TUNA AND BILLFISH SUMMARIES OF MAJOR STOCKS

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Editor

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Parks

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I. Introduction

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I. THIS VOLUME

This volume is a collection of individually authored reports on major tuna and billfish stocks and associated fisheries of interest to the United States. Each report uses information and data assembled from numerous sources to highlight important aspects which the authors deemed important to understand the fishery and stock condition. An overview of major events and economics on a global scale which shaped the tuna industry over the last few years is provided first to help the reader understand and integrate the information presented in each report. A bibliography is provided at the end of each report to guide the reader to additional information.

The authors, scientists of the National Marine Fisheries Service, are experts who have synthesized information and data from workshops, international meetings, scientific publications and elsewhere to produce a clear concise summary for major tuna and billfish stocks and fisheries for the reader. A brief summary of the current catch levels relative to the expected Maximum Sustained Yield (MSY) for a number of these stocks is presented in Table 1. Additionally, limited comments are provided to help the reader understand the condition of each stock. The individual reports should be reviewed for a fuller summary.

2. BACKGROUND

Tuna and billfish are distributed and fished throughout all the major oceans of the world and are considered mobile or highly migratory with movements of over 1,500 miles reported for some species.

Globally, the tunas and billfishes are generally divided into tropical and temperate groups. The most important tropical tunas include yellowfin tuna *(Thunnus albacares)*, skipjack tuna *(Katsuwonus pelamis)*, and bigeye tuna *(T. obesus)*. Important temperate tunas include albacore *(T. alalunga)* and bluefin tuna *(T. thunnus and maccoyii)*. Billfish are generally considered tropical species. The major billfishes, both sport and commercial, include the marlins, striped *(Tetrapturus audax)*, blue *(Makaira nigricans)*, black *(M. indica)* and white *(T. albidus)*, the sailfish *(Istiophorus platypterus)* and spearfish *(T. sp.)*, and swordfish *(Xiphias gladius)*. Virtually all these species of tunas and billfish are the target of both commercial and sport fisheries around the world.

Combined catches of tunas, tuna-like species, and billfish (34 species) exceeded 3,093,067 metric tons (mt) in the mid- 1980's. The major tropical species accounted for over 1,839,073 mt and the major temperate species accounted for 259,472 mt. Billfish catches worldwide were 106,271 mt.

The tunas and billfishes are harvested by industrial, recreational and artisanal fisheries using a great variety of fishing gears. The largest tuna producing countries include Japan, United States, Taiwan, Korea, France and Spain, all of which operate distant water fleets fishing the various populations or stocks of the major species in multiple locations. Figures 1 through 6 show the general distribution of the major tuna and billfish species as well as the locations of major surface (purse seine and pole-and-line gears) and subsurface (longline gear) fisheries. From the figures it is quite evident that the tunas and the associated fisheries are distributed world-wide.

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4. FIGURES

5. ACKNOWLEDGMENTS

The preparation of any edited volume is only possible with the help of many people. I wish to thank those assisting in the production of this volume, particularly, Roy Allen, Iz Barrett, Jean Davis, Shirley Gray, Henry Orr, Cliff Ratcliffe, Ken Raymond, Gary Sakagawa and the individual authors.

Table 1. Summary of Exploitation Levels for Major Tuna Stocks.

Major stock	Catch level relative to estimated msy (mt)	Notes on stock or fishery conditions
Pacific Ocean		
Yellowfin Tuna		
Eastern	MSY:175,000; Recent catch 240,000	Recent catch higher due to increased yield per recruit and higher than average recruitment. No apparent stock problems.
Central-Western	MSY:unknown; Recent catch 200,000+	Higher catch possible, especially with improving yield per recruit.
Skipjack Tuna		
Eastern	MSY:unknown; Recent catch 55,000	Greater catch expected if smaller size fish are caught until recruitment is affected.
Central-Western	MSY:unknown;	Catch declining due to lower effort. Recent catch 600,000+
Albacore		
North	MSY:95,000-150,000; Recent catch 75,000	Current effort is low; higher catches are possible.
South	MSY:35,000+; Recent catch 30,000	Mostly longline catch, higher catches with surface fishery likely.
Bigeye Tuna	MSY:unknown; Recent catch 122,251	Potential unknown. Current catch about 30% lower than peak catch in in the 1970s.
Striped Marlin	MSY:24,000+; Recent catch 20,000	Current catch about 1/2 average 1965-1971 catch. Effort down.
Swordfish	MSY:20,000+; Recent catch 19,000	Catch increasing. CPUE appears near level.
Indian Ocean		
Yellowfin Tuna	MSY:unknown; Recent catch 100,000	Potential unknown, catches and effort up since 1982.
Skipjack Tuna	MSY:unknown; Recent catch 136,000	Potential unknown catches and effort up since 1982.
Bigeye Tuna	MSY:40,000+; Recent catch 42,000	Potential unknown, recent catches up due to increased effort.
Albacore	MSY:20,000+; Recent catch 10,000	Effort down in recent years.

Major stock	Catch level relative to estimated msy (mt)	Notes on stock or fishery conditions
Swordfish		
	MSY:unknown; Recent catch 3,000	Unknown potential.
Atlantic Ocean		
Yellowfin Tuna		
Eastern	MSY:120,000+; Recent catch 96,000	Recent effort lower; catch can be increased; minimum size limit.
Western	MSY:unknown; Recent catch 38,000	Catch steadily increasing; potential unknown; minimum size limit.
Bigeye Tuna		
	MSY:69,000-155,000; Recent catch 73,000	Catch increasing; effort lower in surface fishery; minimum size limit.
Skipjack Tuna		
	MSY:unknown; Recent catch 139,000	Catch increasing in west; unknown potential.
Albacore		
North	MSY:50,000+; Recent catch 40,000	Catch increase possible; effort currently down.
South	MSY:24,000+; Recent catch 25,000	Fishery predominantly longline; additional catch likely with surface effort.
Bluefin Tuna		
East and Med.	MSY:not calculated; Recent catch 23,000	Fishery under regulation for minimum size, mortality rates;stock rebuilding
West	MSY:not calculated; Recent catch 3,000	Fishery under regulation for minimum size and mortality rates; stock size small but rebuilding.
Swordfish (incl. Med.)		
	MSY:not calculated; Recent catch 34,000	Potential unknown; current fishery stable; some local regulations (USA, Italy).

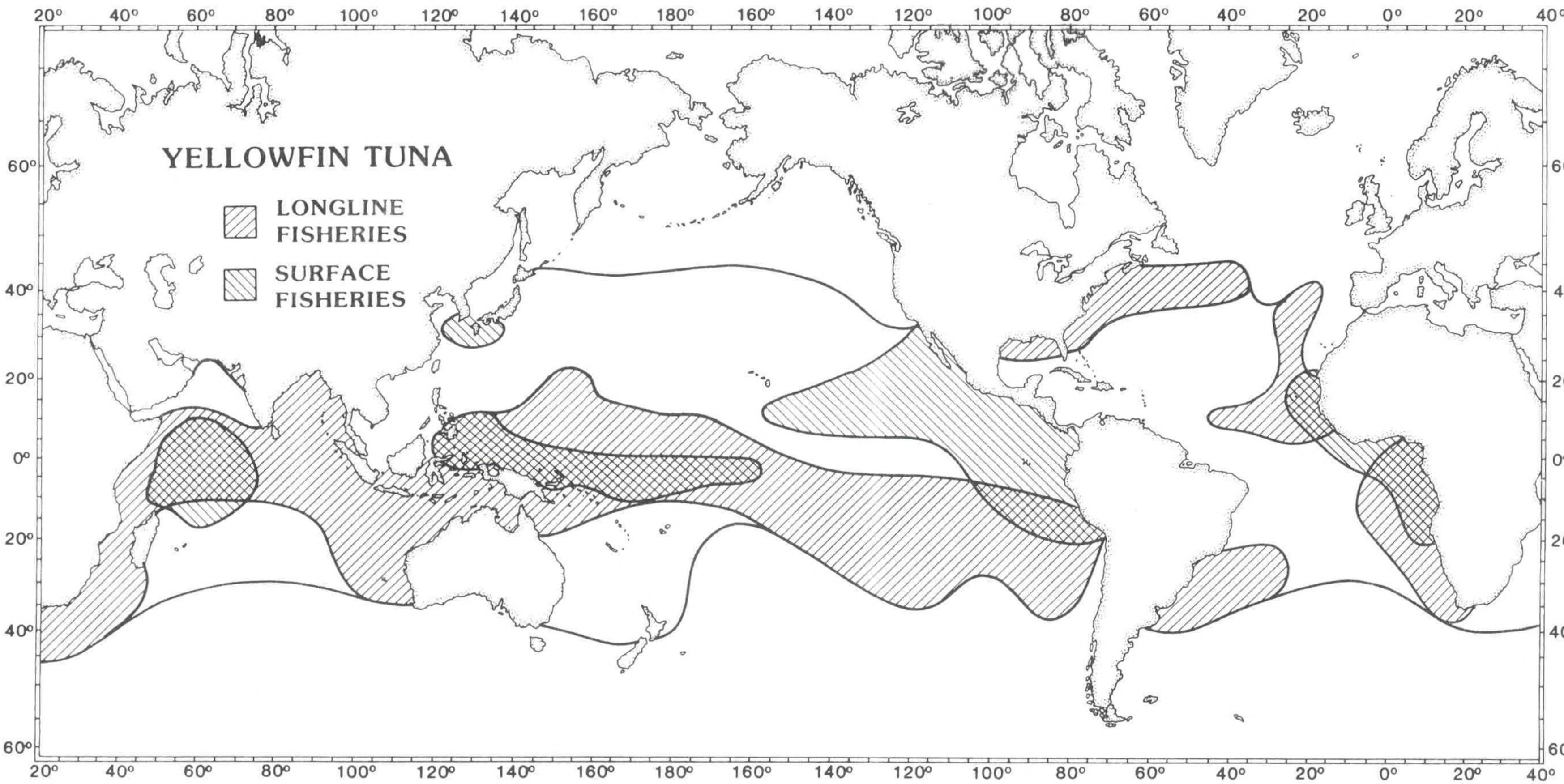
YELLOWFIN TUNA
LONGLINE FISHERIES
SURFACE FISHERIES
20° 40° 60° 80° 100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40°
60° 40° 20° 0° 20° 40° 60°

FIGURE 1

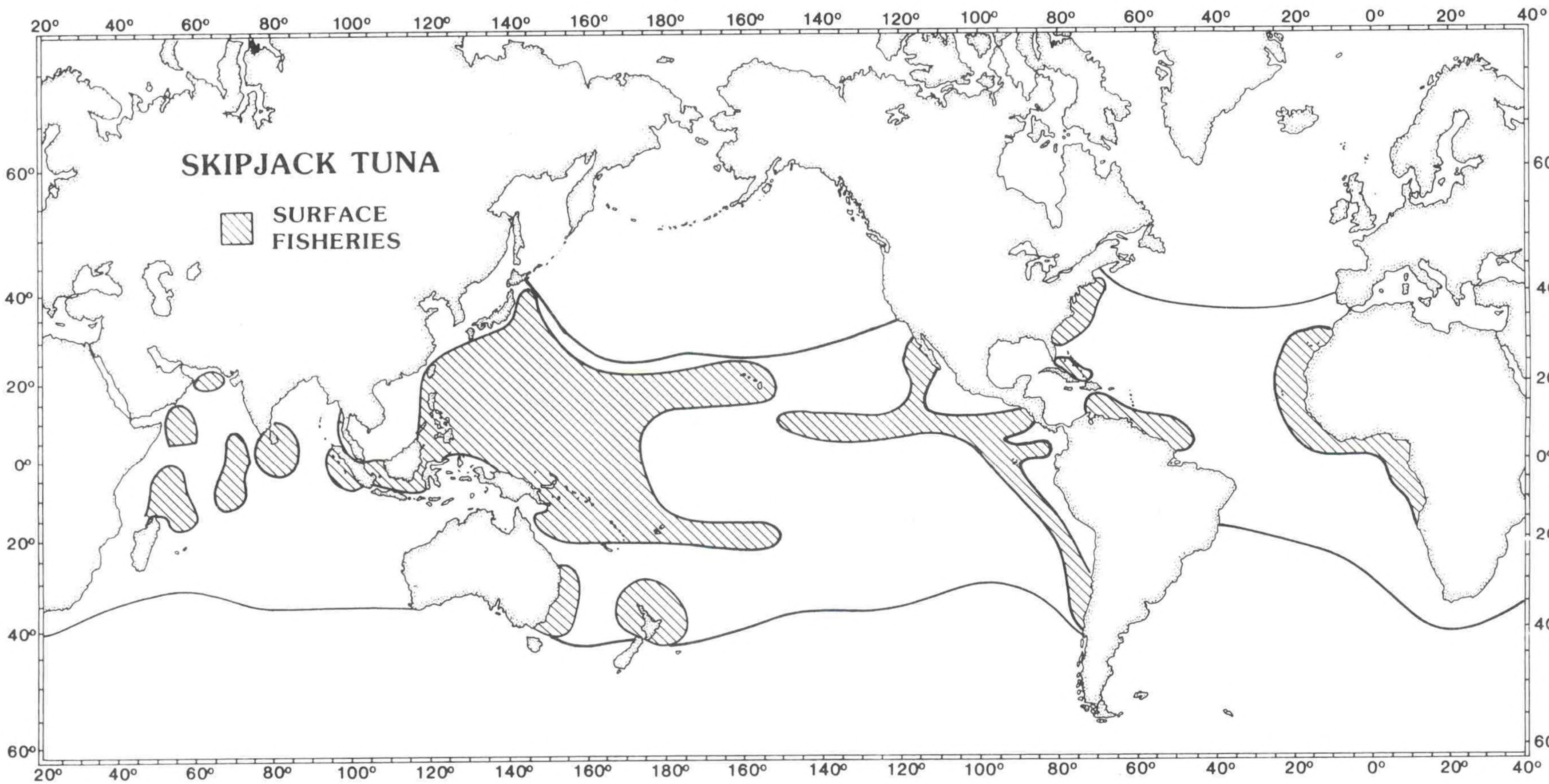

FIGURE 2

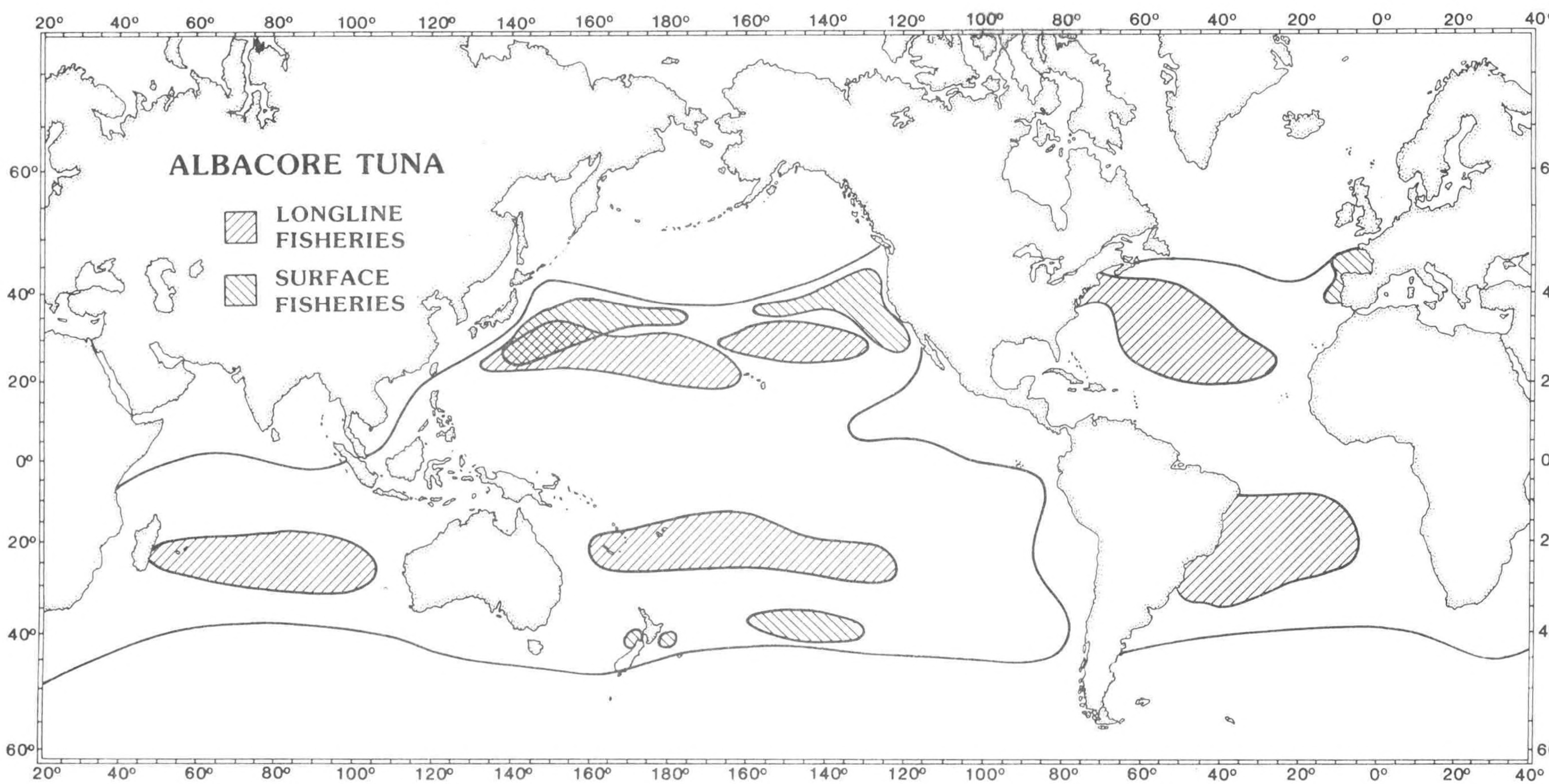
ALBACORE TUNA
LONGLINE FISHERIES
SURFACE FISHERIES
20° 40° 60° 80° 100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40°
60° 40° 20° 0° 20° 40° 60°

FIGURE 3

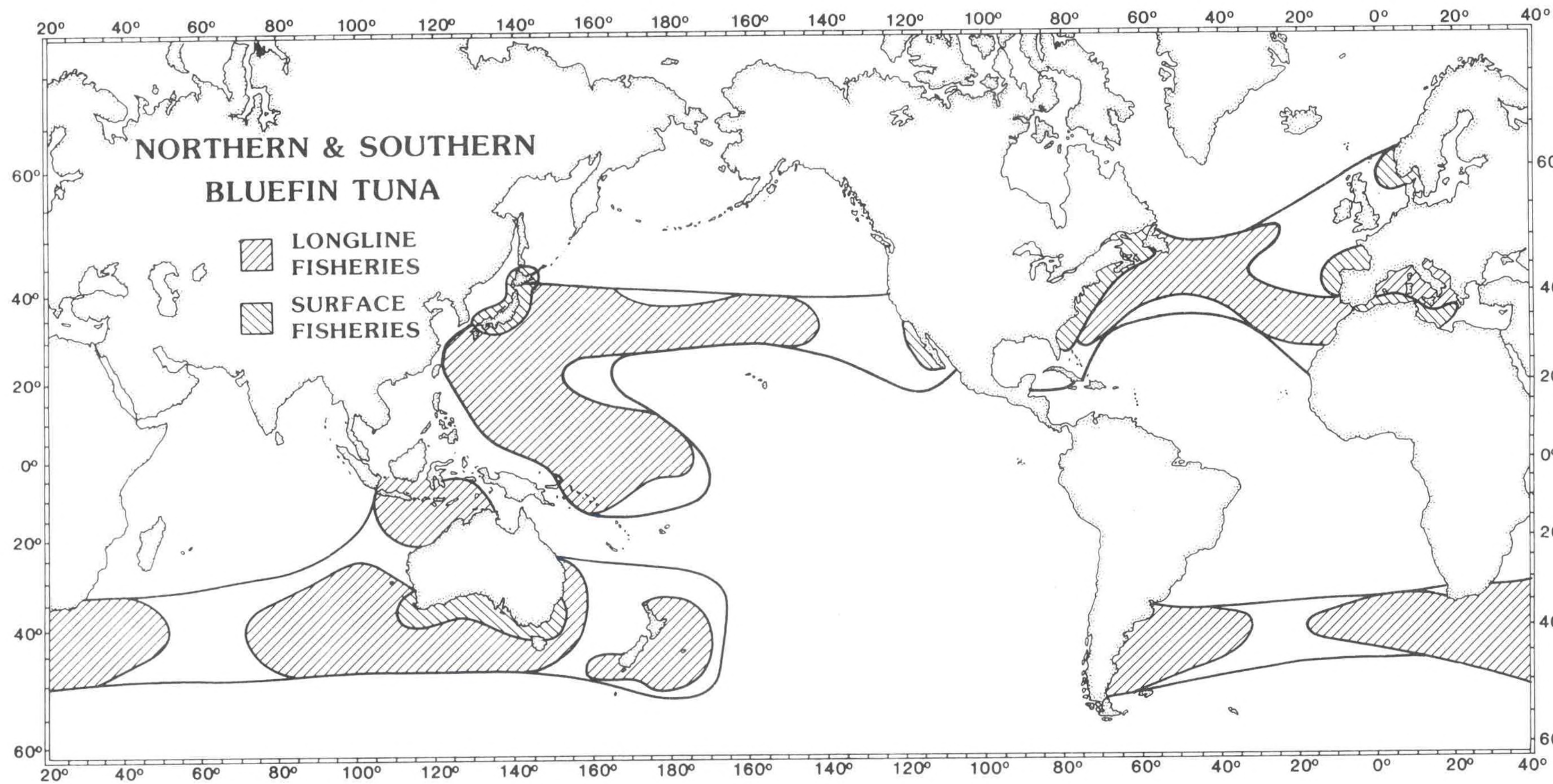
NORTHERN & SOUTHERN
BLUEFIN TUNA
LONGLINE
FISHERIES
SURFACE
FISHERIES
20° 40° 60° 80° 100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40°
60° 40° 20° 0° 20° 40° 60°

FIGURE 4

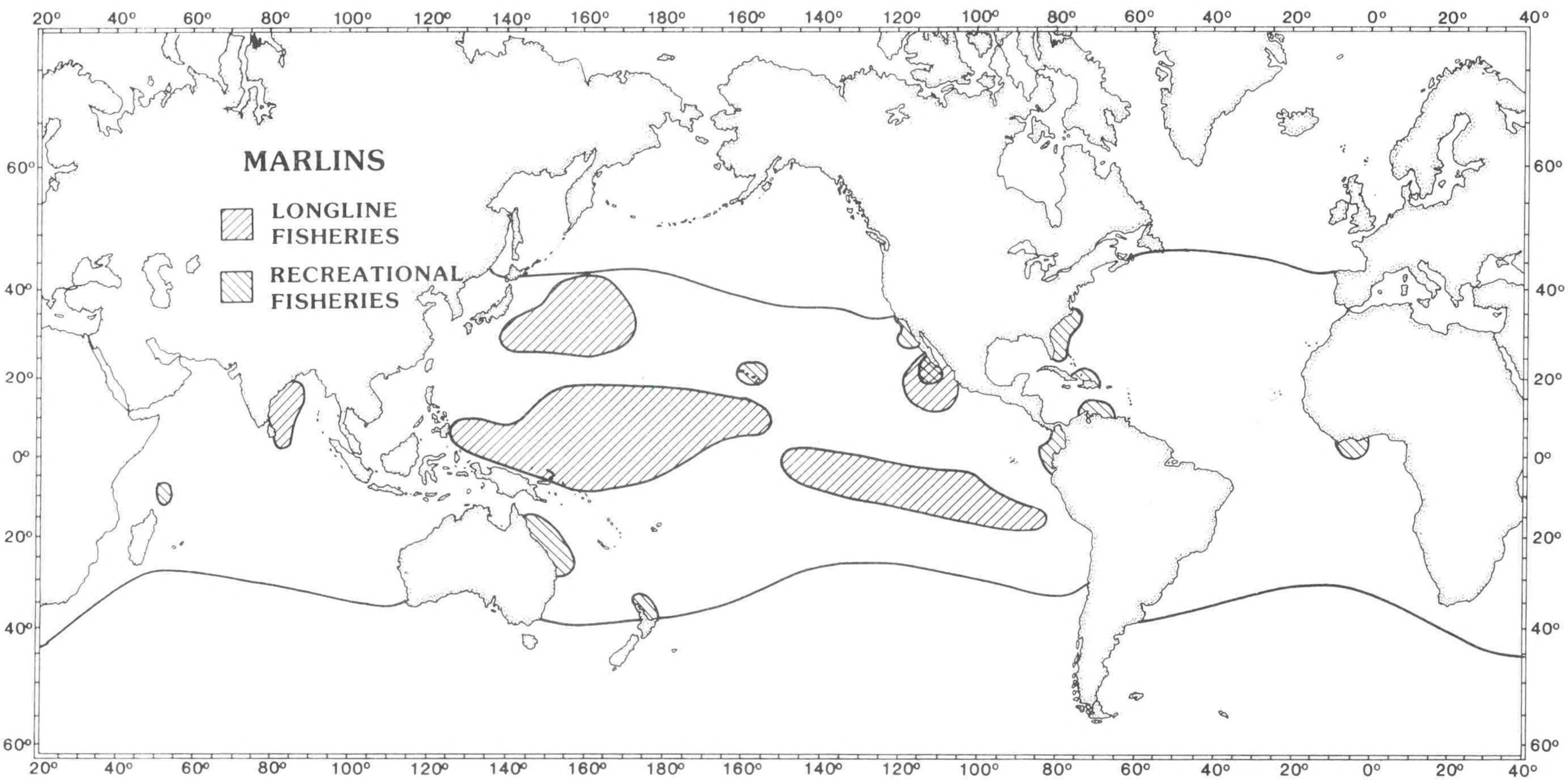

FIGURE 5

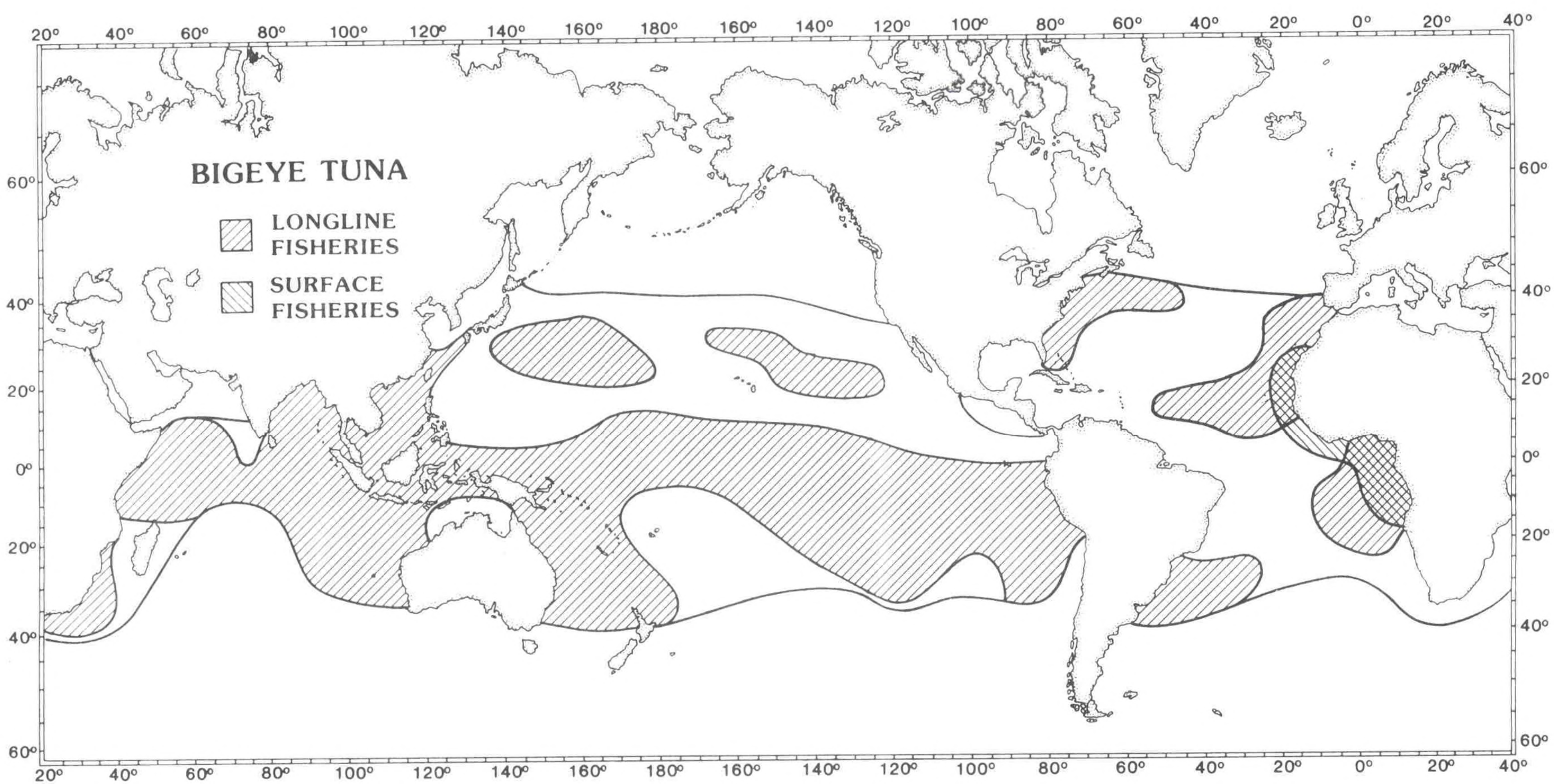

FIGURE 6

II-1. RECENT TRENDS IN WORLDWIDE TUNA PRODUCTION AND TRADE 1987

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I. INTRODUCTION

Worldwide, the production of frozen tuna has increased rather steadily in recent years, from 1.796 million metric tons (mt) in 1980, to 2.099 million mt in 1984, an increase of 17% in five years (Table 1). Simultaneously, global processing of canned tuna rose from 588,000 mt to 777,000 mt, an increase of 32% (Table 2). While these increases in production and processing are impressive in themselves, perhaps more notable is the substantial development in the harvesting and processing capabilities of less developed countries relative to those of the historically dominant tuna producers and processors, namely Japan and the United States. The rapid development of tuna industries in southeast Asia, Latin America, the western Pacific and Africa in most cases has been due to their proximity to abundant tuna resources, relatively low-cost labor sources, and generous government support. However, while these are necessary conditions, the impetus for developing tuna industries in these areas relates to perceived opportunities to penetrate lucrative tuna markets in Japan and the U.S.. When one examines circumstances within the Japanese and U.S. tuna industries leading into the early 1980's, a better understanding is gained as to how these market opportunities came into existence and therefore, why patterns of global tuna production, processing and trade have changed the way they have.

