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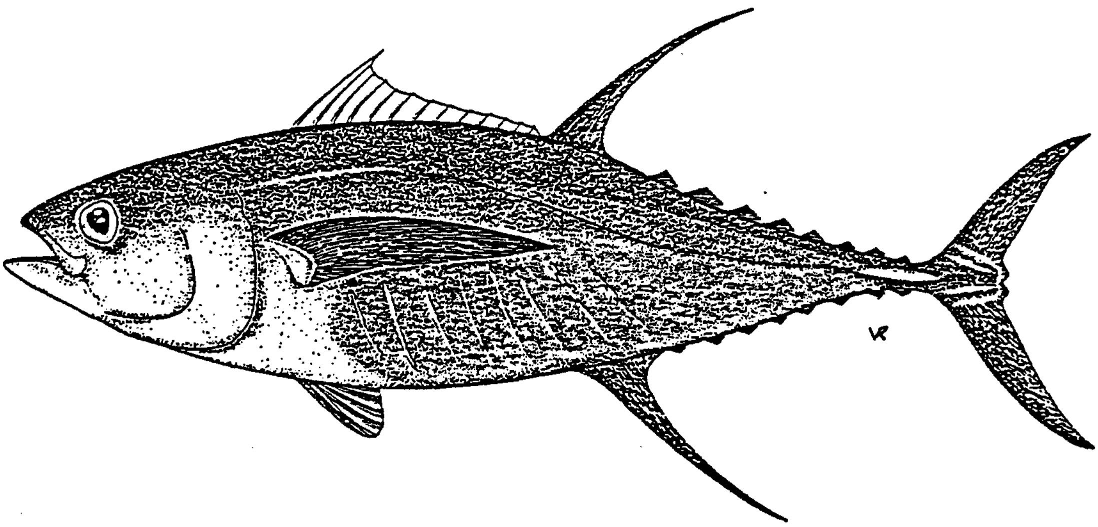
WORKING PAPER 5

OCEANIC FISHERIES PROGRAMME
WORK PROGRAMME REVIEW 1993-94 AND WORK PLAN 1994-95



Oceanic Fisheries Programme (OFP)
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OCEANIC FISHERIES PROGRAMME

The Oceanic Fisheries Programme (OFP), formerly known as the Tuna and Billfish Assessment Programme (TBAP) was established by the 1980 South Pacific Conference to continue the work initiated by its predecessor project, the Skipjack Survey and Assessment Programme (SSAP). The Programme is funded by extra-budgetary contributions from Australia, France, New Zealand and the United States of America. Funding for specific projects during the past four years has also been received from the European Community (EC), the International Centre for Ocean Development (ICOD) of Canada, the Australian International Development Assistance Bureau (AIDAB) and the Food and Agriculture Organisation of the United Nations (FAO).

The OFP mission, as drafted by the Fourth SCTB and endorsed by the Twenty-third Regional Technical Meeting on Fisheries, is "to provide member countries with the scientific information and advice necessary to rationally manage fisheries exploiting the region's resources of tuna, billfish and related species". The structure of the OFP recommended at the Fourth SCTB, i.e. Statistics and Monitoring, Biological Research, Stock Assessment and Modelling, Reporting and Liaison, continues to be used to review work programme activities and to frame work plans. Albacore research, which in previous years had been described separately, is now integrated into these broad work areas. The OFP involvement, on a consultancy basis, in the Philippines Tuna Research Project continues to be described in a separate section. Finally, a status report on the OFP computer system and plans for its enhancement are described.

As was the case last year, the review of the 1993-94 work programme and the presentation of the work plan for 1994-95 have been consolidated into the one document so as to present a more concise picture of the status and direction of the Programme.

1. STATISTICS AND MONITORING

Overview

Statistics and monitoring has been a core activity of the OFP since its inception (as the TBAP) in 1981. At this time, its main priority was the establishment of a regional catch and effort logsheet database to record and monitor the development of tuna fisheries in the region. While this remains a key function, the activities have expanded in several directions, including the development and maintenance of databases for specialist research and review groups (eg., the South Pacific Albacore Research Group and SCTB), the development and maintenance of in-country databases, the publication of fisheries statistics in various forms and the provision of statistical support services. With the imminent start-up of the new EC-funded South Pacific Regional Tuna Resource Assessment and Monitoring Project (SPR TRAMP), port sampling and observer activities have become an important additional function of the OFP.

1.1 Regional Tuna Fisheries Databases

1.1.1 Catch and Effort Logbook Database

Background

Since its inception in 1981, the OFP has maintained a database on industrial tuna fisheries in the region. The main sources of data have been catch and effort logsheets provided to SPC by member countries; the logsheets have been obtained either from distant-water fishing nations (DWFNs) under access agreements or from vessels of domestic fleets. The database is used for research and monitoring purposes; in particular, to assess the state of exploitation of the stocks and to study interactions between the different fleets operating in the region. Monitoring of the fisheries is facilitated through quarterly publication of the *SPC Regional Tuna Bulletin*. Data summaries are also provided to member countries on a quarterly basis. For many member countries, the processed data are returned on diskettes for incorporation into databases which are maintained on computers within each country.

1993–94 Activities

During 1993–94, logsheet data for tuna vessels fishing in the region were received from Australia, the Cook Islands, the Federated States of Micronesia, Fiji, French Polynesia, Kiribati, the Marshall Islands, New Caledonia, Palau, Papua New Guinea, Solomon Islands, Tonga, Tuvalu and the United States. The number of vessels covered by logsheet data held at SPC increased considerably during 1993, to 1,123, including 864 longliners, 80 pole-and-liners, and 179 purse seiners. The increase was largely due to an influx of offshore longliners from mainland China to ports in Micronesia.

Current OFP logsheet data holdings are listed in the OFP Data Catalogue (Information Paper 1). Holdings of length frequency, unloadings and tagging data are also presented in the Data Catalogue.

During 1993-94, the logsheet data entry programmes were extensively revised to take full advantage of features in the latest version of FoxPro, the microcomputer database software used by the OFP. The data entry systems were also adapted for use on the OFP local-area network, which currently runs under Novell Netware 3.11.

1994–95 Work Plan

Maintenance of the catch and effort logsheet database and efforts to improve its coverage will continue. Data entry and reporting programmes will be revised as required; in particular, reporting programmes to identify gaps in coverage by logsheet data and landings data for individual vessels will be developed. A review of the quality of longline and purse-seine logsheet data, in which logsheet data will be compared to landings data collected through port sampling programmes, will also be undertaken.

1.1.2 Standing Committee Database

Background

At the meeting of the Standing Committee on Tuna and Billfish held in Suva on 19-21 June 1989, the Committee considered the problem of inadequate statistical coverage of the fishing activities of DWFNs in the region, including Indonesia, Korea, Japan, Philippines, Taiwan and the USSR. The Standing Committee discussed the establishment of a common database consisting of aggregated data provided by all fishing nations (including DWFNs), which would be separate from the data currently assembled by SPC in the Regional Tuna Fisheries Database (which are contributed only by SPC member countries).

1993–94 Activies

At present, data have been provided to the Standing Committee Database by Australia, Fiji, Japan, Kiribati, Korea, New Caledonia, New Zealand, Papua New Guinea, Solomon Islands, Taiwan, Tonga and the United States. During 1994, updates of DWFN data were received from the Fisheries Agency of Japan and from National Taiwan University. Data for all Japanese fleets and the Taiwanese distant-water longline fleet are current to 1992. In contrast, data covering Korean longliners are current only to 1987. Further, no Korean purse-seine data have yet been received, although the fleet has been active since 1980; the National Fisheries Research and Development Agency of Korea is believed to have compiled logsheet data covering purse seiners since at least 1983.

Exchanges of aggregated data that took place through the Standing Committee Database during 1993-94 included American purse-seine data that were provided to the Fisheries Agency of Japan, and Japanese purse-seine data that were provided to the United States Tuna Foundation. A request by the National Research Institute of Far Seas Fisheries for Korean, Taiwanese and additional American purse seine data is currently being considered by the Federated States of Micronesia, Kiribati, Papua New Guinea and the Forum Fisheries Agency. A request by the Australian Institute of Marine Science for Japanese longline data in order to study the relationship between catch rates of billfish and sea surface temperature was declined by the Fisheries Agency of Japan because similar studies are already being undertaken by scientists in Japan and at the Inter-American Tropical Tuna Commission. A request by the Forum Fisheries Agency for Japanese data is currently being considered by the Fisheries Agency of Japan.

1.1.3 SPAR Database

Background

At the Second South Pacific Albacore Research (SPAR) Workshop, held in June 1989, the participants agreed to the offer made by SPC to act as a clearinghouse for the receival and distribution of albacore data.

1993–94 Activities

At present, catch and effort data have been provided by Australia, Japan, Korea, New Caledonia, New Zealand, Taiwan, Tonga and the United States. Size frequency data have been provided by Australia, Fiji, French Polynesia, Japan and the United States. Data for the SPAR database were updated in preparation for the fifth meeting of the SPAR group, held in Papeete, French Polynesia, from 29 March to 2 April 1993. The SPAR database is available on request to members of the SPAR group.

1994–95 Work Plan

Maintenance of the SPAR database will continue, in anticipation of the next meeting of the SPAR group.

1.2 Port Sampling

Background

Sampling of size and species composition of landed catches in port often provides a convenient means of monitoring these characteristics of the commercial catch. These data are fundamental for stock assessment and fishery interaction research. The amounts unloaded are also useful information that can be used to verify logsheet data and to estimate annual catches.

1993–94 Activities

During 1993, port sampling programmes to collect biological data and/or landings data were supported by the OFP in American Samoa, Federated States of Micronesia, Fiji, French Polynesia, Guam, Marshall Islands, New Caledonia and Palau. The amount of purse-seine transshipment activity in the region increased considerably, particularly in Chuuk (Federated States of Micronesia) and Honiara (Solomon Islands), following the ban on transshipment at sea implemented by FFA members countries in June 1993. During 1994, sampling of length frequency and species composition were initiated on Kiritimati (Kiribati) and in Honiara, while the compilation of unloading data began at Tarawa (Kiribati) and in Rabaul (Papua New Guinea). The port sampling data are forwarded on a quarterly basis to SPC, where they are then processed.

A port sampling workshop was convened by SPC in Weno, Chuuk, Federated States of Micronesia, from 17 to 20 January 1994, with assistance from the Micronesian Maritime Authority (Information Paper 2). The participants included port samplers and supervisors of port sampling programmes in each of the countries and territories mentioned above (with the exception of French Polynesia). The meeting reviewed current transshipment and port sampling activies, discussed sampling protocols, and observed the sampling of longliners and purse seiners.

Port sampling forms were extensively revised by the OFP following recommendations made at the port sampling workshop. The revised forms were distributed during March 1994; most port sampling programmes have since adopted the revised forms. Subsequent to the revision of the port sampling data entry forms, modifications to data entry and reporting programmes for port sampling data were undertaken by the OFP. Components of the port sampling data entry and reporting programmes have also been adapted for use in in-country database systems.

1994–95 Work Plan

Existing sampling programmes will continue to be supported during 1994–95. The Lomé IV-funded South Pacific Regional Tuna Resource Assessment and Monitoring Project (SPR TRAMP) will enable sampling programmes to expand, where necessary. Under SPR TRAMP, a Port Sampling and Observer Supervisor, based in Noumea, and five or more local samplers, will be recruited.

1.3 Observers

Background

To date, the OFP has played mainly an advisory role with respect to observer programmes in the western tropical Pacific. Since the inception of the observer programme on American purse seiners under the US treaty, which is administered by FFA, the OFP has played a key support role in observer training, design of data collection forms, processing of observer data and data quality assessment.

1993–94 Activities

During 1993–94, this advisory role to the American purse-seine observer programme continued. Financial and technical assistance was provided by SPC to the Micronesian Maritime Authority (MMA) to initiate placement of observers aboard Taiwanese purse seiners and to monitor transshipment. A longline observer form was developed and tested in collaboration with MMA staff.

1994–95 Work Plan

The OFP will continue to support the US treaty and national observer programmes. Under SPR TRAMP, the OFP will have substantial funding available for the placement of scientific observers aboard commercial tuna fishing vessels over the next five years. It is intended to recruit four scientific observers, who will be expected to spend up to 75 percent of their time at sea, involving vessels of all fleets. The main role of these observers will be the collection of biological and fishing effort data; the OFP will also attempt to accommodate requests from other agencies and member countries for the collection of other data and the training of national observers.

During 1994–95, the OFP will initiate discussions with member countries, FFA and other relevent agencies regarding their plans for observer placement in coming years. Taking this information into account, the OFP will develop procedures for onboard sampling and a sampling design for the placement of SPC observers. Ideally, the SPC observer programme will form part of a regionally-coordinated observer effort that includes other agencies and national programmes.

1.4 SPC Regional Tuna Bulletin

Background

The quarterly *SPC Regional Tuna Bulletin* provides summaries of catch and effort by month, gear type and fishing nation, for most commercial tuna fleets in the SPC area, as well as reports of tuna-related meetings, research projects, etc. It has been distributed since the first quarter of 1988 to fisheries officers within the region and to research institutions and industry within the region and beyond.

1993–94 Activities

During 1993, the Tuna Bulletin was improved in several respects; changes to the statistical methodology resulted in more accurate estimates of catch rates and fishing effort.

1993–94 Work Plan

The *Tuna Bulletin* will continue to be published on a quarterly basis.

1.5 SPC Tuna Fishery Yearbook

Background

At the third meeting of the Standing Committee on Tuna and Billfish (SCTB), held in June 1990, the members of the committee called for the OFP to compile fishery status reports, in order to facilitate the review by the SCTB of the OFP work programme and to place the work of the OFP in perspective. The status reports, which contain historical and current estimates of annual catches, by species, for each of the fleets that have operated in the SPC area, have since been produced each year and presented at meetings of the SCTB.

1993–94 Activities

The report on annual catches up to 1992 was presented to the sixth meeting of the SCTB, held on Pohnpei in June 1993. In previous years, the status report has been published in the OFP Technical Report series. The 1992 report was the first published as the *SPC Tuna Fishery Yearbook*. The Tuna Fishery Yearbook, 1993, was published just prior to the seventh meeting of the SCTB, held in Koror in August 1994.

1994–95 Work Plan

Another edition of the *SPC Tuna Fishery Yearbook* will be produced, with estimates of annual catches up to 1994 and revisions of historical estimates.

1.6 National Fishery Statistics Systems

Background

Commencing in 1988, tuna fishery databases have been developed and installed on computers in fisheries departments of thirteen SPC member countries. The systems are customised according to the needs of the member country, but typically allow the production of data summaries and maps of fishing activity within their EEZ. Some systems also include a logsheet data entry component that allows in-house data processing. In cases where data entry is carried out at SPC, regular data updates are sent via Peacesat or on diskette by mail.

1993–94 Activities

During 1993–94, several countries (Federated States of Micronesia, Kiribati, Marshall Islands, New Caledonia, Papua New Guinea, Solomon Islands) received updated systems and further programming support for their in-country fisheries databases from OFP staff. In-country systems have been updated to take advantage of new features in FoxPro, and to incoporate new components for port sampling programmes.

1994–95 Work Plan

During 1994–95, OFP staff plan to visit several countries to provide programming support and database development, including further upgrading of their existing systems. The installation of a fisheries database system in French Polynesia was planned for July 1994.

1.7 Statistical Support for Other SPC Fisheries Projects

Background

Statistical support has been provided to other SPC fisheries projects, in addition to the research and assessment work of the OFP, in particular the Deep Sea Fisheries Development Project, the Inshore Fisheries Research Project and the Regional Fisheries Training Programme. Data management for the tagging projects conducted by the OFP has been carried out since 1989.

1993–94 Activities

Support provided during 1993–94 concerned continuing maintenance of database systems for the Regional Tuna Tagging Project and the provision of data summaries for country reports. With the completion of tagging activities during 1992, programming assistance continued with tag recovery data processing. A new query interface for the tagging data was also developed. Support was also provided for the preparation of country reports in the form of tables and figures summarising catch, effort and tagging data.

1994–95 Work Plan

During 1994–95, support will continue to be provided on request to other SPC programmes, as resources allow.

1.8 Liaison With Other Fisheries Statistics Agencies

Background

Since its inception, the OFP has been involved with other agencies concerned with tuna fisheries statistics, notably the Food and Agriculture Organization of the United States (FAO), the Indo-Pacific Tuna Development and Management Programme, and the Inter-American Tropical Tuna Commission.

1993–94 Activities

The OFP was represented at the fifth session of the Expert Consultation on Indian Ocean Tunas on Mahé, Seychelles, from 4 to 8 October 1993. In addition to a review of the status of stocks, including those that are shared between fisheries in the Indian Ocean and the Western Pacific, the meeting resulted in a fruitful exchange of approaches to tuna fisheries research and statistics.

The OFP was also represented at the Ad Hoc Consultation on the Role of Regional Fishery Agencies in Relation to High Seas Fishery Statistics in La Jolla, California, United States of America, from 13 to 16 December 1993. The meeting was organised by FAO in the context of the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks; SPC participation was funded by FAO. The meeting reviewed the statistics that are currently reported on the high seas and collated by regional fishery agencies; specified the requirements for statistics on the high seas for research and management; and advised on the high seas fishery statistics to be collected and disseminated by FAO.

1994–95 Work Plan

The Ad Hoc Consultation on the Role of Regional Fishery Agencies in Relation to High Seas Fishery Statistics also considered the possible extension of the Coordinating Working Party on Atlantic Fishery Statistics (CWP) to cover areas outside the Atlantic Ocean. The CWP has FAO as its secretariat; it is a forum for recommending standards and designing statistical collection systems which are subsequently used outside the Atlantic area, notably including the South Pacific. Given the global nature of many of the issues which are discussed at CWP, the Ad Hoc Consultation recognized the usefulness of extending the CWP brief to a global level. It is intended that the Sixteenth Session of CWP, which may be held in March 1995, will adopt the extension of its brief, in the presence of prospective member agencies, possibly including the OFP.

2. BIOLOGICAL RESEARCH

Overview

With the delayed implementation of SPR TRAMP, the focus of the OFP's biological research continued to be RTTP and Albacore Research Project tag return data processing and analysis. Substantial progress has been made in the areas of estimation of RTTP tag reporting rates and analyses of growth data. Less progress has been made in other areas. The analysis of yellowfin and bigeye morphometric data been held over pending the implementation of SPR TRAMP and recruitment to the new Senior Fisheries Scientist (Biologist) position. The analysis of yellowfin stomach contents sampled during the RTTP has been postponed indefinitely due to its low priority; it is not discussed in this year's report. The analysis of yellowfin gonad index data collected during the RTTP has been cancelled because of the lack of size coverage in the samples. However, a major study of yellowfin reproductive biology, coordinated by the University of Hawaii, is now underway, and the OFP is a collaborator on that project. The only new activity is this section is an informal collaborative study (with US National Marine Fisheries Service, Honolulu Laboratory) investigating the environmental determinants of skipjack fishery production in the western equatorial Pacific.

