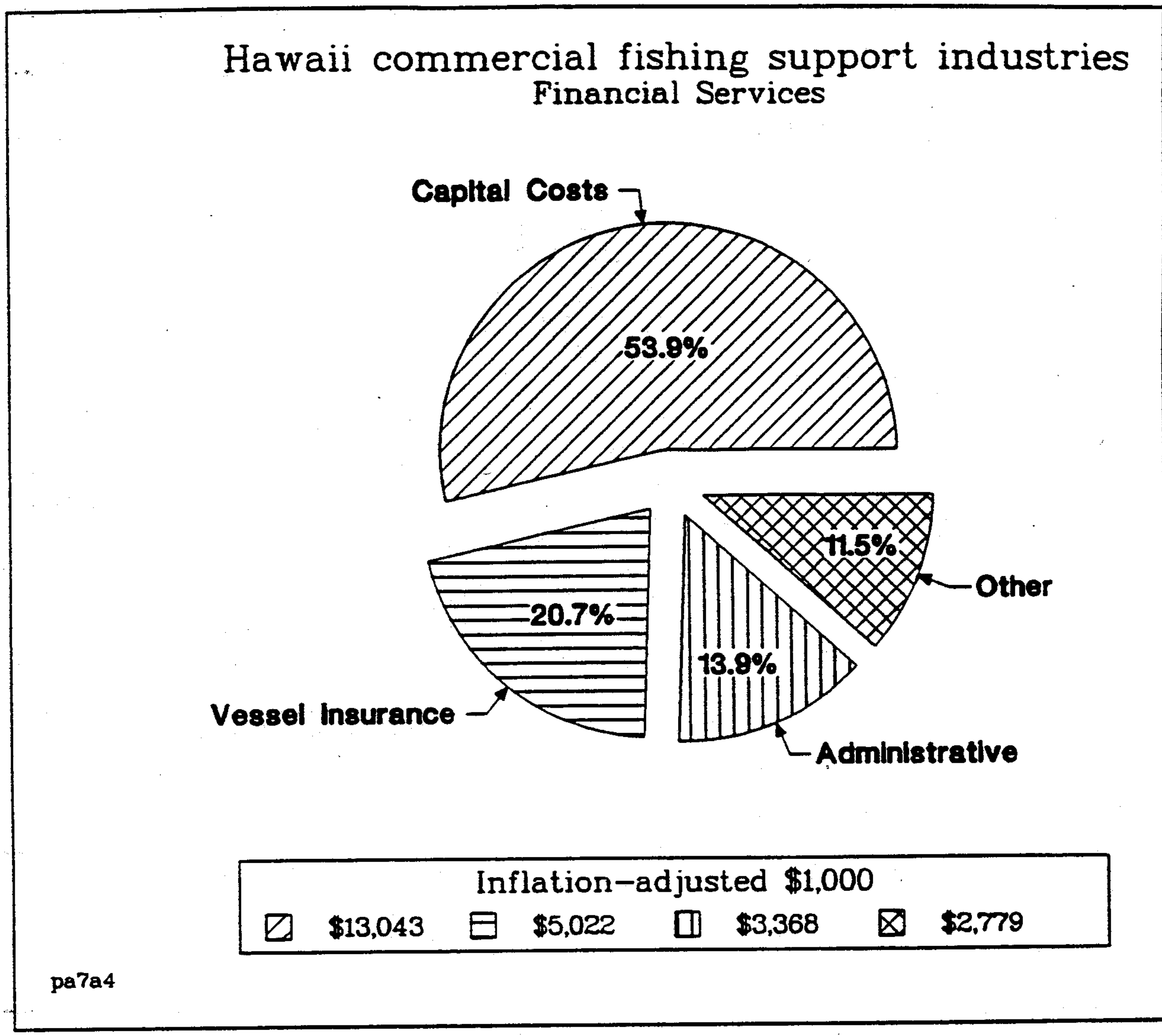
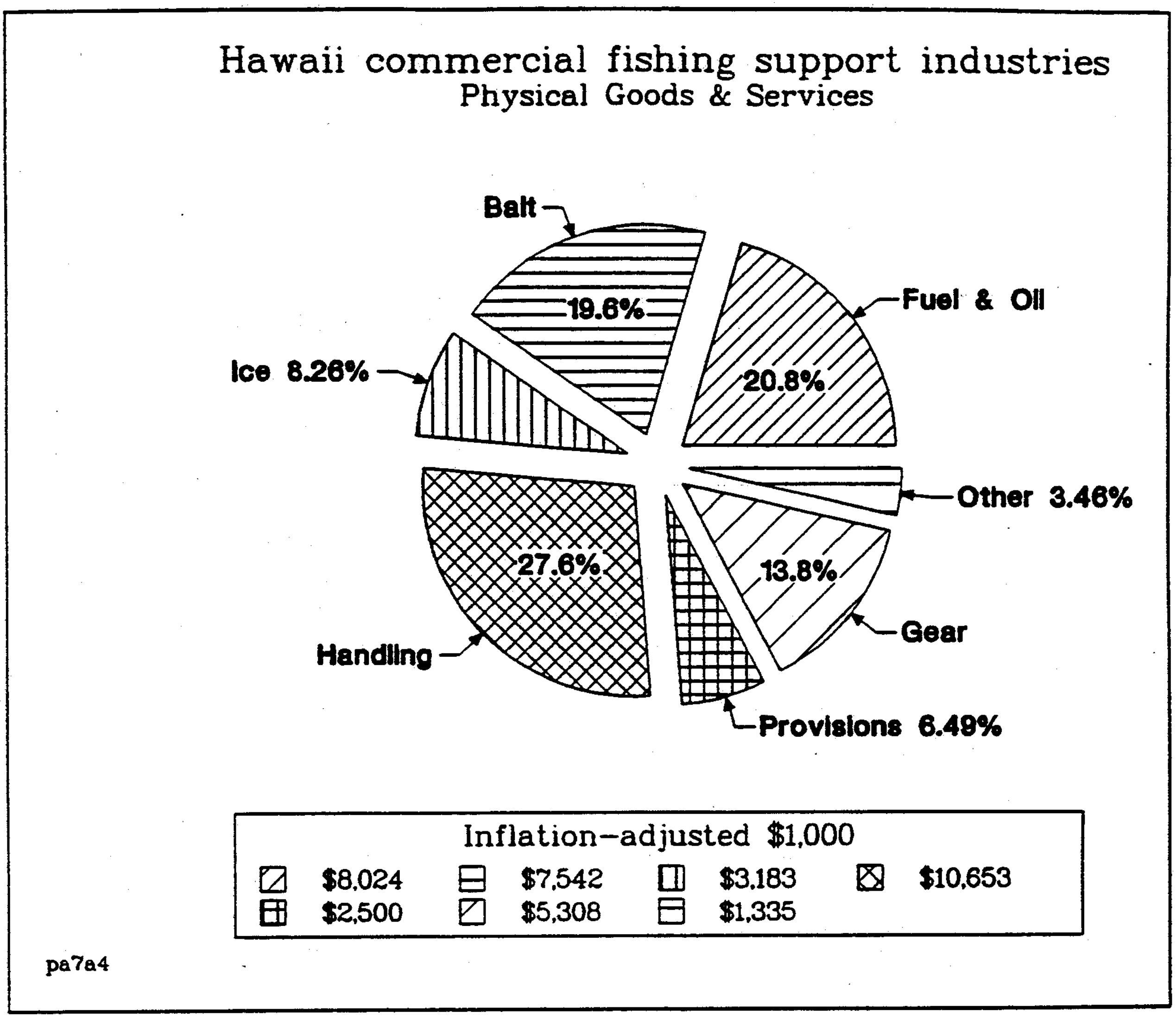