2. THE JAPANESE TUNA INDUSTRY

Japan has a long history as the world's largest tuna producer. In the 1930's, Japanese vessels conducted tuna fishing operations in the coastal and off-shore waters of the Japanese archipelago, and the waters of Micronesia using pole-and-line (baitboat) gear mainly for skipjack tuna and longline gear for other tuna and billfish species. The vessels were small by today's standards, not much more than 25 meters in length or 100 tons capacity.

During the 1950's and 60's, Japanese tuna fishing operations expanded rapidly as larger, distant-water vessels were added to the fleet. Japanese vessels started fishing tuna in the Atlantic, Pacific and Indian Oceans delivering the bulk of their catches to base ports established in countries such as Palau, Federated States of Micronesia, Papua New Guinea, Solomon Islands, Fiji, Malaysia, Maldives, Seychelles, Mauritius, Madagascar, Spain, Brazil, Uruguay, and Ghana. Because of problems in maintaining the quality of the catch for the domestic market, distant water tuna operations were export oriented, while the coastal fleets concentrated on supplying Japan's fresh fish (sashimi) markets.

By the close of the 1960's, the rate of expansion of Japanese tuna fishing activities became difficult to maintain. The rapid growth of the Japanese economy contributed to greatly increased costs of operating vessels, fishing trips increased in length as daily catch rates declined, and the development of the modern international purse seine fleet dampened the demand for Japanese exports of frozen tuna. These factors and others greatly reduced the economic return to export oriented, distant-water fishing operations. At the same time advancements in on-board freezing technology enabled Japan's distant-water longline fleet to switch to the production of tuna for the profitable sashimi market rather than for the canned market. Since sashimi grade tuna had to be brought back to markets in Japan, this breakthrough together with the decline in overseas markets reduced the need to maintain foreign-based landings ports.

The Japanese tuna industry was confronted by a number of additional problems as it entered the 1970's. After adjusting to changing conditions experienced in the late 1960's, Japanese fleets then faced the worldwide oil crisis of 1973. To offset the sharp increase in fuel prices, the government extended financial assistance to the fleets and cooperated with the tuna industry to foster the development of more energy-efficient and less labor intensive fishing operations. Then, in 1977, coastal nations around the world began implementing exclusive economic zones (EEZs). This had an immediate impact on the fishing operations of Japan's distant-water tuna fleets. At that time, more than 40% of Japan's tuna production occurred in waters within the EEZs of 54 foreign nations (Matsuda, 1987). With the introduction of extended jurisdiction, Japan introduced a policy of negotiating access agreements with coastal states that had large tuna resources within their EEZs. By 1986, Japan had reached agreement with 15 foreign countries on the exploitation of tuna resources in their EEZs. Nonetheless, the imposition of EEZs has significantly impacted Japanese fishing operations. As the 1970's came to a close, Japan's tuna industry was trying to deal with a number of issues that had adversely affected its fishing operations, including: (a) drastically increased fuel costs, (b) rising labor costs because of Japan's greatly increased standard of living, (c) increased vessel construction and outfitting costs, (d) extended duration of fishing trips due to decreased catch rates and, (e) fishing restrictions and access costs associated with extended jurisdiction (Fujinami, 1987).

To address these issues, the Japanese industry and government embarked upon a program of fleet rationalization and modernization in 1980. The program was designed to increase tuna fishing productivity by streamlining the existing baitboat and longline fleets, and expanding the highly efficient high seas purse seine fleet. As can be seen in Tables 3 and 4, this program has been quite successful. Through 1983, there was a reduction in the combined baitboat-longline fleet of 18% by number while the number of purse seiners more than doubled (Table 3). Moreover, this was achieved without any sustained loss in overall production: as shown in Table 4, Japan's total tuna catch rose 8% from 1980 to 1984.

Not only has the fleet rationalization program resulted in improved overall productivity, it has been attuned to the changing preferences of Japanese consumers. Compared to the markets for tuna in the U.S. and western Europe, the market for tuna in Japan is highly diversified. According to information provided by the Food and Agriculture Organization of the United Nations (F.A.O., INFOFISH, 1986) about 80% (approximately 350,000 mt) of the annual supply of billfish, bluefin tuna, bigeye tuna and yellowfin tuna enters the traditional sashimi market. The remaining landings of these species, an increasing proportion of which is yellowfin, are canned. Albacore is consumed exclusively as canned tuna in Japan. The average annual supply of albacore during the 1980's has been 60,000 - 70,000 mt; 30% - 40% is canned for domestic consumption and the balance is either exported as canned product, or as raw frozen fish to foreign processors.

Skipjack tuna is consumed in a number of different product forms. The total annual supply in the 1980's has ranged between 300,000 and 360,000 mt, of which 70% is used domestically and the remainder exported. Canned products have accounted for 60% - 70% of skipjack exports; the balance has been frozen, destined for canneries overseas. About 65% of the domestically consumed skipjack is smoke-dried (arabushi, katsuobushi and kezuribushi), 15% is canned, and the rest has been used for sashimi and tataki (lightly roasted skipjack).

The diverse pattern of tuna consumption in Japan has tended to stabilize the overall demand for tuna during the 1980's. A weakening of the traditional sashimi market -- in response to changing dietary preferences among younger Japanese, an increase in the variety and quantity of competitive seafood products, and high prices for sashimi relative to other fishery products -- has been compensated for by an increase in canned tuna consumption and increased utilization of skipjack tuna for katsuobushi. Slackening demand however has created an oversupply situation in the sashimi market, which depresses prices throughout the sashimi production system. Due in part to depressed prices, in conjunction with rising operating costs for Japanese vessels and the obstacles associated with access to increasingly important (with regard to resource availability) foreign EEZs, domestic production has declined. Nonetheless, the sashimi market remains highly attractive, and the void in domestic production has created an opening for low-cost foreign producers to penetrate this market. Indeed, imports of sashimi grade tuna and billfish rose from 91,700 mt in 1980 to 102,500 mt in 1984, an increase of 12% in five years, while domestic production fell 11% from 267,100 mt to 237,800 mt (INFOFISH, 1986).

The future of the Japanese tuna industry is dependent upon a number of factors, prominent among which are: (a) increasing costs of fleet operations owing to the phenomenal growth in Japan's economy which has intensified competition within the country for productive resources, (b) changing domestic tuna consumption patterns and the development of alternative markets (c) the dramatic increase in foreign production capacity, (d) the strength of the Yen against foreign currencies, and (e) access to areas of abundant tuna resources. While it is difficult to predict to what extent these factors will affect Japan's tuna industry, it seems fairly clear that in order to remain competitive in the rapidly expanding international markets for raw and processed tuna, both industry and government will have to continue to be as perceptive as they have in the past to adapt to the rapidly changing technological, political and economic circumstances which characterize these markets.

3. THE UNITED STATES TUNA INDUSTRY

The U.S. is second to Japan as the world's largest tuna producer. It is however, the world's largest processor and principal market for canned tuna, and therefore leads all nations in imports of frozen and canned tuna. In recent years the U.S. tuna industry has undergone some significant changes in response to the unprecedented increase in international production and trade in frozen and canned tuna.

Conditions within the U.S. tuna industry during the late 1970's and early 1980's served to stimulate world production, processing and trade. The record high prices for raw tuna in the U.S. (Table 5) were a strong incentive for many nations, particularly those with readily accessible tuna resources within their EEZs, to initiate or expand tuna production activities with catches targeted for the U.S. market. This began a downward trend in world prices for frozen tuna which induced an increase in canned tuna production worldwide, with most of the output destined for the U.S.

Prior to the 1980's, with the exception of sporadic fishing in the Atlantic and central-western Pacific, the U.S. distant- water tropical tuna fleet operated almost exclusively in the eastern Pacific Ocean. A significant movement to the central- western Pacific began in the early 1980's as rising competition, Central and South American EEZ access problems, declining catch rates -- due in part to a strong El Niño -- and restrictive marine mammal regulations hampered operations of the fleet. By 1982, there were 30 U.S. purse seiners operating in the central-western Pacific, with the number peaking at 61 in 1984. Since then there has been a movement back to the eastern Pacific. Reduced domestic demand for small skipjack tuna -- prevalent in central-western Pacific catches -- and exceptionally good fishing for yellowfin tuna (the species commanding the highest ex-vessel price from both domestic and foreign processors) helped contribute to the resurgence of U.S. fishing operations in the eastern Pacific. However, these developments took place during a period which saw a substantial build-up in global frozen tuna production, a U.S. economic recession, a near total reduction in continental-U.S. processing capacity and revised tuna procurement strategies on the part of domestic processors.

Historically, U.S. processors have relied on close integration with the U.S. fleet to secure dependable supplies of tuna which were then supplemented through imports to meet processing requirements. With reliable supplies of frozen tuna now becoming available from numerous sources outside the U.S., long-term supply arrangements with the U.S. fleet were no longer as critical, and processors lessened their dependence on U.S. vessels. Confronted with low world prices for tuna, prices below the vessel's break-even level, many vessels were compelled to leave the fleet. Between 1980 and 1985, the U.S. tropical tuna fleet (purse seiners and baitboats) had experienced a 30% decrease in number and an 11% reduction in carrying capacity (Table 6).

Deterioration of vertical integration within the U.S. tuna industry, together with the factors discussed above, has motivated U.S. vessels to look farther abroad with regard to alternative fishing areas and marketing opportunities. This is observed in a growing number of foreign charters, flag transfers, and unparalleled exports of domestically-caught tropical tuna beginning in 1984 (Table 7). Exports appeared to represent a particularly significant opportunity whose potential was enhanced by development of the western Pacific fishing grounds and the proximity of these grounds to important new southeast Asian processors, and also by improved fishing in the eastern Pacific. In the latter instance, the preponderance of large yellowfin tuna in the catches has stimulated U.S. exports to European tuna markets where large yellowfin command a premium price. This is in contrast to the east Asian markets where, due to relatively low labor costs, there is a greater demand for smaller, lower priced yellowfin and skipjack tuna which are relatively abundant in nearby waters.

Adding to the problems within the U.S. tuna industry at this time was the rapid and substantial increase in the volume of U.S. canned tuna imports in water. Intense competition from overseas processors started to occur in the early 1980's (Table 8) when tuna canned in water began to surpass tuna canned in oil in popularity among U.S. consumers, and rising production costs within the U.S. industry brought about record high prices at the ex-vessel, wholesale and retail levels. This combination of events plus a disparate tariff[1] on tuna canned in water provided an opportunity for lower priced, low-cost imports to inundate the domestic market. As a result, imports have made significant inroads into the strongest growing segments of the U.S. tuna market-tuna packed in water for sale to private label and institutional customers. Since consumers of private label and institutional packs tend to purchase on the basis of price and not brand loyalty, these market sectors are characterized by extreme price sensitivity and very narrow profit margins. In order to maintain a presence in these sectors, domestic processors have had to accept greatly reduced prices for their packs.

Even though foreign processors have concentrated on the private label and institutional sectors of the domestic canned tuna market, sales of U.S. nationally advertised brands have also been affected. As rising costs of production pushed the price of domestically canned tuna higher, the widening price spread at retail induced consumers to substitute the much lower priced privately labeled imported tuna for the more familiar advertised brands.

To offset declining revenues, domestic processors acted to lower production costs by taking advantage of latent offshore production capacity. By closing continental plants and expanding facilities in American Samoa and Puerto Rico processors sought to realize significant cost savings associated with closer proximity to the developing fishing grounds, lower labor costs, financial incentives offered by the host governments, and economies resulting from consolidating operations. Moreover, the move to offshore processing was accompanied by accelerated development of the central-western Pacific and Indian Ocean fishing grounds which contributed greatly to a rapidly growing worldwide supply of frozen tuna. Ex-vessel prices started to decline, further contributing to a reduction in operating costs for U.S. processors

In the wake of these events retail prices of domestically- packed canned tuna began to decline and sales started to rebound. Nonetheless, domestic processors were unable to benefit fully from reduced operating costs as prices of canned imports continued to decrease, renewing downward pressure on domestic prices. Thus, domestic processors continued to experience substantially lower profit margins, and a strong incentive for they themselves to import canned tuna was created.

The adversities that befell domestic processors in the early 1980's filtered downward to U.S. tuna fishermen in the form of significantly lower ex-vessel tuna prices and increased difficulties and delays in landing and disposing of their catches. Also, as indicated above, processors became anxious to divest themselves of interests they held in tuna vessels and reduce financial support they provided to independently owned vessels. To the fleet's dismay this occurred following a period of soaring interest rates that left many newer vessels -- financed at variable interest rates -- with unmanageable debt service which further contributed to the fleet contraction described earlier.

Yet even with the dramatically reduced fleet, deliveries of domestically-caught tropical tunas increased in 1983 and 1984 (Table 7) reflecting improved productivity of the remaining active vessels (Herrick and Koplin, 1986). On the other hand gross earnings per vessel, based on the total value of domestically-caught tropical tuna receipts, did not improved. Again, these circumstances reflect the abundant supply of frozen tuna worldwide, and the influence of international market conditions on the U.S. ex-vessel price.

The impact of recent events in the U.S. tuna industry has not been confined to the tropical tuna fishery. Continental cannery closures and relocations threatened the U.S. albacore fleet with the virtual disappearance of its traditional market. Given this prospect the albacore sector of the U.S. tuna industry has directed a significant amount of attention and effort toward developing a restaurant and retail trade for fresh or fresh frozen albacore. Successful development of a fresh/frozen market for albacore will especially benefit small-boat fishermen whose albacore fishing operations are particularly vulnerable to lthe west coast cannery closures and the costs of transshipping to offshore sites. On the other hand, large-boat fishermen, due to the more specialized nature of their albacore fishing operations (i.e. more extensive operating range and greater carrying capacity), are probably in a better position to service the offshore cannery needs.

Fresh tuna products may be a viable alternative for tropical tuna vessels as well. Bluefin, bigeye and yellowfin tuna are usually available within relatively close range of major population centers on the west coast where there are growing markets for these popular, highly valued, "sushi" grade tuna species. Currently these markets are being supplied by imports and to a large extent by shipments from the U.S. east coast and Hawaii. These circumstances present an opportunity for market penetration by west coast tuna fishermen, particularly the small- boat operators who have been especially disadvantaged by the reduction in west coast processing capacity.

4. CONCLUSIONS

While the tuna industries of Japan and the U.S., the major forces in global tuna production and trade, are showing signs of stability, the future of the industry worldwide is very uncertain. The traditional, sashimi market in Japan is subject to declining consumption as tuna eating habits change among younger consumers. Yet more foreign tuna producers are targeting the Japanese fresh tuna market attracted by the relatively high prices that yield higher economic returns for their tuna investments. The diversity of tuna consumption in Japan tends to offset the decline in the sashimi market, and the Japanese industry has taken steps to meet increased demand in alternative markets, as well as improve efficiency in production for the sashimi market through a major fleet rationalization program.

The U.S. industry is still emerging from the massive restructuring begun in 1982-83 which has seen a substantial contraction of U.S. tuna production capacity, and a move by the major U.S. processors to shift their operations to lower-cost non-continental U.S. territories. It is difficult to tell at what level domestic processing will stabilize, because total canned volume has fluctuated considerably since 1982. Continuing high levels of imports can be expected, particularly from Thailand and the Philippines, as well as from newcomers to the U.S. canned tuna market, Mexico and Venezuela.

The U.S. tuna fleet will continue striving to improve its productivity in order to remain competitive with the rapidly growing foreign fleets. As relations between the U.S. fleet and U.S. processors evolve from a contractional to a market transactions orientation, vessels will likely avail themselves of opportunities provided by the widespread rise in global processing capacity.

5. FOOTNOTES

1. Foreign processed canned tuna packed in oil is subject to a 35% tariff and therefore U.S. imports are negligible. Foreign processed canned tuna not in oil is under a tariff rate quota which allows 20% of the previous years domestic production (excluding American Samoa) to enter at 6% ad valorem; imports above the quota level enter at 12.5% ad valorem. Efforts to have the tariff on "not in oil" revised upward in recent years have not been successful.

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Table 1. World tuna production by major tuna fishing nations, (thousand metric tons, live weight) 1980-84.

NATION	1980	1981	1982	1983	1984
JAPAN	723	642	674	696	788
UNITED STATES	226	222	199	266	263
SPAIN	101	122	131	126	132
INDONESIA	73	84	90	103	115
PHILIPPINES	79	95	103	119	104
FRANCE	72	69	69	84	100
TAIWAN	106	90	104	104	99
MEXICO	34	68	45	38	78
REP. KOREA	110	105	108	89	71
VENEZUELA	4	6	4	39	53
SOLOMON Is.	23	26	20	34	36
MALDIVES	28	26	20	26	32
ECUADOR	19	19	21	15	29
GHANA	9	15	29	33	22
BRAZIL	10	24	17	17	22
PANAMA	21	16	25	14	20
SRI LANKA	20	21	22	23	18
AUSTRALIA	14	18	21	22	16
OTHER	124	119	109	98	101
TOTAL	1,796	1,787	1,811	1,946	2,099

SOURCE: Food and Agriculture Organization of the United Nations, Yearbook of Fishery Statistics, Catches and Landings, 1984.

Table 2.- Canned tuna producers, 1980-84, (thousand metric tons)

NATION	1980	1981	1982	1983	1984
UNITED STATES	275	287	246	268	275
JAPAN	95	111	113	117	124
ITALY	48	49	48	52	59
THAILAND	*	8	15	28	59
FRANCE	25	23	30	35	38
SPAIN	43	40	37	37	30
IVORY COAST	18	26	29	26	23
PHILIPPINES	11	18	19	24	23
MEXICO	15	20	13	11	22
TAIWAN	*	14	11	15	13
ECUADOR	5	12	11	7	12
OTHERS	53	70	65	74	99
TOTAL	1,176	1,356	1,274	1,378	1,554

SOURCE: Food and Agriculture Organization of the United Nations, Yearbook of Fishery Statistics, Fisheries Commodities, 1984.

Table 3. Japanese licensed tuna fleet, number of vessels by gear type, 1970-83

Year	Gear Type: Baitboat	Longline	Purse Seine
1970	512	1549	10
1975	696	1411	10
1980	569	1515	13
1981	546	1428	24
1982	473	1354	33
1983	433	1267	33

Source: Food and Agriculture Organization of the United Nations, INFOFISH, 1986(b); Fujinami(1987)

Table 4. Japanese tuna production, (thousand metric tons), 1980-84.

Year	Fresh	Frozen	Total
1980	253.2	543.4	796.6
1981	228.6	474.8	703.4
1982	231.0	490.3	721.4
1983	235.9	533.2	769.1
1984	228.5	635.0	863.5

Source: Food and Agriculture Organization of the United Nations, INFOFISH, 1986.

Table 5. U.S. cannery ex-vessel (weighted) prices (dollars per short ton), 1979-85.

Year	Albacore		Skipjack		Yellowfin	
	Nominal	Real[1]	Nominal	Real[1]	Nominal	Real[1]
1979	1,286	787	728	445	863	528
1980	1,659	930	1,063	596	1,180	661
1981	1,800	920	1,030	527	1,170	598
1982	1,387	669	965	465	1,123	542
1983	1,268	589	799	371	1,032	479
1984	1,252	560	760	340	982	440
1985	1,087	469	622	269	820	354

[1]Adjusted for inflation using GNP implicit price deflator (1972=100)

Source: Herrick and Koplin, 1986(a), 1986(b).

Table 6. Number and capacity of U.S. baitboats and purse seiners, 1979-85.

Year	Baitboats Quantity	Baitboats Capacity	Purse Seiners Quantity	Purse Seiners Capacity	Total Quantity	Total Capacity
		Short tons		Short tons		Short tons
1979	28	2,557	125	111,750	153	114,307
1980	25	2,186	122	111,752	147	113,938
1981	18	1,602	119	109,123	137	110,725
1982	14	1,147	121	114,466	135	115,613
1983	34	2,059	108	107,244	142	109,303
1984	24	1,808	97	98,649	121	100,457
1985	9	696	81	83,957	90	84,293

Source: International Trade Commission, 1986; Herrick and Koplin, 1986(b).

Table 7. U.S. cannery receipts of domestically-caught frozen tuna, U.S. direct exports of domestically-caught frozen tuna and U.S. imports of frozen tuna (metric tons), 1979-85.

Year	Domestic Production Cannery Deliveries	Domestic Production Direct Exports	Imports
1979	223,956	5,369	317,571
1980	220,437	2,051	333,559
1981	217,139	1,254	326,267
1982	206,075	3,921	248,933
1983	259,672	530	224,086
1984	231,437	29,524	244,952
1985	194,372	31,634	231,950

Source: Herrick and Koplin, 1986(a), 1986(b).

Table 8. U.S. supply of canned tuna (1,000's pounds), 1979-85.

Year	Domestically Processed	Imports	Total Supply
1979	620,237	53,703	673,940
1980	602,043	63,551	665,594
1981	626,964	70,844	697,808
1982	538,493	87,575	626,067
1983	590,616	122,324	712,940
1984	614,270	162,318	776,588
1985	545,006	213,954	758,960

Source: Herrick and Koplin, 1986(b).

III-1. CENTRAL AND WESTERN PACIFIC SKIPJACK TUNA 1987

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1. INTRODUCTION

This report is a review of the status of skipjack stocks and fisheries in the central and western Pacific. The area of concern is the tropical and sub-tropical region of the central and western Pacific exclusive of the neighborhood of the Hawaiian Islands. The area corresponds roughly to FAO (United Nations Food and Agriculture Organization) regions 61, 71, 81 and the southwest part of 77 (Figure 1).

This report is based largely on fishery data compiled by FAO and the SPC (South Pacific Commission) and on the results of the SPC Skipjack Survey and Assessment Programme (Skipjack Programme for short), conducted in the region from 1977 to 1981. Further information can be obtained from a summary report of the Skipjack Programme (Kearney, 1983), from a skipjack resource assessment paper (Kleiber, Argue, and Kearney, 1987), and from a series of technical reports and country reports of the Skipjack Programme and its successor, the Tuna and Billfish Assessment Programme. These reports are listed in Appendix A.

2. DESCRIPTION OF THE FISHERIES

An up-to-date description of tuna fisheries in the central and western Pacific is given by Anon (1986) and of skipjack fisheries in particular by Sibert (1986). What follows is a summary of this and supplementary information from other sources.

2.1 Gear

Skipjack have presumably been harvested in the central and western Pacific since aboriginal times. Artisanal fishing of skipjack with lures trolled from a wide variety of local craft continues in most parts of the region today. In some areas traditional fishing methods have been adapted to small commercial operations, as in the bonitier fishery in French Polynesia. Artisan fishing accounts for only a small portion of the total catch of skipjack in the region.

The great majority of skipjack harvested in the region is caught by pole-and-line and purse seine vessels, most operated by distant water fishing nations (DWFNs), and some by local or joint-venture companies.

Commercial harvest of skipjack in the region by pole-and- line gear has been developed mostly by the Japanese and most rapidly since World War II as new techniques were discovered for transporting live bait over long distances. During the 1970's locally based pole-and-line fisheries have been established (manyby joint-venture) in several countries of the region. Not all of these have persisted.

Prior to 1980, some purse seining of skipjack had occurred in subtropical areas in the region. Then, beginning in early 1980s with the development of gear for deeper and faster sets, purse seine vessels began moving into the tropical parts of the region and now account for a major part of the catch. Although longline vessels fish for tuna extensively in the region, very few skipjack are caught by this gear.

2.2 Fishing Activity

The trend in skipjack catch in the central and western Pacific and world-wide from 1970 to 1985 has been mostly upward (Figure 2). The central and western Pacific region accounts for a very substantial share of the world skipjack catch. The principal DWFN operating in the region has been Japan, but a growing proportion of the catch has been taken by the United States in recent years. An increasing amount of the catch is being taken by purse seine vessels (Figure 3).

Fishing activity is not uniformly distributed in the region. Figures 4 and 5 show the geographic distribution of catch by pole-and-line and purse seine vessels reported to the SPC for 1982 through 1985.

3. ECONOMIC ASPECTS OF SKIPJACK FISHING

Skipjack from the central and western Pacific are landed and sold in many ports throughout and beyond the region. Local and joint-venture fisheries usually deliver to local ports where there are either marketing, processing, or transshipment facilities. The principal landing ports for DWFN vessels in the region are in Japan, Guam, and American Samoa.

The price of skipjack rose steadily through the 1970s, but since then it has dropped considerably (Figure 6) coinciding with the rapidly increasing catch in the early 1980s. The price is probably reacting to a saturated market for canned tuna, the major product of skipjack and other tunas. It is likely that economic, rather than biological factors, are regulating this fishery. The drop of catches in the region and world-wide in 1985 (Figure 2) hints that the fishery is responding to the drop in price.

A significant economic aspect of skipjack fishing in the central and western Pacific is its importance, or potential importance, to island economies. The dollar value of skipjack taken by DWFNs from the economic zones of island countries can be significant relative to the revenues of those countries. Table 1 gives this comparison for the 1970s, when most of the island countries were declaring 200-mile economic zones and contemplating the relative benefits of licensing DWFN vessels or establishing their own local commercial fleets. The table underscores the seriousness of the issue for countries in the region. All the island countries depend significantly on outside economic aid,some to a large extent. For many of them, the fish resources, particularly skipjack resources, in their economic zones represent the most feasible escape from dependency on foreign aid. Even in the case of countries that did not have large catches taken from their own waters, the potential was presumed there because of the catch taken from neighboring countries. The high economic stakes in fisheries from the point of view of island countries is a principal factor leading to the start-up of the Forum Fisheries Agency in 1979 for the purpose of furthering the economic well-being of those countries through utilization of their fish resources and to give them unity and strength in dealing with the DWFNs.

4. STOCK ASSESSMENT

4.1 Stock Structure

Prior to the SPC Skipjack Programme, it was proposed that the skipjack population in the central and western Pacific consists of two (Fujino, 1976; Fujino, Sasuk and Okumuraz 1981) or more (Sharp, 1978) discrete stocks. The evidence for these discrete stocks was from geographic variability in the occurrence of protein variants in skipjack blood samples. In addition to tagging, the Skipjack Programme collected blood samples much more extensively than had been done before. A geographic cline was found in the occurrence of variants of one protein with no observable sharp discontinuities (Anon, 1981), and the tag results showed no evidence of barriers to movement within the region (Figure 7). The interpretation is that the skipjack population is not panmictic (complete mixing does not occur across the whole region within one generation), but there is no evidence for isolated genetic stocks.

With the extensive skipjack movements shown in Figure 7, it may be surprising that the population is not panmictic. However, the map in that figure is misleading because it greatly over- emphasizes long distance tag returns. The majority of tags was in fact recovered within 200 nautical miles of the points of release (Figure 8), which stretches the commonly held notion that skipjack is a highly migratory species.

4.2 Impact of Fishery on Stocks

The evidence of tagging data is that the skipjack population has a high turnover rate, perhaps as high as 200% per year, and that the fishing mortality at the time of the Skipjack Programme was in general small relative to the turnover (Kleiber et al., 1987). The exploitation rate (ratio of fishing mortality to turnover) was estimated to be between 3% and 4% for the aggregate of all fisheries in the region (including DWFN fleets). For local fisheries of island countries, the exploitation rate was less than 10%, with the exception of Papua New Guinea, Solomon Islands, and New Zealand (Table 2). The implication is that the skipjack population at the time of the Skipjack Programme was not much affected by the fishery, except possibly in a few local areas, and was in that sense under-exploited.

