TUNA AND BILLFISH SUMMARIES OF MAJOR STOCKS

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National Marine Fisheries Service
Southwest Fisheries Center

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FOREWORD

This volume is intended to provide readers with information on the status of tuna and billfish stocks and background information on the fisheries exploiting those stocks which are of interest to the United States and its constituents. Each summary contains the best information available at the time of preparation by NMFS scientists. While virtually all the information contained in the volume is publicly available, the collation of information from varied and often obscure sources is particularly useful.

This volume is intended to be a"living" document. Periodically, at unspecified intervals, new reports will be added to the volume and old reports replaced by updated ones. The volume organization is designed for this purpose. Updated material will be sent to registered holders of the volume and may also be available from "Chief, Pelagic Fisheries Resources Division, Southwest Fisheries Center, P.O. Box 271, La Jolla, California, 92038."

I would welcome comments on the concept and contents.

Izadore Barrett
Director
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I. Introduction 1987

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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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ICCAT, 1985. **Report for the biennial period, 1984-1985 (part 1 1984), English version.** International Commission for the Conservation of Atlantic Tunas. Madrid, Spain. 290p.

4. FIGURES

1. Distribution of yellowfin tuna and major surface and longline fisheries.

2. Distribution of skipjack tuna and major surface and longline fisheries.

3. Distribution of albacore and major surface and longline fisheries.

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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.

The many reviewers who provided the authors with constructive criticism are heartly thanked.

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.

Table 1 (continued)

Major stock	Catch level relative to estimated msy (mt)	Notes on stock or fishery conditions
Swordfish	MSY:unknown; Recent catch 3,000	Unknown potential.
<u>Atlantic Ocean</u>		
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).

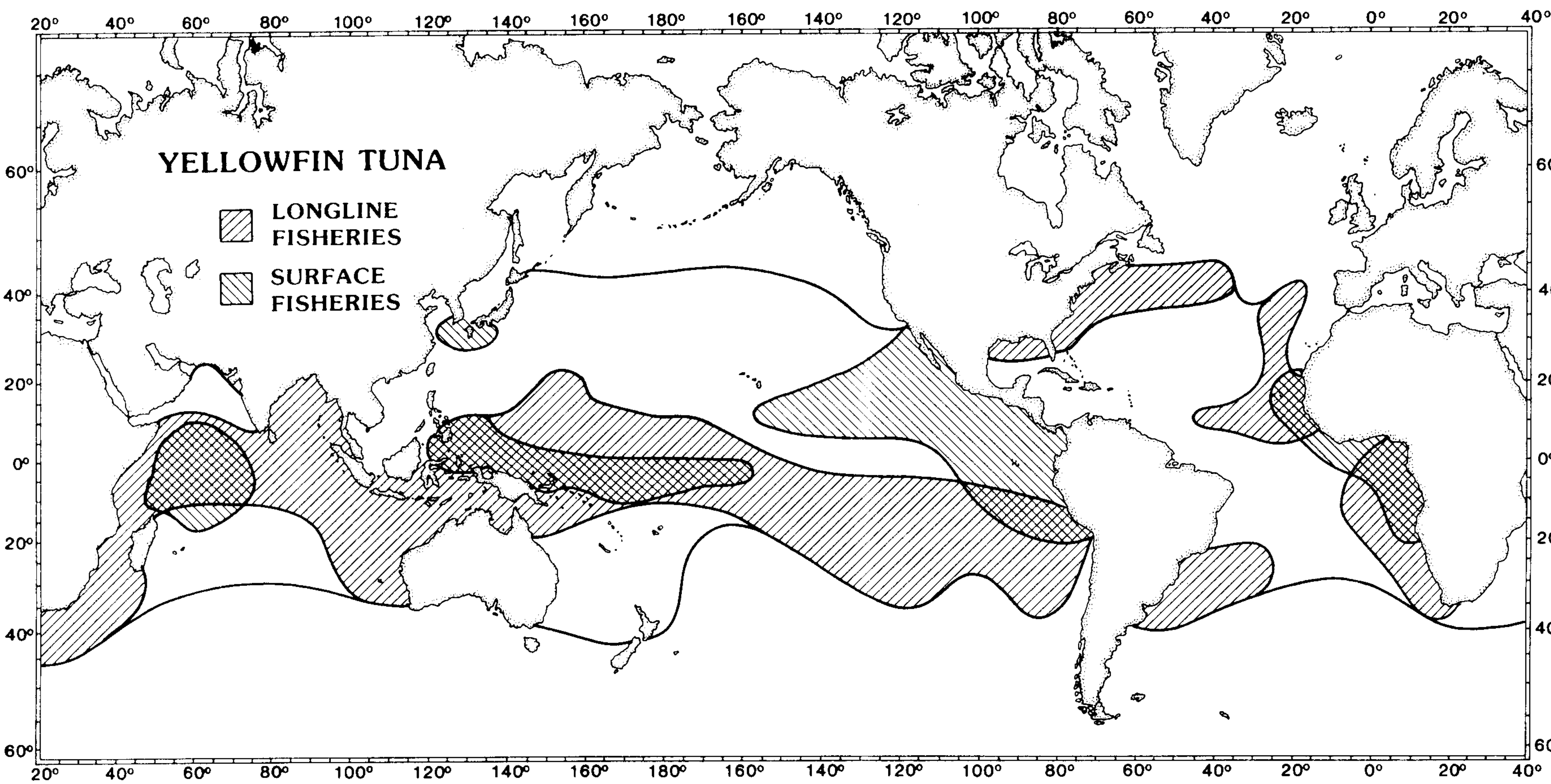

FIGURE 1

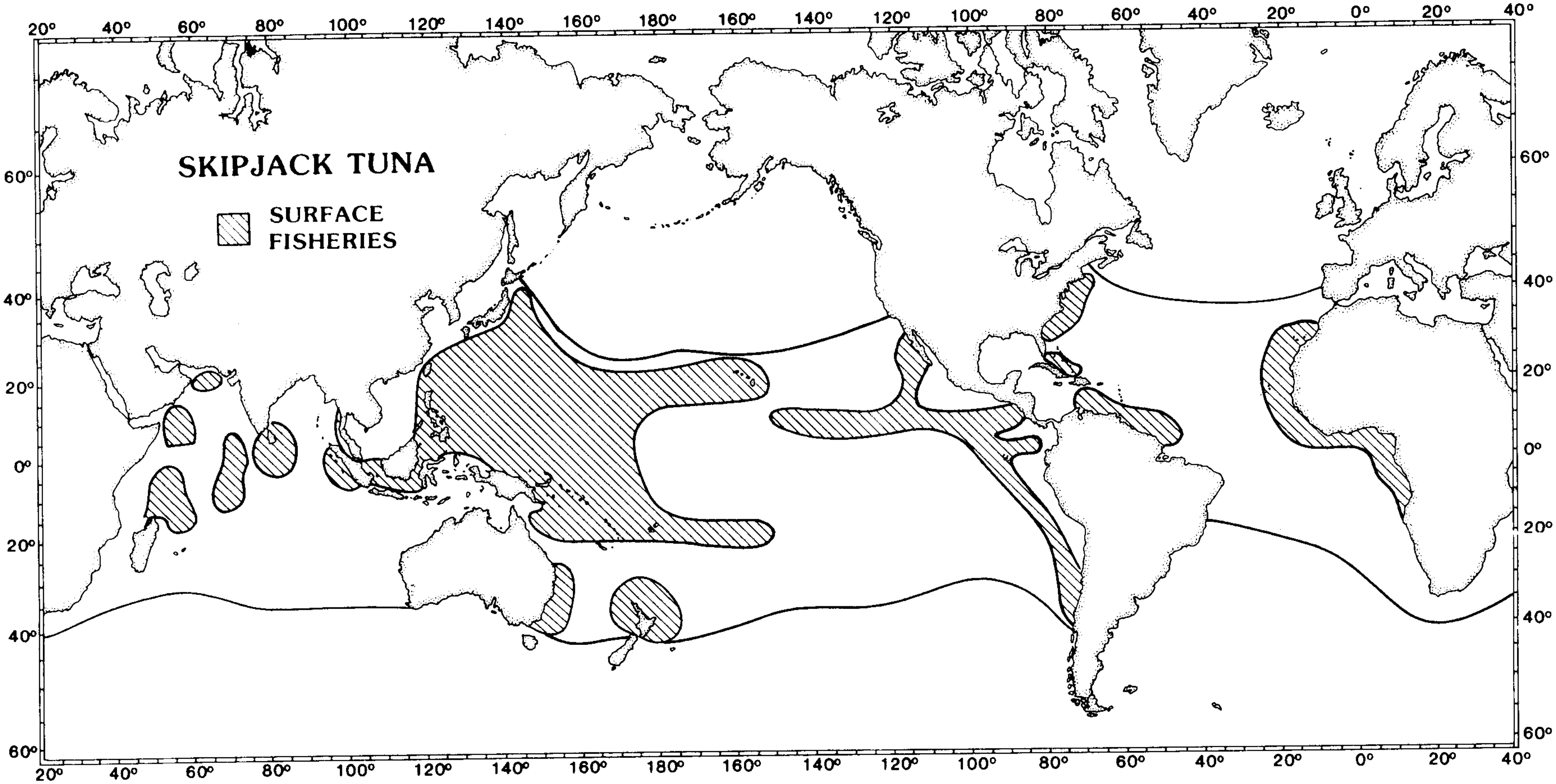

FIGURE 2

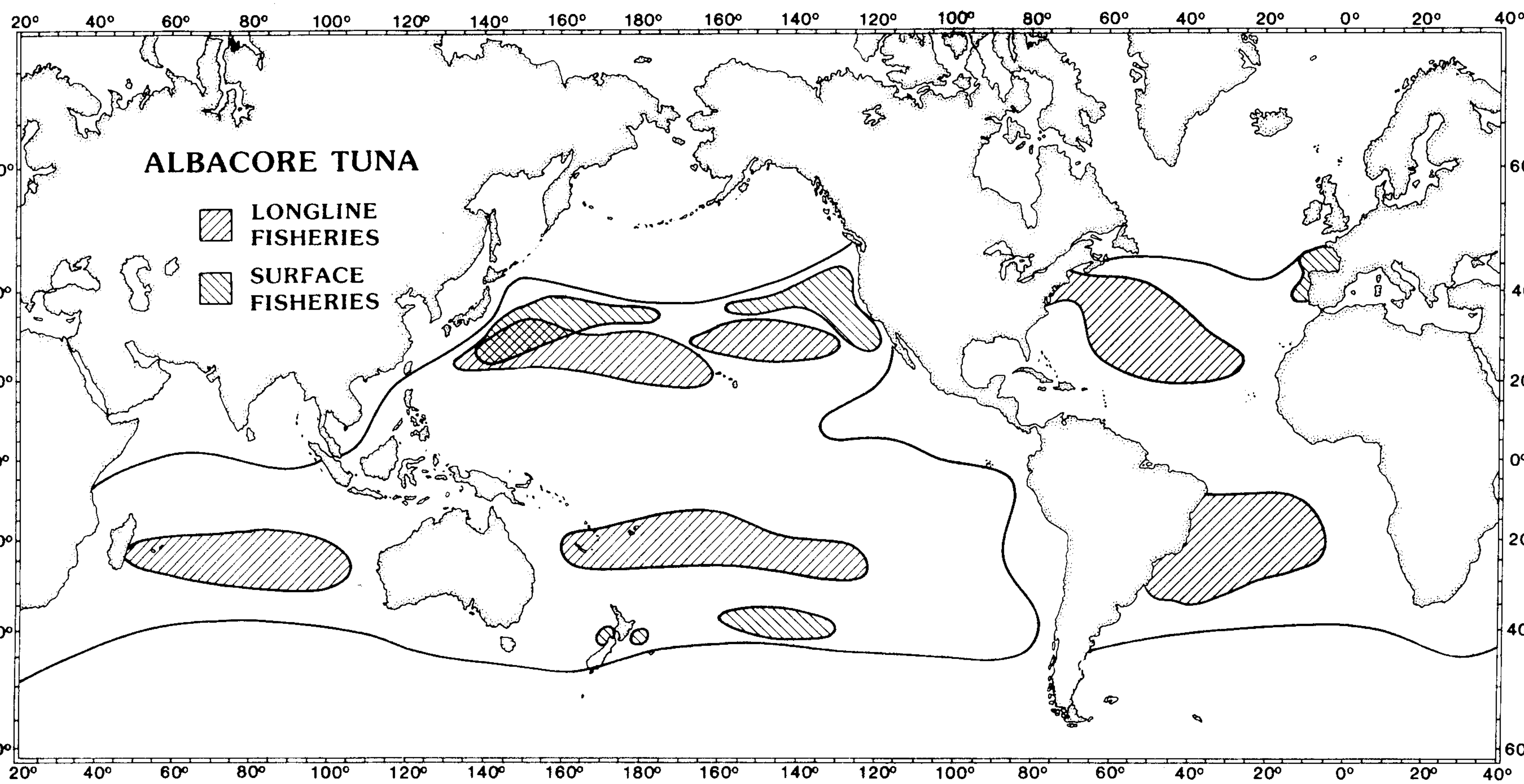
ALBACORE TUNA
LONGLINE FISHERIES
SURFACE FISHERIES
20° 40° 60° 80° 100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40°
60° 40° 20° 0° 20° 40° 60°

FIGURE 3

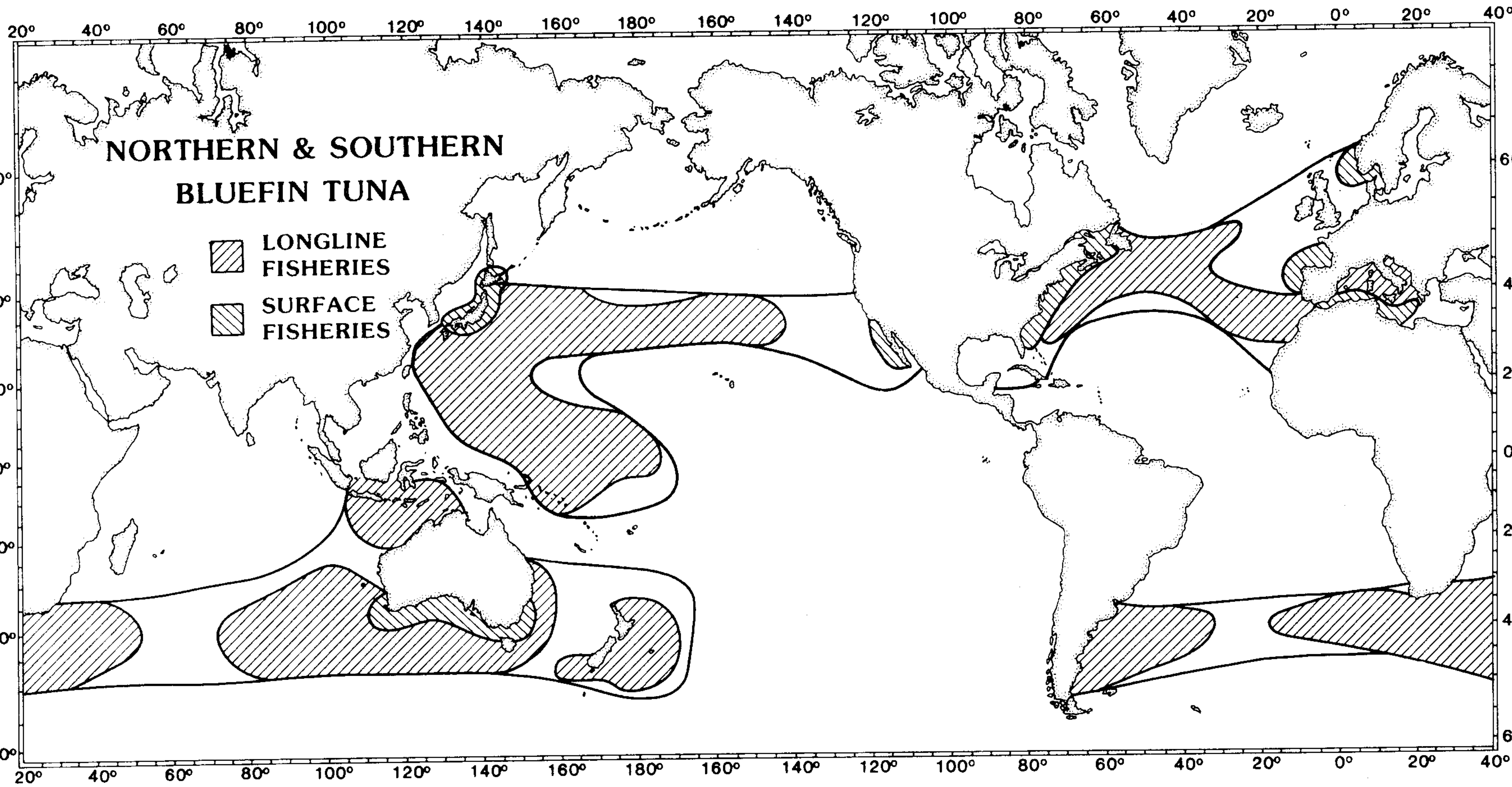
NORTHERN & SOUTHERN
BLUEFIN TUNA
LONGLINE
FISHERIES
SURFACE
FISHERIES

FIGURE 4

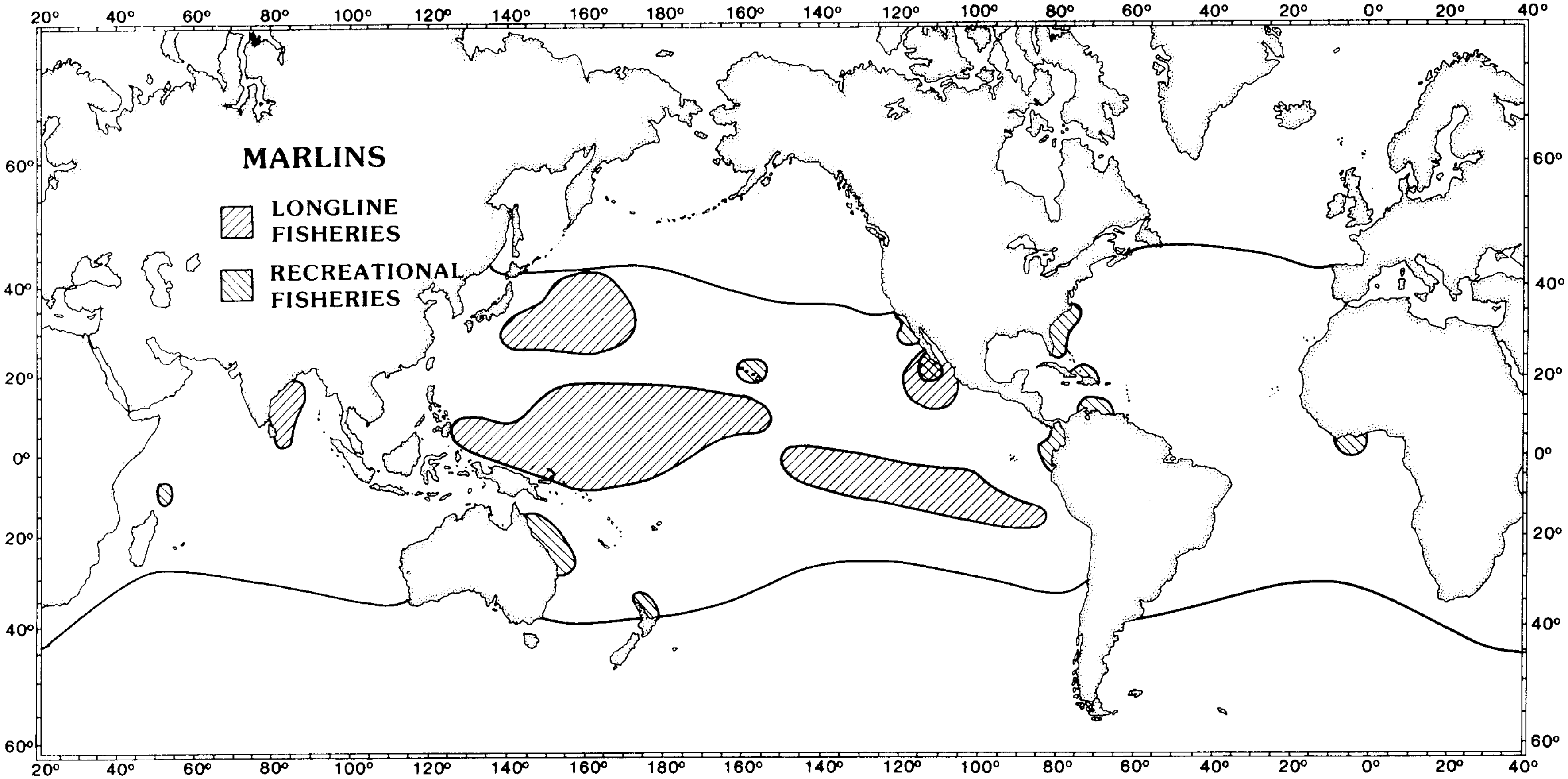
MARLINS
LONGLINE FISHERIES
RECREATIONAL FISHERIES
20°
40°
60°
80°
100°
120°
140°
160°
180°
0°

FIGURE 5

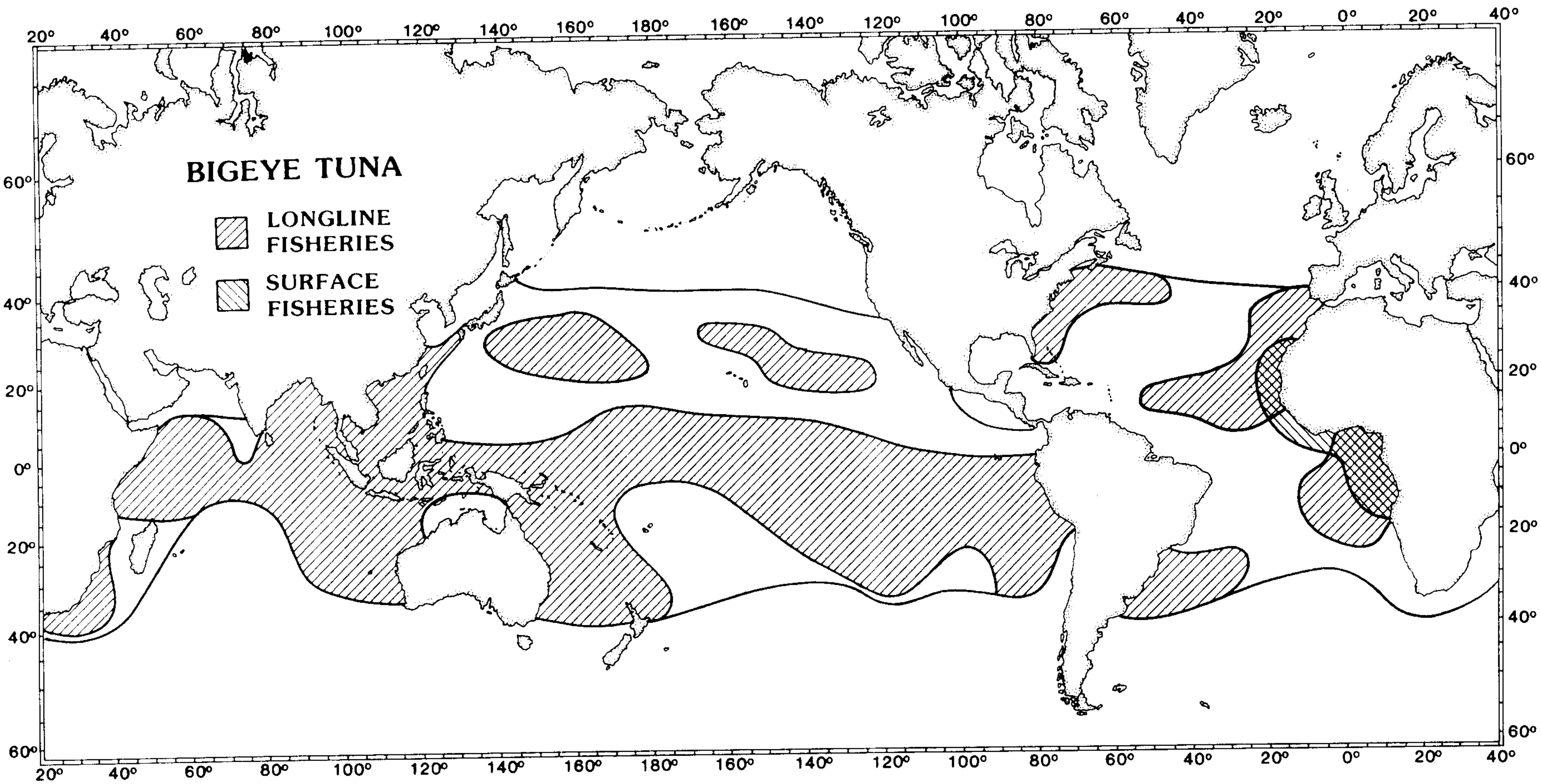
BIGEYE TUNA
LONGLINE FISHERIES
SURFACE FISHERIES
20° 40° 60° 80° 100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40°
60° 40° 20° 0° 20° 40° 60°

FIGURE 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 onboard 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 production (thousand metric tons), 1980-84.

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	588	678	637	694	777

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-

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	84,653

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). Island country revenue estimates are from Inder (1978) and 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" refers to revenues generated by local industry.