Figure III-18. Physical goods and services components of direct support industry income created by Hawaii's commercial pelagic fishery.



In terms of direct income from recreational fishing, information is also limited. The MRFSS found 1981 recreational fishing expenditures (all species) for private fishing vessels at $9.6 million and $3.2 million for charter boat fishing. Samples, et. al. (1984) estimated charter fishing revenue to be $8.1 million in 1982.

Meyer (1987) estimated direct expenditures of $24 million from small boat fishing for 1985. The 1991 USFWS National Survey of Fishing, Hunting and Wildlife-Associated Recreation estimated that $71.8 million fishing trip-related expenditures occurred in Hawaii in 1991 (USWFS, 1993).[16] Recently a State of Hawaii economic development research report estimated charter fishing expenditures at $11.5 million, and billfish tournaments at $3.9 million (MacDonald and Markrich 1992).

Finally, the hedonic (*non-market*) value of recreational fishing and the income-substitution effects from the subsistence element of the tuna and pelagic fisheries are also poorly quantified. Meyer (1987) estimated hedonic benefits of $240 million for the Hawaii small boat fishery. However, allocation of these figures to pelagic fishing, per se, was not attempted and the methodology was experimental. However, it is clear that, although not adequately quantified, recreational fishing represents an important economic sector in Hawaii's pelagic fishery.