2.1 Regional Tuna Tagging Project

Background

The RTTP was a three-year project undertaken by the OFP, with 3.5 million ECU in funding from the European Community Sixth European Development Fund (Lomé III). The project was expressly designed to provide practical answers to questions raised by tuna fisheries interaction and tuna exploitation generally within the region. The project is providing information on the population characteristics of yellowfin, skipjack and, to a lesser extent, bigeye, so that these questions can continue to be addressed using various modelling approaches. Tagging was carried out mainly from the chartered Tuvaluan pole-and-line vessel, *Te Tautai*. Also, locally-based vessels were used on an opportunistic basis for specific in-country components in Solomon Islands, Kiribati and Fiji (which also contributed to the overall objectives of the project). The operations of the *Te Tautai* began in December 1989, following initial work in Solomon Islands during the second half of 1989 on Solomon Taiyo Ltd pole-and-line vessels. The vessel charter was completed in December 1992.

1993-94 Activities

With the completion of vessel charter in December 1992, activities in 1993-94 have been restricted to conducting additional tag-seeding experiments on board purse seiners, processing of the 589 tag recoveries received during the past year and administrative follow-up as required. The large task of data quality screening and editing has been started but has been interupted with the termination of the RTTP-funded Research Officer position. This task will be carried out by the new SPR TRAMP position of Research Officer (Data).

Overview of project results

With the completion of field activities now some 18 months past, relatively small numbers of additional tag returns are expected in the next year. We therefore present the following overview of tag release and return numbers, double-tagging results and tag-seeding results.

RTTP tag releases and returns

Including the various in-country tagging projects (Fiji, Kiribati and Solomon Islands, but excluding the experimental handline releases at Kapingamarangi, FSM), a total of 133,257 tunas were tagged and released during the RTTP. At 30 June 1994, 14,571 of these (11%) had been returned, as summarised in Table 1, below.

Table 1. RTTP tag releases and returns as at 30 June 1994.

	Yellowfin	Skipjack	Bigeye	Longtail	Total
Releases	33,525	92,377	6,795	82	132,779
Returns	3,443	10,739	450	3	14,635
Rate (%)	10.27	11.63	6.62	3.66	11.02

Releases were distributed widely throughout the western tropical Pacific, from Philippines and eastern Indonesia in the west to Kiribati in the east (Figure 1). Reported recaptures also spanned this area, reflecting the essentially continuous spatial distribution of the fisheries across the western equatorial Pacific (Figure 2).

Releases and returns by country of release

Tagged tuna were released both in country EEZs and in high-seas areas. The in-country releases, and associated recoveries (Table 2), will be extremely valuable for the analysis of country-specific interaction and exploitation questions. Such analyses are now routinely incorporated into National Fisheries Assessments (Country Reports). The 1992 Solomon Islands and 1993 PNG Country Reports include extensive analyses of both the in-country tagging data and the RTTP data as a whole. A more qualitative analysis of the Fiji data has been incorporated in the recently completed Fiji Country Report, while the Palau data are currently under analysis.

Figure 1. Geographical distribution or RTTP tag releases.

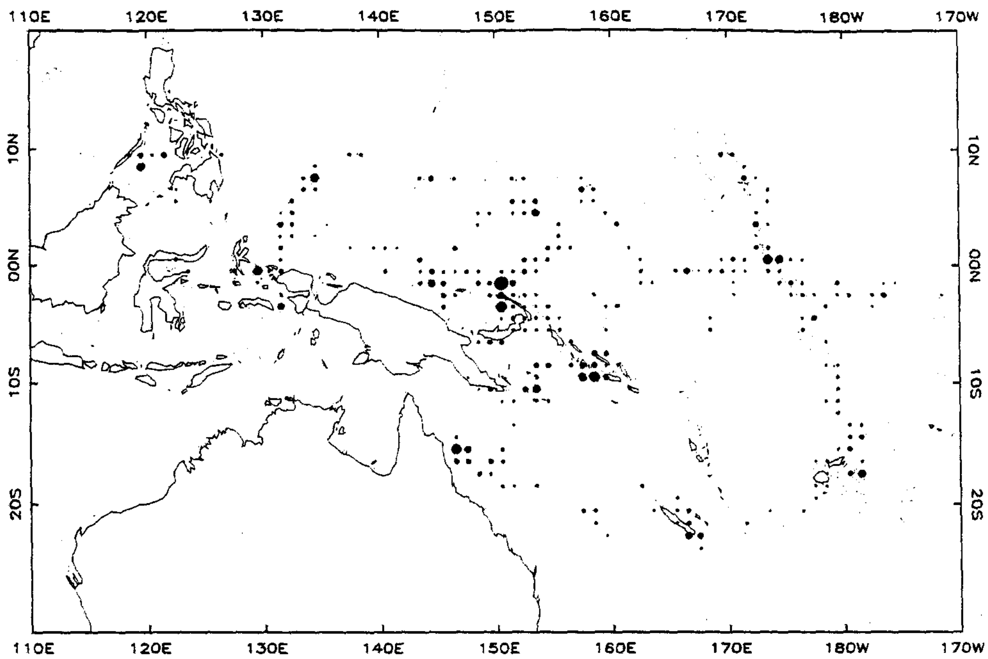


Figure 2. Geographical distribution of RTTP tag returns with known positions.

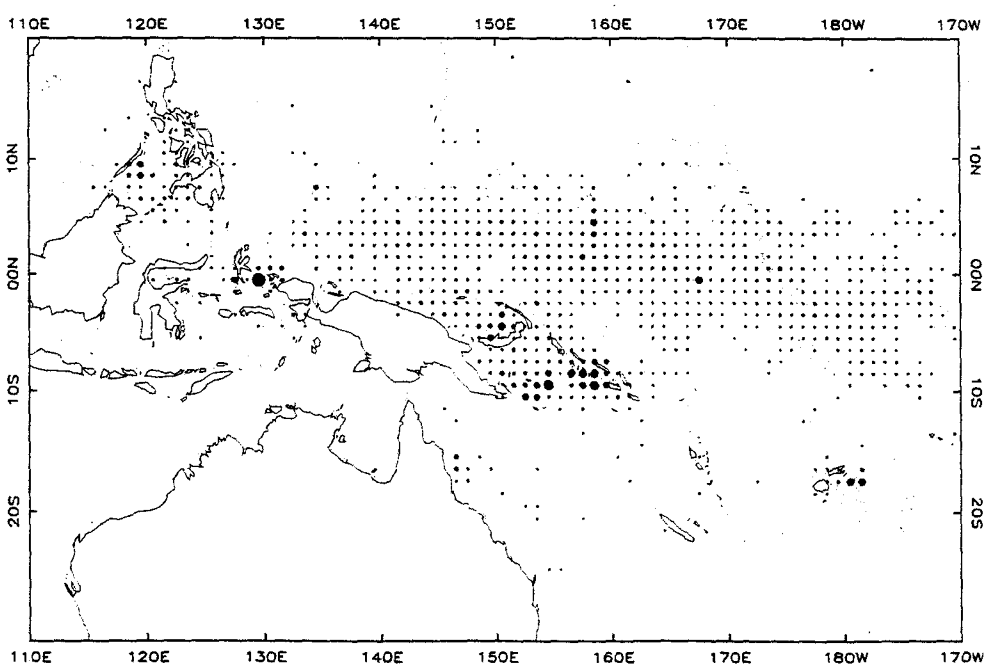


Table 2. In-country tag releases and associated recoveries, as at 30 June 1994.

Release country	Releases			Recoveries			Rate (%)		
	SKJ	YFT	BET	SKJ	YFT	BET	SKJ	YFT	BET
Australia	4,535	2,908	4,274	54	66	119	1.2	2.3	2.8
Fiji	3,995	1,000	4	496	39	1	12.4	3.9	25.0
FSM	8,713	2,572	268	1,027	219	63	11.8	8.5	23.5
Howland Baker	19	23	1	4	8	0	21.1	34.8	0.0
Indonesia	5,721	2,717	46	875	502	8	15.3	18.5	17.4
International waters	345	164	140	29	17	15	8.4	10.4	10.7
Kiribati	10,012	3,032	1,016	765	230	97	7.6	7.6	9.5
Marshall Is.	2,148	17	0	64	1	0	3.0	5.9	
New Caledonia	4,806	695	1	41	1	0	0.9	0.1	0.0
Nauru	1,439	21	0	367	1	0	25.5	4.8	
PNG	27,326	13,789	894	3,843	1,610	119	14.1	11.7	13.3
Philippines	5,073	1,017	19	709	155	3	14.0	15.2	15.8
Palau	4,582	2,625	67	531	320	7	11.6	12.2	10.4
Solomon Is.	11,892	2,725	52	1,865	273	8	15.7	10.0	15.4
Tuvalu	790	123	11	55	2	0	7.0	1.6	0.0
Vanuatu	72	0	0	0	0	0	0.0		
Wallis and Futuna	909	97	0	9	1	0	1.0	1.0	
TOTAL	92,377	33,525	6,793	10,734	3,445	440	11.6	10.3	6.5

Returns by recapture vessel gear type and nationality

Tags were recaptured by at least 6 different fishing gears and by vessels or individuals of at least 20 countries (Table 3). The distribution of returns by these categories generally reflects the vulnerability of the three species to the different gears and the levels of effort by different nations in the western Pacific. All species were recaptured in greatest numbers by purse seiners, with the large industrial fleets of Japan, Korea, Taiwan and USA accounting for the majority of returns. Large numbers of skipjack and yellowfin were also recaptured by the much smaller Philippines and Solomon Islands purse seine fleets; this reflects the large number of FAD-associated tuna tagged in PNG and Solomon Islands waters in close proximity to areas routinely fished by these fleets. Skipjack were also caught in large numbers by pole-and-line vessels, particularly those based in countries where large numbers of tags were released (eg. Solomon Islands, Fiji and Indonesia). Some yellowfin were recaptured by pole-and-line vessels, but only in Indonesia were the returns of comparable magnitude to skipjack. Relatively few longline returns have been received to date. In the case of skipjack, this is not unexpected as skipjack are not caught by longline in significant numbers. Most of the longline recoveries of yellowfin and bigeye have been from fish tagged in the Coral Sea off Cairns, North Queensland, in late 1991 and 1992, and many of these returns have been from Australian longliners fishing in the vicinity of the release location.

Table 3. Tag return numbers, by recapture vessel gear and nationality, as at 30 June 1994.

Gear	Nationality	SKJ	YFT	BET
Gillnet	Philippines	5		
	TOTAL	5		
Handline	FSM	1	4	
	Indonesia	32	26	1
	Japan			3
	Malaysia	1		
	PNG	1		
	Philippines	103	59	1
	USA		1	
	TOTAL	138	90	5
Longline	Australia		25	43
	China			1
	FSM		2	
	Japan		11	11
	Korea		1	3
	New Caledonia		1	1
	Philippines		2	
	Taiwan	2	2	1
	Unknown		1	
	USA	1		
	TOTAL	3	45	60
Pole & line	Australia		4	7
	Fiji	488	34	1
	Indonesia	782	424	8
	Japan	102	1	
	Kiribati	68	5	
	Palau	52	8	
	Solomon Is.	759	41	
	Tuvalu	138	35	47
	Unknown	5		
	TOTAL	2394	552	63
Purse seine	Australia	40	33	1
	FSM	34	16	2
	Indonesia	31	36	2
	Japan	1366	450	51
	Korea	605	267	13
	New Zealand	2		
	Philippines	1925	859	62
	Solomon Is.	991	206	10
	Soviet Union	1	1	
	Taiwan	758	252	12
	Unknown	278	160	11
	USA	1894	418	143
	TOTAL	7925	2698	307
Troll	American Samoa	1		
	Fiji		1	
	FSM	11	2	
	Indonesia	1		
	Kiribati	5	2	
	Northern Marianas	1		
	PNG	1	2	
	Philippines	119	9	
	Palau	1		
	Solomon Is.	12	2	
	Unknown	1	1	
	Vanuatu	1		
	TOTAL	154	19	0
Unknown	Australia	1		
	Indonesia	2		1
	Japan	8	9	3
	Philippines	33	8	
	Palau		1	
	Solomon Is.	64	11	1
	Unknown	7	12	
	TOTAL	115	41	5
TOTAL	TOTAL	10734	3445	440

An analysis of longline and purse seine recoveries of yellowfin larger than 100 cm fork length suggests that, in the equatorial area bounded by 10°N-10°S, there have been fewer longline recoveries than would be expected if the recapture probabilities are simply a function of the numbers of large yellowfin caught by purse seine and longline gears. Details of this analysis and some hypotheses that might explain the shortfall in longline returns are presented in Section 3.4.

Returns by discovery location

The complex nature of product flow from the fishing grounds to processing facilities (see SCTB6, IP.2) in the region and beyond resulted in tag returns being returned from a wide variety of locations (Table 4). With most of the western Pacific purse seine and pole-and-line catch processed for canning, most of the tagged fish were detected at unloading facilities associated with canneries or in the canneries themselves, rather than on board the vessels. Large numbers of returns were therefore received from American Samoa (2 major canning companies), Japan (2+), Thailand (3+), Philippines (9), Indonesia (10) and Solomon Islands (1). Even though many of these tags were recovered from canneries, it was often possible to determine reasonably accurate recapture dates and locations given information on the vessel, well, and well position from which the batch of fish had been delivered. This was usually the case for returns from the American Samoan canneries, where purse seiners generally unload directly to the canneries. However, it was rarely the case for returns from Thailand, where most of the fish is delivered by large reefer vessels and information on the recapture vessel (apart from its identity) is not immediately available.

Obvious omissions from Table 4 are particularly informative with respect to tag reporting rates. Very few tags were returned directly from Korea, despite significant quantities of western Pacific caught tuna being delivered directly to canneries in the Pusan area. Approximately half of the Korean catch from the western Pacific (about 200,000 t per year in total) is shipped directly to Korea, while the rest is processed in Thailand. Almost all of the Korean purse seine recoveries (almost 900) were returned from the Thai canneries. There is no reason to suspect that catches shipped directly to Korea contained substantially different numbers of tagged fish than catches shipped to Thailand. It is clear that large numbers of tagged fish were shipped to Korea and never returned to SPC. This is probably a reflection of lack of penetration of publicity materials (eg., Korean language posters) to the canneries and unloading locations in Korea.

Table 4. Tag return numbers, by discovery location, as at 30 June 1994.

Country	Skipjack	Yellowfin	Bigeye
American Samoa	1,618	337	101
Australia	6	53	107
Ecuador	1		
Fiji	493	35	4
FSM	25	11	2
Guam	1	2	
Indonesia	927	512	13
Japan	1,435	464	57
Kiribati	78	8	
Korea	3	1	
Marshall Is.	5		
Northern Marianas	129	58	17
Malaysia	1		
New Caledonia	1	1	1
New Zealand	5	2	
PNG	22	7	1
Philippines	2,234	963	65
Puerto Rico	222	55	19
Palau	54	9	
Solomon Is.	1,929	285	11
Singapore	2	1	
Soviet Union	1	1	
Thailand	1,534	640	41
USA	5		1
Vanuatu	1		
Wallis & Futuna	2		
TOTAL	10,734	3,445	440

Double-tagging experiments

An important aspect of the RTTP has been the estimation of tag loss due to processes such as tag shedding and non-reporting. Estimates of such losses are essential if unbaised estimates of mortality rates are to be obtained from the tag return data. Double-tagging experiments were carried out at various times during tagging operations, and the returns of these tags have allowed the estimation of tag-shedding rates, which have been incorporated into the tag-attrition analyses reported in section 3. A summary of the double-tagging results is given in Table 5.

Table 5. Results of double-tagging experiments carried out during the RTTP.

Species	Number released	Number returned			Return rate (%)
		With 2 tags	With 1 tag[1]	Total	
Skipjack	2,557	211	10+22	243	9.5
Yellowfin	1,493	175	14+14	203	13.6
Bigeye	491	70	6+4	80	16.3

[1] X+Y indicates X primary (tagged first) tags and Y companion (tagged second) tags recovered.

Although the numbers tagged are not large in relation to single-tag releases, the results are useful from several perspectives. First, the overall return rates from double-tagged skipjack and yellowfin are almost identical to the return rates of their single-tagged counterparts released from the same schools and weighted by the double-tag release numbers in each school (9.0% and 13.7% respectively). The weighted return rate for bigeye single tags was considerably higher (22.8%) than the double-tag return rate, but much smaller numbers of releases were involved. This suggests that carrying an additional tag did not unduly affect survival of tagged skipjack and yellowfin, and may indicate low tagging-induced mortality in general. Second, there were no significant differences in retention rates of the primary and companion tags for yellowfin and bigeye; however, for skipjack, where one tag was retained, it was more likely to be the companion tag than the primary tag.

Tag-shedding models have been fitted to these data and, in the case of skipjack and yellowfin, incorporated into tag-attrition models. The tag-shedding model used allows for a proportion of all tags to be shed immediately and a continuous shedding rate to operate thereafter. In the case of bigeye, the immediate shedding rate was estimated to be 7.8%, with continuous shedding estimated to be zero. For skipjack, 3.3% of tags were estimated to be shed immediately, with a continuous shedding rate of about 9% per year. For yellowfin, 6.5% of tags were estimated to be shed immediately, with a continuous shedding rate of about 2% per year. Therefore, after one year at liberty, about 12% of skipjack and 8% of yellowfin would have lost their tags. These shedding rates compare more than favourably with tuna tagging experiments carried out elsewhere (see Hampton and Kirkwood 1990 for details).

Tag-seeding experiments

With the assistance of MMA staff in Pohnpei and NMFS staff in Pago Pago, tag-seeding experiments have been carried out since 1990. MMA and US Multilateral Treaty observers on purse seiners were asked to discretely tag five dead fish before they were placed in wells. With various assumptions, the return rate of these seeded tags provides an estimate of the rate of reporting of genuine tags. We suspect that, because the observers were not experienced taggers, tag detachment while in the well may have contributed to the non-return of some seeded tags. Nevertheless, the seeding results can be used to derive at least a minimum, and hence conservative, estimate of the reporting rate of RTTP tags.

To date, 488 tags have been seeded during 103 observer cruises. Of these, 310 (64%) have been returned. For a variety of reasons, including variable effectiveness of the RTTP publicity campaign and variable cooperation by tag finders, it is unlikely that this aggregate estimate represents an unbiased overall reporting rate for RTTP tags. We therefore investigated several factors - species, unloading location and time - that we felt could potentially affect tag reporting rate.

Tag reporting by species

While there is no *a priori* reason to suspect that tag reporting might vary by species, we made an initial examination of the tag-seeding data to verify that this was indeed the case. While the point estimates show some differences, the 95% confidence intervals (based on the binomial distribution) overlap to a large extent (Table 6). On this basis, we have pooled the tag-seeding data across species in considering variation in reporting rates by unloading location and time.