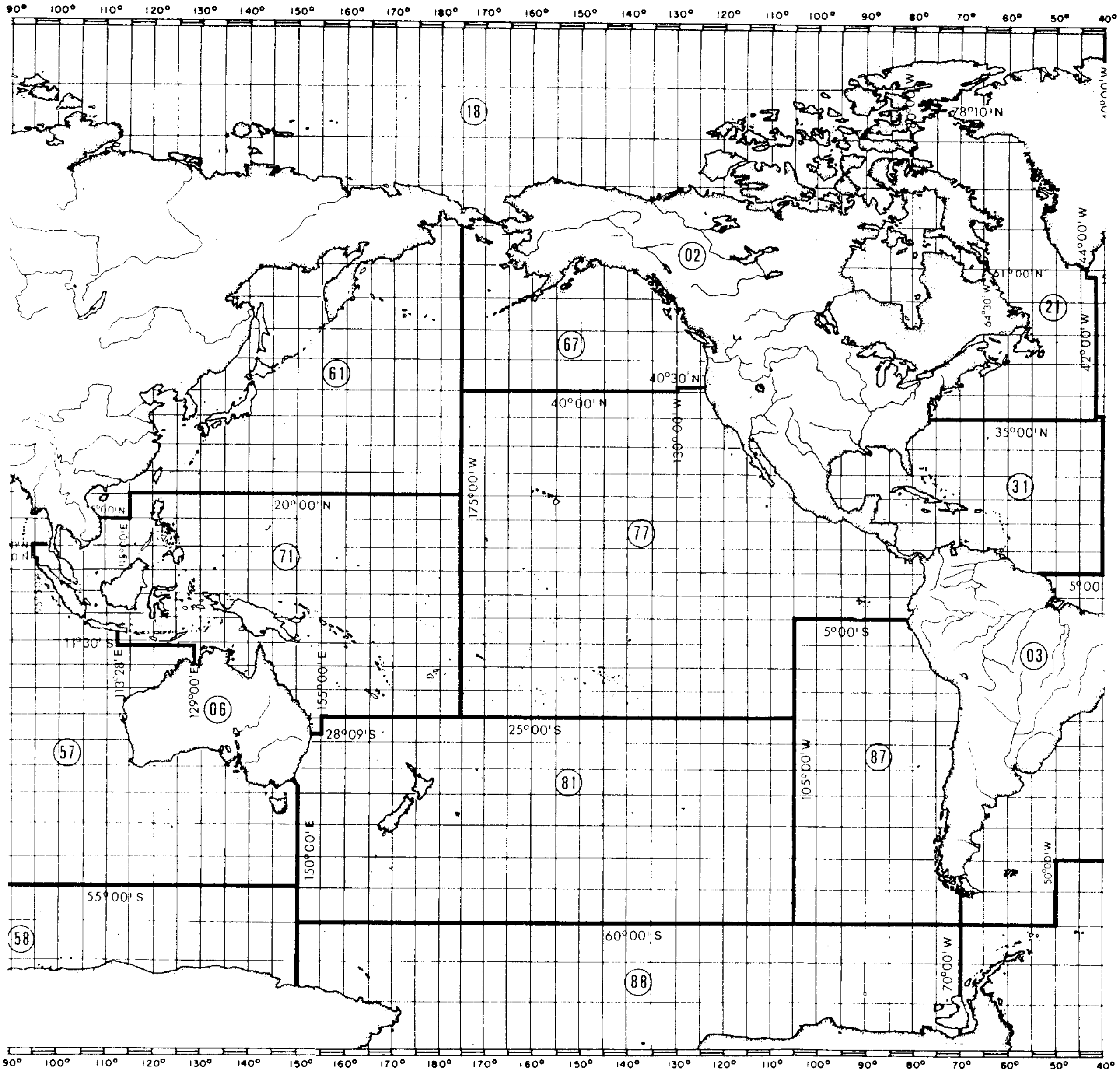
	Kiribati			Niue			Papua New Guinea		
	catch M$	revenue M$		catch M$	revenue M$		catch M$	revenue M$	
year		tot	local		tot	local		tot	local
72	2.4				2.20	1.02	4.5		
73	0.2	8.7	6.3				11.7		
74	7.4	19.3	16.6		2.14	0.30	30.8	432	156
75	1.7	32.9	30.3		2.95	0.25	11.8	572	253
76	9.4	19.5	16.0		2.89	0.27	5.6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

	Solomon Islands			Tokelau			Tuvalu		
	catch M$	revenue M$		catch M$	revenue M$		catch M$	revenue M$	
year		tot	local		tot	local		tot	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		

	Trust Territories			Wallis & Futuna			Cook Islands		
	catch M$	revenue M$		catch M$	revenue M$		catch M$	revenue M$	
year		tot	local		tot	local		tot	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
Papua New Guinea	0.05 - 0.08	0.32 - 0.46	0.13 - 0.18
Solomon Is. (1977)	0.01 - 0.05	0.13 - 0.34	0.06 - 0.17
Solomon Is. (1980)	0.01 - 0.05	0.07 - 0.26	0.10 - 0.25
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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20°00'N
175°00'W
5°00'S
11°30'S
113°28'E
129°00'E
155°00'E
28°09'S
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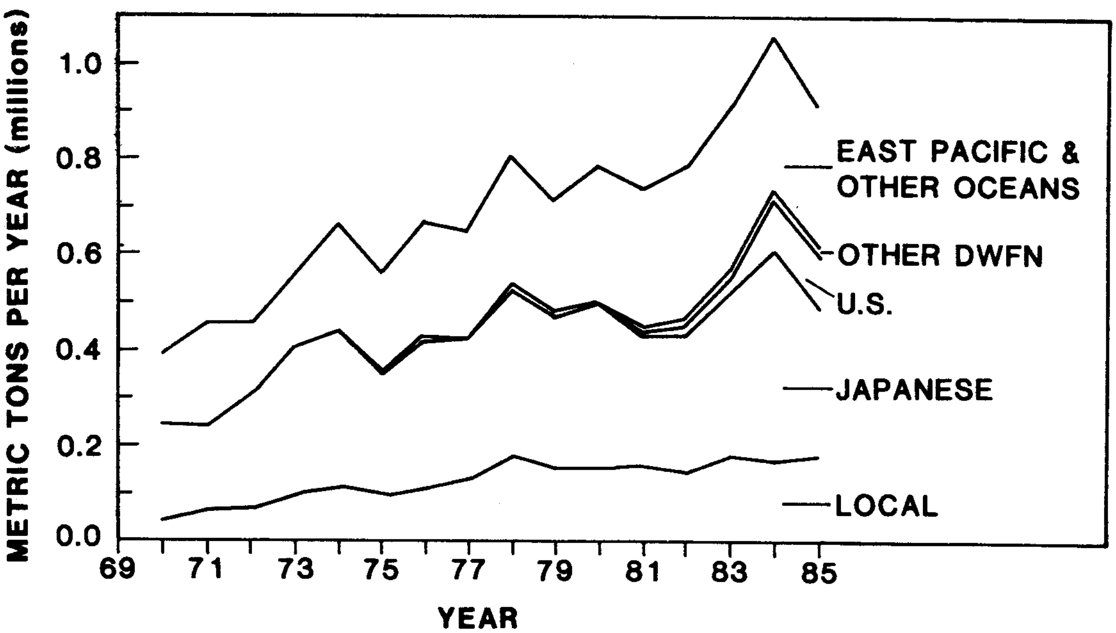
105°00'W
150°00'E
55°00'S
60°00'S
50°00'W
70°00'W

FIGURE 1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0.2
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71
73
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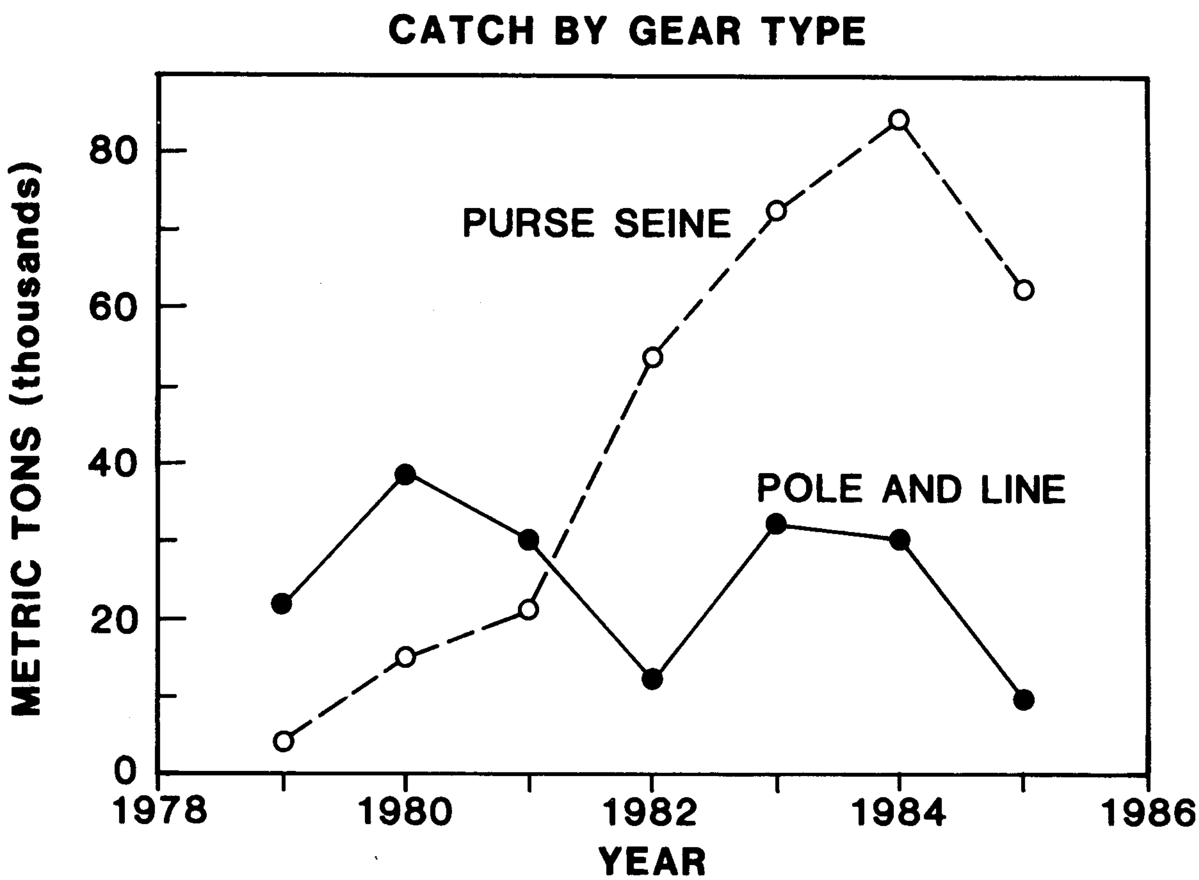
YEAR
EAST PACIFIC &
OTHER OCEANS
OTHER DWFN
U.S.
JAPANESE
LOCAL

FIGURE 2


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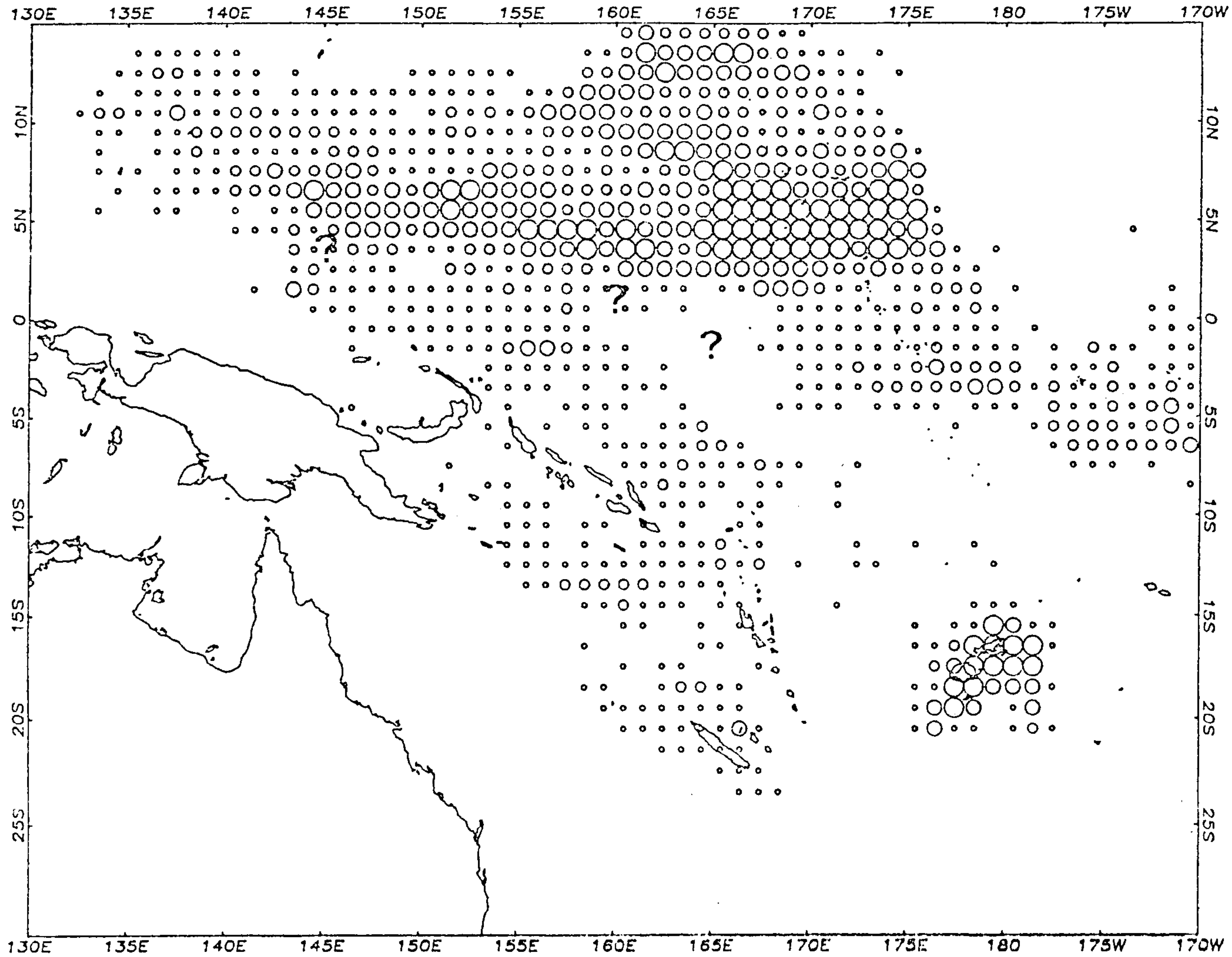
PURSE SEINE
POLE AND LINE
1978
1980
1982
1984
1986
YEAR

FIGURE 3



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51-150 METRIC TONS

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> 400 METRIC TONS

FIGURE 4

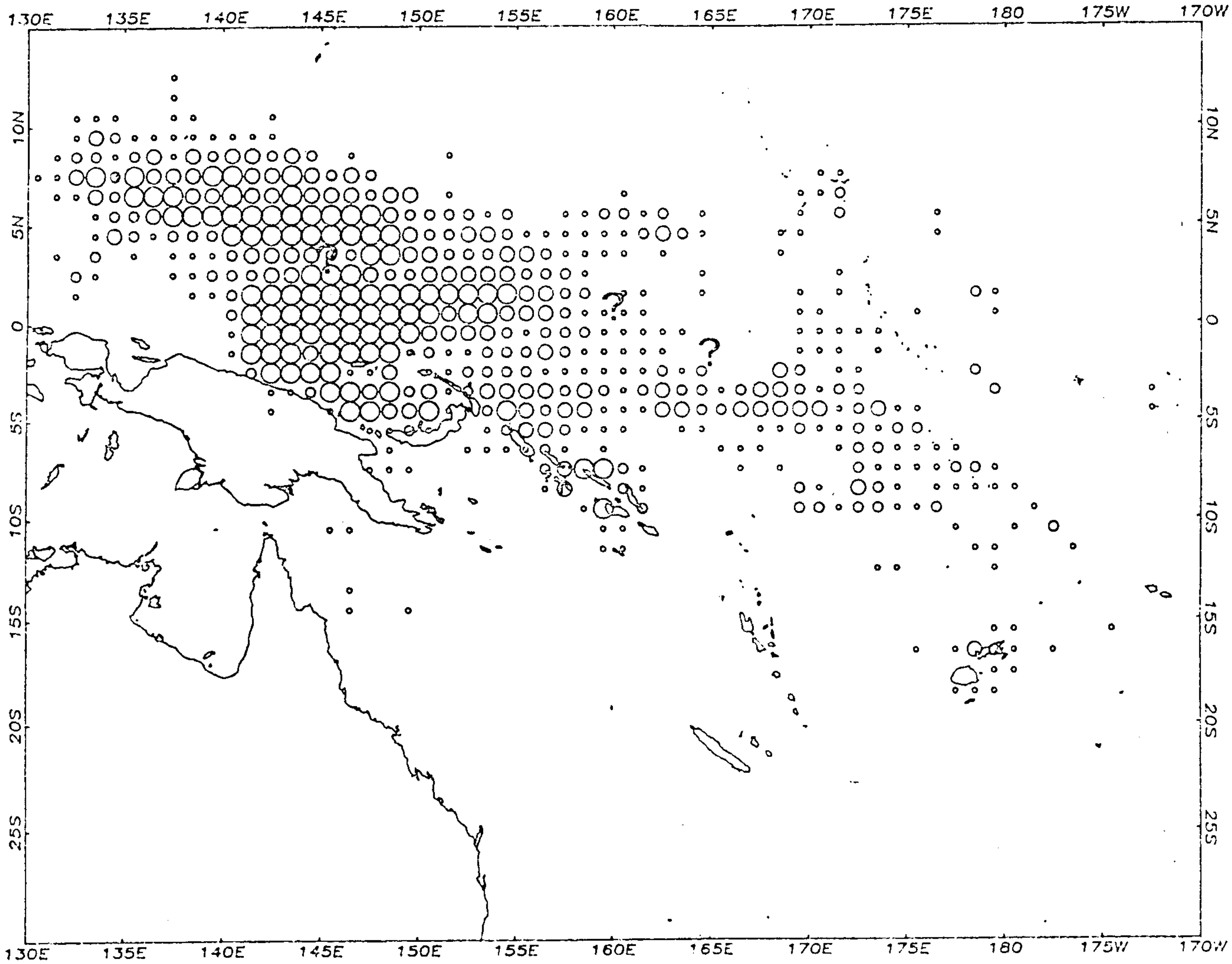

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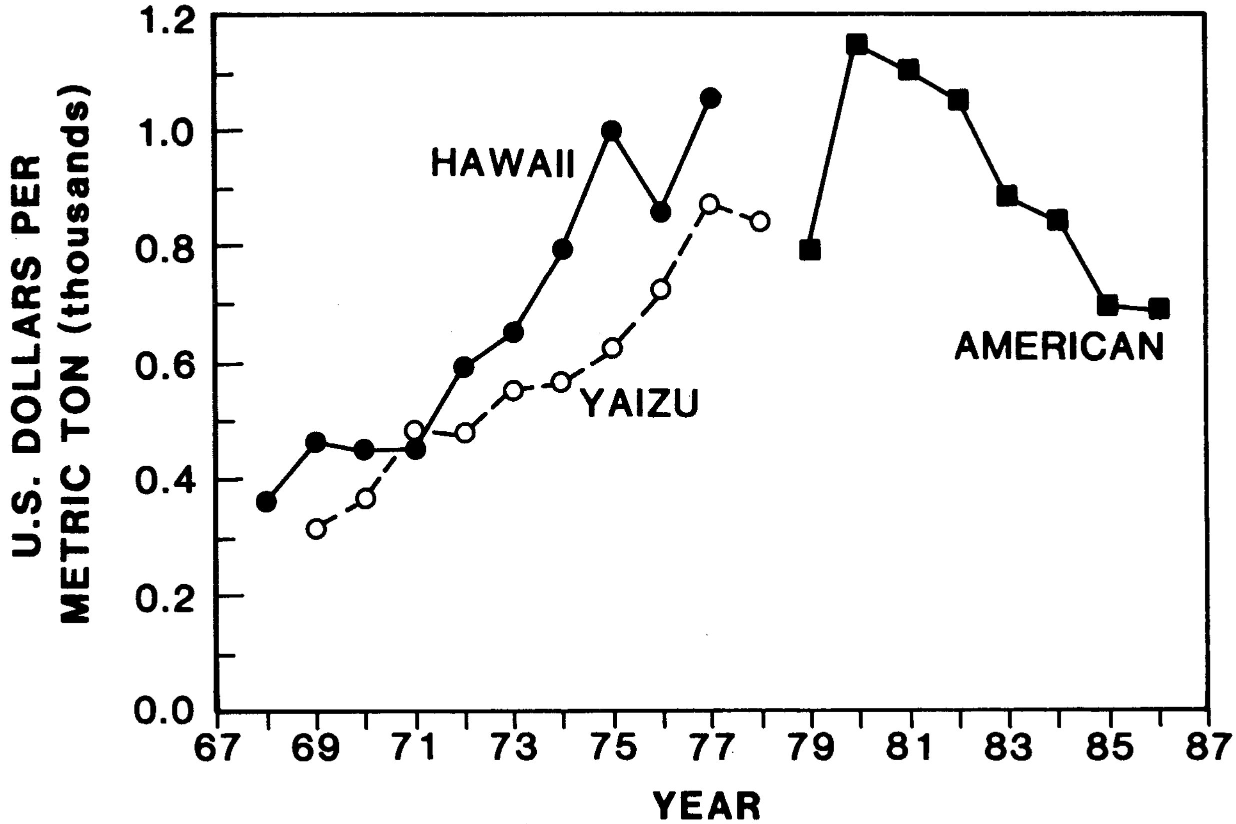
FIGURE 5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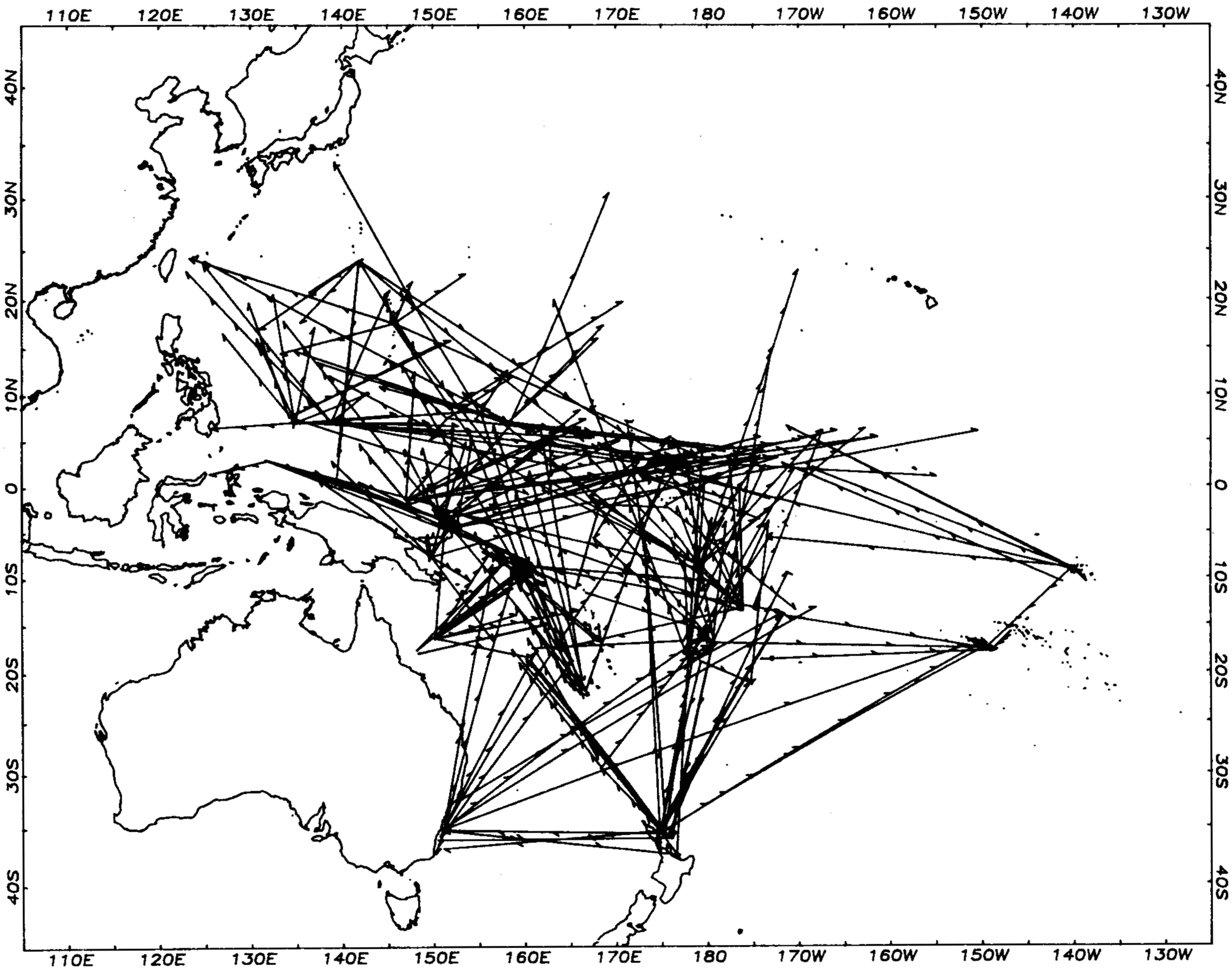
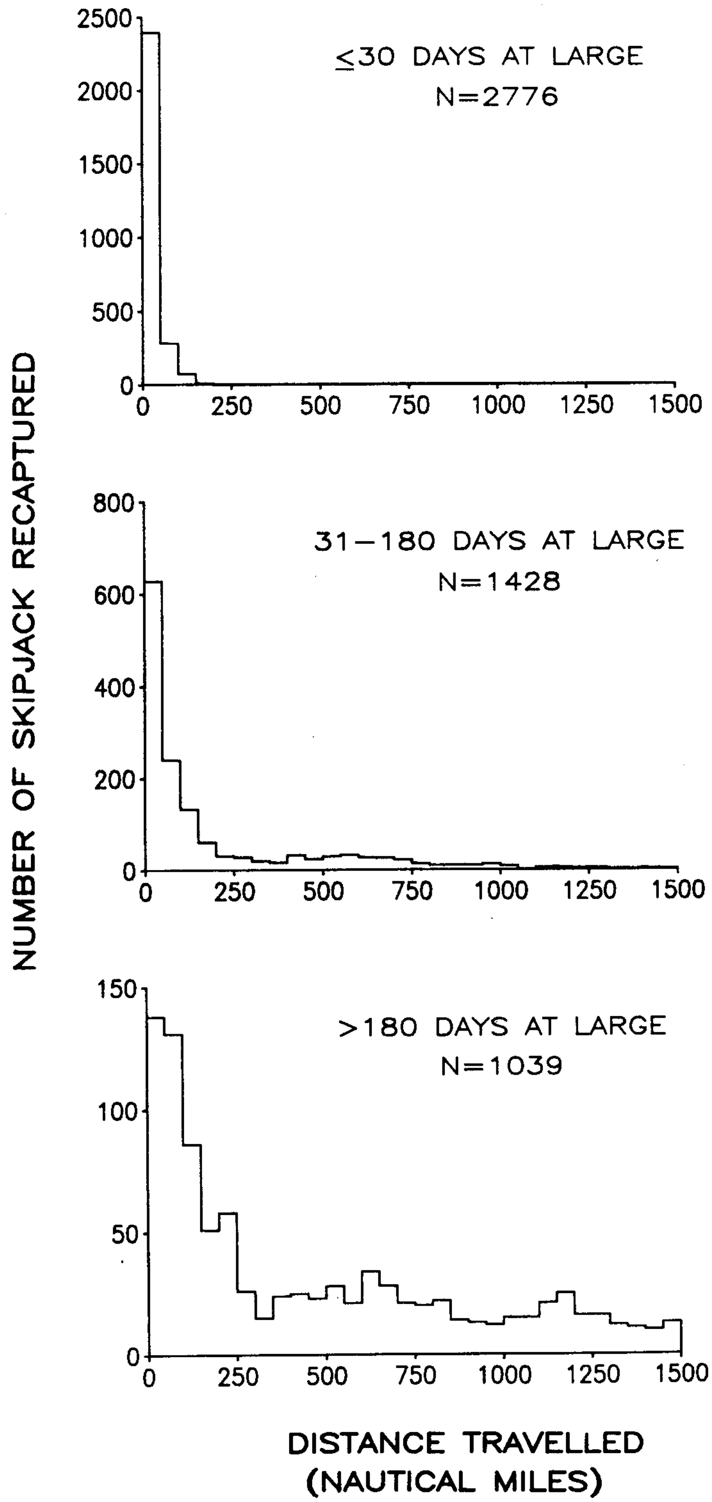
1.0
0.8
0.6
0.4
0.2
0.0
U.S. DOLLARS PER METRIC TON (thousands)
HAWAII
YAIZU
AMERICAN
67
69
71
73
75
77
79
81
83
85
87
YEAR

FIGURE 6



110E
120E
130E
140E
150E
160E
170E
180
170W
160W
150W
140W
130W
40N
30N
20N
10N
0
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
0
250
500
750
1000
1250
1500
>180 DAYS AT LARGE
N=1039
150
100
50
0
0
250
500
750
1000
1250
1500
DISTANCE TRAVELLED
(NAUTICAL MILES)

FIGURE 8

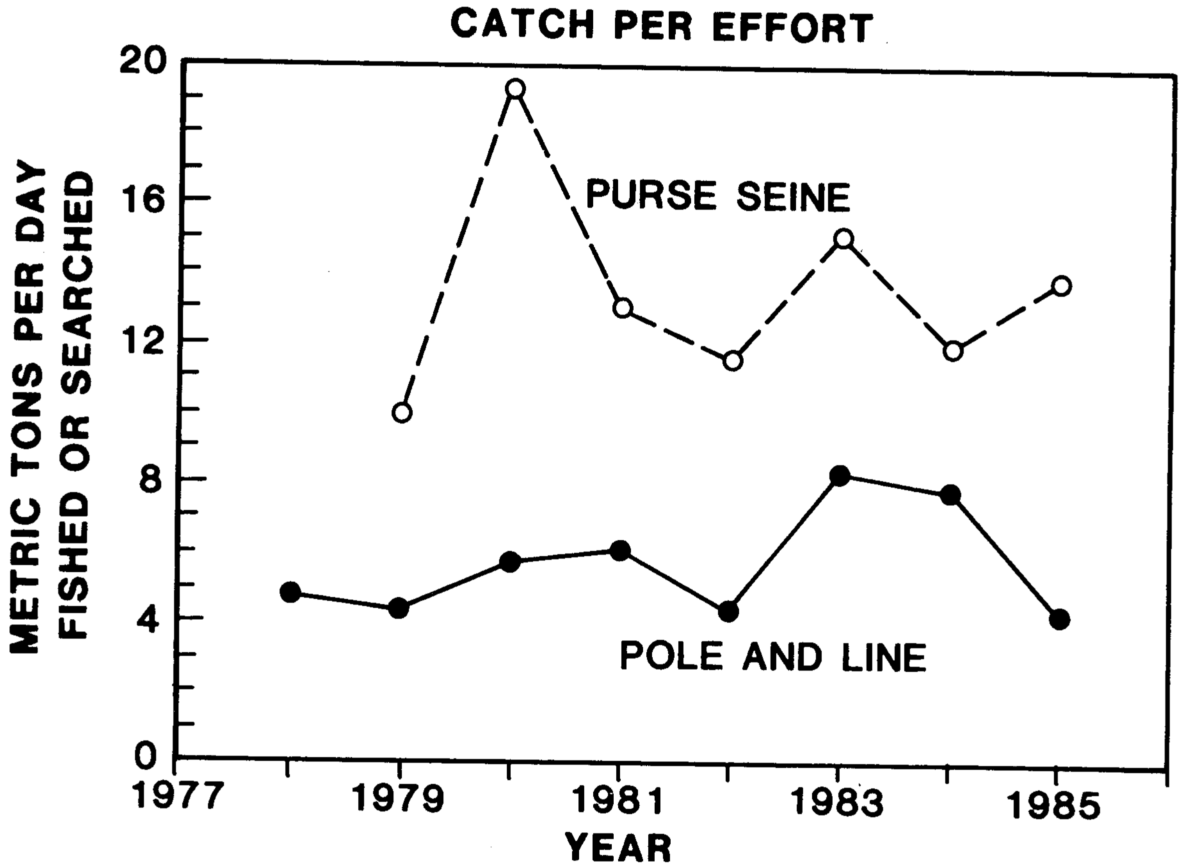

CATCH PER EFFORT
METRIC TONS PER DAY
FISHED OR SEARCHED
20
16
12
8
4
0
PURSE SEINE
POLE AND LINE
1977
1979
1981
1983
1985
YEAR

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.

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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

The preparation of this report was assisted greatly by information on the skipjack tuna pole-and-line fishery contained in manuscript by Bert S. Kikkawa and by information on the longline fishery contained in manuscript by Victor A. Honda. Unpublished data on longline catch and effort were provided by Jerry A. Wetherall and Marion Y. Y. Yong.

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).

