Hawaii's Pelagic Fisheries

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Introduction

Hawaii's pelagic fisheries are small in comparison with other Pacific pelagic fisheries (NMFS, 1991), but they are the largest fisheries in the State (Pooley, 1993b), and much larger than other U.S. island-based fisheries in the western Pacific (Hamm et al.[1]). Stocks of tuna, billfish, and other tropical pelagic species supply most of the fish consumed by Hawaii residents and support popular recreational fisheries.

In recent years (1987–91) the composition and magnitude of Hawaii's commercial pelagic fisheries have changed. The longline fishery greatly expanded and the troll, handline, and pole-and- line fisheries declined (Ito[2]). The expansion of the longline fishery was consistent with fishery development plans that viewed pelagic fish resources as underexploited (State of Hawaii Division of Aquatic Resources (HDAR) 1985). Pelagic fish resources available to Hawaii fisheries may be capable of sustaining even greater yields. However, the decline of the troll and handline fisheries has raised concerns regarding the continued availability of pelagic species and local overfishing (Boggs[3], Ito[2]).

Pelagic fish availability is synonymous with local abundance, here defined as the amount of fish present within the range of the local fishery. Overall abundance refers to population size, which is greater than local abundance unless the entire population resides within range of the local fishery. The stock structure of large pelagic species is unclear, but a common assumption is that pelagic populations extend over much wider areas than are covered by Hawaii's fisheries (Skillman, 1989a, 1989b; Suzuki, 1989, In press; Miyabe, In press).

Availability probably depends on overall abundance, but the availability of fish to Hawaii's pelagic fisheries is also highly seasonal (Shomura, 1959; Yoshida, 1974; Skillman and Kamer[4]), suggesting that highly mobile pelagic fish change their distribution in response to environmental conditions (Seckel, 1972; Mendelssohn and Roy, 1986), or to enter different areas for reproduction. Availability may also be confounded with catchability, defined as the vulnerability of fish to being caught by a given type of fishing gear. Catchability is also influenced by environmental conditions (Sharp, 1978; Hanamoto, 1987).

The limited mobility of most island fishermen causes yield to be poor when availability is low. Intense local fishing effort is not likely to cause a decline in overall abundance unless there are discrete stocks residing in, or periodically returning to, island waters. Otherwise, the fishing mortality caused by Hawaii fisheries is minor compared with overall fishing mortality caused by larger Pacific fisheries. Thus, local fishing pressure is unlikely to cause a significant reduction in overall abundance.

Even though locally exploited pelagic stocks may be wide-ranging, and relatively invulnerable to local fishing pressure, catch per unit effort (CPUE) in local fisheries may decline if local fishing effort is so intense that most

[1]D. C. Hamm, R. S. Antonio, and M. M. C. Quach. 1992. Fishery statistics of the western Pacific. Vol. VII. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep H-92–06, var. pag.

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ABSTRACT—Hawaii's diverse pelagic fisheries supply the bulk of the State's total catch. The largest Hawaii fishery is the recently expanded longline fishery, which now lands about 4,400 metric tons (t) of broadbill swordfish, Xiphias gladius; *1,500 t of bigeye tuna,* Thunnus obesus, *and 3,000 t of other pelagic species annually. The increased catch of these other species has raised concerns regarding the continued availability of yellowfin tuna,* T. albacares; *blue marlin,* Makaira mazara; *and mahimahi,* Coryphaena hippurus, *in the small-vessel troll and handline fisheries which target those species.*

Analysis of catch per unit effort (CPUE) statistics from Hawaii's fisheries did not provide strong evidence of recent declines in availability related to local fishery expansion. A more influential factor was variation in Pacific-wide CPUE, representing overall population abundance and catchability. Exogenous factors, including Pacific-wide fishing pressure, may overwhelm the influence of local fishing pressure on fish availability.

[2]R. Y. Ito. 1992. Western Pacific pelagic fisheries in 1991. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-92-15, 38 p.

[3]C. H. Boggs. 1991. A preliminary examination of catch rates in Hawaii's troll and handline fisheries over a period of domestic longline fishery expansion. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin Rep. H-91-05, 62 p.

[4]R. A. Skillman and G. L. Kamer. 1992. A correlation analysis of Hawaii and foreign fishery statistics for billfishes, mahimahi, wahoo, and pelagic sharks, 1962–78. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-92-05, 44 p.

fish entering the local area are soon caught. It is hypothesized (Sathiendrakumar and Tisdell, 1987; Boggs, In press) that if fish availability depends on immigration, increases in local fishing effort result in an asymptotic yield, beyond which further increases in local effort do not increase the catch, and local CPUE declines. The possible impact of local fishing effort on the CPUE and profitability of Hawaii's pelagic fisheries is currently an issue of great concern to Hawaii's fishery managers (Boggs[3], In press).

This paper describes Hawaii's longline, troll, and handline fisheries for pelagic species, trends in landings and CPUE over time, and problems with the data used to monitor these fisheries. Changes in the apparent relative availability of fish (local CPUE) are reviewed in relation to local fishery expansion and overall abundance (Pacific-wide CPUE). Current attempts at managing for optimum yield and the outlook for these fisheries are described. The Hawaii skipjack tuna fishery is covered in a separate paper (Boggs and Kikkawa, 1993).

Synopsis of the Fisheries

The fishing methods, target species, vessel sizes, yields, and operational areas of Hawaii's domestic pelagic fisheries are diverse. The commercial sectors are largely composed of the pole-and-line and longline fisheries utilizing large (>12 m) vessels. The small-vessel troll and handline fisheries include poorly differentiated commercial, recreational, and subsistence components. The pole-and-line fishery targets skipjack tuna, *Katsuwonus pelamis,* and lands about 1,000 metric tons (t), (2.2 million lb) annually for sale to the local market (Boggs and Kikkawa, 1993). The longline fishery targets broadbill swordfish, *Xiphias gladius;* and bigeye tuna, *Thunnus obesus*, and now lands about 9,000 t (20 million lb, including all species) much of which is exported. The commercial, recreational, and subsistence troll and handline fleets primarily target yellowfin tuna, *T. albacares*; mahimahi, *Coryphaena hippurus*; and blue marlin, *Makaira mazara*; annual commercial landings (all species) now average about 2,300 t (5.2 million lb). No valid estimates exist for current recreational or subsistence landings (Pooley, 1993a).

Up until 1980 distant-water longliners from Japan caught between 1,300 and 5,000 t of tuna and billfish annually within the Exclusive Economic Zone (EEZ) around Hawaii (Yong and Wetherall, 1980) but since 1980 there has been no legal foreign longline fishing conducted in the EEZ. The Fishery Management Plan (FMP) enacted by the Western Pacific Regional Fishery Management Council (WPRFMC) was designed to regulate billfish catches by these foreign distant-water longliners (WPRFMC[5]). The Japanese distant-water pole-and-line fishery for skipjack tuna that operated in the Northwestern Hawaiian Islands (NWHI) through 1992 was the only foreign fishery operating legally within the EEZ after 1980 (Boggs and Kikkawa, 1993).

Although the primary target species of the domestic longline fishery are different from those of the troll and handline fisheries, the longline fishery also catches about 1,300 t (2.8 million lb) of yellowfin tuna, blue marlin, and mahimahi (combined). This creates a potential for fishery interaction between the longline and small-vessel troll and handline fisheries. Potential interactions, impacts on endangered species, the possibility of localized overfishing, and gear conflicts (Pooley, 1990) prompted the WPRFMC to establish regulations for the domestic longline fishery in 1990 (Dollar and Yoshimoto[6]). A moratorium on entry of longline vessels into the Hawaii fishery and prohibited areas for longline fishing were established in 1991.

[5]WPRFMC. 1986. Fisheries management plan for the pelagic fisheries of the western Pacific Region. Western Pacific Regional Fisheries Management Council (WPRFMC), Honolulu, HI 96813, 380 p.

[6]R. A. Dollar and S. S. Yoshimoto. 1991. The federally mandated longline fishing log collection system in the western Pacific. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-91-12, 35 p.

The Longline Fishery

Fishing Methods

Longline fishing gear consists of main line strung horizontally acros 1–100 km of ocean, supported at regular intervals by vertical float lines connected to surface floats. Descendin from the main line are branch lines each ending in a single, baited hook The main line droops in a curve fron one float line to the next and bear some number (2–25) of branch line between floats. Fishing depth depends on 1) the lengths of the float lines and branch lines, 2) the sag in the main line, and 3) the position of the branch line, the deepest branch line positions being in the middle of the droop. Fishing depth affects the efficiency with which different species are captured (Hanamoto, 1976, 1987; Suzuki et al., 1977; Boggs, 1992).

