REPORT OF THE SECOND MEETING OF THE WESTERN PACIFIC YELLOWFIN TUNA RESEARCH GROUP

Honolulu, Hawaii
June 17-24, 1992

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PREFACE

The Western Pacific Yellowfin Tuna Research Group is an informal organization of interested scientists and fisheries officers engaged in research on the population biology of yellowfin tuna and in monitoring of the fisheries exploiting this species in the central and western Pacific Ocean. The Group was organized in 1990 to encourage collaborative research among the interested scientists. Its objectives are to exchange information and data, plan and cooperate in research projects, and foster common understanding on the condition of the yellowfin tuna stock and advice on management issues. Meetings held to date:

First meeting -- June 20-21, 1991, Port Vila, Vanuatu
Second meeting -- June 17-24, 1992, Honolulu, Hawaii, U.S.A.

Technical assistance in preparing this second meeting report was provided by Karen Handschuh, Ken Raymond and Connie Blair of the Southwest Fisheries Science Center.

La Jolla, CA
U.S.A.
May, 1993

1.0. INTRODUCTION

The Western Pacific Yellowfin Tuna Research Group (WPYRG) was organized in 1990, following a recommendation at the third meeting of the Standing Committee on Tunas and Billfishes, to facilitate collaborative research on western Pacific yellowfin tuna for management advice. The participants are scientists and fishery officers of south Pacific island nations, distant-water fishing nations, the South Pacific Commission (SPC) and the Forum Fisheries Agency (FFA), who have an interest in research and management of the tropical tunas of the western and central Pacific Ocean. At its first meeting (Port Vila, Vanuatu, June 1991), the Group took note of the limited progress made in reducing the uncertainty about the status of the yellowfin stock and of the urgent need for developing scientific advice for fishery management. The Group, therefore, agreed on the goal of assessing the condition of the yellowfin tuna stock(s) of the central-western Pacific region in order to provide scientific advice for informed fishery management decisions. The Group identified three resource-related questions frequently asked by fisheries administrators that should be addressed over the near term:

(1) What is the safe level of yield and exploitation for the stock?

(2) What is the level of interaction among the different fisheries? and

(3) What factors contribute to local depletion?

The Group also agreed that the study area would be bound by 40° N and 40° S, Australia, and 120° E on the west and 150° W on the east. Within this study area, seven statistical areas (WPYF areas) were established for reporting and compiling fishery statistics (Figure 1).

The second meeting of the Group was organized with the intention of developing a comprehensive data base for conducting a stock assessment by 1993 or 1994 and for outlining specifications for conducting that assessment. In preparing for this meeting, a work plan was developed and WPYRG participants were assigned specific tasks. Participants had also agreed that confidential data provided to the workshop for analyses would not be duplicated and should be returned to the contributors immediately after the conclusion of the meeting.

2.0. AGENDA AND RAPPORTEURS

The second meeting, or workshop, was held at the East-West Center, Honolulu, Hawaii under the Chairmanship of Gary Sakagawa and in conjunction with the fifth meeting of the SPC Standing Committee on Tuna and Billfish (SCTB5). The opening ceremony included welcome addresses by Louis "Buzz" Agard (past chairman of the U.S. Western Pacific Regional Fishery Management Council [WPRFMC]), Kitty Simonds (WPRFMC), Barry Raleigh (University of Hawaii), and Jerry Wetherall (National Marine Fisheries Service [NMFS]); representatives of organizations with tuna research interests in Hawaii. Opening speeches were given by Hélène Courte (SPC) and Antony Lewis (SPC) representing the organizers of the meeting.

An ambitious workshop agenda was adopted and rapporteurs were appointed (Appendix 1) with Peter Ward as coordinator. The participants (Appendix 2) agreed that the workshop report would deviate from tradition and be structured as a synopsis of information on critical stock parameters and advice on research needs to close information gaps. Working documents (Appendix 3) were distributed and used as the basis for focusing the discussion of the Group. Where appropriate, references to working documents are made in this report by document number preceded by WPYRG2/. Rapporteurs for major sections of this report were as follows:

Review of Fisheries -- Peniasi Kunatuba

Review of CPUE Indices -- Tom Polacheck

Review of Stock Structure -- Stephen Yen

Review of Age and Growth -- Chris Boggs

Review of Reproductive Biology -- Dave Williams

Review of mortality Rates -- Pierre Kleiber

Review of Fisheries Data Base for Age-Structured Model -- Al Coan, Tim Lawson, John Hampton

3.0. REVIEW OF FISHERIES

Yellowfin tuna is an important commodity for the "sashimi," canning and fresh-fish markets. In the western Pacific, fisheries have developed and expanded since the 1950s to meet the growing and shifting demands of these markets.

A review of the fisheries and their characteristics was conducted by the Group to gain an understanding of the fisheries and trends in production of yellowfin tuna. The results (Table 1) indicate that few fisheries predominately target yellowfin tuna and a large share of the annual yellowfin tuna catch is taken by fisheries targeting other species (e.g., skipjack tuna) or a mixture of species (e.g., bigeye tuna and yellowfin tuna). The catch has increased rapidly since about 1969 owing to expansion of purse-seine fishing. The total catch during the 1960s was in the 40,000 to 50,000 t range (Figure 2). Since 1969, it increased by about 16% per year to 307,000 t in 1990.

Recent developments in major western Pacific fisheries that catch yellowfin tuna were reported by participants. The reports provided in this section indicate a trend of expansion, especially in the purse-seine fisheries, and increased catches of yellowfin tuna.

3.1. AUSTRALIA (reported by P. Ward; WPYRG2/5)

Australian yellowfin tuna fisheries are on the fringe of the immense yellowfin tuna resource of the western Pacific. The appearance of yellowfin tuna off the east coast of

Australia varies seasonally and from year to year with catches often linked to the incursion of warm water from the Coral Sea southward along the east coast.

Catches of yellowfin tuna in the eastern Australian fishing zone range between 1,000 and 6,000 t, averaging about 3,800 t a year. Most of the yellowfin tuna catch is taken by longline, both domestic and foreign. Longline was first used off New South Wales in 1954. The fishery expanded rapidly after 1984 following the successful airfreighting of chilled yellowfin tuna to the sashimi market of Japan. After rapid growth in 1985-87, high operating costs and variable catch rates forced some fishermen to leave the fishery. Fewer than 100 vessels are now active, accounting for about 30% of yellowfin tuna caught in the eastern Australian fishing zone. Australian longline fishermen have been keen to develop joint ventures with the Japanese or to charter foreign longliners mainly to take high-value southern bluefin tuna in southern waters. This component of the fishery is expected to expand in the next few years.

The Japanese have fished for tunas and billfishes off the east coast of Australia since the early 1950s. Japanese fishing activities have been progressively restricted since the declaration of the Australian fishing zone in 1979. Nevertheless, the Japanese longline fishery remains the major fishery taking yellowfin tuna in the eastern Australian fishing zone, accounting for 65% or more of the yellowfin tuna taken there.

In 1965 the Japanese, using handlines and pole-and-line, established a fishery for yellowfin tuna and bigeye tuna in the northwestern Coral Sea. One to two hundred tons of yellowfin tuna are taken by this fishery each year. Recent activity in this fishery has been sporadic because access restrictions have disrupted operations.

Tunas, including yellowfin tuna, and marlins have been taken by anglers off eastern Australia since the early 1900s. During the 1970s, angling for yellowfin tuna rapidly grew in popularity. This growth continued in the 1980s and will continue in the 1990s.

3.2. INDONESIA (reported by N. Naamin; WPYRG2/9)

Traditionally, the center of the Indonesian tuna fishery is the eastern part of the Indonesian EEZ where 80% of the Indonesian tuna catch is made. There are five species of tuna caught in the EEZ: yellowfin tuna, bigeye tuna, albacore, southern bluefin tuna and skipjack. Yellowfin tuna is a significant catch and caught by four fishing gears: longline, purse-seine, pole-and-line and handline.

Longline fishing commenced in 1952, targeting yellowfin tuna. About 150 vessels were active in 1990. The largest annual yellowfin tuna catch by longliners was 9,717 t in 1988; the average catch is 5,170 t a year.

Handline is also used to target yellowfin tuna. Handlining has been practiced by artisanal fishermen since the early 1930s on traditional fish aggregating devices (FADs) or "rumpon." About 260 boats fished in 1990 and caught a record 3,196 t of yellowfin tuna. The average catch for this fishery is 2,020 t per year. Both longline and handline fisheries are increasing.

Purse seining for skipjack tuna and yellowfin tuna commenced in the EEZ in 1980 and recently expanded into distant waters. The purse-seine catch consists of about 70% skipjack tuna, 26% yellowfin tuna and 4% bigeye tuna. Three boats fish each year in the EEZ, averaging 2,070 t per vessel. This fishery is expected to slowly increase.

Although skipjack tuna is the target of the Indonesian tuna pole-and-line fishery, yellowfin tuna is a significant bycatch at 5% - 12% of the total catch. The fishery commenced in the early 1940s. Since 1983, deployment of deepwater FADs in combination with state-funded fisheries nucleus estates (enterprises) have encouraged pole-and-line fishing. Nine hundred pole-and-line boats reported catches in 1990. The average annual catch for this fishery is 2,800 t per year for the 1980s.

3.3. JAPAN (reported by S. Tsuji)

The large-scale Japanese longline fishery developed after 1952 and expanded to cover most of the tropical Pacific by the mid-1950s. Yellowfin tuna and albacore were the targets of the fishery in the early years. Targeting shifted to bigeye tuna and southern bluefin tuna in the early 1970s with expansion of the Japanese sashimi market and development of deep-freezing technology. Increased demand for bigeye tuna resulted in the introduction of deep longlining in the mid-1970s to improve the catch rate for this species.

The Japanese distant-water pole-and-line fishery also commenced in the early 1950s and established year-round operations in the western Pacific by the mid-1960s. This fishery targets skipjack tuna and, at higher latitudes, albacore as well. Yellowfin tuna accounts for less than 5% of the total catch. This fishery is on a decline and has been replaced by the Japanese purse-seine fishery since the early-1980s.

Tuna purse-seine fishing by Japan in the tropical Pacific started in the mid-1960s on an experimental basis. Year-round operations in the western Pacific were established in the 1970s. The fishing ground was mainly off Papua New Guinea, in the early years, and then it expanded eastward. The fishery is now restricted to the high seas and EEZs where bilateral access agreements exist. Thirty-one single seiners and seven units of group seiners are currently involved in this fishery. Their catches average about 25% yellowfin tuna and 75% skipjack tuna.

3.4. KOREA (reported by T. Lawson)

Korean longliners commenced fishing in the western and central Pacific in the late-1950s. Albacore was the target until the late-1970s. In the early-1970s Korean longliners switched to targeting yellowfin tuna and, later, bigeye tuna in more tropical waters. Catches of yellowfin tuna ranged between 6,000 and 21,000 t during the 1980s.

Korean purse seiners commenced fishing in 1980. The fleet of two vessels in 1980 increased to 37 in 1991. The proportion of yellowfin tuna in the catch has varied up to 30%. Yellowfin tuna catches increased with the increase in fishing activity, reaching about 48,500 t in 1991.

3.5. PHILIPPINES (reported by R. Ganaden)

From an initial production of 9,000 t of tunas in 1970, Philippine production has markedly increased to 336,000 t in 1991. There are primarily two tuna fishery sectors in the Philippines -- "municipal" and "commercial." These are differentiated on the basis of vessel size: all vessels smaller than 3 gross registered tons (GRT) are considered municipal, while larger vessels are classified commercial vessels.

The fishing methods within the municipal sector comprise handlines, longlines, gillnets, ring nets, and troll lines as well as fish corrals (traps). Handlining is the most productive of these gears and target large yellowfin tuna for export to the sashimi markets. It accounts for 79% of the total yellowfin tuna catch; the highest catch was in 1986 at 36,188 t. The total yellowfin tuna catch for the municipal sector has been stable at around 37,000 t per year.

The commercial sector developed with the introduction of the modern purse-seine in 1962. This sector rapidly expanded in the mid-1970s, fueled by increasing world tuna prices as well as widespread use of anchored FADs or "payaos." This resulted in an increase in yellowfin tuna production by purse seiners from 4,133 t in 1978 to 18,728 t in 1984. Within the EEZ, this fishery has since stabilized at around 14,000 t per year. Catches made by purse seiners fishing in distant waters of the western Pacific under access agreements have been increasing and are not included here but are reported by the host countries.

Catches in the Philippines are slowly dwindling, possibly from overfishing and reduced efficiency of vessels operating in overlapping fishing areas. A recent Philippine study indicated that the potential for increased tuna landings from traditional fishing areas was limited and any increase would probably result from expanding fishing in the east or southeast. The study also indicated that a Philippine-based, distant-water purse-seine fleet would have a distinct advantage over the United States, Japan, Korea, and Taiwan fleets by being closer to the center of the productive fishing areas of the western Pacific.

3.6. SOLOMON ISLANDS (reported by S. Diake)

Yellowfin tuna is caught by several fishing methods in Solomon Islands waters (EEZ): pole-and-line vessels belonging to two locally-registered companies; licensed Japanese pole-and-line, and group and single purse-seine vessels fishing under contract to three local companies; American purse seiners fishing under the Multilateral Fisheries Treaty; Japanese longliners, and Taiwanese longliners, targeting albacore and fishing under license arrangements.

During the 1991 fishing season 37 pole-and-line Solomon Islands vessels and 36 long-range pole-and-line Japanese vessels fished in the EEZ. Total yellowfin tuna catches by the domestic pole-and-line vessels were 1,726 t. In 1992, 32 domestic pole-and-line vessels and 24 Japanese pole-and-line vessels operated in the EEZ.

In 1991, three chartered group purse seiners caught an estimated 2,900 t of yellowfin tuna, and a single purse seiner caught about 1,400 t. Six purse seiners (both chartered and owned by domestic tuna companies) are licensed to fish in 1992, but so far only four vessels have fished. The total yellowfin tuna catch for March 1992 was 1,642 t.

Longline operations in Solomon Islands waters are mainly conducted by licensed foreign vessels, principally from Japan and Taiwan. In 1991, 40 Japanese and 20 Taiwanese longline vessels were licensed and, in 1992, 20 Japanese and 25 Taiwanese longline vessels were operating in the EEZ.

3.7. TAIWAN (reported by C.-L. Sun; WPYRG2/10)

The total annual catch of yellowfin tuna by Taiwan vessels (all gears) rose from 16,392 t in 1975 to a peak of 25,595 t in 1979. Since then, from a low of 14,002 t in 1986, production has fluctuated between 19,000 and 24,000 t, averaging 21,660 t a year.

Taiwan entered the distant-water tuna longline fishery in the early 1960s, rapidly expanding from fishing areas in the South China Sea and from the base port of Kaohsiung. In 1963, operations extended to the South Pacific where albacore is the target species. Yellowfin tuna is a bycatch and averaged about 1,200 t annually during 1980-90.

The offshore tuna longline fishery target mainly yellowfin tuna. Most of the vessels are based at Tungkang and fish in the South China Sea. The tuna catch goes to the sashimi market of Japan. The average annual (1970-90) catch of yellowfin tuna by this fleet is 13,069 t.

The Taiwan distant-water purse-seine fleet is based in Taiwan and operates primarily in the western part of the WPYRG study area. The total number of vessels in the fleet during 1984-90 ranged between 5 and 31. Currently, the fleet consists of 44 single purse seiners. A limit has been imposed on the number of vessels for this fishery because of the limited fishing grounds and rapid build-up of the fleet.

The yellowfin tuna landings for this purse-seine fishery increased from 252 t in 1984 to a peak of 16,640 t in 1991. Yellowfin tuna average 20% of the total landings for this fishery; the remainder is mostly skipjack tuna. The yearly catch of yellowfin tuna for the period 1984 to 1990 averaged 5,606 t.

Before 1981, the tuna longline fisheries (distant water & offshore) were the major Taiwan fisheries for yellowfin tuna in the central and western Pacific. Currently, the distant-water purse-seine fishery is the dominant fishery, and this is likely to continue in the 1990s.

3.8. UNITED STATES (reported by A. Coan; WPYRG2/1)

There are two types of U.S. fisheries for yellowfin tuna in the central and western Pacific: a distant-water large-purse seine fishery that targets skipjack and yellowfin tunas, and local, small-scale or artisanal fisheries that target a mixture of tunas and tuna-like species. The distant-water fishery operates in a large area of the western Pacific and is conducted using vessels of 1,000 to 1,800 t carrying capacity.

The distant-water purse-seine fishery commenced in 1976-78 when three U.S. vessels conducted exploratory fishing expeditions during part of the year, and it landed an average of 200 t of yellowfin tuna a year. Since then, year-round operations were established and the fishery grew rapidly to peak at 62 vessels in 1983 before declining to 41 vessels in 1990. Yellowfin tuna landings peaked at 66,400 t in 1987, decreased to 25,200 t the next year and then increased to 57,000 t in 1990. For 1980-90, the average was 35,100 t per year. Preliminary statistics for 1991 indicate a decline to approximately 40,000 t with 40 purse seiners. For 1992, the number of vessels is likely to increase to above 40.

Skipjack tuna, the other major species caught by this fishery, peaked at 124,300 t in 1984, and decreased to 87,600 t the following year before proceeding upward again to 107,400 t in 1990.

The small-scale fisheries operate within the EEZs of the Hawaiian Islands, Guam and the Northern Marianas Islands. They consist of small vessels (3 - 20 m in length) using mainly longline, handline and troll fishing gears.

