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Shimizu, Japan, 23-31 January 1995

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SUMMARY REPORT

of the

SECOND FAO EXPERT CONSULTATION

ON INTERACTIONS OF PACIFIC TUNA FISHERIES

Shimizu, Japan, 23-31 January 1995

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This publication results from the Second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. The Consultation was hosted by the National Research Institute of Far Seas Fisheries in Shimizu, Japan, from 23-31 January 1995. The Consultation was organized by the FAO Trust Fund project "Cooperative Research on Interactions of Pacific Tuna Fisheries", in close collaboration with regional and national institutions involved in tuna fisheries research in the Pacific (see Acknowledgments).

The information presented at the Consultation was compiled by TUNET, a network of ten Working Groups organized by the FAO project. That information was contributed by scientists of regional and national institutions studying tuna stocks and fisheries, mainly in the Pacific, but also in other areas.

Distribution

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studying tuna fisheries interactions in the Pacific)

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ABSTRACT

This publication presents the Summary Report of the Second FAO Expert Consultation of Interactions of Pacific Tuna Fisheries held in Shimizu, Japan from 23-31 January 1995. The objectives of the Consultation were to:

- review and integrate the outcome of the studies on tuna fisheries interactions,
- summarize the extent of tuna fisheries interactions and unresolved research problems and
- formulate guidelines for research on tuna fisheries interactions.

These objectives concentrated on biological aspects of skipjack and yellowfin tuna in the Pacific and are addressed in the Summary Report.

The Consultation concluded that concerns about interactions among Pacific tuna fisheries are likely to increase as fisheries further develop in the future. The number of quantified interactions has increased, but it is still small due to difficulties associated with evaluating such interactions. The understanding of fisheries interactions has been also significantly enhanced.

Tuna fisheries interactions vary in significance, depending on the biological characteristics of the species involved, the sizes of fish caught, the local and stock-wide rates of exploitation, and the distances among fisheries. Based on these relationships, general qualitative guidelines on the likely extent of interactions are presented.

Only specifically-designed studies may adequately quantify interactions among tuna fisheries. Comprehensive research guidelines are offered for such studies. Well-designed tagging experiments studies may provide the most reliable information about interactions. Guidelines for the collection of data, biological and ecosystem research, modelling, and alternative methodologies for studying tuna fisheries interactions are also included.

Interactions may be reduced by decreasing the intensity of fishing, and by increasing the distances among fisheries.

ACKNOWLEDGMENTS

The editors of this document thank the Organizing Committee, session moderators, rapporteurs, and participants of the Consultation for their efforts and collaboration in preparing the Summary Report (see Appendix A). Thanks are also due to the authors and reviewers of papers presented at the Consultation for their valuable contributions.

The Consultation was made possible through the close cooperation of tuna fishery researchers in the Pacific region. Funds for organization of the Consultation were provided by the Government of Japan. Technical expertise, data, computer facilities, and funds for preparatory work, and for the Consultation itself, were contributed by many institutions, especially:

- Commonwealth Scientific and Industrial Research Organization (Hobart, Australia),
- FAO/UNDP Indo-Pacific Tuna Programme (Colombo, Sri Lanka),
- Inter-American Tropical Tuna Commission (La Jolla, USA),
- International Commission for the Conservation of Atlantic Tunas (Madrid, Spain),
- Institut Français de Recherche Scientifique pour le Développement en Coopération (Noumea, New Caledonia),
- National Research Institute of Far Seas Fisheries (Shimizu, Japan),
- Southeast Asian Fishery Development Center (Kuala Terengganu, Malaysia),
- South Pacific Commission (Noumea, New Caledonia), and
- South Pacific Forum Fisheries Agency (Honiara, Solomon Islands).

National research laboratories in many countries of Latin America, Southeast Asia, and the South Pacific also contributed significantly to the work before and during the Consultation.

Particular thanks are extended to the host of the Consultation, the National Research Institute of Far Seas Fisheries, and to local organizers, Drs Ziro Suzuki, Sachiko Tsuji, and Tsutomu Nishida of that institute.

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SECOND FAO EXPERT CONSULTATION ON INTERACTIONS OF PACIFIC TUNA FISHERIES

Shimizu, Japan
23-31 January 1995

SUMMARY REPORT

1. OFFICIAL OPENING

The Second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries (hereafter referred to as the Consultation) was called to order at 10.00 hours on 23 January 1995 in the meeting room of the Hinode Center, Shimizu, Japan, by the Chair, Mr. Richard Shomura. Mr. Shomura introduced Dr. Hiroshi Hatanaka, Director of the National Research Institute of Far Seas Fisheries, who officially opened the Consultation. Dr. Hatanaka welcomed participants to Shimizu and noted the importance of tuna research to his Institute. He extended his wishes for a successful Consultation, which could contribute greatly to sustainable use of tuna resources in the world.

Mr. Shomura introduced Dr. Jacek Majkowski of FAO. On behalf of FAO, Dr. Majkowski welcomed all distinguished guests and participants of the Consultation. He cordially thanked the National Research Institute of Far Seas Fisheries for hosting the Consultation, and expressed gratitude to the government of Japan for its significant financial contribution to the Consultation through an FAO Trust Fund. Dr. Majkowski also acknowledged the major contributions of various other countries, their fisheries research institutions, and scientists that made holding the Consultation possible. He also outlined the objectives of the Consultation (see the Preface section and the Programme of the Consultation in Appendix A).

2. ADOPTION OF AGENDA

Following the Opening Session, Mr. Shomura introduced the Provisional Programme and noted the several changes to the Agenda. The revised Programme (Appendix A) was officially accepted by the participants. Lists of participants and contributed papers for the Consultation are given in Appendices B and C, respectively.

3. BACKGROUND INFORMATION

The rationale for focussing the Consultation on the Pacific tuna fisheries and the importance of tuna fisheries interaction were described by J. Majkowski (Paper 1). The Pacific is the dominant producer of tunas and tuna-like species in the world; in 1991, its reported catch of 3 million metric tons represented about 68% of the world's catch of tuna and tuna-like species. The 1991 Pacific catch was about 68% greater than the 1980 Pacific catch. This dramatic increase resulted from an increase in fishing effort and a geographical expansion of fishing areas, factors which could lead to a higher incidence of tuna fisheries interactions. Recent attention to fisheries management of highly-migratory species is reflected in the outcome of the International Conference on Responsible Fishing, the FAO-organized Technical Consultation on High Seas Fishing, the United Nations Conference on Environment and Development, and the Sessions of the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Species. These meetings have led to the development of an International Code of Conduct of Responsible Fishing. An integral part of this Code of Conduct will be the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. Regardless of this interest in the management of tuna fisheries, the Pacific is the only ocean where there is neither an all-encompassing fishery body, nor a technical programme for tuna and tuna-like species that would encompass the entire ocean. J. Majkowski also outlined the relationship between the Consultation and the FAO project sponsoring it, including the objectives of the project. He indicated that the outcome of the previous Consultation (First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries) provided a challenge to the scientific community to determine whether there are only few interactions, or that interactions exist that scientists have not detected to date.

The difficulties in studying tuna interactions were summarised in a paper entitled "Common Themes in the Proceedings of the First Consultation on Interactions of Pacific Tuna Fisheries" by R. Shomura (Paper 2). A review of the papers presented at the First Consultation noted that studying tuna fisheries interactions by analysing fisheries data and statistics faced shortcomings in fisheries data, including insufficient standardisation, lack of pertinent data, and difficulties in gaining access to data. While tagging may provide direct evidence of interaction, this type of information also has its shortcomings, such as tagging-related mortality, tag loss, non-reporting of tag recoveries, uneven distribution of tag releases, lack of fishing effort in some areas of species distribution, high cost of tagging experiments, and the relatively extended time needed to implement tagging experiments. While understanding tuna interactions by use of dynamic models appears to show considerable promise, it was generally recognised that models to describe tuna fisheries interactions are still in the early developmental stages.

4. FACETS AND TYPES OF TUNA FISHERIES INTERACTIONS

(Moderator - G. Sakagawa, Rapporteur - P. Callaghan)

Research on tuna fisheries interactions has largely focussed on the biological elements of the interaction. However, it is recognised that there are many ways, besides biological effects, in which activities in one fishery can affect the performance of another fishery. These cause-and-effect forces are collectively referred to as "fisheries interactions". The search for management solutions to fisheries interaction and its associated problems will require an understanding of the relationships involved. These relationships are extremely complex, and often include environmental, biological, economic, political, and social aspects.

Six papers were presented during this session. The first paper (Paper 3), presented by P. Kleiber, contained suggestions for the classification of fisheries interactions. It lists three broad categories (see Figure 1):

1) market-related interactions, where price, cost, and competitive conditions in one fishery affect activities in another fishery;

2) gear interactions, where the deployment of gear in one fishery interferes with fishing activity in another fishery; and

3) stock-mediated interactions, where fishing effort in one fishery has an impact on the abundance or availability of the target fish population in another fishery. The stock-mediated category is further subdivided into:

   a) direct interactions, which arise between fisheries aiming to harvest the same individuals, and

   b) secondary interactions, which result as one fishery impacts the resources of another fishery.

In addition, both the direct and secondary categories have temporal and spatial (geographic) dimensions. The temporal dimensions consist of concurrent, consecutive, recruitment, and trophic categories, while the spatial dimensions range from coincident to remote.

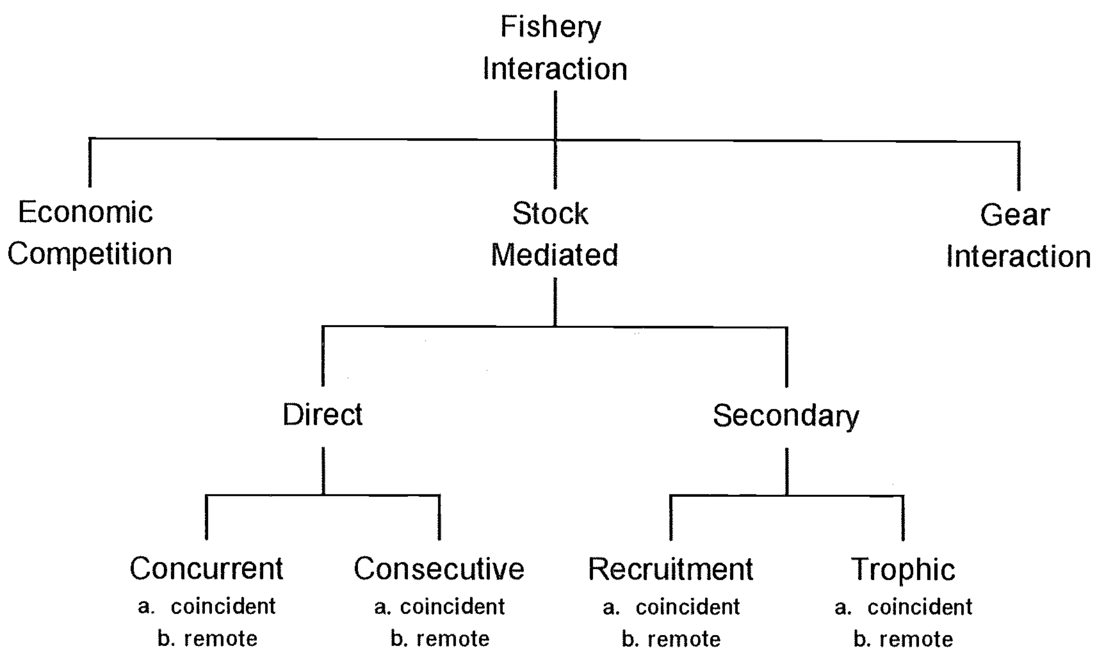

Figure 1. Schematic typology of fishery interaction mechanisms (adapted from Kleiber, Paper 3).

The second paper (Paper 5) by T. Kingston provided further information on the types of tuna fishery interaction problems faced by the South Pacific Forum Fisheries Agency (FFA) member countries, the implications of these problems, and the measures being taken to address them. In light of growing populations and the needs of developing countries, fisheries management must involve more than just resource stability. Management must also take into account the political and economic realities involved, while attempting to maximise the flow of benefits from fishery resources.

The third paper (Paper 7), presented by J. Hampton, provided evidence that effort to understand, assess, and manage fisheries interactions is supported in Article 5(a) and Article 7 of the "Draft Agreement for the Implementation of the Provisions of the United Nations Convention of the Law of the Sea of 10 December 1982, relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks." Article 5(a) of the Draft calls for "conservation and management measures to ensure long-term sustainability and promote optimum utilization of straddling fish stocks and highly migratory fish stocks." Article 7 requires that compatible conservation and management measures be applied to straddling stocks and highly-migratory stocks throughout their range. Accomplishing the intent reflected in both of these Articles will clearly require an understanding of the processes involved in fisheries interactions.

Two papers presented evidence of implied tuna fisheries interactions in the Atlantic Ocean (Paper 4, presented by P. Miyake) and in Philippine waters (Paper 6, by N. Barüt). The evidence in both papers was based on recaptures of tagged fish and comparisons of catch levels and size/age differences between fish harvested by longlines and a variety of surface gears in adjacent and separated locations. It was recognised that while these methods present indication of possible fisheries interaction, they do not confirm its existence or provide a measure of its intensity. Both presenters recognised the need for further research and the consideration of a wide variety of influences.