One longline "set" is made per day of fishing, and for long main lines the deployment and retrieval may take almost 24 hours. Often the end of the line deployed first is retrieved last, so individual hooks may fish for a few hours, or all day (average ca. 12 hours). Traditionally the gear was set so that it fished primarily during daylight. For bait, Hawaii longliners used locally caught scad, *Decapterus* and *Selar* spp.; imported squid, *Loligo* sp.; sardines, *Sardinops caerulea*; herring, *Clupea pallasi*; and saury, *Cololabis saira.*

The Hawaii longline fishery began in 1917 off Waianae, Oahu, using techniques imported from Japan. Hawaii longline vessels evolved from the wooden sampan-style baitboats used in the pole-and-line fishery for skipjack tuna (June, 1950). The sampans used in the early years of the fishery (ca. 1950) were 12–19 m (40–63 ft) in length, high-bowed, and diesel-powered. They carried about 12 t of ice to chill an average catch of about 3 t (7,000 lb) of fish caught over an average trip of 10.5 days (June, 1950).

Old-style longlines were made of rope and composed of individual units called "baskets" named for the bamboo containers they were stowed in (June, 1950). Each basket was made

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tharu2

up of the float line, main line, and branch lines necessary for one segment of longline (one droop of the line). Poles with flags were attached to the floats to mark the gear, and longlining was generally referred to as "flagline" fishing.

Historical Development and Decline

Historically, the longline fishery was the second largest commercial fishery in the state after the pole-and-line fishery. By the 1930's longliners landed most of the 1,000 t (ca. 2 million lb) of yellowfin tuna, bigeye tuna, and albacore, *Thunnus alalunga*, landed in the Territory of Hawaii (June, 1950). After a hiatus during World War II the fishery quickly recovered, landing 900 t (2 million lb) of tuna, and 700 t (1.5 million lb) of billfish and other species in 1948. Landings continued to rise, reaching a record level of 2,000 t (4.4 million lb) in 1954 (Fig. 1A). The longline fishery declined in the late 1950's through the mid-1970's to reach a similar level of landings as the commercial troll (Fig. 2) and handline (Fig. 3) fisheries.

In the early years most of the catch was reported to have been in HDAR statistical areas 2–20 n.mi. (3.7–37 km) off Waianae, Oahu, and off Kona, Hilo, and Hamakua, Hawaii (June, 1950). Shomura (1959) reported greatly improved catch rates for bigeye tuna by longline vessels fishing off the windward coasts (i.e., Hilo) in winter as opposed to the traditional practice of fishing off sheltered leeward coasts (i.e., Waianae, Kona). Hida (1966) reported a growing number of longliners extending their range 100–400 n.mi. south of Oahu, and noted that CPUE was better than average in the southern area.

The species composition of longline landings changed over time. During 1951–64, more than 50% of longline landings (by weight) were bigeye tuna, also called ahi (a Hawaiian name), ahi mebachi, or "bluefin." True bluefin tuna, *Thunnus thynnus*, are rarely caught by Hawaii fishermen. Before 1950 and in the 1970's bigeye tuna and yellowfin tuna (also called ahi) made up roughly equal proportions of the catch (Fig. 1A). The proportion of blue marlin in the catch was higher than that of striped marlin, *Tetrapturus audax*, in the early 1950's but striped marlin became more predominant from the early 1960's to the present (Fig. 1A). Both marlin species are also called au (the Hawaiian name) or "swordfish," but they should not be confused with broadbill swordfish (Fig. 1B), which became the primary target species in the 1990's (Dollar[7]). Local common names for the pelagic species are often used for reporting catch statistics, resulting in some confusion.

The decline of the Hawaii longline fishery in the late 1950's through mid-1970's was characterized by a lack of new investment. Only a few new steel or fiberglass boats were built or added to the fleet between 1950 and 1982. Only 3 out of 11 boats surveyed in 1982 were built after 1970 (Hawaii Opinion[8]). Most longline vessels oper-

[7]R. A. Dollar. 1992. Annual report of the 1991 western Pacific longline fishery. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-92-11, 26 p.

[8]Hawaii Opinion, Inc. 1984. A cost earnings study of the longline and handline fishing fleets in Hawaii, a summary of the survey. Prepared for NMFS, 2570 Dole St., Honolulu, HI 96822–2396, contract number 81-ABC-00267, 113 p.

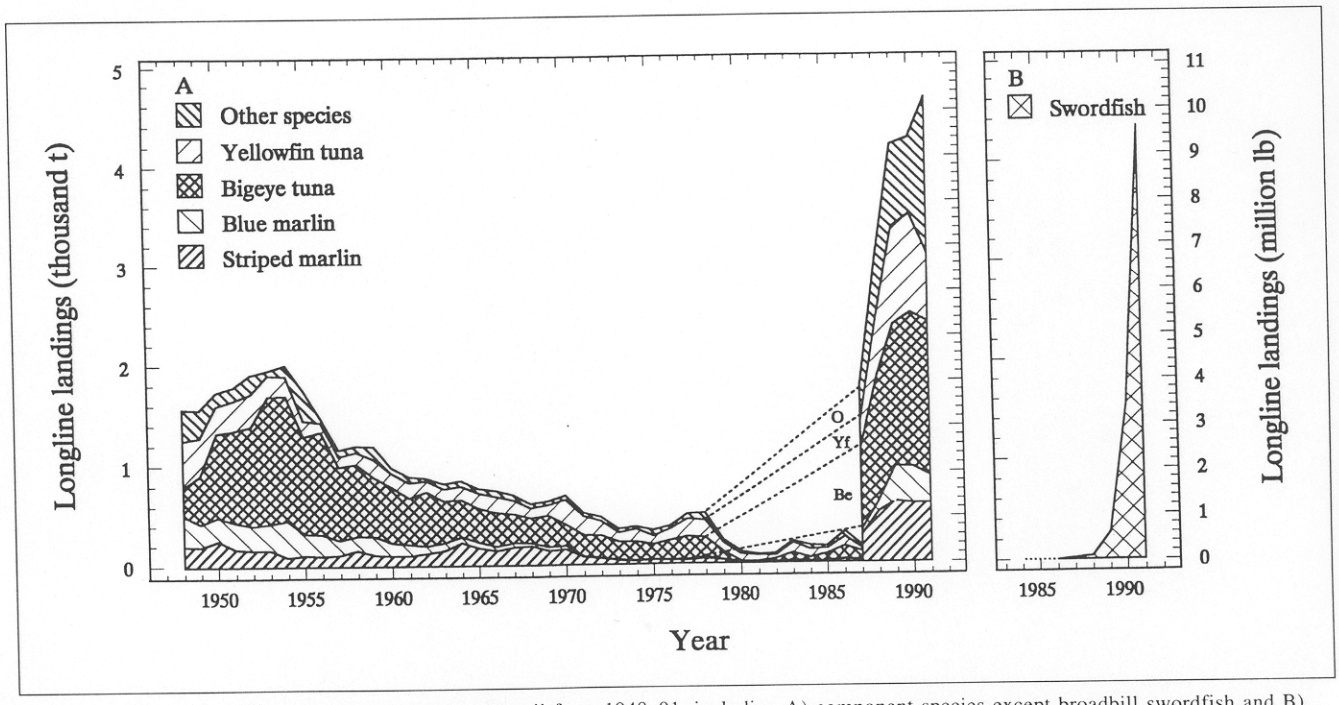

Figure 1.— Longline landings (in t and lb) in Hawaii from 1948–91, including A) component species except broadbill swordfish and B) broadbill swordfish. Total landings are the sum of stacked components. Dashed lines show corrected 1979–86 estimates for total landings, other species (O), yellowfin tuna (Yf), and bigeye tuna (Be). Sources: 1948–86, HDAR data; 1987–91, NMFS estimates.

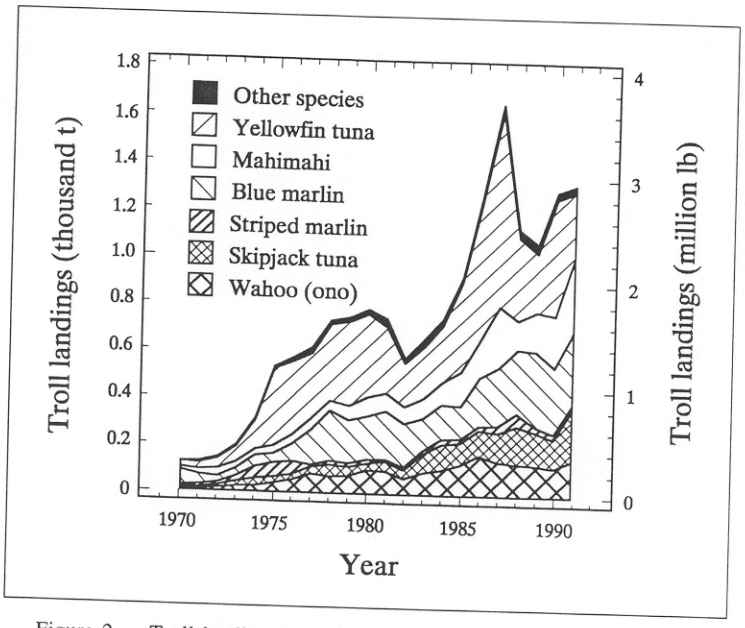

Figure 2.— Troll landings in metric tons (t) and pounds (lb) in Hawaii from 1970–91. Total landings are the sum of stacked components. Source: HDAR data.

ating through 1982 were veterans of the 1940's and 1950's. Low profitability probably contributed to the lack of investment in new vessels.

