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**An investigation of the fishery interactions and population dynamics of skipjack tuna
(*Katsuwonus pelamis*) in waters of the Solomon Islands**

(A joint proposal by the Solomon Islands Ministry of Natural Resources, Fisheries Department, Honiara, Solomon Islands and the South Pacific Commission, Tuna and Billfish Assessment Programme, Noumea, New Caledonia)

INTRODUCTION

1. The evaluation of tuna fishery interactions (the effect of one fishery on another) and stock assessment (estimating the degree to which the fisheries affect the fish population) are currently priority activities of the Tuna and Billfish Assessment Programme (TBAP). The predecessor of the TBAP, the Skipjack Survey and Assessment Programme (SSAP) also addressed these problems and documented its findings in a number of technical reports. However, since the SSAP, there have been substantial developments in the tuna fisheries, both locally based and by distant water fishing nations (DWFNs), of a number of island countries, resulting in new concerns regarding fishery interaction and the state of the tuna stocks.
2. The TBAP is currently engaged in two main activities that address these new concerns. First, at a regional level, an investigation of the western Pacific yellowfin resource is planned and funding for a large-scale tagging programme has been approved by the EEC. Second, a number of island countries have expressed concerns regarding specific fishery interactions and stock assessment on a more local scale. This proposal, developed and to be undertaken jointly by the Solomon Islands Ministry of Natural Resources, Fisheries Division (SIFD) and the TBAP, seeks primarily to (i) evaluate existing and potential fishery interactions in waters of the Solomon Islands, particularly with respect to the pole-and-line and purse-seine fisheries, (ii) provide an assessment of the current state of the skipjack population in the area, and (iii) obtain information on various other aspects of skipjack population dynamics that are particularly relevant to the Solomon Islands. The responsibilities of each organisation are listed in Appendix 1.

BACKGROUND INFORMATION

Skipjack Survey and Assessment Programme

3. The SSAP conducted two surveys in waters of the Solomon Islands, the first during the period 1 November to 4 December 1977, and the second during the period 25 May to 28 June 1980. The results of these surveys have been extensively documented in Argue and Kearney (1982) and Kleiber, Argue and Kearney (1983, 1987).

4. In the 1977 survey, 2,611 tuna (95% skipjack) were tagged, all but 417 in the vicinity of New Georgia Sound (the Slot; Figure 1). In the 1980 survey, 4,475 tuna (83% skipjack) were tagged, all but 383 in the vicinity of New Georgia Sound. A total of 607 returns resulted from these tagging experiments. During the two surveys, 858 yellowfin were tagged, mostly in the region of the Shortland and Santa Cruz Islands, of which only 15 have been recovered. Details of tag returns for skipjack releases are given in Table 1.

TABLE 1. RELEASES OF TAGGED SKIPJACK DURING 1977 AND 1980 IN THE WATERS OF SOLOMON ISLANDS, NUMBERS OF RECOVERIES MADE INSIDE AND OUTSIDE THE SOLOMON ISLANDS FISHERY ZONE, AND NUMBERS OF RECOVERIES FROM UNKNOWN RECOVERY LOCATIONS. Percentages of tags recovered are in given brackets (after Argue and Kearney 1982).

	1977	1980	Total
Numbers tagged	2490	3731	6221
Local recoveries	82 (3.3)	439 (11.8)	521 (8.4)
International recoveries	5 (0.2)	13 (0.4)	18 (0.3)
Unknown locations	3 (0.1)	50 (1.3)	53 (0.9)
Total recoveries	90 (3.6)	502 (13.5)	592 (9.5)

5. Of the 1980 releases of skipjack in the vicinity of New Georgia Sound, 16% were recovered. Because this is the area in which the existing fisheries concentrate, it is anticipated that most releases from the proposed programme will be in this area. Therefore, the 1980 recovery rate gives some indication of the minimum recovery rate that might be expected in the proposed programme.

