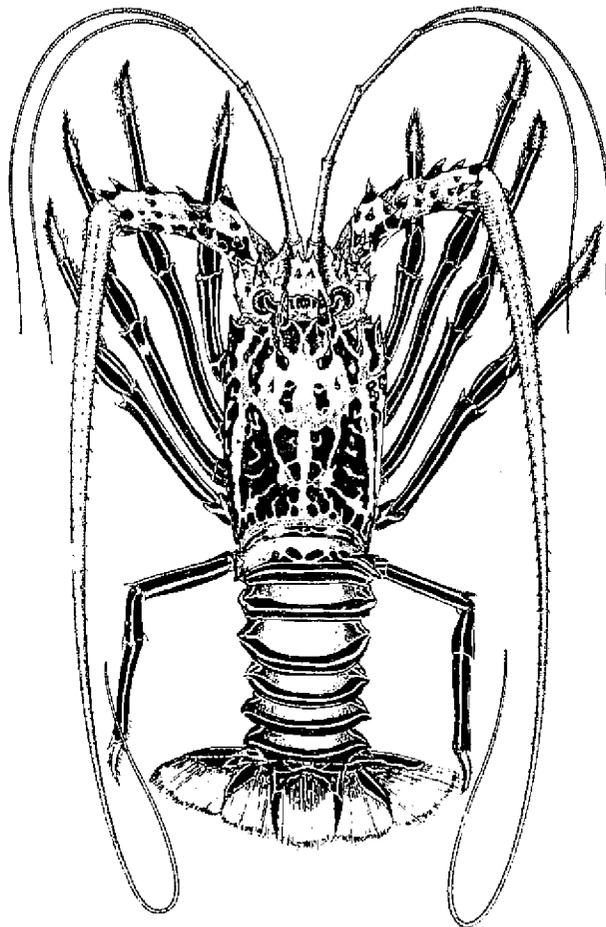


WORKSHOP REPORT

WORKSHOP ON PACIFIC
INSHORE
FISHERY RESOURCES

NOUMEA, NEW CALEDONIA, 14-25 MARCH 1988



Inshore Fisheries Research Project
South Pacific Commission
Noumea, New Caledonia

SOUTH PACIFIC COMMISSION.

WORKSHOP ON PACIFIC INSHORE FISHERY RESOURCES
(Noumea, New Caledonia, 14 - 25 March 1988)

REPORT

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PREFACE

The concept of a Workshop on Pacific Inshore Fishery Resources, bringing together island fishery scientists and managers, regional resource specialists, and resource specialists from outside the region, was developed in parallel with the SPC Inshore Fisheries Research Project (IFRP), a new SPC activity aimed at supporting and strengthening the national capacities of Pacific Island countries to collect and interpret data relevant to the management of their inshore fishery resources.

The main aims of the workshop, the first major activity of the IFRP, were

- to summarise present management related knowledge of the major fishery resources of the South Pacific;
- to disseminate the practical experience of Pacific Island fisheries officers in research and management issues;
- to familiarise participants with relevant work being carried out in other countries and research institutions;
- to identify national and regional inshore fishery research priorities, and recommend on specific areas of activity to be addressed by the IFRP;
- to provide opportunities for national participants to review and discuss in-country research projects with specialists and other Island country representatives working in similar fields.

This Report of the Workshop essentially provides summaries of the discussions which followed presentation of papers by workshop participants in the 32 topic sessions, under twelve agenda items. The summaries were prepared by the appointed moderators of these sessions, who in most cases presented a keynote address or review paper. They focus on the identification of mutual concerns, gaps in available knowledge, and consensus views on future work needed. Annex 1 contains summaries of the extra-plenary working groups that were convened to address particular technical issues of concern to participants.

Pacific Island country representatives, the SPC Secretariat and the FFA Research Co-ordinator also met out of plenary to discuss country research needs with a view to identifying areas of activity to be addressed by the IFRP. Some of the perceived constraints on fisheries research within the region are included as Annex 2.

The large amount of documentation tabled is listed in Annex 3 and also under the relevant sessions where it was presented. Originals of these documents are retained by the IFRP.

Various agencies contributed generously to enable this unique gathering to take place. They included:

International Centre for Ocean Development (ICOD)
Forum Fisheries Agency (FFA)
FAO/UNDP Regional Fishery Support Programme (FAO/UNDP RFSP)
United Kingdom Overseas Development Administration (UKODA)
Government of New Zealand
Government of Australia

In addition, a large number of organisations contributed by partly or wholly financing the attendance of representatives at the Workshop. These were:

- Australian Centre for International Agriculture Research (ACIAR)
- Australian Institute of Marine Science (AIMS)
- Australian Maritime College (AMC)
- British Development Division in the Pacific (BDDP)
- Committee for the Co-ordination of Offshore Prospecting in the South Pacific (CCOP/SOPAC)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Forum Fisheries Agency (FFA)
- FAO/South Pacific Coastal Regional Aquaculture Development Programme (SPRADP)
- FAO/UNDP Regional Fishery Support Programme (FAO/UNDP RFSP)
- Government of Australia
- Government of Papua New Guinea (PNG)
- Great Barrier Reef Marine Park Authority (GBRMPA)
- International Centre for Living Aquatic Resource Management (ICLARM)
- James Cook University of North Queensland (JCU)
- Institut français de recherche scientifique pour le développement en coopération (ORSTOM)
- Queensland Department of Primary Industry (QDPI)
- United Kingdom Overseas Development Administration (UKODA)
- University of Hawaii (UOH)
- University of the Ryukyus (UOR)
- University of the South Pacific (USP)
- US National Marine Fisheries Service (NMFS)

The combined expertise, experience and enthusiasm of the more than one hundred participants made the workshop the productive and informative exchange that the Commission had envisaged. The Secretariat acknowledges with gratitude the contributions of all participating organisations and individuals.

Day 7 : Tuesday 22 March

Stock and habitat enhancement
 Reseeding and introductions
 Artificial reefs
 Fish aggregation devices

Day 8 : Wednesday 23 March

Other resources
 Beche-de-mer
 Commercial seaweeds
 Semi-precious corals
 Reef-building corals
 Turtles

Day 9 : Thursday 24 March

Inshore fishery management and regulation
 Options for fishery management
 Traditional marine resource management concepts
 Destructive fishing practices

Fisheries and coastal zone management

Day 10 : Friday 25 March

Future Pacific Island inshore fishery research requirements

Closing formalities

Agenda

Day 1 : Monday 14 March

Opening formalities

Introduction

Stock assessment methodologies and techniques

The collection and use of fishery statistics

Day 2 : Tuesday 15 March

Finfish resources

Deep-water snappers, groupers and allied species

Shallow-water snappers, emperors and allied species

Reef fish

Day 3 : Wednesday 16 March

Finfish resources (continued)

Inshore baitfish

Open-water baitfish

Large coastal pelagic species

Sharks

Day 4 : Thursday 17 March

Reef resources: survey techniques and methods of study

Telemetry, remote sensing, and the use of environmental data

Day 5 : Friday 18 March

Crustacean resources

Tropical lobsters

Deep-water shrimps

Penaeid shrimps

Crabs

Day 6 : Monday 21 March

Mollusc resources

Trochus

Green snail

Pearl shell

Giant clam

Other mollusc resources

INTRODUCTION

The SPC Secretary-General, Mr Palauni M. Tuiasosopo, welcomed delegates in an introductory speech which underlined the importance of the workshop to the region. He emphasised that it brought together for the first time Pacific Island scientists and resource specialists from tropical areas of the world to discuss research into, and management of, Pacific Island inshore marine resources.

The Chairman of the meeting, SPC Fisheries Adviser Mr Bernard Smith, outlined the administrative procedures applying to the meeting. The session closed with a brief presentation by SPC Senior Inshore Fisheries Scientist Mr Garry Preston which outlined the history of the workshop and its relationship with the SPC Inshore Fisheries Research Project (BP.56).

Participants were urged to bear in mind that as well as discussing technical aspects of the resources in question, the Commission hoped to obtain guidance on appropriate future directions for the Inshore Fisheries Research Project.

STOCK ASSESSMENT METHODOLOGIES AND TECHNIQUES

Moderator: Dr Ray Hilborn

Main reference document:

A syllabus for tropical fisheries stock assessment, by C.J. Walters and R. Hilborn. South Pacific Commission, 1986 (Training Course manual)

Relevant papers:

Stock Assessment - Computer programmes for use in tropical fisheries - M. King (BP.23)

Evaluation of the SPC Inshore Fisheries Research Project, the Workshop on Inshore Fishery Resources, and related activities - SPC Secretariat (BP.56)

The session moderator gave an introductory presentation which drew attention to the limited amount of Pacific Island experience in stock assessment and the consequent need to learn from the mistakes made elsewhere. Dr Hilborn's presentation, the ensuing discussion session and various working groups scheduled outside formal meeting hours raised a number of important and sometimes controversial issues, some of which are summarised in the following paragraphs.

The main reasons for stock assessment are to provide information on which management decisions can be based. The information usually required is the determination of the size of stock or exploitable resource, or the prediction of how the resource will respond to exploitation. If some sort of constraint prevents the use of this information in making management decisions, then the case for collecting the information is questionable. Even if stock assessment indicates that a change in management strategy is required, the change is unlikely to happen unless significant visible benefits are likely to result. However, in most fisheries, management decision will become possible at some future time (perhaps one of crisis in the fishery), hence there is usually ample justification for on-going stock assessment work.

Understanding the relationship between stock size and production (growth plus recruitment) is fundamental. For this it is necessary to have estimates of abundance (by survey, depletion experiment or spatial catch per unit effort (cpue) data) and the spatial distribution of the catch itself. Spatial variation in exploitation rates allows the estimation of points on a graph of stock size vs production. Archipelagos provide very useful experimental systems in this context. However, due to the mobility and selective activity of fishing units, changes in catchability, evolution of new gears etc, cpue information from commercial catches is often not a good measure of abundance. It is now recognised that surveys are usually needed to obtain reliable abundance estimates. Surveys in virgin areas can be used to estimate maximum sustainable yield (MSY) by subtracting 50 - 70% to account for non-sustainable production. Thereafter, provided that standardised gear is used, repeat surveys can be used to monitor changes in mortality rates.

Fisheries managers may not need absolute information on stock size, but rather data on whether the stocks are relatively over- or under-fished. Pacific Island fisheries are, by their nature, very difficult to assess in absolute terms because of their fluctuating multi-species, multi-gear characteristics. The need for comprehensive catch statistics was questioned, as rough extrapolations may be adequate. Nevertheless, there is a need for good data on fishing effort, and on historical catch and effort information from fisheries based on sessile organisms, which are difficult to monitor via changes in cpue alone. There was a variety of opinion on the utility of length-frequency information to estimate mortality rates in exploited stocks. The use of length-adjusted catch curves is valuable in this context, but there are reservations about the implicit assumptions this technique makes, particularly those of constant recruitment and non-varying (eg density-independent) growth rates.

Data on changes in catch rates are therefore valuable for stock assessment, as is information on the potential for non-sustainable yield, particularly in the early part of a fishery's development. MSY can be a misleading concept in virgin or underexploited fisheries, since it represents an equilibrium condition. MSY cannot be reliably estimated when a fishery first starts, and in most cases, it must be exceeded in order to be known. Just as important as changes in yield, and perhaps more so, are the changes in catch rate associated with the fishery's development. It is nevertheless useful to use MSY as an argument against over-capitalisation in the early stages of a fishery, and to underline the fact that high initial catches will decline. Some fisheries are cyclical or catastrophic in nature and undergo massive population fluctuations independent of the level of fishing effort. However, most of the known examples derive from temperate rather than tropical areas. In order to assess the effects of fishing effort in these (and other) fisheries, surveys of unfished areas make useful controls. Fisheries of this type do not lend themselves to prediction of the long-term effects of exploitation.

It was noted in the context of multi-species fisheries that recruitment overfishing of certain vulnerable species can occur without major economic detriment to the fishery. In many cases the most valuable or desirable species are the first to be overfished in this way, and it may never be possible for them to return to their original levels of abundance. Growth overfishing was considered to be generally less important than recruitment overfishing in the Pacific.

As fisheries develop in the region, fisheries management regimes will also be needed and these should be responsive. Responsive management acknowledges that it may be necessary to reduce effort when stock assessment indicates that overfishing is occurring. However, it

allows more rapid acquisition of information on the response of the fishery to changing levels of effort, and permits maximisation of the benefits that accrue. Management should be based on co-operation with fishing interests, not antagonism. It is important to generate contact with and feedback from fishermen so that they are able to participate in the development of management regimes in which they can recognise direct benefits. The general feeling was that fishermen tend to respond well to this approach, particularly where the future of the resource is uncertain.

THE COLLECTION AND USE OF FISHERY STATISTICS

Moderator: Mr Michael Molina

Main reference document:

The collection and use of fishery statistics by M.E. Molina (WP.6)

Relevant papers:

Fiji's fisheries data collection and information system - S.P. Sharma (BP.13)

Local fisheries data collection in Kiribati - C.C. Mees (BP.20)

A report on the market survey of reef and lagoon fish catches in Western Samoa - N. Helm (BP.30)

Past and present data collection systems of the bottom fishery in Tonga: a comparison - S. Langi (BP.39)

The collection and uses of inshore reef fisheries information to assess and monitor the shelf fisheries of the Kingdom of Tonga using the ICLARM approach. Summary of the first year's activities and results - K. Felfoldy-Ferguson (BP.41)

Guam inshore fisheries survey - G. Davis (BP.43)

Guam offshore fisheries survey - R. Myers and G. Davis (BP.44)

Guam fisheries data processing - R.F. Myers (BP.45)

Summary of Information papers 17 and 18: Data acquisition and processing system for the domestic pole and line fishery in Solomon Islands - P.N. Nichols and Y. Ota, Data acquisition and processing system for the domestic purse seine fishery in Solomon Islands - P.N. Nichols and Y. Ota (BP.99)

Etude socio-économique du groupement des pêcheurs d'Oundjo, commune de Voh, Nouvelle-Calédonie - Service Territorial de la Marine Marchande et des Pêches Maritimes, Nouméa, Nouvelle-Calédonie (BP.55)

Priorities and pragmatism : Fisheries statistics programmes in the Cook Islands - N.A. Sims (BP.100)

Statistiques des pêches maritimes et l'aquaculture en Nouvelle-Calédonie (1976-1986) - M. Palladin (IP.13)

Data acquisition and processing system for the domestic pole and line fishery in Solomon Islands - P.N. Nichols and C. Maruyama (IP.17)

The session was opened with a keynote address which summarised many of the generalised aspects of the collection and use of fishery statistics in the region and suggested several

topics for discussion. It was emphasised that fishery statistics are collected for scientific, economic and socio-economic purposes. Each of these categories may have differing approaches and requirements. Oral summary presentations of written reports were then delivered by participants from the Cook Islands, Fiji, Guam, Kiribati, New Caledonia, Tonga and Western Samoa. The reports described specific fishery statistics programmes currently utilised in these countries.

From the presentations it became apparent that there exists a good deal of overlap in what these programmes are intended to accomplish. Consistently shared objectives include the aims of establishing baseline numerical descriptions of various fishery sectors and of monitoring changes in the evolution of new or existing fisheries.

Representatives from the Cook Islands, Fiji, Kiribati and Tonga provided the most direct examples of how fishery programmes are utilised to support economic development. The clearest example was presented in the case of Tonga, whose programme is geared to assess the feasibility and profitability of an emerging deep bottom fishery. Cases in which fishery statistics are used by development banks in evaluating loan applications or in monitoring loan repayments were given by the speakers from Fiji, New Caledonia and Tonga.