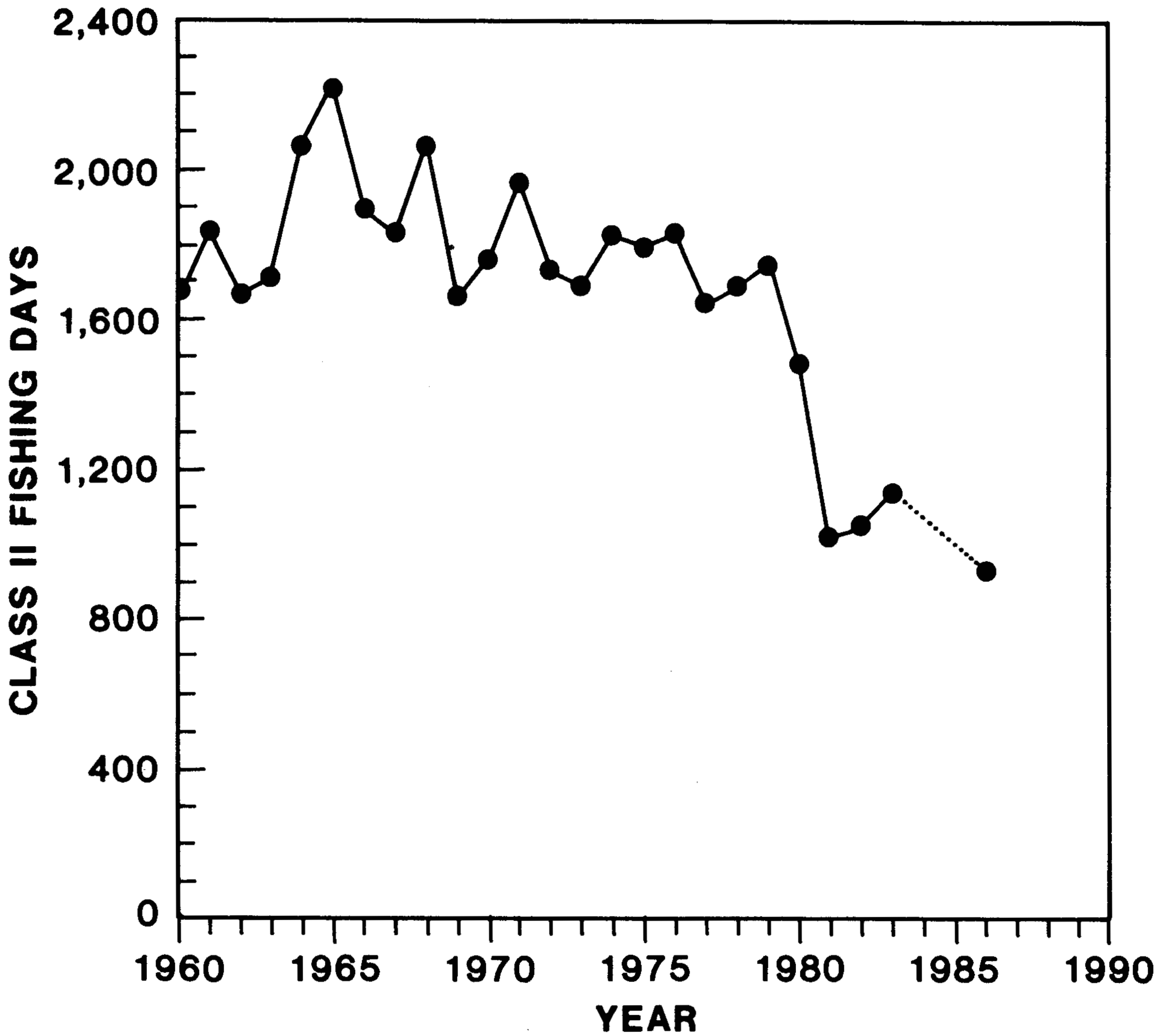

2,400
2,000
1,600
1,200
800
400
0
CLASS II FISHING DAYS
1960
1965
1970
1975
1980
1985
1990
YEAR

FIGURE 1

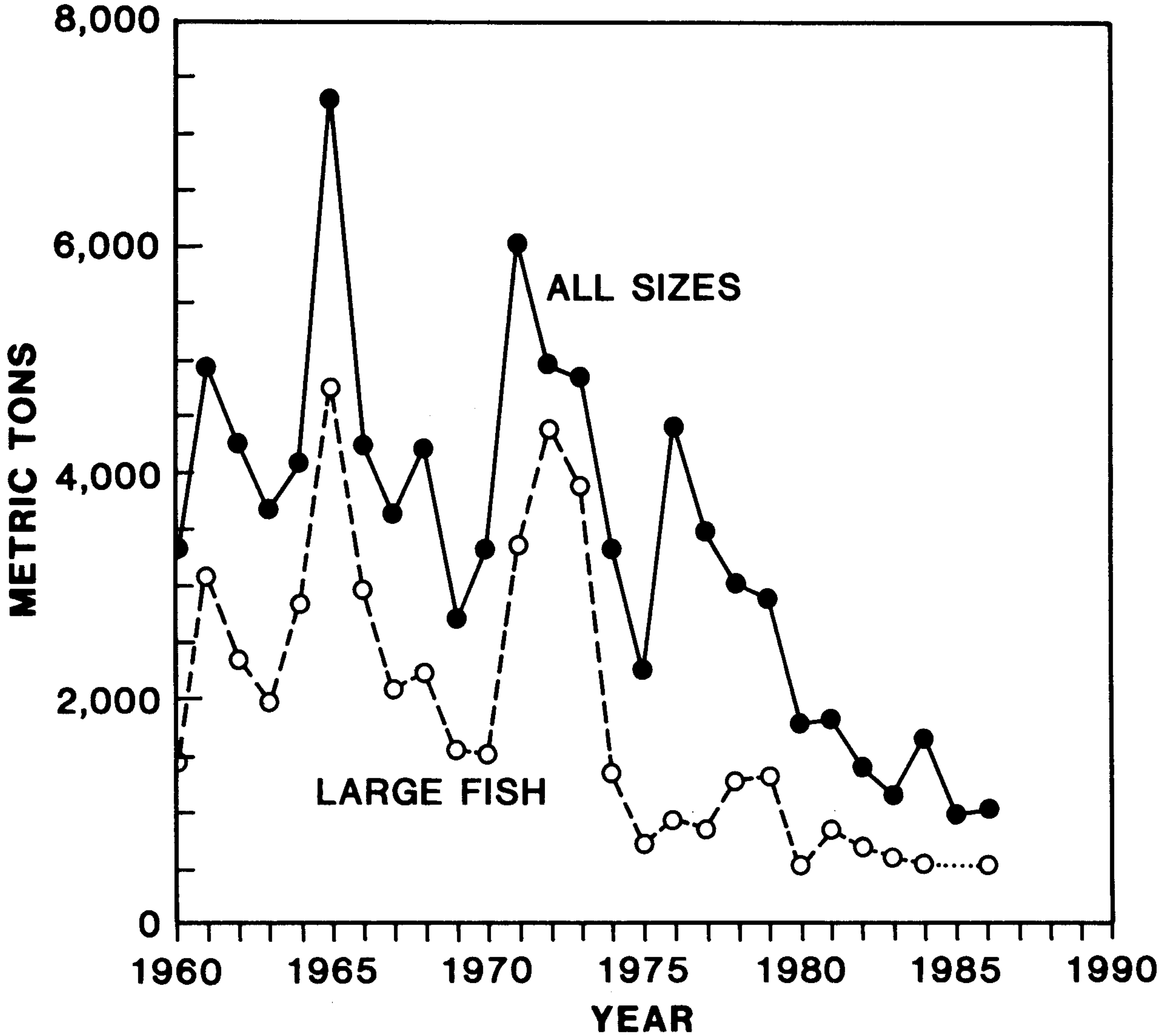
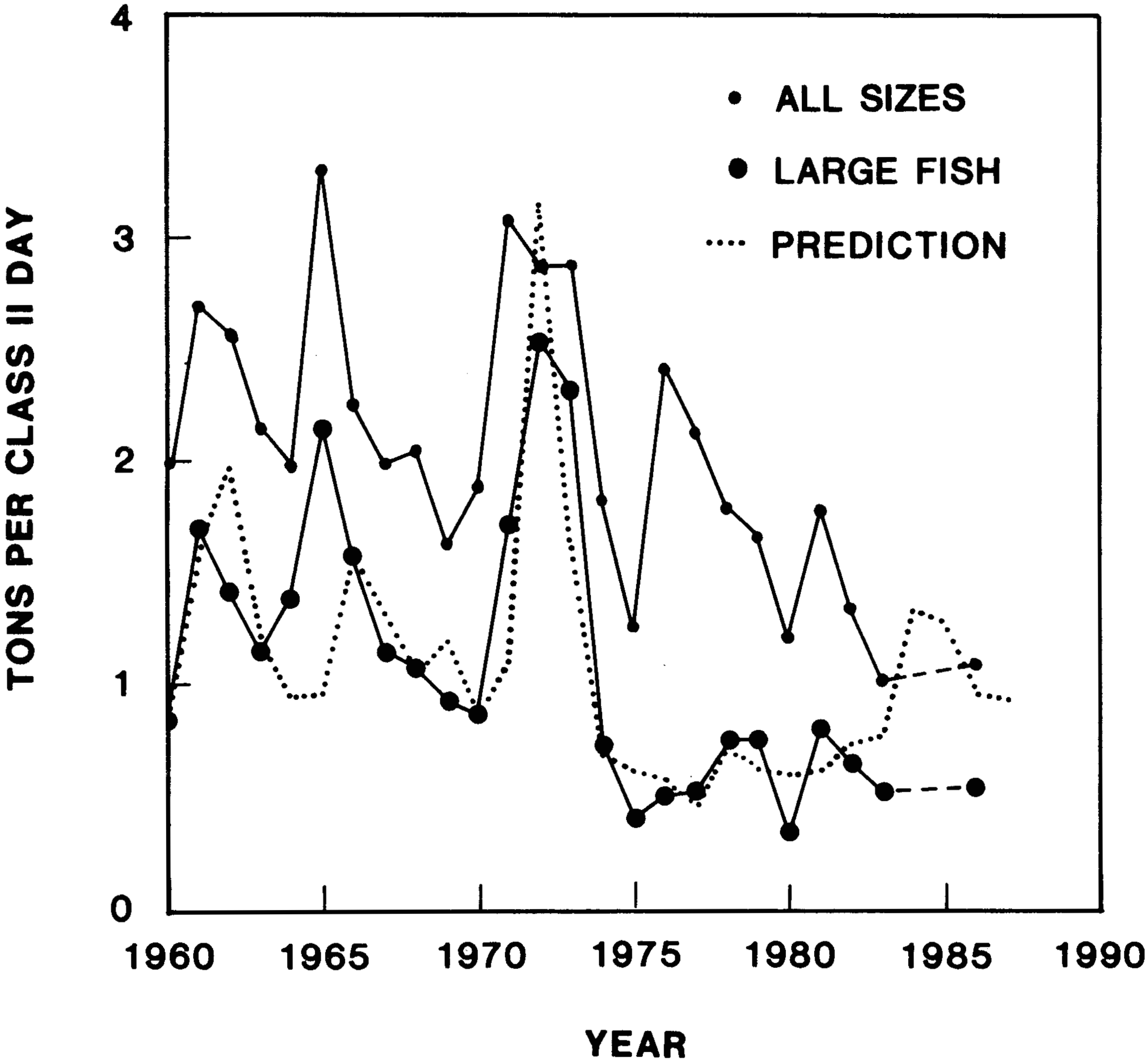
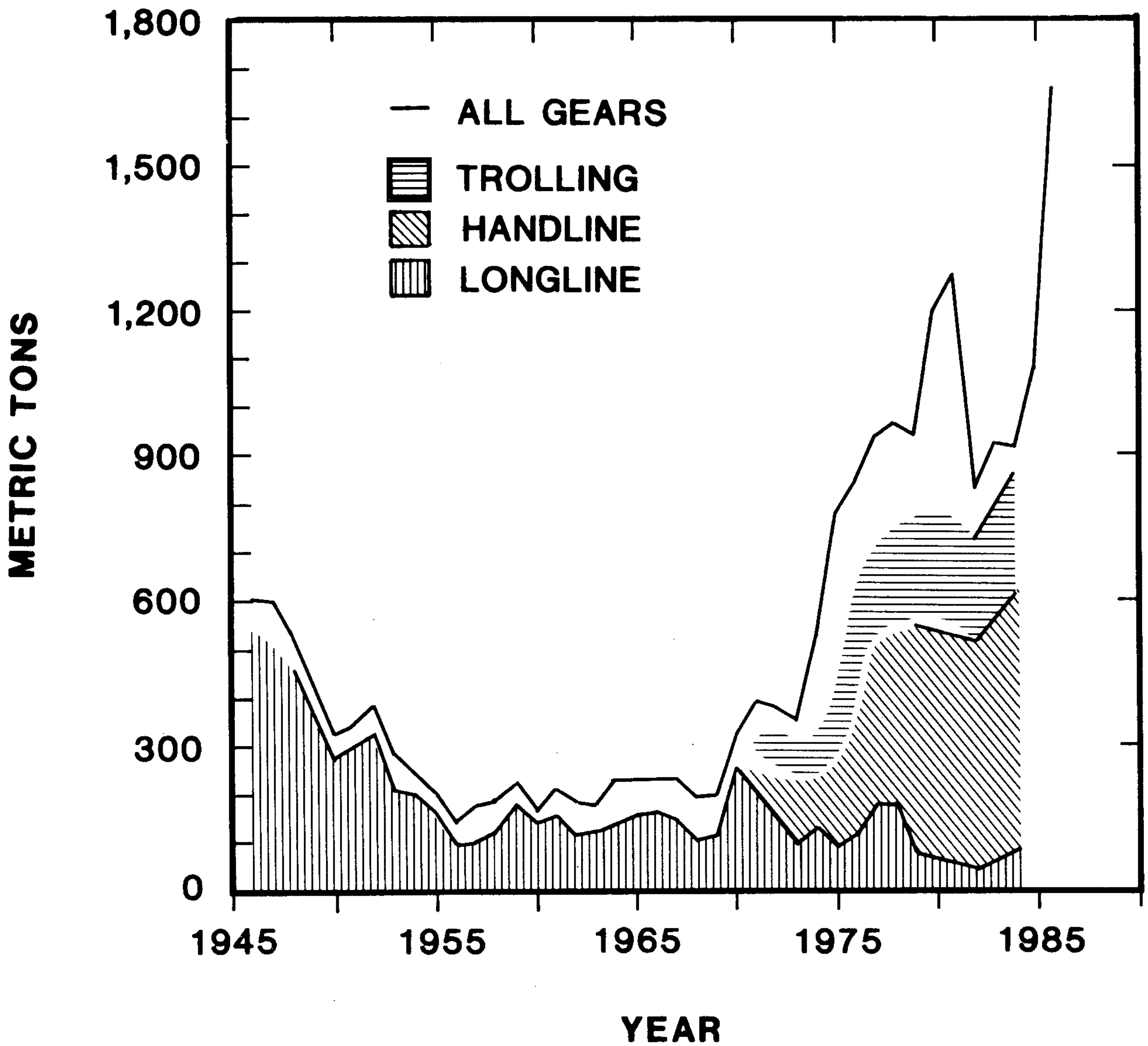

8,000
6,000
4,000
2,000
0
METRIC TONS
ALL SIZES
LARGE FISH
1960
1965
1970
1975
1980
1985
1990
YEAR

FIGURE 2



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

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

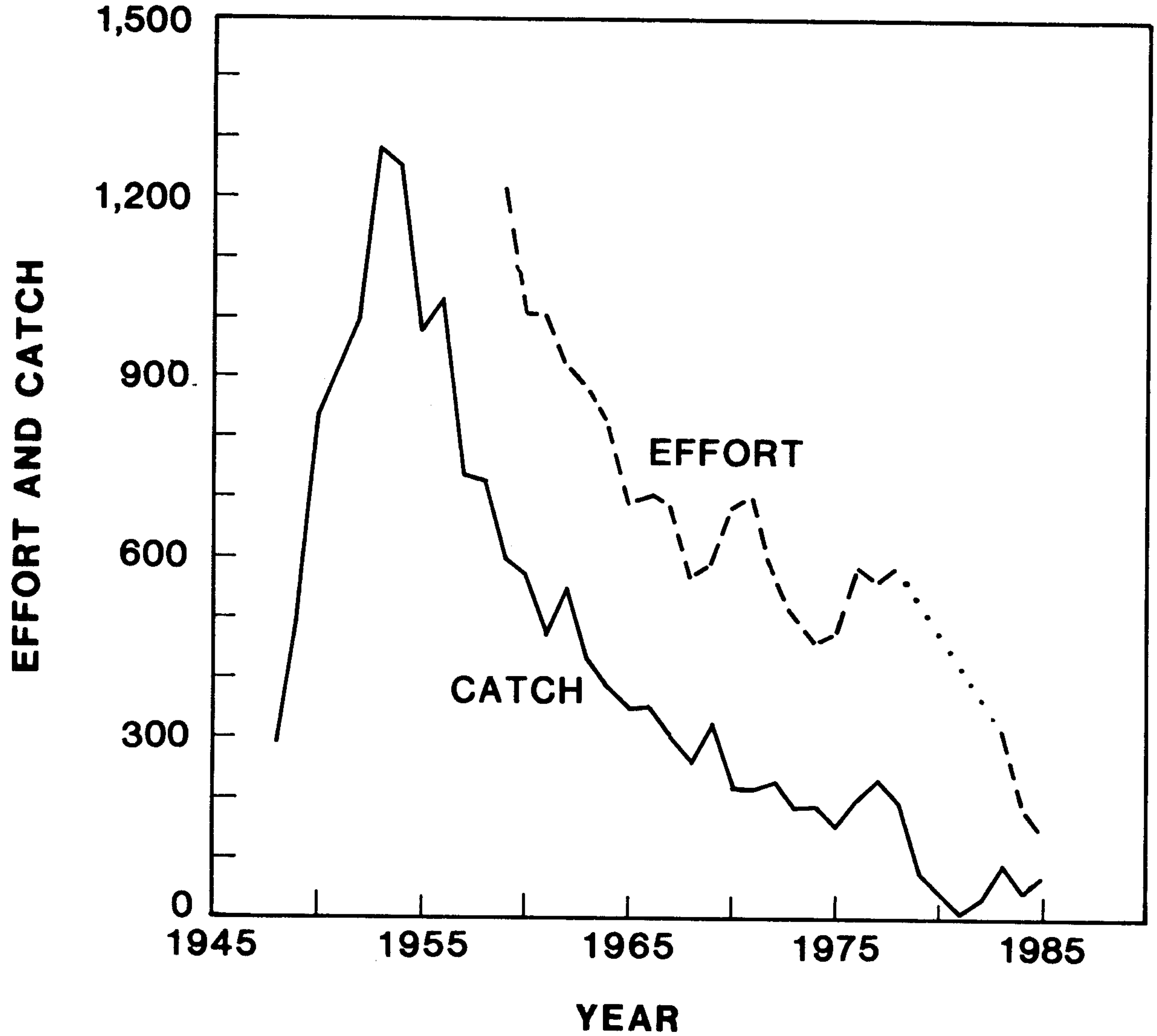

1,500
1,200
900
600
300
0
EFFORT AND CATCH
EFFORT
CATCH
1945
1955
1965
1975
1985
YEAR

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.

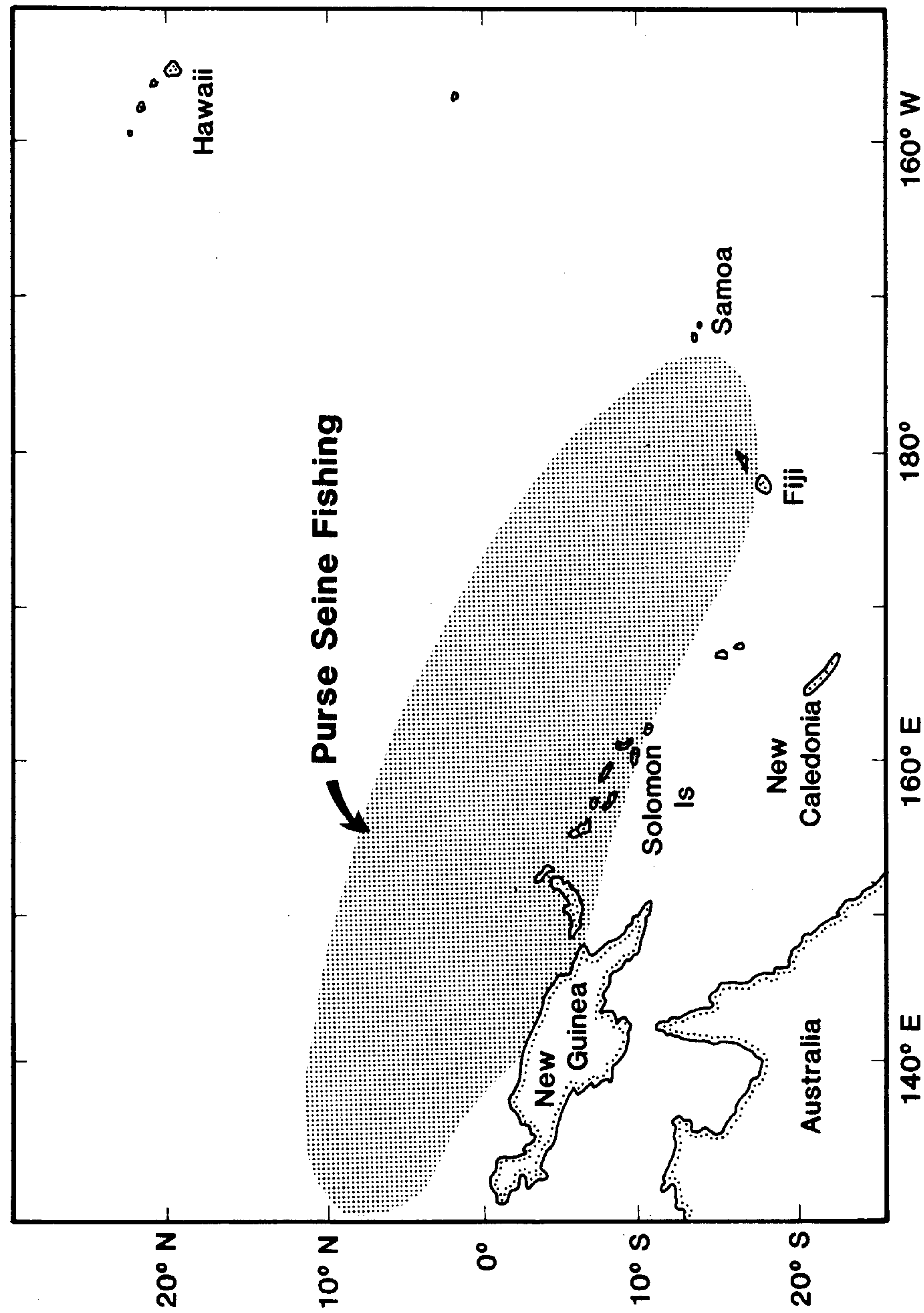
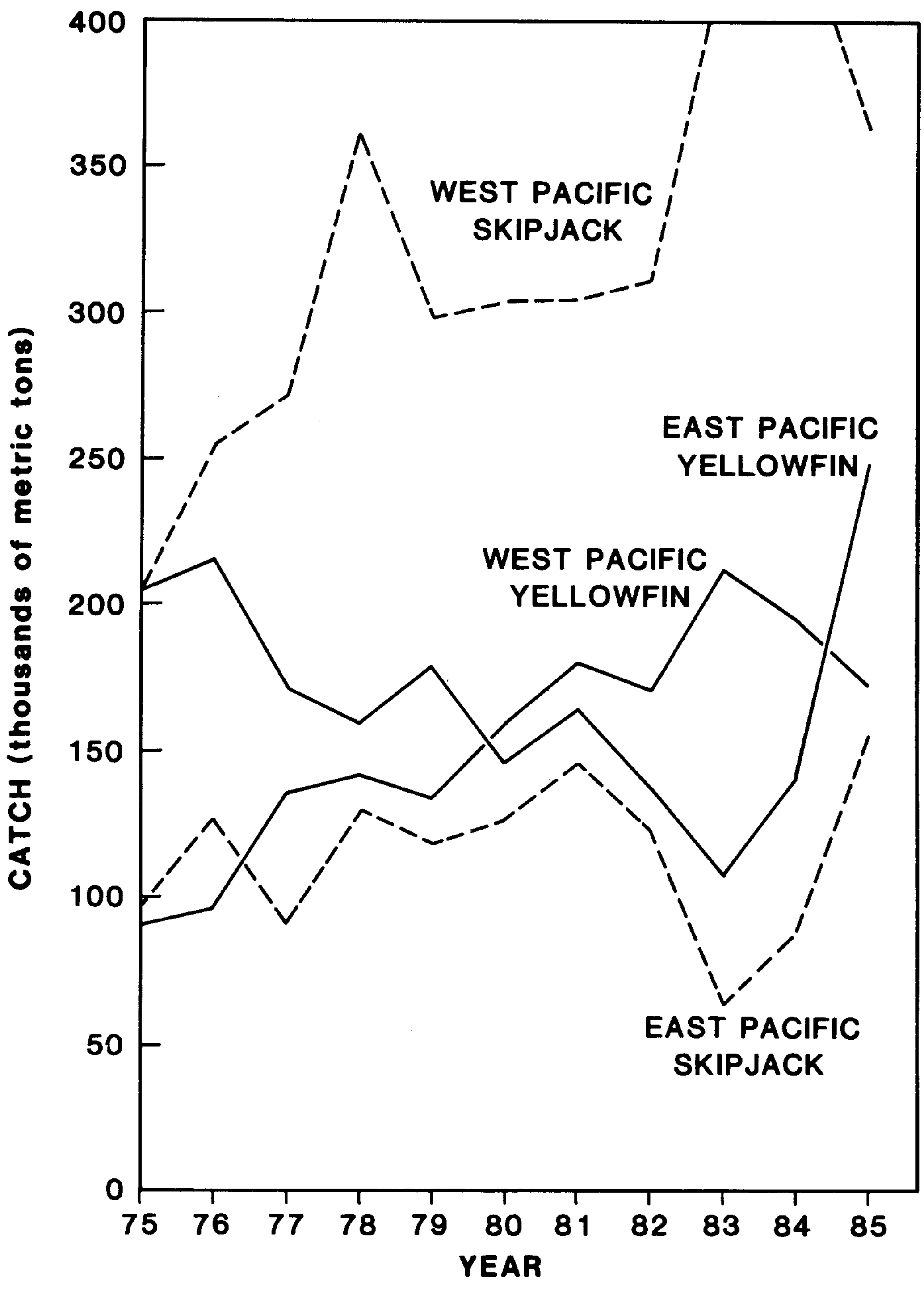

Purse Seine Fishing
Hawaii
Samoa
Fiji
Solomon Is
New Caledonia
New Guinea
Australia
20° N
10° N
0°
10° S
20° S
140° E
160° E
180°
160° W

FIGURE 1



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

FIGURE 2

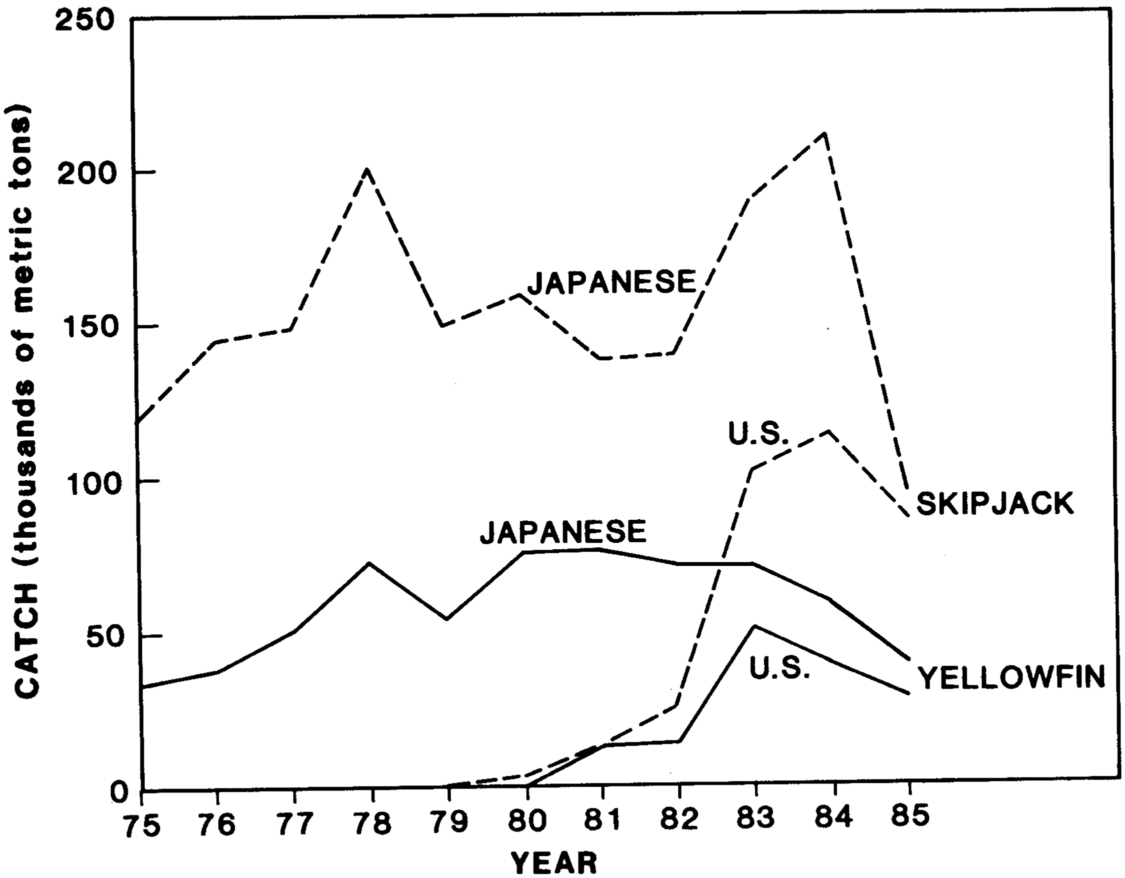

250
200
150
100
50
0
CATCH (thousands of metric tons)
JAPANESE
U.S.
SKIPJACK
JAPANESE
U.S.
YELLOWFIN
75
76
77
78
79
80
81
82
83
84
85
YEAR

FIGURE 3

Norman Bartoo
Southwest Fisheries Science Center
La Jolla California

1. INTRODUCTION

This report is a review of albacore (*Thunnus alalunga*) stocks and fisheries in the North Pacific Ocean. The fisheries and the resource covers the Pacific from Japan to the west coast of the United States and from approximately 25° north latitude to approximately the Subarctic Transition Zone (STZ; an oceanographic feature marking the location where Arctic waters meet warmer temperate waters).

