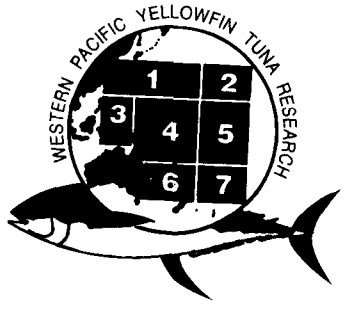
Report of the Third Meeting of the Western Pacific Yellowfin Tuna Research Group

Pohnpei,
Federated States of Micronesia
June 21-23, 1993



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CONTENTS

APPENDICES

PREFACE

The Western Pacific Yellowfin Tuna Research Group (WPYRG) is an informal organization of scientists and fisheries officers engaged in research on the population biology of yellowfin tuna (*Thunnus albacares*) and in monitoring the fisheries exploiting this species in the central and western Pacific Ocean. The Group was organized in 1990 as the result of concerns with expanding fisheries and significant increases in catches of yellowfin tuna from the western Pacific. The Group's purpose is to exchange information and data, plan and cooperate in collaborative research projects, foster a common understanding of the condition of the yellowfin tuna stock and to offer scientific advice on fishery management issues. Meetings held to date:

First meeting-- June 20-21, 1991, Port Vila, Vanuatu
(Host: Vanuatu Fisheries Department)

Second meeting-- June 17-24, 1992, Honolulu, Hawaii, U.S.A.
(Host: U.S. National Marine Fisheries Service)

Third meeting-- June 21-23, 1993, Pohnpei, Federated States of Micronesia
(Host: Micronesian Maritime Authority)

This third report of the WPYRG is published with the technical assistance of Connie Blair, Al Coan, Karen Handschuh, and Ken Raymond of the Southwest Fisheries Science Center, La Jolla, California.

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Report of the Third Meeting of the Western Pacific Yellowfin Tuna Research Group

1.0. INTRODUCTION

The Western Pacific Yellowfin Tuna, *Thunnus albacares*, Research Group (WPYRG) includes scientists and fishery officers of South Pacific island nations, distant-water fishing nations, and international organizations (the South Pacific Commission [SPC], Forum Fisheries Agency [FFA], and the U.N. Food and Agriculture Organization [FAO]) who are interested in research and management of the tropical tunas in the central and western Pacific Ocean. At its first meeting (Port Vila, June 1991), the Group defined the central study area as mainly waters bounded on the north by 40° N, on the west by Australia and 120° E, on the east by 150° W, and on the south by 40° S (Figure 1). Within this study area, seven statistical areas (Western Pacific Yellowfin Tuna [WPYF] areas) were established for reporting and compiling fishery statistics. The Group also took note of the limited information on the condition of the yellowfin tuna stock and of the urgent need for

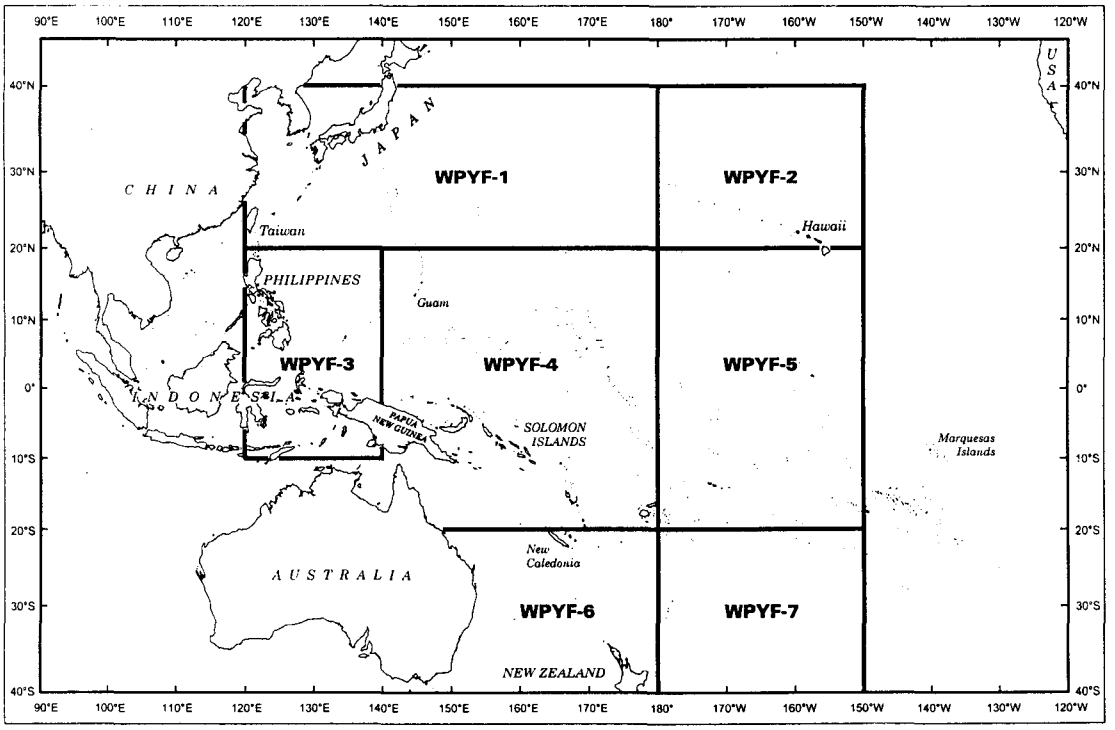

Figure 1. WPYRG study area and statistical areas (Western Pacific Yellowfin Tuna [WPYF]) for reporting fisheries statistics.

developing scientific advice for fishery management. The Group agreed on an overall goal of assessing the condition of the yellowfin tuna stock(s) in the study area in order to provide scientific advice for fishery management decisions. This goal was further defined in terms of three resource-related questions frequently asked by fisheries administrators: What is the safe level of yield and exploitation for the stock? What is the interaction among the different fisheries? and What factors contribute to local depletion? The Group also agreed to a strategic plan for answering these questions within a period of approximately 3 years, beginning in 1991.

At its second meeting (Honolulu, June 1992), the Group reviewed information on population parameters of yellowfin tuna of the central and western Pacific (stock structure, age, growth, reproduction and mortality); began assembling and evaluating a comprehensive data base for conducting a length-based or age-based stock assessment; and reviewed possible stock assessment approaches. The Group concluded that there was scattered and incomplete information on the population dynamics of the stock; that available data for a length-based or age-based assessment were insufficient; and that alternative assessment methods, including non-traditional ones, will be required for conducting a stock assessment.

The third meeting of the Group was held in Pohnpei, Federated States of Micronesia (FSM), under the chairmanship of Gary Sakagawa. For this meeting, the Group focused on reviewing accomplishments of its 1992-93 work plan. The theme for the third meeting was analysis of catch-per-unit effort (CPUE) indices for monitoring trends in abundance.

2.0 AGENDA AND RAPPORTEURS

The chairman welcomed the participants (Appendix A) and solicited their advice concerning meeting procedures and the draft agenda for the meeting. After modifications were made to the draft agenda, the agenda (Appendix B) was adopted. Rapporteurs were appointed by the chairman, and Peter Ward was designated as coordinator for the WPYRG report. Rapporteurs for major sections are as follows:

-Review of Fisheries Developments and Outlook -- *B. Thoulag*

-Review of Fisheries Data -- *A. Coan* and *T. Lawson*

-Review of Management Issues and Functions -- *A. Lewis*

-Assessment Model -- *P. Kleiber*

-Tag-Recapture Analysis -- *T. Murray*

-Catch-per-Unit Effort (CPUE) Analysis -- *J. Hampton*

-Length-Weight Relationship, Age and Growth, Reproductive Biology, Stock Structure -- *A. Lewis*

-Work Plan for 1993-94 -- *G. Sakagawa*

Working papers (Appendix C) for the meeting were distributed. References to working papers in this report are made by document number preceded by "WPYRG3/."

3.0. REVIEW OF FISHERIES DEVELOPMENTS AND OUTLOOK

The tropical tuna fisheries of the central-western Pacific were reviewed by the Group to gain a current understanding of yellowfin tuna catches and trends in the fisheries. The fisheries of Indonesia, Japan, the Philippines, the Republic of China (Taiwan), and the United States (U.S.) received special attention because, collectively, they produce about 80 percent of the region's annual total yellowfin tuna catch and experts were present to report on their recent developments.

Catch and effort statistics for fisheries landing yellowfin tuna from the central-western Pacific Ocean were compiled from available information (Appendix D). For fisheries in which recent years' statistics were not available, the most recently reported annual value is carried forward, that is, assumed constant for recent years. A margin of uncertainty is, therefore, present in the total values for recent years used in this report, particularly for 1991 and 1992 statistics. Nonetheless, the totals are rough indicators of the fisheries' performance and will become more precise with time as missing statistics are better estimated or are reported by agencies.

The results of the review showed that yellowfin tuna catches from the central-western Pacific Ocean continue to increase (Figure 2). The catch in 1992 is estimated to be 395,000 t, an increase of about 11 percent in 1991 and 24 percent in 1990. Purse seine catches continue to dominate the total, approximately 56 percent in 1992, and continue to increase at a faster rate than for other gears. Because most of the purse seine catch is used for canning purposes, this indicates that raw material demands for the canned tuna market continue to be high. Longline and handline catches, on the other hand, are principally used for fresh fish products, particularly "sashimi."

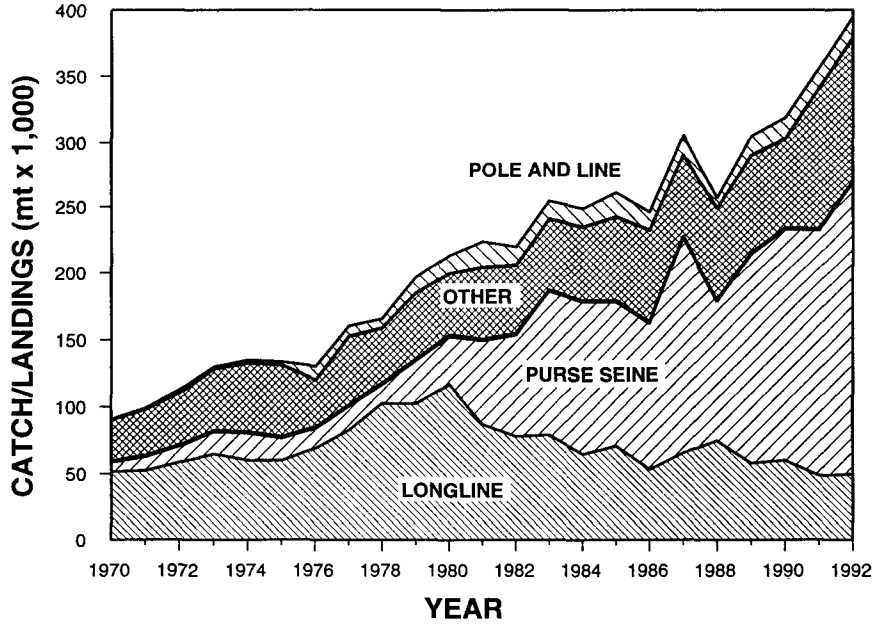

Figure 2. Total catch by gear of yellowfin tuna from the central-western Pacific Ocean.

Reports provided to the Group indicated that tropical tuna fleets will continue to expand in the immediate future. Particularly, growth is anticipated in longline fleets based in island countries that target tunas for the sashimi markets. Purse seine fleets of island countries also appear to be on an increase. The total catch of yellowfin tuna, however, is not anticipated to increase in proportion to the expansion of fishing effort because the increased effort will be directed at other species as well.

3.1 Indonesia (reported by *N. Naamin*)

Indonesian fishermen use two major fishing areas in Indonesian waters to fish for tunas: the western part (FAO area 57); and the eastern part (FAO area 71 or WPYF area 3). About 80 percent of the Indonesian tuna catch is from the eastern part and 20 percent is from the western part.

Preliminary estimate of the Indonesian longline catch of yellowfin tuna for 1992 is 6,242 t, compared to 6,059 t in 1991 and 5,508 t in 1990. Since 1990, many longliners (mostly small longliners of 50 gross registered tons [GRT] or less) have successfully used milkfish, *Chanos chanos*, as live bait. Fishermen report that this technique has doubled--in some cases tripled--the catch rate as compared to the traditional method of using dead bait. Some of these longliners target yellowfin tuna for the sashimi market of Japan. Twice daily air freight shipments of catches occur from Jakarta and Denpasar to Tokyo or Osaka, Japan.

Purse seine catches of yellowfin tuna were 5,872 t in 1991 and 4,599 t in 1992, about double the 1990 catch (2,665 t). This increase was due to joint venture operations beginning in 1992 between Indonesia and Philippine fishing companies. The companies use 100 small ring-net vessels, known as "Katamarau" fishing boats, that fish in the Sulawesi Sea (North Sulawesi). The vessels deploy more than 300 "rumpons" or fish aggregating devices (FADS), and use very strong lights to aggregate the tuna near the rumpons. The catch consists of large amounts of small-sized tunas. This has resulted in conflict with local artisanal fishermen who depend on catches of small-sized tunas.

Since late 1990, the "Nucleus Estate for Smallholders" which is a cooperative arrangement operated by the government, with privately-owned fishing boats and government supported infrastructures, expanded to remote areas in Sulawesi; north of Mollucas; and in Fak-Fak which is in Irian Jaya. The companies use FADS, and handline and pole-and-line gear for tunas. As a result of this expansion, pole-and-line catches of yellowfin tuna increased from 4,433 t in 1990 to 5,472 t in 1991 and 5,319 t in 1992.