A paper by R. Shomura, R. Harman, and G. Sakagawa (Paper 8) provided a review of three examples of pelagic fisheries interactions in the Pacific (eastern Pacific dolphin, high-seas gillnet, and Hawaii pelagic fisheries), and noted the critical role played by human interaction in the management decisions related to each of the cases.

In the discussion, it was noted that special-interest groups are often able to arouse public opinion to the extent that management actions are initiated which may not be based on the best available scientific information. On the other hand, scientifically-supported management measures which are aimed at obtaining the best biological or economical yield are often frustrated because they lack consideration of political or social reality (See Paper 4 by P. Miyake and P. Kebe). Humans, not fish, initiate and propose solutions for fisheries interactions. This state of affairs points to the need for inclusion of social, cultural, and economic considerations, as well as biological and environmental factors, into the study of interaction processes and in the development of options to ameliorate these effects. It also suggests a need for the scientific community to make efforts to increase public understanding of the complex forces involved in fisheries interactions and the technical elements involved in the formulation of rational solutions.

With increasing demand for scarce fishery resources, it is inevitable that interaction problems will become increasingly entwined with conservation and allocation considerations. A clear understanding of the interaction relationships within and among fisheries is absolutely necessary if optimal resource management is to be achieved.

5. REVIEW OF STUDIES ON TUNA FISHERIES INTERACTIONS

(Moderator - R. Shomura, Rapporteurs - J. Ianelli, G. Sakagawa, and W. Bayliff)

A wide range of papers was presented in this section. In order to provide a mechanism for orderly discussions, papers were grouped as (1) General Methodology, (2) Data Information, (3) Yellowfin Tuna, (4) Skipjack Tuna, (5) Albacore, (6) Bluefin Tunas, (7) Small Tunas, and (8) Others. There were no specific papers on bigeye tuna, however, the species was included in several discussions. Although the Consultation focussed on Pacific tuna fisheries interactions, it was recognised that tuna interactions also occur in other oceans and adjacent seas. Thus, relevant interaction papers from other regions were included.

5.1 General Methodology

M. Bertignac began this session with presentation (Paper 9) of a simulation model for tagging experiments in the western Indian Ocean. The study objectives included analyses on the number of releases required for reliable parameter estimates and a measure of the extent of interactions between commercial purse-seine fisheries and small-scale artisanal fisheries. Precision-of-movement parameters increased with greater numbers of releases and recaptures. Also, the interaction coefficient, as presented, was more reliably estimated for higher levels of recaptured fish in the affected fishery. The need to tag fish in both fisheries appeared to be important. The ensuing discussion noted that an advection coefficient was not used in this model and that in some cases this might be useful. Evidence from tagging results in the Atlantic show regular advective movement of adult yellowfin tuna between the western and eastern Atlantic. The geographical distribution of yellowfin tuna sizes taken in the Indian Ocean suggests that a similar advective pattern may exist in the Indian Ocean. Relatively few returns were required to get a good coefficient of variation; this was attributed to the relative simplicity of the model.

W. Hearn presented some new features of his experimental approach to studying interactions among fisheries in separate grounds (Paper 10). Key features of the method developed in this study is that tagging is not required in the affected fishery and estimation of parameters of the underlying population model is not required to evaluate the interaction. In addition, effort data are not required. A modification of his methodology allows the requirement of re-releasing tagged fish in the first fishery to be relaxed.

P. Kleiber presented a basis of a model for studying interactions of yellowfin tuna fisheries in the western Pacific (Paper 11). The model involves the adaptation of an age-based model used for South Pacific albacore to yellowfin and extending the model to be spatially disaggregated. The model is specifically designed to accommodate missing data and to incorporate disparate sources of data. Once parameter estimates are attained, interactions among fleets can be investigated by varying the effort of one fleet in the model and noting the change in catch of other fleets. There was some concern that it may be difficult for the model to estimate transfer rates for the larger fish.

5.2 Data Information

W. Bayliff presented a brief history of his indexed bibliography of papers on tagging of tunas and billfishes (Paper 12). This compilation is worldwide, and is available in electronic (computer) form.

S. Moberly presented a demonstration of software which generates reports from the Northwest Marine Technology™ archival tag (Paper 17). The main feature of this software is the facility with which data can be displayed and reviewed from archival tags.

A. Mullen presented a paper which described his research into data relevant to a study of tuna fisheries interactions in the Philippines and Indonesia (Paper 13). He noted the role of baitfish in tuna fisheries interaction, an aspect which had not previously been considered. It is unlikely that fishing for bait limits the food of tunas. However, there are other indirect limitations in terms of bait production due to degradation of baitfish habitat in mangrove areas and the use of baitfish as food for local communities. It was noted that several tuna canneries are apparently operating below capacity.

P.E. Chee presented a paper on the monitoring of Taiwanese tuna longliners landing at Penang Harbour, Malaysia (Paper 14). The tuna landed are primarily fresh yellowfin and bigeye. About 50-60% of the catch is air-freighted to Japan for the sashimi market; the remainder is frozen and exported for canning. The vessels are generally made of fibreglass, and range from 50-80 tons (GRT). The landings appear to be very seasonal; also, the average weights appear to be highest during winter. The seasonal pattern observed in the data may be attributed to market conditions.

D. Moon presented a paper on the long-term trends of yellowfin tuna catch-per-unit-effort (CPUE) of the Korean tuna longline fishery and purse-seine catch of yellowfin in the Pacific Ocean (Paper 15). In this paper, a case was made for lack of evidence of interaction between purse-seine and longline fisheries on yellowfin tuna. It was pointed out that the longline catch rates are presented as nominal catch rate, and some standardisation may be appropriate. During the discussion, it was noted that the declining purse-seine catch rates for the Korean fleet has not been apparent in the catch rates for other fleets.

N. Miyabe presented a paper on problems with species identification of juvenile tunas in the catches of the surface fisheries in the Philippines (Paper 16). The importance of correctly identifying different species of tunas at juvenile stages was discussed and morphological and genetic analyses were presented. The present sampling showed that 23% of juvenile fish reported as yellowfin tuna are bigeye. This suggests that large quantities of juvenile bigeye tuna may be caught in Philippine waters. As the catch of large numbers of bigeye tuna by surface fishing may be of great importance to interactions with the longline fisheries, sampling for species composition should be actively pursued in order to estimate the amounts of the various species of tuna caught.

J. Sibert made a presentation about the cooperative arrangement, created by the Western Pacific Regional Fishery Management Council, between the University of Hawaii and the US National Oceanic and Atmospheric Administration, to conduct research on pelagic fisheries to assist the Council in its effort to manage pelagic fisheries in American Samoa, Guam, Hawaii, and the Northern Mariana Islands. Several projects are underway that are relevant to the study of fishery interaction. These include a yellowfin spawning study, a small-scale tagging project, and development of an analytical movement model.

J. Hampton made a presentation of current research activities on fishery interaction in the central and western Pacific. Currently there is a limit of 205 purse-seine vessels in the western and central Pacific. Whether this limit is appropriate is unknown, in terms of the economic benefits to the Pacific Island countries. The South Pacific Commission (SPC) is collaborating with FFA and the University of Queensland to develop a multi-fleet, multi-species model to assess the economic benefits of different levels of purse-seine effort. A discussion followed regarding the pattern of tagged yellowfin recaptures among gear types. The number of large yellowfin tuna recaptures by longliners is significantly less than expected, given the catches of the same-sized fish by purse-seine and longline gears. Some of the hypotheses being considered include under-reporting by longliners, incomplete availability of tagged yellowfin to longline gear, and lack of independence of tag recapture observations. In respect of the last hypothesis, it was noted that over 20 instances have occurred of two or more yellowfin tagged in the same school being recaptured in the same purse-seine set more than 100 days later. It was noted that the recovery rate of tagged bigeye tuna was usually higher than the rate observed for yellowfin tuna. This may indicate a differential vulnerability of these two species taken by longline and purse-seine gears. It was also noted that large yellowfin caught by purse seine are usually more reproductively active than large yellowfin caught by longline. This difference in yellowfin tuna reproductive activity has been observed in all oceans.

5.3 Yellowfin Tuna

Tuna fisheries catching yellowfin tuna have received considerable attention in the investigation of fisheries interactions largely because they involve different types of gears, and different sizes of fish are targeted by the different gears. Also, yellowfin tuna are caught in large numbers and are of significant economic value. Nine studies dealing with interactions in yellowfin tuna fisheries were reviewed by the Consultation for information on the extent of interactions. Five studies (Papers 18, 19, 20, 21, and 22) dealt with fisheries in the eastern Pacific Ocean (EPO), and one each on fisheries in the central-western Pacific (Paper 23), Philippines (Paper 24), Indian Ocean (Paper 25), and Atlantic Ocean (Paper 26). The focus of the studies was on interactions among surface gears, or between purse-seine and longline gears.

The five studies on the EPO tuna fisheries were of different levels of conceptualisation. Three (Papers 18, 19, and 20 presented by A. Mullen, A. Anganuzzi, and A. Mullen, respectively) were related, and dealt with methods of modelling spatial-temporal transfer/diffusion of yellowfin tuna and spatial-temporal distribution of fishing effort in the region. The results from the modelling were then used to evaluate effects of prohibiting fishing on dolphin-associated and log-associated schools on the overall catch of yellowfin and skipjack tunas in the EPO and on catches of different fleets. The results indicated minor (less than 20%) reduction in the total tuna catch but, within that total, there appeared significant trade-offs between yellowfin and skipjack. A fishery which sets on dolphins is likely to yield more yellowfin than skipjack. Cessation of sets on dolphins is likely to lead to a decline in catch of yellowfin and an increase in that of skipjack. Conversely, cessation of log sets is likely to lead to an increase in the yield of yellowfin and a decline in that of skipjack. The changes associated with a cessation of sets made on dolphins appears to confirm the results of a simpler, spatially-aggregate model. There was a spirited discussion as to whether the model should be termed a diffusive model, dispersal model, or a transfer-coefficient model.

One study (Paper 21, presented by M. Dreyfus-León) on the EPO fisheries used correlation analysis with fisheries data to show possible interaction between purse seiners fishing in two locations. The one located to the south, primarily a log-school area, may possible affect catches in the northern location. Another study (Paper 22, presented by S. Ortega-Garcia) showed how temperature affects the relative abundance index for the purse-seine and longline fisheries. Both studies were exploratory, and require further investigation; independent information is needed to validate cause-and-effect implications from the correlation results. Also, because longline fishing off Mexico largely targets billfishes, data from this fishery appear to be ill-suited for demonstrating interaction with the purse-seine fishery; the purse-seine fishery generally targets yellowfin and skipjack tunas.

Three studies of yellowfin tuna fisheries in the central-western Pacific (Paper 23, presented by G. Sakagawa), the Indian Ocean (Paper 25, presented by T. Nishida), and the Atlantic Ocean (Paper 26, presented by A. Fonteneau) had a common theme of investigating the extent of interaction between longline and surface fisheries. Using catch-effort data, the studies on the central-western Pacific Ocean and Indian Ocean fisheries demonstrated poor correlation between longline catch rates and development of the purse-seine fisheries on a regional basis. Longline catch rates characteristically decrease sharply from a high level, before stabilizing at a low level. For each region, the significant decline occurred well before the introduction of purse-seine fishing, and well before large catches were produced by the surface fisheries. However, when the data are analysed by small areas, a reduction in the proportion of small-size fish in the longline catch occurred with the buildup of purse-seine fishing in some areas.

Tag-recapture experiments to demonstrate interaction between longline and surface fisheries were used in two studies involving the central-western Pacific Ocean (Paper 23) and Atlantic Ocean (Paper 26) yellowfin tuna fisheries. The experiments demonstrate interaction between longline and surface fisheries for yellowfin tuna. However, the interaction is weaker than expected if a common stock is being exploited by the fisheries. Tag returns from longline gear have been much less than expected theoretically for a common, homogeneous population of large yellowfin tuna available to both fisheries. Furthermore, tagging experiments using different designs and incorporating biological information were discussed as necessary to explore the reason for this weak interaction.

The Atlantic tagging results were used to develop an east-west movement model for a single yellowfin tuna population in the Atlantic Ocean (Paper 26). The tagging of large yellowfin tuna in the western Atlantic by sport fishermen in the USA has shown a systematic west-to-east advective movement; a movement possibly in response to a homing instinct associated with the spawning grounds located in the Gulf of Guinea. The model was then used to explore possible effects of increased fishing by one fishery on another, in particular, between fisheries located in the western and eastern Atlantic Ocean. Although the model has a number of built-in assumptions that require validation, it showed greater effects on yield between fisheries catching similar sizes of yellowfin tuna than between fisheries catching different sizes of fish.

The study of the Philippine fisheries (Paper 24 presented by N. Barüt) examined the possible interaction between handline gear, which catches principally large yellowfin tuna, and other surface gears, which catch mainly small yellowfin tuna. The fisheries rely on fish-aggregating devices (referred to as "payaos" in the Philippines) to aggregate the fish. These payaos are anchored in water 8-10 nautical miles apart. Tagging experiments suggest that the exploitation of small fish is high, and purse-seine and ringnet gears compete for similar sizes of fish. Interaction of the handline gear with other gears is not clear, largely because handline gear takes only large fish. However, an indirect interaction occurs through trophic processes. Large yellowfin tuna are believed to feed heavily on the small tunas around the payaos, and thus the surface gears affect the food source of the fish targeted by the handline fishery.

