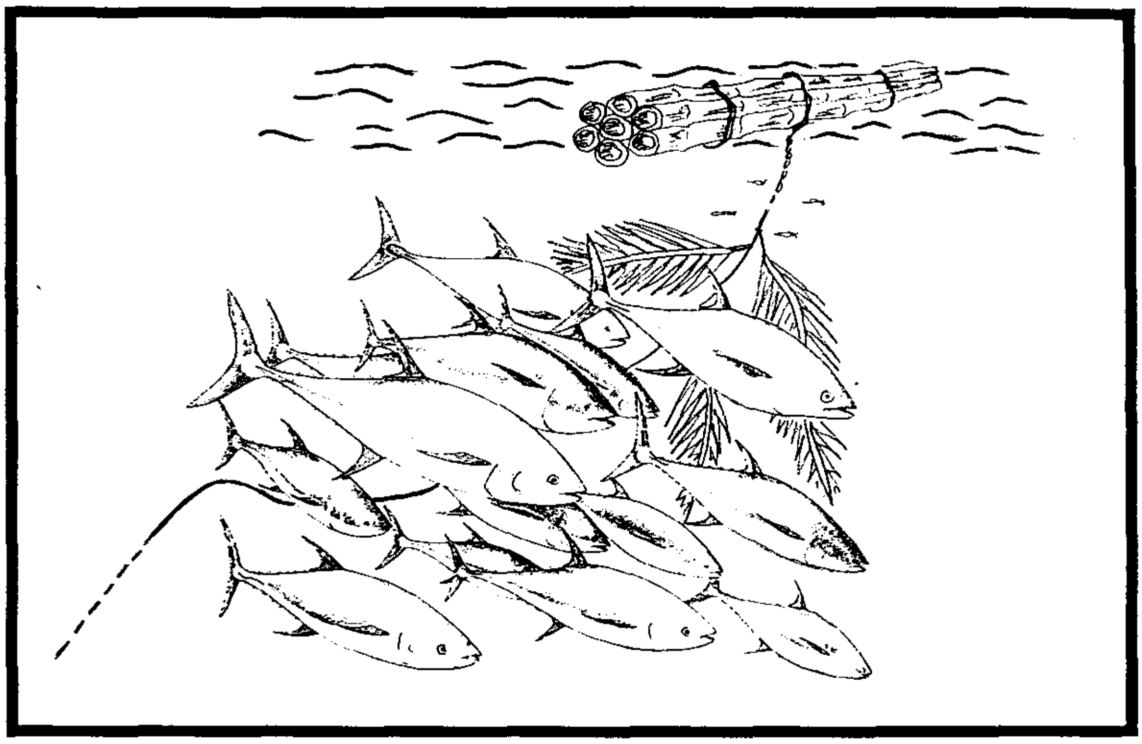
THE ASSESSMENT OF THE INTERACTION BETWEEN FISH AGGREGATING DEVICES AND ARTISANAL FISHERIES

Document 3: Fiji Country Report



FISHERIES MANAGEMENT SCIENCE PROGRAMME

OVERSEAS DEVELOPMENT ADMINISTRATION

Project R. 4777

MRAG Ltd

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Contents

Executive Summary

Fish Aggregation Devices (FADs) have been deployed around the islands of Fiji for over a decade. The 1982 Annual Report of the Fiji Fisheries Division argued that '[FADs can reduce] the usual time- and fuel-consuming activities of searching out and chasing schools of tuna. This could ease commercial fishing pressure on coastal reefs and lagoons, especially those around urban centres.' Anecdotal reports suggest that most sites have been successful in both aggregating fish and fishermen, particularly for FADs deployed off Suva on Viti Levu and at a number of sites off the west coast of Vanua Levu.

Constraints on the financial resources of the Fiji Fisheries Division have prevented any detailed assessment of the value of FADs, their contribution to overall fisheries production and how they actually perform one of their main roles of reducing fishing effort on heavily exploited reef and estuarine resources. This lack of detailed knowledge of the performance of FADs is currently hindering the efficient use of the allocated budget, some of which is routinely used on alternative programmes within the Fisheries Division's extensive workplan.

This research project had two objectives; firstly to gather information on the benefits and value of the FAD programme to local fishers and secondly to develop a better understanding of the factors that determine the use of FADs by small-scale commercial fishers. This understanding will then be utilised to establish working guidelines, in the form of a handbook, for the assessment of FAD deployment and monitoring programmes for use by national fisheries departments.

Three study sites, determined by the current FAD deployment programme of the Fiji Fisheries Division, were chosen; Nubukalau Creek fish landing site and market, Lautoka fishing port and Ba Bridge Service Station (see Figure 1). Although a number of shallow-water and deep-water FADs were deployed near the west coast sites there were no reports of the use of these FADs by fishermen (with the exception of game-fishermen). The results of the base-line reef study in this area will therefore be presented in separate documents and this report will focus on the third site at Nubukalau Creek market.

This research will confirm that FADs are a proven success in providing new fisheries opportunities. But, the perceived notion that they can attract reef fishermen from over-exploited reef resources to relatively under-exploited pelagic resources appears to be a gross simplification of the truth. It is believed that the use-rate of FADs is determined partly by availability of alternative resources but also by cultural and geographical factors. This report therefore includes observations on the status of local reef fishery resources as well as observations on the performance of the FAD.

Sections 1 and 2 provide a general background to Fiji and its fisheries. Sections 3 and 4 describe the choice of FAD study sites and the status of the adjacent reef fisheries. Historical and current data FAD deployments are described in Section 5. Data collection methods, presentation of data and their analysis are outlined in Section 6. Section 7 offers conclusions and recommendations.

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Vinaka Vaka Levu.

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1. Background

1.1 Geography and Population

The 322 islands of Fiji are located between 15° and 22° South and 174° East to 177° West with a total land area of 18,272 sq. km. The geography of the group is dominated by the two large islands of Viti Levu and Vanua Levu, and the Fiji group is part of the Fiji Plateau which rises to the north of the New Hebrides Trench (see Figure 1). The islands are arranged in a horse-shoe shape with the island of Vanua Levu forming the northern boundary and the largest (10,429 km^2) and economically dominant island of Viti Levu located to the south-west of Vanua Levu. The other significant islands in terms of land area are Taveuni, Kadavu, Gau and Ovalau.

There are numerous smaller islands with two significant chains; the Yasawas are located about 25 miles off the north-west coast of Viti Levu. Between these islands and Viti Levu is an area of shallow seas (<100m) containing extensive areas of coral reefs and islets. The second extensive chain of islands, the Lau Group, runs in a north-south arc some 150 miles to the east of Viti Levu. (see Figure 2).

Fiji has a population of 758,000 (provisional 1992 estimate) consisting of two main racial groups; the native, melanesian Fijians (49%) and the Fijian Indians (46%). Other ethnic groups include Chinese (1%), European and part-European (1%), and other groups which contribute 3% to the overall population. The two main islands of Viti Levu and Vanua Levu have approximately equal proportions of melanesian Fijians and Indian Fijians. The population growth rate of Fiji was estimated at 1.1% per annum in 1990.

There are two major towns; Suva, the capital, is on the south-east coast of Viti Levu and has a population of 69,665 (1986) in the urban centre itself with another 71,608 in suburban areas. Lautoka (on the north-west coast of Viti Levu) has an urban population of 28,728 and a suburban population of 10,329 (1986). Nausori and Lami, satellite towns of Suva have populations of 13,982 and 16,707 respectively. There are three other towns of significance; Nadi (serving the international airport) has a total population of 15,220 and Ba (which is also on the west coast of Viti Levu) has a population of 10,260 while Labasa the capital of Vanua Levu has a population of 16,537 (1986).

1.2 Economy

Fiji, which achieved independence from Britain in 1970 and became a republic in 1987, has become the most developed of the Western Pacific nations and the least aid-dependent (excluding Nauru) of the Pacific nations with development funds from donor nations only forming 10% of total Government expenditure. The country is sub-divided into four divisions for administrative purposes and these divisions extend to the Ministry of Agriculture and Fisheries. The four divisions can be identified in Figure 2.

Domestic production is dominated by the production of sugar with 426,000 tonnes produced in 1992 which accounted for 41% of exports. The majority of sugar production is carried out by Indian Fijians who lease land from native Fijians and is centred on the western area of Viti Levu (which has the required climate); western Viti Levu is therefore the most important economic zone in Fiji. Other significant economic activities include garments (20% of exports) and gold (11% of exports); tourism, also concentrated around western Viti Levu, was worth F$336 million in 1992.

A tuna cannery operates on the island of Ovalau and contributes 5.3% of total exports. Imports are dominated by transport equipment (25%), manufactured goods (25%) and petroleum products (14%). The official unemployment rate was 6% in 1992 and the rate of inflation was 4.9%.

Figure 1: Location of Fiji in the Western Pacific

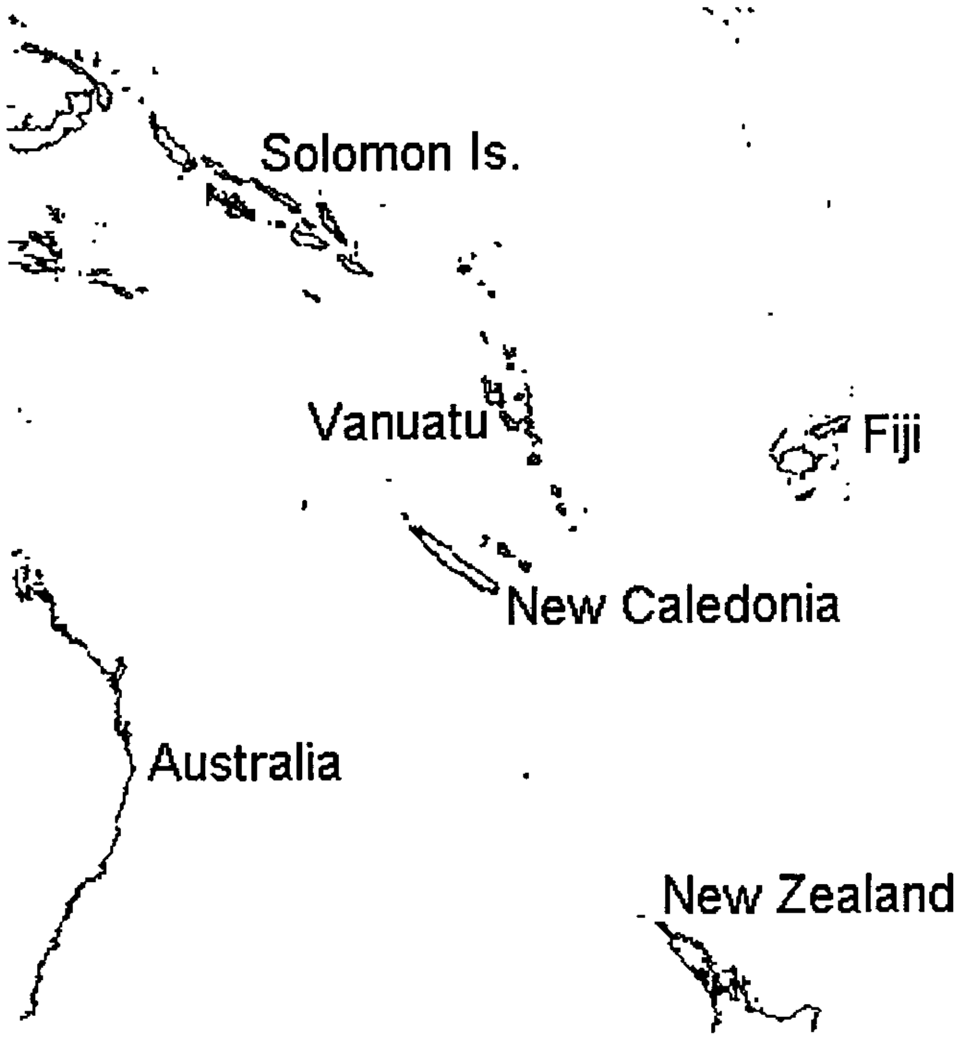
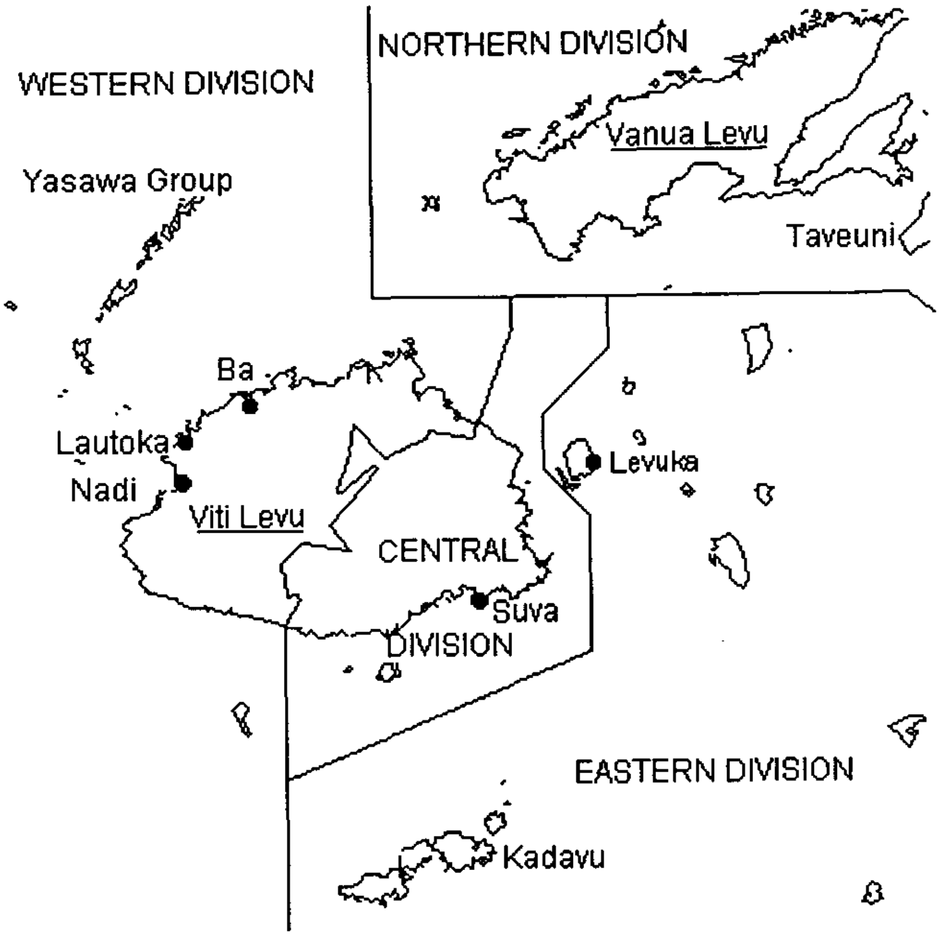


Figure 2: Location of Major Towns on Viti Levu, Fiji



2. General Description of the Fisheries

The Fijian fisheries sector can be conveniently divided into four sectors ;

- The Industrial Tuna Fishery
- Artisanal or Small-Scale Commercial Fishery
- Subsistence Fishery
- Commercial Aquaculture

2.1 The Industrial Fishery

The industrial fishery is based on the canning of locally-caught and imported tunas. There are two components in this sector; the Government owned IKA Corporation, which runs a number of pole and line vessels and Korean long-line vessels which are chartered to IKA; and three private fishing companies which export chilled and frozen fish and sashimi-grade tunas, primarily to markets in the Japan and Hawaii. These companies are also involved in long-line operations within the 12-mile limit and landed 883 tonnes of yellowfin, albacore and bigeye tunas in 1992. The domestic fleet has been growing consistently since 1989 when only 5 vessels were active.

