

SOUTH PACIFIC COMMISSION

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**Summary of Tuna and Billfish Assessment Programme
Activities**

(Paper Prepared by the Secretariat)

1. The Tuna Programme has experienced important changes during the previous year. Staff turnover was unusually large and the main computer system was replaced. In spite of disruptions, Programme staff have been very active and progress was made in all priority areas.

2. An important evaluation of the TBAP was carried out for the Committee of Representatives of Governments and Administrations (SPC/Fisheries 19/WP.3). This evaluation concluded that there are serious communication problems between the Tuna Programme and South Pacific Commission member governments and administrations. It would seem that many countries are either not aware of, or are misinformed about, Tuna Programme activities. This summary of programme activities therefore not only reviews progress in the last year, but also describes the basic activities normally conducted by the Tuna Programme under major priority areas.

**Priority 1. Collection and evaluation of fisheries data and maintenance
of regional oceanic fisheries assessment data base.**

General Activities

3. The creation of a regional oceanic fisheries data base is a complex and expensive undertaking. It is a process that goes far beyond the simple accumulation of statistics on fishing. SPC/Fisheries 19/WP.2 describes in detail potential components and steps involved to include these components into a useful fisheries data base. Logsheets recording daily fishing activities are a cornerstone of such a data base.

4. The Tuna Programme has had the responsibility of processing daily logsheets from from both foreign and domestic fishing vessels since 1981. Logsheets are the core of any data base used for the assessment of regional tuna stocks, and the processing and analysis of logsheet data is the major preoccupation of the statistics staff of the Tuna Programme. Logsheets from foreign vessels are forwarded to member countries under the terms of the agreements which enable them to fish in the Extended Economic Zones (EEZs) of the region. Member countries then forward the logsheets to the SPC for processing. Normal processing involves entry of data into the main computer system and the production of summaries as outlined in SPC/Fisheries 19/WP.2.

5. The content and design of the logsheets were developed in consultation with member countries. The first regional logsheets were adopted by the Thirteenth Regional Technical Meeting on Fisheries (RTMF) in 1981 and subsequently revised by the Eighteenth RTMF in 1986 in light of changing requirements and practical experience. The currently approved logsheets are available in the languages of the foreign fleets operating in the region: English, Japanese, Chinese, Korean and Russian.

6. Applications of logsheet data have evolved steadily since the inception of the statistics project. Logsheets summaries have also evolved in response to requests by member countries. Routine summaries include tabulations of total catch taken by month, total catch per vessel trip, and tonnage landed at different ports. Maps displaying the daily positions of all vessels during each month are also produced. In addition, most Forum Fisheries Agency member countries have authorized the SPC to provide these summaries to the FFA in a format compatible with the FFA computer system. At the end of each quarter of the year, the contents of the logsheet data base are summarized to provide up to date reviews of data holdings to fisheries managers.

7. The Tuna Programme holds several other kinds of data in addition to logsheets. There is a growing body of length-frequency data derived from national sampling programmes in the region and from research cruises by foreign vessels. At present, these data are not incorporated into any formal data base structure and are only analysed on an *ad hoc* basis, usually in response to a specific request. An increasing volume of data of this type is expected in conjunction with the US multilateral fishing agreement. It will eventually be utilized to detect overlap in size of fish vulnerable to different gear types. It will also be used to evaluate changes in size distribution as an early warning of overfishing. Some countries forward summarized data in machine-readable format from their own data processing systems rather than forwarding raw logsheets. These data files can generally be incorporated into various summarized data bases. Landing data is also beginning to accumulate from a diversity of sources and can be used as alternative estimates of total catch for comparison with logsheet summaries.

8. Many fishing nations publish summaries of tuna catches which can be used to extend the coverage of Tuna Programme data holdings back to the early 1960s and to areas beyond EEZs. All available published information of this type has been incorporated into a data base compatible with the daily logsheet information. A graphical summary of this historical record showing the distribution of tuna catch rates in the central Pacific is in preparation and will be published as a Tuna and Billfish Assessment Programme Technical Report.

Progress

9. Activities under this priority were the most severely affected by staff and computer turnover. The smooth transfer of data base activities to the new hp9000 computer was accomplished by maintaining (and enhancing) the old HP1000 system while gradually transferring the work load to the hp9000. Thus, by maintaining the HP1000, statistical services were continued at normal levels — and even improved — during the transition period. All major components of the log sheet data base system are now implemented on the hp9000.

10. One of the principal reasons for changing to a new computer system is to utilize modern data base management software. Evaluation of commercially available data base software is a critical preliminary step in the transfer of the statistical system to the hp9000. Unfortunately, none of the three commercial packages reviewed by the Tuna Programme statistics staff have proven suitable. Several other excellent packages are currently under evaluation and it is very likely that one of these will be selected. Although all existing software have been implemented on the new computer, some of the expected improvements to be derived from the hp9000 will be deferred until data base management software is installed. Selection and implementation of such software is the first priority of new statistics staff.

11. The volume of data processed was higher this year than in previous years with more than 83,000 records added to the data base. Logsheets from Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Palau, Papua New Guinea, Solomon Islands, and Tuvalu were processed, representing approximately 49,000 daily records. The remainder comprised of unloading sheets contributed by Palau (27,000 records from 1964–82) and 1985 data from the American Tunaboat Association (7,000 records).

12. Modifications were made to the handling of vessel and port name spellings so that problems with trip accounting attributable to spelling errors were greatly diminished. Other modifications were introduced to reduce problems derived from miscoding of trip dates. Residual difficulties remain with both of these areas and will be eliminated during the coming year.

13. The problem of duplicate log forms became more severe. It is not uncommon for a photocopy of a form to arrive 6 - 8 months after the same form (or earlier photocopy) had been previously processed. In one batch of forms, about 20% of the logsheets had been received previously. The problem is not confined to a single country or to a single fishing fleet. Tuna Programme staff can generally detect these problems before processing becomes too advanced, but there are certainly some duplicated log forms in the data base yet to be eliminated.

14. The solution to the problem of log sheet duplication is to ensure that there are accurate document accounting procedures in fisheries offices. Such a system has numerous advantages. It would enable in-country staff to correlate log sheets received with licences issued, to know when duplicate log sheets have been received from fishing vessels, to conduct preliminary analyses of the data prior to forwarding logsheets to the SPC for complete processing. The Tuna Programme would be pleased to receive requests for assistance in establishing in-country document accounting systems.

15. The extent of data coverage remains unchanged with little or no data received on activities in international waters. The previous analysis of coverage by fleet has been updated and expanded to include coverage estimates from Japanese longliners (SPC/Fisheries 19/WP.6). Coverage estimates for the 50 - 70 tonne size class, which account for about 47% of total longline trip-days range from 60 to 80%.

16. The agreement between the American Tunaboat Association (ATA) and the South Pacific Commission is considered by both parties to be a valid interim measure for supplying data, but few data have been received from the ATA for 1986. The ATA is apparently not receiving data from its members. No progress was made in attempts to obtain data from ATA vessels for the period prior to 1984. The multilateral fishing treaty with the United States is expected to increase the quantity of data received from U.S. flag purse seiners. These vessels, however, only account for a relatively small portion of the total catch of tuna in the SPC region. Greater efforts are required to improve data coverage from the distant water fleets of Japan, Korea, Taiwan and Russia for areas of international water.

17. One of the major purposes for the establishment of the Standing Committee on Tuna and Billfish was to begin cooperative arrangements with Distant Water Fishing Nations (DWFNs) for compilation and analysis of high seas data. Unfortunately there have been impediments to the establishment of this committee (SPC/Fisheries 19/WP.1).