6. On the basis of the 1977 and 1980 surveys, estimates of skipjack population size vulnerable to the local pole-and-line fishery, monthly throughput (the biomass of skipjack passing through the fishery each month), monthly turnover (the proportion of total skipjack biomass renewed each month), fishing mortality and harvest ratio (the proportion of total skipjack deaths due to fishing) were calculated. Primarily, because of bad weather, the results of the 1977 survey were not considered to be fully reflective of the actual situation in the region at the time. The estimates based on the 1980 survey are presented in Table 2.

TABLE 2. ESTIMATES OF SKIPJACK POPULATION SIZE, MONTHLY THROUGHPUT, MONTHLY TURNOVER, AVERAGE MONTHLY FISHING MORTALITY AND HARVEST RATIO BASED ON THE 1980 SSAP SURVEY. The values given in brackets are 95% confidence intervals (after Kleiber, Argue and Kearney 1987).

Population size (mt x 10 ³)	89	(49-185)
Throughput (mt x 10 ³ per month)	13	(9-22)
Turnover rate (per month)	0.16	(0.09-0.26)
Average fishing mortality (per month)	0.027	(0.014-0.047)
Harvest ratio	0.17	(0.11-0.24)

7. These results indicated that there was a substantial resource of skipjack available in the Solomon Islands fishing zone. Also, the low harvest ratio further suggested that, at 1980 levels of fishing, there was considerable room for expansion of skipjack catch.

8. Analyses of Solomon Islands tagging data to determine fishery interactions have been confined to between country interactions. On the basis of SSAP results, it was determined that 10-15% of skipjack throughput in the Solomon Islands fishery could result from immigration from outside the Solomon Islands fishing zone, the remainder being due presumably to local production (i.e. recruitment directly from spawning areas) or immigration from unknown areas. It was therefore felt that neighbouring fisheries were not having a substantial effect on the Solomon Islands fishery (and vice versa).

9. At the time of the SSAP, tuna fishing in the Solomon Islands was predominantly a local pole-and-line activity. Since then, major changes have taken place, particularly with regards to the development of purse-seining (see below). Therefore, the proposed tagging programme would provide a timely re-evaluation of the Solomon Islands skipjack resource and address the local fishery interaction problems of most concern.

The Solomon Islands tuna fishery

10. The Solomon Islands lie between 4 and 16 degrees south and between 153 and 173 degrees east, in the region of the intertropical convergence zone. Tuna are abundant in these waters, supporting a commercial fishery that has been operating since the early 1970s. The industry has grown dramatically over the years, comprising an ever increasing share of foreign exchange earnings and private sector employment (Anon 1985).

11. Based on the findings of the SSAP that indicated that skipjack catches could be increased several fold (Argue and Kearney 1982), the Solomon Islands Ministry of Natural Resources has sought to further develop its domestic fleet, ultimately to reach a production level of around 75,000 mt per year.

12. The fleet is presently comprised of 34 pole-and-line boats ranging between 60 and 120 grt, a group seining operation (net boat, search boat and two carriers), one chartered single seiner and two new Government-owned single seiners. The pole-and-line fleet is comprised of vessels owned by the National Fisheries Development Corporation Ltd (NFD) and Solomon Taiyo (Soltai), a joint venture. Part of the fleet is Okinawan, operating under charter to Soltai. The encouraging performance of the group seining operation (Table 3) that began in 1980 resulted in the Solomon Islands Government undertaking a major project involving the design and construction of the two new single seiners.

TABLE 3. SUMMARY OF SURFACE FISHERY CATCH AND EFFORT FOR TUNAS IN WATERS OF SOLOMON ISLANDS, 1980-1988.

Year	<u>Pole-and-line</u>			<u>Purse seine</u>		
	Catch (mt)	Effort (days)	CPUE (mt/day)	Catch (mt)	Effort (days)	CPUE (mt/day)
1980	21900	4993	4.4	-	-	-
1981	22600	5259	4.3	2400	121	20.2
1982	17300	4858	3.6	4500	209	21.4
1983	29300	6185	4.7	6900	228	30.1
1984	30600	6397	4.8	5400	166	32.8
1985	25000	6966	3.6	5700	188	30.7
1986	38600	7663	5.0	5900	177	33.6
1987	22700	6781	3.3	7389	192	38.2
1988	30110	8030	3.7	10729	334	32.1

13. Domestic exploitation of surface tuna concentrates in and around the main group archipelago (MGA), the group seining operation often relying on fish aggregation devices (FADs). The pole-and-line fleet fishes mainly inside the MGA baseline. The group seiner is not permitted to fish within the MGA baseline, but is allowed to fish in non-archipelagic territorial waters (i.e., between the MGA baseline and 12 mi. line). All single seiners must fish outside of territorial waters.