The tuna cannery is located on the island of Ovalau at Levuka and is operated by the Pacific Fishing Company (PAFCO). PAFCO processed 11,416 tonnes of fish in 1992 of which 25% was imported (half the quantity processed in 1991) including skipjack tuna from the Solomon Islands and albacore tuna from Korean and US fishing vessels. Exports of canned fish (primary to the United Kingdom and Canada) were valued at F$32 million (a decline of 32% on the 1991 figure). PAFCO also exported 1,092 tonnes of raw fish valued at F$4.5 million.

2.2 The Artisanal Fishery

- **Management Background**

Commercial fisheries activity can only be undertaken by fishermen licensed by the Fisheries Department. There are currently two types of license; Inside the Demarcated Area (IDA) and Outside the Demarcated Area (ODA). IDA licenses are only issued by the Fisheries Department to fishermen who have obtained the permission of the customary owner to fish in the area under his ownership (the demarcated area); customary ownership is held by Fijian chiefs. Licenses are issued at nominal cost (F$4.0) to all fishermen who apply and complete an application form (information is collected on vessel-type, number of crew, fishing gear and which areas they have legal access to).

The Fijian system of customary marine tenure is manifested by the demarcation of areas called Qoliqoli (pronounced ngoligoli). Indigenous Fijians have access to qoliqoli if they are members of the same tribe (matagali) as the customary owner.

Qoliqoli, the boundaries of which are now administered by the Native Land Trust Board (NLTB), extend as far as the outer reef-edge except in areas where large areas of reef are 'enclosed' by outlying islands, such as in the case of both the east and west coast of Viti Levu. Figure 3 shows the boundary of waters enclosed within qoliqoli on Viti Levu, although this boundary is still subject to final confirmation by the NLTB, which is expected in 1996.

Access to these areas for commercial fishermen from different matagali or fishermen who are not members of any matagali (namely European or Indian Fijians) requires both a license from the Fisheries Department and permission from the customary owner. This permission is obtainable through a so-called 'goodwill' payment, which is generally valid for one year. The level of payments varies from F$50 to as much as $F500 per year.

In recent years this system has come under considerable criticism, notably from the fishermen (who are predominantly Indian Fijians); there has been some abuse of the system with some customary owners charging high access fees. Although the costs remain relatively small compared with the returns some of the more successful fishermen can obtain, the major problem is that the owners require a single payment at the beginning of the year and this is a major obstacle for many fishermen.

This has led some fishermen to fish inside qoliqoli for which they are not licensed, creating tensions between resource owner and resource user. Fishermen are now forming associations aimed at creating a united stance to negotiate a standard access fee from the custom owners. There are also some calls for the development of arbitration boards with Fisheries Division staff mediating in negotiations.

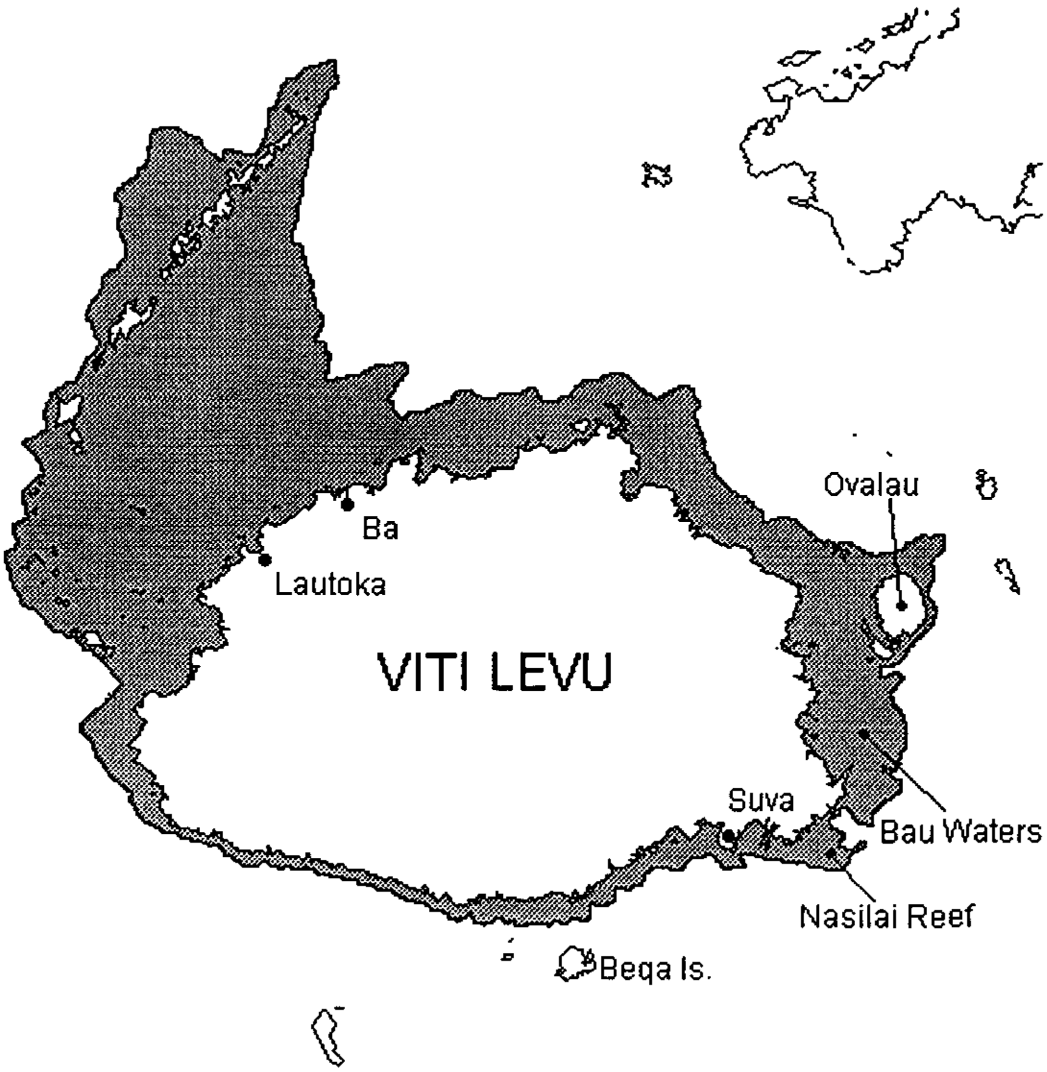
There has been much discussion in recent literature of the role that customary marine tenure (CMT) may play in future inshore fishery management options in the Pacific region (eg Johannes *et al*, 1993). In Vanuatu the Fisheries Department are already developing management tools based on CMT, utilising custom knowledge to develop a system of closed areas and fishing gear restrictions (Hickey, pers comm, 1994). If CMT is to be an appropriate and effective management option in Fiji then proper organisation of the qoliqoli system is clearly required. The strength of the current system is apparent when considering the eastern Lau group; in 1992 no IDA licences were issued by the Fisheries Division at the request of the paramount chief, Tui Nayau. Furthermore, the relatively small areas over which much of the fishing is carried out (making effective surveillance a realistic option) predisposes the system to be a potentially effective management tool if combined with current fisheries management methods.

The obvious flaw with the system as it currently stands is the potential financial rewards available to the resource owners and this problem needs to be addressed, perhaps through the creation of a ceiling on good-will payments. Associated with this would be limits on fishing effort within each qoliqoli determined by the status of stocks within each area.

- **Fisheries Production**

In 1992 total fish production by the small-scale commercial sector was estimated at 3965 tonnes worth F$13.4 million (Anon, In Press). The catch composition is dominated by 6 families which formed 86% of the total catch, although there are significant regional variations in the relative significance of each family. The 6 major families are Scombridae (641 mt); Lethrinidae (584 mt); Carangidae (434 mt); Mugilidae (494 mt); Serranidae (442 mt) and Sphyraenidae (522 mt).

Figure 3: Area Enclosed within Traditional Fishing Grounds (Qoliqoli)



2.3 The Subsistence Fishery

Subsistence fisheries in Fiji remain significant. Many communities, especially those on the less developed islands have little access to paid-employment opportunities and subsistence food production (both agricultural and fisheries) is obviously important. Fish and non-fish species are collected using various fishing gears, and women play a very significant role in the fishery especially in the collection of shell-fish.

There are however insufficient data available to obtain accurate estimates of the total subsistence catch in Fiji. In 1980, an interview survey of approximately 9% of households in coastal villages yielded an estimate of 14,000 tonnes of fish and non-fish. This figure forms the basis of the annual estimate which is increased by 200 tonnes per annum. In 1993 an ACIAR/CSIRO baitfish project also undertook a survey to estimate subsistence catches although the results of this were not available at the time of writing this report.

2.4 Aquaculture

There are three main areas of interest in aquaculture in Fiji; prawn farming (principally *Macrobrachium rosenbergi*), seaweed production (*Eucheuma spp*) and farming of Tilapia (*Tilapa mossambica*).

The area with possibly the most potential is that of fish-farming, both for more traditional freshwater species (such as Tilapia) and also for mari-culture of high value reef species such as Coral Trout (*Plectropomus* spp). Coral Trout populations are vulnerable to over-fishing because of the relative ease of capture from both hooks and spear-fishing. There may also be some risk of Ciguatera fish poisoning in wild populations.

Tilapia farming has increased significantly in Fiji since 1990, there were 128 farms operating during 1992 producing 45.9 tonnes of fish. A small number of demonstration farms produced 26 tonnes compared to an overall total of just 16 tonnes for the entire sector in 1991. Many small-scale farms have been constructed providing inland villages with easy and regular access to fish as well as providing opportunities for income generation. The Fisheries Division has been involved with growing fingerlings for sale to farms and, with the assistance of two U.S. Peace Corps workers, has been able to provide practical advice on the planning and development of small-scale farming enterprises.

2.5 Background Information on Fisheries

- **Fisheries Infrastructure**

The provision of extensive infrastructure items (ports, boat building facilities, ice-machines etc) has been reliant on cooperation between Fiji and aid-donor nations, primarily Japan. This aid has to some extent been linked to the level of Japan's interest in fishing for tunas in Fiji's economic exclusion zone (EEZ). There are currently no Japanese fishing vessels in the EEZ and as a result the quantity of development funds originating from Japan is on the decline. However, the contribution to fisheries infrastructure has been considerable. Of particular value was the construction of a port complex in Lautoka; this was a well planned project incorporating offices and workshops for the Fishery Department's Western Division headquarters; a finger jetty capable of providing mooring space for over 100 local boats including larger commercial vessels; a slip-way and a cafe and shop for local fishermen. The port is very well used by all sectors of the community and would seem to be a model of well-targeted development expenditure.

The other significant contribution from development funds (in association with Government expenditure) has been the provision, over a number of years, of ice-machines to 14 centres around the country. These ice-machines are clearly essential to maintain fish-quality, especially if the potentially lucrative tourist resorts are to be fully exploited by local fishermen. To this end, two Japanese advisors have been involved in a 2-year fish quality project based in Lautoka and funded by the Overseas Foundation for Cooperation in Fisheries (OFCF).

The future needs for fisheries infrastructure include the construction of a fisheries jetty at Lami (west of Suva and the headquarters of the Fiji Fisheries Division) and the recognition of Nubukalau Creek in Suva as a *de facto* fish market and therefore the construction of stalls and the provision of clean-water and ice-making facilities.

■ Boat-Building and Vessel-Types

There are a number of boat yards catering to the needs of different user groups. The more significant sites are at Lautoka and Ba in the western division and in Suva. Until 1993 there was a boat yard in Lami, sharing the site with the Fisheries Division headquarters, building a variety of fishing vessels particularly an 8.6 metre inboard-powered vessel of FAO design. The costs of this type of vessel had been subsidised under the Japan Rural and Artisanal Fishing Project and included a number of Yanmar engines. In 1992 a total such 14 vessels were constructed but in 1993 the last of these engines was used. Because the cost of the engine constitutes 50% of the total cost of the boat the boat building programme was terminated in August, 1993.

These 8.6 metre vessels are commonly sold to rural trainees and established commercial fishermen around the country but are particularly popular amongst islanders from the Yasawa Group (western Viti Levu) where local fishing cooperatives utilise them in youth training schemes. They are a fairly robust vessel and are suitable for long fishing trips and are safe fishing platforms in all but the roughest seas; they can make up to 8 knots. These vessels are also important in providing transportation for Yasawa islanders and their produce to the markets on Viti Levu.

The second commonly used vessel are marine-ply 'half-cabins' which are locally made in Suva, Lautoka and Ba. These vessels, ranging from 20' to 28' L.O.A., operate with 40 HP outboards and are the preferred craft for the majority of the Indian Fijian fishermen on both the east and west coasts of Viti Levu. The cost of this type of vessel depends on the LOA and the exact specifications (galvanised versus copper nails and on whether Dynal cloth is used) but range from F$2,860 for a 20' vessel to F$5,326 for a 28' vessel with copper nails and Dynal cloth.

The final vessel type commonly used in fisheries are Yamaha fibreglass punts. Most of these vessels also use 40 HP outboard engines and are very robust in construction. The FAD fishermen of Suva all use this type of vessel which is virtually unsinkable and provides a practical fishing platform for trolling although no shelter from the sun or from bad weather conditions is provided. Price varies with LOA and ranges from F$2,150 (4.34m) to F$6,210 for a 7.69m craft.

The most commonly used outboard motor in the artisanal fleet is the Yamaha Enduro 40HP (long-shaft) which is currently priced at F$3,826.

■ Finance Information

Given the costs of purchasing and maintaining a fishing boat, engine and fishing gear, the majority of fishermen require some sort of financing assistance. This generally comes in two forms; partnership with a private entrepreneur (whether a fish-dealer or not) or, and more commonly in the Eastern Division, loans from the Fiji Development Bank.

The maximum loan is generally around F$5,000 for the purchase of the two designs of open-boat and F$10,000 for the FAO 28-Foot diesel vessel. Interest rates are set at 8% which is low compared with loans obtained for agricultural projects which are set at between 15% and 30%. The default rate varies between areas; the Ba branch of the development bank has a default rate of 40% compared with a default rate of 60% for the Lautoka branch. Because of these high default rates the FDB in July 1992 changed its loans policy and now only assists established clients in, for example, the purchase of a new engine. In 1992 183 loans were approved (58% of requests) with a mean value of F$2801 (Anon, In Press).

- **Marketing Information**

There are five principle outlets for fishermen;

- Municipal markets
- Hotels, Restaurants and Cafes
- Butchers and Fish Dealers
- Retail shops and Supermarkets
- Roadside stalls

There has been a significant shift in emphasis from municipal markets, which handled 50% of total sales in 1978, to alternative private outlets. Principal amongst these are the shops and supermarkets, and the fish-dealers. Non-municipal outlets accounted for 80% of total sales in 1992.

Much of the decline in sales at municipal markets has been attributed to the costs of utilising the market facilities but it is also the result of the development of a more entrepreneurial fishery which requires a more flexible marketing approach rather than simply direct selling at market. At many of the formal market sites (municipal and non-municipal) the fish are sold not by fishermen but by fish-dealers who act as a clearing house for the catch. Many fishermen are quite satisfied with this arrangement because it frees time to undertake other work or to simply rest and in some cases partnerships have been established between fish-dealers and fishermen. Many fish-dealers contract fishermen to work for them, the revenues being divided into equal shares covering boat and engine maintenance, loan repayments, crew share and the owners share. In these situations the fishermen generally receive lower prices than they could obtain by selling the fish themselves but have the advantage of low-risk fishing with costs being met by the boat owner.

3. *Choice of Study Sites*

Three sites were chosen, all on the island of Viti Levu; the choice of site was determined by the on-going FAD programme of the Fiji Fisheries Division.

Nubukalau Creek Market, the site in Suva, was chosen because fishermen already had access to FADs, and because the landing site also functioned as a market site, facilitating data-collection.

