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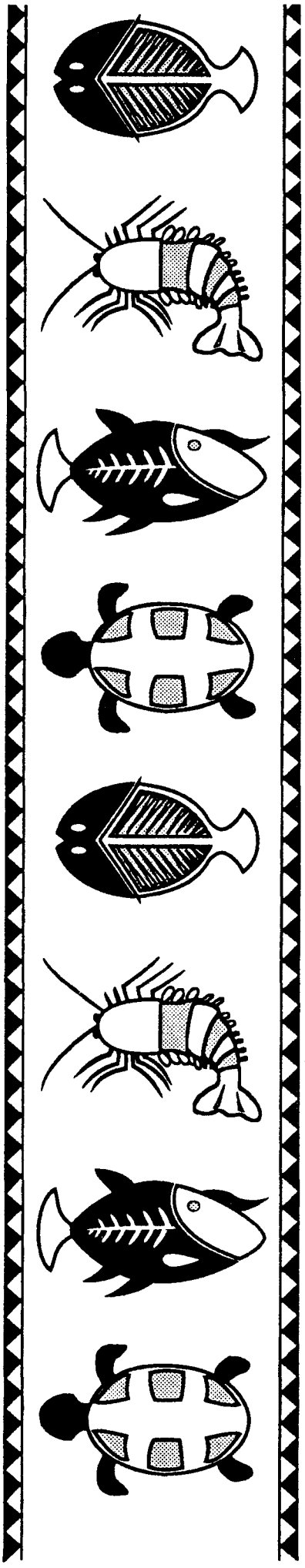

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Inshore Fisheries Research Project
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THE MARINE RESOURCES OF PALMERSTON ISLAND, COOK ISLANDS

Report of a survey carried out in September 1988

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THE MARINE RESOURCES OF PALMERSTON ISLAND, COOK ISLANDS

Report of a survey carried out in September 1988

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SUMMARY

This reports presents the information gathered during a short (10-day) survey of the marine resources of Palmerston Island, Cook Islands, carried out in September 1988. The report essentially consolidates, in publishable form, the draft version of the survey results and fishery management recommendations presented to the Cook Islands Ministry of Marine Resources in early October 1988.

The original intention was to publish the present report immediately after the survey. However, this was not achieved for a variety of reasons, including the rapid dispersal of the team members immediately after the survey, the obligation of some team members to turn their attentions to new field projects, and the desire on the part of the team to integrate into the report additional information on Palmerston's fisheries, especially fishing lore, which was not included in the original draft presented to the Ministry of Marine Resources.

One of the major aims of the survey was to establish baseline information which would serve as a reference for future work. This being the case, the publication of the present report, even if belated, is still considered worthwhile. In order to place the survey information in the public domain, in 1995, the Information Section of SPC's Coastal Fisheries Programme took over the task that had been put aside by the original authors.

However, in order to enable publication of the survey results with a minimum of further delay, it was decided not to integrate the additional information on Palmerston's fisheries and fishing lore. This information may in due course be published in another form, possibly as articles in the *SPC Fisheries Newsletter* or Information Bulletins.

The principal aims of the survey were to gather data which might be used to assess the exploitation status of the island's parrot-fish resource, widely was believed to be over-fished, and to propose management options for the fishery if these proved necessary. Subsidiary aims were to gather data on levels of exploitation of the island's other marine resources, and to identify areas in which alternative fishing activities that might relieve fishing pressure on the parrot-fish resource, might be developed.

Within the short time available, the survey is believed to have achieved most of its original objectives. A large amount of essential background material on the resources present, the fisheries based on them, and socio-economic factors pertaining to the island was accumulated rapidly, providing a basis for more detailed specific work on individual resources.

The general lack of reliable historical production data severely constrains detailed resource assessment. However, the relatively small size of the atoll has allowed useful approximations to be provided on the basis of experience in other areas.

The parrot-fish fishery, a biologically unique and virtually unknown quantity both within-country and elsewhere, was described and salient features identified. Based on this, possible management strategies were outlined to the Island Council, and the various options discussed. The benefit of this feedback was incorporated into a draft management plan for Government consideration. Further development opportunities and areas for increased Government involvement were also identified.

The success of this survey was largely a result of the excellent organisation and support provided by the Palmerston community generally, and the Fisheries Officer in particular. The survey team was able to base much of its work on existing knowledge and catches, supplemented with some independent objective observation. The team was fortunate to have access to fishermen skilled in a range of appropriate techniques, and used these as a primary sampling method.

One of the major achievements of the survey has been to provide an objective appraisal of a large body of existing information, to formulate carefully considered management advice based on this, and to establish baseline information which will serve as a reference for future survey work.

RÉSUMÉ

Le présent rapport a pour objet de faire état des informations recueillies au cours d'une brève campagne (10 jours) d'évaluation des ressources marines au large de l'île de Palmerston (Îles Cook), menée en septembre 1988. Il s'agit essentiellement de présenter sous une forme condensée la première version des résultats de cette campagne et des recommandations relatives à la gestion des ressources marines auxquelles elle a abouti et dont a été saisi au début d'octobre 1988 le service national des ressources marines des Îles Cook.

A l'origine, le rapport devait paraître immédiatement après cette campagne. Il ne l'a pas été pour diverses raisons, notamment la dispersion rapide des membres de l'équipe immédiatement après l'accomplissement de leur mission, l'obligation pour certains d'entre eux de se consacrer à de nouveaux projets sur le terrain, et la volonté de l'équipe d'intégrer dans le rapport des informations complémentaires sur les ressources marines de Palmerston, et surtout sur les techniques traditionnelles de pêche. Or ces informations ne figuraient pas sur la première version présentée au service national des ressources marines.

L'un des principaux objectifs de cette campagne était de réunir des informations de base sur lesquelles fonder de futurs travaux. Cela étant, la publication du présent rapport, quoique tardive, demeure utile. Désireuse de diffuser ces mêmes informations, la section information du programme pêche côtière de la Commission du Pacifique Sud a entrepris au cours de l'année 1995 de mener à bien la tâche inachevée par les auteurs d'origine du rapport.

Toutefois, afin que les résultats de cette campagne puissent être publiés sans autre délai, il a été décidé de ne pas y ajouter les informations complémentaires au sujet des ressources halieutiques et des techniques traditionnelles de pêche de Palmerston. Cette information pourra être publiée en temps opportun sous une autre forme, sans doute dans la *Lettre d'information sur les pêches* publiée par la CPS ou d'autres bulletins d'information.

La campagne visait essentiellement à permettre de recueillir des données qui pourraient servir à évaluer le niveau d'exploitation de la ressource en poisson-perroquet de l'île, réputé faire l'objet de surpêche, et, au besoin, de proposer des méthodes de gestion pour cette ressource. Elle visait aussi accessoirement à réunir des informations sur le niveau d'exploitation des autres ressources marines de Palmerston, et de repérer celles qui pourraient faire l'objet d'une exploitation, de façon à alléger la pression dont fait l'objet la ressource surexploitée de poisson-perroquet.

Malgré les courts délais impartis pour mener à bien cette campagne, la plupart des objectifs visés à l'origine ont pu être atteints. De nombreuses et importantes informations sur les ressources existantes, l'activité de pêche à laquelle elles ont donné lieu, et les facteurs socio-économiques particuliers à cette île ont été réunis rapidement, constituant ainsi un point de départ à des travaux plus approfondis sur différentes ressources.

De manière générale, l'absence de données historiques fiables sur la production halieutique de Palmerston limite sérieusement l'évaluation détaillée des ressources. Toutefois, la superficie de cet atoll étant relativement faible, il a été possible de faire des approximations utiles en fonction de ce qui avait été constaté dans d'autres zones.

La pêche du poisson-perroquet, ressource exceptionnelle sur le plan biologique et présente en quantité indéterminée à ce jour aux Îles Cook et ailleurs, a été décrite en détail ainsi que ses principales caractéristiques. Diverses stratégies de gestion ont été proposées au conseil de l'île et étudiées avec ce dernier. Les avis émis lors de ces entretiens ont été pris en compte dans le projet de plan de gestion soumis aux autorités nationales. D'autres créneaux et domaines propices à une participation accrue des services nationaux compétents ont également été recensés.

Le succès de cette campagne s'explique principalement par l'excellente qualité de l'organisation et de l'appui logistique fourni par la collectivité de Palmerston en général, et par l'agent du service des pêches en particulier. Les membres de l'équipe chargée de cette campagne d'évaluation des ressources marines de Palmerston ont pu étayer une bonne partie de leurs travaux sur les connaissances existant localement, qu'ils ont complétées

de leurs observations objectives et indépendantes. Ils ont pu utiliser des techniques de pêche très bien maîtrisées par les pêcheurs locaux pour effectuer leurs principaux travaux d'échantillonnage.

Cette campagne a surtout permis d'évaluer avec objectivité d'importantes quantités d'informations déjà réunies, de formuler des recommandations avisées sur la gestion des ressources marines, et de regrouper des informations de base qui pourront servir de référence.

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1. INTRODUCTION

1.1 Background

With the development of more regular shipping services to Palmerston Island over the last 20 years, an otherwise isolated island community has become increasingly more important as a source of fresh fish for Rarotonga, where the reef resources are particularly heavily exploited. As copra prices, previously the main source of income for the island, declined during the 1970s, the small resident population (66 persons), with its skilled fishermen, rapidly developed the capability to supply large volumes of fish (up to 5 tonnes) on a roughly monthly basis. After a decade of commercial harvesting, concerns were raised by local residents in the mid-1980s regarding the level of exploitation of the primary target groups, notably the parrot-fish (family Scaridae). Decreases in catch volume and in the average size of fish were perceived to have occurred.

A review of the research activities within the Ministry of Marine Resources (MMR) and fisheries development in general (Lewis, 1986) noted these concerns. It was recommended that a baseline resource survey of Palmerston Island be undertaken as a priority activity and that the Palmerston catch be more closely monitored. Preliminary guidelines for the survey were identified (Appendix 1).

The Cook Islands Fisheries Act, which, at the time of writing, was pending tabling in Parliament, directs the Ministry to prepare a Fisheries Management Plan for designated fisheries, with specific conservation and management objectives. The Palmerston parrot-fish fishery clearly warrants designation as such a fishery.

Given this background, the Ministry of Marine Resources sought both technical and financial assistance through regional fisheries bodies (the Forum Fisheries Agency, the South Pacific Commission and the United Nations Development Programme/ Food and Agriculture Organization Regional Fishery Support Programme) to enable it to undertake the required baseline survey and assist with the preparation of a parrot-fish fishery management plan.

Recognising the relevance of this short-term island resource appraisal to other countries of the region, the agencies involved jointly agreed to incorporate a secondary objective: the sharing of the survey experience with fisheries officers of other Pacific Island countries and the utilisation of their expertise in the survey. Firm plans were made to undertake the survey in September 1988 for a two-week period.

This report presents details of the survey methodology and results, describes the fishery resources of Palmerston and their exploitation, discusses management options, and makes recommendations on future resource development and monitoring.

1.2 Palmerston

Palmerston Island, the summit of a volcanic mass rising 4,000 m from the ocean floor, lies approximately 440 km north-west of Rarotonga, at around latitude 18° S and longitude 160° 23' W (Figure 1). The atoll is roughly trapezoidal, with the longest dimension in the north-south axis being 11 km, and in the east-west axis 8.5 km (Figure 2). Six main islets are located on the reef rim, along with numerous smaller motus and sand cays. Only one islet, Home Island, is inhabited. The total emergent land area is estimated to be 202.3 ha (Irwin & Main, 1984).

The fringing reef is broad, up to 1 km wide in parts, and has an estimated reef perimeter length of 29.8 km. An estimated 1,380 ha of the reef rim dries at low spring tides. The consolidated limestone platform that forms the elevated crest on the seaward side of the reef is thickly encrusted with *Porolithion* and *Lithothamnion*.

The coral communities of the atoll have not been described in detail, but are faunistically poor. Massive and encrusting corals predominate, with soft corals relatively rare. Crown-of-thorns starfish (*Acanthaster planci*) are present at low levels of abundance. On both leeward and windward sides, the emergent reef rims are

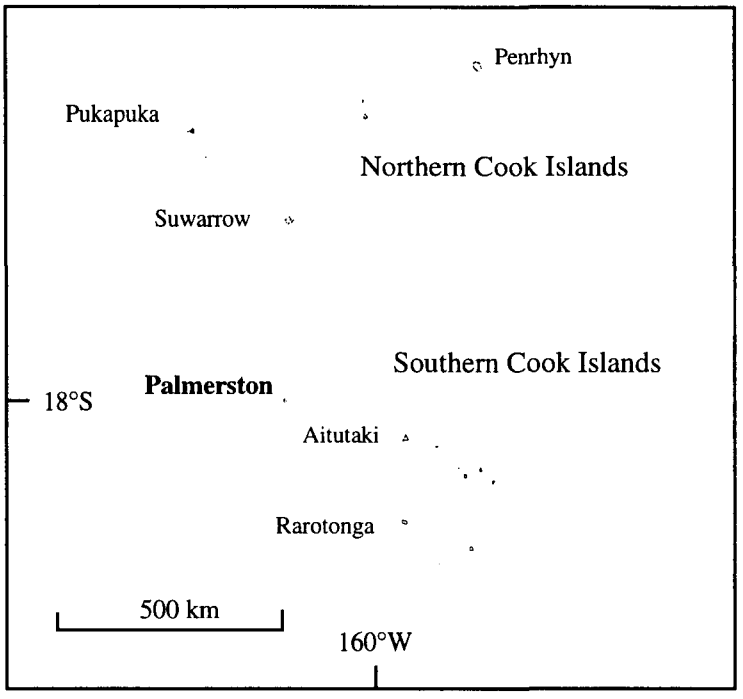

Figure 1 : Cook Islands

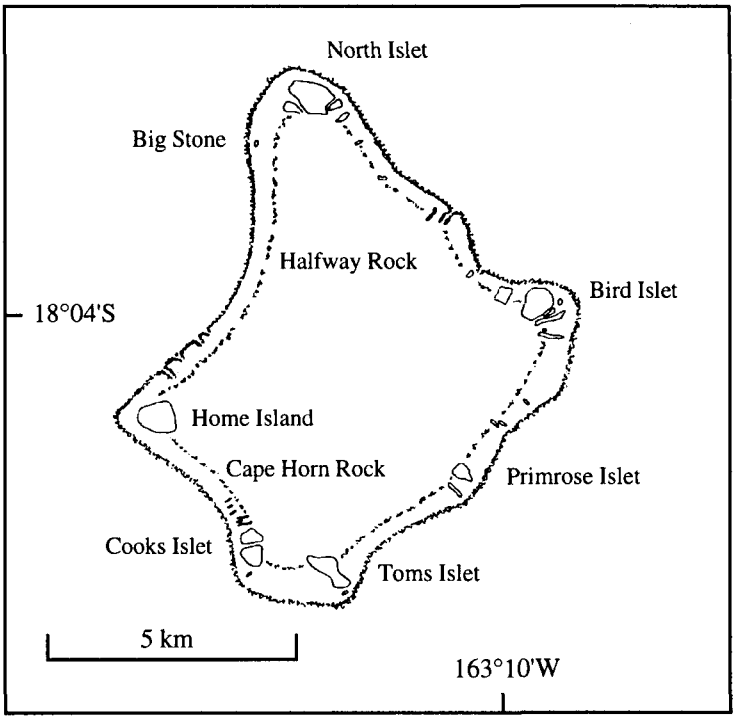

Figure 2 : Palmerston Island

dissected by surge channels with a variously developed shallow moat on the lagoon side. A wide reef flat (up to 1 km) with scattered live corals is present in all areas. The inner reef edge generally descends steeply into the lagoon proper.

The lagoon has a maximum depth of 34.6 m (Irwin & Main, 1983) and is largely enclosed, with several shallow passages on the leeward (north-western) side navigable only by dinghies. The estimated area of the lagoon is about 2,859 ha, of which about 1,340 ha is greater than 20 m in depth. Coral heads, formed by

predominantly *Montipora, Porites* and *Acropora* corals, and typically heavily covered on the sides with long strands of macroalgae (*Caulerpa*), are uniformly distributed throughout the lagoon. The lagoon floor at most depths is covered in fine calcareous silt, and no distinct seagrass beds occur.

Outside the lagoon, the bottom shelves away steeply, particularly on the leeward side. Bathymetric data are not available, but no seamounts are believed to exist near Palmerston. Underwater spurs of reef project seaward into deep water off points adjacent to the major islets. The atoll lies in the trade-winds belt, with E-SE winds predominating. It is swept by a generally weak (<0.2 knot) westerly setting current, with mean annual sea surface temperatures of 27.5°C (range 26.0 – 28.5°C) and normal salinity (35.5 ‰, range 35.3 – 35.7 ‰) (Pianet, pers. comm., based on several sources).

The atoll flora is similar to that described in detail for Aitutaki and Rarotongan reef islands (Stoddart & Gibbs, 1975) with common Pacific atoll species predominating. These include *Pemphis* on the seaward margin, *Suriana, Scaevola, Pandanus*, coconut, *Guettarda, Pisonia* and *Casuarina.*

The avifauna is relatively limited. The red-tailed tropic bird or boatswain bird (*Phaethon rubricauda*), the common noddy (*Anous stolidus*), the white stern (*Gygis alba*), the reef heron (*Demigretta sacra*) and the Pacific fruit pigeon (*Ducula pacifica*) breed on various islets. The greater frigate bird (*Fregata minor*) and shore birds, such as *Charadrius* and *Heteroscelus*, are seen in good numbers.

Apart from small numbers of rats and mice, primarily on Home Island, no mammals occur. Coconut crabs (*Birgus latro*) persist in small numbers. Land crabs (*Cardisoma carnifex*) and hermit crabs (*Coenobita)* are common. Green turtles (*Chelonia mydas*) nest on several islands. Hawksbill turtles (*Eretmochelys imbricata*) are occasionally sighted.

In general, the marine invertebrate fauna is species-poor. Several types of mollusc and crustacean are exploited for food. These include giant clams (*Tridacna maxima*), green snails (*Turbo setosus*) and crayfish (*Panulirus penicillatus*). Two holothurians, *Holothuria atra* and *Stichopus chloronotus,* are ubiquitous and abundant.

The ichthyofauna of Palmerston atoll has been partially described (Grange & Singleton, 1985) and, particularly in the lagoon, is relatively impoverished. More complete lists of fishery-associated species are provided in Sections 4 and 5, and in Appendix 2. In general, planktivorous fishes are rare in the lagoon, with carnivores low in both species abundance and diversity. Herbivores (Scaridae and Acanthuridae) form the most conspicuous ichthyofaunal element. Outside the reef, the usual range of tropical epipelagic/oceanic species is present. Benthic ichthyofauna of the deep outer-reef slope areas is reduced in comparison with the western Pacific.

2. SURVEY PROTOCOL

2.1 Survey aims and priorities

The primary aim of the survey was to:

(a) Provide baseline information on the parrot-fish (Scaridae) fishery and other fishery resources at Palmerston Island, and identify and establish appropriate monitoring and management measures. (Both the Ministry of Marine Resources [MMR] and the Palmerston Island Council wished to see a formal management plan prepared and presented).