Data Sharing

18. The South Pacific Commission maintains a policy of data confidentiality policy whereby data held by the SPC are not released to a third party without authorization from the agency which initially supplied the data. This policy protects both the SPC and member countries from misuse of data. Unfortunately, this policy also restricts the flexibility of the SPC to cooperate with other agencies.

19. The SPC has made official requests to FFA member countries for a blanket authorization to transmit any fisheries data in our possession to the FFA. Most FFA members have responded positively to this request and the Tuna Programme now routinely forwards data supplied by FFA members to the Agency.

20. The Tuna Programme has also received requests from FAO and Indo-Pacific Tuna Programme for summaries by statistical area of catch reported to the SPC. Again, the SPC has made official requests to members for authorization to forward these data. The responses received have been, with one exception, favourable.

21. Some national fisheries agencies publish summaries of catches by their distant-water fleets. These summaries are highly aggregated — usually by 5° geographic square, month or quarter, and gear type, but there are many variations in level of aggregation. As indicated above, these have been incorporated into the Tuna Programme data base and provide useful supplementary data, particularly for high seas areas. Most international fisheries organizations (for example, Inter-American Tropical Tuna Commission, International Commission for the Conservation of Atlantic Tunas, Indo-Pacific Tuna Programme, FAO and International Pacific Halibut Commission) also publish aggregated summaries of catches in their areas of responsibility.

22. No geographic summaries have been published by the South Pacific Commission, but regional summaries were circulated at the 1986 RTMF. Similar regional summaries, accompanied by graphical presentations and a brief analysis, were published in South Pacific Commission Fisheries Newsletter No. 38. During the next year most of the major technical impediments to the calculation of accurate geographic data summaries will have been removed.

23. SPC members should consider the possibility of publishing these summaries as a means of exchanging data with other organizations. Aggregation of data and tabulation by gear type, 5° geographic square and month would adequately protect the confidentiality of the data. The inevitable time lag between time of fishing and time of publication would further reduce the sensitivity of the data. It would be possible to omit data from these summaries in order to respect the views of countries objection to such publication.

24. The advantages of publishing data summaries are significant. Such publication enables the SPC to cooperate with various FAO programmes more easily and facilitates exchange of information with other institutions. More importantly perhaps it assists in establishing the credentials of the SPC as a research agency.

Priority 2. Assessment of interaction between fisheries for oceanic species.

25. The Tuna Programme has given the problem of interaction between fisheries priority attention for several years and has achieved significant results. Most of these results have been published in the South Pacific Commission Fisheries Newsletter or in the Tuna and Billfish Assessment Programme Technical Report series, but some results have not yet been published. It is appropriate therefore to review the major conclusions.

26. The concern for interaction between fisheries for oceanic species, in particular tuna, stems from the great diversity of tuna fisheries operating in the South Pacific Commission region. One or more of the following can be found in every member country of the South Pacific Commission:

- small-scale subsistence fishermen who consume what they eat;
- artisanal fishermen who sell on local markets;
- local commercial pole-and-line vessels who may sell their catch to a local processor or to a processor within the region or who may transship their catch to processors outside of the region;
- local purse seine vessels who may sell their catch to a local processor or to a processor within the region or who may transship their catch to processors outside of the region;
- pole-and-line fleets belonging to DWFNs, primarily Japan;
- purse seine fleets belonging to DWFNs, which include Japan, Korea, Taiwan, and the United States;
- longline fleets selling catch to processors in the region;
- longline fleets of DWFNs which sell catch outside of the region; and
- a variety of other arrangements such as the joint venture purse seining or pole-and-line operations.

27. Each of these fisheries has a unique economic structure and importance, but each fishery depends on sustaining a reasonable catch rate for its success. In areas where several of these fisheries are operating simultaneously, it is vital to have some indication of the effects they may have on one another in order to rationally plan further development of fisheries. The critical question is, does increased catch by one fleet decrease the catch rate in another? The importance of this question will grow as national fishing enterprises grow.

Types of Fishery Interaction

28. In general, four types of fishery interaction can be recognized:

1. Subsistence and Artisanal — Commercial. Subsistence fisheries have been in existence as long as human habitation of the region, and artisanal fisheries are developing as an important form of cash income and employment in the region. Serious concern exists as to how these important small-scale fisheries will be affected by the development of large-scale commercial fishing.
2. Local — Distant Water Fleet. Local commercial fleets are equally concerned about the advent of large-scale DWFN fishing fleets. The locally based purse seine and pole-and-line fleets in Fiji, Kiribati, Papua New Guinea, Solomon Islands, and Tuvalu are important national business ventures.
3. Interaction between commercial gears. It is generally felt that purse seine boats and pole-and-line boats may fish the same populations of skipjack; in some parts of the world, they may even fish the same schools. Concern about interaction is therefore very strong and the likelihood of interaction is very high. Similar concern is expressed for potential interaction between surface (primarily purse seine) and longline fishing for yellowfin. Although the longline catch of yellowfin per vessel is low in tonnage, it is high in landed value, and contributes significantly to revenue from access agreements. Because the number of longline vessels is so high — about 1300 out of 1670 entries in the FFA regional register are longliners — the revenues from longline vessels are very important.
4. Interaction between countries. The fact that tuna have traditionally been classified as highly migratory, has led most people, including biologists, lawyers and economists, to assume *a priori* that there will be strong interaction between tuna fisheries in different countries.

Factors which Control Interaction

29. When two fisheries operate on the the same stock, such as purse seine and pole-and-line fleets fishing surface schools in the same place, the interaction — or more accurately competition — is direct and immediate; what one boat catches is not there for the other boats. Such direct interaction is unusual in the western Pacific; the subsistence, artisanal, pole-and-line and seine fleets operate in spatially distinct areas, sometimes only a few kilometres apart, but more often hundreds of kilometres apart. In such cases the effects of interaction are indirect and the analysis of the problem is more difficult.

30. In general, the effects and intensity of the interaction between two fisheries depend upon a number of factors.

31. **Distance between fisheries.** Distance is the most obvious factor which mediates interaction. If fishing grounds are large or widely separated, interaction between fisheries operating in them will be small. If we are concerned about the interaction between countries, the countries with large EEZs such as Federated States of Micronesia, Kiribati, and French Polynesia, would have less to be worried about than countries with small EEZs such as Western Samoa and Wallis and Futuna. The first two major surface fisheries for tuna that developed (eastern Pacific and eastern Atlantic) both began in locations with very small EEZs, and the inter-country interaction is probably very large. The EEZs in the western Pacific are very large and inter-country interactions may be less important than in other areas of the world.

32. **Movement rates.** If fish are stationary, the interaction between fisheries in separate areas will be small or non-existent. The traditional view of skipjack and yellowfin as highly migratory, moving rapidly from one country to another suggests that movement rates are high. As we will see below, how much the fish move in relation to distance between fisheries will greatly affect how strongly two fisheries interact.

33. **Natural mortality rate.** A more subtle factor that affects the intensity of the interaction is the natural mortality rate. If individuals are dying at a high rate, then few will live to move from one country to the other, and consequently interaction will be less than if mortality rates were low. Thus, all other things being equal, we expect fisheries for skipjack to interact less than fisheries for yellowfin simply because skipjack appear to have a higher natural mortality rate.

34. **Intensity of fisheries.** The final factor affecting interaction will be the intensity of the fishery. Large fisheries have both a larger impact and are in turn more severely affected than small fisheries.

Progress to Date

35. The importance of the four factors cited above can be simply verified by common sense. The difficult task is to find a way to relate these factors so that quantitative estimates of the effects of interaction may be calculated. In this way, the effects on existing fisheries of a proposed expansion or new development can be predicted (at least approximately). This area of fisheries science has received little attention and one cannot simply look up a convenient formula in a textbook on fisheries.