With the development of purse seining in the region it is possible that this sanguine assessment should be changed. However, the lack of any clear trends in catch-per-effort since the time of the Skipjack Programme (Figure 9) gives no indication that the population is nearing a fully or over exploited state.

4.3 Fishery Interaction

In a situation where the exploitation rate is low, one would not expect there to be a large impact of one fishery on another, even if the range of the fisheries was overlapping. Two measures of interaction were estimated from the Skipjack Programme data (Kleiber et al., 1984; Sibert, 1984). For the most part there was little indication of significant potential or actual interaction between countries. The exceptions were closely neighboring countries with well developed fisheries operating in their waters, and even then, the interaction was mild -- most likely less than 10% (less than 10 mt decline in the catch of one fishery due to a 100 mt increase in the catch of another fishery).

Simulation modeling (Kleiber, unpubl.) shows that the geometry of the situation is important. When local fisheries are surrounded by "buffer zones" of un-fished waters, interaction is mild. But when fishing grounds extend up to common boundaries, interaction can become significant, particularly if one fishery surrounds another. Models of interaction based on movement of fish between fisheries obviously need to incorporate information on movement behavior. The information used so far is based on tag returns, but the analyses of the tag data for fish movement are incomplete because catch and effort data are still not available for the two fleets that recovered a large proportion of the tags -- the Japanese pole-and-line and American purse seine fleets. Until the tag data are analyzed together with the requisite fishery data, the conclusions about fish movement and fishery interaction must remain tentative.

5. OUTLOOK

The biological status of the skipjack population in the central and western Pacific seems to be good. There is no indication that the fishery is having an untoward impact on the population. However, there are many examples of fisheries collapsing where indications of collapse were not visible except with benefit of hindsight. It is therefore very important to continue monitoring this valuable and important fishery, and for doing so it would be desirable to have a formal international institution in the region comparable to the Inter-American Tropical Tuna Commission in the eastern Pacific or the International Commission for the Conservation of Atlantic Tunas in the Atlantic. The recent formation at SPC of the Standing Committee on Tuna and Billfish is a step in that direction.

The real limiting factor for the skipjack fishery in the central and western Pacific, and indeed world wide, appears to be economic -- the world demand for skipjack being the limiting element. Unless the demand increases dramatically, this will probably continue to be the case, and in the central and western Pacific the island countries (through the Forum Fisheries Agency) will continue bartering with the DWFNs for their share of this resource.

The harvest will likely continue to be carried out by a mixture of licensed DWFN and local vessels with a continued trend toward purse seine and away from pole-and-line gear. The activities of the DWFN fleets will probably fluctuate as these vessels migrate round the world's oceans following the most favorable market and fishing conditions for skipjack and, importantly, other tunas. The artisanal skipjack catch, though small, will probably continue to be an important part of the cultural life of many of the island countries in the region.

Fears of negative interaction between the various players will continue to arise, but investigation of such interaction will be hampered by lack of more definitive knowledge of skipjack movement patterns. Such patterns might be elucidated from existing tag data if the necessary fishery data were made available. An international working group on interaction between tuna fisheries in the Pacific has been formed under FAO sponsorship, and it is to be hoped that this working group will gain access to the requisite data.

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7. FIGURES

Figure 1. FAO statistical areas in the Pacific.

Figure 2. Annual skipjack catch, world-wide and from central and western Pacific. Source: FAO data tape for FAO statistical areas 61, 71, and 81 plus area 77 exclusive of catch by American countries.

Figure 3. Total annual catch by pole-and-line and by purse-seine vessels reporting to SPC. Data from Sibert (1986).

Figure 4. Distribution of pole-and-line skipjack catch, 1982 through 1985. The "?" symbols indicate areas where data coverage is incomplete. Reproduced from Sibert (1986).

Figure 5. Distribution of purse-seine skipjack catch, 1982 through 1985. The "?" symbols indicate areas where data coverage is incomplete. Reproduced from Sibert (1986).

Figure 6. Ex-vessel price of skipjack in Yaizu (1969-1978), Honolulu (1968-1977), and average of American ports in Honolulu, Puerto Rico, California, Guam, and Pago Pago (1979-1986). Data from [U.S.] National Marine Fisheries Service, and Hawaii Division of Fish and Game.

Figure 7. Straight line representations of movements of skipjack tagged by the Skipjack Programme. Movements plotted have been selected to show no more than two examples between any pair of ten-degree squares, one in each direction, and no more than two examples of movement wholly within any ten-degree square. Tick marks on the arrows represent time-at-large with one tick mark per 90-day interval. Reproduced from Kearney (1983)

Figure 8. Numbers of skipjack tag recoveries by distance traveled and time-at-large. Reproduced from Kearney (1983).

Figure 9. Catch per effort for pole-and-line and purse-seine vessels reporting to SPC. Redrawn from Sibert (1986).

Table 1. Value of skipjack catch taken by vessels of one DWFN from the economic zones of nine island countries compared with the revenues of those countries. Value of catch determined from ex-vessel prices in Yaizu (NMFS data) and Japanese pole-and-line catch by country (Skipjack Programme 1980). The island country revenue estimates from Inder (1978). Do not include the value of catch because at the time no funds generated by the catch accrued to the island countries. The "tot" revenues include foreign aid, and "local" revenues are revenues generated by local industry.

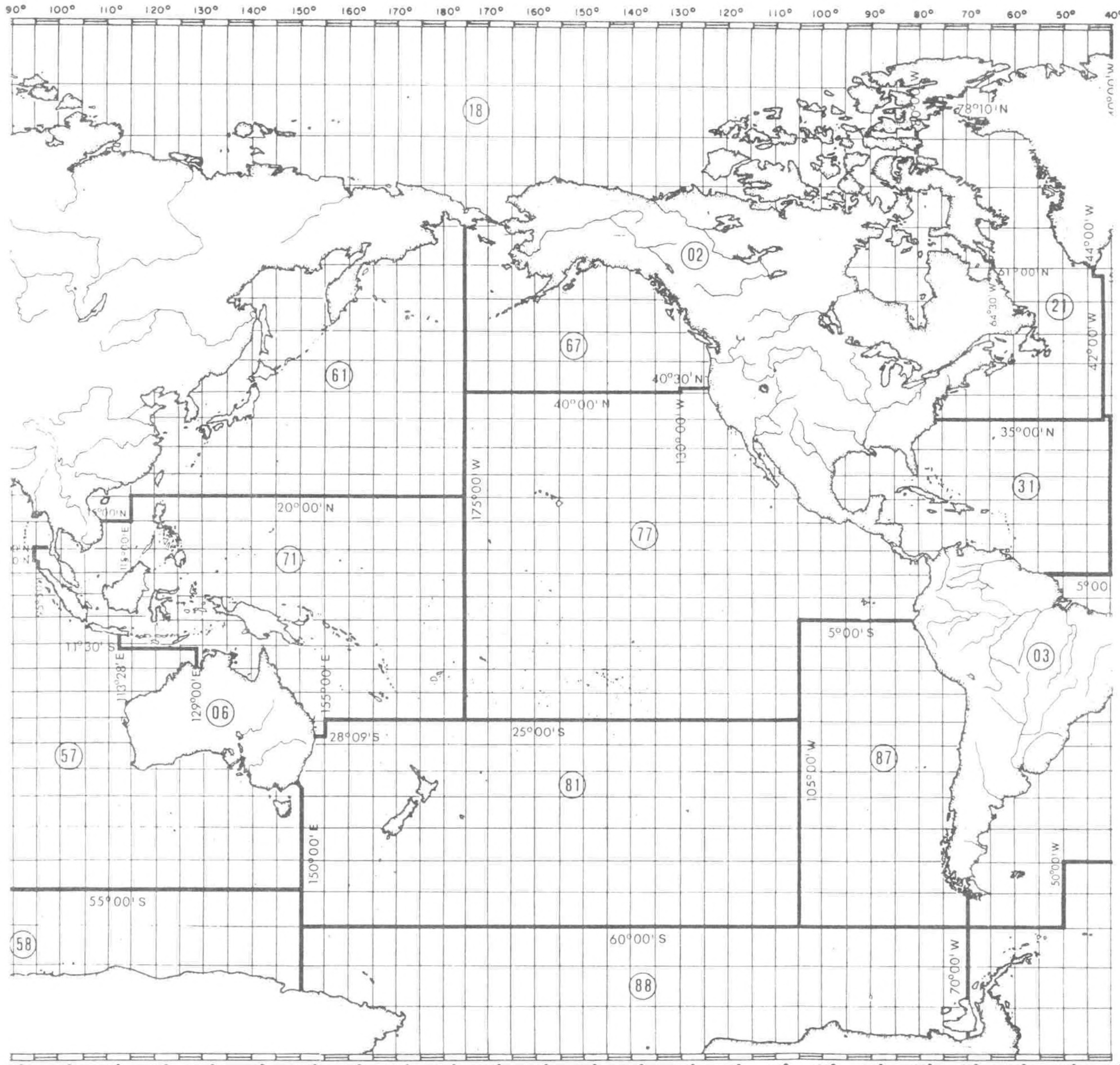
year	Kiribati catch M$	Kiribati revenue M$ tot	Kiribati revenue M$ local	Niue catch M$	Niue revenue M$ tot	Niue revenue M$ local	Papua New Guinea catch M$	Papua New Guinea revenue M$ tot	Papua New Guinea revenue M$ local
72	2.4				2.20	1.02	4.5		
73	0.2	8.7	6.3				11.7		
74	7.4	19.3	16.6		2.14	0.30	30.8	432	156
75	1.7	32.9	30.3		2.95	0.25	11.8	572	253
76	9.4	19.5	16.0		2.89	0.27	5.6	609	318
77	13.1			0.01	3.76	0.48	13.9	613	319
78	24.8						2.1		

year	Solomon Islands catch M$	Solomon Islands revenue M$ tot	Solomon Islands revenue M$ local	Tokelau catch M$	Tokelau revenue M$ tot	Tokelau revenue M$ local	Tuvalu catch M$	Tuvalu revenue M$ tot	Tuvalu revenue M$ local
72	<0.1	14.0	6.2				0.05		
73	0.1	12.4	6.6			0.06			
74	3.9	15.3	9.4				0.01		
75	5.0	16.0	9.0	0.11	0.52	0.03	0.26		
76	14.2	20.0	10.7	1.24	0.67	0.07	5.45		
77	6.8			0.03	0.74		0.51	1.8	1.0
78	0.2			0.01			0.85		

year	Trust Territories catch M$	Trust Territories revenue M$ tot	Trust Territories revenue M$ local	Wallis & Futuna catch M$	Wallis & Futuna revenue M$ tot	Wallis & Futuna revenue M$ local	Cook Islands catch M$	Cook Islands revenue M$ tot	Cook Islands revenue M$ local
72	21.5							4.1	2.4
73	53.1	79.6	5.7						
74	32.0				4.40	0.53		4.5	2.6
75	21.7	70.2	6.9	0.08	6.96	0.54	0.02		
76	34.2	100.2	5.6	0.05	7.33	0.82			
77	57.8	87.6	9.7	0.04			0.01	11.4	7.5
78	33.0							13.0	9.5

Table 2. Fishing mortality, total attrition rate and exploitation rate estimates for the SPC region and for sub-areas within the region. Data from Kleiber et al. (1987).

	Fishing mortality (mo^{-1})	Total attrition (mo^{-1})	Exploitation rate (unitless)
SPC Region	0.005 - 0.008	0.15 - 0.20	0.03 - 0.04
Trust Territories & Guam	0.004 - 0.013	0.14 - 0.36	0.02 - 0.05
New Zealand	0.13 - 0.22	0.30 - 0.52	0.33 - 0.60
Fiji	0.004 - 0.017	0.13 - 0.26	0.03 - 0.07
Society Is.	0.001 - 0.055	0.20 - 1.30	0.005 - 0.048
Gilbert Is.	0.01 - 0.04	0.16 - 0.69	0.03 - 0.08



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02
61°00' N
21
44°00' W
42°00' W
67
61
40°30' N
40°00' N
130°00' W
35°00' N
20°00' N
175°00' W
31
71
77
5°00'
11°30' S
5°00' S
03
113°28' E
129°00' E
155°00' E
06
28°09' S
25°00' S
57
81
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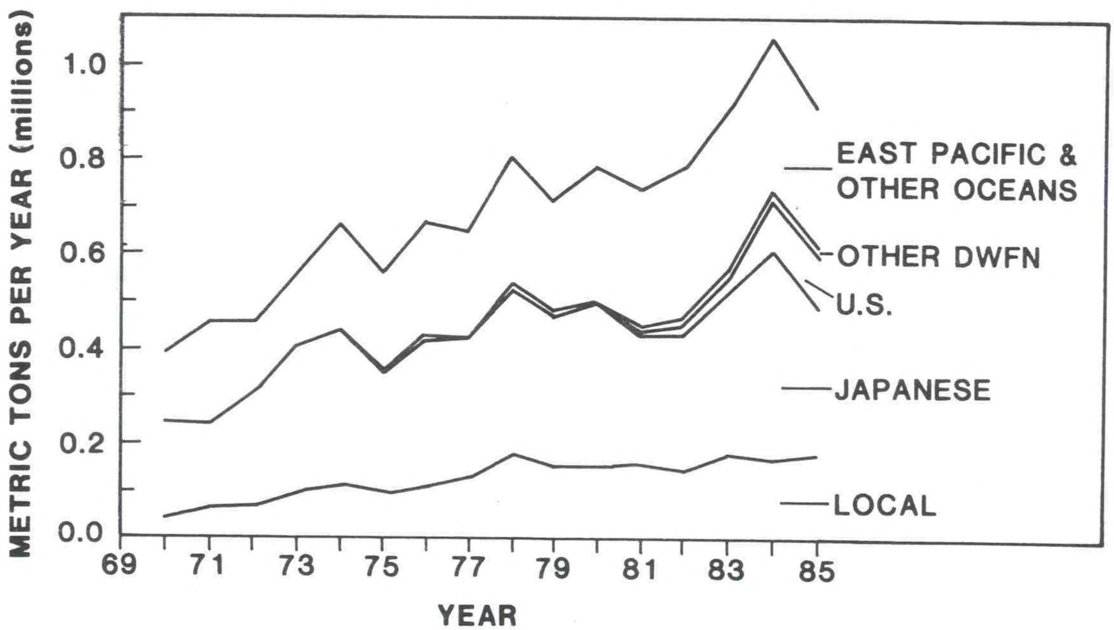
55°00' S
58
60°00' S
70°00' W
88

FIGURE 1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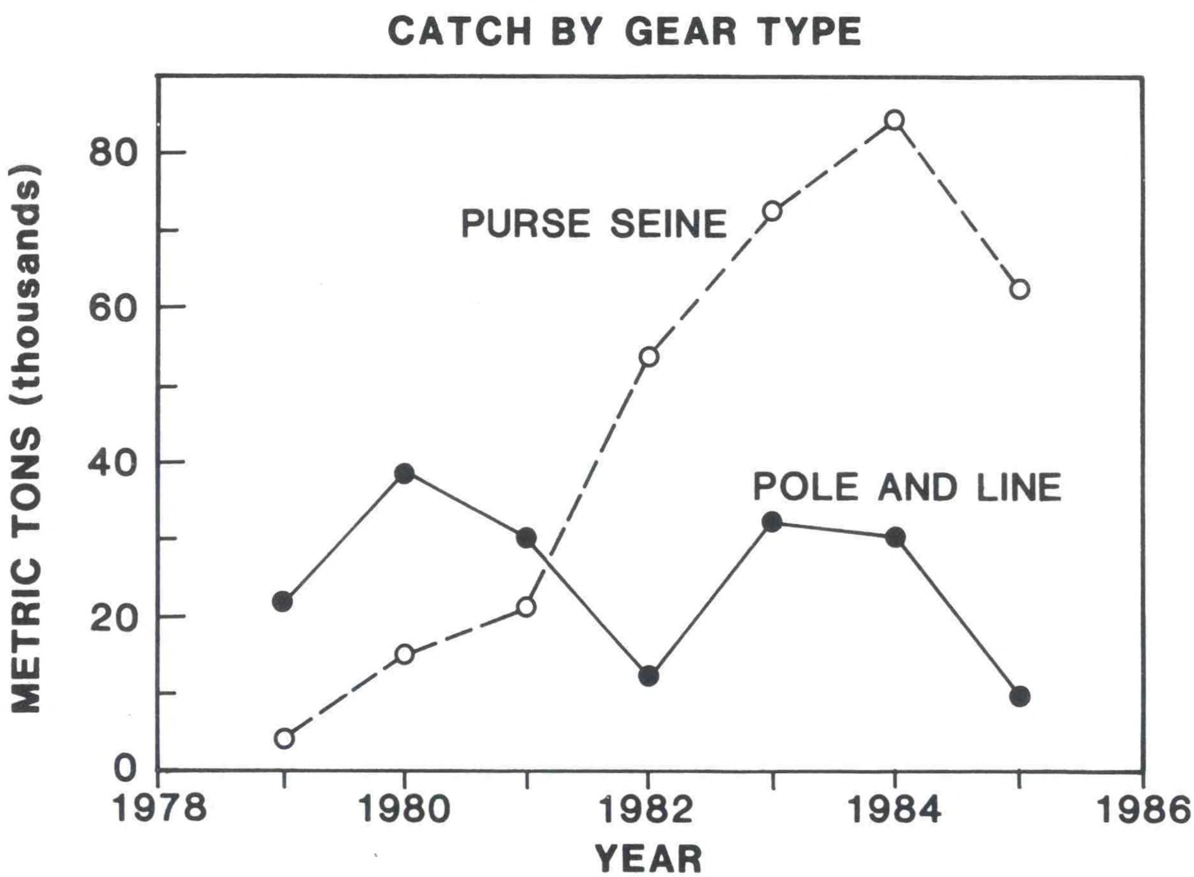
0.8
0.6
0.4
0.2
0.0
69
71
73
75
77
79
81
83
85
YEAR
EAST PACIFIC &
OTHER OCEANS
OTHER DWFN
U.S.
JAPANESE
LOCAL

FIGURE 2


CATCH BY GEAR TYPE
METRIC TONS (thousands)
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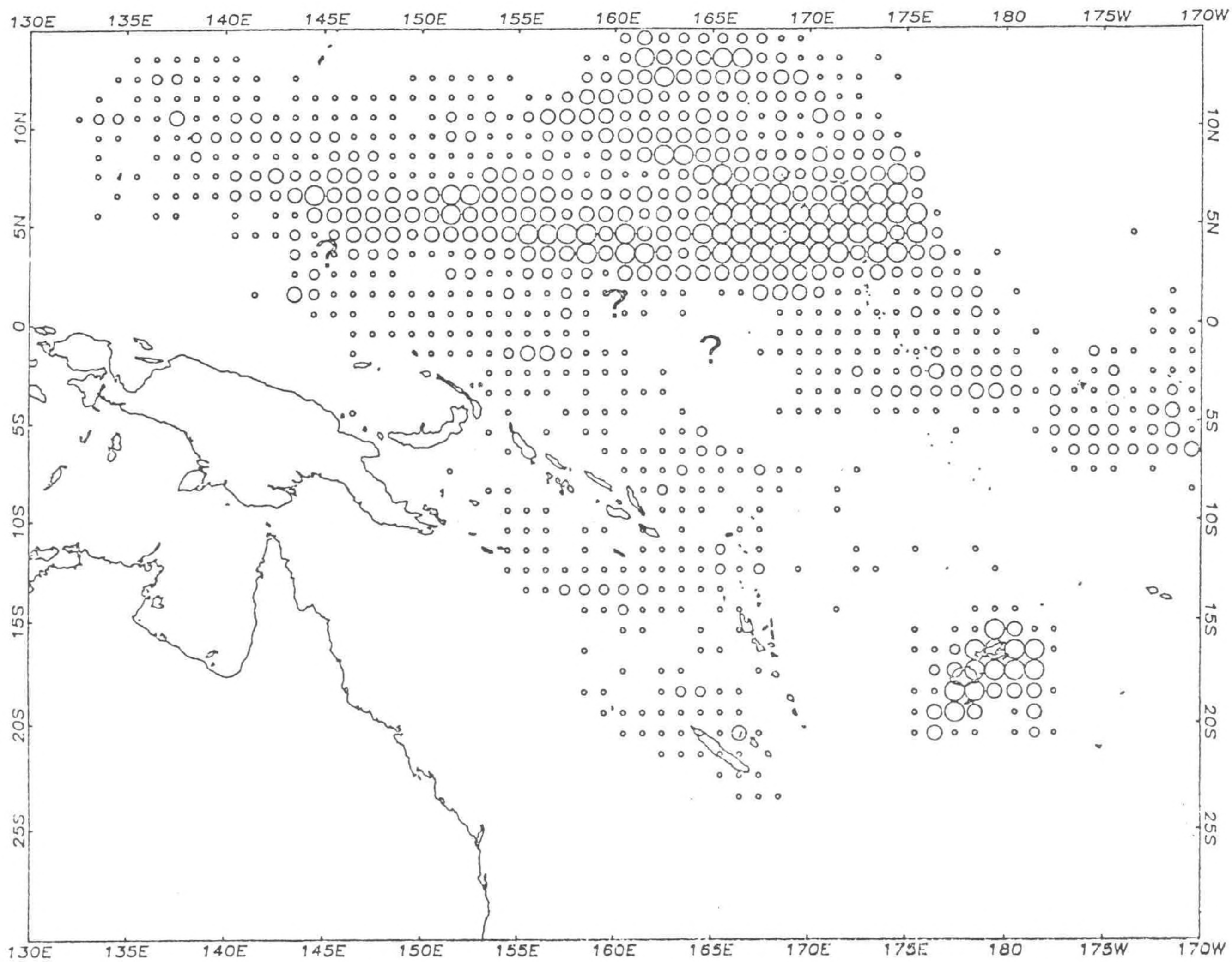
20
40
60
80
PURSE SEINE
POLE AND LINE
1978
1980
1982
1984
1986
YEAR

FIGURE 3



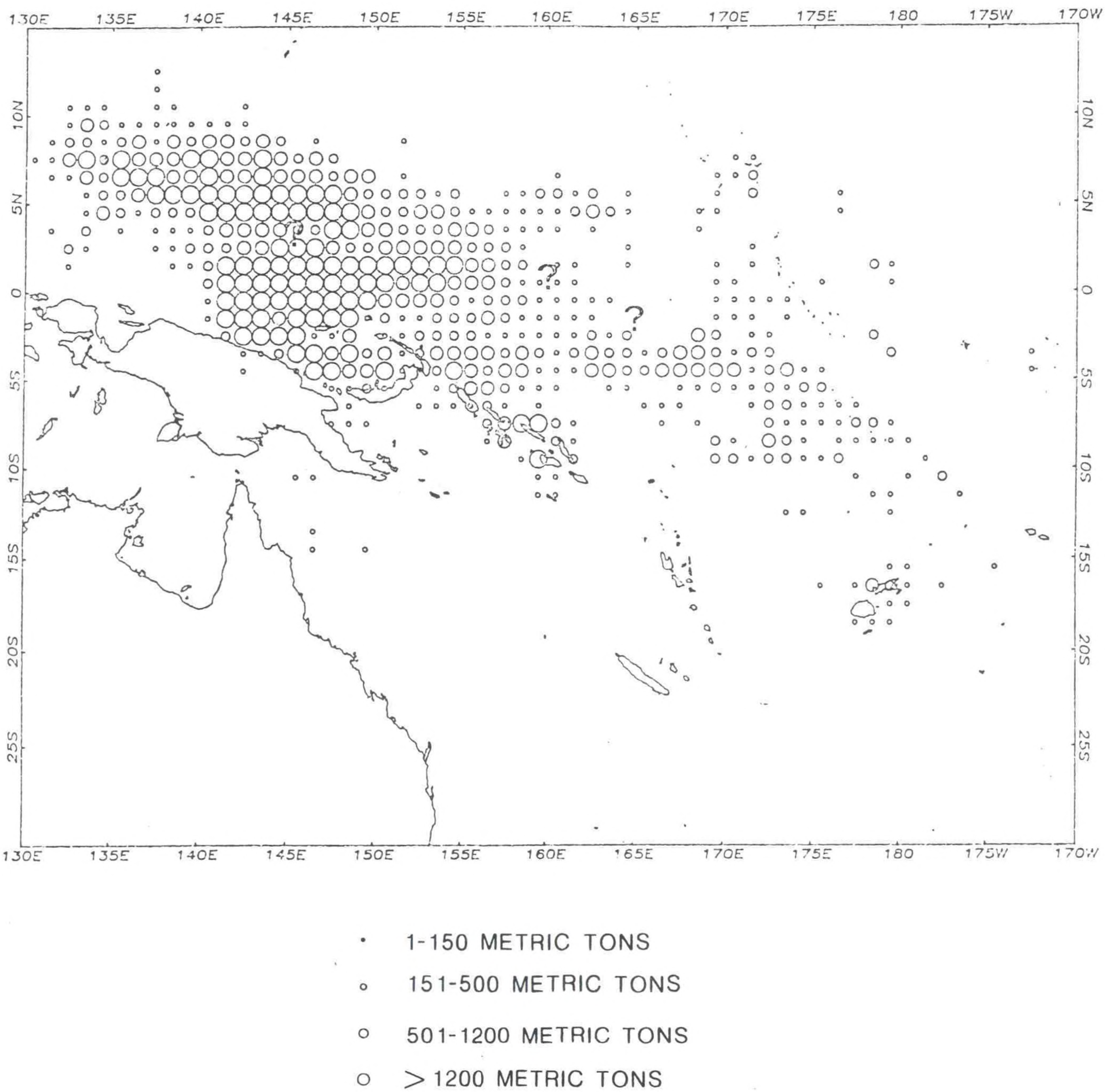
• 1-50 METRIC TONS

∘ 51-150 METRIC TONS

○ 151-400 METRIC TONS

○ > 400 METRIC TONS

FIGURE 4



130E
135E
140E
145E
150E
155E
160E
165E
170E
175E
180
175W
170W
10N
5N
0
5S
10S
15S
20S
25S
?
1-150 METRIC TONS
151-500 METRIC TONS
501-1200 METRIC TONS
> 1200 METRIC TONS

FIGURE 5

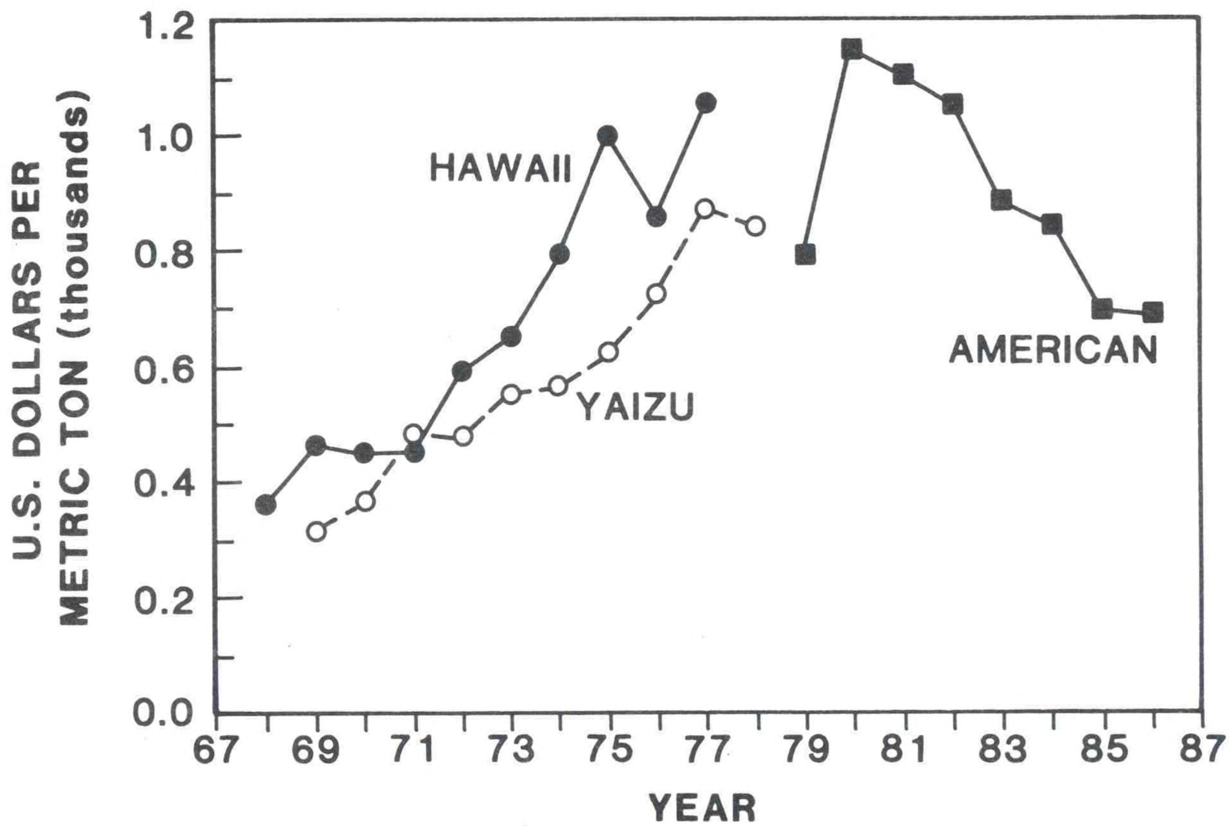

1.2
1.0
0.8
0.6
0.4
0.2
0.0
U.S. DOLLARS PER
METRIC TON (thousands)
HAWAII
YAIZU
AMERICAN
67
69
71
73
75
77
79
81
83
85
87
YEAR