As secondary aims the project was to:

(b) Assess the status of the principal fishery resources of the atoll and its environs in order to identify possible ways of diversifying fishing effort and maximising economic returns within the limits of sustainable yields;

(c) Provide an inventory of the marine resources of the island, including commonly used local names, fishing lore and fishing methods;

(d) Promote technical cooperation within the region by enabling fisheries officers from other Pacific Island countries to participate in the survey and share their experience.

Timely reporting of the survey results was required by the funding agencies and the MMR. Basic data logging and analysis were carried out while the team was on Palmerston, and this allowed team members to discuss and consolidate their ideas on the status of the various fishery resources being studied, usually in consultation with island fishermen. The team's last activity prior to departure from Palmerston on 1 October was to participate in a final meeting of the Island Council, in which suggested management options were outlined and discussed. Subsequently, in a meeting held on 4 October, a preliminary draft report was presented to the MMR in Rarotonga, summarising the survey results and the management options already discussed with the Island Council. A copy of the report was also forwarded to the Island's Chief Administrative Officer.

Finally, following the team's departure from Rarotonga, full compilation of all the survey and associated information was undertaken by FFA, MMR and SPC team members working separately on different sections. This was consolidated into the present comprehensive report at SPC headquarters, with MMR and FFA team members' reviews and revisions being incorporated by correspondence. A draft report was circulated for comment among participants and reviewers in February 1989. The final report was formally submitted to Cook Islands Government in April 1989, some six months after the survey was completed.

Full consultation with the people of Palmerston Island and the Island Council was expected to occur, and ongoing communication of additional analysis and output to be maintained.

2.2 Logistics

Difficulty of access meant that the timing of the survey was dictated by the schedule of shipping available to transport the team from Rarotonga to Palmerston, some 440 km distant. The original plan to travel on the 80 ft (24.4 m) inter-island sailing vessel *Evohe* had to be cancelled due to mechanical problems with the vessel. However, the fish transport vessel, M.V. *Intrepid,* was late departing on its normal monthly schedule and was able to transport six of the survey team initially, leaving on 17 September. The *Intrepid* was chartered for the team's outstanding transportation requirements from Rarotonga to Palmerston and return. The five remaining members of the team departed Rarotonga on 22 September. Apart from one individual who had to leave for Rarotonga on the return voyage of the *Intrepid* on 24 September, all team members departed Palmerston Island on 1 October.

Personnel assembled for the survey, initially planned for a total time in-country of three weeks, included five MMR Research Division staff, the FFA Research Co-ordinator, the SPC Senior Inshore Fisheries Scientist, an SPC short-term resource survey consultant and nominated fisheries officers from Tuvalu, Kiribati and Fiji (Appendix 3). In addition the survey team was assured of—and received—the full cooperation of island residents and the services of the Ministry's Fisheries Officer stationed on Palmerston.

Accommodation was provided in a single large dwelling by the Fisheries Officer's family, and food provided from a set daily levy. Vessels, motors and nets used during the survey were made available by MMR and the Fisheries Officer.

Although the fundamental approach was to establish close working relationships with island fishermen and make the maximum use of their normal gear, some specialised equipment was required to carry out detailed survey work. As a general working principle, equipment was kept as simple as possible to assist with compatibility if another survey is conducted, and to ensure relevance to similar resource surveys elsewhere in the region. The equipment, listed in detail in Appendix 4, included the following:

(a) three 4 – 6 m aluminium dinghies powered by 25 hp outboard motors;

(b) SCUBA tanks, diving gear, and a portable compressor;

(c) marine survey equipment (1 x 1 m quadrats, transect lines, manta boards, underwater writing equipment, etc.);

(d) wooden deep-water handreels and ancillary gear;

(e) small mesh gill nets;

(f) spear guns and assorted fishing gear.

Photographic equipment was available for general use as well as to record specimens of interest. Reference material, including a range of taxonomic keys, and a portable Hewlett-Packard Vectra microcomputer were also taken to assist with report compilation while on the island.

Standard data sheets were prepared for all expected activities prior to leaving Rarotonga, for centralised storage and analysis. These were modified on Palmerston as required during the course of the survey.

Team members worked day and night as required, according to tidal, lunar and weather variables. With the arrival of the second half of the team, activities were generally carried out by three mobile groups.

2.3 Activities

With the survey team arriving in two stages, the overall survey strategy was as follows:

Week 1

By establishing contact with island fishermen and village leaders, all available background information on fishing methods, species taken, gear usage, disposition of effort, size composition of the catches and inventories of existing fishing equipment was collected and collated. The occupants of the ten houses within the village on Home Islet were interviewed on their fishery-related activities by a survey team member who was born on the island. A prepared questionnaire (Appendix 5) was used in conjunction with informal discussions to elicit relevant information relating to the daily fishing activities of island residents. Familiarisation trips were undertaken with local fishermen, and species identification of difficult groups (e.g. Scaridae), both underwater and in their catches, resolved.

Week 2

Intensive resource surveys (sedentary resources), catch sampling (finfish) and, for unexploited resources, exploratory fishing activities, were carried out under an overall plan formulated at the end of Week 1, by three independent working groups deployed as required.

In deference to the experience-sharing component, group personnel were freely interchanged to maximise exposure to sampling and fishing methods, without compromise to the survey objectives.

2.4 Methods

Prior to departure from Rarotonga, MMR and Statistics Office records were examined to gather as much historical information as possible on fishery production and on changes to the population and economy of Palmerston. Immediately on arrival, a comprehensive household survey was carried out and this generated a great deal of subjective but vital data on patterns of fishing catch and effort, as well as historical and

general anecdotal information relating to Palmerston Island fishermen's perceptions of changes in the status of the various resources.

In addition, relevant biological data were gathered in the field on key resources (e.g. Scaridae, crayfish) as often as practicable. Because of the prevailing ban on exports, all parrot-fish sampling had to be done by the team with the help of the Fisheries Officer, a proficient fisherman in his own right. Sedentary resources were sampled using line transects, variable-sized quadrats and intensive spot searches, while finfish resources were investigated using those fishing methods normally used for their capture, and by visual census. Size structures for exploited populations were established wherever possible.

Table 1 summarises sampling methods utilised for each of the resources investigated. Figure 3 indicates the location of sampling sites for each of the resources investigated.

Table 1: Summary of sampling methods for each resource

Resource	Methods and gear
Tridacnid clam	Cross-reef transects, 100 m x 2 m (reef crest) Patch reef transects, 20 m x 2 m Quadrats, 10 m x 10 m (reef crest) Quadrats, 1 m x 1 m (patch reefs)
Parrot-fish	Drive-net fishing, 100 yds x 4-inch mesh gill net Underwater visual census Visual census while reef walking
Trochus	Intensive reef search
Green snail (**ariri**)	Along-reef transects, 100 m x 2 m (reef crest)
Crayfish	Surge zone, free diving (snorkel) Visual census while reef walking
Sand clams (**ka'i**)	Presence / absence observation
Carangids (**koperu**)	Bottom-set gill net, 100 yds x 1 3/4" mesh net
Squirrelfish (**marau**) / Big-eye (**kupa**)	Light-line trolling (local Palmerston method)
Deep bottom fish	Drop-line fishing in deep water
Assorted reef fish	Drop-line fishing Rod fishing on reef top
Mullet	Gill netting, 100 yds x 4" mesh net
Beche-de-mer	Free-swimming searches 100 m x 2 m transects on reef crest Quadrats, 10 m x 10 m (reef crest)

The field survey methods used during the two-week period varied in their ability to produce the maximum amount of information possible from rapid, broad-brush assessments. Few methods could realistically be expected to encompass all variables required for a detailed assessment of the status of the resources in this time frame, and it is worth appraising the relative usefulness of the methods employed in the present context.

Line transects, intensive spot searches, random quadrat throws and visual counts were all used to provide direct counts of the numbers and densities of sedentary resources.

Line transects (2 m band width) were laid across the reef flat at five sites around the lagoon (Figure 3). Whilst these provided good information on faunal zonation across the broad reef flat, most organisms encountered were of marginal economic interest. Detailed counts within identified zones were then necessary to provide direct, meaningful density estimates for particular species in normal habitats (e.g. 200 m^2 quadrats on the reef crest to estimate the density of surf red fish, and *Turbo* counts along 20 m stretches of reef

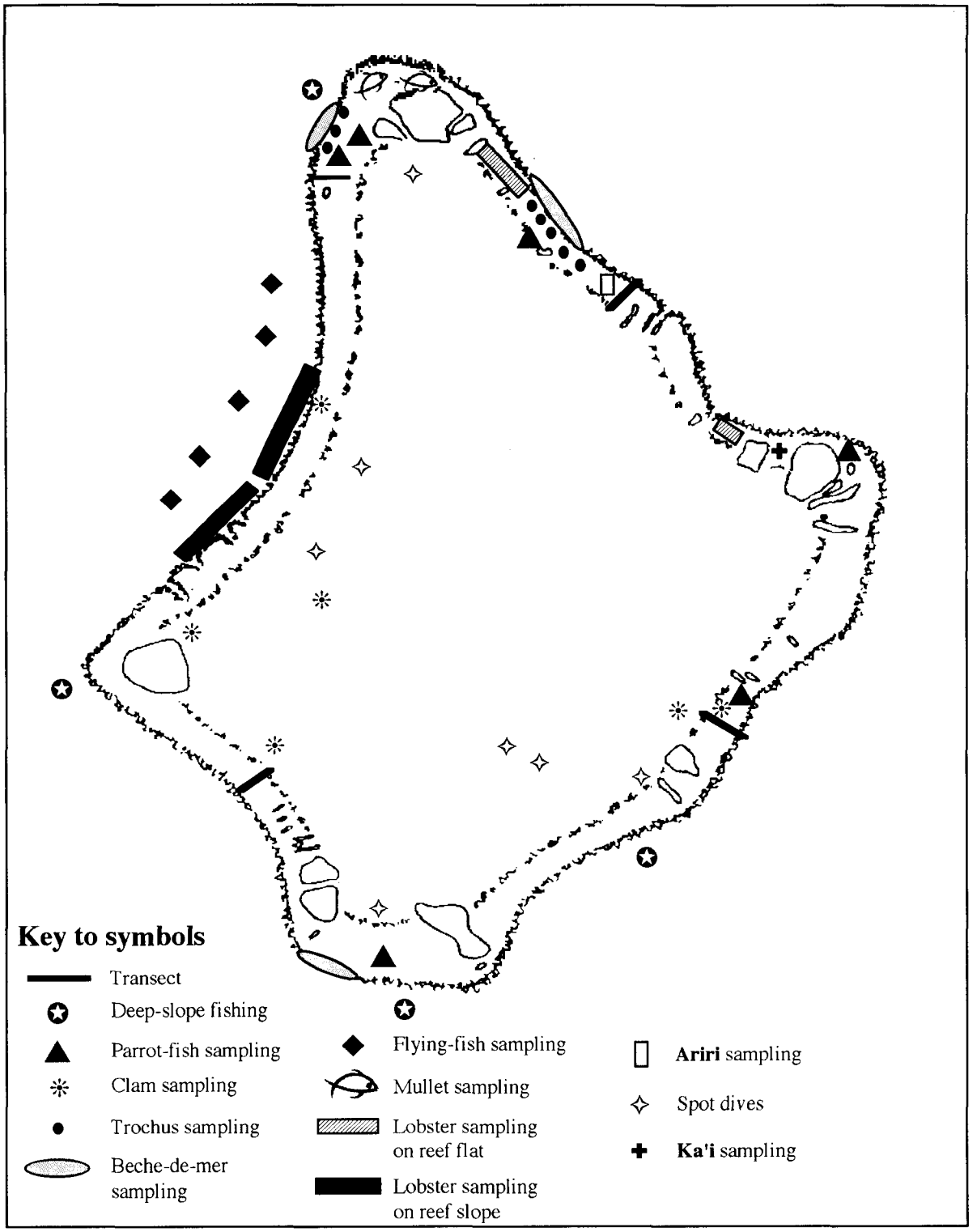

Figure 3 : Location of sampling, fishing and survey sites

crest). On a larger scale, crayfish (*Panulirus*) were surveyed by intensive dive searches and reef flat searches at night along measured distances (up to 1 km).

Quadrats (1 m^2) were found useful in measuring giant clam densities within habitats, but they add little to the overall appreciation of the size of the resource unless done in large numbers.

Visual searches provided useful qualitative data, such as establishing the presence or absence of target organisms (e.g. commercial beche-de-mer, trochus), and in the compilation of the ichthyofaunal checklist.

They also proved of some quantitative value in assessing relative abundance of scarid species in two habitats (reef front and reef flat) at high and low tides.

Manta tows were trialled but ultimately not employed. Most target organisms were in either shallow or turbid water, in the surf or heavy surge zone, or likely to be disturbed by vessel noise and the presence of divers.

With the survey emphasis on exploited organisms, the fishermen of Palmerston and their normal gears were utilised for the main methods of sampling, allowing indices of abundance to be extrapolated from their catch rates. Effort units were difficult to establish in some cases (e.g. the parrot-fish drive-in fishery). In the time available, typical catch rates and composition of the catch (species, size) were established for most fisheries, although the variables affecting these (e.g. lunar phase, seasonality and weather) could not be fully accounted for. During the household survey, all fishing equipment on the Island was catalogued, along with general patterns of effort, and consumption and distribution of the catch.

Some exploratory fishing was also carried out, notably in the case of deep-water snapper fishing, where improved gear was used to fish in outer-reef-slope waters deeper than those normally fished by Palmerston Island residents. This produced good catches at various locations (Table 12). For this resource, catch per unit of effort (measured in reel-hours) was taken as a meaningful indicator of abundance and community composition for comparison with results from elsewhere in the Pacific. The Samoan-type handreel and terminal hook arrangement employed during the survey have almost become the standard gear in survey work and in commercial fisheries that target these resources in the Pacific Islands region.

Vertical longlining was not attempted, but appears to have potential (see Section 5.8). Bottom-set gillnetting outside the reef for *Decapterus* was unsuccessfully attempted on one occasion. Static gill net fishing, a standard survey method, was not undertaken due to problems faced with shark damage to the nets.

3. FISHING ON PALMERSTON ISLAND

3.1 Social organisation

Since its initial settlement by William Marsters in 1860, the population of Palmerston Island has reached as high as 140. Following a series of cyclones between 1925 and 1935, significant emigration occurred and the current permanent population (1986 census) is officially 66 persons (Turua, 1988). The population lives in 10 households in a single village on Home Island; over 50 per cent of the population are less than 15 years of age. Fishing and agriculture are recorded as the main economic activities of the island residents, with 20 per cent of the population engaged in income-generating activities (Turua, op. cit.).

All residents are direct descendants of the three original settler families, or are related by marriage (Appendix 6). The allocation of land and access to 'traditionally' managed resources on the atoll (such as boatswain birds) is divided equally between the three family branches. Each family is also represented on the Island Council, the local government authority.

The Cook Islands Government provides a number of services to the island, and these are staffed by local residents. They include a small school, a meteorological station, a radio communication facility, a first aid post, an agricultural advice service, and a MMR fisheries facility.

3.2 History of commercial fisheries development

Palmerston residents have a proud history of self-sufficiency, largely based on well developed fishing skills that, since initial settlement, have been adapted to the exploitation of a wide range of fishery resources. With the steady decline in copra prices (especially during the 1980s) fisheries have developed to the point of being the main income source for the island, and fishing activity occupies a central role in island life.

With the development of more regular shipping services to the island in the late 1960s and early 1970s following the acquisition of the F.V. *Ravakai* by the Fisheries Department, fishing activity gradually moved towards a commercial scale. The F.V. *Ravakai* commenced regular monthly services in 1973 and from this time 1 – 3 t of fish, primarily whole parrot-fish on ice, was exported per trip every 6 – 8 weeks, with occasional shipments of close to 5 t. One fisherman alone is reported to have shipped 90 t of fish in the period 1973 – 1975, although it was not possible to verify these figures. At that time virtually all parrot-fish were taken using coconut-frond scare lines (**rau**) in particular areas, a practice which continued until the introduction of monofilament nets in the late 1970s.

During a mishap at sea in 1975, the F.V. *Ravakai* overturned, but was salvaged. It resumed service in 1977 until its final demise in Cyclone Sally in 1987. Other vessels (M.V. *Miss Geraldine*, S.S. *Stella Maris*) offered intermittent services, and with the initiation of a regular shipping run to Pago Pago from Rarotonga in 1984, more regular services have been provided by the M.V. *Manuvai* and M.V. *Mataora*. The well-equipped M.V. *Intrepid*, deployed in mid-1988, now provides the primary service to the island.

Chest freezers were introduced to the island in 1973, but fish prices remained low (7–15¢/lb, 15–33¢/kg) due to the relatively poor quality of the fish after transport on ice. The increase in the number of freezers and generators on the island and the advent of freezer transport capacity on the *Manuvai*, the *Mataora,* and, more recently, the *Intrepid*, has seen a steady increase in fish prices to the levels shown in Table 2.

Table 2: M. V. *Intrepid* FOB fish buying prices at Palmerston Island, September 1988

	NZ$/kg
Tuna (head on)	2.20
Reef fish (head on)	2.50
Tuna (head off)	3.00
Flying fish (head on)	3.00
Fillets (wahoo, skinned barracuda)	5.50
Giant clam (whole meat, less kidney)	2.50

One fisherman vacuum-packs fillets on the island, whilst others use plastic wrap. An Island Council ban is currently in force on the export of parrot-fish and crayfish, due to the management concerns described in Section 1.

3.3 Patterns of fishing activity

Commercial fishing activity is closely tied to expected vessel movements, although the acquisition of freezers has introduced more flexibility in this regard. The other main influences on both commercial and subsistence fishing are lunar/tidal cycles, weather, and seasonal changes in fish availability, usually associated with spawning runs. All fishing activity is proscribed during the Sunday daylight hours for religious reasons.

Pelagic fishing is generally carried out on the leeward (NW) side of the island (although some trolling occurs on the windward side). The primary activities are tuna down-lining (day-time), flying-fish netting (night-time), trolling for wahoo, barracuda and tunas (*Acanthocybium*, *Sphyraena*, *Thunnus*) and bottom fishing for various species, including oilfish (*Ruvettus*), snappers (*Lutjanus*), breams (*Lethrinus*), groupers and cods (*Epinephelus*, *Plectropomus*), trevallies (*Caranx*, *Carangoides*), soldier fish, squirrel fish and bullseyes (*Sargocentron*, *Ostichthys*, *Priacanthus*, *Myripristis*). Moon phase influences flying-fish fishing in particular.

On the reef crest, shellfish (*Turbo* and limpets) are collected, as are crayfish (*Panulirus*) at night; rod fishing is practised, and parrot-fish are netted near the surge channels, nowadays with monofilament gill nets. As noted earlier, scare-line fishing (**rau**) was an important and productive communal activity. Rabbit fish (*Siganus*) are netted during spawning aggregations in the period November to February, and mullet (*Crenimugil*) are netted around full moon in selected localities. Other fish species (*Priacanthus* [**ku pa**], *Myripristis* [**ku**]) are trolled at night along the reef edge. Tidal cycles are of obvious importance to these reef fisheries and moon phase influences crayfish collection and **ku pa** and **ku** trolling.