III.F Relative Importance of Pelagic Fisheries to State of Hawaii

The relative contribution of commercial fisheries to Hawaii's economy is small. The US Bureau of Economic Analysis indicates that the total contribution of "Agricultural service, forestry and fisheries" to the state's Gross State Product in 1989 was $111 million, or about 0.4% of the state's Gross State Product (Hawaii DBEDT 1991). The pelagic fisheries accounted for about $71 million in total revenue in 1992, and probably accounted directly for less than one thousand jobs (full-time equivalents). Thus, even a large change in the condition of the pelagic fisheries will not constitute a large change in Hawaii's overall labor picture or economy.

The size and economic values of the commercial troll and handline fisheries have not been well defined. Most vessels used in commercial fishing in Hawaii are undocumented, and state-registered vessels. According to state records, there were more than 14,000 state registered vessels in Hawaii as of 30 December 1990. Of these, 1,038 were listed as being engaged in "commercial fishing" (State Department of Transportation). Relatively few of the vessels listed as used in commercial fishing are used full-time in the fisheries, and it is assumed that those used full-time are mostly engaged in pelagic fisheries. The permit programs for the crustacean and bottomfish fisheries of the Northwestern Hawaiian Islands show only about 50 vessels (the majority of which are documented) operate in those fisheries, and even these

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[16] These expenditure estimates include fishing of all types (e.g., fresh-water and saltwater) and all modes of fishing (e.g., shoreside, charter-boat, small boat). No separate estimates of expenditures related to pelagic recreational fishing are available.

vessels may operate part-time in pelagic fisheries. The total number of trips taken by troll and handline vessels in 1992 was estimated at about 30,000 trips. Thus, the "average" vessel would have taken about 30 trips. More likely, a small number of vessels were used nearly full time (e.g., about 160 trips per year), while the larger majority were used on weekends and holidays to supplement income from other occupations.

The fisheries often have greater importance to isolated communities (e.g., Waianae and Haleiwa on the island of Oahu, which have relatively large numbers of troll fishermen; Hilo, Hawaii, which has large numbers of handline fishermen; Miloili, Hawaii, with a native Hawaiian fishery interest; and Kailua-Kona, Hawaii, and Kewalo Basin, Oahu, which are significant charter fishing centers). Unfortunately, there are no studies providing useful data on overall employment, labor market characteristics, and demographics for people in these communities relative to fisheries. Thus, the impacts of changes in landings, and ultimately in vessel activity patterns, cannot be described in terms of employment rates, incomes, labor education and mobility, community structure and stability, or the ability of potentially displaced fishermen to find other jobs. Determining if any current troll or handline fishermen would shift to the longline fishery if entry were open to new people is also difficult given the available data.

The number of people who rely on pelagic fisheries as a significant or dominant source of food in a subsistence fishery has not been estimated. Determining the impact of current regulations on native Hawaiian fishermen is also problematic. For example, it is not known how many native Hawaiian fishermen would have entered the pelagic longline fishery in the absence of the current limited entry program. Similarly, it is not known if native fishermen have been adversely affected by increased catches by longline vessels or other non-native Hawaiian fishermen in or near communities in which these native Hawaiian fishermen live.

III.G Protected Marine Resources & Longline Fishery Interactions

Twelve federally protected marine animals are known to have had interactions with Hawaii-based longline vessels within or beyond the 200-mile EEZ surrounding the Hawaiian archipelago (Table III-20).

III.G.1 Status of Protected Species

Hawaiian Monk Seal

The primary habitat of the Hawaiian monk seal is the Northwestern Hawaiian Islands (NWHI), specifically Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, French Frigate Shoals, Necker Island, and Nihoa Island. The major pupping islands are in the NWHI, but monk seals are seen occasionally on beaches in the main Hawaiian Islands.

Table III-20. Protected Species Reported Interacting with the Hawaii-based Longline Fishery.

Marine Mammals:

- Hawaiian monk seal (*Monachus schauinslandi*) - endangered
- Humpback whale (*Megaptera novaeangliae*) - endangered
- False killer whale (*Pseudorca crassidens*) - protected
- Dolphin spp. - protected

Sea Turtles:

- Green turtle (*Chelonia mydas*) - threatened
- Leatherback turtle (*Dermochleys coriacea*) - endangered
- Olive ridley turtle (*Lepidochlys olivacea*) - endangered
- Loggerhead turtle (*Caretta caretta*) - threatened
- Hawksbill turtle (*Eretmochelys imbricata*) - endangered

Sea birds:

- Laysan albatross (*Diomedea immutabilis*) - protected
- Black-footed albatross (*Diomedea nigripes*) - protected
- Booby (*Sula* sp.) - protected

"Endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta. (Class Insecta was determined by the Secretary to constitute a pest whose protection under the Endangered Species Act would present an overwhelmingly and overriding risk to man.)

"Threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

"Protected species" means, for the purpose of this amendment, any marine mammal, migratory seabird or listed species protected under the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA) or Migratory Bird Treaty Act. Marine mammals listed as threatened or endangered are covered under both the MMPA and ESA.