Fishermen at the two other landing sites chosen, Lautoka Fishing Port and Ba Bridge Service Station landing, did not have access to FADs at the outset of the report but the Fisheries Division planned to deploy some FADs in the area. These two sites therefore permitted the collection of pre-deployment data on the nature of current fishing activities. Both these sites were ideal from a practical viewpoint because they were the primary landing and distribution points for the two towns. The fishery in this area is well structured and data collection was simplified because of the relatively regular timing of landings, the large number and variety of fishing boats and the ease of access for data-collectors. Lautoka Fishing Port is also the location of the headquarters of the western division of Fiji Fisheries Division.

3.1 Nubukalau Creek Market, Suva

As discussed in Section 2.5, municipal markets have declined in importance in the Central Division; one of the more significant non-municipal (and unofficial) markets to evolve at the expense of the municipal market has been at Nubukalau Creek in the centre of Suva. As the name suggests the site is located besides a (tidal) creek entrained within stone walls. Fishermen can bring their boats to the creek and tie-up alongside the market place. The catch is displayed on tarpaulins and excess fish is held in old refrigerators; the fish are washed down with water from the (polluted) creek. In fact, the sale of fish at this site is technically illegal and while fishermen and fish-dealers are not actually restricted from selling fish there has not been any permanent market stalls built, there is no provision of ice and therefore the quality of fish for sale can be poor.

There are three groups selling fish at this site; the FAD fishermen (this was the primary site where FAD-caught fish were sold at the commencement of the project); reef fishermen (particularly on Saturdays) from the surrounding area and fish dealers who buy fish from local fishermen as well as importing fish from other islands, particularly from Beqa and Kadavu to the south and the Lau group to the east. Spear fishermen also use this site to land their catch and generally sell the catch to fish dealers when they arrive back from the nights fishing.

- **The Geography and Environment of the Area**

The climate of south-east Viti Levu is characterised by large annual rainfall (mean of 3161 mm per year) and a mean temperature of 77.2° F. Oceanographic conditions are dominated by the south-east Trade winds which prevail between June and October. The mean wind speed in July, 1993 was 6.6 knots (at 0900 hours) with 29 days recording gusts of over 15 knots. There is of course much variability in weather, particularly in years of climate disruption. In 1993 the western Pacific experienced an El Nina Southern Oscillation (ENSO); In December, typically characterised by calm weather, the mean wind speed was 3.7 knots (at 0900 hours) but with 16 days recording gusts in excess of 15 knots.

There are three primary environments in the local fishery catchment area; the fringing reef and lagoon of Suva Harbour and Laucala Bay; the Rewa River and the estuary area around Laucala Island and Nukulau Island; and the large expanse of mangrove, reef and lagoon of Bau waters on the east coast extending around to Nasilai reef to the east of Suva (see Figure 4).

The lagoon and reef areas around Suva can be described as partly degraded as a result of pollution stemming from shore-based industry, domestic sewage, run-off water from the urban environment and from pollution associated with the port facility of Suva and at Lami to the west. This area however maintains a degree of fishing principally spear fishing on the outer reef, collection of reef invertebrates, and gill-net and handline fishing by both commercial and subsistence fishers. There is also occasional bait-fish collection by the industrial pole and line vessels which tie-up at Lami at the western end of Suva harbour. Outside the lagoon the bathometry is characterised by a number of deep valleys, orientated perpendicular to the coast, increasing in depth to over 1,000 metres within 3 nautical miles of Suva Point.

The Rewa River, to the east of Suva, is a turbid but shallow river which is a major source of fish and shell-fish, in particular of a bivalve mollusc known locally as Kai (*Batissa violacea*) which is manually harvested by women. The river transports large quantities of suspended sediments and is therefore also important in determining the productivity of nearby reefs. During cyclonic storms enormous quantities of sediment flow down the Rewa river; flooding resulting from Cyclone Kina (from December 26th, 1992 to 5th January, 1993) an estimated 50 million tonnes of sediment were carried by river. The principle fishing community in this area is found at the village of Lokia.

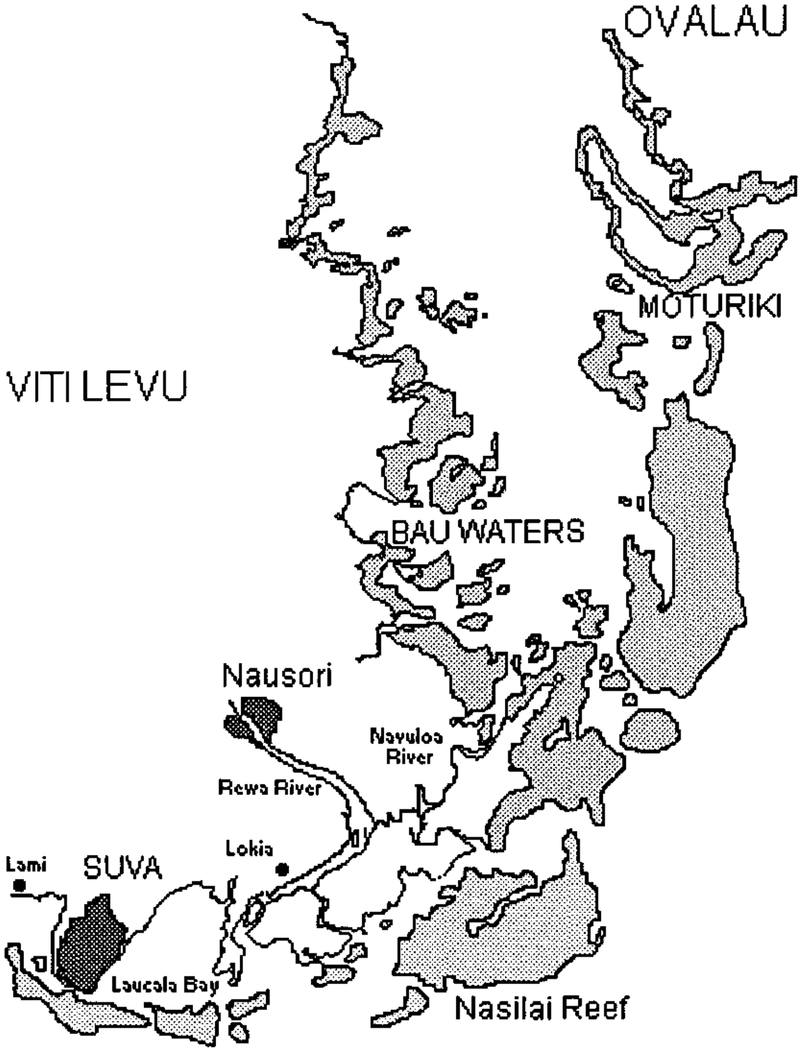
The Bau lagoon is characterized by large numbers of patch reefs and shallow waters (<40metres), and is protected from the prevailing south-easterlies by a large fringing reef to the east. There are fringing mangrove stands along the coast and a number of small rivers flowing east into the lagoon. Fishing (based at Lokia village) includes both gill-net, fish-trap and handline fishing by part-time fishermen who also undertake agricultural production of crops and livestock. Many of the fishermen store their catch over a number of days and bring it to sell in Suva during the latter half of the week.

- **The Economy of the Market Catchment Area**

Suva is the capital city of Fiji and is therefore the seat of Government and its associated administration. There are a number of other diverse economic activities including retailing, the hospitality industry, banking, tourism and construction. There are a large number of schools and the University of the South Pacific is located nearby at Laucala Bay. In addition, there are the regional headquarters of SOPAC and a number of embassies and consulates. Employment opportunities are therefore relatively varied compared with other areas of the country. Statistics are not available for the growth rate of Suva.

Racially the population of Suva reflects the national balance of approximate equality between native Fijians and Indian Fijians. There are an estimated 2,138 Europeans (65% of the total population in Fiji) in the city and 2,500 Chinese (65% of the total population in Fiji). The large numbers of these relatively wealthy sectors of the population will have a significant effect on the local economy. Relative to the western side of Viti Levu, the agriculture is strongly reliant on the cultivation of rice (in which Fiji aims to become self-sufficient), vegetables and the rearing of beef and dairy herds, especially in the rich farmlands of the Rewa River floodplain.

Figure 4: The.Area of the South East of Viti Levu



- Fishermen and Fishing Gears

In 1992, the latest data available at the time of writing, there were 294 vessels licensed to fish in the Central Division IDA and 91 licensed to fish the ODA zone (compared with 735 IDA and 25 ODA licenses in the Western Division). The principle fishing gears employed in the central division are handline, gill-net (both for freshwater and marine species) and trolling (particularly outside the qoliqoli). There is spear fishing (particularly off Suva barrier reef and Beqa and Kadavu Islands). Fish-trapping is also undertaken in certain areas (for example in Walu Bay on the northern shore of Suva Harbour).

- **Markets and Prices**

The principal outlets for fishermen in the Central Division include road-side stalls and municipal markets at Nausori, Navua and Korovou and non-municipal markets at Nubukalau Creek and Laqere. Also of significance are the sales to other outlets including restaurants, shops and fish-dealers. Table 1 shows the breakdown of sales for each outlet in the Central Division (source: Fiji Fisheries Division Annual Report - 1992).

Table 1: Breakdown of Sales in the Central Division.

Outlet	**Weight (Mt)**	**Mean Price (F$)**	**Value(F$000)**
Markets			
Navua	12.44	4.03	50.17
Nausori	52.45	2.99	157.08
· Korovou	1.94	3.09	5.99
Other Outlets			
Nubukulau Creek	196.34	3.92	727.49
Laqere	145.28	4.05	570.03
Roadsides	225.05	4.05	910.50
Hotels, Rests & Cafes	92.47	4.90	453.00
Butchers & Fish Dealers	829.04	4.17	3,454.38
Shops & Supermarkets	336.42	4.58	1,540.67

4. *Status of the Reef Fisheries*

4.1 Historical Catch and Effort Trends

Unfortunately there is little historical data available on catch and effort for Fijian reef fisheries. In 1981-82 a survey of small-scale fishermen selling their catch at municipal markets was undertaken by the Fisheries Division. The results indicated catch-rates of 1.68 kg/man-hr in 1981 and 1.23 kg/man-hr in 1982 (compared with 2.21 kg/man-hr in the Western Division).

The only data regularly collected on effort levels is that of the overall numbers of licences issued to IDA fishermen; in the absence of any alternative data licence numbers can be used as a crude estimate of relative effort. In fact, data collected during this survey suggests that the quantity of effort per license has increased as favoured fishing grounds have become exhausted demanding that fishermen travel further and exert more fishing effort for a similar catch. Caution must be exercised therefore in any analysis of the effort history of the fishery, although its use is still justified in any 'quick and dirty' analysis that is included in an overall assessment of the fishery.

For example Figure 5 shows the number of licences issued and catch per year since 1985 in the Central Division as recorded by Fiji Fisheries. Although data for years prior to 1985 exists, it is thought that the catch is underestimated due to limitations of manpower in the Fisheries Division at that time (G. Preston, pers comm).

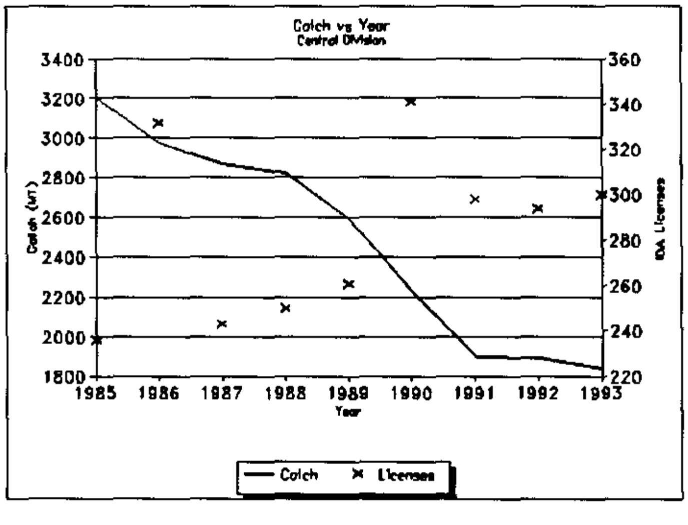


Figure 5 : Annual Commercial Catch vs License Number

There has been an increase of 30% in the number of IDA licenses issued since 1985, but this is not reflected in the catch trends. Given that the estimated effort per license has reportedly increased during this period the decline in catch over this period would appear to give grounds for concern for the state of the fishery as a whole. Over the last three years the total catch has remained similar at around 1800 mt, although this is likely to reflect increasing imports from outer islands. Using the catch and effort data presented in Figure 4 an estimate of CPUE has been calculated (annual catch/number of licenses) by way of indicating the changing abundance of the stocks. Figure 6 shows a plot of CPUE (transformed from ln(CPUE)) against effort describing the exponential curve (r^2 = 0.63) typical of a Fox Surplus Yield Production Model. However, this figure has been included more to emphasise the decline in estimated CPUE rather than as a tool for the development of a production model. Although CPUE is generally used as an index of abundance, changes in real abundance through time are likely to be masked by changes in the location of fishing effort to maintain fishing effort in the areas of highest density. There is therefore real need for more detailed analysis of this fishery to be undertaken by Fiji Fisheries if only to determine whether the perceived decline is real, given the social and economic value of the fishery to the community.

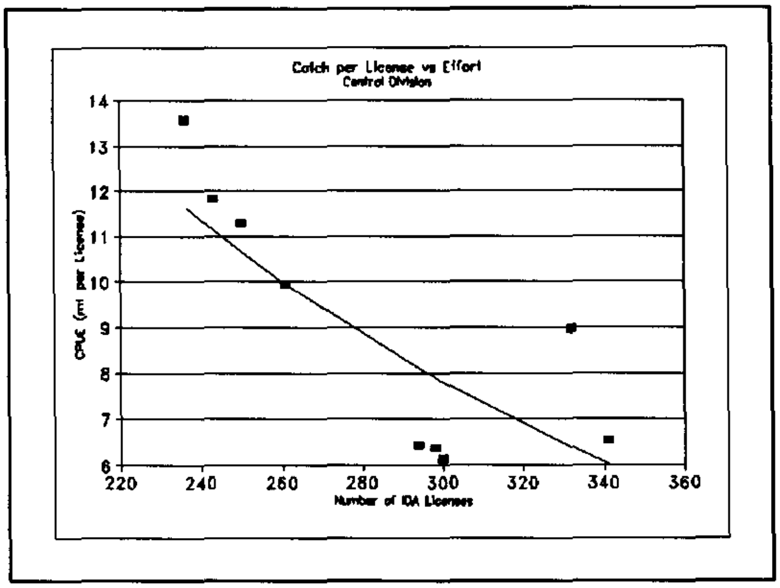


Figure 6 : CPUE vs Number of Licenses

4.2 Species Composition Changes

The inherent complexity of tropical reef ecosystems in terms of inter- and intra-specific interactions implies that fishing effort directed at a particular component of the system will inevitably have impacts on the dynamics of these interactions. For example, heavy fishing pressure on the larger predators would be expected to reduce predation pressure on prey items and the abundance of these smaller species would increase. In fact, much depends on what is currently limiting the abundance of other species; to what extent is abundance limited by predation or is recruitment variability the limiting factor? (Doherty, 1986 etc). Heavy fishing pressure on certain target species will not necessarily have a dramatic effect on species inhabiting lower trophic levels. Bohnsack (1982) reported results from comparisons between two sites experiencing different levels of spear-fishing and found no significant difference between the two sites. However, Koslow *et al.* (1988) reported the results of repeated surveys, over 13-17 years, of two sites which experienced large increases in fishing effort and a control third control site. Results suggested a significant change in the relative abundance of species at the two heavily fished sites.