FIGURE 6


110E
120E
130E
140E
150E
160E
170E
180
170W
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150W
140W
130W
40N
30N
20N
10N
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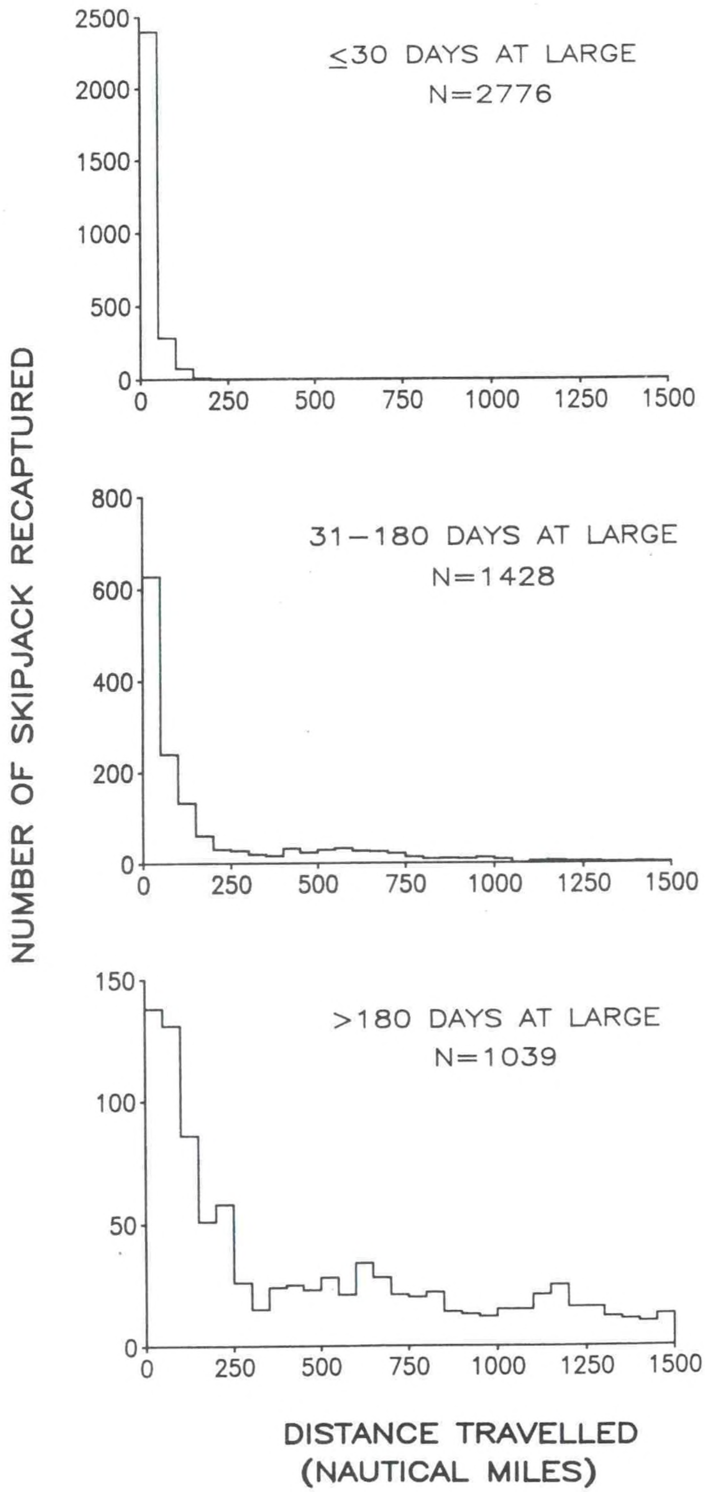
10S
20S
30S
40S

FIGURE 7



NUMBER OF SKIPJACK RECAPTURED
≤30 DAYS AT LARGE
N=2776
2500
2000
1500
1000
500
0
0
250
500
750
1000
1250
1500
31–180 DAYS AT LARGE
N=1428
800
600
400
200
0
>180 DAYS AT LARGE
N=1039
150
100
50
DISTANCE TRAVELLED
(NAUTICAL MILES)

FIGURE 8

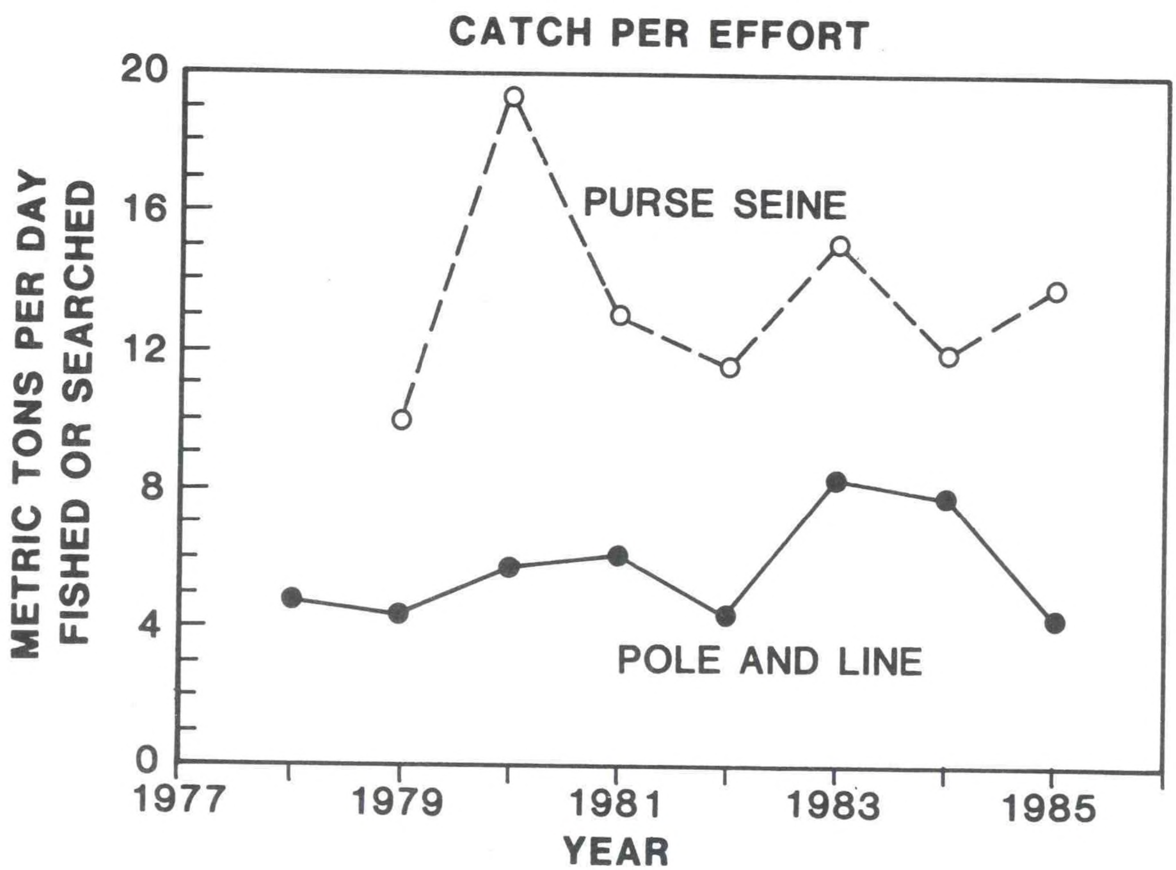

CATCH PER EFFORT
20
16
12
8
4
0
METRIC TONS PER DAY FISHED OR SEARCHED
PURSE SEINE
POLE AND LINE
1977
1979
1981
1983
1985
YEAR

FIGURE 9

Appendix A.

Reports of the SPC Skipjack Survey and Assessment Programme and the Tuna and Billfish Assessment Programme country reports give an assessment of the skipjack and baitfish resources for 20 subareas in the central and western Pacific. Technical reports cover a variety of topics. These reports can be obtained from the South Pacific Commission, B.P. D5, Noumea, New Caledonia.

Country Reports:

No.1, Fiji
No.2, Cook Islands
No.3, Solomon Islands
No.4, Pitcairn Islands
No.5, Kiribati
No.6, New Zealand
No.7, French Polynesia
No.8, Tuvalu
No.9, Vanuatu
No.10, Tokelau
No.11, Tonga
No.12, Papua New Guinea
No.13, Nauru
No.14, Western Samoa
No.15, Niue
No.16, Eastern Australia
No.17, American Samoa
No.18,Northern Mariana Islands, Guam, Palau, Federated States of Micronesia, and Marshall Islands
No.19, Wallis and Futuna
No.20, New Caledonia

Technical Reports:

No. 1 Anon. 1980. Review of preliminary results from genetic analysis of skipjack blood samples collected by the Skipjack Survey and Assessment Programme.

No. 2 Skipjack Programme. 1980. Skipjack fishing effort and catch, 1972-1978, by the Japanese pole-and-line fleet within 200 miles of the countries in the area of the South Pacific Commission.

No. 3 Skipjack Programme. 1981. Fishing effort and catch by long-line fleets of Japan (1962-77) and Taiwan (1967-77) within 200 miles of the countries in the area of the South Pacific Commission.

No. 4 Kearney, R.E. and M.L. Rivkin. 1981. An examination of the feasibility of baitfish culture for skipjack pole-and-line fishing in the South Pacific Commission area.

No. 5 Ellway, C.P. and R.E. Kearney. 1981. Changes in the Fijian bait fishery, 1975-1980.

No. 6 Anon. 1981. Report of the second Skipjack Survey and Assessment Programme workshop to review results from genetic analysis of skipjack blood samples.

No. 7 Kearney, R.E. (ed.). 1982. Methods used by the South Pacific Commission for the survey and assessment of skipjack and baitfish resources.

No. 8 Kleiber, P.K., A.W. Argue, and R.E. Kearney. 1983. Assessment of skipjack (Katsuwonus pelamis) resources in the central and western Pacific by estimating standing stock and components of population turnover from tagging data.

No. 9 Argue, A.W., F. Conand, and D. Whyman. 1983. Spatial and temporal distributions of juvenile tunas from stomachs of tunas caught by pole-and-line gear in the central and western Pacific Ocean.

No. 10 Sibert, J.R., R.E. Kearney, and T.A. Lawson. 1983. Variation in growth increments of tagged skipjack (Katsuwonus pelamis).

No. 11 Lawson, T.A., R.E. Kearney, and J.R. Sibert. 1984. Estimates of length measurement errors for tagged skipjack (Katsuwonus pelamis) from the central and western Pacific Ocean.

No. 12 Kleiber. P., A.W. Argue, J.R. Sibert, and L.S. Hammond. 1984. A parameter for estimating potential interaction between fisheries for skipjack tuna (Katsuwonus pelamis) in the western Pacific.

No. 13 Sibert, J.R. 1984. A two-fishery tag attrition model for the analysis of mortality, recruitment and fishery interaction.

No. 14 Gillett, R.D. 1985. Tuvalu baitfish survey and development project.

No. 15 Gillett, R.D. 1986. Observer trip on United States purse-seine vessel (November-December 1984).

No. 16 Gillett, R.D. 1986. Observations on two Japanese purse- seining operations in the equatorial Pacific.

No. 17 Farman, R.S. 1986. An investigation of longlining activities in the waters of Tonga (24 April - 19 May 1985).

No. 18 Argue, A.W., M.J. Williams, and J.P. Hallier. 1987. Fishing performance of some natural and cultured baitfish used by pole-and-line vessels to fish tunas in the central and western Pacific Ocean.

III-2. HAWAII'S TUNA FISHERIES 1987

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1. INTRODUCTION

Hawaii's tuna fisheries are small compared to other tuna fisheries of the world, but they are the State's largest commercial fisheries. In Hawaii, fishing is socially important, a source of subsistence, and a part of the culture as well as a popular recreational activity. Among Hawaii's fisheries, tuna fisheries are perceived to have the greatest potential for expansion. This perspective is common in islands throughout the tropical Pacific, yet commercial and recreational fishermen express concerns regarding the availability of tuna and overfishing.

Tuna availability fluctuates locally, and the limited range of some island fisheries results in periods of poor yield that are not necessarily related to the condition of the Pacific-wide tuna stocks. On the other hand, there may be stocks that reside in island waters or that emigrate and then return. Over- exploitation of these stocks could result in low yields. Or, the features (i.e., currents, thermal structure, prey concentration) of the habitat that cause tuna to aggregate around the islands could change or be degraded. The movements and catch rates of tuna near islands, the question of local versus pan-oceanic stocks, and the dynamics of habitat features are the topics of current research. Total landings by the various tuna fisheries in Hawaii have been changing rapidly in recent years because of economic factors that have little to do with the condition of the stocks. Markets and product forms have changed, and some fisheries have expanded while others contracted.

2. DESCRIPTION OF THE FISHERIES AND PARTICIPANTS

The important tuna fisheries in Hawaii are the pole-and-line fishery for skipjack tuna *(Katsuwonus pelamis)*, called "aku," and the longline, handline, and troll fisheries for yellowfin tuna *(Thunnus albacares)*, called "ahi." A substantial proportion of longline and handline catches consists of bigeye tuna *(T obesus)*. A few bluefin tuna *(T. Thunnus)* are caught along with the bigeye tuna. These two species also are called ahi and are not always separated from yellowfin tuna in State catch reports . A very small proportion of the catch by longline and handline fisheries consists of albacore *(T. alalunga)* called "ahipahala." This catch is included in the totals given for all tuna species (Table 1). The distant-water troll fishery for albacore that offloads some catch in Hawaii is not covered in this report.

Traditionally, the fishery for skipjack tuna was the largest commercial fishery in the State, with a peak volume of 7,330 metric tons (mt) in 1965. The 1984 closure of Castle and Cooke's tuna cannery in Honolulu--combined with a period of low catch rates, increased fishing costs, and market competition from other tuna products--caused a decline in Hawaii's skipjack tuna fishery in recent years (Hudgins and Pooley, 1987). The commercial fisheries for yellowfin and bigeye tunas expanded and surpassed skipjack tuna production during the mid-1980s. Yellowfin tuna production reached 1,655 mt in 1986 (Table 1).

3. HAWAII'S SKIPJACK TUNA FISHERY

In Hawaii the great majority of skipjack tuna is caught by pole-and-line fishing with live bait. The baitboats used in the fishery are wooden-hulled sampans that carry crews of 7 to 12. Each vessel catches its own bait, mostly anchovy *(Stolephorus purpureus)* called "nehu," in bays, harbors and other sheltered waters. There is no attempt to "harden" the bait, and it is kept for only a few days. The pole-and-line fishery locates skipjack tuna schools by searching for bird flocks and, in recent years, catches some fish around fish aggregating devices (FADs). The vessels usually return to port every night and often work a 6-day week.

The pole-and-line fishery in Hawaii has existed since the late 1800s. Before World War II, there was a fleet of up to 26 vessels which landed an average of 5,000 mt per year from 1937 to 1940. Most vessels constructed before the war averaged about 31 mt displacement and had a bait-well capacity below 3,000 L (800 gallons, Class I). Larger sampans, averaging 58 mt, were built mostly in the late 1940's and 1950's. These generally had a bait-well capacity greater than 3,000 L (Class II).

During the 1950s through the mid-1970s, Hawaii's pole-and- line skipjack tuna catch averaged about 4,000 mt per year. In this period there were large variations in catch from year to year, but there was no long-term trend. Since the mid-1970s, the trend in landings has been downwards, reflecting both a decline in catch rates and a decline in fishing effort. The number of vessels declined steadily from 32 in 1948 to 13-15 during the 1970s. However, due to the increasing proportion of Class II vessels and an increased number of days fished per boat, standardized effort (Footnote 1) averaged about the same in the 1970s as in the 1950s (about 1,700 Class I fishing days per year) (Uchida, 1976; Skillman, 1987; K. Kikkawa, Footnote 2). Standardized effort dropped after 1979 to less than 1,140 Class II fishing days in 1981, 1982, 1983, and 1986 (Figure 1). Only nine vessels fished in 1986; one of these sank in 1987.

In addition to the domestic segment of the fishery, pole- and-line vessels from Japan also catch skipjack tuna within the Fishery Conservation Zone (FCZ) surrounding the Hawaiian Islands, predominantly in the Northwestern Hawaiian Islands. Foreign pole-and-line effort increased from 213 to 767 vessel-days from 1972 through 1977 (Yong and Wetherall, 1980). Foreign catches ranged from 2,000 to 4,600 mt per year during 1974 through 1984 (Boggs, 1987). This fishery is still active, but catch levels are not known. The increase in this fishery in the 1970s coincides with the decline of Hawaii's pole-and-line fishery, but no negative correlation exists between catches in the two fisheries on a year-to-year basis.

3.1 Total catch time-series for Hawaii's skipjack tuna fishery

Based on records dating back to 1948, there were no long- term trends in the annual catch of skipjack tuna, or in catch rates for skipjack tuna, prior to the mid-1970s (Uchida, 1976). Fluctuations in annual catch closely matched fluctuations in the catch rate, reflecting changes in the local abundance or availability of fish. A high degree of variability in catch and catch rate is characteristic of geographically restricted fisheries for skipjack tuna.

During the last two decades, the catch of skipjack tuna in Hawaii has gone from an all time high in 1965 to an all time low in 1985 (Figure 2). A downward trend in skipjack tuna catch began in the mid-1970s, marked by a record low catch of skipjack tuna larger than 6.8 kg (15 lb) in 1974 (Figure 2). Previously, more than half of the annual catch (by weight) had been composed of large ($\geq$6.8 kg) fish. Total catch also dropped in 1974, and in 1975 the catch was the lowest recorded up to that time. In 1976 the total catch was back up to the level of the long-term average. From there it gradually declined towards its present low level. However, the catch of large fish never increased above the 1974 level, and the proportion of large fish in the catch remained well below 50% through

1981. The proportion of large fish in the catch was about 50% in 1982, 1983, and 1986, indicating a return to a more normal size distribution.

In 1981 there was a substantial increase in the catch rate for all sizes of fish (Figure 3) that was not accompanied by a corresponding increase in the total catch. The marked decline in fishing effort in 1980 and 1981 (Figure 1) contributed to this sustained decline in catch. Effective effort has probably declined more than the data (Figure 1) indicate. Economic factors such as rising costs and the closure of the cannery in 1984, have had effects on fishing operations (sections 3.4 and 3.5) that are not accounted for in the way that effort was measured. Thus, in recent years, the relative abundance or availability of fish may have been higher than indicated by the catch rate (Figure 3).

Monthly time-series catch and effort data were analyzed by Mendelsohn (1981), who demonstrated a highly predictable seasonal pattern that was used to forecast month-to-month catches and effort. Summer is the time of peak effort, peak production, and the highest proportion of large fish in the catch. Anomalously large numbers of large fish were reported during the winter and spring of 1986-87. The time series of annual skipjack tuna catch in Hawaii has been found to be correlated with sea-surface temperature and salinity (Seckel, 1972; Mendelsohn, 1986), and various models have been used to predict annual catches based on these environmental variables. A trend of increasing sea-surface temperature and salinity during the past decade seems to have negatively influenced the availability of skipjack tuna, especially large skipjack tuna, around Hawaii. Reduced availability may be caused by movements of water masses that influence the movements of tuna, or temperature and salinity changes may affect food production or the survival and growth of juvenile tuna.

3.2 Geographic distribution of Hawaii's skipjack tuna fishery

Catches by the Hawaii domestic pole-and-line fishery have always been restricted to the areas around the eight main islands. Several vessels once were based on Hawaii and Maui, but now only one Maui boat is in operation and the rest work out of Kewalo Basin on Oahu. These vessels catch bait in Pearl Harbor and Kaneohe Bay. In the 1970s and 1980s, most of the catch came from around Oahu and from areas within 37 km of the south and west coast of Lanai. In the 1950s and 1960s, when there were more boats based on the outer islands, sizable catches also came from areas within 37 km of the northeast coasts of Maui and Hawaii.

Catch rates are consistently higher than average for trips made to "oceanic" areas more than 37 km from shore, mostly south and west of Oahu (Uchida, 1966, 1976). The catch from "oceanic" areas averaged about 25% of the total catch from the 1950s through the early 1960s (Uchida, 1966). From 1974 through 1981, the "oceanic" catch averaged only about 20% of the total catch (footnote 2). This decline began after fuel prices increased in 1973.

3.3 Distribution of Hawaii's skipjack tuna catch by participant and gear

Extrapolating from 1984 catch levels by the Japanese pole- and-line vessels fishing in the Northwest Hawaiian Islands suggests that the foreign catch amounts to about four times the domestic catch. About 11% of the commercial domestic catch of skipjack tuna is caught on gear other than pole-and-line. Roughly 10% was caught by commercial trollers in 1985.

3.4 Status of the skipjack tuna stock

Hawaii's skipjack tuna fishery is too small to affect the widespread stocks of skipjack tuna in the Pacific. Uchida (1976) showed that in Hawaii fishing intensity had no effect on catch rates during a time when domestic catches were as high as current levels of Hawaii's domestic and foreign catch combined. More research and current data are needed to establish whether the Pacific-wide increase in catch has affected the availability of skipjack tuna to Hawaii fishermen but the consensus is that it has not.

The status of the baitfish stocks is poorly documented. The catch-per-unit of effort (trip) for baitfish in the 1970-81 period (footnote 2) averaged higher than in the previous decade (Uchida, 1977). This may be due to fewer vessels exploiting the resource or to vessels fishing longer (per trip) to collect bait. A lack of bait is frequently cited as a problem by the fishermen.

3.5 Economic aspects of Hawaii's skipjack tuna fishery

Low earnings since the 1960s have curtailed investment in new boats. The only recently constructed (1971), steel-hulled vessel in the fishery became too expensive to operate in recent years. Attempts to increase profits by selling more high-priced, fresh aku faced market limitations even before the cannery closed. During 1970-85, price per ton rose 45%, but costs rose 75% (after inflation). To offset fuel (200%) and insurance (390%) cost increases, the share of profit paid to crews was kept low and repairs were postponed (Pooley, 1987). This has resulted in safety problems and depreciation. Without regular maintenance a vessel experiences trouble obtaining the insurance that is required for entering U.S. military harbor areas to catch bait.

Total catch is correlated to the annual average catch rate (Uchida, 1976) and to the proportion of large fish in the catch as well as negatively correlated with the price of fuel (Hudgins, 1986). Large skipjack tuna (6.8 kg) command higher prices than smaller skipjack tuna in the fresh fish and cannery markets. Comparing 1982 to 1974, the decrease in annual catch attributable to fuel price increases was estimated to have reduced annual revenue by $1.3 million. Over this same period, a decrease in catch attributable to reduced catch rate (Figure 3) and a low proportion of large fish in the catch (Figure 2) were estimated to have reduced annual revenue by $1.0 and $0.36 million, respectively (Hudgins, 1986).

The mechanism by which fuel price increases affect the catch has not been documented, but clearly, the fuel price rise that began in 1973 did not immediately affect standardized effort (Figure 1). Perhaps expensive fuel, as well as poor maintenance, results in restricted scouting for schools of fish and fishing closer to land. It has been suggested that fishing around FADs increases the proportion of small fish in the catch, but FAD fishing seems to be mostly a last resort when schools of larger fish cannot be located. The catch of small and extra small fish increased 1976 whereas FADs were not deployed for a full year until 1980 (Hudgins, 1987).

The increase in the catches of yellowfin and bigeye tunas during the 1970s and 1980s resulted in competition for the fresh tuna market. Skipjack tuna is priced lower than yellowfin tuna but has fewer fresh product forms and is not widely accepted as a fresh product. In 1985, the average ex-vessel price for skipjack tuna was only $2.48/kg ($1.13/lb), whereas the average price for yellowfin tuna was $3.13/kg ($1.42/lb). Yellowfin tuna can readily be sold for cooking to the restaurant market in Hawaii and for export. Skipjack tuna has not gained much acceptance in these markets. Yellowfin and bigeye tunas are preferred over skipjack tuna for sashimi in many markets. Recently, Japan has been promoting skipjack tuna for sashimi in its domestic markets. For many years Japan has exported to Hawaii flash-frozen skipjack and yellowfin tunas that, although acceptable for sashimi, can be distinguished as inferior to fresh tuna.

The closure of Honolulu's tuna cannery in 1984 cost the skipjack tuna fishery an estimated $0.5 million in annual sales, and the loss would have been much worse had the fishery not already been so reduced (Hudgins, 1986). The lack of a cannery market is especially troublesome during the summer when the skipjack and yellowfin tuna fisheries reach peak production. The lack of a single marketing organization for the pole-and-line vessels sometimes results in severe competition and devastating price reductions (Boggs and Pooley, 1987a). Many of the vessels now operate under a quota system to avoid flooding the market. An expanded market, and product forms with a long shelf life to absorb peak production during the summer, are seen as the greatest economic concern of the skipjack tuna industry (Boggs and Pooley, 1987b). A group of investors purchased the cannery facility in 1985 with the intention of integrating it into a marine-oriented tourist center, but the cannery has not yet reopened. Making tuna canning profitable in Hawaii will probably require promotion of specialty packs that appeal to tourists and local residents, because production of normal canned tuna in Hawaii is too expensive to compete on the world market (King, 1987).

3.6 The outlook for Hawaii's skipjack tuna fishery

The future of the fishery depends primarily on economic factors rather than on the status of the stock, although another period of low numbers of large fish would reduce profits and drive more fishermen out of business. The National Marine Fisheries Service (NMFS) will continue its efforts to understand and predict changes in availability. The best thing that could happen with regard to local availability of fish would be for the large fish to be less seasonal, with fish available during the times of year when they are typically scarce, as happened in 1986-87. This allowed many of the vessels to make their first major profit in recent years. The State of Hawaii is researching market expansion and supporting experiments to try and increase shelf life. The industry is looking for new product forms and trying to reopen a cannery. At the very least, the limited local market will support a continued fishery to supply fresh skipjack tuna, but this market may not support all the vessels in the present fleet.

4.0 HAWAII'S YELLOWFIN AND BIGEYE TUNA FISHERIES

Up-to-date information on Hawaii's yellowfin and bigeye-tuna fisheries is scarce. Hawaii's tuna fisheries have been a low priority for monitoring and research during the era of the Fishery Management Plan development and application. In the past, the longline fishery was the second largest commercial fishery in the State after the pole-and-line fishery, but it declined through the 1960s and 1970s and is now smaller (in terms of catch) than the troll and handline fisheries. Historically, this fishery captured mostly bigeye tuna but in the 1980s yellowfin and bigeye tunas have alternated in comprising the largest proportion of the longline catch. All of Hawaii's fisheries for yellowfin tuna also catch billfish and other pelagic species in small proportions to the catch of tuna (Anonymous, 1986).

Most of Hawaii's longline fleet is composed of relatively small (12 to 160-mt) boats. Some of these boats now operate different gears at different times of year. This, and failure to report catches, make tracking the number of vessels in the fishery difficult. The number appears to have declined from 76 in 1950 to a minimum of 16 in 1979, and then to have increased to 27 by 1983. This recent resurgence is not reflected in the State of Hawaii catch statistics for yellowfin and bigeye tunas (Figures 4 and 5). Longline catches were reported by only 8 vessels in 1980-81, and 14 in 1983-84. A survey of boats carrying longline gear showed a total of 37 in 1984 (Footnote 3); this figure has been used to correct catch data for under- reporting by multiplying reported catch by the ratio of 37/14 = 2.86 (Hudgins and Pooley, 1987).

The Hawaii longline or "flagline" fleet contains the traditional wooden sampans as well as newer, steel and Fiberglas vessels. Three of eleven boats surveyed in 1982 were built after 1970 (Hawaii Opinion, Inc., 1984). The operation is a scaled- down version of that used by the distant water fishing fleets of Japan, Korea, and Taiwan. The only unit of effort available from State of Hawaii statistics is the trip, and the amount of gear set per trip and length of trip changed over the years. Currently, the number of hooks per set varies from 120 to 660 and the number of sets per trip varies from 1 to 4 (Hawaii Opinion Inc., 1984). The number of reported trips was 137-369 in 1981 through 1985 compared to 450-600 trips in the 1970s. Since 1980, no foreign longline effort has been reported in the FCZ around the Hawaiian Islands.