The majority of the small-scale fishery catches are made in the coastal waters of Hawaii. Hawaii's fishery probably started in the 1930s, but landings were first recorded officially in 1954. Yellowfin tuna landings increased from 140 t in 1956 to a peak of 1,800 t in 1988 before decreasing slightly to 1,700 t in 1990. Landings for American Samoa, Guam and the Northern Marianas have been as high as 80 t per year between 1979 and 1989. The average small-scale fishery landings for the 1980-90 period was 1,400 t. In the future, landings are expected to remain relatively steady at current levels with moderate increases for the Hawaiian fishery.

4.0. REVIEW OF CPUE INDICES (WPYRG2/8, 11, and 12)

Several studies have examined yellowfin tuna catch rates for the central and western Pacific longline and purse-seine fisheries. These studies calculated catch rates by various methods, ranging from simple ratios of total catch divided by total fishing effort, to average catch rates by area and season (e.g., Honma's method), and multi-variate analyses (e.g., general linear model).

Analyses of purse-seine data show either no temporal trend in catch rates or slight increases. Japanese longline data show a steep decline from the early 1950s to the mid-1970s with no consistent trend since then. There has been no recent analysis using available data and the general linear model. Also, there has been no recent study to examine catch rates for pole-and-line or artisanal fisheries.

The Group discussed sources of data for CPUE analyses and made a list of available data (Table 2). This list includes only holdings that are currently available for use by workshop members, including fisheries in which yellowfin tuna is the target species or in which yellowfin tuna makes up more than 20% of the total catch, and for fisheries that cover a time period of four or more years.

4.1. Constraints

Major problems arise in interpreting catch rates (catch-per-unit effort [CPUE] indices) as measures of relative abundance of yellowfin tuna from both the longline and purse-seine fisheries. For longline fisheries data, the major concern is the relationship between the portion of the stock vulnerable to longline gear and the total stock. Longline catch rates for yellowfin tuna typically decline sharply during the early period of the fishery before leveling off, suggesting a rapid and substantial reduction in total stock abundance. Development of a purse-seine fishery after this point of leveling off, however, typically results in high purse- seine catch rates and large catches that exceed the peak annual longline catch. Results such as these have not been reconciled with respect to measuring abundance.

A major concern with purse-seine fisheries data is that no simple relationship exists between a day of fishing--the common measure of effort--and the actual searching and harvesting behavior of the fishermen. These can result in a non-linear relationship between CPUE and abundance.

For both longline and purse-seine CPUE indices, it is critical to standardize the indices to account for factors (other than abundance) that affect catch rates or to properly stratify the data used to compute CPUE indices. This could correct some of the non-linearity effects noted above.

CPUE indices can be used to obtain at least three different types of information:

(1) time series of relative abundance for the portion of the stock vulnerable to the gear used;

(2) time series of relative abundance for the recruited portion of the stock; and

(3) time series of relative abundance for particular age/size classes.

For (1), simple catch rates may be sufficient. But even here, inconsistencies in catch rates for the same years between gears such as purse-seine and longline make interpretation difficult. For (2), it is essential that catch rates are standardized, preferably within the context of a statistical model and for the entire time series in order to detect changes in trend. For (3), sufficiently detailed spatial, temporal and length/age data need to be available, preferably for individual fishing operations. Such data are not currently available and need to be collected with well-designed and managed observer programs.

Besides abundance, many other factors can affect catch rates, including fishing area, season, vessel characteristics, fleet characteristics, technological improvements, environmental factors (e.g., El Niño), targeting, access arrangements, fishing mode (e.g., deep or regular longline sets) and, for purse seining, the presence or absence of skipjack tuna. These factors should be considered when standardizing effort.

General linear modeling approaches are preferable for deriving standardized catch rates, yet such approaches require extensive data and analyses. Difficulties with these approaches may arise because results can be sensitive to zero catches. Furthermore, if significant interactions exist among the terms in the model, including year effect, interpretation of the temporal trends is difficult. It is also important, though often difficult, to determine the correct variance and covariance structure and degrees of freedom for the parameters of the model. Often, all individual fishing operations are considered independent and this results in inflated degrees of freedom being used for testing significance of differences among variables.

4.2. Further Work

While general linear modelling approaches can be used to some extent with aggregated data, the analyses are best performed with data from individual fishing operations. Two primary sources of such data for western Pacific yellowfin tuna are logbook data held by the SPC and by the National Research Institute of Far Seas Fisheries (NRIFSF). These two data sources overlap to some extent, but the SPC data are more comprehensive in diversity of fleets and fisheries, whereas the NRIFSF data cover a wider geographic area and a longer time period for Japanese vessels (Table 2). Furthermore, detailed logbook data exist for the other fleets, such as Korean, Taiwanese and the United States', covering a wide geographic area, but availability of the detailed data is unclear. The complexity of these data and the time required for analyses require that the work plan for future work be developed carefully (see Section 10.3).

5.0. REVIEW OF STOCK STRUCTURE (WPYRG2/7)

Previous work on the stock structure of Pacific yellowfin tuna, mostly carried out before 1980, has provided little evidence for the existence of discrete genetic structure. This is not surprising given the ecological characteristics of yellowfin tuna.

The available data (Table 3) indicate that some form of stock structuring (defined here in functional terms) is present and that Pacific yellowfin tuna should not be regarded as a unit stock. Structure may involve size-by-area (demographic) effects in addition to isolation-by-distance effects at one or more life- history stages. However, until more information is available on size composition of the yellowfin tuna population by area, stock structure can best be incorporated into assessments by defining large-scale geographical units in which the exchange rates between units are likely to be small (i.e., limited mixing). In the immediate future, tagging data appear to be the most likely source for improved estimates of exchange rates (Table 3).

6.0. REVIEW OF AGE AND GROWTH (WPYRG2/4)

Age and growth, although often discussed together, are separate components that have different uses in stock assessments. Age determination is essential for assessment techniques such as virtual population analysis and cohort analysis, which use age-specific information to reconstruct the population. Growth information, on the other hand, is essential for estimating biological production in models of the yield-per-recruit type, but is not essential for population reconstruction techniques if ages of fish are available.

6.1. Growth Estimates

Age and growth studies on central and western Pacific yellowfin tuna are summarized in Table 4. The studies are of two types: those based on hard parts and those based on length-frequency analyses. They describe similar growth patterns and average growth rates for western Pacific yellowfin tuna (Table 5). Missing from Table 4 are tagging studies, another common source for information on growth.

There have been only a few successfully executed tagging programs for yellowfin tuna in the western Pacific. The SPC, in particular, has had well-planned and executed tagging programs that resulted in reliable data, particularly size measurements at release and recapture, for growth analysis. Data on several thousand returns of yellowfin tuna are available, and more are expected from current tagging efforts. These data are being held by the SPC and have not yet been fully analyzed. Also, otoliths, including those from tetracycline-injected fish, are held by the SPC. The SPC is urged to carry out a comprehensive analysis of the data and samples for age and growth information.

6.2. Age Determination

There are few direct ways to determine the age of yellowfin tuna reliably. Of the studies conducted so far, reading of otolith marks appears to be the most promising technique. However, the technique is tedious and slow. It needs further development in order to speed the processing and to enhance the capability to age large numbers of fish on a routine basis.

Lacking this age-determination capability, growth curves and age-length keys have, so far, been used instead to determine the ages of yellowfin tuna from lengths. These techniques are inherently biased for particularly large fish even if the population age distribution is stable from one period to another (Figure 3). Some improvement to these techniques can be made by constructing and using an age-at-size (as opposed to a size-at-age) relationship. However, such a relationship still contains some biases and is specific to one age distribution only. If the population age distribution is different from that represented by the relationship because of changes due to variable recruitment, growth, or mortality, then it can result in gross inaccuracies. The use of growth models combined with size data is, therefore, not a satisfactory method for estimating age distributions of the catch. Rather, it is necessary to routinely determine the ages of fish in the catch directly from hard parts.

6.3. Further Work

Because there is currently no rapid and easy way to age yellowfin tuna on a routine basis, more robust stock assessment models must be used in assessing the condition of the yellowfin tuna stock. Initially, models that make use of broad age classes, particularly for older yellowfin tuna, should be used to reconstruct the population. Otolith collections held by the SPC should also be processed to determine the proportion of ages involved in length-frequency modes and to test the procedure of using broad age classes and for verifying age marks with tetracycline labeled otoliths.

7.0. REVIEW OF REPRODUCTIVE BIOLOGY (WPYRG2/13)

Studies on the reproductive biology of yellowfin tuna were reviewed for information on seasonality of spawning, length at first maturity, spawning periodicity, and sex ratio.

7.1. Seasonality of Spawning

In general, yellowfin tuna spawn throughout the year in equatorial waters and during spring-summer in higher latitudes (Table 6). Several variations on this pattern are of interest. The first is apparent bimodal spawning peaks, probably related to transition periods between the monsoon seasons, in the Philippines region north of 10° N. The second variation is apparent differences in peak spawning activity in the equatorial regions (Figure 4): November-April in the western equatorial region (10° N - 5° S, 130° - 170° E) and March-September in the central equatorial region (10° N - 10° S, 180° - 120° W). Thus, peak spawning activity apparently occurs at complementary times in the WPYF areas 3, 4, and 5.

Fishing on free-swimming schools in each region appears to be correlated with this spawning activity. The highest proportion of purse-seine sets on free-swimming schools in the western region (Japanese vessels) occurs in January and February. The highest CPUE from fish free-swimming (but not log-set) schools in the central region (U.S. vessels) is in August and September.

7.2. Length at Maturity

Some studies suggest that female yellowfin tuna may reach maturity as small as 57 cm fork length (FL), but these have not been based on histological studies. The smallest mature yellowfin tuna yet determined with histological analysis is 84 cm FL from the eastern tropical Pacific. Gonadosomatic studies of longline-caught fish suggest that the majority of fish in the longline fishery may not reach maturity until 110-120 cm FL. Histological studies of yellowfin tuna in the western Coral Sea found 50% of yellowfin tuna examined mature at 120 cm FL in the longline fishery and at 108 cm FL in the handline fishery. These results suggest that yellowfin tuna in the surface fisheries are "more mature" than those in the longline fishery. It has further been suggested that yellowfin tuna in coastal waters may reach maturity at a smaller average size than those elsewhere.

7.3. Spawning Periodicity

Only recently has it become possible to measure the frequency of spawning of individual yellowfin tuna using histological examination of post-ovulatory follicles. These data indicate that yellowfin tuna spawn every 1-2 days (Table 7). It is not known whether individual yellowfin tuna keep spawning throughout the season (or year!). Spawning frequency in fish taken by the Japanese handline fishery in the Coral Sea over a 28-day period increased from 1.89 to 1.14 days. This increase was significantly correlated with surface water temperature that rose from 25.5 to 27.5° C. Yellowfin tuna probably spawn during the afternoon and night. The spawning fraction (number of mature yellowfin tuna with post-ovulatory follicles) probably increases with length of fish.

7.4. Sex Ratio

Sex ratios for longline-caught yellowfin tuna are consistently 1:1 until fish reach approximately 120 cm FL, after which male yellowfin tuna predominate (Table 8). There has, however, been no rigorous assessment of spatial or temporal variability in the sex ratio in the western and central Pacific of fish caught in the longline fishery. Neither has sex ratio been systematically analyzed for fish caught in the surface fisheries and in the same areas fished by the longline fisheries. The fate of female yellowfin tuna at around 120 cm FL or larger is not clear. The conventional opinion is that the high physiological demand of spawning takes its toll on the females before they reach a large size; hence, high natural mortality rather than reduction or cessation of growth is likely the cause for the skewed sex ratio.

7.5. Further Work

Yellowfin tuna caught in surface fisheries appear to mature at a smaller size, and mature-sized fish spawn in greater proportion than fish caught in the longline fisheries. Little is known about sex- and spawning-dependent dynamics in yellowfin tuna. Whether yellowfin tuna in spawning condition are more vulnerable to surface fisheries than at other times is not clear. Also, whether these mature surface fish are less vulnerable at other times to longline gear is still uncertain and requires investigation.

The behavioral differences of yellowfin tuna caught by the surface and longline fisheries remain unclear. Because of the lack of age data, size-dependent and age-dependent reproductive behavior cannot be distinguished from existing data. Hence, there is uncertainty as to whether yellowfin tuna that mature at a small size in inshore waters are early developers or slow growers and whether yellowfin tuna in the longline catch that reach maturity at larger sizes are slow developers or fast growers. These topics need to be studied with a comprehensively designed plan that includes both aging and sexing of each fish and with concurrent analyses of the reproductive status of fish caught by a range of sampling techniques in the same area.

The relative contribution of different parts of the stock- to-egg production and the production of recruits is entirely unknown. Some outstanding questions include whether spawning frequency and seasonal differences exist between unassociated and associated schools and between coastal and offshore schools; whether yellowfin tuna that have longer spawning seasons spawn less frequently than those with a shorter season; and whether tuna that spawn close to islands or other highly productive areas contribute a disproportionate amount to reproductive success than those that spawn on the high-seas.

8.0. REVIEW OF MORTALITY RATES (WPYRG2/6)

Studies on natural mortality rate of yellowfin tuna are summarized in Table 9. The results indicate four categories of methods to estimate the natural mortality rate:

(1) catch curve analysis, which depends on many assumptions, some of which are likely to be violated;

(2) integrated stock analysis methods, which do not require as many restrictive assumptions as catch curve analysis and can estimate other parameters as well as natural mortality although they demand more data, such as catch-at-length;

(3) tagging methods, which are perhaps the most promising;

(4) life-history methods, which can give preliminary estimates.

All methods have potential problems in distinguishing natural mortality from other components of total mortality or phenomena that are confounded with natural mortality (e.g., emigration).

Estimates of instantaneous natural mortality rate (*M*) for yellowfin tuna in the Pacific (both east and west) range from 0.3 to 2.5 a year. An estimate from preliminary analysis of SPC tag data (WPYRG2/2) is 1.07 a year (95% confidence interval of 0.92 to 1.22). This estimate is confounded with emigration, though probably only to a minor extent.

Future analyses should investigate the possibility of natural mortality varying with age or size or with location, thus requiring models with size, age, and/or spatial structure. An integrated approach being developed at SPC for South Pacific albacore might be applied to estimating *M* for yellowfin tuna although current technical difficulties with yellowfin tuna catch-at-size data for the western Pacific (see Section 9.5) may not warrant such an analysis. Nonetheless, the SPC tag-recapture data should be analyzed further for information on natural mortality rates for yellowfin tuna.

9.0. REVIEW OF FISHERIES DATA BASE FOR AGE-STRUCTURED MODEL

Several months before the workshop, Data Correspondents who were familiar with major yellowfin tuna fisheries in the western Pacific provided catch, effort, and length-frequency data for the WPYRG data base. These data were for constructing a time series of yellowfin tuna catches by size for 1970-1990. Correspondents from Australia, Fiji, Indonesia, Japan, New Caledonia, New Zealand, the Philippines, Republic of China (Taiwan), and the United States provided data. Data were also provided by the SPC for fisheries in Palau, Papua New Guinea, Solomon Islands, and Tonga.

Table 10 contains an inventory of data assembled for the WPYRG data base. Data Correspondents provided four types of data for each of their assigned fisheries: annual catches of yellowfin tuna and number of vessels by fishing method (WPYRG Form C); catches by WPYF area, month and set type (WPYRG Form E) or without set type (WPYRG Form D); and length-frequency data by WPYF area and month (WPYRG Form L-F).

While most of the data had been compiled before the meeting and were ready to be used to construct a time series of catch-at-size, several issues highlighted by the Group indicated that further work on the data base was necessary:

- Korean longline -- Data by 5° square and month are available from publications by the National Fisheries Research and Development Agency (NFRDA) with catches reported in numbers of fish. When catches are converted to metric tons using annual coverage rates and year-specific mean weights (kg), the results are inconsistent with other estimates of annual yellowfin tuna catches published by NFRDA. This inconsistency may be the result of small errors in estimated mean weight, but this source could not be verified as the source. Nevertheless, the 5° square-month data were used to prorate the annual yellowfin tuna catch for the Korean longline fishery into catches by quarter and WPYF area.

- Taiwanese longline -- Catch data provided by the National Taiwan University are complete for small (<50 GRT) Taiwan-based vessels. But, for small vessels operating and based within the SPC region (Guam, Koror, Majuro, Pohnpei, and Yap) since 1987, data are incomplete and limited to some statistics on transshipments. Catch and effort data are also available but only for vessels based in Taiwan and in American Samoa.

- Japanese longline -- Catch data provided by the National Research Institute of Far Seas Fisheries do not include data from small vessels (<50 GRT) based in Guam since 1987 and based, more recently, in Koror and Pohnpei. Problems were also noted in the length-frequency data, namely that (1) quantities of small fish (<20 cm), much smaller than normally caught with this gear, were reported for some years, and that (2) length-frequency samples were aggregated into 10° x 20° blocks, some which cross different WPYF areas. The original data need to be reviewed and appropriate corrections made where possible.

- Japanese purse-seine -- Length-frequency data were aggregated and labeled WPYF area 4. Since the fishery operates in both areas 3 and 4, the data need to be recompiled and separated by area.

- Transshipments -- Available statistics may be useful in estimating missing catches for small vessels not covered by the Correspondents or other sources.

- Joint venture or charter vessels -- Data for these vessels are often not included in the flag country statistics. Correspondents were asked to make sure that they identify and include data for these vessels in their submissions and that proper procedures be used to prevent duplication (double counting).

- Artisanal fisheries -- NMFS provided data for small-scale commercial and subsistence fisheries in Hawaii, Guam, and the Northern Marianas. Data for similar subsistence and small-scale commercial and sport fisheries in other western Pacific areas were not available. A rough estimate of the annual catch for these missing fisheries is 3,000 t per year.