This report summarizes existing information from several sources which are listed in the Bibliography, and includes data and results collected under an informal agreement among Canadian, Japanese, Taiwanese and United States fishery 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 landings by country and gear since the early 1950s are given in Table 1. The timing of the fisheries for albacore is such that the albacore stock is subjected to one or more fisheries at any given time throughout the stocks range.

The North American fishery occurs during late spring, summer and autumn months (Figure 1) and almost exclusively catches pre-adult age fish. In the late spring, vessels fish in the mid-Pacific from the Emperor Sea Mounts (172° east longitude) to the area north of Midway Island and the Hawaiian Islands (175° west longitude) along the sub-arctic front where subtropical and cooler subarctic waters meet (35° to 40° north latitude). As summer progresses, the fishery follows the albacore to the North American coast. Commercial fishermen from the United Stares and Canada catch albacore using a several gears. Boats trolling jigs ("jig boats") are by far the most prevalent in the fishery followed by boats fishing with live bait ("baitboats"). Small amounts of albacore are taken as incidental catch by purse seine and drift gill net vessels.

U.S. total landings fluctuated around 20,000 metric tons (mt) from the mid-1950s through the early 1970s. From 1970 through 1990, the landings dropped from the 20,000 mt level to around 2,000 mt. During this same period, effort and catch per effort concomitantly declined.

The recreational catch of albacore varies in its coastal location depending on the distribution of the resource in any given year. Catches range from a few mt to 1,500 plus mt from 1952 to 1992 with no clear pattern (Table 1.).

The Asian fisheries for albacore are conducted mainly by the Japanese, although in the recent past, both Taiwan and Korea made significant catches (Table 1). Currently the major Asian fisheries include Japanese baitboat and longline fisheries. Additionally, small amounts are taken by other gears and countries (see table 1).

The Japanese baitboat fishery operated off the coast of Japan since the early 1920s. This fishery has both small coastal vessels and larger (up to 75 m) vessels which are capable of high seas operations. This fleet fishes for albacore in the spring months along the Kuroshio current, its extension waters and the Subarctic front. Catch and effort in these fishery declined since the 1970s as effort shifted to skipjack tuna (*Katsuwonus pelamis*) production and the albacore resource declined.

The longline fishery has been in operation since the early 1950s and is conducted primarily by Japanese vessels, although Taiwan and Korea also contribute to the longline catch totals (Table 1). The longline fleet catches albacore during the winter months in the central and western Pacific. Longline catch and effort has remained approximately stable since the mid-1970s.

The most recent significant fisheries to develop, and subsequently cease, for albacore are the Asian drift gill net fisheries of Japan, Korea and Taiwan. Two fisheries, one using large mesh gill nets targeted on albacore, and the other using small mesh gill nets targeted on neon flying squid and incidentally catching albacore, operated in various combinations by the three countries. These fisheries began as an offshoot of the Japanese coastal gill net fishery for marlins which operated since the early 1900s. In the early 1980's, albacore catches from the gill net fisheries increased greatly (Table 1) as the fisheries expanded across the Pacific primarily along the Subarctic Front. These gill net fisheries ended abruptly at the beginning of 1993 for political reasons.

3. ECONOMIC ASPECTS

In the United States, albacore consumption is nearly 90,000 mt per year—greatly exceeding domestic production which averaged 18,000 mt per year from 1952 through 1985 and 4,000 mt from the 1985 through 1993 period. During the recent period, the ex-vessel value of the U.S. catch exceeded an average $8 million per year at a price of about $2,000 per mt. Currently, domestic landings account for about 4% to 5% of the annual consumption with the remainder imported from nearly 40 countries.

Even with high demand during the 1970 to 1993 period, the U.S. domestic albacore fishery has experienced economic difficulties. During this period, U.S. west coast canneries closed or reduced operations which provided fewer options for selling domestic catch and therefore less bargaining power for producers. The current ex-vessel price of about $2,000 per mt is approximately the same as in 1980 to 1982 unadjusted for inflation. In addition to constant ex-vessel prices, there have been increases in fuel and operations costs, increases in the cost and difficulty in acquiring insurance, and competition from imported albacore. Finally, declining catch rates (Figure 2) since the mid-1960s to the lowest recorded values in the late 1980s and early 1990s have increased trip lengths and/or reduced catches which contributes to higher production costs and decreased revenues. These difficulties could explain the declining effort and number of vessels participating in the fishery in the last decade.

In Japan, there has also been a trend toward less effort directed at albacore fishing in the last decade or two. A shift in fleet composition from baitboats to purse seiners for more effective harvesting of skipjack tuna, and an increase in consumption of baitboat caught skipjack in the lucrative sashimi market, has reduced the total number of baitboats to about 1/2 of the number operating in the 1970's, and has caused the remaining vessels to concentrate on skipjack even during periods of relatively high albacore availability. This has contributed to decreases in effort and catch of albacore by the Japanese surface fleet. In contrast, the longline fleet has remained relatively stationary over the last 10 years or so in terms of both catch and effort.

In January 1993, the high seas large-scale drift net fisheries around the world ceased operations. This reduced world albacore catch levels in 1993 by an estimated 30,000 mt and North Pacific catch levels by 11,000 mt or more, and displaced an estimated 800 plus Asian drift net vessels in the Pacific. At this time, the economic impact of this fishery change has not been fully evaluated although some vessels are expected to return to the North Pacific albacore fishery using different fishing gears.

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 approaches taken involved biochemical, population-genetics analyses utilizing mitochondrial DNA. Early work was not able to find significant differences between samples taken in different oceans (Graves and Dizon 1989). Recently reported preliminary results of on-going work indicate restriction fragment length polymorphism analysis on mitochondrial DNA is able to discriminate between fish taken at Cape Town, South Africa and at 3 different locations from the Pacific. Current efforts are to resolve differences between North and South Pacific and other locations.

Other results from a number of studies, including tagging studies, suggests that North Pacific albacore exhibit some degree of separation on the eastern side of the ocean at approximately 40° north. These subgroups appear to have different migratory patterns, modal sizes in the U.S. fishery, and birth months, although in the last 10 years or so, the southern subgroup has not been identifiable in the fishery. Should management of albacore become necessary, the presence of subgroups should be considered even if they are not genetically distinct.

4.2 Impact of Fishery on Stocks

Both catch and effort have declined in the Japanese and U.S. surface fisheries which have been generally responsible for the bulk of the albacore catch over time. In the Japanese baitboat fishery CPUE for smaller fish (<= 80 cm FL) decreased about 50% from the early 1970's to the early 1990's although year to year values are erratic (Figure 3).

CPUE trends for the U.S. surface fishery reflect a trend similar to the Japanese surface fishery. From the early 1960's to the 1990's, CPUE has declined about 50% with large year-to-year variation (Figure 2).

Application of non-equilibrium production model analysis, a method incorporating catch and CPUE trends from many fisheries, estimates relative biomass (a ratio of present or forecast biomass to biomass at the maximum sustainable yield level, MSY) and relative fishing mortality (ratio of current or forecast fishing mortality to the fishing mortality at MSY level) was used to examine the condition of the stock.

Results estimate MSY near 72,000 mt per year, which is consistent with similar estimates done previously using different models. The relative biomass and relative fishing mortality trajectories clearly show this model estimates that the north Pacific albacore stock has been exploited beyond MSY since the mid-1970's (Figures 3 and 4). The results also show a stationary to improving trend since the later 1980's, and an improving trend, forecast into the future, assuming constant annual catches of 50,000 mt. The rate of recovery of the stock is sensitive to the total annual catch used in the projection with smaller catches estimating more rapid recovery.

5. OUTLOOK

There is still considerable doubt concerning what catch levels the North Pacific albacore resource can support on a sustained basis, particularly when considering effects of major environmental cycles which may span decades while affecting overall productivity. However, while not all analyses agree completely, there is a generally accepted idea that the albacore stock was fished beyond MSY since the mid 1970's, and is now, with the elimination of the high seas drift gill net fisheries and diversion of effort into other fisheries, being fished with considerably less intensity thus allowing the stock to likely build. Whether the decline in the stock was due solely to fishing pressure or exacerbated by reduced productivity of the stock for other reasons is unclear.

The decreased CPUE in the U.S. fleet, coupled with unfavorable economic factors over the last 15 years, has resulted in a depressed North Pacific albacore fishery, particularly for smaller vessels which do not have the capability to operate far offshore. Many of these vessels are part of the coastal salmon troll fleet. It is not expected that the number of U.S. vessels capable of fishing albacore on the high seas will change rapidly or greatly over the next few years. This suggests that U.S. albacore production will not increase greatly in the next few years and will likely remain near 10,000 mt.

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7. LIST OF FIGURES

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Table 1. Landings of North Pacific albacore in metric tons by fisheries, 1952-1992. Provisional estimates are given in parentheses. -- indicates data not available. (0) indicates less than 1 metric ton.

YEAR	JAPAN[1] POLE & LINE	JAPAN LONG LINE	JAPAN GILL NET	JAPAN PURSE SEINE	JAPAN OTHER GEAR	TAIWAN[4] LONG LINE	TAIWAN GILL NET	KOREA[2] LONG LINE	KOREA GILL NET	UNITED STATES[3] BAIT BOAT	US TROLL	US SPORT	US GILL NET	US PURSE SEINE	US OTHER GEAR	CANADA TROLL	MEXICO OTHER GEAR	GRAND TOTAL
1952	41,786	26,687			237						23,843	1,373				71		93,997
1953	32,921	27,777		38	132						15,740	171				5		76,784
1954	28,069	20,958		23	38						12,246	147						61,481
1955	24,236	16,277		8	136						13,264	577						54,498
1956	42,810	14,341			57						18,751	482				17		76,458
1957	49,500	21,053		83	151						21,165	304				8		92,264
1958	22,175	18,432		8	124						14,855	48				74		55,716
1959	14,252	15,802			67						20,990	0			5	212		51,328
1960	25,156	17,369			76						20,100	557			4	5		63,267
1961	18,636	17,437		7	268					2,837	12,055	1,355			6	4		52,605
1962	8,729	15,764		53	191					1,085	19,752	1,681			8	1		47,264
1963	26,420	13,464		59	218					2,432	25,140	1,161			7	5		68,906
1964	23,858	15,458		128	319	26				3,411	18,388	824			4	3		62,419
1965	41,491	13,701		11	121	261				417	16,542	731			3	15		73,293
1966	22,830	25,050		111	585	271				1,600	15,333	588			9	44		66,421
1967	30,481	28,869		89	520	635				4,113	17,814	707			12	161		83,401
1968	16,597	23,961		267	1,109	698				4,906	20,434	951			10	1,028		69,961
1969	32,107	18,006		521	1,480	634				2,996	18,827	358			12	1,365		76,306
1970	24,376	15,372		317	794	1,516				4,416	21,032	822			9	354		69,008
1971	53,198	11,035		902	367	1,759				2,071	20,526	1,175			11	1,587		92,631
1972	60,762	12,649	1	277	646	3,091				3,750	23,600	637			8	3,558	100	109,079
1973	69,811	16,059	39	1,353	533	128				2,236	15,653	84			14	1,270	0	107,180
1974	73,576	13,053	224	161	959	570				4,777	20,178	94			9	1,207	1	114,809
1975	52,157	10,060	166	159	254	1,494		2,463		3,243	18,932	640			43	101	1	89,713
1976	85,336	15,896	1,070	1,109	285	1,251		859		2,700	15,905	713			27	252	36	125,439
1977	31,934	15,737	688	669	379	873		792		1,497	9,969	537			36	53	0	63,164
1978	59,877	13,061	4,029	1,115	2,097	284		228		950	16,613	810			69	23	1	99,157
1979	44,662	14,249	2,856	125	1,158	187		259	(0)	303	6,781	74			31	521	1	(71,207)

1 Japanese pole & line landings include fish caught by research vessels. Longline landings for 1952-1960 exclude minor amounts taken by vessels under 20 tons; landings are estimated by multiplying annual number of fish caught by average weight statistics. Pole & line, longline, driftnet, purse seine and other gear data for 1952-1991 from Y. Uozumi, et. al. Pole & line and purse seine data for 1992, 1993 from Y. Warashina, et.al.

2 Korean longline landings calculated from Y. Gong using the ratio of landings, in numbers, from the north Pacific. Gillnet landings for 1979-1990 are calculated by multiplying the 1991 CPUE (# fish per pok) by effort (# poks) then multiplying by average weight (1991, 1992: 4.13 kg/fish).

3 U.S. troll boat landings for 1952-1960 include fish caught by bait boats. U.S. troll boat landings for 1984-1988 include gillnet landings. Other gear include andings from Hawaii (mostly longline). Other gear landings for 1979-1986 are raised from data with very low coverage rates.

4 Data provided by H. Liu.

Table 1. (continued)

YEAR	JAPAN[1]					TAIWAN[4]		KOREA[2]		UNITED STATES[3]						CANADA	MEXICO	
	POLE & LINE	LONG LINE	GILL NET	PURSE SEINE	OTHER GEAR	LONG LINE	GILL NET	LONG LINE	GILL NET	BAIT BOAT	TROLL	SPORT	GILL NET	PURSE SEINE	OTHER GEAR	TROLL	OTHER GEAR	GRAND TOTAL
1980	46,743	14,743	2,986	329	1,209	318	--	597	(6)	382	7,556	168			24	212	31	(75,304)
1981	27,426	18,020	10,348	252	904	339	--	459	(16)	748	12,637	195			60	200	8	(71,612)
1982	29,615	16,762	12,511	561	732	559	--	387	(113)	425	6,609	257			84	104	7	(68,726)
1983	21,098	15,103	6,852	350	125	520	--	454	(233)	607	9,359	87			213	225	33	(55,259)
1984	26,015	15,111	8,988	3,380	518	471	--	136	(516)	1,030	9,304	1,427		3,728	138	50	113	(70,925)
1985	20,714	14,320	11,204	1,533	407	109	--	291	(576)	1,498	6,415	1,176	2		83	56	49	(58,433)
1986	16,096	12,945	7,813	1,542	650	--	--	241	(726)	432	4,708	196	3		106	30	3	(45,491)
1987	19,091	14,642	6,698	1,205	189	--	2,514	182	(817)	158	2,766	74	5		136	104	7	(48,588)
1988	6,216	13,904	9,074	1,208	177	38	7,389	109	(1,016)	598	4,212	64	15		318	155	15	(44,508)
1989	8,629	13,194	7,437	2,521	466	544	8,350	81	(1,023)	54	1,860	160	4		272	200	2	(44,797)
1990	8,532	15,928	6,064	1,995	253	287	16,701	20	(1,016)	115	2,603	24	29	71	181	302	2	(54,123)
1991	7,103	10,379	3,401	2,652	399	353	3,398	3	(852)	0	1,845	6	17	0	384	139	--	(30,931)
1992	17,779	(10,379)	(3,401)	4,882	(399)	300	7,866	43	(271)	0	4,572	(2)	0	0	408	511	--	(50,813)
1993	(12,462)	(10,379)	--	(1,830)	(399)	(300)	0	(43)	0	--	6,254	(25)	0	--	(331)	230	--	(32,253)

1 Japanese pole & line landings include fish caught by research vessels. Longline landings for 1952-1960 exclude minor amounts taken by vessels under 20 tons; landings are estimated by multiplying annual number of fish caught by average weight statistics. Pole & line, longline, driftnet, purse seine and other gear data for 1952-1991 from Y. Uozumi, et.al. Pole & line and purse seine data for 1992, 1993 from Y. Warashina, et.al.

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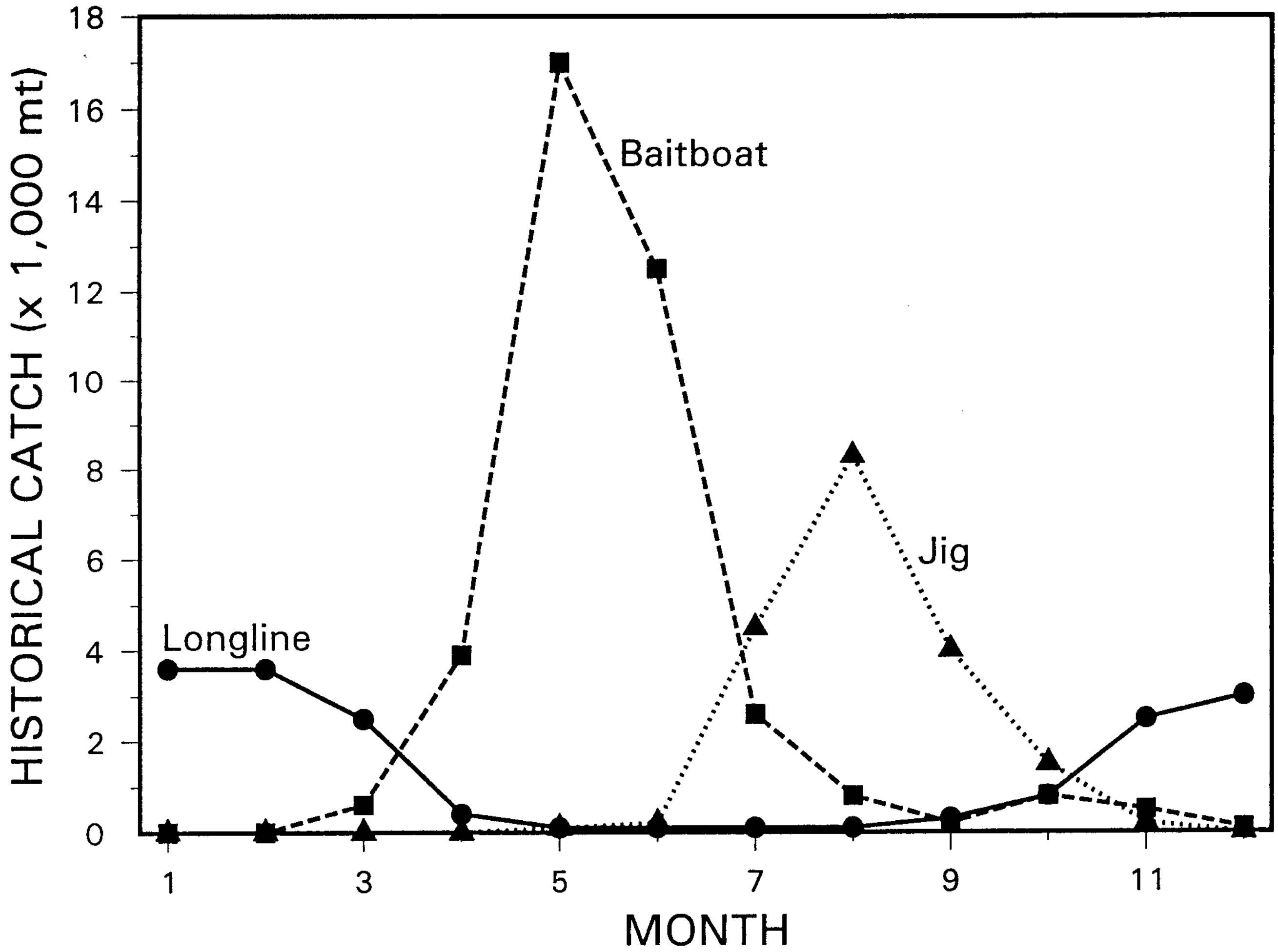
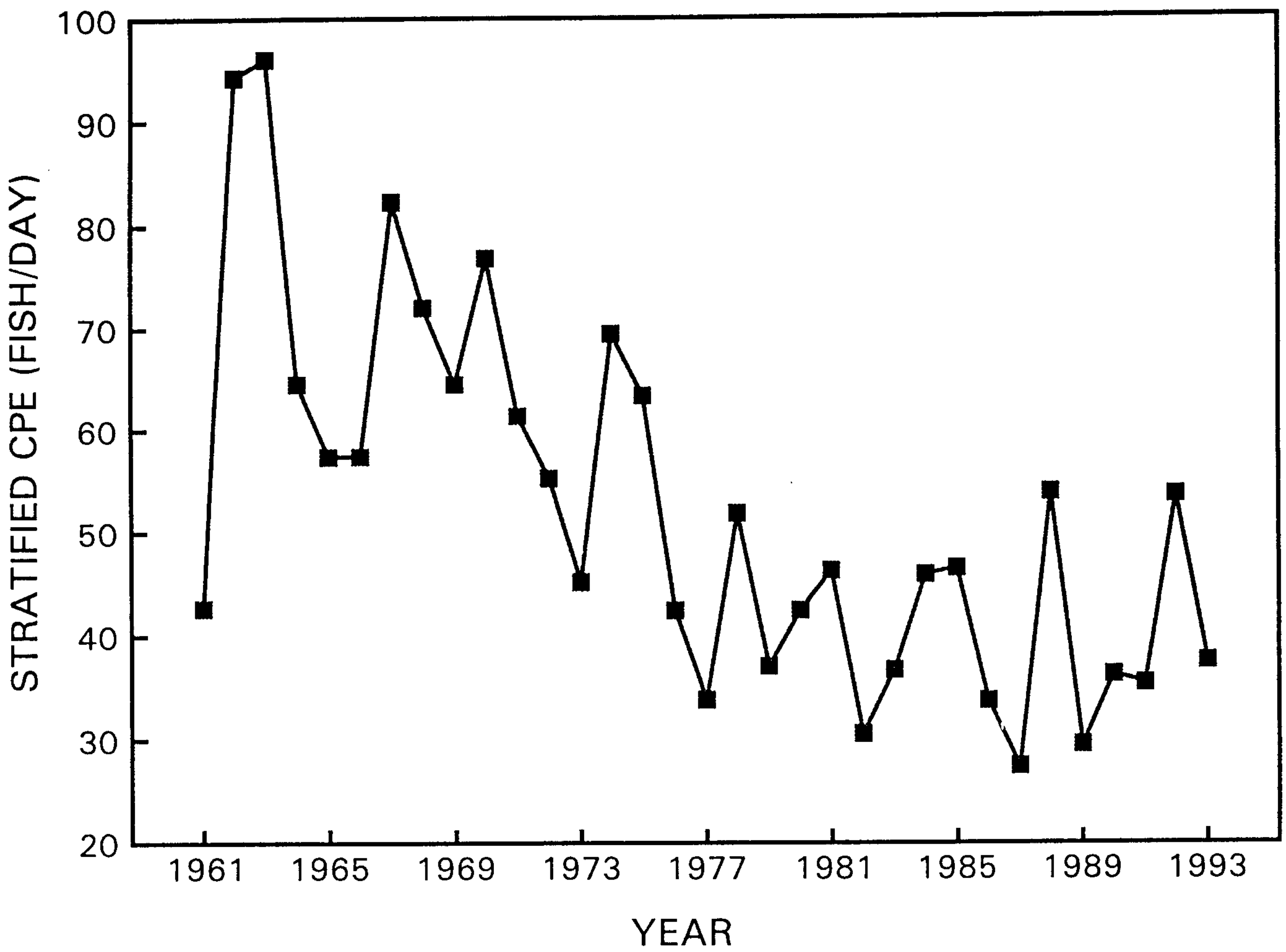


18
16
14
12
10
8
6
4
2
0
HISTORICAL CATCH (x 1,000 mt)
Baitboat
Jig
Longline
1
3
5
7
9
11
MONTH

FIGURE 1


100
90
80
70
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STRATIFIED CPE (FISH/DAY)
1961
1965
1969
1973
1977
1981
1985
1989
1993
YEAR

FIGURE 2

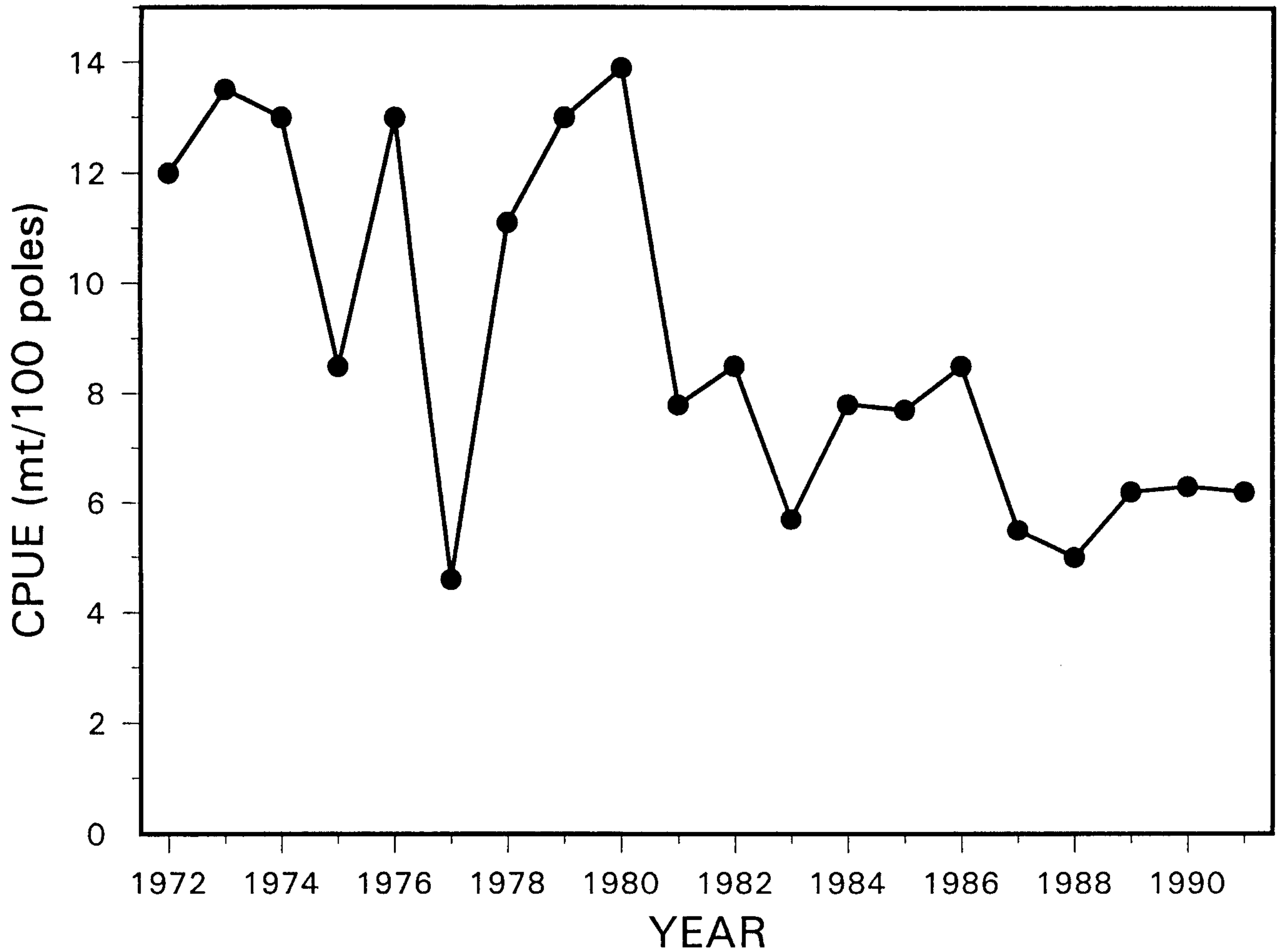
CPUE (mt/100 poles)
0
2
4
6
8
10
12
14
1972 1974 1976 1978 1980 1982 1984 1986 1988 1990
YEAR

FIGURE 3

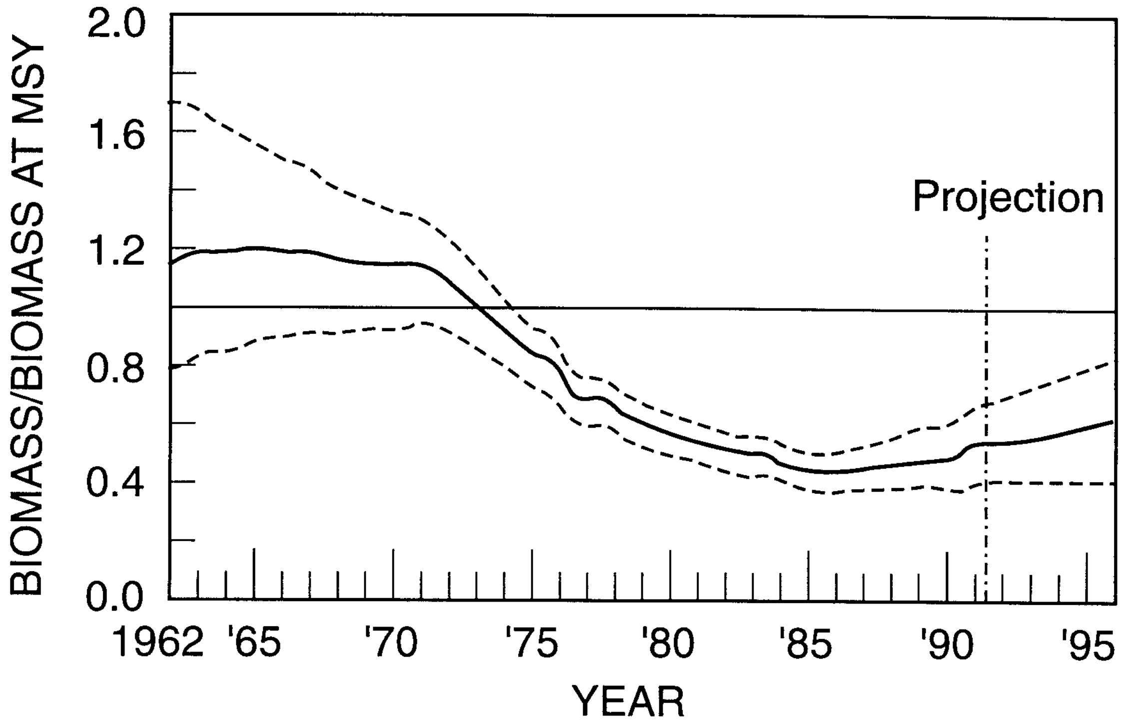

FIGURE 4

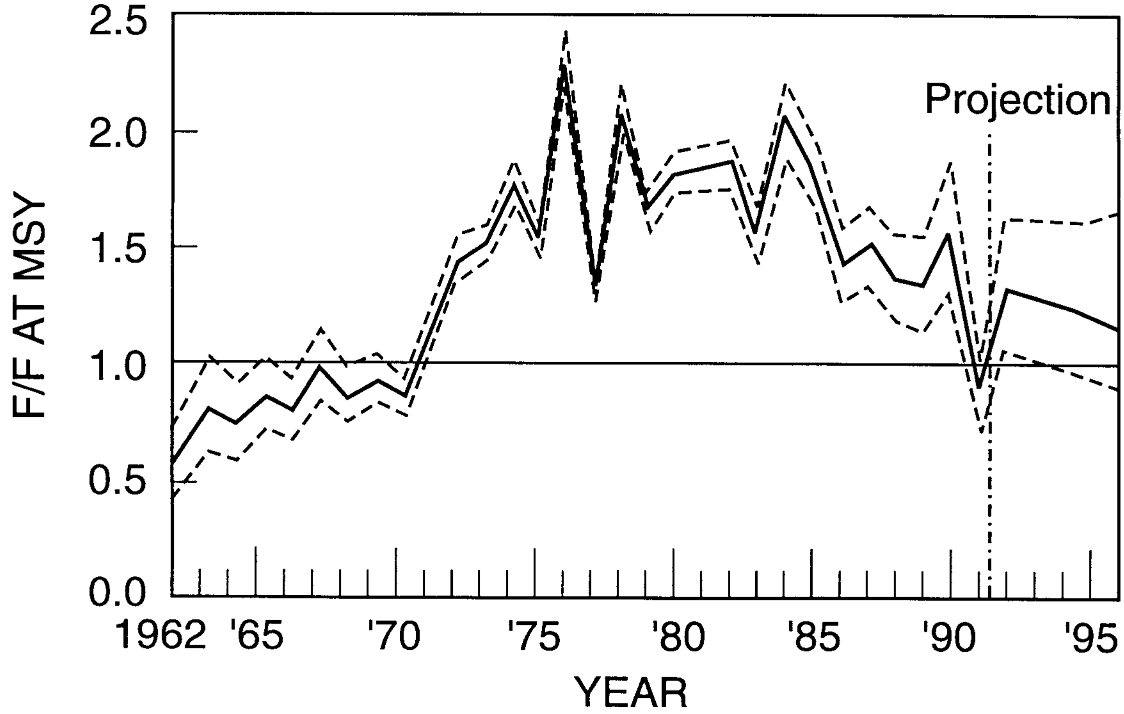

FIGURE 5

III-5 THE EASTERN PACIFIC YELLOWFIN TUNA FISHERY 1989

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1. INTRODUCTION

The world's most productive surface fishery for yellowfin tuna is pursued in the eastern tropical Pacific (ETP). According to FAO (1987) the western Indian Ocean, western Pacific, eastern Pacific, and eastern Atlantic produced yellowfin catches (by all gear) of 90, 174, 248, and 100 thousand metric tons (mt) respectively in 1985. In the ETP, the primarily surface catch east of 150° W in 1986 was 269,000 mt, the largest in history by far; the 1987 catch was even larger, 301,000 mt. Though yellowfin catches from the western tropical Pacific have recently grown rapidly (and actually surpassed ETP catches during 1980 to 1984), those tuna fisheries differ in being more diverse with respect to the production and utilization of catch: perhaps over half of western Pacific yellowfin is taken by longline and other than conventional, purse seine gear, and much is destined for the fresh fish market (especially Philippine and Japanese production) [see Chapter III-3, Ed.]. The ETP fishery yield, in contrast, is dominated by purse seine caught, surface-schooling yellowfin, and the catch is virtually all canned.