The studies noted above on yellowfin tuna fisheries provide general insights into the extent of the fisheries interactions. First, the extent of the interaction is not the same for all fisheries exploiting yellowfin tuna. Second, in areas of high exploitation, some degree of interaction occurs between longline and surface fisheries, but the level appears to be dependent on the stock structure of the population and the availability of the population to the gears. Third, the extent of interactions expressed through indirect sources, such as trophic dynamics, spawner-recruit relation, seasonal availability, etc., are not well understood.

5.4 Skipjack Tuna

J. Ianelli presented his results (Paper 27) on the population structure of skipjack tuna and his examination of interaction potential, using environmental data. He showed that by examining environmental data, inferences on alternative hypotheses of skipjack stock structure can be improved. An east-west pattern of skipjack tuna habitat was demonstrated as a possible mechanism for recruitment into the eastern Pacific, whereas for Hawaii the expected north-south shift in environmental conditions was apparent. In the discussion, it was pointed out that if growth rates were systematically variable between regions, the observed differences in seasonal recruitment patterns would give different results.

R. Rumpet presented data on the stock assessment and interactions of skipjack and yellowfin tuna fisheries in the South China Sea off Sarawak, Malaysia (Paper 28). He reviewed the trends of fisheries for skipjack and yellowfin, and noted that there may be an interaction potential between fisheries in this region and the western Pacific. Because skipjack and yellowfin are often caught in the same schools, it was noted that a multi-species interaction may be likely. The ensuing discussion raised the point that historical Japanese longline data show that adult yellowfin was taken in this region. This evidence and the occurrence of yellowfin larvae in the region suggests that adult yellowfin must be nearby.

J. Sibert presented an analysis of skipjack movement and fisheries interaction in the western Pacific (Paper 29). He demonstrated how aspects of advection-diffusion models are appropriate in a fisheries context. Analysis of data for tagging experiments conducted 10 years apart appear to have significantly different movement patterns. This suggests that movement of skipjack has significant inter-annual variability. In the ensuing discussion, it was pointed out that differences in estimated movement from the two tagging programs may also be due to the drastic changes that have taken place in the fisheries over this time, the differences in the seasons of tag releases, differential reporting rates among fleets (which typically operate in different areas), and variation in skipjack availability in response to variation in the marine environment.

The noted change in catchability for the Japanese pole-and-line fleet between the two tagging programs was discussed, since it appeared to be contrary to the findings by other scientists. A lengthy discussion on the different estimates of natural mortality rates between spatially-aggregated and disaggregated models ensued. It was argued that the interpretation of natural mortality is different for the disaggregated model because in the model, mortality represents a point in space. In the spatial model, the accumulation of fish at the boundaries where there is no effort, and hence no observations, may depress estimates of natural mortality. This issue requires further investigation because of its implications on interaction issues.

The estimated movement parameters were applied to interaction questions in a simulation study. In this part of the study, the skipjack population was assumed to be at equilibrium. Results from the simulation showed that if effort by all purse-seine fleets were increased from zero to twice current levels, the equilibrium yield to various pole-and-line fisheries would be generally reduced by 20 to 40%.

5.5 Albacore

A study by D. Fournier, J. Hampton, and J. Sibert (Paper 30, presented by D. Fournier), which dealt with albacore fisheries interaction in the South Pacific, was presented to the Consultation. A computer model was developed to mimic the population dynamics of albacore in the South Pacific and the effects of competing fisheries on the population as well as on each other were examined. Various scenarios involving prohibition of fishing of one of three fisheries, longline, drift gillnet, and troll, or groups of these fisheries, were examined. The scenarios demonstrated that prohibition of the drift gillnet fishing would result in a maximum of 7% increase in overall catch to the remaining fisheries.

5.6 Bluefin Tunas

Results of bluefin tuna and southern bluefin tuna research were presented in five papers (Papers 31, 32, 33, 34, and 35). The studies on the North Pacific fisheries analysed fisheries data to estimate the east-west movement of fish across the Pacific, abundance of bluefin tuna in the eastern Pacific Ocean, and the spawner-recruit and recruit-spawner relationships for the population. Results of these studies are important as baseline information for fisheries interaction studies.

One study (Paper 35, presented by S. Turner) investigated fisheries interactions in the bluefin tuna fisheries of the Atlantic Ocean. The study used a simple two-stock (management unit) model with low transfer rates between them: 1% transfer per year from east to west, and 4% transfer per year from west to east. Fishing on one of the management units was reduced to determine the effects on the other. The results showed that the western Atlantic unit could be significantly affected by the exploitation level on the eastern Atlantic unit, whereas the level of exploitation on the western Atlantic unit might have little impact on the abundance of the eastern Atlantic unit. The latter result was largely due to the much greater relative abundance of the eastern Atlantic management unit.

Results from tagging experiments on southern bluefin tuna in the 1980s and the 1990s were presented by R. Campbell (Paper 34). These studies investigated interaction between the surface and longline fisheries for southern bluefin tuna. The experiments were well-designed, particularly in the number of tags released by the fisheries and in the attention to maximising tag reporting rates. The results from the 1990s study clearly show rapid and significant interchange of southern bluefin tuna from the major longline fisheries to the surface fisheries and from the surface fishery to the major longline fisheries. The levels of interaction found in this study are much greater than those inferred from the 1980s study, and appear to be due to the much higher reporting rates from longline vessels as the result of the efforts made to maximise tag reporting in the 1990s study. The differences in levels of interaction found in these two studies underlines the need to carefully assess reporting rates if tagging experiments are to be used to investigate potential interactions between fisheries. Still to be established is the interchange with the minor longline fisheries, such as that which takes place off Indonesia. This minor fishery is more recent, and tends to catch very large southern bluefin tuna, sizes that were not tagged in the experiments. However, smaller fish were tagged early in the experiments, and should shortly be large enough to be vulnerable to this fishery. Future tag returns may demonstrate the interaction.

The studies on northern bluefin tuna and southern bluefin tuna provided strong empirical evidence for interaction between longline and surface fisheries. This is a significant finding that may be unique to bluefin tuna fisheries and is clearly related to the over-exploitation observed for these stocks. Over-exploitation is due to the high value of bluefin and high catchability. The population biology and behaviour of northern bluefin tuna and southern bluefin tuna, as well as the fisheries exploiting them, may be special determinants for the strong fisheries interactions. Similar characteristics are not shared by other tuna fisheries, and hence the fisheries interaction is less clear.

5.7 Small Tunas

Papers by T. Yonemori, H. Yanagawa, and L.Y. Pong (Paper 36, presented by T. Yonemori), Raja Bidin, R.H. and Mohd Taupek, M.N. (Paper 37, presented by Raja Bidin, R.H.), S. Chullasorn (Paper 38), and P.E. Chee (Paper 43), discussed fisheries which take longtail tuna (*Thunnus tonggol*), kawakawa (*Euthynnus affinis)*, and frigate tuna (*Auxis thazard)*, in Southeast Asia. These species are taken by purse seines in the South

China Sea and the waters of Thailand and Malaysia, by drift gillnets in the South China Sea and the waters of Thailand, and by trolling in the waters of the east coast of Peninsular Malaysia. CPUE data for the various species and gear types are presented. The CPUEs are not necessarily indicative of abundance, since most of the fisheries have been in existence for only a short time, the fishing gear and fishing techniques have been changing, and the skills of fishermen have increased with experience. Also, in some cases, the target species has changed. Information on size composition, movement, food, and schooling behaviour has been collected and analysed. The potential for interactions among the various fisheries are discussed, but no estimates of the effects of fisheries on the catches of other fisheries have been calculated.

5.8 Others

A paper by N. Naamin (Paper 42) discusses the interactions between the industrial and artisanal tuna fisheries of eastern Indonesia. Baitboats and small purse seiners take most of the industrial catch, which consists mostly of skipjack and yellowfin. The artisanal catch is taken mostly by small baitboats, which also catch mostly skipjack and yellowfin. A paper by P.E. Chee (Paper 43) mentions the fact that yellowfin are caught by purse seines and vertical handlines in Malaysian waters. Since several fisheries operate in the same general areas and harvest the same species of fish, interactions among these fisheries are suspected. P.E. Chee also mentions the possibility of interactions among the fisheries of the various nations of Southeast Asia.

A paper presented by C. Heberer (Paper 40) discusses recent developments in the tuna fisheries of the Federated States of Micronesia (FSM). Revenues derived from exploitation of fisheries resources are the leading source of income in these islands, and hence it is imperative for its residents that these resources be harvested wisely. The revenues have come principally through the licensing of foreign vessels, but the government of the FSM is currently attempting to expand the domestic fishing industry. Purse seiners from Taiwan, USA, Japan, Republic of Korea, and the FSM, baitboats from Japan, and longliners from the People's Republic of China, Japan, Taiwan, and the FSM operate in the Exclusive Economic Zone (EEZ) of the FSM. Concurrent or consecutive interactions probably occur among these fisheries, but have not been demonstrated.

J. Hampton presented a paper by J. Hampton, T. Lawson, P. Williams, and J. Sibert (Paper 41), in which the interactions of the tuna fisheries of Kiribati are discussed. Distant-water purse seiners, distant-water and local baitboats, and local trollers fish for skipjack and yellowfin in the EEZ of Kiribati. The CPUEs of purse-seine vessels and trollers over areas with radii of 300 to 600 nautical miles tended to be positively correlated, while those over areas with radii of 60 nautical miles were negatively correlated. It is likely that the positive correlations in the larger areas were due to fluctuations in abundance or vulnerability to capture of fish which affected both gears the same way, whereas the negative correlations in the smaller areas were due to the activities of the purse seiners which reduced the abundance of fish, and hence the CPUEs of the trollers. Analyses of tagging data were carried out to estimate the average impact of purse-seine fishing on the CPUEs of the Kiribati-based baitboats and trollers. In most cases, the estimated reductions of the catches of the local vessels amounted to less than 10%.

A paper by X. He and C. Boggs (Paper 46, presented by X. He), described a time-series analysis of the fisheries for yellowfin and bigeye in Hawaii. This study was carried out in response to local fishermen and fishery managers who were under the impression that fisheries in the EEZ temporarily reduce the abundance of fish in the area by removing fish more rapidly than they are replaced by immigration or local recruitment. Historically, most bigeye were caught by Japanese and local longline vessels, while yellowfin were caught by these foreign vessels, as well as by local trolling and handline vessels. The analyses were conducted at annual and monthly scales. Above-average catches of bigeye apparently did not reduce CPUEs during subsequent years. A negative correlation was found between total bigeye catches and CPUEs two months later. A negative correlation was also found between yellowfin catches by all gear and longline CPUEs one year later. No other significant correlations were found for yellowfin. The general pattern in the results for both species was for CPUE to be high when catch was high. The use of such data to evaluate the effects of removal of fish on subsequent catches is discussed in detail in this paper.

A. Muhlia-Melo discussed the interactions between the commercial and sport fisheries for tunas and billfishes off Mexico (Paper 39). Tunas are harvested principally by the purse-seine fishery, but are also caught by the baitboat and longline fisheries. Billfishes are taken principally by the longline, drift gillnet, and sport fisheries. Longlining is presently prohibited throughout Mexico's EEZ in the Pacific Ocean, primarily to protect the sport fishery for billfishes. The various fisheries obviously must interact with one another, but the extent of the various interactions is unknown. Unfortunately, complete catch, effort, and CPUE data are not being collected for the sport fishery.

A paper by M. Bertignac and D. Ardill (Paper 44, presented by D. Ardill), discusses some of the interaction issues involved in the fisheries for tunas in the Indian Ocean. Skipjack, yellowfin, and bigeye are taken by artisanal (troll, handline, and gillnet) and industrial (longline and purse-seine) fisheries. Small tunas are caught by the artisanal fisheries. Based on a classification developed by Hampton[1], Type-A (competition for fish at the same stage of their life cycle in the same general area by two or more fisheries), Type-B (effect of fishing a stock at an early stage in its life cycle upon a fishery that exploits the stock at a later stage), and Type-C (effect of fishing a stock in one area upon a fishery that exploits the stock elsewhere) interactions are described in this paper. It was noted that better data on catch, fishing effort and size frequency are necessary, if the magnitudes of the various interactions are to be estimated.

A paper on interactions in the Atlantic Ocean by A. Fonteneau and P. Pallares (Paper 45, presented by P. Pallares) noted that skipjack are not heavily exploited in the Atlantic, so in most cases the various skipjack fisheries do not greatly affect one another, although there may be significant interactions between the fisheries of the Ghana and Liberia areas. Substantial catches of juvenile bigeye tuna are taken in the Atlantic Ocean; the high bigeye catch has reduced the catches of the longline fishery, but not the overall bigeye catch. The

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[1] Classification provided in: Hampton, J. 1994. A review of tuna fishery-interaction issues in the western and central Pacific Ocean. *In* Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 3-11 December 1991, Noumea, New Caledonia, edited by Shomura, R.S., J. Majkowski and S. Langi, FAO Fish. Tech. Pap. 336/1: 138-157.

situation is approximately the same for yellowfin; substantial catches of juvenile yellowfin have reduced the catch of medium-to-large yellowfin by purse seiners and longliners, but this has not reduced the overall catches of this species. Spawning of bluefin takes place in the Mediterranean Sea and the Gulf of Mexico. It had been thought that the limited exchange of fish between the eastern and western Atlantic had negligible impact on either resource. A recent study, however, indicates that it is necessary to take into account the east-west migrations of Atlantic bluefin tuna, even if the movement is at a low level. This is especially true for the assessment of the western component of the stock. The interactions among the various fisheries for bluefin are currently being studied. There are several fisheries for albacore in the Atlantic Ocean, and these probably interact with one another to some extent. For instance, the new albacore drift gillnet fishery was believed to have a negative impact on the CPUE of the traditional pole-and-line fishery. The interactions on the pole-and-line CPUE are presently unknown.