Increased deployment of FADs by the Nucleus Estate cooperative also benefitted the handline fishery, which operates around the FADs. Handline catches increased from 3,196 t in 1990 to 3,835 t in 1991 and 4,794 t in 1992. Since 1991, artisanal fishermen have improved their yellowfin tuna catch rates by using large scads, *Decapterus kurroides*, as live bait in handlining and trolling in the Banda Sea.

The catches of yellowfin tuna by various kinds of traditional fishing gears (for instance, trolling and trap), have also increased. In 1991 and 1992 the catches were 34,959 t and 36,770 t, respectively.

3.2 Japan (reported by *S. Tsuji*)

Catch-and-effort data for Japanese longline and purse seine fisheries were revised according to the WPYRG requirements and updated to include more recent years' data where available. Recent years' statistics are preliminary. Total yellowfin tuna catch for 1991 was about 77,200 t, or about the same as in 1990.

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, *Thunnus alalunga*, were the targets of the fishery in the early years. Targeting shifted to bigeye tuna, *Thunnus obesus*, and southern bluefin tuna, *Thunnus maccoyii*, in the early 1970s with the expansion of the Japanese sashimi market and the 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, *Katsuwonus pelamis*, and, at higher latitudes during the summer months, albacore as well. Yellowfin tuna accounts for less than 5 percent of the total catch. This fishery has been on a decline since the early-1980s. Surviving vessels have increasingly focused on serving the Japanese sashimi market to remain profitable.

Tuna purse seine fishing by Japan in the western tropical Pacific Ocean started in the mid-1960s on an experimental basis. Year-round operations were established in the 1970s, and major expansion occurred in the 1980s. The fishing area for the fleet was mainly off Papua New Guinea, in the early years before it expanded eastward. The fishery is now confined to the high seas and exclusive economic zones (EEZs) of island nations where Japan has bilateral access agreements. Thirty-one single seiners and seven units of group seiners are currently involved in this fishery. Their catches average about 25 percent yellowfin tuna and 75 percent skipjack tuna.

3.3. Philippines (reported by *R. Ganaden*)

In 1991, 95,614 t of yellowfin tuna were caught in the Philippine fisheries. The fisheries can be classified into two main sectors: the "municipal sector" which consists of vessels of 3 GRT or smaller and the "commercial sector" which consists of vessels greater than 3 GRT. The commercial sector produced 50,882 t of yellowfin tuna in 1991. Purse seine (23,911 t) and ringnet (2,977 t) are the main fishing gears used by the commercial sector. Other minor gears include handlines, bagnets, and round-haul seines.

An estimated 44,732 t of yellowfin tuna were taken by the municipal sector in 1991. An accurate breakdown of this catch by fishing gear is not available. However, judging from past information on the breakdown, handline gear is estimated to have taken the

major part of the catch for this sector. This sector targets large yellowfin tuna for export to sashimi markets.

About 15 large Philippine purse seiners operated in the western Pacific, particularly off Papua New Guinea, in 1991. They caught 25,417 t of tunas, of which 8,174 t were yellowfin tuna. Most, if not all, of the catch was landed in the Philippines for canning. The offshore operations of these vessels probably account for most of the increase in the Philippine yellowfin tuna catches in recent years. Some vessels have recently operated in Indonesia waters, but information on their catches is unavailable at this time.

The tuna industry has proven to be a significant foreign exchange earner for the Philippines but is now facing production difficulties. During the 1980s, unrealistic projections of local tuna abundance led to the overbuilding of canning facilities. These facilities are now available while the local resource for cannery-size tuna has decreased because of heavy exploitation. Furthermore, the condition of the Philippine tuna fishing fleet, as a whole, is not good. Most of the vessels are 20-25 years old and approaching the end of their usefulness. These vessels cannot readily be switched to distant-water fishing areas where the resource is not as heavily exploited.

3.4 Taiwan (reported by *C.-L. Sun*; WPYRG3/10)

The annual catch of yellowfin tuna by Taiwan vessels (all gears) increased from 16,520 t in 1975 to a peak of 27,338 t in 1979. Since then, production fluctuated between 14,000 and 24,000 t before increasing markedly to 52,650 t in 1992. This large increase in catch was due to growth and expansion of the Taiwan purse seine fleet.

Taiwan entered the distant-water tuna longline fishery in the early 1960s from the base port of Kaohsiung, with fishing areas in the South China Sea. Starting in 1963, operations extended to the South Pacific, and albacore became the target species. Yellowfin tuna is a bycatch of this fishery, with catches averaging 2,779 t a year during 1970-92.

The offshore tuna longline fishery mainly targets yellowfin tuna. Most of the vessels are based at Tungkang and the fishing is done in the South China Sea. The tuna catch goes mainly to the sashimi market of Japan. The average annual (1970-92) catch of yellowfin tuna of this fleet is 12,483 t.

Before 1981, the tuna longline fisheries (distant-water and offshore) were the major Taiwan fisheries for yellowfin tuna in the central and western Pacific. Since then, a tropical tuna purse seine fishery was established and has become the dominant Taiwan fishery for yellowfin tuna in the western Pacific Ocean. This dominance is likely to continue in the 1990s.

The Taiwan distant-water purse seine fleet is based in Taiwan and operates primarily in the western part of the WPYRG study area. The number of vessels ranged from 5 to 31 during 1984-90. Currently, the fleet consists of 43 vessels. The government of Taiwan has imposed a limit on the number of tuna purse seiners allowed to participate because of

the rapid build-up of the fleet and limited fishing access within the western Pacific. Purse seine landings of yellowfin tuna increased from 252 t in 1984 to 44,459 t in 1992 (averaged 11,118 t a year for the period). Yellowfin tuna average about 20 percent of the total landings for this fishery; the remainder is mostly skipjack tuna.

3.5 United States (reported by *A. Coan*; WPYRG3/2 and 16)

There are three main types of U.S. fisheries for yellowfin tuna in the central and western Pacific: a distant-water purse seine fishery, Hawaii-based commercial fisheries, and artisanal fisheries.

The distant-water purse seine fishery operates over a large area of the western Pacific and targets yellowfin tuna and skipjack tuna. The catch, however, averages about 28 percent yellowfin tuna. The number of vessels participating in this fishery peaked at 63 in 1983, declined to 32 in 1988, and increased again to 44 in 1992. Most vessels in the fleet are of 1,000-1,800 t carrying capacity.

Yellowfin tuna landings for this fishery peaked at 66,400 t in 1987, experienced a significant decline the next year to 25,200 t, increased to 57,100 t in 1990, and declined to 50,300 t in 1992. Both catch rate and average size of yellowfin landed so far for 1993 are below those for the same period last year. The total yellowfin tuna catch for 1993 is projected to be approximately 35,000 t, or lower than the catch for 1992. The number of vessels fishing in 1993 is expected to be the same as in 1992, 44 vessels.

Artisanal and Hawaii-based commercial fisheries operate within the EEZs of Hawaii, Guam, American Samoa, and the Northern Marianas. Primarily handline, troll, and longline gears are used, and they target a variety of tunas, billfishes, and other large pelagic species. The majority of the yellowfin tuna landings is from troll and handline gears operating in waters off Hawaii. Hawaii-based landings of yellowfin tuna peaked at 2,200 t in 1986. Since then, landings have decreased, with 1,200 t reported in 1992. Off Guam, American Samoa, and the Northern Marianas only, artisanal fisheries report significant catches of yellowfin tuna. Annual landings typically are below 90 t.

For 1993, landings are forecasted to be approximately 1,400 t for the Hawaii-based fisheries and about 70 t for the artisanal fisheries of Guam, American Samoa, and the Northern Marianas.

3.6 Others (reported by *T. Lawson*)

Longline fisheries other than those reviewed above that catch yellowfin tuna in the western Pacific involve fleets of Australia, the Federated States of Micronesia, Fiji, Korea, the Marshall Islands, New Caledonia, New Zealand, Tonga and American vessels based in the Marshall Islands. The most recent annual catch estimate for the Korean fleet is 15,179 t, Pacific-wide in 1991. The Australian fleet caught 742 t, while the Fijian and New Caledonian fleets caught 202 t and 230 t, respectively, in 1992. The remaining fleets each caught less than 100 t.

Pole-and-line fleets of Australia, Fiji, Kiribati, Palau, the Solomon Islands, and Tuvalu caught small amounts of yellowfin tuna in 1992. The yellowfin tuna catch by the Solomon Islands fleet in 1992 is estimated to be 1,246 t. This estimate is based on daily catch-and-effort logsheets from vessels; the actual amount landed is probably somewhat greater. The Fijian and Kiribati fleets caught 395 t and 303 t, respectively, in 1992. Yellowfin tuna catches by the remaining fleets were each less than 100 t in 1992.

Purse seine fleets of Australia, the Federated States of Micronesia (FSM), Korea, New Zealand, the Solomon Islands, and Russia reportedly caught yellowfin tuna in 1992 from the western Pacific Ocean. According to data provided by an industry source to SPC, the Korean fleet of 36 large purse seiners caught an estimated 40,315 t of yellowfin tuna during 1992, down from 50,347 t for 1991. The catch by the Solomon Islands large purse seiners during 1992 was 5,093 t, while catches by the remaining fleets were each less than 5,000 t.

4.0 REVIEW OF FISHERIES DATA (WPYRG3/4 and 8)

The 1992-93 work plan for the Group included several fisheries data-related tasks identified by the Group at the second meeting. Major tasks were updating fisheries statistics and evaluating sampling coverage for information on sizes of yellowfin tuna caught by the different fleets. Accomplishments of the Group in 1992-93 are as follows:

4.1 Data Base

The Group reviewed progress made in data assignments and action items identified at the second meeting. The results are as follows:

- Keypunch and incorporate Philippine length-frequency data into base.

  The WPYRG data base was expanded to include length-frequency data for domestic Philippine ring-net and purse seine catches. This resulted in the addition of substantial numbers of small (14-32 cm fork length [FL]) yellowfin tuna to the catch taken in WPYF area 3. It also changed the overall distribution of sizes of yellowfin tuna taken by the surface fishery from the picture developed at the second meeting (Figure 3).

- For Korea and Taiwan, incorporate set-type information on purse seine fisheries into base.

  SPC provided set-type information for purse seine catches from Korea and Taiwan, and this was used to estimate catches by set type. Japanese length-frequency data by set type were substituted for missing size data for catches from Korea and Taiwan. The added SPC data did not change the results significantly from those obtained last year when set-type data were not part of the data base (Figure 4). This is largely because the new information produced a similar proportion of catches by set type as used last year.

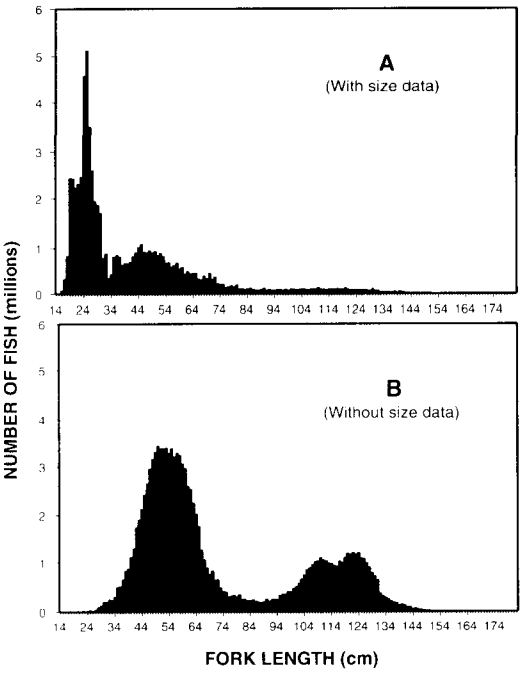

Figure 3. *Comparison of estimated* length-frequency distribution of yellowfin tuna in the total purse seine catch for 1990 with inclusion of Philippine fisheries length-frequency data (A) and without these length-frequency data (B).

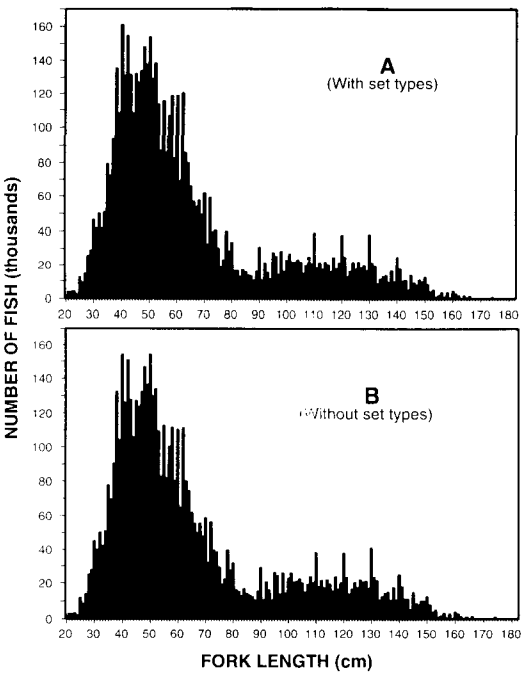

Figure 4. *Comparison of estimated* length-frequency distribution of yellowfin tuna in the purse seine catch for Korea and Taiwan fisheries for 1990 with set-type information (A) and without this set-type information (B).

- Stratify Japanese purse seine data into WPYF areas 3 and 4.

  Area stratification of the Japanese purse seine catches was completed. However, the Group learned of another more serious problem with the length-frequency data. The problem involves missing set-type codes for 1981 and 1982 data; poor sampling coverage of coastal vessel catches, which are largely made in WPYF area 1 and which represent significant amounts; fewer fish being measured in recent years; a tendency to measure fish to the nearest 5 cm; and selective sampling with preference for certain size categories.