- Papua New Guinea pole-and-line -- Length-frequency data for pole-and-line vessels active in Papua New Guinea during 1970–1981 are not in hand and need to be obtained from the Papua New Guinea, Department of Fisheries and Marine Resources (DFMR).

At the first meeting of the WPYRG, it was agreed that fleet-specific catch, effort, and length-frequency data provided by Data Correspondents would be destroyed when the region-wide catch-at-length data base had been constructed. If the original data base were destroyed, however, it would be time-consuming to reproduce if needed in the future.

Because the inventory of data indicated the need for substantial revision of some parts of the data base already created, and because additional data could be secured after the meeting, participants unanimously agreed that the original, confidential fleet-specific data would be held by NMFS and would not be destroyed until six months after the meeting. The Data Correspondents concerned were urged to provide their revised data before the six-month deadline elapses, after which the final version of the catch-at-length data base will be established.

To minimize the work that would be necessary if the need should arise to recreate the data base from the fleet-specific data, the Group agreed that NMFS will return copies of the original data to each Data Correspondent with instructions to store it safely and preserve it. The copies shall be in a format in which the fleet-specific data base could be easily recreated if necessary in the future.

After the original data are destroyed, NMFS agreed to maintain data base software to facilitate re-creation of the fleet-specific data base and to reproduce the region-wide data base if necessary.

9.1. Stratification Procedure

Yellowfin tuna fisheries of the western Pacific are diverse and unique even when different fisheries use the same gear. Stratification procedures were, therefore, developed to account for major differences and to attempt to preserve unique characteristics of the different fisheries.

9.1.1. Set or School Type

Set type was found to have unique characteristics in purse-seine data. Sizes of yellowfin tuna in floating object (i.e. "log") sets, for example, are generally smaller than yellowfin tuna caught in free-swimming schools (i.e., "school" sets) (Figure 5). Also, log sets are predominately a mixture of yellowfin tuna, bigeye tuna, and skipjack tuna whereas school sets are principally of single species. Because log and school sets are the predominant set types in the western Pacific purse-seine fisheries, only two categories were designated for purse-seine set-type: "associated sets" or sets on schools associated with logs--such as FADs and large marine animals--and "unassociated sets" or sets on free-swimming schools.

Different set types (e.g., "regular" and "deep") are recognized in longline fishing. However, sufficient data to determine whether there are significant differences between these set types were not available. Limited studies so far indicate only small differences in sizes of yellowfin tuna caught by the two set types. Consequently, set type was not considered for stratifying the longline data.

Data on school type fished by pole-and-line vessels were not available to evaluate the significance of school type. However, it was felt that the operational procedure used by pole-and-line vessels makes school typing inappropriate. School type, therefore, was not used in stratifying pole-and-line data.

9.1.2. WPYF Area

Each fishery in the study area has unique areas of operation and does not spread fishing effort evenly throughout the study area. The study area was therefore stratified into smaller units for compiling fishery statistics for the WPYRG data base. Seven statistical areas (Figure 1) were established with boundaries based primarily on historical concentrations of fishing effort by the surface fishery.

9.1.3. Time

Catch and length-frequency samples were stratified by WPYF area and quarter, rather than month, because of data constraints. The biggest constraint is in longline length-frequency samples that are too few and small for stratifying on a monthly basis. Hence, they were aggregated into larger time periods to improve sample size and to account for imprecisions in the area and time of capture of sampled fish. Quarterly aggregation was felt to adequately correct these shortcomings in the longline data.

For other fisheries, however, where stratification by month was possible, this was done and all computations were performed using monthly data. The monthly results were then pooled on a quarterly basis and made comparable to other data in the base. Quarters used are as follows: January-March, April-June, July-September, and October-December.

9.2. Estimation Procedure for Annual Catch

Tables 11-14 contain annual yellowfin tuna catches in weight by fishery, 1970-1990, as estimated by the Group. Number of vessels in each fishery was also estimated (Tables 15-17). The following points are important in considering these estimates:

- References for data sources were recorded in order to minimize confusion and to allow verification if required at a later date. Some data were derived from logbooks, which contain daily catches (in some cases, at-sea estimates) and were reported by national agencies. Others were from landings reported by countries or from statistics published by the Food and Agriculture Organization (FAO). The FAO statistics do not indicate the original sources. A third category of data is from the SPC. The SPC statistics are derived from an assortment of published and unpublished reports and communications.

- Published national statistics do not specify whether catches by vessels operating under access agreements or under charter are included. The Group compared reports/statistics and endeavored to eliminate instances of double-counting (Table 2). In particular, FAO statistics for Kiribati, which appear to include catches by foreign fleets, were corrected by using statistics for only the Kiribati domestic pole-and-line fleet (WPYRG2/2).

- Reported catches for the Philippines, 1970-77 and 1988-90, were available for all gears combined (i.e., unclassified by gear type). These catches were prorated into catch by gear type (purse-seine and ringnet, pole-and-line, longline, and others) using data from years when catches were recorded by gear types. The ratio of average catch by gear type to average total catch for 1978 and 1979 was used to prorate unclassified catches for 1970-77. Similarly, data for 1986-87 were used to prorate unclassified catches for 1986-87 (Tables 11 - 12, and 14). Note in Table 12 that purse-seine catches include both purse-seine and ringnet catches combined.

9.2.1. Dressed Weight to Round Weight

Some reported catches were in gilled-and-gutted weight, or dressed weight. To make these catches comparable to other statistics in the WPYRG data base, they were converted to round weight by multiplying gilled-and-gutted weight by a constant, 1.15. This ratio was derived by averaging size-specific conversion factors in the literature over size classes of yellowfin tuna. Independent analysis of data from 939 yellowfin tuna taken off eastern Australia produced the following relation:

$$\text{Round weight (kg)} = 1.27 + 1.12 * \text{Gilled-and-gutted weight (kg)}$$

Round weight of longline-caught fish estimated with this relationship was quite similar to the round weight estimated by multiplying gilled-and-gutted weight by 1.15. However, this ratio tends to produce a more pronounced bias in an estimate than with the above relationship, i.e., underestimate round weight when fish are small and overestimate round weight when fish are large.

9.2.2. Catch in Weight to Catch in Numbers

Numbers of fish caught is required for reconstructing the population structure of yellowfin tuna. Catch statistics, however, are frequently reported in weight. The exception are some longline fisheries, such as for Japan and Korea, in which numbers of fish caught are recorded and the statistics made available.

For fisheries, such as those using purse-seine gear, in which the catch is routinely recorded in weight, the weight must be converted to numbers of fish caught. The estimation procedure adopted by the Group for this conversion essentially involves dividing the total catch in weight by an average weight of fish in the catch (Appendix 4). The average weight is computed from length-frequency samples and a length-weight relationship. The estimated numbers of fish caught could then be apportioned to sizes using the length-frequency (Appendix 4).

For this procedure to provide reliable estimates, adequate and representative length-frequency samples must be available as well as a representative length-weight relationship. An evaluation of adequacy of length-frequency samples will be undertaken by the Group before the next meeting (see Section 10.1). A review of length-weight relationships (WPYRG2/14; Table 18) showed statistically significant differences in relationships among areas, seasons, sexes, years, and fishing methods. Further analysis of the length-weight relationship was, therefore, recommended and a task group was established to undertake the analysis (see Section 10.2).

In the meantime, the length-weight relationship of Nakamura & Uchiyama (1966), derived from 4,822 yellowfin tuna (70-180 cm FL) caught in the central Pacific, was used:

$$\text{Round weight (kg)} = 3.2560 \times 10^{-5} * \text{Fork length}^{3.05834} \text{ (cm)},$$

9.3. Substitution Procedure

Collection of representative length-frequency samples to accurately describe the size composition of the catch by fisheries is a necessary component of a fishery statistical collection program. However, it has not been followed by all agencies responsible for collecting statistics from western Pacific yellowfin tuna fisheries, and consequently, length-frequency samples are missing from a number of fisheries that represent a sizeable catch for 1970-90 (Figure 6). For example, prior to 1981 there are no samples from the major purse-seine catches and since 1980, the coverage averaged 35% - 50% of the annual total catch solely because of sampling programs initiated for the Japanese and U.S. fisheries. (Additional samples from the Philippine fisheries were made available to the Group, but were received too late to be included in this analysis.) For longline catches, the sample coverage for 1970-90 averaged about 55%. For other gear catches, no samples are currently available.

The Group noted that the longline coverage rates, and possibly the purse-seine coverage rates as well, are probably maxima and actually lower if adequacy of sample size and quality of samples are considered. Some samples for other gears, although currently not in the WPYRG data base, likely reside in agencies' files (e.g., SPC and NRIFSF) and need to be retrieved. The Group also identified pole-and-line samples from tagging cruises that need to be secured.

With the incomplete sampling coverage, reconstruction of many of the population structures is impossible without the use of many assumptions and a substitution procedure. The Group adopted a substitution procedure that is described in Appendix 5. It basically involves taking length-frequency samples collected from one time-area-gear stratum and substituting them for another time-area-gear stratum in which there was a catch but no length-frequency sample collected.

The basis for this procedure is primarily to preserve time differences for age determination of catches. Experience with similar substitution procedures for yellowfin tuna in other oceans has shown this procedure to be important. However, the Group felt that a more vigorous statistical analysis of the substitution procedure is required and should be conducted for the next meeting now that additional data have been made available.

9.4. Test Runs

The substitution procedure was executed with data on hand to estimate catch-at-length for 1970-90, but only selected years, representing high and low sample coverage years for purse-seine and longline catches, are presented in this report. Specifics on how the procedure was applied are in Appendix 6. This execution was performed primarily to test the WPYRG data base and computer computational system. The results are preliminary.

The results for purse-seine catches (Figure 7) indicate the smoothing-out of the size distribution and more precise location of modes as sample coverage improved. The results for longline catches (Figure 8) indicate unexpected numbers of small fish (<40 cm FL), which need to be verified.

9.5. Further Work

After reviewing the test runs and taking note of the large amount of substitutions (particularly across years and fleets) and concerns about the quality of the available data, the Group concluded that the information content in the catch-at-length data base, even after all available data are included, was insufficient for use with traditional age-based methods for assessments. The Group strongly recommended that a stock assessment not be conducted with the current data base (including any revised versions produced in the following six months [see Section 10.1]) and age-based assessment methods. However, the Group recommended that the building of a reliable WPYRG data base be continued and given high priority as (1) a tool for evaluating developments in the fisheries and identifying where sampling improvements are needed, and (2) for eventual use with age-based methods for assessments when the information content is sufficient. This latter point requires the commitment of agencies to improve their programs for collection of fishery statistics (see Section 10.1).

Finer stratification, including area, month, gear type, and vessel nationality of the catch-at-length data base, can be incorporated and would be useful for some types of analyses. However, further stratification than currently is configured for the WPYRG data base would conflict with data confidentiality agreements in some cases. Exceptions are possible, if data contributors agree to release finer stratified data. For example, a substantial fishery in the Philippines is conducted with small purse-seine gear that is called ring net. It would be useful to keep data for this gear type separate from data on regular purse-seine gear, but this would compromise confidentiality of vessel nationality. Because such data have been released by the Philippine government in the past, it was agreed that this data set can be held in the data base as *ring net* rather than aggregated with all purse-seine data.

A proposal that was made at the fifth meeting of the Standing Committee on Tuna and Billfish was to reduce inefficiencies in securing data and in maintaining data bases such as those needed for the WPYRG and SCTB by consolidating them. Because the long-term status of the WPYRG data base had not yet been resolved, it was felt that it was premature to make a decision regarding incorporation of the WPYRG data base into the Standing Committee data base or into a formal data submission system. The long-term status of the WPYRG data base will depend on the resolution of concerns for confidentiality and on the necessity of using the WPYRG data base for ongoing and proposed research. These issues will be discussed at the next meeting of the WPYRG.

10.0. FUTURE DIRECTIONS AND PRIORITIES

The Group discussed future directions for research and identified topics requiring attention. There was unanimous consensus that near-term and long-term activities need attention and need to be executed concurrently in order to achieve the goal of the Group as well as to provide information that will allow for more precise advice to be given in the future. The specific needs are listed in sections 10.1, 10.2, and 10.3 below.

10.1. Fisheries Data Base

Collection and processing of fisheries statistics for the WPYRG data base are priority activities and require dedicated attention by WPYRG participants as well as by fisheries administrators of interested countries. Continued long-term and near-term needs are as follows:

(1) Continuation of the compilation, review, evaluation, and exchange of fisheries data that will assist in achieving the objectives of the Group. This activity would continue the development of the data base initiated during the past year and would also include studies to refine or upgrade the quality of data for individual fishing fleets (e.g., Taiwanese purse seine) and for identifying where improvements are needed (e.g., Korean fisheries). The data base would provide a general reference for Group members to monitor fishery trends and to assist in the planning of further research.

(2) Promotion of the requirement of collecting length-frequency samples from all fisheries landing yellowfin tuna. Length-frequency data are just as essential as catch and effort data for monitoring and assessing fisheries. Collection should be at landing ports or aboard vessels by trained technicians, and priority should be given to fleets that are currently not sampled or inadequately sampled (Table 10).

(3) Completion of the following assignments by January 1993 and submission of the results to the Data Base Coordinator, Al Coan:

- Provide detailed information on length-frequency sample coverage (see example in Table 19) -- Coan, Ganaden, Tsuji, Ward; coordinated by Coan.
- Review and report on how catches by foreign vessels or domestic vessels operating under joint venture or charter agreements are treated in reported annual catch estimates -- Lawson, Murray, Rechebei, Sun, Ward; coordinated by Lawson.
- Keypunch and incorporate Philippine length-frequency data into base -- Coan.

- Incorporate set type information for Korea and Taiwan purse-seine fisheries into base -- Coan & Lawson.

- Stratify Japan purse-seine data into WPYF areas 3 and 4 -- Coan & Tsuji.

(4) Completion and reporting at the next meeting (1993) on the following assignments:

- Investigate effects of various substitution schemes across areas and time for Japan longline data -- Tsuji; for U.S. purse seine-data -- Coan.

- Verify catch of small yellowfin tuna (<40 cm FL) appearing in Japanese longline length-frequencies -- Tsuji.

10.2. Biological Studies

Understanding various biological phenomena and being able to accurately estimate biological parameters are critical near-term and long-term stock assessment needs. Specific long-term studies follow:

(1) Investigate factors affecting the vertical distribution and movements of large yellowfin tuna and their effects on vulnerability to purse-seine and longline gears. This knowledge is probably the key to understanding the interaction (if any) between purse-seine and longline fisheries.

(2) Develop a tool for rapidly and reliably determining the age of yellowfin tuna in the catch for routine use. Accurate estimation of the age composition of the catch is critical for producing reliable information from age-structured assessment models.

(3) Improve information on the reproductive biology, particularly the geographical, vertical, and temporal distribution of spawning activity and sex ratio. Improved knowledge would greatly assist in the understanding of recruitment patterns as well as answer outstanding questions identified in Section 7.0.

For the near term, the following biological studies were recommended:

- Complete analysis of growth using tag-recapture data held by the SPC -- SPC.

- Process otolith samples collected by the SPC for age determination -- SPC.

- Create a length-weight data base to facilitate analysis of the effects of various factors on the length-weight relationship and report results at the next meeting (1993) -- Ward. Possible sources of data included the Bureau of Rural Resources (cooperating scientist - Ward), National Marine Fisheries Service (Boggs and Coan), National Taiwan University (Sun), and South Pacific Commission (Hampton). Data collected by Japanese scientists for past studies may not be available, but this needs to be verified (Tsuji).

10.3. Assessment Studies

Stock assessment studies are the building blocks for scientific advice for management decisions. The Group concluded that priority should be given to assessing the current condition of the stock and to estimating the potential yield. The types of studies recommended are as follows. Those listed under (2) should receive priority.

(1) Over the long term, one objective should be the design of an integrated assessment model to fit the available tagging data and to fine-scale catch, effort, and size composition data that are currently held by various research organizations represented in the Group - in other words, the objective is to develop an assessment model, ideally with spatial structure, that could be used to investigate the effects of various levels and patterns of fishing on the yellowfin population (including local depletion) and on the fisheries themselves. This activity might be undertaken by a small group of experts (e.g., from NMFS, SPC, NRIFSF and CSIRO) utilizing, in the first instance, artificial data of the same structure that might eventually be available for analysis. After development and testing, the analysis of real data with the model would take place in a workshop setting. Probably no exchange of data would be necessary for this step and the results of the analysis would be presented in a form that would protect data confidentiality.

(2) With respect to the immediate future, priority should be given to undertaking analyses of existing data by various members to provide broad-scale stock assessment advice (e.g., current status of the stock and estimate of potential yield) to fisheries management agencies. To this end, the Group felt that a tagging-based stock assessment and CPUE-based analysis of abundance appear most promising. Activities listed below would be given priority and results presented for review by the next meeting (1993):

- Conduct further analysis of the SPC tag-return data for a tagging-based stock assessment. This activity is already well advanced and would be completed by Hampton.

- Perform further analysis of purse-seine CPUE and longline CPUE data for developing abundance indices and for determining trends in abundance. Data for this analysis are currently available and held by individual agencies. Some pieces of the data, however, are confidential and are not available to non-agency scientists. Hence, this work must be executed by agency scientists -- Lawson, Kleiber, and Tsuji for analysis of purse-seine data, and Tsuji for analysis of Japanese longline data -- and should follow guidelines described in Section 4.0

11.0. ADMINISTRATIVE MATTERS

A draft workshop report was reviewed by the Group and tentatively approved. It was agreed that the participants would have another chance to review the report and submit comments by mail before a final report is prepared.

The Group discussed the objectives for the third meeting (1993) and the computer needs for that meeting. The chairman noted that participants from the Federated States of Micronesia had offered to host the next meeting and details are being explored with the SPC. The venue, date, and chairperson for the next meeting were, therefore, left to be announced at a later date. In the meantime, the chairman agreed to continue coordination of assignments.