Local sale of fresh fish, mostly for raw consumption, provided a limited market that was easy to saturate, driving down the price (Otsu, 1954). The Hawaii fresh-fish market was the only outlet, because mainland U.S. consumers did not accept tuna as a fresh product. The Japan "sashimi" market was distant and exacted hard-to-meet product standards. Prices offered by tuna canneries were too low to provide adequate profits.

Although the number of vessels declined, the amount of fishing gear deployed in an average trip nearly doubled between the 1950's (Shomura, 1959) and the early 1980's (Hawaii Opinion[8]). The number of hooks per basket, and consequently the length of main line between float lines, also increased, resulting in a deeper gear configuration. A similar shift in gear configuration characterized the distant-water longline fleets of Japan and Korea (Suzuki et al., 1977; Yang and Gong, 1988).

The number of vessels participating in the Hawaii longline fishery over the years is difficult to document because many vessels fished part-time while participating in other Hawaii fisheries. June (1950) identified 49 vessels as primarily longliners (30 in Honolulu), whereas Hawaii Division of Aquatic Resources (HDAR) records indicate 76 registered longline vessels in 1950. Yoshida (1974) states that participation declined from 42 vessels in 1952 to 31 in 1964, and to 20 in 1970. Yuen[9] reported that the longline fleet in Honolulu numbered 15 in 1977, and by 1983 HDAR records showed only 13 registered longline vessels (10 in Honolulu).

The decline in vessels corresponded with the declining trend in longline landings reported to HDAR between 1954 and 1982 (Fig. 1A). However, visual inspection of the Honolulu fleet in 1983 found 37 vessels carrying longline gear (Honda[10]) as opposed to 10 registered with HDAR. Incomplete reporting to HDAR prompted the establishment of a NMFS market sampling program in late 1986 (Pooley, 1993b) and a Federal longline logbook program (Dollar and Yoshimoto[6]) was instituted by the WPRFMC in 1990 to collect more detailed data. A compari-

[9]H. S. H. Yuen. 1977. Overview of fisheries for the billfishes in Hawaii. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin Rep. H-77–19H, 14 p.

[10]V.A. Honda. 1985. An updated description of the Hawaiian tuna longline fishery. NMFS, 300 Ala Moana Blvd., Honolulu, HI 96850–4982, unpubl. manuscri.

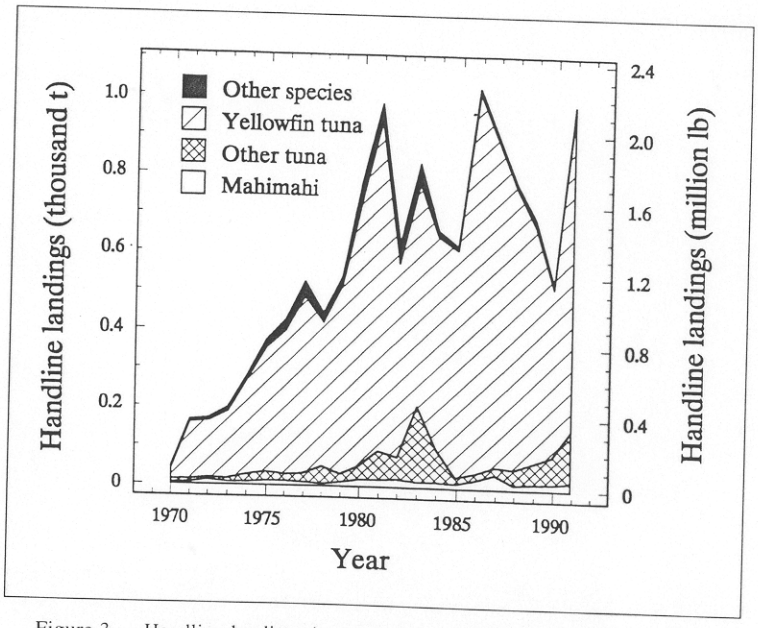

Figure 3.— Handline landings in metric tons (t) and pounds (lb) in Hawaii from 1970 to 1991. Total landings are the sum of stacked components. Source: HDAR data.

son between NMFS estimates of longline landings at wholesale markets and landings reported to HDAR in 1987 showed that less than 20% of longline landings were reported (Ito[2]).

The best available estimates of Hawaii longline landings over time (Fig. 1A) are based on three data sources and a correction to account for underreporting (Pooley, 1993b). HDAR longline data are believed to be relatively complete through 1978 (Pooley, 1993b). NMFS estimates based on market sampling and logbooks (Ito[2]; Pooley, 1993b) are used for 1987–91 (Fig. 1A and 1B). Estimates for 1979–86 (dashed lines, Fig. 1A) are interpolated values between HDAR reported landings in 1978 and NMFS estimates for 1987 (Pooley, 1993b). In contrast, HDAR troll (Fig. 2) and handline (Fig. 3) landings reported to HDAR through 1991 are very similar to NMFS estimates (Pooley, 1993b), and HDAR troll and handline data are used in this paper without correction. The corrected longline data indicate that the nadir of the longline fishery occured in 1975 (not 1982, Fig. 1A).

Revitalization and Expansion

The longline fishery expanded rapidly in the late 1980's to become the largest fishery in the state. The revitalization was due to the development of the local markets and export markets for fresh tuna on the U.S. mainland and in Japan (Kawamoto et al.[11]) and the introduction of new swordfish fishing methods in the late 1980's (Dollar[7]). Participation in the Hawaii longline fishery approximately doubled from 37 vessels in 1987 to 75 in 1989 (Ito[2]) and doubled again to 156 (vessels with permits) by the end of 1991 (Dollar and Yoshimoto[6]). Permits were required by the Federal moratorium on new entrants established in 1991. Only 140 of the vessels with permits were active in 1991. In 1988 landings data first exceeded the record set in 1954 (Fig. 1A) and by 1991 landings reached 9,000 t (20 million lb), including 4,400 t (9.6 million lb) of swordfish (Fig. 1B).

New entrants in the longline fishery were mostly steel-hulled vessels up to 33 m (107 ft) in length, and the majority of these vessels and their operators were former participants in U.S. east coast tuna and swordfish fisheries (Dollar[7]). The present fleet uses modern electronics (Radar, Loran, Global Positioning System (GPS)) to navigate, and uses radio beacons, strobe lights, and radar reflectors to mark the gear. Some vessels obtain sea-surface temperature maps by radio-facsimile (FAX) and most have electronic thermometers for use in finding fish associated with temperature fronts.

Changes in fishing methods and greater amounts of fishing gear characterized the expansion of the longline fleet. In 1988 most vessels still used basket-type, rope longline gear, but they deployed over 3 times as much gear on an average trip as vessels in 1982 (Hawaii Opinion[8], Kawamoto et al.[11]). A few vessels used "bin" gear in which the rope mainline is continuous, rather than composed of baskets, and these vessels deployed similar amounts of gear as those using basket gear (Kawamoto et al.[11]). Continuous nylon monofilament main lines stored on spools and used with snap-on monofilament branch lines were first used in 1985, and by the end of 1988, 29% of the fleet used this new system (Kawamoto et al.[11]). Monofilament gear was popular among new entrants to the Hawaii fishery and became the most prevalent gear type in the fleet. Longliners using monofilament gear tended to deploy over four times as much gear per trip in 1988 (Kawamoto et al.[11]) as was typical of the fleet in 1982 (Hawaii Opinion[8]).

Monofilament longline gear is more flexible in configuration and can be used to target various depths more easily than basket gear because the amount of main line, the number of branch lines, and the sag between floats are adjustable. This flexibility was demonstrated by the switch from traditional deep daytime fishing for bigeye tuna to shallow nighttime fishing, targeting broadbill swordfish in the 1990's (Ito[2]). Both daytime and nighttime methods are still practiced using the same monofilament longline system. In targeting bigeye tuna 12–25 hooks are deployed between floats with lots of sag to reach as deep as 400 m (Boggs, 1992), whereas in targeting swordfish only a few hooks are deployed between floats and the line is kept relatively taut so that it stays in the upper 30–90 m of water. Night fishing employs luminescent "light sticks" which attract broadbill swordfish and bigeye tuna or their prey (Berkley et al., 1981). Large imported squid, *Illex* sp., are used for bait.