  With regard to fish measured to the nearest 5 cm, it was noted that this would not seriously affect analysis with length-based or age-based assessment models, but could affect analyses with models, such as MULTIFAN, used to separate and identify year classes.

- Investigate effects of various substitution schemes across areas and time for Japanese longline data and for U.S. purse seine data.

  Analyses were conducted with data from the U.S. purse seine fishery, with complete sampling coverage present (that is, known profile of sizes of fish caught), to evaluate substitution biases. Various size samples were removed from the data set and substitution schemes were used to replace the missing data following the procedures

adopted last year by the Group. The results showed that substitution of length or age samples, whether by area or month, led to statistically significant differences between the substituted and actual length-frequency distributions. Differences for substitutions based on month were slightly less significant than substitutions based on area. Differences for log sets were slightly less significant than for school-fish sets. Substitution of Japanese length-frequency samples for sizes of fish in the U.S. catches also led to statistically significant differences. In short, the results demonstrated that substitution schemes should not be used because they can produce distortions in the resulting size compositions, and the distortions can be quite different from reality.

The Group noted that problems related to substitution bias can be averted by using analytical models that do not require substitutions. Further discussion of such models is provided in Section 6.1.

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

Japanese longline length-frequency data were reexamined with special attention to checking samples with small (30-40 cm FL) yellowfin tuna. The task uncovered misinterpretation of length measurements during the original processing of data sheets. Corrections were entered into the data base which eliminated the presence of small fish in longline catch records (Figure 5).

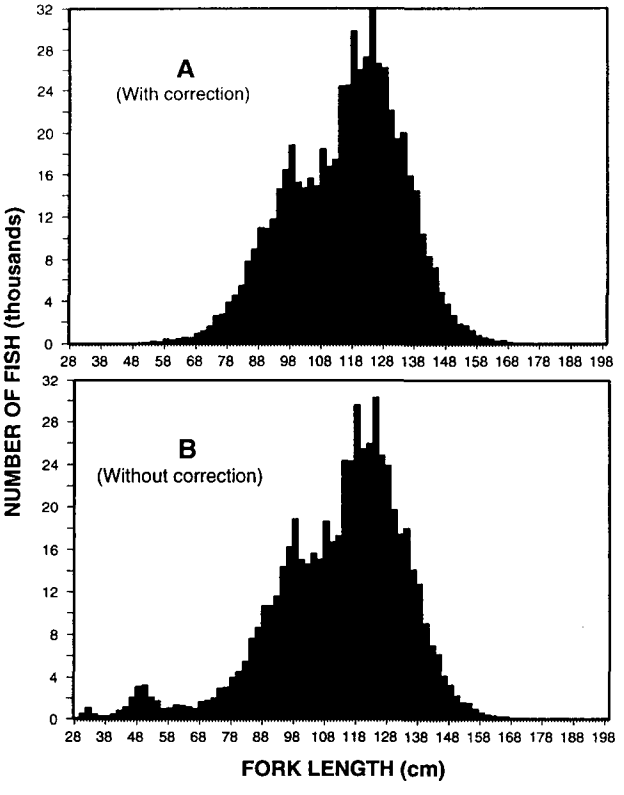

Figure 5. Comparison of estimated length-frequency distribution of yellowfin tuna in the Japanese longline catch for 1970 with correction for small fish measurements in Japanese data (A) and without this correction (B).

- Review and report on how catches by foreign vessels or domestic vessels operating under joint-venture or charter agreements are treated in reported annual catches.

  A review of data reported by countries with joint-venture or chartered vessel arrangements revealed the following:

  Australia Catch -- Catches by Australian longliners reported at the second meeting included catches by domestic longliners, wholly Australian-owned ex-Japanese vessels, and chartered Japanese and Korean vessels. Because Japanese catches are reported for vessels fishing under bilateral access agreements, but not for joint-venture or chartered vessels, the chartered Japanese vessel catches reported in the Australian statistics are not double counted. Chartered Korean vessel catches are also not reported in Korean statistics.

  New Zealand Catch -- Catches by chartered Japanese and U.S. vessels fishing in New Zealand waters are reported by New Zealand authorities as New Zealand catches. The catches of yellowfin tuna for these vessels, however, have been negligible.

  Palau Catch -- Catches by pole-and-line vessels during 1970-1982 include catches by chartered Okinawan vessels and are reported as Palauan catches. Palauan catches during 1985-1992 are for a single domestic vessel.

  Fiji Catch -- Catches of chartered vessels belonging to Taiwan and based in Levuka, Fiji, are reported as distant-water longline catch for Taiwan and are not shown in the Fijian statistics.

The Group also reviewed options for dissemination of the WPYRG catch-by-size data base and for disposition of the original data used to assemble the base. The Group reaffirmed its decision made at the second meeting that the catch-by-size data base would not be distributed because of its questionable accuracy due to extensive substitutions required to generate it, inclusion of some questionable data, and because it would reveal confidential information. The Group also reaffirmed its decision to return original catch, effort, and length-frequency data, which are for the most part confidential, to contributors for safekeeping and maintenance. In the event that the data base must be created again in the future, the data will be available from the contributors. No unauthorized data will be kept by the U.S. National Marine Fisheries Service (NMFS). The NMFS volunteered to maintain computer software that can be used to recreate the data base if needed in the future.

While the Group decided to not maintain a WPYRG catch-by-size data base, it agreed that fisheries statistics by fleet for monitoring of the fisheries should continue to be collected, compiled, updated, and evaluated by data correspondents. Statistics involved are catch, catch-and-effort, and sizes of fish caught. Data to be made available to the Group are total catches and effort (number of vessels), for updating statistical tables in Appendix D.

4.2 Port Sampling

Efforts by the Group in 1992 to construct an accurate time-series (1970-1990) of catch-at-size for yellowfin tuna from the central-western Pacific were frustrated because of missing data on sizes of fish for a substantial portion of the catches. For example, about 45 percent of the purse seine catch and about 50 percent of the longline catch in 1990 had no data on sizes of fish caught. The Group subsequently learned that, in fact, these percentages are considerably higher because of non-random sampling, non-standardized measuring procedures, and questionable reporting of size measurements for some of the reported catches (see Section 4.1). The net result is considerably less reliable data available on sizes of fish than first believed.

Standard substitution procedures, in which available size samples are substituted for catches that lack size data, were thought to be a solution for this inadequate size-sample coverage. However, results of simulation analyses indicated that the procedures can distort the real picture and lead to wrong conclusions (see Section 4.1). Substitution procedures, in fact, are poor solutions and should be avoided. The Group, therefore, reconfirmed its findings of the second meeting that creating an accurate time-series of catch-at-size for past years was not possible because of insufficient data.

The Group also concluded that effort would be better spent on developing and instituting procedures for improving the current data collection activities, in order to avoid past mistakes, than pursuing rescue of historical data. With this in mind, the Group reviewed the landing patterns of the fleets and the sampling activities for size information. Results of the review are as follows:

A profile of landing location by fleets in 1991 was prepared (Table 1). The profile indicated that, among the major fleets, only the catches of Japan, possibly Korea, the Philippines, Taiwan (longline only) and the U.S. fleets were sampled for sizes of fish caught in 1991. The profile also indicated that catches of the purse seine fleets from possibly Korea and Taiwan are not being sampled or not sampled adequately. Large amounts of catch are also being unloaded at sea to reefer vessels by distant-water fishing vessels for shipment to distant ports. These at-sea transfers occur at remote locations and, hence, are largely inaccessible to trained technicians for sampling.

A significant amount of catch from longliners is being landed in island ports for shipment to fresh-fish markets, and local authorities are beginning to collect statistics on these landings. Also, there is a trend towards increased use of automated landing procedures at ports receiving large landings. This has decreased the opportunity for sampling of the catches at such ports.

The Group learned that the Pacific island countries have recently adopted a policy of prohibiting at-sea transshipments and requiring vessels, as part of fishing access agreements, to conduct transshipments at designated island ports as of June 15, 1993. The Group noted that this should allow increased opportunity for collecting data on sizes of fish, and it recommended that port sampling with trained technicians be used to take

Table 1. Landing profile and size-frequency sampling coverage for the 1991 yellowfin tuna catch from the WPYRG study area.

Fleet/Landing Type	Port	Landing (t)	Sampled (t)	Sample Size		Comments
				No. of samples	No. of fish per sample	
LONGLINE						
Australia		742	?	?	?	Sampled
Homeport	Sydney					
Federated States of Micronesia		6	3.2	7	12	Sampled
Homeport	Pohnpei					
Fiji		106	None	None	None	No sampling for YFT. Some ALB sampling.
Homeport	Levuka					
	Suva					
Transship.	Levuka					
Indonesia		6,059	None	None	None	No sampling
Homeport	Biak					
	Ambon					
	Kendari					
	Benoa-Bali					
Japan		23,194	?	?	?	Sampled at-sea mostly
Homeport	Yaizu					
	Shimizu					
	Various other National ports					
Transship.	At-sea					
Korea		9,591				
Homeport	Pusan					
	Pago Pago	517	?	20	25	Sampled by NMFS
Transship.	At-sea					
	Pago Pago					
	Tinian					
New Caledonia		506	None	None	None	No sampling
Homeport	Noumea					
Philippines		2,625	?	?	?	Sampled
Homeport	?					
Transship.	?					
Taiwan						
Distant-water		665	?	?	?	Sampled/not available
Homeport	Kaohsiung					
	Pago Pago		?	20	25	Sampled by NMFS
Transship.	At-sea					
	Chuuk					
	Yap					
	Pago Pago					
Offshore		5,838	?	?	?	Sampled/not available
Homeport	Tungkang					
Transship.	At-sea					
	Chuuk					
	Yap					

TABLE 1. (continued)

Fleet/Landing Type	Port	Landing (t)	Sampled (t)	Sample Size		Comments
				No. of samples	No. of fish per sample	
PURSE-SEINE FISHERY						
Australia		1,353	None	None	None	Sampling
Homeport	?					
Transship.	?					
Federated States of Micronesia		1,185	?	?	?	No sampling
Homeport	Pohnpei					
Indonesia		2,500	None	None	None	No sampling
Homeport	Biak					
Japan		46,230	?	?	?	19,156 fish sampled at-sea mostly
Homeport	Yaizu					
	Others					
Transship.	Bangkok					
	At-sea					
Korea		50,347	None	None	None	No sampling
Homeport	Pusan					
Transship.	At-sea					
	Tinian					
Philippines		26,888	?	?	?	Sampled
Homeport	General Santos					
	Navotas					
	Labuan/Recodo					
Russia		1,114	None	None	None	No sampling
Homeport	?					
Transship.	Honiara					
Solomon Islands		3,275	None	None	None	No sampling
Homeport	Honiara					
	Noro					
	Tulagi					
Taiwan		16,358	None	None	None	No sampling
Homeport	Kaohsiung					
Transship.	At-sea					
	Tinian					
	Pago Pago					
United States		34,987				
Homeport	Pago Pago	9,338	426	77	Port sampling	
	Guam/Tinian					
Transship.	At-sea					
	Tinian					
	Pago Pago					
	Fiji					
POLE-AND-LINE FISHERY						
Fiji		358	None	None	None	No sampling
Homeport	Levuka					
	Suva					

TABLE 1. (continued)

Fleet/Landing Type	Port	Landing (t)	Sampled (t)	Sample Size		Comments
				No. of samples	No. of fish per sample	
Indonesia		5,472	None	None	None	No sampling
Homeport	Biak					
	Sorong					
	Ambon					
	Bitung					
	Kendari					
	Maumere					
	Labuha					
	Luwuk					
Japan		7,800	None	None	None	No sampling
Homeport	Yaizu					
	Various other national ports					
Kiribati		67	None	None	None	No sampling
Homeport	Tarawa					
Solomon Islands		950	?	?	?	Sampled
Homeport	Noro					
	Tulagi					

advantage of this opportunity and to improve data collection. The Group also noted that this recommendation is already being executed by the FSM to monitor the catches landed by distant-water longliners landing at FSM ports for shipment to fresh-fish markets. A preliminary list of designated ports for transshipment activities was assembled (Table 2).

The SPC informed the Group of a 5-year program, beginning in 1994, to improve data collection by augmenting port sampling with four or five samplers and by recruiting scientific observers for deployment on four or five vessels at any one time. The activities will be executed in cooperation with national programs. The Group reviewed the plan and offered suggestions. It felt that because the national laboratories and agencies are responsible for reporting statistics on their flag vessels, the flag vessel countries should make a major effort to collect appropriate fisheries data from their fleets and to cooperate with the SPC program. Furthermore, the Group recommended the following as high priority sampling needs: (1) explore improved sampling procedures for collecting size-frequency data from the Japanese purse seine and longline catches at home ports; (2) institute sampling in designated transshipment ports, starting with major ones with high volume, to collect data on size frequency and species composition of catches being transshipped, particularly from purse seiners and longliners from Korea and Taiwan; and (3) explore sampling of landings by purse seiners from Korea, Taiwan, and the U.S. for transshipment in Guam and Tinian. Lower priority sampling needs include establishing sampling at home ports in Korea for collecting data on size and species composition of purse seine landings. The Group also emphasized the need for proper training of port samplers and sampling that includes the collection of accurate data on the area and date of the catches being sampled.

Table 2. Preliminary list of designated Pacific island ports for transshipment activities by vessels fishing under Pacific island countries access agreements.