The chairman thanked the participants for contributing to a successful meeting and wished them a safe return trip. He also extended a special thanks to the rapporteurs and session moderators for assisting in the meeting and in writing the report; to the NMFS La Jolla staff for the technical and clerical support; to the WPRFMC (K. Simonds) for contributions to the social events; and to the East-West Center staff for the meeting facility and support.

Table 1. Summary of major longline, purse-seine and pole-and-line tuna fisheries for yellowfin tuna in the western Pacific Ocean. Several fisheries taking small amounts of yellowfin tuna, such as artisanal handline or pole-and-line, are not included.

Country	Year Commenced	No. of Boats	Target Species[1]	Largest	Yellowfin tuna catch(t) Avg.	1991	Trend
Longline Fishery							
Australia	1954	70	YFT, BET, SWO	1,132	617	506	increasing
Federated States of Micronesia	1991	2	YFT, BET	-	-	6	increasing
Fiji	1989	8	ALB, BET, YFT	-	-	101	stable
Indonesia	1952	151	YFT, BET	9,717	5,170	5,500	increasing
Japan	1952	-	BET, SBF, YFT	59,000	27,000	25,600	stable
Korea	1958	200	BET, YFT, ALB	21,000	8,000	7,966	stable
New Caledonia	-	-	ALB	-	-	600	stable
Philippines	1980	62	YFT, BET	3,785	1,436	?	declining
Solomon Islands	1973	2	YFT, BET	564	287	0	ceased in 1986
Taiwan							
(distant water)	1963	96	ALB	9,042	1,200	800	stable
(offshore)	1950	800	YFT	22,629	13,069	5,838	declining
Purse-Seine Fishery							
Australia	1987	9	SKJ, YFT	1,040	-	2,300	declining
Federated States of Micronesia	1991	2	SKJ, YFT	-	-	238	increasing

Table 1. (Continued)

Country	Year Commenced	No. of Boots	Target Species[1]	Largest	Yellowfin tuna catch(t) Avg.	1991	Trend
Purse-Seine Fishery (continued)							
Indonesia	1980	3	SKJ	2,665	2,070	2,665	increasing
Japan	1967	38	SKJ, YFT	48,000	40,000	44,600	stable
Korea	1980	37	SKJ, YFT	48,500	35,000	48,500	increasing
Philippines							
(standard)	1962	289	various	22,989	14,244	{95,614}	stable
(ringnet)	1975	524	various	4,838	2,567		declining
Russia	1985	4	SKJ, YFT	3,381	1,215	1,114	declining
Solomon Islands	1980	4	SKJ, YFT	4,410	2,741	3,300	increasing
Taiwan	1982	44	SKJ, YFT	16,640	5,606	16,640	increasing
United States	1976	41	SKJ, YFT	66,400	35,100	40,500	stable
Pole-and-Line Fishery							
Fiji	1976	10	SKJ	823	500	358	stable
French Polynesia	-	-	SKJ	-	-	165	declining
Indonesia	1940	900(?)	SKJ	4,433	2,800	4,433	increasing
Japan	1952	106(?)	SKJ	4,800	1,000	?	declining

Table 1. (Continued)

Country	Year Commenced	No. of Boats	Target Species[1]	Largest	Yellowfin tuna catch(t)		
					Avg.	1991	Trend
Pole-and-Line Fishery (cont.)							
Kiribati	1979	3	SKJ	588	300	?	declining
Solomon Islands	1971	35	SKJ	2,965	756	950	stable

[1] Species codes: ALB = albacore, BET = bigeye tuna, SKJ = skipjack tuna, SWO = swordfish, YFT = yellowfin tuna, SBF = southern bluefin tuna.

Table 2. Inventory of available time-series data (logbooks) for analysis of catch-per-unit of effort indices for yellowfin tuna of the central and western Pacific Ocean.

Country/Gear	Years	Depository
Regional Coverage		
Indonesia		
purse seine (outside EEZ)	1986-89	South Pacific Commission (SPC)
Japan		
longline	1970-90	National Research Institute of Far Seas Fisheries & SPC
purse seine	1975-90	National Research Institute of Far Seas Fisheries & SPC
Philippines		
purse seine (W. Pacific only)	1984-90	SPC
Taiwan		
longline	1970-90	National Taiwan University
purse seine	1983-90	National Taiwan University & SPC
United States		
purse seine	1984-90	SPC
Local Coverage		
Australia		
longline	1986-90	Fisheries Management Authority
Fiji		
pole-and-line	1970-90	Fisheries Division
French Polynesia		
pole-and-line	1979-90	Establissement Pour la Valorisation des Activites Aquacoles et Maritimes
New Caledonia		
longline	1983-90	Service de la Marine Marchande et des Pêches Maritimes

Table 2. (continued)

Country/Gear	Years	Depository
<u>Local Coverage</u> (continued)		
Papua, New Guinea		
pole-and-line	1970-81	SPC
Solomon Islands		
purse seine	1981-90	Fisheries Division
Tonga		
longline	1982-90	SPC

Table 3. Studies on stock structure of yellowfin tuna of the central and western Pacific Ocean (summarized from WPYRG2/7).

Method/Source[1]	Finding	Future Research Needs
Catch and Fish Size Data		
Suzuki, et al. (1978)	Possible discontinuity in longline catches 120° - 140° W); east-west cline in size of fish in central western Pacific	More complete length frequency data by area, all years
TBAP (1990)	East-west cline not clear in size of fish caught by purse seine	
Lawson (1992)	No break in distribution of purse-seine catches	
Spawning and Larval Data		
Suzuki et al. (1978)	Larvae widely distributed, with three possible high density areas	Examine spawning periodicity by area
Koido & Suzuki (1989)	No clear discontinuity in gonad indices; higher indices in surface fish than in longline-caught fish	
Population Parameters		
Suzuki (1991) and Hampton (WPYRG2/6)	No clear pattern in available estimates of growth, mortality, etc. (see comments above on Catch and Fish Size Data)	
Inherited (Genetic) Characters		
Suzuki et al. (1978)	Inconclusive since few Pacific-wide studies	
Anon. (1981)	If analogous to skipjack tuna, mixing negligible between longitudinal extremes within one generation	
Anon. (1981); Lewis (1981)	Some data show-east west clinal trends	

Table 3. (continued)

Method/Source[1]	Finding	Future Research Needs
Tagging Data		
Suzuki et al. (1978)	Limited movement out of eastern Pacific	Continuing analysis of RTTP data; making data from all sources available
Itano and Williams (1990); SSAP data	Significant movement for release in subtropics (up to 3,800 nm)	
Japanese data	Latitudinal movement of subadults (seasonal)	
RTTP data	Meridional movement of releases in tropical area and limited latitudinal latitudinal movement	
RTTP data	Easterly directed movement of larger fish (>90 cm at recapture) in the western tropical Pacific	
Acquired/Combined Origin Characters		
Royce (1964)[2]	East-west cline in morphometric characters across Pacific	Analysis of RTTP morphometric data collected in western and central tropical Pacific
Suzuki et al. (1978)	Wide dispersal of adults throughout much of western Pacific from a central Pacific location (radioisotope data)	
Schaefer (1989; 1991)	Separation of yellowfin from five areas (Mexico, Ecuador, Hawaii, Japan, Australia) with meristics and morphometric characters	

1 SSAP = Skipjack Survey and Assessment Programme (1977-80) of the SPC; RTTP = Regional Tuna Tagging Programme (1989-) of the SPC.

2 Royce, W.F. 1964. A morphometric study of yellowfin tuna Thunnus albacares (Bonnaterre). Fish.Bull., U.S. 63:395-443.

Table 4. Studies on age and growth and estimates of growth parameters (von Bertalanffy model) for yellowfin tuna of the central and western Pacific Ocean (from Suzuki 1991).

Area	Growth parameter K	L_∞ (cm)	t_0 (yr)	Fishing Gear	Sample Size	Method	Fork length Range (cm)	Source
Western	-	-	-	-	6	Vertebrae	-	Aikawa & Kato (1938)
	0.66	150	0.40	Longline	110,000	Length modes	80-150	Yabuta & Yukinawa (1959)
	0.33	190	0	Longline	1,000	Scales	70-140	Yabuta et al. (1960)
	-	-	-	Longline	170	Vertebrae	-	Tan et al. (1965)
	0.36	195	0.27	Longline	200	Scales	60-140	Yang et al. (1969)
Japan	-	-	-	Set net	200	Weight modes	100-120	Kimura (1932)
	0.55	168	0.35	Longline and pole-and-line	50,000	Length modes	30-150	Yabuta & Yukinawa (1957)
	-	215	-	Pole-and line	-	Length modes & scales	35-130	Yokota et al. (1961)
Philippines	0.25	189	-	Various	-	Length modes		White (1982)
Santa Cruz	0.25	189	-	"		"	20-60	"
Opol	0.20	169	-	"		"	20-70	"
General Santos	0.43	182	-	"		"	20-60	"
						"	90-150	"
Labuan	0.29	179	-	"		"	20-60	"

Table 4. (continued)

Area	Growth parameter K	L_∞ (cm)	t_0 (yr)	Fishing Gear	Sample Size	Method	Fork length Range (cm)	Source
Philippines (continued)								
Male	0.30	175	-	Various	-	Length modes	20-60	Yesaki (1983)
Female	0.32	173	-				120-160	
	-	148	0.42	-	-	Length modes	-	Ingles & Pauly (1984) (from Bayliff 1988)
	Linear segments			Ringnet	207	Otoliths	20-80	Yamanaka (1990)
Papua, New Guinea	0.29	181	-	Pole-and-line	-	Length modes	30-96	Wankowski (1981)
Hawaii	0.44	192	0.22	Longline	5,000	Weight modes	70-120	Moore (1951)
	Linear segments			Mainly troll	14	Otoliths	52-93	Uchiyama & Struhsaker (1981)
Pacific	-	-	-	Longline	300	Scales	100-140	Nose et al. (1957)

[1] A review of biology and fisheries for yellowfin tuna, Thunnus albacares, in the western and central Pacific Ocean. FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, Noumea, New Caledonia, 3-11 December 1991, 37 pp.

Table 5. Comparison of estimated size (fork length in cm) at age from various growth curves for yellowfin tuna of the central and western Pacific Ocean (from Suzuki 1991[1]).

	Growth Curve				
Age (Year)	**Moore (1951)**	**Yabuta & Yukinawa (1957)**	**Yabuta, et al. (1960)**	**White (1982; General Santos)**	**Yamanaka (1990)**
1	56	50	53	64	57
2	104	100	92	105	
3	135	129	119	132	
4	156	145	139	149	
5	169	155	154	161	
6	177	160	164	168	

1 A review of biology and fisheries for yellowfin tuna, *Thunnus albacares*, in the western and central Pacific Ocean. FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, Noumea, New Caledonia, December 3-11, 1991, 37 pp.

Table 6. Length (fork length) at first maturity for yellowfin tuna of the central and western Pacific Ocean (modified from WPYRG2/13).

Area	**Length at Maturity (cm)**	**Method**[1]	**Source**
0° - 10° N, 110° - 140° E	>106	GI	Sun & Yang (1983)
10° - 23° N, 110° - 135° E	>112	GI	Sun & Yang (1983)
Western & central	>80 majority >110	GI	Kikawa (1962)
Philippines	>57	Egg Size	Bunag (1956)
Coral Sea			
(handline)	>97 50%: 108	POF	McPherson (1991)[2]
(longline)	>113 50%: 120	POF	"
Central Equatorial	>70 50%: 110-120	GI	Yuen & June (1957)

1 GI = gonadosomatic index method; POF = post-ovulatory follicle method

2 Reproductive biology of yellowfin tuna in the eastern Australian fishing zone, with special reference to the northwestern Coral Sea. Aust. J. Mar. Freshwater Res. 42:465-477.

Table 7. Spawning frequency of yellowfin tuna of the Pacific Ocean based on the post-ovulatory follicle method.

Area	Frequency	Source[1]
Western (purse seine)	1.7 days	Nakaido (1988)
Coral Sea (handline)	1.5 (1.1-1.9) days	McPherson (1991)
Eastern	1.3 days	Schaefer (1988)

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McPherson, G.R. 1991. Reproductive biology of yellowfin tuna in the eastern Australian fishing zone, with special reference to the northwestern Coral Sea. Aust. J. Mar. Freshwater Res. 42:465-477.

Nakaido, H. 1988. Spawning ecology of yellowfin tuna -- investigation of spawning frequency. Proceedings of Japanese Tuna Conference, Shimizu, (Showa 63 nendo) pp. 111-114.

Schaefer, K.M. 1988. Time and frequency of spawning of yellowfin tuna at Clipperton Island, and plans for future studies. Proceedings of Japanese Tuna Conference, Shimizu, (Showa 63 nendo) pp. 118-126.

Table 8. Sex ratio of yellowfin tuna of the central and western Pacific Ocean caught on longline gear (modified from WPYRG2/13).

Area	**Sex Ratio (F:M)**	**Source**
Western	1:1 up to 122 cm, then males predominate	Murphy & Shomura (1955); Shomura & Murphy (1955)
Western & central	1:1 up to 120 cm, then increasing male dominance at larger sizes	Kikawa (1966); Yesaki (1983); Yamanaka (1990)
0-23° N, 110° - 140° E	1:1 at approx. 100-110 cm (1:2 in total sample), increasing male dominance at larger sizes.	Sun & Yang (1983)
Central & east of 120° E	1:1, males predominate at larger size than from western Pacific	Murphy & Shomura (1955); Shomura & Murphy (1955)

Table 9. Estimates of instantaneous natural mortality rate, M (yr^{-1}), for yellowfin tuna of the Pacific Ocean (from WPYRG2/6). ng = not given.

Area	M	Age range (yr)	Method	Source
Western	2.5	>2	Catch curve	Honma, et al. (1971) (after Suzuki 1991)
	0.6-0.9	ng	Life history	WPYRG2/6
	1.07 (0.92-1.22)	0.5 - 2	Tag recapture	SCTB5/3
Western and central	0.34	1-3	Catch curve (sequential recruitment)	Ishii (1967a,1967b,1968, 1969) (after Cole 1990)
	0.91	>4	Catch curve (sequential recruitment)	Ishii (1967a,1967b, 1968, 1969) (after Cole 1990)
	0.3 or 0.9	2-3	Catch curve	Honma et al. (1971) (after Cole 1990)
	1.2	>4	Catch curve	Honma et al. (1971) (after Cole 1990)
	0.3	ng	Life history	Honma et al. (1971) (after Suzuki 1991)
Central	1.1	>2	Catch curve	Honma et al. (1971) (after Suzuki 1991)
Philippines	0.5	ng	Life history	White (1982) (after Suzuki 1991)
Eastern	0.77 (0.64-0.90)	1-3	Catch curve	Hennemuth (1961) (after Cole 1990)
Eastern	0.55-1.05	1-3	Catch curve	Schaefer (1967) (after Cole 1990)
	0.6	1-3	Tag recapture	Bayliff (1971) (after Cole)
	0.6	1-3	Simulation	Francis (1977) (after Cole 1990)

Table 10. Inventory of fishery data for western Pacific yellowfin tuna fisheries, 1970-90, available to the WPYRG. N = not available.

COUNTRY/FISHING GEAR	WPYRG Form[1] C (Catch)	C (Effort)	D	E	L-F	COMMENTS
<u>Australia</u>						
Longline	1987-90	1987-90	1987-90	N	1987-90	
	1979-90	1979-90	1979-90	N	N	Joint venture using Japanese vessels
Purse seine	1988-90	1988-90	N	N	N	
Handline	1979-90	1979-90	1979-90	N	N	Joint venture using Japanese vessels
<u>Fiji</u>						
Pole-and-line	1974-90	1987-90	1981-83, 1985-90	N	N	
<u>Indonesia</u>						
Longline	1978-90	1985-90	1990	N	N	
Purse seine	1980-90	1984-90	1989-90	1990	N	
Handline	1984-90	1987-90	1990	1990	N	
Pole-and-line	1976-90	1985-89	1990	1990	N	
<u>Japan</u>						
Longline	1970-89	1970-89	1970-89	N	1970-89	L-F in 2-cm intervals and by quarter
Purse seine	1970-90	1970-90	1970-90	1970-90	1970-90	L-F by quarter and only from WPYF area 4
Pole-and-line	1971-89	1979-89	1979-89	N	N	
<u>Korea</u>						
Longline	1970-90	1971-90	1975-87	N	N	D in number of fish
Purse seine	1980-90	1980-89	N	N	N	

Table 10. (Continued)

COUNTRY/FISHING GEAR	WPYRG Form[1] C (Catch)	C (Effort)	D	E	L-F	COMMENTS
<u>New Caledonia</u>						
Longline	1983-90	1983-90	1987-90	1987-90	N	
	1983-90	1983-90	1988-90	1988-90	N	Joint venture using Japanese vessels
Pole-and-line	1981-83	1981-83	N	N	N	
	1983-85, 1990	1983-85, 1990	N	N	N	Joint venture using Japanese vessels
<u>New Zealand</u>						
Longline	1974-89	1974-89	1980-90	N	N	Chartered Japanese vessels. Includes some troll catches
<u>Palau</u>						
Pole-and-line	1970-82	1970-82	1970-82	N	N	
<u>Philippines</u>						
Longline	1978-87	1982-90	N	N	N	
Purse seine	1978-87	1980-90	1978-87	N	1980-90	
Handline	1978-87	1980-90	1978-87	N	1980-90	
Gillnet	1978-87	N	N	N	N	
Ring net	1978-87	1980-90	1978-87	N	1980-90	
<u>Papua New Guinea</u>						
Pole-and-line	1970-81, 84, 85	1970-81,	1970-81, 84, 85	N	N	
<u>Solomon Islands</u>						
Longline	1973, 1976-85	1973, 1976-85	1981-85	1981-85	N	E - mostly unknown school types
Purse seine	1980-90	1980-90	1984-90	1984-90	1985-90	E - mostly unknown school types
Pole-and-line	1971-90	1973-90	1981-90	1981-90	1985-90	E - mostly unknown school types

Table 10. (Continued)

COUNTRY/FISHING GEAR	WPYRG Form[1] C (Catch)	C (Effort)	D	E	L-F	COMMENTS
<u>Taiwan</u>						
Longline						
Distant water	1970-90	1975-90	1970-90	N	N	C (Effort) in hooks and number of vessels
Offshore	1970-90	1970-90	1982-90	N	N	
Purse seine	1984-90	1984-90	1984-90	N	N	
<u>Tonga</u>						
Longline	1982-90	1982-90	1982-90	N	N	
<u>United States</u>						
Longline	1970-90	1970-90	1970-90	N	1987-90	L-F in weight frequency
Purse seine	1976-90	1976-90	1981-90	1981-90	1984-85, 88-90	L-F for other years may be available
Handline/Troll	1970-90	1970-90	1970-90	N	N	C (Catch) includes troll catches; only weight-frequency for 1987-90
Pole-and-line	1970-90	1970-90	1970-90	N	1987-90	L-F in weight frequency

[1] WPYRG Form C = Total catch by species and total fishing effort; Form D = Catch of yellowfin tuna by WPYF area and month; Form E = Catch of yellowfin tuna by set type, WPYF area and month; L-F = length-frequency data by WPYF area and month.