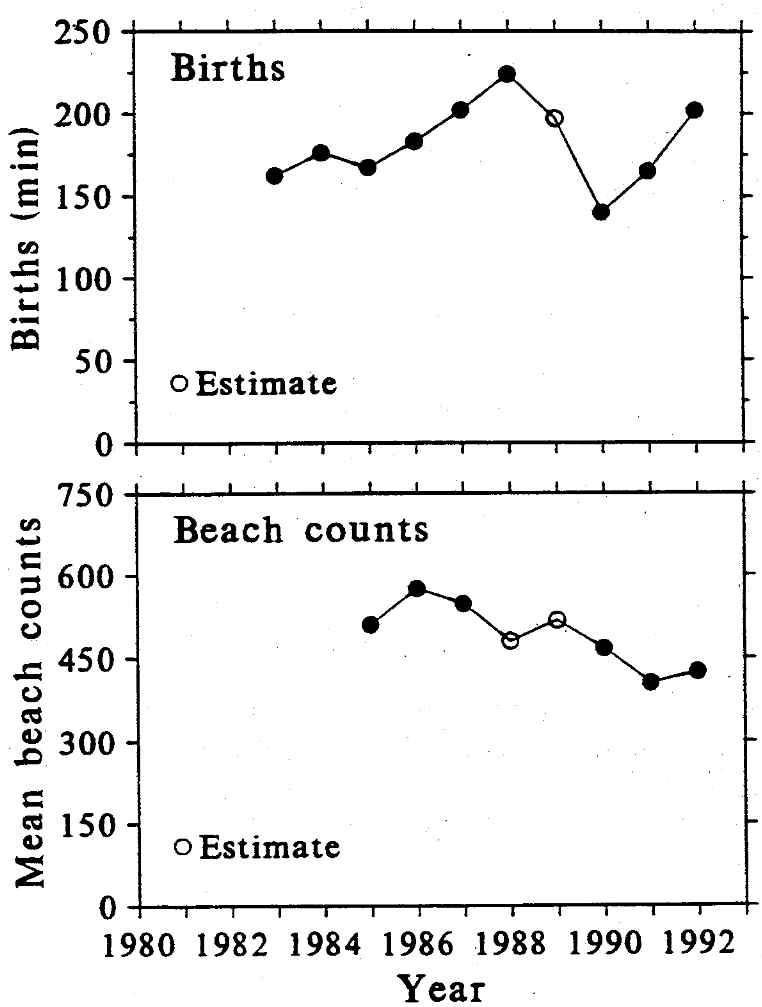
The Hawaiian monk seal is the most endangered seal in the United States. In 1986, the NMFS designated the seal's breeding habitat and surrounding waters out to 10 fm as "critical habitat" (which was expanded to 20 fm in 1988).

In 1992, the Hawaiian monk seal population was estimated at 1,580 animals (Ragen 1993) which was 10% lower than the average estimated size of the population between 1983 and 1988 (Table III-21).[17] The 1992 mean total beach count of 431 seals, excluding pups, at the five major breeding islands was 14% lower than the average annual beach counts for 1985-1991 (Ragen 1993) (Figure III-19).

Between 1983-1991, the minimum number of seal births averaged 180 annually. In 1990 there were only 143 births, perhaps the lowest number in any year during the last decade (NOAA 1991a). In 1992 the number of births increased to 209 (Ragen 1993).

Figure III-19. Mean Beach Counts & Minimum Number of Annual Births of Monk Seals

(Ragen 1993)



[17] No population estimates are available for 1989 - 1991)

Table III-21. Hawaiian Monk Seal Estimated Population Size and Counts

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Est. Total Abundance[a]	1627	1501	1710	1976	1912	1752	----	----	----	1580
Mean Beach Count[b]	----	----	509	575	547	480[c]	517[c]	466	405	431
No. of Births	162	176	167	183	202	224	197[c]	143	165	209

Data source: Ragen 1993; Gilmartin, et.al. (submitted to Mar. Mamm. Sci.)

[a] based on beach counts at French Frigate Shoals, Laysan, Lisianski, Pearl & Hermes, Kure, Midway, Necker, and Nihoa.

[b] based on beach counts, excluding pups, at the five major breeding locations: French Frigate Shoals, Laysan, Lisianski, Pearl & Hermes, and Kure.