The use of fishery statistics in the long-term managing of limited resources among several competing user-groups and for balancing resource-user needs with the forces of rapid coastal development was best illustrated in the case of Guam. Other presentations from the Cook Islands, Fiji and Kiribati also emphasised the importance of utilising statistics as an administrative decision-making and policy-formulating tool in clarifying the need for instituting resource management regulations.

The speakers from New Caledonia provided specific examples of the long-term collection of fishery statistics in monitoring commercial production and in gaining fuller insight into the socio-economics associated with family- and village-oriented fishing groups in their territory. The limited utility of data collected from central fish markets as a way of estimating total fish production was dealt with in the presentation by the participant from Western Samoa.

Specific problems associated with fishery data collection were brought out during the presentations. Several of these were shared among the participating countries. Many of these problems were related to deficiencies in survey design, such as inadequate or under-representative coverage in sampling programmes. Other obstacles included the unreliability of fishermen in reporting accurate information, sociological or cultural barriers to collecting reliable data, the use of inadequately trained personnel for data collection, low funding levels to achieve required results, conflicts in work-related responsibilities and prioritisation of projects, and inefficiencies in government office organisation.

Discussion toward the end of the session dealt with the topic of long-term data collection, primarily from the perspective of in-house government commitment to sustaining many newly-established fishery statistics programmes. It was generally agreed that the long-term monitoring of fisheries was desirable, due to the continuously changing economic and socio-economic conditions found in developing countries, as well as the biological and

environmental fluctuations often associated with exploited fish stocks. Fishery statistics systems should be designed to satisfy information requirements through institutionalising data collection as part of a continuous fisheries programme, and it may be worthwhile to seek legislation to facilitate this.

There was general acknowledgment of the fact that high-level government officials often demand the collection of current reliable fishery statistics even though they pay little regard to what this requires in terms of funding and personnel resources. Even though fisheries officers often must provide data which they feel are not very accurate, they should attempt to enlighten administrations of the realities of what it takes to acquire this information. A possible approach to rectifying this situation would be to seek external funding initially to establish data collection programmes and then convince the local government to continue funding support on a long-term basis.

The design of data collection programmes should be as simple and as cost-effective as possible. Linking stock assessment and fisheries management in a single programme might be desirable. Often too much effort is put into collecting detailed statistics which are never used. More forethought needs to be directed to identifying the actual end-users of statistics. An approach aimed at yielding the crude fishery statistics in which planners are generally interested would reduce the funding and personnel levels required for collecting many of the more detailed data which are not immediately used.

In many government systems fisheries officers are obliged to collect data on many aspects of their fisheries other than for stock assessment purposes. Due to the logistics involved, baseline monitoring for management must often be an exercise separate from the quite specific requirements of stock assessment. There have been cases in the past where baseline monitoring information on fisheries which was not specifically used in the immediate sense was found to be not only quite valuable at some point in the future, but also impossible to obtain had it not been documented previously. The development of improved methods for mathematical data expansion, or data raising, in order to calculate estimates of effort and catch from survey data was suggested as an alternative proposal for increasing the cost-effectiveness of a fisheries monitoring programme.

Finally, while the collection of statistics solely for the sake of their collection was not advocated, baseline monitoring of fisheries should be geared to yield the level of detail that is deemed most useful on a case by case basis, and this may often be influenced by the intensity and pace of development being experienced in any particular situation. Fisheries officers will always be faced with trade-offs in what can be accomplished in the collection and use of fisheries statistics based on the realities of funding, politics, culture and levels of technical ability. There may never be one standard fisheries data collection system that will work best in all cases, and individual governments will eventually have to decide what amounts of detail they desire from their data collection programmes. Various options in the design of fisheries data collection systems exist and governments need to identify avenues available to them for developing innovative approaches to implementing systems which not only meet their specific needs but are also workable within their particular constraints.

FINFISH RESOURCES

Deep-water snappers, groupers and allied species

Moderator: Dr Jeffrey Polovina

Main reference document:

Tropical snappers and groupers : biology and fisheries management by J.J. Polovina and S. Ralston. Westview Press, 1987. 659p.

Relevant papers:

Exploratory trawling on some seamounts in New Caledonia - R. Grandperrin and B Richer de Forges (BP.1)

Pêche des vivaneaux à la palangre profonde en Nouvelle-Calédonie - R. Grandperrin and M. Kulbicki (BP.18)

Progress report on a programme to assess bottom fish stocks on seamounts in Tonga - S.A. and V.A. Langi (BP.34)

Past and present data collection systems of the bottom fishery in Tonga: a comparison - S.A. Langi (BP.39)

The Fiji deep-water snapper fishery - its development and management requirements - A.D. Lewis, A. Sesewa and T. Adams (BP.67)

Assessment of deep-bottom fishes of Solomon Islands - A. Wata (BP.73)

Summary of Information Paper 19: Deep-bottom fishing in French Polynesia - L. Wrobel (BP.77)

A review of deepwater handline fishing in Papua New Guinea - M.R. Chapau (BP.82)

La pêche profonde en Polynésie française - L. Wrobel (IP.19)

Papers and experiences dealing with snapper and grouper fisheries were presented from Hawaii, the Northern Marianas, Tonga, Vanuatu, French Polynesia, New Caledonia, American Samoa, Fiji, Solomon Islands and Papua New Guinea. The full spectrum of exploitation was represented. In Hawaii there is a history of harvesting these resources since World War II. In Tonga and Fiji the resources have only recently come under heavy fishing pressure as a result of export opportunities to Hawaii and mainland USA. In American Samoa, the fishery, especially on the offshore banks, was short-lived, apparently due to recruitment overfishing, and has not yet recovered. In other countries fishery development is at a relatively low level with respect to estimated potential yields.

Estimates of annual sustainable yield of 280 kg per nautical mile of 200m isobath have been derived from work in the Northern Marianas and Hawaii and can be used as conservative target levels for other countries as first approximations. Tonga and Fiji presented descriptions of approaches which use large length-frequency samples and catch and effort data, from which estimates of optimum fleet size of the fishery, will ultimately be developed. In Fiji, a management plan has been developed to control fishing effort based on a first estimate of sustainable yield and give preferred access to local vessels. In Tonga it is thought that the fleet is already large enough to harvest all the sustainable yield but effort regulations have yet to be imposed. The application of bottom longline gear for bottom-fish was presented in the report from New Caledonia. This gear is also used in Fiji. The paper

from Vanuatu presented catch and effort and length-frequency data from a 5-year time series which indicated that the stocks are not yet heavily exploited. Difference in species composition of the multispecies bottom fish resource over short geographic distance was described in the Papua New Guinea presentation. It was concluded that differences in habitat may be responsible. In comparison to catch rates from Tonga and Fiji, data from French Polynesia showed low catch rates even though fishing pressure was light, which emphasised that regional differences in bottom-fish productivity do exist.

The following issues and questions were raised as being of high priority:

- i) How to determine when recruitment overfishing is occurring while the situation is still reversible?
- ii) What are appropriate management measures which maximise social and economic benefits?
- iii) To what extent are islands, banks, and seamounts self recruiting?
- iv) What is the habitat of the early stage juveniles?

Some of these questions were discussed further in an extra-plenary working group. A summary of these discussions is presented in Annex 1b.

FINFISH RESOURCES

Shallow water snappers, emperors and allied species

Moderator: Dr Keith Sainsbury

Relevant papers:

- Ageing of tropical reef fish by density of daily otolith increments - N. Baillon (BP.4)
- Summary of Information Paper 3: Status report - Gillnet selectivity project in Yap, Federated States of Micronesia - C.M. Price (BP.5)
- Survey of the soft bottom carnivorous fish populations using bottom longline in the south-west lagoon of New Caledonia - M. Kulbicki and R. Grandperrin (BP.15)
- A direct test of the effects of protective management on a tropical marine reserve - G.R. Russ and A.C. Alcalá (BP.29)
- Fish-transect surveys in Pohnpei lagoon (Eastern Caroline Islands) to determine the influence of neighbouring habitats on fish community structure - S. James, L. Olter and E. Endere (BP.49)
- Progress report: American Samoa bottom-fish assessment programme - D. Itano (BP.68)
- Status report - Gillnet selectivity project in Yap, Federated States of Micronesia - C.M. Price (IP.3)

The shallow water (<100m) non-reef fisheries of the Pacific region harvest a wide range of species with a diversity of fishing gears. Seven papers were presented in this session, describing the historical and present catch-by-gear of some fisheries, use of standardised survey methods to help develop fisheries and measure the effects of exploitation, techniques of age determination, and sharing some experiences in the management of shallow water snapper fisheries. The importance of the shallow water fish resources in the region was emphasised by many speakers, but it was also pointed out that because they are typically artisanal or exploited by a large number of small scale commercial fishermen, these fisheries are often given lower priority for research and development than the more heavily industrialised fisheries such as the deep water snapper fisheries. A notable exception to this was provided by American Samoa, which after a review of the social and economic values of its actual and potential fisheries has recently shifted the emphasis of its bottom-fish assessment programme from deep water to shallow water.

The difficulties of determining fishing effort and the catches by species and gear for the shallow water fisheries in most of the Pacific Islands were emphasised by many of the speakers, and this is clearly a major problem. This difficulty was particularly stressed by those dealing with very small fisheries or fisheries exploiting many small populations, where the fishery resources were perceived as being in danger of overexploitation but the value of the catch per year was small compared to the costs of collecting data from the fishery. However, it was recognised that there was considerable value in continuing efforts to overcome these problems, because answering the question of how much fishing activities have to be changed to meet a particular management objective ultimately requires information about how much those fishing activities have yielded in the past. Some of the presentations described an approach in which occasional periods of intensive sampling were used to provide occasional "pictures" of the activities of the fishermen and their catches, rather than attempt continuous monitoring. This was seen as a very useful approach when fishing effort and catches by each gear are very difficult or expensive to obtain. Whether this sampling of the fishing activities is conducted continuously or intermittently, however, it was repeatedly stressed that there is a need for the field staff involved to have greater access to recent and relevant literature on methods of sampling, data analysis and taxonomy. There is a particular need for development and distribution of taxonomic keys which can easily be used by field workers with little taxonomic training.

The large numbers of gears being used, and the fact that fishermen change their gear, areas of operation and details of gear deployment for a variety of reasons, mean that catch and effort data from the fishery are not likely to provide a good index of the abundance of populations or the level of exploitation of the resource as a whole. Several examples of this were mentioned during the session, and it was pointed out that in such a situation it was highly desirable to conduct occasional resource surveys with standardised gear and sampling design in order to determine the state of the stocks and the effects of exploitation on the resource. These standardised surveys were considered particularly useful if they can be repeated to provide a time series of data on the state of the resource, if they can be used in conjunction with catch and effort data from the fishery, and if the surveys can be conducted both in areas that are presently fished heavily and in areas that are presently fished a little or not at all. Several examples of the use of standardised surveys were described, using fishing gear that included trawls, traps, gill nets, hand lines and long lines. Traps were found to be particularly useful in several instances, but in one case long lines were found to provide more repeatable results than traps. Choice of the appropriate gear will undoubtedly depend on local conditions, but the importance of conducting a series of standardised surveys was emphasised by many contributors. An extra-plenary working group on the use of traps as a survey tool was subsequently held, and is reported in summary at Annex 1e.

To help overcome some of the practical difficulties in conducting resource surveys with standard gears and collecting data on the activities of the fishermen it was suggested that agencies such as SPC should:

- i) Play an active role in the preparation and distribution of appropriate literature; and
- ii) Assist the regional fisheries officers in the preparation of funding proposals to obtain the additional resources (people, equipment and money) needed to conduct intermittent standardised surveys and "saturation" collection of catch and effort data. This second point might be extended to include the formation of a permanent group of people (a "roving team") that could provide the manpower, equipment and expertise required, and could conduct surveys of fishery resources in the region on request.

Very little is known about the biology, ecology or population dynamics of the main fish species taken in the shallow water fisheries. Even very basic life-history information, such as where the juveniles occur, is lacking for many species. Reproduction was not discussed by any of the participants, although it is known from other studies that lethrinids and serranids are sequential hermaphrodites and that under some circumstances this can effect the response of the population to fishing (although this has been shown not to have been responsible for the collapse of the lethrinid populations in north western Australia). Ageing studies were reported on by several contributors, but again the information available is very sparse. Growth of lethrinids appears to vary regionally. Techniques for examining growth included tag-recapture experiments, annual bands in otoliths, and daily rings in otoliths. Several examples of successful tag-recapture experiments were reported, and the need for validation when using any of the otolith based methods was emphasised. The use of daily rings has been found to be particularly useful, and it was recognised that there was a need for development of daily ageing methods that are fast, economical and available to the fisheries officers and biologists of the region. Considerable expertise in the use of daily ageing techniques exists in and around the region (eg Hawaii, USA mainland, ORSTOM in New Caledonia, AIMS and CSIRO in Australia), and participants considered that regional agencies such as SPC could help link fisheries biologists in the region with these centres of expertise. It was also suggested that it might be useful to encourage development of a central facility for reading otoliths from Pacific Island countries. This was further discussed in an extra-ordinary session, reported in summary at Annex 1g.

Management issues and approaches were varied, in part because of the diversity of shallow water fisheries operating in the region. Two cases were described in which major changes in species composition had occurred, with snappers and emperors declining in abundance and other types of fish increasing. In one case the change was unimportant to the fishery, because all the species involved were of similar value, and in the other case active measures (area closures) had been introduced in an attempt to reverse the change. Use of closed areas also provided some very interesting information on fishery yields from a reef and near-reef fishery. Examination of the fishery yields before and after the failure of a long-existing reserve showed that the total yield from an area was higher when about 25% of the area was held as a reserve than when all of the area was fished. This result suggests that reserves could provide a very powerful management option in the region, and further examination of the use of reserves in management of fisheries in the Pacific region should be actively encouraged.

Another study described repeated surveys of the fish community and catch rates at varying distances from a main population centre, and used the fact that fishing effort decreased with distance from the population centre to determine the effects of fishing on the resource. This was recognised as a very useful approach, which could be applied in many circumstances. This approach to determine the effects of fishing would be greatly strengthened if control areas were available (eg some areas close to and far from the population centre which have not been fished) or if the surveys were repeated around a number of population centres.

There was considerable discussion about the value of drawing together and compiling a report on the experiences that different countries have had with their shallow water fisheries. This was considered to be a very worthwhile project, and would have two main aims. The first is avoidance of the need to repeat the same learning process in all countries. An illustration of this was provided when one delegate reported that his country was considering the introduction of fish "weirs", and was immediately provided with a number of useful experiences about the efficiency, difficulty of control and social implications of the use of "weirs" from countries that already had this fishing gear. The second is to attempt to compile the yields per unit area of habitat which have been achieved and appear sustainable in shallow water fisheries, so that fisheries assessments in the region have some rough estimate of what is a reasonable expectation for their fisheries. It is hoped that some general yield per area estimates could be produced to fulfil the same role as the yield per area estimates compiled for coral reef systems and the yield per mile of 200m depth contour estimates compiled for deep-water snapper fisheries.