36. Of necessity, therefore, a large part of the work carried out by the Tuna Programme has been to develop appropriate statistical methods for analysis of interaction. Most of this work has in turn been directed to the analysis of movement as a factor which controls interaction. Unfortunately, there has been little previous work from which to start. In the 1970s, the Inter-American Tropical Tuna Commission (IATTC) published some studies that showed how fisheries for yellowfin tuna in the eastern Pacific could be influenced by movements of stocks (Francis 1974, 1977). Around the same time, similar methods were applied to the analysis of the results of yellowfin tagging experiments in the eastern Pacific (Ishii 1979). Since that time there have been few quantitative studies of tuna movements that actually predict the numbers of fish which move from place to place.

37. Two primary sources of information are pertinent to the analysis of interaction problems in the western Pacific: catch records from the TBAP data base, and tagging data from the Skipjack Survey and Assessment Programme conducted by the SPC in 1977-1981. Results of analyses of other tuna fisheries may also be applied.

38. Interaction between countries was the first aspect of interaction to be addressed by the Tuna Programme. Every Skipjack Survey and Assessment Programme Final Country Report contains a section on the potential for interaction between pole-and-line fisheries for skipjack in different countries. These evaluations are based on calculations of the number of skipjack caught in one country that might have migrated from another area. The results are summarized in TBAP Technical Report No. 12 (Kleiber *et al.* 1984) which examines the exchange of skipjack between different countries (Table 1). With the exception of the exchange between Federated States of Micronesia (FSM), the Marshall Islands (MAS) and the Northern Mariana Islands (MAR), there appears to be reasonably little interaction. These calculations are based on a very simple analysis and the four controlling factors mentioned above do not enter into these calculations in a clear fashion.

Table 1. Coefficients of interaction between fisheries operating in various countries and territories in the central and western Pacific. Receiver countries are listed across top of table and donor countries down the left margin. From Kleiber et al. 1984.

to →	Papua New Guinea (PNG)	Solomon Islands (SOL)	Palau (PAL)	Federated States of Micronesia (FSM)	Marshall Islands (MAS)	Northern Mariana Islands (MAR)	Fiji (FIJ)	New Zealand (ZEA)	Western Samoa (WES)	French Polynesia (SOC)
PNG	—	2.6	0.8	1.4	0.5					
SOL 1977	1.1	—								
PNG 1980	3.7	—								
PAL 1978			—	8.6	2.2					
PAL 1980	1.6	0.4	—	3.5	1.3	0.7				
FSM	0.7	0.9		—	37.0	10.8				
MAS				17.4	—					
FIJ 1978							—	0.6		
ZEA							6.5	—	2.1	3.6
KIR				<0.1	0.1					

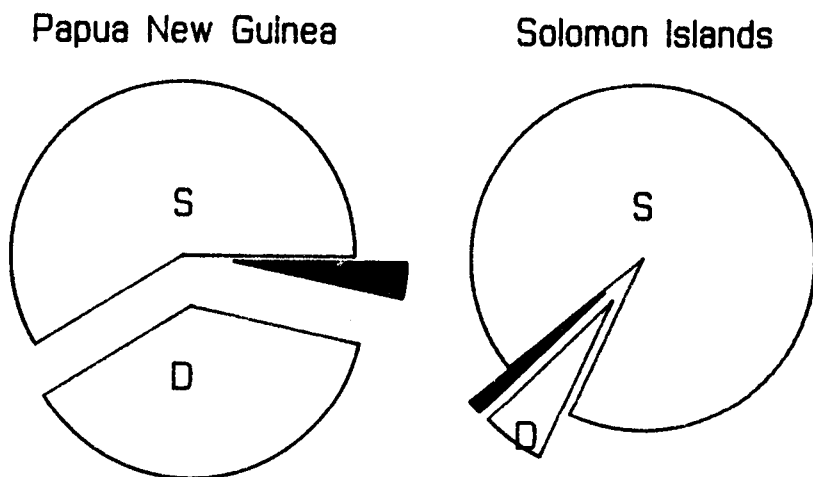


Figure 1. Relative proportions of tagged fish released in Papua New Guinea and Solomon Islands which survive without migrating (S), disappear for unknown reasons (D), and migrate to the other country (dark shaded); from Sibert 1984.

39. Exchange rates between fisheries, fishing intensity and natural mortality were combined in a new method to estimate interaction between countries in TBAP Technical Report No. 13 (Sibert 1984). The method is applied specifically to the interaction between Papua New Guinea and Solomon Islands. Figure 1 shows the estimated exchange rates, loss from natural mortality and movement to other fisheries, and the proportion that stay resident and live. The skipjack populations of the Solomon Islands are relatively stable with low rate of natural mortality and emigration, and small exchange with Papua New Guinea. The Papua New Guinea populations are more dynamic with a higher rate of natural mortality and emigration, but with small exchange with the Solomon Islands. As was seen in in Table 1 and will be discussed further, the fish don't seem to go to any other fisheries.

40. The general approach presented in Technical Report No. 13 was extended to include a larger number of fisheries (Hilborn 1986a). Figure 2 shows estimated survival and exchange rates when this method is applied to seven fisheries, including Palau, Yap, Truk, Ponape, Papua New Guinea, Solomon Islands, and the international waters between these countries. Again, the exchange rates appear to be quite low in agreement with previous analyses.

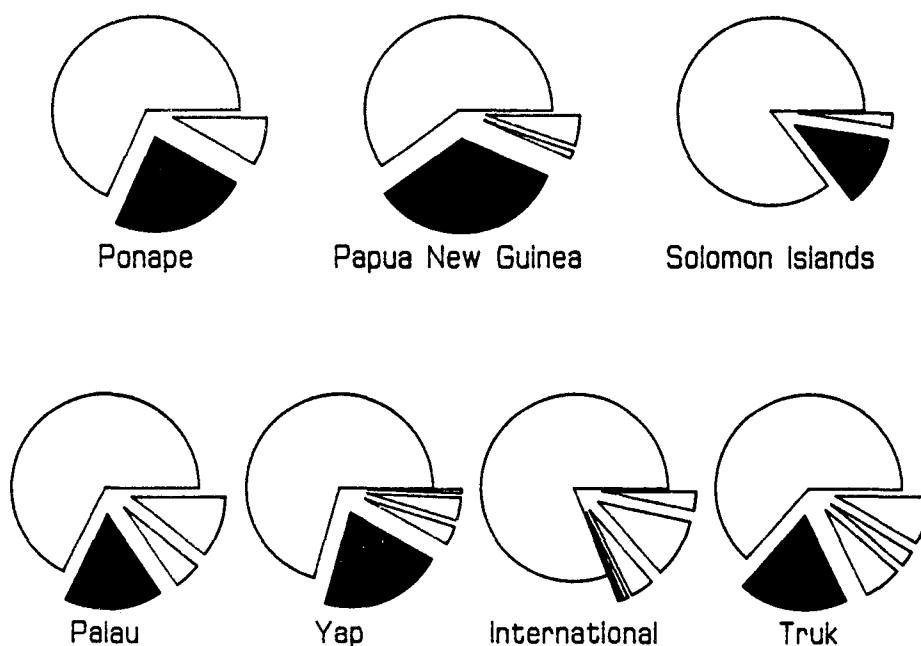


Figure 2. Migrations of tagged skipjack between pole-and-line fisheries in different areas. The area of release is indicated below each figure. The large sector represents the proportion of fish remaining in the fishery. The outset shaded sector represents the proportion of fish that die or migrate to unknown areas. The unshaded outset sectors represent the proportion of fish that migrate to known fisheries; from Hilborn (1986a).