A special "line thrower" is required to put sag into a monofilament longline as it is deployed (Kawamoto et al.[11]; Boggs, 1992) so that it can fish deeply for bigeye tuna. Many new entrants to the fishery in 1989–91 did not invest in line throwers. These vessels fished shallow even when targeting tuna (daytime fishing) and probably contributed to the increase in the relative proportions of yellowfin tuna, blue marlin, and other shallow-swimming species caught by longliners in recent years (Fig. 1A). The increasing longline catch of these species was cause for concern by the small-vessel troll and handline fisheries that target them (Boggs[3]).

The fishing grounds of the Hawaii longline fishery expanded in the 1980's and 1990's. Hawaii fishermen interviewed in 1982 reported that they had to fish farther away from port in order to make good catches (Hawaii Opinion[8]). In 1986 Hawaii longliners began exploring fishing grounds up to 800 n.mi. from the main Hawaiian Islands, and distant-water fishing is becoming more common in the 1990's. Logbook data from the first quarter of 1991 indicate that over half of longline sets were more than 50 n.mi. away from the main Hawaiian Islands, and <2% of sets were made outside the EEZ (NMFS[12]).

Conflicts with other fisheries and interactions with protected species led to the exclusion of the longline fishery

[11]K. E. Kawamoto, R. Y. Ito, R. P. Clarke, and A. E. Chun. 1989. Status of the tuna longline fishery in Hawaii, 1987–88. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-89–10, 34 p.

[12]NMFS Honolulu Laboratory, 2570 Dole St., Honolulu HI 96822–2396, unpubl. longline logbook data.

from nearshore waters in the 1990's. In early 1991 longline fishing was prohibited within a radius of 50 n.mi. off the NWHI (Dollar[7]) to prevent interactions between endangered Hawaiian monk seals, *Monachus schauinslandi*, and surface-fishing longliners that targeted aggregations of swordfish near those islands. In 1989 an informal agreement was negotiated between small-vessel fishermen and longline fishermen whereby longliners would keep >20 n.mi. from the coasts of the main Hawaiian Islands and >10 n.mi. from fish aggregating devices (FAD's). Some vessels, especially subsequent entrants to the fishery, did not comply with the agreement. To mitigate conflicts between longliners and small-vessel troll and handline fishermen, the WPRFMC in mid-1991 established a buffer zone prohibiting longline fishing within a radius of 75 n.mi. off the coasts of Kauai and Oahu, or within a radius of 50 n.mi. off the coasts of Maui, Molokai, Lanai, Kahoolawe, and Hawaii (Dollar and Yoshimoto[6]).

The Troll Fishery

Troll and handline fisheries in Hawaii have not been studied as extensively as the longline fishery. Trolling involves towing lures or baited hooks behind a moving vessel, whereas handlining involves dangling baited hooks from a stationary or drifting vessel. The evolution and operation of the Hawaii troll fishery are poorly documented. Trolling with lures for pelagic species was a traditional Polynesian fishing method, and Hawaii has since been the site of important innovations in big-game troll fishing techniques (Rizzuto, 1983).

The troll fishery has several components: 1) a recreational-subsistence sector which is poorly differentiated from a part-time commercial sector, 2) a charter sector which is recreational for its patrons but commercial for the operators who sell the catch, 3) a part-time commercial sector, and 4) a full-time commercial sector. Most troll vessels are small (5–8 m, 15–25 ft in length), although charter boats range up to 18 m (59 ft). In the mid-1980's large (20–26 m, 65–85 ft) troll vessels transiting the Hawaii EEZ to fish for albacore, *Thunnus alalunga*, in the North Pacific participated briefly in the Hawaii troll fishery, and vessels from the lobster and bottomfish fisheries also participate intermittently in the Hawaii troll fishery. Troll fishing is conducted throughout the Hawaiian islands, generally within 20 n.mi. of shore.

Commercial catch reports to HDAR do not distinguish between different types of troll fishing (i.e., part-time, charter); only fishermen who sell their catch are required to file reports. Reported annual commercial troll catches were <200 t (0.4 million lb) until 1974 (Fig. 2). During 1975–84 catches ranged between 540–790 t (1.2–1.7 million lb) per year, and then the catch rose to a record peak of almost 1,700 t in 1987. Annual catches declined after 1987 but remained >1,000 t (2.2 million lb) through 1991 (Fig. 2).

The troll fishery catches more mahimahi and wahoo, *Acanthocybium solandri,* than all the other Hawaii pelagic fisheries, about half the blue marlin, and about 20% of the yellowfin tuna landed. Yellowfin tuna composed almost half the commercial troll catch from 1975 to 1980, after which its proportion in the catch declined. The proportion of mahimahi and skipjack tuna in the troll catch increased through the 1980's and 1990's. The charter sector of the troll fishery targets blue marlin, and this species accounted for 54% and 39% of estimated charter catches in 1976 (Cooper and Adams[13]) and 1982 (Samples et al.[14]), respectively. In contrast, 87% of full-time commercial troll catches were yellowfin tuna (Cooper and Adams[13]). Changes in the relative size of the different commercial sectors (i.e., charter, part-time) may influence the species composition of the total reported catch (Fig. 2).

Charter vessels in the troll fishery numbered 102 and 119 in 1976 and 1982, respectively (Cooper and Adams[13]; Samples et al.[14]), compared to an estimated 160 full-time commercial, and 1,544 part-time and recreational-subsistence trollers (combined) in 1976 (Cooper and Adams[13]). Proportions of the total troll catch by these sectors in 1976 were 21% charter, 44% part-time commercial and recreational-subsistence (combined), and 35% full-time commercial. About 70% of the charter catch and 60% of the part-time commercial and recreational-subsistence catch was sold (Cooper and Adams[13]). Growth of the troll fishery makes it unlikely that these proportions represent the current situation but the charter fishery is believed to have grown with the expansion of tourism, and the recreational-subsistence fishery remains important (Pooley, 1993a).

The Handline Fishery

There are several types of pelagic handline fishing in Hawaii today. Day-handline fishing is a revitalization of an ancient Hawaiian method called "palu-ahi" for the use of "palu" (chum) to attract and hook ahi (yellowfin tuna). Palu-ahi fishing is also called "drop stone" fishing. A baited hook on the end of the handline is laid against a stone and the line wound around it. Additional pieces of chum are also wound into the bundle which is then tied in a slip knot (Rizzuto, 1983). The bundle is lowered to the preferred depth (commonly 20–30 m). Then the line is jerked to untie the knot so that the baited hook and chum are released.

Night-handline fishing is called "ika-shibi" from the Japanese names for squid (ika) and tuna (shibi). The ika-shibi fishery is an outgrowth of a squid fishery that probably began in the 1920's and did not target tuna until after World War II (Yuen, 1979). Ika-shibi fishermen attract squid to the fishing vessel with a light and catch the squid on jigs or with a gaff. The squid are then used as bait. Ika-shibi or palu-ahi were not distinguished as separate fishing methods in HDAR statistics

[13]J. C. Cooper and M. F. G. Adams. 1978. Preliminary estimates of catch, sales, and revenue of game fish for the fishing conservation zone around the main Hawaiian Islands, by types of troll and longline vessels and by species. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. 24H, 10 p.

[14]K. C. Samples, J. N. Kusakabe, and J. T. Sproul. 1984. A description and economic appraisal of charter boat fishing in Hawaii. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-84-6C, 130 p.

prior to 1982. Subsequently (1982–91) only a fraction of handline landings were reported as palu-ahi or ika-shibi, and so the handline catch statistics have been combined for this report (Fig. 3).

All handline catches were sold on the Island of Hawaii where the fishery was primarily located until 1971 when the rising price for tuna and reduced shipping costs made air shipment to Honolulu economically feasible. The increasing market for fresh fish boosted the development of Hawaii's fisheries in the mid-1970's (Pooley, 1993a). Annual commercial handline landings reported to HDAR increased from 45 t to almost 1,000 t between 1970 and 1981. Since 1981 commercial handline landings have ranged between 500 and 1,000 t (1.1–2.2 million pounds) with major peaks in 1981, 1983, 1986, and 1991 (Fig. 3). The magnitude of the recreational-subsistence sector of the handline fishery is unquantified, but important (Pooley, 1993a).

The composition of the handline catch is almost exclusively tuna; yellowfin tuna is the predominant species (Fig. 3). Mahimahi and other nontuna species make up less than 10% of the catch. Bigeye tuna are an important component of the handline catch (Yuen, 1979) that is not reflected in HDAR statistics. The ika-shibi catch of bigeye tuna ranged from 63 to 120 t (139–265 thousand lb) in 1973–75 (Yuen, 1979), but HDAR records indicate <23 t of tuna other than yellowfin landed by all handline fishing gears in 1973–75 (Fig. 3). This may represent a lack of reporting, but it is also likely that handline fishermen are lumping both bigeye and yellowfin catches as ahi in their catch reports since these species have the same Hawaiian name.