While bearing in mind the natural variability in carrying capacities of different reef sites, Lock (1986), based on work undertaken in Papua New Guinea, argued that there were three phases of evolution of a multi-species/multi-gear fishery. The initial phase of low-effort was characterised by a great diversity in the species composition with large predators (snappers and groupers) and herbivores (surgeon-fish and parrot-fish) relatively common in the catch data. The second phase, associated with increasing fishing effort, was characterized by larger catches of small, predatory snappers. The final phase of evolution was characterized by large numbers of small herbivorous species, for example, rabbitfish (Siganidae). Although still requiring rigorous testing the concept is of significant interest to fishery managers. Lock argued that the progression was caused by reduced inter-specific predation and reduced competition.

A first approach to assessing the significance of any trends in species composition can be carried out simply by plotting the total sales for individual species that are 'indicators' of various trophic levels within the ecosystem. Does this information describe a similar pattern of decline in major predators and increase in smaller predators and planktivores as Lock suggested?

The Figure 7 display sales data for the Central Division from 1986 to 1993. The data covers four representatives of three high-value families of reef fish; Lethrinids, Lutjanids and Serranids.

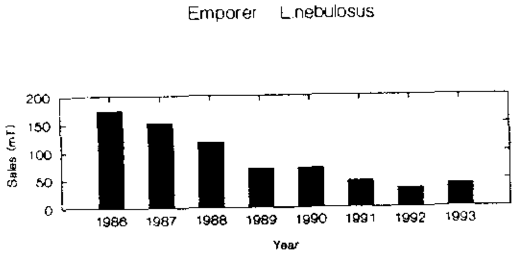
It is clear from these figures that there has been a decline in sales for all these groups. With the exception of the small snapper (*Lutjanus quinquelineatus*) all these species are relatively large carnivores; their position in the food-chain determines a behavioural tendency to be aggressive feeders and therefore susceptible to baited hooks; their inquisitiveness and large-size also make them susceptible to spear-fishing. In general these fish are relatively low in abundance per sq/km of reef, because of the high trophic level they inhabit, a heavily fished reef area would be expected to lose a significant portion of its large predators fairly quickly.

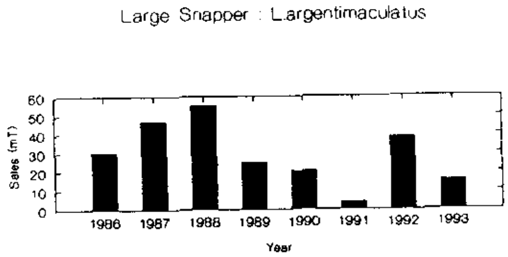
One of the most valued species in Fiji is the Spangled Emporer (*Lethrinus nebulosus*). From the above figure it is clear that this species has declined significantly since 1986. Dalzell *et al.* reported that the majority of lethrinid stocks were probably close to maximum sustainable levels based on a combination of length frequency data, catch data (1982-1987) and biological data obtained from a number of sources. This situation has clearly not abated in the face of increasing fishing effort over the last 8 years since the initial analysis was undertaken. The major concern for the Fiji Fisheries Division is that it appears most species have undergone a decline and there does not appear to be a compensatory increase in the landings of other (probably lower value) species previously under exploited.

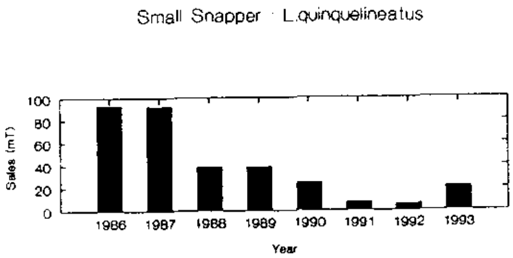
Figure 8 displays sales data for species from four families; Scaridae, Scombidae, Carangidae and Sphyraenidae. Two families (Siganidae and Scaridae) have been chosen to represent species that might be expected to increase according to Lock's theory on species replacement . Two families (Carangidae and Sphyraenidae) have been chosen to represent species that might not have been targeted previously but would also be more resilient to fishing pressure due to their epi-pelagic or neritic life-history. In addition, three families taken by very specific gears; Haemulidae and Acanthuridae (Spear fishing), and Mugilidae (gill-netting) are shown.

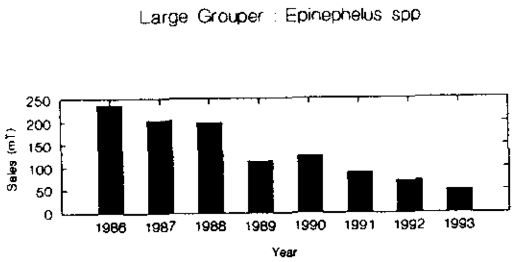
The expected increase in sales of small herbivores is not strongly visible from the figures. Apart from two strong years, in 1990 and 1991 respectively, for the 2 families there appears to be an overall trend of decline in sales. Bearing in mind the inter-annual variability, the sales of neritic and epi-pelagic species appears to be increasing, notably of the trevallies (*Caranx* spp).

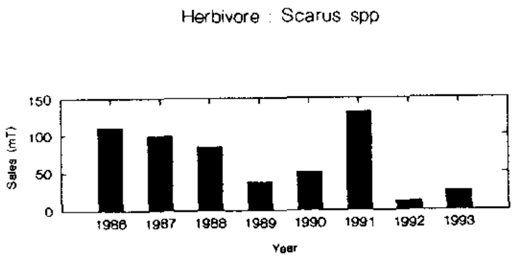
Figure 7 : Catches of Selected Species, Central Division, Fiji











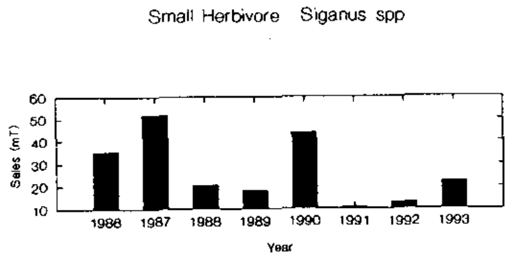
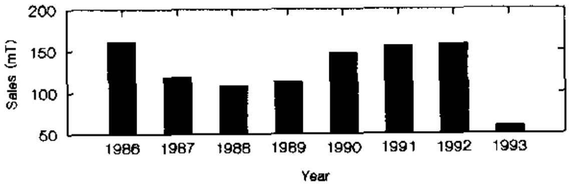
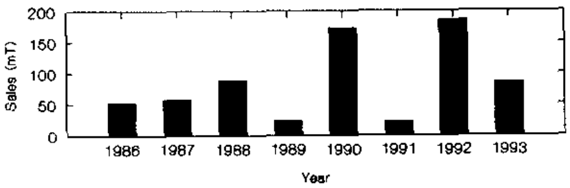


Figure 8 : Catches of Selected Species, Central Division, Fiji

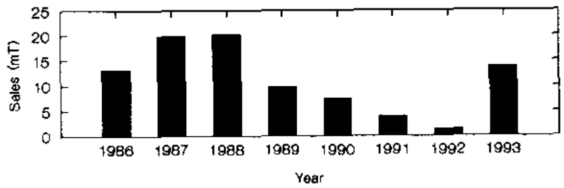
Neritic Predator : Caranx spp



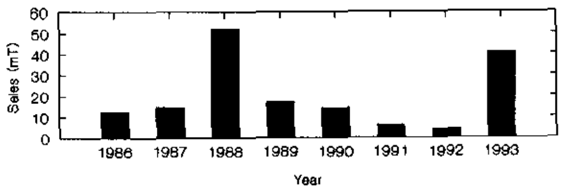
Epipelagic Predator : Sphyraena spp



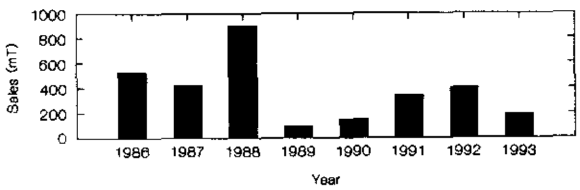
Plectoryhncus spp : Spear



Naso spp : Spear



Valamugil spp : Gillnet



4.3 Current Landings

Figure 9 displays the estimates of the annual finfish sales at Nubukalau Creek Market since 1986. It is clear (especially in 1993) that the market is growing in importance as a supplier of fish to the urban population; the fall in sales in 1987/88 probably reflect the downturn in the economy during this period due to the political events of 1987.

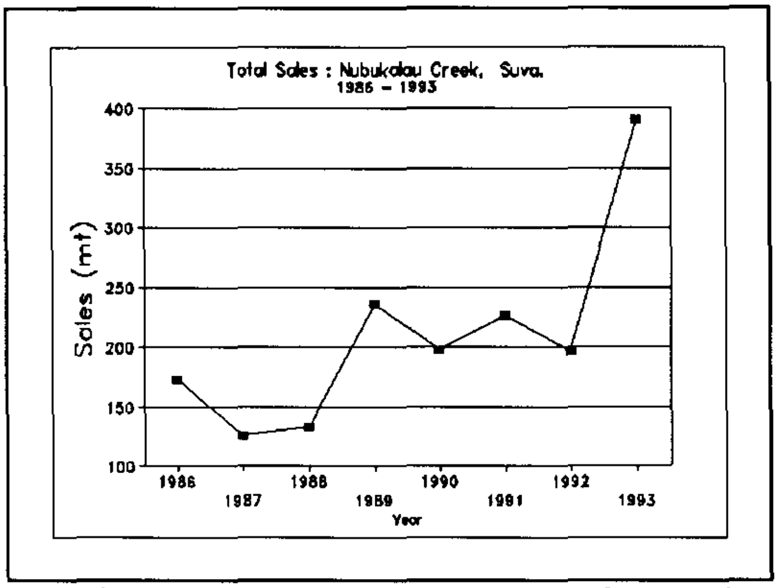


Figure 9 : Historical Finfish Sales - Nubukalau Creek market, Suva, Fiji.

In 1993 some 390 tonnes of finfish were sold at Nubukalau Creek Market comprising 84 named fish; the majority of identifications are carried out to the specific level but a few are only to the generic level (for the sake of simplicity all named fish will be referred to as species). Of this 390 tonnes, 241.5 (55%) were made up of just 10 species, representing 9 families. There is no dominant fishing gear accounting for these top species and they are caught by fishing gears representative of the four main gears in use in the area; gill-net, troll, handline and spear.

The largest contributor were mullets (Mugilidae) known locally as Molisa (*Liza melinoptera*) and Kanace (*Valamugil seheli* and *V.buchanani*), of which 57.3 tonnes were sold. These species are caught typically by gill-nets in shallow coastal waters, lagoons and rivers and estuaries (see Table 2).

The second most significant contributors were the parrotfish (Scaridae, *Scarus* spp), collectively known as Ulavi, some 25.5 tonnes were sold during 1993. This species is generally caught by spear-fishermen (in addition to being caught in gill-nets) and makes a relatively easy target because of its vulnerability while sleeping. Equally significant and also generally caught by spear-fishermen is the unicorn fish (Acanthuridae, *Naso unicornis*), locally known as Ta; 23.7 tonnes were sold during 1993.

The third ranking family in the top ten are the Scombridae, represented by skipjack tuna (same local name), *Katsuwonus pelamis*, of which an estimated 25.2 tonnes were sold (this is believed to be an underestimate and will be discussed later) and the Indian Mackeral (*Rastrelliger* spp) locally known as Salala of which 15.7 tonnes were sold. While Salala is generally caught by gill-net (and possibly by dynamite), skipjack tuna is caught almost exclusively by trolling in open ocean.

Carangids are represented by the trevallies, *Caranx* spp, locally known as Saqa (17.5 tonnes) and the Sphyraenids by two species of barracuda, *Sphyraena* spp, locally known as Oqo (15.6 tonnes). Lethrinids are represented by 1 species in the top ten, *Lethrinus mahensa*, locally known as Sabutu (13.6 tonnes). The final species in the top ten is a Trichiurid (*Trichiurus haumela*) locally known as Tovisi (21.6 tonnes).

The three other species of which greater than 10 tonnes was sold were two lethrinids; *L.nebulosus*, known locally as Kawago (11.9 tonnes) and *L. variegatus*, known locally as Kabatia (12.7 tonnes). The third species registering greater than 10 tonnes was the Lutjanid, *Lutjanus bohar*, locally known as Bati, of which 11.3 tonnes were sold.

Table 2: Summary Table of Sales in Nubukalau Creek market in 1993

SPECIES	WEIGHT (tonnes)	FAMILY	HABITAT
Liza melinoptera & *Valamugil seheli*	57.3	Mugilidae	Shallow coastal waters, lagoons, and rivers and estuaries.
Scarus spp.	25.5	Scaridae	Reef
Naso unicornis	23.7	Acanthuridae	Reef
Katsuwonus pelamis & *Rastrelliger* spp	40.9	Scombridae	Pelagic / Epipelagic
Caranx spp	17.5	Carangids	Reef / Neritic
Sphyraena spp	15.6	Sphyraenids	Neritic / Reef
Lethrinus mahensa, L. nebulosus & *L. variegatus*	38.2	Lethrinids	Reef
Trichiurus haumela	21.6	Trichiurids	Estuarine / Neritic
Lutjanus bohar	11.3	Lutjanids	Reef

5. FAD Deployments

5.1 Historical FAD Deployments off Suva

The first FAD deployments, in 1982, were funded with assistance from the Korean Government and this approach has continued with donor assistance, often in the form of hardware rather than cash. Data on the exact timings and locations of FAD deployments is not easily available, notably for the period prior to 1990 (a single FAD was deployed off Suva Point in both 1990 and 1991) and unfortunately there has been little data collected on the actual performance of the FADs prior to this research. Because of the lack of data on the actual benefits accrued from FAD deployments there has been an understandable reluctance by Fiji Fisheries Division to increase spending on the FAD programme. The 1993 Fisheries Division budget for FAD deployments was F$50,000 but much of this budget was utilised in other areas of the Fisheries Division's work. Data was not available for the total 1993 fisheries budget but in 1992 the total capital expenditure budget was F$ 539,099.

A crude assessment of the effect of FADs in enhancing the exploitation of pelagic species can be seen in Figure 10 which plots the volume of landings of tuna species at the Nubukalau Creek market from 1986. The 1993 data covers the entire survey period and are the adjusted figures. In fact, because the survey period was under 12 months in duration these figures are likely to be an underestimate of the total annual catch for 1993. What appears clear from discussions with fishermen (and from Figure 9) is that there was little if any pelagic trolling or mid-water fishing prior to the deployments in 1990/1991. Tunas were originally unpopular fish amongst local consumers and the low price made full-time open-water fishing inefficient for the local fishermen. Prior to deployments off Suva in 1990 there is clearly a very low level of landings of tunas at the market, a situation that has altered markedly over the last three years.

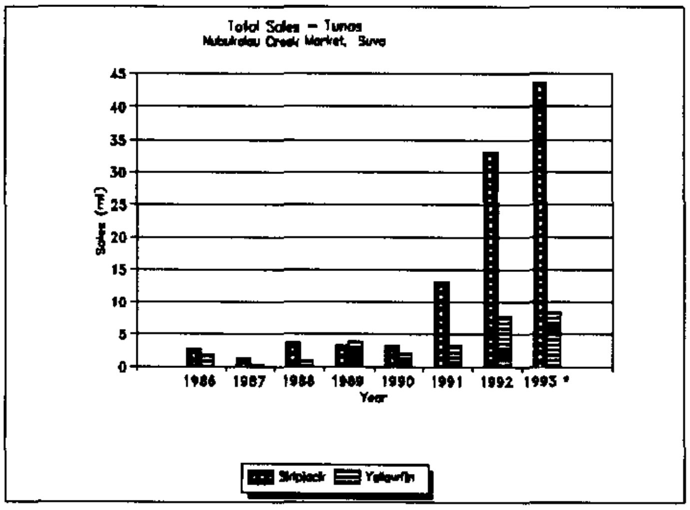


Figure 10 : Annual Sales of Tunas ; Nubukalau Creek market

5.2 The Current FAD Programme

The current FAD deployment programme evolved as a response by the SPC to a request for technical assistance from the Fiji Fisheries. In 1993, an SPC Master fisherman arrived in Fiji to undertake a series of deployments working in association with a local counterpart from Fiji Fisheries. There were two major deployments undertaken, in April and in September with two FADs being deployed off Suva in April (Nasese and Mau; see Table 3); the Mau FAD was lost in June and replaced in the September deployments. The initial deployments utilised the robust spar-buoy design of raft, the Mau FAD was subsequently reported to be stranded on the reef off the near-by island of Beqa but the cause of the loss remains unclear. The September deployments utilised the so-called SPC/Indian Ocean FAD raft (see Figure 11). This design is generally felt to have greater potential longevity (excluding shark-bite) because of the design of the raft section. The low surface area and the flexible surface component, along with the capacity for the raft to absorb high-energy waves by submerging makes this the most popular design currently used in the Pacific region.

