ISSN 1607-7393

Reef Resources Assessment and Management

Technical paper n° 1

The Live Reef Food Fish of Bua Province, Fiji Islands

A first assessment of the stock potential and guidelines for a management policy

by Being M. Yeeting, Pierre Labrosse and Timothy J.H. Adams

SPC
Secretariat of the Pacific Community
Noumea, New Caledonia

February 2001

ISSN 1607-7393

Reef Resources Assessment and Management

Technical Paper no.1

The Live Reef Food Fish of Bua Province, Fiji Islands

A first assessment of the stock potential and guidelines for a management policy

by Being M. Yeeting, Pierre Labrosse and Timothy J.H. Adams

Secretariat of the Pacific Community
NOUMEA
NEW CALEDONIA
February 2001

Original edition: English

Secretariat of the Pacific Community Cataloguing-in-publication data

The live reef foodfish of Bua Province, Fiji Islands: a first assessment of the stock potential and guidelines for a management policy/Being Yeeting, Pierre Labrosse & Timothy J.H. Adams.

(Reef Resources and Management Technical Paper/Secretariat of the Pacific Community; 1)

1. Coral reef fishes – Fiji. 2. Marine Resources development – Fiji. 3. Fish populations – Fiji. 4. Fisheries Management – Fiji
1. Title 2. Secretariat of the Pacific Community 3. Series 4. Labrosse, Pierre 5. Adams Timothy J.H.

639.2099611 AACR2

ISBN 982-203-760.0
ISSN 1607-7393

Prepared for publication and printed at SPC Headquarters, Noumea, New Caledonia, 2001
Fish illustrations on page 4 were reproduced from the *FAO Species Catalogues*

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

SPC	Secretariat of the Pacific Community
CDF	Commodity Development Framework
LRF	Live reef fish
LRFF	Live reef food fish
TNC	The Nature Conservancy
PNG	Papua New Guinea
ICFMaP	Integrated Coastal Fisheries Management Programme
TORs	Terms of Reference
UVC	Underwater visual census

ACKNOWLEDGMENTS

I would like to express a big thank you to the Fiji Fisheries Division for all the assistance and support they provided on my field trips to Fiji to conduct the study. I owe special thanks to the Live Reef Fish Project officer, Indar Dev Raj, and the Manager of Inshore Fishery, Apolosi Turaganivalu, for arranging logistics; Apisai Sesewa for his assistance in the diving work; the senior officers, Malakai Tuiloa and Esaroma Ledua, the Director, Maciu Lagibalavu, and Iliavi Tuwai, Fisheries Officer, for their comments and support. I am also grateful to Tevita Bukabuka of Galoa Island and his family for their hospitality during our stay with them on Galoa, and the two local UVC trainees, Penioni Bolatini and Veresa Taqasi, for their enthusiasm to work with us. Without your help, we would not have completed the work in the given short time.

Thank you.

Being M. Yeeting

Copies of the MOU and data collection forms are available upon request from:
The Reef Fishery Assessment and Management Section,
Coastal Fisheries Programme,
Secretariat of the Pacific Community,
Noumea, New Caledonia.
(contact: http://www.spc.int, e-mail: BeingY@spc.int, or fax: 687 263 818)

EXECUTIVE SUMMARY

With increasing interest by foreign companies in setting up live reef food fish operations in Fiji Islands, the Fiji Fisheries Department decided to ask the Secretariat of the Pacific Community (SPC) to assist them in assessing the potential stock for such operations and set up guidelines for developing and managing a sustainable trade for Fiji.

In response to the request, two trips were made by SPC Integrated Coastal Fisheries Management Project staff to do the required fieldwork in the proposed area of Bua Province. The trips were made between 12 September and 2 October, and 17 and 25 November 1998.

During the trips a series of informal interviews and meetings with local fishers (resource owners), industry people (including fish retailers), government officials and airline officials were conducted to collect information related to the trade. Also, a rapid snapshot assessment of the live reef food fish resources was made using underwater visual census in the proposed area of the operation.

The results obtained from the interviews showed that the fishers of the area fish mainly for subsistence and do not target the live reef food fish species specifically. Most of the fishing is conducted on the nearby reef areas.

About 1–2 tonnes of grouper and rockcod from Bua are sold in Suva every week. These are supplied by a few commercial fishermen based in the Labasa and Dreketi area and are sold at prices ranging from F$5.50 to F$6.50 per kilogram.

Based on the information obtained from local fishers, it was possible to map out likely spawning aggregation areas and spawning periods for some of the important fish species that are regularly fished. Among these species are four important live reef food fish species: the coral trouts (*Plectropomus areolatus*, *P. leopardus* and *P. laevis*) and the grouper (*Epinephelus polyphekadion)*.

From the underwater visual census surveys, a first estimate of the status of the stock was made. Stock of *P. areolatus,* apparently the most abundant live reef food fish species, was estimated at 1600 tonnes.

An analysis of length frequency data for *P. areolatus* showed that those occurring on the barrier reef tend to be bigger (45.4 cm mean length) than those on the inner reefs (23.6 cm).

The combined overall live reef food fish stock for Bua Province is estimated at 3750 tonnes.

A list of management policy guidelines is given to facilitate producing a good development and management plan for a sustainable live reef food fish trade. The list is far from complete and should be regularly reviewed and refined as information becomes available. A good monitoring programme is therefore essential.

A proposed data collection and monitoring programme is also described which aims at collecting the most important information required in order to improve management of the trade.

RÉSUMÉ

Devant l'intérêt croissant manifesté par des entreprises étrangères pour le lancement aux Îles Fidji de la pêche de poissons de récif vivants destinés à la restauration, le ministère des Pêches fidjien a demandé au Secrétariat général de la Communauté du Pacifique (CPS) de l'aider à évaluer le potentiel d'exploitation du stock et à établir des directives en vue de la création et de la gestion d'un commerce durable pour Fidji.

En réponse à cette demande, les agents de la CPS affectés au Projet de gestion intégrée des ressources côtières se sont rendus sur place, dans la province de Bua, pour effectuer deux missions d'enquête du 12 septembre au 2 octobre et du 17 au 25 novembre 1998.

Au cours de ces missions, ils se sont entretenus de façon informelle avec des pêcheurs locaux (propriétaires de la ressource), des professionnels (notamment des marchands de poissons), des fonctionnaires et des représentants des compagnies aériennes, afin de recueillir des informations sur cette filière. Ils ont fait aussi une évaluation rapide des ressources en poissons de récif vivants par comptage visuel sous-marin, dans la zone d'exploitation proposée.

D'après les renseignements recueillis au cours de ces entrevues, les pêcheurs de cette zone pratiquent surtout une pêche vivrière et ne ciblent pas particulièrement les espèces de poissons de récif vivants pour la restauration. Les efforts de pêche se concentrent dans les zones récifales voisines.

Une à deux tonnes de loches et de mérous de Bua sont vendues chaque semaine à Suva. Elles sont fournies par quelques pêcheurs commerciaux de la région de Labasa et de Dreketi, et se vendent entre 5,50 et 6,50 dollars fidjiens le kilo.

Grâce aux renseignements obtenus auprès de pêcheurs locaux, il a été possible de déterminer les zones probables de concentration de reproducteurs et les saisons de frai de certaines des espèces intéressantes qui sont régulièrement pêchées. Parmi elles figurent quatre espèces prisées par les restaurateurs : les saumonées (*Plectropomus areolatus*, *P. leopardus* et *P. laevis*) et la loche crasseuse (*Epinephelus polyphekadion*).

Une première estimation de l'état du stock a pu être faite d'après les comptages visuels sous-marins. Le stock de *P. areolatus*, apparemment l'espèce la plus abondante de poissons de récif réclamés par la filière, a été estimé à 1600 tonnes.

D'après l'analyse des données sur les fréquences de taille de *P. areolatus*, les saumonées présentes sur la barrière récifale sont généralement plus grandes (45,4 cm de longueur moyenne) que celles évoluant à proximité des pâtés coralliens du lagon (23,6 cm).

L'ensemble du stock de poissons de récif vivants de la province de Bua est estimé à 3750 t.

Il a été remis une liste de principes d'une bonne politique de gestion afin de faciliter l'élaboration d'un plan de développement et de gestion propre à assurer un commerce durable de poissons de récif vivants. Cette liste est loin d'être exhaustive et devra être régulièrement revue et affinée au fur et à mesure que l'on en saura davantage sur la ressource. Il est donc essentiel de disposer d'un programme d'observation fiable.

Il est aussi proposé un système de collecte de données et de surveillance des prises qui permettra de recueillir les principales données requises pour améliorer la gestion de ce commerce.

Introduction

Background

All fish-eating communities would unquestionably agree that the best quality and best tasting fish are those you eat almost straight after catching them. Presumably, this was also the observation of the food conscious Chinese, resulting in the extreme form of keeping fish alive until moments before cooking it. Such popular custom in China saw the birth of the live fish trade, which was traditionally limited to cultured freshwater and marine species caught in local waters but has now expanded to wild caught marine fish as the preferred species.

In Hong Kong, with its increasing wealthy population, the demand has been ever increasing. As stocks from Chinese sources became depleted, live fish operators began to extend their activities outwards to more remote and isolated reefs and islands. First into the neighboring Asian countries and then into the Pacific, starting with Palau in the mid-1980s, then Papua New Guinea (PNG), Solomon Islands, Marshall Islands, Kiribati and recently Fiji.

With the high prices the Asian markets are willing to pay, live reef fish trade is becoming an increasingly attractive venture for the Pacific countries and territories. It is very much seen as an opportunity to add value to and maximise returns from their marine resources. Unfortunately the evidence from Asia documented in Johannes and Riepen (1995) has brought up cause for concern. One of the major concerns was the use of cyanide to stun targeted fish species in order to facilitate capturing them. Johannes and Riepen gave a detailed description of this method in their report:

> … a diver chases a large fish into one of the holes in the coral reef below him. Armed with a quart-sized plastic bottle, he squirts a milky fluid (sodium cyanide) into the hole. He awaits a couple of minutes, then rips away the live coral from around the hole. As he works, small fish around him gradually lose their equilibrium, swim in crazy loops, then sink, quivering to the bottom.
>
> The diver pushes his way into the hole and, after a minute or so, emerges with his quarry, now stunned by the milky fluid. He forces a large hook attached to a rope through the fish's thick lips, tows it to the surface, and drops it into a tank of seawater in a waiting skiff.