Two types of handline fishing for tuna are practiced in Hawaii today. The night-handline fishery is called "ika-shibi" after the squid, called "ika," used to catch "shibi" or large tuna. This fishery is an outgrowth of a squid fishery that probably began in the 1920s but did not target tuna until after World War II. All catches were sold on the Island of Hawaii, where the fishery was located until 1971. Then the rising price made it economical to ship fish to Oahu and elsewhere by air (Yuen, 1979). Surveys by Yuen (1979) and Ikehara (1980) indicate that the fishery grew from 30-40 boats in 1976 to at least 230 boats by 1980. The day-handline fishery is a revitalization of an ancient Hawaiian method, called "palu ahi," that uses "palu" (chum) to attract and hook "ahi." Most handline boats are 6 to 9 m and are often crewed by one person.

The size of the commercial troll fishery that catches yellowfin tuna has also increased since the early 1970s and commercial trolling is now the second largest commercial fishery for yellowfin tuna in the State. An estimated 160 trolling vessels operated in 1976, about 76% were trailered, and 80% were about 6 m long (Cooper and Adams, 1980).

The only available estimates of the magnitude of the recreational fisheries for skipjack and yellowfin tunas are taken from Hudgins and Pooley (1987) (Table 1).

4.1 Total catch time series for Hawaii's yellowfin and bigeye tuna fisheries.

Total annual catches of yellowfin tuna declined from a peak in 1946-47 of 600 mt to a low of about 150 mt in 1956 (Figure. 4). The catch remained at a low level of about 200 mt per year until 1970, with the major gear type being longline. Then the annual catch began to climb as the handline and trolling fisheries expanded in the 1970s (Figure 4). In the 1980s the annual catch has been highly variable, ranging between 800 and 1700 mt. Total annual catches of bigeye tuna declined from a peak around 1300 mt in 1953-54 to almost zero in 1981 and in recent years the reported catches have been below 100 mt (Figure. 5).

The decline in bigeye tuna catches was largely due to declining longline effort (Figure. 5), as virtually all of the reported bigeye catch is made by longline. However, some of the decline is due to under-reporting, or misreporting of bigeye tuna as yellowfin tuna. Dealer surveys show that major quantities of bigeye tuna are sold by handline operators yet these quantities do not show up as bigeye tuna in the State of Hawaii statistics. Conversely, some of the increase in yellowfin tuna catches over the last 18 years (Figure. 4) may be due to increased reporting of bigeye tuna as yellowfin tuna.

4.2 Geographic distribution of Hawaii's yellowfin tuna fishery.

Most of the longline fleet is located at Oahu with some vessels also operating out of Hawaii. The distribution of effort based on catch reports has not been summarized, but longline fishermen reportedly must fish farther away from the Hawaiian Islands in order to catch fish (Hawaii Opinion Inc., 1982). In 1986, a domestic longliner from Hawaii pioneered fishing in the Line Islands and the practice became a trend in 1987. The declining proportion of bigeye tuna in the longline catch may be due to a shifting of fishing areas or fishing seasons as been the case in the past (Shomura, 1959).

The handline fishery is concentrated around the Island of Hawaii. "Ika-shibi" fishing is concentrated on the Hilo-side, but the method is spreading and is now practiced on Kauai and Maui.

Some long-time participants believe that the handline fishery has become too crowded. To avoid further crowding, the State of Hawaii has been trying to encourage handline fishing in new areas, but these efforts are hampered by restrictions that prevent the State from entering into contracts with fishermen who do not have insurance.

4.3 Status of the yellowfin and bigeye tuna stocks

Yellowfin tuna appear not as highly mobile as skipjack tuna (Hunter et al., 1986), and very little is known about the mobility of bigeye tuna. The State of Hawaii, Division of Aquatic Resources, has been tagging small yellowfin tuna. Most of the tuna recaptured were very close to the site of tagging; few moved from Oahu to Hawaii. The NMFS has been tracking yellowfin tuna in Hawaiian waters by using ultrasonic telemetry, and the results show that yellowfin tuna visit and revisit the vicinity of FADs or places where the bottom contour along the coast intersects the thermocline. More information is needed, especially on large yellowfin tuna, but the limited data suggest some groups of yellowfin tuna may be associated with the island ecosystem.

One could hypothesize that reductions in local abundance could result from local overfishing of island-associated yellowfin tuna. However, assertions by Hawaii fishermen--that prolonged overfishing has reduced the stocks--are hard to reconcile with the record catches reported in 1986. Local yellowfin tuna availability is probably affected more by the environment than by fishing pressure, but this hypothesis remains to be tested. The local availability of yellowfin tuna was very low in some areas in 1987.

Crude bigeye tuna catch rates (catch per trip), estimated from the longline catch and effort data, (Figure 5) show a downward trend matched by an upward trend in longline catch rates for yellowfin tuna. These trends may reflect a change in species composition due to season and area fished. For yellowfin and bigeye tunas combined, the crude catch rate (catch per trip) in 1985 did not show a decline when compared to earlier years (1958-78) for which data have been analyzed. However, if local fishermen must fish farther and farther from Hawaii to maintain this high catch rate, that would constitute evidence of a sustained decline in the availability of yellowfin and bigeye tunas close to the Hawaiian Islands.

4.4 Economic aspects of Hawaii's yellowfin and bigeye tuna fishery

The market for yellowfin and bigeye tunas was not badly hurt by the closure of the cannery because the catch had expanded specifically to meet the domestic and foreign markets for sashimi-quality fish and fresh fish used for cooking. However, in a year when yellowfin tuna are extremely abundant in Hawaii, the surplus can drive down the price. For example, in 1986, the ex-vessel price was only \$2.62/kg (\$1.19/lb) compared to \$3.13/kg (\$1.42/lb) in 1985. The potential for saturating the market is greatest during the summer when yellowfin tuna are most abundant. In the past 2 years, competition by foreign and mainland U.S. suppliers of yellowfin has increased the potential for an excess supply of fresh yellowfin tuna. The negative impact of a glut could be ameliorated by reopening the cannery or developing flash-frozen product forms to absorb the excess.

The high cost of insurance has become a major problem, especially for Hawaii's handline fishermen. Many have quit because they cannot afford it. Others risk loss of their investment by continuing to fish without insurance. Another problem in the handline and troll fisheries is the low price received for fish affected by the condition called "burnt tuna." This condition, which discolors and gives a bad taste to sashimi, is common in handline- and troll-caught tuna over 35 kg, but rare in longline-caught fish. Active research is under way to find a method to prevent this problem. Quality control over exported fish is important to maintain a viable export trade of sashimi- quality yellowfin and bigeye tunas.

4.5 The outlook for Hawaii's yellowfin and bigeye tuna fisheries

Other yellowfin tuna and bigeye tuna fisheries are competing for the same export markets as Hawaii, and quality could be a determining factor. Hawaii has the advantage of being an established exporter to the U.S. mainland, but the yellowfin tuna fishery in the southeastern United States is expanding its marketing aggressively and is closer to the market. Among fishermen, concern exists over the status of the stocks of yellowfin and bigeye tunas. However, historical catch and effort data require further analysis and additional up-to-date information is needed to determine whether there are valid grounds for this concern. No solid evidence exists for a decline in the abundance of the stocks. Yellowfin and bigeye tunas should continue to be among Hawaii's most valuable fishery resources.

5. ACKNOWLEDGMENTS

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6. FOOTNOTES

1. The effort data were standardized to account for zero-catch trips and for the difference in efficiency between Class I and Class II fishing vessels (Uchida 1976, footnote 2).

2. Kikkawa, B.S. 1986. An update of the skipjack tuna, *Katsuwonus pelamis,* baitboat fishery in Hawaii, 1971-80. NOAA NMFS Southwest Fisheries Center unpublished manuscript.

3. Honda, V.A. 1985. An updated description of the Hawaiian tuna longline fishery. NOAA, NMFS, Southwest Fisheries Center unpublished manuscript. 28 p.

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8. LIST OF FIGURES

Table 1. Hawaii tuna catch (metric tons) and revenue* in 1985 and 1986

Commercial Fishery	Catch (by year) 1985	Catch (by year) 1986	Revenue ($ thousands) (by year) 1985	Revenue ($ thousands) (by year) 1986
Skipjack tuna	956	1,200[a]	2,301	2,575
Pole-and-line	853		2,118	
Trolling	94		168	
Yellowfin tuna	1,180	1,849	4,034	5,240
Handline[b]	543		1,507	
Trolling	387		1,296	
Longline[c]	147		990	
Pole-and-line	103		240	
Bigeye tuna	208	303	1,145	1,450
Longline[c]	201		1,118	
Handline[b]	5		18	
All tuna species[d]	2,409		7,623	
Pole-and-line	959		2,365	
Handline[b]	559		1,550	
Trolling	513		1,506	
Longline[c]	378		2,202	
	1981 Catch		1981 Value	
Recreational[e] Fishery for Skipjack & Yellowfin tuna	2,050		5,300	

* From Hawaii Division of Aquatic Resources (HDAR) 1985 data and 1986 preliminary estimates (unless otherwise noted).

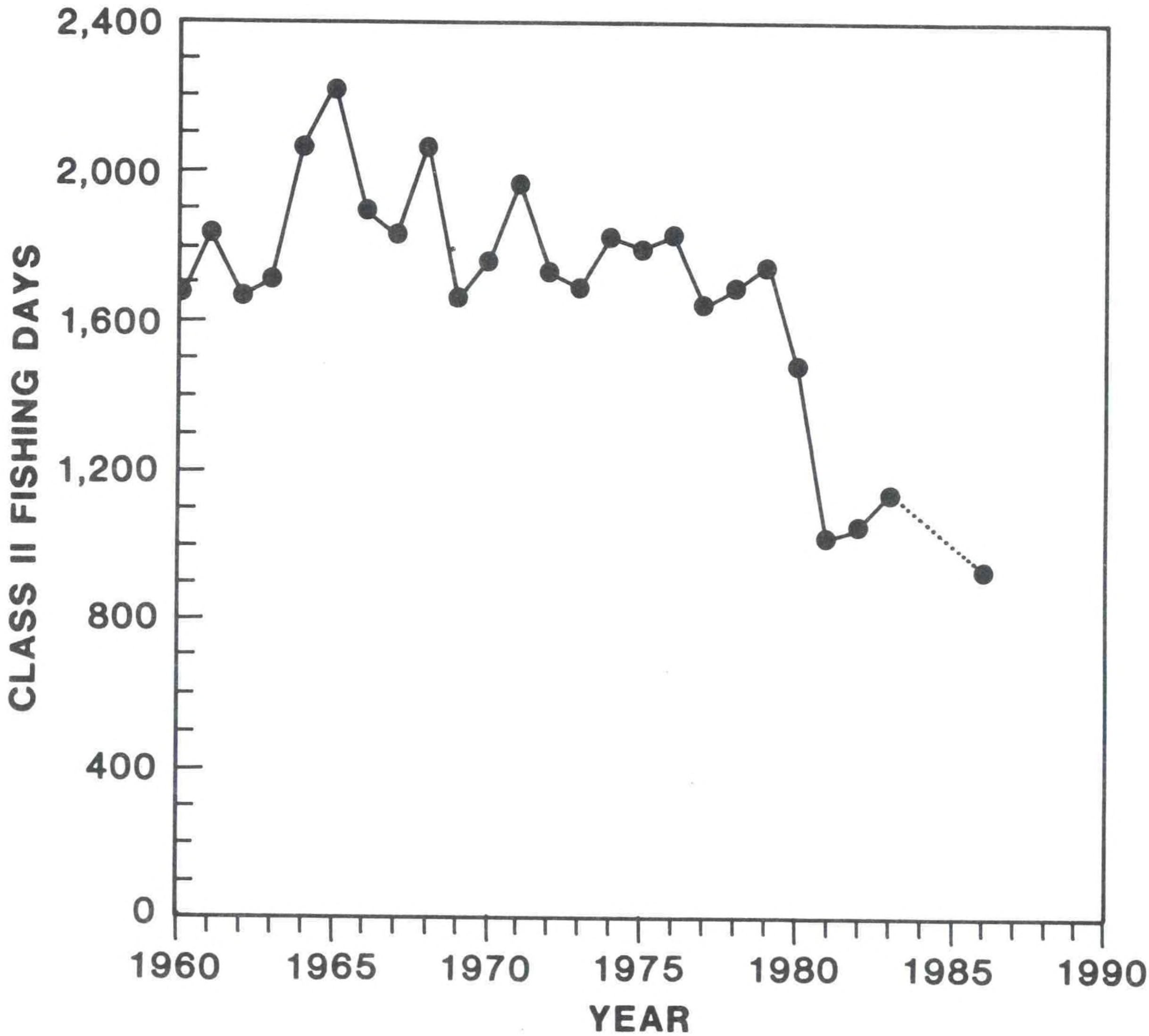
[a] Estimated from NMFS dockside sampling of pole-and-line landings plus extrapolated landings by other gear types.

[b] Data are HDAR totals for gear types 3, 8,9, and 35.

[c] Increased by 2.86 times to account for under reporting (see text). Increased subtotal reflected in species total.

[d] Includes small amounts of albacore and kawakawa (Euthynnus affinis).

[e] From 1981 Marine Recreational Fishing Statistical Survey (Hudgins and Pooley, 1987).



2,400
2,000
1,600
1,200
800
400
0
CLASS II FISHING DAYS
1960
1965
1970
1975
1980
1985
1990
YEAR

FIGURE 1

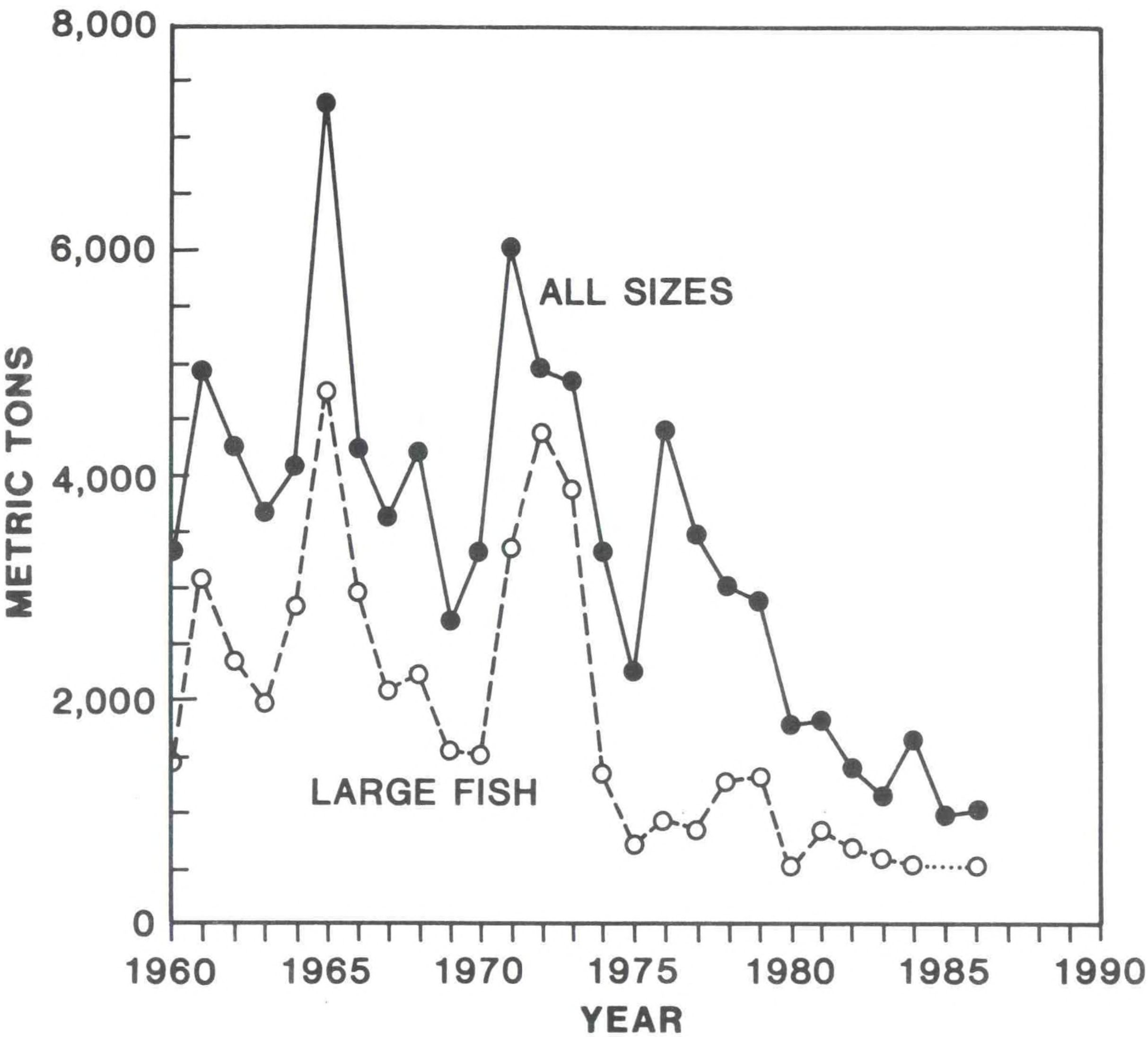

8,000
6,000
4,000
2,000
0
METRIC TONS
ALL SIZES
LARGE FISH
1960
1965
1970
1975
1980
1985
1990
YEAR

FIGURE 2

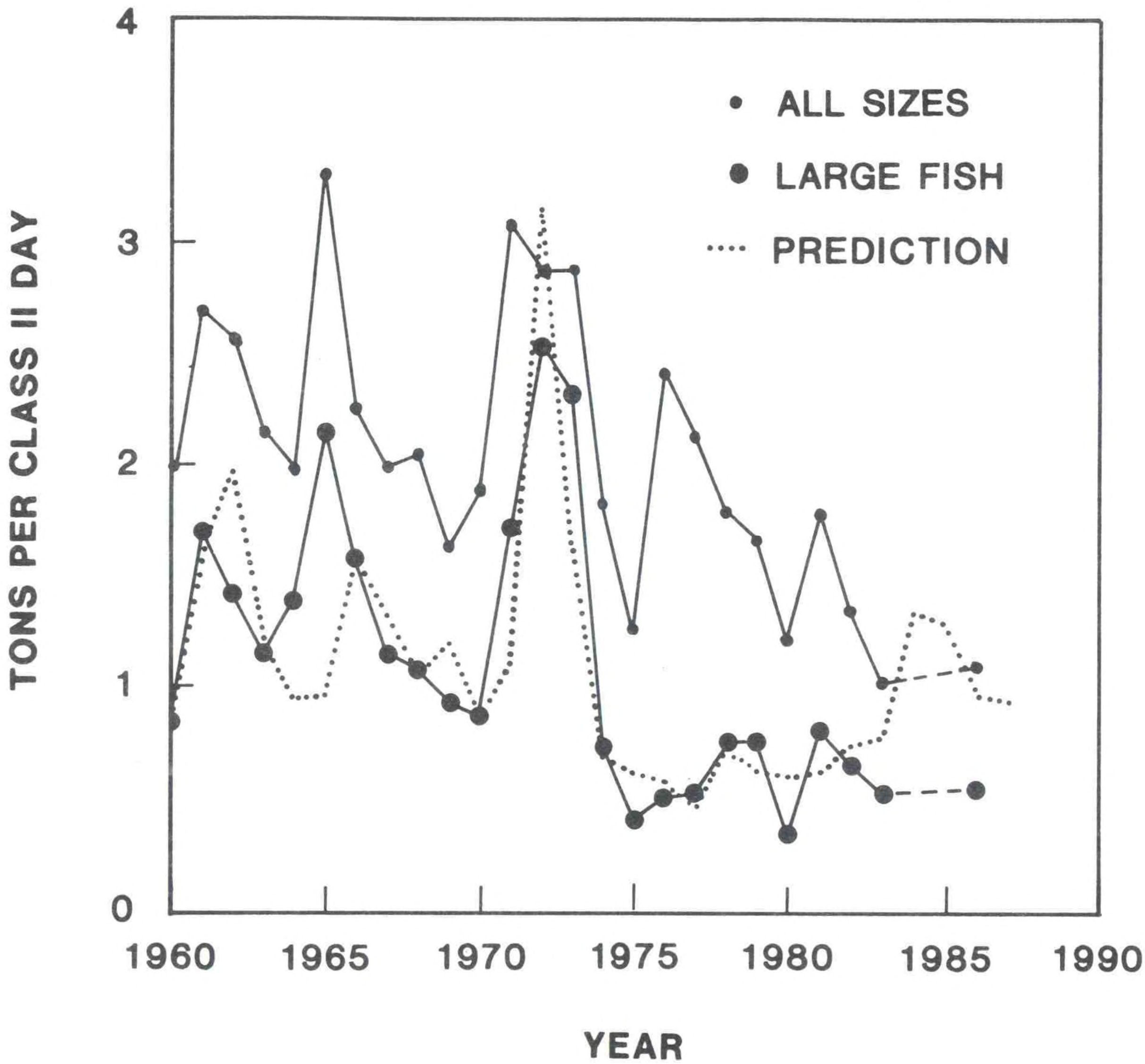
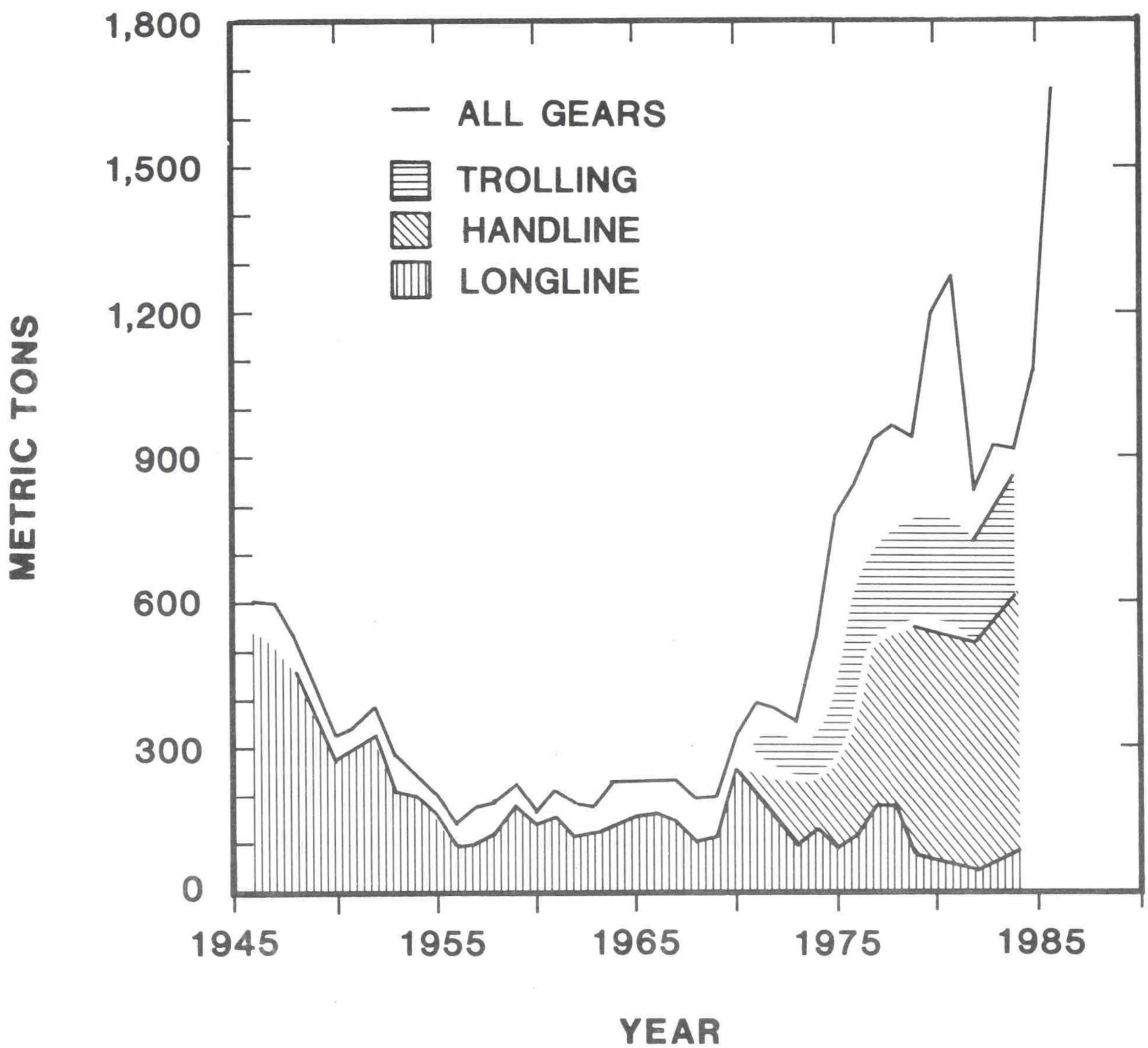

ALL SIZES
LARGE FISH
PREDICTION
TONS PER CLASS II DAY
0
1
2
3
4
1960
1965
1970
1975
1980
1985
1990
YEAR

FIGURE 3



1,800
1,500
1,200
900
600
300
0
METRIC TONS
ALL GEARS
TROLLING
HANDLINE
LONGLINE
1945
1955
1965
1975
1985
YEAR

FIGURE 4

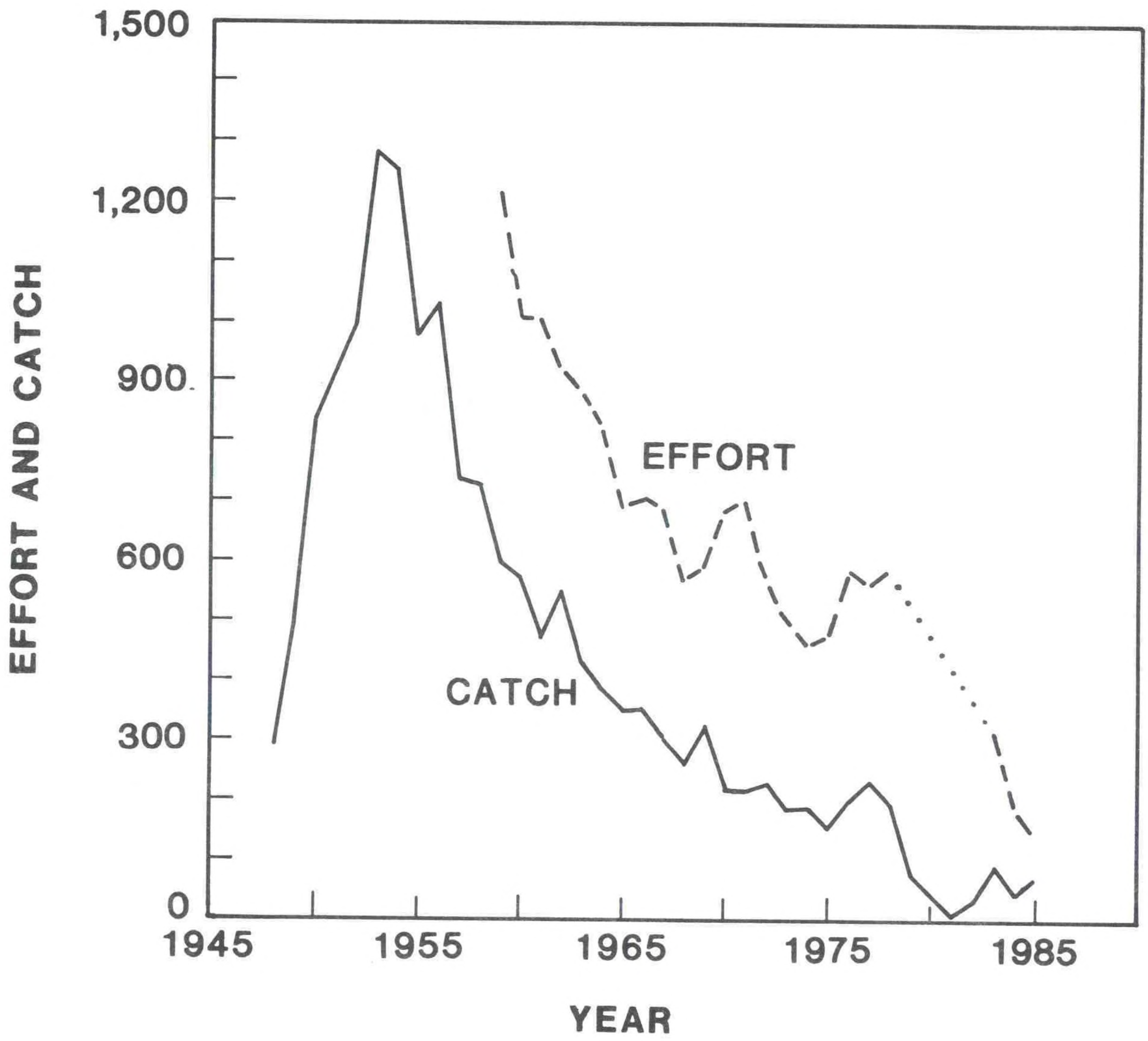

1,500
1,200
900
600
300
0
EFFORT AND CATCH
EFFORT
CATCH
1945
1955
1965
1975
1985
YEAR

FIGURE 5

III-3. WESTERN PACIFIC YELLOWFIN TUNA FISHERIES 1987

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1. INTRODUCTION

Economic and technological developments in the international tuna industry have brought the western Pacific fisheries [see Introduction, I-1] to the forefront of regional tuna production. Long the world's leading producer of skipjack tuna, the western tropical Pacific also surpassed the eastern Pacific in catches of yellowfin tuna *(Thunnus albacores)* in 1980: 158,800 mt vs. 146,300 mt (FAO, 1982). Western Pacific superiority continued through 1984, in part due to poor fishing during the years 1982- 1984 in the eastern Pacific. After 1984, record catches in the eastern Pacific probably surpassed western Pacific catches, at least temporarily. Historically, most western Pacific yellowfin had been taken by longline gear, but after 1983 purse seine caught yellowfin overtook longline production (Sibert, 1986), bringing a new dimension to the western Pacific tuna fisheries.