41. Interaction between commercial gears can be analysed by adapting the same methods used for interaction between countries. In both cases, there are two fisheries operating on stocks connected by a rate of interchange or the per cent of fish in one fishery that move to the other fishery each year. This situation could be considered to be either two separate countries, or the interaction between a commercial fishery offshore and an artisanal or subsistence fishery inshore. The consequences of interaction may be expressed either in terms of changes in catch or in income from fishing. Figure 3 presents typical results from a paper by Tuna Programme staff (Hilborn 1985) where an intense fishery is affecting the catch and profitability in a low intensity fishery. The exchange rate between fisheries is plotted on the x axis and the level of sustainable catch and profitability in the affected fishery is plotted on the y axis.

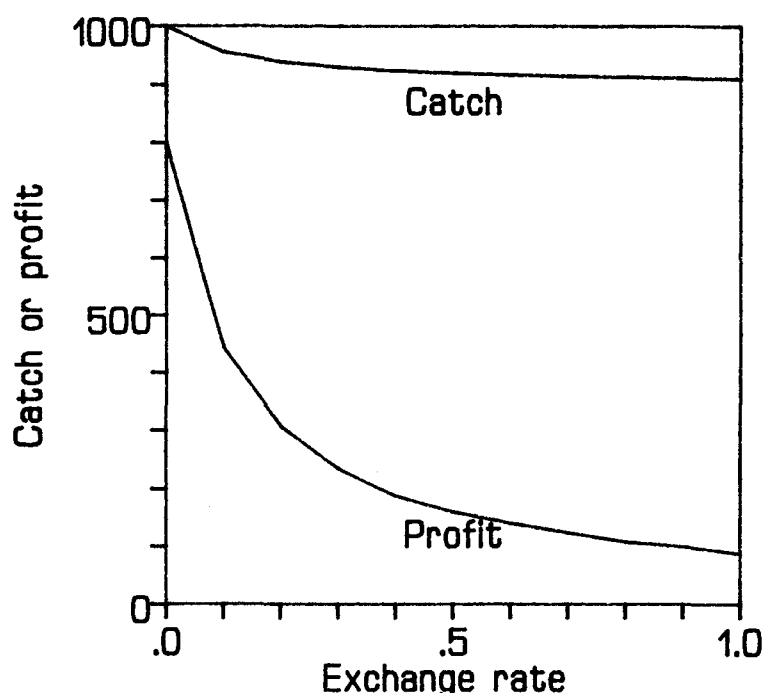


Figure 3. The relative effect of exchange rate between fisheries on catch and profits in the the effected fishery.

42. In this example, the level of catch is reduced by less than 10%, even with a very high exchange rate, while the level of profitability (closely related to CPUE) is much more strongly affected. We should note that the reason the catch is rather weakly affected even with high exchange rates, is that the intense fishery is not terribly intense. This graph highlights the most important feature that emerges from a quantitative analysis of movement; profitability and catch rates will be affected much more strongly than sustainable yield.

43. The potential for interaction between longline and purse seine fisheries is of general concern and has received attention from scientists from different countries (Lenarz and Zweifel 1979; Suzuki 1985; Fonteneau 1985, 1986). Tuna Programme scientists have completed two major studies of potential purse seine — longline interactions.

44. The Japanese do not use purse seine gear in the eastern part of the SPC region, and Tuna Programme staff used this fact to see if the catch rates by longline gear in the eastern part of the SPC region showed a different trend from the western part. Essentially, no difference was found and the conclusion is that there does not appear to be a strong direct interaction between purse seining and longlining for yellowfin given current purse seine intensities (Polacheck 1985).

45. The intensity of interaction between purse seine and longline fleets depends on the rate of exchange of fish between populations vulnerable to each gear type. Vulnerability to gear type is a function of the age or size of the fish and it is possible to calculate the total yield from a mixed gear fishery. Figure 4 from a paper by Hilborn (1986b) shows a typical result from such analysis. Plotted on the x axis is the purse seine fishing effort and plotted on the y axis is the longline effort. The lines on the graph represent contours of total dollar value of the catch. In this example, where it was assumed that the two stocks of yellowfin were highly connected, the optimum value of the catch is obtained with a very intense longline fishery and no surface (purse seine) fishery. If we assume that the two fisheries are only weakly connected, then the value of catch is maximized by a combination of a surface and longline fishery. The results from this analysis are highly dependent on the assumption about connectedness, and since we have almost no yellowfin tagging data in the western Pacific, we know very little about how closely related the surface and longline stocks of yellowfin are.

Conclusions

46. Given what we know from tagging and other biological studies on tuna in the western Pacific we can state the following conclusions:

- Tropical tunas, particularly skipjack, do not move much in relation to the size of the EEZs and natural mortality rates; interaction between countries is probably rather low.
- Reduction in CPUE will be the most severe manifestation of interaction between fisheries. As catches increase, these reductions will be most apparent in the major DWFN fisheries because of their size, but will also occur in local subsistence, artisanal and commercial fisheries. The intensity of the interaction will be related to the distance between the DWFN fleets and the local vessels.

- Interaction between surface and longline fisheries is potentially very important but no information is available to determine the exchange of individuals between these fisheries.
- Given the general lack of reliable data on subsistence and artisanal fisheries at the moment, even if an impact occurs from increased DWFN activity, it will be difficult to distinguish this from natural year to year and month to month changes in catch.

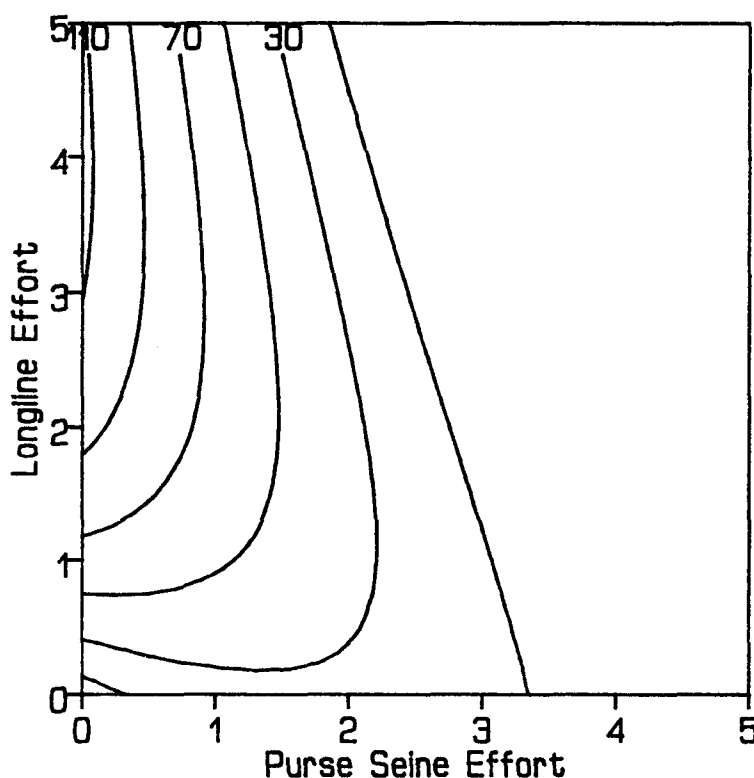


Figure 4. Contour lines of equal income from a mixed gear fishery. The x and y axes are the relative intensities of purse seine and longline fisheries. In this example, the stocks vulnerable to the two gear types are highly connected.

47. We have made considerable progress in the study of fishery interaction. Unlike other regions of the world, the western Pacific appears to have little need for concern about strong inter-country interaction. This conclusion simplifies the political problems of fishery management enormously. In this region we are fortunate to have considered the problem of interaction before it occurs, and although we do expect to see some effects of interaction between fisheries within an EEZ, countries should be in a position to monitor the impacts and respond to them.