The ETP yellowfin fisheries have long been of great importance and interest to the United States. The fishery was developed by California fishermen, first using baitboats, then later purse seiners. The fleet, located in southern California, brought world leadership to the U. S. tuna industry and became the model for modern purse seine fleets of other nations.

Recent economic strictions from a variety of causes, however (see Herrick and Koplin,1986), have forced a restructuring of the American tuna industry. One new difficulty that U. S. fishermen faced came from requirements to reduce the incidental mortality of tuna-associated dolphins, an issue that focused considerable attention upon the ETP fishery. It is only in this fishery that yellowfin are regularly taken by the technique of fishing "on porpoise."

This chapter will review the ETP yellowfin fisheries for comparison with other tuna fisheries of interest to the United States. It will also touch on present concerns and the possible future status of the U. S. high seas tuna fishery, a fishery historically based in California.

2. DESCRIPTION OF THE FISHERY

2.1 History and development

The modern high seas fishery for yellowfin in the ETP is an outgrowth of the Japanese style, live bait tuna fishing pioneered in the early 1900's by fishermen mostly from San Diego's Japanese, Italian, and especially Portuguese communities (Godsil, 1938). Albacore at first, then later the more dependable tropical tunas, were chummed using anchovy and especially sardine bait, and caught with bamboo poles equipped with lures or barbless hooks. Later as the fishery expanded southward of lower Baja California, Mexico, warm-water anchoveta became the main baitfish. The yellowfin tuna was always preferred over skipjack; it kept better and was more valuable for canning.

By 1935 there were at least 70 baitboats in the fishery, and they took nearly 40,000 mt of tuna. These early vessels were small by current standards, but soon the fleet came to be characterized by larger baitboats, the "tuna clippers" that averaged 35 m in length. They fished all along the Middle American coasts up to 1500 km offshore and to south of the Galapagos Islands - a true American distant water fleet.

World War II brought increased demand for tuna, a diversion of many clippers to naval service, and effectively an end to the era of Japanese-descent fishermen in the fleet. Thenceforth, tuna fishing would be a particularly Portuguese-American enterprise.

By 1950 there were 204 baitboats in the fleet. They caught 160,000 mt of tuna of which about 60% was yellowfin (Shimada and Schaefer, 1956). By then there were also a considerable number of small purse seiners in the fishery.

Purse seining for tuna had begun in San Pedro, also soon after the turn of the century. The fishermen were mostly of Yugoslavian descent, and they seasonally seined tuna, especially bluefin, in local waters. The fleet gradually expanded to the south to include catching yellowfin and skipjack, but was infrequently active south of the tip of Baja California. Though the seiners seldom took more than 20% of the total tropical tuna catch, by the 1950's increased demand for tuna coupled with growing problems of baitfish supply - including access to the baitfish resources in coastal waters - and competition from Japanese tuna imports had focused industry interest onto purse seining.

Purse seining was not without its difficulties. The cotton nets deteriorated rapidly under tropical conditions, and handling of the bulky nets was arduous. When these problems were overcome by the development of nylon monofilament nets and, especially, the power block for quickly lifting large seines, there was a massive shift to purse seining (McNeely, 1961).

Following several successful trials with the new gear, some 75 clippers were converted into seiners in the three years 1959 through 1961, doubling the number of seiners in the fleet. During the 1960's an additional 38 seiners were added; their carrying capacity, about 600 mt each, was more than twice that of the converted baitboat clippers (Green et al., 1971). Table 1 summarizes how fleet carrying capacity came to be dominated by purse seiners.

The new purse seine fleet greatly expanded the geographic extent of yellowfin tuna fishing. Freed from restrictions imposed by baitcatching and baitboat fishing, yellowfin were now pursued throughout the ETP, as far west as 140^{o} W off Central America and by a host of nations (see Figure. 1). By 1965 there were 147 seiners in the fishery. Together with the remaining baitboats, 160,000 mt of tuna were caught that year, half of which was yellowfin.

Although other fishing nations were also expanding their fleets, U. S. purse seiners continued to dominate this fishery. In 1975 a fifteen nation fleet of 335 vessels , 67% of which were seiners, took 204,000 mt of yellowfin from the eastern Pacific. Seventy percent of this was caught by U. S. fishermen whose vessels represented 73% of the fleet carrying capacity (Orange and Calkins, 1981). The next largest catch was by Mexico, which took 7% of the harvest. The fishery continued to grow for the rest of the decade - until the particular economic forces of the late 1970's and the 1980's began shifting the advantage away from the U. S. tuna industry.

By 1980 the U. S. fleet's competitive edge was clearly waning. The then 17 nation tuna fleet had reached 172,000 mt carrying capacity, a tonnage greater than the estimated sustainable yield. Of this capacity 98% represented purse seiners, many greater than 1000 mt each. These "superseiners" exemplified the intense physical and economic scramble for the yellowfin quota (see below). The U. S. then accounted for a reduced 57% of this seiner capacity, while Mexico's contribution had risen to 19%. The ETP yellowfin catch, down somewhat from the peak landings of the mid-1970's, was 160,000 mt, 65% taken by the U. S. and 12% by the fast-growing Mexican fleet.

One should note that expansion of the yellowfin fishery, especially to far offshore waters, was made possible not only by the technology of modern purse seining, but by development of the technique of fishing "on porpoise." Fishermen became proficient at catching (and releasing) certain oceanic dolphins, primarily the spotted and spinner species, to take the yellowfin that swim with them. The resulting incidental kill of dolphins led to difficulties with environmentalists after 1972, when the U. S. Marine Mammal Protection Act was passed.

Yellowfin in the eastern Pacific are also caught by longline gear which takes larger, deep swimming tunas. This is primarily a Japanese fishery. In the eastern Pacific there is rather little geographic overlap of longline fishing with surface fishing (Miyabe and Bayliff, 1987); moreover, that longline fishery takes only about 7% of the annual yellowfin catch (IATTC, 1987).

2.2 Total and U. S. yellowfin tuna production

Following irregular catches averaging about 75,000 mt in the 1950's, yellowfin catches climbed rapidly during the 1960's and through the mid-1970's as more, larger, and farther ranging purse seiners increased fleet productivity. Production appeared to have reached its limit after the 1976 peak catch of 192,000 mt (taken in the CYRA, the Commission Regulatory Area, a management regime established in 1966; see Figures 1 and 2). A period of declining catches followed. By then purse seiners had been exploiting surface-schooling yellowfin throughout the eastern Pacific, and there were no new, contiguous fishing areas to be found.

The decline continued through the El Niño year of 1983 when only 83,000 mt were caught and half the U. S. seiner fleet went to the western Pacific in search of better fishing. But catches have rebounded since to unanticipated, record levels.

Table 2 shows that until after 1982, U. S. fishermen took the major share of the CYRA catch by far. Notice, however, that Mexico's share had been gaining steadily, and it surpassed that of the U. S. in 1984. Though Mexican catches have since been similar to that of the U. S., Mexico is certainly the new leader in the ETP yellowfin fishery. Not only have many U. S. seiners been withdrawn, but an increasing number have diverted to the western Pacific fishing grounds in search of more reliable fishing and ex-vessel markets. The Mexican fleet, meanwhile, has continued to grow under government auspices.

3. THE MANAGEMENT REGIME

3.1 IATTC and yellowfin conservation

In 1949 the United States signed a convention with Costa Rica to collect information and to conduct studies that would facilitate maintenance of eastern Pacific tropical tunas and baitfishes at levels producing maximum sustainable yields (MSY). This was the beginning of the Inter-American Tropical Tuna Commission (IATTC). Panama and Ecuador became signatories soon afterwards, and Mexico joined in 1964. Though initial IATTC studies focused on baitfish biology in response to the collapse in 1947 of the very important anchoveta stock in Costa Rica's Gulf of Nicoya, the yellowfin fishery was thought to be under sufficient pressure from the growing international fleet to also bear careful monitoring. The specter of overfishing moved closer after 1960 when baitboats were rapidly converted to purse seiners (while problems concerning tuna baitfish increasingly lost importance). In 1962 the IATTC concluded that the eastern Pacific yellowfin stock had been fished to a population level below that which would produce MSY - estimated to be between 79,000 and 86,000 mt. The catch that year was about 78,000 mt, a large drop from the previous year's 109,000 mt. A catch quota of 75,530 mt was recommended.

This quota, revised to 72,160 mt to allow for stock rebuilding and to account for increased fishing efficiency of the seiners, was finally adopted in 1966. The IATTC has recommended a yellowfin quota every year since (except 1987). These quotas were not implemented after 1979 (see below).

Regulations to implement the quota required that fishing in the CYRA be closed for vessels leaving port after the date when it is estimated that the quota, less by an allowance for incidental catches, should be attained by already landed plus expected catches of yellowfin. During this "closed period," vessels leaving port were to be regulated in that the take of yellowfin in the CYRA be restricted to no more than 15% by weight of the tuna catch (all species) on any trip. In practice, the tuna regulations were modified to accommodate needs of the developing fisheries of coastal states. The first modification (1969) gave special allocations during the regulated or closed season to vessels of not more than 270 mt capacity. Later, larger vessels of developing coastal countries were given special allocations. The complex, actual regulations have been summarized by Peterson and Bayliff (1985).

Special allocations have ranged from the standard 15% allowance for incidentally caught yellowfin during the closed season to effectively no catch restrictions at all. Also vessels that completed a trip before closure and then left port again within 30 days after the closure date were granted (since 1971) another "free trip" of unrestricted fishing. Additionally, certain "experimental fishing" areas were opened within the CYRA for fishing after closure (since 1973). These various adjustments to the quota complicated management of course. Additionally, the increasing fleet capacity both exacerbated competition and made setting of the closure date, so as to effect the quota, increasingly error prone. Increased capacity also brought an earlier closure date each year, and with that, an increase in the fraction of the year's catch taken after closure.

As the fishery expanded, however, catches appeared not to be limited when they surpassed the estimated MSY level; the IATTC therefore began in 1973 an experiment in deliberate overfishing, designed to empirically define MSY. Accordingly, the 1973 quota was set at 118,000 mt, with provisions for catch incrementation if so doing would not likely endanger the stock. The next year the quota was raised to 159,000 mt where it remained until 1979. But after 1977 the fishery appeared to be operating on the right hand limb of the yield-fishing effort curve, and a declining trend in catches began. Various reduced quota levels were thereafter recommended; however their implementation became increasingly more difficult.

To many Latin American countries, the quota system was biased toward U. S. interests, and thwarted their own economic aspirations. Each year it was the U.S. vessels that took most of the annual quota and effectively determined the time of closure of unregulated fishing within the CYRA. Disagreements over policy and national quota allocations led to a system of complex, accomodating, special allocations (see above), a weakening of IATTC management effectiveness during the 1970's, and non- implementation of quotas during the 1980's.

Mexico led the way toward securing a greater share of the yellowfin resource for the Latin American nations. In 1976 she declared a 200-mile Exclusive Economic Zone (EEZ), claiming sovereign rights over tuna within the zone according to Article 56, U. N. Convention on the Law of the Sea (UNCLOS) (details of these developments are described by Barrett (1980)). In 1977 Mexico initiated, with Costa Rica, a plan for a new management regime in which coastal states were to be granted

69% of the annual quota, based upon historical catches by the international fleet within the EEZ's. The U. S. counter-claimed that tuna were "highly migratory," belonging to no one nation, and that the coastal states' share of the resourse should be 45%, based upon the density distribution of the resourse. With agreements upon national allocations of annual quotas already difficult, resourse sharing according to the Mexico-Costa Rica plan could not be resolved. In 1978 Mexico, with a plan to increase its fleet by 104 vessels, withdrew from the IATTC; Costa Rica followed the next year. No agreement could be reached in 1980 upon a conservation regime, and the quota recommended by IATTC was not implemented. Non-implementation of recommended quotas continued through 1986. No quota was recommended in 1987 as the stock was thought to be large enough to support the expected catches. By then Mexico had 38% to the U. S.'s 29% of the ETP fleet capacity.

Meanwhile, U. S. vessels continued to fish in Mexico's 200 mile EEZ without Mexican approval. Several were arrested, and there followed a retaliatory U. S. embargo on Mexican tuna imports from 1980 to 1986. [The earlier "tuna wars" with Peru, Ecuador, and Chile, in which U. S. boats were frequently seized, date from 1947 when those nations declared 200 mile maritime zones.]

3.2 Yellowfin and marine mammal protection

It is a goal of the U. S. Marine Mammal Protection Act (MMPA) of 1972 that the incidental kill and serious injury rate of dolphins in the yellowfin fishery be reduced to negligible levels. Under the Act, incidental "taking" of dolphins by U. S. fishermen is allowed only by permit, and with adherence to regulations such that the take is not disadvantageous to a species stock or contributory to reducing its population level below that giving "optimum sustainable yield," i.e. to "depleted" status.

Since passage of the MMPA, a series of legal and management rulings have established that dolphin stocks affected by the yellowfin fishery be assessed and quotas on dolphin kill be implemented as necessary. Both the IATTC and the National Marine Fisheries Service (NMFS) conduct these studies. The first general permit for yellowfin fishing with regulations on dolphin "take" was issued in 1977 by NMFS, and required a series of decreasing annual, individual stock, kill quotas. The regulations were amended in 1980 and allowed a maximum kill quota of 20,500 dolphins each year, 1981 to 1985, apportioned among the affected species stocks. No quota was allowed for the eastern spinner dolphin as it was considered depleted. The general permit was extended in 1984, continuing the 20,500 kill quota, but allowing a limited kill of eastern spinners. Proceedings for reauthorization of the MMPA, underway in 1988, involved renewed considerations upon the rising dolphin kill by non-U. S. fishermen.

4. PRESENT STATUS OF ETP YELLOWFIN TUNA

Studies of the catch-fishing effort relationship ("production modeling") by the IATTC (see recent IATTC Annual Reports) indicate that average maximum sustainable yield (AMSY) is about 160,000 mt within the CYRA and that the present level of fishing effort is near optimal (by its Convention, the IATTC's objective is management to obtain AMSY). The above estimate of AMSY appears reasonable and is approximated by various versions of the production model. It is unclear, however, as to which version should be correct. Present catches are much above estimated AMSY (254,000 mt in 1987) apparently due to events that have combined to produce a very large stock biomass.

Biomass estimates of CYRA yellowfin have been derived by "cohort analysis," a synthetic procedure that calculates for each year class of fish the biomasses needed to produce the observed annual catches, accounting also for natural mortality. These studies show a biomass decline (temporarily interupted by the strong 1974 year class) from about 310,000 mt during 1968-1971 (when the fishery was first fully expanded geographically) down to about 205,000 mt in 1981, a 34% decline corresponding to the continued, rapid expansion of the fishery. The biomass was at its lowest during 1980 to 1982, but the following 1982-1984 period was one of much reduced fishing effort (poor fishing associated with the 1982-1983 El Niño forced many U. S. seiners to the western Pacific and many have continued to fish there). This reduced fishing effort, plus succeeding good recruitment during 1983-1986, has apparently allowed the stock biomass to increase rapidly between 1983 and 1986. Record catches were taken in 1986 and 1987. These estimates of biomass change constitute a synthesis of stock structure dynamics, useful for estimating exploitation rate, for predictions, and to explain past catches (bearing in mind that the biomass estimates are themselves derived from those catches).

As noted, catch-effort relationships for ETP yellowfin indicate that present levels of fishing are near optimal. It would appear that CYRA catches, under present patterns of fishing, should decrease toward 160,000 mt (AMSY) during the next several years as the stock biomass decreases from fishing (see Figure 3). The biomass in 1986 appeared to be at least as large as the biomasses of the early 1970's, as indicated by cohort and catch-per-unit effort analyses; however since 1986 the stock biomass has likely been decreasing due to the large catches.

5. OUTLOOK

5.1 The Resource

The ETP will continue to be a major supplier of yellowfin to U. S. industry, though the U. S.'s share of the catch will diminish. The importance of the ETP lies in its productivity of yellowfin relative to an increasing world demand for canned tuna (of which the U. S. consumes about half). Its surface yellowfin resourse is the largest in the Pacific, and this resourse is exploited over an area the largest sections of which are outside the EEZ's of coastal nations - an important factor to distant water fleets.

In the years ahead total fishing effort in the ETP will likely increase. Sustainable yields may even prove to be larger than previously estimated. Improved technology and techniques may increase the availability of yellowfin to fishing gear, and fishing effort will likely be expanded into areas, both inside and outside the CYRA, in which exploitation had previously been mainly seasonal. This expansion will be facilitated by the absence of a management regime, although there will be constraints arising from concerns about dolphin mortality.

Without management the ETP yellowfin resourse can be expected to eventually become overexploited as the biomass is reduced to levels that cannot produce AMSY. However this condition may not develop rapidly; the pressure on yellowfin could be mitigated if the fleet redirects its effort onto skipjack tuna because of decline in yellowfin catch rates and average size or because of increases in skipjack availability or price. The possibility of overfishing is real, nevertheless, even though current large catches and high stock biomasses have temporarily deferred this concern. When catches do sufficiently decline, quotas - recommended by the IATTC or similar such body - will again be attractive. However a new system of quota allocation will likely have evolved; coastal states of the ETP will have greater claim to the fishery resources within their EEZs, limiting the U. S. vessels from fishing unrestrictedly for the quota under the first come - first served mode of the past.

5.2 Management

Recent attempts to form new and viable conservation agreements have all but failed, although the plans are not without promise: the U. S.

backed Eastern Pacific Ocean Tuna Fishing Initiatiave (1983) would have open access to the resource and licensing of vessels, with proceeds from the licenses to be distributed to the coastal nations; the Mexican led Latin American Regional Tuna Organization (1985) would guarantee quotas to coastal nations based upon the "concentration" of the resource in the respective EEZs, with individual countries licensing vessels in their EEZs. While these proposals each expressed disparate views, they do implicitly recognize the migratory nature of tunas, the special rights of coastal nations, the need for vessels to have access to the resource, and the economic problems that result from excess harvesting capacity (Greenough and Joseph, 1986). An acceptable management regime will eventually unfold.

Even so, the future fishery could evolve to a condition of area-wise, differential exploitation of the resource by different fleets. There could be a coastal vs. high seas exploitation pattern, the coastal states maintaining an advantage when fishing within their EEZs while the distant water fleets emphasize fishing in the waters beyond. This could result in area specific differences in exploitation rate and pattern of fishing that would affect age segments of the stock differently as they mature, depending upon how the fish move between areas. This in turn could lead to complex considerations on how best to obtain AMSY, and probably to less reliance on the overall fishing yield curve in management. Differential, as opposed to equal access, exploitation could bring disputes as to which fleet is culpable for overfishing, and upon which should specific conservation measures be imposed. IATTC studies have already shown that a fishing pattern which more heavily exploits older fish, found more frequently in the far offshore waters that are fished to a greater degree by distant water fleets, could give a 24% increase in yield from the yellowfin stock (i.e. increased "yield per recruit"). This may explain, in part, the increased catches in recent years.

The concern for the well being of dolphin stocks will also affect management of yellowfin. Dolphin-kill allowance quotas, if made too restrictive because of findings that dolphin stocks are low or depleted, could hamper fishermen. But such kill restrictions could also be advantageous to U. S. fishermen if they can maintain a low kill rate; foreign tuna caught from the same fishery but not taken with comparable standards of dolphin mortality can be prevented from entering the United States. A longer range concern relative to dolphins and rational tuna management may be a growing sentiment in western nations toward protectionism (rather than conservation) of cetaceans.

Both the IATTC and the U. S.'s NMFS have responsibilities concerning the tuna fishery-affected dolphin stocks, but their goals are not entirely compatible. The U. S.'s charter is to keep dolphin stocks at or above "optimum sustainable population" (OSP) levels, and to reduce the kill or serious injury rate toward zero; the IATTC's charge is to maintain a high level of tuna production, to assure the survival of dolphin stocks, and to avoid their needless killing. The biological inconsistencies are apparent. There is clearly a need to better understand what OSP means in terms of the biology of the tuna-dolphin interaction and in terms of AMSY for the exploited yellowfin resourse.

5.3 The U. S. fleet

The 1980's saw the rise of a global, international economy that featured a sustained drop in the prices for food and other raw materials and an uncoupling of manufacturing production from manufacturing labor (Druker, 1987). In the U. S. tuna industry, processors have divested themselves of supporting tuna vessels and concentrated canning operations overseas in American Samoa and Puerto Rico. Only one U. S. mainland cannery, Pan Pacific in California, presently survives. Increasingly, U. S. fishermen compete directly or indirectly with foriegn fishing fleets on the fishing grounds and in marketing their catch; the processing companies in turn compete on the wholesale market for raw supplies and sale of their products (see King, 1987).

The new fishing regime of restricted access to EEZ's and international competition on the raw tuna market requires that surviving U. S. vessels be efficient, mobile, and adaptable. Fleet adjustments between 1975 and 1985 resulted in a 34% decline in U. S. carrying capacity. More innovative adjustments and restructuring arrangements can be expected. The present fleet divides its fishing effort nearly equally between the eastern Pacific (fishing mainly yellowfin) and the western Pacific (fishing mainly skipjack). Resource availability and markets are the driving forces. For now, these pan-Pacific operations serve to maintain a modern, profitable U. S. tuna fleet.

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Peterson, C. L., and W. H. Bayliff. 1985. **Organization, functions, and achievements of the Inter-American Tropical Tuna Commission.** Inter-Amer. Trop. Tuna Comm. Spec. Sci. Rep. No. 5. 56 p.

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7. LIST OF FIGURES

Table 1. CHANGES IN THE ETP TUNA FLEET CARRYING CAPACITY, 1955 - 1985[1]

Fleet	1955	1960	1965	1970	1975	1980	1985
Total Number	263	237	248	266	325	305	198
Total Carrying Capacity ($x10^3$ mt)	45	36	42	66	154	172	118
Seiner Carrying Capacity (%)	17	58	89	92	96	98	98

[1]Sources: Peterson and Bayliff (1985); IATTC.

Table 2. PERCENT OF THE CYRA YELLOWFIN CATCH TAKEN BY EACH COUNTRY[1]

Country	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1987
					Catch ($x10^3$ mt)						
Combined	104	130	139	174	192	167	134	108	129	230	249
					Percent						
USA	87	82	79	68	70	57	61	60	39	28	35
Mexico	4	5	6	9	7	11	14	17	40	41	35
Costa Rica	-	-	<5	<7	<9	3	2	-	2	<10	<8
Panama	-	3	2	4	6	6	4	<13	<2	<10	<8
Ecuador	4	5	2	5	3	4	5	5	9	8	8
Peru	-	<2	<5	1	1	1	-	-	-	<10	0
Japan	<3	<2	3	-	-	-	-	-	-	-	-
Venezuela	-	-	-	-	<9	<10	<9	<13	8	13	14
Others	<2	<5	<8	<7	12	17	15	17	10	<10	<8

[1]A dash indicates <1%.