[c] Estimate

Humpback Whale

The Hawaiian Islands serve as breeding, calving, nursing, and wintering grounds for perhaps as much as one-half the estimated population (1200 to 2000 animals) of central North Pacific humpback whales (Johnson and Wellman 1984, Darling and Morowitz 1986, Baker and Herman 1987). As early as November, the whales begin arriving in Hawaii from the higher latitude North Pacific summer feeding grounds off Alaska and Canada. Their numbers peak in Hawaii between December to March. In April, they begin migrating out of Hawaiian waters and by late May or early June the last whales usually have departed (Naughton & Nitta 1989). A few animals have been sighted in the NWHI (Naughton & Nitta 1989).

During the winter breeding season, humpback whales concentrate in shallow waters, usually less than 100 fm, and are attracted to broad bank areas in the main Hawaiian Islands. Here the whales engage in mating activities and the females bear their young.

The major areas of concentration of whales are the Penguin Bank, the "four island area" between Molokai, Maui, Kahoolawe and Lanai, and the nearshore waters of Hawaii Island between Upolu Point and Keahole Point. On 4 November 1992, most of these areas were designated a Hawaiian Islands Humpback Whale National Marine Sanctuary encompassing all waters within the 100-fm isobath around the islands of Lanai, Maui, and Molokai, including Penguin Bank (the area within 3 nautical miles of Kahoolawe is excluded); the deeper waters between Molokai and Maui (Pailolo Channel from Cape Halawa, Molokai to Nakelele Point, Maui) and waters within 100 fm off Kauai's Kilauea Point National Wildlife Refuge. Few animals have been reported from around the atolls, islands, and banks of the NWHI, although they are seen in the NWHI.

The low population of humpback whales is attributed to commercial whaling in the past. There is no published information that demonstrates whether the present population of humpback whales is stable, increasing, or decreasing in numbers.

False Killer Whale

The false killer whale is found near all the main islands. An aerial survey of the leeward sides (south shore) of Oahu, Lanai, and Hawaii documented a minimum of 470 individuals (Leatherwood and Reeves 1989). However, its occurrence and distribution in the NWHI is unknown.

Dolphin spp.

The two species of dolphins that are found throughout the Hawaiian Archipelago are the bottlenose dolphin and rough-toothed dolphin. Aerial and vessel surveys of inshore waters around the main Hawaiian Islands indicated a minimum of 430 bottlenose dolphins (unpublished data, US Navy). There is no estimate on the abundance of rough-tooth dolphin in Hawaiian waters, although 23 were collected for display purposes between 1963-1981 (Shallenberger 1981).

Green Turtle

Green turtles are found throughout the Hawaiian Archipelago. Their distribution, however, has been reduced with breeding aggregations being eliminated and certain foraging areas no longer utilized in the main Hawaiian Islands (Balazs 1980, Balazs, et al. 1987) Presently, more than 90% of the breeding and nesting activity of Hawaiian green turtles occurs at French Frigate Shoals, in the NWHI (Nitta and Henderson, in prep). The number of females nesting there fluctuates annually, the mean being estimated as high as 300 from 1973-1982 (Balazs 1980, Wetherall 1983). The total mature female population using French Frigate Shoals is presently estimated at approximately 1000 animals (G. Balazs, NMFS Honolulu Laboratory, pers. com.).

Leatherback Turtle

Leatherback turtles, the largest and most pelagic of the marine turtles, are commonly seen by fishermen in Hawaiian offshore waters, generally beyond the 100-fm isobath, but within sight of land. Two areas where sightings often occur are off the north coast of Oahu and west coast of the Island of Hawaii (Balazs et al. 1992). There is indication that the offshore waters surrounding the Hawaiian Islands constitutes regularly used foraging habitat and migratory pathways for the leatherbacks (Balazs et al. 1992). Further to the north of the Hawaiian Islands, a high seas aggregation of these turtles is known to occur at latitude 35°-45°N, longitude 175°-180°W (Skillman and Balazs, in press). The nesting habitat and origin of these leatherback turtles is not known.

Olive Ridley Turtle

Available information suggests that the Olive Ridley regularly uses the Hawaiian pelagic region for foraging and/or developmental migrations by post-hatching juveniles during their "lost year(s)". Juvenile and subadult Olive Ridleys are among the life stages known to be present in Hawaiian waters. Olive Ridleys found in Hawaiian waters are considered endangered because they are assumed to originate from the eastern Pacific breeding aggregations of Mexico; the population in Mexico is listed as endangered (Balazs, et al. 1992).

Loggerhead Turtle

The loggerhead is a cosmopolitan species found in temperate and subtropical waters. Nearly all nesting occurs north of 25° N or south of 25° S (Nitta and Henderson, in prep). Adult loggerheads undertake long reproductive migrations between their historical nesting sites and foraging areas, but their dispersal patterns in foraging areas are not well known for any population (Wetherall, et al., in press).