14. The total domestic surface catch rose from a few thousand mt in 1971 to approximately 44,500 mt in 1986. With the introduction of purse-seining, the proportion of yellowfin has increased from under 1% to 20% of the total catch in 1987, falling back to 15% in 1988. Annual catch per unit effort has fluctuated between 2.8 and 5.8 mt/fishing day for pole-and-line and between 20.2 and 38.6 mt/fishing day for purse-seine. The best pole-and-line catches and catch rates are recorded between June and November. For purse-seining, higher catch rates tend to occur in the summer months (Oct-Feb), although some of the highest monthly catch rates have been recorded in June.

15. Small subsistence and artisanal fisheries operate from many coastal villages. Their catch is small in comparison with that of the industrial sector, but is nonetheless socially and economically important to those villages.

16. Following the reduction in activity of the Japanese pole-and-line fleet, the foreign surface catch has declined from a high of almost 20,000 mt in 1976 to a few hundred mt in recent years (although there was a slight increase in 1985 to 3,323 mt that corresponded to a minor resurgence of activity in the zone). Longline catches (mainly yellowfin) have averaged over 2,000 mt since 1980.

OBJECTIVES OF THE PROPOSED PROGRAMME

17. The objectives of the proposed programme are:

- (i) To estimate skipjack population parameters (natural mortality, fishing mortality, transfer rates, tag shedding rates, tag reporting rate) necessary to assess the existing and/or potential interactions between the Solomon Islands pole-and-line and purse-seine fisheries. If artisanal statistics are available for the period of the tagging programme, artisanal-industrial interaction can also be addressed.
- (ii) To update SSAP estimates of skipjack standing stock, turnover, throughput and harvest ratio in the Solomon Islands region.
- (iii) To estimate other skipjack population parameters of interest (e.g., growth, long range movements, school integrity).
- (iv) To obtain preliminary information on the attraction of tagged skipjack to FADs, movement to FADs and residence time on FADs.
- (v) To train a local Solomon Islands fisheries officer in all aspects of conducting a tagging experiment, including experimental design, tagging and field sampling methods, tag return data collection and processing, data analysis and report writing, so as to enhance the research capability of the Solomon Islands SIFD.

JUSTIFICATION

Locality

18. The Solomon Islands is an ideal location to undertake a research programme such as this. The main reasons for this are:

- (i) The Solomon Islands Government has excellent documentation of its fisheries in the form of catch and effort and length-frequency data. These data, especially the former, are essential for stock

assessment and analyses of fishery interaction to be carried out.

- (ii) The long length of the tuna fishing season and good average catch rates in the Solomon Islands means that there is greater opportunity to tag sufficient numbers of fish than is the case in other countries.
- (iii) The relatively small size of the main fishing area (New Georgia Sound and vicinity) and normally excellent sea conditions are conducive to good geographical coverage of the fisheries.
- (iv) There are pole-and-line vessels operating in the fishery that are suitable and willing to co-operate in releasing tagged fish.
- (v) Almost all skipjack caught in the Solomon Islands region are unloaded locally (the exception being the largely insignificant catch by distant water fishing nations), either for canning or transshipment, therefore the logistics of tag recovery publicity, reward payment, etc are considerably simplified.
- (vi) The presence of FADs in the fishery enables some basic questions relating to their effect on skipjack distribution to be addressed.

Benefits arising from the proposed programme

19. The Government of the Solomon Islands has formulated its development objectives drawing on the results of the SSAP, an experiment that took place under somewhat different conditions than those that exist today. At the time of the SSAP, the national fishery was comprised only of pole-and-line vessels fishing predominantly in New Georgia Sound and large scale foreign purse-seining in adjacent waters had only just begun. However, the introduction of purse-seining (and FADs) and the further expansion of activities that is likely in the near future means that an evaluation of the existing and/or potential interaction between the pole-and-line and purse-seine gears is now necessary. Such information would allow the Solomon Islands Government to plan the development of its fishery while taking account of the effects that such development might have on the various interest groups.