Table 3 : Positions of FADs off Suva Point, Fiji.

FAD	Depth (m)	Distance From Suva	Latitude	Longitude
Nasese	1053	9.8n.mi	18° 16.92 S	178° 29.45 E
Mau •	1230	8.7n.mi	18° 17.23 S	178° 19.58 E

Figure 12 indicates the positions of the two FADs off Suva superimposed on the bathometric characteristics of the area which were important in site selection.

Figure 12: Bathometric Characteristics of the Area Surrounding the Two Sites South of Suva, Viti Levu.

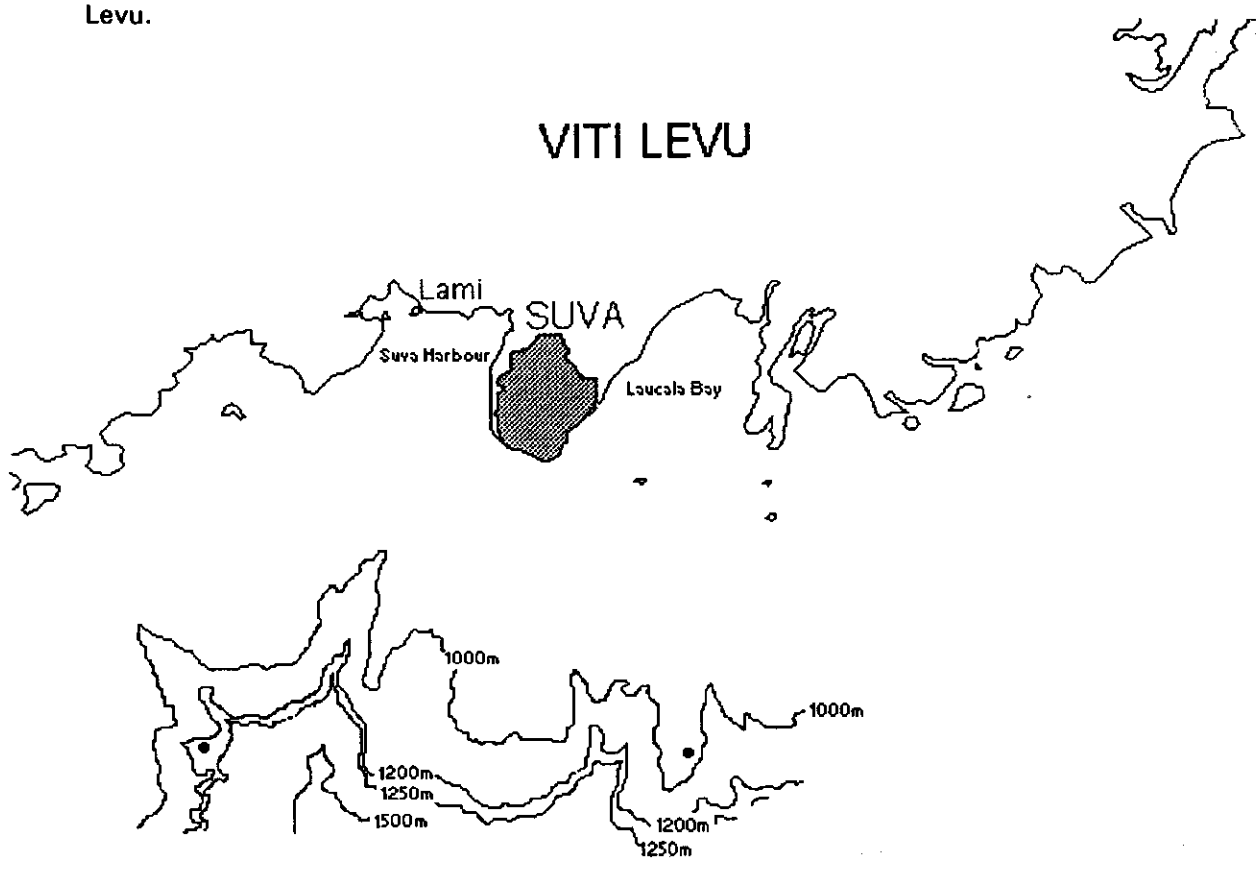
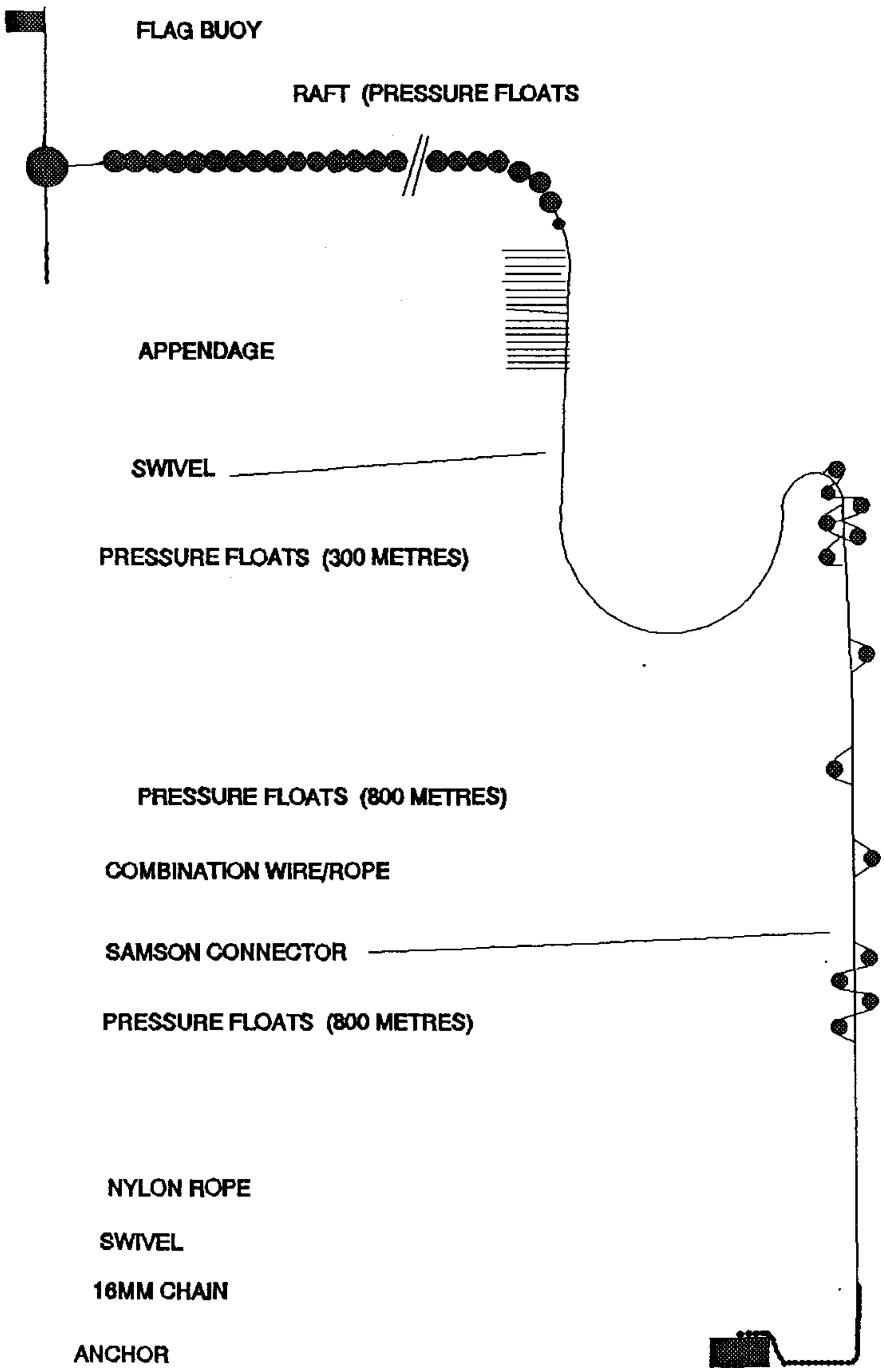


Figure 11 : SPC/Indian Ocean Deep-water FAD Design



6. *Data Collection and Analysis for Nubukalau Creek Market Site*

6.1 Data Collection

The data-collection methodology centred on a creel survey, interviewing fishermen rather than the distribution of log-sheets which the fishermen would complete themselves. Trial data-entry sheets were initially distributed amongst the fishermen of the Port of Lautoka but the response was very poor and this approach was abandoned in favour of direct interviews. A single data-collector was employed for the Nubukalau Creek Market survey and commenced duties in July, 1993.

The sampling regime for the market was based on the regime the Fisheries Division employed for their market survey. This was based on the recommendations of a consultant economist (Swarmy, pers comm). The consultant's work showed that there were a number of days of the week (Thursday to Saturday) which saw the highest trade in fish; the Division's sampling therefore concentrated its effort on these days, the remainder of the week (Monday to Wednesday) were treated as one day; there were therefore effectively four days to sample each week.

Data collection during this project therefore covered each of the three primary days every week with the fourth day rotating each week between Monday, Tuesday and Wednesday. The landing site of Nubukalau Creek was therefore regularly monitored for four days each week with additional days included where possible. During the period of the research an average of 17 days were sampled each month, for a total of 119 days; a coverage rate of 65.4% of working days was obtained for the period.

The data-collector interviewed the FAD fishermen on their return from sea, collecting information on the location and duration of fishing effort (for each fishing gear); species composition by number and weight (an approximate distribution of the catch by species length and weight-class was obtained) for each site and gear. Price information was also recorded. Tunas are not sold as strings or by the kilogramme (except for the larger fish); the vendor sets a price per fish which will obviously depend on the weight but also the condition and the time of day. A 2.5 kilogramme skipjack tuna would usually sell for between F$3.00 and F$5.00.

Additional data such as weather conditions, moon-phase and fishing costs per trip were either extrapolated from the effort data or obtained from alternative sources (eg National Weather Centre and the Fiji Nautical Almanac). Sociological data was collected during interviews in the form of discovering the relationship between the FAD fishermen and those selling the fish, and a number of ad hoc surveys were conducted during the project to gather more detailed information on the FAD fishermen (for example, did they previously fish on the reef resources?).

In addition to the collection of data on the FAD fishery, comparative data was also collected on the reef-fish market that was at the same location. Fish-dealers and fishermen were interviewed to obtain catch and effort data, fishing location and price information. Individual sellers were again interviewed directly. Because much of the reef-fish sold at the market is imported from other areas and sold by dealers rather than the fishermen themselves, the catch and effort data for the reef fishery is less reliable than that obtained for the FAD fishery. Many of the dealers collected fish from a number of fishermen and this was pooled so the exact source of much of the fish was not discovered. Each fisherman or dealer sells their catch at a make-shift 'stall' comprising of a tarpaulin and an old ice-box. Reef fish are sold as bundles or 'strings', usually of the same species and size. Strings were counted, weighed and the mean number of fish recorded. If more than one species was found on a single string the catch was recorded as mixed fish. The mean weight of string was 3.1 kilogrammes costing F$11.22.

6.2 Data Analysis of the Reef Fishery

- **Sales**

Figure 13 shows the distribution of sales by weekday over the period, the figures have been adjusted to account for differential coverage rates.

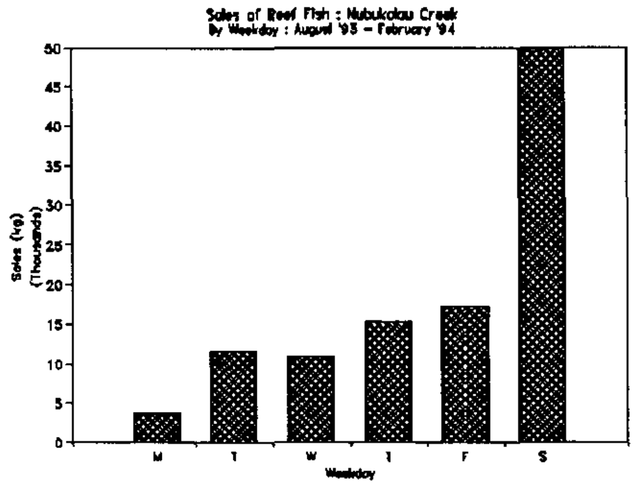


Figure 13 : Sales at Nubukalau Creek market by Weekday

The figure would appear to confirm the sampling programme of the Fisheries Division. On most days the sales of fish are dominated by the fish dealers, while on Saturday the actual fishermen tend to be more in evidence and they sometimes sell fish on behalf of fishermen from the same village or community.

During the data collection process some 1208 stalls were surveyed of which 350 provided data on the effort and area from which the catch originated. Sales were predominately run by fish-dealers (435 stalls operated by male fish-dealers and 139 stalls by female fish-dealers), while 423 stalls were operated by fishermen or their relatives. A total of 276 different vendors (both fishermen and fish-dealers) were interviewed.

There is significant seasonal variation in sales volume and Figure 14 describes the breakdown over the period of the study, the data is presented as sales per day sampled.

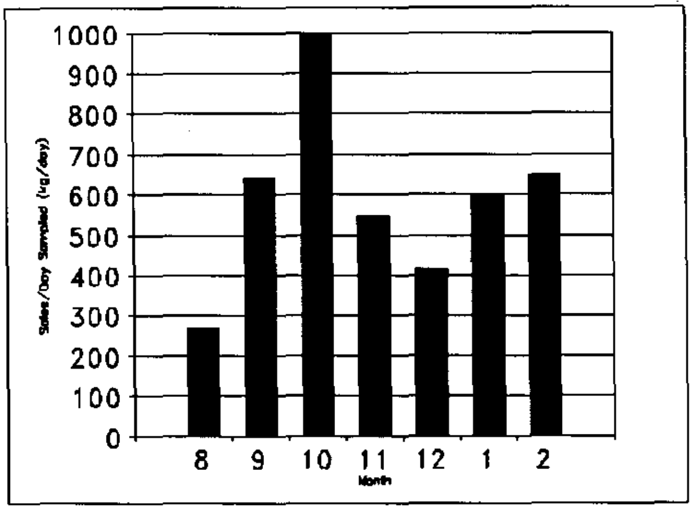


Figure 14: Sales of Reef Fish per Day Sampled

- Fishing Catch and Effort

A number of fishing gears are used including spear-fishing, gill-nets, handline, trolling, fish-traps and poison (derived from a creeper known locally as Tuva). Table 4 shows the breakdown of fishing catch and effort and value (F$) for the fishing trips where information was available; only the top ten sites are included but these together make up 75% of the sampled landings by weight, 84% by effort and 76% by value.

Table 4 : Catch and Effort by Area, Reef Fishery, Central Division.