COUNTRY	PORT	PORT SAMPLER AVAILABLE
Australia	Cairns	No
Federated States of Micronesia	Colonia (Yap)	Yes
	Okat (Kosrae)	Yes
	Kolonia (Pohnpei)	Yes
	Satawan	No
	Moen (Chuuk)	Yes
Fiji	Levuka	Yes
	Pacific Harbour	Yes
Kiribati	Kiritimati	No
	Betio (Tarawa)	No
Marshall Islands	Majuro	No
Nauru	Nauru	No
Papua New Guinea	Port Moresby	No
	Lae	No
	Madang (Sek Harbour)	No
	Wewak	No
	Kavieng	No
	Lorengau	No
	Rabaul	No
Solomon Islands	Honiara	No
	Noro	No
	Tulagi	No
Tuvalu	Funafuti	No
Vanuatu	Malekula	No
	Port Vila	No
Western Samoa	Apia	No

4.3. At-Sea Observers

At-sea observers are increasingly being considered as an important source for collecting detailed fisheries data. The Group noted that there are national observer programs (e.g., Kiribati and FSM) as well as a Forum Fisheries Agency (FFA) observer program in the western Pacific region. These programs need to be carefully designed and coordinated to assure that they meet their objectives, collect data in a uniform manner, and complement, rather than duplicate, each other's efforts. An immediate need that was noted and that the SPC might be able to fill is to train observers in uniform and proper procedures for collecting data.

Two general types of at-sea observer programs are commonly used in fisheries. One is mainly for regulation-compliance purposes and the other is for scientific purposes. Although both may collect similar types of data, the potential for gathering useful stock assessment information is much greater with scientific observer programs than with compliance observer programs. Science programs, however, need to be designed carefully and with a clear purpose in mind if this potential is to be realized. This point is important because fishing behavior of an observed fisherman is likely to be different from an unobserved fisherman. The data gathered by an observer program could, therefore, be inappropriate for generalization to the entire fishery if the design is flawed.

In the western Pacific, the impact of by-catch and discards by the tropical tuna fisheries on the productivity and yield of tunas and other species in the region is of increasing concern. Observer programs are felt to be a mechanism for collecting required data for impact analyses. The SPC's plans, noted above (Section 4.2), and other observer programs in the region, are in part for this purpose.

The Group noted that data from observer programs, either for compliance or science, can be useful for verifying port sampling techniques. For example, measurements taken by observers on vessels can be compared to similar measurements taken independently by port samplers from the same vessels at the time of landings. The comparison can show how well the port sampling procedures provide adequate coverage and a representative profile of the landed catches. The Group recommended that this type of experiment be encouraged where it can be executed, such as in the FSM where observer and port sampling are planned to monitor the purse seiners from Korea and Taiwan fishing in FSM waters.

5.0. REVIEW OF STOCK ASSESSMENTS

5.1. Tag-Recapture Analysis (WPYRG3/13)

Yellowfin tuna tag-recapture data from the SPC Regional Tuna Tagging Project were analyzed using additional analytical refinements to those used in previous analysis of the data. The results of the analysis of the data, which represented 2,341 returns as of September 1992 from 24,318 releases, were reported to the Group. The analysis included use of a simple tag-attrition model to estimate mortality rates, throughput (population turnover rate) and standing stock available to the surface fisheries in the western tropical Pacific. The results were estimates of M of 0.098 to 0.12 mo^{-1}, a high throughput that implies complete replacement of the available population every 8 months and a low harvest ratio of 0.16, that is, proportion of total mortality due to fishing. These results suggest that considerably higher yields (possibly 550,000-800,000 t annually) than currently taken appear possible without serious damage to the stock.

The Group warned of caution in drawing inferences from these results to local conditions because of assumptions in the analytical method and uncertainties in the data. Some points highlighted by the analysis were that the method does not account for spatial variation in the distribution of tagged and untagged fish nor in the pattern of exploitation in the western Pacific, and the method does not account for variation in size or age structure of the tag releases, tag returns, catch, and population. Also, because the tag releases were mainly of small-sized yellowfin tuna and because the longline catches decreased to about 10 percent of total catch during the tag-recapture period, the results pertain primarily to the stock available to the surface fishery. The results should also be considered as rough averages for the region as a whole, while large spatial and size-related variations in yellowfin tuna abundance and mortality possibly exist within the region.

The Group felt that further refinements in the analysis can be undertaken, particularly if size-composition data for recent catches of the purse-seine and longline fleets from Japan, Korea and Taiwan and of the Indonesian and Philippines fleets are collected and/or made

available. The following actions were identified as requiring special attention for progress toward a more refined analysis of the tag-recapture data:

- Size-composition data for catches of all fleets, but particularly those producing substantial catches, need to be made available and incorporated into analyses;
- Catch information on a fine spatial scale for all fleets, especially for the purse seine fleets, needs to be made available and incorporated into analyses;
- Recently tagged fish released in the Indonesia-Philippines region have had time to fully mix in the population, and returns should be appearing in the coming years' catches. These returns need to be incorporated in further analysis of the SPC data.

5.2. Catch-per-Unit (CPUE) Analysis

Various agencies hold time series of detailed catch-and-effort data from fishing logbooks which may contain useful information for determining trends in yellowfin tuna abundance. Because these data contain confidential information as well, they are not available for general circulation. The Group assigned agency scientists the task of analyzing their data independently and to report their findings to the Group. The task included using the general linear model (GLM) and/or general additive model (GAM) to isolate the abundance signal in the data. Five independent studies were carried out and the results evaluated by type of data: "PS" for purse seine data and "LL" for longline data.

5.2.1. Purse Seine Data (WPYRG3/1, 5, 7 and 12)

Four analyses (PS1, PS5, PS7 and PS12) of purse seine CPUE were presented to the Group. These analyses involved fitting a GLM or GAM to CPUE data aggregated by time-area or other strata and with various factors (area, time, etc.) considered as independent variables. The specifications of the analyses (final form) are shown in Table 3, and the resulting standardized CPUEs are shown in Figure 6. Note that PS1, PS7 and PS12 used catch and days fished (including searching time) to compute CPUE, whereas PS5 used catches of individual sets and effort as searching hours or elapsed time between sets for computing CPUE.

The results from Japanese purse seine data (PS7) show no trend for small (<10 kg) yellowfin tuna and an increasing trend for large (>10 kg) yellowfin tuna. Results from Taiwan purse seine data (PS12) show a sharp decline in standardized CPUE during the period 1983-87 and an increase during the period 1989-92. Results from U.S. purse seine data (PS1) show no time-series trend. Likewise, results using both U.S. and Japanese purse seine data, but with a different CPUE estimation procedure (PS5), show no clear trend in standardized CPUE.

These mixed results raised several points with respect to limitations of the data and analytical methodology. With respect to data, the points raised were:

Table 3. Summary of specifications (final Generalized Linear Model [GLM] form) used in analysis of catch-and-effort data for determining trends in abundance of yellowfin tuna of the central- western Pacific Ocean. Analysis number is a code with "PS" for purse seine data or "LL" for longline data followed by the WPYRG3 working paper number.

ANALYSIS NUMBER	DATA SOURCE	CPUE	TRANSFORMATION	DATA AGGREGATION	MODEL VARIABLES/ COVARIABLES[1]
PS1	U.S. purse seine	Tons/day	ln (CPUE + 0.05)	10° square, month, vessel, set type	year, month, 10° square, proportion of SKJ, set type, vessel
PS5	U.S. purse seine	Tons/hour searched	ln (CPUE)	Sets weighted by 1° square and month, associated schools	year, 5° square, set type, and 21° isotherm depth, (21° isotherm depth)^2, year x set type, set type x presence of SKJ
			ln (CPUE)	Sets weighted by 1° square and month, unassociated schools	year, 5° square, set type, and 21° isotherm depth, (21° isotherm depth)^2, year x set type, set type x presence of SKJ
	Japan purse seine	Tons/hour searched	ln (CPUE)	Sets weighted by 1° square and month	year, set type, presence of SKJ, 5° square, sea surface temperature, (sea surface temperature)^2, set type x presence of SKJ
PS7	Japan purse seine	Tons/day	ln (CPUE)	5° square, quarter, <10 kg fish	year, proportion of SKJ catch, proportion of log sets
			none	5° square, quarter, >10 kg fish	year, proportion of SKJ catch, proportion of log sets
LL7	Japan longline	Number/ 1,000 hooks	none	5° square, month	year, quarter, 5° square, quarter x area
LL11	Taiwan longline	Number/ 1,000 hooks	ln (CPUE +1)	5° square, month, peak spawning season-area	year, month, 5° square
			ln (CPUE +1)	5° square, month, non-peak spawning season-area	year, month, 5° square
PS12	Taiwan purse seine	Tons/day	ln (CPUE +1)	2° x 5° area, month	year, month, 2° x 5° area

[1] SKJ = skipjack tuna

- The measurement of fishing effort directed at yellowfin tuna is imprecise for all data sets. For instance, handling time of the purse seine net can be different from set to set; the amount of cooperation among vessels in searching for schools is not reported in logbooks; and multiple sets on the same log are not generally reported. All of these factors contribute to imprecision in the usual measurement of fishing effort--search hours or number of days fished--for purse seiners.

- None of the analyses corrected CPUE for advances in technology; for example, use of helicopters, bird radar, advanced navigation equipment or more powerful winches, which affect fishing power of the vessels. These advances might be responsible for the increasing trend in standardized CPUE in PS5, PS7 and PS12.

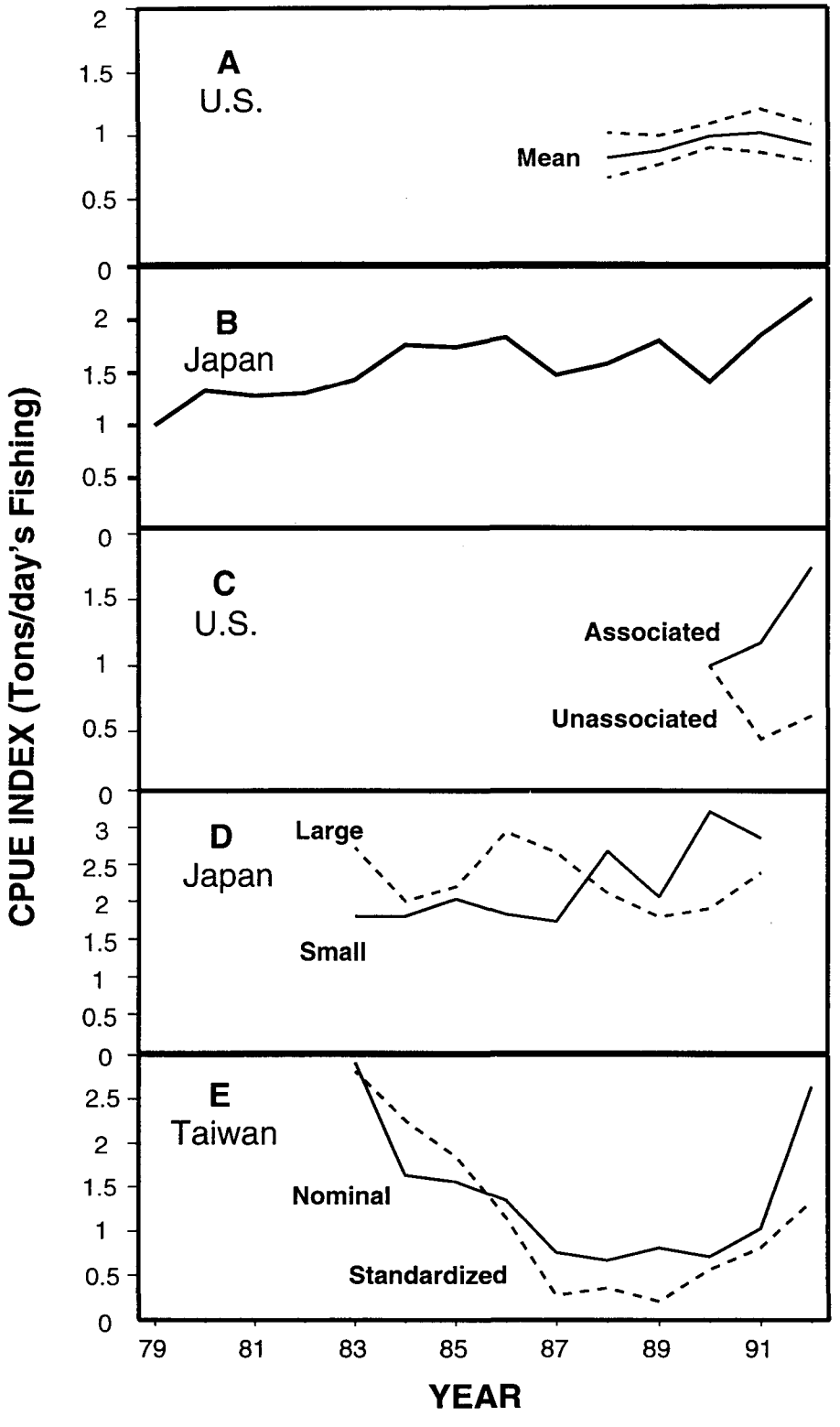

Figure 6. Standardized CPUE of yellowfin tuna using purse seine data. U.S. fishery data (A; source: PS1); Japanese fishery data (B; source: PS5); U.S. fishery data (C; source: PS5); Japanese fishery data (D; source: PS7) and Taiwan fishery data (E; source: PS12). Sources are listed in Table 3.

- The influence of a large component of skipjack tuna in purse seine catches (more than 70 percent), although used as a variable in the analyses, may not have been fully accounted for.