FINFISH RESOURCES

Reef Fish

Moderator: Dr John Munro

Main reference document:

Assessment and management of coral reef fisheries: biological, environmental and socio-economic aspects. In: Proceedings of the Fifth International Coral Reef Congress, Tahiti, 1985, Vol.4, p.545-581, by J.L. Munro and D. McB. Williams

Relevant papers:

The contribution of planktivores and herbivores to yields of fin-fishes from some coral reefs in the Pacific - G.R. Russ (BP.28)

A coral reef fishery for aquarium fish - the Fiji experience - A.D. Lewis (BP.31)

Fish-transect surveys in Pohnpei Lagoon (Eastern Caroline Islands) to determine the influence of neighbouring habitats on fish community structure - S. James, L. Olter and E. Endere (BP.49)

Biologie et stratégie de reproduction de *Naso brevirostris* (Acanthuridae) en relation avec les rendements de la pêche - B. Caillart and E. Morize (BP.76)

La pêche lagonaire dans l'archipel des Tuamotu - A. Stein (BP.81)

Aquarium fish - P. Joannot (BP.84)

FINFISH RESOURCES

Inshore baitfish

Moderator: Dr Sandy Argue

Main reference document:

Inshore tropical baitfish: current resource management knowledge - A.W. Argue (WP.16)

Relevant papers:

Tuna baitfishes: biology, ecology, resources in New Caledonia - C. Conand and M. Kulbicki (BP.3)

The Fijian baitfishery - S.P. Sharma (BP.14)

Summary of Information Paper 8 - A report on a collaborative research programme into baitfish in Solomon Islands, with some preliminary findings - P. Nichols (BP.26)

The status of the Kiribati live-bait fishery - J. Ianelli (BP.59)

Biological study of exploited baitfish species *Stolephorus heterolobus* and *S. devisi* in Western Province, Solomon Islands - P.D. Nichols (IP.7)

A report on a collaborative research programme into baitfish populations in Solomon Islands with some preliminary findings - P.D. Nichols (IP.8)

AIMS Programme description - Coastal pelagic resources - D.M. Williams (IP.21)

The keynote address by the moderator, as well as summarising the previous SPC regional work on baitfish and identifying possible directions for future baitfish work, took the innovative approach of classifying published baitfish papers by subject material and concluded that relatively few presently address stock assessment and management issues, but that this will increase as exploitation levels increase.

Five papers were presented and considerable discussion ensued. Major points emerging from the discussions are briefly summarised.

Inshore baitfish species are primarily used in the region as live-bait for pole-and-line fishing rather than as a food source. General concern was expressed over the potential for species/fisheries interactions. Of particular concern were:

- i) The effect of incidental harvest of juvenile reef fishes during normal baitfishing operations on recruitment to reef fish stocks;
- ii) Impact of bait fish harvest on forage for reef fish stocks, and as a result, the distribution and abundance of reef fishes;
- iii) Impact of bait fish harvest of species utilised directly by artisanal fisheries. (This is of particular concern to Kiribati and to a lesser extent Fiji).

Six papers were presented and discussed in this session, covering a wide range of topics. The address of the moderator concentrated on the possible changes in the composition of reef fish communities in response to intensification of exploitation and on the magnitudes of harvests per unit area of reef or shelf.

Discussions confirmed the enormous importance of all components of the reef fish communities, specifically herbivores/omnivores in addition to the better-studied snappers, groupers and emperors. Issues identified in earlier sessions emerged but were not discussed again in detail.

Several participants reported harvests from particular islands or atolls which conformed with the general estimation of a potential harvest of up to 5 mt/sq km/year when all habitats down to 200m are included and the shelf has a generalised cover of coral reefs, seagrasses, sandy areas and mangroves. More extensive surveys are needed of the habitat coverage of island shelves, combined with accurate catch statistics, before the question of potential harvests from areas of shallow reef can be satisfactorily resolved. Evidence was presented that the largest harvests (over 40 mt/sq km/year) occurred when shallow reefs were intensively fished and planktivorous fishes formed a major component of the reef fish catches. The importance of *Selar crumenophthalmus*, a neritic pelagic species, was noted by several participants.

Discussions of fisheries for live aquarium fishes highlighted the very satisfactory nature of well-run operations, but also revealed a great paucity of information on production parameters which could enable replacement rates to be calculated for these small fishes. Fiji has worked out satisfactory guidelines to regulate its fishery. They have been adapted or requested by other countries in the region.

The seasonality of recruitment of surgeon fish and rabbit fish was discussed. Some areas receive regular recruitment while others reported episodic recruitment. In other areas the presence of juveniles is shown by their frequent occurrence in the stomachs of large pelagic fishes.

The overall consensus was that there was a paucity of estimates of biological parameters which would lead to effective assessment and management of the reef fish stocks which constitute such an important component of island fisheries. These parameters include growth and mortality rates, size at recruitment and maturation, catchability and stock abundance.

A major problem area arises from confusion over the use of various techniques for "appraisal", "survey" and "assessment" - all compounded by the multiplicity of methods and sometimes conflicting advice.

Interactions between bait fisheries and other fish stocks are very complex and difficult to quantify without large expenditures of research funds through well designed programmes.

Solomon Islands has by far the largest bait-fishery in the region (approximately 2000t per year), which has given rise to concerns regarding overharvest at particular bait fishing sites, and conflicts between reef owners and commercial scale bait fisheries. Solomon Islands has in place a large and comprehensive baitfish stock assessment programme aimed at quantifying the importance of baitfish in coral reef ecology, and the population dynamics of and yield from baitfish stocks as well as the development of appropriate management regimes for bait fisheries.

The general point was made that there are few estimates of baitfish standing stock, productivity and harvest rate. Hence it is difficult to quantify the impact of bait fisheries on bait stocks and recruitment. In this regard the Solomon Islands research programme provides a unique opportunity in the Pacific region to improve our understanding of baitfish population dynamics.

In Fiji, the overall condition of the bait fishery appears quite healthy and could probably withstand higher overall harvest levels. The issue of traditional fishing rights at certain bait fishing sites has arisen and the Fiji Fisheries Division has striven to maintain a balance between these concerns and the continued success of the fishery. Bait fishing has continued at some locations in spite of relatively low yields per unit of effort. In these cases baiting occurs near productive payaos used by the pole-and-line vessels, and reasonable tuna catches can be obtained from relatively small catches of baitfish. There is thus a need to continue monitoring the bait fishery with more detailed analyses directed at these heavily fished sites.

Fluctuations in baitfish abundance (recruitment) in Kiribati have had a major impact on the Kiribati pole-and-line fishery. There has also been an observed shift in the apparent relative abundance in favour of the gold-spot herring, an important food fish, with respect to the sardine, the preferred tuna baitfish. Indications are, however, that the bait fishery does not contribute significantly to fluctuations in herring availability. Sprats continue to dominate the fishery and are more readily available than herrings or sardines. At present, several of the vessels are fishing in the waters of Fiji, so potential conflicts between commercial bait fishery and subsistence fishery for gold spot herring are reduced. Wild baitfish stocks in Kiribati are marginal for commercial harvest by existing vessels and success of the fleet will continue to depend on the production of cultured milkfish for use as bait.

New Caledonia no longer has a tuna pole-and-line fishery or commercial bait fishery. A 1.5t per week fishery with bouke ami gear supplies a local fish market in Noumea with baitfish (sardines) for line fishing and anchovies for local consumption.

The Australian Institute of Marine Sciences (AIMS) is investigating aspects of baitfish interactions with predator species under its Coastal and Pelagic Resources and Processes programme, in coastal waters near Townsville, North Queensland. It is hoped the rigorous approach adopted in this work will provide many answers useful to the region.

Other recent work on bait fisheries has involved the development of baitfish data base systems in Fiji and Kiribati with SPC assistance.

Tuvalu and Fiji noted the great importance of communicating stock assessment information to fishermen, managers and politicians in a way that addresses their concerns and is concise and understandable.

With the exception of Solomon Islands, pole-and-line fisheries and dependent bait fisheries are either stable or on the decline in the South Pacific Commission area. Hence, the need for quantitative baitfish stock assessments must be considered in view of other socio-economic development priorities.

FINFISH RESOURCES

Open water baitfish

Moderator: Mr Paul Dalzell

Main reference document:

Fisheries for small pelagics in the Pacific Islands and their potential yields, by P.J. Dalzell and A.D. Lewis (WP.9)

Relevant paper:

Notes on Pacific Island *Decapterus* - R. Gillett (BP.60)

Open water baitfish were defined as essentially the non-clupeoid small pelagic species, found both adjacent to and beyond the reef and lagoon systems within the region. Four species groupings, roundscads (*Decapterus* spp.), big-eye scads (*Selar* spp.), mackerels (*Rastrelliger* spp.) and flying fish (Exocoetidae) were identified as being exploited on a wide scale, although mainly on a subsistence basis. The exceptions were Hawaii, where catches of *Selar crumenophthalmus* and *Decapterus* spp. may be as high as 275 tonnes/year and the harvest worth 350,000 dollars/year, and Fiji, where up to 400 tonnes of *Rastrelliger* spp. are taken in the artisanal fishery.

Apart from the case of Hawaii, it was agreed that the offshore baitfish are probably only lightly exploited within the region. Some concern at the level of flying fish harvests has, however, been reported from Kiribati where the use of kerosene pressure lamps to aggregate these species has been banned in certain islands. It was also agreed that there is no knowledge of the size of this possibly substantial offshore baitfish resource in the region based on direct observations. An empirical method for computing preliminary estimates of pelagic resources in general was suggested.

It was clear that little was known about the biology and population dynamics of offshore baitfish. Concern was expressed about the usefulness of the presently available keys for *Decapterus* spp in the region. Some biological data of a limited nature were available for Hawaiian stocks of *Selar crumenophthalmus* and *Decapterus* spp. Elsewhere, observations on offshore baitfish were anecdotal. It was agreed, however, that landings of offshore baitfish were characterised by extreme variability, as was demonstrated by information on Hawaiian *S. crumenophthalmus* and data on Kiribati catches of flying fish. It was also agreed that catches of offshore baitfish are highly seasonal and the economic impact this may have was touched upon.

It did not appear that offshore baitfish landings will increase markedly within the region in the near future. Some reports of small-scale trials for offshore baitfish catches were presented. The general discussion highlighted the dearth of knowledge on the offshore small pelagic resource in the region. This is in contrast to South East and Central Asia where large-scale exploitation of these resources has generated a relatively large number of studies on biology and population dynamics. A planned detailed investigation into the biology, ecology and population dynamics of coastal pelagic species in tropical north-east Australia should partially redress this balance, as noted earlier.

FINFISH RESOURCES

Large coastal pelagic species

Moderator: Mr Geoff McPherson

Main reference document:

A review of large coastal pelagic fishes in the South Pacific region, with special reference to *Scomberomorus commerson* in north-east Australian waters, by G.R. McPherson (WP.15)

Relevant paper:

Fisheries for large coastal pelagics in Fiji - A.D. Lewis (BP.17)

Fisheries for large coastal pelagic species utilise line gear (troll, drift) for fishes predominantly of the families Scombridae, Carangidae and Sphyraenidae. Generally, a variety of these species support small local commercial and subsistence fisheries which are best developed in high island situations. There are difficulties in collecting good catch and effort data from these fragmented, small-vessel fisheries, but provided they remain line based, they will be essentially self-regulating.

Few biological data are available on most species, except the commercially important *Scomberomorus commerson*. This was summarised in the keynote address. Difficulties with the identification of carangid and sphyraenid fishes still exist. Major taxonomic reviews should soon be available.

Troll fishing operations were not considered to be a representative survey method. Surveys of abundance of the species should therefore include other gear types if possible, although these may not be easy to deploy in coastal or reef waters.

Sport fishing activities for large carangid species are becoming an important component in overall utilisation of the resource. Problems may arise in reconciling the tourism requirements for large trophy-sized fish and the artisanal requirements for juvenile fish caught in near shore waters. Many scombrids of the group undertake seasonal movements and have sexually dimorphic growth rates.

The deployment of FADs in many countries has increased the catch of some coastal pelagic species, whilst opening up new capture possibilities for existing vessels active in coastal pelagic fisheries.

Many species of the coastal pelagic group are probably amenable to management by biological regulation in the absence of catch, effort and biological data, as for example, in the

Fiji *Scomberomorus* fishery. Minimum size limits and protection of juvenile habitat areas would be effective. In those fisheries based on spawning aggregations, more refined identification of peak spawning times would provide potential to protect spawning activity. Other predatory species are readily reduced to low levels even by trolling.

FINFISH RESOURCES

Sharks

Moderator: Mr Geoff McPherson

Main reference document:

Sharks, by G. McPherson (WP.17)

In the keynote address to this session, fishing methods, general biology, management and stock assessment were briefly reviewed.

The taxonomy of both shallow and deep water species was raised as a problem, but difficulties are gradually being overcome with the recent publication of useful reviews. Due to low fecundity, late maturation and relatively slow growth rates, the potential exists for recruitment overfishing of most local shark stocks. With the exception of deepwater fishing trials off New Caledonia, there is no suggestion that any specific or major shark fisheries will develop in the region.

The efficient utilisation of present shark catches, usually taken as by-catch from offshore longline, deepwater snapper and FAD fisheries, is still considered a challenge in the region. A considerable amount of shark utilisation work has been undertaken in the region. These results need to be made generally available and information exchange encouraged.

REEF RESOURCES: SURVEY TECHNIQUES AND METHODS OF STUDY

Moderator: Dr Garry Russ

Main reference document:

Reef resources: survey techniques and methods of study, by G. Russ and J.H. Choat (WP.10)

Relevant papers:

Exploratory trawling on some seamounts in New Caledonia - R. Grandperrin and B. Richer de Forges (BP.1)

Survey of the soft bottom carnivorous fish population using bottom longline in the south-west lagoon of New Caledonia - M. Kulbicki and R. Grandperrin (BP.15)

Security problems with resource surveys of benthic marine organisms - R.H. Chesher (BP.32)

The collection and uses of inshore reef fisheries information to assess and monitor the shelf fisheries of the Kingdom of Tonga using the ICLARM approach. Summary of the first year's activities and results - K. Felfoldy-Ferguson (BP. 41)

Fish-transect surveys in Pohnpei Lagoon (Eastern Caroline Islands) to determine the influence of neighbouring habitats on fish community structure - S. James, L. Olter and E. Endere (BP.49)

Status of giant clam stocks in the Central Gilbert Islands group, Republic of Kiribati - J.L. Munro (BP.54)

Méthodes d'évaluation des stocks d'huitres nacrées et perlières en Polynésie française - A. Intès (BP.66)

(Numerous other papers contain elements describing survey techniques).

Many sessions in the workshop pointed to the need to supplement data obtained from routine catch statistics with data from surveys. Surveys refer to assessments of abundance of a resource carried out by fisheries officers or researchers. This session concentrated specifically on surveys of resources on tropical reefs. The session brought to the attention of the participating countries seven manuals on survey techniques of reefs published from 1978 to 1986 (listed in Annex 1d) and supplemented the information in these manuals with general procedures which will increase the utility of surveys.

A great variety of resources exist on tropical reefs and there is thus a wide variety of survey techniques and methods of study of these resources. The approach taken initially was to provide a general overview of the way to design sampling programmes for any type of resource on a reef. Emphasis was not so much on specific methodologies and standardisation of methods, but rather to utilise sampling and capture methods more efficiently. Issues of the advantages and disadvantages of specific techniques arose during the presentation of papers and in a small working group meeting held after the session (see Annex 1d).

Common themes in the presentations and discussions were the limitations imposed by shortage of time and money. Suggestions that the fisheries manager requires just an estimate, and is not often interested in the confidence limits placed on estimates, are basically true. Much of the supplementary information on sampling techniques presented in WP.10 could be used to improve cost effectiveness in situations where budgets are very limited.

Another major point of discussion was the need for surveys at all. The general feeling was that surveys are an extremely valuable, if not essential, tool. The question of whether surveys need to be repeated arose several times. Again the feeling appeared to be that repeat surveys were desirable, but the question could only be answered in terms of:

- (i) How important is the resource?
- (ii) What is the cost of surveys relative to the value of the fishery?