Within the lagoon, giant clams (*Tridacna maxima*) are excised from coral platforms and rod fishing is practised from coral heads. Other species, such as *Octopus* and sand clam (*Asaphis*) are collected intermittently, as are land crabs (*Cardisoma* and *Birgus*). Boatswain bird (*Phaethon rubricauda*) chicks are collected from several islets, this activity being regulated by enforced community guidelines, and turtles are harvested periodically.

No ice is available on the island and fishing trips are of short duration (usually less than five hours). All fish is frozen slowly in chest freezers and some processing (filleting and packing) occurs. Most fishermen sell through an appointed buyer acting for the vessel owners, although one fisherman sells directly to contacts in Rarotonga.

During the household survey, all fishing equipment on the Island was catalogued, along with general patterns of effort and consumption and distribution of the catch. The information collected is based on interviews conducted using the form shown at Appendix 5, and on direct observations.

Table 3 lists the major types of fishing gear found on the island at the time of the survey. Although metric units are used in the text of this report, Palmerston Islanders continue to use imperial measures for fishing gear specifications and in all other respects, and these have been retained in the table.

Table 3: Catalogue of fishing equipment on Palmerston

Engines		Boats		Gill nets			Fishing lines				Other gears	
HP	No.	Length (ft)	No.	Mesh (ins)	Hung length (ft)	Square (yds)	Breaking strain (lbs)	No.	Breaking strain (lbs)	No.	Details	No.
0 – 7.5	12	0 – 10	1	0 – 1	45	89	0 – 50	6	250 – 300	10	Spearguns	8
7.5 – 20	6	10 – 15	6	1 – 2	330	1,253	50 – 100	11	300 – 450	0	Hand slings	4
20 +	17	15 – 20	12	2 – 3	535	1,903	100 – 150	10	450 – 500	1	Hand spears	9
		others	5	3 – 4	666	2,307	150 – 200	8	Kuralon	2	Scoop nets	13
							200 – 250	10	Unspecified	3		
Total	**35**		**24**		**1,576**	**5,552**				**61**		

Most boats on the island are aluminium welded and riveted dinghies averaging 4 – 6 m in length and powered by outboard motors of a range of sizes. However, when fishing outside the reef (the most common fishing area for commercial fishing operation; see Table 6), 20 – 50 horsepower outboards are used on most boats. Aluminium dinghies have completely replaced the earlier clinker-built sailing dinghies (average 7 m LOA), which now sit idle in boat-houses on the beach.

Based on household survey results, a subjective breakdown of the general patterns of fishing effort on Palmerston was obtained. Survey respondents were asked to state whether they practised the range of fishing methods listed in Table 4 'often', 'sometimes' or 'never'.

The responses are listed in the table, along with an arbitrarily calculated score for each fishing method, derived by assigning a score of two points for each 'often' response, one point for each 'sometimes' response, and no points for each 'never' response.

Table 4: General patterns of fishing effort

Fishing method	Often	Sometimes	Never	Total score (max.=16)
Handlining	7	1	0	15
Trolling	7	1	0	15
Scoop netting (flying fish)	6	1	1	13
Gill netting	4	4	0	12
Deep-bottom fishing	1	7	0	9
Rod and line	3	5	0	11
Spearing (walk)	0	7	1	7
Spear gun	0	6	2	6
Collect giant clam (**paua**)	0	6	2	6
Collect small green snail (**ariri**)	0	6	2	6
Collect crayfish	0	5	3	5

At least one member of each household fishes or gleans daily (except Sunday). Handlining, trolling, and scoop netting of flying fish are the most common methods employed offshore. Gill netting and line fishing are the main methods used on the reef or in the lagoon: the early 1980s saw the introduction of larger-mesh, monofilament gill nets. Collecting giant clam (**paua**) is also becoming increasingly important as an inshore fishing activity.

3.4 Production levels and catch composition

Few reliable statistics relating to fishing effort and catch on Palmerston Island are available. There are, however, two sources of data which provide some indications of typical production levels in recent years.

A record of fish receipts from the Department of Outer Island Affairs is available for one shipment of fish from Palmerston Island to Rarotonga, on 21 November 1986. This indicates that of 2,190 kg of fish shipped, 87.5 per cent were parrot-fish, 6.2 per cent tuna, 1.3 per cent flying fish, 2 per cent wahoo and the balance mainly reef fish.

Monitoring of commercial fish production from Palmerston over the period April 1987 to September 1988 by the MMR provides a second source of data (Table 5). Of fish shipped during this period, 31 per cent (by weight) were parrot-fish (mainly as fillets), while 40 per cent were pelagic species.

A total of over 25 t of fish was shipped, through a period when shipping was fairly unreliable and marketing structures on Rarotonga were poor. On the basis of these limited data and anecdotal information, it appears that between 30 and 40 t of whole fish per year may have been shipped during the early years of commercial fisheries development on Palmerston, with the total volume and percentage of parrot-fish declining in recent years.

Given the persistent difficulties with vessel schedules, it is unlikely that total production for export (whole fish equivalent) has exceeded 40 t in any given year. Shifts in catch composition by species have been common, as market preferences change. Estimated subsistence consumption, based on a high but reasonable 200g/capita/day[1], would amount to approximately 5 t per year.

Subjective estimates of the relative origins and destinations of each household's catches were derived from the household survey, and these are shown in Table 6. Respondents were asked to estimate what overall

[1] Comparative figures of 70g/day in Fiji and 400 g/day in the outer islands of Kiribati are cited by Zann (undated, 1983).

proportion of their fish catch came from the lagoon, what from the reef, and what from the open sea, and to estimate, for each of these three components, what percentage was used for domestic purposes, for community sharing, and for sale.

The pooled results indicate that open-water fishing accounts for nearly 70 per cent of Palmerston's fish catch, and that over 80 per cent of the total catch is ultimately sold, rather than being consumed at home or given away. There is much higher domestic consumption and community use of seafood from the reef and lagoon than of open water fish species.

Table 5: Commercial fish production data, Palmerston, April 1987 – September 1988 (kg)

Month	Rei *Hipposcarus longiceps*	Other parrot fish	Reef fish	Pelagic species	Total
Apr. 87		1,210		425	1,635
May 87					
Jun. 87		1,550	925	2,495	4,970
Jul. 87					
Aug. 87					
Sep. 87		940		1,525	2,465
Oct. 87					
Nov. 87		520	190	160	870
Dec. 87			1,420		1,420
Jan. 88					
Feb. 88		1,510	2,010	1,125	4,645
Mar. 88	169	67	305	21	562
Apr. 88	1,219	33	1,180	427	2,859
May 88		85	45	1,300	1,430
Jun. 88					
Jul. 88		217	1,032	1,331	2,580
Aug. 88		580	186	697	1,463
Sep. 88				725	725
Total	**1,388**	**6,712**	**7,293**	**10,231**	**25,624**
%	5%	26%	28%	40%	100%

Table 6: Origin and distribution of the catch

Fishing zone	Proportion of total catch originating from each major fishing zone (%)	Proportion (%) used for: Domestic consumption	Community sharing	Sale
Lagoon	9.2	29.3	8.7	61.9
Reef	22.5	28.9	10.2	60.9
Open sea	68.2	6.7	1.3	91.9
Average		**13.8**	**4.1**	**82.1**

4. THE PARROT-FISH FISHERY

4.1 General

The herbivorous parrot-fish have long formed the basis of the reef and lagoon fishery on Palmerston. Parrot-fish were traditionally captured with coconut frond scarelines (**rau**), and in previous years were shipped on ice in large volumes to Rarotonga. Since 1985, as improved processing techniques have been developed, parrot-fish fillets have become a common item on Rarotongan restaurant menus.

Monofilament nylon gill nets are now predominantly used to catch parrot-fish. Present fishing activity is dominated by tides, with fish schools being sighted, carefully stalked, and driven into gill nets set across escape channels on the reef rim on early rising or falling tides. Parrot-fish are the most conspicuous finfish resource, and are distributed all around the reef rim, inside the lagoon and on the outer reef slope.

There is a strong belief among Palmerston fishermen that parrot-fish stocks have declined markedly in recent years. The Palmerston Island council, and the fishermen of Palmerston have expressed growing concern for the future of the fishery, and have unilaterally imposed a six-month moratorium on commercial parrot-fish harvesting as a conservation measure.

4.2 Species exploited

Table 7 lists scientific and vernacular names and habitat characteristics of the thirteen species of parrot-fish (family Scaridae) that have been recorded from Palmerston Island. Of these, four (*Hipposcarus longiceps, Scarus altipinnis, S. frontalis* and *S. gibbus*) comprise the bulk of the commercial catch in the parrot-fish fishery.

The remaining species are mostly small and do not feed in large schools on the reef flat where they are vulnerable to capture. It is notable that *S. forsteni*, a prevalent species and significant food fish on other islands of the Cooks, is extremely rare on Palmerston, with only one field sighting recorded during the survey.

Table 7: Scarid species occurring on Palmerston

Species	Pamate (Palmerston) name(s)	Common habitat	Maximum size (cm)
Cetoscarus bicolor	Kakatavake	Outer reef	50
Hipposcarus longiceps	Rei	Ubiquitous	50
Scarus altipinnis	Black show (IP) Blue show (TP)	Ubiquitous	50
Scarus frenatus	Pakati (IP) Koti (TP)	Outer reef	40
Scarus frontalis	Akau	Outer reef	40
Scarus ghobban	Rotea (IP) Mamaringa (TP)	Ubiquitous	50
Scarus gibbus	Greenfish (small) Posho (large)	Ubiquitous	50
Scarus globiceps	Pakati (IP) Koti (TP)	Outer reef	20
Scarus psittacus	Pakati (IP) Koti (TP)	Outer reef	20
Scarus pyrrhurus	Pakati (IP) Koti (TP)	Lagoon and outer reef	20
Scarus schlegeli	Tomore	Lagoon and outer reef	20
Scarus sordidus	Pakati (IP) Koti (TP)	Lagoon and outer reef	20

IP = Initial phase TP = Terminal phase

Several species, mostly not associated with the main barrier reef, are common around coral heads inside the lagoon, and in this situation are not currently exploited to any extent. These include *Scarus schlegeli* (**tomore**),

S. sordidus (**pakati**), and *Hipposcarus longiceps* (**rei**) (which also occurs on the reef rim, where it is exploited). *S. schlegeli* forms seasonal spawning aggregations in the lagoon which could offer some opportunity for harvest, despite the generally small size of the species and its consequent unsuitability for filleting and export.

4.3 Biology and behaviour

The complex life history of parrot-fish usually involves protogynous hermaphroditism, with distinct sexual colour morphs. Juvenile stages are generally nondescript in colour. As the fish develop into initial phase (IP) males and females, they generally adopt a dull red or brown colour.

A proportion of these IPs develop into terminal phase (TP), or secondary males, which exhibit much brighter coloration, with purple, blue, green and orange predominating. In some species, terminal phases may also exhibit morphometric differences from IPs. *S. gibbus* and *S. frontalis*, for example, have much enlarged foreheads in the TP. A few species are monochromatic, lacking distinct IP/ TP colour phases.

Parrot-fish are herbivores, using their beaks of fused teeth to scrape algae from solid substrates, and heavy pharyngeal plates to grind food prior to digestion. Algal turfs appear to constitute the main part of the diet of most Pacific scarids. Some studies have indicated that parrot-fish may grow more quickly than other herbivorous coral reef fishes, although further evidence is required to confirm this.

Scarids are diurnally active, and individuals of the larger species can be found resting at night in crevices or under ledges. Resting *S. gibbus*, IP and TP *S. altipinnis*, and *S. frontalis* were observed along the outer reef slope, close to the reef crest, during night dives on Palmerston. *S. gibbus* are most commonly found on the bottom of the surge channels, to 4 m depth. *S. altipinnis* (TP) and *S. frontalis* are generally found closer to the reef, in crevices or under ledges down to depths of 2 m.

Large schools of *H. longiceps* were observed along the reef front during the day, but very few were observed resting outside the reef at night. *H. longiceps*, *S. altipinnis* (IP) and *S. ghobban* (IP) are reported to rest around coral heads in shallow lagoon waters. Some species will, at times, secrete a transparent, mucous cocoon when resting at night, apparently to limit olfactory tracing by predators.

The larger parrot-fish found on the reef flat are all schooling species. Schools are generally single species, although some mixed schools do occur (Table 8). *C. bicolor* usually occurs in pairs. In smaller species, juveniles and IPs occur in mixed schools, often in association with schools of small acanthurids (surgeon fishes), while the TPs are almost always solitary. At Palmerston Island, only *S. schlegeli* are known to form spawning runs. Mixed schools of IP and TP fish move past Cooks, Toms and Home Islets as they migrate in and out of the lagoon during these spawning runs, in November and December each year.

The remaining species are generally solitary as terminal males. Juveniles and initial phases do form schools, but species identifications are difficult. *Cetoscarus bicolor* usually occurs in pairs as male and female.

Table 8: Schooling associations of scarids on Palmerston

Species	*H. longiceps*	*S. altipinnis*	*S. frontalis*	*S. gibbus*	*S. ghobban*
Hipposcarus longiceps	5	1	1	1	2
Scarus altipinnis		5	4	3	1
Scarus frontalis			5	2	1
Scarus gibbus				5	1
Scarus ghobban					5

Key: 5 = Always together; 4 = Often together; 3 = Sometimes together; 2 = Rarely together; 1 = Never together.

4.4 Distribution and abundance

The four species which are particularly targeted by gill-net fishing are all found in schools on the reef flat. These four species dominated the catch composition for the reef-flat test-fishing conducted during the survey (Table 9).

Table 9: Parrot-fish test-fishing catch composition

Species	No. caught	Average number per set (n=26)	Species composition (% of catch)	Sex composition (% of each species) Female	IP male	TP male
H. longiceps	159	6.1	36.8	47.1		52.9
S. altipinnis	207	8.0	47.9	64.8	9.7	25.5
S. frontalis	45	1.7	10.4	73.1		26.9
S. gibbus	14	0.5	3.2	84.8		15.2
S. ghobban	7	0.3	1.6	42.3		57.7
Total	**432**	**16.6**	**100**	**59.4**	**4.6**	**36.0**

Visual censuses of parrot-fish were carried out to determine the relative species compositions of Scaridae on the reef flat and on the outer reef (Table 10). Reef-flat counts were obtained by walking along an estimated 200 m of reef crest, estimating all scarids seen on the reef crest or flat, where they would be vulnerable to net-fishing.

Outer-reef-slope counts were obtained by visual census conducted simultaneously with, and over the same reef stretch as, the reef-flat count. Observers snorkelled close to the reef crest, counting all scarids seen down to a depth of approximately 7 m. Relative species abundance, as a percentage, is based on the total number of fish from each separate count.

Comparison of the counts conducted at high tide and low tide clearly demonstrates the tendency for the larger species to move onto the reef flat to feed at high tide, and to retreat to the outer reef slope at low tide. No parrot-fish were found at low tide on the reef flat or reef crest.

Table 10: Tidal changes in relative scarid abundance on the reef flat and slope

Species	High tide				Low tide			
	Reef flat		Outer reef		Reef flat		Outer reef	
	No.	%	No.	%	No.	%	No.	%
C. bicolor	0	0	0	0	0	0	3	3
H. longiceps	0	0	2	3	0	0	4	4
S. altipinnis	4	19	7	10	0	0	16	15
S. frenatus	0	0	2	3	0	0	6	6
S. frontalis	2	10	10	15	0	0	3	3
S. ghobban	0	0	0	0	0	0	0	0
S. gibbus	15	71	15	23	0	0	19	18
S. globiceps	0	0	3	4	0	0	4	4
S. psittacus	0	0	6	9	0	0	2	2
S. pyrrhurus	0	0	6	9	0	0	18	17
S. schlegeli	0	0	6	9	0	0	9	9
S. sordidus	0	0	10	15	0	0	20	19
Total	**21**	**100**	**67**	**100**			**104**	**100**

Details relating to parrot-fish sampled, by sex, species and colour phase, where these could be clearly distinguished, are presented in Appendix 7. Length-frequency histograms of each of the sex-related colour phases of captured *H. longiceps*, *S. altipinnis*, *S. frontalis* and *S. gibbus* are shown in Figure 4.

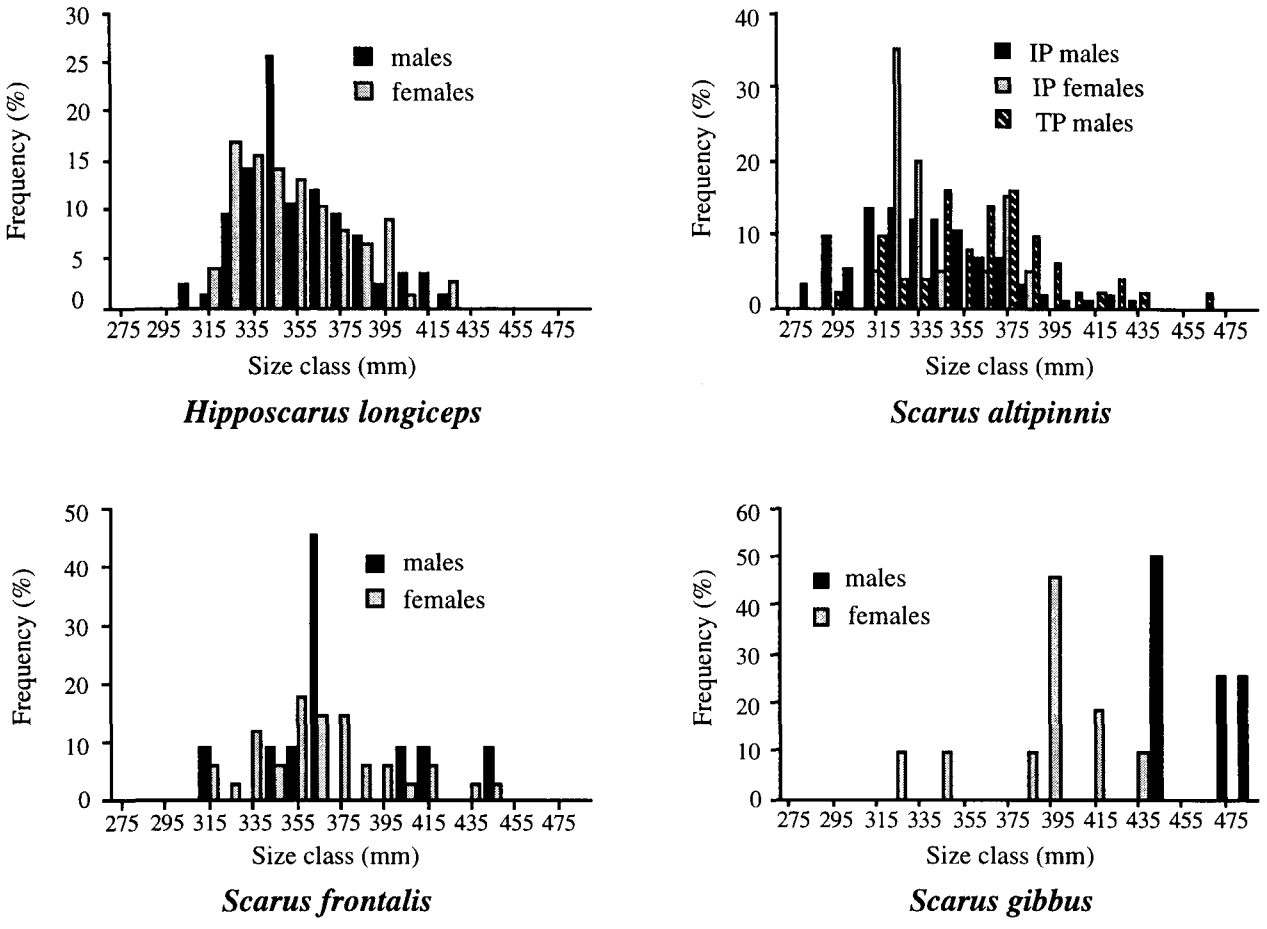

Figure 4: Length frequencies of four species of parrot-fish caught by drive-in gill net

4.5 Harvesting techniques

***Rau** seining*

The principal technique for catching parrot-fish, in the past, involved the use of coconut fronds (**rau**) tied together and used as a scare-line seine to surround an entire school. This method has gradually fallen into disuse over recent years, and was apparently last used in 1987. The decline in use of **rau** follows the increased availability of monofilament gill nets, but is also attributed to decreases in both the number of fish, and the number of able-bodied people on the island to work the long **rau**.