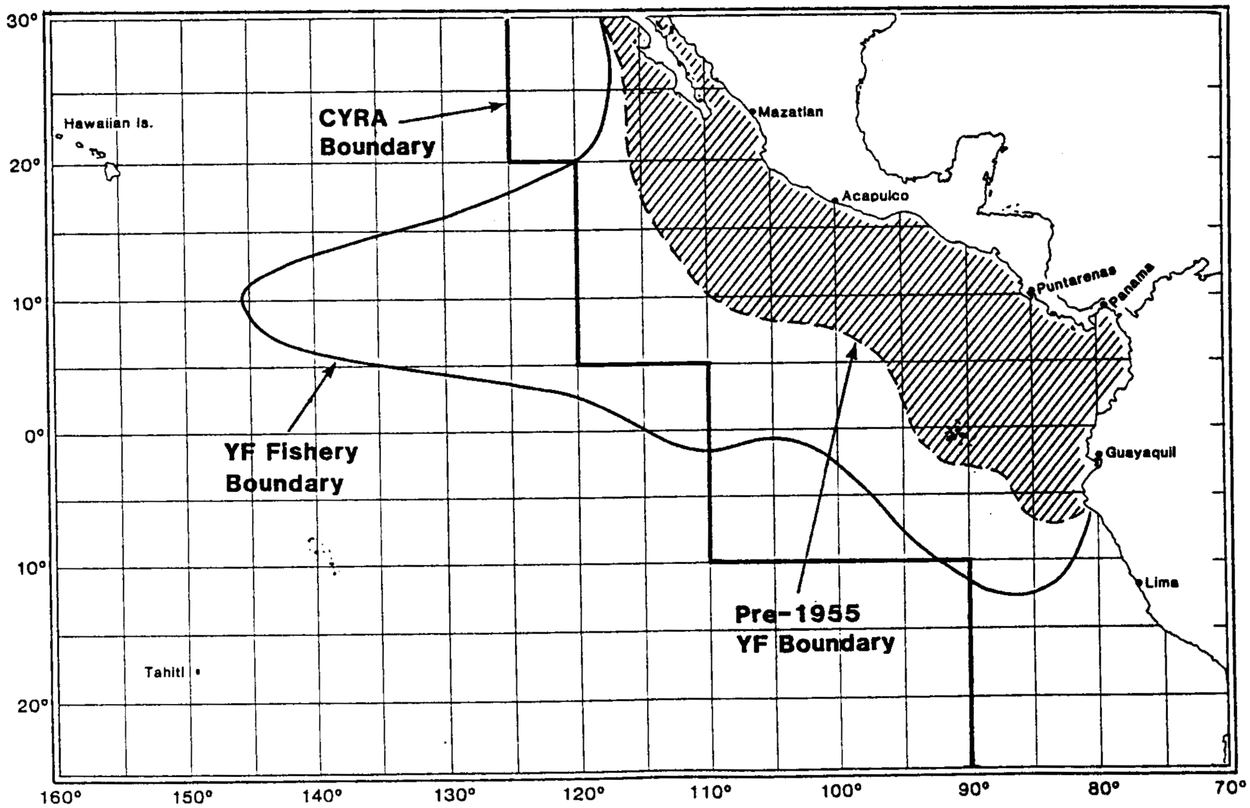
30°
20°
10°
0°
10°
20°
160°
150°
140°
130°
120°
110°
100°
90°
80°
70°
Hawaiian Is.
Tahiti
CYRA Boundary
YF Fishery Boundary
Pre-1955 YF Boundary
Mazatlan
Acapulco
Puntarenas
Panama
Guayaquil
Lima

FIGURE 1

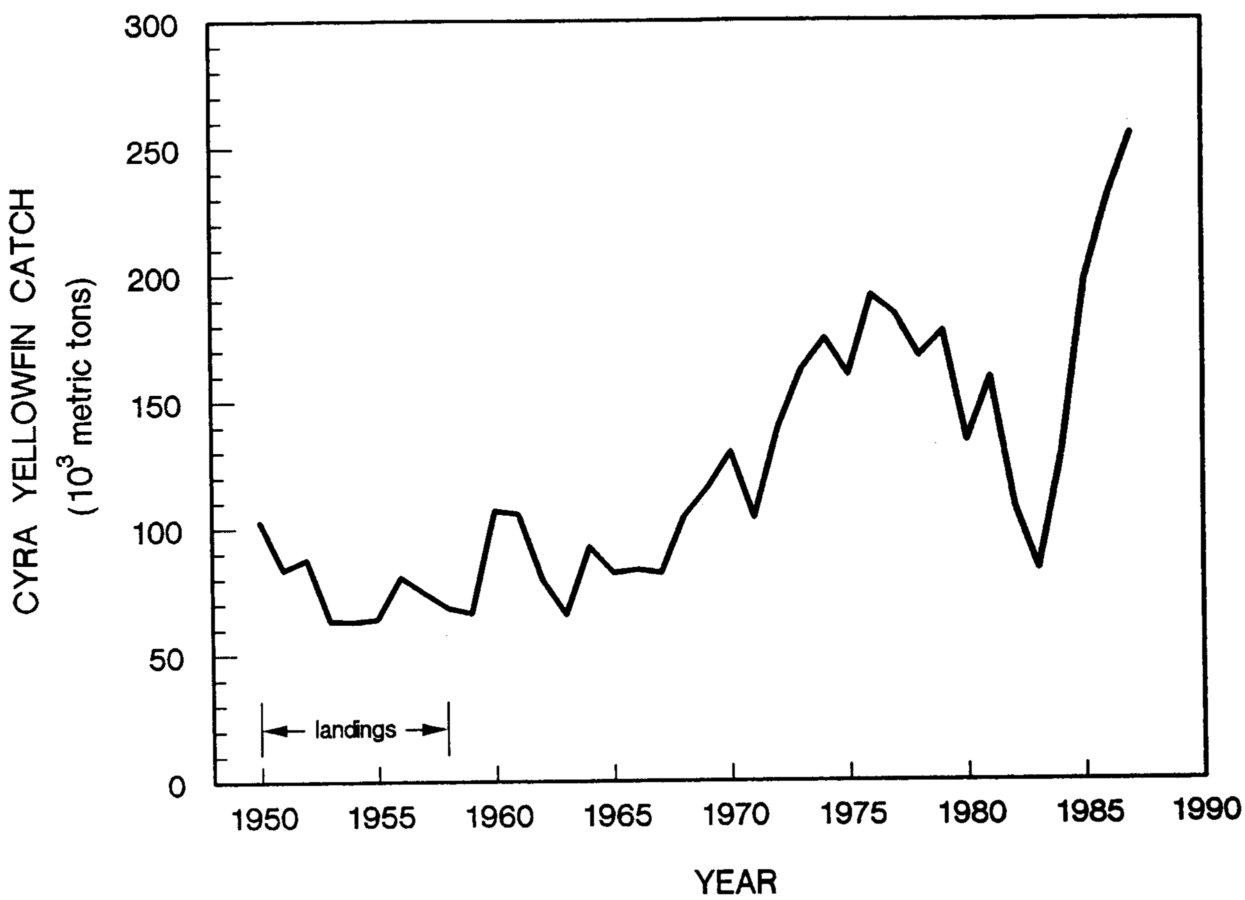
300
250
200
150
100
50
0
CYRA YELLOWFIN CATCH
(10^3 metric tons)
landings
1950
1955
1960
1965
1970
1975
1980
1985
1990
YEAR

FIGURE 2

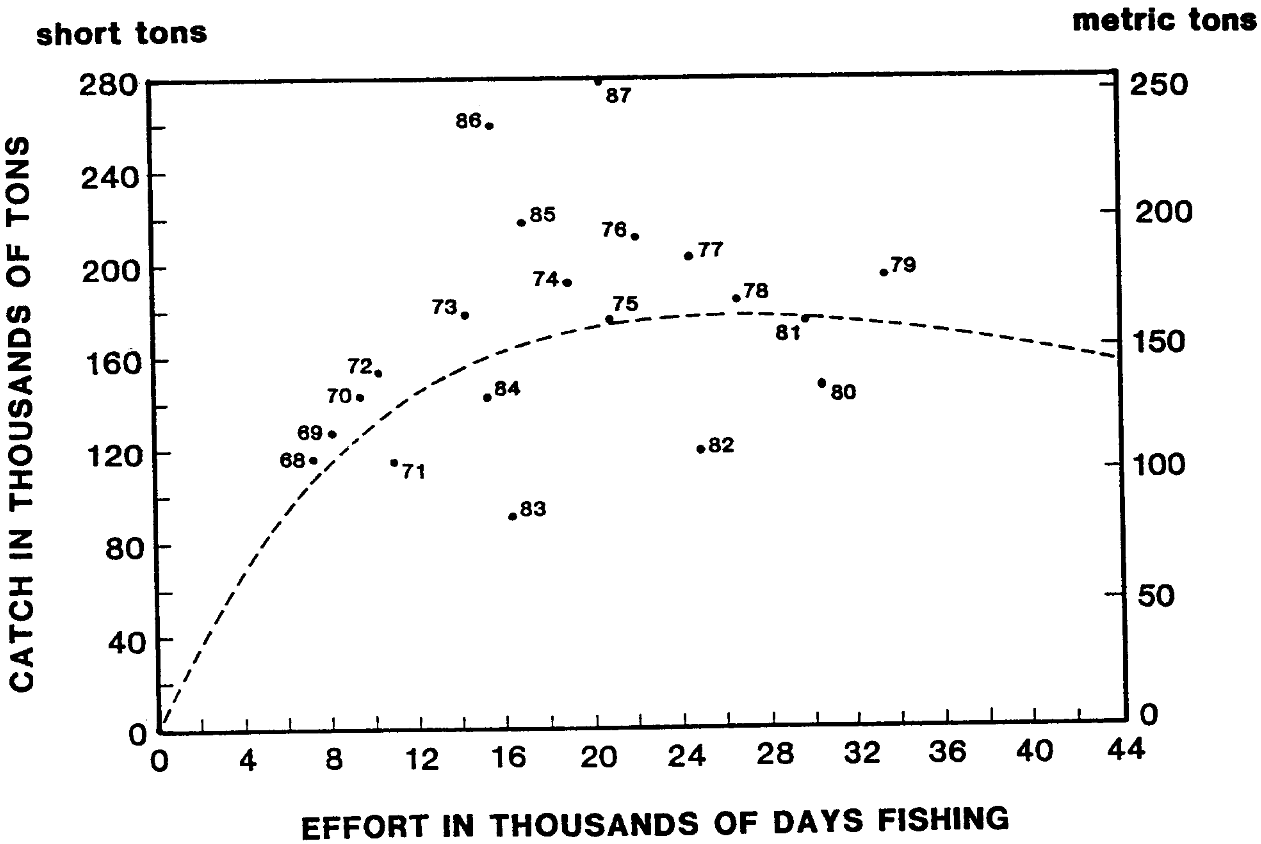

FIGURE 3

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1. INTRODUCTION

The broadbill swordfish, *Xiphias gladius,* is a cosmopolitan species that occurs worldwide between about lat. 50° N and 50° S. It is found year-round in tropical waters and seasonally in temperate waters. Not much is known about the behavior of this animal except that it is a solitary animal, forming concentrations in certain locations, mainly associated with oceanographic fronts and eddies for feeding and, perhaps, mating. This species is highly desirable as a food-fish in the United States. The U.S. currently consumes in excess of 12,000 mt per year with the volume growing at 5-7% per year.

This report provides a brief description of the Pacific fisheries, and an evaluation of the condition of the Pacific stock of broadbill swordfish. The reader should consult the following for additional information: Palko, Beardsley and Richards (1981), and Nakamura (1985) for biological information; Ueyanagi (1974) and Sakagawa (1989) for fisheries information; and Sakagawa and Bell (1980), and Bartoo and Coan (1989) for condition of stocks.

2. DESCRIPTION OF FISHERIES

Swordfish can attain a large size, maximum of about 540 kg, and is prized as both a food fish and a game fish. As a game fish, it is taken principally with rod-and-reel, but is difficult to catch. Only the most dedicated anglers pursue the sport and catch only a few hundred swordfish each year.

In the Pacific Ocean, there are only a few locations where angling for swordfish takes place. The best known location is off California, from San Diego in the south to Santa Barbara in the north (PFMC, 1981). The rod-and-reel fishery there started in the late 1890's. The fishing season is typically from May through December, although most of the catch is landed in July, August and September. About 30 fish per year are caught. The largest catch was 130 fish in 1978.

Fishing is during the day with lures and live bait. Night fishing with bait and light sticks, such as is done in the sport fishery off the U.S. Atlantic coast, has not been adopted in the Pacific fishery.

In contrast, commercial fishing for swordfish is more wide- spread. Thousands of fishermen using various gears are involved in this industry. The worldwide catch is over 50,000 mt annually with the Pacific Ocean contributing about 37%.

Japanese fisheries produced 70% (14,300 mt) of the 1986 Pacific catch, followed by the U.S. and Philippine fisheries with 10% (2,100 mt) each, Taiwanese fisheries with 4% (700 mt), and others with 6% (1,100 mt). This production was largely from highseas fisheries that target tunas. Swordfish is a bycatch, although an important one because it commands a high price. A smaller part (31%) of the production comes from coastal fisheries, some targeting swordfish.

2.1 Highseas Fisheries

Swordfish is taken on the highseas mainly with longline gear by vessels registered in Japan, Korea and Taiwan. Tunas are the target species for these vessels, and swordfish, along with other large pelagic species, are caught incidentally. The swordfish catch during 1972-86 fluctuated between 9,000 mt and 16,000 mt (Figure 1), averaging 12,400 mt. Exceptionally large catches are recorded from specific areas of the Pacific (Figure 2), such as off southeastern Australia and northern New Zealand, along the edge of the Kuroshiro and Kuroshiro Extension Currents, off Mexico, and along the edge of the Peru Current (Figure 3) where oceanographic fronts concentrate food organisms.

In the late 1950's and early 1960's, swordfish was one of the target species of the Japanese highseas longline fleet. The gear was fished during the night in areas such as the northwestern Pacific where swordfish are found in large concentrations. Large catches resulted, and a peak production of 24,000 mt for the Pacific Ocean was made in 1961 (Figure 1).

2.2 Coastal Fisheries

Coastal fisheries employ a variety of gears that catch swordfish both as an incidental species and as a target species. The most common gears are longline, handlines, harpoon, and gillnets. Longlining by coastal vessels is common off Japan and Taiwan, where tunas are the primary target and swordfish is a bycatch. Handlines are used in the Philippines for catching large pelagic species including swordfish. Harpoons have traditionally been used in Japan, Taiwan and the U.S. for catching swordfish. However, only in the U.S. is this gear used to target exclusively swordfish--the others target principally the marlins. Drift gillnets are a more recent innovation for catching large pelagic species. They are being used by mainly Japan, Chile, and the U.S.

The catch of swordfish by coastal fisheries has been growing (Figure 1); increasing from an average of 3,100 mt during the 1970's to 6,100 mt during the 1980's. This growth is largely due to increased fishing with gillnets.

The U.S. drift gillnet fishery off southern California is among the top coastal fisheries producing swordfish. This fishery started in the late 1970's for sharks; principally common thresher, *Alopias vulpinus*, and swordfish. The season is restricted to mid-summer through January in an area south from Point Conception and north of the U.S.-Mexican border, and within about 81 km of the coast (Figure 4). Each season, about 200 vessels are licensed to participate. After a period of rapid expansion when the the catch increased from about 140 mt in 1980 to a peak of 3,100 mt in 1985, the fishery experienced a steady decline in catch (Figure 5). This decline is probably associated with restrictive regulations that have been imposed on the fishery in order to reduce incidental catches of marine mammals.

3. COMMERCIAL MARKETS

Swordfish is sold fresh or frozen as steaks, fillets and for raw consumption. Consumption of raw swordfish is primarily in Japan, where approximately 30% of the world supply is consumed. Steaks and fillets are popular products in the markets of western Europe, consuming 35% of the annual world supply, and the U.S., consuming 22%.

Approximately half of the U.S. annual supply of 12,000 mt of swordfish is produced by the domestic fleets and half is imported from foreign sources. Currently, imports are primarily from Canada, Chile, Ecuador, Spain and Taiwan. The U.S. market is growing at an estimated rate of 5-7% per annum (Lipton, 1986), and ex-vessel prices are firm, averaging $6.95/kg in 1986.

Levels of methyl-mercury residue in swordfish imported into the U.S. are strictly monitored for health safety purposes. The current permissible level is a maximum of 1.0 ppm. Because swordfish, particularly large individuals, frequently exceed this maximum, this regulation has impeded the free flow of imports which once dominated the U.S. market and are attracted by the high prices.

4. CURRENT STATUS OF THE STOCK

The Pacific swordfish population is generally hypothesized to be either a single stock or possibly 3 stocks; one each in the northwest, southwest and east Pacific (Sakagawa and Bell, 1980; Shomura, 1980). Current assessments are based on catch-per-unit-effort (CPUE) trends, primarily of the Japanese longline fishery (Bartoo and Coan, in press; Sakagawa and Bell, 1980).

When considered as a single Pacific-wide stock, the CPUE in areas where swordfish was a target shows a slowly increasing trend through the early 1960's, decreasing about 1/3 and remaining about level since. The drop in CPUE coincides with a change in night-to-day fishing for tunas, which reduced fishing efficiency for swordfish (Suzuki and Warashina, 1977; Sakagawa, Bartoo, and Coan, 1988). The CPUE in areas where swordfish are an incidental catch (the majority of the longline fishing areas) has shown a long-term, slow increase since the early 1960's and without the abrupt change noted in the target areas. This pattern is essentially the same for the three stock hypothesis.

Available data from the Japanese longline fishery indicate that the stock(s) are not being heavily exploited. Sketchy data from other Asian longline fleets as recent as 1985 support this assessment. This conclusion is believed to be conservative because the introduction of deep longlining for bigeye tuna (Suzuki and Warashima, 1977) in the late 1970's, made the longline gear less effective for swordfish. If longline data for the more recent years are corrected for effectiveness, CPUE would be higher and with an upward trend for swordfish. By assuming the trends in CPUE are representative of actual abundance, we conclude that the swordfish stocks in the Pacific can easily support the current level of exploitation and possible more.

5. TRENDS AND OUTLOOK

The world market for swordfish is strong and the supply from particularly the Atlantic and Mediterranean Sea is on the decline because of poor stock conditions. Prices should remain high for the immediate future. The demand can be met with increased catches from the Pacific stocks, which are currently lightly exploited.

The outlook for increased production from the coastal fisheries of the Pacific Ocean, such as the southern California fisheries, is not good. Production is likely to decreased or remain at current levels unless the fisheries expand and exploit additional segments of the stock outside the traditional fishing areas. This will be difficult to do because the fishable area where the coastal gears are effective is limited.

The longline fisheries of the Pacific Ocean, on the other hand, have the greatest potential for increased production. Longline fishing is currently directed principally for the high- valued tunas that are marketed for sashimi, so swordfish is a bycatch. This gear, however, can be directed at swordfish in strategic locations by fishing at night, and using gear modifications, such as light sticks. If this is done, the catch of swordfish from the Pacific Ocean should increase substantially.

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7. List of Figures

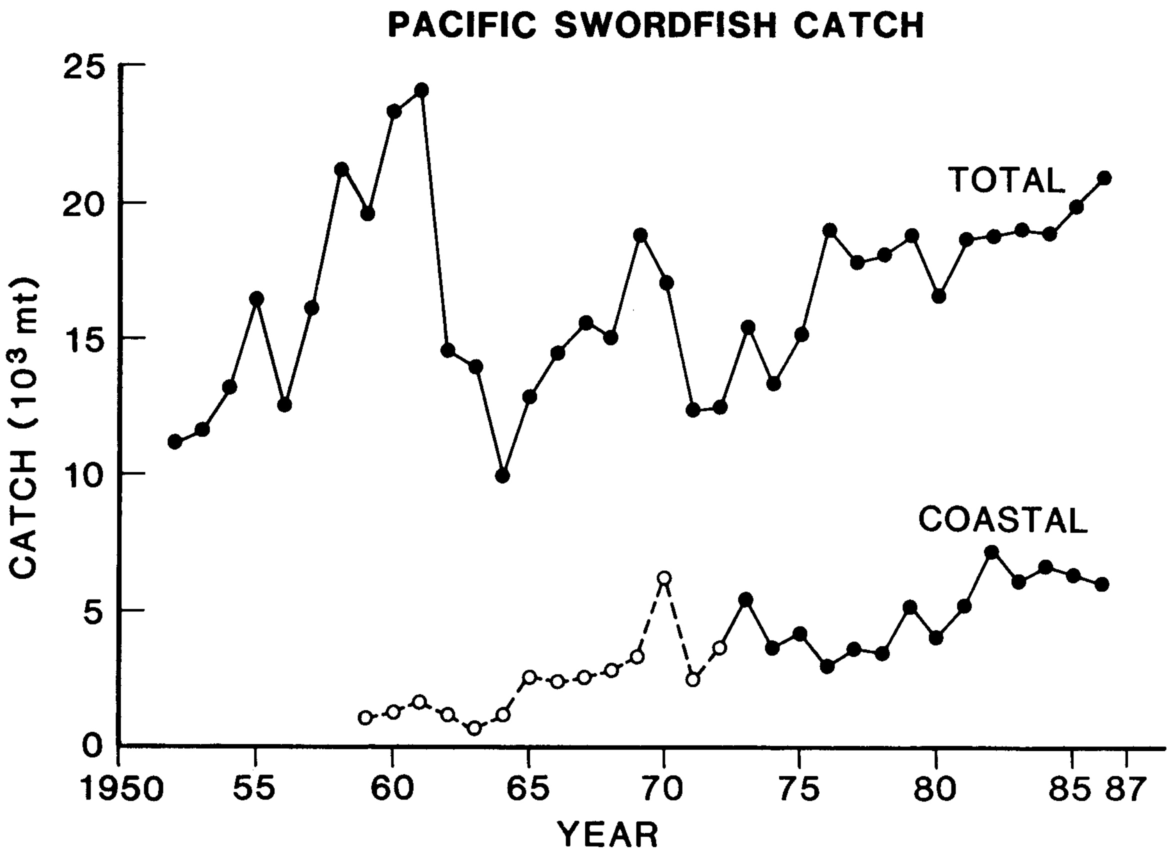
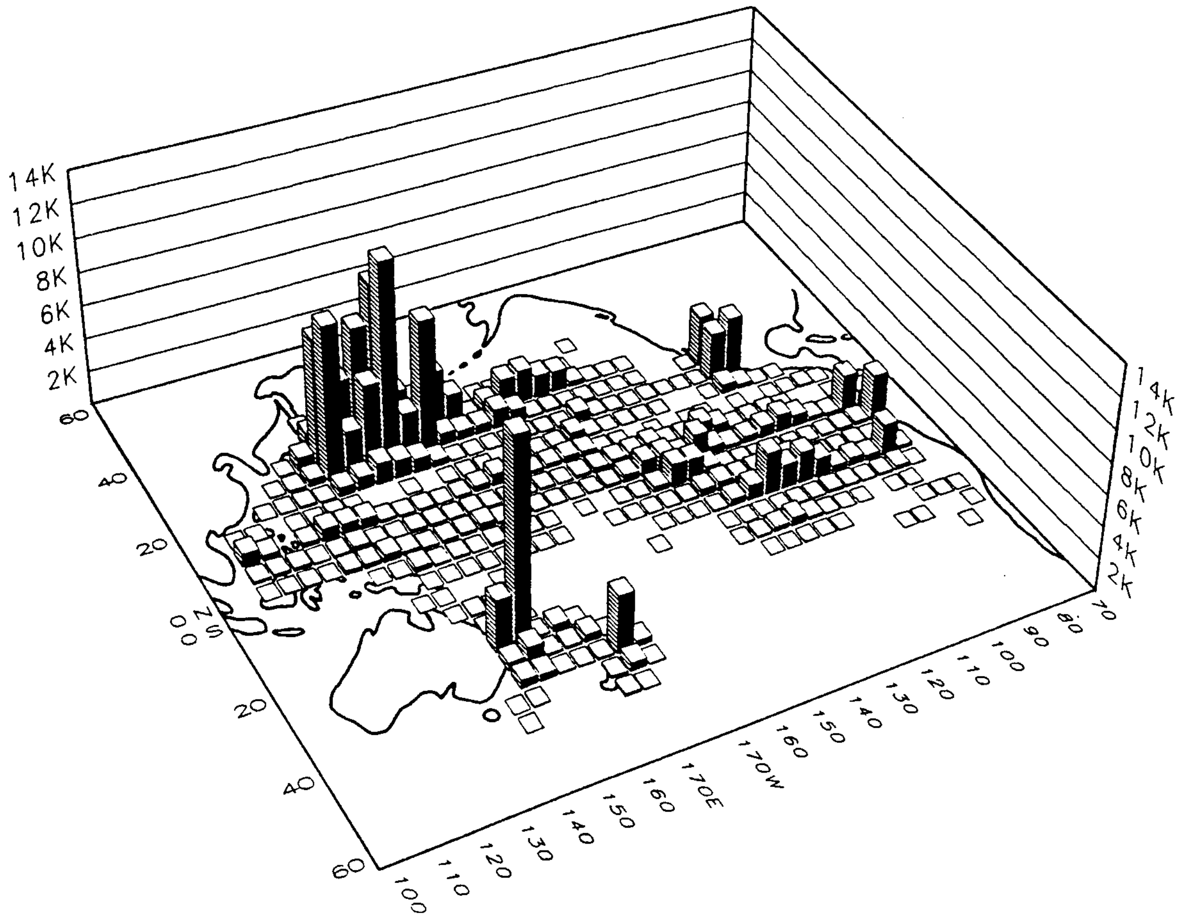

PACIFIC SWORDFISH CATCH
CATCH (10^3 mt)
25
20
15
10
5
0
1950
55
60
65
70
75
80
85 87
YEAR
TOTAL
COASTAL

FIGURE 1


14K
12K
10K
8K
6K
4K
2K
60
40
20
0 N
0 S
20
40
60
100
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120
130
140
150
160
170E
170W
160
150
140
130
120
110
100
90
80
70
14K
12K
10K
8K
6K
4K
2K

FIGURE 2

SWORDFISH FISHING AREAS

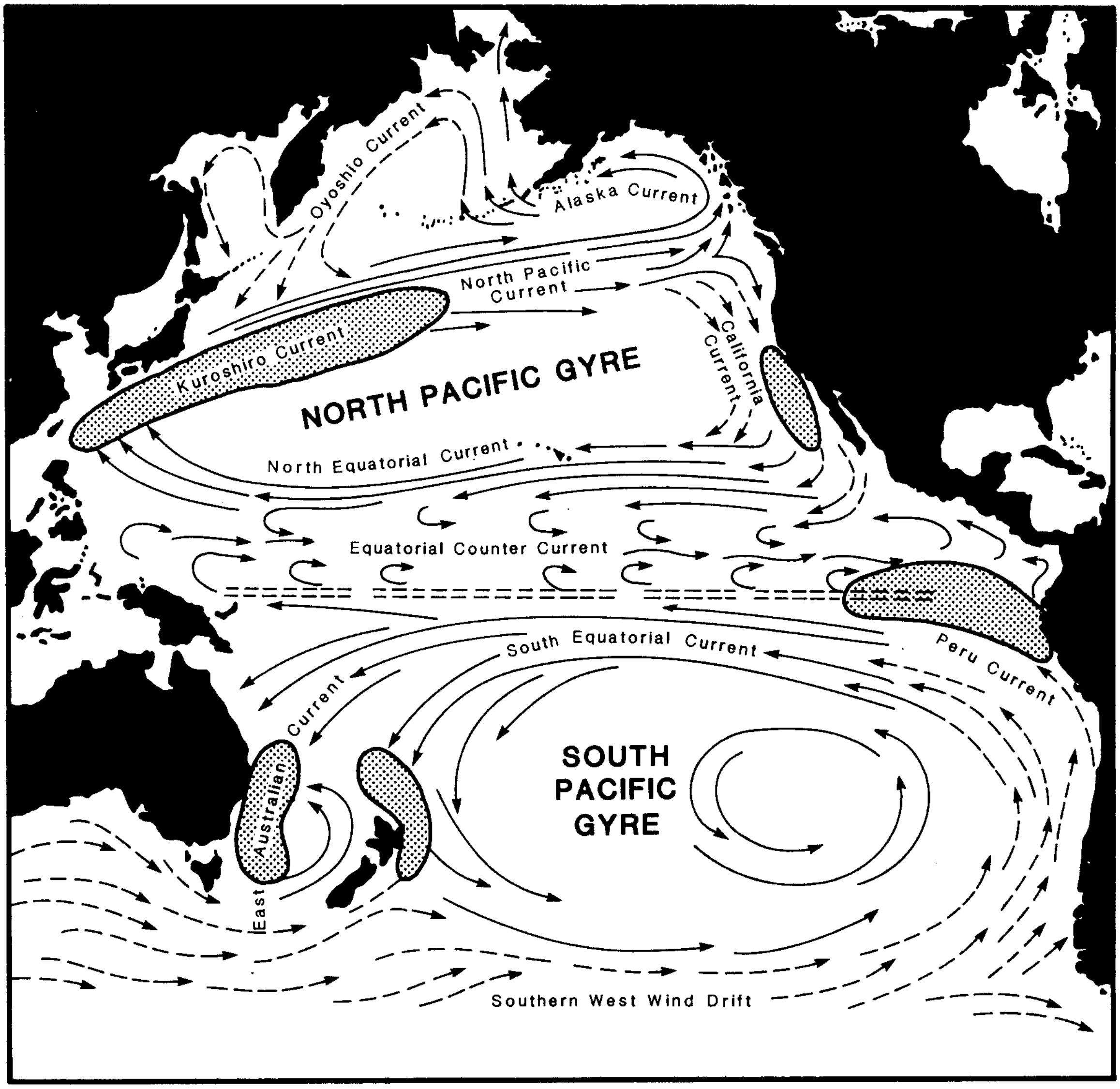

FIGURE 3

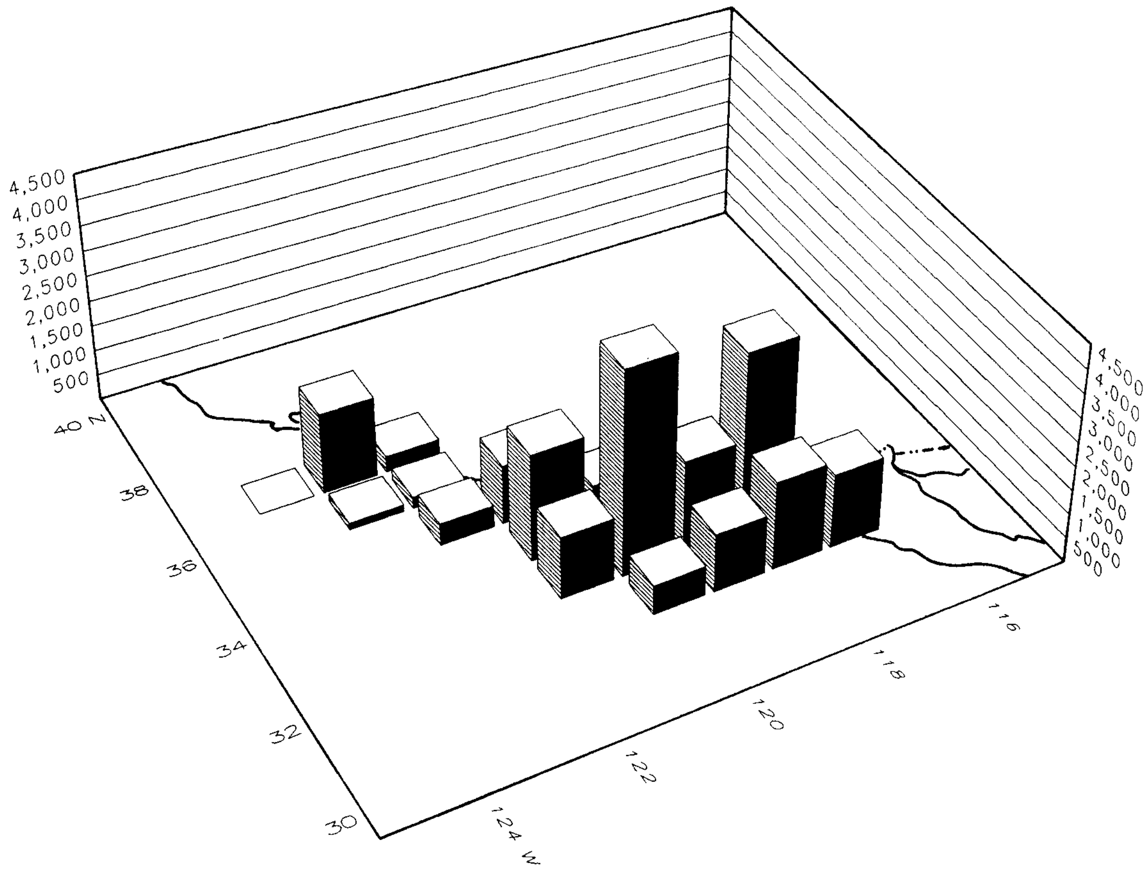
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
40 N
38
36
34
32
30
124 W
122
120
118
116