Table 11. Longline catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-1990. Dash (-) indicates missing or unavailable data.

YEAR	(1) AUSTRALIA	(2) INDONESIA	(3) JAPAN	(4) KOREA	(5) NEW CALEDONIA	(6) PHILIPPINES	(7) SOLOMON ISLANDS	(8) TAIWAN DISTANT-WATER	(8) TAIWAN OFFSHORE	(7) TONGA	(9) USA	TOTAL
1970	-	-	23,631.0	1,500.0	-	612.0	-	3,849.0	6,132.0	-	251.0	35,975.0
1971	-	-	26,632.0	3,975.0	-	685.0	-	8,699.9	5,080.0	-	191.0	45,262.9
1972	-	-	26,262.0	8,850.0	-	712.0	-	9,042.0	3,323.0	-	160.0	48,349.0
1973	-	-	33,314.0	9,000.0	-	851.0	91.0	8,027.7	10,373.0	-	98.0	61,754.7
1974	-	-	29,318.0	11,328.0	-	990.0	-	4,313.3	7,778.0	-	130.0	53,857.3
1975	-	-	33,747.0	7,774.0	-	1,010.0	-	2,554.7	13,539.0	-	102.0	58,726.7
1976	-	-	36,635.0	13,896.0	-	618.0	146.0	3,285.9	12,425.0	-	111.0	67,116.9
1977	-	-	39,980.0	15,585.0	-	972.0	198.0	3,122.8	16,471.0	-	176.0	76,504.8
1978	-	1,216.0	56,719.0	13,087.0	-	689.0	207.0	3,277.7	19,165.0	-	172.0	94,532.7
1979	-	1,274.0	45,478.0	17,977.0	-	907.0	493.0	2,966.4	22,629.0	-	84.0	91,808.4
1980	-	1,478.0	53,974.0	21,470.0	-	1,177.0	564.0	5,525.2	18,265.0	-	72.0	102,525.2
1981	-	1,806.0	47,751.0	8,685.0	-	1,619.0	146.0	1,578.3	17,778.0	-	59.0	79,422.3
1982	-	3,605.0	40,794.0	8,150.0	-	1,897.0	306.0	745.0	16,508.0	81.0	35.0	72,121.0
1983	-	1,048.0	40,443.0	7,057.0	7.0	2,824.0	443.0	492.3	16,260.0	48.0	66.0	68,688.3
1984	-	1,670.0	29,623.0	5,976.0	25.0	1,284.0	213.0	561.0	16,107.0	55.0	77.0	55,591.0
1985	-	2,466.0	36,189.0	6,482.0	119.0	1,819.0	151.0	594.7	13,554.0	44.0	51.0	61,469.7
1986	-	2,437.0	26,132.0	5,996.0	151.0	2,411.0	-	289.3	10,844.0	33.0	92.0	48,385.3
1987	1,486.9	9,254.0	23,493.0	8,078.0	449.0	3,775.0	-	370.9	14,061.0	32.0	272.0	61,271.8
1988	1,150.0	9,717.0	32,257.0	7,578.0	436.0	3,196.0	-	1,255.6	14,337.0	26.0	590.0	70,542.6
1989	779.7	5,124.0	25,128.0	6,210.0	248.0	3,481.0	-	651.3	11,933.0	27.0	998.0	54,580.0
1990	761.3	5,508.0	25,128.0	9,591.0	551.0	2,625.0	-	1,098.4	7,848.0	28.0	1,134.0	54,272.7

(1) From logbooks raised for coverage of 50% (1987-88), 25% (1989), and 15% (1990). In 1983-86, several hundred tons/year may have been caught. Catches prior to 1983 are probably less than 100 tons/year. Includes Japanese joint-venture catches (100% logbook coverage). All data were reported as dressed weights and raised to whole weights by multiplying by 1.15 (P. Ward, pers. comm.).

(2) From Fisheries Statistics of Indonesia, RIMF Sampling Program (N. Naamin, pers. comm.).

(3) From logbook data (Suzuki, 1991, FAO Expert Consultation). 1990 catch assumed the same as for 1989.

(4) From Park (1991, FAO Expert Consultation) adjusted to represent catches from only the central and western Pacific based on SPC catch-effort data. 1975 and 1987 catch-effort data assumed to be applicable for 1970-74 and 1988-90, respectively.

(5) From R. E. Bonnin (pers. comm.).

(6) Catches for 1988-90 and 1970-77 are estimated from data for 1986-87 and 1978-79 respectively. From BFAR Fisheries Statistics (R. Ganaden, pers. comm.).

(7) From logbooks with high coverage rates (Lawson, 1992, SCTB/2).

(8) Distant-water catches from expanded logbook data and offshore catches from landings (C.-L. Sun, pers. comm.)

(9) From landings (A. Coan, pers. comm.).

Table 12. Purse-seine catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-90. Dash (-) indicates missing or unavailable data.

YEAR	AUSTRALIA[1]	INDONESIA[2]	JAPAN[3]	KOREA[4]	PHILIPPINES[5]	SOLOMON ISLANDS[6]	TAIWAN[7]	USA[8]	TOTAL
1970	-	-	164.3	-	6,692.0	-	-	-	6,856.3
1971	-	-	2,867.4	-	7,486.0	-	-	-	10,353.4
1972	-	-	4,183.5	-	7,779.0	-	-	-	11,962.5
1973	-	-	7,281.2	-	9,306.0	-	-	-	16,587.2
1974	-	-	9,418.6	-	10,819.0	-	-	-	20,237.6
1975	-	-	5,594.6	-	11,040.0	-	-	-	16,634.6
1976	-	-	7,648.9	-	6,759.0	-	-	200.0	14,607.9
1977	-	-	6,840.9	-	10,623.0	-	-	200.0	17,663.9
1978	-	-	8,523.4	-	5,143.0	-	-	200.0	13,866.4
1979	-	-	19,013.4	-	12,301.0	-	-	559.0	31,873.4
1980	-	2,177.0	19,701.3	125.0	12,463.0	449.0	-	1,059.0	35,974.3
1981	-	2,275.0	27,160.5	400.0	18,182.0	1,342.0	-	12,973.0	62,332.5
1982	-	1,428.0	31,035.2	2,000.0	17,676.0	1,444.0	-	22,011.0	75,594.2
1983	-	2,013.0	30,818.4	700.0	20,779.0	2,530.0	-	49,599.0	106,439.4
1984	-	2,108.0	38,607.3	100.0	22,989.0	2,397.0	251.9	45,090.0	111,543.2
1985	-	2,107.0	47,897.3	1,600.0	21,591.0	2,882.0	1,007.4	29,012.0	106,096.7
1986	-	1,650.0	44,466.5	2,400.0	17,591.0	2,258.0	2,869.2	36,608.0	107,842.7
1987	-	1,683.0	44,503.7	19,500.0	18,087.0	3,385.0	4,579.3	66,359.0	158,097.0
1988	30.0	1,767.0	30,080.9	16,496.0	18,432.0	4,068.0	6,238.0	25,211.0	102,322.9
1989	15.0	2,520.0	40,862.2	34,726.0	20,075.0	4,410.0	10,603.5	41,241.0	154,452.7
1990	1,040.0	2,665.0	37,605.5	41,603.0	15,142.0	3,825.0	13,693.6	57,132.0	172,706.1

1 High-seas catches only, not including catches within the Australian EEZ. From P. Ward (pers. comm.).

2 From Fisheries Statistic of Indonesia, RIMF Sampling Program (N. Naamin, pers. comm.).

3 From S. Tsuji (pers. comm.).

4 From Lawson (1992, SCTB5/2).

5 Catches for 1970-1977 and 1988-90 are estimated from data for 1978-79 and 1986-87, respectively; include ring net catches. From BFAR Fisheries Statistics (R. Ganaden, pers. comm.).

6 Compiled from logbooks with high coverage rates. From Lawson (1992, SCTB5/2)

7 From landings (C.-L. Sun, pers. comm.)

8 From landings (A. Coan, pers. comm.).

Table 13. Pole-and-line catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-90. Dash (-) indicates missing or unavailable data.

YEAR	FIJI[1]	INDONESIA[2]	JAPAN[3]	KIRIBATI[4]	NEW CALEDONIA[5]	PALAU[4]	PAPUA NEW GUINEA[4]	SOLOMON ISLANDS[4]	TOTAL
1970	-	-	-	-	-	1.0	74.0	-	75
1971	-	-	345.0	-	-	10.0	112.0	141.0	608
1972	-	-	294.0	-	-	56.0	1,345.0	237.0	1,932
1973	-	-	55.0	-	-	41.0	916.0	195.0	1,207
1974	12.0	-	-	-	-	161.0	1,416.0	310.0	1,899
1975	11.0	-	55.0	-	-	298.0	1,744.0	215.0	2,323
1976	83.0	507.0	-	-	-	412.0	8,563.0	474.0	10,039
1977	151.0	591.0	1,676.0	-	-	420.0	4,009.0	363.0	7,210
1978	409.0	1,160.0	769.0	-	-	303.0	3,099.0	524.0	6,264
1979	403.0	1,907.0	5,832.8	-	-	1.0	2,881.0	714.0	11,738.8
1980	233.0	2,269.0	6,188.2	-	-	996.0	3,018.0	658.0	13,362.2
1981	599.0	2,015.0	9,052.6	-	3.0	2,480.0	4,205.0	265.0	18,619.6
1982	813.0	1,887.0	9,491.8	-	41.0	615.0	-	237.0	13,084.8
1983	562.0	1,900.0	9,331.9	253.0	25.0	-	-	660.0	12,731.9
1984	580.0	2,282.0	8,700.1	588.0	-	-	274.0	397.0	12,821.1
1985	724.0	2,344.0	12,919.8	580.0	-	-	930.0	183.0	17,680.8
1986	823.0	2,278.0	8,409.7	123.0	-	-	-	358.0	11,991.7
1987	410.0	2,323.0	8,452.1	143.0	-	-	-	2,965.0	14,293.1
1988	526.0	2,439.0	1,909.4	384.0	-	-	-	2,251.0	7,509.4
1989	506.0	3,553.0	7,799.7	-	-	-	-	1,475.0	13,333.7
1990	516.0	4,433.0	7,799.7	110.0	-	-	-	2,309.0	15,167.7

1 From landings data cross-checked with log sheets; 1989 data include 15 mt from purse seine (S. Sharma, pers. comm.).

2 From *Fisheries Statistics of Indonesia, RIMF Sampling Program* (N. Naamin, pers. comm.).

3 1971-78 catches from Suzuki (1991, FAO Expert Consultation); 1979-89 catches from S. Tsuji (pers. comm.); 1990 catch assumed the same as for 1989.

4 Compiled from logbooks with high coverage rates. From Lawson (1992, SCTB5/2).

5 From R. E. Bonnin (pers. comm.).

Table 14. Unclassified (UNCL) and other gear catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-90[1]. Dash (-) indicates missing or unavailable data.

YEAR	INDONESIA[2] UNCL	INDONESIA[2] HANDLINE	NEW ZEALAND[3] UNCL	PHILIPPINES[4] UNCL	PHILIPPINES[4] GILLNET	PHILIPPINES[4] HANDLINE	USA[5] OTHER	TOTAL
1970	5,500.0	-	0.0	197.0	2,664.0	21,835.0	69.0	30,265.0
1971	5,700.0	-	0.0	219.0	2,981.0	24,429.0	197.0	33,526.0
1972	9,000.0	-	0.0	228.0	3,097.0	25,384.0	214.0	37,923.0
1973	10,200.0	-	0.0	273.0	3,705.0	30,365.0	252.0	44,795.0
1974	10,165.0	-	1.0	316.0	4,307.0	35,300.0	393.0	50,482.0
1975	11,062.0	-	1.0	324.0	4,395.0	36,024.0	677.0	52,483.0
1976	7,530.0	-	0.0	199.0	2,691.0	22,056.0	728.0	33,204.0
1977	10,268.0	-	0.0	311.0	4,230.0	34,665.0	756.0	50,230.0
1978	8,225.0	-	15.0	230.0	4,918.0	24,941.0	791.0	39,120.0
1979	11,482.0	-	16.0	281.0	2,027.0	31,980.0	896.0	46,682.0
1980	11,626.0	-	51.0	432.0	2,301.0	29,235.0	1,124.0	44,769.0
1981	15,793.0	-	26.0	953.0	2,655.0	32,254.0	1,219.0	52,900.0
1982	17,393.0	-	2.0	1,055.0	1,386.0	29,826.0	786.0	50,448.0
1983	15,239.0	-	1.0	3,661.0	1,260.0	32,396.0	853.0	53,410.0
1984	18,140.0	2,250.0	2.0	649.0	2,161.0	31,005.0	834.0	55,041.0
1985	20,130.0	2,540.0	1.0	1,325.0	2,040.0	35,505.0	1,033.0	62,574.0
1986	25,226.0	2,737.0	7.0	824.0	2,137.0	36,188.0	1,623.0	68,742.0
1987	24,732.0	2,793.0	7.0	866.0	2,160.0	26,407.0	1,270.0	58,235.0
1988	26,377.0	2,899.0	5.0	873.0	2,220.0	32,339.0	1,225.0	65,938.0
1989	31,345.0	2,726.0	9.0	951.0	2,418.0	35,221.0	517.0	73,187.0
1990	32,285.0	3,196.0	4.0	717.0	1,824.0	26,566.0	562.0	65,154.0

[1] Catches of subsistance/small-scale fisheries for various Pacific Island nations are not included and in aggregate, may be as high as 3,000 t per year.

[2] From Fisheries Statistics of Indonesia, RIMF Sampling Program (N. Naamin, pers. comm.).

[3] 1970-84 catches are from FAO statistics, 1985-90 catches are from logbooks of chartered Japanese vessels that are not reported by Japan and from catches of domestic flag vessels. The gears are primarily longline and troll but do not include recreational troll (catches range from <2 t to about 45 t per year); from T. Murray (pers. comm.).

[4] Catches for 1970-77 and 1988-90 were estimated from 1978-79 and 1986-87 data, respectively. UNCL includes seine net and bag net fisheries. From BFAR Fisheries Statistics (R. Ganaden pers. comm.).

[5] OTHER includes catches by handline, troll, and some pole-and-line. From landings (A. Coan, pers. comm.).

Table 15. Number (except for Japan) of longline vessels by countries fishing for tunas in the central and western Pacific Ocean, 1970-90. Dash (-) indicates missing or unavailable data.

YEAR	AUSTRALIA[1]	INDONESIA[2]	JAPAN[3]	KOREA[4]	NEW CALEDONIA[5]	PHILIPPINES[6]	SOLOMON ISLANDS[7]	TAIWAN[8] DISTANT-WATER	TAIWAN[8] OFFSHORE	TONGA[7]	USA[9]
1970	0	0	17,919	-	0	-	0	-	829	0	45
1971	0	0	15,072	120	0	-	0	-	863	0	46
1972	0	0	14,535	177	0	-	0	-	899	0	42
1973	0	0	16,166	225	0	-	2	-	1,255	0	32
1974	0	0	17,496	270	0	-	0	-	1,451	0	33
1975	0	0	17,157	250	0	-	0	92	1,411	0	31
1976	0	0	20,230	251	0	-	2	194	1,331	0	33
1977	0	0	16,740	212	0	-	2	176	1,382	0	35
1978	0	-	21,670	225	0	-	2	168	1,670	0	29
1979	0	-	20,782	212	0	-	2	157	1,840	0	21
1980	0	-	23,040	211	0	-	2	182	1,900	0	11
1981	0	-	23,192	210	0	-	2	140	1,846	0	13
1982	0	-	17,867	120	0	61	2	115	1,831	1	10
1983	0	-	18,436	100	1	62	2	65	1,872	1	18
1984	0	-	18,773	95	2	62	2	61	1,944	1	23
1985	0	28	19,860	94	3	55	2	44	2,129	1	23
1986	0	63	15,665	127	2	41	0	51	2,084	1	21
1987	64	79	16,935	130	3	62	0	60	2,207	1	19
1988	62	70	14,262	125	4	27	0	70	1,977	1	25
1989	93	138	16,776	150	4	3	0	85	1,671	1	86
1990	96	151	-	182	7	26	0	96	1,139	1	184

[1] From P. Ward (pers. comm.)