20. In addition, the results of the tagging programme would provide an assessment of the current state of the skipjack population in the Solomon Islands region through the estimation of standing stock, throughput, turnover rate and harvest ratio. The present goal of expanding to a total annual catch of 75,000 mt could then be reviewed in the light of this assessment.

21. In addition to providing the basis for the interaction and stock assessment studies, the tagging data will also generate some ancillary information on the dynamics of skipjack around FADs

(movement to and from, residence time). Although these results will be preliminary, they may well give some valuable insights on the mechanisms of attraction that would prove useful in the planning of dedicated tuna-FAD investigations in the future. Other information, e.g. relating to growth, long range movements, school integrity, etc, will also further the general understanding of skipjack biology in the Solomon Islands fishing zone.

22. Finally, the training aspects of the programme will benefit the Solomon Islands by enhancing their own research capability. Because stock assessment and monitoring is an ongoing process, such a capability is clearly essential for the long-term rational utilisation of the substantial tuna resources of the Solomon Islands. The proposed programme represents a unique opportunity to pursue this objective.

PROPOSAL IN DETAIL

23. The programme is scheduled to begin in July 1989. A tentative timetable for the work programme is given in Table 4.

TABLE 4. TENTATIVE PROGRAMME TIMETABLE

<u>Date</u>	<u>Activity</u>
Jun 89	Preparatory visit of TBAP staff to Honiara to arrange fabrication of tagging cradles and finalise arrangements for the first tagging cruise
Jul-Aug 89	First tagging cruise (Soltai vessel)
Sep-Oct 89	Second tagging cruise (RTTP vessel)
Mar 90	Third tagging cruise (Soltai vessel)
Jun 90	Fourth tagging cruise (Soltai vessel)
Jan-Feb 91	TBAP attachment for SIFD officer
Jun 91	Preliminary report prepared
Jan 92	Final report completed, paper prepared for submission to journal

Field activities

24. Four tagging cruises each of one month duration will be undertaken, with three carried out from a commercial pole-and-line vessel (Soltai) and one (the second) carried out from the chartered Regional Tuna Tagging Project vessel. For the Soltai cruises, the company will be paid four times the market value of fish released as compensation for loss of efficiency due to tagging activities.

25. The areas of tag releases on the three Soltai cruises will generally be determined by the commercial fishing strategy of the tagging vessel, however it is expected that activity will be confined largely to New Georgia Sound and vicinity. There is provision for four days on each Soltai cruise to be on a full charter basis. This will allow some tagging to be carried out in the area of operation of the purse seiners, i.e. outside the MGA baseline. For the second cruise using the RTTP vessel, tagging will be carried out both inside and outside the MGA baseline.

26. Two tagging stations will be manned by teams of two (a third station may be possible on the RTTP vessel). The tagging personnel will comprise 2 or 3 TBAP scientists and 1 or 2 SIFD officers. Fish handling and tagging methods developed by the SSAP (Gillett and Kearney 1982) will be followed as closely as possible.

27. The primary objective of the field activities will be to tag as many tuna as possible, but consideration will also be given to tagging from as many different schools as possible in order to facilitate mixing of the tagged sample with the untagged population. Skipjack will certainly be the dominant tuna species in the catch, with a lesser amount of yellowfin (possibly as little as 1%) also being taken. Yellowfin will be tagged where possible and where the primary objective is not compromised. It is hoped that in excess of 2,000 tuna per cruise will be tagged. Where practicable, some double tagging will be carried out in order to estimate shedding rates. A number of tag seeding experiments will be undertaken in order to estimate the reporting rate. These could be done on the tagging vessel and on purse-seine vessels by Solomon Islands SIFD observers.

28. Tagging will be of two types -- open water and FAD associated. In order to assess the effect of the pole-and-line fishery on the purse-seine fishery (as part of objective i) it will be assumed that tagging in open waters within the MGA baseline will effectively sample skipjack vulnerable to the pole-and-line fishery. As the vessel will in fact be fishing commercially, this will not be an unreasonable assumption.