FIGURE 4

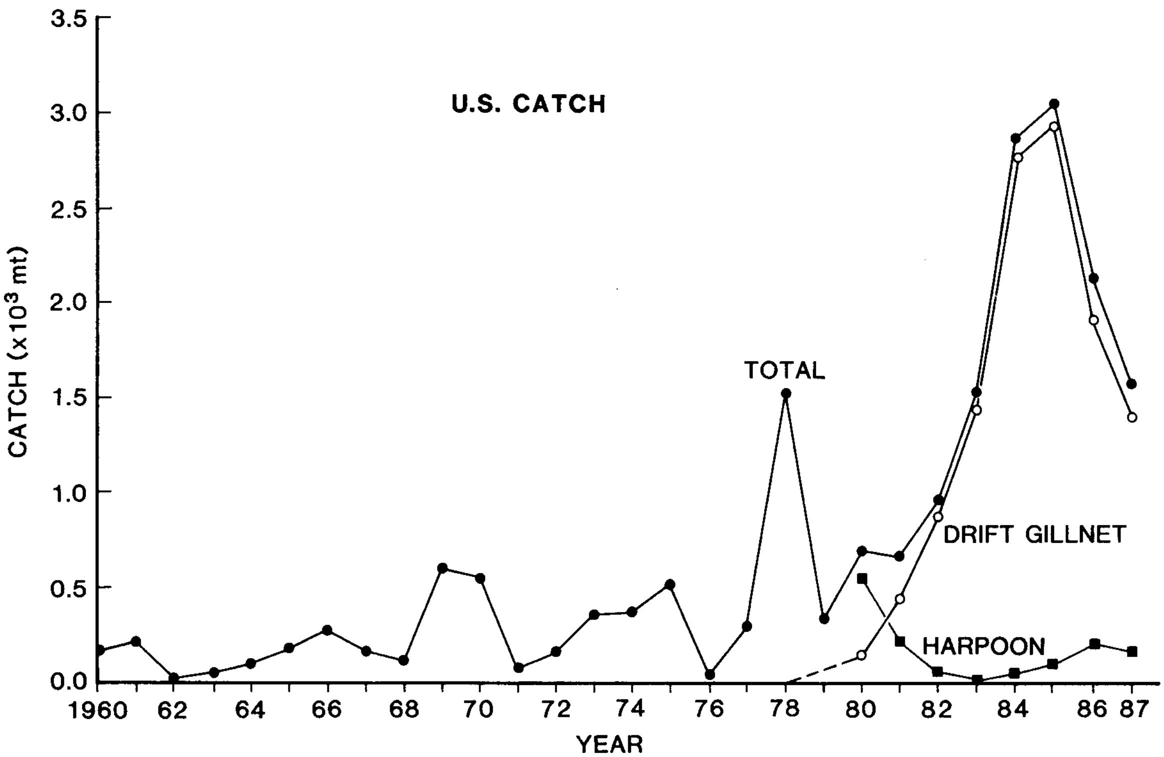
U.S. CATCH
CATCH (x10³ mt)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
TOTAL
DRIFT GILLNET
HARPOON
1960
62
64
66
68
70
72
74
76
78
80
82
84
86
87
YEAR

FIGURE 5

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

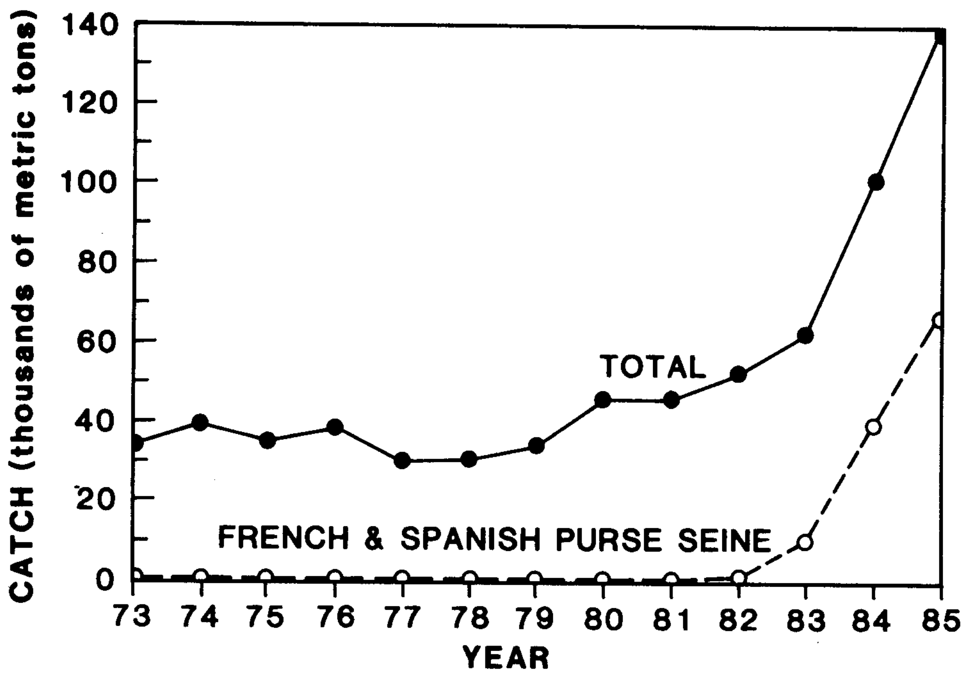

CATCH (thousands of metric tons)
140
120
100
80
60
40
20
0
TOTAL
FRENCH & SPANISH PURSE SEINE
73 74 75 76 77 78 79 80 81 82 83 84 85
YEAR

FIGURE 1

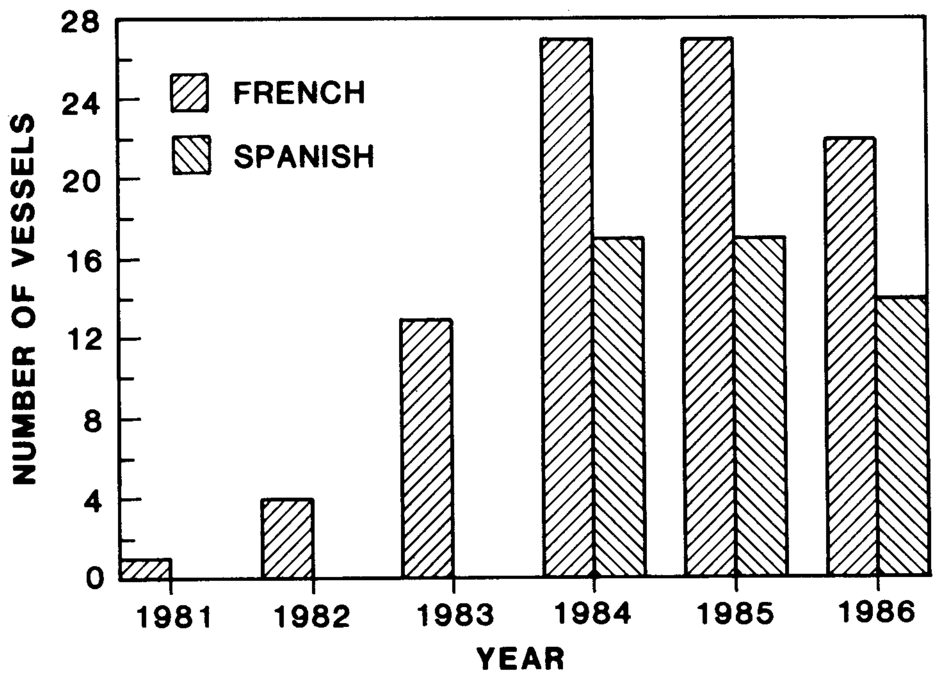
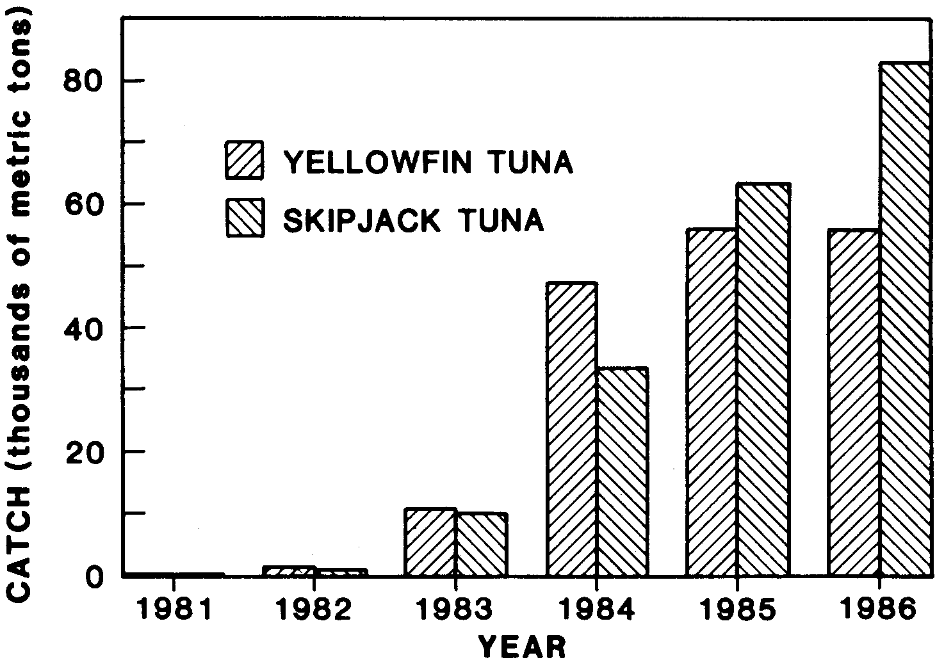

28
24
20
16
12
8
4
0
FRENCH
SPANISH
NUMBER OF VESSELS
1981
1982
1983
1984
1985
1986
YEAR

FIGURE 2



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

FIGURE 3

1985 PURSE SEINE DAYS FISHING

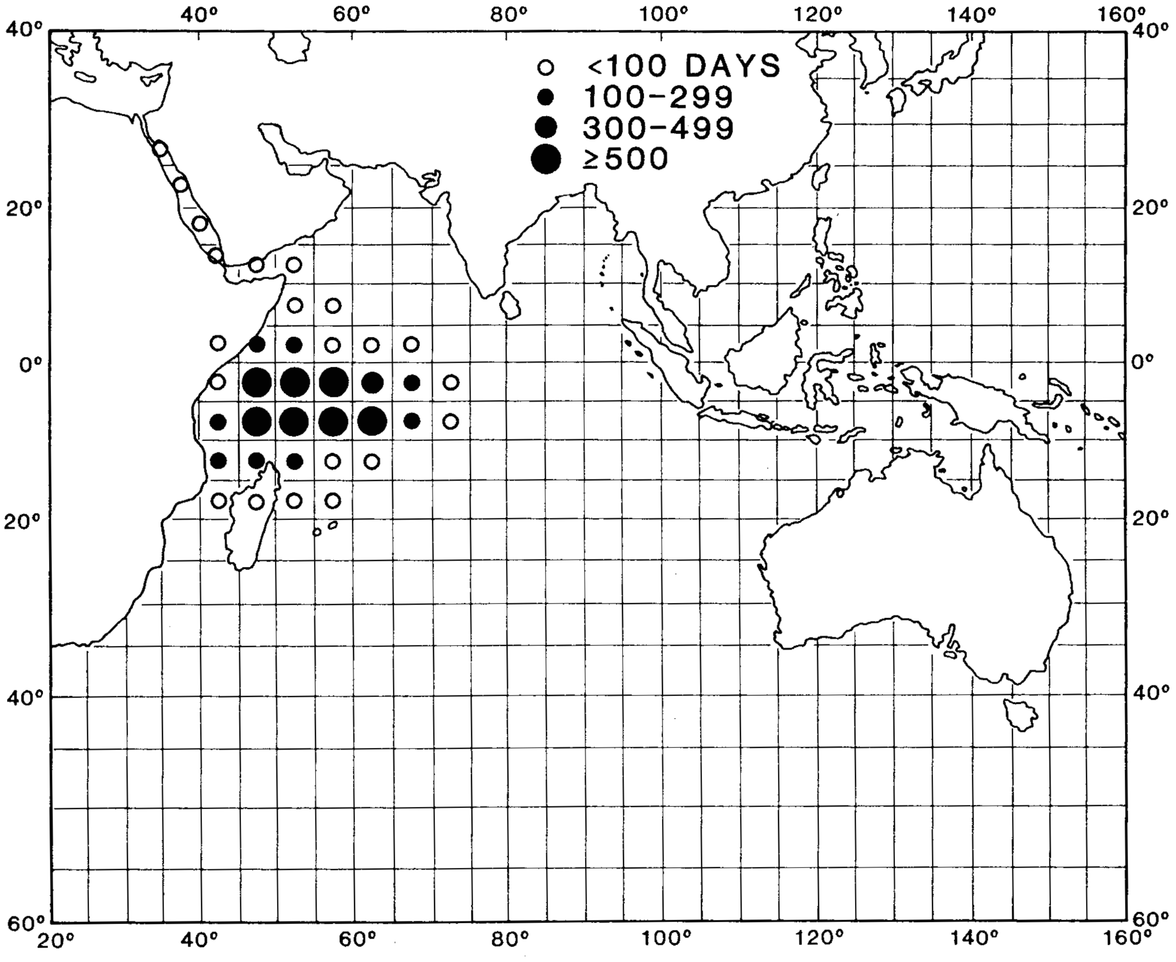


FIGURE 4

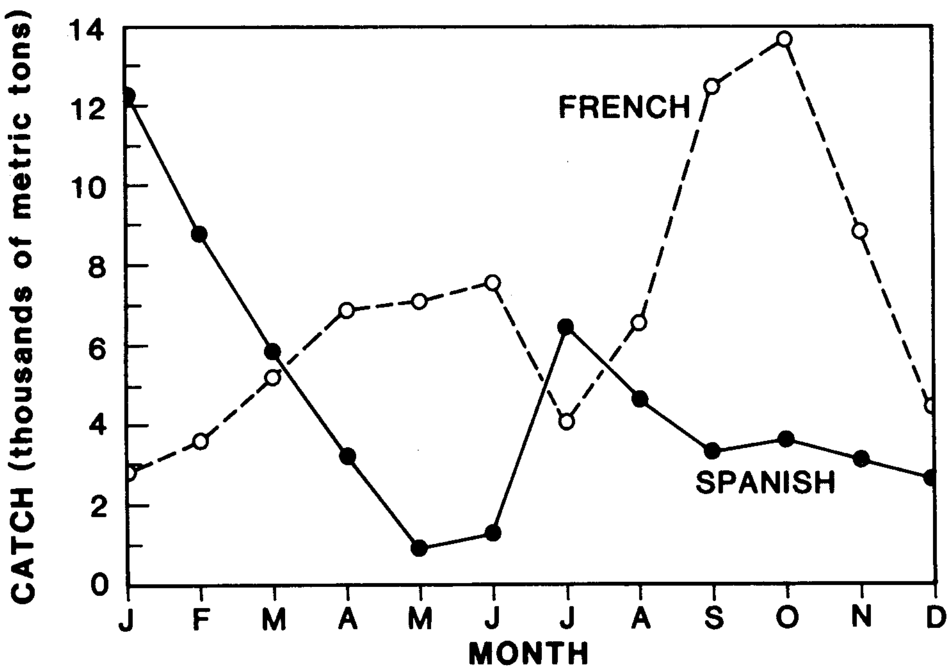

CATCH (thousands of metric tons)
14
12
10
8
6
4
2
0
FRENCH
SPANISH
J F M A M J J A S O N D
MONTH

FIGURE 5

IV-2 INDIAN OCEAN FISHERIES FOR YELLOWFIN TUNA 1989

Wes Parks
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La Jolla, California

1. INTRODUCTION

Yellowfin tuna (*Thunnus albacares*) has become increasingly important in catches of Indian Ocean tuna fisheries. The proportion of yellowfin in total Indian Ocean catches increased from 15 percent in 1974 to 25 percent in 1986 making yellowfin the second most important species, behind skipjack, in 1986 Indian Ocean catches (Figure 1; Table 1). The 1986 yellowfin catch, 114,200 mt, was four times the 1981 catch. Although some of this increase is attributable to increased catches by traditional small-scale fisheries, the major part is due to catches by the large-scale purse seine fleet which began to take a significant part of Indian Ocean tuna catches in 1983.

This chapter reviews information on fisheries for yellowfin tuna in the Indian Ocean. The description is based almost exclusively on working papers presented at the Expert Consultation on the Stock Assessment of Tunas in the Indian Ocean in December 1986 (Anonymous, 1987c). Additional information was taken from statistical publications of the United Nations Food and Agriculture Organization's (FAO) Indo-Pacific Tuna Development and Management Programme (IPTP) (Anonymous, 1988a; Anonymous, 1988b).

2. THE RESOURCE AND FISHERIES

Yellowfin tuna are found throughout the Indian Ocean from the Gulf of Arabia in the north to about 45^{o}S latitude (Figure 2).

At least 34 nations fish for tuna in the Indian Ocean. Of these, 19 recorded catches of yellowfin in 1986 (Table 2). Indian Ocean tuna fisheries can be grouped into two major sectors, large- scale (in the Indian Ocean sometimes referred-to as "industrial") and coastal small-scale ("artisanal") fisheries. In 1986, large- scale fisheries took 57 percent of the total catch of tunas and 82 percent of the yellowfin catch (Figure 3; Table 3). Small-scale fisheries took 43 percent of the total tuna catch and 18 percent of the yellowfin catch.

No Indian Ocean tuna fishery catches yellowfin tuna exclusively but rather a mix of pelagic species that may change both within and between seasons. Yellowfin typically comprises no more than 50 percent of the annual tuna catch of any single Indian Ocean fishery. In 1986, 90 percent of the total catch of tunas, tuna-like fishes and billfish was comprised of, in decreasing order of catch, skipjack, yellowfin, king mackerel, bigeye, kawakawa, albacore, southern bluefin, longtail tuna and tunas unrecorded to species.

The principal yellowfin-catching fisheries are the large- scale longline and purse seine fisheries, which in 1986 took 31 percent and 51 percent respectively of the total yellowfin catch.

2.1. Large-Scale Fisheries

Vessels in large-scale Indian Ocean tuna fisheries are typically long-range vessels primarily of distant water fishing nations (DWFN). There are two major large-scale components, the longline fleets of Japan, Korea and Taiwan, and the purse seine fleets primarily of France and Spain.

Japanese longline vessels began fishing for tunas in the Indian Ocean in the early 1950's followed by vessels from Taiwan and Korea in the 1960's (Amerasiri and Joseph, 1987). These large (200-500 gross mt) longliners target yellowfin and other large tunas and billfish. In 1984, the longline fleet operated in virtually the entire Indian Ocean, from 45^{o}S latitude, north to the Gulf of Arabia and from the coast of East Africa to Indonesia (Figure 4). In 1985, 250 Japanese, 62 Korean and 127 Taiwanese longliners operated in the Indian Ocean (Indian Ocean Fishery Commission, 1985; Anonymous, 1987b).

The longline fishery catches other large pelagic species besides yellowfin tuna--albacore, bigeye and southern bluefin tuna and billfish. In 1986, yellowfin comprised 34 percent of the total longline catch. The Japanese longline fleet in recent years has targeted principally southern bluefin. In 1986, the catch of yellowfin was 11,000 mt, 26 percent of the total Japanese catch of tunas and billfish (Table 2). Korean longliners target principally yellowfin and bigeye; yellowfin catch in 1986 was 14,900 mt, comprised 47 percent of the Korean catch. The Taiwanese fleet targets albacore and in 1986 caught 9,300 mt of yellowfin, 20 percent of the total.

The purse seine fishery became a significant presence in the Indian Ocean 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. Exploratory purse seining in 1981 and 1982 indicated that commercial operations in the Indian Ocean would be successful (Steguert and Marsac, 1986). Subsequently, the French purse seine fleet in the western Indian Ocean grew to 27 vessels by 1985. The Spanish followed the French into the western Indian Ocean fishery in 1984 with 16 vessels. In the early years of the fishery the fleet operated near the Seychelles Islands. The fishery developed rapidly and by 1984 the fishery, composed primarily of French and Spanish vessels plus some from Ivory Coast, Mauritius, Panama and the United Kingdom, had expanded to cover the whole of the western part of the Indian Ocean, moving seasonally between the southern Arabian Sea and the Mozambique channel (Figure 3; Indian Ocean Fishery Commission, 1985).

The purse seine fishery catches a mixture of skipjack and yellowfin and minor quantities of other tuna species with species percentages varying with season and fishing location. In 1986, the overall composition catch was 53 percent skipjack, 43 percent yellowfin and 4 percent other species, primarily bigeye.

Activities of the principal European participants in the purse seine fishery, France and Spain, are mainly governed by fishing agreements between the Seychelles government and the European Economic Community (EEC) to fish in the EEZ (Anonymous, 1987b). Seychelles-based vessels operate both in and outside the Seychelles EEZ. They transship catches at the port of Victoria where they also provision and resupply. The number of purse seiners operating out of the Seychelles reached a maximum of 49 at the end of 1984 (Anonymous, 1987b). In 1986, some of the vessels also fished in the Atlantic Ocean, leaving an average of 35 vessels fishing in the western Indian Ocean at any given time.

The EEC has also arranged access for member nations with other Indian Ocean nations (e.g. Madagascar and Mozambique; Anonymous, 1987b). Victoria, Seychelles and Antananarivo, Madagascar, are the two major ports used by the fishing fleet. Vessels shift ports with season depending on fishing conditions in adjacent areas.

2.2. Small Scale Fisheries

The small-scale sector of the Indian Ocean tuna fisheries is composed primarily of coastal fishing vessels of Indian Ocean coastal nations. Traditional small-scale fisheries for tunas have operated in coastal areas for over 100 years, and in some instances (e.g. the Maldives) perhaps for 1000 years.[1] These fisheries land the entire Indian Ocean catch of small tunas and, in recent years, about half the catch of skipjack and 20 percent of the catch of yellowfin (Yesaki, 1987; Sivasubramanian, 1987).

Of the 23 nations whose small-scale fisheries caught tuna in 1986, 10 reported catches of yellowfin (Table 4). Four nations, Indonesia, the Maldives, Pakistan and Sri Lanka, had yellowfin catches greater than 1000 mt. In 1986, fisheries of these nations took 62 percent of the total small-scale fishing landings of tuna and 93 percent of all small-scale landings of yellowfin.

Compared to the large-scale fisheries, small-scale Indian Ocean fisheries are very heterogeneous and even less directed at any particular species (for a detailed description see Steguert and Marsac, 1986). Most catch a mixture of small yellowfin, skipjack and "other" (unrecorded to species) tunas. In 1986, catches were 37 percent skipjack, 14 percent kawakawa, 10 percent yellowfin and 22 percent other tuna.

Indian Ocean small-scale fisheries vary considerably in all aspects from vessel size and sophistication to target market. In some, vessels are small, unpowered and constructed of wood, and fishermen use hand gear. Catches are sold informally at beach landing sites. In others, vessels are larger, more sophisticated in design and made of fiberglass. Operators of these vessels fish with mechanized gear and deliver to ports where catches are processed in modern facilities, and the product is exported. Most vessels are between 7 and 25 m in length; major fishing gears include gill net, pole and line, troll, purse seine and longline. Gillnet is the most commonly used gear. According to a 1984 survey, gillnet was used by an estimated 50 percent of small-scale fishing vessels for which gear was recorded (Yesaki, 1987; Table 5). The same survey found that 44 percent of the tuna catches for which gear could be determined in 1984 was taken by pole-and-line gear (Table 6).

3. ECONOMIC CONSIDERATIONS

Each of the two major sectors of the Indian Ocean tuna fishery, the large-scale and the small-scale, operates under a different set of economic considerations. In addition, a third entity, the coastal, resource-adjacent nation, operates under a third set of considerations.

Vessels of the large-scale sector are part of the mobile, world-wide, DWFN tuna fleet. These long-range vessels change operating areas rapidly in response to catch rates, demand for raw tuna, market prices and area-specific operating costs (Indian Ocean Fishery Commission, 1985). Their major economic consid-eration is maximum net return.

Vessels of the small-scale sector, not being able to easily change fishing areas, are more closely tied to local economies and in certain instances play a major role in the economies of developing Indian Ocean nations. An example is the tuna fishery in the Maldives, which is a major sector of the national economy. The tuna fishery provides substantial export earnings, employs about 1/3 of the total labor force and is important to the livelihood of most island communities (Hafiz, 1987).

The advent of coastal states' rights to fishery resources in their EEZ's and the development of large-scale fisheries has provided an opportunity for Indian Ocean coastal states to benefit economically from expanding tuna fisheries. An obvious way for a resource-adjacent nation to benefit from foreign fishing is to charge a fee for access to its EEZ. However, the Seychelles, the base of the major part of the large-scale purse seine fishery (the French and Spanish fleets) found that less than 20 percent of the foreign exchange benefits are from access fees.[2] The major part of the benefits to the Seychelles are from payment of port fees, and payment for stevedoring, purchases of food, fuel and supplies.

4. CATCH

Total yellowfin catches increased gradually (65 percent) over a period of eight years from 28,300 mt in 1974 to 46,800 mt in 1982 (Figure 1). Over the same period, catches of all tuna increased 45 percent. Then between 1982 and 1986, a period of 4 years, yellowfin catches increased 144 percent to 114,200 mt as the large-scale purse seine fishery was established, then expanded. Catches of skipjack, the other principal species taken in the purse seine fishery, increased 181 percent during this period, while catches of all tuna increased 64 percent.

Following the beginning of the large-scale longline fishery in the early 1950's, annual longline catches of yellowfin varied between 25,000 mt and 70,000 mt until 1973, when they declined to around 15,000 mt (Anonymous, 1987a). Between 1974 and 1986, yellowfin catches varied between 15,000 mt and 40,000 mt, reaching 36,000 mt in 1986 (Figure 3).

Yellowfin catches were first recorded for the large-scale purse seine fishery in 1978 (239 mt) and remained at a low level through 1982 (1,241 mt; Figure 3). Beginning in 1983, catches of yellowfin by this fishery increased rapidly, reaching 59,000 mt in 1986.

The quality of data on the activities of small-scale Indian Ocean fisheries is improving, due in large part to IPTP efforts. However, data for these fisheries are probably not as complete or accurate as data for large-scale fisheries, especially for years before 1982 when IPTP began. Estimates for the early 1970s indicate that yellowfin catches by the small-scale fisheries were small during this period (11,500 mt in 1974) then increased to 20,800 mt in 1986 (Figure 3; Yesaki, 1987).

5. STATE OF THE STOCKS

Although collection of fishery statistics for Indian Ocean tuna fisheries has improved, very few local field and analytic studies have been done to define the stock structure of yellowfin populations and to estimate biological parameters needed for stock assessment. Because of the lack of basic information, no definitive assessment studies have been performed, however the catch so far does not appear to be excessive.

6. OUTLOOK

Two issues will dominate the near-term future of Indian Ocean fisheries for yellowfin and other tunas: (1) the degree to which tuna fisheries will develop and (2) the growing awareness that some kind of cooperative management of fisheries on commonly exploited tuna resources will probably be necessary.

6.1. Future Fisheries Development

Further development of the large-scale longline fishery is considered unlikely (Indian Ocean Fishery Commission, 1985). The fishery is not primarily a yellowfin fishery, but shifts its target among the various sashimi-quality fish, primarily yellowfin, bigeye, southern bluefin and billfish. This, plus the great mobility of the fleet, suggests that future catches of yellowfin will be related to resource availability as well as species-specific market demand and the economic efficacy of operating in the Indian Ocean relative to that of operating in other areas.

The large-scale purse seine fishery should continue to expand its area of operations, particularly if fishing effort increases (Indian Ocean Fishery Commission, 1985). Prospects for increased effort by the Seychelles-based fleet, and others already operating in the Indian Ocean and South Atlantic fisheries, will be related to future trends in yellowfin and skipjack catch rates relative to rates in the Atlantic.[2] If exploitable resources are found in new areas in the eastern Indian Ocean, some of the current Indian Ocean-South Atlantic fleet may relocate to this area. If South Atlantic resources show greater promise, the combined fleet may favor that area. On a broader scale, the highly-mobile purse seine fleet operates in all oceans, and decisions by vessels in this fleet to fish in the Indian Ocean or elsewhere, will depend on the relative profitability of operating in the various areas. Less-tangible aspects such as the desire to establish a presence in a given area may also influence fleets' presence in the Indian Ocean. Since the target of the purse seine fleet shifts between yellowfin and skipjack, future trends in catches of these species will depend on their relative abundance, market demand and the relative economics of operating in the Indian Ocean.

