COSTAL FISHERIES PROGRAMME

Report of

a pilot fish aggregation device (FAD)

deployment off Port Moresby, Papua New Guinea

27 June 8 August 1992

SOUTH PACIFIC COMMISSION
NOUMEA, NEW CALEDONIA

SOUTH PACIFIC COMMISSION

COASTAL FISHERIES PROGRAMME

REPORT OF

A PILOT FISH AGGREGATION DEVICE (FAD) DEPLOYMENT

OFF PORT MORESBY, PAPUA NEW GUINEA

27 June — 8 August 1992

by

S. Beverly
Consultant Masterfisherman

and

P. Cusack
Fisheries Development Officer

Printed with financial assistance from
The United Nations Development Programme

South Pacific Commission
Noumea, New Caledonia
1993

564/93

Original text: English

South Pacific Commission Cataloguing-in-publication data

Beverly, Stephen.
Report of a pilot fish aggregation device (FAD) deployment offPort Moresby, Papua New Guinea, 27 June—8 August 1992 / S. Beverly and P. Cusack.

1. Fish aggregation device--Papua New Guinea.
I. Cusack, Peter. II. South Pacific Commission. Coastal Fisheries Programme. III. Title.

ISBN 982-203-335-4 AACR2
639.209953

Cover: Photograph of Daugo Island skiff at sea

Prepared for publication and printed at
South Pacific Commission headquarters,
Noumea, New Caledonia, 1993

SUMMARY

In an attempt to diversify artisanal fishing effort away from reef slope and lagoon resources considered to be overfished in some areas, particularly those adjacent to large urban population centres, and to improve the productivity and efficiency of domestic small-scale tuna fisheries, Papua New Guinea's Department of Fisheries and Marine Resources (DFMR) decided to investigate the potential for the deployment offish aggregation devices (FADs) to contribute to these aims. The technical assistance of the South Pacific Commission's Coastal Fisheries Programme (CFP) was sought in making this assessment.

At DFMR's request SPC's Fisheries Development Officer made a visit in June 1991 to several provinces where FADs were considered to have potential benefit. This visit resulted in the recommendation, accepted by DFMR, that a pilot FAD deployment be carded out in the National Capital District before considering expanding such a programme to other areas.

Subsequently, under the Commission's Offshore Fisheries Development (OFD) Project a consultant FAD technician and master fisherman, Stephen Beverly, was engaged to travel to Papua New Guinea to provide technical support to DFMR staff in undertaking an initial FAD deployment. The assistance included the completion of FAD site bathymetric surveys, supervision of the rigging of the FAD mooring, overseeing raft construction, supervision of deployment and the informal training of counterpart DFMR staff in these skills.

SPC equipment was provided for the site survey work, including a deep-water echo-sounder and a Global Positioning System (GPS) navigation unit. These were fitted to a DFMR vessel made available for the project. Two potential FAD deployment zones off Port Moresby were selected by DFMR after consultation with fishermen and local maritime authorities. Surveys of site bathymetry were conducted by running transects and recording depths at 0.25 nm intervals. At the completion of each survey, bottom depths were plotted and contours drawn for each survey zone. A primary FAD deployment site was selected in proximity to the fishing community based on Daugo Island (Fishermen's Island) near Port Moresby, as well as two alternative deployment sites.

Materials for the FAD mooring had been previously imported on DFMR's behalf by a local fishing supply company. A steel FAD raft (buoy) was fabricated to SPC specifications by a local engineering company. Problems were encountered during rigging of the FAD mooring owing to the impossibility of successfully splicing a cored nylon rope procured for the project. It was thus not possible to rig a standard inverse catenary curve mooring. Instead it was decided to rig the mooting entirely of two-in-one braided polypropylene rope and to incorporate a counterweight to sink this floating rope away from the surface. The FAD was subsequently deployed successfully at a site some 5 nm SSW of Daugo Island.

DFMR staff were advised to inspect and maintain the FAD regularly and encouraged to establish a FAD-catch regime. It is expected that results of such monitoring will allow for an assessment of the FAD's effectiveness and value and assist DFMR in formulating a national FAD strategy.