Most handline vessels are 6–9 m in length and are often crewed by 1–2 persons. Surveys by Yuen (1979) and Ikehara[15] indicate that the ika-shibi fishery grew from 30–40 boats in 1976 to at least 230 boats by 1980. In recent years some of the smaller longline vessels and larger commercial troll vessels have also done some handline fishing.

Day-handline fishing was concentrated around the Island of Hawaii and ika-shibi fishing was concentrated off the Hilo coast of Hawaii in the mid-1980's. Traditionally, handline fishing was conducted within a few km of the coast at locations called "ahi koas" where yellowfin and bigeye tuna were especially available. The State (HDAR) encouraged expansion into new areas in the late 1980's. Handline fishing techniques have spread and are now practiced on Kauai and Maui. Some of the largest handline vessels have extended their range to fish around seamounts and weather buoys 100–200 n.mi. from the coast. This new expansion of the fishery may have contributed substantially to the peak in catch reported in 1991, which followed four years of continuous decline (1987–90, Fig. 3). Some fishermen feel that there may soon be too many participants in the handline fishery, and the WPRFMC has been asked to institute a control date for this fishery in anticipation of possible limited-entry management.

The increasing cost of insurance has been a problem for small-vessel commercial fishermen. Many operators could not afford to keep up with rising insurance costs in the late 1980's and some, who weren't willing to risk their assets, stopped fishing. Another economic problem for the commercial troll and handline fisheries is a condition called burnt tuna syndrome (BTS) which discolors and gives a bad taste to sashimi as well as reduces its shelf life (Nakamura et al., 1987). BTS is prevalent in troll and handline-caught fish over 35 kg and uncommon in longline-caught fish. Proper handling can ameliorate BTS (Nakamura et al., 1987) and research is under way to find means to prevent it (Watson et al., 1988).

Abundance and Availability

Background

The primary concern in Hawaii's pelagic fisheries today is whether fishing effort should be limited to protect the local abundance or availability of fish (Pooley, 1990; Boggs[3], In press; Skillman et al., 1993). Increased catches by Hawaii's pelagic fisheries over the last two decades could hypothetically have reduced the abundance of local stocks, if such stocks exist. It is more likely that Hawaii's fisheries exploit locally available fractions of Pacific-wide stocks (Wetherall and Yong[16]; Skillman and Kamer[4]; Boggs, In press). In the latter case immigration may limit yields and excessive fishing effort might result in reduced CPUE (Sathiendrakumar and Tisdell, 1987; Boggs[3], In press). In either case, excessive local fishing pressure should be evidenced by corresponding declines in local CPUE.

Several studies suggest that local fishing pressure can reduce local CPUE for wide-ranging pelagic species (Wetherall and Yong[16], Squire and Au, 1990; Boggs[3], In press; Skillman and Kamer[4]). Many of these studies also found that the relative abundance (CPUE) of fish over a wider geographic area could statistically account for much of the variation in local CPUE. Relative abundance estimated as CPUE is confounded with catchability, so that widespread environmental effects on catchability, as well as true changes in stock-wide abundance, could explain the statistical relationships between Pacific-wide CPUE and local CPUE.

The following examination of Hawaii CPUE time series extending from the early years of each fishery to the present was undertaken to show whether or not the expansion of Hawaii's pelagic fisheries over the last two decades, 1970–91, corresponded with declines in local CPUE. Major declines in local CPUE were often found to predate local fisheries expansion and corresponded with declines in the CPUE of more widespread fisheries. Over the last few decades the time series indicated much interannual variation and little net change in CPUE.

[15]W. N. Ikehara. 1981. A survey of the ika-shibi fishery in the State of Hawaii, 1980. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-82-4C, 12 p.

[16]J. A. Wetherall and M. Y. Y. Yong. 1983. An analysis of some factors affecting the abundance of blue marlin in Hawaiian waters. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-83-16, 33 p.

Calculation of Hawaii CPUE

Longline CPUE was calculated from a combination of data sources including published literature, HDAR data summaries, and NMFS market sample estimates. Troll and handline CPUE was calculated solely from HDAR data summaries because these data identify troll and handline gears (NMFS estimates do not). HDAR summaries do not differ substantially (in total) from NMFS estimates for combined troll and handline (Pooley, 1993b). All available summary statistics (HDAR and NMFS) were used in the present study, but no new analyses of raw data were conducted.

To calculate CPUE in the early longline fishery (e.g., Fig. 4A), Hawaii longline data on two size-classes of vessels for 1948–56 (Shomura, 1959) were combined, and catch was converted from number of fish to weight. The results were similar to 1948–52 CPUE data published by Otsu (1954). The CPUE based on combined data differed little from the data for large vessels (Shomura, 1959), and although vessel size is important, it was ignored in the present study because data summaries by vessel size for subsequent years were not available.

Longline data summaries for 1959–89 and NMFS market sample longline estimates for 1987–89 (Ito[2]; Pooley, 1993b) were used to calculate longline CPUE for later years (e.g., Fig. 4A). HDAR longline data after 1978 are believed to represent only a fraction (ca. <20% Fig. 1A) of the fishery, but complete coverage is not required to calculate a representative CPUE index. No other data were available for 1979–86.

Two longline CPUE indices for 1987–89 were calculated, one from HDAR data, and another from NMFS estimates (e.g., Fig. 4A). The HDAR series from 1979 through 1989 best indicates the longline CPUE trend for those years, whereas the 1987–89 NMFS data best indicate recent CPUE for comparison with the earlier years 1947–78 (e.g., Fig. 4A). Longline CPUE was not calculated for 1990–91 because in these years a fraction of the longline fishery changed fishing methods to target broadbill swordfish, and additional work is needed to categorize the subset of the longline trips in 1990–91 that targeted tuna. The Hawaii swordfish fishery has developed too recently (Fig. 1B) for any trend in CPUE to be indicative of availability.

HDAR data summaries for the troll and handline fisheries from 1970 to 1991 were used to calculate CPUE time series for these fisheries (e.g., Fig. 4B). Prior data are not very important because the troll and handline fisheries were so small before 1970.

CPUE was calculated as the total annual longline, troll, or handline catch (by weight) of a species divided by total annual effort. Effort was estimated either as the annual number of fishing trips (troll and handline fisheries) or the annual number of hooks (longline fishery). Longline hook totals were calculated from the number of trips multiplied by estimates of hooks per trip (Boggs and Hawn[17]). Changes in the amount of gear deployed per trip obtained from descriptions of the fishery (June, 1950; Otsu, 1954; Shomura, 1959; Hida, 1966; Yoshida, 1974; Hawaii Opinion[8]; Kawamoto et al.[11]; Ito[2]) were used to estimate and interpolate the typical quantity of hooks per trip from 1947–89 (Boggs and Hawn[17]). Corrections for changes in efficiency with fishing depth are being developed (Boggs, 1992; Boggs and Hawn[17]) but are not used here.

The NMFS market sampling program counted fishing trips as each occasion that a vessel landed and sold its catch. HDAR data summaries included each unique date of landing for each unique license number in the records as a trip if any pelagic species were caught. Trip counts from both NMFS and HDAR data did not include trips with no catch of any pelagic species (prior to 1992). Such trips were seldom reported. For any given species the count of trips did include trips that did not catch that species but caught another pelagic species.

The lack of data on the number of trips that caught no pelagic species may have caused errors in the effort estimates, but the CPUE time series based on those data may still be indicative of relative changes in availability. The number of zero-catch trips should have been negatively correlated with catch per successful trip (CPUE) since both were dependent on fish availability. Thus, the CPUE time series should still reflect real trends, especially if zero-catch trips represented a modest fraction of total effort. No bias was caused by changes in the fraction of zero-catch trips reported because none were counted. Uchida (1976) found a high correlation between Hawaii pole-and-line CPUE including zero-catch trips and CPUE excluding zero-catch trips.

The effort data for the troll and handline fisheries contained no standardization of trips as a unit of effort, and the longline effort data were standardized only to account for changes in the number of hooks per trip (Boggs and Hawn[17]). Changes in troll or handline fishing power, (number of lines, hooks, or hours, per trip, etc.) or changes in longline, troll, or handline efficiency (class of vessel, gear type, target depth, fishing strategy) may have resulted in biases in the CPUE time series, obscuring trends or giving the appearance of trends where none existed. Although much of the data presented here are decades old, the estimates of CPUE must be considered preliminary until the raw data are reanalyzed and effort standardized to account for changes in efficiency (e.g., Uchida, 1976; Suzuki, 1989).

Despite problems with the nonstandardized CPUE indices, they are the only data currently available. Nonstandardized Hawaii CPUE data for several different gear types often show a similar pattern (Skillman and Kamer[4]) or reflect a pattern similar to that of more sophisticated CPUE indices from nearby fisheries (Wetherall and Yong[16]). These examples suggest that some true information on relative availability is represented by nonstandardized CPUE indices for Hawaii's fisheries.