Area	Catch (Kg)	Effort (Hrs)	Total Value (F$)	CPUE (Kg/Hr)
Noco	4725	2447	16,479	5.56
Lokia.	4464	3221	14,481	2.46
Kadavu	1510	89	5,141	19.96
Nasilai	1354	131	4,238	11.61
Nabakavu	1289	466	4,459	9.80
Kabuna	1204	420	4132	2.95
Suva	1004	176	3,423	8.15
Suvavou	843	152	2,358	11.94
Narai	772	237	2,883	5.47
Rewa	743	337	2,496	5.03

The actual location of fishing effort was not always clear; fishermen sometimes reported the name of their fishing village (eg Lokia) rather than the actual fishing grounds, while others would report the qoliqoli rather than more specific sites within the qoliqoli. For example, Nasilai is in fact inside the Noco qoliqoli, and this data has been reported separately in Table 4. The majority of fishermen based in Lokia village report that they fish Noco qoliqoli when they apply for a licence (Fiji Fisheries Division Licence Records) but they are known to fish elsewhere without the consent of the customary owner, a prime site being the various qoliqoli of Bau Waters. Further complications arise from cultural differences between data-collector and fishermen (or fish-dealer). The original data-collector, an Indian Fijian found problems collecting data from native Fijian fishermen or fish-dealers, while the second data-collector (a native Fijian) developed excellent relations with the Fijian fishermen but found the Indian Fijian fish-dealers more difficult to work with.

Despite these caveats on data quality it is clear that the area around Suva does not provide a significant quantity of fish to the creek market and this is likely a reflection on the status of the resource. The two sites adjacent to Suva (Suva and Suvavou) contribute just 7% (by weight) of all sites for which data was recorded. Clearly much of the fish sold through the market comes from offshore (FADs) and places outside the Suva area.

- **Variation in Species Diversity Between Sites and Gears**

Spatial analysis of the species composition was carried out through the calculation of Species Richness, S, (the number of species recorded in the catch). Species Diversity (D) was calculated according to Simpson's Diversity Index (D) (Begon *et al*, 1986). The equitability, E, relates to the species composition of the catch in terms of the level of domination by one or more species. As E increases so the distribution of species within the sample is more even (equitable), as E falls the evenness falls and the sample is dominated by fewer and fewer species. The results of this analysis are shown in Table 5.

Table 5 : Species Diversity by Site and Fishing Gear

Site	Fishing Gear	Sample Size	Simpson's Diversity Index (D)	Simpson's Equitability (E)	Species Richness (S)
Rewa	Gill-Net	9	10.02	.48	21
Noco	"	41	8.46	.26	33
Lokia	"	50	7.45	.17	44
Suva	"	18	6.57	.27	24
Suvavou	"	12	3.99	.19	21
Nasilai	Spear	17	15.58	.56	28
Noco	"	13	6.69	.39	17
Kadavu	"	11	7.19	.36	20

Bearing in mind Lock's proposal regarding the change in species composition and diversity induced by increasing fishing pressure, one would expect to see significant changes in the relative contribution of species, this has already been shown in Figures 7 and 8 for the central division in general.

However, within the Division one would expect localities closer to centres of population to display lower species diversity and probably lower equitability as the complexity of the community is diminished by fishing pressure. For the gillnet fishery the more distant site of Rewa does record higher diversity and higher equitability but, although the Suva area ranked lowest in diversity, it did not perform as poorly as expected with respect to equitability. In fact, the equitability index for the Suva gill-net fishery was similar to that recorded for Lokia; the catch in both cases is dominated by mullets (29% Lokia and 34% Suva). However, given that much of the gill-net fishery targets the estuarine and riverine environment this is hardly a surprising result. The lowest species diversity was recorded for Suvavou (a small village to the west of Suva); in this case the catch was dominated by the Scombrid, *Rastrelliger* spp (39%) and mullets (28%).

Given the nature of the operation of the gear itself, the gill-net is probably a better indicator of true species diversity/equitability for a given environment than other gears, such as spear-fishing, which are more selective.

Although it was not surprising that diversity and equitability for Nasilai spear fishery was higher than that recorded for the more accessible Noco, the fact that it is higher than the relatively remote Kadavu Island was unexpected. Comparisons of the species compositions reveal quite different types of fishery, however; Noco, closest to the mainland, closest to Suva and the River Rewa is dominated by goatfish (Mullidae, 26%), small omnivores (Lethrinidae, 18%), parrot-fish (Scaridae, 14%) and rabbit-fish (Siganidae, 10%). This site therefore appears to be typical of a fishery that has experienced heavy fishing pressure, as postulated by Lock.

Nasilai on the other hand is dominated by the capture of trevallies (Carangids, 12%), unicorn-fish (Acanthuridae, 8%) and goat-fish (8%); this may reflect the ecology of the reef environment (exposed to south-east Trade Winds and strong currents). Kadavu however is dominated by the capture of parrot-fish (30%), coral trout (Serranidae, 23%) and unicorn-fish (14%). The reef areas around Kadavu are more diverse as well as being less exposed to fishing pressure.

For all these areas one should consider that they are very different environments; although fishing pressure is clearly having an effect on resources in the Central Division, site by site comparison of species diversity as indicators of fishing pressure should always consider the potential of a local environment to sustain significantly greater diversity. What this analysis does indicate is that the three phases of community diversity and composition suggested by Lock are unlikely to be readily identifiable, and the complexities and variability between reef sites suggests that fish communities will react in very different ways.

6.3 Data Analysis of the FAD Fishery

- **The Fishermen**

Landings data was collected from 42 FAD fishermen at Nubukalau Creek but of these only 8 landed more than one tonne of tuna at the market and this group contributed approximately 60% of total landings (unadjusted figure). The value (in F$) of the catch landed by the top 8 fishermen during the survey period was F$56,247 with mean value of F$7,399.

In addition to the 42 for which data exists, other fishermen (including game-fishermen) were reported to be using the FADs, especially during the weekend period. During the period of survey the FADs increased in popularity and Figure 15 displays the number of fishing trips (squares) and the number of fishermen (solid line) recorded per week at Nubukalau Creek.

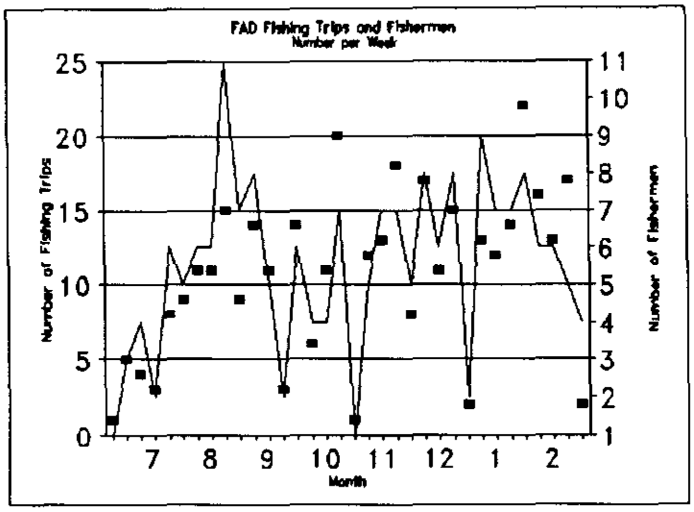


Figure 15: Number of Fishing Trips and Fishermen by Month : FAD Fishery

In general it appears that the majority of the fishermen using the FADs were not previously net or handline fishermen, with former jobs including working as crew on IKA vessels, as labourers and mechanics and as security guards. The top three ranking FAD fishermen had all previously been spear-fishermen. One individual had given up spear-fishing because of his age while the other two reported that they had to travel as far as Kadavu Island and Gau Island to make good catches but that the expense of fuel required to get there and the risks involved led them to change to fishing the FADs. Another two individuals reported that they only began fishing when the FADs were first deployed and that previously they had not been fishermen.

For those reef fishermen from Lokia village who might be interested in utilising the FADs their current vessels (half-cabins) are not suitable for open-water fishing, being of relatively light-weight marine-ply construction and designed for more sheltered waters. The cost of purchasing a new fibreglass Yamaha skiff would be between F$2150 (for a 4.34m vessel) and F$6210 (for a 7.69m vessel and the favoured length). For individuals living in the Suva area access to the FADs is relatively simple while access to the fishing grounds of Noco or the qoliqoli around the Kasa Peninsula and Bau Waters involve travelling larger distances. The individuals who currently regularly and frequently fish the FAD either already possessed a suitable craft (from the spear fishery) or use vessels owned by family members who use the vessels for part-time fishing. There may also be a cultural aspect in the sense that it appears the Indian-Fijian fishermen, while expert at inshore reef fishing, are reluctant to fish the open waters (or to spear-fish), this is similar to the situation in the Western Division. All FAD fishermen were native Fijian.

- **Landings**

A total of 366 fishing trips were recorded by the data-collectors from July, 1993 to mid-March, 1994 and covered a total landing of 29.29 tonnes of skipjack and 5.66 tonnes of yellowfin tunas. Figure 16 displays the monthly landings for skipjack and yellowfin tuna recorded at the Nubukalau Creek Market. The figures have been adjusted up to account for the level of coverage of the survey. The total adjusted landings during the survey period are estimated at 52.11tonnes of tunas, which are becoming the most significant family in terms of landed weight at Nubukalau Creek market.

Overall FAD associated fish have dominated all landings of pelagic fish at the Creek; during the survey period fish worth F$63,933 were landed from the FADs and sold at the market or at FijiFish Ltd (this excludes yellowfin and other species worth F$15,780 sold at FijiFish but from unknown fishing sites although they almost certainly originate from the FADs). Open-water sites have contributed fish worth F$13,062 during the period, approximately 20% by value of total landings. This contrasts with many pelagic fisheries where FADs have been deployed. In the Cook Island pelagic fishery 57% of fishing effort is directed at non-FAD sites (reef drop-offs) compared with 12% for the fishery off Suva. In the Comoros Islands, in the Indian Ocean, 58% of trolling effort was directed at open water fishing sites.

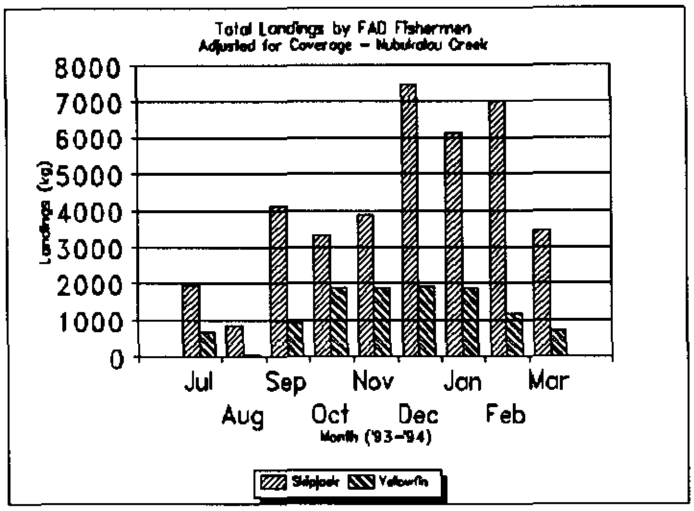


Figure 16 : Landings by Week - FAD Fishery

- **Sales Pattern**

It has been noted that the sales of reef fish at Nubukalau Creek Market varied significantly through the week providing peak days of opportunity for consumers to buy fresh fish; some days would see no reef fish for sale. FAD fishermen however provided a more regular and frequent supply of fish to the market. Figure 17 shows the breakdown on landings (adjusted to account for coverage) of tunas at Nubukalau Creek by weekday. In fact the opposite pattern to that seen for reef fish is seen in this figure; many of the FAD fishermen are Seventh Day Adventists and do not fish on Saturdays, there is also a stronger element of competition from reef fish sellers towards the latter half of the week.

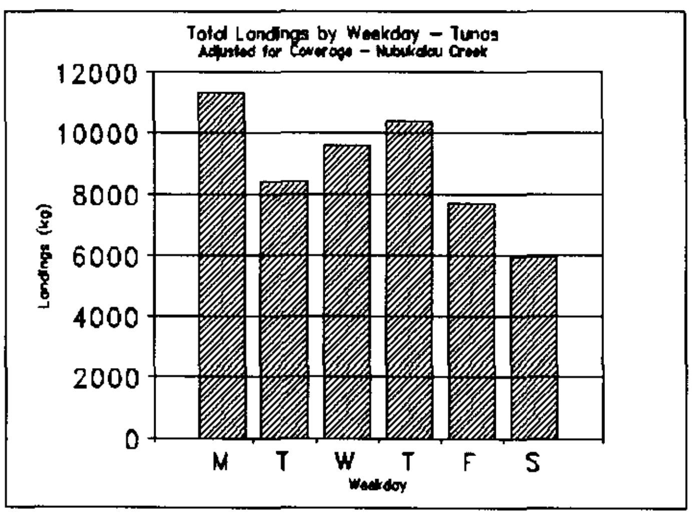


Figure 17 : Landings of Tuna by Week

The actual sales of tunas were carried out by both the fishermen and, more frequently, by spouses or relatives of the fishermen. An estimated 30% of the FAD-caught fish were sold by the fishermen themselves; 31% by the wives of the fishermen; 29.6% by cousins of the fishermen and 7% by the son of one of the fishermen. The remaining proportion was sold by fish-dealers on behalf of the fishermen.

- **Skipjack Tuna Troll Fishery Catch Rates**

Table 6 displays the unadjusted data recorded for the troll fishery from the two FADs and for open-water fishing. Catch per unit effort (CPUE) is calculated as catch (kilograms) per line hour (where time equals time spent fishing around the FAD) while the mean gross value of each unit of effort (VPUE) is calculated as F$ per line hour as determined by the daily market price of tuna species.

Table 6 : Catch, Effort and Catch-Rates for Skipjack Tuna.

Site	Number of Trips	Total Weight (mt)	Total Value (F$)	CPUE (kg/lhr)	VPUE (F$/lhr)
Mau FAD	148	11.01	20,708	12.34	20.56
Nasese FAD	137	12.93	22,415	13.79	24.65
Open Water	53	5.32	10,202	16.38	31.06

An analysis of variance (ANOVA) was computed to test the hypothesis that there is significance between the mean catch-rates between the two FAD sites. The analysis indicated that the difference was insignificant ($F=2.02$, $df=(1,42)$, $P>.25$) and therefore the hypothesis was rejected.

- **Yellowfin Tuna Troll Fishery**

Table 7 below provides catch data for yellowfin tuna, its value and rates.

Table 7 : Catch, Effort and Catch-Rates for Yellowfin Tuna.

Site	Number of Trips	Total Weight (mt)	Total Value (F$)	CPUE (kg/lhr)	VPUE (F$/lhr)
Mau FAD	114	3.71	10,098	4.27	12.93
Nasese FAD	72	1.49	3,618	4.56	12.59
Open Water	29	0.97	2,475	5.40	12.34

Additional, incidental catches included approximately 500 kg of Mahi-Mahi (*Coryphaena hippurus*), and nominal quantities of Albacore tuna (*Thunnus alalunga*) and Rainbow Runner (*Elegatis bipinnulatus*).

FADs are generally perceived to increase catch-rates for fishermen either through aggregating fish and so reducing the search time for fishermen (therefore increasing revenue per hour) or by actually increasing catch-rates relative to open-water sites. The catch-rate data suggests that open-water sites have higher catch-rates, for both yellowfin and skipjack tuna, than FAD sites. The logical explanation for this is that open-water schools have a higher catchability than FAD-associated schools, but the amount of effort expended indicates that such fishing may be opportunistic rather than directed..

Figure 18 displays the catch-rates at each site against time for the troll fishery. During the early part of the survey (weeks 26-37) the only FAD on site was Nasese, the Mau FAD having been lost, hence the concentration of fishing effort on the single site. Fishermen reported that the aggregator on this FAD was becoming heavily fouled around week 35 which corresponds to the declines in the catch-rates. In week 37 the Mau FAD was re-deployed and fishing effort switched to this FAD after week 37, a situation that remained until week 48 after which time both FADs were used.