Next Steps

48. Most of these conclusions are based on analysis of the Skipjack Programme tagging results and there are several good reasons why they should be treated with caution. The Skipjack Survey and Assessment Programme was an assessment programme and not specifically established to define details of movement. Tag releases were planned to coincide with local fisheries and thus seasonal movements in any one area are not readily apparent. Most tagging occurred prior to development of large-scale purse seining, and the current distribution and intensity of the tuna fishery is vastly different from the late 1970s pole-and-line fishery. More data are needed on movements of tuna under current conditions.

49. **Small-scale tagging.** In a pilot test in Kiribati in December 1986, one Tuna Programme scientist tagged and released about 140 skipjack and 50 yellowfin tuna from one of the *Te Mautari* pole-and-line vessels. Several of these tags have been returned by Japanese pole-and-line vessels operating in Kiribati and Marshall Islands. By negotiating cooperative arrangements with fishing companies for the loss of revenue due to tagging activities, this type of tagging programme has the potential to be an effective and economical means for releasing tags in areas where several fleets are in operation.

50. **Large-scale tagging.** The South Pacific Commission has been seeking funding for a large-scale tagging project to provide badly needed data on yellowfin tuna movement and population dynamics in the western Pacific, as well as to update information on the dynamics of skipjack fisheries since 1980. This project was given a very high rating in the regional request for funding from the EEC under the Lome III treaty and funding is expected in 1988.

51. **Re-analysis of Skipjack Programme data.** The results of the Skipjack Survey and Assessment Programme are one of the world's major blocks of tuna tagging data. These results have been well analysed in the context for which they were originally gathered — the assessment of regional skipjack stocks. Nevertheless, the definitive analysis of this data base is impossible without accurate information on the fisheries in operation during the period the tagged fish were at liberty. One of the priority activities of the Standing Committee on Tuna and Billfish will be the analysis of Skipjack Survey and Assessment Programme tagging results using real fisheries data.

Priority 3. Assessment and monitoring the levels of exploitation of stocks of commercially important tuna and billfish species.

52. Fisheries assessment is usually done to assist in the solution of management problems. In mature fisheries, a management problem may be the establishment of catch quotas. In developing fisheries, management problems are quite different. It is necessary therefore to find approaches to fisheries assessment which are appropriate to the management questions to be answered. Tuna Programme staff have published an analysis of the problem of appropriate assessment and management approaches for developing fisheries in South Pacific Commission Fisheries Newsletter No. 35 (Hilborn and Sibert 1986).

Production Models

53. Quantitative assessments of tropical tuna populations are generally based on the analysis of catch and effort data using methods known as "production models". Since the analysis of catch and effort data is fundamental to management of all fisheries, production models are applied to assessment of many species of fish. These models are widely used throughout the world for stock assessment and there is rich literature describing their theory and use (Schaefer 1954; Pella and Tomlinson 1969; Schnute 1977, 1985; Deriso 1980).

54. The concept of a production model is based on the common observation that catch begins to decrease as fishing effort increases to a high level. This relationship is presented in Figure 5 which illustrates a smooth increase in catch as effort increases and then a smooth decline. This particular curve is symmetrical, but it is possible to use almost any shape. The peak of this curve is often called "maximum sustainable yield" or MSY (also " C_{opt} ") and the effort which produces the MSY is called "optimum effort" (f_{opt}).

55. The analysis is often extended into economics. Revenue is closely related to catch so that the same hump-shaped curve can also be used to describe income from fishing. Costs on the other hand are related directly to fishing effort so that the relationship between cost and effort is a straight line. These relationships are presented in Figure 6. As long as the straight line representing costs lies below the curve representing income, the fishery is making a profit. The point where the lines cross is the break-even point where banks want fishing to stop. This point is usually beyond the MSY so that it would seem inevitable to slightly overfish the stock. There is very little incentive to fish at efforts beyond the break-even point, however, and thus very little possibility of obtaining data at very high fishing effort. Therefore, the exact shape of the curve is not only of little importance in a developing fishery, but it is also unknowable.

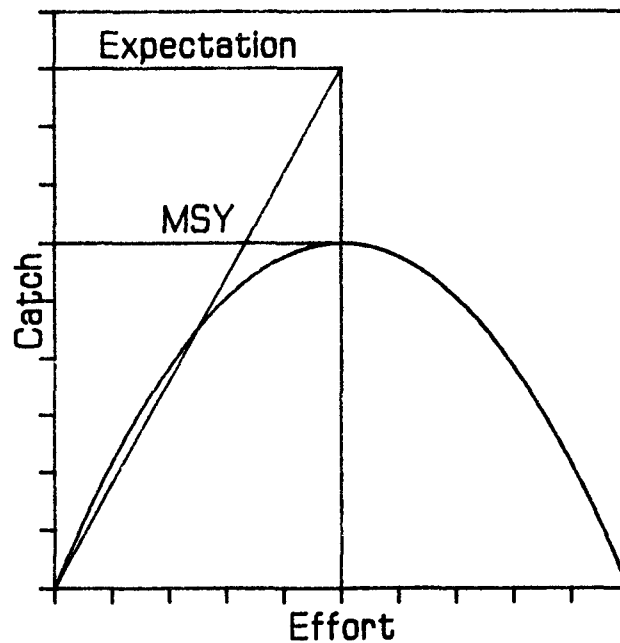


Figure 5. Hypothetical relationship between catch and effort in a simple production model. The top of the curve is called the "maximum sustainable yield". The straight line is an approximate extrapolation of the initial CPUE to the effort level required to produce the MSY.

56. The classical production model approach has a number of features which make it unsuitable for application to current tuna fisheries in the western Pacific.

57. Some applications of production models assume that the fish stock and the fishery are in equilibrium. This assumption does not allow for major changes either in gear efficiency or in apparent stock abundance. In the western Pacific, external forces, such as the El Niño phenomenon, cause major changes in apparent fish abundance (or at least in vulnerability to fishing) and also induce changes in fishing pattern. In addition, recent introduction of large-scale purse seining and increasing dependence on flotsam are both major shifts in gear efficiency.

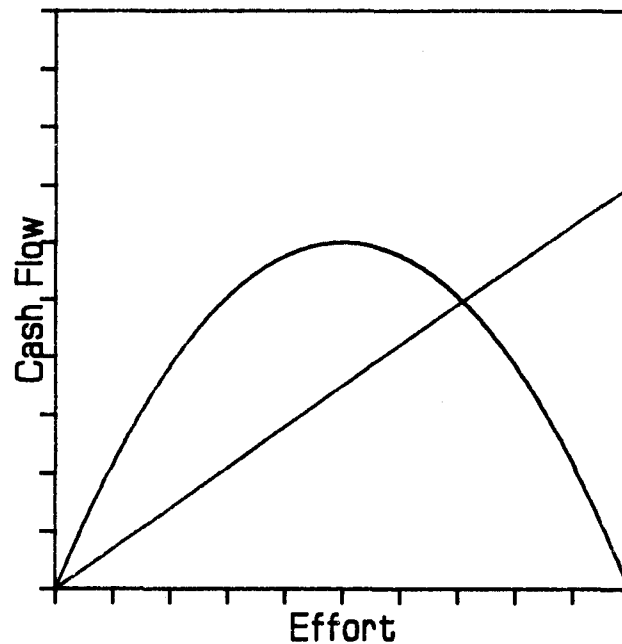


Figure 6. Economic extension of a simple production model. The hump-shaped curve represents the income from the fishery and is a simple multiple of the catch (ie. the catch multiplied by the price). The straight line represents the costs of fishing which is a simple multiple of the fishing effort (ie. there is a constant cost for each unit of fishing effort).