The **rau** is made from up to 200 coconut fronds tied end-to-end. The fronds are split longitudinally, with the stiff central rib removed. The two halves of the frond are twisted around each other to form a 'Christmas-tree spindle'. A single **rau** would last from a week to a month, depending on how well it was cared for and how often it was used.

Rau were generally used at mid-tide, with the ebb preferred. Schools of parrot-fish would be sighted from boats, and the **rau** laid to encircle the school. As the fish would not attempt to swim through the fronds of the **rau**, it could be gradually tightened, and the fish drawn into shallow water. Before the advent of gill nets, the

rau would be overlapped several times (to help ensure the fish did not break the line), before the fish were killed, usually by a blow from a machete. When monofilament nets became more widely available in the late 1970s, gill nets were set around the tightened **rau** and used to haul the school onto a dry area of reef, as with a normal beach seine.

Rau were usually used for fishing on the northern reef stretches from Big Stone to Bird Islet, where larger schools were more common. Schools of up to five or six hundred parrot-fish were reportedly taken in a single set of a **rau**. All of the five species found in schools on the reef flat were taken in the **rau**, but *H. longiceps* dominated the catch.

In the subsistence fishing era, only enough fish to fill immediate subsistence needs were taken from the **rau**, and the rest released. With commercial activities becoming established in the early 1970s, fishermen began to take the entire school. The fish were taken live, and placed in wire-netting cages until the arrival of the vessel to ship them to Rarotonga.

Drive netting

The shift in use from **rau** to monofilament gill nets has resulted in changes in the methods employed. Generally, 9 – 11 cm stretched mesh gill nets, of various lengths and depths (at least 50 m long and 2.5 m deep) are used. Fishing is conducted on a mid-flood or mid-ebb tide, when the fish are feeding on the back reef areas but the tide is low enough to restrict their routes of escape to the sea. Fishermen work along the reef crest, sight and stalk a school, and place the net across the surge channels and gutters through which the fish will flee. The school is then chased seaward into the net. Large fish are usually entangled rather than gilled. Rarely is the entire school taken, however, as some fish escape beneath the lead line (which often tangles on the rough bottom), some escape over the float line (as the current may pull it below the surface), and some will often skirt around the outside of the net or escape via a different surge channel.

Drive nets are used all around the island, although, as with **rau**, the northern sectors produce best results. Today, catches of 50 or more fish in a set are rare, with an average catch rate from survey fishing of only 16.6 fish per set (see Table 9). The catch composition from drive netting is reported to be similar to that taken by **rau**, although as drive nets operate closer to the reef crest, greater proportions of *S. frontalis* and *S. gibbus* are probably taken.

As the fish are severely damaged in the net, they are unable to be kept in holding cages. Drive netting therefore only developed commercial significance on the island once freezers became established, and the fish could be held till the arrival of a reefer vessel.

Throwing spear

Long, multi-pronged throw-spears were widely used on Palmerston Island until about five years ago. Knowledge of the method is well retained, although skills have perhaps declined through disuse. Throw-spear fisheries were essentially a subsistence activity, as fish are badly damaged by the multi-pronged spear-head, and virtually unsaleable. Although scarids were the principal targets, *Caranx* spp. and *Naso* spp. were also commonly taken.

The steel head of the spear has three or four prongs with outward facing barbs. The shaft, 4 – 5 m in length, is made of **tamanu** (*Calophyllum inophyllum*) or imported pine. There were, in effect, two separate fishing styles which used the throw-spear. Reef-stalking involved working along the reef crest and throwing the spear at fish on the reef or in the seaward gutters; in passage-spearing, a fisherman stood at the side of a passage, and jabbed down at fish as they passed beneath.

Reef-stalking was usually conducted on a low flood tide, as parrot-fish began to move up onto the reef. The lower tide allowed greater stealth in walking along the reef crest, and also meant that fewer small fish were on the reef edge to spook the targets. *S frontalis* and *S gibbus* comprised the bulk of reef-stalking catches.

Passage-spearing was usually conducted at dawn and dusk, when fish were moving, respectively, into or out of the lagoon. Most productive fishing occurred in the pre-dawn after a full moon, when there was sufficient moonlight to see the fish, and the ebbing tide forced fish entering the lagoon, against the current, to pass close to the sides of the passage. There were favourite vantage points on each passage from which fish were usually speared. All of the larger scarids were taken by this method, including *Cetoscarus bicolor*.

Other methods

Tahitian-style spear-guns have only been in use on Palmerston for the last few years, and are still only a very minor component of overall fishing effort. Underwater spear-fishing is conducted both outside the reef and in the lagoon, and larger parrot-fish (particularly *S. altipinnis* and *S. gibbus*) are occasionally taken. Smaller scarids are also vulnerable to underwater spear-fishing, but are not considered worthy targets on Palmerston.

Parrot-fish are also a minor by-catch in hook-and-line fishing targeting kyphosids. Hook-and-line fishing is conducted either from a boat beyond the reef or inside the lagoon, in around 10 m water depth, or else by walking along the reef-crest and casting into surge-channels. Handlines or rods are used from boats, but only rods are used on the reef. These methods are used at any time of day, and although tide is irrelevant for fishing from a boat, an ebb towards low tide is preferred for working the reef. Hermit crabs are used for bait, with the tail threaded onto a small hook, and the legs and claws used as burley (**paru**). *H. longiceps* and *S. altipinnis* are the main scarid species caught by this method.

4.6 Handling, processing and marketing

The earliest commercial parrot-fish fishery was based on the sporadic shipping of small volumes of smoke-dried parrot-fish to Rarotonga. When the F.V. *Ravakai* began operation under the Fisheries Department in the early 1970s, gilled and gutted parrot-fish were shipped on ice, and sold 'in the round'. Volumes increased until an average of about 3 t of fish (of which 70 – 80% was parrot-fish) was shipped to Rarotonga every 6 – 8 weeks; this meant a total annual volume of about 15 – 20 t of parrot-fish (T. Marsters, pers. comm.). Fish were sold from the boat, or held in holding freezers, and fetched NZ$ 0.60 – 0.80/lb. The fishery continued virtually unchanged and uninterrupted (except for 2 years in the late 1970s, when the F.V. *Ravakai* was out of commission) for the next 15 years.

The significant changes which have occurred in the fishery over the last few years have all been closely linked to improved handling, processing and marketing of the product. In 1985, plastic-wrapped, frozen parrot-fish fillets began to be sent in freezer boxes to Rarotonga on regular cargo-boat runs. These were sold direct to restaurants and hotels for NZ$ 5.00 – 6.00/kg, and market demand quickly increased. The F.V. *Ravakai* was irreparably damaged during a cyclone at the end of 1986, but by then the frozen parrot-fish fillet trade was predominant. Vacuum-packed products have also been introduced by some fishermen, with still further value added to the product.

The F.V. *Intrepid*, a converted tugboat with 5 t refrigerated storage capacity, began operation as a private enterprise in early 1988. As well as maintaining shipping services for frozen fillets (with the recent decreased regularity of cargo boat runs), the retail facility operated by the Intrepid company in Rarotonga has presented opportunities for diversification of the resource base for commercial fishing in Palmerston.

4.7 Catches and yields

The commercial parrot-fish fishery has operated on Palmerston for the last fifteen years, yet it has only been in the last two years that concern for the status of the scarid stocks has arisen. The perceived increase in the pressure on the resource has accompanied recent developments in handling, processing, and transshipping of fish to the Rarotonga market. In August, 1988, the Palmerston Island Council imposed a six-month ban on the shipping of parrot-fish off the island, although subsistence fishing is still permitted to target scarids.

Data collected on commercial scarid catches and shipments from April 1987 to August 1988 are summarised in Figure 5 as numbers of fish and total weights (usually for fillets only), and in Figure 6 as average fork lengths for the parrot-fish *H. longiceps*, for each month. An increase in numbers and volumes of parrot-fish caught occurred from April 1987 to April 1988, but since then, catches have been negligible[2] . No evident trend in sizes of parrot-fish accompanied these changes in fishing pressure (Figure 6), although informants reported a decrease in average sizes and in the abundance of the most heavily fished species.

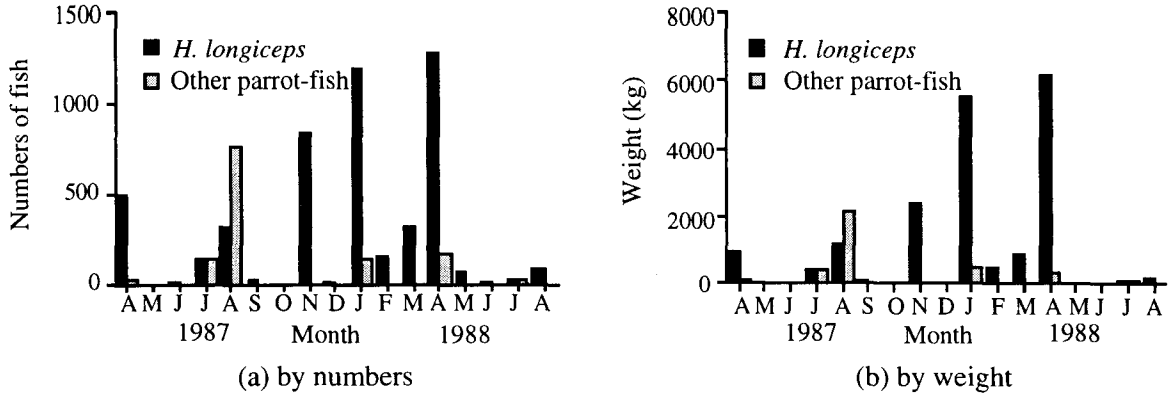

Figure 5: Palmerston parrot-fish catches, April 1987 – August 1988

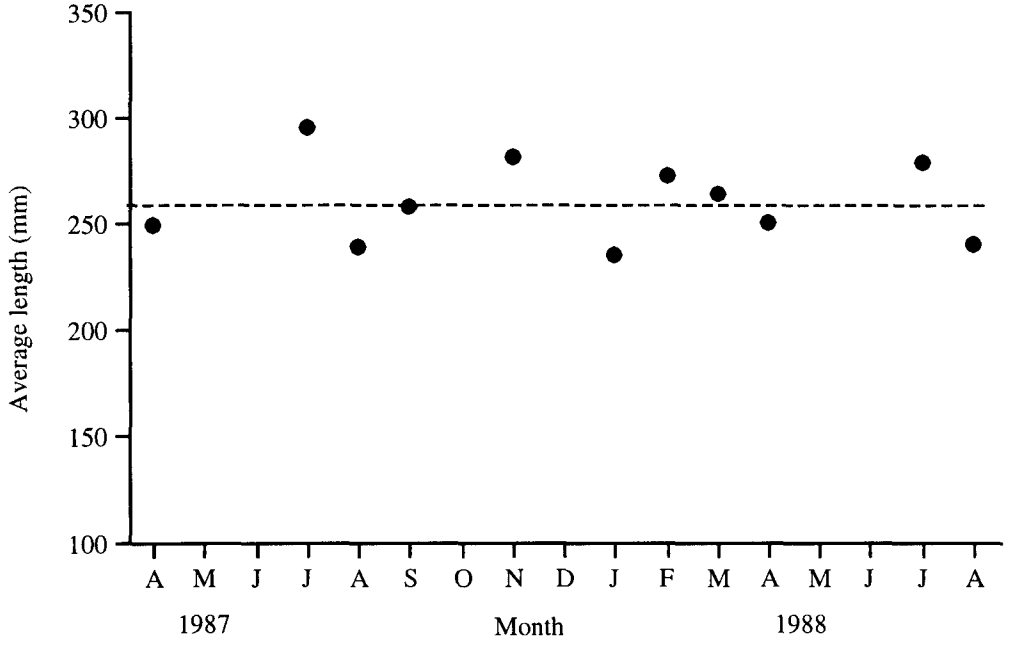

Figure 6: Average fork lengths of Palmerston *H. longiceps* catches, April 1987 – August 1988

The dotted line shows the mean length of total *H. longiceps* catches (260 mm).

[2] It should be noted that these data do not agree with the fish shipment data presented in Table 5. The present data are based on sampling carried out by the MMR officer on Palmerston, while data in Table 5 are drawn from fish shipments at the time of landing in Rarotonga. It is probable that the on-island sampling programme did not achieve 100 per cent catch coverage while the Rarotonga data, being collected from a central source, may have been more complete. In addition, for various reasons, fish were not necessarily shipped as soon as they were caught, but may have been stockpiled on Palmerston for later shipment. There are substantial differences in the monthly production figures as shown in the two data sets, as well as in the totals derived from these figures.

Given the difficulties of estimating absolute abundances of parrot-fish, the commercial catch information, together with the results from the survey fishing, represents the best measures of the status of Palmerston Island scarid stocks presently available. The test-fishing survey data are summarised in Table 9. The predominance of *H. longiceps* and *S. altipinnis* in drive-net catches is evident from these data. *S. frontalis* comprises only a minor proportion of the total catch (10.4%), while only fourteen *S. gibbus* (3.2%) and seven *S. ghobban* (1.6%) individuals were taken during the course of the survey.

Smaller species are virtually unutilised in both the commercial and subsistence fisheries. Even the *S. schlegeli* spawning run is not exploited, and is only of note to local people because of the habit of the fish of beaching themselves on Home Island in large numbers.

The few available estimates of parrot-fish yields from other tropical coral reefs vary between 0.03 and 1.28 t/km^2/yr (Russ & St. John, 1988). Data on previous yields from Palmerston are generally lacking (see Section 3.4), but the limited information available suggests that parrot-fish exports from the island were at least 8.1 t (mainly as fillets) during the 18 months from April 1987 to September 1988 (see Table 5). Assuming that all the fish were fillets, and a recovery rate of 35 per cent, this equates to an annual parrot-fish export of 23.1 t, or about 7.7 t/km^2/yr. Anecdotal information suggests that production was at similar or higher levels, but probably did not exceed 30 t, in the years leading up to this period.

Estimates of parrot-fish secondary production (by two separate methods) on three Philippine coral reefs ranged from 3.56 to 7.64 t/km^2/yr (Russ & St. John, 1988). By definition, sustainable yield from a given fishery cannot exceed secondary production, and in the case of the examples cited by Russ and St. John constituted 10 – 40 per cent of secondary production biomass, i.e. between 0.36 and 3.06 t/km^2/yr.

It would be premature to estimate a sustainable annual harvest for Palmerston Island. However, a simple extension of the above figures to the estimated reef area of Palmerston of 8.95 km^2 provides indicative information on the levels of yield that might be expected[3]. Based on yield estimates of 1.28 t/km^2/yr, an appropriate maximum annual harvest would be about 11.5 t. Based on the secondary production estimates above, total scarid production in Palmerston might be expected to lie between 31.8 and 68.4 t/yr. If an annual yield of between 10 and 40 per cent of secondary production was anticipated, this would lie in the range 3.1 – 27.4 t/yr. Present levels of harvest, estimated at between 23.1 and 30 t, are in or beyond the upper end of this range.

4.8 Management

Concern over an apparent steady decline in abundance and average size has led the Island Council to impose a ban on the export of parrot-fish from the Island. This, more than any biological data, reflects the concern held by the islanders for the status of the resource and underlines the need for establishment of an effective management plan for the fishery.

Unfortunately, there are no useful precedents for monitoring and managing parrot-fish fisheries, and the response of parrot-fish populations to sustained fishing activity is poorly understood. Alcala and Russ (1990) note that, in the Philippines, increased fishing pressure on the reef flat in a newly deregulated marine reserve had the effect of driving parrot-fish from their normal habitat in this area onto the outer reef slope.

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[3] There are some difficulties in applying the figures obtained elsewhere to the Palmerston situation. Other workers have variously estimated reef area to include the sea bed down to 20 m or to 40 m, or have included areas with rugose surfaces. In this case, we only use the surface area of the reef flat to estimate yields and productivity. This is justified because parrot-fish are closely associated with the reef itself and because the relatively shallow (<40 m) waters of the lagoon are not considered to contribute greatly to production of those parrot-fish species on which the fishery is based.

This led to increases in the numbers of parrot-fish observed during visual counts made by diving, even though overall fish yields and catch per unit of effort from this area declined by factors of 50 per cent or more. There may therefore be doubts as to the usefulness of underwater visual census methods for monitoring future changes to the Palmerston parrot-fish fishery.

Because of the nature of the parrot-fish fishery, fishing effort is difficult to quantify. Large but highly variable proportions of fishing time are spent searching for and stalking schools of fish, or removing fish from the net. Usually not all fish are captured and the net rarely functions as an orthodox entrapment barrier. Because of this characteristic, size limits for fish or for net mesh are of limited applicability in this fishery. However, a range of other possible management options to restore this fishery is considered in Table 11.

Table 11 : Management options for parrot-fish

Possible option	Potential problem areas and comments
Limit fish size	All fishing methods presently used injure or kill the fish, hence there is no benefit to the resource. This would only be practical if there was a return to **rau** fishing, which permits small fish to be released with a reasonable expectation of survival.
Impose minimum mesh size for drive-in nets	Drive-in nets do not function in the same way as normal gill nets and most fish are tangled rather than gilled. Altering mesh size would probably not allow size-selective fishing to take place. Since sex reversal occurs, fishing will tend to be selective on male (TP) fish: this may have implications for the reproductive performance of the fishery.
Ban gill nets	Not practical or economically desirable.
Limit amount of fishing by total or seasonal closures, or rest periods (short-term rotating area closures)	Information to determine appropriate periods for closure is lacking, and this is important if the economic benefits from the fishery are to be maximised. Some value if the fish are shy, since this will encourage them to return to the reef flat after being driven away from it by periods of intense fishing. The exploited species do not appear to have major spawning runs, so the main value of this type of resource protection is lost.
Limit areas fished by semi-permanent (long-term rotating area) closures or permanent reserves	Good value for various reasons, including relative ease of enforcement. Allows the build up of a more or less protected pool of breeding fish, while allowing some out-migration of adults which will enhance production from unprotected areas.
Limit amount of catch by total or family quotas	Probably of value, especially if used in conjunction with a system of permanent reserve(s), but considerable difficulties in sharing quotas among competing fishermen, and in enforcing adherence to them.