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[17]C. H. Boggs and D. R. Hawn. Changes in fishing power and estimates of fishing effort for the Hawaii longline fishery, 1948–91. NMFS Honolulu Laboratory, 2570 Dole St., Honolulu HI 96822–2396, unpubl. manuscr.

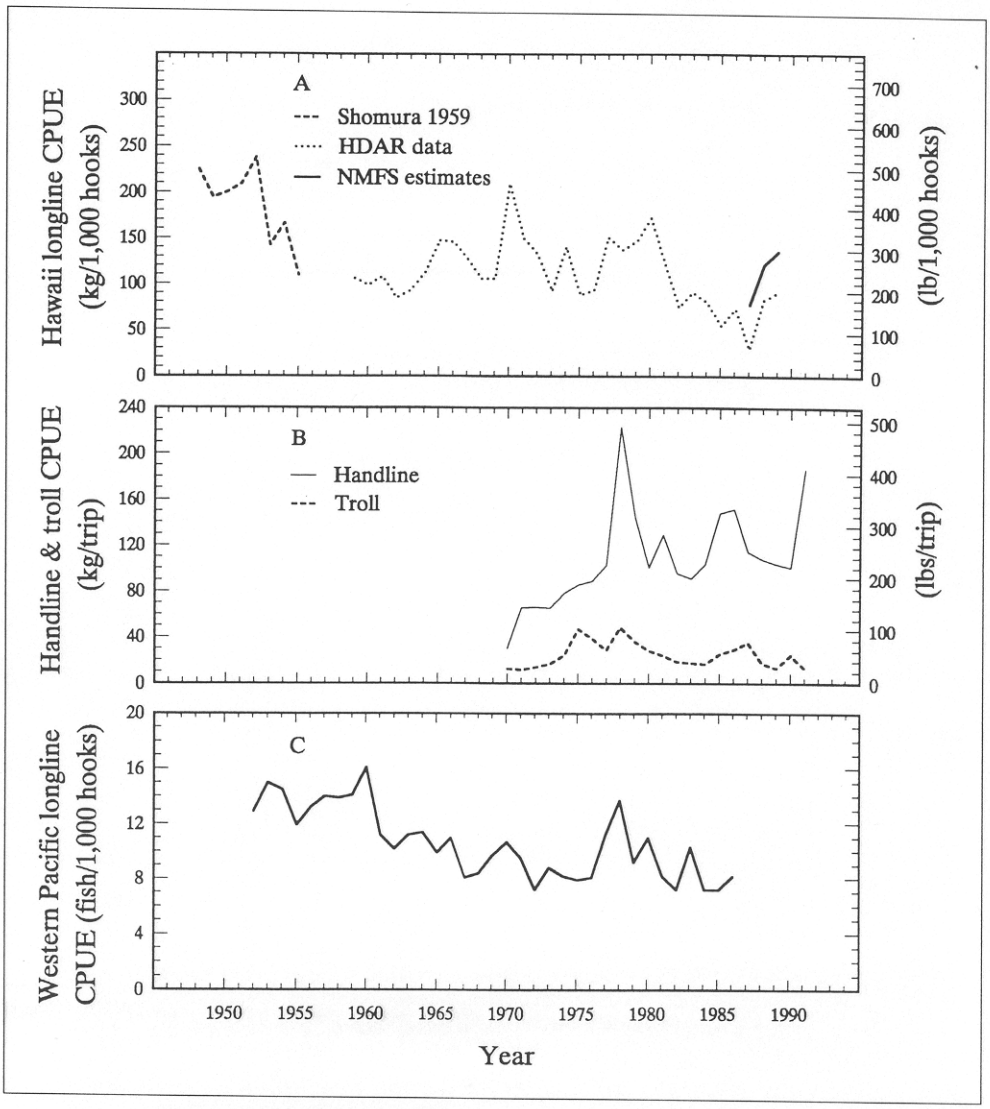

Figure 4.— Yellowfin tuna CPUE time series showing A) Hawaii longline CPUE (kg and lb per 1,000 hooks) from 1948–55 (Shomura, 1959), 1959–89 (HDAR data), and 1987–89 (NMFS estimates); B) Hawaii handline and troll CPUE (in kg and lb per trip) from 1970 to 1991 (HDAR data), and C) western Pacific longline CPUE (in no. fish per 1,000 hooks) in the Japanese fishery from 1952 to 1986 (Suzuki, In press).

CPUE Time Series

Yellowfin tuna CPUE in the Hawaii longline fishery declined between the 1950's and the early 1960's and then ranged between 90–210 kg/1,000 hooks with no clear trend from 1959–81 (Fig. 4A). Yellowfin tuna CPUE based on HDAR longline data declined from 1980–87, recovering somewhat in 1988–89. The more accurate longline CPUE index based on NMFS estimates indicated a return to average longline CPUE in 1988–89 (Fig. 4A).

The 1980–87 decline in yellowfin tuna CPUE for the Hawaii longline fishery occurred during a period of troll (Fig. 2) and longline (Fig. 1A) fishery expansion. However, the subsequent increase in longline CPUE in 1988–89 occurred during the period of greatest longline fishery expansion, while troll and handline fishing levels remained very high. Thus low levels of Hawaii longline CPUE did not correspond consistently with periods of higher fishing pressure.

Yellowfin CPUE in the Hawaii troll and handline fisheries (Fig. 4B) increased from 1970 to 1978 and subsequently declined through 1984. After 1984 Hawaii handline and troll CPUE increased to peaks in 1986 and 1987, respectively, and then declined (Fig. 4B). These declines coincided with expansion of Hawaii's longline, troll, and handline fisheries. However, handline CPUE subsequently increased from 1884 to 1986 and troll CPUE increased from 1984 to 1987 despite continued expansion of the troll and longline fisheries. During the period of greatest expansion of the longline fishery

(1987–89) troll and handline CPUE declined (Boggs[3]). However, troll CPUE returned to a typical level in 1990 and handline CPUE reached a high level in 1991 (Fig. 4B) despite continued high levels of fishing by all three pelagic fisheries. Thus availability (CPUE) of yellowfin tuna in Hawaii did not appear to be closely related to changes in local fishing pressure.

Local availability of yellowfin tuna seemed to follow patterns in the overall abundance or catchability of the stock as indicated by CPUE in wide-ranging Japanese longline and purse seine fisheries. Standardized yellowfin tuna CPUE in the longline fishery of Japan in the western Pacific from 1952 to 1986 (Suzuki, In press) indicated a drop in CPUE between the 1950's and early 1960's, and a decline in the early 1980's (Fig. 4C) similar to that seen in Hawaii longline CPUE data (Fig. 4A). In more recent years (1983–88), Hawaii troll CPUE followed a pattern that was similar to Japanese western Pacific purse-seine CPUE (Suzuki, In press; Boggs, In press; Skillman et al., 1993). Environmental anomalies affecting catchability may contribute much of the corresponding variation seen in CPUE time series, such as the peak in yellowfin tuna CPUE that occurred in 1978 (Fig. 4A and 4B).

An initial increase in bigeye tuna CPUE in the early years of the Hawaii fishery (Fig. 5A) was explained by Shomura (1959) as the result of a change in the area fished during winter as fishermen learned to target bigeye tuna. Set depth also changed between the late 1940's and early 1950's as the practice of buoying up the middle of each basket of gear with an extra float (June, 1950) was abandoned. Deep gear has been shown to be more efficient than shallow gear in catching bigeye tuna (Hanamoto, 1976; Suzuki et al., 1977; Boggs, 1992).

Bigeye tuna CPUE in the Hawaii longline fishery (Fig. 5A) and in the wide-ranging Japanese longline fishery (Fig. 5B) (Miyabe, In press) both showed downward trends from the late 1950's through the 1960's, a distinct drop in CPUE in 1970, a stable period in the mid-1970's, record low levels in 1980–81, and a slight recovery in the mid 1980's. The correspondence between the bigeye tuna CPUE statistics for the entire Pacific and for Hawaii is remarkable, and strongly suggests that local pelagic fish availability is linked to the abundance of a widespread population. An alternative hypothesis that could apply to all of the pelagic species is that CPUE variation is due to widespread changes in catchability associated with environmental trends.