[2] From Fisheries Statistics of Indonesia, RIMF Sampling Program (N. Naamin, pers. comm.).

[3] Number of hooks x 1000 (S. Tsuji, pers. comm.).

[4] Numbers for entire Pacific fleet; from Park (1991, FAO Expert Consultation).

[5] From R. E. Bonnin (pers. comm.)

[6] From BFAR Fisheries Statistics (R. Ganaden, pers. comm.)

[7] From Lawson (1992, SCTB5/2).

[8] Distant-water from Pacific-wide report; offshore from Fisheries Yearbook, Taiwan Area (C.-L. Sun, pers. comm.)

[9] From landings (A. Coan, pers. comm.)

Table 16. Number (except for Japan) of purse-seine vessels fishing for yellowfin tuna in the central and western Pacific Ocean, 1970-90. Dash (-) indicates missing or unavailable data.

YEAR	AUSTRALIA[1]	INDONESIA[2]	JAPAN[3]	KOREA[4]	PHILIPPINES[5]	SOLOMON ISLANDS[6]	TAIWAN[7]	USA[8]
1970	-	-	380	-	-	-	-	-
1971	-	-	7,746	-	-	-	-	-
1972	-	-	9,480	-	-	-	-	-
1973	-	-	9,916	-	-	-	-	-
1974	-	-	6,924	-	-	-	-	-
1975	-	-	8,344	-	-	-	-	-
1976	-	-	10,052	-	-	-	-	3
1977	-	-	8,748	-	-	-	-	1
1978	-	-	9,716	-	-	-	-	2
1979	-	-	13,864	-	-	-	-	8
1980	-	-	13,096	2	570	1	-	14
1981	-	-	18,028	3	697	1	-	14
1982	-	-	23,848	10	785	1	-	24
1983	-	-	33,580	11	686	1	-	62
1984	-	3	38,352	12	712	1	5	61
1985	-	3	38,948	11	724	1	5	40
1986	-	3	36,572	13	685	1	11	36
1987	-	3	36,932	20	813	1	15	35
1988	3	3	36,596	23	779	5	24	32
1989	1	3	35,588	30	198	4	22	34
1990	9	3	32,492	-	549	4	31	41

1 Not including vessels fishing in the Australian EEZ. From P. Ward (pers. comm.).

2 From Fisheries Statistics of Indonesia, RIMF Sampling Program (N. Naamin, pers. comm.).

3 Successful days fished for 1970-82; days fished for 1983-1990. From S. Tsuji (pers. comm.).

4 From Park (1991, FAO Expert Consultation).

5 Include ring net vessels. From BFAR Fisheries Statistics (R. Ganaden, pers. comm.).

6 From logbooks with high coverage rates. From Lawson (1992, SCTB5/2).

7 From landings (C.-L. Sun, pers. comm.).

8 From landings (A. Coan, pers. comm.).

Table 17. Number (except for Japan) of pole-and-line vessels fishing for yellowfin tuna in the central and western Pacific Ocean, 1970-90. Dash (-) indicates missing or unavailable data.

YEAR	FIJI[1]	INDONESIA[2]	JAPAN[3]	KIRIBATI[4]	NEW CALEDONIA[5]	PALAU[4]	PAPUA NEW GUINEA[4]	SOLOMON ISLANDS[4]
1970	-	-	-	-	-	10	5	-
1971	-	-	-	-	-	20	29	-
1972	-	-	-	-	-	11	45	-
1973	-	-	-	-	-	12	43	11
1974	-	-	-	-	-	24	47	11
1975	-	-	-	-	-	21	48	12
1976	-	-	-	-	-	33	40	14
1977	-	-	-	-	-	23	51	20
1978	-	-	-	-	-	26	48	20
1979	-	-	63,755	-	-	21	45	23
1980	-	-	61,379	-	-	31	50	22
1981	-	-	62,243	-	1	36	44	23
1982	-	-	58,695	-	3	20	-	25
1983	-	-	50,011	-	3	-	-	27
1984	-	-	49,080	-	-	-	-	30
1985	-	1,115	43,555	-	-	-	-	33
1986	-	1,287	40,871	4	-	-	-	35
1987	8	1,170	38,929	4	-	-	-	34
1988	11	1,577	15,881	6	-	-	-	34
1989	14	921	32,771	5	-	-	-	33
1990	14	~900	-	5	-	-	-	33

1 From Fiji Fisheries Department landings data cross-checked with log books (S. Sharma, pers. comm.).

2 From Fisheries Statistics of Indonesia, RIMF Sampling Program (N. Naamin, pers. comm.).

3 Days fished (S. Tsuji, pers. comm.).

4 From logbooks with high coverage rates. From Lawson (1992, SCTB5/2).

5 From R. E. Bonnin (pers. comm.).

Table 18. Length-weight relationships for yellowfin tuna of the central and western Pacific Ocean. Relationships are of the form $W=aL^b$, where L is the fork length (cm) and W is the whole weight (kg) or gilled-and-gutted weight (kg) (from WPYRG2/14).

Area	*a*	*b*	Length Range (cm)	Weight	Sample Size	Year(s)	Fishing Gear	Source
Western & Central Pacific	6.006640×10^{-3}	3.1878	100-150	gilled & gutted	11,344	1949-55	longline, from fish markets	Kamimura & Honma (1959)
Japan & South-western Pacific	2.51211×10^{-5}	2.939597	26-157	whole	2,043	na	mainly longline	Morita (1973)
Philippines	2.352×10^{-5} 4.322×10^{-5}	2.84682 2.87651	85-180 100-155	whole	99(males) 43(females)	1960	longline	Ronquillo (1963)
	3.10615×10^{-5}	2.869	15-65	whole	na	1979-82	mainly ring net	White (1982)
Eastern Australia	1.46517×10^{-5}	3.031646	62-166	whole	934	1980-91	longline	Ward (unpub.)
	8.3536×10^{-6}	3.1132	62-196	gilled & gutted	2,815	1980-91	longline	Ward (unpub.)
Central Pacific	3.2560×10^{-5}	3.05834	70-180	whole	4,822	na	probably longline	Nakamura & Uchiyama (1966)
Hawaii	2.852×10^{-5}	2.9045	29-72	whole	59	1951-55	troll	Tester & Nakamura (1957)
Eastern & Central Pacific	3.49515×10^{-5}	2.868069	63-148	whole	46	na	mainly longline	Morita (1973)

Table 19. Example form for reporting detailed information on sampling coverage for length-frequency data.

COUNTRY: Australia

Yr	Month/ Qtr	Size of area	WP Area	School Type	Number of fish Sampled	Number of Samples	Level of Coverage (% catch)	Type of Measure	Comments
90	1	1°	4	-	97	23	5	fork length	fresh, 2cm
90	2	5°	5	log	123	12	12	fork length	frozen at landing
91	5	1°	5	-	562	2	1	dressed wt	raised to length using Nakamura's LW equation

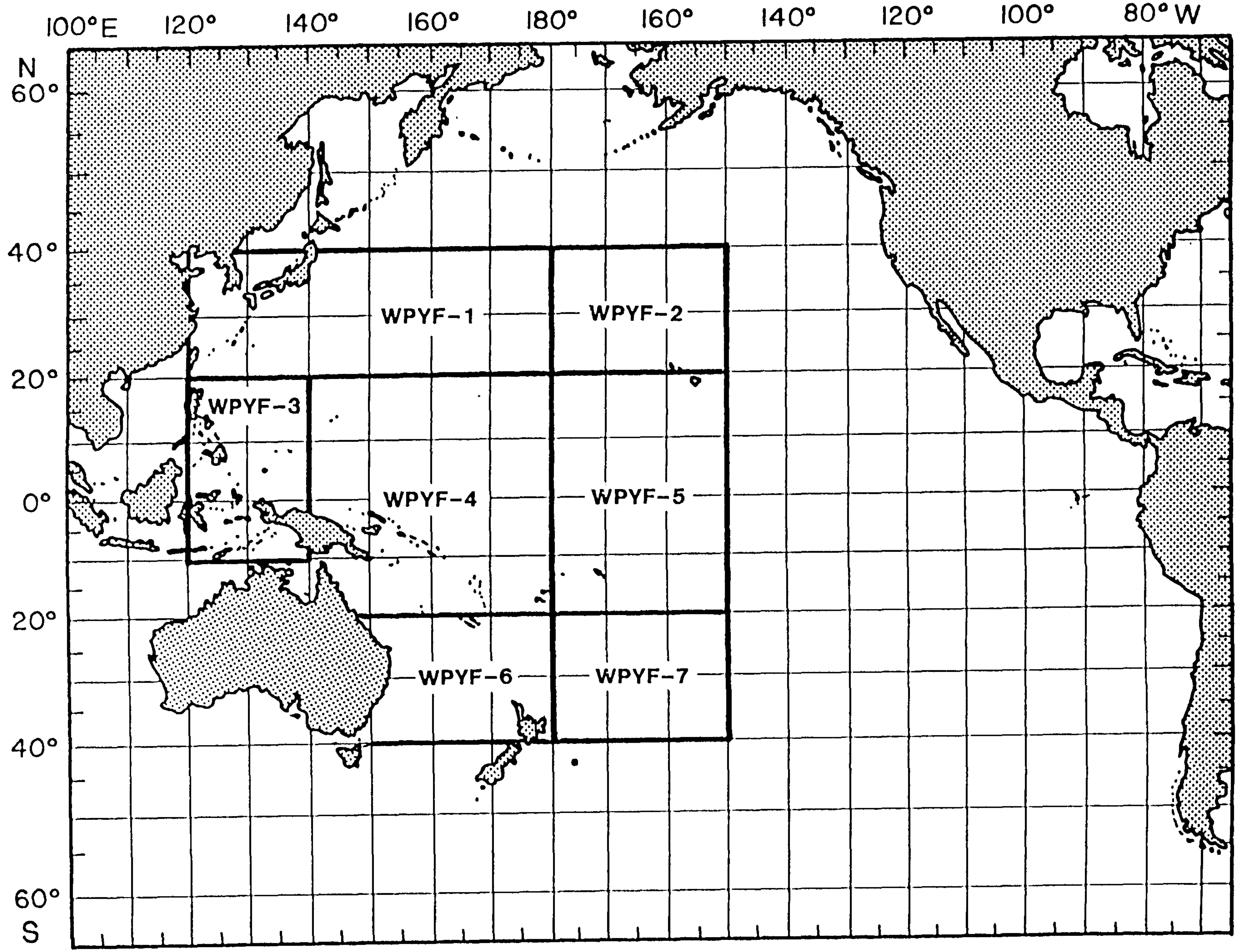

Figure 1. WPYRG statistical areas for compiling fisheries data.

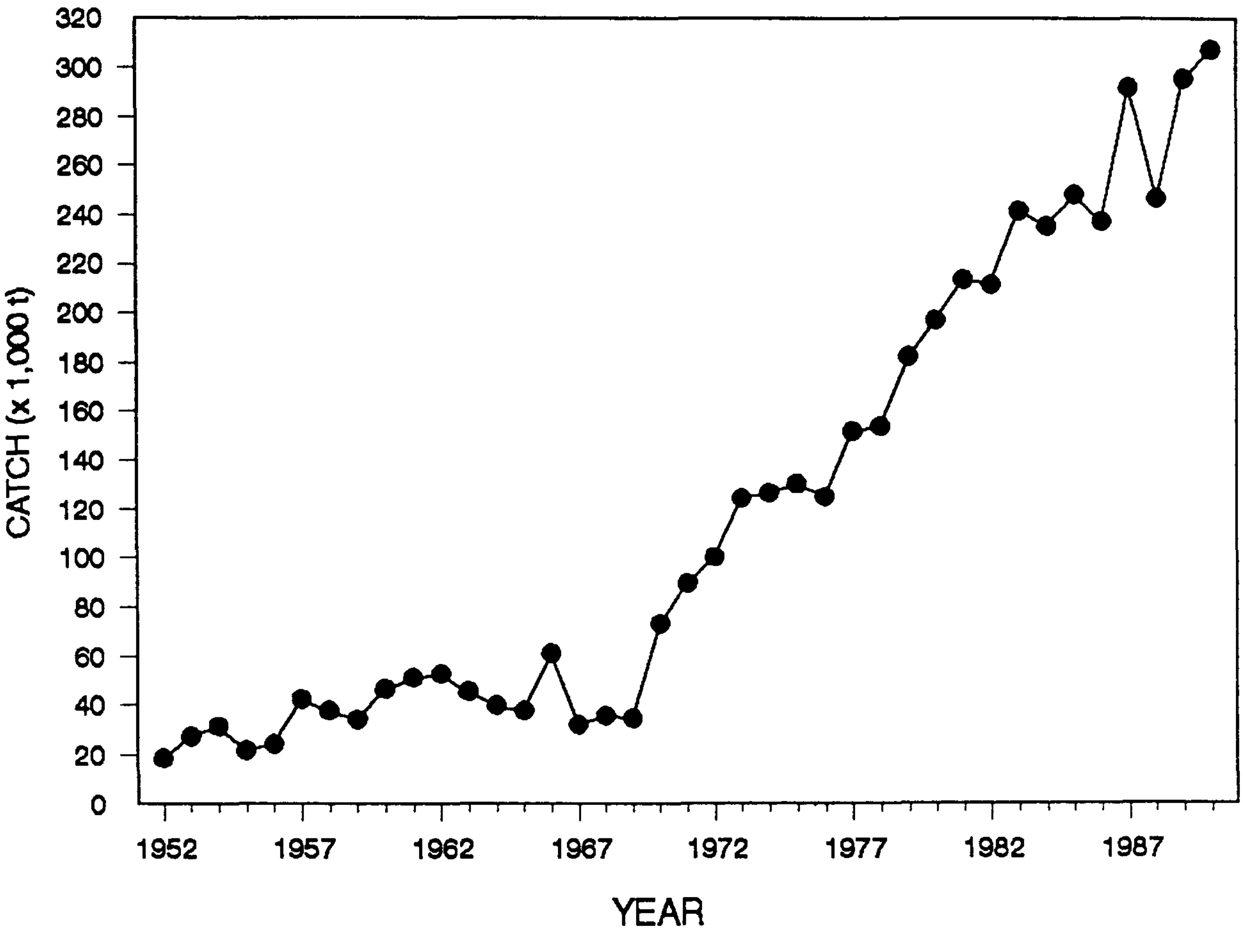

Figure 2. Total catch of yellowfin tuna from the central-western Pacific. Catches for 1952-69 are incomplete, but include catches of major fleets; catches for 1970-90 are estimates by the WPYRG.

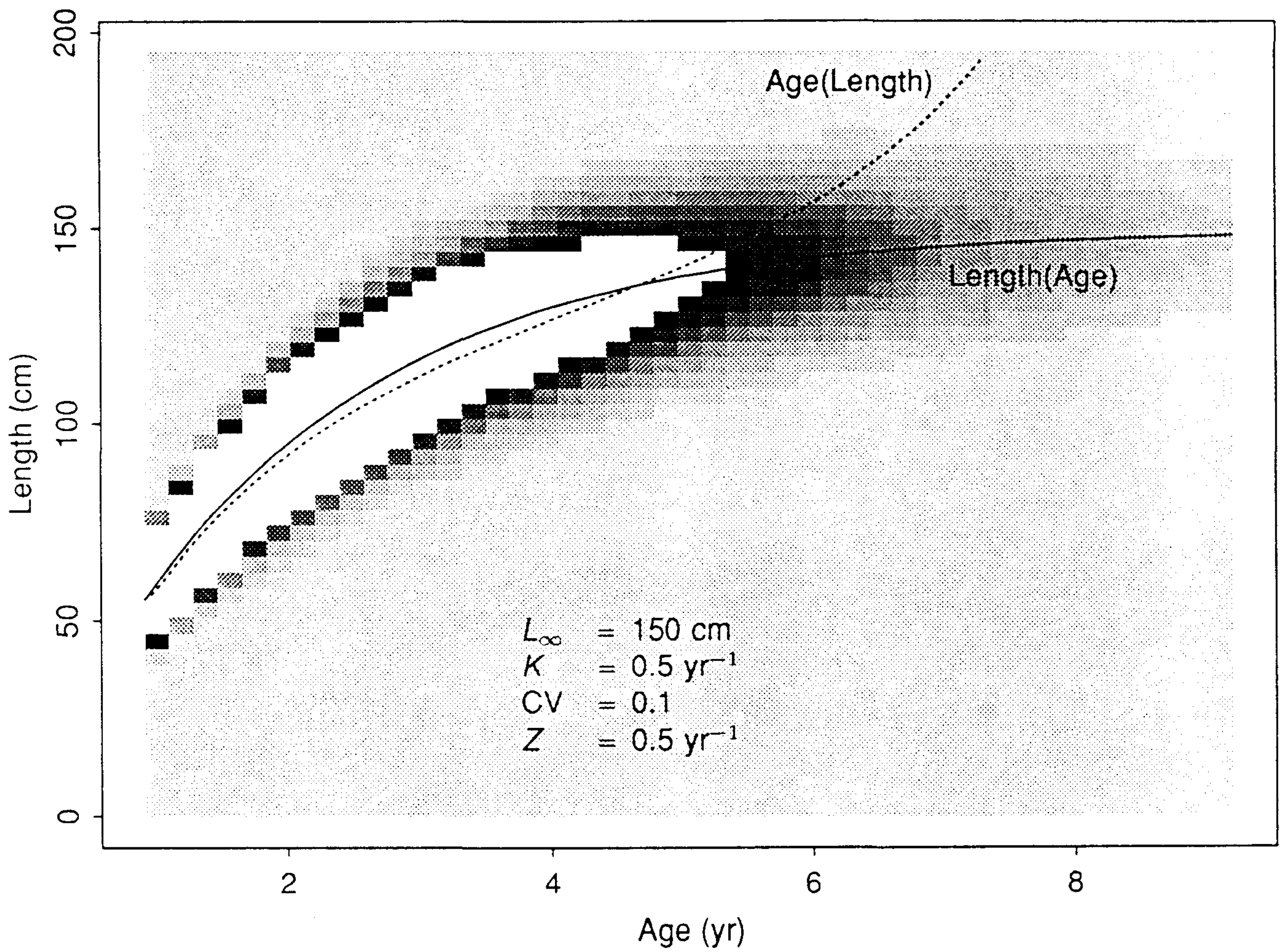

Figure 3. A simulated growth curve for yellowfin tuna using typical estimates of von Bertalanffy growth parameters (L_∞ = 150 cm and k = 0.5). Shading indicates scale of probability density (white = highest probability, followed by black = next highest and light grey = lowest) of fish represented by the function under the following conditions: constant recruitment, normal distribution of expected size at age with CV = 0.1 and Z = 0.5. The curve designated "Length (Age)," or length on age, is mean length along vertical slices of the probability distribution. The curve designated "Age (Length)," or age on length, is mean age along horizontal slices of the probability distribution. (From WPYRG2/4)