6. EXTENT OF TUNA FISHERIES INTERACTIONS
(Moderator - Z. Suzuki, Rapporteur - S. Tsuji)

Relevant papers under this agenda item were presented in the Plenary Session, while in-depth discussions were held in a small-group discussion session.

6.1 Presentation of Papers

A. Fonteneau presented a review of interactions among tuna fisheries based primarily on experiences encountered in the Atlantic Ocean (Paper 45). In analysing fisheries interactions, he noted that attention should be drawn to four problem areas. The first is the possible existence of cryptic biomass distributed outside of the fishing area, which could lead to an overestimation of exploitation rate. The second problem area is the different migration patterns noted for the commercially-important tuna species; these patterns range from a diffusive-type of movement associated with skipjack to the advective-type of movement associated with bluefin tuna. These differences in migration pattern appear to be associated with differences in the spawning and feeding areas. Skipjack are at one extreme with expanded spawning and feeding areas, while at the other extreme, bluefin tuna have discrete spawning and feeding areas. The third problem area is that while most analyses of tuna dynamics assume a constant natural mortality rate, it is more likely that the natural mortality rate changes with the life stage of the tuna. A high rate probably occurs at the juvenile and maturing ages and a relatively low natural mortality rate at the middle ages. The fourth problem area to note is that changes in abundance based on CPUE tend to be intensified when a fishery operates in a boundary zone of the distributional range of the species; this factor points to the importance of local depletion.

Z. Suzuki reviewed a table prepared by N. Bartoo (Paper 47) which summarised the extent of interaction in tuna fisheries. The interactions were classified by the three types described by Hampton (see footnote 1). The three types include: Type A - competition for fish at the same stage in their life cycle in the same general area by two or more fisheries, Type B - the effect of fishing a stock at an early stage in its life cycle upon a fishery that exploits the stock at a later stage, typically with a different gear, and Type C - the effect of fishing a stock in one area upon a fishery that exploits the stock elsewhere. Case studies of interactions were reviewed from the perspective of whether the tuna species was tropical or temperate in distribution. It was generally recognised that the intensity of interaction appears to be more apparent with fisheries harvesting temperate tuna species than those directed to tropical species.

6.2 Small-Group Discussions

Discussions held during the plenary and small-group session on trends of tuna fisheries interactions were organised into four categories. The categories included (l) review and revision of tables summarising the extent of tuna fisheries interactions (original tables provided in Paper 47), (2) potential fisheries interactions, (3) multi-species nature of fisheries interaction, and (4) mitigation of interaction.

6.2.1 Review of the extent of fisheries interactions

The tables summarising the extent of fisheries interaction (Paper 47) were reviewed and revised, based on information provided during the discussion of the small group. The revised tables are provided as Tables 1A and 1B. Special reference was made to the size of fisheries noted in the tables. The term "small" refers to the size of the operating vessels and not the level of exploitation. Additionally, a summary of the basic biological characteristics of the commercially-important tuna species was prepared (Table 2).

Between the First and Second FAO Expert Consultations on Interactions of Pacific Tuna Fisheries, the number of tuna fisheries in the Pacific for which evidence exists for interactions significantly increased. Also in the same period, a significant number of additional tuna fisheries interactions was quantified. It was noted that quantifying interactions requires adequate fishery data and/or information from tagging experiments and other sources as well as involved mathematical analyses, few of which were developed before the First FAO Expert Consultation. Therefore, progress toward such quantification is not expected to be rapid. It was noted that such data and information have been accumulating. In particular, progress was noted for small tunas including longtail and kawakawa, for which little information was available at the First Consultation, but several papers were presented at the Second Consultation. However, this information was still insufficient to quantify interactions among fisheries catching these species.

As mentioned above, the small number of quantified tuna fisheries interactions is not necessarily the reflection of existence of only few interactions, but may be due to the small number of fisheries for which sufficient data and technical capacity exist to assess them.

The Small Group concluded that the quantified fisheries interactions were significant for temperate tuna species like southern bluefin. For tropical species like skipjack and yellowfin tuna, their significance varied from one case to another, perhaps reflecting the local rates of exploitation and migration, including their non-directional and directional components. Therefore, for these species, it was difficult to make any generalizations. Also, the Small Group noted that there were few quantified interactions for bigeye and small tunas and, consequently, their significance is unknown.

The Small Group noted that fisheries interactions are likely to be significant for tuna species with a directional migration, long life span, low natural mortality, high levels of aggregations of fish during certain life stages including spawning and stable recruitment, especially if their rate of exploitation is high. For the species with other biological characteristics and rates of exploitation, the studies presented at the Consultation indicated that significant fisheries interactions may also exist, but not in all cases. The features listed at the beginning of this paragraph may be used as an quantitative guide to whether we are likely to expect significant interactions or not. As an easy reference, the Small Group prepared a summary of biological characteristics of the principal tuna species (see Table 2).

As a conclusion, it was agreed that a better understanding on the biology of tunas and their fisheries, better data including those from tagging experiments, improved methods for their analysis and development of well-designed research programmes specifically for this purpose were essential to enhance our understanding of the extent of tuna fisheries interactions. In meantime, the guidelines presented in this section may provide some initial indication of interactions to likely be expected.

6.2.2 Potential fisheries interactions

The Small Group decided to list potential interactions expected additionally in the near future only, concentrating on resource-mediated fisheries interactions, while being aware of importance of economic, social and environmental factors. This emphasis followed from the objectives of the Consultations and those of the project sponsoring it. The non-biological factors have to be taken into account, especially when considering fisheries management options. It was noted that the profitability of fishing, including market considerations has been determining the operational pattern and intensity of fisheries and future fisheries interactions. For example, the demand for sashimi-quality catches and the profitability of such fishing has stimulated a development of small scale longlining by many coastal nations as well as some distant water fishing countries.

Most potential future interactions of tuna fisheries in the Pacific fall into the types of interactions listed in Tables 1A and 1B. They are mostly related to an expected intensification of exploitation rather than the development of new type fisheries.

In addition to the small-scale longlining mentioned above, most Southeast Asian and Pacific island countries are expected to continue the expansion of tuna fisheries mainly for small tunas in the first region and for skipjack and yellowfin tuna in the latter region. This intensification is expected to include an increase to the number and size of vessels and/or an improvement to the fishing efficiency by switching to more commercial and modern techniques. The expansion of fisheries will affect artisanal fisheries, including a competition and fishing gear conflicts on a local scale. This situation may lead to a further expansion of fishing areas and/or a switch to high seas. The last development may cause an interaction with the existing large-scale commercial fisheries on the high seas. Especially, strong concerns were expressed on the effect of the rapid development of small-scale longlining on the various fisheries.

An examination of the list of fisheries interactions (Tables 1A and 1B) showed that most potential interactions are related to expected increases in the exploitation level through increased effort and improved fishing efficiency, rather than to the establishment of new fisheries. In Southeast Asia, fisheries for small tunas are expected to continue expanding with increased effort and improved efficiency. The Pacific island countries expect a continued expansion of fisheries for skipjack and yellowfin tunas. A possible chain-reaction scenario was described which included expansion of fisheries having an impact on artisanal fisheries (including associated gear competition and fleet conflicts), followed by further expansion of industrial fisheries into areas of existing high-seas fisheries. This moves the interaction problem from one area to another. Strong concern was expressed on the effect rapid development of small-scale longlining throughout the central and western Pacific will have on the various existing artisanal and small-scale commercial fisheries.

Other areas of potential fisheries interactions include the capture and discard of small fish; these small fish are dead or near-dead when discarded. The magnitude of this problem is not established, since adequate data are lacking. It was noted that substantial amounts of discards could have major impacts on fisheries dependent upon larger-size fish.

The Group warned about the potential effects further increase in exploitation will have on interactions. The difficult problem of reducing fishing capacity after fisheries interactions have become apparent was recognised, and it was generally agreed that preventive measures are preferred.

6.2.3 Multi-species nature of fisheries interactions

Two examples of multi-species interactions were discussed. The first was the impact juvenile bigeye tuna caught by purse seiners have on the catch rate of longline-caught bigeye tuna. Although juvenile bigeye are a bycatch of the purse-seine fishery, their mortality can be considered serious since the bigeye stock in the Pacific is already heavily exploited.

The most prominent example involving multi-species interaction is the marked difference in species composition among the purse-seine catches from dolphin, log, and school sets. It was noted that a shift in major fishing mode, such as encountered in the eastern Pacific may lead to significant impacts on other fisheries and on the resources. From the mid-1980s to the early 1990s, more sets were made on dolphin-associated tunas than on free-swimming or log-associated tunas. Due to legal and industry-imposed restrictions, however, it has become increasingly difficult to market tunas caught in association with dolphins, and in 1993, for the first time since 1984, the number of sets on free-swimming schools of tunas exceeded the number of sets on dolphin-associated tunas. Sets made on dolphin-associated fish take almost nothing but large yellowfin, whereas those made on free-swimming and log-associated tunas take large amounts of skipjack, undersized yellowfin, and other species, most of which are unmarketable.

6.2.4 Mitigation of fisheries interactions

The Consultation noted that interactions need not always be considered negative. Some acceptable management objectives, such as developing fisheries for under-exploited populations, may necessarily result in increased interaction between various sectors of the fishery. In such cases, actions to mitigate interaction may necessarily conflict with other management objectives.

Maintaining or reducing the overall exploitation rate will reduce a risk of severe fisheries interactions. In most cases, the employment of greater distances between fisheries and/or fishing gears, will mitigate gear conflicts and/or fisheries competition. Time-area closures and modifications of fishing gear and techniques may also reduce exploitation rates, thus, reducing the likelihood of fishery interactions. It was noted, however, that some of these measures might also intensify the interactions. The effect of different measures on interactions may be examined by simulation studies.

7. UNRESOLVED RESEARCH PROBLEMS AND GUIDELINES FOR RESEARCH

(Moderators - C. Boggs and R. Deriso, Rapporteurs - A. Anganuzzi and J. Hampton)

There was general agreement that substantive progress in understanding fisheries interactions can be made only by an iterative process of carrying out needed research and evaluating the results of this research in order to guide future research directions.

Similar to Agenda Item 6 (Extent of Tuna Fisheries Interactions), the subject of unresolved problems and development of guidelines for their resolution was carried out in two parts. Relevant papers were presented in Plenary Session. A small-group meeting of interested participants was held afterward to discuss details.

7.1 Philosophy Concerning Interaction Studies

It was noted that the study of interactions is generally narrower in scope than the study of population dynamics. The main point of interaction studies is to quantify the effect that one fishery has on some other fishery. The information needed to understand population dynamics is frequently the same as that needed for an interaction study, but acquiring the input information is not necessarily an interaction study in itself.

Certain studies can be considered as belonging to both categories but, in most cases, the difference is clear. The correct strategy for addressing particular interactions can be characterised as going from the top to bottom: identifying the specific types of interaction and the necessary types of research needed in each case. In reviewing the many potential interactions described in this and the First Consultation, it is clear that similar unresolved problems recur in most interaction studies, and in most population dynamics studies as well. Rather than reiterate how these problems recur in each type of interaction study, the trend in the discussion and in the papers presented in this session is to move directly to address these critical and recurrent problems.

7.2 Presentation of Papers

A review of some of the technical issues involved in the study of interactions was introduced by A. Anganuzzi (Paper 48). The first point noted was that interactions represent conflicts of interest. This means that there will be pressure to produce precise estimates of interaction levels. Therefore, powerful methods of analysis, combined with appropriate data in terms of type, coverage, and quality will be required. These requirements will differ according to the type of interaction considered, since the relevant parameters needed to assess the level of interaction might differ among interaction types. For example, for the simplest case, where the two interacting fisheries are concurrent in time and space, fish movement parameters are less necessary. On the other hand, if the two fisheries occur at different places of a migratory circuit, time-space factors must be taken into account. Complex interactions mediated by trophic relationships are the most difficult to quantify, because of data requirements, and because the mechanisms underlying the interactions are usually not adequately understood.

A strategy was proposed that would encompass two stages: first, where the interaction is identified and quantified, and second, where management recommendations are offered. Several tools can be used for the identification stage (e.g., correlation and stock-structure analyses), to be followed by the formulation of a conceptual model. Simulations can help in organising the available information and will provide guidance in the selection of the statistical tools to actually estimate the interaction, as well as the appropriate data requirements. Given the amount of information provided by the different types of data and their limitations, tagging is the preferred option for the study of interactions. The design of tagging experiments can be greatly enhanced by the use of simulations. An important concern is accounting for the tag recaptures that are not reported. In particular, there is reason to suspect that reporting rates are not equal for the various fisheries. A possible solution for this problem would be a tag that is detected by some method independent of visual detection by the fishing industry, e.g., inserted wire tags that are detected by special equipment placed at canneries and auctions.

Regarding the second stage, the assessment of management options, it is necessary to recognise that in some cases the allocation problem (implicit in an interaction) can be solved by optimising the productivity (biological or economic) of the population. In other circumstances it is necessary that managers specify as clearly as possible their intended objective. Once the objectives are specified, a number of alternative management strategies may be identified. The assessment of management options requires consideration of existing uncertainties and alternative hypotheses. Adaptive policies could also be explored as a way to learn more about the dynamics of production. These types of policies are designed to deliberately manipulate the system in order to provide more contrast in the data and, therefore, better ability to discriminate among alternative hypotheses.