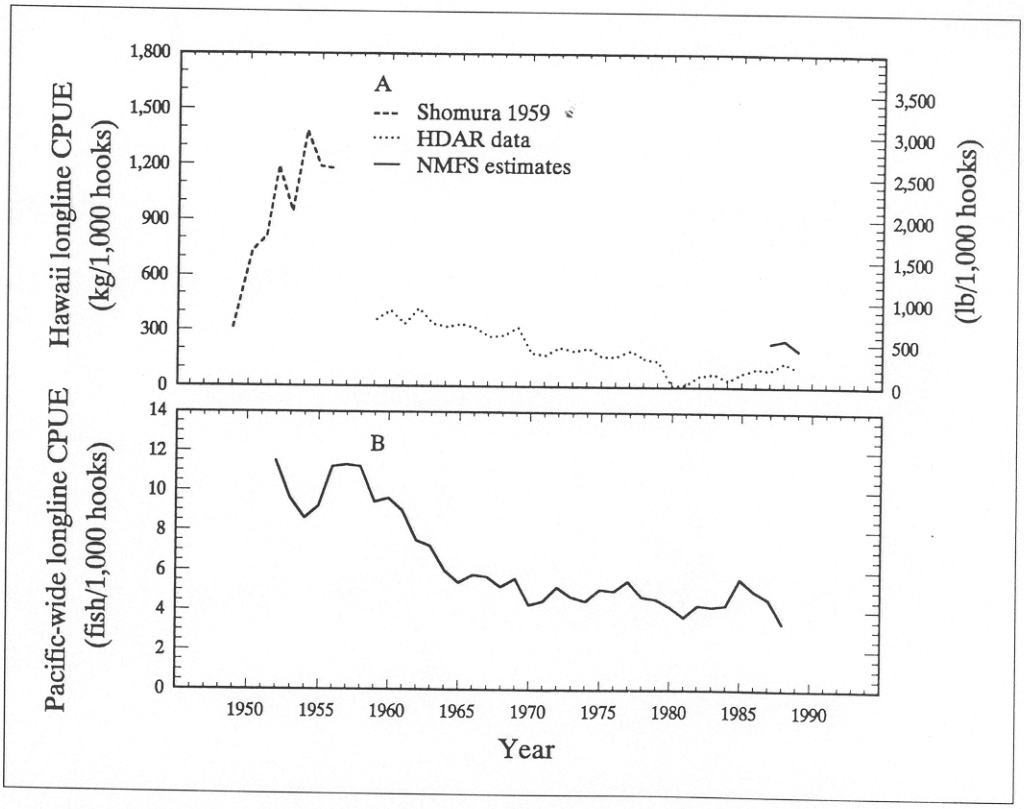

Figure 5.— Bigeye tuna CPUE time-series showing A) Hawaii longline CPUE (in kg and lb per 1,000 hooks) from 1949 to 1956 (fiscal years ending in June, Shomura, 1959), 1959–89 (HDAR data), and 1987–89 (NMFS estimates), and B) Pacific-wide longline CPUE (in no. fish per 1,000 hooks) in the Japanese fishery from 1952 to 1987 (Miyabe, In press).

For bigeye tuna, the Hawaii longline CPUE continued to recover in the late 1980's (Fig. 5A), whereas Japanese CPUE declined (Fig. 5B). The increasing trend in Hawaii bigeye tuna CPUE in the 1980's brought the CPUE index based on NMFS wholesale market sample back up to a level slightly higher than the average for 1970–78 (Fig. 5A) suggesting that local longline fishery expansion in the 1980's did not negatively affect bigeye tuna availability.

The blue marlin CPUE time series for the Hawaii longline fishery (Fig. 6A) showed peaks and minima for the same years as the Hawaii troll CPUE time series (Fig. 6B). The close correspondence between blue marlin CPUE in these two fisheries suggests that both CPUE time series reflected true changes in availability or catchability despite the limitations of the available statistics.

Blue marlin (Fig. 6A) and striped marlin (Fig. 7A) CPUE in the Hawaii longline fishery followed a pattern similar to Japanese longline CPUE data (Fig. 6C and 7B), as noted by Wetherall and Yong[16] and Skillman and Kamer[4]. This correspondence was not limited to the long-term decline in CPUE characteristic of longline fisheries in all oceans. Rather, for striped marlin both increases and decreases in CPUE in the Hawaii longline fishery (Fig. 7A) corresponded with CPUE changes in the North Pacific Japanese longline fishery (Fig. 7B).

The sharp increase in longline CPUE for blue and striped marlin in 1989 probably reflected the increased use of monofilament longline gear without

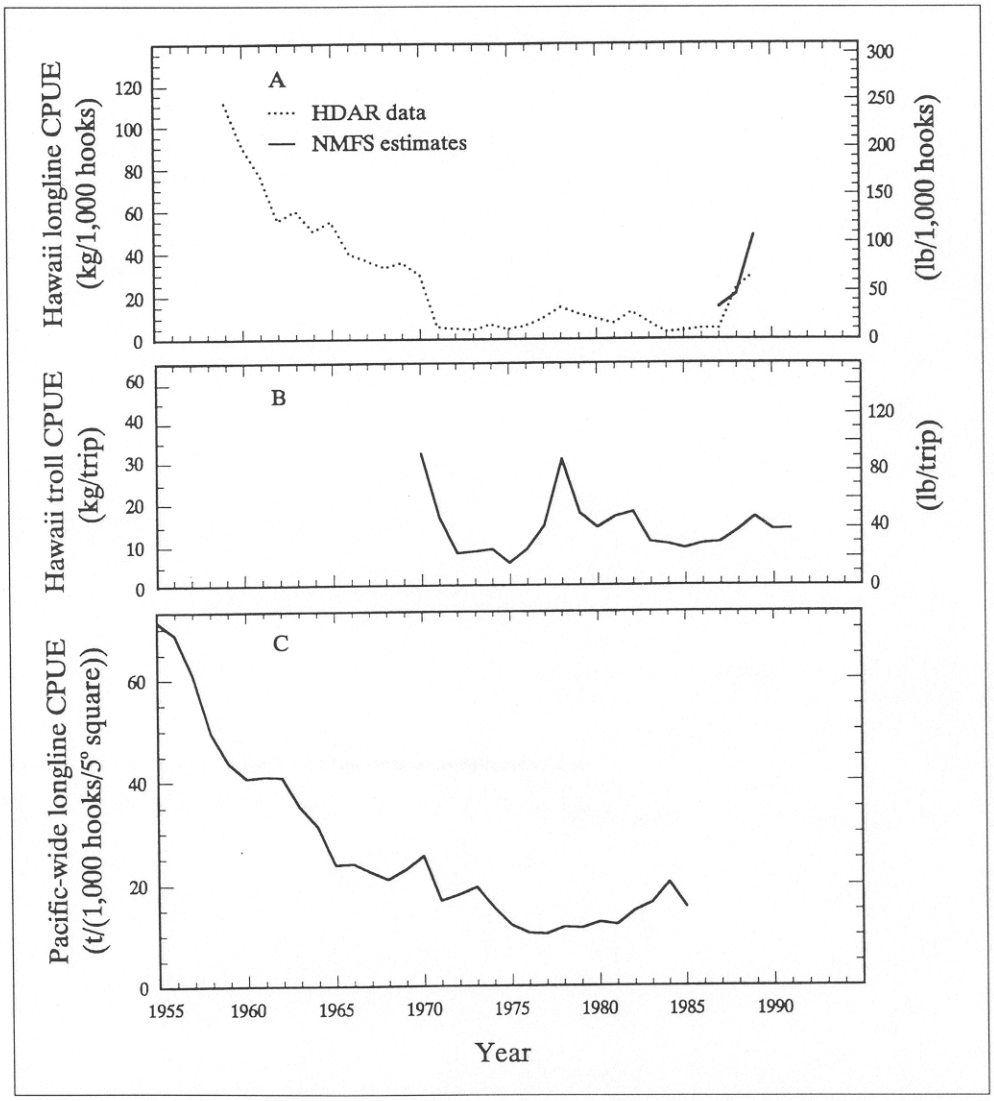

Figure 6.— Blue marlin CPUE time-series showing A) Hawaii longline CPUE (kg and lb per 1,000 hooks) from 1959 to 1989 (HDAR data), and 1987–89 (NMFS estimates), B) Hawaii troll CPUE (in kg and lb per trip) from 1970 to 1991 (HDAR data), and C) Pacific-wide longline CPUE (in t per 1,000 hooks per 5° square) in the Japanese fishery from 1955 to 1985 (Suzuki, 1989).