Cyanide fishing, as it is commonly called, has been shown to kill not only small fish species but also coral as described in a 1997 study on the effects of cyanide on corals conducted at One-Tree Island by Ross Jones. In areas where cyanide has been used it leaves a trail of dead barren corals. It has therefore been labeled as a destructive fishing method and has been banned. Unfortunately, with the high demand and prices for live reef fish in the Hong Kong market, some companies are still using it in order to increase catches. Pacific Island nations with little experience or awareness of this destructive fishing method are in danger of entering what appears to be an attractive trade and doing harm to their reef resources. In addition the lack of management policies, regulations and legislation to address the trade has made them potential targets for greedy operators who only want to make money and give little consideration to long-term sustainability of the resource. Such has been the case in the recent past and despite the warnings and available information documenting the dangers of the trade provided by regional and environmental organisations (FFA, SPC, TNC etc.), some Pacific countries have still opted to go into the trade without precautionary measures set in place.

In the late 1990s Fiji got into the live reef food fish (LRFF) trade. With interest shown by some overseas LRFF companies it was identified as a potential income-generating project by the Fiji Fisheries Department under their Commodity Development Framework (CDF) programme in 1998. With preliminary arrangements being negotiated for one overseas LRFF operator to start, Fiji, unlike the other countries in the Pacific, has taken a very wise move by seriously looking at the management and regulatory issues relating to this fishery based on experiences and lessons learned from other countries. The primary aim is to set up an LRFF industry that is sustainable in the long term. The Fiji Fisheries therefore decided that the first step was to know about the potential and the extent of their LRFF resource and to set up a management structure in the form of policies, regulations and legislation for the trade.

In August of 1998, the Secretariat of the Pacific Community (SPC) received a letter of request for assistance from the Ministry of Foreign Affairs and External Trade in Fiji on behalf of the Fiji Fisheries Department. The request was for assistance in setting up guidelines for a live reef fish trade management policy for the Bua Province of Vanua Levu, which has been allocated as the first area for a live reef fish operation.

In order to provide realistic and practical management guidelines, we felt that: (1) some understanding of the current legislation pertaining to the ownership and use rights of fisheries resources was required; (2) a general view of the importance of the fisheries resources to the local community should also be considered; and (3) information relating directly to the fisheries resources should be acquired both from local fishermen and from independent surveys.

The limitations of such a short study must be understood. The methods employed are 'quick and dirty', with the aim of providing a snapshot view of the fisheries resource present especially in a fishery where no previous information has been recorded. The results should therefore be taken as preliminary estimates to be refined as more information becomes available. To this effect, a monitoring programme is important for the fisheries to provide the needed information for better management of the resources in the future. A recommended monitoring programme is outlined in this report.

Fiji fisheries legislation

Management of the live reef fish trade would require some forms of regulative measure and legislation to ensure long-term sustainability. The laws relating to Fiji's marine resources can be found in Chapters 158, 158A and 149 in the Laws of Fiji. These have been summarised and discussed by Richards et al. (1994) and Fong (1994). For the purpose of this study we shall look at the laws that set the basis for customary fishing areas and how these laws are put into practice.

The laws relating to the marine resources of Fiji are cited as the Fisheries Act which makes provision for the regulation of fishing. The Fisheries Act recognises Fijian people's customary right to fish in traditional fishing grounds (qoliqoli), which are generally from the outer edge of the reef to the shore. All Fijians have the right to fish in their qoliqoli for their own consumption. The Act also allows Fijians to decide which commercial fishermen shall be allowed to fish in their fishing right areas and to impose restrictions on them. Access for commercial fishers to fish in the fishing right areas is often granted on payment of a fee to the customary owners.

The customary fishing rights law is administered jointly by the Native Lands and Fisheries Commission, Provincial Councils and Fisheries Division. The Native Lands and Fisheries Commission is responsible for settling and marking out boundaries of fishing areas while Provincial Councils decide, in consultation with the customary fishing right owners, which commercial fishers will be allowed to fish in the customary areas.

Fisheries Division's role is to provide advice on the fisheries to customary owners, issue licences (after permission has been granted by fishing right owners) and enforce regulations and restrictions. For enforcement, the Fisheries Division has a network of honorary Fish Wardens who are appointed by the Minister of Agriculture, Fisheries and Forestry on the request of chiefs or leaders of fishing right area owners. These Fish Wardens are usually members of the group owning the customary fishing right area to be protected.

The LRF operation target area, Bua Province

The Province of Bua is one of the three provinces in Vanua Levu, the second biggest island in the Fiji group (see Figure 1). The province forms most of the southern part of Vanua Levu. It consists of 54 villages with a predominantly local Fijian population of just over 9000. The Bua Provincial Council, the administrative body for the province, is in Nabouwalu, which is located almost on the southernmost tip of the island.

In early 1998 Satellite Seafoods Ltd, an Australian-based company, submitted a proposal showing its interest in setting up a live reef fish venture in Fiji. The Fiji Fisheries Division in consultation with the Bua Provincial Council and customary fishing right owners of the districts of Bua, Lekutu and Navakasiga considered the proposal and have agreed to let the company operate in the respective fishing right areas . The main target fishing area would be in the Lekutu and Navakasiga districts and is owned by the vanua (tribes) of these two districts. This area would also contain the company's base and their fish storage cages. The second target fishing area, which is just south of the first fishing area, is owned by the vanua of Yavusa Bua, Koroma, Tacilevu, Nauava (Tiliva), Dalomo, Burenitu (Nawailevu), Bua and Rukuruku. Both fishing areas are regarded as prime fishing grounds. The first fishing right area was the only area that the Fisheries Division of Fiji requested a survey of and was therefore the only area visited by Integrated Coastal Fisheries Management Programme (ICFMaP) staff.

The total area of the Lekutu and Navakasiga District fishing right area is about 1600 km^2, while the second target fishing area, just south of the first one, has an area of about 357 km^2. Both fishing areas consist of patch reef corals that are concentrated around Ovatoa and Nandongo Reefs. The reef area in the fishing zone that was surveyed is made up of about 432 km^2 of inside reef areas and about 84 km^2 of barrier reef. Thus the total reef area in the fishing right area is about 516 km^2 or about 30% of the total fishing right area.

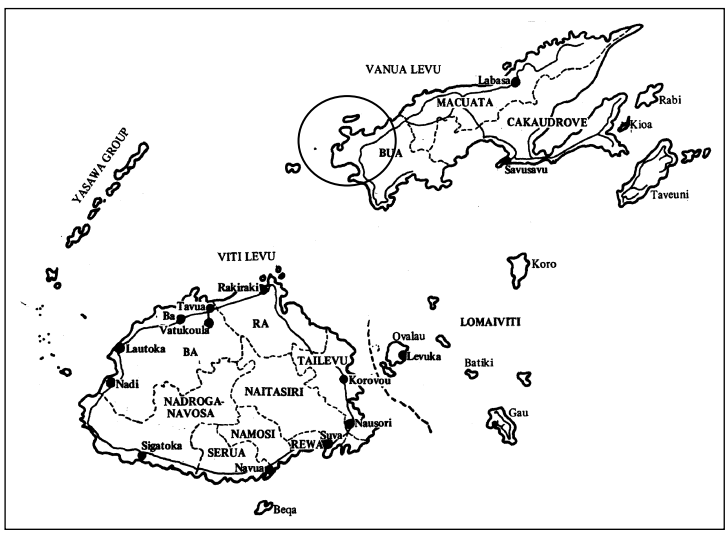


Figure 1. Fiji Islands and the Bua Province fishing ground

The live reef fish company and its plan

The partners in this new live reef fish venture are Satellite Seafoods (Fiji) Ltd, an Australian-owned and based company, and Altracor (Fiji) Ltd which is a fully local-owned Fijian company. Shares are 70% and 30% respectively. The directors and shareholders of the companies are:

Altracor (Fiji) Ltd
Mr Kafoa Muaror – Lawyer
Ms Agnes Elkjaer – Manager

Satellite Seafoods (Fiji) Ltd
Mr Bruce Trewavas – Consultant, Australia
Mr Carsten Elkjaer – Manager, Australia

The company plans to use local fishermen and their existing boats for catching fish, and will provide assistance in modifying boats and training fishermen to catch and maintain the fish alive. The company will set up about 20–25 fish cages, of 4 m x 4 m x 6 m (depth), each with a capacity of 500 kg of live fish. A live fish transport vessel (F/V *Crested Tern*) capable of holding up to 4 tonnes of live fish, would be brought in from Australia to collect the live fish from the fish cages and transport it to a main holding facility in Vanua Levu. The live fish would then be shipped overseas using a live fish carrier vessel. Yong Shing Fishery Co., based in Hong Kong, has already met with the company representatives to indicate its interest in transporting the fish on its vessel Yong Sheng Lai 18. The company is hoping to export a minimum of 10 tonnes of live fish each shipment, which will include coral trout species, groupers, rock cods and the humphead wrasse.

A memorandum of understanding between the people of Galoa in the District of Lekutu and Satellite Seafoods (Fiji) Ltd has been drawn up. This outlines the payment procedures, training and other assistance that the company will provide and what the people of Galoa are required to do (Appendix 1).