The best strategy when making decisions about resurveys is to prioritise the fisheries and argue strongly for follow-up surveys for at least the most important resources.

Several presentations highlighted the advantages of using several independent sampling techniques and resource surveys, and integrating the results. This point was emphasised again in the extra-plenary working group held after the main session.

A particularly useful suggestion to those working on limited budgets was to encourage involvement by local fishermen in survey work. A specific case arose of involvement of local fishermen in a fishing survey, carried out as a fishing competition.

Some of the taxonomic problems of tropical reef fish were highlighted. One of the most common problems was relating local names to current scientific names. A need was identified for clear calibration of local and scientific names. One potential solution is publication of colour charts which include a photograph of each local species, the current scientific names and space beneath each photograph to allow local fishermen to recall the local name. This approach has apparently been successful in PNG.

A concluding point was that it is probably not a good idea to start thinking about standardisation of survey methods on reefs at this time. It will be better to use methods which are found best for the specific location and resource, and to concentrate on improving sampling designs.

TELEMETRY, REMOTE SENSING, AND THE USE OF ENVIRONMENTAL DATA

Moderator: Mr Dan Claasen

Main reference document:

Nearshore fisheries habitat assessment - remote information acquisition and analysis, by D.B. van R. Claasen (WP.20)

Relevant papers:

Assessment of the biomass of corals of the Faviidae family on a commercially exploited reef in New Caledonia - P. Joannot and W. Bour (BP.25)

Introduction au traitement d'images SPOT - W. Bour (BP.27)

A micro-computer-based resource mapping system for Pacific Islands - R.H. Chesher (BP.33)

The presentations by Mr Dan Claasen (GBRMPA) and Mr Willy Bour (ORSTOM) stressed the fact that remote sensing is but another information gathering tool with synoptic and multispectral characteristics useful in resource mapping. The wide area coverage of the tool makes it possible to integrate data from point and small area sources and extend it to areas which cannot be readily visited, with some degree of confidence and potential cost savings. Like any tool, it should be used only when appropriate and cost-effective.

Mr Paul Holthus of SPREP gave an example of an end result which used aerial photo-interpretation as a matter of course and as only one data source amongst the many used to produce a resource atlas. Background papers BP.25 and BP.33 provide additional examples of information inputs to resource questions and planning with some remotely sensed data input.

Participants from Tonga and Solomon Islands saw immediate applications in shallow water habitat mapping for fisheries and trochus harvesting projects respectively. Both these projects could potentially benefit from proven shallow water mapping techniques using SPOT data. Clarification was requested on what assistance was available to SPC countries. Dr Bour summarised the availability and costs of SPOT data (average cost per 60 km x 60 km scene - US\$ 3000). He said ORSTOM would be pleased to be involved in some way in projects of this nature. It was indicated that SPC was planning a greater involvement in remote sensing in co-operation with ORSTOM.

In summary, potential users should, if necessary with expert assistance, carefully evaluate any use of remotely sensed data before committing themselves. They need to pay particular attention to:

- The type of information required and the appropriateness of remotely sensed data in meeting that information need;
- Ensuring that the data are used within the constraints of existing or proposed projects, as this places realistic demands on the technology and will facilitate meaningful evaluation in comparison to existing techniques;
- Using a planned, multi-stage sampling approach to information acquisition;
- Regional co-operation in developing remote sensing advisory and support systems.

CRUSTACEAN RESOURCES

Tropical lobsters

Moderator: Mr Jim Prescott

Main reference document:

Tropical spiny lobster: An overview of their biology, the fisheries and the economics with particular reference to the double spined rock lobster *P. penicillatus*, by J. Prescott (WP.18)

Relevant papers:

Growth and mortality rates and state of exploitation of spiny lobsters in Tonga - J.L. Munro (BP.51)

Growth of the spiny lobster *Panulirus ornatus* in the Torres Strait - J.T. Trendall, R.S Bell and B.R. Phillips (BP.91)

The keynote address expressed cautious optimism for the development of lobster fisheries for *Panulirus penicillatus* in various countries in the SPC region. It was pointed out that the resource is not large, but has high value and is in strong demand. Throughout the lower latitudes of the region there is probably little need for management at the present time, in so far as the stocks are not growth overfished. This is the result of the large size at recruitment relative to the maximum size. This is not true for Tonga where the lobsters are apparently being caught at very small sizes.

The question of recruitment overfishing in lobsters was discussed at some length. Mr Jeff Polovina stated that preliminary results of sampling around the banks in the northwestern Hawaiian Islands indicated that larval recruitment may be bank specific, as large numbers of larvae of various stages were being taken in close proximity to the banks. He further noted that some banks appear to be far more productive than others and believed that this was due to better recruitment on some banks, possibly due to the particular oceanographic

features associated with them. The point was, however, made that the species concerned (*P. marginatus*) is endemic to the Hawaiian Archipelago and may not have as long a larval life as *P. penicillatus*.

Recruitment overfishing remains a difficult issue in the SPC region. It has been suggested that caution be used in places that are particularly isolated, but in general, unless the species becomes heavily exploited over an extensive part of its range, there is no need to protect breeding females if the size at recruitment remains larger than the mean size at maturity.

Management in some form may be necessary for a fishery to remain profitable to all sectors. It was suggested that this could take the form of "limited entry" in the collection/middleman sector, closed seasons, or a combination of the two. The intention of such a management system is to maintain the CPUE at a profitable level for the fishermen and ensure that the middlemen get large enough catches from the fishermen to remain profitable and continue to offer the marketing infrastructure that is essential for a successful fishery, particularly for demanding export markets.

Some concern was expressed about the appropriateness of using length frequency data for stock assessment of lobsters. The method assumes that growth rates, and recruitment (annually) are constant, and this is not necessarily valid. However, it was noted that length converted catch curves fit the data consistently well, and that there is no evidence that the growth rate of lobsters changes substantially during adult life. If the data from the early stages are adequate, perhaps the extrapolated curve will adequately represent the growth of the lobster over its entire life.

In each of the studies discussed that estimated the growth rate, there were limitations to the data. In the tagging studies the curves were based on relatively few growth increments. It was encouraging that in each case the results were similar and seemed to fit quite well with the observed maximum sizes and the apparent more rapid growth of male lobster that leads to the larger average size of males in each population studied. The growth rates for *P. ornatus* were estimated from a combination of aquarium studies and tagging. This appeared to work very well and overcame the problems normally experienced in tagging and recapturing small lobster in order to get growth measurements over the complete size range of a species.

Only small increases in yield per recruit over the range of reasonable rates of fishing mortality in Tonga were predicted from increasing the size at capture. It is possible that such minimum size restrictions may not be warranted. In other words, because of likely error in the estimates that lead to the predicted yield per recruit at varying rates of fishing mortality and at various lengths of capture, increases of 10 to 20 percent may not be real. Introduction of minimum size restrictions is the conservative approach and certainly will not have a negative impact on the catches. It should therefore be adopted if the restrictions can be enforced.

Comment from the Tonga country representatives indicated that in Tongatapu very small lobster are now being caught and sold as a result of the introduction of a new fishing method in which small lobster are 'hooked' from their holes with a squid jig. The method should be immediately eliminated, and a minimum size limit introduced if the mean size of capture

does not increase as a result. The problem of management in this fishery is one of high population density, a high value for the product, and perhaps few economic alternatives.

The workshop heard that many countries in the region already have some form of restrictive management. Much of this has been adopted largely on the basis of overseas experience with temperate water species, and not of biological or economic factors in the region. Such regulations should be reviewed within the region and if necessary guidelines developed on a regional basis. A questionnaire has been circulated to the participants requesting information on regulations in their countries.

CRUSTACEAN RESOURCES

Deep-water shrimps

Moderator: Dr Mike King

Main reference document:

Topic review: Deep-water shrimps, by M. King (WP.13)

Relevant paper:

Summary of a survey of deep-water shrimps in the Central Gilbert Islands, Kiribati - G.L. Preston (BP.88)

Surveys for deep-water shrimps have been conducted in many Pacific Island countries, from Papua New Guinea in the west to Tahiti in the east. Although many surveys were preliminary ones, deep-water shrimps have been found in virtually all surveyed areas. In many cases however, catch rates have been low (less than a mean of 2 kg/trap/night). Most interest has been in exploiting shrimps of the genus *Heterocarpus*, particularly *H. laevigatus* which occurs in maximum abundance in depths between 500 to 700m.

Biological knowledge of the species is extensive and was summarised in WP.13. There is less information available on economic aspects of potential fisheries, including estimated fishing costs and likely market prices. The most recent economic information is based on a survey last year in Kiribati (see BP.88).

The deep-water shrimp fishery in Hawaii, which declined after 1983, appears to be entering a period of regrowth (oral presentation by Dr Jeff Polovina). Dr Polovina summarised recent work in Hawaii and the Marianas, and a video film taken from a manned submersible was presented out of session. The film showed deep-water shrimps exiting traps with comparative ease and the use of underwater video equipment to improve trap designs was noted.

There appears to be a continuing interest in exploiting what seems to be a widespread and relatively accessible resource in many small island countries. However, the success of any deepwater shrimp fishery is highly dependent on long-term mean catch rates and likely market prices for the product (see the break-even curves in WP.13). In any case annual yield estimates (200- 600 kg per square nautical mile) suggest that shrimp stocks are likely to support only small fisheries. Catch rates in intensive trapping operations have been shown to decline over a short period.

CRUSTACEAN RESOURCES

Penaeid shrimps

Moderator: Dr Tony Lewis

Main reference document:

The penaeid shrimp resources of the Pacific Islands, by A.D. Lewis (WP.1)

Relevant papers:

Queensland's near reef trawl fisheries - M.C.L. Dredge (BP.80)

Penaeid prawn research in Papua New Guinea - S.J. Frusher (BP.86)

Some aspects of the commercial prawn fishery of the Gulf of Papua, Papua New Guinea - L.J. Opnai (BP.96)

Despite the presence of large valuable fisheries for penaeids on the western margin of the region, opportunities for the development of commercial penaeid shrimp fisheries in the region are limited by the general absence of suitable soft bottom inshore habitat. The exception is Papua New Guinea where a sizable trawl fishery has existed in the Gulf of Papua since the early 1970s. This fishery has been well researched and regulated until the recent relaxation of licence limitation, contrary to scientific advice, which underlines the necessity of input to the political decision making process.

It was felt that potential existed for the development of small scale fisheries, typically using beam trawls, in areas near river mouths on the larger high islands. It was pointed out, however, that such fisheries often target specifically on juvenile stages and their development should proceed with caution, unless other options such as offshore fisheries for adults do not exist. It was also noted that many small scale prawn surveys have been carried out in the region but relatively few have been well documented.

With the recent development of penaeid mariculture, small scale fisheries could also serve as sources of brood stock of suitable species.

The issue of the possible negative interaction of lagoon trawl fisheries in larger islands with nearby reef fisheries was briefly addressed.

Outside Papua New Guinea stock assessment issues did not need to be considered in the absence of developed commercial fisheries.

CRUSTACEAN RESOURCES

Crabs

Moderator: Dr Ian Brown

Relevant papers:

Coconut crab ecology in Vanuatu - W.J. Fletcher (WP.7)

Projet d'étude du crabe de paletuviers (*Scylla serrata*) en Nouvelle-Calédonie - S. Delathière (BP.19)

Changes in spanner crab (*Ranina ranina*) stocks in Southern Queensland: evidence from commercial logbooks - I.W. Brown (BP.79)

The keynote address by the session moderator provided a general overview of the current status of exploitation of a variety of crab resources in the Pacific region. These included the coenobitid *Birgus latro* (coconut crab) and other land crabs of the genera *Geograpsus*, *Sesarma*, *Metopograpsus* and *Cardisoma*, as well as the inhabitants of the mangrove ecosystem (*Scylla serrata* and *S. paramamosain*), coral reefs (eg *Carpilius maculatus*), sandy offshore areas (*Portunus*, *Thalamita*, and *Ranina*), and deep outer reef slopes (*Geryon*).

Available details and/or estimates of annual production for each species were provided, and the salient biological and life-history features (where known) were briefly outlined. Particular attention was given to those features of significance to actual or potential management problems.

Dr Rick Fletcher outlined the results of an ACIAR-funded study of growth and recruitment in the coconut crab (*Birgus latro*) populations in Vanuatu. The crabs are very slow-growing, taking up to 12 years to reach marketable size, and having a life-span of 40-50 years. There was also strong evidence of extended recruitment failure on the islands of Vanuatu. Both these factors make the species exceptionally susceptible to overexploitation, and rapid decline in stocks is apparent.

Mr Stephen Delathière explained the background and reasons for a detailed biological and socio-economic study of mud or mangrove crab fisheries in New Caledonia which are presently subject (in certain areas, at least) to heavy fishing pressure.

Dr Ian Brown presented a brief summary of the history and present status of spanner crab (*Ranina ranina*) stocks in Southern Queensland and Northern New South Wales, Australia. Data from a voluntary logbook scheme indicate a 50% drop in catch rates since the fishery started in about 1980. Evidence for a spring recruitment pulse was also noted.

Mr Joel Opnal spoke about the history of two commercial mud crab fishing schemes established in the western Gulf of Papua (PNG).

General discussion centred on the problems of managing coconut crab stocks; the potential for development of spanner crab fisheries in the Pacific, and consideration of mud crab resource assessment.

Coconut crabs

The question of slow (and even negative) growth in enclosed crab populations was raised, with reference to possible ranching techniques. If ranching is to be successful the animals would need free-range access to a large area such as an island. The setting aside of an island as a sanctuary for coconut crabs is a useful means of maintaining a proportion of the broodstock.

Questions relating to the duration and behaviour of the larval stage, and factors such as density and food supply which might affect larval survival in a culture situation, were discussed. It was pointed out (from evidence from Christmas Island populations of *Gecarcoidea natalis*) that periodic recruitment failure amongst land crab populations on small islands may be a regular phenomenon. It was also pointed out, with regard to possible habitat seeding operations, that little success has yet been achieved in rearing larvae through the glaucothoe to the first crab stage.

Spanner crabs

Several delegates referred to isolated observations and records of *Ranina* in their countries. These included Fiji (Bligh Water), American Samoa (during a deep-water trapping survey by the "Townsend Cromwell"), Vanuatu (one specimen in Port Vila market captured by a fisherman), and New Caledonia (small juveniles caught in east and west coastal lagoons).

Mud or mangrove crabs

There was a brief discussion of an observed decline in populations of the land crabs *Sesarma* and *Cardisoma* with increasing production of *Scylla paramamosain* in Western Samoa. This situation results from the use of the small land crabs as bait for mud crab traps. Fiji also expressed concern at the steadily increasing production of *Scylla* in recent years.

MOLLUSC RESOURCES

Trochus

Moderator: Mr Warwick Nash

Main reference document:

Synoptic study of trochus in the Pacific, by W. Bour (WP.3)

Relevant papers:

Trochus management and exploitation in Pohnpei State, Federated States of Micronesia - E.F. Curren (WP.8)

Summary of Information Paper 6: Rapid identification of the sex of live trochus, with particular respect to mariculture - C. Hoffschir (BP.21)

Trochus research in the Cook Islands and its implications for management - N.A. Sims (BP.37)

Yap proper trochus stock assessment: 1987 - J. Fagolimul (BP. 63)

Summary of Information Paper 16: Trochus: Yap proper stock assessment and prefatory market survey - J. Fagolimul (BP.65)

The Queensland trochus fishery and management-related aspects of trochus biology - W. Nash (BP.75)

Reflection sur la gestion des ressources de trocas: cas de la pêcherie de Polynésie française - S. Yen (BP.87)

Some aspects of the resources and exploitation of the Papua New Guinea reef and lagoon associated commercial sessile invertebrates - C. Tenakanai (WP.101)

Méthode d'identification rapide de sexe des trochus vivants en vue d'aquaculture -
C. Hoffschir (IP.6)

Yap trochus sales: 1986 - Marine Resources Division (IP.15)

Trochus: Yap proper stock assessment and prefactory market survey (IP.16)

In his keynote address, Dr Willy Bour reviewed many important topics, including growth, mortality, reproduction and the determination of sustainable yield for the fishery, and described a procedure for carrying out cohort analysis for trochus. Dr Bour also presented an historical account of the fishery in New Caledonia.