During the ensuing discussion, it was noted that the cost of analysis might be of the same order as the cost of collecting the data. It was also noted that the cost of long-term tagging programs might be prohibitive, and that consideration must be given to alternative ways of estimating movement rates, such as the use of spatially-disaggregated indices of abundance. On the other hand, it was noted that tagging provides the most reliable information regarding the level of interaction, something that the analysis of fishery data by itself cannot prove.

Some participants recommended that more emphasis should be placed on the inclusion of environmental and economic data into the assessment of potential interaction, since such factors can cause, mitigate, or exacerbate interactions. Another comment referred to the need for understanding the population dynamics, including environmental impacts. Once this is achieved, characterization of the interaction may become easy.

It was also emphasized that, although the role of the biologist is restricted to providing information to the managers, the managers often need assistance in identifying the full range of actions that may be available.

C. Boggs introduced his paper (Paper 49), in which he listed 18 questions that identified voids or unresolved questions relevant in the study of interactions. He recognised that significant progress had been made since the First Consultation, but that more work was still needed. He also noted that no one had submitted any issue or problem that he or she felt was resolved. To provide an agenda for subsequent discussion, he organized his list of questions and problems submitted by the participants into the following areas:

1) using fishery data to estimate or detect interactions,
2) biological or ecosystem studies to augment fishery analyses,
3) tag-and-recapture studies,
4) other methodologies, and
5) modelling interactions.

This list was subsequently expanded with further contributions from participants (Table 3).

Some comments were offered regarding the issues raised by Boggs' list of questions. Regarding the tagging data, it was noted that although complete fishery data from all fishery sectors were not needed to identify or even quantify interactions, the use of catch and effort data allows one to extract the most information from a tagging experiment.

Some participants also suggested that new theories of fishing should be developed that would be appropriate to analyse basin-scale problems. Such theories would explicitly include spatial variability in the stock, more dynamic descriptions of the exploitation process, and the social and economic forces which motivate fishing.

J. Ianelli presented some of his views on the biological issues that are critical in addressing interactions. He noted that demographic processes need to be considered. Among these, consideration must be given to the reproductive processes and the question of how spawning potential ratios (SPRs) relate to various reproductive parameters. Egg, larval, and juvenile survival rates need to be estimated, together with somatic growth rates. The question of stock structure has to include consideration of spawning site fidelity, that is, whether fish return to their natal area to spawn. The degree of stock integrity, and the effect of environmental conditions on the distribution of the population must also be considered.

A number of multi-specific considerations were also mentioned. The first step is to define pelagic communities. Then, the range of habitat should be delineated. To gain insight on the effect of fisheries, the relationship between the mode of fishing and species composition of the catch is needed. Finally, in order to address trophic interactions, knowledge about diet and feeding patterns, and how these relate to the patterns of fishing mortality by gear type and areas are required. Trophic information may be particularly important in fisheries where fish-aggregating devices (FADs) are commonly used, as FADs may make prey species more vulnerable to predation and exploitation.

Regarding the processes related to recruitment, there is a need to establish whether there is a pattern that would suggest a relationship, or lack thereof, between recruitment and spawning stock size, and whether there is indication of density-dependence in the mortality rate of early life stages. The effect of environmental conditions on recruitment should be assessed, considering the possibility of area-specific processes. Information on such biological characteristics can be obtained from specifically designed studies.

Tagging programs are obviously important; there is a need to investigate alternative tagging methods which release fish over extended periods. The use of archival tags is promising, although there is a potential danger in extrapolating the results obtained from a limited number of individual histories to the total population. In any case, simulations can assist in the design of more effective tagging experiments. Other direct studies to address questions related to the stock structure include genetic analyses and the analysis of hard parts to look for chemical signatures. Examples from other case studies (Pacific halibut, sablefish, stellar sea lions, Pacific whiting) can also be useful as guidance for future studies.

The power to evaluate the statistical significance of interactions can be low, even with extensive tagging data. Where interactions exist, well-conducted tagging experiments with high reporting rates can be used to obtain estimates of the amount of the interaction. However, if reporting rates are low, the power to detect the amount, or even the existence of an assumed interaction, could be low. Biological studies can contribute additional qualitative evidence. Future research should be oriented to develop extended movement models, such as RASCALS, that would include the early life history. Simulations should be used to design data-collection procedures, and emphasis should be placed in obtaining reliable estimates of stock size for the population involved in the interactions.

7.3 Small-Group Discussion of Research Problems and Guidelines

A small group met to consider in detail some of the more important issues discussed in Boggs' paper (Paper 49), as well as some additional issues raised by participants. The issues chosen for discussion were those for which the group could provide useful advice. A list of all of the questions raised is presented in Table 3. A summary of the issues discussed in detail by the group, and issues and suggestions submitted by participants, is given below.

7.3.1 Using fishery data to estimate or detect interactions

Discussions on fishery data addressed the following questions noted in Table 3:

- A.1 - Can CPUE be used as an index of abundance?
- A.3 - Do data collection systems need improvement?

Can CPUE be used as an index of abundance? (A1)

Two key problems were identified in estimating relative abundance from CPUE. These were:

- A nonlinear relationship between CPUE and abundance, brought about by contraction of the range of the population or the existence of an unavailable or "cryptic" portion of the stock. The CPUE gives an index of abundance only within the area in which effort is expended. Changes in the distribution of effort or abundance within that area will cause changes in CPUE unless it is assessed using a spatial-stratification scheme. If the fishery is sustained by movement from elsewhere, its CPUE gives little information concerning the larger population which may be properly considered as part of the stock.

  Possible approaches to address this problem include:

  - the use of archival tags to get information on the range of individual fish,
  - surveys in new fisheries using different types of gear, including hydroacoustic methods, to estimate the abundance of the entire stock,
  - surveys of the entire range of the stock, possibly using management "incentives" to encourage commercial vessels to fish where they would not normally fish, and
  - the use of spatial models that deal explicitly with movement and spatio-temporal variations in abundance.

- Difficulties in estimating "effective" effort, in particular, accounting for the non-random distribution of fish in relation to environmental variables, and accounting for technological changes in fishing operations that increase fishing power.

  The group felt that the use of appropriate statistical procedures to "standardise" effort was the most appropriate solution to this problem. It was recognised that standardisation may require the collection of additional data, such as environmental data and data on the fishing operations themselves. It was further recognised that all of the required data (e.g., data on repeated sets on logs) was not likely to be available from logbooks, and that observer programmes were probably the best way to collect some types of ancillary data. In relation to the problem of changes in fishing power, gear trials can sometimes be used to estimate the change in gear efficiency when modifications to fishing methods are made.

In addition to the discussion, there were other suggestions or comments submitted by some participants:

- Experts should periodically review indices of abundance and the data required for them. Several different indices should be used for each fishery in case one proves more robust than another over time.

- When using CPUE as an index of abundance, consideration must be given to the fact that the CPUE might be affected by interaction.

Do data collection systems need improvement? (A3)

There was general agreement that data-collection systems should be improved in order to provide sufficient information (e.g., fishing depth of longlines, operational details of purse seiners) for the standardisation of CPUE. Specific problems or questions identified included:

- Should data-collection systems cover all scales of fishing activity, or just the larger industrial fisheries?

  Artisanal fisheries are very important in some areas, and judgment needs to be exercised. However, industrial fisheries can be more cost-effectively monitored than diverse small-scale fisheries, which are always difficult and expensive to sample. Such monitoring, along with surveys or tagging in the small-scale fisheries, might be sufficient to provide reasonable estimates of interaction. Routine data collection from small-scale fisheries (particularly species and size composition and total catch data) should be improved if possible, as resources allow, and be guided by well-designed sampling schemes. Sampling by qualified individuals should be conducted periodically to check the species identification of catches, and staff of fish-handling facilities should be trained and encouraged to correctly identify fish.

- Does length-frequency sampling from schools lead to bias because of size segregation in schools?

  The size distribution of fish taken by purse seiners may provide a biased estimate of the true size distribution in the total fish population. In the best case, sampling programmes will provide only the sizes of fish caught from those schools.

- How can data on vessel operations be best collected?

  Observer programmes represent the best alternative, although they are expensive and logistically complex. Standardisation of data-collection protocols, whether they involve observer or logbook programmes, would be desirable in some areas. Various remote-sensing techniques can be applied to gathering data on vessel operations. For example, an ORSTOM programme in the Atlantic uses GPS (global positioning system) recorders on small vessels to record exact fishing locations at a reasonable cost.

  Some participants noted that the problem of non-reporting of fishing activities by vessels of flag-of-convenience is progressively increasing in all oceans. Use of import statistics may offer some solution.

7.3.2 Biological or ecosystem studies to augment fishery analyses

Under Section B of Table 3, the following questions were discussed by the group:

- B.10 - Are environmental factors affecting the extent and nature of the interactions?

- B.28 - What are the effects of schooling behaviour on population estimates derived from models that assume independence of individual fish?

Are environmental factors affecting the extent and nature of the interactions? (B10)

A need was identified to develop hypotheses concerning the environmental mechanisms involved in interactions. There is also a need to monitor and measure key oceanographic conditions on the relevant scales that may influence tuna fisheries interactions, with emphasis on availability and vulnerability of fish to the fishing gear and migration of fish.

Data to be collected may emphasise ocean thermal conditions (like sea-surface temperature), ocean thermal structure, e.g., frontal structure (horizontal and vertical), current boundaries, and ocean productivity.

Application of ocean models to fisheries problems, combined with the utilisation of satellite remote-sensing measurements, can prove to be a valuable and inexpensive tool, particularly considering that these data are already available in most areas. Temporal stability in the thermal structures can also be a relevant property to the distribution of fish.

Some participants recommended that correlation studies be carried out to explore the relation between abundance indices and environmental indices. Some participants also suggested that archival tags should be used to relate environmental data to fish movement. Studies are needed to explore the relationship between the targeting practices of fishermen and particular environmental features, such as fronts.

It was mentioned that several types of data from drifting and moored buoys in the Pacific can be easily accessed and retrieved through the Internet, and information on retrieval procedures is available.

What are the effects of schooling behaviour on population estimates derived from models that assume independence of individual fish? (B28)

Schooling behaviour has not been incorporated into stock/interaction analyses to date. Two questions were identified:

- Analyses typically assume that tagged tuna behave independently, whereas in reality there appears to be some degree of school integrity that persists over time. Published data indicate that schools of skipjack break up within a few weeks, but unpublished data show that yellowfin may remain together for many months. Given that most tag releases have been from smaller tuna caught in schools, could this bias various estimates of interaction based on tagging data?

  A simulation study that incorporates schooling behaviour could provide an indication of the degree of bias and impact on variance estimates.

- Can schooling behaviour be a key factor to explain the apparent differences between large yellowfin tuna exploited by purse seiners and longliners?

Additional information regarding this problem might be obtained from LIDAR studies (appropriate, however, only in about the upper 50 m of the water column) or acoustic tags to monitor school structure and dynamics. Tagging of longline-caught fish would provide a valuable comparison to tagging from surface schools. Longline-caught fish that are too small to retain might be tagged and released. Further information on vertical segregation of the yellowfin stock may also be obtained from looking at swim bladder development or other physiological characteristics (e.g., maturation) and any heterogeneity in that development (which might indicate different behavioural characteristics).

Schooling behaviour can also influence the linearity assumption between catch rates and stock density.

In another submission from some of the participants, concern was expressed that not enough attention has been paid to the possibility of recruitment overfishing of most stocks of tunas. This subject was not discussed in detail by the group, but it was felt that it was important for assessing potential consequences of interactions. A possible solution to this void would be to :

- Compare indices of abundance of spawners and recruits for as many stocks of tunas as possible.

- Estimate SPR for as many stocks as possible to attempt to determine if there is some minimum safe level of SPR.

Recruitment overfishing has not, however, been observed in most stocks of tunas; possible exceptions are the Atlantic bluefin tuna and the southern bluefin tuna.

7.3.3 Tag-and-recapture studies

To what extent are the results of tagging experiments reproducible? (C13)

There was concern regarding the use of population parameter estimates (particularly movement) based on tagging analyses to predict future interactions when the results of tagging experiments may not be reproducible, i.e., the estimates may change substantially over time. For example, there is evidence that the movement patterns of skipjack, yellowfin, bluefin, and albacore change considerably over time, probably in response to environmental conditions. The question of changes in movement parameters with changes in population density was also raised. Some participants suggested that "dispersion only" movement patterns may be more appropriate to use in estimating future interactions, in situations where the advective component of movement appears likely to be less temporally stable. However, some data indicate that dispersive patterns are just as unstable as advective patterns.

The solution to this problem lies in conducting repeated tagging experiments over long-enough periods so that the variation in movement is adequately captured. Long-term experiments may also allow some resolution or even prediction of the variation by relating it to various environmental conditions and/or biomass levels. If the variation cannot be explained, the application of a long-term average movement pattern may be sufficient to predict average interactions under equilibrium assumptions. Such "average case" predictions would be less precise.

Other points submitted by the participants of the Group, but not extensively discussed, included options to address:

- How can tag reporting be promoted and tag reporting rates (and other loss rates) be estimated? (C12)

  In each fishery, tag rewards should be uniform for all returned tags, regardless of the organization which tagged the fish, and the rewards should be paid immediately by personnel who visit the vessels to collect logbook data, measure fish, etc. A tag-reward poster should be posted at each facility in ports where fish from the fishery in question are landed, and this should state the amount of the reward and the fact that rewards are paid immediately. If necessary, the various organizations can reimburse one another later.