Target species

Generally the target species are those fish species with potential for selling to the live reef fish markets. The most popular LRF species include Serranidaes (coral trouts, groupers and rock cods) and the humphead wrasse (*Cheilinus undulatus*). For Fiji, the Fisheries Division provided a preliminary list of fish species that they were interested in harvesting for the live reef fish trade. The list includes:

Cromileptes altivelis	-	barramundi cod
Cheilinus undulatus	-	humphead wrasse
Plectropomus areolatus	-	squaretail coral grouper
Plectropomus leopardus	-	leopard coral trout
P. laevis	-	chinese grouper
Epinephelus cyanopodus	-	blue maori grouper
E. fuscoguttatus	-	blotchy grouper
E. polyphekadion	-	marbled grouper
E. malabaricus	-	orange spotted cod
E. maculatus	-	trout grouper
E. merra	-	honeycomb rockcod
E. coeruleopunctatus	-	white spotted grouper
Lutjanus argentimaculatus	-	mangrove jack

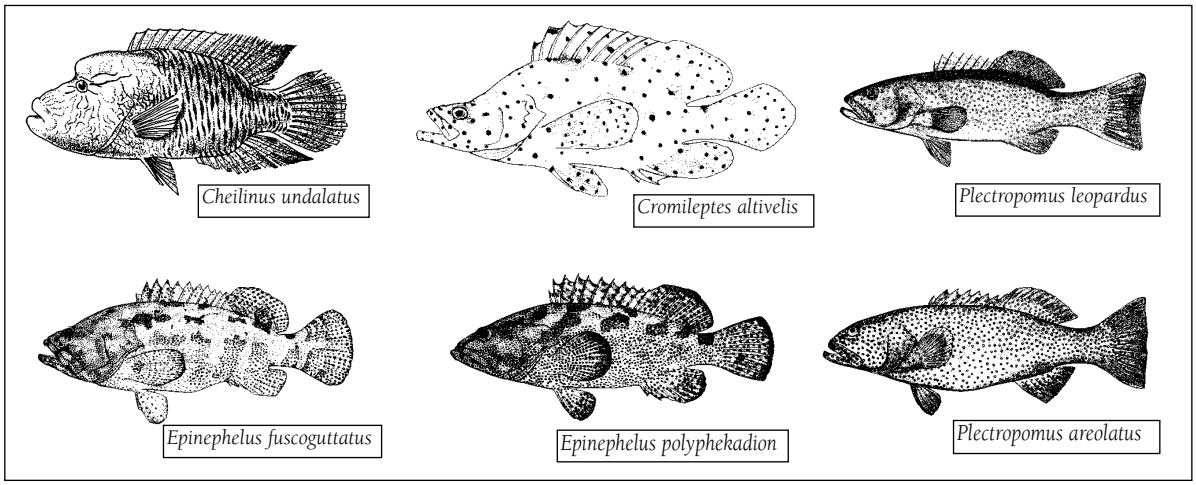


Figure 2. The main important live reef fish food fish species in Fiji.

OBJECTIVES AND TERMS OF REFERENCE

The request for assistance from Fiji was passed on to the ICFMaP of the SPC. Essentially, the request was for an assessment of the potential LRF species in the fishing area and for some management guidelines to use in formulating a management policy and regulations for the trade. To make sure that the needs of the Fisheries Division were met, Terms of Reference (TORs) were drawn up. The initial TORs are briefly outlined below.

1. To find the correlation of the species to be harvested under the live reef fish trade with other species in the area and how harvesting it will affect the food chain as a whole.
2. To draw up the life cycles of the coral trout and cod species.
3. To compare the rate of recovery of the target species to the rate of harvest.
4. To find out where the spawning aggregation sites are for coral trout and cod species and the times of the year when spawning occurs.
5. To give an approximate existing stock estimate for the potential target species.
6. To design catch data forms and establish a monitoring programme for catch, effort and export.
7. To set up a database for the live reef fishery in Fiji that can link and exchange information on a regional level.
8. To formulate guidelines and make recommendations towards a management policy and regulations for the live reef fish trade in Fiji.

Given the urgency of the matter, that the live reef fish operators were anxiously waiting for the go-ahead and limitations on the type of assistance and duration (three weeks) ICFMaP provide, it was necessary to leave out those TORs that would require long-term studies. After consultation between the Fiji Fisheries Division and ICFMaP, it was agreed to leave out TORs 2 and 3, to do some broad-brush preliminary work on 1, 4 and 5, and to look in detail at 6, 7 and 8.

The overall study was a collaborative effort between ICFMaP and Fiji Fisheries Division. The ICFMaP provided the specialist assistance of one of its staff members to carry out the field work, analyse the data and prepare a technical report outlining recommendations and guidelines for a management policy, the travel expenses of ICFMaP staff, and production and publication of the final report.

The Fiji Fisheries Division provided assistance of two staff, organisation of any formal or traditional permission needed to carry out research in the customary fishing grounds, local travel expenses including the use of a boat, arrangements of formal meetings and basic office space at the Fisheries Division's office.

METHOD

Field methods

A visit was made to the Bua fishing area from 12 September to 2 October and then from 17 to 25 November 1998 to complete all the required fieldwork. The fieldwork conducted in the target area included informal interviews with local fishermen in the area and fish retailers in Suva and fish surveys using underwater visual census (UVC).

Informal interviews

The usefulness of traditional information obtained from local fishermen in guiding fisheries research has been demonstrated by several researchers (Johannes 1981, 1987; Ruddle et al. 1992). The lack of baseline information on fishing activities in the Bua Province therefore made it appropriate to conduct informal interviews, to collect basic local information that could be useful in the preliminary assessment of the live reef fish potential.

Fishermen from two villages (Galoa and Tavea) in the Bua Province were interviewed on an informal basis with the help of the local fisheries project officer who acted as a translator. Fishermen were asked basic questions relating to fishing activities, fishing seasons, spawning seasons and spawning grounds for different species but with emphasis on the live reef fish target species. Questions were chosen carefully in order not to lead fishermen. Maps and fish charts were used as much as possible to facilitate locating fishing grounds and to make sure the correct species were talked about.

In addition to the interviews with local fishermen, fish shops in Suva were also visited and the managers or owners were interviewed in order to get an idea of the importance and value of the LRF target species on the local market. Particular attention was paid to those fish dealers purchasing fish from the Bua Province.

A list of the standard questions asked of fishermen and fish dealers is given in Appendix II.

Field surveys

Underwater visual census (UVC)

UVC is an inexpensive technique for providing rapid estimates of relative abundance, biomass and length frequency distributions of reef fish. It involves the counting and estimation of fish sizes observed underwater by divers on a given transect. It has been used extensively in reef fish studies of population dynamics, ecology and management (Thresher and Gunn 1986; Cappo and Brown 1996) as well as in studies to describe the effects of fishing on shallow water demersal reef fish (Russ 1985; Kulbicki 1988; Samoilys 1988; Russ and Alcala 1989; Ayling and Ayling 1992; Watson and Ormond 1994; Samoilys et al. 1995; Jennings and Polunin 1996). Samoilys (1992) and Samoilys and Carlos (1992) discuss the advantages and disadvantages of this method.

In this study the method was chosen because it enabled us to get a rapid assessment of the area in the limited time available, it was non-destructive and it was simple to use, requiring a minimum of manpower and simple equipment. Because of this simplicity the Fiji Fisheries could use the method to resurvey the area to monitor the fisheries through time.

For the study 50 m x 5 m strip transects were used. Sampling stations were selected randomly in both the inner reef and barrier reef areas but with sampling designed to look at the effects of depth (less than or equal to 10 m = shallow; greater than 10 m = deep) in both reef areas.

Densities and mean length of fish were estimated from the UVC surveys. From these biomasses were then calculated using length–weight relationships for the same species in New Caledonia (Letourneur et al. 1998). Where no such relationship existed, then the one for the closest species was used. Stocks were then estimated for the reef areas.

The accuracy of visual underwater fish size estimation is of great importance. It has been shown that such estimates can be improved with practice (QDPI; 1995; Samoilys (ed.) 1997). Time was therefore spent on practice trials.

An array of fish models of known sizes were tied on a string and placed underwater. Observers were then asked to estimate the sizes and compare their estimates with the actual known lengths. The exercise was repeated until each diver's estimates were consistently close to the known sizes. The exercise was compulsory for all observers who would be estimating fish sizes underwater.

With estimated mean sizes of the different targeted species known from the surveys, estimated mean weights (**W**) in grams of fish were calculated from the length–weight relationship:

$$\mathbf{W = aL^b} \qquad (1$$

L is the length in centimetres of fish from the transects and the values of **a** and **b** are estimated by ordinary least squares regression through a log transformation of the above equation to get the linear relationship:

$$\mathbf{Ln\ W = ln\ a + b\ ln\ L} \qquad (2$$

Published values of **a** and **b** for the same species (or, where not available, the closest relation, mainly derived from New Caledonia) were used. (Letourneur et al. 1998). With values of **W** known and densities calculated from the transects, it was possible to calculate the mean biomass (**B**) standardised to kg/1000m^2 for the different target species observed by using the relationship:

$$\mathbf{B = DW} \qquad (3$$

where D = density = number of fish per 1000 m^2

From the biomass estimates above, first estimates of the stock of each species for the area surveyed can be calculated from the equation:

$$\mathbf{S = Ba}$$

where B = biomass
a = total reef area in the fishing right area

Line intercept transects

To measure coral cover, a line intercept transect technique similar to that described by English et al. (1994) was used. A 20 m line intercept transect was done along with the 50 m fish transects to get an idea of bottom coral cover in the transect stations.

Substrate categorisation also followed that described in the English et al. (1994) survey manual where corals are grouped simply into acropora or non-acropora as either branching, encrusting, digitate, massive, submassive or tabulate and soft corals.

The sampling design

A total of 39 fish transects were done in 13 sampling stations. Twenty-four transects (8 stations) were selected randomly on the inner reef areas and 15 transects (5 stations) were on the barrier reef area (Figure 3). Based on anecdotal information obtained from the local fishermen, it seemed that the inner reef areas were generally fished more heavily than the barrier reef areas. All sampling stations were confined to reef areas, with no sampling on sandy bottom parts of the fishing right area. The total area sampled was 9.75 km^2 which is 2 per cent of the total reef area in the Bua fishing right area.

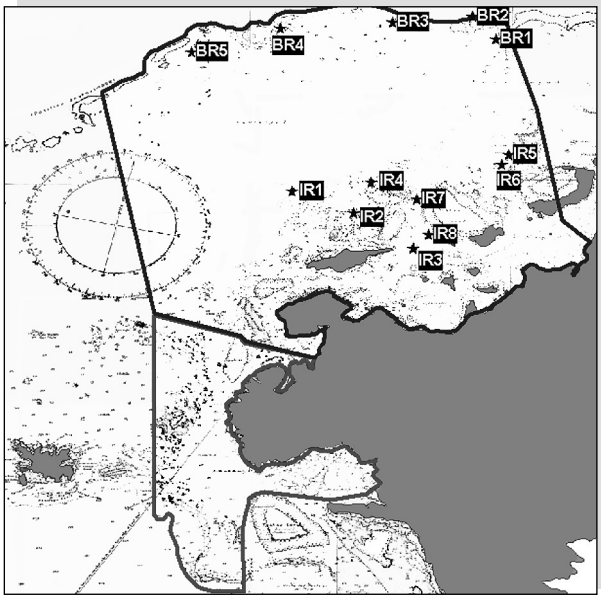


Figure 3: The sampling stations (BR = barrier reef, IR = inner reef) (Scale: 1:150,000)

The densities of adult fish have been correlated with reef-habitat characteristics such as height (Thresher 1983), size (Warner and Hoffman 1980), depth (Thresher 1983) and coral cover (Bell and Galzin 1984; Bell et al. 1985) to name a few. Depth and coral cover were therefore considered in the sampling design to measure their effects on the distribution and density of the targeted fish species in the fishing area. The depth margin chosen was 10 metres, thus all areas surveyed shallower or equal to 10 metres are regarded as the shallow sites and those deeper than 10 metres are the deep sites. Of the eight inner reef stations, four were considered deep and four were shallow. In the barrier reef stations, three were deep and two were shallow. This gave us seven deep stations and six shallow stations.