- Only the Taiwan purse seine data (PS12) indicated a consistent decline in standardized CPUE for any part of the time series examined, and even then, the decline occurred prior to 1987 when catches for this fleet were relatively minor; therefore, this may not represent a real decline in abundance. Futhermore, variable reliability in reported data by the different vessels of this fleet is an additional factor.

- The other analyses (PS1, PS5 and PS7) indicate either stable or increasing trends in standardized CPUE over the time series analyzed. Because of the various limitations of the data and models, and our lack of knowledge regarding yellowfin tuna schooling dynamics, it is not possible to say to what extent standardized CPUE reflects stock biomass. However, the Group noted that declines in CPUE would not be expected if the low exploitation rates estimated from tagging data (see Section 5.1) are accurate.

With respect to limitations of the models, it was pointed out that the models deal with only variables presented; hence, although highly statistical significant variables are identified by the models and partitioned out of the CPUE, this does not exclude the possibility that other more powerful explanatory variables exist. Because of the data limitations noted above, many more explanatory variables need exploring and are still embedded in the standardized CPUE.

It is clear that the approach of using standardized CPUE from commercial purse seine fisheries to monitor trends in stock biomass is beset with problems, many of which may be unresolvable and inherent in the data. For this reason, it would not be wise to devote a large amount of effort to developing models for standardization purposes. Nominal or standardized CPUE, on the other hand, will continue to be useful for monitoring fishery performance and should continue to be tabulated. More sophisticated models using catch, effort and other data will be required to make the crucial link between CPUE and stock biomass.

5.2.2. Longline Data (WPYRG3/7 and 11)

Results of two analyses, LL7 and LL11, using longline data and GLM were reviewed by the Group. The main features of the analyses are shown in Table 3 and the resulting standardized CPUEs are shown in Figure 7.

The analysis of Japanese longline data (LL7) was restricted to the tropical areas (WPYF areas 3, 4, and 5). The results do not show any distinctive overall trend, although the standardized CPUE declined in the last four years. The Group noted that the analysis did not standardize for changes in targeting for yellowfin tuna or bigeye tuna; although such targeting, as indicated by number of hooks per basket, was shown to significantly affect

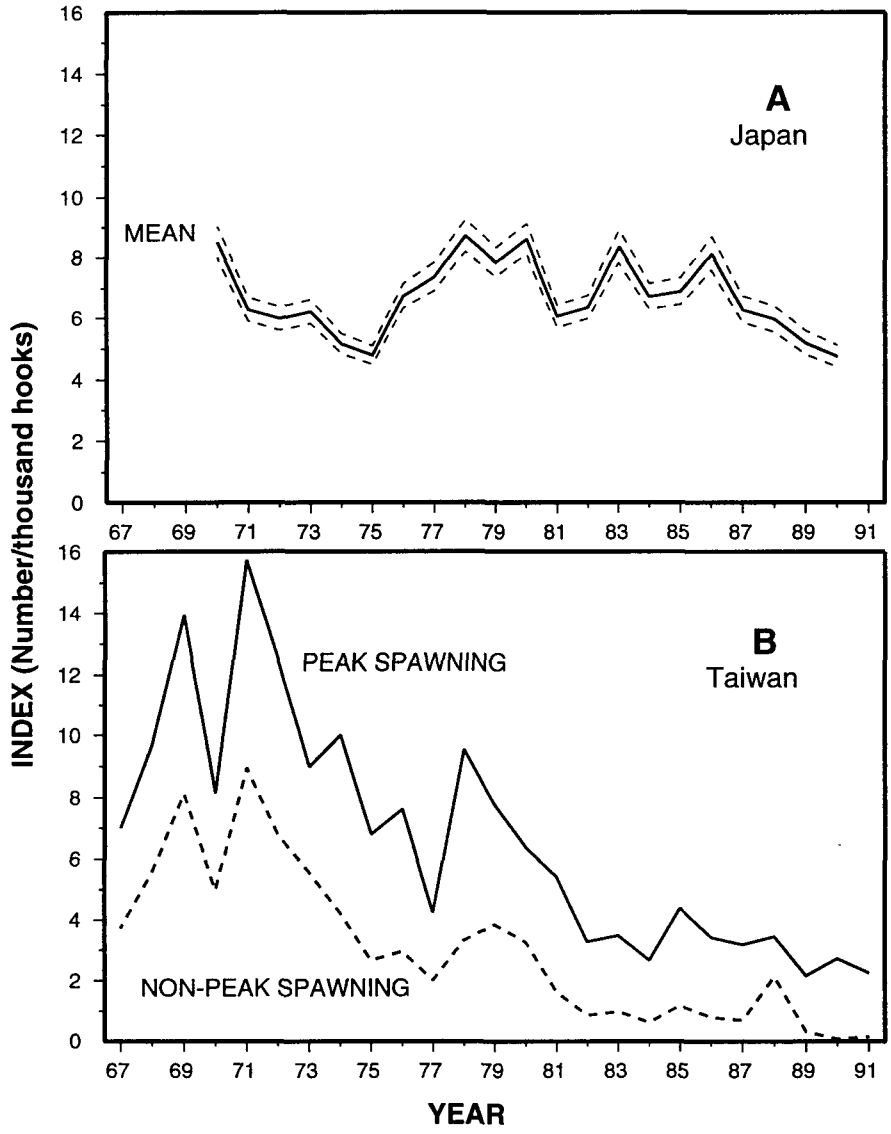

Figure 7. Standardized CPUE of yellowfin tuna using longline data. Japanese fishery data (A; source: LL7) and Taiwan fishery data (B; source: LL11). Sources are listed in Table 3

yellowfin tuna CPUE during the time period. Hence, the results are difficult to interpret as reflecting changes in yellowfin tuna biomass.

The analysis of Taiwan longline data (LL11) was restricted to data from the distant-water fleet (as opposed to offshore fleet or all fleets combined). The results show a sharp decline in standardized CPUE from the early 1970s to the early 1980s. However, because the data were from essentially an albacore-targeting fleet working mainly in subtropical waters of the South Pacific, the results are probably not tracking yellowfin tuna abundance.

As with the analyses of purse seine data, these analyses with longline data present problems in relating standardized CPUE to stock biomass. The Group suggested that these analyses might be improved by taking into account the effects of species targeting and changes in the environment, e.g., El Niño. A possible way to incorporate targeting, if only an approximation, is to use the number of hooks fished only in water temperatures preferred by yellowfin tuna.

5.2.3. CPUE and Fisheries Interaction (WPYRG3/7)

One analysis dealing with possible competition between fishing gears was reviewed by the Group. The analysis used Japanese longline data from areas in the western Pacific. It showed a decline in longline CPUE, and fewer small yellowfin tuna in the longline catch over time in the main fishing area of the Japanese purse seine fleet. In adjoining areas of light purse seine fishing, however, no such change occurred in size composition. These results are consistent with the hypothesis of local interaction effects, and if true, have important implications with respect to movement rates and stock structure of yellowfin tuna. It is also possible that changes in species targeting by the fleet, as noted above (Section 5.2.1), affected the results. Further analysis of the data that accounts for species targeting would be worthwhile.

6.0 REVIEW OF RESEARCH PROJECTS

6.1. Assessment Model

A brief report was provided on progress to date on the modeling assignment made at the second meeting:

> *"...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... 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 activity..."*

The progress report noted that soon after the second meeting, a proposal was prepared to initiate the assignment. The proposal was to convene a small working group of modelers for the purpose of designing an assessment model. The proposal was submitted for funding by the University of Hawaii, from a special fund for research on large pelagic species. The proposal called for the small group to produce an initial design of the model at a workshop of about a week's duration and to have the design available in time for this third meeting of the WPYRG for review and decision on next phases. Unfortunately, approval for funding of the proposal was delayed and was not received in time to hold the workshop as planned. The workshop has been rescheduled for November 1993.

The Group reviewed the objectives of this project and emphasized that the expectations should not be for a customized model able to produce precise and reliable estimates of

stock assessment parameters when information in the data does not exist to support such estimates. Furthermore, work on the model should not inhibit efforts to improve size-frequency sampling or to expand collection of fisheries data. In fact, the modeling effort would complement sampling efforts and assist in evaluating sampling schemes and in highlighting areas that are most sensitive to lack of data.

The Group discussed the ramifications of the delay in the project and the rescheduled workshop, particularly the process of deciding on the next steps to take after the design is completed. The Group agreed that the workshop should be held and the report produced. That report should then be circulated to the funding agency and members of WPYRG for review and comment. If the Group should approve the design (through correspondence), then the modeling group would proceed to the next phase in implementation of the model. A progress report of this project would be presented at the next meeting of WPYRG.

6.2. Archival Tag Development (WPYRG3/15)

A report on a newly developed electronic (archival) tag, which is being used on southern bluefin tuna, *Thunnus maccoyii*, by the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, was presented to the Group. The archival tag is designed around a microprocessor that controls acquisition and storage of data from sensors measuring a field of parameters within the tagged fish's environment at time intervals. One parameter, light level, is particularly essential because it is used to calculate the position of the fish at intervals during its time at liberty.

Archival tags currently used on southern bluefin tuna are internally placed and have an operational life of 5 years. They are pressure tested to 500 m; they collect data on swimming depth, ambient temperature, and light level; and they cost $800-900 (in Australian dollars) each. Four of 100 nonoperational archival tags released in March 1992 have been returned. This was a test of tag retention and the return rate is similar to that of conventional dart tags. In June and July 1993, 100 operational tags will be deployed in fish captured off Port Lincoln, south Australia, and off southeast Tasmania.

The Group noted that the tag has considerable potential for use in yellowfin tuna studies, but it appears to be too large for sizes of yellowfin tuna generally available for tagging in the central-western Pacific. Because miniaturization of the electronics is progressing rapidly, a suitable, smaller tag for deployment in yellowfin tuna might be available soon. The Group recommended that this development be monitored.

6.3. Age and Growth

Age determination based on counts of presumed daily rings in otoliths remains the most promising method for ageing tropical tunas. The Group noted that the SPC Regional Tuna Tagging Programme (RTTP) systematically collected more than 700 yellowfin tuna otoliths over a large area of the western tropical Pacific. Attempts had been made to validate the observed "daily" rings by an oxytetracycline tagging experiment in the Solomon Islands. Results from the relatively small number of returns (11 fish) suggest that ageing of western Pacific yellowfin tuna based on otolith reading will be more difficult than previously found

for eastern Pacific yellowfin tuna. A similar difficulty has been experienced for otolith readings of western Pacific skipjack tuna.

The large amount of RTTP tag-recapture data for yellowfin tuna is expected to provide a good source of growth estimates for western Pacific yellowfin tuna. Growth estimates will be developed from a screened subset of the tagging data during 1993-94, along with the possible application of MULTIFAN methods to available length-frequency data.

6.4. Length-weight Relationships (WPYRG3/6)

The Group reviewed results of a survey to determine the quality, coverage of geographic area, season, fishing method, and availability of length-weight data for yellowfin tuna in the central-western Pacific. The results indicated that length-weight data collected under controlled conditions and with uniform methods for population-level analysis are rare. The largest holding of data collected since 1988 appears to be held by the SPC. The Group felt that further work on length-weight relationships is not of high priority at this time but encouraged the continued collection of high quality length-weight data by trained personnel. Also, collection of data for testing the effects of handling methods (for example, freezing and brine treatment) of fish aboard the vessels on length-weight relations is encouraged.

6.5. Reproductive Biology

At the second meeting, the Group noted the need for reproductive studies to better understand geographical, vertical (surface versus longline fisheries), and temporal variation in spawning activity, sex ratios, and size at first maturity. Japan's National Research Institute of Far Seas Fisheries (NRIFSF) outlined plans for a cooperative project that will focus on the reproductive biology of surface (handline and purse seine)- and subsurface (longline)-caught yellowfin tuna. Similar projects, in various stages of development, were described by other participants. The Group concluded that coordination and collaboration among the interested scientists would enhance the success of the projects. Collaborators were identified and they included scientists from Japan, the Federated States of Micronesia, the Philippines, the United States, and the SPC. The scientists agreed to pool their resources into a single large-scale project. Data sources and samples for the project will be collected by trained personnel aboard Japanese longline training vessels, and from commercial longline and purse seine vessels operating in the WPYRG study area. S. Tsuji and D. Itano were designated as coordinators. The Group also urged members to assist particularly with obtaining samples.

6.6. Stock Structure (WPYRG3/14)

CSIRO (Australia) reported on a one-year pilot study on the delineation of yellowfin tuna stocks in the western Pacific. The organization's researchers found that the allozyme variation method of delineation appeared to allow for separation of eastern and western Pacific yellowfin tuna whereas the mitochondrial DNA sequencing method showed insufficient heterogeneity for such separation. Geographical variation in otolith microchemistry appeared to offer some prospect for typing a yellowfin tuna's spawning area. They reported, however, that more work is needed on the temporal stability of the microchemical

signal and on the extent of fine-scale variation and distribution of the chemicals in the habitat. They also reported that their analytical procedures need more development. Despite the preliminary nature of the work, the Group considered the results to be interesting and promising; it encouraged CSIRO to continue its work and report progress to the Group from time to time.