In the North Pacific the only major nesting beaches are in the southern part of Japan (Dodd 1978). Although reliable counts are not available, as many as 2,000-3,000 loggerheads may nest annually on beaches throughout Japan. Immature loggerheads encountered during driftnet fishing in the North Pacific may have originated from nesting beaches in Japan, being transported to the north and east by the Kuroshio Current and its extension (Wetherall, et al. in press). Loggerheads reportedly taken in the Hawaiian longline fishery for swordfish may be of the same origin.

Hawksbill Turtle

The hawksbill occurs circum-globally and is the most tropical of all marine turtles. The hawksbill is commonly considered one of the most endangered species of marine turtles due to the long history of international commercial trade in tortoise shell.

Hawksbills encountered in the North Pacific high seas drift gillnet fisheries may originate from the scattered, low level, nesting sites to the southwest in the Hawaiian Islands (Balazs et al. 1990). An alternate, or additional, origin may be the beaches in southern Japan, including the Ryukyu Islands (Uchida and Nishiwaki, 1982, Kamezaki 1987, Teruya and Uchida 1988).

Laysan Albatross, Black-footed Albatross, and Booby species

Although the distribution of the Laysan albatross ranges widely over the North and central Pacific oceans, it nests primarily in the NWHI. Nesting activity and several chicks have been observed on Kauai and Oahu in the main Hawaiian islands. The current population of Laysan albatross is estimated at 2.5 million.

The Black-footed albatross also breeds in the NWHI. It is estimated that the population of black-footed albatross is 200,000. There are 6,590-7,950 breeding pairs for the three species of booby (Harrison 1990).

The Laysan and Black-footed albatross, and Masked, Brown and Red-footed booby are protected under the Migratory Bird Treaty Act. The US Fish and Wildlife Service enforces prohibitions on the purposeful taking of these birds within US waters.

III.G.2 Interaction between Hawaii-Based Longline Fishing Vessels and Endangered and Protected Species

In Hawaii, fisheries (including the longline fishery) are currently classified by NMFS as Category III under the Marine Mammal Protection Act (MMPA). This means that, although interactions with marine mammals may occur, these animals would not normally be hooked, snagged, injured or killed during fishing operations, and no special MMPA permits are required to conduct fishing operations.

In general, an interaction between a longline vessel and protected species means an animal is accidentally hooked or entangled, or the catch or bait is removed by the protected animal. All interactions are required to be recorded by vessel operators on federal daily logsheets that are submitted to the NMFS. Since no protected species can be retained, interactions are reported as number of animals released alive, injured, or dead (RAID).

As in most logbook programs, not all fishermen accurately report interactions but this misreporting is unquantified. Of 1,665 longline trips taken in 1991, only 7% (118 trips) reported interactions with protected species. On the other hand, six of the ten longline trips (60%) that were accompanied by NMFS observers that year had interactions (WPRFMC 1991).

Non-reporting or underreporting of interactions by fishermen is primarily attributed to the fear of punishment by the federal government, using the logbook information for documenting violations related to protected resources. This fear still persists even after the NMFS has clarified to what extent interaction data from fishing logbooks provided by fishermen, voluntarily or involuntarily, will be used in prosecution for takes of protected species (56 FR 13613, 3 April 1991). According to NMFS, "the totality of the circumstances, including the nature of the interaction and the context in which the take occurred, will be considered. The determination of the legality of a take and appropriate sanctions will be made on a case-by-case basis".

In 1991, longline vessel operators reported that 184 protected animals were taken and released alive, injured, or dead (NMFS, Honolulu Laboratory, unpublished data). In 1992, this number decreased to 180, as reported in the logbooks (Table III-22). Over 80% of the 1992 interactions occurred outside the EEZ of Hawaii, while 16% took place inside the zone (Table III-23).

Hawaiian Monk Seal

Foreign longline vessels reportedly fished in the NWHI during the 1950s, and the first accounts of domestic vessels from Hawaii longline fishing in the NWHI were reported in the early 1980s. These vessels primarily targeted bigeye and yellowfin tuna, and fished away from the activity centers of monk seals. With the development and expansion of Hawaii's longline swordfish fishery in 1990s, however, longliners began fishing closer to the NWHI, especially around "66 Fathom Bank" near French Frigate Shoals, St. Rogatien and Brooks Banks, and Gardner Pinnacles. As many as 20 vessels reportedly conducted longline fishing for swordfish in the NWHI during part of the season.