Table 6. Tag-seeding results, by species.

Species	Number seeded	Number returned	Return rate	95% c.i.
Skipjack	311	203	0.653	0.600 - 0.706
Yellowfin	141	84	0.596	0.517 - 0.677
Bigeye	30	21	0.700	0.541 - 0.853
Unknown	6	3	0.500	0.223 - 0.882

Tag reporting by unloading location

With the majority of tags, particularly from fish recaptured by purse seiners, being found by vessel unloaders and cannery workers, it was expected that vessel unloading location would be a significant source of variation in tag reporting rate rather than any particular characteristic (such as nationality) of the vessel itself. We therefore attempted to classify each individual tag-seeding experiment according to the destination of the catch into which the tagged tuna were placed. Where at least some of the seeded tags were recovered, this was done on the basis of the information accompanying the returned tags. In cases where none of the seeded tags were recovered, the unloading location could usually be determined from information provided by the observer or knowledge of general fleet practices.

There was substantial variation in reporting rate by unloading location (Table 7). American Samoa, a major source of genuine tag returns primarily by US purse seiners (see Table 4), had the highest reporting rate, a point estimate of 79%. Substantial numbers of genuine tags were also recovered in Japan and Thailand; the point estimates of reporting rates from these locations were similar, about 40%. Western Pacific caught tuna are also shipped directly in significant quantities to Korea (to canneries in the Pusan area) and Philippines (SCTB6, IP.2). Large numbers of tags have been returned from the Philippines and indications (including the small number of seeded tags) are that the reporting rate is high. However, few genuine tags (Table 4), or any of the 19 seeded tags believed to have been shipped to Korean canneries, have been returned from that location. These results show the importance of accounting for unloading location when considering reporting rates of RTTP tags.

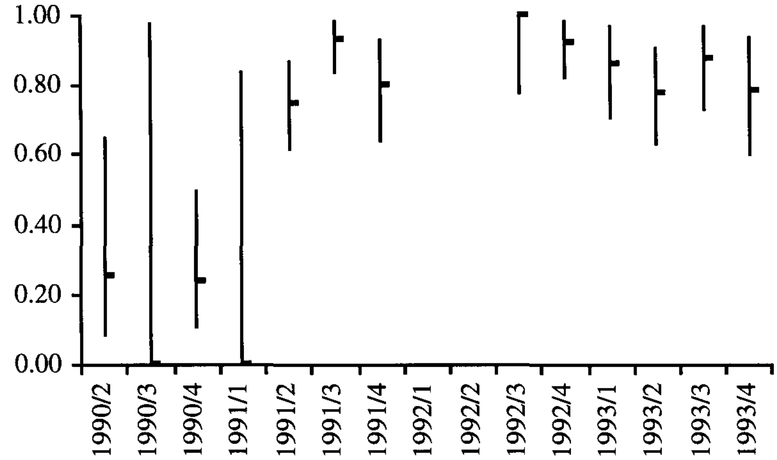
Table 7. Tag-seeding results, by unloading location.

Country	Number seeded	Number returned	Return rate	95% c.i.
American Samoa	294	233	0.793	0.745 - 0.837
Ecuador	1	0	0.000	0.000 - 0.975
Japan	72	30	0.417	0.314 - 0.539
Korea	19	0	0.000	0.000 - 0.176
Philippines	5	4	0.800	0.478 - 0.995
Puerto Rico	16	9	0.563	0.354 - 0.802
Solomon Islands	5	5	1.000	0.478 - 1.000
Thailand	72	30	0.417	0.314 - 0.539
Unknown	4	0	0.000	0.000 - 0.602
Total	488	310	0.635	

Tag reporting by time

It is possible that tag-reporting rates could vary over time due to the timing of publicity efforts and the resulting awareness and interest of potential tag finders in the tagging programme. Unfortunately, insufficient tag seeding was carried out to examine time-series trends for each of the major unloading locations individually. It was possible, however, to construct a quarterly time series for one location, American Samoa. Here, the point estimates of reporting rate were low during 1990 and the first quarter of 1991, after which they increased sharply and remained high until the end of 1993 (Figure 3). However, during the early period when the point estimates were low, the numbers of tags seeded were also low, and there are wide confidence intervals about the point estimates. While there is some evidence of lower reporting rates during this period, there is also a significant probability that the low point estimates are chance occurrences resulting from inadequate numbers of seeded tags. It is also possible that the inexperience of the observers during the early period resulted in higher rates of detachment of seeded tags, thus reducing their chance of being returned.

Figure 3. Reporting-rate estimates and 95% confidence intervals by quarter, based on seeded tags recovered in American Samoa.



An overall estimate of reporting rate

An overall estimate of reporting rate and some measure of its uncertainty are required for the tag-attrition analyses described in section 3.1. We have noted that there is substantial variation in reporting rate according to unloading location, and possibly for other factors as well. For this reason, the simple proportion of all seeded tags returned (0.64) is unlikely to be an unbiased estimator of the overall reporting rate. Additionally, the construction of confidence intervals on this estimate based on binomial theory would be inappropriate as the assumptions of a binomial experiment (independent trials with identical probability of success) do not hold. We therefore need some means of weighting the various location-specific reporting rates derived from the tag-seeding experiments to produce an average reporting rate. We used the number of tags (non-seeded) returned from each location as the weighting factors. The procedure consisted of estimating the number of tags actually recovered in each location by dividing the number of returns by the estimated reporting rate. The numbers of tags recovered in Korea and Taiwan could not be estimated in this way because the estimated reporting rates and/or the numbers of tags returned were zero. We therefore used the estimated numbers of tags recovered from Taiwanese and Korean purse seiners in Thailand, multiplied by the ratio of deliveries by these fleets to Taiwan or Korea to deliveries to Thailand. This procedure makes the not unreasonable assumption that the occurrence of tagged tuna in Korean and Taiwanese catches is the same for fish delivered to their home ports as for fish delivered to Thailand. A variance estimate and 95% confidence intervals on the weighted average were obtained using a parametric bootstrap procedure in which the individual reporting rates were independently sampled from their probability distributions (1,000 samples) and a weighted average pseudo reporting rate constructed for each. Where tag seeding was not carried out in a particular unloading location but tags were returned from that location (cf. Tables 4 and 7), we made the assumption that the reporting rate was >0.5, with a uniform probability distribution between 0.5 and 1.0. Philippines and Solomon Islands, where only 5 tags were seeded in each location, were also placed in this category. This procedure produced an overall average reporting rate estimate of 0.59 with 95% confidence intervals of 0.49-0.66 (Table 8). These estimates have been used in the tag-attrition analyses reported in section 3.1.

Table 8. Estimation of an overall reporting rate for RTTP tag returns.

Discovery location	Reporting rate	Probability distribution	Number of tags returned	Estimated number of tags recovered
American Samoa	0.79	B(0.79,294)	2,056	2,603
Japan	0.42	B(0.42,72)	1,956	4,657
Korea	0.00	Certain	4	1,581
Puerto Rico	0.56	B(0.56,16)	296	529
Taiwan	0.00	Certain	0	287
Thailand	0.42	B(0.42,72)	2,215	5,274
Others	0.75	U(0.5,1.0)	8,092	10,789
TOTAL	0.56 (0.46-0.66)		14,619	21,233

Probability distributions: Binomial (Rate, Number), Uniform (Lower, Upper)
Estimated no. tags recovered = no. tags returned / reporting rate (locations except Korea and Taiwan). Estimated no. tags recovered in Korea = estimated no. Korean-caught tags recovered in Thailand (664/0.42) x ratio of landings in Korea (100,000) to Korean landings in Thailand (100,000 t). Estimated no. tags recovered in Taiwan = estimated no. Taiwanese-caught tags recovered in Thailand (935/0.42) x ratio of landings in Taiwan (20,000 t) to Taiwanese landings in Thailand (155,000 t).

1994-95 Work Plan

Work in 1994-95 will focus on screening the RTTP tagging data base for errors/missing data, as well as processing the few tag returns that are expected. The data screening task will be carried out by the SPR TRAMP Research Officer (Data), and will involve detailed examination of each tag return to correct errors and, where possible, assign values to missing data fields. Extensive cross-checking of the tag return data with recapture vessel logsheet records will be carried out in order to verify tag recapture dates and locations, and to assign approximate values where these data are missing. This work will be an important precursor to finalising many of the tag data analyses described later in this report.

2.2 Albacore Tagging

Background

The OFP undertook, with EC funding, a dedicated albacore tagging project in 1990-91 using a chartered Fijian pole-and-line vessel, suitably modified for trolling. Albacore tagging was continued into a second season (1991-92) in the central South Pacific, the coastal waters of New Zealand and the Tasman Sea by six observers placed on commercial troll vessels. This work was meant to complement and extend earlier albacore tagging carried out by the US National Marine Fisheries Service (NMFS) and the New Zealand Ministry of Agriculture and Fisheries (MAF). The objectives of the tagging project were primarily to obtain information on the movements, stock structure and growth of albacore in the South Pacific. If sufficient tags were returned, information on fishing and natural mortality might also be obtained.

1993-94 Activities

Activities during 1993-94 were restricted to processing tag returns and database development to facilitate data queries and reports.

Overview of project results

Tag returns have now been received over a three year period for the SPC releases and longer for the earlier NMFS and MAF releases. The following summary of albacore tagging results is presented for information.

Albacore tag releases and returns

Since the early 1980s, 17,297 albacore have been tagged in the South Pacific by the OFP, NMFS and MAF. Of these 112 (0.65%) have been recaptured and the tags returned. A summary of release and return numbers by agency is given in Table 9.

Table 9. South Pacific albacore tag release and return numbers, as at 30 June 1994.

Agency	Number released	Number of returns	Return rate (%)
MAF	578	3	0.52
NMFS	6,803	24	0.35
SPC	9,916	85	0.86
TOTAL	17,297	112	0.65

Returns by recapture vessel gear type and nationality

Albacore have been fished by longline (Taiwan, Japan and Korea), troll (mainly New Zealand and US) and driftnet (Japan and Taiwan) in the South Pacific, and recaptures of tagged albacore have been received from most of these fleets (Table 10). However, in stark contrast to tropical tunas, by far the majority of returns (102 of 112) have been from longliners (mainly Taiwanese). This is probably indicative of the relative exploitation rates of the longline and surface fisheries; however, differential reporting rates may also have contributed to the disparity in returns by the different gears.

Table 10. Albacore tag return numbers, by recapture vessel gear and nationality, as at 30 June 1994.

Gear type	Nationality	No. of returns
Driftnet	Japan	2
	TOTAL	2
Longline	Japan	9
	Korea	1
	Taiwan	91
	USA	1
	TOTAL	102
Troll	Australia	1
	New Zealand	3
	USA	3
	TOTAL	7
Unknown	Japan	1
	TOTAL	1
TOTAL	TOTAL	112

Returns by discovery location

Almost all albacore tags were found on board the vessel at the time of recapture and handed in to fisheries officers in the port of landing (mostly Pago Pago and Levuka) or in the vessel's home port.

Returns by time at liberty

Albacore tags have been returned up to 5+ years at liberty. The few returns by troll and driftnet vessels were evenly distributed over the first 3 years at liberty, while most returns by longliners occurred during the second year at liberty (Table 11).

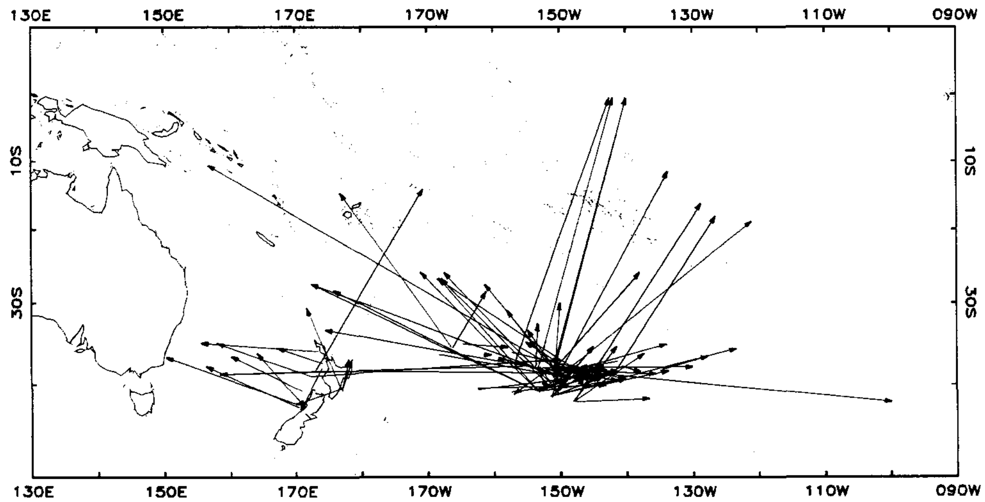
Table 11. Returns of tagged albacore by time at liberty and recapture gear.

Time at liberty (yr)	Surface	Longline	Total
0-1	3	19	22
1-2	3	47	50
2-3	3	24	27
3-4		8	8
4-5		3	3
5-6		1	1

Movement of tagged albacore

Most tagged albacore have been released in the central South Pacific, centred at about 150°W (Figure 4). These fish have been observed to move extensively to the east, west and north. Of the albacore tagged off the east and west coasts of New Zealand, most recaptures have occurred in the Tasman Sea, although movements have been observed from this area to the north and to the east into the central Pacific. There appears to be little evidence in these data of spatial segregation of the stock within the main fishing area.

Figure 4. Movements of tagged albacore in the South Pacific.



1994-95 Work Plan

Further small numbers of tag returns from longliners are expected during 1994-95. Tag returns will continue to be processed and rewards paid according to standard procedures. Analyses of the data will be undertaken as appropriate.

2.3 By-catch and Discards in Western Pacific Tuna Fisheries

Background

A review of by-catch and discards in western Pacific tuna fisheries commenced during 1991-92 following a recommendation of SCTB 4. The objective of the study is to review by-catch and discard practices of the industrial tuna fisheries operating in the western Pacific, using logsheet data provided to SPC member countries, observer data, and published and unpublished reports. The review is intended to provide authoritative background information on this topic and to point the way towards any further studies or data collection programmes that may be required.

1993-94 Activities

A draft of the review has been completed and is available for perusal as WP.7. Recommendations are now sought regarding the content of the review and its publication, if appropriate.

1994-95 Work Plan

The report will be finalised and published with amendments from Standing Committee as required. Collection of further data on by-catch and discards will be considered in the sampling design for the SPR TRAMP observer programme.

2.4 Age and Growth of Tropical Tunas

Background

The age and growth of tropical tunas are important aspects of their population dynamics. Tag returns are now providing a large amount of information on growth of skipjack, yellowfin and bigeye. Also, during the RTTP, 704 yellowfin and 61 bigeye tuna otolith samples were collected. In combination, these data, along with a growing database of size composition data, should provide much new information on age and growth of tropical tunas.

1993-94 Activities

Examination of OTC-marked yellowfin otoliths

In last year's report, the results of an examination of the otoliths of 12 yellowfin that had been tagged and injected with oxytetracycline (OTC) were reported. The yellowfin had been tagged in the Solomon Islands in September-October 1991 during a routine RTTP cruise. The examination was carried out by Dr Alex Wild of the Inter-American Tropical Tuna Commission. He concluded that yellowfin otoliths from the western Pacific were much more difficult to interpret and showed greater variability in increment spacing than those from the eastern Pacific. Dr Wild recently re-examined the 3 otoliths that had accurate recovery dates (Table 12). While there was some improvement in the rings:days correspondence for tag T00159, the earlier conclusions remain unchanged. Three additional features were noted. First, the OTC mark was usually associated with a topographic change on the otolith surface, suggesting that yellowfin were stressed at the time of tagging. This stress mark sometimes partially obscured the first few increments deposited after tagging, creating additional uncertainty in the total count. Second, the bipartite structure of the otoliths was not well defined or contrasted. Finally, it seems likely that some of the finer increments were obliterated by the acid etching process that was intended to enhance the contrast of the increments. As a result, daily increment formation cannot be ruled out, however additional samples and, in the light of Dr Wild's experience, delicate handling and processing techniques, will be required for validation.

Table 12. Results of the yellowfin oxytetracycline experiment for returns with accurate recapture dates.

Tag number	Mean no. rings	95% confidence interval	Days at liberty
T00105	44.4	42.6 - 46.2	50
T00138	21.3	20.7 - 21.9	21
T00159	157.0	155.0 - 159.0	175

Analysis of tagging data

The analysis of growth increment data for tagged skipjack, yellowfin and bigeye began during 1993-94. This work is being undertaken by Mr Sylvester Diake, Principal Fisheries Officer of the Solomon Islands Fisheries Department, Ministry of Natural Resources, under the supervision of OFC staff, as part of the requirements for the degree of MSc at the Australian Maritime College. Mr Diake has spent two extended periods in Noumea for this purpose.

The RTTP provided a large amount of tag return data suitable for growth analysis. After initial data screening to eliminate missing and inaccurate recapture lengths and dates, returns from 4,253 skipjack, 1,603 yellowfin and 116 bigeye were found to be suitable for inclusion in the analysis. Both von Bertalanffy and linear growth models were fitted to the data sets; in each case the von Bertalanffy model provided a significant improvement in fit over the linear model. After some initial trial fits to the tagging data, we ran an extensive series of estimations on simulated data to determine an appropriate error structure for the analyses. It is well known that the standard Fabens (1965) fitting procedure for the von Bertalanffy model tends to result in biased estimates of asymptotic length, L_∞ and growth coefficient, K (Chien and Condrey 1987; Kimura et al. 1993). If length at release for the i th tag return is L_i, length increment is ΔL_i and the time at liberty is Δt_i, the model can be written as

$$\Delta L_i = (L_\infty - L_i)\left(1 - e^{-K\Delta t_i}\right) + e_i$$

where e_i is a normally distributed observation error having a mean of zero and variance σ^2. The simulations confirmed that the bias in the estimated parameters results from the assumption that L_i is measured without error. We therefore included terms for L_i measurement error (e_L), observation error (e_o) and in addition, a term for individual variation in L_∞ ($e_{L\infty}$). The latter term was included because it is able to explain the increasing variation in ΔL_i with increasing time at liberty that was apparent in each of the data sets. Each error term was assumed to be normally distributed with a mean of zero. With this error structure, the observation model becomes

$$\Delta L_i = (L_\infty - L_i)\left(1 - e^{-K\Delta t_i}\right) + e_{L\infty_i}\left(1 - e^{-K\Delta t_i}\right) + e_{L_i} e^{-K\Delta t_i} + e_{o_i}$$

where L_∞ is now interpreted as the population mean asymptotic length. The variance of ΔL_i is now a function of K and Δt_i, and can be written

$$\sigma^2_{\Delta L_i} = \sigma^2_{L_\infty}\left(1 - e^{-K\Delta t_i}\right)^2 + \sigma^2_L e^{-2K\Delta t_i} + \sigma^2_o$$

With this error structure, we found that unbiased and precise (cv<0.1) estimates of L_∞ and K can be obtained from data simulated with realistic error magnitudes. Unbiased estimates of the variance terms can also be obtained, although generally with low precision (cv>0.3).