  Direct contact between scientific liaison officers and fishing vessels and personnel involved in handling and marketing landings should also be used to help promote the tagging study and to directly recover tags and distribute rewards quickly.

  Despite such existing efforts, non-reporting may remain high. Techniques to measure movement that are independent of tag reporting, such as archival tags that report data to satellites or to listening stations may be needed.

  Fish should be double-tagged with dart and coded-wire tags, and a portion of the catches should be monitored with detectors for coded-wire tags. The results should produce estimates of the rates of tag shedding and non-reporting of tags.

7.3.4 Other methodologies

Several methodologies were discussed. These include:

- It would be useful to have a tag that, similar to PIT tags, would have a unique electromagnetic signature and that could be detected automatically by some passive device that could be installed on boats or processing plants.

- The significance of the differences obtained from the analysis of micro-constituents in otoliths needs to be validated. Relating specific signatures to particular conditions might be difficult because those differences can have multiple origins.

- Aerial surveys can be used to provide fishery-independent estimates of abundance in some cases. A potential problem exists with the estimation of the time that the schools are located near the surface, where they can be detected. This problem might be solved with the data obtained from archival tags.

- ORSTOM has been developing useful hydroacoustic survey methods that may also be used to provide fishery-independent estimates of abundance.

- Bar-code systems were mentioned as a way to simplify the sampling and recording procedures for fishery observers and research surveys.

7.3.5 Modelling interactions

The moderators felt that although question E18 regarding economics was very important, it should not be discussed here, as it was the subject of another section. The following question was discussed by the group:

How can simulation models be effectively applied? (E24)

The group agreed, that in addition to providing structure or interaction estimation procedures, simulations should be used for:

- identifying the mechanisms underlying interactions,

- assessing the statistical power of methods of analysis, and

- providing insight on the nature and extent of the data requirements.

In some cases, simulations can be used to bound the levels of potential interactions. For example, a simulation can show that in order to have a significant interaction between two fisheries, unreasonable values would have to be assumed for some of the key parameters. However, the use of simulations to estimate precise interactions would be inadvisable, primarily because there will be little support for some guesses for the parameter values. It was also noted that whatever data are available can be used to turn a simulation model into an estimation procedure. In summary, it was agreed that simulation provided a good tool to organize the information available and identify alternative hypotheses.

In proceeding to estimate interactions, the various models described in the two consultations all have merits. The choice of which model to choose depends a lot on the types of information which are practically obtainable. For example, if a tagging study is not practical, statistical analyses of catch and effort data, or estimates based on movement and natural mortality rates from similar fisheries are options. If tagging is practical, but fishery data are limited, there are other options.

Other points regarding modelling and simulations that were submitted by some participants are:

- Providing assistance in modelling for developing nations (E.20)

  Many of the papers presented in this Consultation, as well as in the First Consultation, are descriptive accounts of fisheries and allude only to possible existence of fishery interactions. It may be that the proper data do not exist, but data may not be the prevailing problem. Many countries could use technical assistance in reviewing the situation and developing models for the potential interactions that concern them. The level of expertise required to model interactions may not be available in these countries, and they might want to request such assistance. Then, these countries could be well on the way of determining if the perceived interaction is significant or, at least, have a more directed plan of action.

- Strategies for assessing management options under alternative hypotheses should be proposed. (E.25)

8. INFORMAL SESSIONS

Three informal evening sessions were held during the Consultation to accommodate participants interest in (1) non-biological factors of tuna fisheries interactions, (2) atlas of tuna fisheries, and (3) software demonstrations.

8.1 Non-Biological Factors of Tuna Fisheries Interactions
(Moderator/Rapporteur - P. Callaghan)

Participants discussed fisheries interaction problems within a broad inter-disciplinary context. Many participants felt that fisheries interaction issues, as they are defined for the purposes of this Consultation, almost always become inextricably intertwined with fisheries allocation and stock assessment issues.

Most fishery interactions require some management intervention because they result in a redistribution of fishery resources among various groups of humans. When fishery interactions take place, it is not fish, but human welfare, that is being redistributed. Viable solutions to welfare imbalances might arise out of a number of disciplines other than fishery science. Furthermore, in many cases, it is entirely possible that perceived welfare imbalances might be alleviated or mitigated through political, economic, or social means without ever completely understanding the chain of cause-and-effect events leading to the imbalance.

There was consensus among participants that the broad fishery management interaction process can be described by the diagram shown in Figure 2. This diagram presents fisheries interactions as arising out of human choices and actions in Fishery A. These choices and actions occur in response to exogenous and endogenous political, social, economic, and environmental forces. The effects are then transmitted from Fishery A, through a series of interconnected cause-and-effect relationships, or conduits, in such a way as to impact the environment and human welfare of participants in Fishery B. The participants in Fishery B then react in political, social, and economic ways in an attempt to protect their perceived gains, or rectify and mitigate their perceived losses. In addition, there may be naturally-occurring ecological reactions in Fishery B. All these reactions provide feedback impacts on Fishery A, as well as impacts on other fisheries and social institutions.

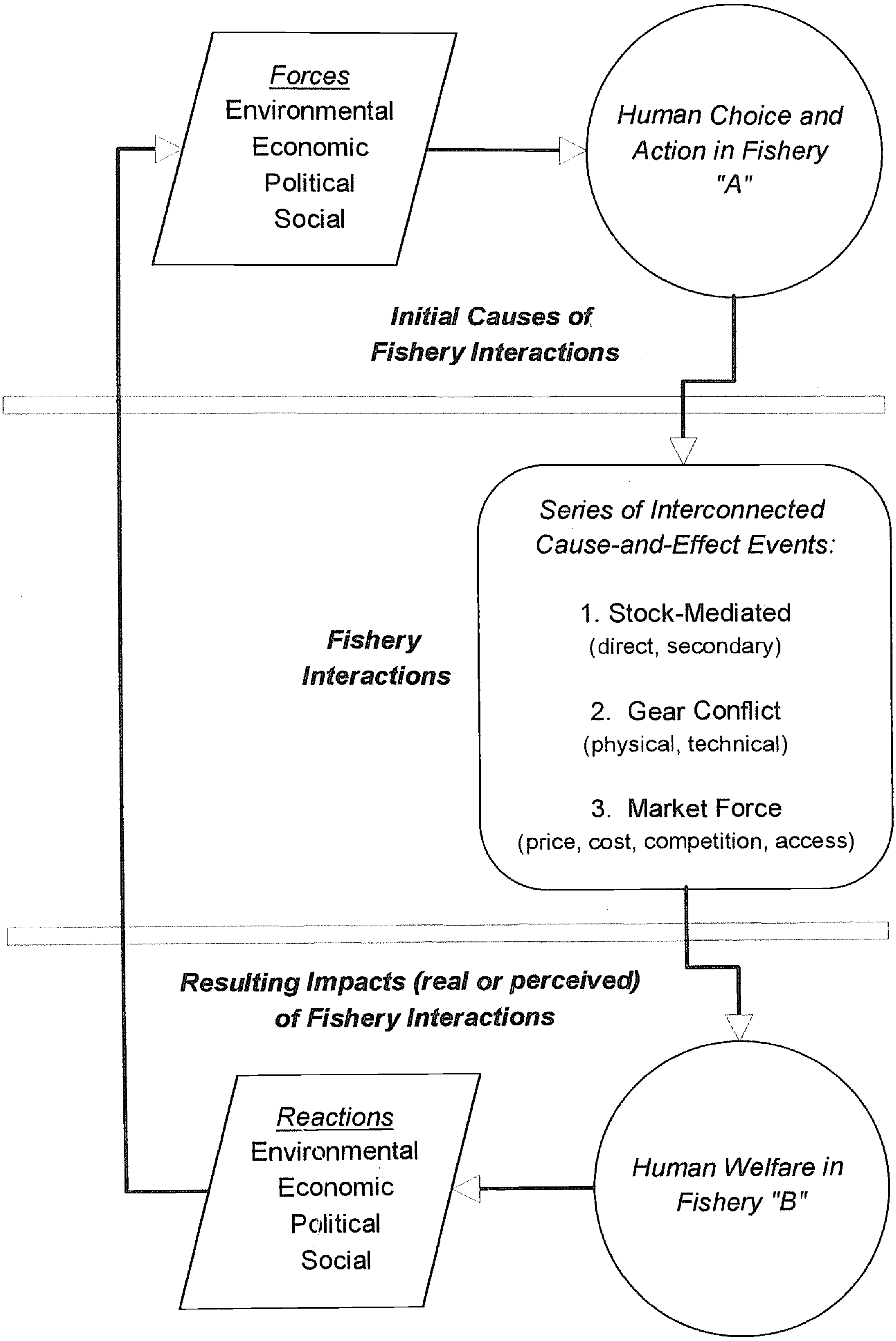

Figure 2. The fishery management interaction process.

The three conduits for transmission of cause-and-effect events from Fishery A to Fishery B are classified by P. Kleiber (Paper 3) as: 1) stock-mediated interaction, 2) gear interaction, and 3) market-force interaction. Participants agreed that stock-mediated interaction, and to a lesser extent gear-conflict interaction, have provided the main focus of this Consultation. It was felt that there was need for enhanced research efforts aimed at more thoroughly exploring the process, extent, and importance of gear-conflict and market-force interactions and their associated management solutions.

Participants mentioned that fisheries scientists are often asked to provide evidence and measurement of stock-mediated interaction in order to justify preconceived management actions. In reality, these actions are proposed to mitigate perceived welfare imbalances arising out of gear conflicts and market-force interactions. To better deal with these situations, fishery science must clarify the types of problems for which it can provide timely solutions, and identify the types of problems which require a broader multi-disciplinary perspective.

Some participants also noted that special research attention should be paid to small (incremental) interactions. It was noted that relatively small stock abundance changes can result in very large welfare impacts on artisanal, subsistence, and sports fisheries. These small fisheries often operate with technology which requires relatively high stock density in order to sustain acceptable local exploitation rates. For these fisheries, local availability is much more important than total stock abundance.

8.2 Atlases of Tuna Fisheries

(Moderator/Rapporteur - D. Ardill)

The IATTC publication "Statistics of the Eastern Pacific Ocean Tuna Fishery, 1979 to 1992" was presented. This report, published in response to a large volume of requests for information received by the IATTC, provides information on the catch, fishing effort, and species composition of the EPO purse-seine and baitboat fleets. These fleets fish principally for tuna and tuna-like species. Average distribution of yellowfin and skipjack tuna catches are given in graphical format, and statistical catch and effort data are presented in tabular format. Data aggregation is by year, 10° area, vessel size class, and species. A table presents EEZ catches in the EPO.

The Indo-Pacific Tuna Programme (IPTP) is in the process of preparing an atlas of catch and fishing effort for the Indian Ocean. This publication follows an atlas prepared in 1984, which has been in great demand, particularly from industry participants and prospective investors.

The atlas will include annual catch and effort charts by 5° area for longline and purse seine from the beginning of these fisheries in 1952 and 1982, respectively, and up to 1992. Monthly charts will also be prepared covering 1992 for both fisheries. The longline charts are presented separately for tunas and billfishes because of the large number of species involved, and because billfish catches are small compared to those of tunas. The justification for presenting billfish catches comes from increased interest in these species in the Indian Ocean.

For this atlas, the IPTP wishes to show the maximum possible amount of information in each graphical presentation in order to avoid having to consult many charts for each time period. The format proposed is, for each grid area, a pie chart showing catch by species, with the area proportional to the catch, superimposed on bar charts showing nominal fishing effort and CPUE. Longline catches are in number of fish and effort in number of hooks. Purse-seine catches are in tonnes, with effort in days.

There was some discussion on whether it would be preferable to present longline data in number or weight of fish, as presentation in numbers could give the impression that catches of small fish, such as albacore, were more significant to those of larger species. Some of the group participant were also of the opinion that the use of a logarithmic scale to present the data masked the difference between small and large catches. Logrithic scaling was found to be necessary, as the difference between the largest and smallest figures throughout the time series was too great to present on a linear scale. Finally, it was suggested that standardised effort might be preferable to nominal effort in the longline charts.

The data for the standardisation of effort are not available at IPTP, but the possibility of transforming weights to numbers will be examined. The use of a scale based on the square root may be a satisfactory compromise.

The group was informed that FAO will, in the context of preparation of a range of atlases, envisage the preparation of catch and effort atlases covering the Atlantic and Pacific Oceans. This will depend on data being made available by the institutions collecting tuna data for these oceans. The conditions under which these data are supplied and the final format of these atlases are still to be discussed. It was suggested, however, that consistent effort data might not be available in all cases.

8.3 Software Demonstrations

(Moderator/Rapporteur - J. Sibert)

Several different types of software were demonstrated during the Consultation. S. Moberly and P. Eckstrom demonstrated the software used to interrogate the Northwest Marine Technology archival tags and to subsequently manipulate the data from the tags. D. Ardill of the IPTP demonstrated the use of the MapInfo geographic information system (GIS) to create maps of tuna fishing activities in the Indian Ocean. These maps will become part of an "Atlas" summarising the history and distribution of tuna fishing in the Indian Ocean. D. Fournier of Otter Research Ltd., demonstrated a high level language for the rapid development of reliable non-linear statistical models for fisheries applications. P. Kleiber of the US National Marine Fisheries Service and J. Sibert of the University of Hawaii demonstrated several pieces of software to create alternative "scenarios" of tuna movement, exploitation, and management. Finally, a number of movement simulations were run on an ad hoc basis during meeting breaks, including a conflict-resolution simulator from ID Software, Inc.