The important observation to make is that catch-rates for all three sites show an increase towards the latter period of the survey. While the mean catch-rate for the survey period is lower for FAD fishing than open-water sites the mean catch-rates for all three sites during the latter period are in fact similar. If catch-rates were continually higher at open-water sites fishermen would probably have fished those sites more often. There appears to be a seasonal effect that affects catch-rates at all sites (perhaps related to the depth of euphotic zone).

However the figure also indicates that from week 7 all fishing effort has been reported as being located at open-water sites which suggests (given the approximate equality of catch-rates between sites up to that time) that the FADs are no longer succeeding in aggregating tunas. There are two possible reasons for this; firstly that due to some behavioural attribute tunas are not prone to aggregation during this period, this may be a function of seasonal changes in the abundance of food leading to dispersal of aggregated schools.

Secondly, reports from the fishermen suggest that the loss of the sub-surface aggregator is the main reason for the dispersal of the schools; they remain fishing schools in the vicinity of the FADs (Nasese and Mau areas) but do not report as fishing 'on' the FADs themselves.

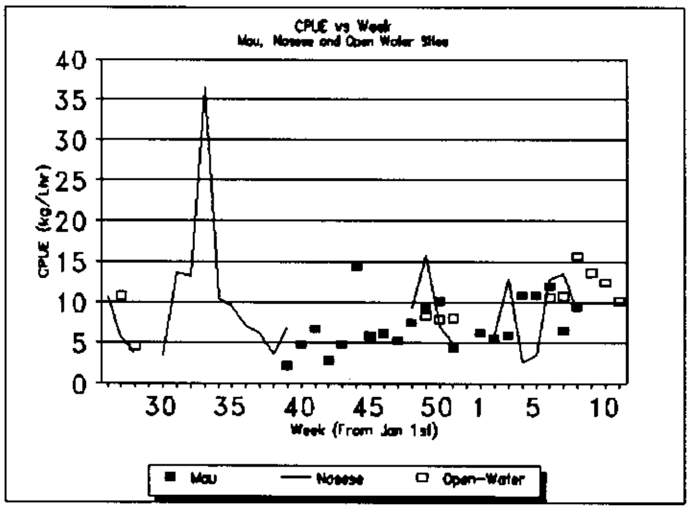


Figure 18: CPUE in Each Site per Week

Figure 19 displays the mean trip length by week for the fishery. The period of longest mean fishing trip per week corresponds with the period of lowest catch-rates (see Figure 18) suggesting an inverse relationship between catch-rate and trip length.

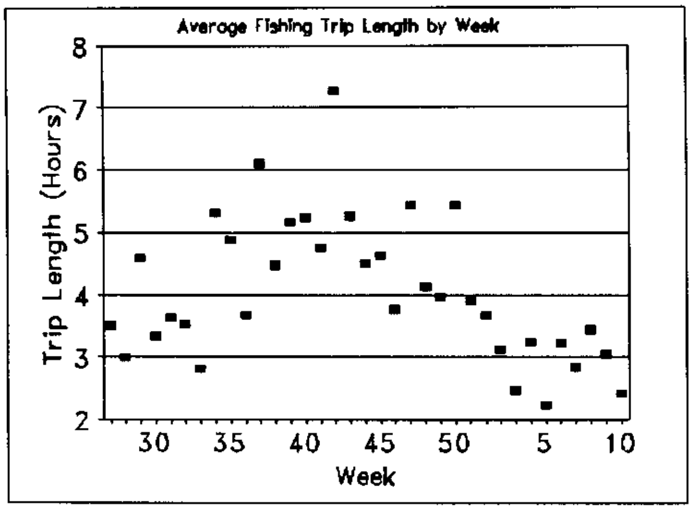


Figure 19: Average Fishing Trip Length per Week

Figure 20 describes a plot of the CPUE against mean trip-length (the data has been aggregated by week) for Mau FAD. A regression of Ln(CPUE) against fishing trip length was calculated (R^2 = 0.857; a = 3.85, b = -0.145) and the resulting model (back-transformed) has been fitted to the scatter-plot of CPUE against trip-length in Figure 19.

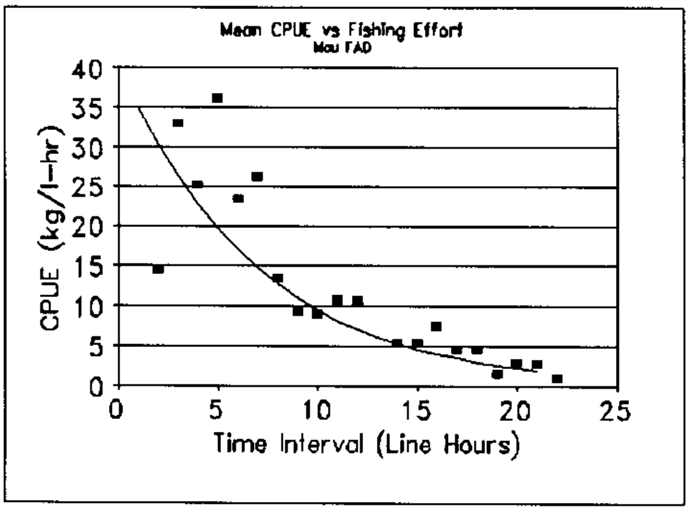


Figure 20: CPUE against Mean Trip Length for Mau FAD

Figure 21 shows equivalent data for Nasese FAD (R^2 = 0.844, a = 3.77, b = -0.119). This model would appear to fit the data more realistically than that described for the Mau FAD which displays many positive residuals; these result from the effect of the single low catch-rate point corresponding to 2 line-hours of effort, however the point covers four fishing trips and there are no other reasons to discard it.

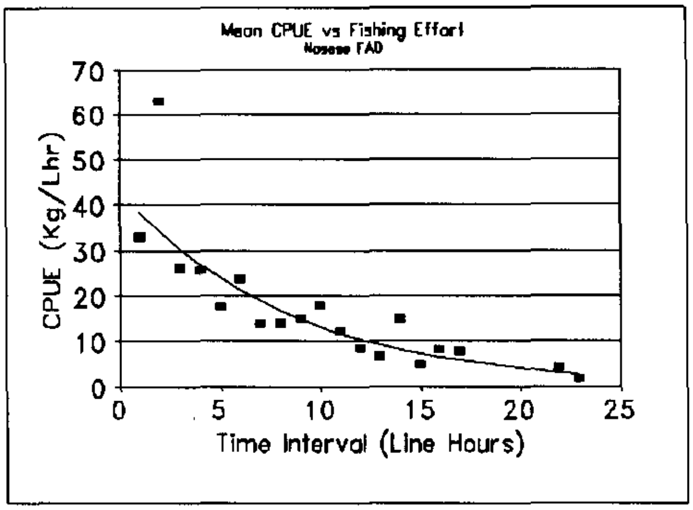


Figure 21: CPUE against Mean Trip Length for Nasese FAD

In both cases there is an exponential decline in the catch-rates with increasing trip-length; this is probably the effect of the time of the fishing activity. A general rule of thumb regarding the best time to troll is that the peak 'bite' is from around dawn to about 0900hrs. Of course what is not known is the catch-rate at each hour during these fishing trips which could help explain why fishermen continue to fish as catch-rates drop below the minimum required to cover costs. Figure 22 displays the relationship between mean total catch and fishing effort for Mau FAD.

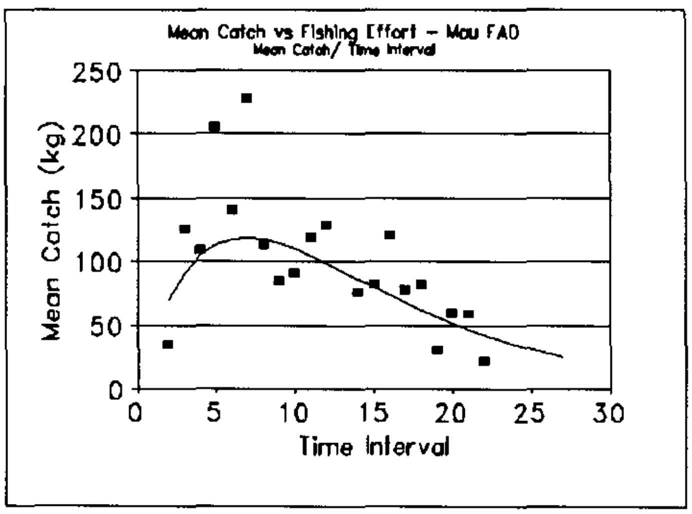


Figure 22: Mean Catch against Fishing Effort for Mau FAD

At the Mau FAD the peak mean-catch of 227.9kg per trip was realised after 7 line-hours of fishing effort at the FAD. Using the relationship between CPLHR and effort described above, a curve has been fitted which corresponds to a peak catch of 118.5 kg made after 7 line-hours.

Figure 23 describes corresponding data for the Nasese FAD. A very similar pattern is shown as that seen at the Mau FAD but for this FAD the model predicts the peak catch at 133.4 kg after 8 line-hours fishing effort at the FAD.

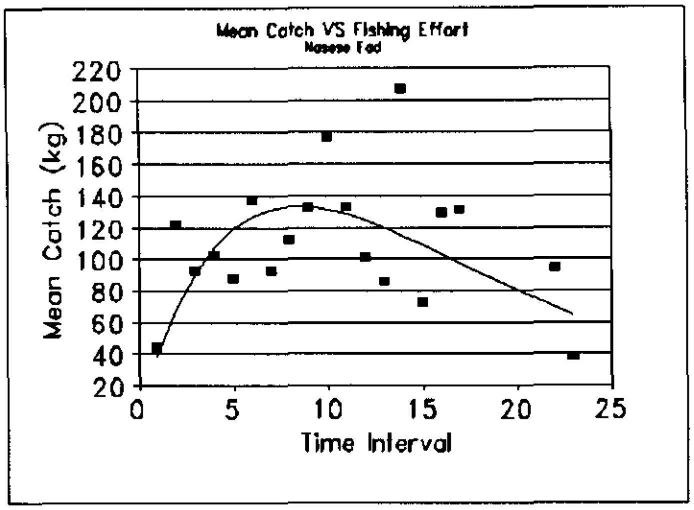


Figure 23: Mean Catch against Fishing Effort for Nasese FAD

■ **Possible Influences on Catch Rates**

Given that there is a relationship between trip-length and catch-rate what are the possible key explanatory variables that would account for both this relationship and the seasonality in catch-rate described in Figure 16? Is the variability explained by seasonal factors (eg increasing sea-surface temperature) or by factors determined over a smaller temporal scale?

Step-wise multiple linear regression was carried out using the MultiVariate General Linear Hypothesis (MGLH) feature in SYSTAT Version 5.03 in an attempt to explain the variation in catch-rates, preliminary analyses were carried out at two temporal scales; by week and by day. The parameters investigated were :

Number of Trips per Day : Fishermen often comment that when too many vessels fish one FAD they interfere with each other and so reduce collective catch-rates, this is of importance when considering the number of FADs to deploy in an area and the expectations that they will attract effort away from the reef fishery.

Trip Length : This has already been discussed in terms of how the actual timing of the fishing is thought to impinge on catch-rates, such that high-catch rates are recorded at dawn which steadily decline through the day to increase again at dusk.

Daily Total Catch and Effort : This is obviously related to the number of trips per day but has been included from the perspective of a possible depletion effect resulting from large quantities of effort.

Mean Wind Speed and Highest Recorded Gust : These are included for the obvious reasons of affecting both the operation of the vessels and possibly the catchability of tuna by affecting the visibility of the lure itself.

Mean weekly catch-rates were regressed against mean trip-length, mean weekly wind-speed (data provided by the Fiji Meterological Service), the mean maximum wind speed, the total number of fishing trips during each week and the total number of individual fishermen operating. SYSTAT assigned two variables as being explanatory of the variance in the catch-rates, mean trip-length (b_1) and mean maximum wind speed (b_2) ; the coefficients are as follows :

$R^2 = 0.41$, $a = 44.531$, $b_1 = -2.183$, $b_2 = -0.755$, $P = 0.003$

The relationship between trip-length and catch-rates is expected. However, there are other features that may well be as important such as the depth of the mixed layer/euphotic zone and wind speed.

During an environmental impact assessment, by NSR Environmental Consultants Ltd, of a proposed mining operation to the west of Suva, data was collected on the depth of the mixed and euphotic layer of coastal waters around Suva. The euphotic zone depth increased from 60 metres (January to May, 1993) to a maximum of 120 metres from June to October 1993 (weeks 26 to 44) (Placer Pacific Ltd, 1994). While high catch-rates during the middle of this period prevent observation of a clear correlation, the consistently low catch-rates from week 36 to week 48 suggests that this area of research deserves more attention. In fact there is likely to be complex interaction between a number of variables including the effect of sea-state on boat-handling and catchability of the fishing gear, and the depth of euphotic zone. Furthermore there is likely to be a degree of inertia in the response of the mixed layer and euphotic zone to prevailing winds.

Manuals on fishing techniques often report on the relationship between the weather and fishing success; one of the most important influences on catch-rates while trolling is the sea-state. Although there are as many theories as there are fishermen on what constitutes perfect fishing conditions in general it is a combination of trade-offs between the effects of high sea-state (poor conditions affecting the performance of the vessel but possibly enhancing the performance of the fishing gears) and the effects of low sea-state (lures become too visible to the fish but vessel performs well and schools are easily sighted). Anecdotal reports from the FAD fishermen off Suva suggest that overly calm weather is as bad for fishing as rough weather.

Does wind speed affect the volume of water available in which tunas can forage and therefore reduce the catchability of surface fishing gears? The southern hemisphere winter is characterized by the South-East Trade winds; prolonged wind has the effect of increasing the depth of the mixed layer which in turn tends to increase the depth of the euphotic zone. The deeper euphotic zone has the effect of increasing the potential volume in which tunas can forage and therefore reduce their vulnerability to surface fishing methods such as trolling.

6.4 Development of Mid-Water Fishery

As can be seen from the data the FAD fishery is dominated by trolling; however the occasional capture of large yellowfin tunas with trolling gear stimulated the fishermen to try other gears and in November, 1993 the fishermen began to experiment with mid-water fishing while tied to the FAD raft. Simple handlines strung on plastic reels were used with baited tuna-circle hooks on a trace line as the terminal rig; FAO/Samoan reels are not used by these fishermen although this relatively simple and cheap addition to the boat could facilitate landings of larger tuna. This fishery was a significant development because the larger size of fish landed (from 25kg to 85 kg) were of high-value species including yellowfin, albacore (*Thunnus alalunga*) and big-eye tuna (*Thunnus obesus*) and Marlin (Istiophoridae). The majority of the larger fish were sold to a local export company, FijiFish Ltd, to be exported to Hawaii and the Japanese sashimi market. The size of the fish caught by handline were in general too large for the local consumers at the Nubukalau Creek Market, although some fish were sold to restaurateurs. The data from FijiFish Ltd covers records from 05-11-93 to 08-02-94 and includes sales records for 30 fishermen; Table 8 below shows the breakdown of the catch by species.

Table 8 : Synopsis of sales by FAD fishermen to FijiFish Ltd.

Species	Weight (kg)	Number of Fish	Total Value (F$)	Average Price/ Kilo
Albacore	516	30	1,393	2.65
Big-Eye	24	1	144	6.0
Marlin	133	7	314	2.66
Mahimahi	547	57	1,655	3.0
Skipjack	6	1	9	1.5
Wahoo	18	1	45	2.5
Yellowfin	5,374	171	21,599	3.7

A total of 6.62mt of tunas were sold to Fijifish during the period for which data is available worth a value of F$25,159 to the fishermen. Sashimi quality yellowfin fetched F$5.00 per kilo, with some fishermen receiving in excess of F$300 for a single fish.