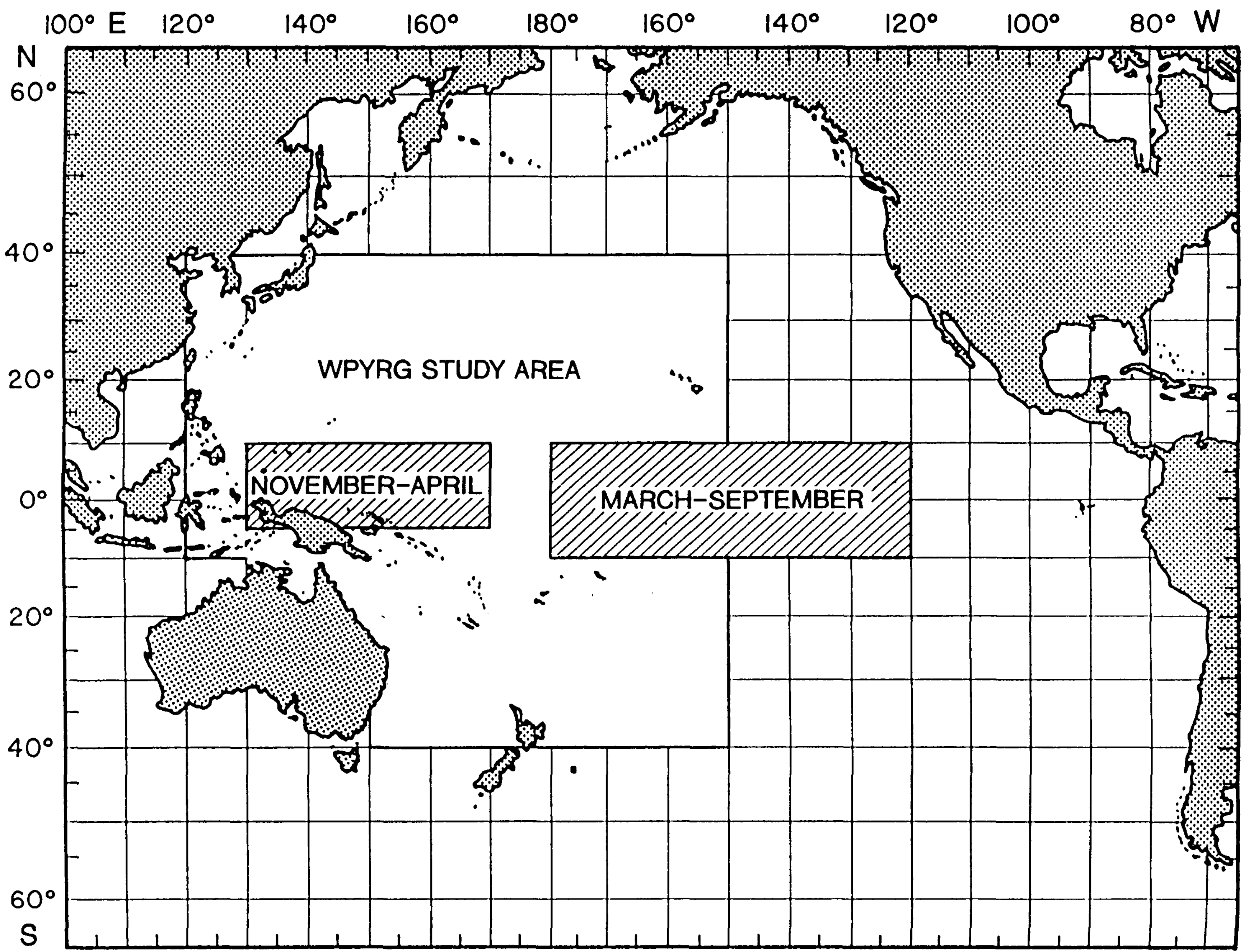

Figure 4. Areas in the central-western Pacific Ocean where yellowfin tuna have exhibited different peak spawning periods.

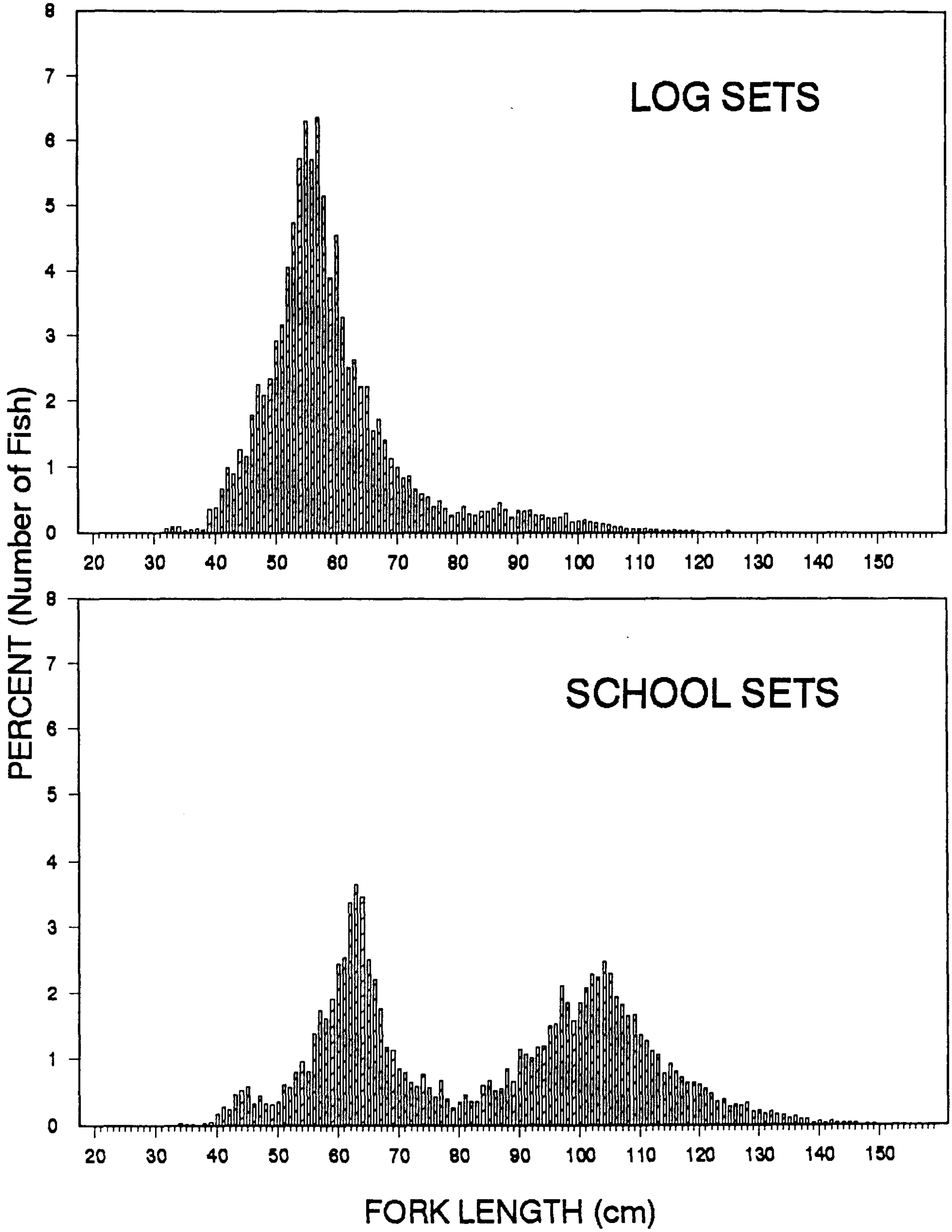

Figure 5. Length-frequency distribution of yellowfin tuna caught in log (associated) and school-fish (unassociated) sets of U.S. tuna purse seiners fishing in the western Pacific Ocean.

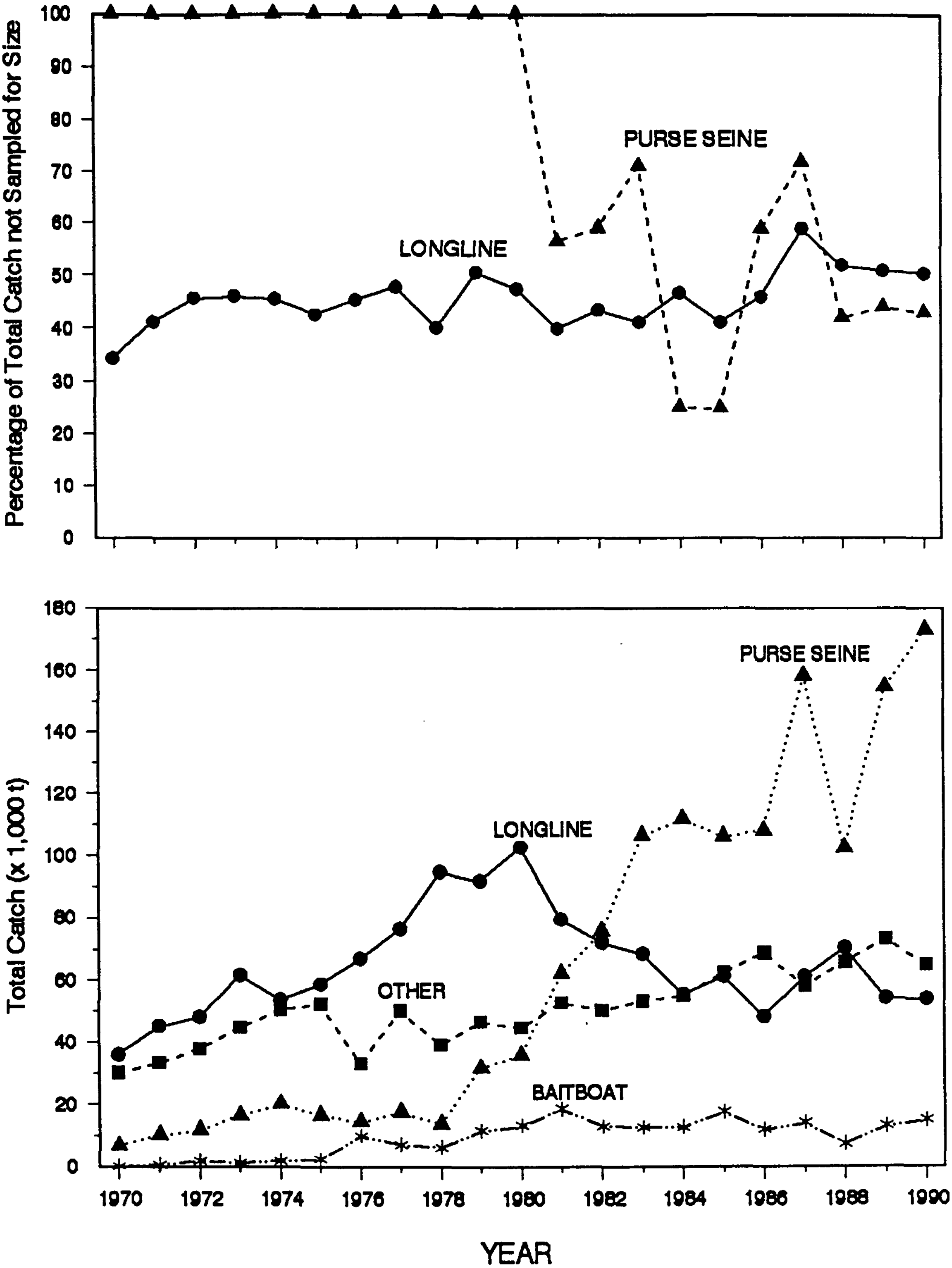

Figure 6. Catch of yellowfin tuna by gear and percentage of the catch by gear not sampled for size frequency.

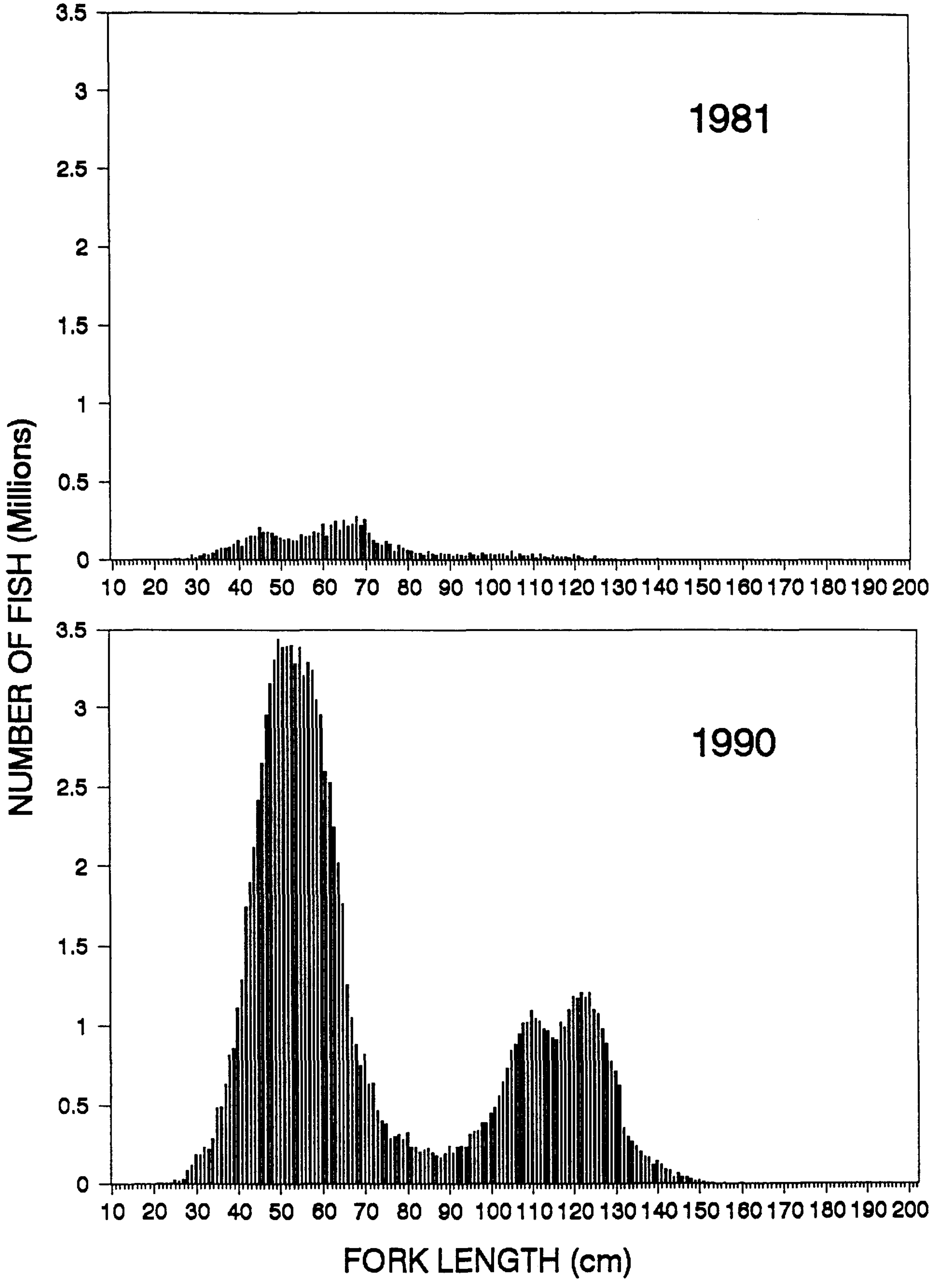

Figure 7. Trial run of estimated length-frequency distribution of yellowfin tuna in the total catch of purse seiners fishing in the central and western Pacific Ocean. 1981 represents a year with low (25%) sampling coverage for length frequency, and 1990 represents a year of high (53%) sampling coverage.