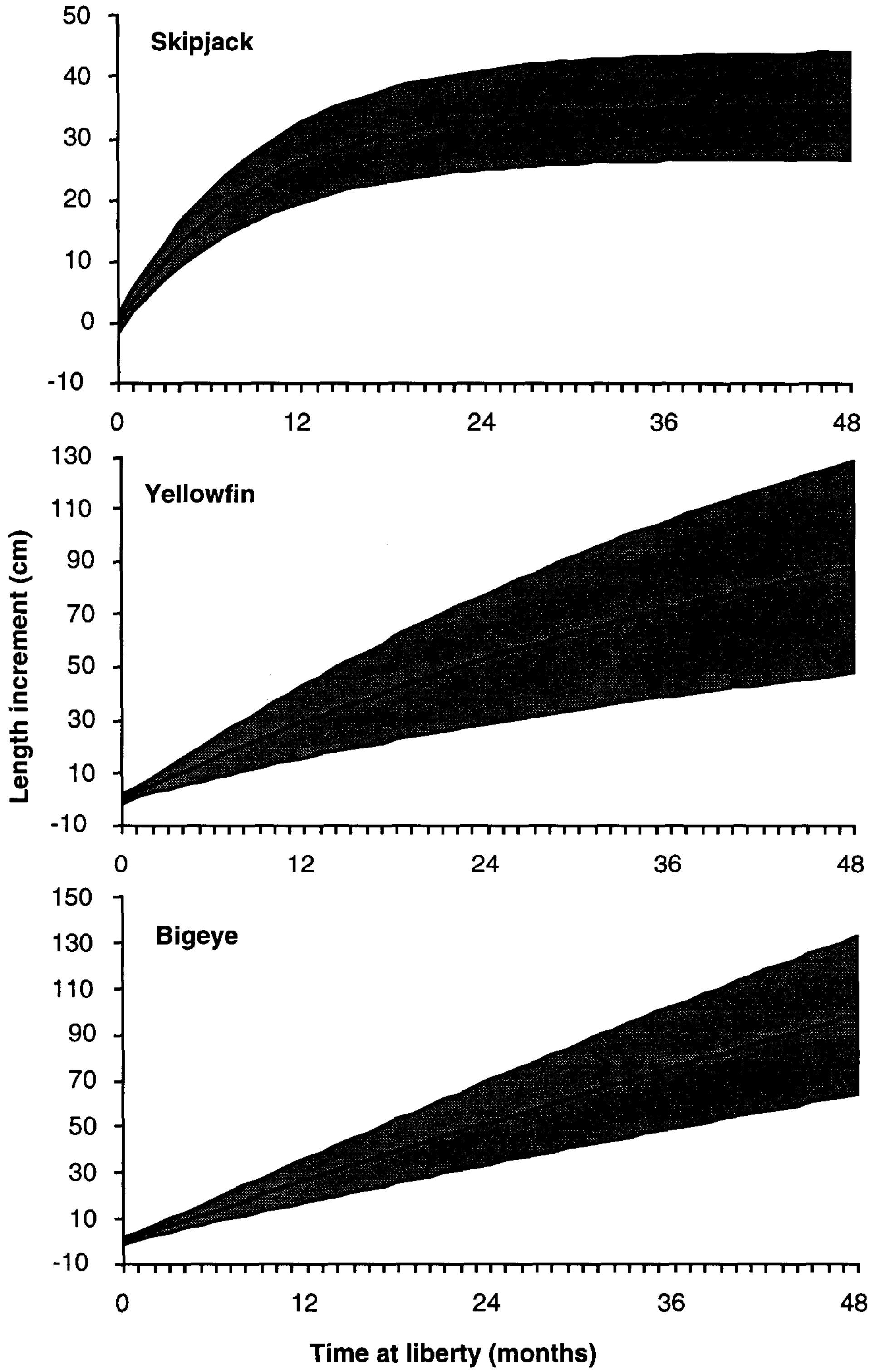
The fits to skipjack, yellowfin and bigeye tagging data yielded the parameter estimates shown in Table 13. In each case, σ^2_L was estimated to be zero, while most of the variance in ΔL_i , particularly for yellowfin and bigeye, was ascribed to $\sigma^2_{L_\infty}$. The estimates of L_∞ and K for skipjack are within the ranges reported in the literature (see Wild and Hampton 1993), however those for yellowfin predict somewhat slower growth rates than have been previously estimated (Suzuki 1993). The very large L_∞ and small K estimates for bigeye reflect an almost linear relationship between length increment and time at liberty over a wide range of release lengths. The linearised growth rate of about 29 cm per year is comparable to other growth estimates for bigeye (see Miyabe 1993).

The large $\sigma^2_{L_\infty}$ estimates suggest that there is substantial individual variability in growth in tropical tunas. The combined impact of the variance components on the predicted length increments of skipjack, yellowfin and bigeye released at 30 cm and recaptured after 0-4 years at liberty is shown in Figure 5. The length increment standard deviations widen markedly with increasing time at liberty, particularly for yellowfin and bigeye. If these plots are indicative of the variation in length at age for these species, length-based assessment techniques may not provide sufficient information on the age structure of the catch to produce reliable assessments. The consistency of the growth estimates obtained from tagging data with those obtained from multiple length frequency analysis (MULTIFAN) is currently under investigation.

Table 13. Growth estimates for tropical tunas based on tag return data.

Parameters	Skipjack	Yellowfin	Bigeye
L_∞ (cm)	65.6	181.0	524.0
K (yr^{-1})	1.32	0.219	0.0557
$\sigma^2_{L_\infty}$ (cm^2)	72.4	4778	29662
σ^2_o (cm^2)	2.62	3.09	2.85
σ^2_L (cm^2)	0.00	0.00	0.00
n	4253	1603	182

Figure 5. Graphical representations of skipjack, yellowfin and bigeye growth increments based on a 30 cm release length and the parameter estimates given in Table 13. The shaded areas represent ±1 standard deviation.



1994-95 Work Plan

Until the issue of ring formation periodicity is resolved, it is probably not worthwhile attempting a complete reading of the RTTP otolith set. However, a sample of 20 yellowfin otolith sets (4 sets from each 10 cm length class between 30 cm and 80 cm) was recently sent to Dr Bernard Stequert (ORSTOM, Brest) to see if his technique is capable of revealing the increments more clearly than the acid etching technique. If the increments are clearly visible and can be counted with a minimum of ambiguity, we would then consider a further OTC experiment to validate the increment periodicity.

No additional fits of growth models to the RTTP tagging data are envisaged at this stage. We now plan to analyse length frequency data sets for each species using the MULTIFAN computer package to see whether any information on growth can be extracted from the data, and if so, whether the growth estimates are consistent with those obtained from tagging data. This work will complete Mr Diake's MSc studies at the OFP.

2.5 Assessment of Western Pacific Yellowfin Stock Structure by Analysis of Morphometric and Meristic Characters

Background

During the RTTP, morphometric (13 measurements) and meristic (gill raker count) data for 996 yellowfin and 83 bigeye were collected. These data are potentially useful for detecting possible geographical structure in the western Pacific yellowfin stock.

1993-94 Activities

Analysis of this data set has not yet been undertaken due to shortage of manpower.

1994-95 Work Plan

This work is of relatively low priority and will be undertaken as time and manpower permit. Subject to this, the data will be analysed using well-known statistical techniques (multivariate regression, discriminant analysis, etc). The objectives of the analysis will be (i) to assess and describe the geographic variation in the characters and (ii) based on the findings of (i), to test various hypotheses regarding spatially-distinguishable geographical groupings that may indicate some degree of spatial structuring of the stock. The possibility and desirability of combining these data with those from a similar study in the eastern Pacific will be investigated.

2.6 Yellowfin Tuna Reproductive Biology

Background

A substantial amount of data on yellowfin gonad stage, weight and other variables was collected during the course of the RTTP. However, the large proportion of juvenile yellowfin in this sample and the lack of histological preparations has limited its use in the determination of yellowfin reproductive parameters. The OFP is now collaborating with the University of Hawaii, NRIFSF (Japan) and the Micronesian Maritime Authority (FSM) in a large-scale sampling programme dedicated to this task.

1993-94 Activities

The OFP assisted in the design of the large-scale sampling programme being coordinated by the University of Hawaii. Field work commenced in April 1994, while preliminary analysis of sampled gonad tissues has been carried out to confirm sample quality and processing and storage techniques.

1994-945 Work Plan

The OFP will collect gonad samples in support of this project as the new SPR TRAMP observer programmes on purse seiners and longliners are implemented.

2.6 Environmental Determinants of Tuna Fishery Production in the Western Equatorial Pacific

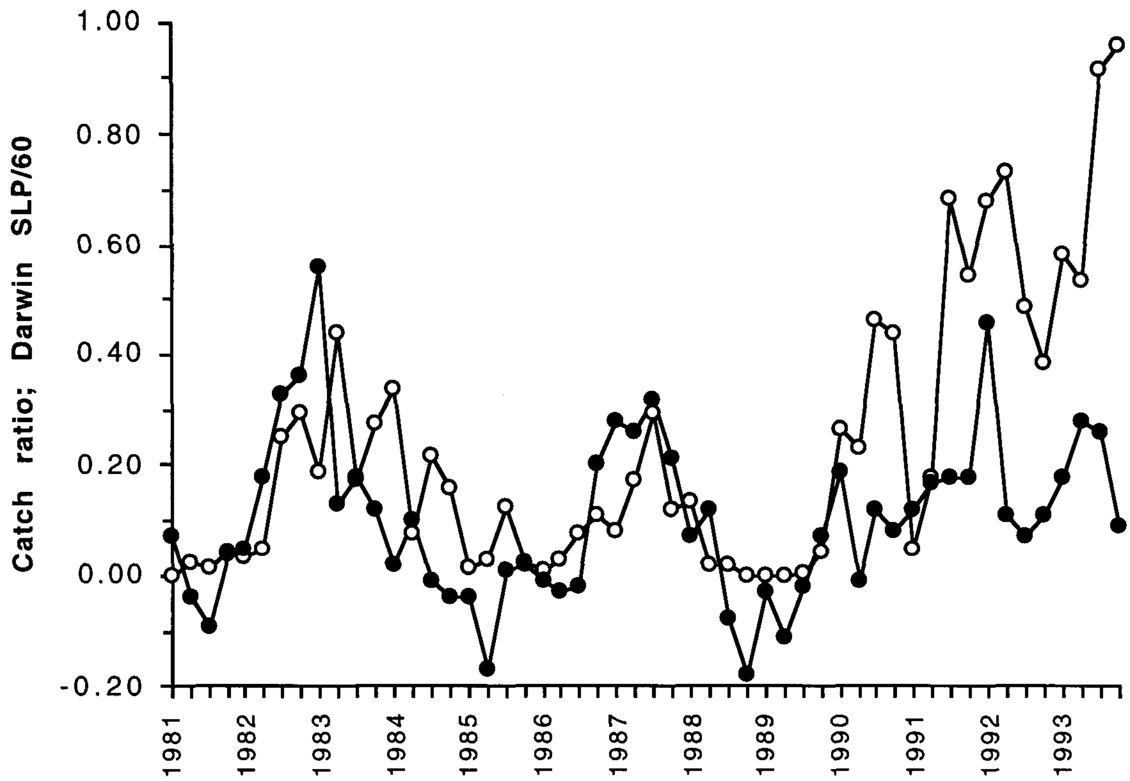
Background

Detailed fishery and biological data from the purse seine fishery are available since 1980, and comprehensive oceanographic and meteorological data from the TOGA and TAO Programmes are available since 1986. Together, these data provide an excellent opportunity to (i) examine spatial and temporal variation in skipjack population and fishery dynamics and (ii) use physical data to explain aspects of the observed spatial and temporal variation. Ultimately, this description may lead to a physical-biological model of skipjack production in the western equatorial Pacific. Some informal collaboration with Dr Jeffrey Polovina, National Marine Fisheries Service, Honolulu Laboratory, on exploratory analyses of these data began in 1993-94.

1993-94 Activities

We have focused on the east-west spatial variation in the purse seine data. We have found that the fishing is generally concentrated in the western end of the equatorial Pacific, just north and east of PNG. However, during *El Nino*-Southern Oscillation (ENSO) events, when winds and currents have an easterly direction, the fishing grounds expand over 2,000 nmi. to the dateline. NOAA Coastal Zone Colour Scanner satellite images show that, during the 1982-83 ENSO, the normal equatorial upwelling to the north of PNG was replaced by a band of chlorophyll rich water extending from PNG to the dateline. We hypothesize that skipjack habitat is linked to the waters enhanced by terrestrial input from PNG, and this habitat can expand and contract with the strength of the westerly winds. We have documented strong correlations between the eastward expansion of the fishing grounds and Darwin sea level pressure (Figure 6), strength of westerly wind and westerly current.

Figure 6. Quarterly time series of the proportion of the USA and Japanese purse catch taken to the east of 165°E (solid circles) and the Darwin sea level pressure mean deviation (open circles).



1994-95 Work Plan

We will examine Japanese pole-and-line skipjack catches from 1979-92 to see whether the same east-west movement of fishing grounds is apparent. We will also continue to work with the purse seine data, specifically using catch per set data, to examine how the expansion and contraction of habitat impacts school dynamics – is catch per set (school size) reactive or insensitive to habitat area changes? Finally, we hope to explore whether fine scale oceanography can explain spatial and temporal patterns in the distribution of schools.

3. ASSESSMENT AND MODELLING

Overview

The assessment and modelling activities of the OFP continued to focus on the detailed analysis of RTTP results. Analyses of these and other data are proceeding on several fronts, some of which are collaborative efforts with scientists from the University of Hawaii, Otter Research Ltd, the National Research Institute of Far Seas Fisheries (NRIFSF, Japan), the Inter-American Tropical Tuna Commission, the University of Queensland and the Forum Fisheries Agency. The tagging-based assessment work has been further refined with new estimates of the tag reporting rate and its variability. This work has resulted in regional estimates of average skipjack and yellowfin exploitation rates, and based on this, some indication of conservative maximum catches for both species have been obtained. Work on the development of a spatial model of tagged tuna dynamics and the application of such a model to both the SSAP and RTTP data sets has progressed well. This model will ultimately allow finer scale questions regarding the local effects of exploitation and fishery interaction to be examined. The model is currently being used to estimate the impact of the purse seine fishery on the Kiribati pole-and-line fishery, as part of the FAO funded interaction case study for Kiribati. Assessment of South Pacific albacore using a length-based model is now close to completion, and a proposal is currently being developed to add spatial structure to the model for application to western Pacific yellowfin. The second and final visit of a JICA-funded Japanese scientist to the OFP took place during the last year, resulting in substantial progress on the purse seine–longline interaction question and bigeye stock assessment. Plans are now in place to use many of the results of these populations dynamics modelling efforts in bioeconomic analyses of western Pacific tuna fisheries, and ACIAR funding for a collaborative project with the University of Queensland and Forum Fisheries Agency has recently been approved.

3.1 Skipjack and Yellowfin Assessment Using Tagging Data

Background

Two of the principal objectives of the RTTP were to provide a first overall assessment of the status of the western Pacific yellowfin stock and to provide a reassessment of the status of the skipjack stock. To this end, a preliminary analysis of aggregate RTTP results, for the purpose of evaluating the status of the stocks and their exploitation potential, was presented at SCTB 4 (WP.3). The analysis has been periodically updated as tag returns have continued. Also, the analytical methods used have been extended to provide hopefully realistic estimates of uncertainties on the parameter estimates and on conclusions based on those parameters.

1993-94 Update

The most recent update includes new tag-return data, as well as the revised estimate of reporting rate and its variability. The analysis is based on a tag-attrition model, having the structure

$$\hat{r}_{ij} = N_i e^{[-(F+M+S)(j-1)]}(1-\alpha)(1-\delta)\beta \frac{F}{F+M+S}\left[1-e^{-(F+M+S)}\right]$$

where $\hat{r}_{ij}$ is the predicted number of tag returns in month j from releases in a prior month i, N_i is the number of releases in month i, F is the instantaneous rate of fishing mortality, M is the instantaneous rate of natural mortality, S is the instantaneous rate of tag shedding, α is the proportion of releases that shed their tags immediately on release, δ is the proportion of releases that die immediately as a result of the tagging operation and β is the tag reporting rate. Estimates of S, α and β are available from double-tagging and tag-seeding experiments (section 2.1) and we have assumed an immediate tagging mortality of 0.05. Estimates of parameters F and M are obtained by fitting the observed to the predicted tag returns using a multinomial log-likelihood function. We obtained confidence intervals for the estimates using a bootstrap procedure to create 1,000 replicate data sets and corresponding sets of replicated parameters estimates. The bootstrap procedure had the following sources of error:

- a multinomial observation error in the tag return data
- error from uncertainty in tag-shedding parameters
- error from uncertainty in the tag reporting rate
- error from uncertainty in the tagging mortality rate

The 2.5 and 97.5 percentiles of the distributions of the replicated M and F estimates were used as approximate 95% confidence intervals.

We used the exploitation rate, $\hat{E} = \frac{\hat{F}}{\hat{F}+\hat{M}}$, as an indicator of the impact of the fishery on western Pacific skipjack and yellowfin stocks. We also used the various parameter estimates to predict E for a range of average catch levels so as to make an assessment of exploitation potential for both species using precautionary principles. These extrapolations of E were undertaken within the bootstrapping procedure so that estimates of uncertainties associated with the extrapolated values could also be obtained. The parameter estimates and their confidence intervals are shown in Table 14.