29. FAD associated fishing is not part of the normal operations of pole-and-line vessels in the Solomon Islands. However, setting on FADs by purse-seiners is commonplace and is, in fact, the principal method of operation of some purse-seiners in the Solomon Islands. In order to assess the effect of the purse-seine fishery on the pole-and-line fishery, an effective tagged sample of fish

vulnerable initially to the purse-seine fishery will be required. Therefore, special arrangements, as indicated above, will be made with the tagging vessel to devote some time during each cruise to FAD associated tagging outside the MGA baseline. Tagging on FADs and in open waters outside the MGA baseline will also be carried out from the RTTP vessel. This activity is also required for the execution of objective (v).

30. Return of tags will be encouraged through a publicity campaign, canvassing of employees at unloading and processing facilities, payment of a reward for each tag returned and a lottery. Publicity, tag return collection and data processing will be co-ordinated by SIFD in Honiara. Initial training and follow-up consultations will be given by the TBAP in this regard.

Data analysis

31. When the majority of tag returns have been received, a SIFD officer will begin a 2-3 month attachment to the TBAP in Noumea for the purpose of receiving training in analytical techniques and actively participating in data analysis.

32. The mathematical models used for the analysis of interaction and the estimation of standing stock, turnover, throughput, etc (objective iii) will be those developed by Sibert (1984), Hilborn *ms.* and Kleiber, Argue and Kearney (1982, 1987), respectively, with appropriate modifications for multiple release sets. Detailed catch and effort data from both the pole-and-line and purse seine fisheries will also be utilised in these analyses. Standard methods are available for other analyses of the tagging data that might be appropriate (e.g. growth).

Reporting of results

33. A report will be submitted to the Solomon Islands Government for their consideration. With the approval of the Solomon Islands Government and respecting any confidentiality requirements that they deem appropriate, a version of this report may be considered for publication (under joint authorship of TBAP and SIFD) in SPC's Technical Report Series or in a recognised scientific journal, with a non-technical summary given in the SPC Fisheries Newsletter. TBAP staff will travel to Honiara to discuss the results of the programme with government and industry representatives as required.

BUDGET

<u>Item</u>	<u>A\$</u>
(a) Travel	
Attachment of SIFD officer to TBAP	
1 HIR-NOU-HIR	925
Per diem in Noumea 90 days (at \$55/day)	4,950
Accommodation (at \$43/day)	3,870
TOTAL TRAVEL	<u>9,745</u>
(b) Vessel payments (excludes RTTP vessel charter)	
Compensation based on \$1.00/kg x 4 of tuna released x 3 kg per tuna average x 6,000 releases	72,000
12 days full charter (at \$3,000/day)	36,000
TOTAL VESSEL PAYMENTS	<u>108,000</u>
(c) Equipment	
(i) 2 tagging cradles	500
(ii) 10,000 tags (at \$0.50 ea.)	5,000
(iii) Tag applicators	500
(iv) Lap-top computer	3,000
(v) Miscellaneous	500
TOTAL EQUIPMENT	<u>9,500</u>
(d) Maintenance	
(i) Tag rewards (at \$6.00/tag) 20% of 4000 single tagged; 20% of 2000 double tagged	9,600
(ii) Tag lottery	2,000
(iii) Publicity	1,000
(iv) Freight, postage, etc	1,000
TOTAL MAINTENANCE	<u>13,600</u>
<u>TOTAL FUNDS SOUGHT</u>	<u>\$140,845</u>

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APPENDIX 1. RESPONSIBILITIES OF THE TBAP AND SIFD

<u>Activity</u>	<u>Responsibility</u>
Secure funding for the programme	TBAP
Purchase/provision of equipment	TBAP
Provision of field staff	TBAP/SIFD
Training	TBAP
Collection and processing of all data generated by the programme, and provision of copies to TBAP	SIFD
Provision of all relevant catch, effort and length-frequency data	SIFD
Data analysis and preparation of reports	TBAP/SIFD