Total closure of the fishery for protracted periods would probably result in some recovery of stocks, but neither the time scale nor the magnitude of the recovery can be confidently defined. Total prolonged closures could also have significant impacts on the economy of the island, given the limited opportunities for development of alternative commercial fisheries. Periods of at least two years would probably be necessary before any real increases in fish size or numbers were noticeable.

A rotational closure system or permanent closure of a single stretch of reef would seem more appropriate, given the importance of the fishery to the economy of the island. A permanent reserve area over a 3 – 5 km

length of reef and the adjacent lagoon area could also prove of value in management of other commercial fisheries, and is strongly recommended. Again, however, little is known of parrot-fish migration and dispersal patterns at this scale. An initial closure (for, perhaps, the six-month period currently in effect) would optimally be followed by re-assessment of the stocks, with export quotas established to restrict subsequent effort. Quotas could be imposed on either an island-wide or an individual family basis over quarterly or annual periods. A total export quota of 10 t of parrot-fish (equivalent to 3.5 t of fillets) per year would be a reasonable initial estimate.

4.9 Development opportunities

There would appear to be little opportunity to further increase the value of parrot-fish products. The use of available woods (e.g. **nganie**, *Pemphis acidula*) or chemical agents for producing smoked parrot-fish fillets on-island could be investigated. Some marketing trials of fish-meal from the minced remnants of filleted parrot-fish could also be pursued, with the Rarotongan pig- and chicken-food markets appearing promising.

Underexploited scarid stocks can be found on the outer-reef slopes of some areas, but fishing using set gill nets is restricted by the shark problem, and commercial spear-fishing is not an option. The *S. schlegeli* spawning run might be exploited, but the small size of even TP *S. schlegeli* means that minimal commercial returns could be expected. Overall, the emphasis should be on management of the available currently exploited stocks to maximise yields, with an ongoing data collection programme to provide a sounder basis for future management decisions.

5. OTHER FISHERIES AND FISHERY RESOURCES

5.1 Mullet

Several species of mullet are widespread throughout the lagoon and on the reef crest. The largest of these, the warty-lipped mullet (*Crenimugil crenilabis* [**kanae**]), is captured on the reef flat with drive-in gill nets several nights each side of the full moon, as they feed inshore in schools at high tide. Length-frequency data for mullet caught during the survey are presented in Figure 7.

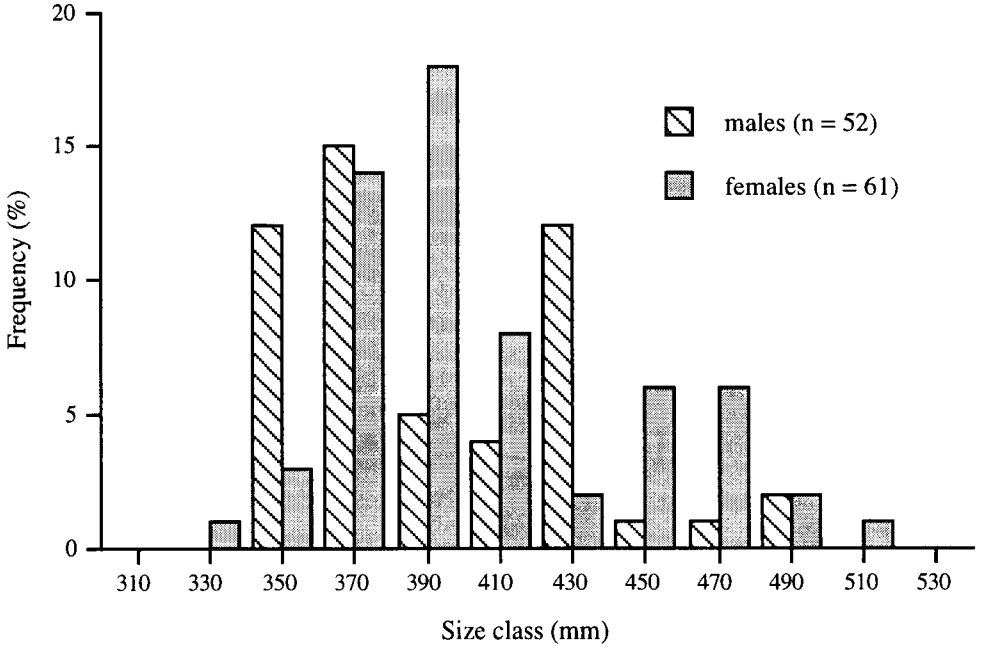


Figure 7: Length frequencies of warty-lipped mullet (*Crenimugil crenilabis*)

The small sharp-nosed mullet (*Chaenomugil leuciscus* [**wowa**]) is captured for bait. The diamond-scale mullet (*Liza vaigiensis* [**ka'a**]), another large but more solitary species, is captured only incidentally.

Of the three mullet species present at Palmerston Island, only the **kanae** is subjected to any significant fishing pressure. This is restricted to a relatively small number of nights per month, in selected areas, although the species is widely distributed in reef and lagoon habitats. Annual production has probably not exceeded 5 t and the resource is probably under-utilised. As with other schooling fish, **kanae** catchability may decline as the frequency of exposure to the gear (gill nets) increases.

5.2 Rabbit fish

Spawning-associated aggregations of rabbit fish (*Siganus argenteus* [**maemae**]) occur around full moon in the November – March period. At this time they are captured in large numbers by drive-in nets at specific localities on the lagoon edge.

5.3 Predatory reef and lagoon fishes

Rods, usually made from 3 – 4 m lengths of bamboo (*Bambusa vulgaris*), are used during low tides to take a variety of species from surge channels, including *Epinephelus*, *Lutjanus*, *Myripristis* and *Caranx*. On moonlit nights, the reef rim near the surf line is trolled and jigged with small lures to catch *Myripristis* and *Priacanthus*.

These catches are generally for subsistence use, but any surplus may be exported to friends or family in Rarotonga.

Rods are used to catch a variety of species from the vicinity of coral heads (*Lutjanus*, *Epinephelus*, etc.). The monocle bream (*Monotaxis grandoculis* [**mu**]), the coral trout (*Plectropoma laevis*) and the Maori wrasse (*Cheilinus undulatus* [**maratea**]) are especially targeted by handlining. The latter species however, have a history of being ciguatoxic, and are currently not fished.

Some trolling occurs within the lagoon for small barracuda (*Sphyraena*) and trevally (*Caranx*). Lagoon reef-fish catches are generally small and are mainly used for subsistence consumption. The presence of sharks generally precludes the use of set gill nets in the lagoon.

Based on a conservative estimate of 1.5 t/km^2/yr, and an estimated shallow-reef area (<20 m) of approximately 8.95 km^2, annual reef fish production (excluding parrot-fish) is estimated at some 13.5 t/yr.

5.4 Shark

Shark resources are currently not utilised. The white-tip (*Triaenodon obesus*) and grey reef sharks (*Carcharhinus amblyrhynchos*) are the dominant species on the reef front and in the lagoon. The black-tip reef shark (*C. melanopterus*) is peculiarly absent from Palmerston.

5.5 Bottom fish

Bottom fishing is conducted by anchoring in the lee, or by mooring onto a series of anchor buoys deployed on the leeward side of the island. By varying the length of the anchor or mooring lines, the boats can be drifted into deeper water to bottom fish in the required depths. In shallower water the black-tipped rock cod, *Epinephelus fasciatus* (**atea**) and lunar-tailed cod, *Variola louti* (**oka**) are taken. The deep-bottom fishery is not heavily exploited at present and several localities (see Fig. 3) were surveyed by the team with good results (Table 12 and Appendix 8).

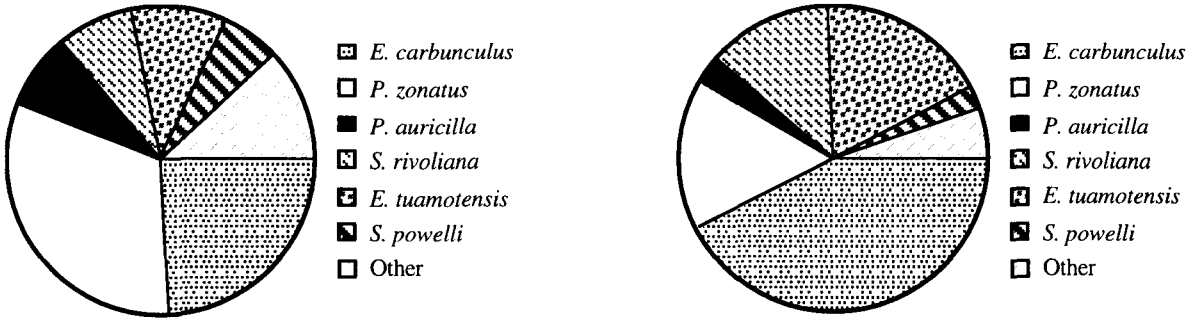
Table 12: Deep-water catch and effort data

Location	Effort (reel-hours)	Catch		Catch per unit of effort	
		No.	Weight (kg)	No. per reel-hour	Weight (kg) per reel-hour
A	9.5	19	88.3	2.0	9.3
B	7.3	8	6.5	1.1	0.9
C	2.0	3	4.4	1.5	2.2
D	6.0	13	25.0	2.2	4.2
E	4.3	7	12.2	1.6	2.8

A relatively restricted range of snapper species is taken in deeper water (>150 m), including the ruby snapper *Etelis carbunculus* (**paru marau**), the banded flower snapper *Pristipomoides zonatus*, groupers (*Epinephelus tuamotuensis* (**paru aroa**)) and others (Table 13, Figure 8 and Appendix 8). Snake mackerel (*Promethichthys prometheus*) are taken at night.

Table 13: Species composition of the deep-water catch

Species	Number	% by no.	Total wt (kg)	% by wt
E. carbunculus	12	24	58.0	42.5
P. zonatus	16	32	21.7	15.9
P. auricillia	4	8	3.8	2.8
S. rivoliana	4	8	18.0	13.2
E. tuamotuensis	5	10	24.3	17.9
S. powelli	3	6	3.2	2.4
Others	6	12	7.3	5.3
Total	**50**	**100**	**136.3**	**100**



(a) by number (b) by weight

Figure 8: Deep-water catch composition

Deep-water snappers are little fished at present, with most handlining on the reef slope targeting other species in shallow water (e.g. *Epinephelus fasciatus*, *Variola louti*, etc). Although finite, this resource does have potential for increased catches. Based on derived yields of 300 kg per nautical mile of 100 fathom isobath per year elsewhere in the Pacific (Polovina & Ralston, 1987), an annual yield of approximately 5 t is predicted. Higher catches could be expected initially, including larger fish of each species, until equilibrium

catch levels are approached. The capture of two large *Etelis carbunculus* (28.5 and 19.5 kg) during the survey suggests the resource is lightly exploited at present.

Occasional catches of oilfish (*Ruvettus pretiosus* [**vena**]) are made by night handlining with a specially-fashioned hook and bait, at considerable depth. Small volumes are sold, but poor market acceptance restricts effort and most of the catch is consumed on the island.

A fishery targeting black trevally (*Caranx lugubris* [**rui**]) also exists. The depths fished for this species range from the surface to 100 m.

5.6 Inshore small pelagics

Small, schooling carangids (both *Decapterus* [**koperu**] and *Selar* [**ature**]) are taken outside the reef, primarily for use as bait. **Koperu** are attracted with grated coconut flesh and poled with short rods, whereas the **ature** are jigged at night under lights.

The population dynamics of these two species are not well understood, but it seems likely that **ature** at least may be sustained by local spawning rather than ocean recruitment. On the basis of annual yield estimates for the Marianas Islands of 0.4 to 0.9 t/nm of 100 fathom contour (Polovina et al., 1985), an indicative annual yield of 7 to 17 t for Palmerston Island is projected. However, actual yields from Palmerston should realistically be expected to be less, assuming greater productivity around western Pacific high islands.

Koperu recruitment and life history are poorly known. It is a more oceanic species than **ature**, and increased catches could probably be achieved and sustained with improved capture methods. An unsuccessful attempt was made during the survey to catch **koperu** with a bottom-set gill net.

Failure of the trial was attributed to inadequate experience of the method by team members, as well as the fact that it was carried out outside the **koperu** season. This technique, and experimental fishing with a hoop net, both justify further investigation, as a shortage of these valued baitfish is occasionally a constraint to offshore fishing operations.

5.7 Flying fish

Twenty-two species of flying fish (Exocoetidae) have been described from the Indian and Pacific Oceans, and it is likely that a number of these occur in the Cook Islands. At least five species have been collected from the waters around Rarotonga (R. D. Gillett, pers. comm.). The taxonomy of the family is still confused and needs to be thoroughly revised. Identification is difficult, given the incomplete nature of most available keys, and the situation is further confused by the fact that young stages (up to about 10 cm) are often quite different in appearance from adults.

On Palmerston Island, flying fish are taken in large numbers by the use of long-handled scoop nets, and 150 watt lights attached to a helmet, from aluminium dinghies skilfully manoeuvred at speed. These fish currently comprise a significant proportion of fish exports, but fishing effort is governed by varying and irregular market demand in Rarotonga.

Although probably distributed all around the atoll, flying fish (average weight approximately 300 g) are mainly taken on the lee coast within several hundred metres of the reef edge. Several hundred may be taken in an evening's fishing, with dark nights following the full moon producing the best catches.

The present method of fishing for flying fish has replaced the earlier methods of burning coconut frond torches or pressure lanterns from paddled canoes or sailing boats. This increase in effectiveness has apparently not resulted in a decline in the availability of flying fish to island fishermen.

No flying-fish survey work was undertaken, but specimens of the two main species (the 'blue' and the 'purple' flying fish) which comprised Palmerston fishermen's catches were taken and sent for species identification by a taxonomic specialist. They were later identified as *Cheilopogon unicolor* ('blue') and *Cheilopogon atrisignis* ('purple'). Representative size frequencies were also obtained from a sample of each species (Figure 9).

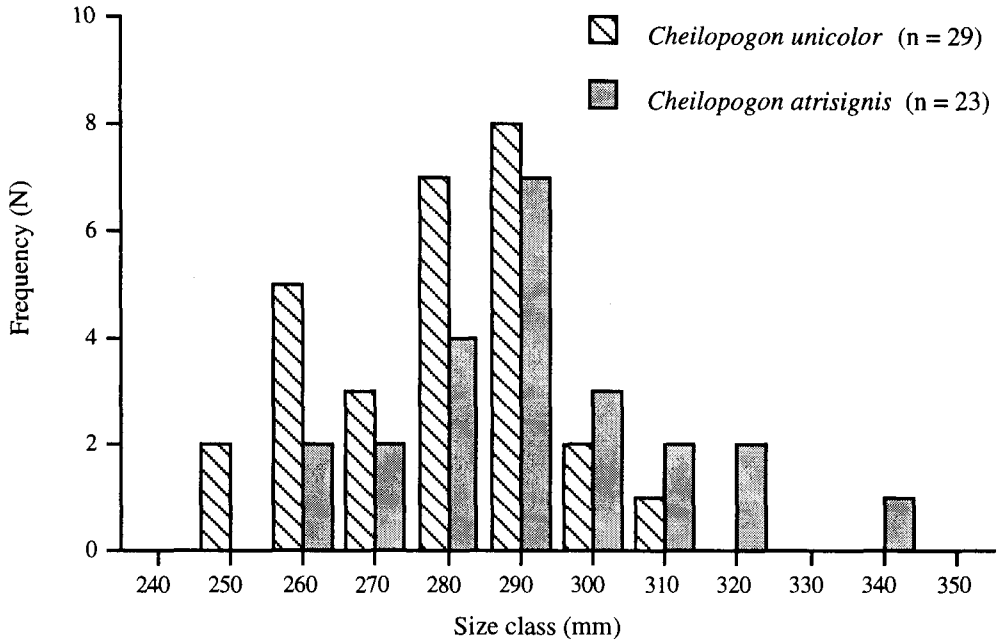


Figure 9: Length frequencies of two species of flying fish (*Cheilopogon unicolor* and *Cheilopogon atrisignis*)

5.8 Oceanic migratory species

Tunas, wahoo (**pa'ara**), barracuda (**ono**) and flying fish (**marara**) can be regarded as wide-ranging species, with the populations in the vicinity of Palmerston Island probably subject to continual turnover and replacement. These resources are therefore unlikely to be vulnerable to over-exploitation by the efforts of Palmerston Island fishermen alone, and catches are limited only by vessel range, bait supply, weather, market demand and other logistical factors.

Tuna, primarily sub-adult yellowfin tuna (*Thunnus albacares* [**ahi**]) are taken by down-lining with dropstones and baits or by trolling baits or artificial lures. No survey work was undertaken for this resource, but survey team members accompanied several fishing trips. Most dropstone fishing is carried out on the leeward side of the atoll, typically in depths of 80 – 120 m in daylight. Chopped fish is used as burley, with leaves wrapped around a bundle of burley, a baited hook, and a large coral stone or clam shell for weighting.

Dropstone catches examined comprised 16 yellowfin in the size range 63 – 79 cm length to the caudal fork (LCF), with similar sizes observed in export shipments. Smaller numbers of large yellowfin, bigeye tuna (*T. obesus* [**tuava**]) and albacore (*T. alalunga* [**to'everi**]) are also taken, together with wahoo (*Acanthocybium solandri* [**pa'ara**]) and barracuda (*Sphyraena barracuda* [**ono**]). Catches vary only slightly with season, being generally best from March to November.

Trolling, mostly carried out around the atoll using rigged baits such as flying fish and **ature**, produces a similar range of species as well as skipjack (*Katsuwonus pelamis* [**atu**]) in the summer months, and an occasional billfish. May to September are the main trolling months for **pa'ara** and **ahi** trolling.

Each fisherman has favoured trolling techniques and locations, the latter generally on the windward side of the atoll. Dawn and dusk trolling yields best catches of tuna and barracuda, but trolling for **pa'ara** generally occurs throughout the day. Catches are variable, with **pa'ara** the favoured species because of its size and market acceptability. Prior to the introduction of freezers, tunas were slabbed, salted and sun-dried for export to Rarotonga.

It was not possible to determine yield estimates for these species but resources could clearly sustain catches greater than at present levels. The resources themselves do not represent a constraint.

5.9 Giant clams

Giant clams, mainly *Tridacna maxima*, have only been harvested commercially in response to recently increased market demand and prices. This has followed the imposition of harvest bans in Aitutaki, long the traditional source of supply for Rarotonga (Lewis, 1987). Giant clams are clearly vulnerable to over-exploitation, given slow *T.maxima* growth rates and ready accessibility. However, theoretically at least, abundance can be easily monitored and harvest closures (total or rotational) introduced as required.