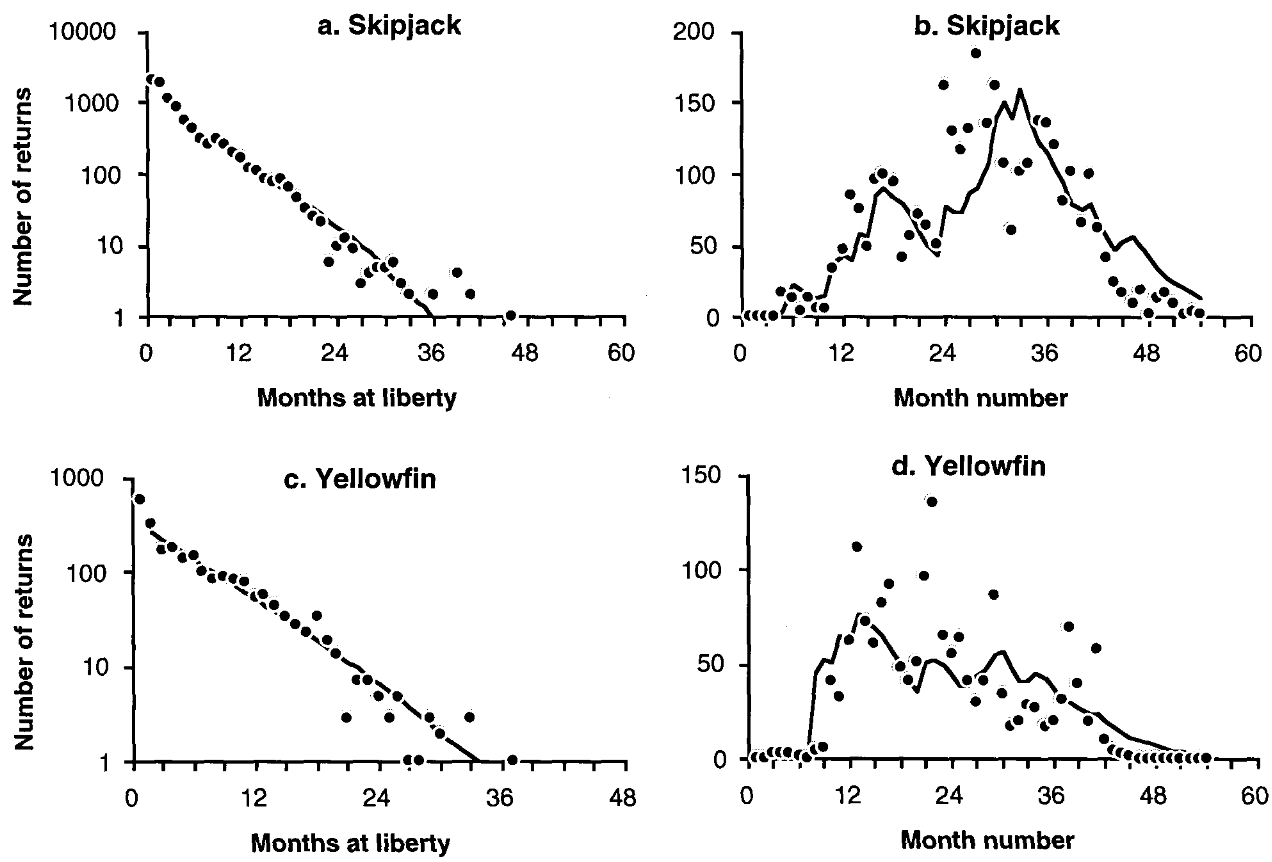
Table 14. Skipjack and yellowfin population parameters and their 95% confidence limits, based on analyses of tagging data.

Skipjack	Mean	Lower 95% CI	Upper 95% CI
Model parameters			
Natural mortality rate (per month)	0.130	0.115	0.142
Fishing mortality rate (per month)	0.032	0.026	0.041
Derived parameters			
Exploitation rate	0.200	0.161	0.252
Input parameters			
Immediate tag shedding rate	0.034	0.000	0.068
Continuous tag shedding rate (per month)	0.007	0.000	0.016
Reporting rate	0.560	0.470	0.650
Immediate tagging mortality	0.050	0.001	0.180
Yellowfin			
Model parameters			
Natural mortality rate (per month)	0.128	0.116	0.139
Fishing mortality rate (per month)	0.032	0.025	0.041
Derived parameters			
Exploitation rate	0.200	0.163	0.250
Input parameters			
Immediate tag shedding rate	0.063	0.032	0.096
Continuous tag shedding rate (per month)	0.002	0.000	0.008
Reporting rate	0.560	0.470	0.650
Immediate tagging mortality	0.050	0.001	0.180

Tag returns during the first 4 months after release not included in skipjack parameter estimation. Tag returns during the first month after release not included in yellowfin parameter estimation. Releases of skipajck and yellowfin <40 cm FL and PTRP releases excluded from the analysis.

The tag attrition curves plotted against time at liberty (Figures 7a and 7c) show the expected log-linear behaviour of tag returns with time. Model fit is extremely good while the tag return rate is greater than about 10 returns per month (up to about 20 months at liberty). The time-series plots of tag returns per month (Figures 7b and 7d) show substantial scatter about the model predictions. This results from the model's inability to predict monthly variation in fishing mortality (F is assumed to be constant) or to account for spatial patterns of tag releases and fishing effort (the model is spatially aggregated). These and other limitations have important implications for the interpretation of the parameter estimates. First, the lack of temporal variation means that the estimates reflect average conditions that existed in the population and fishery during the RTTP. As the model fitting procedure gives more weight to the period when large numbers of tags were being returned (the data that have lower variance), we could consider the reference period of the model to be primarily early 1990 to early 1993. Second, the model does not consider size-related effects such as size selectivity of the various gears in the fishery. This means that the parameter estimates are also averaged in some way across fish size. The sizes of tagged skipjack were generally typical of those caught in the fishery; therefore the skipjack parameter estimates are probably broadly representative of the exploited size range. However, most of the yellowfin tagged were small fish (40-60 cm FL), probably in their first or second year of life. With most weight in the parameter estimation given to tag returns less than 2 years at liberty, the yellowfin parameter estimates may not be indicative of natural or fishing mortality rates pertaining to larger yellowfin of about age 4 or older. Finally, the spatially aggregated nature of the model means that there is no clear definition of the spatial bounds of the analysis. The area encompassing most of the tag returns (10°N-10°S, 120°E-170°W) is probably a reasonable approximation, but there is the possibility that the *M* estimates have been somewhat inflated by movement of tagged fish away from this general area to areas of little or no fishing effort.

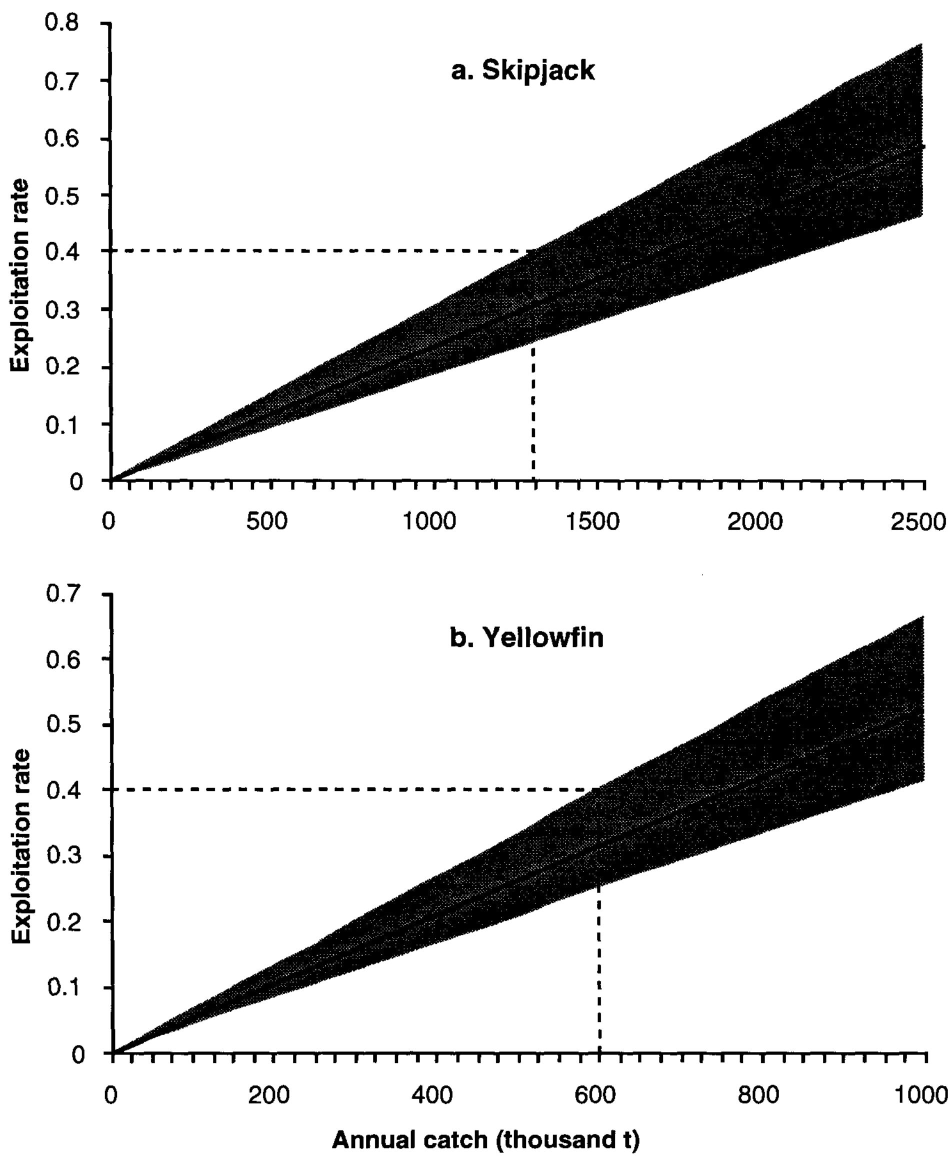
Figure 7. Observed tag returns (dots) and model predictions (lines) aggregated by time at liberty (a and c) and month of recapture (b and d). In b and d, month 0 is June 1989.



With these limitations in mind we can attempt to draw some general conclusions from the parameter estimates. The estimated mortality rates and their confidence intervals for both species are almost identical, and result in derived exploitation rates of 0.2 (0.16-0.25). While there is no clear indication regarding what might be an appropriate biological reference point in terms of exploitation rate for tropical tuna, Kleiber et al. (1987) noted that skipjack exploitation rates up to about 0.7 should be possible on yield-per-recruit grounds. On the other hand, Patterson (1992) presented empirical evidence for over-exploitation of small pelagic species at $E>0.4$. On either criterion, we would conclude that low to moderate levels of skipjack and juvenile yellowfin exploitation existed in the western tropical Pacific during 1990-1993.

It is of considerable interest for future management plans to make some estimates of total catches that might be possible according to some biological reference point. In the absence of other information and in the interests of adopting conservative (or precautionary) biological reference points, we have used 0.4 as the maximum allowable exploitation rate. We can then compare this reference point with predicted exploitation rates and their 95% confidence limits across a range of skipjack and yellowfin catch levels in the western tropical Pacific (Figure 8). For skipjack, an annual catch of about 1.3 million t would limit the exploitation rate to <0.4 with a probability of 0.975 (the dotted lines in Figure 8a). For yellowfin, the comparable annual catch is 600,000 t.

Figure 8. Predicted exploitation rate as a function of annual catch. The grey area represents the 95% confidence region of the predicted exploitation rate.



We believe that the these catches represent reasonable overall limits for western Pacific skipjack and yellowfin that are consistent with available information and are precautionary in nature. Our approach was precautionary in that:

- a conservative estimate of tag reporting rate was used, which, if anything, may have resulted in some over-estimation of F;
- other potential sources of tag loss (tagging mortality and tag shedding) were included in the analysis to minimise the risk of under-estimating F;
- realistic estimates of uncertainties in the model parameters and the derived exploitation rates were obtained;
- a conservative biological reference point (E=0.4) was chosen; and
- the uncertainties in predicted exploitation rates at different catch levels were estimated and maximum catches chosen such that the resulting exploitation rate would be within the biological reference point with a high probability.

1994-95 Work Plan

This work will be finalised and written up for publication during 1994-95. Some comparative work with the earlier Skipjack Survey and Assessment Programme data set will be included in the final paper.

3.2 Development of Tuna Movement Models

Background

Tuna movement is recognised as playing a major role in determining the extent of actual and potential interaction between fisheries. The OFP and its collaborators have devoted considerable research over the past ten years to this topic in recognition of its importance in determining sound fisheries management policies for SPC member countries.

The Food and Agriculture Organisation of the United Nations (FAO) has provided funding in support of a two-phase research project aimed at developing a model capable of estimating movement and other parameters from tag recapture data, and applying the model to tagging data sets for skipjack tuna in the western Pacific. The project is a collaborative effort between the OFP and Otter Research Ltd (Drs J. Sibert and D. Fournier). During the first phase, a prototype model, based on a diffusion-advection equation, was developed and evaluated using simulated data that mimicked observed tuna movement data. Implementations on different computer hardware were compared. The model was able to accurately estimate the movement parameters used in the simulations and could be used to distinguish between alternative hypothesised movement patterns on statistical grounds. This work was presented to the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries (Sibert and Fournier 1994), and subsequently approved by FAO as satisfying the terms of reference of phase 1.

1993-94 Activities

Phase 2 has concentrated on applications of the model to the SSAP and RTTP data sets, developing graphical tools for reviewing model results and the addition of a module that uses the estimated movement, mortality and catchability parameters to perform an interaction analysis for spatially separated fisheries. A separate progress report fo this work will be presented.

1994-95 Work Plan

During 1994-95, more fits to the RTTP data set will be carried out. In particular, the spatial grid will be extended westwards to include Philippines and Indonesia, and possbily northwards to include seasonal skipjack fishing close to Japan. Alternatives to the regional parameterisation of movement will also be investigated. A possible candidate is the use of sea surface temperature to modify movement probabilities. It is anticipated that at least 3 papers will be prepared to document the work undertaken – one describing the methodology, one describing skipjack movement patterns in the western Pacific and one discussing the impact of estimated skipjack movement on fishery interaction.

3.3 Case Study of Fishery Interaction in a Pacific Island Country: Kiribati

Background

This project received strong support from Pacific Island countries at the 1991 FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. Kiribati was nominated as the subject for the case study because of the presence of a number of different scales of fishing activity in the EEZ – artisanal/subsistence, small-scale commercial and large-scale industrial – and the presumed availability of data for these activities. A proposal for funding the study was prepared and submitted to FAO. After lengthy review, FAO agreed to fund the study in early 1993. The objectives of the project are:

- To quantify the overall levels of exploitation of skipjack and yellowfin tuna in the Kiribati EEZ (primarily the Gilbert group);

- To quantify the interaction between artisanal, domestic commercial and DWFN purse seine fleets operating within the Kiribati EEZ;
- To quantify the interaction between fisheries operating in the Kiribati EEZ and large-scale industrial tuna fisheries throughout the greater western tropical Pacific.

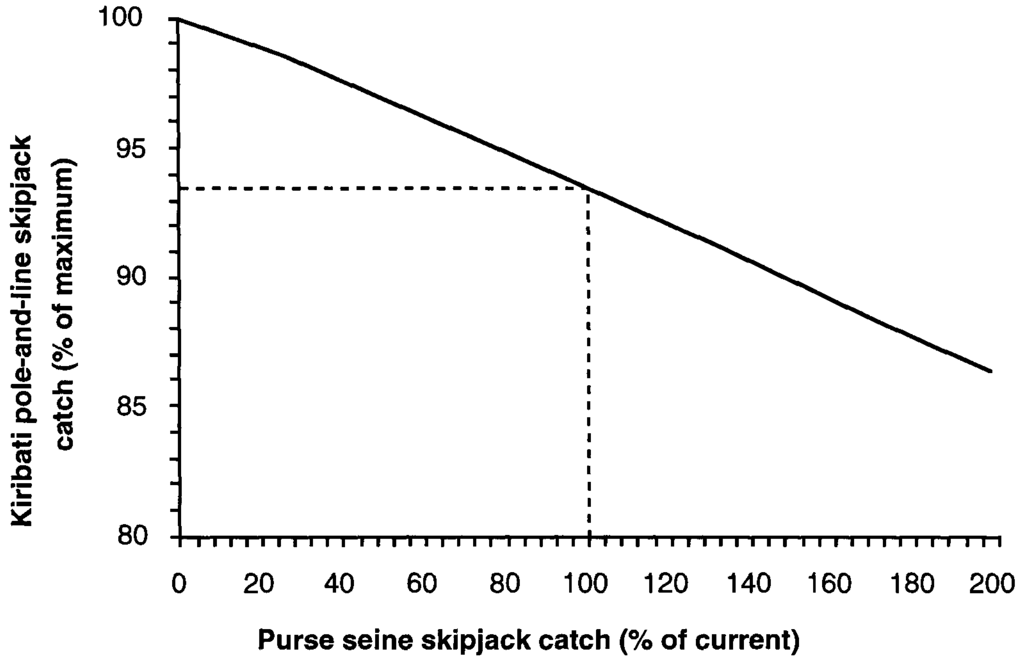
1993-94 Activities

Activities during the past year have concentrated on processing the backlog of logsheet data for the Te Mautari pole-and-line fleet and processing and compiling statistics on artisanal catch and effort from artisanal fishing surveys conducted sporadically over the years. The artisanal statistics have now been compiled, and we expect to receive Te Mautari logsheets for 1993 in the near future. Once these data have been processed, statistical analyses of catch-per-unit-effort (CPUE) trends can begin to see whether interaction effects are detectable in these data.

Tagging carried out in Kiribati waters during the RTTP has provided some insight into the overall levels of exploitation in Kiribati waters and the extent of interaction between large-scale purse seine fisheries and the Kiribati pole-and-line and artisanal fisheries. Of the 10,012 skipjack and 3,032 yellowfin tagged in Kiribati waters, 765 and 230, respectively (7.6%) have been recovered. This recovery rate is lower than the RTTP average (about 11%) and is possibly indicative of below average fishing mortality in Kiribati and surrounding areas. This would be at least partly because, until recently, only one of the four major purse seine fleets (USA) had regular access to the Kiribati EEZ.

Some preliminary interaction analyses for skipjack have been undertaken using the spatial model described in section 3.2. For this analysis, we used the RTTP parameter estimates (natural mortality, movement and catchability parameters for 11 different purse seine and pole-and-line fleets, including Kiribati) and the 1990-93 average distribution of effort to estimate the average impact of different levels of purse seine catch on the Kiribati pole-and-line catch. This essentially involved using the estimated parameters for tagged fish in a total biomass simulation in which the distribution of recruitment was assumed, for lack of other information, to be uniform in time and across the spatial grid under consideration (10°N-25°S, 130°E-170°W). The analysis therefore integrates the information on tuna movement, natural mortality and fleet specific catchability with the spatial and seasonal distributions of effort by those fleets to produce an average impact under equilibrium conditions. The impact of the large-scale purse seine fishery on the Kiribati pole-and-line catch estimated from this preliminary analysis is fairly modest – it is estimated that the development of purse seine fishing from a level of zero to its 1990-93 average level (about 620,000 t of skipjack) would have resulted in a 7% decline in average Kiribati pole-and-line catch (Figure 9). As the impact curve is close to linear, a doubling of skipjack from its 1990-93 average level could be expected to have a similar impact on Kiribati pole-and-line catch. Given the seasonal, inter-annual and other variation in catch and CPUE likely to be experienced by a limited range fishery, it is doubtful whether this level of interaction could be detected in time series of catch and effort data from the Kiribati pole-and-line fishery.

Figure 9. Estimated impact of different levels of equilibrium purse seine catch on the equilibrium catch of the Kiribati pole-and-line catch.