Although long extant, these fishing industries now have features of immature, expanding fisheries. As is typical of such fisheries, standard fishery statistics are incompletely available to management agencies. Nevertheless, it is possible to understand much of what is happening. Information gleaned from various reports is used to describe yellowfin tuna in the western Pacific, within a context of the total Pacific tuna fisheries.

2. DESCRIPTION OF THE WESTERN PACIFIC TUNA FISHERIES

2.1 Development

The distant water fleets that fish the high seas supply most of the tuna to the tuna industry; the development of this fishing capability was led by Japan, whose fishing activities now largely characterize the western Pacific fisheries. Following World War II, Japan rapidly renewed the expansion of its tuna fisheries into the western Pacific (Matsuda and Ouchi, 1984). Landings of longline-caught yellowfin tuna (and also bigeye tuna and albacore) increased rapidly through the 1950's, early surpassing skipjack tuna catches of the more localized, baitboat fleet. But yellowfin tuna catches peaked in the early 1960's while skipjack tuna production accelerated with development and establishment of new bait transporting systems and overseas fishing bases (there were 53 by 1974). By the late 1970's catches of yellowfin tuna plus other large tunas, and skipjack tuna had each reached about 350,000 mt (all areas), longliners had begun targeting the more valuable bigeye tuna, and there had been several trials to develop a more efficient purse seining technique for skipjack tuna. And, by the early 1980's, Japan had begun to actively de-emphasize its baitboat fleet to concentrate on year-round purse seining for skipjack tuna.

The new purse seine fishery involved fishing on logs and took considerable yellowfin tuna along with the skipjack tuna. Geographically, log fishing is pursued in equatorial waters of the Caroline Basin north of New Guinea, where logs washed from the high islands are accumulated by the Equatorial and Equatorial-Counter currents (Figure. 1).

Meanwhile the U.S. purse seine fishery for yellowfin tuna and skipjack tuna in the eastern tropical Pacific had been buffeted by narrowing economic and other constraints. When the 1982-83 El Niño (anomalous ocean warming) event brought additional deterioration to eastern Pacific fishing conditions, at least 65 of 127 U.S. purse seiners left for the western Pacific. The environmental anomaly had accelerated a trend toward the west that had begun when U.S. seiners first began exploratory fishing off New Zealand in 1974 (Petit, 1984). More U.S. seiners tried the western Pacific in the succeeding years, but it was not until after 1982 that a substantial number fished there year round (Table 1).

2.2. Catches by Country and Gear

Catches of both yellowfin and skipjack tunas by country for the years 1982 to 1985 are presented in Table 2 for FAO areas 71 (W. Tropical Pacific), 61 (NW Pacific), and 81 (SW Pacific). These data (FAO, 1985) are subject to revision, but are sufficient to show both the relative magnitude of catches and relative importance of yellowfin tuna among countries. Japan and American catches clearly stand out among the nations with distant water fleets. Total Area 71 yellowfin tuna catches have recently ranged between 175,000 and 200,000 mt, approximately.

Similar data for the years 1975 to 1985 (FAO, 1982, 1979, 1977) were assembled to show time trends (Figures 2, 3). One [note: The patterns shown may partly be an artifact of the particular FAO volumes used; data are not necessarily consistent between volumes.] Figure 2 compares trends in yellowfin and skipjack tuna catches in the western tropical Pacific (FAO Area 71) and in the eastern tropical Pacific (FAO Area 77). Notice the 1983 drop in eastern Pacific catches of both yellowfin and skipjack and the simultaneous rise of these catches in the western Pacific. This was the effect of the 1982-83 El Niño. Figure 3 compares Japanese and American yellowfin and skipjack catch trends in the western tropical Pacific. Notice the rapid increase of the early 1980's, reflecting growth of the new purse seine fishery for skipjack tuna (Japan), and both skipjack and yellowfin tuna (U.S.A.). The significance of the 1985 drop in catches is presently undetermined.

There is limited information on the partitioning of tuna catch according to gear, but 1981 - 1985 data supplied to the South Pacific Commission (Sibert, MS) can be used to show the relative importance of tuna species within gear types. Table 3, from these data, indicates that yellowfin tuna made up an average of 27% of the purse seine catch, 3% of the baitboat catch, and 64% of the longline catch. In the latter, yellowfin tuna showed a decreasing and bigeye tuna an increasing trend reflecting increased emphasis on the second species. Table 4 indicates that in 1981 about 25% of the yellowfin tuna was taken by seiners and 75% by longliners; by 1985, however, the situation had nearly reversed. The changing Japanese longline fishing strategy to bigeye tuna explains the shift in species composition (Sakagawa, Coan and Bartoo, in press).

3. STOCK ASSESSMENT

3.1 Size Composition

Yellowfin tuna caught under logs by purse seiners are mainly small, with length-frequency modes generally between 40 and 65 cm, or 2.6 - 12.1 lbs. (Gillett, 1986a; Iizuka and Watanabe, 1983). These sizes are very similar to those of the skipjack tuna with which they are caught. However, larger yellowfin, more than 100 cm in length (55 lbs.), are also taken by seiners though much less frequently and usually from schools not associated with logs. Such schools appear to be more prevalent east of the main log-fishing grounds, where they may sometimes account for nearly 20% of the skipjack plus yellowfin tuna catch by the seiners (Tanaka, 1983).

3.2 Population Segments Fished

Until recently more than half the yellowfin tuna caught in the western Pacific was taken by longliners, which fish to more than 150 m depth. Such fish are generally larger than 100 cm. This fishery, and apparently the population segments exploited, is widespread across the tropical Pacific (excepting the eastern tropical Pacific west of Middle America), and extends into temperate seas as well.

In contrast, the purse seine fishery, operates near the surface, primarily exploiting "logfish." Logs evidently continuously attract tunas, as well as other fishes, particularly at night. Purse seine sets on logs are made before dawn, if sonic inspection reveals suitable amounts of tuna. The catch is mainly skipjack tuna, but nearly always mixed with other species, including yellowfin tuna. The yellowfin tuna are usually similar in size to the skipjack and can amount to 25 - 40% of the catch (Tanaka, 1983; Gillett, 1986a). There may be lesser amounts (10%) of bigeye tuna and other log-associated species present. The latter include rainbow runner, scad, triggerfish, dolphinfish, sharks, and marlin (Gillett, 1986b). When large sized skipjack, yellowfin, or bigeye tunas are also present under logs, they apparently lurk beneath the main body of 40 - 60 cm tuna (Farman, 1987).

Free-swimming tuna, sometimes accompanied by birds, sometimes with whales, are fished by both baitboats and purse seiners. About 20% of the seiner catch may be from such schools (Sibert, MS). Many apparently free schoolfish schools fished by baitboats may actually be log-associated. Free schools are usually pure skipjack tuna (Farman, 1987), but can also be mixed with yellowfin tuna. Yellowfin tuna occur more frequently in free schools than in schools under logs (Gillett, 1986a). On the eastern sectors of the purse seine grounds (toward the Gilbert and Ellice Is.) mixed skipjack-yellowfin tuna schools seem to be more common, the individual fish larger, and the catch per set higher. Yellowfin tuna may be up to 30 lbs. and amount to 20-25% of the schoolfish catches there (Tanaka, 1983). Some schoolfish consist of even larger yellowfin and bigeye tuna, in the 50 lb. range. American seiners are more likely to fish these schoolfish, trying for larger yellowfin in spite of lower success rates (i.e., percent of purse-seine sets yielding 5 or more tons) on such schools in comparison to log-fish tuna (Tanaka, 1983).

3.3 Status of Stocks

The South Pacific Commission has assessed the status of yellowfin in the western Pacific, using 1979-86 data supplied by member Commission countries. Statistically, there was no compelling evidence found for over-exploitation (Sibert, 1986, Polacheck, MS). While catch rates in the longline fishery do show a long-term decline, the highly variable catch-effort relationship suggested an overall CPUE of about 2 fish/100 hooks, unaffected by level of effort. Similarly, there was no statistical evidence of a decline in CPUE with increasing effort in the purse seine fishery, where the catches appeared to increase linearly with effort, currently at about 5 tons/day fishing. There was no statistical evidence either for a correlation between purse seine and longline catch rates, a topic of concern since young fish surviving the surface fishery presumably are later exploited by the longliners.

The purse seine fishery for small yellowfin tuna thus appears to be in an expanding, immature phase, while the longline fishery for large fish may be near maturity, but probably is not over-exploited either. One must take this assessment with some caution, however. Data submitted to the Commission were incomplete, and there is always the question of correct interpretation of catch rates, in particular, those of the purse seine fishery on log-associated yellowfin tuna. If for no other reason, therefore, total landings must be continuously monitored.

4. OUTLOOK

4.1 Industrial Tuna, Growth and Prospects

Western Pacific countries rapidly increased their production and processing of tuna for the international market during the early 1980's. Capitalizing on rising production costs and retail sale prices in the U.S. industry, Asian countries substantially increased exports of canned and raw tuna to the United States. By 1985 canned tuna imports, mainly from Thailand, Japan, the Philippines, and Taiwan, tripled those of 1979, and about 25% of U.S. cannery receipts of raw tuna were being imported from the western Pacific (Herrick and Koplin, 1986a). Together with U.S. catches from the region, the western Pacific had become the most important source of tuna for the U.S. tuna industry, which by then had considerably retrenched.

4.2 Extended Jurisdiction Effects

Development and management of western Pacific tuna fisheries will become more complicated as territorial claims by island and coastal states are formalized. Most of these nations signed the 1982 U.N. Convention of the Law of the Sea (UNCLOS) treaty and declared 200 mile territorial seas. The international standing of the treaty will likely allow them to eventually gain control of most of the tuna resources within their extended territories, and from these tuna they expect economic rent from licensing fees or direct or cooperative harvesting. Growth of industrial tuna production, both from localized skipjack tuna fisheries (many are joint ventures) and distant water purse seine fisheries on skipjack and yellowfin tuna, will require mechanisms to deal with these territorial claims. Multi-national regional fishing agreements that recognize both the resource claims of the coastal/island states and the technical/economic expertise of distant water fishing nations would be a preferred method. An example of this is the fishery access agreement the United States signed with certain Pacific Island states in 1987. Similarly, resource management devices, such as quotas, may have to be allocated in some accordance with the various national claims.

4.3 Research

Tuna research in the western Pacific will also be affected by the resource claims within extended territorial seas. Some research proposals will have strong economic and political implications. As the nations maneuver for fishery and economic advantage under the UNCLOS regime, there will be both claims of local depletion with need for intense localized tagging and behavioral studies, and arguments for international management, large scale experiments, and maximizing of total, regional yields. All will likely agree, however, on the need to learn more of the relationship between surface and deep yellowfin tuna stocks, between log-fish and schoolfish yellowfin tuna, and to learn of the determinants of the different schooling behaviors that affect catchability. On the practical side, techniques will be developed to better capture schoolfish, especially the larger, more valuable schoolfish yellowfin tuna, which apparently are more prevalent in the eastern portion of the purse seine grounds (Suzuki, 1982). If large fish are, or do become, an important component of the surface catch of yellowfin, there will be a more direct link to the subsurface fishery. The latter's catch rate would then be more likely to decline with that of the surface fishery, as has happened in the eastern Pacific (IATTC, 1987).

4.4 The New U.S. Tuna Regime

The dramatic 1983 surge of U.S. seiners into the western Pacific was directly related to the anomalous El Niño event, but a similar surge back to the eastern Pacific did not occur when the environment returned to normal, nor should it have been expected. Having gained experience in the west, and with the industrial environment ever changing, the U.S. fleet could never again be the same. Henceforth U.S. seiners will likely work both sides of the Pacific, each to greater or lesser extent depending upon fishing and market conditions. This would be a natural result of lessened demand for U.S. raw tuna by surviving American processors grown less dependent upon any one producing segment, of reduced ex-vessel prices for tuna (large yellowfin tuna was down to about $800/sh. ton in recent years), and of various other problems related to offloading catches to fewer canneries. In seeking a more reliable resource and market environment, U.S. seiners expanded their efforts to the west and, in recent years, vigorously increased their deliveries to foreign canneries (29,000 mt in 1984 vs. 2,900 tons average for the 1979-83 period (Herrick and Koplin, 1986b)). Although yellowfin tuna caught in the western Pacific may be mostly small, and actually a by-catch of the skipjack tuna fishery, fishing in that region may be a rather dependable enterprise. The canneries are near, they rely primarily on skipjack-sized fish, and log-fishing for yellowfin and skipjack tuna has a very high success rate, approximately 86% of sets yielding >1 mt/set (Gillett, 1986b). Furthermore the 1987 U.S. agreement with certain Pacific Island states will provide access to fishing areas. The new east-west yellowfin tuna fishing regime that has emerged in the Pacific represents a diversification of fleet operations and economics in times of increased international competition in all areas of American industry.

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6. FIGURES

1. Map showing general area of central-western Pacific purse seine fishing grounds.

2. Trends of eastern vs. western Pacific yellowfin tuna and skipjack tuna catches.

3. Recent trends in yellowfin tuna and skipjack tuna catches in the western Pacific.

Table 1. Estimates of numbers of Japanese and American purse seiners operating year-round in the western Pacific

	1979	1980	1981	1982	1983	1984	1985	1986
U.S.A.	4	6	12	16	65	60	40	36
Japan	16	14	24	33	33	32	39	39
Total	20	20	36	49	98	92	79	75

Notes: From IPFC 1986, Petit 1984; U.S.A. seiners include some non-U.S. seiners from the eastern Pacific.

Table 2. Yellowfin and skipjack catches (in thousands of mt) by country from the western Pacific according to FAO

Country	1982 YF	1982 SJ	1983 YF	1983 SJ	1984 YF	1984 SJ	1985 YF	1985 SJ
Area 71 (w. trop. Pacific)								
U.S.A.	0.8	3.0	12.9	13.7	41.5	114.3	28.8	85.7
Japan	76.0	158.9	77.1	137.1	60.3	210.4	39.0	95.1
Korea	7.4	1.6	2.7	3.0	1.4	13.7	1.9	11.3
Other	2.4	-	1.4	-	1.0	-	1.1	-
Philipp.	48.0	31.2	56.2	38.4	59.9	44.7	64.3	60.5
Indon.	17.6	44.2	21.9	46.9	25.1	64.0	29.1	69.9
Fiji	0.2	2.0	0.8	5.9	1.8	4.4	1.1	3.3
Papua N.G.	3.0	31.0	3.5	20.5	0.4	2.4	0.4	2.4
Solomons	0.3	22.2	1.2	23.9	2.8	33.2	3.7	26.8
Kiribati	3.1	4.8	3.0	5.0	4.0	6.2	4.8	3.3
Pac. Is. Tr.	-	4.2	-	5.4	-	5.4	-	5.4
Area Total	158.8	303.1	180.8	299.9	197.2	498.7	174.2	362.8
Area 61 (NW Pacific)								
Japan	12.4	126.9	16.5	152.0	26.0	225.3	26.6	111.9
Korea	+	-	0.3	+	-	0.1	+	2.8
Other	17.4	3.3	17.0	2.7	17.3	1.5	17.8	1.6
Area Total	29.8	130.2	33.8	154.7	43.2	227.0	44.4	116.3
Area 81 (SW Pacific)								
U.S.A.	0.5	1.4	-	4.0	-	-	-	-
Japan	0.7	0.1	0.6	+	0.4	0.2	0.6	+
Korea	5.2	0.9	0.8	+	0.4	+	0.1	-
Other	0.1	+	+	+	0.1	-	0.1	-
Austr.	0.1	0.4	0.1	0.2	0.1	0.2	0.1	0.2
N. Zeal.	+	5.2	+	8.1	+	3.9	+	1.1
Area Total	6.6	8.0	1.5	12.4	0.9	4.3	0.9	1.3

Table 3. Percent tuna species composition by gear each year.

Gear	Sp.	1981	1982	1983	1984	1985	
Purse seine	SJ	68	70	78	70	74	
	YF	31	29	21	29	25	
	Other	1	1	1	1	1	
Totals	%	100	100	100	100	100	
	Catch	30.8	76.1	98.4	303.4	213.3	X 10^3 mt
Baitboat (pole/line)	SJ	98	93	98	98	95	
	YF	1	5	2	2	4	
	Other	1	2	1	+	1	
Totals	%	100	100	100	100	100	
	Catch	39.1	22.6	46.9	33.8	21.8	X 10^3 mt
Longline	SJ	-	-	-	-	-	
	YF	72	65	72	55	56	
	BE	14	18	14	21	25	
	Other	14	17	13	24	18	
Totals	%	100	100	100	100	100	
	Catch	1534.3	1528.3	1312.2	1535.7	1652.4	X 10^3 mt

Table 4. Percent yellowfin tuna taken by different gears each year in the western Pacific.

Gear	1981	1982	1983	1984	1985
Purse seine	26	45	46	80	69
Baitboat (P/L)	1	2	2	1	1
Longline	74	52	53	19	30
Total	100	100	100	100	100

Note: Baitboat catches may be 60% under-reported in data used (Sibert MS). This should not affect percentages for yellowfin since little are taken by baitboats anyway. Similar calculations show that virtually all bigeye are taken by longliners and that skipjack are taken by both baitboats and purse seiners.

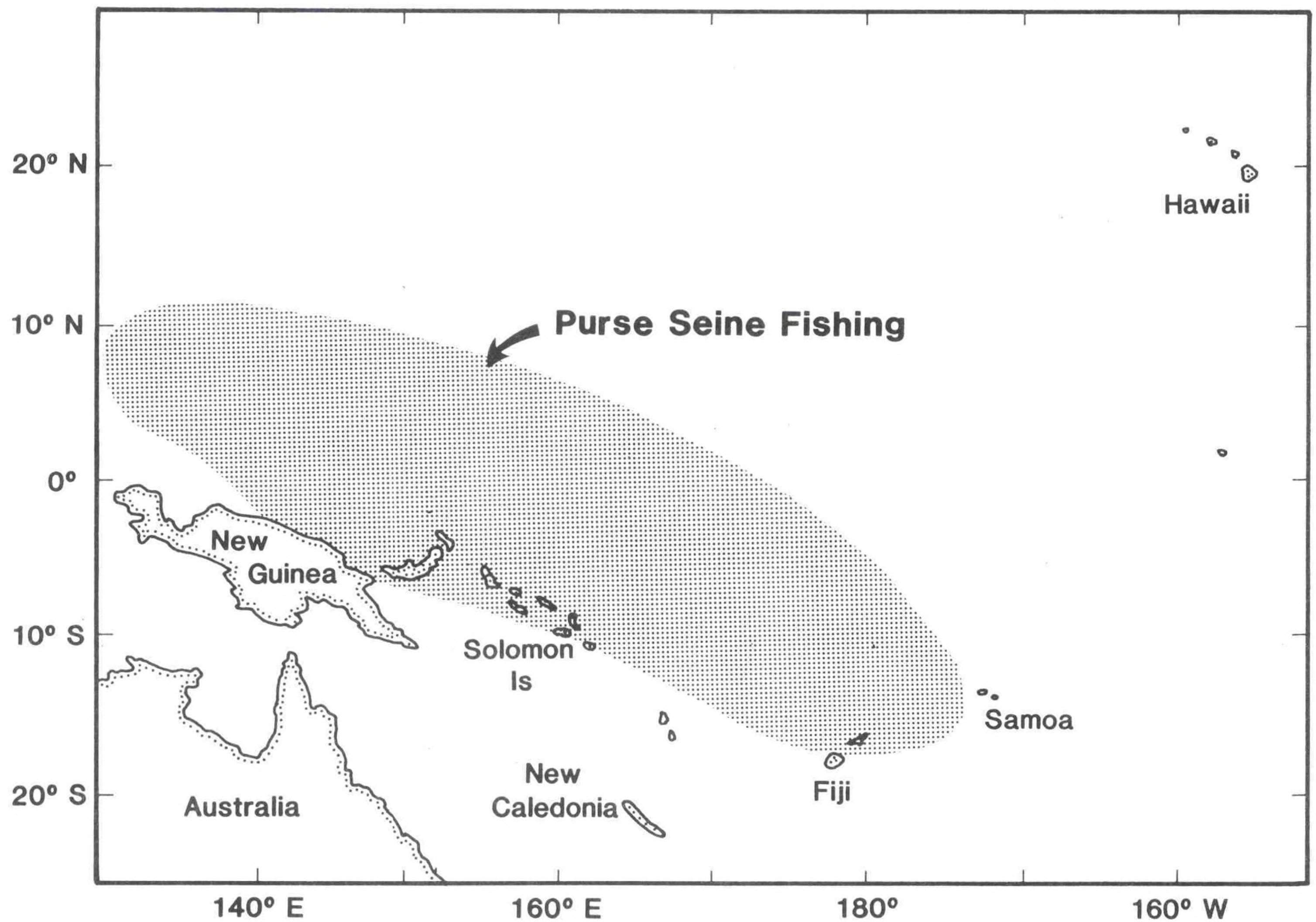
Purse Seine Fishing
Hawaii
Samoa
Fiji
New Guinea
Solomon Is
New Caledonia
Australia
20° N
10° N
0°
10° S
20° S
140° E
160° E
180°
160° W

FIGURE 1

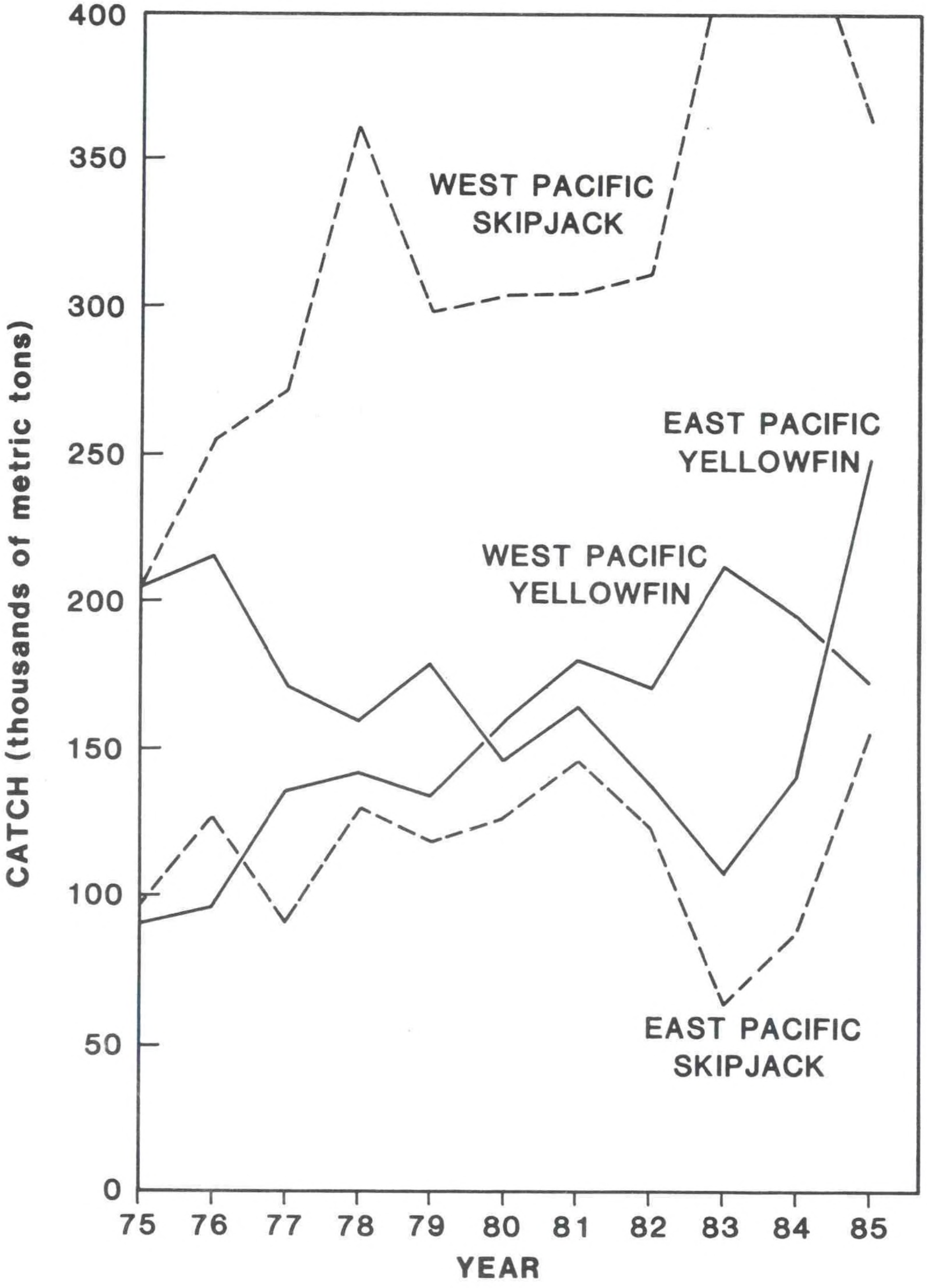
400
350
300
250
200
150
100
50
0
CATCH (thousands of metric tons)
WEST PACIFIC
SKIPJACK
EAST PACIFIC
YELLOWFIN
WEST PACIFIC
YELLOWFIN
EAST PACIFIC
SKIPJACK
75
76
77
78
79
80
81
82
83
84
85
YEAR

FIGURE 2

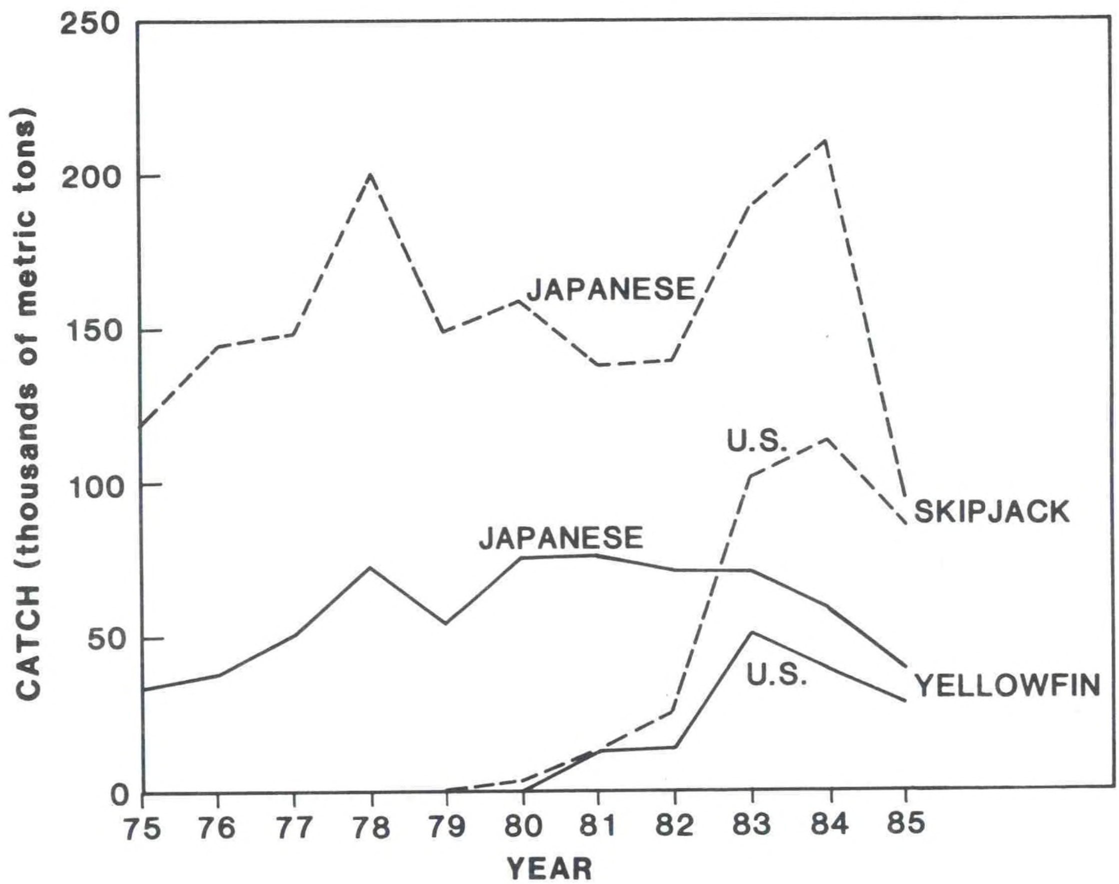
250
200
150
100
50
0
CATCH (thousands of metric tons)
JAPANESE
U.S.
SKIPJACK
JAPANESE
U.S.
YELLOWFIN
75
76
77
78
79
80
81
82
83
84
85
YEAR

FIGURE 3

III-4. NORTH PACIFIC ALBACORE TUNA 1988

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1. INTRODUCTION

This report is a review of albacore *(Thunnus alalunga)* stocks and fisheries in the North Pacific Ocean. The area of concern covers the breadth of the Pacific from Japan to the west coast of North America and concentrates on the regions north of approximately 25 degrees north latitude.