7.0. REVIEW OF MANAGEMENT ISSUES AND WPYRG OBJECTIVES (WPYRG3/3)

In 1990, the Group defined its short-term objectives as a series of three questions, which were further refined in 1991. This year, the Group examined the objectives in view of recent developments in western Pacific tropical tuna fisheries as well as in light of emerging management issues, particularly concern about increased catches of small fish (<40 cm FL). The results are as follows:

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

The SPC Regional Tuna Tagging Project has provided useful estimates of exploitation rates on a regional scale and Group members are making progress in addressing this question. However, the Group recognized the need to corroborate the results with results from other methodologies, for example, age-structured models and ancillary information. Furthermore, concerns remained over safe levels of exploitation and yield on a sub-regional scale, as exemplified by local differences in catch rates for longline fisheries, and the impact of increased catches of small fish (<40 cm FL).

2. What factors contribute to local depletion?

Regarding this second question, the Group felt that a return to the original 1990 wording -- Can the yellowfin tuna stocks be locally managed (or depleted)? -- might be more appropriate. There is considerable interest in local impacts of increased catches, especially in sub-tropical areas, for instance, in Australia and in fisheries adjacent to heavily exploited tropical areas, for instance, in eastern Indonesia.

3. What is the level of interaction among the different fisheries?

Treating this third question in the broadest sense, longline-purse seine interaction studies appear to be a clear priority followed by interaction studies involving the vulnerability of yellowfin tuna of various sizes to different gears. It is recognized, however, that the interpretation of longline hook rates is unclear at this time, which is a serious impediment to progress in fully addressing this question.

The Group deferred redefinition of the objectives until after a stock status and associated resource-related questions are addressed by the Group in 1994. The 1994 meeting,

originally envisaged as the final meeting in a series of three, will be organized to assess the condition of the stock. At that time, the Group could take up this matter of objectives in light of its findings as well as future plans for the Group, in particular, in view of emerging interests in allocation/optimization questions.

8.0. WORK PLAN FOR 1993-94

A work plan for 1993-94 was prepared after some discussion. The Group principally focused on tasks and assignments that have already been started and that will contribute to the Group's objectives (see Section 7.0) in 1994.

8.1. Data Base Improvements

- Explore procedures for improving port sampling for length-frequency data in Japan - S. Tsuji; and in Taiwan - C.-L. Sun.

- Update catch and fishing effort (number of vessels) for WPYRG statistical tables - A. Coan (coordinator), R. Ganaden, T. Lawson, N. Naamin, C.-L. Sun, S. Tsuji, P. Ward.

- Facilitate training of at-sea observers for uniform and proper collection of data, including length-frequency and species composition data and biological samples. In addition, develop procedures to verify accuracy and effectiveness of observer programs - SPC.

- Cooperate in implementing the SPC plan to augment national programs for sampling of currently undersampled fleets - All.

- Investigate salvaging of historical Japanese purse seine length-frequency data by stratifying catches into broad size classes, that is, kg. and 10 kg. - S. Tsuji.

- Implement studies to compare size-frequency samples from at-sea observers and port samplers from the same vessels - C. Heberer, SPC.

- Cooperate in obtaining more precise fishery data for Korean fleets - All.

8.2 Assessment Studies

- **Assessment Model Project.** Distribute the report of the assessment model meeting (November 1993) to WPYRG members for approval. If the design is approved, the modeling group will begin implementing the next phase and will present a progress report at the next WPYRG meeting - P. Kleiber (coordinator), J. Hampton, T. Polacheck, J. Sibert, S. Tsuji.

- **Tag-recapture Data Analysis.** Pursue further refinements to the analytical model, including incorporating additional parameters, especially spatial structure and size of fish component, and further evaluation of assumptions through

collaborative efforts. To assist in this effort, the following assignments for reassembling data are made:

- Size-frequency data for all fleets must be collected and assembled - All.

- Catch and set data on a fine spatial scale, that is, finer than 1° or 5° square, need to be compiled for all fleets, but especially for the purse seine fleets - A. Coan, R. Ganaden, C.-L. Sun, S. Tsuji.

- Tag returns from the Indonesia/Philippines tag releases need to be reanalyzed after the releases have fully mixed in the population - SPC.

- **CPUE Analysis.** Pursue selective investigations using CPUE models, concentrating on the following:

  - Continue to monitor purse seine CPUE as an indicator of fishery performance - A. Coan, C.-L. Sun, S. Tsuji, SPC.

  - Investigate ways of developing a better measurement of purse seine effort - All.

  - Develop a longline CPUE index that takes into account species targeting, e.g., include only fishing within the potential yellowfin tuna habitat, defined by thermocline depth and preferred temperature - C.-L. Sun, S. Tsuji.

- **Surface Fishery-longline Fishery Interaction.** Execute two approaches to investigating their interaction:

  - Refine analyses of CPUE from purse seine and longline fisheries, incorporating detailed information on catches, effort, size composition, tag returns, and environmental factors -NRIFSF, SPC.

  - Execute large-scale study on reproductive biology of large-sized yellowfin tuna caught in purse seine and longline fisheries - All, D. Itano and S. Tsuji (coordinators).

8.3. Biological Studies

- Develop standard methods and sampling procedures for collecting quality length-weight data - P. Ward.

- Cooperate and assist in collecting gonad samples in support of the large-scale study on reproductive biology - All, D. Itano and S. Tsuji (coordinators).

- Analyze data contained in the RTTP tag-recapture and size-frequency data bases for yellowfin tuna growth rates - SPC.

- Facilitate collection of length-weight data by trained personnel, particularly by at-sea observers and port samplers - A. Coan, C. Heberer, P. Ward, SPC.

- Encourage validation studies that use hard parts for age determination - All.

9.0 ADMINISTRATIVE MATTERS

The Chairman reviewed the objectives of the WPYRG and noted that the results of this third meeting indicate that the Group has completed virtually all assignments of its 1992-93 work plan and is making significant progress in meeting its objectives. He reminded the Group that the focus for the short-term is to conduct scientific investigations to enable the Group to answer the three resource-related questions (see Section 7.0) outlined in the Group's strategic plan. That plan specifies that answers to the questions will be developed over the course of three meetings or by 1994. Because this was the second meeting in the series (third for the WPYRG), the next meeting will be the third in the series and a crucial one. All new data and information pertinent to addressing the questions must be reviewed and weighed against existing information. Conclusions will need to be developed and used to answer the three resource-related questions--safe yield, fisheries interaction, and local depletion. Furthermore, the Group will need to consider follow-up objectives for the Group to address in the years following 1994.

Election of a new WPYRG chairman was discussed. After some discussion, the Group decided that Gary Sakagawa should continue to serve in the position and to guide the Group's work for another year. The Chairman thanked the Group for the vote of confidence and pledged to continue to guide the Group through consultation and involvement of members. He also advised the Group that preparation for the next meeting will require close attention to maximizing the availability of new information through collaborative effort of the members. A preliminary work plan (Section 8.0) has been prepared and establishes the tone for this cooperative/collaborative effort. Adjustments to the work plan are likely in the months ahead as members discover new or alternative approaches as well as conflicts with other commitments; consequently, he plans to be in contact with members during the year.

The time and venue for the 1994 meeting were discussed. No decision was made except to follow customary practice. That is, this matter would be handled with SPC and in consultation with key WPYRG members because the WPYRG meeting is customarily held in conjunction with the annual meeting of the SPC Standing Committee on Tuna and Billfish. In this way, the travel and meeting costs are kept low for many of the participants.

The Group agreed that approval of the meeting report will be accomplished through correspondence using the following process: Soon after the meeting, a complete draft will be distributed to participants for their comments. Comments are to be sent to the Chairman within a specified time. For contentious points, the Chairman shall consult with key members to resolve matters. A final text will then be printed and distributed at the earliest opportunity.

The Chairman thanked the host, the Micronesian Maritime Authority (MMA), the staff of the MMA, especially Bernard Thoulag, and the Federated States of Micronesia (FSM) private-fishery sector, especially Peter Sitan, for services in support of the WPYRG meeting and for the extra effort in making the meeting a success and the participants' stay in FSM an enjoyable one. He also thanked the participants for their contribution and cooperation in completing the business of the Group on schedule and the rapporteurs for preparing notes for the record and the meeting report.

The meeting adjourned on June 23, 1993.

APPENDIX A

LIST OF PARTICIPANTS

APPENDIX A. LIST OF PARTICIPANTS

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APPENDIX B

AGENDA

APPENDIX B. AGENDA

MONDAY, JUNE 21 (8:30 A.M. - 5:00 P.M.)

1. Introduction

(Chairman: *G. Sakagawa*)

- Opening comments
- Review of agenda and schedule
- Appointment of rapporteurs

2. Review of fisheries developments and outlook

(Leader: *B. Thoulag*)

- Indonesia -- *N. Naamin*
- Japan -- *S. Tsuji*
- Philippines -- *R. Ganaden*
- Taiwan -- *C-L. Sun*
- U.S. -- *A. Coan*
- FSM -- *C. Heberer*
- Others -- *T. Lawson*

3. Review of fisheries data base

(Leader: *A. Coan*)
(Rapporteur: *A. Coan and T. Lawson*)

- Data substitution -- *A. Coan*
- Analysis of sampling -- All

4. Review of management issues and functions

(Leader: *R. Ganaden*)
(Rapporteur: *A. Lewis*)

- Status -- *G. Sakagawa*
- Focus for 1994 -- All

5. Review of assessment model project

(Leader: *G. Sakagawa*)
(Rapporteur: *P. Kleiber*)

- Status -- P. Kleiber

TUESDAY, JUNE 22 (8:30 A.M. - 5:00 P.M.)

6. Analysis of tag-recapture data

(Leader: *J. Hampton*)
(Rapporteur: *T. Murray*)

- SPC tagging -- *J. Hampton*
- Archival tag -- *J. Gunn*

7. Analysis of CPUE data for abundance trends

(Leader: *G. Sakagawa*)
(Rapporteur: *J. Hampton*)

- Purse seine data
  - Japanese fishery -- *S. Tsuji*
  - Taiwan fishery -- *C-L. Sun*
  - U.S. fishery -- *P. Kleiber*
  - Others -- *T. Lawson*
- Longline data
  - Japanese fishery -- *S. Tsuji*
  - Taiwan fishery -- *C-L. Sun*

8. Review of advances in biological information

(Leader: C-L. Sun)
(Rapporteur: A. Lewis)

- Ageing -- A. Lewis
- Length-weight analysis -- P. Ward
- Maturity schedule -- S. Tsuji, D. Itano
- Stock structure -- J. Gunn

9. Work plan for 1993-94

WEDNESDAY, JUNE 23 (8:30 A.M. - 5:00 P.M.)

9. Review of work and schedule for 1993-94 (continued)

10. Adoption of report

11. Review of administration matters

12. Adjournment

APPENDIX C

LIST OF WORKING DOCUMENTS

APPENDIX C. LIST OF WORKING DOCUMENTS

Document Number	Title and Author
WPYRG3/1	Yellowfin catch per effort in the western Pacific by the United States purse seine fleet. (*P. Kleiber*)
WPYRG3/2	U.S. fisheries for yellowfin tuna in the central and western Pacific, 1991-93. (*A. L. Coan, Jr.*, and *D. Prescott*)
WPYRG3/3	A review of the WPYRG objectives. (*G. Sakagawa*)
WPYRG3/4	Effects of substitution of length-frequency samples between sampled and unsampled strata. (*A. L. Coan, Jr.*)
WPYRG3/5	Indices of abundance of yellowfin tuna in the western Pacific determined from purse seine catch-and-effort data. (*T. Lawson*)
WPYRG3/6	Catalogue of yellowfin tuna length-weight data. (*P. J. Ward*)
WPYRG3/7	CPUE analysis of Japanese fisheries for yellowfin tuna in the central and western Pacific. (*S. Tsuji*, and *H. Okamoto*)
WPYRG3/8	Problems of Japanese purse seine size data. (*S. Tsuji*)
WPYRG3/9	Yellowfin tuna landings for FSM flag purse seine and longline vessels. (*C. F. Heberer*)
WPYRG3/10	Status of the Taiwan's fisheries for yellowfin tuna in the central and western Pacific Ocean, 1991-93. (*C.-L. Sun*, and *S. Z. Yeh*)
WPYRG3/11	Standardized catch rates of yellowfin tuna, *Thunnus albacares*, from the Taiwan tuna longline fishery in the central and western Pacific Ocean. (*C.-L. Sun*, and *S. Z. Yeh*)

Document Number	Title and Author
WPYRG3/12	Trend of abundance index of yellowfin tuna from Taiwan purse seine fishery in the central and western Pacific Ocean. (*C.-L. Sun*, and *S. Z. Yeh*)
WPYRG3/13	Assessment of western Pacific yellowfin on the basis of a large-scale tagging experiment. (*J. Hampton*, and *A. D. Lewis*)
WPYRG3/14	Progress report on the use of otolith microchemistry, allozyme and mitochondrial DNA analyses for the delineation of western Pacific yellowfin tuna stocks. (*J. Gunn*, *B. Ward*, and *P. Grewe*)
WPYRG3/15	Archival tagging of southern bluefin tuna. (*J. Gunn*, *T. Polacheck*, *T. Davis*, and *M. Sherlock*)
WPYRG3/16	Yellowfin tuna landings in American Samoa, 1976-1992 (*P. Craig*)

APPENDIX D

FISHERIES STATISTICS FOR YELLOWFIN TUNA CAUGHT IN THE CENTRAL AND WESTERN PACIFIC OCEAN AND MONITORED BY WPYRG

APPENDIX D. Fisheries statistics for yellowfin tuna caught in the central and western Pacific Ocean and monitored by WPYRG.