1994-95 Work Plan

During 1994-95, we will undertake a tag attrition model analysis, using available data for the Kiribati EEZ, to quantify the overall levels of exploitation of skipjack and yellowfin tuna. Partitioning of fishing mortality between purse seine, local pole-and-line and artisanal gears would provide some indication of the level of interaction expected among these fisheries. The large-scale skipjack movement model will be used to further examine various scenarios of purse seine fishery effects on the Kiribati pole-and-line fishery. In particular, we intend to examine the effects of changes in the spatial distribution of fishing effort and alternative assumptions regarding the distribution of recruitment on the interaction analysis. Finally, we will examine various CPUE trends and associated abundance indices to see whether there is any empirical evidence of interaction effects in the fisheries data. A report on this work will be finalised and presented to the Government of Kiribati and the Second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, to be held in Japan in January 1995.

3.4 Interaction Between Surface and Longline Fisheries for Yellowfin

Background

This issue has for some years been a concern for SPC member countries and its resolution was one of the major objectives of the RTTP. The concern is essentially that large catches of yellowfin by purse seiners may have a detrimental impact on catch rates by longliners. It is clear that a yellowfin population dynamics model that integrates all the factors that could affect such interaction – movement, natural mortality, fishing mortality, size selectivity and the spatial distribution of effort for both gears – is required. This is one of the motivating factors for the proposed development of the model described in section 3.5. Additionally, for Pacific Island countries, the issue of optimum mix of gears from the point of view of maximizing access revenues is important. This question will be investigated in the collaborative project described in section 3.6.

One factor that has a substantial bearing on the potential for interaction between surface and longline gears concerns the availability of the yellowfin population to these gears. It has long been suspected that longline fisheries may exploit only a fraction of the total yellowfin stock of a size vulnerable to longlining (typically fish >100 cm FL). This suspicion has been fueled mainly by the fact that estimates of maximum sustainable yields based on production models fitted to longline catch and effort data have subsequently been greatly exceeded as purse seine fisheries have developed and the catches of both small and large yellowfin increased. That this has not resulted in the stock collapses that would have been predicted by the production models has led scientists to suspect that yellowfin may only be partially available to longline gear, ie., that some significant part of the stock never becomes exposed to longline fishing. The tagging data generated by the RTTP has provided a means of testing this hypothesis, and it was decided that this topic would be an appropriate area of cooperation between the OFP and the NFIFSF.

1993-94 Activities

Naozumi Miyabe, a scientist from the NRIFSF, visited Noumea for two months in early 1994. Using Japanese longline and purse seine length frequency data that was made available for the study and the RTTP tagging data, an analysis was carried out to test the null hypothesis that the relative probabilities of capture of large (>100 cm FL), tagged yellowfin by purse seine and longline gear are determined only by the relative catches by these gears. The null hypothesis would be true if yellowfin were equally available to both gears; if the null hypothesis was rejected, unequal availability is one alternative hypothesis that might be posed.

We chose a reference area for the study (10°N-10°S, 130°E-170°W) that encompassed much of the purse seine fishery and a substantial amount of the longline fishery. From this area, 181 returns of tagged yellowfin >100 cm FL were received between 1991 and 1993. Only 4 of these were from longliners. We stratified these returns by 10 cm length classes and years, then estimated the catch in number of yellowfin for the same strata using Japanese and OFP data holdings. The expected numbers of returns for each stratum by purse seine and longline gears under the null hypothesis were calculated by apportioning the total number of returns in each stratum according to the estimated catch number by each gear. The observed and expected numbers of returns are shown in Table 15. Overall, approximately 160 purse seine returns and 21 longline returns would be expected under the null hypothesis.

Typically, χ^2 tests (with 1 degree of freedom) would be used to test the null hypothesis. Unfortunately, the power of the test is low when one or more of the expected frequencies is small. Generally, such tests are recommended only where all expected frequencies are at least 5. Therefore, the test was applied to various aggregations of year and length class categories so that the expected number of both purse seine and longline recoveries was ≥ 5. For all but 2 of the 9 such tests, the probability of correctly accepting the null hypothesis was <0.05.

The null hypothesis can also be assessed by calculating the cummulative binomial probabilities of obtaining the observed number of longline recoveries or fewer in each stratum, assuming the null hypothesis is correct. Some of the probabilities were high (even where no longline returns were observed) because of low numbers of returns overall (5 out of 13 >0.5), but several (with higher numbers of returns) were low (5 out of 13 <0.1), suggesting that, overall, the null hypothesis is highly unlikely.

Table 15. Observed (O) and expected (E) returns of large, tagged yellowfin in the reference area during 1991-1993, by length class and gear type (PS:purse seine, LL:longline)

Length	1991				1992				1993				1991-1993			
class	PS		LL		PS		LL		PS		LL		PS		LL	
(cm)	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E
100-109	43	40.4	0	2.6	35	34.7	2	2.2	13	10.2	0	2.8	91	85.4	2	7.6
110-119	13	11.2	0	1.8	22	18.5	0	3.5	9	9.1	1	0.9	44	38.8	1	6.2
120-129	2	1.7	0	0.3	18	13.9	0	4.1	7	7.7	1	0.3	27	23.3	1	4.7
130-139	3	2.4	0	0.6	7	4.8	0	2.2	2	1.8	0	0.2	12	9.1	0	2.9
140-149	0	0.0	0	0.0	0	0	0	0	3	2.9	0	0.1	3	2.9	0	0.1
≥100	61	55.7	0	5.3	82	72.0	2	12.0	34	31.8	2	4.2	177	159.5	4	21.5

A reduced probability of tagged yellowfin recovery from longliners could result from:

- Tagged yellowfin recaptured by longliners are less likely to be reported than tagged yellowfin recaptured by purse seiners. Given that longline recoveries are highly likely to be detected at the time of capture or as fish are being processed on board the vessel, the probability of a tag being found in the first place is probably higher for longliners than for purse seiners. However, the long duration of typical longline voyages could result in tags being misplaced or forgotten. Also, there may still be tags recaptured during 1991-93 that have not yet been returned because the vessel has not yet returned to port. At this stage, we cannot discount the possibility that the shortfall in tag returns by longliners was due to non-reporting of tags.

- Recaptures of tags are not independent events, but are highly clumped with respect to their probability of capture by the two gears. This might occur if numbers of tagged yellowfin tended to remain in the same school over lengthy periods and therefore were exposed to fishing gear in groups rather than as individuals, thus reducing the effective sample size. There is some evidence of this in the overall RTTP tagging data – there are 25 instances of 2 or more tagged yellowfin being recaptured in the same purse seine set 100 days or more after being released from the same school. If such cohesive behaviour is common, the observation of very few longline returns could occur by chance with a higher probability than indicated by the statistical tests, which assume independence.

- Large yellowfin tend to belong to one of two groups, one available principally to surface gear such as purse seine and the other available principally to subsurface gear such as longline. In this case, few longline returns would result if most of the tag release effort was directed towards the surface group. While there is no direct evidence that this is the case, some characteristics of the tag return data suggest that different groups of tagged yellowfin may have had different availability ot longline gear. Two of the four longline recoveries were released from the same school, while the other two were released in the same location two days apart. Several similar instances have been noted for the SSAP yellowfin releases, where only 12 longline recoveries were recorded. A consistent feature of most longline recoveries of tagged yellowfin from both the SSAP and RTTP is that they were of larger than normal size at release (>60 cm FL). By contrast, the returns of large yellowfin by purse seiners were generally of the smaller, typical size when released (50-60 cm FL). At this stage, it is not clear why size at release might be correlated with the probability of capture by longline.

1994-95 Work Plan

While no definitive results have been obtained from this study, we have established that there has been a significant shortfall in returns of large tagged yellowfin by longline, and identified several hypotheses that might explain this observation. During 1994-95, collaboration with the I-ATTC and possibly ORSTOM is planned to see if tagging data sets in the eastern Pacific and Atlantic Oceans exhibit similar features. Depending on the results and on the availability of funding, a research project aimed at testing some of the proposed hypotheses might be planned. One possibility would be a tagging experiment on yellowfin captured by longline, using conventional and/or archival tags.

3.5 Development of an Integrated Model for Yellowfin Assessment

Background

The Western Pacific Yellowfin Research Group (WPYRG) formed a sub-committee to examine the prospects for developing an integrated model of yellowfin dynamics, incorporating both size and spatial structure. Such a model is required to address the three key issues that WPYRG has focused on – maximum yield, local depletion and interaction.

1993-94 Activities

The sub-committee (Drs Fournier, Hampton, Kleiber, Polacheck, Sibert and Tsuji) met in Honolulu in November 1993, with funding assistance from the University of Hawaii Pelagic Fisheries Research Program (PFRP). A modelling strategy, building on the length-based albacore assessment model (SPARCLE), was developed. They key extension of SPARCLE envisaged is that spatial structure, initially in the form of the 7 WPYRG areas, will be incorporated into the model. Inputs to the proposed model will include total catch and effort data, length frequency samples and tagging data, all variously stratified by gear, fleet, area and time period.

A draft funding proposal to be submitted to the University of Hawaii PFRP has been developed and will be discussed in detail at the Fourth Meeting of the WPYRG.

1994-95 Activities

Contingent on the succes of the funding proposal, it is intended that work on the project begin in the last quarter of 1994, continuing for two years. The work would be carried out by Dr David Fournier, working in close collaboration with the OFP and other members of the sub-committee.

3.6 Bioeconomic Modelling of Western Pacific Tuna Fisheries

Background

While substantial progress has been made over the past five years in estimating the various biological parameters of exploited tuna stocks in the western Pacific, the wider issue of the optimal level of fishing has yet to be taken up. Some of the population models that have been developed can now be used as the basis of bioeconomic models which will address the issue of the optimal amount of purse seine effort from an economic standpoint.

A collaborative three year project involving the University of Queensland (UQ), the Forum Fisheries Agency (FFA) and the OFP has recently been approved for funding by the

Australian Centre for International Agricultural Research (ACIAR). The objectives of the project are:

- To determine the optimal level of purse seine effort within an EEZ, taking account of the interaction with the pole-and-line fishery and fisheries in adjacent EEZs, the movement of skipjack stocks, the distributions of purse seine and pole-and-line effort and the use of fish aggregation devices; and

- To determine the optimal level of purse seine effort in the region as a whole, taking account of the interaction between purse seine and longline fisheries, and the impact on tuna prices of any significant change in purse seine harvests in the region.

1993-94 Activities

UQ is taking the lead role in the implementation of this project, with the OFP and FFA as collaborating partners. During 1993-94, the OFP participated in the project design and planning in collaboration with UQ and FFA.

1994-95 Work Plan

During 1994-95, the project Research Fellow (UQ) will visit Noumea and collaborate with the OFP on the integration of existing population models with the economic component.

3.7 South Pacific Albacore Assessment

Background

The principal objective of SPC's three-year Albacore Research Project, with funding support from the Canadian International Centre for Ocean Development (ICOD) and the EC was to produce a first assessment of the South Pacific albacore stock and to estimate the level of interaction between the surface and longline fisheries. Tagging was not expected to provide sufficient information to base the assessment on these data alone; given the available data, a length-based assessment approach was considered to have the greatest likelihood of success. Therefore, length frequency sampling by observers and port samplers and various biological investigations (age and growth, reproductive biology) were initiated to supplement the existing South Pacific Albacore Research (SPAR) database. The biological studies were undertaken specifically to validate the annual periodicity of length frequency modes, a key assumption of the length-based analysis. At the same time, a major model development exercise was initiated. Using ICOD funds, Otter Research Ltd were contracted to extend the MULTIFAN computer program so that an age-structured analysis based on length data could be undertaken. The model development and biological studies have now been completed; we are therefore able to present the following summary of assessment work carried out to date.

South Pacific Albacore Length-Based Assessment

The SPARCLE Model

The model developed for assessment of South Pacific albacore has become known as the SPAR Catch-at-Length Estimator, or SPARCLE. The model is based on the concept of a "fishery", which is thought of as a collection of vessels that are assumed to have the same catchability and selectivity (although these may be permitted to change slowly over time). Each fishery has associated with it a number of fishing incidents, which occur during some fishing period. The catch, effort and a catch length frequency sample for each fishing incident for all fisheries constitute the input data to the model. Effort and/or length frequency data may be missing for some fishing incidents.

The standard (Beverton and Holt) notion of an age-structured population underlies the model. For a simple situation with one fishery and one fishing incident per year, the standard catch equations are applied. These equations predict the catch at age for each year as a function of the initial size of each cohort, the fishing mortality rates by age class and year and the natural mortality rate, which is assumed constant for all years and age classes. In order to fit the model to data, the number of free parameters must be constrained in a realistic way. This is done by restricting the freedom of the fishing mortality parameters such that they are assumed to be composed of an age effect (selectivity) and a time effect (catchability). For a problem involving n years and r age classes and with known effort for each year, this restriction reduces the number of fishing mortality parameters from $n.r$ to $n+r$. The problem with this approach is that selectivity often changes with time, and this can mask important changes in the population if not properly accounted for. We have therefore allowed selectivity to vary slowly over time by assuming it has the time series structure of a simple random walk with relatively small variance. The time series structure of catchability is treated in the same way. This is done in a Bayesian fashion, with priors determining the relative variances of selectivity, catchability and effort deviations.

To implement this age-structured approach, we of course need estimates of the catch at age for each fishing incident. We derive these estimates from the length frequency samples, assuming that:

- the lengths of the fish in each age class are normally distributed around their mean length;
- the mean lengths-at-age lie on a von Bertalanffy growth curve; and
- the standard deviations of the actual lengths about the mean lengths-at-age are a simple linear function of the mean lengths-at-age.

This procedure involves the estimation of 5 parameters (3 determining the form of von Bertalanffy growth and 2 determining the relationship between the standard deviations of length-at-age to the mean lengths-at-age). This is essentially the same as the MULTIFAN method of estimating growth parameters from length frequency data. The key difference is that with MULTIFAN, the proportions at age are additional free parameters that must be independently estimated. In the SPARCLE model, the proportions at age are constrained by the catch equations in the catch-at-age analysis.

The parameters of the model (those determining the age structure of the catch and those that relate length composition to age composition) are estimated by maximising the log-likelihood function, which is composed of contributions for the length-frequency data, for the observed total catches and for the Bayesian priors on the distributions of the errors contributing to the estimated fishing mortalities. These components are weighted according to prior assumptions made about the accuracy of the observed length frequency and catch data and the variances of the error distributions. The rationale for using this procedure was to attempt to develop a fitting procedure that is robust to the large variability in length data in particular that is likely to be a feature of real fisheries data.

Analysis of South Pacific Albacore Data

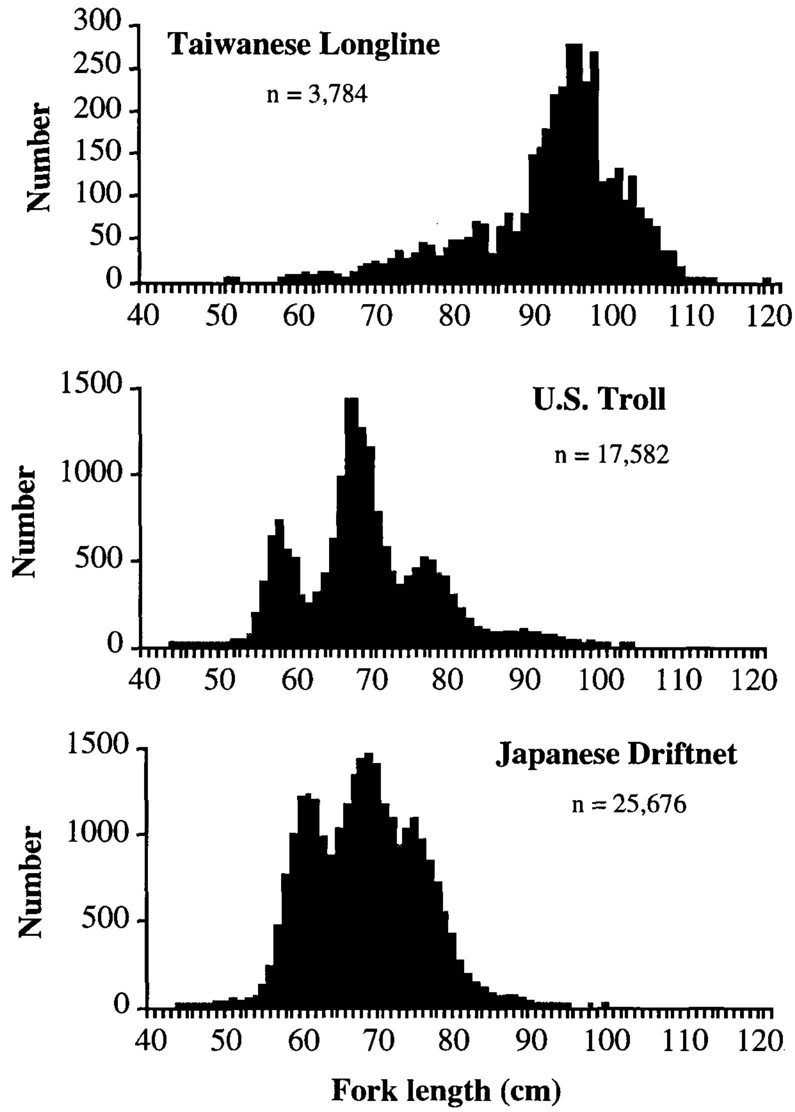
For the application of the model to South Pacific albacore, we defined 4 fisheries as shown in Table 16. Note that there are substantial gaps in both the effort data and length frequency data for some fisheries and that the data do not have a consistent temporal stratification. These are common features of many fisheries data sets, and SPARCLE was built to deal with such vagaries in a consistent fashion. The sizes of albacore taken by these fisheries varies considerably; Figure 10 shows some examples of length frequency distributions. Note that the longline data consist mainly of larger fish and have little modal structure. In contrast, the troll and driftnet data consist mainly of smaller fish having a distinct modal structure. This means that most of the information on growth will be derived from the surface fishery data, and as a result, that variation in cohort sizes in the early part of the time series when the surface fishery did not exist may be underestimated.

Table 16. Definition of South Pacific albacore fisheries used in the SPARCLE analysis.

Fishery	Data stratification	Catch data	Effort Data	Length frequency data
High seas longline	annual	1962-1991	1967-1991 [1]	1967-1991
STCZ troll	monthly	1986-1992	1986-1992	1986-1992
NZ troll	annual 1969-80 monthly 1981-92	1969-1992	1981-1992	1988-1992
Driftnet	monthly	1989-1990	1989-1990	1989-1992

[1] Longline effort was standardised against Taiwanese effort, as this is the only fleet to have consistently targeted albacore during the 1962-1991 period. Total longline effort was therefore calculated by dividing total longline catch by Taiwanese longline CPUE.

Figure 10. Examples of length frequency distributions for the longline, troll and driftnet fisheries.