Longline operations for swordfish attract seals because the longline is baited with squid, the gear is fished close to the surface with luminescent "light sticks", and the lines are close to the banks and drop-offs where the seals often feed at night. In 1990 and early 1991, incidental hookings and snagging of seals by longliners targeting swordfish were confirmed. Seven injured seals were observed during a survey at French Frigate Shoals in 1990. In 1991, nine monk seals were observed at French Frigate Shoals with jaw or head injuries not attributable to natural causes. In response to these reports, on 1 March 1991, the Council requested that the Secretary of Commerce implement an emergency closure to longline fishing within 50 nm of certain NWHI. A temporary closure was established on 18 April 1991. In a 15 May 1991 Biological Opinion rendered by NMFS on Amendment 2 to the FMP, it was further recommended that a moratorium be imposed on all longline fishing within 50 nautical miles of the islands and atolls of the NWHI from Nihoa Island to Kure Atoll. On 14 October 1991, under the final regulations implementing FMP Amendment 3, all longline fishing was prohibited within a 50-nm protected species zone around all NWHI as well as within 100-nm corridors between these banks and islands.

Since the protected species zone was established, there has been no reported or observed incidence of interaction between longliners and monk seals.

Table III-22. Interactions Between Longliners and Protected Species in 1992

Species	No. Released Alive	No. Released Injured	No. Released Dead
Turtle:			
Green Turtle	29	0	0
Leatherback	32	0	0
Loggerhead	2	0	0
Olive Ridley	1	0	1
Hawksbill	1	0	0
Dolphin:	1	0	1
False Killer Whale:	2	0	0
Seabird:			
Albatross	18	8	65
Booby		3	6
Other	5	2	3
TOTAL: N = 180	91 (51%)	13 (7%)	76 (42%)

Data Source: NMFS longline logbook program (unedited data).

Table III-23. 1992 Location of Protected Species Interactions

Species	Inside the EEZ (No.)	Outside the EEZ (No.)
Turtle	11	55
Dolphin	0	2
False Killer Whale	2	0
Seabird	15	85
Other	1	9
TOTAL:	29	151

Data Source: NMFS longline logbook program (unedited data).

Whales

Humpback Whale

In 1991 a humpback whale was observed entangled in longline gear in the NWHI (Dollar 1991) and a second was reported entangled in longline gear off Lanai. There were no longline interactions reported with this species in 1992.

On 2 March 1992, FMP Amendment 5 established a longline area closure of 50 and 75 nautical miles around the main Hawaiian Islands to prevent gear conflicts between longline vessels and troll/handline vessels (57 FR 7661, 4 March 1992). Since the longline prohibited area encompasses most of the humpback whales' primary breeding and calving areas (Molokai, Maui, Lanai and Kaho'olawe), the potential for entanglement with longline gear has been substantially reduced.

False Killer Whale

The Japanese have estimated the loss of their longline catch to killer whales in tropical waters of the Pacific as being around 10% (R. Shomura, pers. com). These whales also have been known to feed on the catch made by Hawaiian longline vessels. In 1990 a NMFS observer reported catch loss by a longliner to a solitary false killer whale on one set in mid-Pacific waters (Dollar 1991).

Dolphin spp

In 1991, there was one report of a longline interaction with a dolphin. Two interactions were reported in 1992 in which an unidentified dolphin, reportedly taken about 500 miles north of the Hawaiian Islands, was released alive; the other animal, reported as a striped dolphin, was taken outside the EEZ and released dead by the longliner.

Turtles

In 1992, marine turtles accounted for 35.5% of the interactions reported in longline logbooks. Interactions with turtles occurred outside the EEZ 83% of the time and 17% within the EEZ. Turtle interactions remained about the same in 1991 and 1992.

The rate of turtles taken within the EEZ remained unchanged at two per million hooks for 1991 and 1992. Although the number of turtles taken outside the EEZ increased between both years, the turtle take rate remained the same at nine per million hooks despite a 40% (1.7 million hooks set) increase in fishing effort from 1991 to 1992 (Table III-24).

Table III-24. Longline-Turtle Interactions Inside/Outside the EEZ

	1991		1992	
	Inside	Outside	Inside	Outside
No. of Takes	15	52	11	55
No. Hooks Set[a]	7,907,650	4,416,036	5,544,475[b]	6,142,106[b]
Takes/1 Million Hooks	1.8	11.7	1.9	8.9

a Data source: NMFS, Honolulu Laboratory
b Preliminary Data

Green Turtle

In May 1990, a green turtle was observed at French Frigate Shoals with monofilament line similar to longline leader protruding from its mouth (NMFS SWFSC 1990). During 1991, 19 green turtles reportedly were taken by longline gear (Nitta and Henderson, in prep). Logbook data for 1992 showed that 29 green turtles were taken and released alive by longliners, with over 80% of the interactions occurring outside the EEZ. Many of the logbook entries do not distinguish between snagging, entanglement, and capture on baited hooks. There are no data on the survival rate of hooked turtles released alive.