Densities of *T. maxima* are generally lower on Palmerston Island than on Aitutaki and some other Cook Islands, but are still quite high in some areas (>20/ m^2). Up to 26 clams/m^2 were recorded from coral heads near Home Islet, with a mean of 6.5/m^2 for 45 quadrats.

Length data for clams from various locations around the atoll are given in Figure 10. On each site more than a hundred clams were measured. Larger clams (12 – 20 cm) are selectively culled from inner reef flat areas and coral heads. Clams over 20 cm occurred in relatively small numbers.

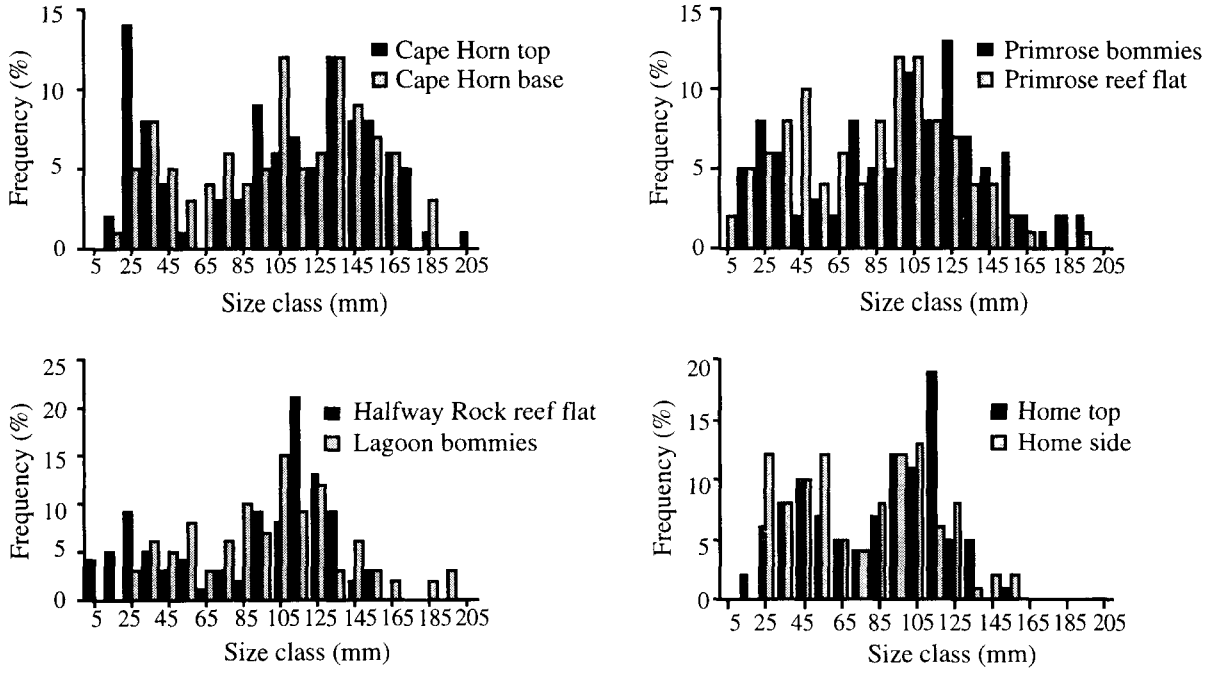


Figure 10: Length frequencies of giant clam (*Tridacna maxima*) at different sites

As well as *T. maxima*, the larger *T. squamosa* also occurs in the lagoon, but is rare. Two, measuring 28.5 cm and 21.0 cm total length, were collected during the survey.

Average densities on the 'drying reef rim' were estimated from cross-reef transects to be 0.31/m^2. The total area of the reef rim is estimated to be 1,380 ha. An estimate of the standing stock of *Tridacna maxima* that could be harvested is 4 million clams. Conservative estimates of 20 clams/kg and an annual sustainable yield of 5 per cent of the standing stock results in an estimate for the annual harvest of 10 t/yr. This does not include deeper-water clams which would remain as unutilised broodstock.

5.10 Trochus and pearl shell

Trochus and black-lip pearl shell have both failed to become established in commercial quantities following their introduction.

Trochus (*Trochus niloticus*) were introduced in the late 1960s and early this decade, 3,000 more were released (Sims, 1985). However, only small numbers persist in limited areas of the northern reef. It appears unlikely that trochus will constitute a major economic resource for the island and only very limited harvesting occurs at present.

Introduced to Palmerston from Manihiki in the late 1950s, the black-lip pearl oyster (*Pinctada margaritifera*) has not become successfully established. Only one specimen was located during the survey and the atoll probably represents a latitudinally marginal habitat for this species.

5.11 Snails and limpets

The reef-crest surge channels are inhabited by several molluscs which are harvested primarily for subsistence use. The small green snail (*Turbo setosus* [**ariri**]), is the predominant target, but limpets (*Acmaea* sp.?) are also collected. **Ariri** densities in the range 2 – 21 per 20 m of reef crest (mean 12.1, s.d. 6.5, n=7) were recorded. Length-frequency data for 85 **ariri** measured at Palmerston Island are presented in Figure 11. **Ariri** are harvested at low levels only and have some potential for increased production.

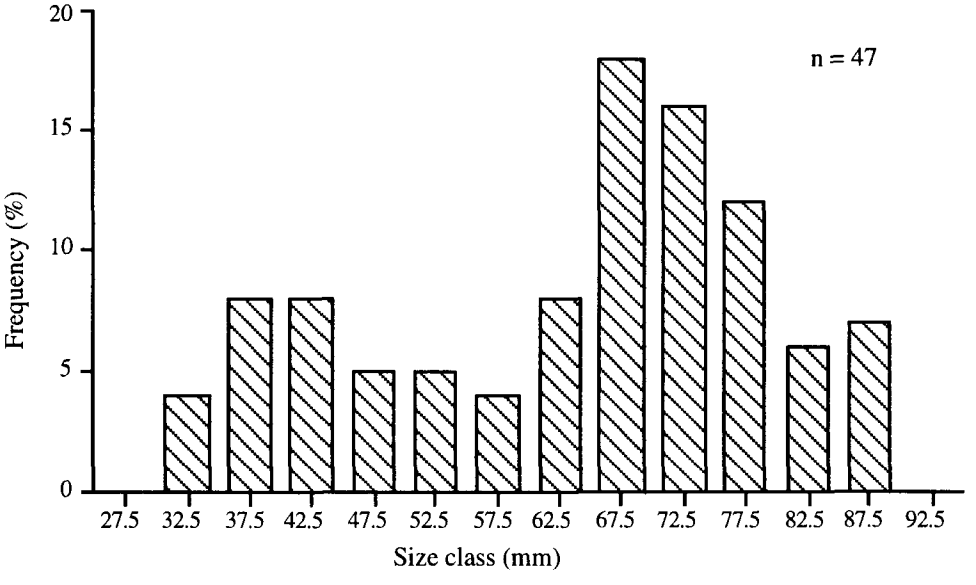


Figure 11: Length frequencies of small green snail (*Turbo setosus*)

5.12 Squid

Ocean squid and lagoon squid were not observed except in the stomachs of fish or from the regurgitations of young red-tailed tropic birds. They may represent a minor unexploited bait resource in nearshore areas.

5.13 Crayfish

Crayfish (*Panulirus penicillatus*) are captured all around the reef rim at night by hand, usually on rising tides on dark nights. Little night diving is done but during the survey this method produced 60 crayfish at a catch rate of 2 per man-hour by unskilled divers. The length-frequency data for the crayfish captured is presented for each sex in Figure 12.

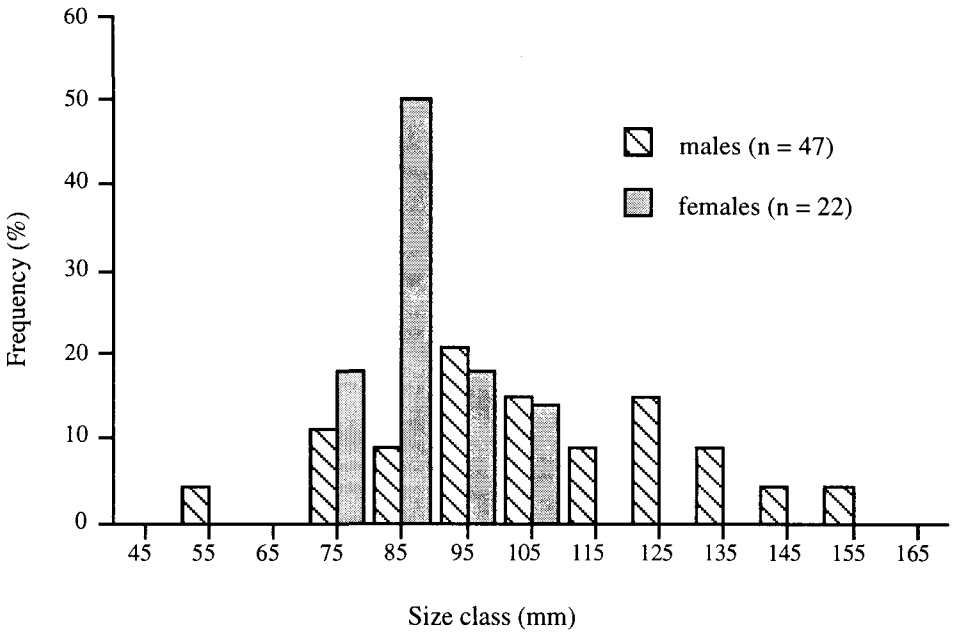


Figure 12: Length frequencies of crayfish (*Panulirus penicillatus*)

The crayfish resource is believed to be relatively small and vulnerable to over-exploitation. It is therefore currently subject to a six-month export ban. Small quantities were previously exported to Rarotonga.

Historical details of crayfish catches are not available, but effort is assumed to have been sporadic. Based on survey results and work carried out elsewhere in the tropical Pacific (Prescott, 1988), an indicative sustainable yield of 0.7 t p.a. (whole weight) of *Panulirus penicillatus* from the 29.8 km of coastline is suggested.

This resource, although small by volume, represents considerable commercial value and should not be subject to increased exploitation until adequate market returns are obtainable. The long larval planktonic phase of crayfish means that recruitment probably occurs from the islands upstream in the prevailing current regime, rather than from local spawning.

As well as *P. penicillatus*, a second crayfish species, *Panulirus longipes*, reportedly occurs, but if so, it is rare. The slipper lobster (*Parribacus* sp.) is occasionally harvested in small numbers from the reef rim, but the resource is small and could only provide a minor supplement to *Panulirus* catches.

5.14 Sea cucumbers

The holothurian fauna of Palmerston appears depauperate and no sea cucumbers are harvested for food, although *Holothuria leucospilota*, which is eaten elsewhere in the Cook Islands, is common under reef-flat cover.

Intensive searches at various places in the lagoon revealed the presence of only three common holothurians. *Holothuria atra* and *Stichopus chloronotus* are ubiquitous and abundant, and *Bohadschia argus* is present at low densities on the lagoon floor. None of these are recognised species of high commercial value on the international market in smoke-dried beche-de-mer (van Eys & Philipson, 1989), although *S. chloronotus,* as well as *H. atra* greater than 20 cm in length and 140 g in weight, could perhaps be considered marginally economic to process.

The surf red fish, *Actinopyga mauritiana*, occurs at moderate density on the reef crest (average 8/100 m^2) and reef front. For two years in the 1930s it was collected and processed for export to Tahiti, but no commercial exploitation has occurred since that time. No beche-de-mer is currently processed.

In the most recent review of beche-de-mer fisheries in the central and western Pacific, Conand (1988) drew attention to the lack of information relating to their dynamics and sustainable yields. Based on the limited number of density measurements made, a standing stock of approximately 14 t of surf red fish may be present on the reef crest of Palmerston Island. This is a conservative estimate, based on the mean density of 8 *A. mauritiana* per 100 m^2 of the reef rim, and does not include those animals found on the upper reef slope or in the moats on the lagoon side of the reef crest. Perhaps 3 – 5 t of this might be harvestable annually on a sustainable basis, and this translates to approximately 0.3 – 0.5 t of dried product.

5.15 Turtles

The turtle resource, in the forms of both live animals and eggs, appears to be lightly harvested on Palmerston Island. Adults of the green turtle (*Chelonia mydas*), and to a very minor degree, hawksbill turtle (*Eretmochelys imbricata* [**onu**]), are captured at night, and the eggs are also collected from time to time. Occasionally, turtles of around 50 cm shell length are harvested for sale of the shell (at approximately NZ$ 50.00 each). Others may be collected for subsistence use or to send to friends and relatives in Rarotonga. Spearing of turtles is currently banned. Any commercial harvest should be discouraged.

5.16 Miscellaneous other resources

The lagoon and various islet-associated habitats support a variety of other marine resources harvested on a small scale for food. These include the following:

- Octopus (*Octopus* sp. [**eke**]), hand-collected on the reef flat;
- Sand clams (*Asaphis violascens* [**ka'i**]), collected under intertidal coral rocks;
- Land crabs (*Cardisoma carnifex* [**tupa**]), collected at night along the shoreline;
- Coconut crabs (*Birgus latro* [**unga**]), collected in small numbers on some islands at night.

Other crustaceans occasionally collected on the reef rim include the three-spot crab (*Carpilius maculatus*), and swimming crabs (*Thalamita* sp.).

The echinoid (sea urchin) fauna of Palmerston appears species-poor, and none are harvested.

6. MANAGEMENT OF EXISTING FISHERIES

6.1 General

With the gradual decline in copra prices and the relegation of this activity to a subsidiary role in the economy of Palmerston Island, commercial fishing activities have come to dominate the local economy. The parrot-fish fishery has become a major component of these. Any management recommendations thus need to take into account the pivotal economic role of the parrot-fish fishery to the island.

It is worth noting that where management is required, the mechanisms exist for it to be instituted rapidly and policed effectively. This is demonstrated by the bans on parrot-fish and lobster exports already put in place by the Island Council in response to a perceived need for these measures.

A further demonstration occurred after the survey team met with the Island Council on the final day of the survey. In response to the team's suggestion that more accurate fishery statistics could be gathered if fish exports could be examined by the Fisheries Officer prior to loading on board the transport vessel, a regulation authorising such examination was instituted immediately, and the first loading examinations took place the same day.

Many of the present fisheries are operating at subsistence level, and, given market preferences, this is unlikely to change. Most of the offshore fisheries, as noted, are unlikely to incur the need for management given the continuous and rapid turnover of the exploited populations. However, several inshore fisheries, either now or in the future, may require some management input. The following sections recommend measures for consideration in these cases.

6.2 Parrot-fish

With the basic assumptions that :

(a) a return of parrot-fish stocks to levels observed in the early 1970s is the desired long-term goal, and

(b) economic disruption be minimised,

a range of management options has been considered (see Section 4 and Table 11), and was dicussed with the Palmerston Island Council at the conclusion of the survey. These include limitations of fish size, gear (mesh) size, gear bans, limitations on fishing effort, areas fished, catch, and total closure of the fishery for various periods of time.

The team's conclusions regarding management of the parrot-fish fishery are based mainly on anecdotal reports of a decline in abundance and average size, supported by a limited amount of historical production data. Information collected during the survey provided good 'snapshot' descriptions of the resource population at the time, but because virtually no management-related fishery data are available from parrot-fish fisheries elsewhere, the information collected during the survey cannot be used for comparative purposes at present.

Work under way in South East Asia and Australia (G. Russ, H. Choat, pers. comms.) will hopefully provide useful comparisons in the next 3 – 4 years. Additionally, the data collected during the survey will be essential as a baseline for monitoring the recovery of Palmerston parrot-fish stocks.

After careful consideration of all options, the following are recommended for implementation. The final decision should be taken by the Island Council after further consultation with the Ministry of Marine Resources.

1) Total closure of the parrot-fish fishery

Except for subsistence and monitoring, this is recommended for a minimum of two years. Accompanying this option should be a renewed commitment on the part of MMR to develop or support alternative fisheries, preferably the offshore fisheries, with FAD deployment an obvious strategy.

Under this option, recovery would hopefully proceed relatively quickly, but at considerable economic sacrifice. In all possibility, the two-year period may be insufficient for total recovery, but should allow significant increase in standing biomass. There are insufficient data on the biological parameters of the main target species to accurately predict the likely recovery period.

2) Partial closure, with catch and area restrictions

Establish a permanent reserve where no fishing would be allowed. This should be a sizable proportion of the total reef—at least 25 per cent, preferably more. In conjunction with this, it is suggested to either introduce an annual catch quota (no more than 10 t p.a. for 5 years) or impose enforced rest periods (1 month fishing, 3 months off).

Under this option, recovery would be more prolonged, but some economic return would be possible in the interim.

In either case, it will be necessary to accumulate biological and production data for long-term yield assessments and to enable the effectiveness of any management measures to be measured. Catch information should be collected and regularly summarised, and the recovery of the fishery monitored.

6.3 Giant clams

As giant clam exploitation on Palmerston is increasing following the market gap created by the harvest ban (**raui**) imposed at Aitutaki, it is recommended that exports be closely monitored. Rotational closures of commercial harvesting and size restrictions should be considered by MMR and the Island Council for implementation, as exploitation proceeds.

6.4 Crayfish

No further export is recommended until market prospects have been fully investigated. When the fishery reopens, a catch quota should be established in consultation with the MMR.

6.5 Turtles

The present ban on spearing turtles should be continued, and turtle nesting areas should be included under the provisions of any permanent reserve established. The Island Council could consider reviving the practice whereby families reared a required number of turtles to a pre-determined size. This appears to have worked satisfactorily in the past, even though the proportion of reared turtles remaining in the vicinity of the island for subsequent harvest cannot be determined.

6.6 Summary of management issues

The possible options for the future management of the commercial fisheries of Palmerston Island are summarised in Table 14.

Table 14 : Summary of possible options for the future management of the commercial fisheries of Palmerston

Fishery	Management options
Parrot-fish (**Rei**)	Size limits on fish. Impose minimum mesh size. Ban gill nets altogether. Seasonal or periodic closures. Rotating areas open to fishing. Establish permanent reserves. Total catch quotas. Individual/family catch quotas. Total closure for a set number of years.
Giant clam (**Paua**)	Size restrictions. Rotational closures. Careful monitoring of exports recommended.
Crayfish (**Koura**)	No further exports recommended until market prospects have been fully investigated, with a view to a value-added product. On opening, catch quotas and bans on diving deserve consideration.
Turtle (**Onu**)	Present ban on spearing maintained. Nesting areas established as reserves. Re-establish family rearing of turtles to a predetermined size.

7. FISHERY DEVELOPMENT

7.1 Resource status and potential yields

The fishery resources of Palmerston Island are limited compared with those of the high islands of the western Pacific, but similar in scope to those recorded for other central Pacific atolls. This in part reflects the reduced range of habitats, particularly those which have terrestrial links (e.g. mangroves, estuaries), but is also a result of the attenuation in species diversity eastwards across the Pacific.