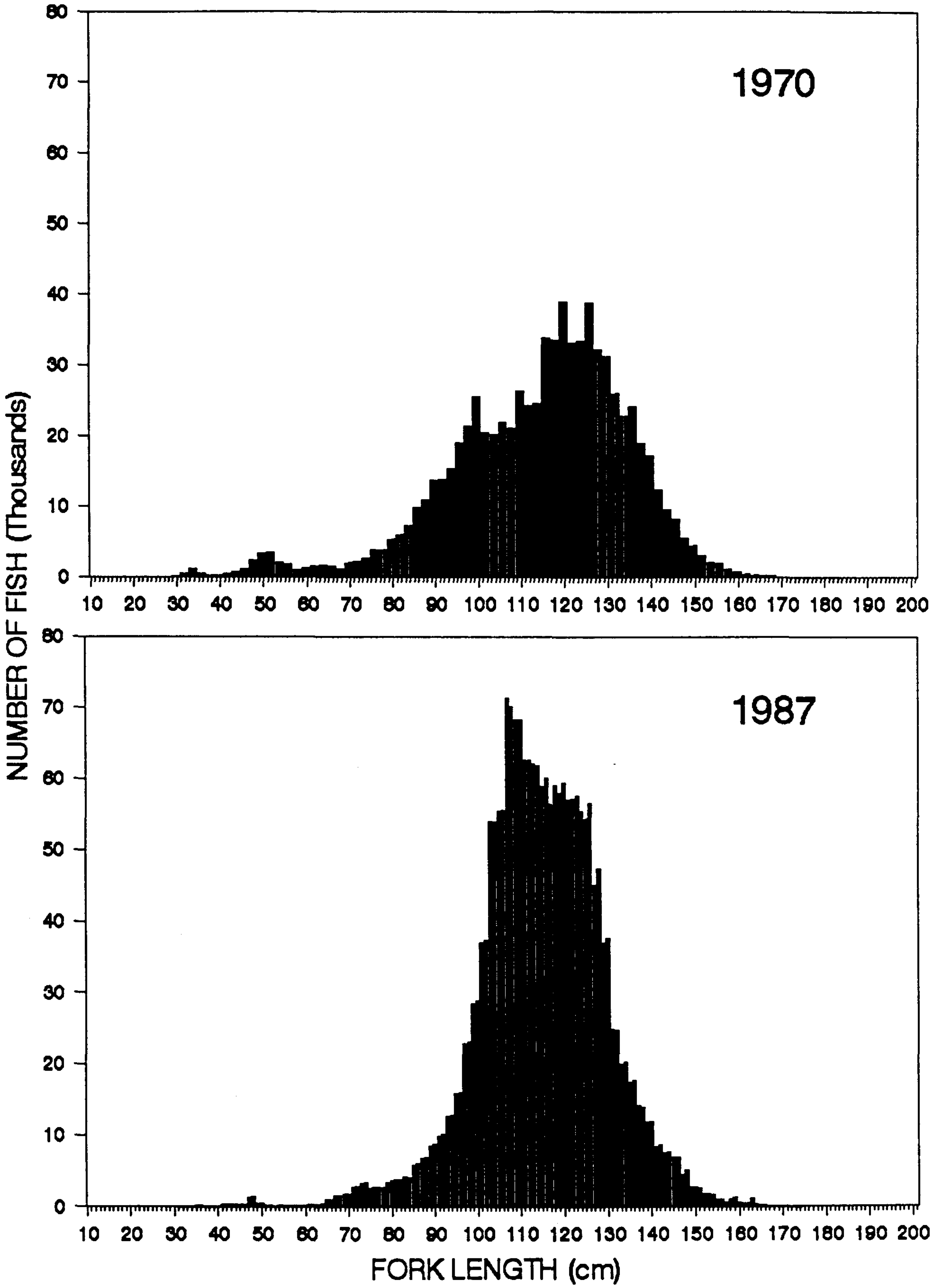

Figure 8. Trial run of estimated length-frequency distribution of yellowfin tuna in the total catch of longliners fishing in the central and western Pacific Ocean. 1970 represents a year with high (65%) sampling coverage for length frequency, and 1987 represents a year of low (40%) sampling coverage.

APPENDIX 1

APPENDIX 1. MEETING AGENDA FOR THE WESTERN PACIFIC YELLOWFIN TUNA RESEARCH GROUP.

SCHEDULE AND AGENDA
JUNE 16 - 24, 1992
East-West Center, Honolulu, HI U.S.A.

TUESDAY, JUNE 16

6:00 P.M. Registration and reception (check with front desk of Outrigger West Hotel for room number)

WEDNESDAY, JUNE 17

8:30 A.M. - 5:00 P.M. Data Correspondents' Meeting (Pacific Room, East-West Center)

Chairperson: Al COAN
Rapporteur: Tim LAWSON

- Data inventory
- Review of length-weight and conversion factors

Chairperson/rapporteur: John HAMPTON
Reviewer: Peter WARD

6:00 P.M. Registration, reception and Organizers' meeting (Outrigger West)

THURSDAY, JUNE 18

8:30 A.M.- 9:30 A.M. Opening ceremony for Standing Committee on Tuna and Billfish Program meeting and Western Pacific Yellowfin Tuna Research Group workshop (Pacific Room, East-West Center)

9:30 A.M. Coffee Break

10:00 A.M.- 5:00 P.M. SPC Fifth Standing Committee on Tuna and Billfish Program meeting (Pacific Room, East-West Center)

Organizer: Tony LEWIS

7:00 P.M. Dinner (voluntary; TBA)

FRIDAY, JUNE 19

8:30 A.M.- 6:00 P.M. SPC Fifth Standing Committee on Tuna and Billfish Program meeting (continued)

6:00 P.M. Organizers' meeting (Outrigger West)

SATURDAY, JUNE 20

8:30 A.M.- 5:00 P.M. WPYRG Workshop (Asia Room, East-West Center)

Chairperson: Gary SAKAGAWA

1. Opening comments.

2. Review of Data Correspondents' Meeting

Chairperson: Al COAN

3. Data substitution

Chairperson: Al COAN

SUNDAY, JUNE 21

FREE DAY

MONDAY, JUNE 22

8:30 A.M.- 5:00 P.M. WPYRG Workshop (continued)

4. Report on Data Base

Chairperson: Al COAN

5. Review of major fisheries

Chairperson/rapporteur: Peniasi KUNATUBA

6. Review of CPUE indices

Chairperson/rapporteur: Tom POLACHECK

7. Review of stock structure

Chairperson/rapporteur: Stephen YEN

8. Review of age and growth

Chairperson/rapporteur: Chris BOGGS

6:30 P.M. Dinner reception (Waikiki Aquarium)

TUESDAY, JUNE 23

8:30 A.M.- 5:00 P.M. WPYRG Workshop (continued)

9. Review of reproductive biology

Chairperson/rapporteur: Dave WILLIAMS

10. Review of mortality rates

Chairperson/rapporteur: Pierre KLEIBER

11. Review of follow-on tasks and assignments

6:00 P.M. Organizers' meeting (Outrigger West)

WEDNESDAY, JUNE 24

8:30 A.M.- 5:00 P.M. WPYRG Workshop (continued)

■ Preparation of report (rapporteurs)

Coordinator: Peter WARD

■ Review of Data Base

12. Adoption of report

13. Election of chair

14. Discussion of time and place

15. Adjournment

APPENDIX 2

APPENDIX 2. LIST OF PARTICIPANTS FOR THE WESTERN PACIFIC YELLOWFIN TUNA RESEARCH GROUP WORKSHOP, HONOLULU, HAWAII, JUNE 16–24, 1992

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APPENDIX 3

APPENDIX 3: LIST OF DOCUMENTS

Document Number	Title and Author
WPYRG2/1	U.S. Fisheries in the Central and Western Pacific (*Atilio L. Coan, Jr.*)
WPYRG2/2	Assessment of Skipjack and Yellowfin Tuna Stocks in the Western Tropical Pacific, Using data from Large-Scale Tagging Experiments (*John Hampton*)
WPYRG2/3	Central and Western Pacific Yellowfin Tuna Fisheries Catches and Vessel Participation (*Atilio L. Coan, Jr.*)
WPYRG2/4	Age and Growth of Yellowfin in the Central and Western Pacific: List of Relevant Data (*Pierre Kleiber*)
WPYRG2/5	Yellowfin Tuna Fisheries of the Eastern Australian Fishing Zone (*Peter J. Ward*)
WPYRG2/6	Natural Mortality Rate of Pacific Yellowfin Tuna: A Review (*John Hampton*)
WPYRG2/7	Stock Structure of Pacific Yellowfin - A Review (*Antony Lewis*)
WPYRG2/8	Preliminary analysis of CPUE for purse-seine fisheries in the western Pacific (*Timothy Lawson*)
WPYRG2/9	Review of Yellowfin Tuna Fishery in the Eastern Part of Indonesian Waters (*Nurzali Naamin*)
WPYRG2/10	Taiwan's Yellowfin Tuna Fisheries in the Central and Western Pacific Ocean (*Chi-Lu Sun and Su-Zan Yeh*)
WPYRG2/11	Operation and CPUE of Japanese Purse Seine in the Western Tropical Pacific (*Sachiko Tsuji*)
WPYRG2/12	Memorandum of Longline CPUE for Yellowfin Tuna (*Ziro Suzuki*)

Appendix 3 (continued)

Document Number	**Title and Author**
WPYRG2/13	A Review of Reproductive Biology of Yellowfin Tuna in the Central and Western Pacific Ocean *(Chi-Lu Sun and Su-Zan Yeh)*
WPYRG2/14	Length and Weight Relationships for Yellowfin Tuna in the Western Pacific *(Peter J. Ward and Cesar M. Ramirez)*
WPYRG2/15	Urgency in formulating effective international management body for tuna resources in the western and central Pacific *(Ziro Suzuki)*

APPENDIX 4

APPENDIX 4: PROCEDURE FOR ESTIMATING NUMBERS OF FISH IN THE CATCH (IN WEIGHT) WITH LENGTH-FREQUENCY SAMPLES

1. Convert each length sampled to a weight using a length-weight relationship;

2. Calculate the sample catch in weight at each length by multiplying the number of fish caught at each length by the weight at each length (estimated in [1]);

3. Estimate the total weight of the sample by summing the weight for each length (estimated in [2]);

4. Estimate the average weight of fish in the sample by dividing the total weight of the sample (estimated in [3]) by the total number of fish in the sample;

5. Estimate the total number of fish caught in the fishery by dividing the total weight of fish caught in the fishery by the average weight (estimated in [4]);

6. Estimate raising factors for each length in the sample by dividing the number of fish sampled at each length by the total number of fish in the sample; and

7. Estimate the number of fish caught at each length by multiplying the total number of fish caught (estimated in [5]) by the raising factor for each length (estimated in [6]).

APPENDIX 5

APPENDIX 5: LENGTH-FREQUENCY SUBSTITUTION CRITERIA FOR WPYRG DATA BASE

1) SAME FLEET SAME QUARTER ADJACENT AREA

2) SAME FLEET ADJACENT QUARTER SAME AREA

3) SAME FLEET ADJACENT QUARTER ADJACENT AREA

4) COMPARABLE FLEET AND SET TYPE SAME QUARTER AND AREA

5) COMPARABLE FLEET AND SET TYPE SAME QUARTER ADJACENT AREA

6) COMPARABLE FLEET AND SET TYPE ADJACENT QUARTER SAME AREA

7) COMPARABLE FLEET AND SET TYPE ADJACENT QUARTER ADJACENT AREA

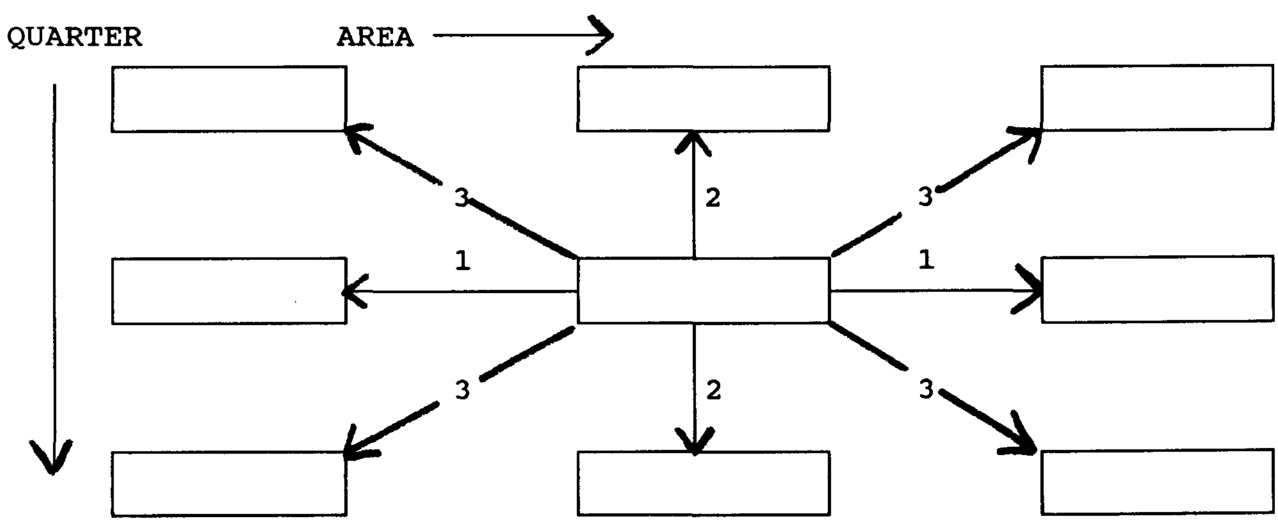
8) ADJACENT YEAR SAME FLEET SAME AREA AND QUARTER

9) ADJACENT YEAR SAME FLEET SAME QUARTER ADJACENT AREA

10) ADJACENT YEAR SAME FLEET ADJACENT QUARTER SAME AREA

11) ADJACENT YEAR SAME FLEET ADJACENT QUARTER AND ADJACENT AREA

EXAMPLE:



APPENDIX 6

APPENDIX 6: PROCESSING PROCEDURES USED TO GENERATE TEST RUN CATCH-AT-LENGTH ESTIMATES.

Catch-at-length was estimated for each fishery (gear) by country. The estimates were then aggregated by fishery. The general steps are as follows:

1. The annual estimated catch was distributed among quarter/WPYF area strata using the ratio of sample catch in each stratum to total sample catch for all strata.

2. The length-frequency data in each stratum was then expanded to the annual catch in each stratum (from 1) using the ratio of annual stratum catch (in weight) to weight of fish in the length-frequency sample.

Data handling procedures and the substitution schedule for strata with catch, but no length-frequency data, are as follows:

LONGLINE FISHERIES 1970 and 1987:

Japan:

Length-frequency data submitted for 1970 and 1987 by quarter, WPYF area and 2-cm intervals were converted to 1-cm interval format by simply dividing the numbers of fish in the 2-cm intervals equally and assigning them to 1-cm intervals.

Taiwan:

Distant water fishery catches (in weight) were prorated into quarter/WPYF area strata with 5-degree logbook data. Because the logbook catch data are in numbers of fish and no length-frequency data are available for the catches, the size composition is assumed to be the same as for the Japanese longline catch for 1970 and 1987.

Landing data for the offshore fishery were available for 1982 onward. To prorate the 1970 catch into quarter/WPYF area strata, landing data from the closest year (i.e., 1982) were chosen for this purpose. For length-frequency data, which were not available, data from the Japanese longline catch for WPYF area 3 were substituted.

Korea:

Five-degree logbook data were used to prorate the 1987 catch into quarter/WPYF area strata. Because logbook data were not available for 1970, proration was done with 1975 logbook data with the assumption that the distribution in both years is similar.

Length-frequency data from the Japanese longline catch for 1970 and 1987 were substituted for missing data.

New Caledonia:

Length-frequency data from the Japanese longline catch were substituted for missing data.

United States:

1970 length-frequency data for WPYF areas 2 and 5 and from the Japanese longline catch were substituted for 1970 missing data.

Size-frequency data collected in 1987 were in weight frequencies. They were converted to length frequencies using the length-weight relation (see Section 9.2.2.).

Tonga:

1987 length-frequency data for WPYF areas 5, 6, and 7 from the Japanese longline catch were substituted for 1987 missing data.

Indonesia:

Distribution of the 1987 catch by quarter/WPYF area is assumed to be the same as that of the Taiwan longline inshore fishery in 1987. 1987 length-frequency data for WPYF area 3 from the Japanese longline catch were substituted for 1987 missing data.

Philippines:

Distribution of 1970 and 1987 catches by quarter/WPYF area is assumed to be the same as that of the Taiwan longline inshore fishery. 1970 and 1987 length-frequency data from the Japanese longline catch for WPYF area 3 were substituted for missing data.

PURSE-SEINE FISHERY 1981 and 1990:

Japan:

Length-frequency data were available in aggregated form for the fishery in WPYF area 4. The fishery, however, operates in principally two areas, WPYF area 3 and 4. The data are assumed to be representative of catches in both WPYF areas.

United States:

1981 length-frequency data, all set types combined, from the Japanese purse-seiner catch were substituted for 1981 missing data.

Solomon Islands:

Length-frequency data, all set types combined, from the Japanese purse-seine catch were substituted for missing 1981 data.

Taiwan:

Length-frequency data, all set types combined, from the Japanese purse-seine catch were substituted for missing data for both years.

Korea:

Distribution of catches by quarter/WPYF area in 1981 and 1990 is assumed to be the same as that of the Japanese purse-seine fleet, all set types combined. Similarly, length-frequency data, all set types combined, from the Japanese purse-seiner catch were substituted for missing data for both years.

Indonesia:

Distribution of catches by quarter/WPYF area in 1981 and 1990 is assumed the same as that for log sets only of the Japanese purse-seine fleet.

Length-frequency data from the Japanese purse-seiner catch, log sets only, for those years were substituted for missing data for both years.

Philippines:

Length-frequency data are available for purse-seine and ring-net gears; however, they could not be processed in time for this test run. Instead, length-frequency data for log sets only from the Japanese purse-seine catches were substituted.

Ring-net and purse-seine catches were combined. Distribution of the catches by quarter/WPYF area is assumed to be the same as that for log sets only of the Japanese purse-seine fleet.