The report is in fact a summary of (and consists primarily of excerpts from) an albacore management information document (Albacore Task Force, in prep.) which was produced by the Albacore Task Force of the Southwest Fisheries Center (U.S. National Marine Fisheries Service). That document is in turn a summary of results of albacore research fostered by the Albacore Task Force and fishery data collected under an informal agreement among Japanese, Canadian, and the United States fisheries scientists.

2. DESCRIPTION OF THE FISHERIES

Albacore in the North Pacific have been fished by North American and Asian fishermen since the early 1900s. Annual catches since the early 1950s are given in Table 1.

The North American fishery occurs during the summer and autumn months (Figure 1) when the migrating albacore are closest to the North American coast. Commercial fishermen from the United States, and to a lesser extent Canada, harvest them by means of several surface fishing gears. Trolling vessels (jig boats) are by far the most prevalent followed by baitboats. Incidental catches are made by purse seines and drift gill net vessels. U.S. commercial catch of albacore has declined from approximately 20,000 metric tons (mt) per year in the early 1970s to less than 10,000 mt per year (Figure 2a), reflecting a concommitant decline in effort.

The traditional North American fishery is primarily near shore. However, in the past 10 years, North American fishermen have been fishing farther offshore, some as far west as the international dateline, in an attempt to locate high catch rate areas and to extend the fishing season.

Albacore has also proved to be a popular sport species particularly off the coast of California, south of San Francisco, where they come closest to shore (Holts, 1985), and off northern Oregon and southern Washington.

In addition to the North American fishery North Pacific albacore are harvested by several other, predominantly Japanese, fisheries. These include the Japanese baitboat, longline, and gill net fisheries as well as similar but smaller fisheries of several other nations.

The Japanese baitboat fishery consists of various sizes of vessels and has operated off the coast of Japan since the mid 1920s. This fleet, which fishes primarily for skipjack tuna, *(Katsuwonus pelamis),* also fishes for albacore along the Kuroshio and Subarctic Current fronts during the spring months (Figure 1). In recent years, South Korean baitboats have also participated in the albacore harvest. Like the U.S. commercial catch, the Japanese baitboat catch and effort has declined during the 1970s and 1980s (Figure 2b).

The longline fishery has been in operation in the North Pacific since the early 1950s and is composed primarily of Japanese vessels and, more recently, those from Taiwan and South Korea. This fleet catches albacore in the central and western north Pacific during the winter months (Figure 1) but shifts its emphasis to tropical tunas and billfish during the remainder of the year. The longline catch and effort had a decline during the late 1960s and early 1970s but has be relatively stable since then (Figure 2c).

The most recently developed fishery for north Pacific albacore, and the one for which we have the least information, is the Japanese gill net fishery, which began as an offshoot of the coastal gill net fishery for marlins and high-seas fishery for squid. Gill net catches of albacore were recorded beginning in 1972. Most of the reported catches from 1972 through 1980 were incidental catches made near the Japanese home islands. In 1981 albacore catches increased substantially (Table 1) due to the expansion of the fishery eastward along the Kuroshio extension north of the traditional Japanese baitboat fishing grounds and albacore becoming the target species.

3. ECONOMIC ASPECTS

In the United States, demand for albacore greatly exceeds domestic supply. United States fishermen landed an average of 18,000 mt of North Pacific albacore annually from 1952 through 1985, worth approximately $25 million (at current ex-vessel prices). These landings typically represent only 20% of the total domestic albacore consumption. The remainder is imported from as many as 40 other nations.

In spite of the generally high demand, during the 1970s and 1980s the U.S. domestic albacore fishery has been beset with various economic difficulties. The domestic fleet faced the closing of U.S. west coast canneries, giving fewer alternatives for selling their catch and therefore less bargaining power. The ex-vessel price for albacore fluctuated dramatically in the 1970s and declined sharply in the early 1980s (Figure 3). In addition there have been increases in fuel costs, increases in the cost and difficulty in acquiring insurance, and competition from imported albacore. These difficulties could explain the declining effort (and therefore catch) during the last two decades.

In Japan, the shift towards more efficient operations has brought about a shift in fleet composition from baitboats to purse seiners for more effectively harvesting skipjack and for selling baitboat-caught skipjack in the more lucrative sashimi market. This has undoubtedly contributed to the decreases in effort and landings of albacore by the Japanese surface fleet.

In very recent years, some of the economic problems have been alleviated. Japan has been developing a domestic market for canned albacore, increasing the demand at a time of lowered catch. Coupled with the increasing value of the yen, these factors have helped to elevate the global dollar price of albacore. In addition, fuel costs have been improving, and the domestic fishery has been developing additional markets for albacore products.

4. STOCK ASSESSMENT

4.1 Stock Structure

The determination of stock structure of albacore is of particular importance due to the wide geographical distribution and extensive migrations which occur in the species. The most direct approach involved biochemical, population-genetics analyses, and utilizing mitochondrial

DNA. In this work Graves and Dizon (1989) found no significant genetic differences between albacore taken in the North Pacific and off of South Africa.

In contrast to the genetic evidence the results from a number of studies, including the cooperative NMFS/AFRF albacore tagging studies, suggest that North Pacific albacore on the eastern side of the ocean are to some degree segregated into northern and southern subgroups with the dividing line at approximately 40 degrees north. These subgroups appear to have different migratory patterns (Laurs and Nishimoto, 1979; Laurs, 1983), modal sizes in the U. S. fishery (Brock, 1943; Laurs and Lynn, 1977; Laurs and Wetherall, 1981), growth rates (Laurs and Wetherall, 1981), and birth months (Wetherall et al., 1987). Should management of albacore become necessary, these dissimilarities might require that these subgroups be managed as separate stocks even though they do not appear to be genetically distinct.

4.2 Impact of Fishery on Stocks

Declining catch in both the Japanese and American surface fisheries is parallelled by declining effort (Figure 2a,b). In both fisheries the period of decline follows a decline in CPUE (Figure 4 a,b) which implies that stocks (or availability of stocks) might be declining. However, we cannot say that the decline in CPUE is attributable to the harvest pressure from the fisheries.

In fact most other evidence implies that the fisheries are not having a significant impact on the stocks. Landings (Figure 2c) and CPUE (Figure 4c) in the longline fishery have been relatively constant for the past decade, and the size composition in catches in the area where the largest albacore are taken, the area the Japanese refer to as the main spawning area, has remained nearly constant from 1965 to 1981 (Shiohama, 1985). Therefore the spawning stock does not appear to be affected.

Likewise the average size of fish throughout the longline and the surface catch has not changed much since the early 1970's (Figure 5). Earlier changes in average size in baitboat and longline catch during the 1960s are unlikely to be related to the declines in CPUE which occurred several years later.

Based on tag return data (Laurs and Nishimoto, 1979), Kleiber and Baker (1987) have shown that for the average conditions prevailing in the 1970s and early 1980s, only 6% of albacore reaching 25 cm are ever harvested (exploitation rate is 6%). For 65 cm fish the exploitation rate is 12%. In either case the exploitation rate is low and implies that the stocks are not fully exploited.

4.3 Fishery Interaction

To address a potential concern of fishermen and fishery administrators, that of interaction among fishing fleets, Kleiber and Baker (1987) used a simulation model of north Pacific albacore. The nominal behavior of the model, based on an average year in the fishery, was compared with the behavior when the effort in one of the fleets was either doubled or halved. At the current level of exploitation, the largest interaction was an 8% loss of longline catch due to a doubling of baitboat effort (Table 2).

5. OUTLOOK

Although there is still considerable doubt concerning what catch levels the North Pacific albacore resource could support on a sustained basis there are few of the normal signs that occur when a fishery is heavily exploited other than the decline in CPUE in the surface fisheries from the late 1970s to the mid-1980s. Whatever the cause of this decline (changes in the albacore population or changes in fleet composition and operations), the decreased CPUE has combined with a series of unfavorable economic factors which have collectively resulted in a depressed North Pacific albacore fishery.

The principal responses of the National Marine Fisheries Service to the reduced catch, effort and CPUE in the traditional U.S. albacore fishing grounds have been: 1- to work with the industry in the development of distant water albacore fisheries, first in the central and western North Pacific and more recently in the South Pacific, 2- to broadcast fishery advisories to the public during the albacore season, 3- to examine the possibility of a forecasting model to supplement fishery advisories with predictions on time and space scales (fortnight and one degree squares) which could be used in real time by albacore fishermen (Mendelssohn and Husby, In Prep), 4- to make economic models to help fishermen in budget planning (Herrick and Carlson, 1986).

Recently the CPUE in the traditional U.S. fishery has increased and in addition the CPUE in the developing U.S. South Pacific albacore fishery appears to be high. Also several of the trends in unfavorable economic factors have reversed, which should help to increase the competitiveness of U.S. fishermen.

A factor of some concern now is the developing gill net fisheries in the Pacific, including those which are targeting albacore as well as those which target other species but take albacore as a by-catch. In both cases, the catch data for albacore are not well-known, and even less well-known are the rates at which albacore escape from gill nets and dead and moribund albacore drop out of gill nets. The appearance of gill net marked albacore in the catch of other surface fisheries promises to make this a contentious issue.

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7. LIST OF FIGURES

Table 1. Catch of albacore in the North Pacific in metric tons, 1950-1987.

	Japan					Taiwan	United States				Canada	
Year	Bait-boat	Long-line	Gill net	Other gear	Total	Long-line	Bait-boat	Jig-boat	Sport	Total	Jig-boat	Grand Total
1952	41,786	26,687	-	237	68,710	-	-	23,843	1,373	25,216	71	93,997
1953	32,921	27,777	-	132	60,830	-	-	15,740	171	15,911	5	76,746
1954	28,069	20,958	-	38	49,065	-	-	12,246	147	12,393	-	61,458
1955	24,236	16,277	-	136	40,649	-	-	13,264	577	13,841	-	54,490
1956	42,810	14,341	-	57	57,208	-	-	18,751	482	19,233	17	76,458
1957	49,500	21,053	-	151	70,704	-	-	21,165	304	21,469	8	92,181
1958	22,175	18,432	-	124	40,731	-	-	14,855	48	14,903	74	55,708
1959	14,252	15,802	-	67	30,121	-	-	20,990	0	20,990	212	51,323
1960	25,156	17,369	-	76	42,601	-	-	20,100	557	20,657	5	63,263
1961	18,636	17,437	-	268	36,341	-	2,837	12,061	1,355	16,253	4	52,598
1962	8,729	15,764	-	191	24,684	-	1,085	19,760	1,681	22,526	1	47,211
1963	26,420	13,464	-	218	40,102	-	2,432	25,147	1,161	28,740	5	68,847
1964	23,858	15,458	-	319	39,635	26	3,411	18,392	824	22,627	3	62,291
1965	41,491	13,701	-	121	55,313	16	417	16,545	731	17,693	15	73,037
1966	22,830	25,050	-	585	48,465	16	1,600	15,342	588	17,530	44	66,055
1967	30,481	28,869	-	520	59,870	17	4,113	17,826	707	22,646	161	82,694
1968	16,597	23,961	-	1,109	41,667	15	4,906	20,444	951	26,301	1,028	69,011
1969	32,107	18,006	-	1,480	51,593	21	2,996	18,839	358	22,193	1,365	75,172
1970	24,376	15,372	-	956	40,704	23	4,416	21,041	822	26,279	354	67,360
1971	53,198	11,035	-	1,262	65,495	24	2,071	20,537	1,175	23,783	1,587	90,889
1972	60,762	12,649	1	921	74,333	25	3,750	23,608	637	27,995	3,558	105,911
1973	69,811	16,059	39	1,883	87,792	35	2,236	15,667	84	17,987	1,270	107,084
1974	73,576	13,053	224	1,065	87,918	40	4,777	20,187	94	25,058	1,207	114,223
1975	52,157	10,060	166	402	62,785	28	3,243	18,975	640	22,858	101	85,772
1976	85,336	15,896	1,070	1,394	103,696	37	2,700	15,932	713	19,345	252	123,330
1977	31,934	15,737	688	1,039	49,398	61	1,497	10,005	537	12,039	53	62,051
1978	59,877	13,061	4,029	3,209	80,176	53	950	16,682	810	18,442	23	98,694
1979	44,662	14,249	2,856	1,280	63,047	81	303	6,801	74	7,178	521	70,827
1980	46,743	14,743	2,986	1,516	65,988	-	382	7,574	168	8,124	212	74,324
1981	27,426	18,020	10,348	956	56,753	-	748	12,694	195	13,637	200	70,590
1982	29,615	16,762	12,511	1,054	59,942	-	425	6,661	257	7,343	104	67,389
1983	21,098	15,103	6,884	471	43,556	-	607	9,512	87	10,206	225	53,987
1984	26,015	15,111	10,569	3,898	55,593	-	832	9,576	1,427	15,563	50	71,206
1985	20,714	14,320	13,132	1,940	50,106	-	872	7,059	1,176	9,107	56	59,269
1986	12,000	12,945	9,749	-	34,694	-	309	4,834	196	5,339	30	40,034
1987	20,000	-	-	-	-	-	146	2,783	48	2,977	<1	-

Remarks:
1. Figures for 1986-87 are preliminary.
2. Japanese longline catches for 1952-60 exclude minor amounts taken by vessels under 20 tons. Longline catches in weight are estimated by multiplying annual number of fish caught by average weight statistics.
3. Japanese baitboat catches include fish caught by research vessels.
4. U.S. Jigboat catches for years 1952-60 include fish caught by baitboats.
5. U.S. catches from 1961 to 1985 include Hawaii.
6. U.S. total for 1984 include 3,728 mt caught by purse seines.

Table 2. Interaction matrix for annual catch in weight. The values given are the differences between the catch under altered effort and the nominal catch (percent of nominal catch in parentheses).

effect → cause ↓		difference (MT X 10^3) baitboat	longline	U.S. Troll
baitboat effort	X 2	46.88 (85.1)	-0.71 (7.5)	-0.27 (1.5)
	X ½	-26.43 (47.9)	0.39 (4.1)	0.14 (0.8)
longline effort	X 2	-0.21 (0.4)	9.32 (98.4)	-0.02 (0.1)
	X ½	0.11 (0.2)	-4.72 (49.8)	0.01 (0.1)
U.S. effort	X 2	-0.69 (1.3)	-0.24 (2.5)	17.09 (93.3)
	X ½	0.37 (0.7)	0.12 (1.3)	-9.00 (49.1)

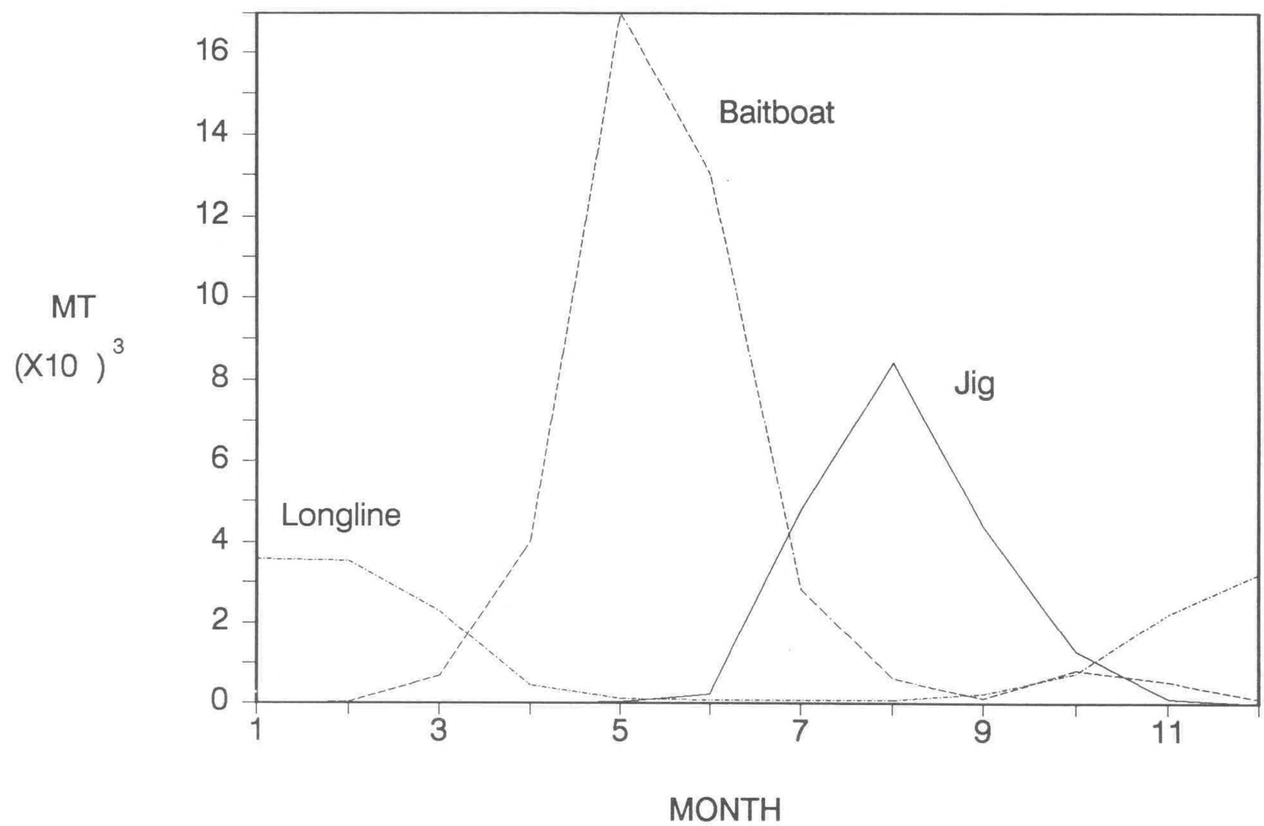

Figure 1. Seasonality of North Pacific albacore catch by major fleets. Average catch by month over the years 1961-1983 for the jigboat fleet, 1960-1982 for the Japanese bait-boat fleet, and 1969-1982 for the Japaese longline fleet.

a.

b.

c.

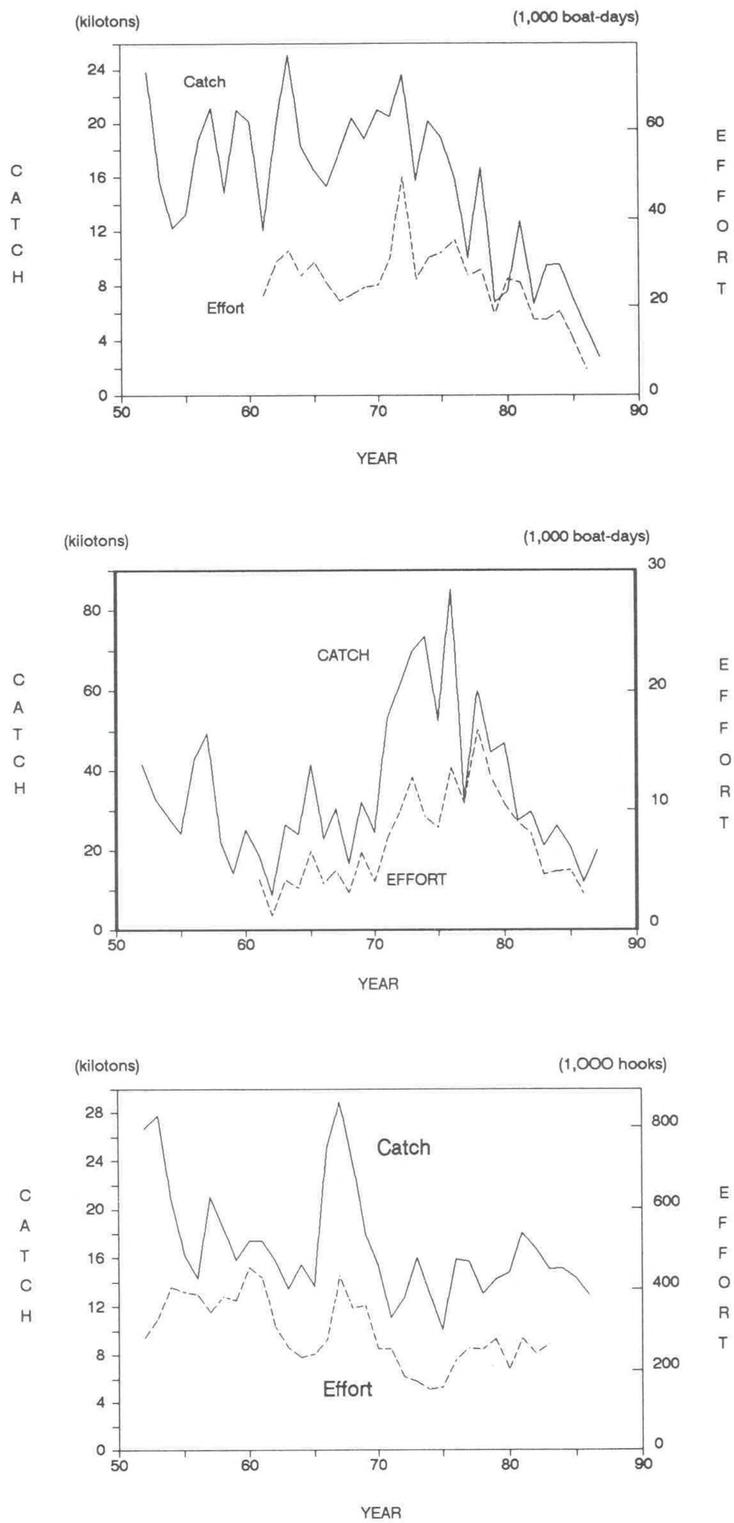

Figure 2. History of catch and effort by major North Pacific albacore fleets: a) United States jigboat fleet, b) Japanese baitboat fleet, c) Japanese longline fleet.

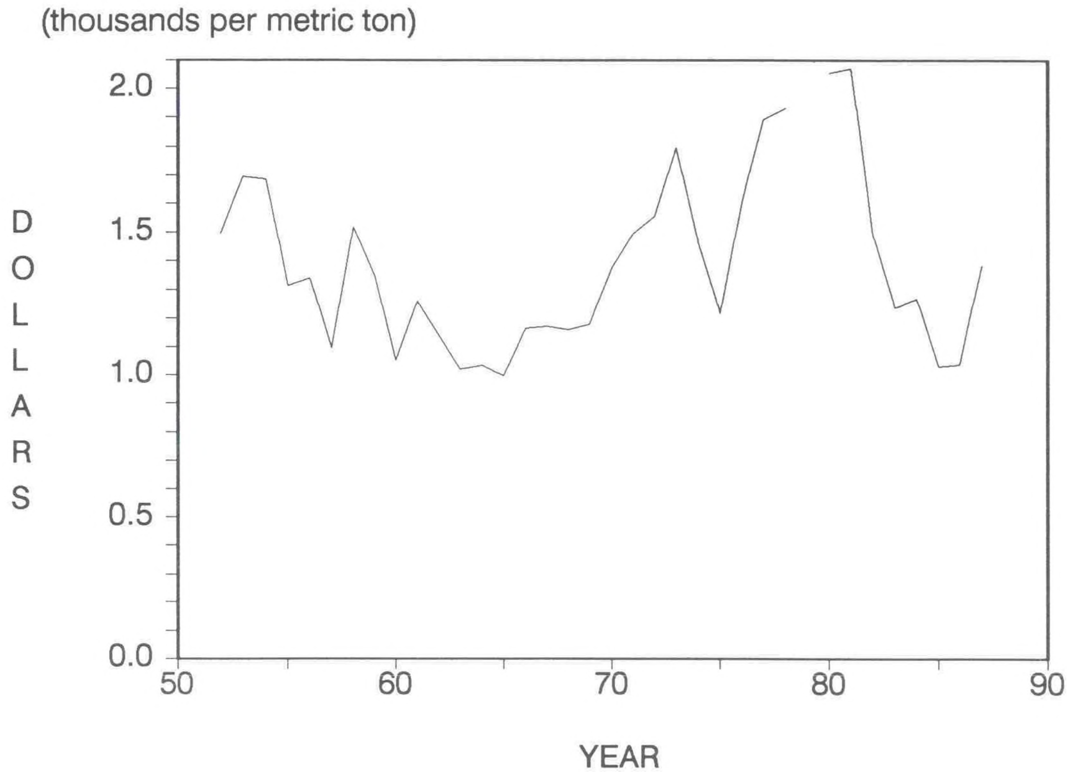

Figure 3. Average yearly ex-vessel prices of albacore in California ports, adjusted to 1982 constant dollars. Data from California Marine Fish Catch Bulletins, California Department of Fish and Game. Value for 1979 was not plotted because of a "glitch" in data base.

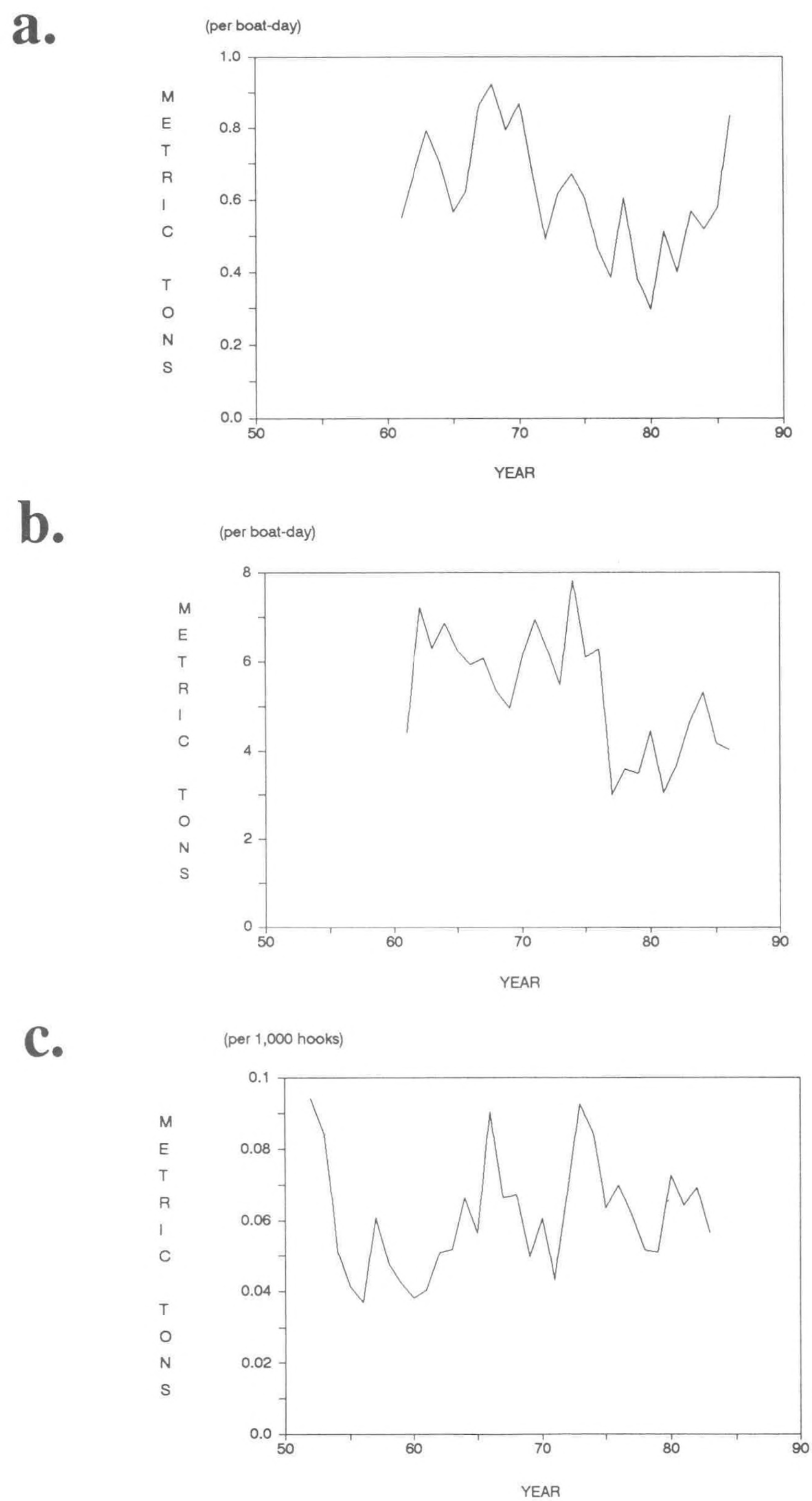

Figure 4. History of CPUE for major North Pacific albacore fleets: a) United States jigboat fleet, b) Japanese baitboat fleet, c) Japanese longline fleet.