For the time period under consideration (1962-1992), 154 fishing incidents, as defined in SPARCLE, were realised by the fisheries. During this time, the total longline catch remained relatively stable, varying between 1.5 and 3.0 million fish (Figure 11). In the mid 1980s the surface fishery developed, with the large surge in catch in 1989-90 resulting from the activities of Taiwanese and Japanese driftnetters. There has been a steady decline in Taiwanese longline CPUE since the beginning of the data series (Figure 12). The challenge for SPARCLE, therefore, is to determine the extent to which this is due to changes in biomass or to changes in catchability.

Figure 11. Estimated total catches of South Pacific albacore by surface (troll and driftnet) and longline fisheries, 1962-1992.

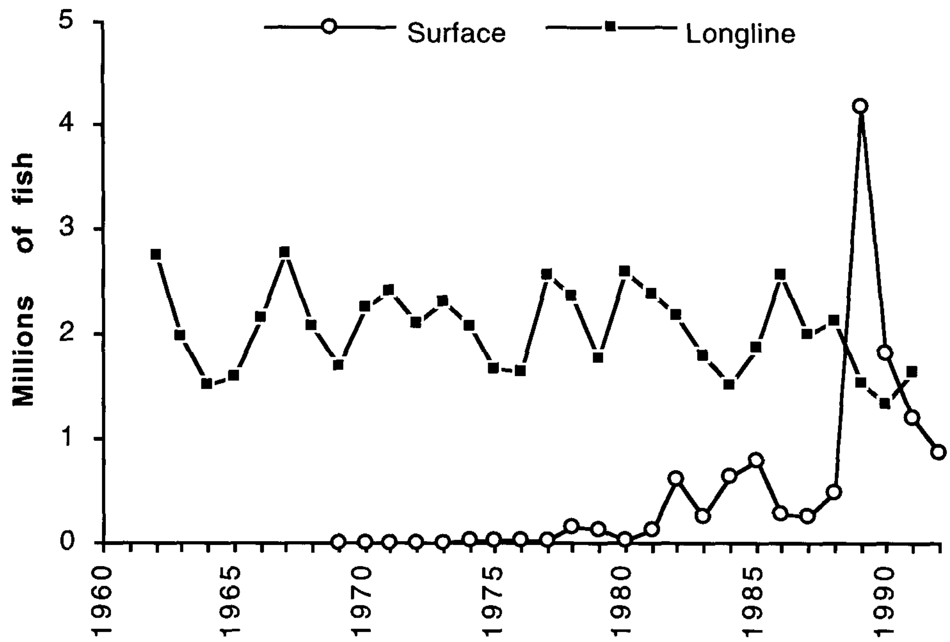
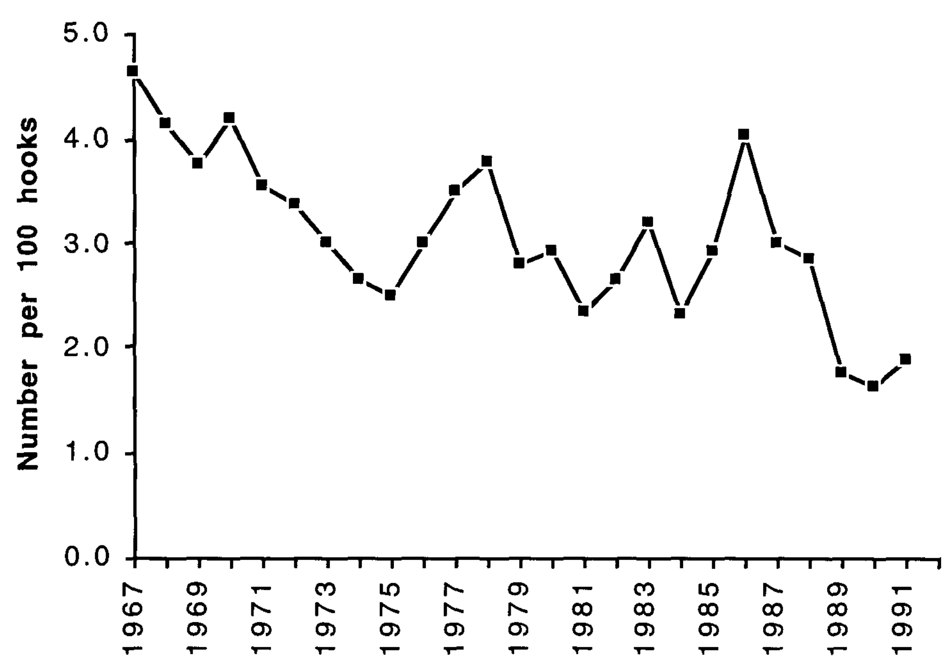


Figure 12. Taiwanese longline CPUE for South Pacific albacore, 1967-1991.



Many different SPARCLE runs on the albacore data have now been completed. These runs have tested the effects of various assumptions (such as the number of significant age classes in the length frequency data) and constraints (such as the form of the selectivity schedule for the different fisheries) on the parameter estimates. While, in theory, the rate of natural mortality, M, can be estimated by SPARCLE, it is unlikely that sufficient information exists in real fisheries data to do this. Attempts to estimate M from the albacore data produced biologically impossible values (very close to zero), therefore we chose to fix M at either 0.2 or 0.4 yr^{-1}. We did, however, assume higher M values for the oldest 3 of the 8 significant age classes in order to account for the rapid disappearance of female albacore from the population at lengths >96 cm.

For the majority of the runs, similar patterns in the time series of population biomass, recruitment and catchability by fishery were obtained. A representative set of results is shown in Figures 13-15. In this fit of the model, M was fixed at 0.2 yr^{-1} for the first five age classes and at 0.3 yr^{-1}. for the last three age classes. The normalised selectivities (Figure 13) reflect the proportion of the population of each age class available to a fishery, relative to the most available age class. The three surface fisheries have similar patterns, although the NZ troll fishery has a larger availability of albacore from the youngest age class (possibly age 3). On the other hand, only the very oldest fish are fully selected by the longline fishery.

The predicted trends in catchability suggest that catchability in the longline fishery has been decreasing since the beginning of the time series (Figure 14). The longline effort deviations are tight, indicating a good fit of observed and predicted effort. The effort deviations are larger for the other fisheries, and the catchability trends appear to be less significant.

Figure 13. Normalised selectivities for each fishery.

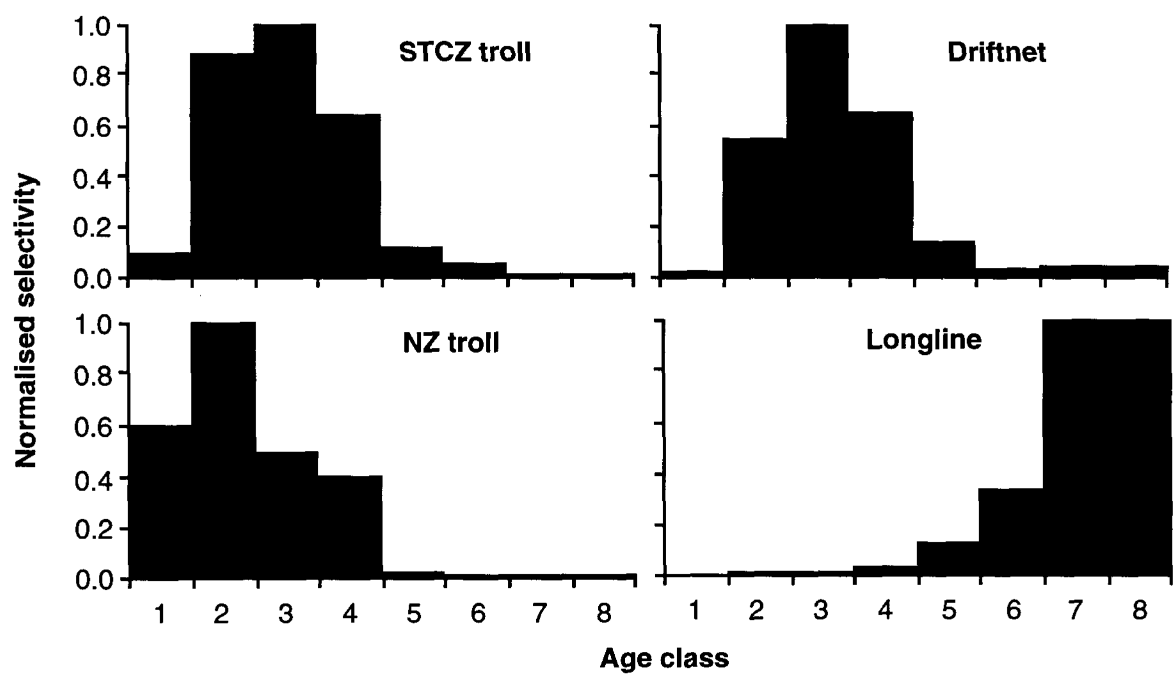
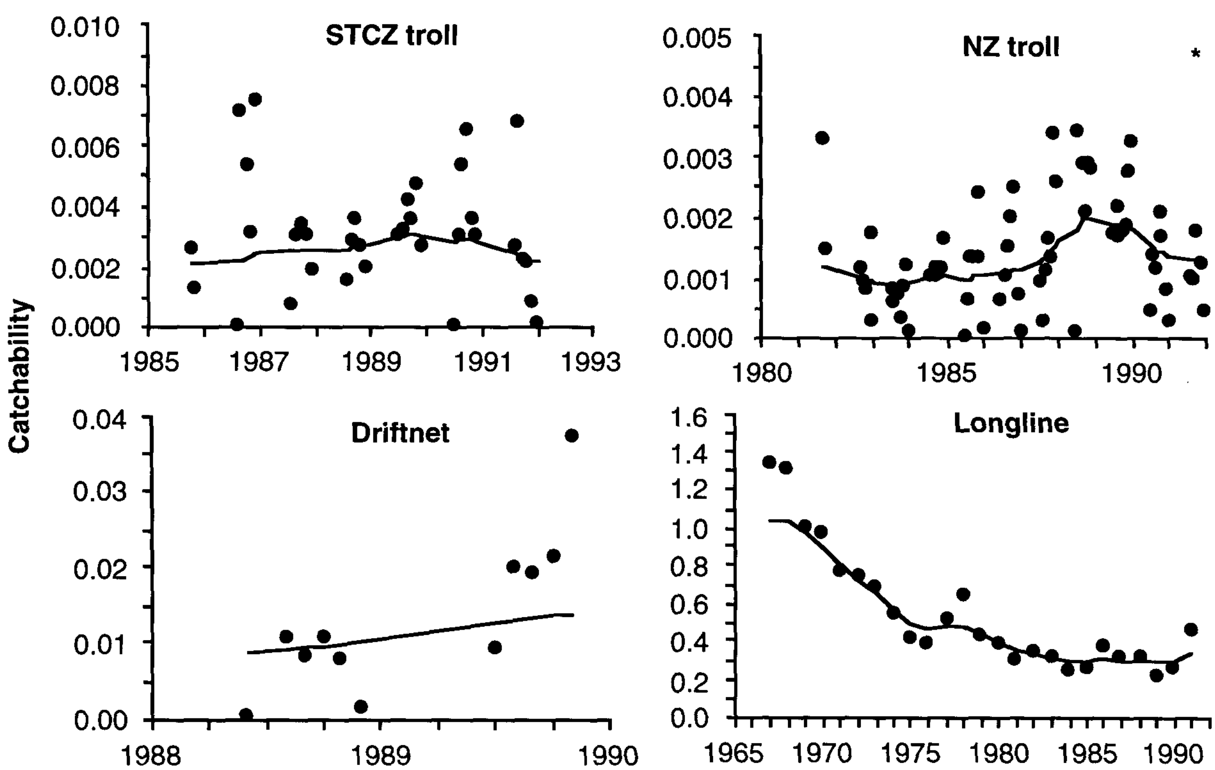


Figure 14. Estimated time series of catchability for each fishery.

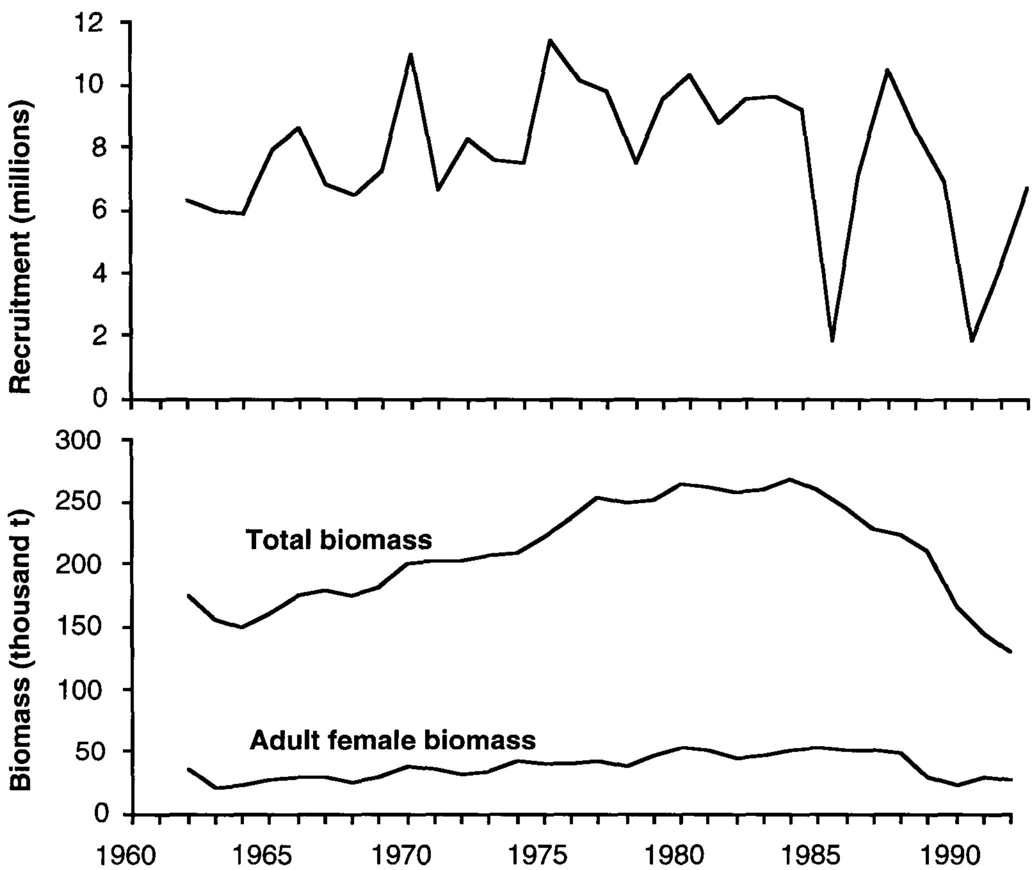


The estimated time series of recruitment and population biomass (Figure 15) are critical to our assessment of the stock. The recruitment time series is unremarkable but for very low recruitments in 1985 and 1990. These probably correspond to the 1982-83 and 1987-88 spawning seasons. It is interesting to speculate whether environmental conditions related to the ENSO events that were in progress during those years (see Figure 6) might have played a role, eg., by causing poor larval survival. However, it is also possible that the much greater variability in estimated recruitment from the mid-1980s on reflects the much better information on year class strength inherent in the surface fishery data compared to the longline fishery data. It may be that similar variation in recruitment occurred throughout the time series, but the estimates are smeared because of ageing errors during the period when only the longline fishery operated.

The total biomass time series shows a decline from the mid-1980s onwards as the two poor year classes moved through the population. This decline is likely to continue for several years, and its impact on longline catch rates will be substantial. The estimated adult female biomass was calculated using sex ratio at size data, and shows a sharp drop in 1988 and 1989 as the poor 1985 year class reached adult size. A further drop would be expected in 1993 when the poor 1990 year class recruits to the adult stock.

While the poor recruitments and associated biomass decline are probably due to factors other than fishing, continued fishing at the current or increased levels could exacerbate the decline. If Figure 15 is an accurate portrayal of the current stock condition, we would have to conclude that overfishing is now a possibility. The analysis indicates that longline fishing mortality is high relative to fishing mortality by the surface gears (which have declined further in recent years), therefore we would caution countries against further development of albacore-targeted longlining until there is some evidence of stock recovery.

Figure 15. Estimated time series of recruitment and relative biomass.



1994-95 Work Plan

During 1994-95, the work will be written up for publication and for presentation to the next meeting of the SPAR group.

3.8 National Fisheries Assessments (Country Reports)

Background

National Fisheries Assessments (NFAs) are produced by the OFP to inform member countries of the status of their tuna fisheries and the stocks that support them. The reports are based primarily on logsheet data obtained through access agreements with DWFNs and submitted to SPC by the member country concerned. Recent reports have been upgraded, and now include sections on the biology of the major tuna species, oceanographic influences in the EEZ, reviews of the fisheries and analyses of data, assessment of stocks and management recommendations. In some cases, the reports have included analyses of RTTP and/or in-country tagging project data, enabling more quantitative assessments and management advice.

1993-94 Activities

During 1993-94, one NFA was completed (PNG) and the results presented to Government officials. This report incorporated an analysis of RTTP tagging data, thus enabling some specific questions regarding the impact of the fisheries on tuna stocks in PNG and fishery interaction to be answered. An Australian scientist, Mr Albert Caton, was seconded to the OFP, with financial assistance from AIDAB, to assist with the PNG report. During 1993-94, a Fisheries Research Scientist (Mr Peter Ward) was recruited to the OFP primarily to work on the NFA project. Following his recruitment, a second NFA, for Fiji, has been completed in draft form. The draft is currently being considered by the Government of Fiji. Work on a report for Palau commenced recently.

1994-95 Work Plan

After the Fiji report is finalised, a presentation of the work will be made to Government and industry officials in Suva in Spetember 1994. The Palau report will then be finalised and similarly presented. Following these commitments, the OFC will prepare NFAs in the order that official requests are received by member countries. To date, official requests have been received from Marshall Islands, Tonga and Vanuatu (in that order). We hope to complete these reports during 1994-95.