Several representatives presented country status papers, and briefly described the management regimes operating in their respective countries. Mr Stephen Yen also described in detail the strategy of introduction of trochus to French Polynesia, and to various areas within French Polynesia itself. In both the Cook Islands and French Polynesia, the total annual catch is set at a pre-determined proportion of the estimated total exploitable stock biomass (within the legal size range). In the case of the Cook Islands, this figure is 30 percent, and in French Polynesia it is 23 percent.

The presentation by Mr Warwick Nash, as well as much of the discussion that ensued at the end of the trochus presentations, was concerned with the problem of obtaining accurate estimates of stock abundance in order to determine whether overfishing was occurring. There is evidence that the conspicuousness (and therefore catchability) of trochus changes through time, and that this is probably related to aggregation behaviour for spawning. A consequence of this is that estimation of stock abundance becomes even more difficult, and may greatly affect assessment. A major point of discussion was the problem of being able to determine whether stocks were declining because of overfishing.

In discussion, the retrospective nature of cohort analysis was pointed out; it is used to reconstruct the abundance of each year class from some time in the past up until the present, but it cannot be used to predict what will happen in the future unless recruitment rates are constant through time. This assumption may be violated for any of a large number of reasons, such as fluctuations in environmental conditions. In addition, it cannot be assumed that recruitment to the fishery will be unaffected by the rate of fishing itself. If this assumption is violated, cohort analysis cannot be used to forecast stock abundances in the future, or to determine an optimal catch level.

It was also pointed out that trochus are eminently suited to many of the types of experimentation outlined in the first session of the workshop. Being a sedentary species with limited dispersal capabilities (in some cases at least there is evidence that trochus populations may be self-recruiting on the scale of individual reefs), the relationship between stock size, recruitment rate and level of fishing mortality can be determined by comparing various combinations of these on different reefs. Trochus would appear to be one of the more amenable exploited species for this sort of manipulation.

The utility of a maximum size limit to protect big old fecund animals was considered. As animals larger than the maximum size limit will eventually die of old age, the continuing effectiveness of a maximum size limit would rely on fishing pressure on the stocks in the legal size range being sufficiently low to allow an adequate proportion to grow beyond the maximum size.

MOLLUSC RESOURCES

Green snail

Moderator: Dr M. Yamaguchi

Main reference document:

Biology of the green snail (*Turbo marmoratus*) and its resource management, by M. Yamaguchi (WP.11)

A review of the limited biological data available on green snail, with additional information on historical export statistics, was presented by the moderator, which indicated the vulnerability of green snail stocks to over-exploitation. Fecundity and early development of the snail were additionally described. Mr Stephen Yen summarised the present status of an introduced green snail stock, established but not commercially exploited, around the island of Tahiti. There were discussions on the failure of the introduction of the snail into New Caledonia and on the interactions between the green snail and other herbivorous gastropods such as trochus.

Little is known about the ecology of the green snail in the field, so future studies should be directed to this area for a better understanding of its resource management.

MOLLUSC RESOURCES

Pearl shell

Moderator: Mr Neil Sims

Main reference document:

Pearl oyster resources in the South Pacific: research for management and development, by N.A. Sims (WP.4)

Relevant papers:

Méthodes d'évaluation des stocks d'huitres nacrères et perlières en Polynésie française - A. Intes (BP.66)

Stock assessment of pearl-oyster resources in the Cook Islands - N.A. Sims (BP.83)

Le stock naturel de nacre *Pinctada margaritifera* L. dans l'atoll de Scilly - A. Intes, P. Laboute and M. Coeroli (IP.22)

L'huitre perlière de Polynésie française - A. Intes and M. Coeroli (IP.23)

The current state of knowledge and the history of pearl-shell and pearl-culture research and development were reviewed. Recent stock assessment studies in French Polynesia and the Cook Islands were also described (BP.66 and BP.83). Along with the ORSTOM bibliography on black-lip pearl oysters (Intes and Coeroli, 1985), these represent a solid basis for researchers working with pearl oysters to begin, at least, to ask the right questions.

The keynote address highlighted two areas of the life history of pearl oysters with significance to management: the fast growth in shell diameter in the first two or three years and the slow development of female sexual characteristics. These attributes mean that size

regulations and standard yield per recruit models are of reduced relevance to pearl-shell fisheries, where recruitment overfishing is usually the main issue.

Pearl-shell fisheries have generally been heavily over-exploited, although reduced fisheries remain in some countries. It was strongly recommended that large, permanent reserves be established to protect breeding stocks. Countries should also consider tightening pearl-shell fishery regulations, and encouraging development of small-scale pearl-oyster culture activities.

Hatcheries for pearl-oysters present considerable potential for re-establishment or enhancement of natural stocks, and supplying spat for culture facilities, but some cautions and controls are called for. Disease problems can usually be prevented by careful handling and husbandry, but the spread of pathogens should be contained by limiting trans-shipment of hatchery-bred or wild-stock oysters between locations. The genetic purity of reproductively isolated pearl-oyster populations should also be maintained by restricting trans-shipment. Baseline pearl-oyster pathology surveys and genetic studies were identified as research priorities, probably best left to larger research organisations.

Pearl-oyster research in Pacific Island countries should concentrate on assessing current stock levels, and identifying suitable locations and seasons for setting of spat-collectors. Where pearl-culture activities are initiated, optimum locations and farming practices need to be identified by comparative growth trials. The methods and results of most previous research work are published, but there is a need to centralise this information, and to make it freely available to researchers. Regional research-support organisations could probably best provide this service.

MOLLUSC RESOURCES

Giant clams

Moderator: Dr Tim Adams

Relevant papers:

Status of the MMDC Giant Clam hatchery, Republic of Palau - G. Heslinga, T.C. Watson and T. Isamu (BP.24)

Giant clams in Fiji - T.J.H. Adams (BP.50)

Status of giant clam stocks in the Central Gilbert Islands group, Republic of Kiribati - J.L. Munro (BP.54)

Giant clam ocean nursery and reseeded projects - C.M. Price (BP.57)

Giant clam resource investigations in Solomon Islands - H. Govan (BP.70)

Recruitment in the giant clams *Tridacna gigas* and *T. derasa* at four sites on the Great Barrier Reef - R.D. Braley (BP.92)

Distribution and abundance of the giant clams *Tridacna gigas* and *T. derasa* on the Great Barrier Reef - R.D. Braley (BP.93)

Spatial distribution and population parameters of *Tridacna gigas* and *T. derasa* - R.D. Braley (BP.94)

Tridacna derasa introduction in American Samoa - D. Itano and T. Buckley (BP.98)

Recruitment in the giant clam *Tridacna gigas* and *T. derasa* on the Great Barrier Reef - R.D. Braley (IP.10)

Distribution and abundance of the giant clams *Tridacna gigas* and *T. derasa* on the Great Barrier Reef - R.D. Braley (IP.11)

Spatial distribution and population parameters of *Tridacna gigas* and *T. derasa* - R.D. Braley (IP.12)

Fisheries for giant clams (Tridacnidae: Bivalvia) and prospects for stock enhancement - J.L. Munro (IP.14)

The session concentrated on stock assessment and management of natural stocks rather than issues related to mariculture. Giant clams are classified as endangered species and in most countries natural stocks have been greatly reduced. The Fiji experience was reviewed in detail. Four major conservation strategies were identified for consideration :

- i) Reseeding or restocking reefs. This is probably a misplaced hope as success will be constrained by vulnerability of juveniles to predation, and high cost. At the level of effort required for success, reseeded is essentially ranching or farming.
- ii) Farming, to divert effort from natural stocks. This is presently constrained by availability of initial investment capital, production time-lags and uncertain market potential.
- iii) Legislation. Much depends on the present status of clam stocks, but in many cases a total ban on exports could be recommended, and traditional resources mobilised.
- iv) Aggregation of broodstock in reserves. This is probably the most effective immediate option, especially if reinforced by public education.

The necessary strategy, or mix of strategies, to be applied would depend very much on individual area circumstances, but regional assistance with surveys, formulation of management plans and co-ordinated surveillance of poachers would be useful.

Dr John Munro spoke briefly on the status of giant clams in the Pacific region, as the results of the Kiribati survey had been covered in the survey techniques session, and generally reinforced the conclusion that stocks in many areas are depleted and extinctions have occurred.

Ms Charmaine Price summarised efforts in Yap to enhance limited natural stocks of giant clams by introducing mariculture *T. derasa* juveniles from Palau.

Mr Hugh Govan, from the newly-established ICLARM Coastal Aquaculture Centre, outlined preliminary findings on the distribution and abundance of giant clam species in Solomon Islands, on experience largely gained in the collection of broodstock. A preliminary list of local names for the various species of giant clams was circulated, and contributions on vernacular names in different countries solicited.

Dr Richard Braley presented some of the results of his work on the Great Barrier Reef. These highlighted the distribution and abundance of the larger species, the erratic, but sometimes significant nature of recruitment, and the habitat preference of certain species for areas with branching coral.

Discussion was kept to a minimum due to the lack of time, and also the fact that a major conference on all aspects of giant clams will be held next month at James Cook University in Australia.

MOLLUSC RESOURCES

Other mollusc resources

Moderator: Dr Tony Lewis

Major reference document:

Miscellaneous mollusc resources of Pacific Islands, by A.D. Lewis (WP.2)

Relevant papers:

Queensland's near reef trawl fisheries - M.C.L. Dredge (BP.80)

Recruitment overfishing in a tropical scallop fishery - M.C.L. Dredge (IP.1)

This session attempted to cover mollusc resources not included under the previous four sessions. The species involved are large in number, though generally important primarily only in the subsistence sector, where they may constitute major components of the catch. A review of the major groups (bivalves, gastropods and cephalopods) was presented.

Stock assessment was not felt to be urgently required other than in a few cases eg Kiribati (*Anadara*), and Fiji (*Batissa*), although countries were advised to collect baseline information on species harvested and the approximate volume of landings. These are generally felt to be under-estimated.

There was believed to be potential for increased catches in some cases, eg squid generally and scallops in some countries, and for production enhancement through mariculture in other cases, eg *Anadara*.

Finally, it was pointed out that many of the species considered were useful indicators of habitat degradation and are often the first to be affected by coastal developments, underlining the value of obtaining baseline information on these resources.

STOCK AND HABITAT ENHANCEMENT

Reseeding and introductions

Moderator: Dr Mike Gawel

Relevant papers:

Giant clam ocean nursery and reseeded projects - C.M. Price (BP.57)

Pacific Islands trochus introductions - R. Gillett (BP.61)

Reseeding and introductions - M.J. Gawel (BP.97)

Tridacna derasa introduction in American Samoa - D. Itano and T. Buckley (BP.98)

Table of species introductions in the Pacific Islands - M.J. Gawel (BP.106)

Reseeding and introductions were defined, for the purposes of this session, to be limited to marine dwelling organisms and to exclude fouling organisms and contents of tuna live bait wells. Some of the reasons for introducing new species to island inshore environments were described and possible problems and impacts noted by the moderator.

A previously circulated questionnaire had each island group from the SPC area record its known marine species introductions. The results were presented in a table showing introduced species by country. Each representative then briefly confirmed and explained his island's record of introductions shown in the table. Excepting Niue, all islands had experienced introductions. Twenty-two species or genera were identified as having been introduced and having succeeded or failed, while species planned to be introduced in the near future were also noted. Available sources of stocks for introductions were suggested.

Methods of trochus transfer used successfully in Yap were described by Mr Jerry Fagolimul. Investigations in American Samoa to ensure *Tridacna derasa* from Palau were free of contaminants before introduction were summarised by Mr Troy Buckley. Dr James Parrish presented information on results of marine species introductions to Hawaii, some of which have had negative impacts. Dr Barry Pollock noted competition and diseases resulting from introductions in Australia. He recommended using extreme caution in considering introductions because of genetic and disease factors, and ecological effects. The spread of disease which has severely damaged cultured black lip pearl oysters in the Tuamotus following transfer of stocks among atolls was noted.

Dr John Munro explained aspects of the ICES Protocol regarding introductions, and drew attention to the risks inherent in the transfer of unquarantined biological material.

The moderator suggested that officials planning to introduce species should:

- clearly define their objectives and anticipate impacts comprehensively;
- know the biology, definite species identification, and life history of species to be introduced;
- examine stock being introduced to ensure it is free of diseases, parasites and associated species;
- utilise quarantining before and after transfer;
- consider sterile hybrids or species unable to breed in natural island conditions.

A plea was made for solidarity among Pacific nations in resisting requests for transfer of stock of Pacific species to the Atlantic. It was suggested that plans for introductions might be reviewed by staff of the IFRP and their referees before introductions were implemented.

STOCK AND HABITAT ENHANCEMENT

Artificial reefs

Moderator: Dr Richard Brock

Main reference document:

Habitat and fisheries enhancement strategies for Pacific Island coral reefs, by
R.E. Brock (WP.21)

Following the keynote address and a summary of co-operative Hawaiian/Japanese work by Dr Polovina, the discussion of artificial reefs was centred on three general themes: financial considerations, stability of reef materials, and the production versus aggregation question.

Financial considerations arising here ranged from problems associated with the costs of materials for reef construction to the expense incurred in their deployment. A partial solution suggested was the use of locally available materials of opportunity suitably modified for the local oceanographic regime. This problem will continue to persist and may never be solved.

A second financial-related question was one raised regarding liability - specifically who, or what organisation, should be the responsible party for any mishap that may occur on or because of an artificial reef? Again no complete answer was found amongst the participants other than that this question needs to be brought before individuals with a knowledge of the law.

One interesting statement with respect to the economics of artificial reefs is that the costs may appear high on first inspection but if a high cost reef is constructed for non-consumptive uses (eg for tourism), these costs may be trivial relative to the income generated by such use.

Questions regarding the stability of artificial reef materials were posed. Answers to such questions are site specific. Material stability is dependent upon reef design and weight, water depth, substratum composition and anticipated wave forces.

Much discussion centred on the question of whether artificial reefs actually enhance production or whether they merely aggregate fish. Rationales were developed supporting both views. The consensus of opinion was that there is no single answer, and that the production aspects of an artificial reef are dependent upon reef age, size, location, biotic composition and successional stage. Thus there is a continuum between mere aggregation and significant production generation. Dr Jeff Polovina presented a graphical interpretation of the production versus aggregation question using the Shaefer biomass model, which indicated that the impact of the artificial reef depends on the fishery's position located on the yield curve.

The following ideas emerged from this session:

Artificial reefs may have a place in fisheries development programmes, but if they are to be considered, there should be an appropriate management programme in place;

Aspects of the expensive "high tech" reefs may have application in the region, but more research should be done to better define salient features that can be incorporated into designs using local materials;

Artificial reef research should focus on low-cost highly effective aspects of enhancement, such as small mid-water FADs, that may have immediate use in the region;

Further quantitative work should be done to resolve the production versus aggregation question for specific localities and reefs;

Artificial reefs are just one of many management tools. Before artificial reefs are deployed, other management tools which might produce the same benefits at a lower cost such as limited entry and reserves, should also be considered. When artificial reefs are used some restriction on fishing effort may also be appropriate.