Leatherback Turtle

Leatherback turtles have had the highest number of reported interactions with longliners compared with the other turtle species. In 1991, 38 (58%) of the turtle interactions involved leatherbacks. Also, during a 1991 NMFS research cruise to the NWHI, a leatherback was reportedly hooked and released alive during experimental longline fishing operations (Skillman and Balazs, in press). In 1992, 32 (50%) of 64 turtles reported taken and released alive by longliners were leatherback turtles.

Olive Ridley Turtle, Loggerhead Turtle, and Hawksbill Turtle

In 1991 seven longline interactions were reported with Olive Ridley turtles (2), loggerhead turtles (4) and hawksbill turtles (1). Interactions during 1992 numbered 5, two Olive Ridley turtles, 2 loggerhead, and 1 hawksbill turtle. Only one of the turtle interactions in 1992 resulted in mortality (one Olive Ridley turtle).

Sea birds (Albatross and Booby)

Seabirds, especially the albatross, reportedly have the highest number of RAID's of all the protected resources observed in interactions with the longline fishery. In 1991, albatross mortality was 116 (78%) of all seabird-associated interactions; in 1992, albatross mortality was lower (91) but still comprising 65% of the interactions. No distinction was made in the logbooks between species of albatross (Laysan or Black-footed).

Incidences of mortality associated with longline gear are attributed to the feeding pattern of albatross where they feed at dusk on squid as a primary food item. Longline fishing vessels targeting swordfish also set their longline gear at sunset and use squid for bait. Albatrosses are attracted to the baited longline gear as it is being deployed and many are hooked and drowned as the line sinks below the ocean surface.

Takes of boobies by longline gear are relatively minor compared to the albatross. Logbook data indicate that interactions with boobies numbered 8 and 9, for 1991 and 1992, respectively. Again, no distinction was made in the logbooks between the booby species (masked or brown).

III.H Habitat Conditions and Trends in Environmental Conditions

Pelagic species that are managed under the FMP are distributed throughout the north, central, and western Pacific oceans generally between the latitudes of 40 - 45° N. latitude and 40° S. They occupy mostly the surface waters to a depth of at least 250m, but usually stay above the thermocline (WPRFMC 1986). There is no information to indicate that the habitat conditions of the EEZ differ significantly from those described in the FMP (Section 6.8). The introduction of low level pollution from point and non-point sources is ongoing. These sources include runoff from high islands, volcanic eruptions on the seafloor, sewage from island outfalls and ships, oil from ship bilges and accidental spills, and marine debris originating from land or ships. NMFS (Honolulu Laboratory) has conducted some studies on the effects of turbidity on the survival of eggs and larvae of tunas and billfishes as part of a research on the

impacts of manganese nodule mining and processing at sea (NOAA 1984). The preliminary results showed no impact but were considered inconclusive.

There are many federal and state laws to protect habitat conditions in the EEZ and state waters. In 1987, the US Marine Plastic Pollution Research and Control Act (MPPRCA), was enacted to prohibit the discharge of plastics into the EEZ and state waters, and to require all US ports and terminals to provide garbage reception facilities. The MPPRCA directly affects domestic longline vessels in the swordfish fishery because of their use of plastic "luminescent" light sticks to attract swordfish (see section III.C.1.a).. In 1992, the Hawaii-based longline vessels used nearly 2.5 million light sticks. Under the MPPRCA and MARPOL Annex V[18], all longliners are prohibited from discarding used light stick plastic casings into the ocean and are required to return them to port for appropriate disposal.

The habitat conditions throughout the EEZ are generally expected to remain at a high quality level with or without the FMP amendment. However, variation in the environment has pronounced effects on pelagic fisheries (Seckel 1972, Mendelssohn and Roy 1986). There is no evidence of any sustained environmental anomaly detrimental to Hawaii's fisheries, but little is known of the environmental factors that affect availability and catchability. A temperature-related decline in skipjack tuna availability in the mid-1970s ended in the 1980s (Boggs and Kikkawa 1993).

Variability in CPUE due to environmental factors creates major problems for stock assessment and optimization of yield (Amendment 4, Appendix A). Quantifying the impacts of fishing pressure on the local abundance of fish is difficult because the effects of environmental variation appear to be much more pronounced than the effects of fishing pressure. No effort limitation scheme will be able to prevent Hawaii's fisheries from experiencing alternating periods of low and high CPUE resulting from environmental variations. The best way for fishermen to overcome highly-localized, environmentally-induced variations in CPUE would be to emulate the distant-water fishing nations and develop highly-mobile fisheries that can operate over a wider range of the Pacific, locating the fish where they are most abundant.

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[18] MARPOL stands for "marine pollution". MARPOL V means Annex V of the International Maritime Organization's Convention for the Prevention of Pollution from Ships which prohibits at-sea disposal of plastics.