4. PHILIPPINES TUNA RESEARCH PROJECT

Overview

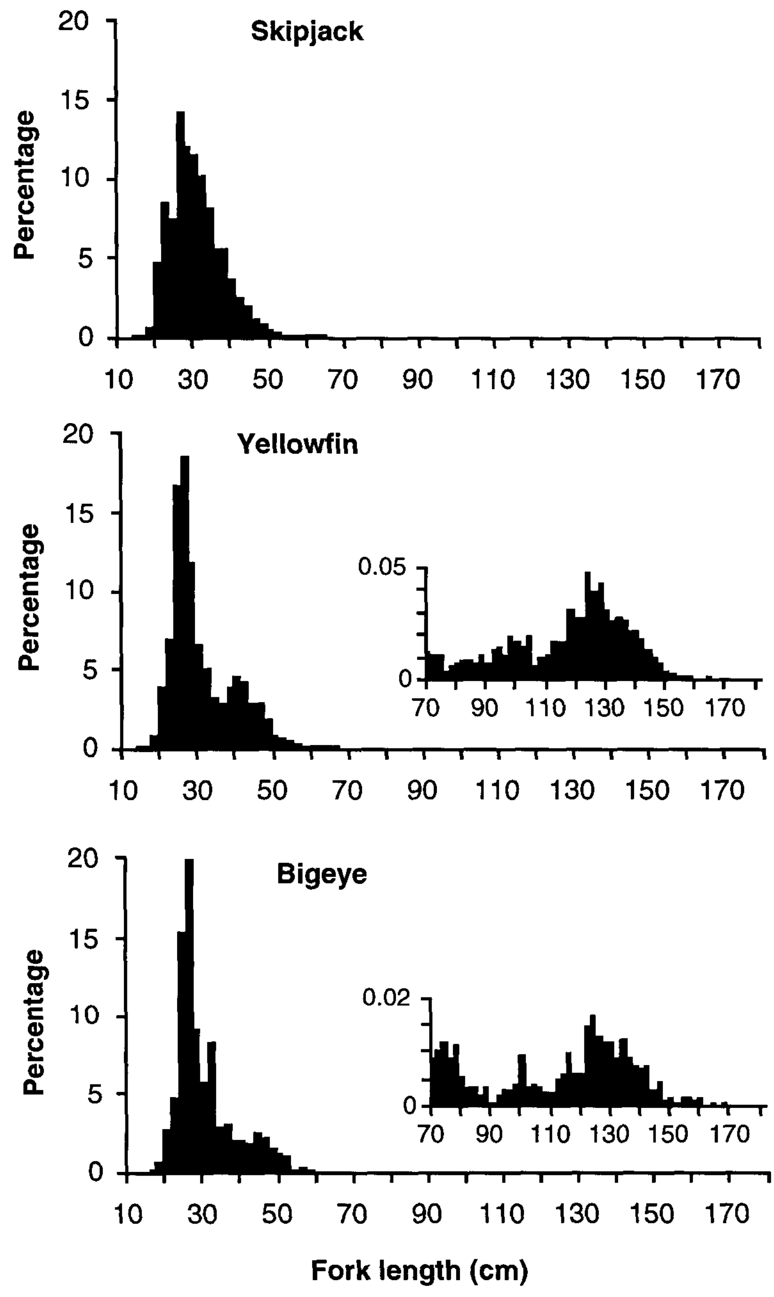
The catches of skipjack, yellowfin and bigeye by the Philippines domestic fishery represent a substantial component of the western Pacific tuna harvest – an average of about 14% for 1990-1992. The relatively small area from which these fish are taken and their small average size has led to concerns that this level of local exploitation may not be sustainable in the long term and that impacts of the harvest may be felt beyond the immediate area. As a result of these concerns, the Phillipines Government initiated the Philippines Tuna Research Project (PTRP), with the goal of assessing the current status of oceanic tuna stocks in Philippines waters. Given the relevence of the Project to concurrent regional efforts being undertaken, the OFP, under the auspices of the Western Pacific Fisheries Consultative Committee, was contracted as technical consultant to the Project. A two-pronged approach was adopted to meet the project goal. Earlier tagging work by the RTTP in the Philippines had demonstrated the feasibility of conducting large-scale tagging in the area, therefore a further period of intensive tagging was carried out with the objectives of quantifying local exploitation rates and their effects on fisheries in adjacent areas. The second approach was to put in place procedures to undertake long-term monitoring of catch, effort and size composition from the fishery, so that ongoing assessment of the stocks will be possible. The tagging project and associated analysis of data have been completed, while the landed catch and effort monitoring system (LCEM) has been put in place and is functioning smoothly. A proposed continuation of the OFP involvement to carry out an analysis of historical longline data for the northern Philippines, as well as further LCEM and tagging analysis support, has not yet been approved.

In this section, we present a brief overview of the LCEM and a summary report of the tagging project and the associated data analysis.

Landed Catch and Effort Monitoring System (LCEM)

Collection of vessel landings, effort data (days fished) and length frequency samples has been carried out since January 1993 at 13 landing sites throughout the Philippines. These sampling sites cover the major fishing areas of the Philippine Sea (Quezon and Surigao), Moro Gulf (Zamboanga City, Pagadian City, General Santos City), Sulu Sea (Puerto Princessa City) and the South China Sea (Zambales). Under the proposed PTRP extension, 6 more sampling sites will be added to cover the northern South China Sea, Bohol Sea and Samar region of the Philippine Sea. An integrated database, which allows the production of summaries of raw and raised data, has been developed. As an example, raised length frequency distributions of the skipjack, yellowfin and bigeye catches in 1993 are shown in Figure 16.

Figure 16. Length frequency distributions of the Philippines domestic fishery catch of skipjack, yellowfin and bigeye in 1993. For yellowfin and bigeye, the insert graphs show enlargements of the distributions for medium-large fish (≥70 cm FL).



Philippines Tagging Project

Tag releases and recoveries

Work began in April 1992 with trial tagging of ringnet-caught tuna. While the trial was considered successful from the point of view of releases, none of the 157 tuna tagged and released have been recaptured to date, suggesting that there may be survival problems with tuna captured and tagged in this manner. The major tagging effort was therefore concentrated on the pole-and-line vessel *Te Tautai*, which was chartered from August to October 1992 for this purpose. During this period, 13,695 tuna were tagged, with releases distributed widely throughout the major fishing areas of the Celebes Sea/Moro Gulf, Sulu Sea and Philippine Sea. Recoveries have been high, with 3,563 tag returns (26%) documented (Table 17). This is due both to high fishing intensity and very high project awareness among the diverse Philippine fishing community.

Table 17. PTRP tag releases (excluding experimental ringnet releases) and returns as at 12 May 1993.

	Yellowfin	Skipjack	Bigeye	Total
Releases	6,505	5,921	1,269	13,695
Returns	1,480	1,726	357	3,563
Return rate	22.8%	29.2%	28.1%	26.0%

Analysis of data

To assess the impact of the fishery on local stocks, we analysed the tag return data for the three species with a spatially-stratified, tag attrition model, providing estimates of natural mortality (*M*s) and fishing mortality rates (*F*s) in three areas, the Celebes Sea, Sulu Sea and Philippine Sea, as well as rates of transfer (*T*s) among the areas (Table 18). *F* and *M* were allowed to vary among areas but were assumed to be constant over time within areas. When the backlog of catch and effort data are processed, it may be possible to relax the assumption of constant *F*. The model was run for two assumed reporting rates, 0.9 and 0.7.

Estimated natural mortality rates are high, several times comparable estimates obtained for the same species in the western tropical Pacific surface fisheries. There is some evidence from previous studies (Yesaki 1983) that high natural mortality rates of small tuna aggregated near payaos could be due in part to predation by large, adult yellowfin, bigeye and possibly other large pelagics. Fishing mortality rates are also high, representing exploitation rates of up to 0.5.

Table 18. Parameter estimates and coefficients of variation (CV) estimated from skipjack, yellowfin and bigeye tagging data (1992 releases). Mortality and transfer rates have units of 10 d^{-1}. Subscripts refer to areas: 1 Celebes Sea; 2 Sulu Sea; 3 Philippine Sea.

Model	Skipjack				Yellowfin				Bigeye			
Param.	Est.	CV	Est.	CV	Est.	CV	Est.	CV	Est.	CV	Est.	CV
M_1	0.230	0.048	0.191	0.053	0.292	0.034	0.239	0.038	0.190	0.094	0.140	0.119
M_2	0.177	0.047	0.156	0.049	0.152	0.057	0.142	0.057	0.114	0.380	0.106	0.282
M_3	0.320	0.044	0.238	0.055	0.209	0.203	0.168	0.227	0.355	0.178	0.334	0.176
F_1	0.158	0.068	0.197	0.066	0.250	0.052	0.305	0.048	0.223	0.090	0.275	0.086
F_2	0.081	0.067	0.102	0.066	0.032	0.087	0.041	0.084	0.023	0.605	0.031	0.463
F_3	0.460	0.061	0.543	0.057	0.177	0.299	0.215	0.260	0.063	0.349	0.077	0.297
T_{12}	0.008	0.293	0.008	0.293	0.017	0.241	0.016	0.224	0.027	0.432	0.026	0.445
T_{13}	0.001	0.734	0.001	0.730	*	*	*	*	*	*	*	*
T_{21}	<0.001	1.041	<0.001	1.038	0.001	0.562	0.001	0.518	*	*	*	*
T_{23}	0.001	0.412	0.002	0.411	0.003	0.482	0.003	0.308	*	*	*	*
T_{31}	0.005	0.448	0.005	0.448	0.021	0.470	0.023	0.796	*	*	*	*
T_{32}	*	*	*	*	*	*	*	*	0.010	0.215	0.007	1.076
E_1	0.399	0.035	0.497	0.034	0.448	0.024	0.545	0.022	0.506	0.045	0.624	0.040
E_2	0.311	0.039	0.3915	0.038	0.1719	0.054	0.220	0.052	0.169	2.254	0.225	3.311
E_3	0.586	0.024	0.6912	0.022	0.435	0.174	0.531	0.139	0.147	0.261	0.185	0.189
Input Param.												
β	0.900		0.700		0.900		0.700		0.900		0.700	
α	0.033		0.033		0.070		0.070		0.070		0.070	
λ	0.003		0.003		<0.001		<0.001		<0.001		<0.001	

* indicates no observed movements of tagged tuna between these areas – transfer parameter assumed to be zero.

Despite this heavy exploitation of small tuna, growth over-fishing appears to be prevented by the high rates of natural mortality. However, if the high natural mortality rates are indeed due in part to the presence of large numbers of payaos, as suggested by Yesaki, increases in yield per recruit might well be obtained if an increase in the size at first capture was accompanied by a reduction in the number of payaos. In any case, with the estimated fishing mortality rates and the possibility of artificially elevated natural mortality, it is not surprising that CPUEs for small tuna have declined drastically as the fishery has developed over the past two decades.

With such high exploitation rates, the risks of recruitment over-fishing could be substantial if there are strong linkages between local juvenile and adult spawning populations. In the case of skipjack, it is possible that a significant proportion of the local spawning stock is of Philippines origin, although there is evidence of mixing with skipjack in adjacent areas of the western tropical Pacific. Such mixing may provide some buffer against local recruitment over-fishing. In the case of yellowfin and bigeye, the apparent scarcity of medium-sized fish in Philippines waters (see Figure 16) suggests that there is likely to be little linkage between local juvenile and adult spawning populations. Tag returns from large yellowfin recaptured in the Philippines but released 1-3 years earlier in a wide variety of locations throughout the western tropical Pacific support this theory. Thus, there would appear to be little prospect for local recruitment over-fishing resulting directly from the activities of the local fisheries. However, if adult yellowfin and bigeye are dependent on juvenile tuna as a major prey item, the fisheries targeting juvenile tuna could impact the spawning stocks through depletion of this food source.

1994-95 Work Plan

During 1994-95, we plan to re-do the tagging analysis, incorporating catch or effort data to enable the parameterisation of time-variable fishing mortality, and produce a final report of the analysis. Any additional work by the OFP on the PTRP depends on the approval of an extension of the PTRP for an additional year. Subject to this approval, the OFP, as technical consultant, would

- prepare a report on historical fishing activities, mainly by longliners of distant-water fishing nations, in the Philippines EEZ;
- provide ongoing technical support to the LCEM database;
- undertake additional analyses of PTRP/RTTP tagging data, eg., using the spatial model described in section 3.2, to investigate questions regarding the impacts of the Philippine fishery on fisheries in adjacent areas.

5. REPORTING AND LIAISON

Background

The reporting and liaison function of the OFP ensures that (i) member country requirements are adequately catered for by the work of the Programme; (ii) the results of OFP research are communicated in appropriate form to member countries; and (iii) member countries receive the best available scientific advice regarding the management of their tuna fisheries. Much of this is achieved through informal contact between OFP staff and Fisheries Officers during country visits, regional meetings, etc, and through formal presentation of work at meetings such as this.

1993-94 Activities

Results of OFP work were reported back to member countries at several levels - in broad outline to regional meetings (CRGA, October 1993, May 1994; and FFC, May 1994), in greater detail to the 25th Regional Technical Meeting on Fisheries, where technical seesions on OFP work are now held, and the Sixth Standing Committee on Tuna and Billfish (June 1993). OFP work also provides an important contribution to the work of specialist research groups (WPYR group, June 1993, and SPAR).

Reporting was provided to specific countries in the form of national assessments (see above), and responses to specific queries on current status of stocks, likely effects of different harvest strategies, etc. Technical input to regional review processes, eg. the Annual Consultation on the US Multilateral Treaty on Fisheries (April 1994) and the 2nd Symposium on Western Pacific Tuna Fisheries, and to sub-regional bodies, notably the 13th Annual Meeting of Parties to the Nauru Agreement (April 1994) and the PNA Task Force (January 1994) also occurred. Technical support was also provided to the South Pacific delegations to the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks during its second session in New York in March 1994. Statistical reporting occurred at formal publication level (*SPC Regional Tuna Bulletin* and *Tuna Fishery Yearbook*) and directly to countries on receipt of data (see section 1).

Reporting to countries involved in RTTP activities continued through a series of informal customised reports on interim tagging results. These followed previous activity reports, which detailed field activities in different countries during the course of the project. Detailed reports in the OFP Technical Report series continued to be published.

Regular liaison was maintained with other regional and international organisations, particularly the FFA, but also the US National Marine Fisheries Service, the Western Pacific Regional Fishery Management Council, the Inter-American Tropical Tuna Commission, the Indo-Pacific Tuna Management and Development Programme, the Food and Agriculture Organization, the Japan National Research Institute of Far Seas Fisheries, the Tohoku National Fisheries Research Institute, the National Taiwan University, the Research Institute of Marine Fisheries (Indonesia), the Bureau of Fisheries and Aquatic Resources (Philippines), the Western Pacific Fisheries Consultative Committee and organisations in

Australia and New Zealand, to promote collaborative research and exchange of information. Participation in consultations held by several of these organisations occurred, and OFP staff made presentations at relevant scientific conferences, as circumstances allowed, eg. Lake Arrowhead Tuna Conference (May 1994).

1994-95 Work Plan

The informal contact, formal reporting activities and advisory services undertaken in 1993-94 will continue in 1994-95. With the delayed implementation of SPR TRAMP, work has been delayed on the publication of the results of the RTTP in the form of a monograph. It is hoped that, with staff levels to be boosted with the implementation of SPR TRAMP, this ambitious task can be started in 1994-95.

6. THE OFP COMPUTER SYSTEM

Background

The OFP computer system has always been an integral component of the work of the Programme. It is required to process and store the large volume of statistical data that is generated by the fisheries in the region and to undertake analyses of those data in support of programme objectives.

1993-1994 Status

As of December 1993, OFP staff have at their disposal 24 computers, including a new HP-9000 F30 minicomputer purchased with New Zealand funding and which replaces the tired and ailing 845S; a new HP 9000 715/33 workstation; a Sun IPC Sparcstation; 18 IBM PC compatible desktop and notebook computers, and 3 Apple Macintoshes. While several of the older 80286-based computers were retired from service, they were replaced by new 80486 machines, keeping numbers in use constant. The OFP also upgraded 4 of its 80386-based microcomputers to 80486 standard, allowing them to run the latest Microsoft Windows applications much more productively. This has become increasingly important for the Programme as other agencies in the region shift towards greater reliance on Windows and Microsoft products, as recommended by the Information Technology staff of FFA.

All computers were fully linked to the OFP network system by the end of 1993, allowing rapid and easy data access and file transfer amongst all users and platforms. The OFP Netware 3.11 server was upgraded to provide better performance and more disk space to users, and to allow a larger subset of the catch and effort logbook database and several other databases to remain available online for easy access by PC users.

A dedicated tape backup workstation assembled from parts obtained from system upgrades was installed to service the Novell server and PC workstation community. The contents of the server file system are backed up according to a daily incremental / weekly comprehensive scheme onto digital data storage tape for transfer to the OFP fireproof safe, or offsite to the SPC's safe deposit box. This provides the OFP with a measure of disaster protection for critical data resources resident on the Novell server, matching procedures already in place for the OFP minicomputer.

Windows for Workgroups 3.11 was studied and found to be a better product than Windows 3.1 for OFP purposes, leading to its adoption as the standard for all OFP microcomputers capable of running Windows. Though the peer-to-peer aspects of the system are not essential for an organization already running under a Novell network environment, the better all around stability of the product makes it a better choice, and the built-in electronic mail facilities will prove very useful once the Inshore Fisheries Program joins the OFP LAN in mid-1994, and again when the OFP moves to the new SPC site sometime in 1995 and is no-longer together on the same floor.

Some preliminary study of client-server configurations utilizing Microsoft Access and ORACLE was undertaken, but actual trials were delayed due to a pressing need to move production ORACLE applications off of the old HP minicomputer and onto the new machine as quickly as possible. It had been hoped that the new machine could for a time be used as a test-bed for the software trials, but the rapidly worsening condition of the old 845S precluded this option.

OFP programming staff designed and implemented a comprehensive query system under FoxPro for DOS which provides users with a simple-to-use, menu-driven data extraction application capable of satisfying 80% of routine data retrieval tasks. Versions were provided for both the catch and effort database, and the tuna tagging database.

1994-1995 Work Plan

The design and construction of a new headquarters complex for the SPC has provided OFP computer staff an opportunity to participate in all aspects of network planning and design, both for the OFP and for the SPC as a whole. Current specifications provide for a fiber-optic network backbone to link all SPC buildings, while 10Base-2 cable configured in a star topology will be employed for connecting individual nodes within each building. The OFP will in addition provide 10Base-T services within each office in order to make use of existing patch panel and network equipment, and to provide a basis for future expansion into 100 MB/s ethernet technology when such services are required. The current SPC headquarters construction schedule provides for the OFP to move into its new offices sometime in mid-1995.

Upgraded minicomputer services and associated equipment will allow OFP to experiment with various client-server configurations. Top priorities in this area include selection of an easy-to-use PC-based front end for handling routine ORACLE data queries, and a faster, more convenient method for mapping query results, possibly based on a menu driven application running under the MapInfo product, which FFA are currently prototyping via an outside development contract.

System enhancements and upgrades will continue to be performed on servers and workstations as required, in order to keep the OFP up to date with the main stream of computer industry software developments, and to maintain compatibility with FFA and various computer systems in the region supported by them. The last few remaining DOS-only IBM PC compatible OFP workstations will be upgraded to Windows hardware standards by the end of 1994. WordPerfect and Lotus 123, long the OFP word-processing and spreadsheet standard applications, will be phased out of routine use by December 1994 in favor of Word for Windows and Excel. OFP database applications written under FoxPro for

DOS are currently being migrated to FoxPro for Windows, a project expected to be completed by mid-1995. Modifications and enhancements to the FoxPro data query systems will remain an ongoing task .

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