STOCK AND HABITAT ENHANCEMENT

Fish aggregation devices

Moderator: Mr Richard Farman

Main reference document:

Fish aggregation devices: what next?, by R. Farman (WP.14)

Relevant papers:

A cost-benefit analysis of FADs in the artisanal tuna fishery in Rarotonga - N.A. Sims (BP.36)

Fish aggregation device (FAD) enhancement of offshore fisheries in American Samoa - R.M. Buckley, D.G. Itano and T.W. Buckley (BP.69)

Research on fish aggregation devices (FADs) in Papua New Guinea during 1984 and 1985 - S.D. Frusher (BP.78)

La pêche à la traine autour des dispositifs de concentration de poissons mouillés à Vanuatu - E. Cillaurren (BP.89)

Report on the fish aggregation device programme in American Samoa - D.G. Itano (IP.20)

The keynote address reviewed the information on FADs available to date. The empirical nature of the often conflicting evidence at hand was first emphasised and a different approach to summarising the results proposed. The following questions were thus asked:

Do FADs work ?:

- Will they aggregate fish?
- Will they increase CPUE and total catch?

and, if they do :

- How great an increase in production can be expected?
- What impact may FADs have on the existing fisheries/resources?
- Are they cost effective?

It was concluded that FADs deployed in areas of higher productivity located at suitable depth and away from the coast/reef will indeed aggregate fish. Although circumstantial, the evidence suggests that fishing success will increase for most gears and most species. Total catch will increase because the deployment of FADs may be an incentive to go fishing, allow the operation of alternative gears or just increase the CPUE for the same amount of effort. The lack of quantitative information on the time of residence of the aggregated fish, however, precludes more detailed estimates. The study of the behaviour of tuna under FADs may eventually bring some light to the subject if the mechanisms of attraction are better understood.

It is difficult to be categorical about the potential impact of intensive fishing around FADs. The best documented fishery in the Philippines offered little information save from the potential for growth overfishing. Fishermen fishing for deep swimming tunas were noted to co-exist with the large purse seine operations quite harmoniously.

Cost effectiveness was reviewed by category of fishing. The conclusion was that the cost effectiveness of FAD deployment programmes will depend in part on the gear used to exploit the aggregations and also on the objectives of the programme, eg. sport fishing vs artisanal use.

Reporting on the 4th International Symposium on Habitat Enhancement, Dr Richard Brock noted the salient results from the FAD-related studies presented there. Dr Brock also reported on his own work on the diet of yellowfin at the rafts and elsewhere.

Mr David Itano presented the results of test fishing around FADs in American Samoa. The data spanned three years and included open water as well as bank areas. The evidence presented showed a significant increase in CPUE at FADs over open waters, comparable to that obtained on the more productive banks.

Mr René Grandperrin reported on work carried out in Vanuatu (BP.89). The paper compared the situation before and after the deployment of six FADs near the island of Efate. There was a marked increase in the number of long range trips after the deployment of the FADs, and most of the effort was exerted at the FADs. CPUE at the FADs was significantly higher than in either coastal or open waters prior to deployment.

Dr Jacques Chabanne reported on his work in French Polynesia, where a FAD fishery is shared between the fleet of "bonitiers", trolling for tuna and pelagics with pearl shell lures, and the poti-marara boats, handlining for deep swimming tunas. Although it is difficult to partition the catch between FADs and open waters, on the basis of a few well documented cases, the increase in CPUE was estimated to be about 20% over that in open waters.

Mr Neil Sims presented a cost benefit analysis of the artisanal fishery of the Cook Islands. FADs have been shown to be cost effective, particularly if deep water fishing is taken into consideration.

Several delegates spoke about their respective experiences, and the support of SPC in the area of mooring design and ancillary fishing methods was noted on several occasions. The delegate from Solomon Islands expressed his country's concern about possible interaction between its surface fisheries and the steps they have taken to study this problem with assistance of SPC. From various contributions other aspects of FADs surfaced, such as their ability to lengthen the "season" of some species, mahimahi in particular. Some delegates also noted that successful FADs will divert effort from other fisheries, which is particularly attractive where there is overexploitation of, for example, bottom fish stocks.

Dolphins have been reported to be a nuisance at FADs, completely inhibiting fishing in some cases. No solution was readily apparent: noise had been tried as a deterrent in Hawaii and dolphins were found to habituate to it rapidly.

In conclusion, although FADs have been found effective, it is difficult to establish definite guidelines to optimise yields or cost effectiveness because the major problem associated with FAD research is the lack of quantitative information. The SPC has been encouraged to co-ordinate future activities, such as the correlation of traditional fishing lore about tuna holes with topographical or oceanographical features, in order to identify which particular features maybe useful in planning the location of a FAD; and to standardise future data collection. In the meantime, experimental research by various organisations on the feeding habits of yellowfin, the behaviour of tuna under FAD rafts, and the dynamics of aggregation will continue.

OTHER RESOURCES

Beche-de-mer

Moderator: Dr Chantal Conand

Main reference paper:

Beche-de-mer in New Caledonia: Biology and fishing, by C. Conand (WP.5)

Relevant paper:

The status of the beche-de-mer resource and exploitation in Papua New Guinea - C.D. Tenakanai (BP.108)

The keynote address, based on ORSTOM studies in New Caledonia, reviewed:

the current status and evolution of export-oriented beche-de-mer fisheries on the local, regional and global scale;

the commercial value of the various exploited species, their ecology and evaluation of the resources; and

the biological parameters of these species required for resource management.

Fiji's presentation emphasised the recent changes in the species exploited, going from high value species to medium or even low value ones and the rapid increase of the volume of the exports from 60t to over 600t in two years.

Other presentations from Papua New Guinea (BP 108), French Polynesia, Solomon Islands and Guam provided the information on the present status of their fisheries and in some cases stock assessment of the main species planned or recently undertaken.

Beche-de-mer fisheries of the region are essentially artisanal in nature, and fluctuate markedly in space and time, due to interaction between stock depletion on a local scale and socio-economic factors. From the Fiji experience it appears that some interaction between the artisanal fishery for export and the traditional fishery for local consumption may occur with regard to sandfish (*H. scabra*).

The same commercial species, clearly identified in the SPC Handbook, are distributed throughout most of the region but their abundance is variable depending on the respective importance of various habitats in each country. Four main habitats have been identified with respect to the occurrence of commercial species. The evaluation of the resources in these habitats is possible with simple survey methods (quadrats). Extrapolation to wider zones will ultimately be possible with the use of satellite imagery which enables the large scale mapping of shallow-water reef habitats.

The biology of these soft-bodied animals is particularly difficult to study. The number of studies carried out is still rather low for such large and abundant invertebrates. There is a need for more research on reproduction, growth and mortality of some species, in particular the teatfish (*H. nobilis*) and blackfish (*A. miliaris*). It is recommended that workers use large samples on a time scale of a few years to obtain meaningful results. Recruitment is a poorly understood process fundamental to understanding the population dynamics of beche-de-mer.

It has been pointed out that the different species show considerable variation in growth rate, fecundity and mortality. Fishery management must therefore consider each species separately. Different regulations, including size limits, quotas and closed seasons, are in use for resource management in and around the region, whilst there are no regulations at all in some countries. It is recommended that export statistics be gathered, by species and by area, to monitor the state of the export-oriented fishery as a basis for eventually introducing appropriate regulations as necessary.

OTHER RESOURCES

Commercial seaweeds

Moderator: Dr Steve Nelson

Main reference document:

Development of phycocolloid-related industries in Oceania, by S.G. Nelson (WP.12)

Seaweeds are used for a variety of purposes including human consumption, food for other organisms, bait, sources of biologically active compounds and sources of industrial phycocolloids.

On some islands, and particularly in Fiji and in the Mariana Islands, seaweeds are harvested as fresh vegetables and sold in local markets. Several species of *Gracilaria* and *Caulerpa* are the main algae in these markets.

A number of countries have initiated the cultivation of *Eucheuma*. These include Fiji, Vanuatu, Solomon Islands, Kiribati, the Federated States of Micronesia, the Cook Islands and Tonga. Only Fiji and Kiribati have developed the industry to the point where the seaweeds have been marketed. A number of difficulties were encountered in the culture of *Eucheuma*, including grazing by fishes, storm damage and disease. Some concern was expressed regarding the commercial viability of this enterprise within the region with predicted increases in seaweed production from S.E. Asia.

Preliminary work has been undertaken within the region, and particularly in the Federated States of Micronesia and Guam, to assess the feasibility of marketing agar-bearing seaweeds in the genera *Gracilaria* and *Polycavernosa*. Additional work is needed in terms of both taxonomy and characteristics of the extracts. Information on marketing and economics is also lacking.

The farming of seaweeds is a desirable industry for remote islands in that it could serve to provide a source of income from a non-perishable, easily transportable product, and aid in combating urban drift. However, enterprise entails risks mediated by market fluctuations, competition from nearby areas and prospects of crop loss. These risks can be minimised through proper management of the resources, accurate marketing projections, and proper site selection for seaweed cultivation.

OTHER RESOURCES

Semi-precious corals

Moderator: Dr Jim Parrish

Main reference document:

Semi-precious corals in the Exclusive Economic Zone (EEZ) of New Caledonia, by B. de Richer Forges and R. Grandperrin (BP.2)

Relevant papers:

Black corals - post harvest aspects - P.W. Philipson (BP.47)

The CCOP/SOPAC precious coral programme in the South Pacific - J.V. Eade (BP.105)

The status of black coral harvesting and pink coral exploratory surveys within the region was reviewed. Regional countries produce about eight per cent of the global black coral harvest and in-country processing is being encouraged. Deep-water tangle net and dredging surveys (CCOP/SOPAC, ORSTOM) have revealed traces of pink coral, but outside Hawaii commercial scale beds have not yet been discovered. Options for further surveys and processing of both black and pink coral were outlined.

In discussion the possibility of replanting black corals was raised. A brief previous study in PNG was cited and there were reliable reports from Fiji that the single black coral harvester there routinely replants the tips from colonies, fastening them firmly at the original site. They have apparently grown successfully. A SPREP report on a black coral survey in Tonga was confidential and thus not available.

Island representatives were impressed by the high potential value of the resource. Therefore it is important that prospecting continue despite the danger of poaching. Some island governments may feel that they have adequate enforcement resources to control

poaching. However, it was pointed out that coral beds are often very remote from the surveillance base, in uninhabited areas. As an example, there has apparently been massive poaching of Hawaiian precious corals despite the presence of Coast Guard surveillance. Island governments are likely to be willing to put considerable investment and effort into prospecting for and developing precious coral resources if they are convinced that commercial beds are present. Hence, it is important to be sure whether the resource is present.

There has been some improvement in the survey methodology used by CCOP/SOPAC over the life of the programme, and the long-term agenda calls for resurvey of some areas done early in the programme. Surveys done in the Solomon Islands were among the best completed. The potential for use of satellite imagery to detect uncharted seamounts as possible sites for coral beds was discussed. Present SEASAT imagery is apparently capable of giving a gross indication of very large submerged features (e.g. chains of seamounts) based on gravity anomalies. Further developments of satellite systems within the next 4-5 years may permit finer resolution of seamounts based on precise detection of anomalies in sea level.

Mr James Eade outlined deep-water exploration activity of CCOP/SOPAC of the recent past and immediate future, e.g. the Gilbert section of Kiribati (completed) and Fiji. There was a brief discussion of the potential for using manned submersibles in prospecting. CCOP/SOPAC conducted a workshop on this subject and all countries attending were interested in this possibility. In view of the high cost of bringing the equipment into the region, it seemed that the only practical approach would be to establish liaison with large science-funded programmes that may sponsor submersible projects in the region, and piggyback on such projects. CCOP/SOPAC is collecting island expressions of interest and communicating with potential science support agencies.

OTHER RESOURCES

Reef-building corals

Moderator: Mlle Pascale Joannot

Relevant papers:

Assessment of the biomass of corals of the Faviidae family on a commercially exploited reef in New Caledonia - P. Joannot and W. Bour (BP.25)

An assessment of coral exploitation in Fiji - F. Viala (BP.91)

Reef-building corals are harvested as a renewable resource in several countries of the region, for sale as whole or worked ornamental objects. Two papers described, respectively, the method of biomass evaluation for the family Faviidae on the Tetembia reef in New Caledonia where coral is commercially harvested, and an overview of coral exploitation in Fiji.

Discussions confirmed the need for scientific studies, particularly on growth rates of exploited coral species, and for careful management. The imposition of quotas was discussed but there are insufficient data to properly assess the value of this approach as a management measure.

Dr Barry Pollock described reef protection policy in Australia. There are 10 to 12 coral sites currently exploited in Australia but with a conservative quota imposed (4t/year for all species) there seems little risk of over-exploitation.

It was recognised that reef-building corals may be at risk from sources other than commercial harvest. Discussion of the damage to coral reefs caused by *Acanthaster planci* followed information provided by the representatives of American Samoa and Guam. Other causes of damage to living coral include boat anchors, and Australia and Guam are considering mooring systems to overcome this.

It was noted that the experience of one country can assist other countries considering coral harvest, and it was recommended that preliminary site studies be undertaken before giving permits for exploitation. It appears that apart from Fiji, New Caledonia and the Philippines, coral exploitation is not at present well developed in the Pacific.

OTHER RESOURCES

Turtles

Moderator: Dr Jim Parrish

Main reference document:

Status of sea turtles in the South Pacific, and management needs, by J.D. Parrish (WP.22)

In reviewing the status of turtles as a widely distributed but diminishing resource in the region, the moderator drew attention to the 1979 SPC Workshop and its recognition of the need for improved data and management to maintain generally depressed stocks. Turtles are a shared regional resource, as tagging has demonstrated. They exhibit slow and variable growth (40-50 yrs to sexual maturity), relatively low fecundity, high natural mortality and nesting beach fidelity. The vulnerable populations are threatened from a variety of sources.

Mr Jim Prescott presented a report on the commercial turtle fishery in the Torres Strait south of Daru in Western Papua New Guinea. The rate of exploitation there has been relatively high for a number of years. Recently good lobster harvests and demographic factors have resulted in a large increase in numbers of boats and motors. Increases in catches of turtles have not been detected, but the great increase in fishing power provides a high potential for this.

For 4 years this fishery has been monitored by examining a major fraction of the catch landed at Daru. Preliminary results were reported based on a sample of 2555 green turtles and 43 hawksbills. The catch appears to be comprised of turtles that breed in the general area, turtles migrating through the area enroute between feeding and nesting grounds, and resident feeding turtles. The fishery appears to land at least several thousand kilograms of meat per year (a large amount compared to the local population) and to provide a very attractive income to the fishermen. A long-term monitoring programme - biological, catch, and socio-economic - is planned.

Dr Robert Johannes commented on the use of turtles by Torres Strait islanders in 17 communities. The people of these communities appear to have no conservation ethic, probably because turtles and other seafood have always been superabundant. A great deal of turtle meat per capita is consumed - about 200 g per day. A significant management consideration is that in Torres Strait, turtles are concentrated in great numbers that migrate widely and are also harvested by many other peoples elsewhere in their migrations. Meaningful management must include efforts by all the harvesting groups and probably will

require much more population research. If adequate management does not come about soon enough, the life history characteristics of turtles may lead to a sudden, catastrophic crash.