The study therefore considered two main sampling designs. The first design (Figure 4a) aimed to estimate and compare the densities of important LRFF species on the barrier reef area and the inner reef area and the second design (Figure 4b) aimed to estimate stocks in shallow and deep reef areas.

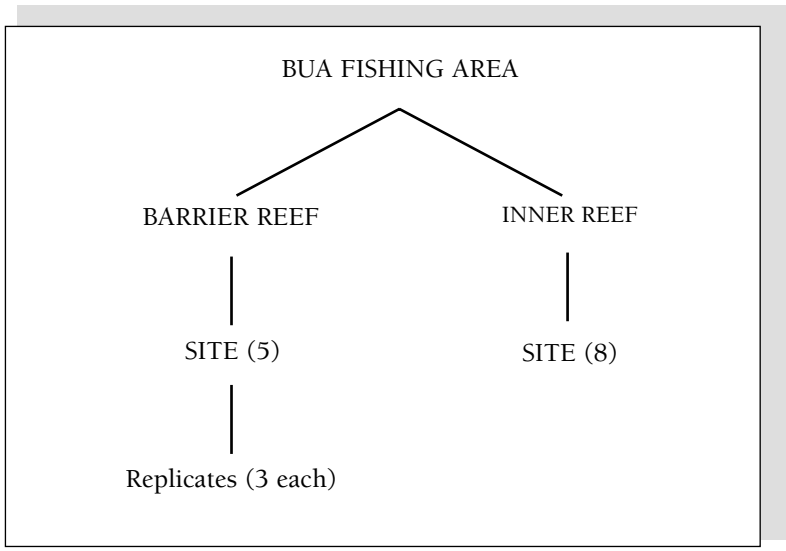


Figure 4a. The sampling design to estimate and compare density and biomass of LRFF species on barrier and inner reef areas of the Bua fishing area.

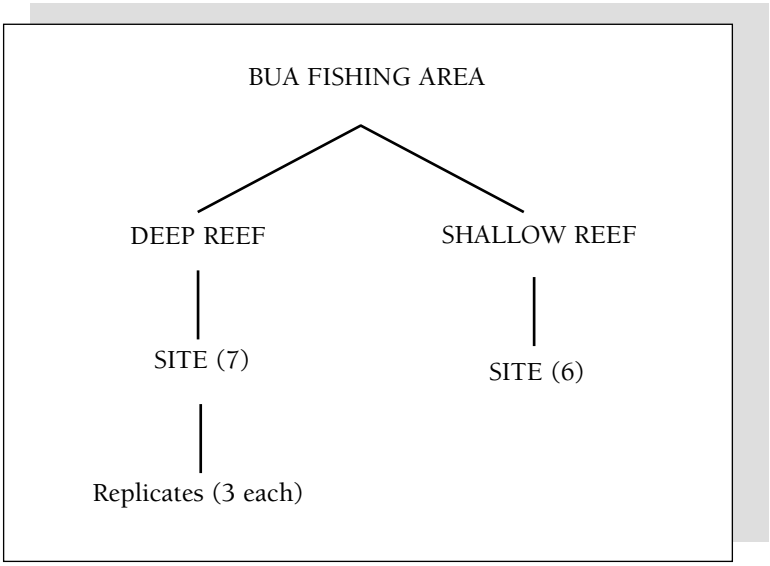


Figure 4b: The sampling design to estimate and compare density and biomass of LRFF species on deep and shallow reef areas of the Bua fishing area.

RESULTS

Fishing activities

Seven fishermen were interviewed. Three of the fishermen were from Galoa Island and four were from Tavea. Ages of the informants ranged from 39 years to 65 years. All informants were born on the islands and have been living on the islands all their life. From the interviews it became apparent that the community of Tavea does more fishing than the Galoa community. Part of the reason is that the fishermen of Galoa have recently become very involved in diving for bêche-de-mer, which has taken a lot of their fishing time.

The dominant fishing activity for both islands is handlining on the nearby reefs from small skiffs. These trips seldom go far, in order to save fuel and because most boats used are not big enough. The bigger boats on the islands, especially in Galoa, are all used for going out further from the shores to dive for bêche-de-mer. On Galoa there are about twenty people taking part in bêche-de-mer diving. All bêche-de-mer diving is done using hookah. The divers are fully aware of the dangers in using this apparatus (accidents have happened) but most of them feel it is the best way of getting good income for the family.

Other fishing activities include gillnetting on the shallow reef areas and spear fishing, which are more commonly practised by the fishermen from Tavea. In Galoa quite a number of women have taken the role of fishing, mainly gleaning on the nearby reefs for clams and crabs. Most fishermen fish mainly for subsistence, but when they have a surplus they sell it locally to other people in the community. On Tavea part-time commercial fishermen try to catch fish to sell to the middlemen based in Lekutu who then sell it to fish shops in Suva. Fishermen do not seem to target any particular species of fish.

Fish sales (local retailing)

Only a few fishermen from Galoa and Tavea engage in commercial fishing activities. Most of those who fish commercially are from the Labasa area or Dreketi; they sell their fish to a middleman who then ships it to the Suva market.

Reef fish sold to fish retailers are graded into three main categories: A, B and C. Most retailers only buy fish from fishermen within the A and B grades. The grading of fish varies between retailers and middlemen and also depends on supply and demand. The A grade fish, which sell at prices ranging from F$5.50 to F$6.50 per kilogram and include such fish as rockcods, trevallies, reef snappers and emperors. Barracudas are graded either A or B depending on the retailer. Prices of B grade fish are between F$4.30 and F$4.70 per kilogram.

Retailers in Suva who buy fish from the Bua area claim that they are not getting enough fish and therefore have to supplement their supply by buying New Zealand imported fish such as mullets, ling and snappers. Also, people are becoming more health conscious and this is causing a general increasing preference of fish over meat.

The total amount of fish coming from Bua and sold in the Suva market was estimated at 7–8 tonnzs per week. Of this only about 20–30% were species of interest to the LRFF trade.

Spawning aggregations and sites

Although fishermen interviewed claim that they are not fully aware of spawning seasons of fish species, the information they provided in relation to the quantities of particular fish at different times of the year suggested strongly that spawning seasons and aggregations do exist.

Most of the fishermen interviewed (all except for one) said that they have come across big schools of donu (*Plectropomus areolatus, P. laevis* and *P. leopardus*) while out fishing. Table 1 summarises the fishermen's observations.

Table 1: Spawning periods and sites obtained from fishermen interviewed

Fish species	Spawning period	Spawning aggregation sites
Plectropomus areolatus	October–December December–January September–December December September ? March	Ovatoa Reef passage Barrier Reef Nauqina Reef (pass connected to Tevoro Pass) Ovatoa Reef passage Marovo Reef Yanganga Island reef edge Nauqina Reef (pass connecting Tevoro Pass to Nandongo Reef)
Plectropomus leopardus	March ? No season	Nauqina Reef (pass joining to Barier Reef) Barrier Reef
Plectropomus laevis	October–December March	Ovatoa Nauqina Reef (pass connected to Tevoro Pass)
Epinephelus polyphekadion	July September–December	Ovatoa Reef passage Nauqina Reef (pass joining to Barrier Reef)
Valamugil seheli	November– April	Around Ovatoa Reef
Liza vaigiensis	November – April	Around Ovatoa Reef
Siganids	November–December December–January November–January but mainly in January	Around mangrove areas ? Reef edges around Nandongo Reef and Ovatoa Reefs Ovatoa Reef
Cheilinus undulatus	?	Ovatoa Reef
Lutjanus gibbus	?	Northern parts of Nandongo Reef and around rocks at Ovatoa Reef

Although the fishermen's opinions on spawning periods seemed to vary, especially for *Plectropomus areolatus*, there seems to be some common agreement that the spawning season is around about the southern summer months. Of the spawning aggregation sites noted, the Ovatoa passage and Nauqina Reef are the most referred-to areas. The possible spawning aggregation sites based on the results of the interviews are shown in Figure 5. Future plans for a sampling and monitoring programme should note the need to confirm these claims.

Figure 5. Possible spawning aggregation areas (grid-shaded) (Scale: 1:150,000)

Underwater visual census (fish transects)

A total of 39 fish transects were done in 13 sampling stations; 24 transects (8 stations) on inner reefs and 15 transects (5 stations) on the barrier reef area. This gives a total sampling area of 9.75 km^2 (2% of the total reef area in the fishing area).

Numbers of fish seen

In this sampling area, 75 fish were seen, comprising 12 species from four genera of interest in the LRFF trade (Table 2). Of these 11 species were seen on the inner reefs and only 7 on the barrier reefs. Considering the more important fish species for the LRFF trade, 4 species of the genus *Plectropomus* (coral trout) were seen on the inner reefs compared to only 2 species on the barrier reef. *Cheilinus undulatus* was observed in both the inner reef and barrier reef areas. The rest of the species were Serranids (rockcods and groupers).

Table 2: LRFF species seen on the transects

Species seen	Reef area seen	Nos seen
Cephalopholis argus	IR, BR	9
C. miniata	BR	1
Cheilinus undulatus	IR, BR	4
Epinephelus fuscoguttatus	IR, BR	3
E. maculatus	IR	4
E. merra	IR	6
E. ongus	IR	1
E. polyphekadion	IR, BR	3
Plectropomus areolatus	IR, BR	27
P. laevis	IR, BR	6
P. leopardus	IR	4
P. maculatus	IR	7

IR = Inner reefs, BR = Barrier reef

The numbers of most of the species seen during the survey were low, as shown in Table 2, except for *Plectropomus areolatus*. The low numbers could relate to the small sampling area. This has implications for the accuracy of the estimates for biomass and the stocks of those fish species. Therefore further calculations and processing of the results are limited to those species that occur in large enough numbers to give reliable estimates. This includes *Plectropomus areolatus, P. maculatus* and *Cephalopholis argus*. All the other Serranids are grouped and treated together whilst *Cheilinus undulatus* is considered too low in numbers to be included.