58. The western Pacific tuna fishery is a developing fishery, a fact which not only violates the assumption of equilibrium but also imposes practical limitations on the use of MSY as a development tool. The MSY concept can be misleading because it suggests that if fishing effort is set to the optimum, then the MSY can be harvested without further attention. While this may be the case in some mature fisheries, developing fisheries will by definition be operating well below the MSY. If the CPUE observed in the initial development of the fishery is used to predict the yield from the fishery when it is fully developed, economic losses can be guaranteed because CPUE decreases as effort is applied to the stock. Figure 5 shows the difference between yield at MSY and yield that might be expected based on initial estimates of CPUE. There is a possibility of serious economic losses if planning is based on the expectation that catch per effort (ie. profits) at MSY will be as high as during the initial stages of development.

59. In a developing fishery, there is typically no information from conditions of very high exploitation. Rather, there is, if there has been a policy of data collection, simply a record of increasing catch in response to increasing effort. Figure 7 illustrates this condition with data from the purse seine skipjack fishery in the western Pacific. An attempt to calculate MSY from data such as this would be an abuse of the data.

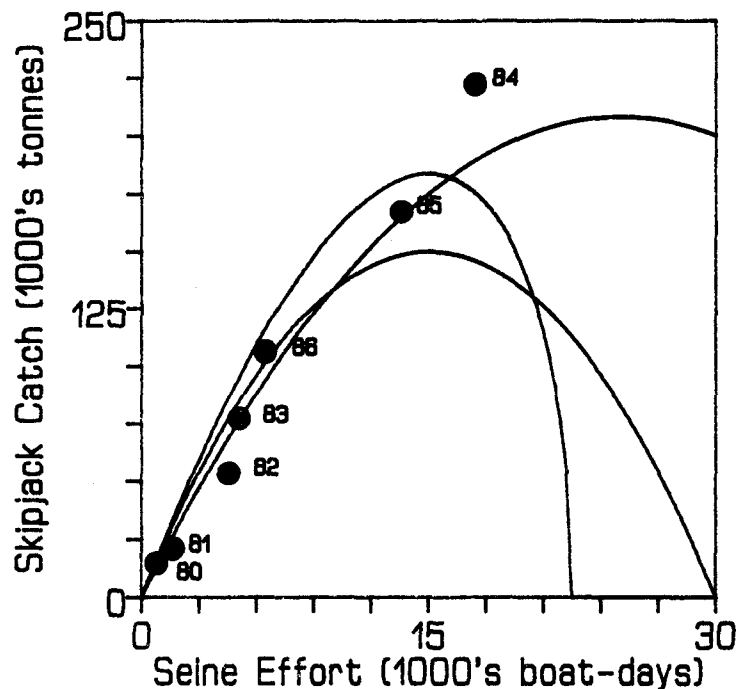


Figure 7. Attempts to fit production models to real data. The solid circles are annual purse seine fishing effort and skipjack catch in the western Pacific from the Tuna Programme data base. The curves represent production models assuming different values for MSY and optimum effort. Clearly, any one curve fits the points as well as the others.

Alternatives to Production Models

60. Tuna catches in the western Pacific have increased tremendously since 1979 with the introduction of purse seining, and it is important to know what current levels of exploitation are in relation to the ability of the stock to sustain further exploitation. Those responsible for developing and managing fisheries need to know how much catch can be increased without inducing intolerable levels of competition between fisheries or seriously damaging stocks.

61. The solution is not easy. It is necessary to systematically increase catches until the point is reached where catch begins to decrease. This common sense approach is not without its problems. It is difficult to be sure that an observed decrease in catch rate is due to overfishing or to some transitory climatic factor. Furthermore, it is inevitable that once the stock becomes fully exploited, some reduction in effort will be required. Developers and managers must understand this fact of life very clearly and be prepared for the consequences. These consequences need not be severe if the situation is understood from the beginning and if an adequate data gathering programme is in place.

State of the Fishery

62. An important activity of the Tuna Programme is the analysis of data holding to provide an up-to-date evaluation of the status of the tuna stocks in the region. These data reviews will soon be published quarterly in the South Pacific Commission Fisheries Newsletter. Major reviews are also produced and these have been presented to recent Technical Meetings as well as to larger audiences (SPC/Fisheries 18/WP.1 and SPC/Fisheries 19/Information Paper 1).

63. Figure 8 illustrates trends in catch per unit effort in the major fisheries for the period 1980-86. Figure 9 illustrates the relationship between catch and effort for the same period. In spite of the increased levels of exploitation, there are no clear indications that harvests have increased to the point that restrictions on overall fishing effort are required. Trends in CPUE are relatively unremarkable and catch is generally proportional to effort.

64. The yield of the fishery per unit area of fishing grounds relative to well-developed fisheries in other areas can be used as an index of the level of exploitation. In 1984, the year for which reported catch is highest, the total reported yellowfin harvest was approximately 93,000 metric tonnes. The number of 1° geographic squares in which there was fishing effort is equivalent to approximately 8,100,000 km². The productivity is therefore roughly 11 metric tonnes per 1000 km². In the eastern Pacific, the Inter-American Tropical Tuna Commission recommended catch to be taken from the Commission Yellowfin Regulatory Area (CYRA) is usually between 180,000 and 200,000 short tons per year. The area of the CYRA is about 10,000,000 km² and the productivity of the fishery is thus roughly 17 metric tonnes per 1000 km². (Note this estimate of CYRA productivity is certainly too low because some areas with no fishing effort were unavoidably included.) Therefore, the yield of the western Pacific yellowfin fisheries is less than its potential if the stocks are as productive as those in the eastern Pacific.

65. The two lines of evidence presented here — trends in CPUE and relative productivity by area — are consistent. On a regional basis, tuna stocks are currently exploited at a relatively low level and catches could be increased substantially without adverse effects.

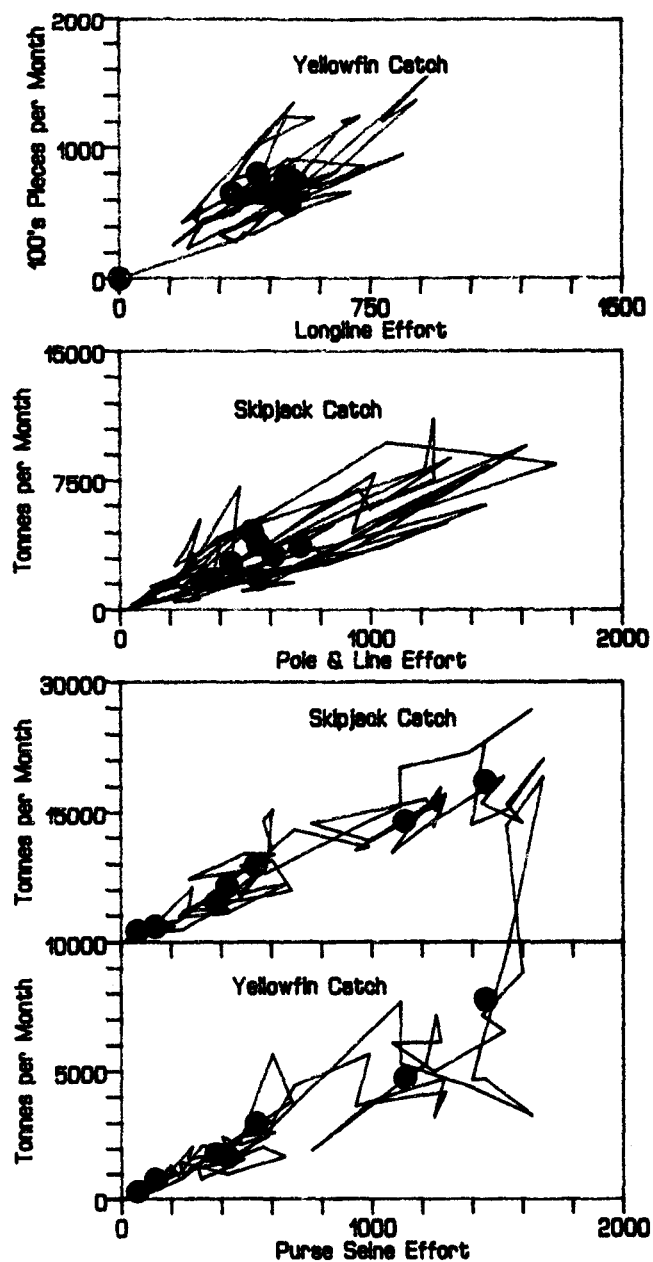


Figure 8. Catch per unit effort for the major tuna fisheries of the region. Lines connect monthly averages and circles are annual averages.