Small-scale Indian Ocean tuna fisheries should continue to develop. At least one small-scale fishing nation, the Maldives, exports a significant proportion of its tuna catch, a situation likely to be repeated by other Indian Ocean nations. The Maldives and other small-scale fishing nations are increasing catches by improving existing gear or by introducing new, more efficient gear types. Post-harvest processing and marketing infrastructure is gradually improving, however significant developments in this area will probably require foreign investment and expertise. These trends, will continue as many fleets modernize and expand to take advantage of the improving world market for tuna (James and Jayaprakash, 1987).

Close proximity to the resource may also provide an opportunity for coastal nations to economically enter yellowfin fisheries--such as longline fisheries in and near their EEZ's-- that might be less economical for DWFNs (Indian Ocean Fishery Commission, 1984). This development is heavily dependent on developing domestic or export markets and the ability to follow the strict quality standards demanded in the sashimi market.

6.2. Future Management

The need for international management of Indian Ocean tuna fisheries is increasingly discussed in area fishery management forums (Anonymous, 1987b). Coastal nations are concerned that continued expansion of both small-scale and large-scale tuna fisheries both inside and outside Indian Ocean EEZ's could affect catches. Most often mentioned is their concern that the rapidlygrowing purse seine fishery will expand to areas adjacent to those used by the small scale fisheries. They fear that this may adversely affect the availability of fish in waters traditionally exploited by their fishermen and may ultimately lead to decreased catches in small-scale fisheries (Anonymous, 1987a; Anonymous, 1987b).

Events directed at developing cooperative international management of Indian Ocean tuna fisheries have begun. The 1985 Consultative Phase of the first Indian Ocean Marine Affairs Cooperation Conference, attended by 35 states and 22 international organizations, was the first international attempt to move toward formal international cooperation (Anonymous, 1987b). The IOFC Committee for Management of Indian Ocean Tunas met in June 1988 to discuss possible long-term institutional arrangements. The Committee agreed that a new body should be established under Article XIV of the FAO constitution. In late 1988, FAO circulated a draft agreement to establish an Indian Ocean Tuna Commission. The draft was discussed at a conference in April 1989 convened to prepare a final agreement. Interested parties could not agree on principles, but agreed to continue efforts toward a tuna management regime.

7. FOOTNOTES

[1]Joel Nageon de Lestang, Director, Resource Management, Seychelles Fishing Authority, P.O. Box 449, Fishing Port, Mahe, Seychelles, pers. commun. August 1989.

[2]MICHAUD, P. Seychelles' response to rapid development in industrial tuna fishing. Presented to the Ninth Meeting of the IOFC Committee on the Management of Indian Ocean Tuna, Colombo, Sri Lanka, December 1986, 14 p.

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9. LIST OF FIGURES

Table 1. Catches (mt) of tuna in the Indian Ocean, by species, 1974-1986 (anon. 1988b).

Species	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Yellowfin	28297	28390	30090	50898	44683	36982	34064	36435	46828	60663	93503	100768	114243
Bigeye	21183	30959	23659	31511	47379	31027	31303	32378	39144	44168	35604	41949	42904
Albacore	14964	5361	6170	9713	16653	16211	11637	13233	23205	17180	15119	9628	25358
Southern bluefin	30543	21273	26866	26395	17122	16944	24205	26065	29136	36741	30163	28002	21908
Skipjack	39502	35165	38612	30294	30461	33916	45835	45792	52620	61594	101922	134994	148110
Longtail	2126	2421	3046	3305	1936	4589	3215	5710	15337	15957	16329	28962	21570
Kawakawa	15832	16756	16529	15019	9660	14480	8282	23113	25507	21322	29080	25978	28369
Frigate	0	0	0	0	0	0	0	0	0	0	0	2466	1626
Bullet	0	0	0	0	0	0	0	0	0	0	0	617	67
Frigate bullet	6006	4057	2708	3086	1661	1701	1595	2908	4967	5675	9337	3418	10942
Bonito Indo-Pacific	0	0	0	0	0	0	0	0	0	0	0	2762	0
Tunas	36476	28616	38578	39738	38431	41965	55558	34369	46048	42810	33232	58876	49337
TOTAL	194929	172998	186258	209923	207986	197815	215694	220003	282792	306110	364289	438420	464434

Table 2. Catches (mt) of yellowfin tuna in the Indian Ocean by flag of fishing vessel, 1974-1986 (Anon. 1988b).

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Australia	0	0	0	3	15	28	34	0	8	18	41	43	42
China (Taiwan)	800	523	425	4733	3261	2878	2723	1817	3526	4211	1369	5099	9313
Comoros	100	100	100	100	100	100	100	100	110	120	130	140	140
France	0	0	0	0	0	0	0	260	1224	10773	33611	32231	35519
Indonesia	1071	869	1317	2345	2811	3236	3348	3350	3740	5888	4247	4543	3270
Iran	0	0	800	0	0	341	322	0	0	0	0	0	0
Ivory Coast	0	0	0	0	0	0	0	0	0	0	5107	3046	562
Japan	4415	4719	2744	2061	4263	2023	3440	4701	6355	7232	7467	9372	11115
Kenya	0	0	0	0	0	0	67	171	204	322	0	0	0
Korea	11563	11694	12840	31383	25165	17788	12537	11777	18654	15337	9895	12017	14891
Maldives	4128	3774	4891	4473	3584	4289	4229	5284	4004	6241	7123	6066	5321
Mauritius	0	0	0	0	15	5	1	1	0	1057	1284	914	851
Mozambique	0	0	0	0	0	0	0	0	0	15	188	15	15
Pakistan	0	0	0	0	0	0	0	0	0	0	0	0	2093
Panama	0	0	0	0	0	0	0	0	0	0	2441	3236	3432
Seychelles	150	100	50	80	100	128	357	949	518	157	198	147	10
Spain	0	0	0	0	0	0	0	363	55	0	13796	15411	17532
Sri Lanka	6070	6611	6915	5720	5369	6166	6906	7662	8350	9046	6439	6716	7977
Tanzania	0	0	0	0	0	0	0	0	0	0	0	0	600
United Kingdom	0	0	0	0	0	0	0	0	0	0	155	1177	1050
Yemen Dem.	0	0	0	0	0	0	0	0	80	80	12	511	510
TOTAL	28297	28390	30090	50898	44683	36982	34064	36435	46028	60663	93503	100768	114243

Table 3. Catches (mt) of tuna by small-scale and large-scale fisheries in the Indian Ocean by species in 1986 (data: Anon. 1988b).

Fishery	Species[1]												
	YFT	BET	ALB	SBF	SKJ	LOT	KAW	FRI	BLT	FRZ	BIP	TUN	TOTAL
Small-scale	20126	179	0	0	73935	21435	28369	0	0	12635	0	43300	199979
Large-scale	94117	42725	25358	21908	74175	135	0	0	0	0	0	6404	264822
Total	114243	42904	25358	21908	148110	21570	28369	0	0	12635	0	49704	464801

[1]Abbreviations:

YFT=yellowfin; BET=bigeye; ALB=albacore; SBF=southern bluefin; SKJ=skipjack; LOT=longtail; KAW=kawabawa; FRI=frigate; BLT=bullet FRZ=frigate/bullet; BIP=Indo-Pacific bonito; TUN=not identified to species.

Table 4. Catches (mt) of tunas by countries having small-scale fisheries in the Indian Ocean by species in 1986 (data: Anon. 1988b).

Country	Species[1]												
	YFT	BET	ALB	SBF	SKJ	LOT	KAW	FRI	BLT	FRZ	BIP	TUN	TOTAL
Bangaladesh	0	0	0	0	0	0	0	0	0	0	0	67	67
Comoros	140	0	0	0	360	0	1300	0	0	0	0	140	1940
Djbouti	0	0	0	0	0	0	0	0	0	0	0	30	30
Egypt	0	0	0	0	0	0	0	0	0	0	0	300	300
India	0	0	0	0	3195	185	18116	0	0	8485	0	2780	32761
Indonesia	3270	0	0	0	10954	0	0	0	0	0	0	21600	35824
Iran	0	0	0	0	0	11710	1870	0	0	326	0	0	13906
Israel	0	0	0	0	0	0	0	0	0	100	0	0	100
Kenya	0	0	0	0	49	0	0	0	0	0	0	0	49
Maldives	5321	0	0	0	45445	0	1071	0	0	1779	0	415	54031
Mauritius	190	179	0	0	0	0	0	0	0	0	0	400	769
Mozambique	15	0	0	0	80	0	0	0	0	0	0	280	375
Oman	0	0	0	0	0	0	0	0	0	0	0	11728	11728
Pakistan	2093	0	0	0	105	3275	1225	0	0	18	0	3535	10251
Reunion	0	0	0	0	0	0	0	0	0	0	0	190	190
Saudia Arabia	0	0	0	0	0	0	0	0	0	0	0	264	264
Seychelles	10	0	0	0	0	0	323	0	0	0	0	0	333
Sri Lanka	7977	0	0	0	13737	0	1360	0	0	1367	0	4	24445
Tanzania	600	0	0	0	0	0	0	0	0	0	0	70	670
Thailand	0	0	0	0	0	1895	0	0	0	0	0	1497	3392
U.A.E.	0	0	0	0	0	3973	1396	0	0	540	0	0	5909
Yemen AR	0	0	0	0	0	307	438	0	0	0	0	0	745
Yemen Dem	510	0	0	0	10	90	1270	0	0	20	0	0	1900
Total	20126	179	0	0	73935	21435	28369	0	0	12635	0	43300	199979

[1]Abbreviations: See Table 3

Table 5. Estimated numbers of tuna fishing vessels by gear type for various countries in the Indian Ocean in 1984 (Yesaki, 1987).

Country	Mechanized[1] GN	PL	T	PS	Non-mechanized PL	T	UNCLASS	Total
India	2362	263	-	221	-	-	133019	135865
Indonesia	1188	-	2237	260	-	-	-	3685
Iran	1464	-	-	-	-	-	-	1464
Maldives	-	-	-	-	561	3115	-	5003
Oman	-	-	-	-	-	-	-	-
Pakistan	274	-	-	-	-	-	-	274
Somalia	-	-	-	-	-	-	-	-
Sri Lanka	2541	-	-	-	-	-	-	2541
Thailand	30	-	-	153	-	-	-	183
U.A.E.	-	-	-	-	-	-	-	-
Yemen, P.D.R.	-	-	-	-	-	-	-	-
Total	7859	1590	2237	634	561	3115	133019	149015

[1]Abbreviations: GN=gillnet; PL=pole and line; TL=troll; PS=purse-seine

Table 6. Estimated tuna catch (mt) by gear type for various countries in the Indian Ocean in 1984 (Yesaki, 1987).

Country	Mechanized[1] GN	PL	T	PS	Non-mechanized PL	T	UNCLASS	Total
India	-	3037	-	-	-	-	-	3037
Indonesia	-	-	8009	7004	-	-	-	15013
Iran	13615	-	-	-	-	-	-	13615
Maldives	-	50602	-	-	416	2495	-	53513
Oman	-	-	-	-	-	-	-	-
Pakistan	3951	-	-	-	-	-	-	3951
Somalia	-	-	-	-	-	-	-	-
Sri Lanka	24980	-	-	-	-	-	-	29490
Thailand	52	-	-	7317	-	-	-	7369
U.A.E.	-	-	-	-	-	-	-	-
Yemen, P.D.R.	-	-	-	-	-	-	-	-
Total	42598	53639	8009	14321	416	2495	-	121478

[1]Abbreviations: See Table 5

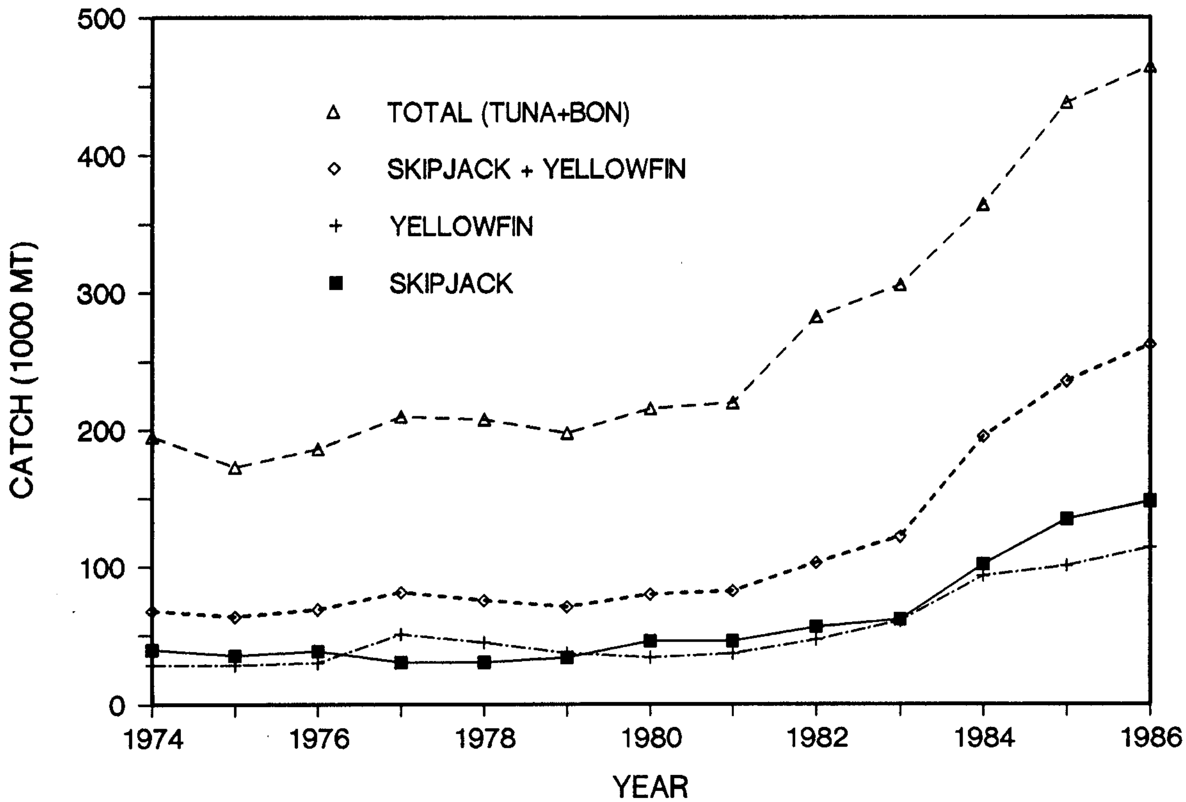

TOTAL (TUNA+BON)
SKIPJACK + YELLOWFIN
YELLOWFIN
SKIPJACK
CATCH (1000 MT)
0
100
200
300
400
500
1974
1976
1978
1980
1982
1984
1986
YEAR

FIGURE 1

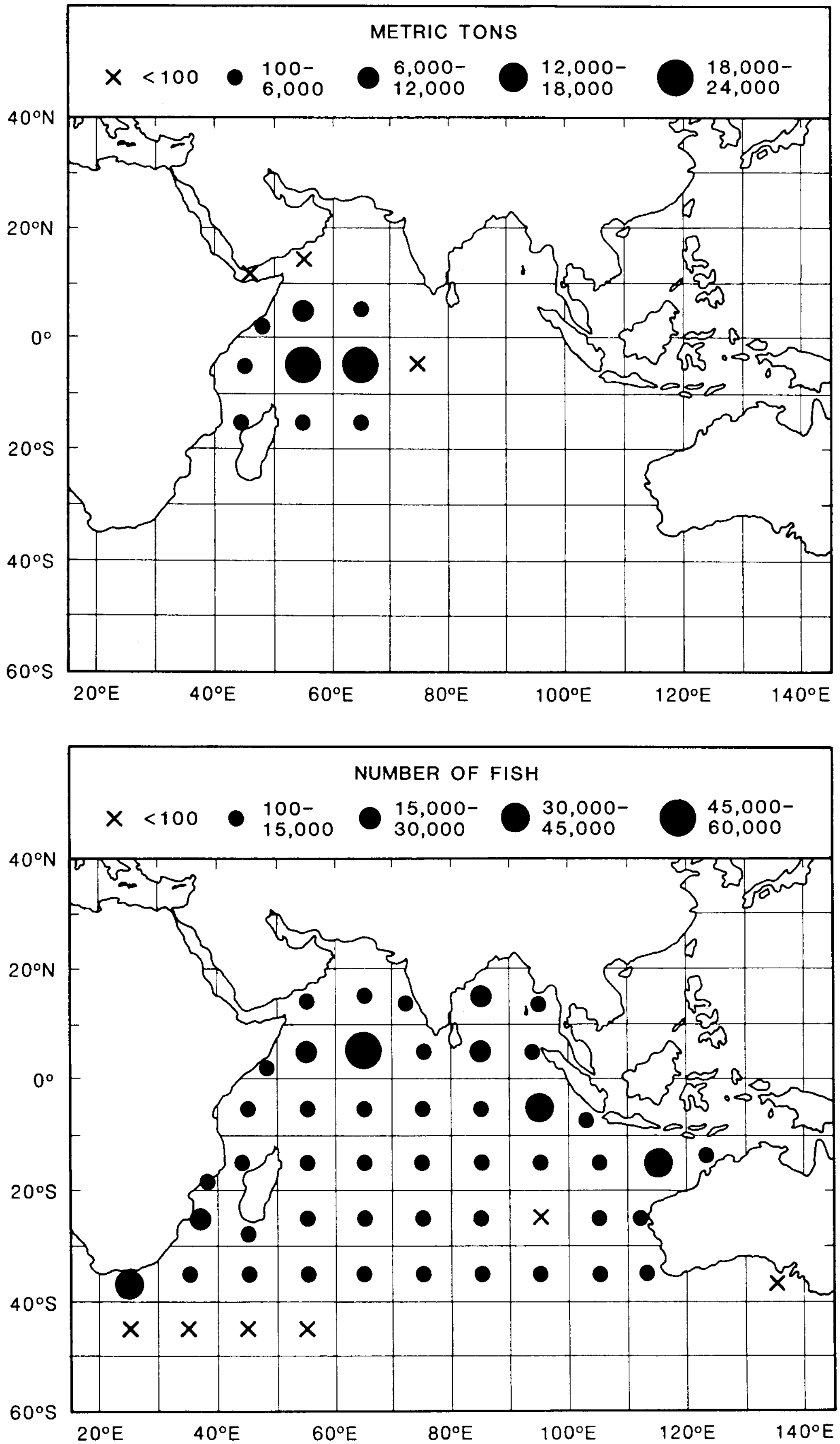
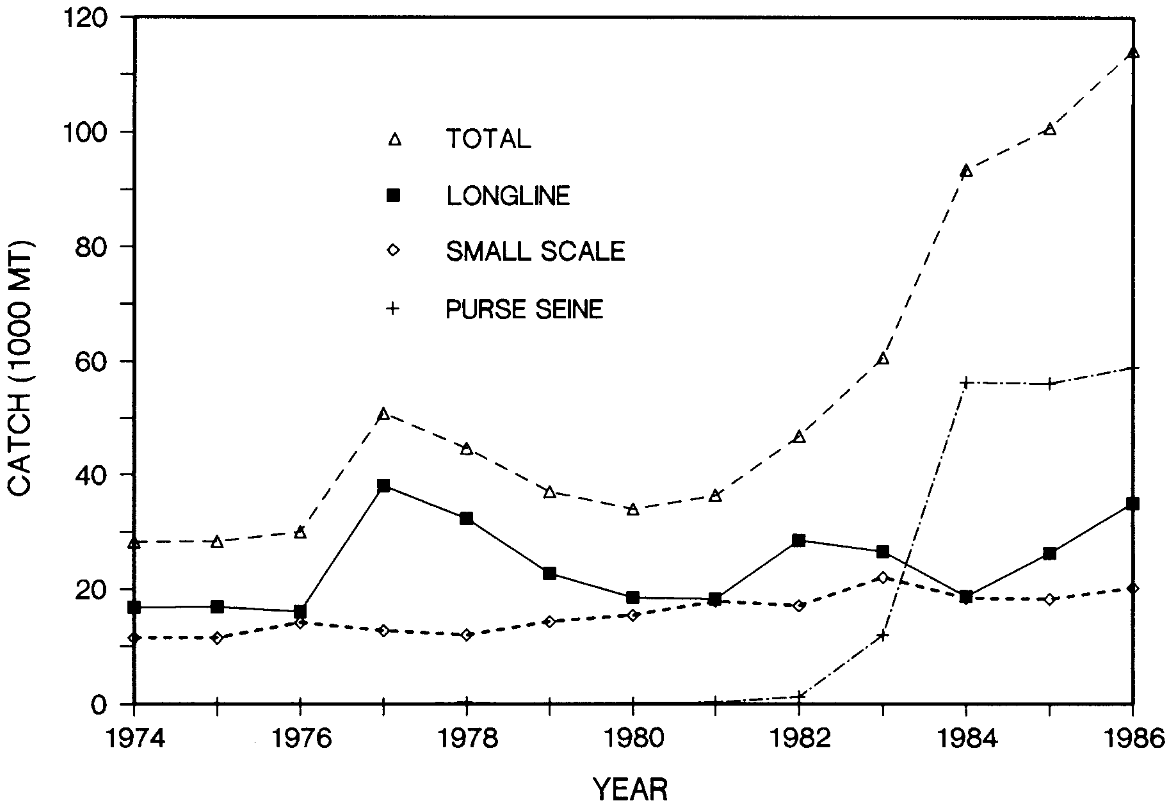

METRIC TONS
× <100
100-6,000
6,000-12,000
12,000-18,000
18,000-24,000
40°N
20°N
0°
20°S
40°S
60°S
20°E
40°E
60°E
80°E
100°E
120°E
140°E
NUMBER OF FISH
× <100
100-15,000
15,000-30,000
30,000-45,000
45,000-60,000
40°N
20°N
0°
20°S
40°S
60°S
20°E
40°E
60°E
80°E
100°E
120°E
140°E

FIGURE 2



120
100
80
60
40
20
0
CATCH (1000 MT)
TOTAL
LONGLINE
SMALL SCALE
PURSE SEINE
1974
1976
1978
1980
1982
1984
1986
YEAR

FIGURE 3

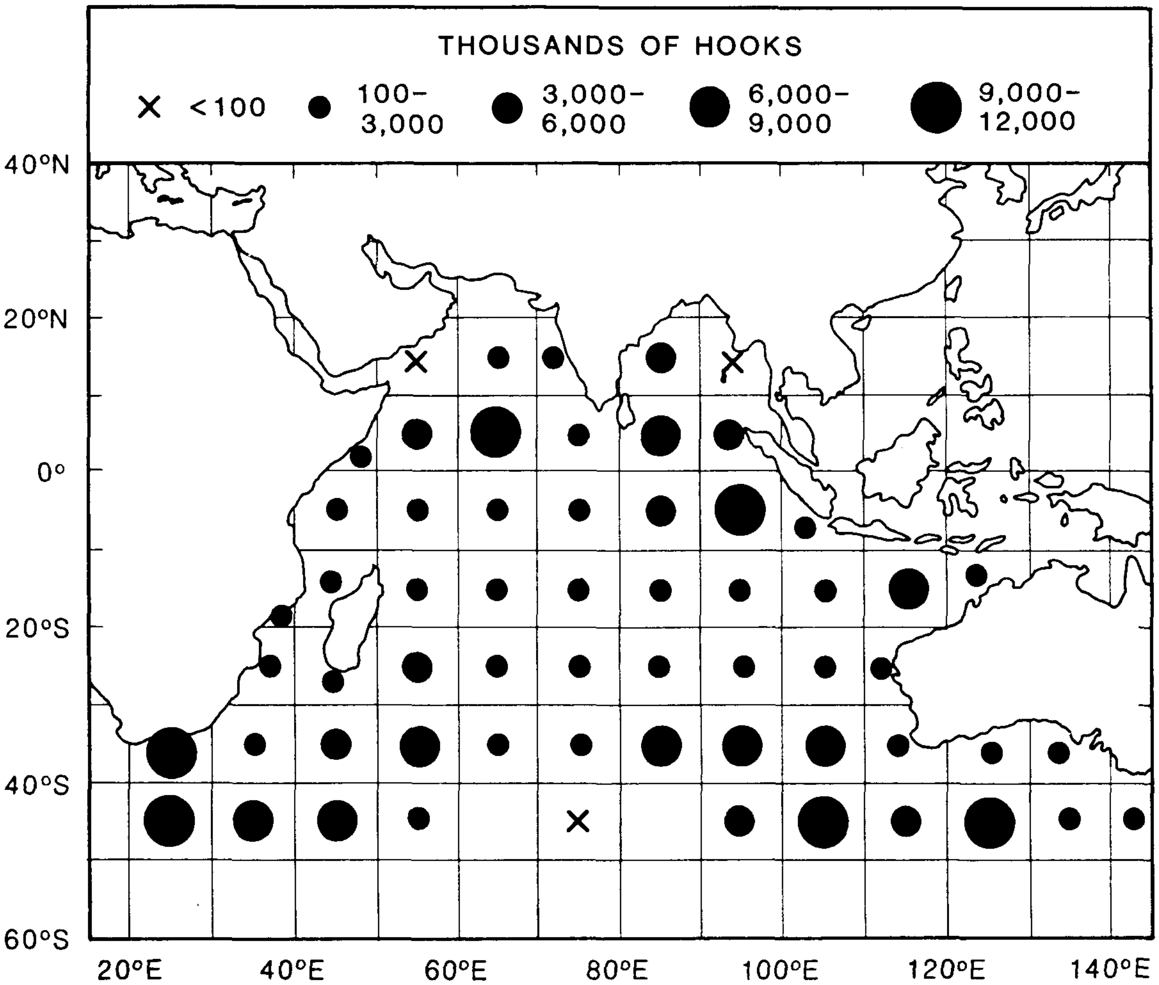

THOUSANDS OF HOOKS
× <100
100– 3,000
3,000– 6,000
6,000– 9,000
9,000– 12,000
40°N
20°N
0°
20°S
40°S
60°S
20°E
40°E
60°E
80°E
100°E
120°E
140°E

FIGURE 4

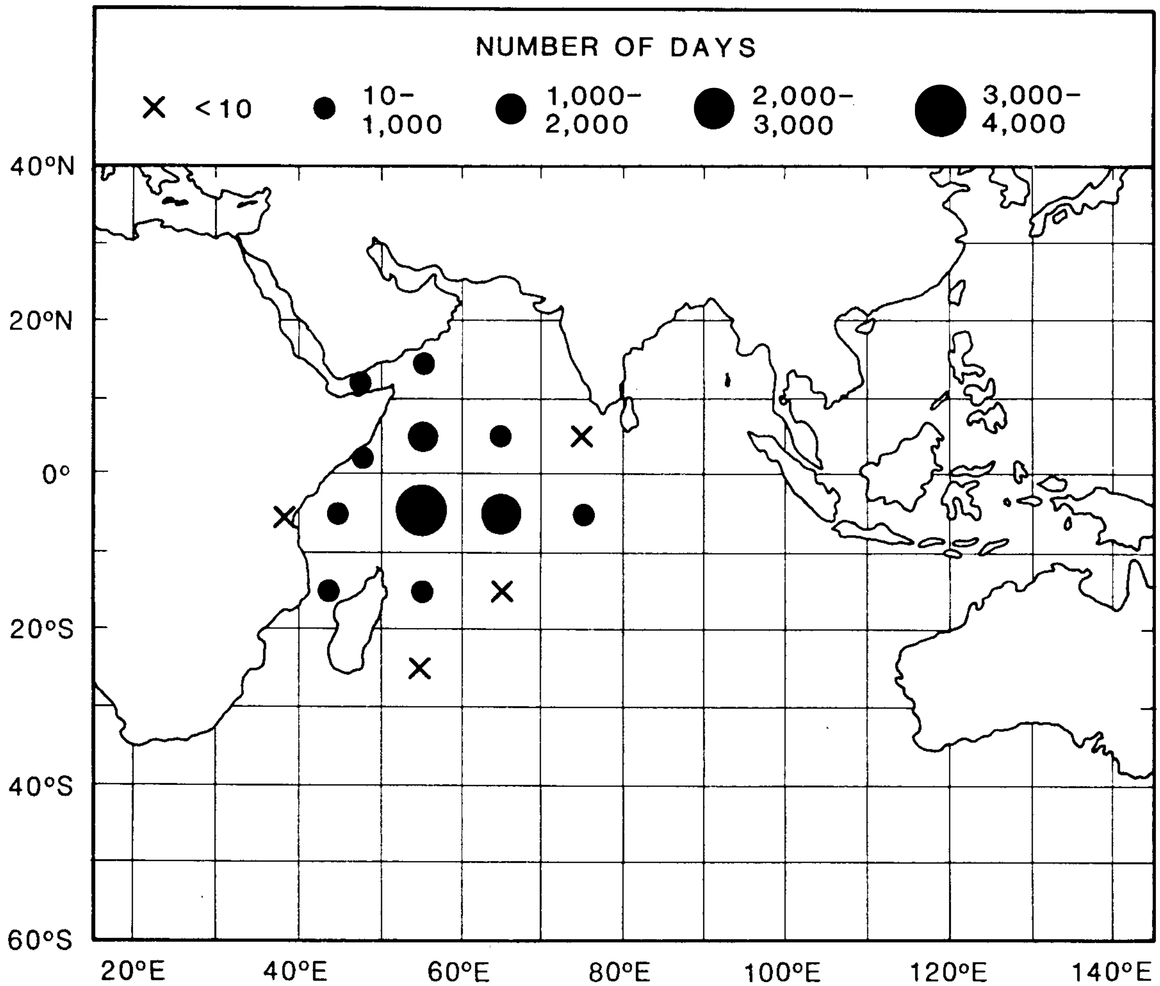

NUMBER OF DAYS
<10
10-
1,000
1,000-
2,000
2,000-
3,000
3,000-
4,000
40°N
20°N
0°
20°S
40°S
60°S
20°E
40°E
60°E
80°E
100°E
120°E
140°E

FIGURE 5