Mean lengths and weights of main species

Figure 6a shows the mean sizes of the three species that occurred at the inner and barrier reef stations while Figure 6b shows their calculated mean weights.

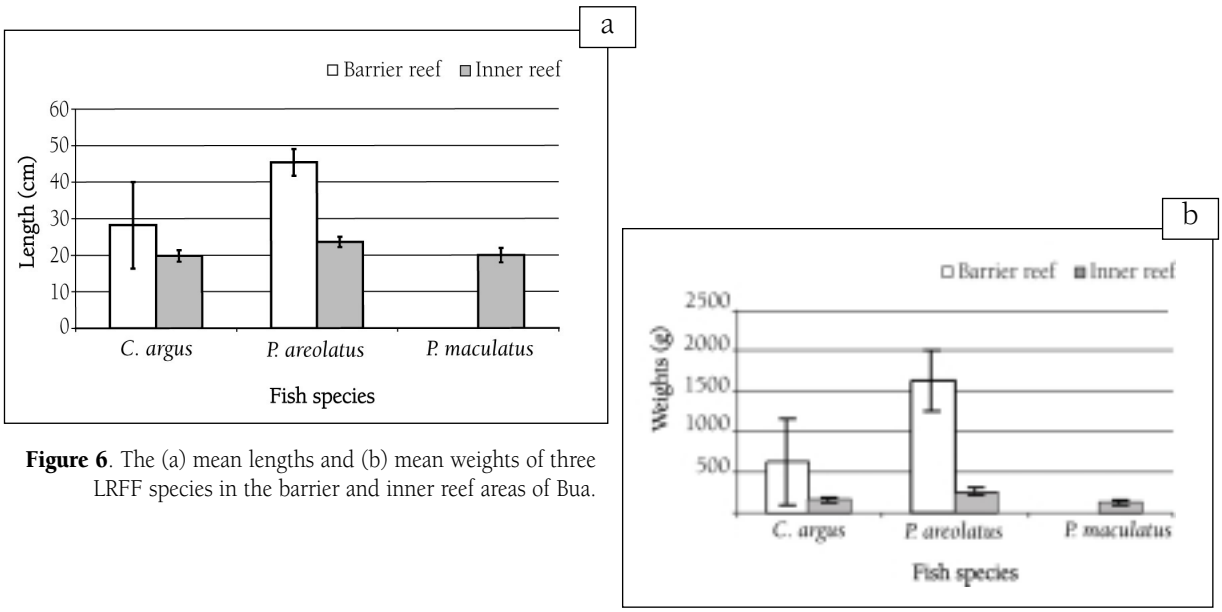


Figure 6. The (a) mean lengths and (b) mean weights of three LRFF species in the barrier and inner reef areas of Bua.

There is no significant difference between mean lengths and weights of *C. argus* found in the barrier reef and those found in the inner reef areas. *P. maculatus* was recorded only in the inner reefs. For *P. areolatus*, however, it seems that those fish found on the barrier reef stations are significantly larger in terms of length and weight than those in the inner reef areas. This is clearly demonstrated when comparing the size frequency of this species between the two reef areas (see Figure 7).

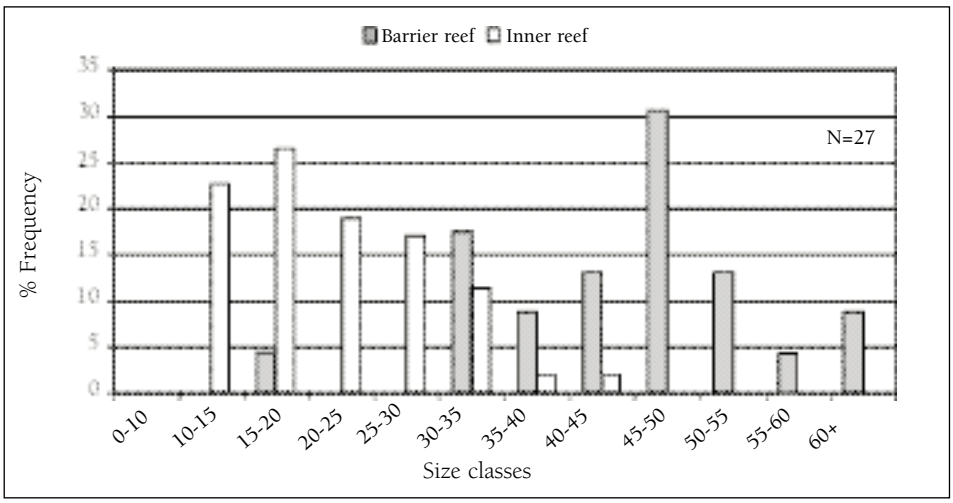


Figure 7. Length frequency distributions of *P. areolatus* in inner and barrier reefs of Bua

The mean size of fish in the shallow fishing areas (≤10 metres deep) was compared with those in the deep fishing area (>10 metres) over 7 fish species that were observed at the two different depths during the surveys (see Figure 8). Most of the four species recorded showed no apparent difference in mean lengths except for *E. maculatus*, which seemed to show preference of larger fish for deeper areas, and *P. maculatus*,

showing larger individuals in shallow reef areas. For the more important *P. areolatus* species, a simple t-test was conducted to compare the mean length of fish from the deep reef areas against shallow areas. The results confirm that there is a high significant difference ($P<0.05$), implying that larger *P. areolatus* are more likely to be found in deeper reef fishing areas.

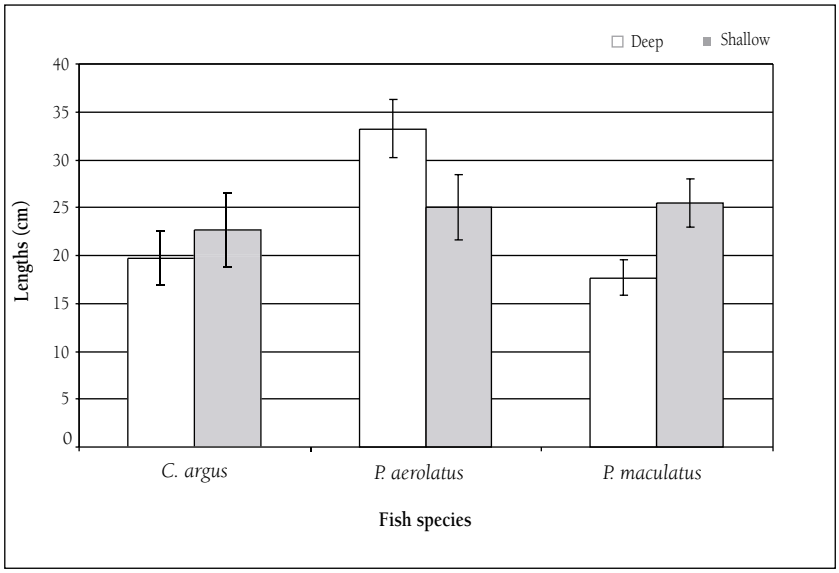


Figure 8. Mean length of LRFF species from deep and shallow stations in Bua

Fish density, biomass and stocks

It is important to note that for some fish species, numbers seen were low (less than 4 individuals). Fish densities calculated from these low numbers could give unreliable biomass and stock estimates and therefore caution should be taken when looking at figures for these species. It is recommended that these figures should be revised and refined with more surveys in the future.

Unfortunately we can only give very rough estimates of density and biomass for three species from our data, namely *P. areolatus, P. maculatus* and *C. argus* (see Table 3). The two latter species are not very important in terms of abundance or the LRFF trade and therefore will not be discussed in further detail.

Table 3. Overall mean density and biomass of selected species for the total Bua Province fishing area (with standard errors).

Species	Mean densities nos/1 000 m²	Mean biomass kg/1 000 m²	Mean stock Tonnes
Cephalopholis argus	2.05 ±0.69	0.53 ±0.26	274.75 ±134.68
Plectropomus areolatus	8.72 ±2.00	5.12 ±1.31	1604.10 ±438.10
Plectropomus maculatus	0.92 ±0.34	0.12 ±0.05	59.86 ±25.80
ALL SERRANIDS	15.59 ±4.73	7.46 ±2.64	2813.52 ±1123.53
TOTAL LRFF	16.00 ±6.79	8.74 ±4.42	3749.62 ±1613.06

Using the overall mean density of fish species for the total Bua fishing area, the estimated total LRFF stock in the area comes to about 3,750 tonnes. This is likely to be an underestimate since it has been shown, at least for some species (e.g *Plectropomus areolatus*), that length frequency distribution might be different in different reef areas (barrier or inner). However, the estimate is useful in giving a very rough picture of what is potentially there.

In any case the Serranids (groupers, rockcods and coral trouts) form an important part of the stock, constituting 75% of the total estimate. This proportion is dominated by *Plectropomus* species (51%), mostly of *P. areolatus* (82% of the *Plectropomus* total).

For *P. areolatus*, the density was found to be higher in the inner reef areas than the barrier reef areas (Table 4). Biomass however was the opposite, being higher in the barrier reefs than the inner reefs. This difference could be related to the size (weight) of fish; generally fish on the barrier are larger than those on the inner reefs (see previous section).

Table 4: Densities and biomass of P. areolatus on the inner eeefs and the varrier reefs (with standard errors)

Reef area	Densities nos/1 000 m²	Biomass kg/1 000 m²	Estimated stock (tonnes)
Inner	10.33 ± 3.08	2.15 ± 0.47	928.29 ± 204.19
Barrier	5.07 ± 1.48	8.04 ± 2.79	675.81 ± 233.91
Total	8.72 ± 2.00	5.12 ± 1.31	1604.10 ± 438.10

Considering these differences between the barrier and inner reef areas, it is more appropriate to calculate separate stock estimates for the two areas in order to get a more realistic stock estimate for the Bua fishing area. From the density estimates for the different fishing areas, the total stock estimate for *P. areolatus* comes to just over 1,600 tonnes of which 58% comes from the inner reefs and 42% from the barrier reefs (see Table 4).