9. GENERAL DISCUSSION AND CONCLUSIONS

- The Consultation recognised that there are significant concerns regarding the impact of interactions of Pacific tuna fisheries interactions in many countries (see Agenda Items 5 and 6). Further development of fisheries in the future may result in increased interactions among these fisheries.

- The Consultation noted that tuna fisheries interactions may result from economic and social forces, and cause economic and social impacts. Such interactions that have negative effects on some fisheries, however, do not necessarily have a detrimental impact on the productivity of tuna stocks.

- Since the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, the number of quantified interactions has increased, but this number is still small due to difficulties in evaluating such interactions (see Agenda Item 5). Much of the considerable progress made since the First Consultation has resulted from studies sponsored or encouraged by FAO's project entitled, "Cooperative Research on Interactions of Pacific Tuna Fisheries".

- Fisheries interaction studies have significantly enhanced the understanding of stock-mediated effects on tuna fisheries. These studies have demonstrated that the extent of tuna fisheries interactions varies in significance, depending on the biological characteristics of the species involved, the local and stock-wide rates of exploitation, the distance between fisheries, and the sizes of fish caught (see Agenda Item 6).

- Based on the above-mentioned relationships, the Consultation formulated some general qualitative guidelines regarding the likely extent of tuna fisheries interactions (see Agenda Item 6). These guidelines may be used before conducting studies that are specifically designed to address concerns related to specified interactions. The Consultation stressed that only such studies may address the concerns with adequate confidence.

- Studies on tuna fisheries interactions should utilize the significant research experiences gained so far, and the research guidelines formulated at the Consultation (see Agenda Item 7). Twenty-seven questions related to unresolved problems were categorized into five areas: (1) catch, fishing effort, and environmental data, (2) biology and ecosystem, (3) tagging and recaptures, (4) alternative methodologies, and (5) modelling interactions of tuna fisheries. Research guidelines were offered for these questions. Generally, it was felt that well-designed tagging experiments offer the most reliable information regarding the level of tuna fisheries interaction. However, information from such studies needs to be complemented with reliable statistics of catch and fishing effort, and placed in an integrated framework of research. The Consultation noted that, in many cases, these studies may require the possibly difficult tasks of collecting new or improved data and conducting tagging experiments.

- The Consultation suggested that interactions may be reduced, if this is desired, by decreasing the intensity of fishing and/or increasing distances between fisheries, noting that specific interaction studies may define desirable changes to fishing patterns and/or intensity.

10. RECOMMENDATIONS

During the Consultation, various research recommendations were formulated. These recommendations are listed in Section 7 ("Unresolved Problems and Guidelines for Research") and Section 9 ("General Discussion and Conclusions"). To avoid repeating these research recommendations out of context in this section, the only recommendation provided here is directed to the FAO:

- The FAO should seek additional funding to continue the project "Cooperative Research on Interactions of Pacific Tuna Fisheries". The project should facilitate

    1) the execution of studies mentioned in Agenda Item 7, and

    2) the exchange of information on these studies and other research on tuna fisheries interactions, concentrating on the needs of developing countries.

11. ADOPTION OF REPORT

Participants reviewed a draft report of the Consultation on 31 January 1995. Based on participants comments and corrections the content of the report was approved and adopted by the Consultation. The task of final editing of the report was left for later consideration.

12. ADJOURNMENT

Upon adoption of the report of the Consultation, Mr. Shomura, as Chairman of the Consultation, extended his thanks and appreciation to the participants in concluding a useful and successful meeting. Dr. Majkowski, in his closing remarks, extended FAO's appreciation to the National Research Institute of Far Seas Fisheries for hosting the Consultation and providing the excellent support to the Consultation. He especially thanked the Director of the Institute, and Drs. Z. Suzuki, S. Tsuji, and T. Nishida of the Institute.

Mr. Shomura closed the Second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries at approximately 10.00 hours on 31 January 1995.

Table 1A. Summary of major interactions in the same area, time, and life stage.
(For explanation of symbols, see legend following Table 1B.)

Data from Bartoo[1]					Data from Present Consultation	
Fishing Gears	Species	Evidence	Quantified (significance)	Reference	Quantified (significance)	Reference
Tropical Tunas						
LgPS vs LgPL	YF, SJ, BE	F, A, T	No (Unknown)	1, 6	T (Slight: SJ)	a
SmPS vs SmPL	YF, SJ	F, A, T	A, T (Slight)	1, 14	-	-
LgPS, PL vs SmPS, PL	YF, SJ	F, A, T	No (Unknown)	1	T (Slight: SJ)	a
LgPS, PL, LL vs ART	YF, SJ, BE	F, A, T	No (Unknown)	1	A, T (Slight: SJ, YF)	i
LgPS vs LgLL	YF	F, A, T	-	-	A (Slight)	b
LgLL vs SmLL	YF, BE	F, A	No (Unknown)	1	-	-
SmPS vs ART, SmTR	LOT, KAW, FR, YF, SJ	-	-	-	No (Unkn.)	g, h, j, m
Temperate Tunas						
SmTR vs TRAP, OT	BF(N)	F, A, T	No (Unknown)	3, 4, 5	-	-
LgLL vs LgSURF	BF(S)	F, A, T	A, T (Large)	7, 3	T (Large)	f
LgTR vs LgDRIFT	AL(S)	-	-	-	T (Large)	d

[1] Paper 47 from present Consultation

Table 1B. Summary of interaction in different area and different or same life stage
(For explanation of symbols, see legend following the table.)

Data from Bartoo[1]					Data from Present Consultation	
Fishing Gears	Species	Evidence	Quantified (significance)	Reference	Quantified (significance)	Reference
Tropical Tunas						
LgPS vs LgPS	YF, SJ, BE	F, A, T	No (Unknown)	1, 6, 8	A (Slight-Moderate)	a, k
LgPS vs LgPL	YF, SJ, BE	F, A, T	No (Unknown)	1, 6, 8	T (slight: SJ)	c
LgPS, PL vs SmPS, PL	YF, SJ	F, A, T	No (Unknown)	1, 8	A, T (Slight)	i
LgPS, PL, LL vs ART	YF, SJ, BE	F, A	No (Unknown)	1	A, T (Slight)	i
LgLL vs SmLL	YF, BE	F, A	No (Unknown)	1	-	-
LgPS, PL vs SmLL, LgLL	YF, BE	F, A	No (Unknown)	1, 6, 8	-	-
SmPS vs ART, TR	LOT, KAW, FR, YF, SJ	F, A	-	-	No (Unknown)	g, h, j, m
Temperate Tunas						
SmTR vs LgPL	AL(N)	F, A, T	A, T (Slight)	1, 2, 9	-	-
LgLL vs LgSURF	AL(N)	F, A, T	No (Unkn.)	1, 9	-	-
LgLL vs LgSURF	AL(S)	F, A, T	No (Unkn.)	1, 10	A (Slight)	d
Small-fish Fisheries vs Large-fish Fisheries	BF(N)	F, A, T	No (Unkn.)	3, 4, 5	A (Large)	e
LgLL vs LgSURF	BF(S)	F, A, T	A, T (Large)	7, 3, 11	T (Large)	f
LgSURF vs LgSURF	BF(S)	F, A, T	A, T (Large)	7, 3, 11	T (Large)	f

[1] Paper 47 from present Consultation

Legend for Tables 1A and 1B

Fishing Gear:

Lg = large scale gear; Sm = small scale gear; PS = purse seine; PL = pole-and-line; LL = longline; ART = artisanal gear; TR = troll; TRAP = traps; OT = others; SURF = surface fisheries; DRIFT = drift gillnet

Species:

YF = yellowfin tuna; SJ = skipjack tuna; BE = bigeye tuna; LOT = longtail tuna; KAW = kawakawa; FR = frigate tuna; BF(N) = northern bluefin tuna; BF(S) = southern bluefin tuna; AL(S) = southern albacore

Evidence:

F = fishery data; T = tag data; A = assumed

Quantified (Significance):

T = tagging; A = analysis

References from Bartoo:

1. A review of fishery-interaction issues in the western and central Pacific Ocean, *John Hampton*, FAO Fish. Tech. Pap., 336/1, 1994.

2. Assessment of interaction between North Pacific albacore, *Thunnus alalunga*, fisheries by use of simulation model, *P. Kleiber and B. Baker*, (Abstract only), FAO Fish. Tech. Pap., 336/1, 1994.

3. World Meeting on Stock Assessment of Bluefin Tunas: Strengths and Weaknesses, *Deriso, R.B. and W.H. Bayliff* (editors), IATTC Spec. Rept. No. 7.

4. Interactions among fisheries for northern bluefin tuna, *Thunnus thynnus*, in the Pacific Ocean, *William H. Bayliff*, FAO Fish. Tech. Pap., 336/1, 1994.

5. A review of the biology and fisheries for northern bluefin tuna, *Thunnus thynnus*, in the Pacific Ocean, *William H. Bayliff*, FAO Fish. Tech. Pap., 336/2, 1994.

6. A brief analysis of fishery interaction for bigeye tuna in the Pacific Ocean, *Naozumi Miyabe*, FAO Fish. Tech. Pap., 336/1, 1994.

7. An overview of interaction issues among the fisheries for southern bluefin tuna, *Tom Polacheck*, FAO Fish. Tech. Pap., 336/1, 1994.

8. Progress report on a large-scale investigation on the reproductive biology of yellowfin tuna in the central and western Pacific region, *David Itano*, Rept. Fourth Meet. West. Pac. Yellowfin Tuna Res. Grp. WPYRG 4/2, 1994.

9. A review of the biology and fisheries for North Pacific albacore (*Thunnus alalunga*), *Norman Bartoo and Terry J. Foreman*, FAO Fish. Tech. Pap., 336/2, 1994.

10. A review of the biology and fisheries for albacore, *Thunnus alalunga*, in the South Pacific Ocean, *Talbot Murray*, FAO Fish. Tech. Pap., 336/2, 1994.

11. Review of the aspects of southern bluefin tuna biology, population, and fisheries, *A. Caton*, FAO Fish. Tech. Pap., 336/2, 1994.

12. Report of WPYRG yellowfin assessment model development workshop, Honolulu, November 8-12, 1993, *Pierre Kleiber*, Pret. Fourth Meet. West. Pac. Yellowfin Tuna Res. Grp. WPYRG 4/3, 1994.

13. Yield per recruit: Is there potential benefit from a size limit on skipjack and yellowfin catch?, *Pierre Kleiber*, Rept. Fourth Meet. West. Pac. Yellowfin Tuna Res. Grp. WPYRG 4/4, 1994.

14. Case study of Solomon fisheries, *Pierre Kleiber*, (Source not clear).

References from Present Consultation:

a. Interactions between the northern and southern yellowfin tuna (*Thunnus albacares*) fisheries in the eastern Pacific (G. Compeán-Jiménez and M. Dreyfus-León) (Paper 21)

b. CPUE analysis of Japanese fisheries for yellowfin tuna in the central and western Pacific (S. Tsuji and H. Okamoto, 1993, WPYRG 3/5)

c. Skipjack movement and fisheries interaction in the western Pacific (J. Sibert, J. Hampton, and D.A. Fournier) (Paper 29)

d. A method for estimating fishery interactions from South Pacific albacore catch-at-length data using the SPARCLE model (D.A. Fournier, J. Hampton, and J. Sibert) (Paper 30)

e. Status of northern bluefin tuna in the Pacific Ocean (W.H. Bayliff, 1991, IATTC Special Rep. No. 7)

f. Interactions between surface and longline fisheries for southern bluefin tuna based on recent tagging results: The importance of reporting rates (T. Polacheck, W. Hearns, and W. Whitelaw) (Paper 34)

g. Interactions of longtail tuna fisheries in the western part of South China Sea (T. Yonemori, H. Yanagawa, and Lui Yean Pong) (Paper 36)

h. Interactions of Thai tuna fisheries: Problem, research and development (S. Chullasorn) (Paper 38)

i. Case study of fishery interaction in an Pacific island country: Kiribati (J. Hampton, T. Lawson, P. Williams, and J. Sibert) (Paper 41)

j. Tuna fisheries interactions in Malaysia (P.E. Chee) (Paper 43)

k. Interactions between mode of fishing and category of vessel in catches of tunas in the eastern Pacific tuna fishery (A.J. Mullen *et al.*) (Paper 20)

l. Summary of suspected interactions and the evidence for them (N. Bartoo) (Paper 47)

m. Interaction and migration of small tuna in Malaysian waters (Raja Bidin, R.H. and Mohd Taupek, M.N.) (Paper 37)

Table 2. Major biological characteristics of selected Pacific tunas.

Species	Age at Maturity (years)	Approximate Longevity (years)	Maximum Weight in Catch (kg) (maximum 5% of catch)	Estimated *M*	Size of Spawning Area (relative to distribution)
Skipjack Tuna	1	5	10	1.5	very large
Yellowfin Tuna	2-3	8	90	0.9	large
Bigeye Tuna	3	10	130	0.4	moderate
Albacore	4-5	12	40	0.2-0.4	moderate
Northern Bluefin Tuna	5	20	300	0.2-0.3	very small
Southern Bluefin Tuna	6	20	150	0.2-0.3	very small

Table 3. Questions considered under Agenda Item 7.