Table D1. Longline catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D2. Purse seine catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D3. Pole-and-line catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D4. Unclassified or handline, gillnet, troll and other gear catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D5. Total catches (t) of yellowfin tuna (sum of Tables D1 - D4) by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D6. Number (except for Japan) of longline vessels by countries fishing for tunas in the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D7. Number (except for Japan) of purse seine vessels fishing for yellowfin tuna in the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

Table D8. Number (except for Japan) of pole-and-line vessels fishing for yellowfin tuna in the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

List of Footnotes

Table D1. Longline catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	AUSTRALIA[1]	FSM[2]	FIJI[3]	INDONESIA[4]	JAPAN[5]	KOREA[6]	MARSHALL ISLANDS[7]	NEW CALEDONIA[8]
1970	-	-	-	-	40,970	1,500	-	-
1971	-	-	-	-	35,664	3,975	-	-
1972	-	-	-	-	38,301	8,850	-	-
1973	-	-	-	-	38,094	9,000	-	-
1974	-	-	-	-	37,214	11,328	-	-
1975	-	-	-	-	36,685	7,774	-	-
1976	-	-	-	-	40,420	13,896	-	-
1977	-	-	-	-	47,794	15,585	-	-
1978	-	-	-	1,216	66,576	13,087	-	-
1979	-	-	-	1,274	57,623	17,977	-	-
1980	-	-	-	1,478	69,063	21,470	-	-
1981	-	-	-	1,806	56,520	8,685	-	-
1982	-	-	-	3,605	47,864	8,150	-	-
1983	-	-	-	1,048	51,808	7,057	-	7
1984	-	-	-	1,670	39,654	5,976	-	25
1985	-	-	-	2,466	46,830	6,482	-	119
1986	-	-	-	2,437	32,161	5,996	-	151
1987	1,487	-	-	9,254	29,237	8,078	-	449
1988	1,150	-	-	9,717	37,827	7,578	-	436
1989	864	-	10	5,124	29,878	6,210	-	248
1990	770	-	23	5,508	32,408	9,591	-	551
1991	742	6	106	6,059	23,194	(9,591)	-	506
1992	785	74	202	6,242	(23,194)	(9,591)	9	230

YEAR	PHILIPPINES[9]	SOLOMON ISLANDS[7]	TAIWAN[10]		TONGA[7]	USA[11]	TOTAL
			Distant-water	Offshore			
1970	612	-	3,849	6,132	-	251	53,314
1971	685	-	8,700	5,080	-	191	54,295
1972	712	-	9,042	3,323	-	143	60,371
1973	851	91	8,028	10,373	-	88	66,525
1974	990	-	4,313	7,778	-	126	61,749
1975	1,010	-	2,555	13,539	-	84	61,647
1976	618	146	3,286	12,425	-	111	70,901
1977	972	198	3,123	16,471	-	176	84,319
1978	689	207	3,278	19,165	-	172	104,390
1979	907	493	2,966	22,629	-	233	104,103
1980	1,177	564	5,525	18,265	-	495	118,037
1981	1,619	146	1,578	17,778	-	614	88,747
1982	1,897	306	745	16,508	81	397	79,553
1983	2,824	443	492	16,260	48	556	80,543
1984	1,284	213	561	16,107	55	607	66,152
1985	1,819	151	595	13,554	44	466	72,526
1986	2,411	0	289	10,884	33	479	54,841
1987	3,775	0	371	14,061	32	272	67,016
1988	3,196	0	1,256	14,337	26	590	76,113
1989	3,481	0	651	11,933	27	998	59,424
1990	2,625	0	1,098	7,848	28	998	61,448
1991	(2,625)	0	665	5,838	19	726	(50,077)
1992	(2,625)	0	828	6,819	19	410	(51,027)

Table D2. Purse seine catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	AUSTRALIA[12]	FSM[2]	INDONESIA[4]	JAPAN[5]	KOREA[7]	MEXICO[7]	NEW ZEALAND[7]
1970	-	-	-	164	-	-	-
1971	-	-	-	2,867	-	-	-
1972	-	-	-	4,184	-	-	-
1973	-	-	-	7,281	-	-	-
1974	-	-	-	9,419	-	-	-
1975	-	-	-	5,595	-	-	-
1976	-	-	-	7,649	-	-	-
1977	-	-	-	6,841	-	-	-
1978	-	-	-	8,523	-	-	-
1979	-	-	-	19,013	-	-	-
1980	-	-	2,177	19,701	125	-	-
1981	-	-	2,275	27,161	400	-	-
1982	-	-	1,428	31,035	2,000	-	-
1983	-	-	2,013	30,818	700	-	239
1984	-	-	2,108	38,607	100	1,174	231
1985	-	-	2,107	47,897	1,600	-	170
1986	-	-	1,650	44,467	2,400	-	-
1987	-	-	1,683	44,504	19,500	-	-
1988	30	-	1,767	30,081	16,496	-	-
1989	15	-	2,520	40,862	34,726	-	-
1990	1,040	-	2,665	37,606	41,602	-	-
1991	1,353	1,185	2,500	46,230	50,347	-	-
1992	1,479	2,113	2,200	(46,230)	40,315	-	-

YEAR	PHILIPPINES[9]		RUSSIA[7]	SOLOMON ISLANDS[7]	TAIWAN[13]	USA[11]	TOTAL
	Purse seine	Ringnet					
1970	(4,920)	(1,772)	-	-	-	-	6,856
1971	(5,504)	(1,982)	-	-	-	-	10,353
1972	(5,719)	(2,060)	-	-	-	-	11,963
1973	(6,842)	(2,464)	-	-	-	-	16,587
1974	(7,954)	(2,865)	-	-	-	-	20,238
1975	(8,117)	(2,923)	-	-	-	-	16,635
1976	(4,969)	(1,790)	-	-	-	200	14,608
1977	(7,810)	(2,813)	-	-	-	200	17,664
1978	4,133	1,010	-	-	-	200	13,866
1979	8,760	3,541	-	-	-	559	31,873
1980	8,188	4,275	-	449	-	1,059	35,974
1981	14,343	3,839	-	1,342	-	12,973	62,333
1982	16,288	1,388	-	1,444	-	22,011	75,594
1983	17,418	3,361	-	2,530	-	49,599	106,678
1984	18,728	4,261	-	2,397	252	45,090	112,948
1985	15,381	6,210	570	2,882	1,007	29,012	106,837
1986	12,640	4,951	432	2,258	2,869	36,608	108,275
1987	15,171	2,916	3,381	3,385	4,579	66,359	161,478
1988	(14,368)	(4,064)	850	4,068	6,238	25,211	103,173
1989	(15,648)	(4,427)	1,535	4,410	10,604	41,640	156,387
1990	(11,803)	(3,339)	621	3,825	13,694	57,132	173,326
1991	23,911	2,977	1,114	3,275	16,358	34,987	184,237
1992	(23,911)	(2,977)	437	5,093	44,459	50,258	(219,472)

Table D3. Pole-and-line catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	AUSTRALIA[7]	FIJI[14]	FRENCH POLYNESIA[7]	INDONESIA[4]	JAPAN[15]	KIRIBATI[7]	NEW CALEDONIA[8]
1970	-	-	-	-	-	-	-
1971	-	-	-	-	345	-	-
1972	-	-	-	-	294	-	-
1973	-	-	-	-	55	-	-
1974	-	12	-	-	-	-	-
1975	-	11	-	-	55	-	-
1976	1	83	-	507	-	-	-
1977	-	151	-	591	1,676	-	-
1978	16	409	-	1,160	769	-	-
1979	-	403	161	1,907	5,833	-	-
1980	-	233	253	2,269	6,188	-	-
1981	-	599	472	2,015	9,053	210	3
1982	5	813	368	1,887	9,492	170	41
1983	-	562	238	1,900	9,332	239	25
1984	5	580	426	2,282	8,700	528	0
1985	-	724	243	2,344	12,920	503	0
1986	-	823	232	2,278	8,410	721	0
1987	-	410	149	2,323	8,452	156	0
1988	-	526	274	2,439	1,909	383	0
1989	63	506	187	3,553	7,800	848	0
1990	22	516	55	4,433	(7,800)	143	0
1991	10	358	105	5,472	(7,800)	67	0
1992	1	395	87	5,319	(7,800)	303	0

YEAR	NEW ZEALAND[7]	PALAU[7]	PAPUA NEW GUINEA[7]	SOLOMON ISLANDS[7]	TUVALU[7]	USA[11]	TOTAL
1970	-	1	74	-	-	18	93
1971	-	10	112	141	-	22	630
1972	-	56	1,345	237	-	25	1,957
1973	-	41	916	195	-	14	1,221
1974	-	161	1,416	310	-	23	1,922
1975	-	298	1,744	215	-	25	2,348
1976	-	412	8,563	474	-	43	10,083
1977	-	420	4,009	363	-	21	7,231
1978	-	303	3,099	524	-	62	6,342
1979	-	1	2,881	714	-	49	11,949
1980	-	996	3,018	658	-	91	13,706
1981	-	2,480	4,205	265	-	89	19,391
1982	-	615	-	237	53	106	13,787
1983	-	0	-	660	51	55	13,062
1984	-	0	274	397	27	54	13,273
1985	-	15	930	183	-	103	17,965
1986	-	19	0	358	12	114	12,967
1987	-	22	0	2,965	90	78	14,645
1988	-	38	0	2,251	21	76	7,917
1989	-	5	0	1,475	7	10	14,454
1990	-	8	0	2,309	26	17	(15,329)
1991	2	-	0	950	6	20	(14,790)
1992	-	14	0	1,246	2	19	(15,186)

Table D4. Unclassified or handline, gillnet, troll and other gear catches (t) of yellowfin tuna by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	FIJI[16]	INDONESIA[4]		NEW ZEALAND[17]	PHILIPPINES[18]		
	TROLL	UNCL	HANDLINE	UNCL	UNCL	GILLNET	HANDLINE
1970	-	5,500	-	-	(197)	(2,664)	(21,835)
1971	-	5,700	-	-	(219)	(2,981)	(24,429)
1972	-	9,000	-	-	(228)	(3,097)	(25,384)
1973	-	10,200	-	-	(273)	(3,705)	(30,365)
1974	-	10,165	-	1	(316)	(4,307)	(35,300)
1975	-	11,062	-	1	(324)	(4,395)	(36,024)
1976	-	7,530	-	-	(199)	(2,691)	(22,056)
1977	-	10,268	-	-	(311)	(4,230)	(34,665)
1978	-	8,225	-	15	230	4,918	24,941
1979	-	11,482	-	16	281	2,027	31,980
1980	-	11,626	-	51	432	2,301	29,235
1981	-	15,793	-	26	953	2,655	32,254
1982	-	17,393	-	2	1,055	1,386	29,826
1983	3	15,239	-	1	3,661	1,260	32,396
1984	-	18,140	2,250	2	649	2,161	31,005
1985	3	20,130	2,540	1	1,325	2,040	35,505
1986	2	25,226	2,737	7	824	2,137	36,188
1987	2	24,732	2,793	7	866	2,160	26,407
1988	9	26,377	2,899	5	(873)	(2,220)	(32,339)
1989	26	31,345	2,726	9	(951)	(2,418)	(35,221)
1990	20	32,285	3,196	4	(717)	(1,824)	(26,566)
1991	13	34,959	3,835	4	(1,628)	(4,142)	(60,331)
1992	15	36,770	4,794	8	(1,628)	(4,142)	(60,331)

YEAR	TAIWAN[19] (UNCL)	USA[20] (UNCL)	OTHER[21] (UNCL)	TOTAL
1970	406	51	-	30,653
1971	363	175	-	33,867
1972	331	189	-	38,229
1973	441	238	-	45,222
1974	334	370	-	50,793
1975	426	652	-	52,884
1976	1,359	685	-	34,520
1977	428	735	-	50,637
1978	1,517	698	-	40,544
1979	1,743	848	-	48,377
1980	901	1,041	-	45,587
1981	634	1,132	-	53,447
1982	565	686	-	50,913
1983	317	796	-	53,673
1984	1,037	790	-	56,034
1985	825	969	-	63,338
1986	847	1,569	-	69,537
1987	3,066	1,662	-	61,695
1988	3,583	1,074	-	69,379
1989	484	858	-	74,038
1990	2,153	931	-	67,696
1991	824	925	-	(106,661)
1992	544	787	-	(109,019)

Table D5. Total catches (t) of yellowfin tuna (sum of Tables D1 - D4) by country from the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes. (Table D5 continues on next page).