ACKNOWLEDGEMENTS

The South Pacific Commission acknowledges with gratitude the co-operation provided by the administration and staff of the Department of Fisheries and Marine Resources to Coastal Fisheries Programme staff during their work in Papua New Guinea. Particular thanks are offered to First Assistant Secretary, Resouce Development/Extension and Training, Rai Alu, and to Louis Aitsi, First Assistant Secretary, General Services, as well as Len Rodwell, Noan Pakop, Rakwa Leka and the captain and crew of the FV *Kikori Tamate*.

The commission also acknowledges with gratitude the many people in the private sector who gave freely of their time and services in support of the project, including Maurice Brownjohn of The Net Shop, Neil O'Reilly of Port Moresby Transport, Ron Holgate of Engineering and Marine Services, and Merv Penny of the Port Moresby Game Fishing Club.

SPC's role in this project was made possible through funding support provided by the United Nations Development Programme to the Commission's Offshore Fisheries Development Project.

CONTENTS

LIST OF FIGURES

1. INTRODUCTION

The South Pacific Commission's Coastal Fisheries Programme includes two Projects concerned with capture fisheries development.

The Deep Sea Fisheries Development (DSFD) Project, which has operated since 1978, is a mobile field assistance rural development project with the following broad, objectives:

- To promote the development or expansion of artisanal fisheries throughout the region, based on fishery resources which are locally under-utilised, in particular the deep-bottom resources of the outer reef slope and offshore aggregations of pelagic species;

- To develop and evaluate affordable, appropriate technology, fishing gear, fishing techniques and fisheries enhancement methods which will enable both subsistence and commercial fisher-men to increase sustainable catch levels substantially;

- To provide practical training in fishing techniques and fisheries enhancement methods to local fishermen and government fisheries extension workers.

The **Offshore Fisheries Development (OFD) Project**, initiated in mid-1992 with funding support by the United Nations Development Programme, operates under a similar strategy, but has as its particular mandate the provision of technical assistance to member countries in the development of fish aggregation device (FAD) programmes and small- to medium-scale tuna fisheries.

The DSFD project has operated in Papua New Guinea on four occasions. A 1979 visit was based at Kimbe, West New Britain (Fusimalohi & Crossland, 1980) and a second visit, during 1982, operated at Port Moresby, at Samarai and Manus Islands. A third, during 1984, visited West New Britain, Manus, and East Sepik Provinces (Chapman, in press) while the fourth visit was to Oro Bay in Northern Province, Rabaul in East New Britain and Kavieng in New Ireland (Wellington, in press). Each of these field visits was concerned with developing the capacity of rural fishing communities to make best use of local fish resources. Project activities included test fishing to assess deep reef slope and coastal pelagic fish resources the development and demonstration of gear and techniques appropriate to promote better utilisation of such resources by artisanal fishermen and women.

The current technical assistance project was undertaken by the OFD Project following a request to SPC by the Government of Papua New Guinea for support in developing a national FAD use programme with particular emphasis on the use of FADs in fisheries adjacent to larger urban populations. Such a programme, by possibly enhancing the efficiency and productivity of offshore fisheries, was seen as having the potential to relieve fishing pressure on stressed inshore resources by diversifying effort.

Following a visit in June 1991 by SPC's Fisheries Development Officer to assess the potential for FAD use in various provinces and the subsequent recommendations made to Papua New Guinea's Department of Fisheries and Marine Resources (DFMR), DFMR decided to initiate a pilot FAD programme in the National Capital District, which encompass the nation's capital Port Moresby. A consultant masterfisherman and FAD technician, Stephen Beverly, was engaged by SPC to provide technical assisitance to DFMR Staff in. completing the rigging and deployment of the FAD.

The consultant worked with DFMR between 27 June and 8 August 1992. Project activities during this time included fitting out of the survey vessel, assembly of FAD mooring components, completion of bathymetric surveys, calculation of the mooring configuration, supervision of the rigging of the FAD mooring, and supervision of the deployment. Emphasis was given to informal practical training of counterpart DFMR staff at each stage of the project.