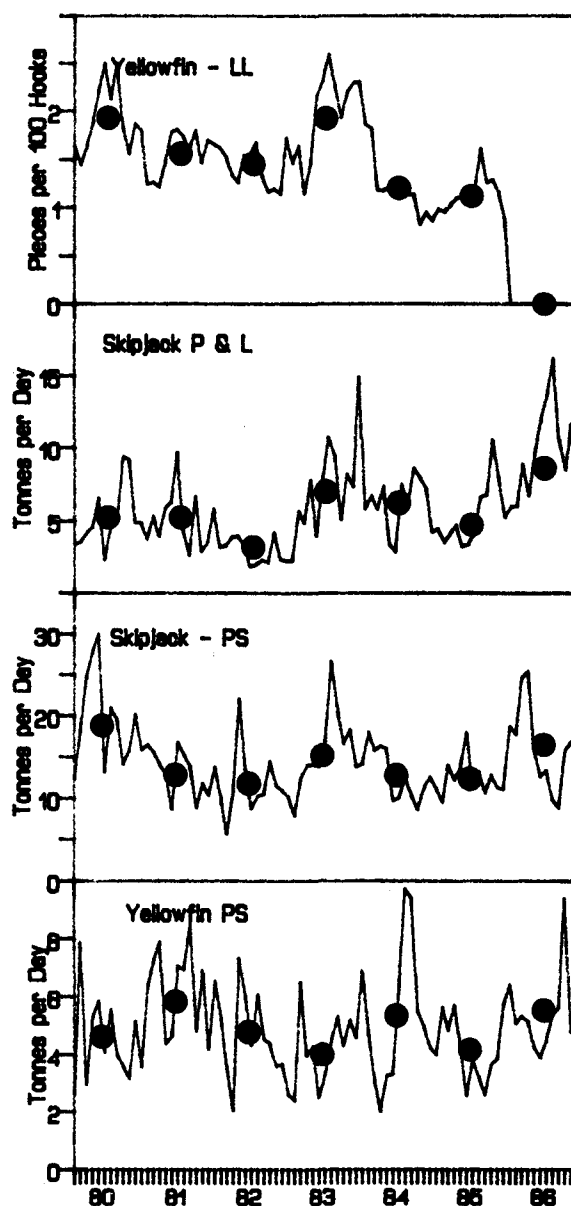


Figure 9. Relationship between catch and effort for the period 1980–86. Lines connect monthly averages and circles are annual averages. Effort units for purse seine and pole-and-line are days fished plus days searched; effort units for longline are hundreds of hooks.

Next Steps

66. While it is true that levels of exploitation on a regional basis appear to be relatively low, the local situation needs examination. Some tuna fleets operated in a coordinated manner and fishing effort is sometimes very intense in a localized area. Furthermore, many SPC countries are planning expansion of local fishing fleets. The effects of locally intense fisheries need to be examined and the condition of tuna stocks evaluated on an individual country basis.

Priority 4. Studies on the biology and ecology of commercially important tuna, billfish and bait species.

Ecology of commercially important tuna species: Tuna-Environment Studies

67. For two years, Tuna Programme staff have been collaborating with biologists and physical oceanographers from ORSTOM on the difficult problem of using data on the "climate" of the ocean to predict catches of tuna. Preliminary results of this work are presented in a separate paper prepared by the ORSTOM group.

Baitfish Studies

68. Two requests were received to study catches of baitfish supporting local commercial pole-and-line vessels and advise on developing effective methods of monitoring catches and maintaining statistics of baitfishing activities.

Kiribati Baitfishery

69. Baitfishing data from the Kiribati national pole-and-line fleet were compiled from the earliest log-book records and from other surveys conducted in Kiribati into a common format. The method of recording these data already in use by the fleet managers was revised to improve ease of use and consistency for future assessment purposes. Artisanal fisheries data compiled by the Fisheries Division were used to examine potential interactions between the commercial baitfishing operations and local fisheries. The data were analysed to assess the impact commercial baitfishing may have on :

- local fishing communities;
- the lagoon ecosystem;
- the natural baitfish stock condition, and
- baitfish productivity in relation to future development of the local pole-and-line fishery.

70. One species, *Herklotsichthys quadrimaculatus*, is caught by both artisanal fishermen and the pole-and-line vessels. However, the latter do not appear to exploit these as effectively as other species due to the erratic attractability of this species to night-lighting. Beach-seining by the pole-and-line vessels in the past has led to complaints by locals that *H. quadrimaculatus*, otherwise available to their cast-nets, become too scarce. In response, the commercial vessels have curtailed beach seining in these areas. Indirect interaction effects between these fisheries, such as reduced abundance of fish lower on the food chain depressing the abundance of commonly utilized food species, were not possible to assess explicitly. Incidental removal of juvenile and larval species of fish and invertebrates is considered insignificant based on several hundred observations of bouki-ami in other areas. In general, it is considered that the whole ecosystem effect of baitfish harvesting would be slight in view of many other factors contributing to variable abundance of reef species.

71. Catch rate patterns did not show trends indicative of overfishing for all baitfish species combined. For individual species, compensating shifts of apparent abundance were noted between the sardine *Amblygaster sirm* and *H. quadrimaculatus*. In the early part of the pole-and-line baitfishery, the catch rate for *A. sirm* was quite high and the catch rate for *H. quadrimaculatus* relatively low. Over a two- to three- year period the apparent abundance shifted in favour of *H. quadrimaculatus*. A possible explanation for this phenomenon is that *H. quadrimaculatus* met with more favourable recruitment conditions while *A. sirm* met with increasingly poorer ones.

72. In summary, the current practices of the pole-and-line baitfishery within Kiribati do not appear to interact directly with local fishing methods by overfishing common food species (*H. quadrimaculatus*), or indirectly, by depleting species that other food-fish eat. With regards to future development plans for the pole-and-line fleet, in view of variable availability and catch rates of certain baitfish species, continued production of milkfish is encouraged. While increases in baiting effort, i.e. the addition of more boats, may not contribute to decreases in catch rates over time, the variability of the catch rates for short periods of time will continue to be a problem for continual operation of pole-and-line vessels.

73. Based on the observations and analyses, the following recommendations were offered which may be of application in other areas:

1. Restrict beach seining activities by commercial pole-and-line vessels in areas where local fishing communities regularly rely on catching *H. quadrimaculatus*;
2. Encourage accurate collection of baitfishing details, particularly the number of sets during a given night, species composition of the catch, and the number of standard buckets loaded;
3. Improve the quality and quantity of milkfish to enhance baitfish supply during periods of low natural bait catches.

Fijian Baitfishery

74. A Tuna Programme scientist spent two weeks working with staff in the Fiji Fisheries Offices in order to :

- assist in modernizing the way baitfish data are handled and processed;
- conduct investigations on the catch patterns of the pole-and-line fleet by species and area over a broad time period, and
- provide follow-up statistical training for a fisheries officer specifically in the use of computer software packages with data bases for conducting analyses and generating reports.