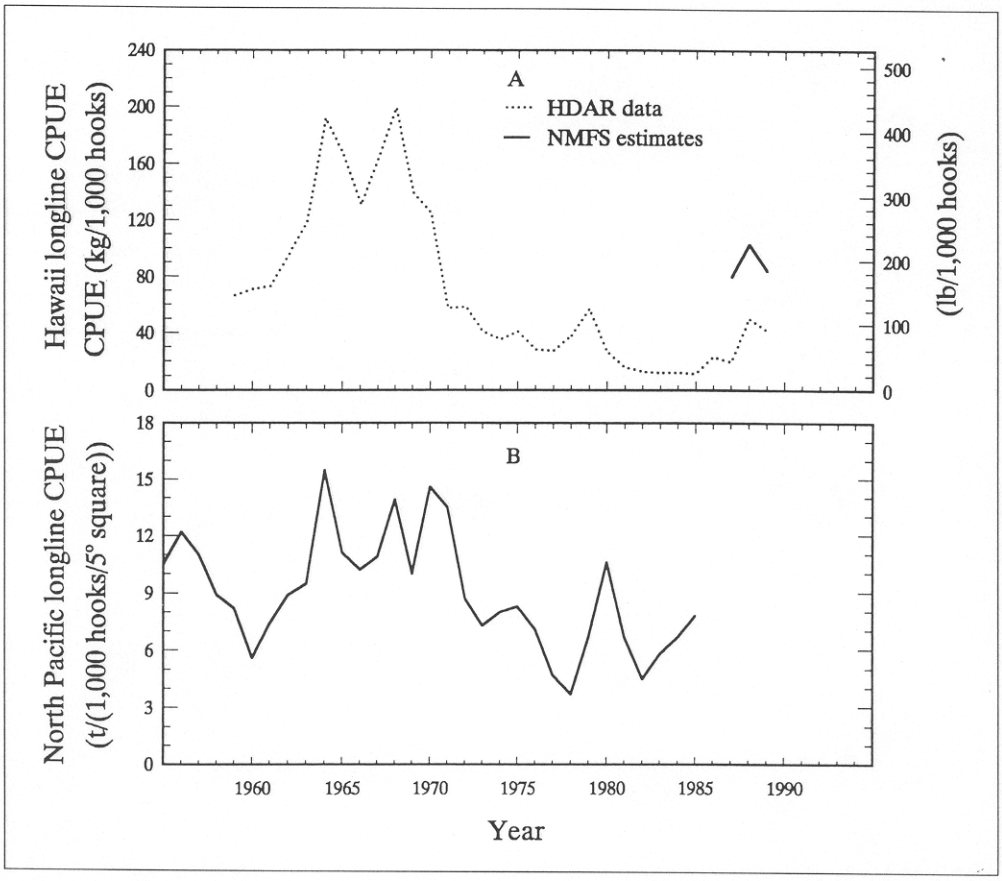

Figure 7.— Striped marlin CPUE time series showing A) Hawaii longline CPUE (in kg and lb per 1,000 hooks) from 1959 to 1989 (HDAR data), and 1987–89 (NMFS estimates), and B) North Pacific longline CPUE (in t per 1,000 hooks per 5° square) in the Japanese fishery from 1955 to 1985 (Suzuki, 1989).

line-throwers, which resulted in shallower sets and increased the efficiency of the gear for marlin (Suzuki, 1989; Boggs, 1992). Blue marlin CPUE in the troll fishery appears to be at a normal level and relatively stable (Fig. 6B) despite the expansion of Hawaii's pelagic fisheries.

Mahimahi CPUE in the Hawaii longline fishery (Fig. 8A) reached a peak in 1972 and a minimum in 1988 that were mirrored in the Hawaii troll and handline CPUE data (Fig. 8B). Troll and handline CPUE data corresponded with each other very closely. Mahimahi CPUE appears to be increasing in both the troll and handline fisheries.

Outlook for the Pelagic Fisheries

The absence of clear declining trends in local CPUE associated with local fishery expansion, combined with distinctly seasonal variations in CPUE (Shomura, 1959; Yoshida, 1974; Skillman and Kamer[4]), suggests that pelagic fish availability in Hawaii was most strongly affected by factors other than local fishing pressure. Anomalies in whatever factors control seasonal availability could also be the major source of interannual variation in CPUE. Research leading to an ability to forecast changes in pelagic fish availability could ameliorate fishermen's concerns that local fishing pressure has decreased fish availability. Development of new methods to locate or predict productive fishing areas could increase the yield and efficiency of Hawaii's pelagic fisheries. However, greatly increased fishing efficiency and yield might then have some negative impact on local fish availability.

Decreases in fish availability caused by local fishing pressure may have been obscured by biases such as increased fishing power, expansion into more productive fishing grounds, economic influences on fishing operations, and environmental influences on local abundance and catchability. Further analysis of catch and effort data as well as an improved data collection system are needed to attempt to account for such biases. However, the parsimonious explanation of the available data is that locally exploited stocks have not yet been impacted by the expansion of Hawaii's pelagic fisheries.

Long-term declines in the overall apparent abundance of many pelagic species occurred several decades ago (Figs. 4C, 5C, and 6C), before the latest (1970–91) expansion of Hawaii's pelagic fisheries. Pacific-wide declines in CPUE do seem to affect Hawaii's fisheries, and could reflect full exploitation or even overexploitation of the stocks. However, reduction of local

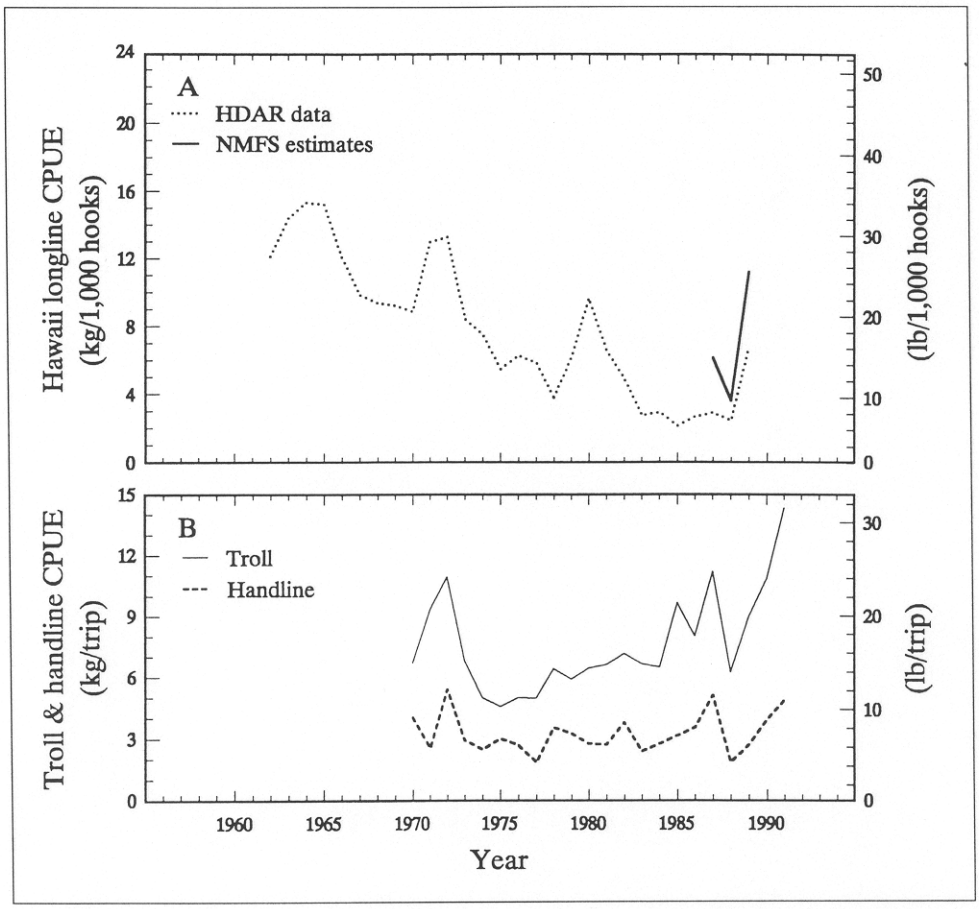

Figure 8.— Mahimahi CPUE time series showing (A) Hawaii longline CPUE (kg and lb per 1,000 hooks) from 1962 to 1989 (HDAR data), and 1987–89 (NMFS estimates), and (B) Hawaii troll and handline CPUE (in kg and lb per trip) from 1970 to 1991 (HDAR data).

fishing effort from current levels would not substantially affect stock-wide abundance because of the relatively small scale of Hawaii's pelagic fisheries. An exception might be the nighttime longline fishery for broadbill swordfish, which has been operating for too short a time to evaluate. However, with annual landings of 4,400 t and continued growth, the Hawaii swordfish fishery may be expected to contribute significantly to total fishing mortality on the stock. Historically, maximum total Pacific yields of swordfish have been on the order of 20,000 t per year (Bartoo and Coan, 1989).

If fishery managers can prevent physical conflicts between the longline and small-vessel troll and handline fisheries in Hawaii (Pooley, 1990; Skillman et al., 1993), and if adequate markets continue to support the profitable operation of all fishery sectors, then Hawaii's pelagic fisheries should continue to expand. No strong evidence suggests that the local availability of fish is a factor limiting further expansion. However, this optimistic assessment is based on statistics and analyses that may be inadequate; therefore, better fishery monitoring systems are needed.

Acknowledgments

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