Coral cover

The coral cover in the areas surveyed could be considered as generally good with no signs of bleaching or extensive damage by the few crown-of-thorns seen in the area during the dives. The diversity of coral forms was basically similar in the inner and barrier reef areas, including various soft corals, submassive, branching and digital acropora corals, tabular, massive and submassive non-acropora corals and various fungidae corals.

Some differences were seen between the inner reef and the barrier reef. Figure 9 shows the proportions of different coral types found in these two fishing areas. The inner reef was generally much more rubbly than the barrier reef. The dominant coral forms include: soft corals (13%), mainly *Lobophyton* spp., *Sinularia* spp. and *Dendronephthya* sp.; massive corals (8%), *Platygyra* sp.; encrusting acroporas (4%), *Montipora* sp. and *A. palifera;* and the fire coral (2%) (*Millepora*).

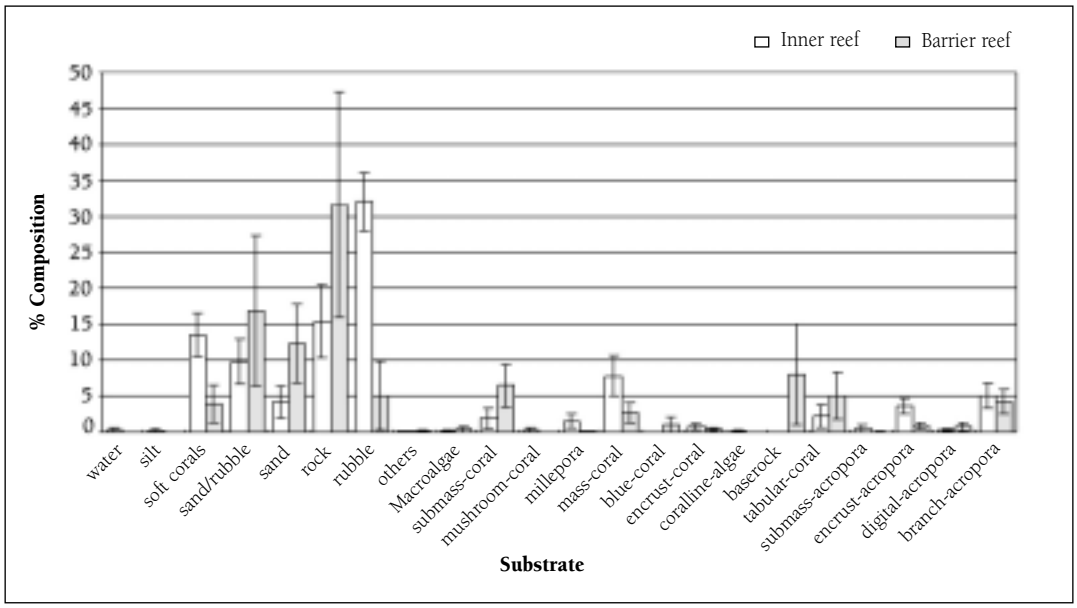


Figure 9. Bottom type of inner reef stations and barrier reef stations in Bua

The barrier reef areas were more rocky (32%), with basement rock (8%) and sandy to rubbly areas being more common (29%). The patchy live coral cover was dominated by submassive Porites (7%), *Heliopora* (2%), and a few acropora especially of the branching type *A. grandis* (4%).

The strong correlation of live coral cover to the abundance of fish has been reviewed in depth (Doherty and Williams 1988; Williams 1991) and proven in many studies (Bell and Galzin 1984; Bouchon-Navaro et al. 1985; Eckert 1987; Hourigan et al. 1988). The present study does not intend to prove these claims but looks at coral cover as a check on the abundance of live reef fish species recorded.

Comparing the two different reef areas, it seemed that the inner reef area has slightly more live coral on average per area surveyed (37%) than the barrier reef area (26%), which seemed to relate well to the higher density of *P. areolatus* described on pages 13–14. This difference therefore supports the separate calculation of biomass for the two different reef areas.

FINDINGS AND RECOMMENDATIONS

General findings

The study was intended to give a snapshot view of the current status of the reef fish species with potential for the live reef fish trade. The primary aim of such a study is to give indications of what is there. The actual stock estimates of the different fish species are expected to provide some basis for management decisions before more information becomes available. The information gathered from the interviews and the underwater surveys, although preliminary, provides baseline data that will be valuable in directing future efforts to further knowledge and understanding of the live reef fish species.

The results obtained from the interviews strongly indicate that local fishing efforts are mostly concentrated on the nearby reefs. The lack of big boats, the cost of fuel and the safety consciousness of local fishermen are major factors that contribute to concentrating fishing efforts on the nearby reefs rather than the Great Sea reefs. Unfortunately it seems from the interviews that one of the most commonly fished nearby reefs is a possible spawning aggregation site for the *Plectropomus* species and some of the groupers.

Fisheries Division should follow up the information from the interviews to try and verify the location of the spawning aggregation sites and periods. Once this has been verified then it is recommended that a ban be put on fishing at spawning aggregation sites.

The accounts of some fishing trips described by some local fishermen indicate that there has been quite a lot of fishing during spawning aggregations done unintentionally. There is a great possibility that this may have taken its toll by reducing the stocks of some of these Serranids. There is however a strong need for the Fisheries Division to take steps to find out more about these spawning aggregation periods and sites. This could be simply done by monitoring fish catches from the area and by visiting the potential aggregation sites at least once a month (for a year), possibly more frequently during those months that have been reported to be spawning aggregation times.

It was also evident that quite a large number of fishermen from Galoa Island are involved with bêche-de-mer diving. All of these fishermen use hookahs, and it is important to make sure that hookahs are not used in the live reef fish trade. Fisheries should undertake an awareness programme showing the dangers of using hookahs (with examples from Asia) and then follow this up by establishing regulations against its use in the live reef fish trade.

The results from the underwater surveys provided some first estimates of the status of the stock. The results showed that among the Serranids *Plectropomus areolatus* is the most abundant and most important species in both in the inner reef and the barrier reef areas. However, the mean lengths of this species differ between the two areas, with the larger fish found on the barrier. This could be the result of overfishing on the inner reefs as they are closer to the fishing villages of the area.

For the live reef fish trade, *P. areolatus* is likely to be the main target species, being the only species that occurred in good abundance and being one of the preferred species in the trade. The estimated total of the

species for the whole fishing area is just over 1,600 tonnes. This is equivalent to a wholesale value of US$56 million in the Hong Kong market (based on 1994 prices in Johannes and Riepen 1995). The maximum sustainable yield for the area was difficult to estimate with the information available but is expected to be much less. This lack of information calls for a monitoring programme.

The size of this fish is an important factor to consider in the live reef food fish trade. The mean length of *P. areolatus* in the inner reef areas is about 23.6 cm compared to 45.4 cm on the barrier reefs. This equates to weights of 0.26 kg and 1.6 kg respectively. With the preferred weights of fish in the LRFF market being between 0.8 and 1.5 kg, the best area to fish would be the barrier reef.

For the inner reefs the smaller coral trouts should be investigated further. Considering the small size of the fish and the possibility that spawning aggregation areas are located in the inner reefs, then suspending fishing for coral trout species and imposing size limits for subsistence fishing are a possible management option as a start. Once the spawning periods and sites have been worked out then these areas should be marked and set up as marine reserves where fishing is banned.

The valuable *Cheilinus undulatus* was seen in very low numbers. Although our survey results would need to be verified by more surveys, the very low numbers should be noted and a total ban on fishing for this species should be considered as a precautionary approach before more information and survey results are available. Such a ban should go in line with efforts to start research into the ecology and biology of the fish species.

The numbers of other Serranids and other fish species counted on the transects were too low to give reliable estimates. The general low density could be a result of underestimation relating to the sampling method used; the width of the transect was fixed at 5 metres and therefore with limited time the sampling area was very small in relation to the total fishing area. This could be improved by doing a lot more transects in the future and possibly by adopting a transect method of unfixed widths which would enable surveying of more extensive areas.

This new industry should be carefully monitored and controlled. Information and experience from South East Asia should be used to avoid repeating mistakes and to make the industry a sustainable one.

There is a strong need to set up management regulations backed up by specific legislation for the trade. The legal framework already exists under the Fisheries Act for the imposition of specific legislation and regulations for better management of a live reef fish trade operation. The legislation and regulations would need to be carefully worded in order to be effective as a management measure for the live reef fish trade.

The customary fishing rights law provides an effective local framework for keeping control of fishing activities in the fishing area and for enforcing regulations; a small council made up of all the different parties involved should be formed and empowered to protect the interest of the resource owners. A coordinated plan for enforcing regulations, together with an outline of the different responsibilities, should be established to ensure that enforcement efforts are well supported from the community level right through to the government.

Proposed management policy guidelines

1 The government regulatory agencies should recognise the live reef fishery as a distinctive fishery and therefore should:

(a) License it separately from other fishing activities.
(b) Have carefully worded contracts between the company and the government and resource owners, to ensure environmentally and economically sound operations.
(c) Establish a catch and export monitoring programme with companies being responsible for maintaining record sheets and logs of catch–effort data and submitting them regularly to the relevant government agency.
(d) Ban transshipment of live reef fish at sea; require all live reef fish transport vessels to clear from a recognised port or airport where they can be checked and monitored before departing for Hong Kong.

(e) Consider placing spawning aggregation sites of target species off limits to commercial fishing, or close commercial fishing entirely during spawning seasons.
(f) Ban the possession, use, storage and/or transportation of any explosives or noxious substances (including sodium cyanide) on all fishing boats, fish transport vessels and LRF operators' facilities.
(g) Ban the possession, use, storage and/or transportation of compressed air (scuba and hookah) on live reef fishing boats and fish transport vessels.
(h) Provide advice and awareness materials to local fishermen and communities concerning the problems associated with live reef fishing and how to minimise them.
(i) Provide advice to resource owners or local entrepreneurs who wish to enter into a formal agreement with a live reef fish export company to strengthen their ability to negotiate with foreign dealers.
(j) Restrict fishing for live reef fish to locals only to maximise benefits to the local community and to encourage the idea of resource owners taking care of their own resource.
(k) Ban the export of the fingerlings of live reef fish, and place size limits on adult target fish species.
(l) Place an export ban on wild-caught *Cheilinus undulatus* (Maori wrasse/napoleon fish) until a full stock assessment in the fishing right area has been completed.
(m) Consider an environmental impact assessment (EIA) for each live reef export operation, the costs of the EIA to be borne by the LRF operator.
(n) Establish an annual underwater visual census monitoring programme that would be coordinated and carried out by the Fisheries Agency with assistance provided by local divers who have been trained in using the method. The costs of fuel and hire of survey equipment where necessary should borne by the LRF operator.