75. The importance of managing a data base system on the commercial fisheries and using this data to perform analyses on the baitfish stocks of Fiji was stressed by the Fisheries Division staff. In recent years, the question of proprietary rights of certain baitfishing sites has become an issue between the commercial fishermen and the local government councils. The Fisheries Division in the past has been required to report on the baitfish catch from a specific area, of which there are over 120 different sites. This outlined one of the requirements of a data base system for the data the department normally collects. Prior to this, such data retrievals at a moment's notice were difficult, if not impossible. In terms of conducting a scientific analyses on the baitfish stocks, the complexity of the situation necessitates a flexible approach to data base access. The multispecies nature of the fishery, and the fluctuating abundance of small pelagic species in general, requires a systematic, well-planned, approach to data summarization.

Future Studies

76. Work on baitfisheries during the past year demonstrated concern for potential effects of commercial baitfisheries on subsistence fishing and the need for accurate record keeping. The Tuna Programme is ready to extend these studies in other countries when requested and to cooperate with other organizations involved in baitfish research.

Priority 5. Provision of fisheries observers and advice on development of observer programmes.

77. No requests were received from countries for further training of on-board fisheries observers. The South Pacific Commission observer manual has been revised and published.

78. A major increase in observer activity is expected in relation to the multilateral fishing agreement with the USA. Tuna Programme staff are working closely with the FFA to organize these activities.

Priority 6. Monitoring the use of fish aggregation devices.

79. Few activities were undertaken under this priority during the past year. As mentioned above in the review of fisheries interaction, one Tuna Programme scientist tagged and released about 140 skipjack and 50 yellowfin tuna from a local pole-and-line vessel operating around a FAD on the Maiana Bank in Kiribati. Tagging projects of this scale could be done in other countries in which there are substantial commercial fisheries operating on FADs.

Priority 7. Provide assistance to countries in the implementation of appropriate systems to monitor artisanal and subsistence fisheries.

80. In January 1987, a Tuna Programme scientist made a preliminary assessment of the artisanal and subsistence fisheries of Malaita Province in Solomon Islands. The principal objective of the visit was to evaluate data collection possibilities. In the process, the information on the size and distribution of the artisanal fleet was updated and the different fishing methods were described. The subsistence fishery was also censused through direct observation and interviews.

81. Plans were completed for a project to improve data collection procedures in Palau. A consultant biostatistician has been identified and work is to begin in November.

82. The system in place in Tuvalu is continuing and the person involved recently received additional training in Japan. Tuna Programme staff continue to offer advisory services when required.

83. Analysis of the collection of fisheries statistics in general suggests several common problems. The collection of accurate statistics is often not given real priority. As a consequence, the responsibilities for data collection are not clearly defined and other apparently more urgent tasks interfere with data collection and analysis. The importance and purposes of data collection are often not understood by those actually doing the job. Finally, more training is required in data handling practices in general and in the use of computers for the maintenance and analysis of fisheries statistics.

Priority 8. Provide assistance to countries in training fisheries biologists in various aspects of quantitative fisheries methods.

84. In the course of providing assistance in the analysis of problems related to baitfisheries, Tuna Programme staff have been able to provide considerable assistance to fisheries staff in the collection and analysis of baitfish data. Assistance included the design of suitable forms for the collection of data and the implementation of microcomputer systems for the manipulation of baitfish data.

85. As a follow-up to the baitfish work, a Fijian fisheries officer spent two weeks at South Pacific Commission headquarters refining microcomputer skills.

86. As a follow-up to field work in Tonga, the fisheries officer responsible for collection of fisheries statistics in Tonga spent two months at SPC headquarters. He received a complete introduction to microcomputer administration and the use of commercial software for the collection and analysis of fisheries statistics.

References

- Deriso, R.B. 1980. Harvesting strategies and parameter estimation for an age-structured model. *Canadian Journal of Fisheries and Aquatic Sciences* 37:268-282.
- Fonteneau, A. 1985. Surface versus longline tropical fisheries in the Atlantic Ocean: what interactions? Paper presented at the Expert Consultation on the Stock Assessment of Tuna in the Indian Ocean, 28 November – 2 December 1985, Colombo, Sri Lanka.

- Fonteneau, A. 1986. Competition between tuna fisheries; a critical review based on Atlantic examples. Paper presented at the Indian Ocean Fishery Council Conference, 4-12 December 1986, Colombo, Sri Lanka.
- Francis, R.C. 1974. TUNPOP, a computer simulation model of the yellowfin tuna population and the surface tuna fishery of the eastern Pacific Ocean. *Inter-Amer. Trop. Tuna Comm. Bull.* 16:233-279.
- Francis, R.C. 1977. TUNPOP: a simulation of the dynamics and structure of the yellowfin tuna stock and surface fishery of the eastern Pacific Ocean. *Inter-Amer. Trop. Tuna Comm. Bull.* 17:215-269.
- Hilborn, R. 1985. Spatial models of tuna dynamics in the western Pacific: is international management necessary? Paper presented at the Second Workshop of Renewable Resource Management (9-12 December 1985), Honolulu, Hawaii.
- Hilborn, R. 1986a. Analysis of fish tag movements by the method of maximum likelihood. (Unpublished manuscript.)
- Hilborn, R. 1986b. Interaction between surface and longline fisheries for yellowfin tuna (*Thunnus albacares*). (Unpublished manuscript.)
- Hilborn, R. and J.R. Sibert 1986. Is international management of tuna necessary? *Fisheries Newsletter* No.39, South Pacific Commission, Noumea, New Caledonia.
- Ishii, T. 1979. Attempt to estimate migration of the fish population with survival parameters from tagging experiment data by the simulation method. *Inv. Pesq.* 43:301-317.
- Kleiber, P., A.W. Argue, J.R. Sibert and L.S. Hammond. 1984. A parameter for estimating potential interaction between fisheries for skipjack tuna (*Katsuwonus pelamis*) in the western Pacific. *Tuna and Billfish Assessment Programme Technical Report* No. 12, South Pacific Commission, Noumea, New Caledonia.
- Lenarz, W.H. and J.R. Zweifel. 1979. A theoretical examination of some aspects of the interaction between longline and surface fisheries for yellowfin tuna (*Thunnus albacares*). *Fish. Bull.* 76:807-825.

- Pella, J.J. and P.K. Tomlinson. 1969. A generalized stock production model. *Inter-Amer. Trop. Tuna Comm. Bull.* 13:421-496.
- Polacheck, T. 1985. Yellowfin tuna (*Thunnus albacares*) catch rates in the western Pacific. (Unpublished manuscript.)
- Schaefer, M.B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Inter-Amer. Trop. Tuna Comm. Bull.* 1:25-56.
- Schnute, J. 1977. Improved estimates from the Schaefer production model: theoretical considerations. *Journal of the Fisheries Research Board of Canada* 34:583-603.
- Schnute, J. 1985. A general theory for analysis of catch and effort data. *Canadian Journal of Fisheries and Aquatic Sciences* 42:414-429.
- Sibert, J.R. 1984. A two-fishery tag attrition model for the analysis of mortality, recruitment and fishery interaction. *Tuna and Billfish Assessment Programme Technical Report No. 13*, South Pacific Commission, Noumea, New Caledonia.
- Suzuki, Z. 1985. Interaction study on yellowfin stock between longline and purse seine fisheries in the western Pacific. Paper presented at the Expert Consultation on the Stock Assessment of Tuna in the Indian Ocean, 28 November - 2 December 1985, Colombo, Sri Lanka.