YEAR	AUSTRALIA	FSM	FIJI	FRENCH POLYNESIA	INDONESIA	JAPAN	KIRIBATI	KOREA
1970	-	-	-	-	5,500	41,134	-	1,500
1971	-	-	-	-	5,700	38,877	-	3,975
1972	-	-	-	-	9,000	42,779	-	8,850
1973	-	-	-	-	10,200	45,430	-	9,000
1974	-	-	12	-	10,165	46,633	-	11,328
1975	-	-	11	-	11,062	42,335	-	7,774
1976	1	-	83	-	8,037	48,068	-	13,896
1977	-	-	151	-	10,859	56,311	-	15,585
1978	16	-	409	-	10,601	75,868	-	13,087
1979	-	-	403	161	14,663	82,469	-	17,977
1980	-	-	233	253	17,550	94,952	-	21,595
1981	-	-	599	472	21,889	92,733	210	9,085
1982	5	-	813	368	24,313	88,391	170	10,150
1983	-	-	565	238	20,200	91,958	239	7,757
1984	5	-	580	426	26,450	86,961	528	6,076
1985	-	-	727	243	29,587	107,647	503	8,082
1986	-	-	825	232	34,328	85,037	721	8,396
1987	1,487	-	412	149	40,785	82,193	156	27,578
1988	1,180	-	535	274	43,199	69,817	383	24,074
1989	942	-	542	187	45,268	78,539	848	40,936
1990	1,832	-	559	55	48,087	(77,814)	143	51,193
1991	2,105	1,191	477	105	52,825	(77,224)	67	(59,938)
1992	2,265	2,187	612	87	55,325	(77,224)	303	(49,906)

YEAR	MARSHALL ISLANDS	MEXICO	NEW CALEDONIA	NEW ZEALAND	PALAU	PAPUA NEW GUINEA	PHILIPPINES	RUSSIA
1970	-	-	-	-	1	74	(32,000)	-
1971	-	-	-	-	10	112	(35,800)	-
1972	-	-	-	-	56	1,345	(37,200)	-
1973	-	-	-	-	41	916	(44,500)	-
1974	-	-	-	1	161	1,416	(51,732)	-
1975	-	-	-	1	298	1,744	(52,793)	-
1976	-	-	-	-	412	8,563	(32,323)	-
1977	-	-	-	-	420	4,009	(50,801)	-
1978	-	-	-	15	303	3,099	35,921	-
1979	-	-	-	16	1	2,881	47,496	-
1980	-	-	-	51	996	3,018	45,608	-
1981	-	-	3	26	2,480	4,205	55,663	-
1982	-	-	41	2	615	-	51,840	-
1983	-	-	32	240	0	-	60,920	-
1984	-	1,174	25	233	0	274	58,088	-
1985	-	-	119	171	15	930	62,280	570
1986	-	-	151	7	19	0	59,151	432
1987	-	-	449	7	22	0	51,295	3,381
1988	-	-	436	5	38	0	(57,060)	850
1989	-	-	248	9	5	0	(62,146)	1,535
1990	-	-	551	4	8	0	(46,874)	621
1991	-	-	506	6	-	0	(95,614)	1,114
1992	9	-	230	8	14	0	(95,614)	437

Table D5. (continued)

YEAR	SOLOMON ISLANDS	TAIWAN	TONGA	TUVALU	USA	OTHER	TOTAL
1970	-	10,387	-	-	320	-	(90,916)
1971	141	14,143	-	-	388	-	(99,145)
1972	237	12,696	-	-	357	-	(112,520)
1973	286	18,842	-	-	340	-	(129,555)
1974	310	12,425	-	-	519	-	(134,702)
1975	215	16,520	-	-	761	-	(133,513)
1976	620	17,070	-	-	1,039	-	(130,112)
1977	561	20,022	-	-	1,132	-	(159,851)
1978	731	23,960	-	-	1,132	-	165,142
1979	1,207	27,338	-	-	1,689	-	196,302
1980	1,671	24,691	-	-	2,686	-	213,305
1981	1,753	19,990	-	-	14,808	-	223,917
1982	1,987	17,818	81	53	23,200	-	219,847
1983	3,633	17,069	48	51	51,006	-	253,956
1984	3,007	17,957	55	27	46,541	-	248,407
1985	3,216	15,981	44	-	30,550	-	260,665
1986	2,616	14,890	33	12	38,770	-	245,619
1987	6,350	22,077	32	90	68,371	-	304,834
1988	6,319	25,414	26	21	26,951	-	(256,582)
1989	5,885	23,672	27	7	43,506	-	(304,302)
1990	6,134	24,793	28	26	59,078	-	(317,799)
1991	4,225	23,685	19	6	36,658	-	(355,765)
1992	6,339	52,650	19	2	51,474	-	(394,704)

Table D6. Number (except for Japan) of longline vessels by countries fishing for tunas in the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	AUSTRALIA[22]	FSM[2]	FIJI[3]	INDONESIA[4]	JAPAN[23]	KOREA[24]	MARSHALL ISLANDS[7]
1970	-	-	-	-	173,658	-	-
1971	-	-	-	-	178,461	120	-
1972	-	-	-	-	174,801	177	-
1973	-	-	-	-	161,856	225	-
1974	-	-	-	-	188,374	270	-
1975	-	-	-	-	164,424	250	-
1976	-	-	-	-	181,085	251	-
1977	-	-	-	-	172,115	212	-
1978	-	-	-	-	189,460	225	-
1979	-	-	-	-	216,801	212	-
1980	-	-	-	-	224,759	211	-
1981	-	-	-	-	241,909	210	-
1982	-	-	-	-	224,575	120	-
1983	-	-	-	-	197,756	100	-
1984	-	-	-	-	202,750	95	-
1985	-	-	-	28	210,863	94	-
1986	-	-	-	63	183,850	127	-
1987	64	-	-	79	182,306	130	-
1988	62	-	-	70	202,165	125	-
1989	93	-	4	138	185,000	150	-
1990	98	-	6	151	176,802	182	-
1991	82	2	9	145	(176,802)	(144)	-
1992	88	6	18	141	(176,802)	(167)	4

YEAR	NEW CALEDONIA[8]	PHILIPPINES[25]	SOLOMON ISLANDS[7]	TAIWAN[26]		TONGA[7]	USA[11]
				DISTANT-WATER	OFFSHORE		
1970	-	-	-	-	829	-	45
1971	-	-	-	-	863	-	46
1972	-	-	-	-	899	-	42
1973	-	-	2	-	1,255	-	32
1974	-	-	-	-	1,451	-	33
1975	-	-	-	92	1,411	-	31
1976	-	-	2	194	1,331	-	33
1977	-	-	2	176	1,382	-	35
1978	-	-	2	168	1,670	-	29
1979	-	-	2	157	1,840	-	21
1980	-	-	2	182	1,900	-	11
1981	-	-	2	140	1,846	-	13
1982	-	61	2	115	1,831	1	10
1983	1	62	2	65	1,872	1	18
1984	2	62	2	61	1,944	1	23
1985	3	55	2	44	2,129	1	23
1986	2	41	0	51	2,084	1	21
1987	3	62	0	60	2,207	1	37
1988	4	27	0	70	1,977	1	50
1989	4	3	0	85	1,671	1	80
1990	7	26	0	96	1,139	1	138
1991	6	(26)	0	82	800	1	140
1992	4	(26)	0	92	1,898	1	123

Table D7. Number (except for Japan) of purse seine vessels fishing for yellowfin tuna in the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	AUSTRALIA[27]	FSM[2]	INDONESIA[4]	JAPAN[28]	KOREA[29]	MEXICO[7]
1970	-	-	-	134	-	-
1971	-	-	-	2,735	-	-
1972	-	-	-	3,339	-	-
1973	-	-	-	3,493	-	-
1974	-	-	-	2,439	-	-
1975	-	-	-	2,936	-	-
1976	-	-	-	3,539	-	-
1977	-	-	-	3,080	-	-
1978	-	-	-	3,422	-	-
1979	-	-	-	4,884	-	-
1980	-	-	-	4,611	2	-
1981	-	-	-	6,345	3	-
1982	-	-	-	8,391	10	-
1983	-	-	-	9,133	11	-
1984	-	-	3	10,537	12	2
1985	-	-	3	10,771	11	-
1986	-	-	3	10,303	13	-
1987	-	-	3	10,377	20	-
1988	3	-	3	9,994	23	-
1989	1	-	3	9,595	30	-
1990	9	-	3	8,573	-	-
1991	4	3	3	7,603	37	-
1992	3	4	3	(7,603)	36	-

YEAR	NEW ZEALAND[7]	PHILIPPINES[30]	RUSSIA[7]	SOLOMON ISLANDS[7]	TAIWAN[13]	USA[11]
1970	-	-	-	-	-	-
1971	-	-	-	-	-	-
1972	-	-	-	-	-	-
1973	-	-	-	-	-	-
1974	-	-	-	-	-	-
1975	-	-	-	-	-	-
1976	-	-	-	-	-	3
1977	-	-	-	-	-	1
1978	-	-	-	-	-	2
1979	-	-	-	-	-	8
1980	-	570	-	1	-	14
1981	-	697	-	1	-	14
1982	-	785	-	1	-	24
1983	7	686	-	1	-	62
1984	5	712	-	1	5	61
1985	5	724	5	1	5	40
1986	-	685	8	1	11	36
1987	-	813	5	2	15	35
1988	-	779	5	4	24	32
1989	-	198	5	4	22	35
1990	-	549	5	4	31	40
1991	-	(549)	4	3	40	41
1992	-	(549)	3	3	43	44

Table D8. Number (except for Japan) of pole-and-line vessels fishing for yellowfin tuna in the central and western Pacific Ocean, 1970-92. Dash (-) indicates missing or unavailable data; values in parentheses are estimates; footnotes are contained in the List of Footnotes.

YEAR	AUSTRALIA[7]	FIJI[31]	FRENCH POLYNESIA[7]	INDONESIA[4]	JAPAN[32]	KIRIBATI[7]	NEW CALEDONIA[8]
1970	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-
1976	9	2	-	-	-	-	-
1977	-	6	-	-	-	-	-
1978	14	6	-	-	-	-	-
1979	-	8	-	-	63,755	1	-
1980	-	11	46	-	61,379	-	-
1981	-	12	51	-	62,243	2	1
1982	20	14	46	-	58,695	2	3
1983	-	13	46	-	50,011	4	3
1984	8	11	51	-	49,080	4	0
1985	-	7	49	1,115	43,555	4	0
1986	-	6	51	1,287	40,871	4	0
1987	-	8	64	1,170	38,929	4	0
1988	-	11	53	1,577	15,881	5	0
1989	-	14	56	921	32,771	6	0
1990	-	14	55	900	(32,771)	5	0
1991	-	11	31	872	(32,771)	3	0
1992	-	11	-	849	(32,771)	3	0

YEAR	NEW ZEALAND[7]	PALAU[7]	PAPUA NEW GUINEA[7]	SOLOMON ISLANDS[7]	TUVALU[7]	USA[11]
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	-	21	45	21	-	-
1980	-	31	50	22	-	-
1981	-	36	44	23	-	-
1982	-	20	-	25	1	-
1983	-	0	-	27	1	-
1984	-	0	-	30	1	-
1985	-	1	-	33	1	-
1986	-	1	0	35	1	-
1987	-	1	0	34	1	-
1988	-	1	0	34	1	-
1989	-	1	0	33	1	-
1990	-	1	0	33	1	-
1991	4	-	0	32	1	-
1992	-	1	0	32	1	-

List of Footnotes (Appendix D Tables)

[1]From logbooks, P. Ward (pers. comm.). Data raised for coverage of 50% (1987-88), 75% (1989), and 85% (1990) of logbooks. 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) not reported by Japan. Original data were reported as dressed weights and raised to whole weights by multiplying by 1.15.

[2]From SPC Regional Tuna Bulletin (3rd quarter 1992) for 1991 and Micronesian Maritime Authority actual unloadings for 1992.

[3]From S. P. Sharma (pers. comm.).

[4]From Fisheries Statistics of Indonesia, RIMF sampling program, N. Naamin (pers. comm.).

[5]From logbooks, S. Tsuji (pers. comm.).

[6]From Y. C. Park (1991, FAO Expert Consultation). Data for 1975 to 1987 adjusted to represent catches from only the central and western Pacific based on catch-effort data collected by SPC. 1975 catch-effort data used to prorate catches for 1970-74 and 1987 data to prorate catches for 1988-90.

[7]From logbooks, T. Lawson (1993, SCTB6/2).

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

[9]From BFAR Fisheries Statistics, R. Ganaden (pers. comm.). Ring net and purse seine catches for 1988-90 and 1970-77 were prorated using data for 1986-87 and 1978-79 respectively.

[10]From logbooks for the distant-water fleet and landings for the offshore fleet, C.-L. Sun (pers. comm.).

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

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

[13]From landings, C.-L. Sun (pers. comm.).

[14]From landings, S. P. Sharma (pers. comm.). Data cross-checked with logbooks; 1989 data include 15 mt from purse seine.

[15]From Z. Suzuki (1991, FAO Expert Consultation) for 1971-78 and from S. Tsuji (pers. comm.) for 1979-89. 1990-92 catches assumed the same as for 1989.

[16]From S. P. Sharma (pers. comm.). Data from artisanal and commercial fisheries.

[17]From FAO statistics for 1970-84 and from logbooks for 1985-90, T. Murray (pers. comm.). Includes chartered Japanese vessel catches not reported by Japan. Gears are primarily longline and troll. Recreational troll catches (range from t to about 45 t per year) are not included.

[18]From BFAR Fisheries Statistics, R. Ganaden (pers. comm.). Catches for 1970-77 and 1988-90 were prorated using 1978-79 and 1986-87 data, respectively. UNCL gear includes seine nets and bag nets.

[19]From C.-L. Sun (pers. comm.). Includes troll and pole-and-line gears.

[20]From landings, A. Coan (pers. comm.). Includes catches by handline, troll, and some pole-and-line gears.

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

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

[23]From S. Tsuji (pers. comm.). Number of vessels is unavailable. Data represent number of hooks x 1000.

[24]From Y. C. Park (1991, FAO Expert Consultation). Data represent number of vessels in the entire Pacific.

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

[26]From Fisheries Yearbook, C.-L. Sun (pers. comm.). Distant-water fleet operates Pacific-wide.

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

[28]From S. Tsuji (pers. comm.). Number of vessels is unavailable. Data represent days fished.

[29]From Y. C. Park (1991, FAO Expert Consultation).

[30]From BFAR Fisheries Statistics, R. Ganaden (pers. comm.). Data include ring net fleet.

[31]From landings, Fiji Fisheries Department, S. P. Sharma (pers. comm.). Data cross-checked with logbooks submitted to Fiji Fisheries Department.

[32]From S. Tsuji (pers. comm.). Number of vessels is unavailable. Data represent days fished.