2 The government should ensure that an incoming company provides as much detail as possible about its intended operation in its initial proposal. The details of the plan should include as a minimum:

(a) A detailed description of the proposed operation.
(b) Ownership, control and management of the operation/company.
(c) Target species.
(d) How fishermen would hired, used and paid.
(e) A summary of negotiations with the customary owners and any agreements or terms reached.
(f) Fishing methods, equipment and treatments to be used.
(g) Infrastructure (existing and proposed).
(h) Human resource requirements, noting clearly where foreigners or non-citizens would be required, what they would be doing and for how long.
(i) Training components (a detailed plan), stating clearly where locals would be trained, what training they would get, and reasons.
(j) Fish storage, processing and transportation mechanisms.
(k) The proposed market.
(l) Operational budget.

The licence agreement

The live reef fishing licence agreement should be carefully worded and should be in line with the present fisheries laws and regulations as well as encompassing the customary ownership laws. At the minimum the licence should be awarded along the following rules and conditions. Any non-compliance with these conditions should result in suspension and loss of the licence.

(a) Licences should be issued for specific locations or areas for a maximum of one year, renewable upon review.
(b) One operator per designated area is permitted.
(c) The LRF company should endeavor to resolve customary ownership rights and compensation issues before the licence is awarded. The applicant must produce a signed agreement with the recognised customary owners in which the terms of access and usage are explicitly set out. Any terms of the agreement must not conflict with national or provincial laws or policies and must be endorsed by the respective provincial authorities in the presence of an authorised Fisheries Licensing Officer(s) before a licence can be issued.

(d) Where foreign vessels are used, the foreign crewmembers should be limited to a minimum required to operate the vessel and maintain the fish.
(e) Foreigners or non-citizens should not be involved in the actual capturing process except for training purposes.
(f) LRF transport vessels should not be allowed to do any fishing.
(g) Fish should not be delivered or transshipped to another vessel without prior written permission.
(h) The size of the LRF transport vessel and the number of holding pens should be limited in relation to the proposed and agreed production target.
(i) The licensee must permit a fisheries officer to board the vessel at any time and provide accommodation for the officer free of charge while the vessel is operating under license.
(j) Export of live reef fish should be done only from designated ports or airports.
(k) The use, storage and/or transportation of scuba or hookah equipment should not be permitted.
(l) The use, storage and/or transportation of any explosives or noxious substances (including sodium cyanide) for the purpose of killing, stunning, disabling or taking of fish should not be permitted.
(m) Licensees must maintain a detailed daily record of catches or purchases as required by Fisheries in a prepared record form. The records should be submitted every month. The Fisheries Division would treat these data with strict confidentiality.
(n) The vessel, its owners, operators and crew must protect the coral reefs from damage at all times during the fishing and vessel operation.
(o) With the LRF trade being considered as a limited-entry fishery then it is only appropriate to impose fees for access to the resources as a licence condition.

To go with the management regulations and enforcement, a good monitoring programme is essential to make sure that the companies are continuously in compliance with the rules as well as to collect basic information that will be valuable for the future management and development of the industry. A monitoring programme is proposed below. The actual forms could be obtained from the Reef Fishery Assessment and Management Section of the SPC Coastal Fisheries Programme.

The monitoring programme

Data collection programme

A data collection system was therefore proposed which involves most of the players in the fishery. Data collection is made a requirement and responsibility of the LRFF company. The Fisheries Division is however the main authority, taking charge of regular monthly record submissions by the company, collecting biological information on fish that died during the handling stages, processing and analysing the data and reviewing management decisions and options.

The proposed data collection programme consists of four sheets to be filled in as described below.

1. Fishing data sheet. To be filled in by the fishermen as they go out on a fishing trip. It basically details information on the fishing effort, fishing conditions, fishing location(s) and fish catches (species, length and weight). These are to be handed in to the LRFF company site manager on arrival at the LRFF holding cage site after the trip.

2. Catch summary form. To be filled in by the LRFF company site manager when stocking the holding cages. It records the number and weight of fish put into the holding cages by species and also records the species, number and weight of fish that are dead at this stage of handling. The dead fish are to be kept aside for further data collection. Dead fish later found in the holding fish cages should also be recorded on this form.

3. Biological data sheet (dead fish). This is to be filled by the Fisheries officer in charge of the LRFF industry. It collects biological information on the dead fish collected during handling. The data sheet records species, length, weight, sex, maturity stage, gonad weight and stomach content. The Fisheries officer is expected to be responsible for this, but we anticipate problems keeping dead fish frozen until the Fisheries officer visits the holding cage station rather than selling the fish fresh. The ideal solution is to train someone on site on how to handle the fish, sex, measure, weigh and gut. We therefore propose that the Fisheries officer organise with the site manager to have the dead fish measured, weighed, sexed

(gonads should also be weighed), and gutted. The guts can then be frozen in a sealed plastic bag properly labelled for later identification.

4. Export data sheet. This is the final sheet to be filled in before the live fish are exported overseas. It is to be filled by the LRFF company site manager, and is basically a record of the species, numbers and weight of fish exported live overseas.

The data sheets have been designed for filling in with the minimum effort. The sheets to be filled in by the site manager are records that they would need to keep for themselves anyway. Coding the data is a desk job for the Fisheries officer, a list of codes used is provided. The SPC Reef Fishery Assessment and Management Section would continue to provide assistance where required to get the monitoring programme off the ground, especially in data analysis. All information would be kept confidential.

Resource assessment

Resource assessment forms the second part of the monitoring programme and is basically the Fisheries Division's responsibility. The purpose of the assessment work is to observe the long-term impact of the industry on the reef fish stocks, check regularly for signs of destructive fishing methods such as 'cyanide-fishing', and build up information on spawning seasons and spawning aggregation sites. It is recommended that field assessment should be done twice a year for the first two to three years and then once a year after that.

The fieldwork would involve using the underwater visual census (UVC) method. The method used should be consistent for every sampling done. Some training on the UVC method used was given to the local village divers and Fisheries personnel involved in the study. The SPC Reef Fishery Assessment and Management Section could however provide further training on an improved version of this method that would be standardised as a package (field method and analysis tools) throughout the region for possible comparison with other areas.

REFERENCES

Ayling, A.M. and Ayling, A.L. (1992). Bramble Reef replenishment area – baseline survey. Report to the Great Barrier Reef Marine Park Authority. 22 p.

Bell, J.D. and Galzin, R. (1984). Influence of live coral cover on coral-reef fish communities. Mar. Ecol. Prog. Ser. 15:265–274.

Bell, J.D., Harmelin-Vivien, M.L., and GALZIN, R. (1985). Large scale spatial variation in abundance of butterflyfishes (Chaetodontidae) on Polynesian reefs. Proceedings 5th International Coral Reef Symposium 5:421–426.

Bouchon-Navaro, Y., Bouchon, C. and Harmelin-Vivien, M. L. (1985). Impact of coral degradation on a chaetodontid fish assemblage (Moorea, French Polynesia). Proceedings 5th International Coral Reef Symposium, Tahiti 5:427–432.

Cappo, M. and Brown, I.W. (1996). Evaluation of sampling methods for reef fish populations of commercial and recreational interest. CRC Reef Research Centre, Tech. Rep. No. 6, Townsville 72 p.

Doherty, P.J. and Williams, D.McB. (1988). The replenishment of coral reef fish populations. Oceanography and Marine Biology Annual Review 26:487–551.

Eckert, G.J., (1987). Estimates of adult and juvenile mortality for labrid fishes at One Tree Reef, Great Barrier Reef. Mar. Biol. 95:167–171.

English, S., Wilkinson, C. and Baker, V. (1994). Survey manual for tropical marine resources. ASEAN–Australia Marine Science Project: Living Coastal Resources. Australian Institute of Marine Science, Townsville. 368 p.

Fong, G.M. (1994). Case study of a traditional marine management system, Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. FAO, Rome. 85 p.

Hourigan, T.F., Tricas, T.C. and Reese, E.S. (1988). Coral reef fishes as indicators of environmental stress in coral reef. In: D.F. Soule and G.S. Kleppel (eds), Marine organisms as indicators. Springer-Verlag, New York. 107–136.

Jennings, S. and Polunin, N.V.C. (1996). Effects of fishing effort and catch rate upon the structure and biomass of Fijian reef fish communities. J. Appl. Ecol. 33:400–412.

Johannes, R.E. (1981). Words of the lagoon: fishing and marine lore in the Palau district of Micronesia. University of California Press, Berkeley. 245 p.

Johannes, R.E. (1987). Traditional beliefs and fisheries management in Oceania. Naga, the ICLARM Quarterly, October 1987:5.

Johannes, R.E. and Riepen, M. (1995). Environmental, economic, and social implications of the live reef fish trade in Asia and the Western Pacific. Report to the Forum Fisheries Agency and the Nature Conservancy. 81 p.

Jones, R.J. (1997). Effects of cyanide on coral. SPC Live Reef Fish Information Bulletin No. 3:3–8.

Kulbicki, M. (1988). Correlation between catch data from bottom longlines and fish censuses in the SW lagoon of New Caledonia. Proceedings 6th International Coral Reef Symposium, Australia 2:305–312.

Letourneur, Y., Kulbicki, M. and Labrosse, P. (1998). Length–weight relationship of fishes from coral reefs and lagoons of New Caledonia – an update. Naga, the ICLARM Quarterly 21(4):39–46.

Queensland Department of Primary Industries (QDPI). (1995). Application of underwater visual census to assessing coral reef fish stocks in the Tropical Pacific. Project No. 9304. Final Project Report.

Richards, A., Lagibalavu, M., Sharma, S. and Swamy, K. (1994). Fiji fisheries resource profiles. FFA Report No. 94/4. 166 p.

Ruddle, K., Hvding, E. and Johannes, R.E. (1992). Marine resources management in the context of customary tenure Marine Resource Economics 5:351–363.

Russ, G.R. and Alcala, A.C. (1989). Effects of intense fishing pressure on an assemblage of coral reef fishes. Mar. Ecol. Prog. Ser. 56:13–27.

Russ, G.R. (1985). Effects of protective management on coral reef fishes in the Central Philippines. Proceedings 5th International Coral Reef Symposium, Tahiti 4:219–224.