Mr René Grandperrin made some comments on turtles in New Caledonia. There has recently been a very active public education programme on turtle biology and conservation. In 1979 an aerial survey of all beaches in the country was made to estimate the turtle populations in all areas including the Loyalty Islands. Some additional data on turtle fisheries and turtle use were accumulated by personal interviews with fishermen in a number of areas. At Huon Island (in the extreme north) in December, a very large concentration of nesting turtles was surveyed.

The problem of morbidity and mortality of turtles due to consumption of plastic and other nonbiodegradable debris was discussed. The U.S. NMFS in Honolulu has been instrumental in promoting a good deal of national and international activity to develop control measures for the debris problem.

INSHORE FISHERY MANAGEMENT AND REGULATION

Options for fisheries management

Moderator: Dr John Munro

Main reference document:

Management of coastal fishery resources in the South Pacific region, by J.L. Munro and S.T. Fakahau (BP.52)

Relevant papers:

Inshore fisheries development and management: the South Pacific experience; an overview - P. Kunatuba (BP.6)

The regulation of fisheries in Kiribati - C.C. Mees (BP.10)

A direct test of the effects of protective management on a tropical marine reserve - G.R. Russ and A.C. Alcalá (BP.29)

Les ressources cotières en Polynésie française - EVAAM (BP.62)

Country paper: Kingdom of Tonga - Research, management and legislation - V. Langi (BP.71)

The moderator reviewed the options available for the management and regulation of fisheries. The need to recognise that the process involves managing fishermen, as opposed to fishes, was emphasised, as was the need for a good understanding of social and economic factors impinging on the fisheries. Overviews of the Pacific situation and of fisheries regulation and management in Kiribati and Tonga were also received.

In discussion it was recognised that there are currently few, if any, Pacific Island inshore fisheries which are managed. The need for sharing of information on management policies was emphasised. It was also suggested that copies of fisheries legislation should be circulated in the region to permit more suitable regulations to be developed.

There was much support for the concept of preparation of educational materials, posters and informative articles on fisheries management and conservation, particularly for distribution to schools, churches and other local groups.

INSHORE FISHERY MANAGEMENT AND REGULATION

Traditional marine resource management concepts

Moderator: Dr Robert Johannes

Relevant papers:

Traditional management of marine resources in New Caledonia - M.H. Teulières (BP.38)

Traditional Pacific Islander management of inshore fisheries: the SOPACOAST initiative - G.B.K. Baines (BP.46)

Presentations were made in this session concerning traditional fishing rights systems and other customs which have functioned as marine resource management measures in Micronesia (Yap), Melanesia (New Caledonia), and Polynesia (the Cook Islands). Speakers made the following points:

Recognising that :

such customs exist,

considerable practical, accurate knowledge exists among island fishermen concerning their marine resources,

this knowledge and these customs are not well documented and are being eroded by the impacts of westernisation and development,

modern marine resource management programmes will be more effective if those who formulate them take into consideration these customs and this knowledge, and

fishermen can have significant problems which may sometimes be easily remedied if they are brought clearly to the attention of marine resource managers,

it was recommended that more attention be given to the aforementioned knowledge, customs and problems.

It was recognised, in addition, that Island marine resource managers are often too busy to establish the close sympathetic links with fishermen (especially those located in remoter areas) that are necessary in order to obtain relevant information. The following approaches were therefore suggested :

employing liaison officers with appropriate interests, sympathies and personalities to provide information links between village fishermen and marine resource departments,

encouraging fishermen to set up councils and elect representatives to help provide such links, and

seeking more support for researchers to investigate and record relevant knowledge, customs and problems. The SOPACOAST programme (BP.46) is an example of such efforts.

Among the important subjects that require such study are:

Traditional fishing rights. Among those countries where recorded knowledge exists for only a small fraction of existing traditional fishing rights systems are Papua New Guinea, Solomon Islands, New Caledonia and Vanuatu. The relevance of such customs to the location and operation of tuna baitfishing, FADs and aquaculture deserves particular attention;

Knowledge concerning the timing and location of spawning aggregations of reef and lagoon fishes. Such knowledge can facilitate stock monitoring and the establishment of closed areas or closed seasons to conserve stocks;

Traditional measures that have served intentionally or otherwise to conserve stocks or habitats and whose continuing or renewed practice might be encouraged through formal government recognition.

INSHORE FISHERY MANAGEMENT AND REGULATION

Destructive fishing practices

Moderator: Mr Paul Holthus

Main reference document:

SPREP questionnaire on destructive fishing methods: summary of results (WP.19)

The session moderator reviewed the results of the SPREP questionnaire on destructive fishing methods which was completed by participants at the 19th SPC Regional Technical Meeting on Fisheries. Responses indicated a wide variety in the types, levels, and seriousness of destructive fishing practices in each country. In particular, problems with dynamite fishing were highlighted, as was the need to control access to sources of explosives.

Country legislation and enforcement capabilities were reviewed, along with existing levels of prosecution and penalties for destructive fishing. The potential for effective enforcement through traditional, village-based controls was discussed.

The questionnaire respondents and session participants identified education as a top priority in dealing with the problem of destructive fishing. Potential responses include the development of posters, videos and school materials and public awareness raising campaigns. The need for adequate and appropriate legislation and enforcement was also discussed. Information needed to address the identification of fish caught through the use of explosives was also raised. Dr Tony Lewis reviewed development of an SPC-funded manual to address aspects of this problem in Fiji.

The moderator summed up the session by reiterating the need for educational materials and the intention of SPREP to work with the IFRP in this important area.

FISHERIES AND COASTAL ZONE MANAGEMENT

Moderator: Mr Paul Holthus

Relevant papers:

The importance of mangroves to the ichthyofauna of the New Caledonian lagoon - P. Thollot - PB.22)

Summary of Information Paper 24: Links between inshore fisheries resources and mangroves in tropical Australia: implications for coastal zone management in the South Pacific - A.I. Robertson (BP.107)

The moderator began the session with a review of coastal resource management and the linkages between coastal resource systems. The importance of fisheries management in the broader context of island environmental management was stressed. An example of the various development activities affecting most island countries and their effects on near-shore fisheries was provided. The role of island fisheries officers in providing the information on near-shore fishery resource distribution, abundance and use for purposes of environmental management was highlighted.

The need for the involvement of fisheries departments in the development of coastal resource management plans in collaboration with other government agencies and especially fishermen was emphasised. In addition, the moderator highlighted the need for fisheries officers' input into environmental impact assessment (EIA) of specific development project activities.

Dr Alastair Robertson summarised current research on the importance of mangrove areas to near-shore fisheries, especially through the export of nutrients and their importance as juvenile fish nurseries. Dr Barry Pollock outlined the establishment of fisheries habitat reserves in Queensland.

The moderator summarised the session by emphasising the need for integrated, inter-agency coastal management planning especially involving fishermen and other resource users, fisheries departments and related government agencies. In particular the value of habitat protection through the establishment of preserves within a zoning plan framework was noted.

FUTURE PACIFIC ISLAND INSHORE FISHERY RESEARCH REQUIREMENTS

Moderator: Mr Elisala Pita

Relevant paper:

Fisheries research in the South-west Pacific: a summary of some of the problems - A. Wright (BP.48)

This final Friday morning session followed on from three extra-plenary evening sessions held earlier in the workshop. During the first and second of these evening sessions, delegates from each SPC Island member country described the specific inshore fishery research and management problems they faced in their own localities, as well as referring to broader problem areas not necessarily restricted to fisheries research or even fisheries in general. The Secretariat subsequently consolidated the country presentations into a summary of problem areas identified by the delegates. This was further discussed and refined during the third session, resulting in the list of specific and more general problem areas presented in

Annex 2. This listing was circulated to all participants during the Friday morning session and used as a basis for some of the discussions.

The session opened with presentations from the co-ordinators of the special interest working groups on the use of fish traps as: survey tools; otolith reading; survey techniques; assessment of deep-bottom fish stocks; stock assessment techniques; crabs; estimating trochus stock abundance. Each presentation consisted of a short summary of the main points emerging from the relevant groups' discussions. The essential points are noted in Annex 1.

A number of participants and resource specialists commented further on the summary of problem areas as circulated, and representatives of technical organisations were invited to comment on aspects of their own organisations' work programmes that might be relevant to the list. Those who made statements included the representatives of the USP - IMR, CCOP/SOPAC, FAO South Pacific Regional Aquaculture Development Programme (SPRADP), ICLARM and FFA.

The Secretariat then gave an item by item account of the problem areas that were in the capacity of the SPC Inshore Fisheries Research Project to address.

The first three major areas - manpower and training, funding and technical support, and internal communications - were broad ranging problems that in many cases required concerted internal action on the part of national governments, rather than external solutions. The IFRP could assist in executing or assisting with specific activities in any of these fields but its financial and manpower resources would not stretch to major programmes.

External communications and information: these two areas are expressly to be addressed by the joint SPC/USP/FFA Pacific Island Marine Resource Information System (PIMRIS), which will have a major component based at SPC headquarters and which will work in close co-operation with the IFRP.

Statistics, data analysis and experimental assessment, finfish research, and management. Most of the specific problem areas listed under these headings involve discrete activities of the type in which it was originally envisaged that the IFRP would become involved. A number of specific country projects to assist in gathering and interpreting fishing statistics, and to carry out surveys, are already in the planning stages. It is envisaged that these areas will be the main focus of the IFRP's activities.

Mariculture. Given the existence of the FAO/SPRADP, and the orientation of the IFRP, it is unlikely that mariculture-related activities will figure highly in its activities.

The meeting requested the Secretariat to prepare a document, based on the summary of problems identified in Annex 2, that indicated the main areas to be addressed by the IFRP, and submit it for the information of the 20th SPC Regional Technical Meeting on Fisheries to be held in August 1988.

CLOSING FORMALITIES

The meeting was formally closed by the SPC Acting Secretary-General, Mr Jon Jonassen. Mr Jonassen commended the enthusiasm and energy of the participants and thanked the many SPC staff and others for their hard and dedicated work in helping make the workshop the success that it undoubtedly had been.

SUMMARIES OF EXTRA-PLenary WORKING GROUP DISCUSSIONS

a. Computer techniques for stock assessment

A suite of computer programmes, based on simple techniques of estimating biological parameters and yield of fish stocks, was presented in out-of-session evening workshops. The programmes, written in BASIC for the Apple Macintosh, are documented in BP.23.

There was considerable interest from country delegates in obtaining the programmes, although not necessarily for use on Apple Macintosh hardware. Copies of either the programmes or programme listings were supplied to several participants. There was also some interest in using spreadsheet software for fisheries applications.

b. Deep-water snapper stock assessment approaches

The discussions in this group identified the following indicators which might be useful to determine an optimum level of effort: (1) Annual catch and effort per 200 m isobath from each bank; (2) the ratio of total mortality to growth derived from length- frequency data; (3) the relative spawning stock biomass from each bank; (4) a measure of the large fish in the catch, such as the length where 90% of the catch are smaller than that length, and (5) a measure of the species composition.

It was highlighted that in most situations there are several islands, banks, or seamounts fished at varying degrees of intensity. By collecting and analysing catch, effort and length-frequency data to compute the previously mentioned indicators on a site specific basis, numerous observations each year may be obtained. Plots of these indicators against effort per length of 200 m isobath can be used to identify levels of effort which are optimal.

It was stressed that there will likely be large differences between early non-equilibrium yields and the long-term sustainable yields and that long-term sustainable catch rates might be 50% or less of initial catch rates. It was suggested at the beginning stages of the development of the fishery that some islands or banks be closed to fishing until levels of optimum effort are identified. It was agreed that Mr David Itano and Dr Jeff Polovina would look at data from American Samoa to see if monitoring guidelines could be derived from the history of the collapse of that deepwater bottom fish fishery.

There was considerable interest in the wide variation in maximum size of *Etelis carbunculus* across the Pacific and investigation of growth curves from different areas was proposed as a way of testing several hypotheses which might account for the size differences. The question of the recovery rate once the deepwater bottom fish resources at an island or bank have been overfished was raised frequently. It was suggested that a useful experiment would be to fish an area down to a very low abundance level over a several year period and then follow the recovery rate.

c. Inshore baitfish

During the meeting several countries in the region with active bait fisheries for tuna pole-and-line fishing expressed interest in further discussion of baitfish stock assessment, particularly in the context of Solomon Islands' comprehensive baitfish stock assessment

programme. Accordingly a small working group consisting of representatives from Solomon Islands, Fiji, Kiribati and Federated States of Micronesia (Yap) met with Dr Sandy Argue, Mr Paul Dalzell and Mr Geoff McPherson after the 23 March session. Discussion centred on four topics:

Age and growth

It was noted that standard length frequency samples should be supplemented by samples (minimum sample size approx. 25) from a range of sizes of each of the major bait species at each baiting location for daily-ring age analyses from otoliths. Estimation of growth rate (K) and L_{∞} from age/size data provide useful comparison with similar parameter estimates from length-based models (ELEFAN). Given K, L_{∞} and average seawater temperature for baitfish stocks subject to light fishing pressure, "natural mortality" can be estimated from Pauly's empirical relationship. Given biomass and "natural mortality" estimates, a first approximation of potential yield can be calculated using the Garcia modification of Gulland's simple equation (ICLARM Fishbyte Volume 5(2)). Also of value are direct measures of recruitment from age/size, catch and effort information. These observations coupled with environmental (e.g rainfall) and spawning stock measures provide valuable insight into the relationship between harvest (catch) and recruitment.

Biomass

Direct measures of biomass of baitfish stocks using echo integration technology was discussed. Although this technology is complex, the potential utility of biomass estimates per unit area of habitat for the purpose of estimating potential yield, or to evaluate productivity of different baiting sites, warrants consideration. It was noted that baitfish are generally more evenly distributed at night, and therefore more amenable to echo-sounding. Also of value would be relative measures of baitfish distribution in relation to baiting lights. The idea here would be to try to define a "zone of influence" of the baiting lights, which in turn would provide insight into the effect of baitfishing on the distribution of forage fish on nearby reefs.

Spawning

A precise assessment of female reproductive condition is possible by histological examination of formalin-preserved ovarian tissue from freshly caught fish (see Hunter et al (1986) in NMFS Fishery Bulletin 84 (4)). Spawning frequency (i.e. numbers of batch spawnings per time period), total egg release, and frequency of spawning individuals in the total female population can be estimated using histological procedures. Hence, the technique provides data from which seasonality in spawning can be assessed. There are several regional agencies with expertise in applying this technique to tropical species and the histological specimens can be prepared by laboratories associated with most regional hospitals. Training sufficient to reliability interpret samples apparently can be accomplished in a few weeks.

Reef fish interactions

Baitfishing may affect abundance and distribution of reef fish that are important in nearby artisanal and subsistence fisheries. Knowledge of the level of exploitation in the baitfishery is obviously a first step in assessing the potential for interaction. If baitfish are only lightly exploited then it is unlikely that the catch of baitfish is having a direct effect on the amount

of forage available for reef fish. On the other hand, the baitfishing method (night lights in particular) may be changing the distribution of baitfish and their predators. For example, it is possible that bait lighting itself moves the baitfish away from the reef and many predators follow. Thus apparent abundance of reef fish could be significantly reduced on reefs nearby baiting locations where there was nightly baitfishing activity. The group discussed ways to assess whether this was taking place. It was noted that predators are easily captured from the bait boats (from bouki-ami hauls or by line fishing before and after baitfishing), and that large numbers should be able to be tagged with dart tags. Subsequently, reefs could be monitored by divers, perhaps using scuba and under-water sleds, for reoccurrence of tagged fish; as well, artisanal and subsistence fishermen would presumably recover tags. This approach would allow quantification of the exchange of predators between the baitfishing site and nearby reefs, and might also provide a reasonable number of tagged reef fishes for measurement of other population parameters (e.g. growth, stock size, mortality, movement).

d. Reef Survey Techniques

Specific points on methodology for estimating total abundance and relative abundance of any type of resource on a reef were introduced briefly. A discussion on potentially useful survey techniques on reefs followed. Potentially useful methods were identified as follows:

Reef Fish

Total abundance

There was general agreement on the great difficulty of estimating total abundance of reef fish but the following methods were considered potentially useful.