Some fish families prominent in commercial catches in, for example, Fiji and Tonga, are totally absent or present in very reduced numbers in Palmerston (e.g. emperors (Lethrinidae), sweetlips (Plectorhynchidae) and silver biddies (Gerridae)). The total number of harvested species is relatively low (less than 150, see Appendix 2), as is the range of available invertebrates. The inshore ichthyofauna is dominated by herbivores (Scaridae, Acanthuridae, and Siganidae) and periphyton feeders (Mugilidae) to an extent not seen in most areas.

On the basis of visual observations, the lagoon is suspected to be relatively unproductive in terms of production biomass. Planktivorous fishes (e.g. fusiliers (Caesionidae) and sprats (Clupeidae)) are rare or absent, midwater fishes are uncommon and very few detritivores are seen. The absence of terrigenous inputs no doubt contributes to this, but low primary productivity probably prevails.

Patterns of exploitation track the limited resource availability, with epipelagic resources (tunas, flying fish, etc.) providing an independent, continually renewable resource, supplemented by less robust substrate-related resources from the reef and lagoon. A variety of specialist fishing techniques has been developed to make the best use of the limited range of lagoon and reef resources.

Only with export-oriented commercial exploitation has come the relatively recent threat of over-exploitation in this fragile system. It is logical that any future significant increase in production should come from offshore rather than lagoon resources, continuing management inputs being required to safeguard the latter.

Many fishery resources of Palmerston Island are exploited at subsistence level only and will continue to be so, given market preferences, resource size and availability. Included in this category are oilfish, sand clams, land crabs, octopus, lagoon parrot-fish, most small predatory reef fishes (including holocentrids and priacanthids) and **ature**, the big-eyed scad.

The remaining resources are subject to increasing exploitation for commercial use. The state of their exploitation is examined in Section 5 and their potential yields are estimated where possible. Table 15 summarises the estimated potential yields for the major fishery resources of Palmerston Island. These should be regarded as indicative only, but provide some basis for planning resource management.

Table 15: Summary of yield estimates by species

Resource	Estimated sustainable harvest for Palmerston (kg/yr)	See Section...
Parrot fish	10,000	4
Reef fish	13,500	5.3
Deep-water fish	5,000	5.5
Small, schooling pelagics	7,000 – 17,000	5.6
Giant clam	10,000	5.9
Crayfish	700	5.13
Beche-de-mer	300 – 500	5.14

Note: Estimates are based on available information relating to reef area and the harvests of the same or similar organisms elsewhere.

7.2 Development opportunities and constraints

All available resources, with the exception of sharks and beche-de-mer, are exploited to varying extents at present. There are however, opportunities to increase the volume of catches of some resources and to augment the economic return from others.

In terms of resource potential, tunas, **pa'ara** and flying fish provide the best opportunity to significantly increase the volume of catches. Constraints relate to equipment available for fish storage and catch handling capability. Larger (>20 kg) tunas comprise a small proportion of the catch at present, and these could probably be exploited more extensively with vertical longlines in suitable areas. Freezing fish of this size with present equipment, however, would be unsatisfactory.

The deployment of fish aggregation devices (FADs) around the island could bring benefits by increasing the vulnerability of tunas and other species not commonly taken at present (e.g. *Coryphaena*, *Elagatis*), and in fuel savings. As small vessels range further offshore, appropriate safety measures would also need to be applied.

Recent rapid commercial development of the flying-fish resource has progressed to the extent that production (1.5 t per month) had temporarily satisfied demand in Rarotonga at the time of the survey. The fishery could probably sustain higher catches and, despite the obvious constraint that will be presented by high transportation costs, it may be appropriate to investigate markets beyond Rarotonga (e.g. Island communities in New Zealand) to provide stability in this fishery. **Koperu** (round scads) and **ature** (big-eye scad) may sustain increased catches, and improved capture methods for **koperu** should be trialled. It seems likely that the fishing season for this species in Palmerston will be longer than in Rarotonga, an advantageous situation for Palmerston fishermen.

Palmerston is perhaps the best source of medium and large deep-water snappers in the Southern Cook Islands and fishing for these species could be more actively pursued by one or two vessels fitted with

wooden reels. This is particularly attractive, as the species taken have ready market acceptance and the reels could also be used for other purposes, such as trolling and vertical longlining. Smaller, whole snapper are already accepted by the Rarotongan restaurant market and special packs of fillets from larger fish could also be prepared. Snappers provide a good example of a resource with only relatively small catch increase expectations, but with prospects to achieve high unit value of properly prepared product. Marketing initiatives are needed to tap the highest-priced markets in Rarotonga.

The crayfish resource is small but valuable, and catches have been poorly marketed to date. Existing markets in Rarotonga should be re-assessed in terms of the product form required. There would seem to be scope for production of quality frozen tails (all crayfish are captured alive) and possibly packs of head and leg meat. The resource itself requires further assessment and a management plan may need to be prepared in consultation with the Island Council prior to the lifting of the present ban.

Subject to the long-term success of any management measures introduced, opportunities for further development of the parrot-fish fishery would seem restricted in the short term to exploitation of the presently under-utilised lagoon species and species which do not ascend the reef flat to feed (**tomore,** *Scarus schlegeli*, and **pakati**, *Scarus frenatus*). However, these are generally small and a requirement would be that market research should precede any increased exploitation. **Tomore** forms large seasonal spawning aggregations which could be selectively harvested.

No large increases in **kanae** (mullet) catches can be expected and efforts should be directed towards improving the end value of the product. There is an apparent strong demand for smoked mullet (an acknowledged high-quality product in many countries), but the lack of suitable smoking wood on Palmerston represents a constraint in this regard. This might, however, be more thoroughly investigated, along with consumer acceptance of 'hard' salted/ dried and split mullet, and the potential for making use of chemical smoke preparations.

Processed surf red fish (beche-de-mer) currently attract prices in the range US$ 4.00 – 6.00 (NZ$ 6.50 – 10.00)/kg free on board (FOB) for quality product (van Eys & Philipson, 1989). This may represent an opportunity for development provided appropriate marketing arrangements can be made. Any intensive exploitation should be regulated to keep harvest initially within a suggested limit of 0.5 t p.a. of finished product (see Section 5.14).

The possibility of commercial shell development, based on either trochus or black-lip pearl shell, appears poor. In the case of trochus, available habitat is apparently not entirely suitable either for settlement or for population increases, and therefore further attempts at seeding are probably not justified. The latitude of Palmerston is close to the southerly limit of black-lip pearl oyster distribution and prospects for the establishment of a naturally sustained population from introduced stocks would seem poor.

Giant clams should continue to be viewed as a supplementary rather than a major income source and production should be monitored more closely. Introduction of larger species (e.g *Tridacna derasa*) should be deferred, pending the results of trials at Aitutaki, but the Palmerston lagoon appears to have numerous areas of potentially suitable habitat.

Shark resources are presently totally unutilised, and the abundance of sharks actually constrains the use of some fishing methods in the lagoon. Although the two common species (*Triaenodon obesus* and *Carcharhinus amblyrhynchos*) are not internationally marketed species, they may still provide a good-quality product (portions) for the fish-and-chip trade if properly bled and handled on capture, and if larger individuals are avoided. This possibility should be pursued with clearly labelled trial shipments to Rarotonga prepared for consumer evaluation.

The constraints to fisheries development on Palmerston are many and it is a tribute to the island's fishermen, past and present, that the existing level of development has been achieved. The formidable array of obstacles include irregular and expensive transport links (passed on in the form of reduced and only recently attractive fish prices), unsatisfactory initial freezing arrangements (the proliferation of chest freezers has greatly as-

sisted overall development, but cannot be expected to produce top-quality products), variable market requirements in a relatively small demand situation (long-term harvest planning thus becomes difficult for some species), high operating costs (in particular fuel for vessels and plant) and limited access to technical developments and modern gear. Weather, restricted and difficult access to the open sea, a relatively poor resource base and other functional constraints exist, but these generally are offset by the adaptability and skill of individual fishermen.

The three main areas where assistance is required are: in promoting the diversion of fishing effort towards the exploitation of offshore resources; in adding value to the catch by improvements to catch-handling practices and to the on-shore equipment used for processing and storage; and in supporting improved marketing of Palmerston products.

The deployment of one or more FADs is an obvious way in which the exploitation of oceanic fishery resources might be made more effective. The steep angle of descent of the outer reef slope on all sides of the atoll makes it essential that a bathymetric survey precede possible FAD deployments.

As Palmerston continues to develop as the major external supply of domestic fish to Rarotonga, increased Government support of fisheries development is clearly warranted. This has been relatively minor to date.

In the past there have been unhappy experiences with communally shared plant (blast freezers and cold storage). Despite this, there is much which could theoretically be achieved through the use of central storage facilities. The operation of a central blast freezer, at least for large fish or during periods of high catches, would appear to offer advantages over the present situation.

Such a central facility would ideally be managed on a day-to-day basis by an Island Fisheries Officer with expanded duties and responsibilities, but with ultimate authority and answerability for security of product and plant residing with the CAO. Alternatively, or additionally, individual fishermen could look at the possibility of acquiring small, power-efficient plate freezers to improve the quality of their frozen fish fillets.

A central processing or storage facility would also provide a location in which fish intended for export could be certified (for compliance with Island Council regulations or bans), and where better production data could be collected. The current lack of production data remains a major impediment to the development of rational management policies.

Government also has a definite role to play in promoting the orderly marketing of Palmerston product, by arranging marketing trials, providing technical information and monitoring market opportunities, both at home and abroad. As noted earlier, increasing the value of Palmerston Island fishery production by improved processing and marketing may have a more important income-generating potential than increasing catch quantities alone.

7.3 Government support

It is recommended that Government inputs to the Palmerston fishery, through the MMR, be increased in four key areas as follows:

1) Support of offshore fishery development and increased catch of pelagic species, by selective deployment of FADs

This would assist in defraying the economic costs associated with parrot-fish management. A thorough bathymetric survey should precede any deployment. Given the successful history of Palmerston fishermen with setting and utilising their own shallow-water fishing buoys, FAD deployments would probably be more cost-effective here than at any other location in the Cook Islands. A combination of shallow- and deep-water FADs should be considered.

2) Marketing development in support of Palmerston products

Marketing trials, surveys of potential markets (domestic and international) and provision of technical advice and training on alternative processing techniques are all required. Several regional programmes (SPC, FAO/UNDP) could be of assistance in this regard. The work would not conflict with the existing transport and marketing arrangements, and would simply identify more lucrative options. Provision of improved small-scale equipment (e.g. blast freezers) on a major family basis should be considered.

3) Collection of baseline information relating to the exploitation of all marine resources on Palmerston Island

Formulation of management plans, and resource assessment generally, has been considerably hampered by the lack of data on basic production levels of particular species, let alone size composition of the catch, catch per unit of effort, etc. It is strongly recommended that increased effort be directed to collection of such data, a tractable problem in a situation where fish leaving the island are now inspected. Properly designed data collection sheets should be prepared, and necessary advice and support provided to the Fisheries Officer resident on the Island.

4) Increased role for the Fisheries Officer in data collection

The Fisheries Officer on the island should be expected to take a greater role in the monitoring and management of the island's fisheries. This is well within his capabilities, and given his own skills as a fisherman, it is possible that detailed and representative catch/effort and size composition data could be provided for individual fisheries and an annual census of fishing equipment on the island conducted. These skills could also be harnessed in the experimental development of alternative fisheries for higher-value market products.

In addition to an ongoing commitment to provide inputs to the long-term management and monitoring process, MMR should generally become more involved in fisheries development on Palmerston, given its growing status as the prime supplier of fresh domestic fish to Rarotonga. This has not been accorded full recognition in the past and needs to be addressed. MMR's effort and achievement in instituting the present survey can only serve as a useful platform in this regard.

8. ACKNOWLEDGEMENTS

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The survey team thrived on the generous hospitality and support provided by the Palmerston Fisheries Officer's family. It was a pleasure for the visiting members of the team to work alongside Young Bill Marsters. His knowledge of the atoll and its resources contributed significantly to the work accomplished during the stay on the atoll.

The team is grateful for the cooperation and assistance of the Rarotonga-based staff of the Cook Islands Ministry of Marine Resources, who assisted in the organisational stages of the project.

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- Forum Fisheries Agency,
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PALMERSTON ISLAND FISHERY RESOURCE ASSESSMENT SURVEY PROGRAMME

OUTLINE

The Palmerston Island Fishery Resource Assessment Survey (PIFRAS) is designed to:

1. Provide baseline information on the parrot-fish (Scaridae) fishery on the atoll, and identify and establish appropriate monitoring and management measures;

2. Identify and assess alternative fishery resources on the atoll, to enable diversification of artisanal fisheries;

3. Enable Fisheries Research Officers from other countries within the region to participate in an island-specific survey, as a training exercise.

The survey will be conducted over a 10-day period (approximately, depending on shipping schedules), around early September (boats permitting, again).

DESCRIPTION

Parrot-fish fishery survey

The techniques employed to assess parrot-fish stocks and the impact of the fishery and to address management issues will be:

1. Participation in fishing trips with island fishermen, to observe methods employed and obtain indications of species and size selectivity, and other aspects of each method;

2. Design and implementation of objective, repeatable surveys to assess the stock status of the most heavily exploited species. This could involve visual census surveys and trial-fishing to obtain information on CPUE rates, relative species abundance and length-frequency population structure for each species, as appropriate;

3. Determination of appropriate means for on-going monitoring of effort and catches in the fishery, and training of the local fisheries officer in the collection of such data;

4. Meeting with the traditional island leaders to establish a realistic framework for managing the fishery, in light of both the findings of the above, and of the social and cultural traditions of the fishermen, and their commercial needs.

Alternative fishery resources

The PIFRAS will undertake trial-fishing operations to determine the commercial viability of alternative artisanal fishery resources. As necessary, rapid-method stock assessment surveys will be designed and implemented during the time on-island. Ongoing fisheries monitoring programmes will be established, and repeatable surveys of stocks will be conducted, as appropriate.

Possible resources to be targetted and the primary areas of investigation include:

1. *Trochus niloticus*. Have previously introduced trochus attained exploitable levels? How can the fishery be monitored and managed?

2. Tridacnid clams (*T. maxima*). Can stocks sustain increased commercial exploitation? What controls are necessary on the fishery?

3. Turban/green snails (*Turbo setosus/argyrostomus/*etc). What is the abundance of natural stocks, and what potential for commercial exploitation?

4. Rock lobsters (*Panulirus penicillatus* and other spp.). Could stocks sustain increased commercial exploitation?

5. Mullets (Mugilidae) and other reef and lagoon fishes. Which species are amenable to and could sustain increased fishing pressures?

6. Deep-bottom snappers (*Etelis* spp., etc). Do catch rates make this a viable artisanal fishery?

7. Beche-de-mer (Holothurians, or sea-cucumbers). Which species are present, and in what abundance?

8. *Decapterus* and other baitfish. Can more efficient methods (e.g. Opelı net, vacuum packing) make these species viable as foodfish or bait for the Rarotongan market?

Training

The design, implementation, and interpretation of results from island-specific surveys are specialised skills. Logistical limitations of time, manpower, and equipment are imposed, and 'broad-brush', 'quick-and-dirty' survey techniques are called for. The scope of PIFRAS has been broadened to allow participation of suitably qualified Fisheries Research Officers from other island countries, to provide an opportunity for training in these important skills.

FISHES OF PALMERSTON ISLAND

Fishes of commercial or subsistence importance which were collected, observed, or reliably reported by informants during the Marine Resource Survey of Palmerston Island, September, 1988.

	Palmerston name
PHYLUM CHORDATA	
CLASS CHONDRICHTHYES	
ORDER CARCHARHINIFORMES	
CARCHARHINIDAE - Requiem sharks	
Carcharhinus amblyrhynchos	**Papera**
Carcharhinus falciformis (identified from set of jaws and description by Bill T. Marsters).	
Triaenodon obesus	**Ngarara**
ORDER RAJIFORMES	
DASYATIDIDAE - Sting rays	
Dasyastis sp.	
MYLIOBATIDAE - Eagle rays	
Aetobatus narinari	**Tamanu**
CLASS OSTEICHTHYES	
ORDER ELOPIFORMES	
CHANIDAE - Milkfishes	
Chanos chanos Salmon	
PLOTOSIDAE - Eel catfishes	
Plotosus lineatus Catfish	
ORDER ANGUILLIFORMES	
MURAENIDAE - Moray eels	
Gymnothorax javanicus	**Va'a roa**
Gymnothorax sp. (*eurostus* ?)	
OPHICHTHIDAE - Snake eels	
(Two specimens of an unidentified Ophichthid were obtained from the stomachs of deep-water snappers).	
ORDER ATHERINIFORMES	
EXOCOETIDAE - Flying fishes	**Maroro**
Cheilopogon unicolor	
Cheilopogon atrisignis	
Cypselurus poecilopterus	
HEMIRAMPHIDAE - Halfbeaks	**Ishe, Tikoroto**
(Unidentified Hemiramphids were observed both in the lagoon, and outside the reef.)	