Samoilys, M.A. and Carlos, G. (1992). Development of an underwater visual census method for assessing shallow water reef fish stocks in the south-west Pacific. ACIAR Project PN8545. Final Report, April 1992. 100 p.

Samoilys, M.A. (1988). Abundance and species richness of coral reef fish on the Kenyan coast: the effects of protective management and fishing. Proceedings 6th International Coral Reef Symposium, Australia 2:261–266.

Samoilys, M.A. (1992). Review of the underwater visual census method developed by the DPI/ACIAR project: visual assessment of reef fish stocks. Conference and Workshop Series QC92006. Department of Primary Industries, Queensland. 55 p.

Samoilys, M. (ed) (1997). Manual for assessing fish stocks on Pacific coral reefs. Training series QE97009. Department of Primary Industries, Queensland. 78 p.

Thresher, R.E. (1983). Environmental correlates of the distribution of planktivorous fishes in the One Tree Reef lagoon. Mar. Ecol. Prog. Ser. 10:137–145.

Thresher, R.E. and Gunn, J.S. (1986). Comparative analysis of visual census techniques for highly mobile reef associated piscivores (Carangidae). Environ. Biol. Fishes 17(2):93–116.

Warner, R.R. and Hoffman, S.G. (1980). Population density and the economics of territorial defense in a coral reef fish. Ecology 61:722–780.

Watson, M. and Ormond, R.F.G. (1994). Effect of an artisanal fishery on the fish and urchin populations of a Kenyan coral reef. Mar. Ecol. Prog. Ser. 109:115–129.

Williams, D.McB. (1991). Patterns and processes in the distribution of coral reef fishes. In: P.F. Sale (ed), The ecology of fishes on coral reefs. Academic Press Inc., Sydney.

APPENDIX I

MEMORANDUM OF UNDERSTANDING
BETWEEN THE PEOPLE OF GALOA AND SATELLITE SEAFOODS (FIJI) PTY LTD

Satellite Seafoods Pty (Fiji) Ltd of Australia will have a permit to operate from Galoa Island in the Tikina of Lekutu and the Province of Bua situated on the North Western coast of the island of Vanua Levu. This memorandum of understanding binds the above company and the people of Galoa Island to ensure the smooth operation of the live reef fish trade there after endorsements from respective parties and the Fiji Fisheries Division on this document.

1. Satellite Seafoods Pty (Fiji) Ltd will purchase live reef fish from the fishermen in the Province of Bua at a price of $F10.00 per kilogram according to the size requirements and species as specified in their original proposal to Fiji Fisheries Division. The company reserves the right to reject fish which they believe is not in a healthy condition and not fit for the live reef fish trade. An initial payment of $F4.00 per kilogram will be made to the fishermen bringing the fish to the sea cages constructed by the company at suitable locations in the proximity of Galoa Island. The balance of $F6.00 per kilogram will be paid after the fish is loaded on to the live fish transport vessels from Hong Kong.

2. Satellite Seafoods Pty (Fiji) Ltd. will share the fishermen's training expenses, and the knowledge gained with the Fisheries Division. All the interested fishermen will be trained to enable them to undertake this trade.

3. Satellite Seafoods Pty (Fiji) Ltd will employ locals from Galoa Island and the Province of Bua whenever opportunities arise provided the locals have the required skills.

4. Satellite Seafoods Pty (Fiji) Ltd will provide three dories with engines to Galoa Island selected fishermen depending on their performance.

5. Anchorage will be provided at Galoa Island for a barge for the purpose of housing a caretaker.

6. Provisions for the supply of fuel to the fishermen will be accommodated by Satellite Seafoods Pty (Fiji) Ltd at the normal market price.

7. Satellite Seafoods Pty. (Fiji) Ltd will make provisions to maintain regular supply of fresh water to the people of Galoa Island.

8. The costs of extra running hours of the electricity generator on Galoa Island and Satellite Seafoods Pty (Fiji) Ltd if the need arises, will be borne by Satellite Seafoods Pty (Fiji) Ltd.

9. Progress meetings between the people of Galoa Island and Satellite will be conducted every three months in the presence of officials from Fisheries Division and the Bua Provincial office. Financial reports will be compiled and presented by the company accountant to the Fisheries Division and the Bua Provincial Office.

10. Satellite Seafoods Pty (Fiji) Ltd will offer shares to the people of Galoa Island/Bua Province after twelve months of operation. These will be reviewed at the three monthly meetings. The first twelve months should see Satellite Seafoods Pty (Fiji) Ltd on a sound footing.

11. Fishing gears for the purpose of catching live reef fish will be provided by Satellite Seafoods Pty (Fiji) Ltd free of charge initially. However fishermen will be required to purchase their own from the company after this.

12. Satellite Seafoods Pty (Fiji) Ltd will wherever possible assist the local fishermen in the marketing of the by-catch (any dead fish or species not suitable for the live reef fish trade).

Signatories

Galoa Island rep.
Galoa Island rep.
Galoa Island rep.
Satellite Seafoods Pty (Fiji) Ltd
Fisheries Division
Bua Provincial Council

APPENDIX II

A. Questions asked of local fishermen

- How old are you?
- How long have you lived here?
- How long have you been fishing?
- What kind of fishing do you do?
- Where do you usually go fishing?
- Do you target any particular fish species?
- During the time you have been fishing have you noticed big schools of a particular fish? (If yes) What fish was it? (A fish picture book was used to identify the fish) And how big was the school? (in terms of area covered)
- How many individuals approximately were there in the school?
- When did you see the school?
- Where did you see the school? (Reef area was identified with aid of a map and the name of the reef was recorded if known)
- Do you have any general knowledge of spawning aggregations and spawning seasons in the Bua fishing area that you personally have observed or have learned from your forefathers or other older fishermen through their past experiences?

B. Questions asked of fish dealers

- Where do you get your fish?
- How much fish do you usually get or need every week?
- What is the demand for fish like?
- Do you target on selling particular fish species?
- What is the most popular fish among your customers?
- How much do you buy your fish for?
- How much do you sell your fish for?

Data Collection Sheets

1. Codes for filling in data forms

Sex codes

Male	1
Female	2
Immature	3
Indeterminate	9

Sexual stages
(gonad condition)

STAGE	MALES	FEMALES
Stage 0	Thread	Thread
Stage 1	Long and thin	Slight vascularisation
Stage 2	Does not run when cut	Opaque, no eggs visible
Stage 3	Runs slightly when cut	Granular appearance
Stage 4	Runs when cut	Eggs beginning to break away
Stage 5	Runs when pressed	Eggs can be pressed out
Stage 6	Gonad flaccid & pale (after spawning)	Gonad flaccid; gonad cavity empty (after spawning)
Stage 9	Indeterminate	Indeterminate

Stomach content codes

Empty		0
Fish		100
Crustaceans		200
	Crabs	210
	Shrimps	220
Molluscs		300
	Bivalve	310
	Gastropod	320
	Crayfish	342
Worms		400
Echinoderms		500
	Urchin	510
	Starfish	540
	Sea cucumber	550
Algae		600
Others		700
	Soft coral	710
	Sponge	720
	Jellyfish	740

2. Biological data sheet (dead fish)

								Stomach content							
Ref.	Species	Code	Length (mm)	Weight (g)	S	St	G.W. (g)	Code	%	Code	%	Code	%	Code	%
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															
/															

3. Catch summary

Ref. Record number / Year

Fisher's code

Species	Code	N alive	W (kg) alive	N dead	W (kg) dead
	Total				

4. Customs data sheet

	Record number		Year
Ref.		/	

Species	Code	N alive	W (kg) alive
	Total		

5. Fishing data sheet

Record number **Year**

Ref. ⌊⌊⌊⌊⌊⌋⌋⌋⌋⌋ / ⌊⌊⌋⌋

Month **Day** **Year**

⌊⌊⌋⌋ / ⌊⌊⌋⌋ / ⌊⌊⌊⌊⌋⌋⌋⌋

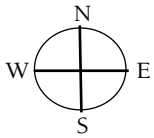
FISHERMAN

Name **Code**

⌊_____⌋ ⌊⌊⌊⌊⌋⌋⌋⌋

WEATHER

Wind direction



Wind spreed ⌊⌊⌋⌋ **knts**

Clouds coverage (%) ⌊⌊⌊⌋⌋⌋

Conditions of the sea[1] ⌊⌋

FISHING INFORMATION

Location 1 (name) ⌊_____⌋

Travelling time ⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn

Mean speed of boat ⌊⌊⌋⌋ knts

Time of arival	Time of departure	Bottom types [2]	Number of lines	Number of hooks/line
⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌋	⌊⌊⌋⌋	⌊⌊⌋⌋

Location 2 (name) ⌊_____⌋

Travelling time ⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn

Mean speed of boat ⌊⌊⌋⌋ knts

Time of arival	Time of departure	Bottom types [2]	Number of lines	Number of hooks/line
⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌋	⌊⌊⌋⌋	⌊⌊⌋⌋

Location 3 (name) ⌊_____⌋

Travelling time ⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn

Mean speed of boat ⌊⌊⌋⌋ knts

Time of arival	Time of departure	Bottom types [2]	Number of lines	Number of hooks/line
⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌋	⌊⌊⌋⌋	⌊⌊⌋⌋

Location 4 (name) ⌊_____⌋

Travelling time ⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn

Mean speed of boat ⌊⌊⌋⌋ knts

Time of arival	Time of departure	Bottom types [2]	Number of lines	Number of hooks/line
⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌋	⌊⌊⌋⌋	⌊⌊⌋⌋

Location 5 (name) ⌊_____⌋

Travelling time ⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn

Mean speed of boat ⌊⌊⌋⌋ knts

Time of arival	Time of departure	Bottom types [2]	Number of lines	Number of hooks/line
⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌊⌋⌋ h ⌊⌊⌋⌋ mn	⌊⌋	⌊⌊⌋⌋	⌊⌊⌋⌋

[1] 1 = calm, 2 = low rough, 3 = rough, 4 = very rough, 5 = heavy, 6 = very heavy, 7 = enormous

[2] 1 = barrier reef, 2 = intermediate reef, 3 = fringing reef, 4 = bottom lagoon, 5 = mangroves and estuarines.

5. Fishing data sheet (cont'd)

Fish Catch

Species	Code	Length (mm)	Weight (g)	Loc.[1]

[1] Location : 1, 2, 3, 4 or 5