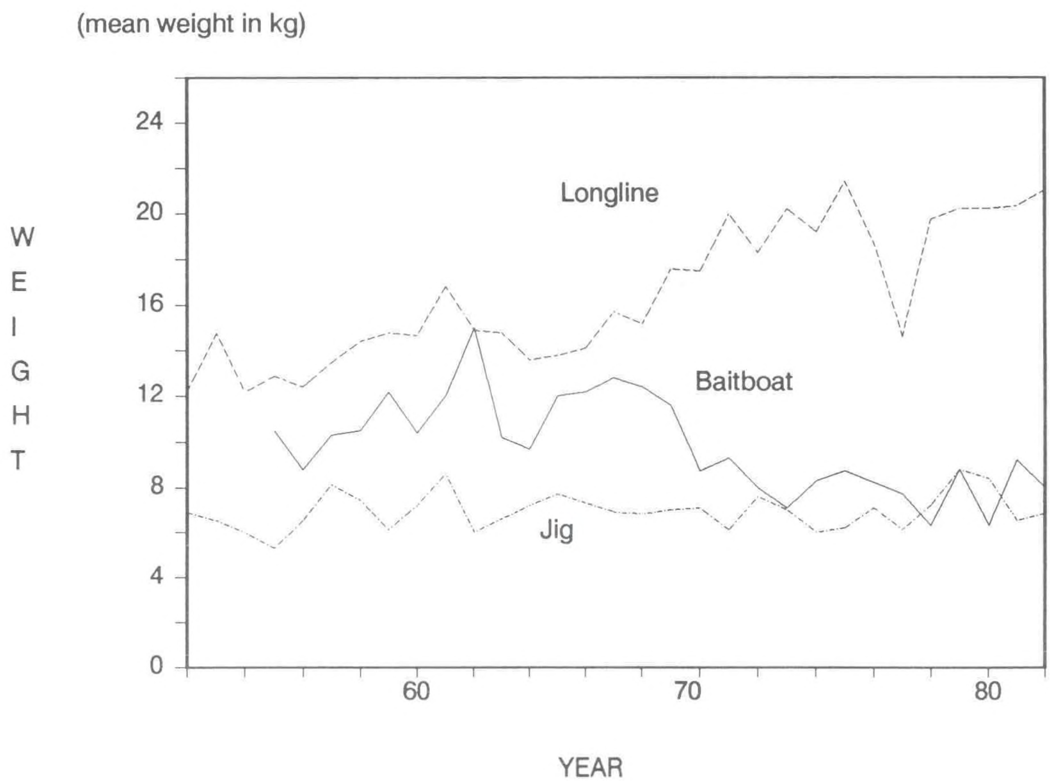

Figure 5. Average size of fish over the years 1952-1982 in North Pacific albacore catch by fleet.

IV-1. INDIAN OCEAN SKIPJACK TUNA 1987

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1. INTRODUCTION

Skipjack tuna (*Katsuwonus pelamis*) is becoming an increasingly important component of the catches of Indian Ocean tuna fisheries. The total Indian Ocean catch of skipjack in 1985 was 139,000 mt, three times the 1981 catch (Figure 1). Although some of this increase is attributable to increased catches by traditional artisanal fisheries, the major part is due to catches by the French/Spanish purse seine fleet which became a significant part of the Indian Ocean fishery in 1983. Catches by the French/Spanish fleet increased from near zero in 1981 to 67,000 mt in 1985, 48% of the total Indian Ocean catch of skipjack in that year.

2. PARTICIPANTS

Indian Ocean fisheries taking skipjack tuna include artisanal fisheries based in nations bordering the Indian Ocean using a variety of gear types, distant-water fisheries of non- Indian Ocean nations using long-line vessels and, the most recent entry, the fishery operating from ports in the western Indian Ocean using large French and Spanish tropical purse seiners.

Coastal pole-and-line artisanal fisheries based in Sri Lanka, and in the Maldive and Laccadive Islands have taken tunas, including skipjack, for over a hundred years (Amarasiri and Joseph, 1986). Today skipjack is the most important of the pelagic tunas in Indian Ocean artisanal fisheries which also includes vessels of India, the Comoro Islands, Kenya, Mauritius, Mozambique, the Seychelle Islands, and Indonesia. Once limited to un-motorized pole and line vessels, these fisheries are becoming increasingly mechanized. In the Maldives, where the the principal Indian Ocean artisanal tuna fishery is based, motorized pole and line vessels outnumbered those without engines for the first time in 1982.

In addition to pole-and-line vessels, present-day Indian Ocean artisanal tuna fisheries utilize small purse seiners, gillnetters and trollers (Anon., 1987b). The artisanal fishery in the Maldives primarily uses wooden pole-and-line vessels of 8 to 12 meters in length, most of which are now motorized (Hafiz, 1986). The fishery based in Sri Lanka uses gillnet vessels of 9 meters in length and 3.5 gross mt capacity, small trollers, and pole-and-line vessels (Amarasiri and Joseph, 1986). The Indonesian fishery uses gillnet vessels (2.5 - 4 gross mt), purse seiners (19 - 26 gross mt and trollers (4.5 - 29 gross mt)(Gafa, 1986).

Japanese longline vessels began fishing for tunas in the Indian Ocean in the early 1950's (Amarasiri and Joseph, 1986). They were later joined, and superseded in terms of skipjack catches, by vessels from Taiwan and Korea. These large (200 - 500 gross mt) longliners are efficient harvesters of yellowfin and other tunas but catch few skipjack in any of the world's tuna fisheries and are minor participants in the Indian Ocean fishery. The longline catch of skipjack in 1975 was 306 MT, less than 1% of the total Indian Ocean catch in that year.

The recent significant increases in skipjack catches by Indian Ocean fisheries began in the early 1980s when French and Spanish interests relocated large purse seiners from fishing grounds off the west coast of Africa to the western Indian Ocean. Encouraged by the success of exploratory fishing in 1981, the French purse seine fleet in the western Indian Ocean grew to 37 vessels by 1985 (Figure 2). The Spanish followed the French into the western Indian Ocean fishery in 1984 with 17 vessels. The combined French/Spanish fleet catches both yellowfin and skipjack tuna; transshipments from the Seychelles of tuna taken by the fleet in 1986 consisted of 55% skipjack, 42% yellowfin and 2% bigeye. The total western Indian Ocean catch of skipjack tuna by the French/Spanish fleet increased from 210 mt. in 1981 to 67,000 mt in 1985 (Figure 3).

3. ECONOMIC ASPECTS

In an era of global competition, the future success of the distant water fleets and to a large extent the artisanal fleets will depend not only on the continued abundance of skipjack and other tunas but on the regional economic infrastructure.

Both distant water and artisanal participants in the Indian Ocean tuna fishery are taking steps to develop the infrastructure necessary to efficiently harvest the skipjack resource. Most Indian Ocean skipjack are caught in the western regions of the ocean. In the Seychelle Islands, a long-time western Indian Ocean transshipment station, local interests have begun to improve facilities available to tuna fishermen. A U.S.40 million dollar port facilities improvement program in Victoria is nearing completion and work has begun on a cannery developed by a Seychelle/French joint-venture (Michaud, 1986). Other resource- adjacent nations have joined in licensing agreements for non- national tuna fishing vessels to operate in their EEZ's and at least one other country, Thailand, operates tuna canneries. Sri Lanka is engaged in joint exploratory fishing with foreign collaborators (Amarasiri and Joseph, 1986).

Indian Ocean nations with artisanal fleets, often heavy consumers of tuna themselves, often also export large quantities. Approximately half of the 1985 catch of the artisanal tuna fishery in the Maldive Islands, the largest Indian Ocean artisanal tuna fishery, was exported (Hafiz, 1986). Many Indian Ocean artisanal tuna fleets are modernizing and expanding to take advantage of the improving world market for tuna. Many are increasing catches by improving existing gear or by introducing new, more efficient gear types.

4. GEOGRAPHIC SETTING

Adult skipjack tuna are found throughout the Indian Ocean from the Gulf of Arabia in the north to 40 deg south latitude. Though the stock structure of Indian Ocean skipjack has not been investigated, it is likely that skipjack in the Indian Ocean are of a single stock with possible interchange with skipjack stocks in other oceans. Historically Indian Ocean skipjack fisheries have operated in the northern waters around the Maldive Islands, Indonesia, Sri Lanka and in the Gulf of Aden (Matsumoto et al., 1984). Artisanal fishing traditionally has concentrated in nearshore areas most accessible to the small, non-powered vessels used in these fisheries. Areas fished by artisanal fisheries will expand as fleets become mechanized.

The French/Spanish purse seine fleet also operates largely in areas around islands and other nearshore areas where they pursue both skipjack and yellowfin tunas. The fleet operates in the western Indian Ocean, traditionally the area of the highest catches (Figure 4), taking skipjack and yellowfin tuna in the same area though at different times of the year

(Figure 5). The minor longline catches of skipjack are been scattered throughout the region.

5. CATCH TRENDS

The recorded total catch of skipjack tuna from the Indian Ocean has increased dramatically since 1982 (Figure 1), due in part to increased catches in the artisanal sector and in part to catches in the new French/Spanish purse seine fishery. Catches have increased in artisanal fisheries particularly those in the Maldives, Sri Lanka and Indonesia where artisanal fleets are increasing their share of the world market largely through gear modernization. In 1985 Indian Ocean artisanal fisheries caught 69,600 mt of skipjack, a 59% increase over the 1981 catch. Improved statistics within artisanal nations may account for some of the recent nominal increases in catch (Yesaki, 1986).

The recently-entered French/Spanish purse seine fleet has clearly been the major contributor to recent dramatic increases in skipjack catches (Michaud, 1986). The combined 1985 catch of this fleet was was 67,000 mt up from 210 mt in 1981. In 1986, 126,800 mt of tunas taken by the fishery were transhipped from Port Victoria, Seychelles, of which 69,700 mt was skipjack (the remaining 57,100 mt was primarily yellowfin) (Anon., 1987a).

6. CATCH BY COUNTRY AND GEAR

Skipjack catches in all Indian Ocean tuna fisheries remained basically constant during the 1970's (Table 1). In the early 1980's, catches in nearly all country/gear combinations increased, in some cases considerably. Higher catches were experienced in both artisanal fisheries and in the French/Spanish purse seine fleet in the western Indian Ocean which became a significant part of the fishery after 1982. The French/Spanish fleet quickly dominated Indian Ocean skipjack catches taking 48 % of the total 1985 Indian Ocean catch compared to a 0.5% share in 1981. Within the artisanal segment, where skipjack are the most important component of the tuna catch, the three major harvesters, the Maldives, Sri Lanka and Indonesia, caught 89% of the artisanal catch using small baitboats, trollers, gillnetters and purse seiners.

7. STATUS OF THE STOCK

In December, 1986, the Indian Ocean Fisheries Commission convened an expert consultation on the stock assessment of Indian Ocean tunas. In the report of the meeting, members of the Consultancy noted that there are no estimates of either the size or the status of the Indian Ocean skipjack resource. Considering skipjack tuna in analogous situations in other oceans, they stated that they presumed

"*... that there is a very large population of skipjack in the Indian Ocean, and that this population has high fecundity, high natural mortality rate and rapid turnover. It is therefore assumed that, despite the considerable increase in catches of skipjack in the last few years, there need be no immediate concern about overfishing.*"

8. OUTLOOK

Although there is as yet no specific assessment of the status of Indian Ocean skipjack tuna, comparisons to other exploited world skipjack stocks suggests that the Indian Ocean stock is capable of providing large sustainable annual yields. In addition, Indian Ocean nations are vigorously improving the economic infrastructure to assist the efficient harvest of all tunas. Considering these facts, Indian Ocean skipjack tuna can be expected to increasingly contribute to the world supply of tuna.

Currently there are no U.S.-registered commercial tuna vessels fishing for skipjack tuna in the Indian Ocean. U.S. interest in this skipjack tuna resource is therefore limited to procurement of Indian Ocean skipjack traded on the world market.

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10. FIGURES

1. Catches of skipjack tuna in the Indian Ocean, total and for the French/Spanish purse seine fishery, 1973 - 1985.

2. Number of vessels in the French/Spanish purse seine fleet operating in the western Indian Ocean, 1981 - 1985.

3. Catches of yellowfin and skipjack tuna by the French/Spanish purse seine fleet, 1981 - 1985.

4. Number of days of purse seine fishing by the French/Spanish fleet by 5 - degree square, 1985.

5. Catch by month of yellowfin and skipjack tuna taken in the French/Spanish purse seine fleet, 1985.

Table 1. Catches of Skipjack Tuna in the Indian Ocean by Country and Gear, 1973-1985.

Country	Gear	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Australia	UNCL	0	133	523	404	26	49	58	37	0	0	0	0	550
China (Taiwan)	LL	14	39	83	42	18	5	11	9	20	11	9	22	8
Comoros	UNCL	300	250	300	250	300	300	300	300	300	300	300	300	300
France	PS	0	0	0	0	0	0	0	0	210	771	10075	31598	40924
India(1)	UNCL	0	0	0	0	0	0	0	0	1803	2399	1801	3488	3276
Indonesia	PS	0	0	0	0	0	0	0	0	0	284	0	356	388
	UNCL	4100	4447	3925	5513	4034	4093	6524	7573	6579	11548	12458	10091	9214
Country Total		4100	4447	3925	5513	4034	4093	6524	7573	6579	11832	12458	10047	9602
Japan	LL	0	31	23	16	4	11	3	6	13	5	3	2	0
	BB	0	0	0	0	0	0	0	0	7	0	0	0	0
	PS	0	0	0	0	0	908	0	478	0	0	592	0	0
	UNCL	0	0	0	0	0	0	0	0	10	0	0	0	0
Country Total		0	31	23	16	4	919	3	484	30	5	595	2	0
Kenya	LL	0	0	0	0	0	0	0	0	3	1	2	0	0
	UNCL	0	0	0	0	0	0	0	0	68	96	31	45	45
Country Total		0	0	0	0	0	0	0	0	71	97	33	45	45
Korea	LL	0	72	200	63	151	253	65	43	48	57	8	0	0
Maldives	BB	18761	21760	14601	19603	14032	13549	17798	23074	20198	15694	19491	31713	42170
	UNCL	434	400	257	489	310	275	338	487	419	187	210	335	432
Country Total		19195	22160	14858	20092	14342	13824	18136	23561	20617	15881	19701	32048	42602
Mauritius	PS	0	0	0	0	0	0	41	990	1726	2414	2453	2500	2026
	UNCL	0	0	0	0	0	14	10	4	5	3	0	350	0
Country Total		0	0	0	0	0	14	51	994	1731	2417	2453	2850	2026
Mozambique	BB	0	0	0	0	0	0	0	0	0	0	60	154	80
Pakistan	GILL	0	0	0	0	0	0	0	0	0	0	733	694	1309
	UNCL	0	0	0	0	0	0	449	134	446	5156	0	0	0
Country Total		0	0	0	0	0	0	449	134	446	5156	733	694	1309

Table 1. (continued)

Country	Gear	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Seychelles	UNCL	100	50	10	10	20	10	10	0	0	0	0	0	0
So. Africa	UNCL	0	0	0	0	0	0	0	0	0	0	13	0	0
Spain	BB	0	0	0	0	0	0	0	0	179	14	0	0	0
	PS	0	0	0	0	0	0	0	0	0	0	0	8079	26108
Country Total		0	0	0	0	0	0	0	0	179	14	0	8079	26108
Sri Lanka	BB	0	0	0	0	0	0	0	0	0	1987	2095	1510	1757
	GILL	0	0	0	0	0	0	0	0	0	10600	11178	8714	10070
	UNCL	10400	12321	15243	12222	11399	10994	8309	12700	13758	563	699	1395	291
Country Total		10400	12321	15243	12222	11399	10994	8309	12700	13758	13250	13972	11619	12118
Yemen Dem.	UNCL	0	0	0	0	0	0	0	0	0	400	400	12	7
Species Total		34109	39503	35165	38612	30294	30461	33916	45835	45792	52590	62611	101359	138921

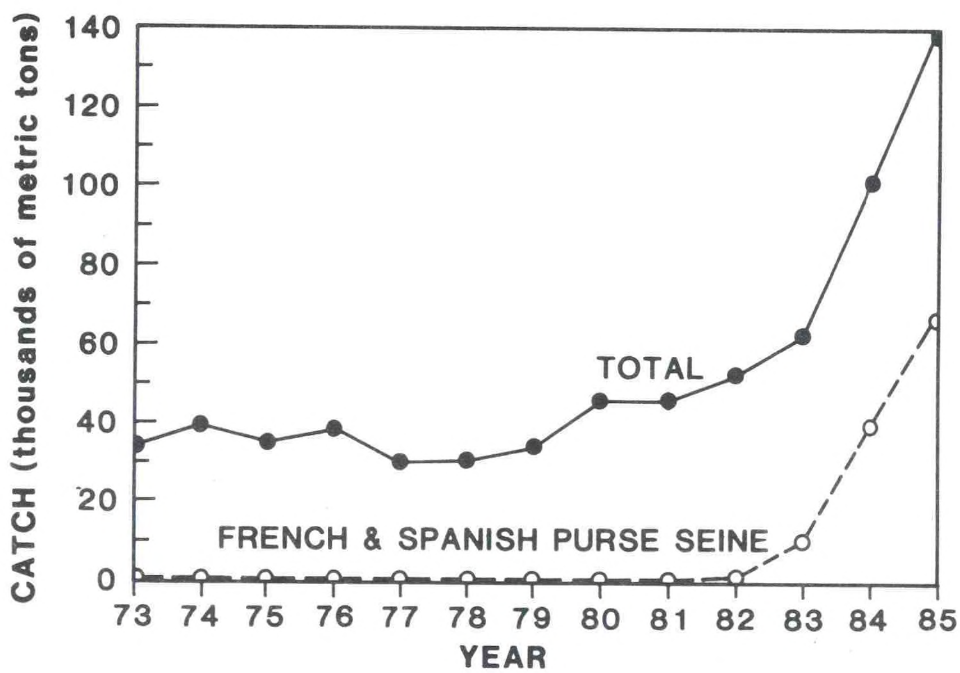
CATCH (thousands of metric tons)
140
120
100
80
60
40
20
0
TOTAL
FRENCH & SPANISH PURSE SEINE
73 74 75 76 77 78 79 80 81 82 83 84 85
YEAR

FIGURE 1

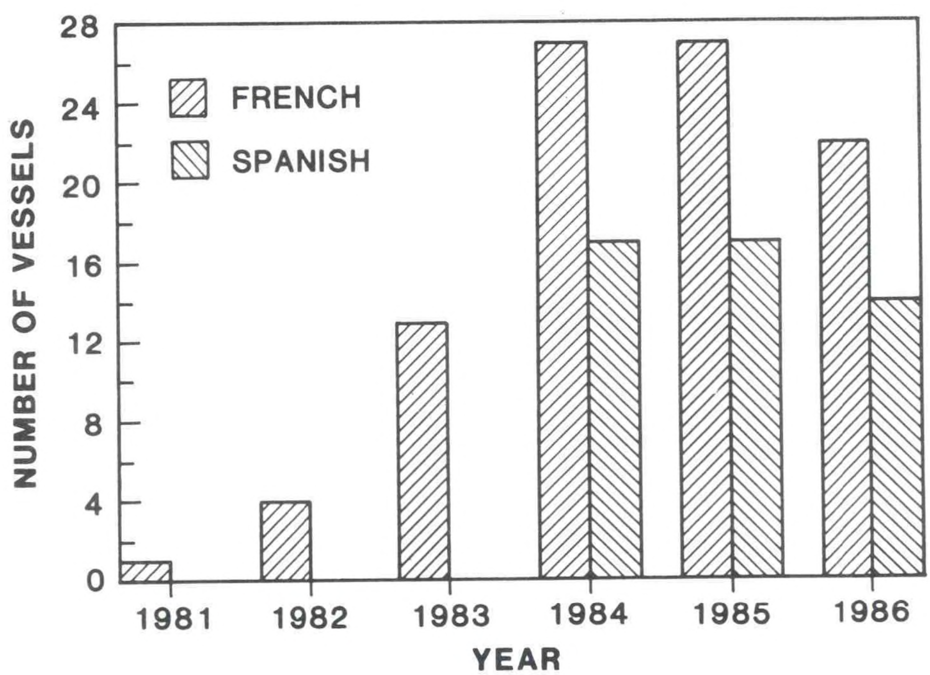
28
24
20
16
12
8
4
0
NUMBER OF VESSELS
FRENCH
SPANISH
1981
1982
1983
1984
1985
1986
YEAR

FIGURE 2

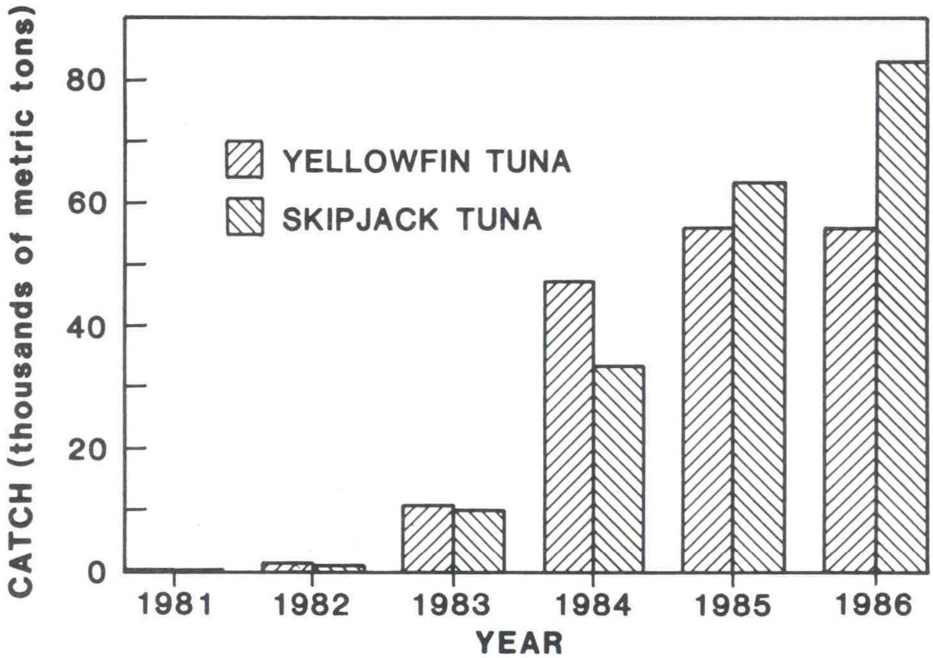
CATCH (thousands of metric tons)
80
60
40
20
0
YELLOWFIN TUNA
SKIPJACK TUNA
1981
1982
1983
1984
1985
1986
YEAR

FIGURE 3

1985 PURSE SEINE DAYS FISHING

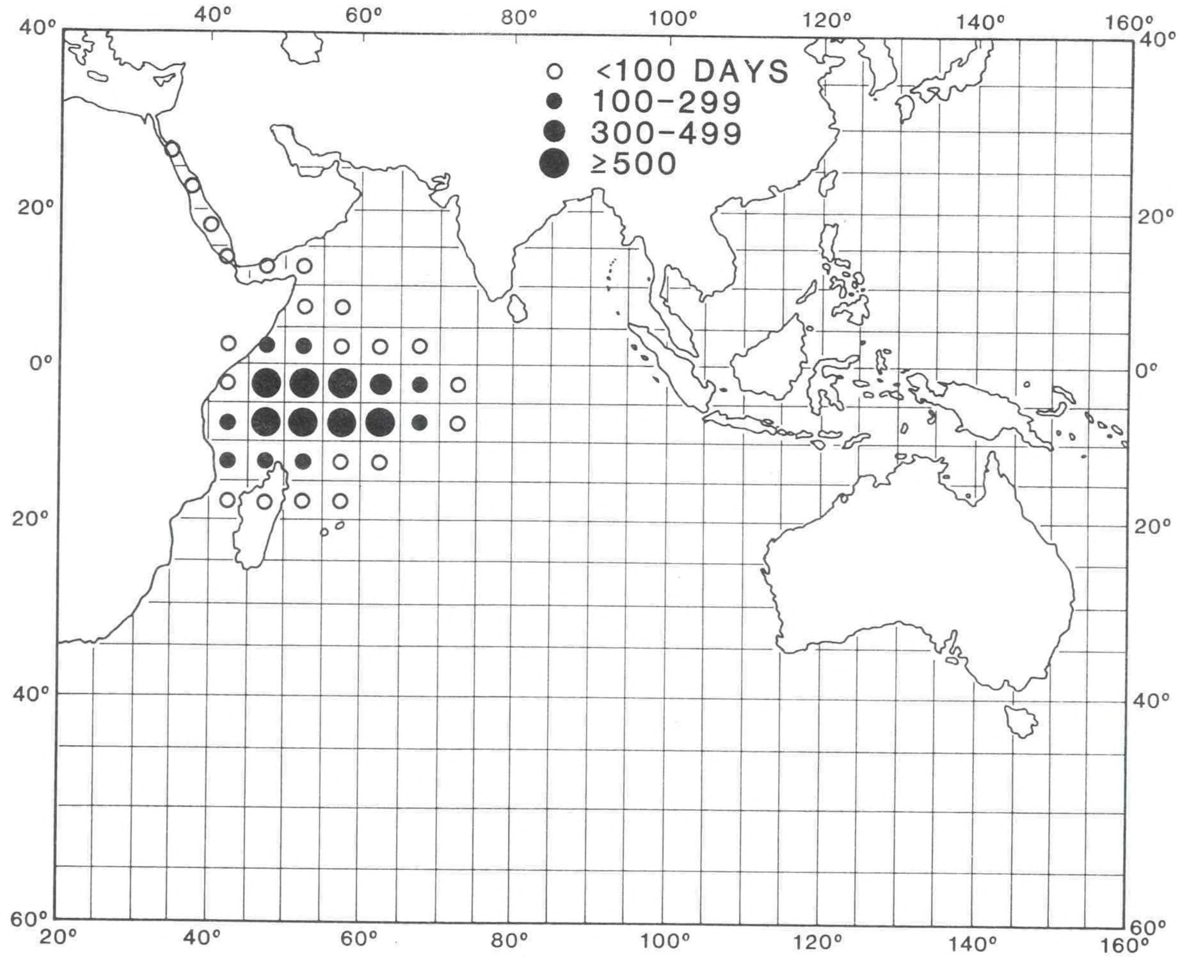

FIGURE 4

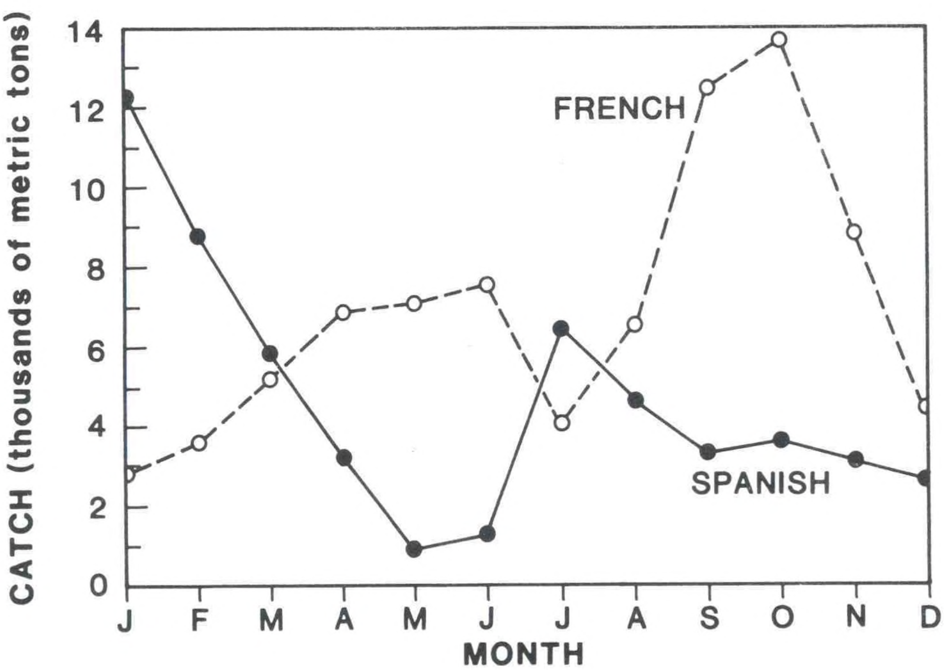
CATCH (thousands of metric tons)
14
12
10
8
6
4
2
0
FRENCH
SPANISH
J F M A M J J A S O N D
MONTH

FIGURE 5