BELONIDAE - Needlefishes
Ablennes hians **Aku**
Platybelone argala platyura

ORDER BERYCIFORMES

HOLOCENTRIDAE - Squirrelfishes
Myripristis adusta **Marau**
Myripristis berndti **Marau**
Myripristis violacea **Nato**
Myripristis woodsi **Marau**
Neoniphon opercularis
Neoniphon sammara
Sargocentron caudimaculatum
Sargocentron spiniferum **Ta**
Sargocentron tiere **Tukoro**

ORDER SYNGNATHIFORMES

AULOSTOMIDAE - Trumpetfishes
Aulostomus chinensis

FISTULARIIDAE - Cornetfishes
Fistularia commersoni **Taverevere**

ORDER PERCIFORMES

SERRANIDAE - Groupers
Anthias pascalus
Anthias sp.
Cephalopholis argus **Blaicot**
Cephalopholis sonnerati (?)
Cephalopholis spiloparaea **Rari**
Epinephelus fasciatus **Atea**
Epinephelus hexagonatus **Tarao**
Epinephelus merra **Tarao**
Epinephelus tauvina **Aroa**
Epinephelus tuamotuensis **Paru aroa**
Epinephelus socialis **Ngatara**
Plectropomus laevis **Tonu**
Saloptia powelli
Variola louti **Oka**

KUHLIIDAE - Mountain basses **A'ore**
Kuhlia marginata (?)
Kuhlia mugil

PRIACANTHIDAE - Big-eyes
Heteropriacanthus cruentatus **Kupa**

CIRRHITIDAE - Hawkfishes
Cirrhitus pinnulatus **Patuki toka**
Neocirrhites armatus
Paracirrhites arcatus
Paracirrhites forsteri
Paracirrhites hemistictus

MUGILIDAE - Mullets
Chaenomugil leuciscus **Wowa**
Crenimugil crenilabus **Kanae**

Liza vaigiensis	**Ka'a**
SPHYRAENIDAE - Barracudas	
Sphyraena barracuda	**Ono**
Sphyraena novaehollandiae	**Tatu**
POLYNEMIDAE - Threadfins	
Polydactylus sexfilis	**Moi**
CARANGIDAE - Jacks and trevallies	
Carangoides ferdau	**Pakeva**
Carangoides orthogrammus	**Pova**
Caranx ignobilis	**Urua**
Caranx lugubris	**Ru'i**
Caranx melampygus	**Titiara, ashiu**
Caranx sexfasciatus	**Komuri**
Decapterus macarellus	**Koperu**
Elagatis bipinnulatus	**Roroa**
Gnathanodon speciosus	
Scomberoides lysan	**Rai**
Selar crumenophthalmus	**Ature**
Seriola rivoliana	**Paru komuri**
Seriola dumerili (?)	**Paru komuri**
Trachinotus baillonii	**Kaoke**
CORYPHAENIDAE - Dolphinfishes	
Coryphaena hippurus	**Mahi mahi**
LUTJANIDAE - Snappers	
Aphareus furcatus	**Paru tarakii**
Etelis carbunculus	**Paru marau**
Lutjanus bohar	**Angamea**
Lutjanus fulvus	**Tangau**
Lutjanus kasmira (?)	
Lutjanus monostigmus	**Taiva**
Macolor niger	
Pristipomoides auricilla	
Pristipomoides filamentosus	
Pristipomoides zonatus	
CAESIONIDAE - Fusiliers	
Pterocaesio tile	**Uri uri**
LETHRINIDAE - Emperors	
Gnathodentex aureolineatus	**Tarakii**
Lethrinus amboinensis (?) (field sighting)	
Lethrinus kallopterus	
Lethrinus xanthochilus	**Iroa**
Monotaxis grandoculis	**Mu**
MULLIDAE - Goatfish	
Mulloides flavolineatus	**Vete**
Mulloides vanicolensis	**Vete**
Parupeneus barberinus	**Ka'uru**
Parupeneus bifasciatus	**Ka'uru**
Parupeneus cyclostomus	**Ka'uru**
Parupeneus multifasciatus	**Ka'uru**
PEMPHERIDAE - Sweepers	
Pempheris oualensis	**Mother marau**

KYPHOSIDAE - Rudderfishes

Kyphosus bigibbus	**Nanue, pipi**
Kyphosus cinerascens	**Katutu nanue, pipi**

CHAETODONTIDAE - Butterflyfishes

Chaetodon auriga
Chaetodon citrinellus
Chaetodon ephippium
Chaetodon lunula
Chaetodon ornatissimus
Chaetodon quadrimaculatus
Chaetodon reticulatus
Chaetodon trifascialis
Chaetodon ulietensis
Chaetodon unimaculatus
Forcipiger flavissimus
Forcipiger longirostris
Hemitaurichthys polylepis
Hemitaurichthys thompsoni
Heniochus chrysostomus
Heniochus monoceros
Megaprotodon trifascialis

POMACANTHIDAE - Angelfishes

Centropyge flavissimus
Centropyge loriculus
Pomacanthus imperator
Pygoplites diacanthus

POMACENTRIDAE - Damselfishes

Abudefduf septemfasciatus
Chromis viridis
Chromis xanthura
Dascyllus aruanus
Dascyllus flavicaudus

LABRIDAE - Wrasses

Cheilinus chlorurus	**Marairai**
Cheilinus fasciatus	
Cheilinus undulatus	**Maratea**
Coris aygula	
Epibulus insidiator	
Gomphosus varius	
Halichoeres hortulanus	
Halichoeres trimaculatus	
Hemigymnus fasciatus	
Hologymnosus sp. *(annulatus?)*	
Labroides bicolor	
Labroides dimidiatus	
Thalassoma hardwicke	
Thalassoma lutescens	

SCARIDAE - Parrot fishes

Cetoscarus bicolor	**Kakatavake**
Hipposcarus longiceps	**Rei**
Scarus altipinnis	IP-**Black show**
	TP-**Blue show**
Scarus forsteni (?)	TP-**Koti**
	IP-**Pakati**

Scarus frenatus	TP-**Koti**
	IP-**Pakati**
Scarus frontalis	**Akau**
Scarus ghobban (?)	TP-**Mamaringa**
	IP-**Rotea**
Scarus gibbus	Small-**Greenfish**
	Large-**Poshow**
Scarus globiceps	TP-**Koti**
	IP-**Pakati**
Scarus psittacus	TP-**Koti**
	IP-**Pakati**
Scarus pyrrhurus (?)	TP-**Koti**
	IP-**Pakati**
Scarus schlegeli	**Tomore**
Scarus sordidus	TP-**Koti**
	IP-**Pakati**
GOBIIDAE - Gobies	
Nemateleotris magnifica	
Ptereleotris zebra	
GEMPYLIDAE - Snake mackerels	
Gempylus serpens	**A'a manga**
Prometichthys pometheus	**Manga**
Ruvettus pretiosus	**Vena**
SCOMBRIDAE - Mackerels and tunas	
Acanthocybium solandri	**Pa'ara**
Gymnosarda unicolor	**Tawatawa**
Katsuwonus pelamis	**Atu**
Thunnus albacares	**Ahi**
Thunnus obesus	**Tuava**
Thunnus alalunga	**To'everi**
ISTIOPHORIDAE - Billfishes	**Akura**
Istiophorus platypterus	
Makaira spp.	
ZANCLIDAE - Moorish idols	
Zanclus cornutus	**Tiitii**
ACANTHURIDAE - Surgeonfishes and unicornfishes	
Acanthurus achilles	**Shukutoto**
Acanthurus blochii	**Palangi**
Acanthurus glaucopareius	
Acanthurus guttatus	**Api**
Acanthurus leucopareius	
Acanthurus lineatus	
Acanthurus mata	
Acanthurus nigricauda	**Palangi**
Acanthurus nigrofuscus	
Acanthurus nigroris	
Acanthurus olivaceus	**Maito**
Acanthurus thompsoni	
Acanthurus triostegus	**Manini**
Ctenochaetus striatus	**Kikoshami**
Ctenochaetus strigosis	
Naso brachycentron?	
Naso brevirostris	**Ume**
Naso lituratus	**Shi shi**

Naso unicornis	**Ume**
Naso vlamingii	**Ume**
Naso thorpei	**Ume**
Naso tuberosus (?)	
Zebrasoma veliferum	
Zebrasoma flavescens	
SIGANIDAE - Rabbitfishes	
Siganus argenteus	**Mae mae**
ORDER PLEURONECTIFORMES	
BOTHIDAE - Lefteye flounders	
Bothus mancus	**Patikirara**
Bothus pantherinus	
ORDER TETRAODONTIFORMES	
BALISTIDAE - Triggerfishes	**Kokiri**
Balistapus undulatus	
Balisistoides viridescens	
Melichthys vidua	
Rhinecanthus aculeatus	
Rhinecanthus rectangulus	
MONOCANTHIDAE - Filefishes	
Aluterus scriptus	
Cantherhines dumerili	
OSTRACIONTIDAE - Trunkfishes	
Ostracion meleagris	**U'e**
TETRAODONTIDAE - Pufferfishes	
Arothron hispidus	**U'e**
DIODONTIDAE - Porcupinefishes	
Diodon hystrix	**Totara**
ORDER SCORPAENIFORMES	
SCORPAENIDAE - Scorpionfishes	
Pontinus macrocephalus	

PALMERSTON ISLAND FISHERY RESOURCE ASSESSMENT SURVEY TEAM
(15 Sept. – 9 Oct. 1988)

• Ministry of Marine Resources, Cook Islands	Ian Bertram Ned Howard Kelvin Passfield Neil Sims Tangiau Tearii
• Palmerston Island Fishery Officer	Bill Marsters
• Forum Fisheries Agency	Drew Wright
• South Pacific Commission	Garry Preston
• South Pacific Commission, consultant	Anthony Lewis
• Ministry of Natural Resources, Kiribati, fisheries division	Being Yeeting
• Ministry of Natural Resources, Tuvalu, fisheries division	Sautia Maluofenua
• Ministry of Primary Industries, Fiji, fisheries division	Filipe Viala

LIST OF GEAR USED FOR THE PALMERSTON ISLAND RESOURCE SURVEY

	Specifications/Description	No.; Source
Scuba/snorkelling		
1.	Scuba compressor + etc.	1; MMR
2.	" tanks	5; MMR
3.	" backpacks	5; MMR, D.Wright
4.	" regulators etc. (gauges)	7; MMR, D.Wright, F.Viala
5.	Spearguns	1; MMR, B. Marsters
Fishing		
6.	V.L.L. handreel + etc	2; SPC
7.	Etelis handreel + etc	2; SPC
8.	Gill nets (1 x 3 1/2", 1 x 4")	1 of each; B. Marsters
9.	Bait gill net (1 x 1 1/4")	1; SPC
10.	Fillet knives	some; MMR, B. Marsters
11.	Measuring boards	2; SPC
12.	Scales (50 kg by 1 kg, 10 kg by 100 g)	3; SPC
13.	Keys (for I.D.)	lots; SPC, FFA, MMR
14.	Echosounder + battery	1; MMR
15.	Parachute anchor	1; MMR
Survey gear		
16.	Transect ropes	2; MMR
17.	Quadrats	2; SPC, MMR
18.	Manta boards	1; SPC
19.	Calipers	2; MMR
20.	Rulers	lots; MMR
21.	Clipboards and U/W slates	lots; MMR, SPC
22.	U/W paper	some; MMR
23.	U/W camera	3; SPC, MMR, FFA
24.	U/W flashlights	6; SPC, MMR, D.Wright
25.	Pencils	lots; MMR
Other		
26.	First Aid kit	2; SPC, MMR
27.	O.B. Motors (3 x 25 hp, 1 x 9.9 hp)	4; B. Marsters, MMR
28.	Battery charger	1; MMR
29.	Portable computer and printer	1; MMR
30.	Aluminium dinghies	3; B. Marsters
31.	Tide tables	1; MMR

HOUSEHOLD SURVEY FORM

HOUSEHOLD IDENTITY

Name of head of household: Total no. in household:
Name of individuals who fish:

Name	When last went fishing?	Where?	What gear used?

What percentage of the household's total catch comes from each of the following sources?

Lagoon	Reef flat	Outside reef	Total

What proportion of each catch is used for the following purposes?

	Home consumption	Sharing	Sale
Lagoon			
Reef			
Outside reef			

Which of the following forms of fishing are used by the household?

	Often	Sometimes	Never	Seasonally
Fish drives				
Gill netting				
Scoop netting (flying fish)				
Cast netting				
Handlining				
Rod and line				
Trolling				
Deep-bottom fishing				
Spear-gun fishing				
Spear fishing while walking				
Collecting crayfish				
Collecting shells				
Collecting beche-de-mer				
Collecting seaweed				
Gleaning (general collecting)				
Poisons				
Dynamite				
Other (specify)				

Description of fishing gears owned by household

BOATS Total number: Describe each boat:

Type	Length	Propulsion	Engine h.p	Price paid	Year acquired	Shared with?

GILL NETS Total number: Describe each net:

Mesh size	Length	Depth	Mono/multi	When bought?	Who repairs?	Shared with?

OTHER NETS (e.g. cast nets, scoop nets) Describe each one:

Type of net	Material	Comments

FISHING LINES Total number: Describe each line:

Material	Diameter (mm)	Est break strength	Type of fishing mainly used for (eg. handlining, trolling, etc.)

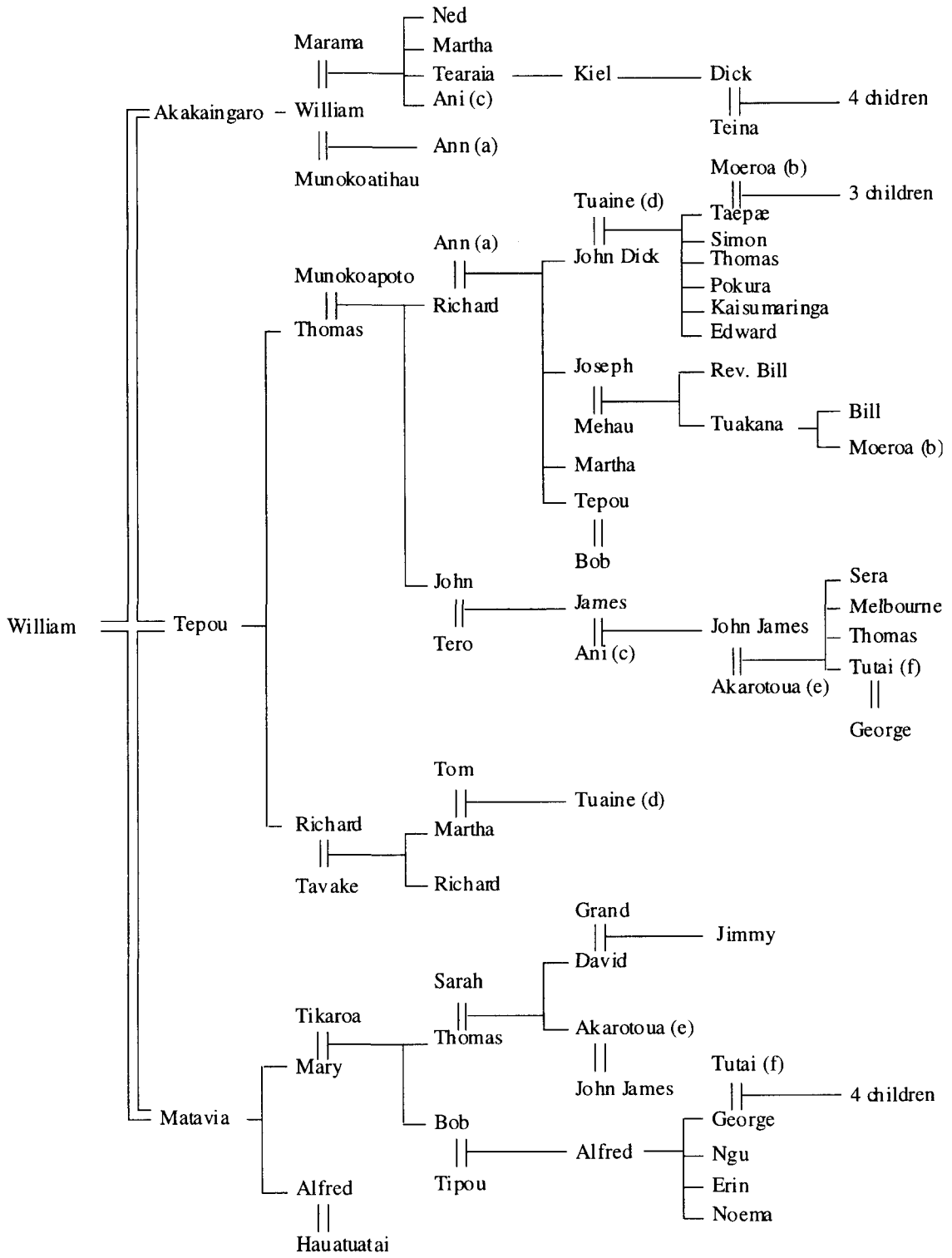
OTHER (e.g. spearguns, hand spears, etc.) Describe each one:

Main species of finfish caught (note season if applicable)

Local name	Gill net	Fish drive	Hand line	Rod & line	Spear gun	Fish spear	Troll	Scoop net

Notes:

GENEALOGY OF THE MARSTERS FAMILY FOR THE CURRENT RESIDENTS OF PALMERSTON ISLAND



Notes: 1. A double line (||) indicates marriage.
2. Some people appear in more than one place in this genealogy. They are coded with a letter for easier identification—e.g. Ann (a).

PARROT-FISH SAMPLING BY SEX/SPECIES

Date set	*Hipposcarus longiceps*			*Scarus altipinnis*				*Scarus frontalis*			*Scarus gibbus*			*Scarus ghobban*			All species		
	F	M	Total	IF	IM	TP	Total	F	M	Total	F	M	Total	F	M	Total	F	M	Total
21-Sep																			
1	4	13	17	19	5	6	30	3	0	3	3	0	3	1	0	1	30	24	54
2	8	12	20	0	0	9	9	1	2	3	1	0	1	0	1	1	10	24	34
22-Sep																			
1	5	2	7	5	1	6	12	4	1	5	2	2	4	0	0	0	16	12	28
2	16	9	25	11	1	5	17	0	0	0	0	0	0	0	0	0	27	15	42
24-Sep																			
1	0	1	1	2	0	0	2	0	0	0	0	0	0	0	0	0	2	1	3
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	5	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	6
4	2	3	5	6	0	0	6	0	0	0	0	0	0	0	0	0	8	3	11
26-Sep																			
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	8	1	7	16	0	0	0	1	0	1	0	0	0	9	8	17
5	0	0	0	5	1	2	8	1	0	1	0	0	0	0	0	0	6	3	9
6	2	1	3	0	1	2	3	0	0	0	4	0	4	0	1	1	6	5	11
27-Sep																			
1	18	19	37	0	0	0	0	0	0	0	0	0	0	0	0	0	18	19	37
2	8	5	13	0	0	0	0	0	0	0	0	0	0	2	0	2	10	5	15
3	2	2	4	0	0	0	0	6	1	7	0	0	0	0	0	0	8	3	11
4	2	4	6	14	0	0	14	0	0	0	0	0	0	0	0	0	16	4	20
28-Sep																			
1	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	2	0	2
2	6	5	11	9	2	4	15	0	0	0	0	0	0	0	0	0	15	11	26
3	1	2	3	12	1	3	16	0	1	1	0	0	0	0	0	0	13	7	20
4	0	1	1	8	1	9	18	5	2	7	1	0	1	0	0	0	14	13	27
30-Sep																			
1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
2	0	0	0	32	6	0	38	13	5	18	0	0	0	0	0	0	45	11	56
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total																			
25	**75**	**84**	**159**	**134**	**20**	**53**	**207**	**33**	**12**	**45**	**12**	**2**	**14**	**3**	**4**	**7**	**257**	**175**	**432**

DEEP-WATER CATCH DATA

LENGTH (mm)	WEIGHT (kg)
Aphareus furcatus	
340	0.6
Caranx lugubris	
410	1.6
Etelis carbunculus	
260	0.3
335	0.6
345	0.8
355	1.0
370	1.0
380	0.9
380	1.0
415	1.4
420	1.4
430	1.8
975	19.5
1085	28.5
Total number	12
Total weight	58.1
Average weight	4.8
Epinephelus tuamotuensis	
510	2.0
740	5.6
740	6.4
755	7.5
580	2.8
Total number	5
Total weight	24.3
Average weight	4.9

LENGTH (mm)	WEIGHT (kg)
Pontinus macrocephalus	
290	0.5
Pristipomoides auricilla	
360	0.8
370	0.9
380	1.0
380	1.1
Total number	4
Total weight	3.8
Average weight	1.0
Pristipomoides filamentosus	
500	2.1
Pristipomoides zonatus	
285	0.4
310	0.7
320	0.7
350	1.1
355	1.1
390	1.3
395	1.3
400	1.6
405	1.5
410	1.5
410	1.6
420	1.6
420	1.7
420	1.8
430	1.8
440	2.0
Total number	16
Total weight	21.7
Average weight	1.4

LENGTH (mm)	WEIGHT (kg)
Saloptia powelli	
360	0.8
380	0.9
440	1.6
Total number	3
Total weight	3.3
Average weight	1.1
Seriola rivoliana	
490	1.5
580	3.5
690	5.4
800	7.6
Total number	4
Total weight	18.0
Average weight	4.5
Variola louti	
460	2.1