(Symbols: * indicates a contributed item; + indicates an item discussed in detail during the Small Group Session. All other items are discussed in Paper 49.)

A. USING FISHERY DATA TO ESTIMATE OR DETECT INTERACTIONS

1. Can CPUE be used as an index of abundance? (+)
2. Is it necessary or practical to construct historical time series of catch and effort data for all fisheries?
3. Do data collection systems need improvement? (+)
4. What are the factors limiting the progress of stock assessment in the Pacific?
5. What arrangements for cooperation in data collection, compilation and analysis are required?

B. BIOLOGICAL OR ECOSYSTEM STUDIES TO AUGMENT FISHERY ANALYSES

6. Are genetics studies useful in defining which resources are jointly exploited by several fisheries?
7. Is further attention to estimating growth rates required?
8. How can estimates of natural mortality by size/age be obtained?
9. Is there any practical application for multi-species approaches?
10. Are environmental factors affecting the extent and nature of interactions? (+)
23. Are there rules of thumb or techniques that could measure or detect recruitment overfishing? (*)
28. What are the effects of schooling behaviour on population estimates derived from models that assume independence of individual fish? (*, +)

C. TAG-AND-RECAPTURE STUDIES

11. Is tagging longline-caught tuna practical and could it resolve the question of stock availability to surface and longline gears?
12. How can tag reporting be promoted and tag reporting rates (and other loss rates) be estimated?
13. To what extent are the results of tagging experiments reproducible? (+)

D. OTHER METHODOLOGIES

14. Are there new technologies that can be applied to surveying tuna populations?
15. Are there new technologies that can be applied to tracking tuna?

E. MODELLING INTERACTIONS

16. Should "absolute" interaction be estimated in addition to "marginal" interaction?
17. Should extrapolation from small interactions be avoided?
18. Should the results of interactions be expressed in economic terms?
20. Is assistance for developing countries in modelling required? (*)
24. How can simulation models be effectively applied? (*, +)
25. Should models be designed to assess management options? (*)

Appendix A

PROGRAMME

SECOND FAO EXPERT CONSULTATION ON INTERACTIONS OF PACIFIC TUNA FISHERIES

Shimizu, Japan
23-31 January 1995

Organising Committee

Dr. Jacek Majkowski	Convenor (FAO, Rome, Italy)
Mr. Andhi Isarankura	Administrative Secretary (FAO, Rome, Italy)
Mr. Richard Shomura	Consultation Chairman (UH, Honolulu, USA)
Dr. Ziro Suzuki	Consultation Vice-Chairman and Local Organizer (NRIFSF, Shimizu, Japan)
Dr. Tsutomu (Tom) Nishida	Local Organizer (NRIFSF, Shimizu, Japan)
Dr. Sachiko Tsuji	Local Organizer (NRIFSF, Shimizu, Japan)
Dr. Richard Deriso	(IATTC, La Jolla, USA)
Dr. John Hampton	(SPC, Noumea, New Caledonia)
Mr. Tony Kingston	(FFA, Honiara, Solomon Islands)
Dr. Gary Sakagawa	(NMFS, La Jolla, USA)
Dr. John Sibert	(UH, Honolulu, USA)

Objectives

1) To review and integrate the outcome of studies on tuna fisheries interactions,
2) to summarize
   - the extent of tuna fisheries interactions, and
   - unresolved research problems, and
3) to formulate guidelines for research on tuna fisheries interactions, concentrating on biological aspects of skipjack and yellowfin tuna in the Pacific.

Structure and Organisation

After the opening and announcements on logistic arrangements (Agenda Items 1 and 2 below), the Objectives of the Consultation and background information on FAO's project: "Cooperative Interactions of Pacific Tuna Fisheries" sponsoring this and previous Consultations will be presented and considered (Agenda Item 3). To place the Objectives of the Consultation in a broad perspective, all facets and types of tuna fisheries interactions will be acknowledged (Agenda Item 4), even those not to be considered in detail at the Consultation. Concerns related to interactions will be outlined. General requirements for fisheries management advice and research will be discussed (Agenda Item 4).

As most papers on studies on tuna fisheries interactions were dispatched to potential participants in December 1994, only their aspects of direct relevance to the Objective of the Consultation will be very briefly presented (Agenda Item 5). Each presentation will be followed by specific questions, answers and observations (a conference-style session). More general considerations may be flagged during these follow-up discussions, but their full elaboration will be postponed to Agenda Items 6 to 8.

Comparisons among the interaction problems, studies, research approaches and methods and other general observations will be made in the context of Agenda Items 6 to 8. These Agenda Items will be advanced by working at the Plenary Session and in small groups (a workshop-style session). This work will be arranged by the Moderators in consultation with the Organizing Committee. A Preparatory Meeting of the Moderators and Rapporteurs will be organized in the afternoon of 22 January 1995 (Sun.).

Computer software related to tuna fisheries interactions will be presented in small groups (see Agenda Item *). Specific research problems will be discussed also in small groups and reported to the Plenary Session if appropriate (see Agenda Item **).

The Report of the Consultation is aimed at comprehensively addressing its Objectives rather than at fully or chronologically reflecting all stages of advancing them. The discussion and questions related to individual presentations will be also reflected in the Report.

To facilitate a prompt adoption of the Report, Rapporteurs will submit their parts of Report to the secretariat within 24 hours from the completion of their Sessions after consulting their content with the relevant Moderators. Participants will be requested to communicate their specific suggestions for modifications directly to the Rapporteurs within 24 hours from the distribution of the first draft of Report.

The second draft of Report will be distributed in the morning of 31 Jan. (Tue.). In the afternoon of that day (Agenda Item 9), only the issues that could not be resolved directly among individual participants, the Rapporteurs and the Moderators will be allowed to be considered at the Plenary Session.

Documentation

Most papers to be presented at the Consultation and other background reports were dispatched by the Local Organizers (Dr. Ziro Suzuki, Dr. Sachiko Tsuji and Dr. Tsutomu (Tom) Nishida, NRIFSF, Shimizu, Japan) to the invited participants in December 1994. The deadline for their submission by the authors to the Local Organizers was November 15, 1994.

The style and format of the submitted papers should be the same as those in the Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, which have been distributed to all recipients of Circular Letters to TUNET Members and published as FAO Fisheries Technical Papers 336/1 and 336/2. Additional copies of the Proceedings can be obtained from FAO.

The Report of the Consultation together with the presented and/or tabled papers, if appropriate, will be published in the Proceedings of the Consultation in the form of FAO Fisheries Technical Paper.

ANNOTATED AGENDA

Monday (23/1), morning and afternoon

1. Opening of the Consultation

2. Adoption of the Agenda, Announcements on Logistic Arrangements and Other Preliminary Matters

3. Background Information and Objectives of the Consultation

   {The objectives and execution of FAO's project sponsoring the Consultation will be reported, indicating the project's emphasis on biological aspects of interactions of skipjack and yellowfin tuna fisheries in the Pacific. The relationship among the project and the First and Second FAO Expert Consultations and their objectives will be outlined.}

4. Facets and Types of Tuna Fisheries Interactions

   {As an introduction, the definition and meaning of fisheries interactions will be explained. The existence of broad range of interactions and their various facets will be acknowledged and the related concerns outlined (biological, economic, social and political). The facets and types of interactions, on which the Consultation will concentrate will be highlighted. General requirements for fisheries management advice related to such interactions and for research will be discussed.}

Monday (23/1), evening

Drinks hosted by FAO

Tuesday (24/1) and Wednesday (25/1), mornings and afternoons and Thursday (26/1), morning

5. Review of Studies on Tuna Fisheries Interactions

   {Studies sponsored by FAO's project associated with the Consultation and other research on tuna fisheries interactions will be presented, critically reviewed, discussed and integrated. The presentations will be divided into topics of: methodology, data and other information, yellowfin, skipjack, albacore, bluefin, small tunas and non-species specific.}

Wednesday (25/1) to Friday (27/1), evenings

*[1] Demonstration of Computer Software Related to Tuna Fisheries Interactions

{A detailed programme of the Demonstration will be announced by its Moderator, Dr. John Sibert at the beginning of demonstration. The demonstration will be held in small groups.}

**[1] Discussions on Specific Research Problems by Small Groups of Participants. Small group discussions included "Non-biological factors of tuna fisheries interactions" and "Atlas of tuna fisheries".

{These discussions may be carried out in a small group(s) of participants. The outcome of these discussions may be reported to the Plenary Session before the Adoption of Report and incorporated to the Report of the Consultation}.

Thursday (26/1), afternoon and Friday (27/1) and Saturday (28/1), mornings and afternoons

6[2]. Extent of Tuna Fisheries Interactions

{The extent of suspected interactions, the empirical evidence for them and their scientific quantification will be summarised. It will be discussed whether interactions are a problem now and/or likely to be a problem in the future and if yes, in what circumstances (species, fishing intensity and methods, geographical areas, etc.}

7[2]. Unresolved Research Problems and Guidelines for Research

{Types and facets of unresolved research problems critical from the view point of fisheries management will be identified to concentrate further discussions around them. Various approaches to studying tuna fisheries interactions will be summarized. Their assumptions and requirements for data, other input information, computational techniques and computer software and hardware will be outlined. The feasibility of their application in various circumstances will be discussed. Conditions under which they may be effective will be identified. Observations will be made on most appropriate ways of formulating and executing research programmes, recognizing the existence of various types and facets of interactions, their uniqueness in many cases and previous experiences with their examination.}

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[1] Agenda Items * and ** held simultaneously.

[2] Agenda Items 6 and 7 may involve:

a) a *Plenary Session on Thur. afternoon* subsequently covering Items 6 and 7 in general (the presentation of papers, preliminary comments and discussion and the formulation of two small groups corresponding to Items 6 and 7 and the determination of their assignments for Friday),

b) *two simultaneous meetings of small groups on Friday* to discuss the topics in detail, and

c) *Plenary Session on Saturday afternoon* to present and critically review the outcome of the discussions of the small groups, including the presentation of Reports on Items 6 and 7 (*Saturday morning* left for the completion of the Reports and their printing, copying and distributing).

Sunday (29/1), morning and afternoon

An excursion to be organized by the National Research Institute of Far Seas Fisheries and sponsored by FAO.

Monday (30/1), morning

An excursion to a local place of tuna landings organized by the National Research Institute of Far Seas Fisheries.

Monday (30/1), afternoon

8. Other Discussions and Conclusions

{Conclusions on the extent of tuna fisheries interactions, unresolved research problems and the availability of suitable research approaches or methods and the feasibility of solving the critical research problems will be summarized. Implications of these conclusions and other discussions for the provision of fisheries management advice will be considered in the light of presently increased interest in management of high seas resources and highly migratory species in particular. If considered appropriate, the Consultation may also make suggestions and/or recommendations regarding the research required to address the most important and urgent problems of tuna fisheries interactions in the Pacific and arrangements for its execution, etc.}

** Reports on the Outcome of Discussions on Specific Research Problems by Small Groups of Participants.

Tuesday (31/1), morning

Reading the Report

Tuesday (31/1), afternoon

9. Adoption of Report
10. Adjournment of the Consultation

Agenda Item	Moderator(s)	Rapporteur(s)
1	Mr Richard Shomura	Mr David Ardill
2	Mr Richard Shomura	Mr David Ardill
3	Mr Richard Shomura	Mr David Ardill
4	Dr Gary Sakagawa	Dr Paul Callaghan
5	Mr Richard Shomura	Dr James Ianelli
		Dr Gary Sakagawa
		Dr William Bayliff
6	Dr Ziro Suzuki	Dr Sachiko Tsuji
7	Dr Chris Boggs	Dr John Hampton
	Dr Richard Deriso	Dr Alejandro Anganuzzi
8	Mr Richard Shomura	Dr David Ardill
9	Mr Richard Shomura	Dr David Ardill
10	Mr Richard Shomura	Dr David Ardill
*	Dr John Sibert	Dr John Sibert
**	Mr David Ardill	Mr David Ardill
**	Dr Paul Callaghan	Dr Paul Callaghan

Hours of Various Activities

Registration
09:00 to 10:00 on Jan. 23 (Mon.), 1995

Morning and Afternoon Sessions
10:00 to 12:00 on the first day (Jan. 23, Mon.) and
09:00 to 17:00 on the remaining days

Evening Sessions
17:30 to 19:30

Lunch breaks
12:30 to 13:30

Coffee breaks
10:30 to 10:45 and
15:00 to 15:15

Additional Information

Information on

- weather conditions in Tokyo and Shimizu in January,
- the transportation from the Tokyo airport to Tokyo and Shimizu hotels,
- recommended hotels in Tokyo and Shimizu,
- the transportation from the hotels to the conference facilities,
- a visit to a fish market in Tokyo for participants staying overnight there and
- excursions from Shimizu and Tokyo on Jan. 29 (Sun.) and other days before and/or after the Consultation has been separately sent by the Local Organizers to all recipients of Circular Letters to TUNET Members in a form of Announcement from the Local Organizers.

Appendix B

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This publication presents the summary report of the second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, held in Shimizu, Japan from 23 to 31 January 1995. The objectives of the consultation were to review and integrate the outcome of the studies on tuna fisheries interactions; to summarize the extent of tuna fisheries interactions and unresolved research problems; and to formulate guidelines for research on tuna fisheries interactions. In addressing these objectives the consultation concentrated on biological aspects of skipjack and yellowfin tuna in the Pacific.

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