The development of this fishery was significant for two reasons. Firstly it is one of the few small-scale commercial FAD fisheries in the Pacific region where the fishermen sell directly to an export firm. The requirements of high fish quality demanded that the fishermen take ice to sea and in general this led to an improvement in the quality of tunas for sale at Nubukalau Creek; the ice remaining from the fishing trips is used to hold the smaller skipjack and yellowfin on sale to the public.

The export market potential also led to the development of a full commercial operation; a fish-dealer from Feeders Seafood Ltd contracted a vessel (crewed by Rabi Islanders, originally from the island of Banaba, in Micronesia) specifically to fish the deep-swimming tunas. This vessel would spend the night fishing while tied up to one of the FAD rafts (particularly Mau FAD). However, the small-scale fishermen believed that the night-time activity affected the schooling patterns of the surface-schools of skipjack and yellowfin and therefore had a negative effect on their fishing the following morning; this created the first signs that the conflict that so often plagues FAD programmes was developing. The troll fishermen requested that the Fisheries Division ban the Rabi islanders from the FADs, they felt they had 'ownership' of the FADs. However, at the time of writing no serious conflict had developed between the different user-groups.

6.5 The Economics of FAD Fishing

How has the fishery developed in terms of weekly value of landings and what effect has this had on the behaviour of the fishermen?

Figure 24 on the next page displays the weekly (unadjusted) value of landings from FADs. There is clearly an increase in the weekly value of the landed catch, particularly after the development of the export market for Sashimi quality yellowfin tuna.

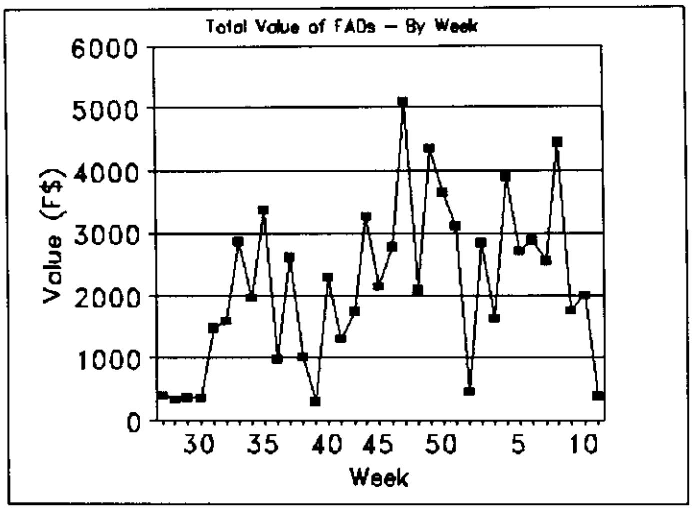


Figure 24: Total Value of FADs by Week

Although the value of landings continued to increase through the period of research the market price for tunas did not significantly decline as a result of excess supply. Market prices for tuna at Nubukalau Creek are generally below those obtained for reef-fish; where fish prices could reach F$5.00/kg for the higher value species such as Donu (*Plectropomus* spp), tuna prices rarely exceeded F$2.50 per kilo. Figure 25 shows the mean weekly price obtained for skipjack tuna, the horizontal line represents the average price over the survey period. Even within the price band shown in the figure there were obviously fluctuations through the day dependent on landings by other fishermen and the sales of tuna.

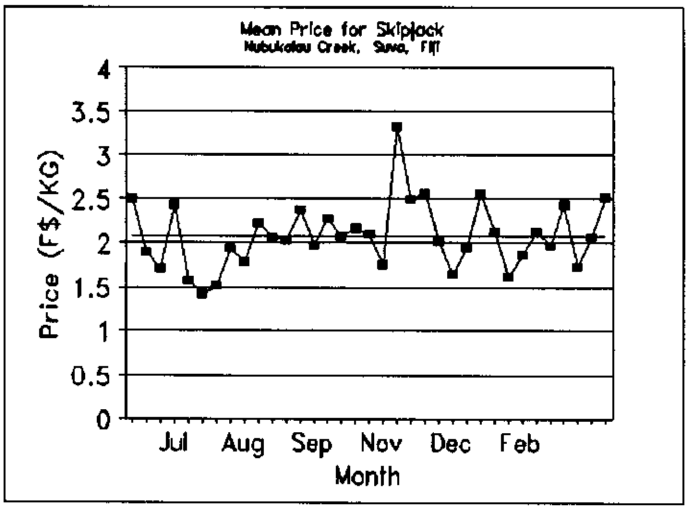


Figure 25: Mean Price for Skipjack by Month at Nubukalau Creek

What is the optimal time for fishermen to spend fishing during any one fishing trip? A regression of the (log) mean value per trip against length of time spent fishing around the FAD was computed for the skipjack troll fishery data and from this a curve of expected revenue per hour fishing was calculated. Figure 26 displays the relationship between costs and the revenues from the skipjack troll fishery around Mau FAD. The costs curve includes fixed costs (theoretical repayment on bank loans over 100 fishing trips per year) and variable costs (engine maintenance, opportunity cost of fishing and fuel costs). Costs refer to the hourly cost rather than costs per line-hour, costs are not dependent on the number of lines utilised with the exception of crew costs which have already been factored in (although in general the crew tends to be friends or family and are not paid by an hourly rate but rather get paid in kind). The maximum returns on fishing (F$267) are realised after 7 line-hours of fishing while the maximum economic yield (MEY) of F$155 is realised after 5 line-hours of fishing effort.

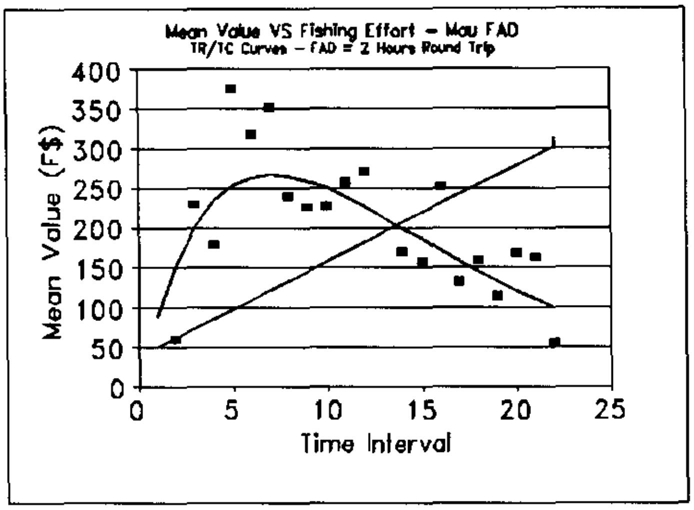


Figure 26: Mean Value against Fishing Effort for Mau FAD

Any subsequent deployments will have to be assessed in terms of a trade-off between increased travel time and profitability and the marginal gross value of an additional FAD. Figure 27 displays a series of curves of profitability against the round-trip travel time to the FAD. The catch-rates and costs are assumed to be the same as used for the previous analysis. It can be seen that an 100% increase in travel time to the FAD reduces profits by approximately 17%; however, one should bear in mind that increasing distance requires earlier starting times for the fishermen if they are to fish during the period of peak catch-rates. Furthermore some (recreational) fishermen may be deterred from using the more distant FADs because of the higher initial 'investment' required simply to get to the FAD and return to port. This will lead to a lower aggregate catch and therefore the marginal value of the FAD will be significantly lower than one would expect based on the economic performance of more proximal FADs.

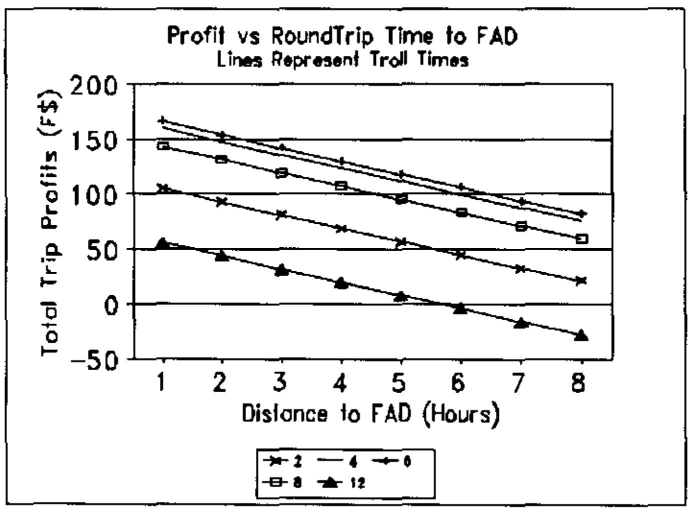


Figure 27 : Profit against Roundtrip Time to FAD

7. *Conclusions and Recommendations*

Conclusions

- **The Need For FADs**

The majority of Pacific island nations are currently undergoing a period of rapid population growth and, in association with this, a rapid increase in the rate of exploitation of fisheries resources. Historians and anthropologists believe that most islands were more heavily populated prior to contact with Europeans, however the post-contact period of their histories were almost without exception characterised by rapid de-population resulting from imported diseases, black-birding and inter-tribal warfare. However, while exploitation rates of marine resources were certainly high during the pre-European period, the impact was far less than that of the current exploitation levels due to the introduction of modern fishing techniques and fishing gear, especially the use of mono-filament lines and gill-nets and outboard engines. The current trend of population growth shows little sign of abating as nutrition and health-care standards improve across the region. The demands placed on natural resources are further increased by the rise in urbanisation and the growth of transitory populations (tourists) within the region. In 1992 an estimated 279,000 tourists visited Fiji.

Artisanal fisheries production in Fiji increased from an estimated 2,650 mt in 1981 to an estimated 4,338 mt in 1986. From 1986 however overall landings have declined to an estimated 3,953 mt in 1992. The situation in the Central Division is more severe however, Part I, Section 4.1 described the decline in landings of fish in the Central Division of Fiji, the estimated landings have declined from 3,002 mt in 1986 to 1,892 in 1992, a decline of 40% (Fiji Fisheries Division).

Faced with this decline in production what are the options available to Fiji Fisheries Division to maintain both the livelihood of the fishermen and the supply of fresh fish to the large urban markets? A possible consideration would be to increase the movement of fish from less-populated areas to those with the heaviest demand, and indeed there is already subsidised transport of fish from the Lau Group to Suva. A number of local companies and entrepreneurs are also developing markets on Viti Levu for fish originating in Vanua Levu's waters. This option clearly fails to address the needs and problems that fishermen on Viti Levu, particularly in the Central Division, experience. It is a common complaint of fishermen in the area that they feel their trade is being threatened by 'imports' of fish from other regions of Fiji, they argue that not only is the market for their fish possibly threatened by old, poor quality fish being dumped in Suva, but that the price is driven down by the supplies from outside. Similarly, many fishermen from Lokia village, when interviewed about their fishing activities, reported that they have to spend much more time looking for good grounds than they believe they previously had to. It is not uncommon for fishermen to travel as much as 18 miles in one night searching for good fishing.

Fish Aggregation Devices have been heralded as the solution to many of the problems of over-fishing of reef areas; the expectation was so great that in 1991 Greg McIntosh, the inventor of a mono-filament FAD equipped with 'sea-kites', convinced his congressman that his invention was 'going to feed the world' (P.Watt, pers comm).

■ **Do FADs Work ?**

Increased Landings?

This research has assessed the impact that two FADs deployed off Suva, the capital of Fiji, have had on local fisheries production and the extent to which fishermen have been attracted away from other resources in the area. The FADs off Suva are an unquestionable success; a total of 41.62 mt of tunas were caught by FAD fishermen during the period of study valued at an estimated F$79,700. Of this figure 34.95 mt were landed at Nubukalau Creek and a further 6.6 mt were sold to an export company, FijiFish Ltd. Local sales equate to 13% of total finfish sales at the market during this period. A coverage rate of 65% was achieved for the survey period, therefore the adjusted weight of fish caught at the FADs during this period is 52 mt.

Has there been a reduction of effort on the reef fishery?

Prior to the deployment of FADs there was no established small-scale pelagic fishery. During the survey period 42 fishermen were known to fish the FADs of which 8 fishermen could be described as full-time FAD fishermen; three of these fishermen had previously been spear fishermen but only two were active spear-fishermen prior to the deployment of the FADs. The deployment of FADs therefore appears to have had little effect in reducing the effort on coastal reef and estuarine fisheries, with the possible exception of the spear-fishery.

Are further employment opportunities created from marketing of FAD-caught fish?

The FAD fishermen in general did not sell their catch to fish-dealers as is commonly done in the reef fishery. Direct employment opportunities created from the marketing of FAD-caught fish were therefore generally limited to family members; the wives of the fishermen were not directly paid by the fishermen to sell the fish but at least one of the wives has taken up a role as a fish-dealer with a number of client fishermen in addition to selling the fish caught by her husband. The cousins involved as vendors also acted as fish-dealers by buying the fish and selling on to the public but had not been involved in fish marketing prior to FADs. What appears to have developed therefore is a relatively small clique of native Fijians involved in the FAD fishery, fishermen who work together (often fishing together in a single boat). Family members and friends are generally used as crew with payment in terms of a cut of the returns from fishing. Given that an hourly wage for a labourer is around F$1.00-1.50 per hour, fishing the FADs is a lucrative option. However, the numbers of fishermen that are 'full-time' FAD fishermen appears constant although more individuals are becoming involved in the FAD fishery on a part-time basis borrowing or hiring boats.

■ **Economic Returns**

The 3 FADs deployed by Fiji Fisheries Division cost an estimated F$13,000 in total (costs are unavailable for certain items of hardware, they originated from an aid-donor project).

The expenditure by the Fisheries Division equates to an effective subsidy of F$0.31 per kilogramme of fish landed from the FADs. If the adjusted figures, namely 52mt, are used the subsidy falls to F$0.25 per kilogramme (excluding the sales to FijiFish). If the FADs last an additional 1 year and an equivalent weight of fish is landed (52*2) then the subsidy falls to F$0.125 per kilogramme.

A total of 42 fishermen exploited the FADs with 8 fishermen landing 60% of the total unadjusted weight. The mean earnings of these fishermen during the survey period were F$7,399, equivalent to F$142 per week. All the FAD fishermen surveyed were native Fijians.

The Future

There has been some doubt amongst senior personnel within the fisheries department of the effectiveness of FADs; given that the FADs are expected to reduce fishing effort on the reef fishery one could argue that the FADs have not achieved this goal. However, they have proved to be successful in stimulating the development of what is essentially a new fishery which is contributing a significant weight of fish to the Nubukalau Creek market and employment opportunities for a number of fishermen. The development of the export market with FijiFish Ltd is a particularly encouraging feature of the fishery.

FAD deployment is a complex issue the success of which depends not only on the aggregation of tunas but also careful site selection. If additional FADs are to be deployed in the area around Suva, detailed consideration must be given to the spacing of FADs (to maintain the optimal performance of each individual FAD). Equally important however is the identification of the target user-group. Increasing distance from port will clearly have to be weighed against potential revenues.

Before any further establishment of FAD projects in Fiji, it is recommended that a rigid assessment of the fishermen will respond to the extent that has occurred around Suva. This is particularly important where FADs are considered for more remote areas where not only are existing resources less-exploited but where marketing opportunities are smaller. In Suva the capabilities of the local markets to absorb more tunas, which are generally less popular than reef fish, remains in doubt. The deployment of additional FADs around this area therefore should be carefully considered. However, there is certainly a demand for more FADs to be deployed in the area, notably amongst those individuals who do not fish the FADs regularly. They feel that the hard-core of FAD fishermen unfairly dominate the existing FADs and that additional deployments will facilitate their own fishing performance by reducing crowding around an individual FAD.

The FAD Handbook addresses these issues and should therefore form the basis of any future assessment of the need for FADs in Fiji.

Appendix 1: Bibliography

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