Mark recapture techniques (a cost-effective, non-labour intensive method).

Visual estimates using spawning aggregations (with supplementary censuses simultaneously at other sites). There was general recognition that visual estimates of total abundance are extremely time consuming and probably not cost-effective.

Relative abundance

Non-destructive methods - eg visual census

Capture techniques of various kinds.

Benthic Invertebrates

Total abundance

Mark-recapture

Transect counts

Depletion experiments (cumulative catch vs catch per unit effort)

Relative abundances

Non-destructive - visual methods

Capture techniques of various kinds

Again, the point is the quality of the sampling design, rather than the specific technique.

A specific case for monitoring fish and corals in American Samoa was discussed.

Manuals on survey methods for reefs

ASEAN-Australia Co-operative Program in Marine Science (1986). A manual of survey methods for living resources in coastal areas. Townsville, Australian Institute of Marine Science.

Birkeland, C., S.S. Amesbury and J. Ash (in press). Handbook of research methods for tropical ocean ecosystems. Guam, University of Guam

Dahl, A.L. (1982) Coral reef monitoring handbook. Noumea, SPC.

Kenchington, R.A. and B.E.T. Hudson (1984). Coral reef management handbook. Jakarta, Unesco. ISBN G2-3-102203-2. 281pp.

Stoddart, D.R. and R.E. Johannes (1978). Coral reefs: research methods. Paris, Unesco. ISBN 92-3-101491-9.

SPC/UNEP (1984). Coral reef monitoring handbook. (UNEP) Reference Methods for Marine Pollution Studies No. 25. Prepared by SPC. Geneva, United Nations Environmental Programme.

UNESCO (1984). Comparing coral reef survey methods. Unesco Reports in Marine Science 21. Jarkarta, Unesco.

e. Traps for routine fishing and data acquisition

This extraplenary session was attended by a small group of participants. There was general agreement that traps, being entirely passive, are highly suited as standardised fishing gears. Advantages were seen in developing a standard design suitable for making comparative studies. They are also of much use for tagging studies because the catch is usually entirely unharmed.

The group agreed that a trap fishing bibliography should be developed. Dr J. Munro agreed to do this, with assistance from other members of the group. It was also agreed that the group would keep in touch in a loose network.

f. Mud crab (*Scylla*) resources

A small group met to discuss the concerns in their respective countries over increasing catches of mud crabs and appropriate methods for assessing stocks. These countries included Fiji, FSM (Pohnpei), Guam and Papua New Guinea.

Noting the recent separation of *Scylla serrata* into two species (*serrata*, *paramamosain*), some people felt that further taxonomic problems remained and that a third species may exist in the region.

The difficulty of obtaining reliable catch and effort data on mud crabs was raised, since the fishery is an artisanal/subsistence one. The appropriateness of single sex capture as a regulatory method was discussed, as were tagging methods. The group agreed to endeavour to maintain contact in an informal way.

g. Otolith reading

Accurate estimates of fish age are useful for stock assessment and management purposes. Otoliths provide the most appropriate means to achieve accurate age estimates.

Annual otolith ageing techniques are still valid and applicable to the region. They can be conducted within the region but require validation either by tetracycline marking or marginal increment analysis. These techniques can be slow and costly in terms of manpower and large sample sizes.

Microstructural analysis of otoliths using presumed daily increments is an alternative method for fish ageing and age validation. While analysis costs are higher on a per sample basis, substantially smaller sample sizes are required.

The equipment required for daily increment ageing is expensive. There is no likelihood that laboratories with this equipment will be established in the region, but opportunities exist for the development of 'co-operative' fishing ageing research programmes in association with external organisations, utilising both whole and microstructural otolith techniques.

Budgetary and institutional constraints would exist for external organisations involved in a service function on fish ageing. However, formally established 'co-operative' research programmes involving combinations of joint data collection, analysis and publication may be possible. Training attachments in order to facilitate the analysis of samples could be an integral part of a 'co-operative' programme.

The following organisations are involved in fish ageing programmes:

- Australian Institute of Marine Science (small coastal pelagic baitfish species)
- CSIRO, Hobart and Cleveland (pelagic (larval), inshore baitfish, reef and deep water temperate species)
- James Cook University, Townsville (shallow water reef and estuarine fish species)
- National Marine Fisheries Service, Hawaii (shallow reef and deep water snapper species)
- ORSTOM, Noumea (shallow water reef species; has completed a programme on deep water snapper)
- Queensland DPI, Cairns (large pelagic and shallow reef species)
- University of Hawaii (pelagic, shallow reef and deep water snappers)

Some of the above institutions are already fully committed to their own programmes. However, there is potential for co-operative research agreements with CSIRO, which conducts daily and annual increment ageing using optical bands and scanning electron

microscopy, and with the University of Hawaii, which carries out daily increment ageing using scanning electron microscope techniques. Training attachments in association with co-operative research programmes within the region could be arranged at NMFS, Hawaii, and ORSTOM, Noumea. Both these institutions conduct daily increment ageing.

A commercial daily increment ageing service is provided by Dr Ed Brothers of Speciality Testing and Equipment, Ithaca, New York, based on an hourly rate.

There is a need for the establishment of an age and growth information bibliography for the region. ORSTOM is to undertake a more formal review of tropical fish ageing studies, including from within the region. In order to meet background information requirements for the region, plans are being made for a less formal bibliography to summarise all current research programmes which would facilitate an exchange of information between organisations that could develop into 'co-operative' research programmes on fish ageing.

h. Surveys of trochus stocks

The group, moderated by Mr Warwick Nash, focused on ways to carry out effective surveys of trochus resources and to obtain representative indications of their relative abundance and the ways in which they may be responding to changes in exploitation.

Most discussion centred on the mechanics of carrying out surveys. In particular, since trochus are nocturnal, somewhat cryptic animals, more information can be gathered by surveys carried out at night. Similarly, surveys carried out at spawning times will result in a greater number of aggregated animals being sampled in shallow areas.

The importance of seeking anecdotal information from trochus divers or collectors, and using this in experimental design, was underlined. In many cases, a great deal of information can be gathered from fishermen that otherwise would be very expensive to collect, or may be unavailable.

Mr Nash undertook to compile a more detailed set of guidelines for use in designing trochus surveys.

Annex 2

**CONSTRAINTS ON PACIFIC ISLAND FISHERY RESEARCH,
AS IDENTIFIED BY ISLAND PARTICIPANTS**

Manpower and training

- General lack of manpower
- Lack of general technical training
- No formal accreditation of short-term or occasional training activities.
- Specific forms of training required:
 - Counterpart or attachment training
 - External or in-country postgraduate level training
 - Computer training
 - Training for data technicians
 - Training in stock assessment
 - Public and school-level education on fishery research and management

Funding/technical support

- Shortages of operational funds
- Reluctance by aid donors to cover recurrent operational costs.
- Lack of general technical support
- Lack of funding for long-term research activities
- Need for cost-sharing of research facilities (vessel)
- Specific funding requirements:
 - Funds to compensate fishermen for collecting fishing data

Internal communications

- Need for improvement of awareness of the need for fishery research among administrators and decision makers.
- Need for presentation in digestible form of research/management information to decision makers, and "validation" of this information by support from external organisations.

External communication

- Lack of contact and dialogue with specialists/researchers elsewhere
- Lack of contact with organisations and institutions
- Lack of computer links between countries and organisations

Information

- Lack of access to information generally
- Specific Information needs:
 - Literature
 - Translators of Japanese and French technical material into English
 - "Peascesat" type conference link
 - Lack of taxonomic guides to planktonic, juvenile and adults of commercially important species
 - Need to indentify individuals who can identify specimens

Statistics

Need for improvement of fishery statistics generally

Lack of specific statistics on:

fish catches

fishery economics

fish exports

historical fishery information

Difficulties in interpreting questionable fishery statistics

Lack of information on the economic implications of fishery development activities

Need for programming assistance to translate old records to new computer formats or systems.

Data analysis/experimental design

Need for general assistance in this field

Need for advice on long-term research programmes

Surveys and stock assessment

Need for general assistance in this field

Specific survey and assessment priorities:

Beche-de-mer

Trochus

Lobster

Green snail

Pearl shell

Freshwater mussel

Overfishing in Tarawa lagoon

Resource surveys in Phoenix Islands

Historical changes in cpue

Improvement of catch and yield estimates

Need to develop standardised 'broadbrush' survey techniques applicable to all countries

Need for advice on utility of L/F based methods for single-species based fisheries

Finfish research

Need for research into improved fish capture methods

Need for research on effects and performance of FADs

Continuation of existing baitfish research activities

Need to estimate deep-bottom fish resource size, appropriate levels of harvesting, and appropriate management approaches

Need for access to ciguatera testing facilities

Management

- General need for advice on managing different fishery situations
- Lack of information on which to base regulations
- Need for studies on impact of introducing trochus on local fauna
- Lack of information on traditional marine tenure and its application to management
- Need for documentation of traditional fishing knowledge
- Need for studies of impacts on fisheries of:
 - General coastal development
 - Urbanisation and population growth
 - Causeway construction
 - Reef blasting
- Identification of critical lagoon habitats
- Environmental monitoring

Mariculture

- Need to identify appropriate mariculture, species, sites and culture techniques
- Lack of advice on sponge culture
- Need for assistance with green mussel hatchery

LIST OF WORKING PAPERS

Working papers

- WP.1 The penaeid shrimp resources of the Pacific Islands, by A.D. Lewis
- WP.2 Miscellaneous mollusc resources of Pacific Islands, by A.D. Lewis
- WP.3 Synoptic study of trochus in the Pacific, by W. Bour
- WP.4 Pearl-oyster resources in the South Pacific. Research for management and development, by N.A. Sims
- WP.5 Beche-de-mer in New Caledonia: biology and fishing, by C. Conand
- WP.6 The collection and use of fishery statistics, by M.E. Molina
- WP.7 Coconut crab ecology in Vanuatu, by W.J. Fletcher
- WP.8 Trochus management and exploitation in Pohnpei State, Federated States of Micronesia, by E.F. Curren
- WP.9 Fisheries for small pelagics in the Pacific Islands and their potential yields, by P.J. Dalzell and A.D. Lewis
- WP.10 Reef resources : survey techniques and methods of study, by G.R. Russ and J.H. Choat
- WP.11 Biology of the green snail (*Turbo marmoratus*) and its resource management, by M. Yamaguchi
- WP.12 Development of phycocolloid-related industries in Oceania, by S.G. Nelson
- WP.13 Topic review : deep-water shrimps, by M. King
- WP.14 Fish aggregating devices : what next?, by R. Farman
- WP.15 A review of large coastal pelagic fishes in the South Pacific region, with special reference to *Scomberomorus commerson* in North-East Australian waters, by G.R. McPherson
- WP.16 Inshore tropical baitfish : current resource management knowledge, by A.W. Argue
- WP.17 Sharks, by G.R. McPherson

- WP.18 Tropical spiny lobster : An overview of their biology, the fisheries and the economics with particular reference to the double spined rock lobster *P. penicillatus*, by J. Prescott
- WP.19 SPREP questionnaire on destructive fishing methods : summary of results
- WP.20 Nearshore fisheries habitat assessment - remote information acquisition and analysis, by D.B. van R. Claasen
- WP.21 Habitat and fisheries enhancement strategies for Pacific Island coral reefs, by R.E. Brock
- WP.22 Status of sea turtles in the South Pacific and management needs, by J.D. Parrish
- WP.23 Semi-precious corals in the South Pacific : prospects for development and management of their fisheries, by J.D. Parrish

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- BP.2 Semi-precious corals in the exclusive economic zone (EEZ) of New Caledonia, by B. Richer de Forges and R. Grandperrin
- BP.3 Tuna baitfishes : biology, ecology, resources in New Caledonia, by F. Conand and M. Kulbicki
- BP.4 Ageing of tropical reef fish by density of daily otolith increments, by N. Baillon
- BP.5 Status report - gillnet selectivity project (Yap, Federated States of Micronesia), by C.M. Price
- BP.6 Inshore fisheries development and management : the South Pacific experience; an overview, by P. Kunatuba
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- BP.8 Fisheries research and management problems in Kiribati - Country statement, by B.M. Yeeting
- BP.9 A summary of fisheries legislation in Kiribati, by B.M. Yeeting
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- BP.11 Resource survey in Kiribati, by C.C. Mees
- BP.12 Country statement - Federated States of Micronesia, by M. Gawel
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- BP.42 Country statement - Guam, by R.F. Myers
- BP.43 Guam inshore fisheries survey, by G. Davis
- BP.44 Guam offshore fisheries survey, by R.F. Myers and G. Davis
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- BP.46 Traditional Pacific Islander management of inshore fisheries : the SOPACOAST initiative, by G.B.K. Baines
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- BP.63 Yap Proper trochus stock assessment : 1987, by J. Fagolimul
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- BP.102 Country statement - Tokelau
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- IP.3 Status report - gillnet selectivity project in Yap, Federated States of Micronesia, by C.M. Price

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- IP.5 Biological survey of mullets in Tonga. Results of the first 6 months, by S.A. Langi, T.A. Latu and S. Tulua
- IP.6 Méthode d'identification rapide du sexe des trocas vivants en vue d'aquaculture, by C. Hoffschir
- IP.7 Biological study of exploited baitfish species *Stolephorus heterolobus* and *Stolephorus devisi* in Western Province, Solomon Islands, by G.K. Tiroba
- IP.8 A report on a collaborative research programme into baitfish populations in Solomon Islands, with some preliminary findings, by P.V. Nichols
- IP.9 Eel fishing with fyke nets : A pilot project in Solomon Islands, by M.J. Batty and P.V. Nichols
- IP.10 Recruitment in the giant clams *Tridacna gigas* and *T. derasa* at four sites on the Great Barrier Reef, by R.D. Braley
- IP.11 Distribution and abundance of the giant clams *Tridacna gigas* and *T. derasa* on the Great Barrier Reef, by R.D. Braley
- IP.12 Spatial distribution and population parameters of *Tridacna gigas* and *T. derasa*, by R.D. Braley
- IP.13 Statistiques des pêches maritimes et de l'aquaculture en Nouvelle-Calédonie (1976-1986), by Service territorial de la marine marchande et des pêches maritimes
- IP.14 Fisheries for giant clams (Tridacnidae : Bivalvia) and prospects for stock enhancement, by J.L. Munro
- IP.15 Yap trochus sales : 1986, by Marine Resources Division
- IP.16 Trochus : Yap Proper stock assessment and prefactory market survey, by J.J. Fagolimul
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- IP.19 La pêche profonde en Polynésie française, by L. Wrobel
- IP.20 Report on the fish aggregation device program in American Samoa, by D. Itano and T. Buckley
- IP.21 AIMS Programme description - Coastal pelagic resources, by D.M. Williams
- IP.22 Le stock naturel de nacre *Pinctada margaritifera* L. dans l'atoll de Scilly, by A. Intes, P. Laboute and M. Coeroli

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- IP.25 Resultats préliminaires du programme d'études des dispositifs de concentration de poissons en Polynésie française, by J. Chabanne
- IP.26 Introduction of Tridacnid clams to Yap State : 1987 status report by Marine Resources Management Division

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