2. BACKGROUND

2.1 General

Papua New Guinea (PNG) has a land area of some 476,500 sq km comprising the eastern half of the New Guinea mainland, the Bismarck Archipelago (Manus, New Ireland and New Britain), Bougainville and Buka. Hundreds of smaller islands lie within PNG's borders, scattered across the Bismarck, Solomon and Coral Seas.

The central core of the mainland is a massive cordillera interspersed with wide valleys at altitudes up to 1800 m. Alluvium derived from active mountain erosion is deposited extensively in the broad, swampy Sepik River Basin and the low, swampy plain of the Fly River and Gulf of Papua. New Britain, New Ireland and Bougainville are part of high island arcs.

Tropical rainforest covers about three-quarters of the country. The remainder is covered in savannah, grassland and swamps. Some 97 per cent of all land is held under customary tenure and part of this is used for subsistence agriculture (much of it on a shifting or rotational basis). Cash crops include copra, coffee, rubber, palm oil and tea, grown on smallholdings and on plantations. There is some forestry.

Except in high altitudes the climate is tropical with uniformly high temperatures and regular heavy rainfall. PNG is one of the largest constantly wet areas in the world and rainfall in some areas ranges up to 5000 mm annually. South-east trade winds predominate from May to October, and the north-east monsoons from December to March. During the transition winds are variable with periods of hot, humid calm.

Population is esitimated at nearly 3.5 million, 98 per cent of whom are indigenous Melanesians. The rugged topography has divided the country into numerous regional settlements and has contributed to a remarkable cultural diversity. There are more than 700 indigenous spoken languages, which fall into two main groups, Papuan and Melanesian. Pidgin was first used in trade and has become the common language, though English is taught in schools and is widely understood.

The majority of the work force is engaged in primary production, either at subsistence level or in cash-cropping. Mining is important and a number of small manufacturing industries produce for the local market. The main exports are copper, gold, coffee, cocoa, copra and coconut oil, and fish.

Politically independent since 1975, the country is divided into 19 administrative provinces, with the national capital at Port Moresby on the southern coast of the mainland. The national unit of currency is the PNG kina (1 kina = 100 toea).

2.2 Existing fisheries

PNG's extensive coastline and offshore archipelagos present a great diversity of coastal types and marine environments. The Gulf of Papua is characterised by large delta areas, mud flats and mangrove swamps. The North Coast and the high island coasts are typified by fringing coral reefs and narrow lagoons. Some of the smaller island clusters lie adjacent to extensive submerged reef systems or broad shallows.

Arfisanal fisheries throughout the country reflect the diversity of coastal environments and, although an important element in subsistence food-gathering, are poorly developed by Pacific standards. This reflects to some extent the traditional preoccupation with agriculture common in Pacific states having large areas of arable land available.

Along the mainland and high island coasts and in the smaller island communities fishing activities include the harvesting of the reef flats, spearfishing, shallow-water handlining from dugout canoes, netting, and trapping in the freshwater reaches of the larger rivers.

Only limited use has been made of FADs in the artisanal fishery. A 1984 deployment of two FADs off the north-western coast of the mainland indicated that the productivity of troll fishing could be increased significantly under certain conditions. Only one of these FADs (deployed in 390 m) successfully aggregated fish and is reported to have consistently provided troll catches averaging 12 kg/hr/vessel, tripling the annual harvest of tunas by fishermen in Wewak (Fresher, 1986). However, a series of nine FADs deployed under a Japanese Overseas Fisheries Cooperation Foundation (OFCF) project in East New Britain during 1983/84 was much less productive, with a troll catch of 2.7 kg/vessel/day being recorded (Anon, undated).

Commercial exploitation of local marine resources has long been dominated by the offshore tuna fishery, conducted by foreign-based vessels and foreign vessels based locally under joint venture arrangements. During the 1970s a domestic pole-and-line fishery was the most productive Pacific-based tuna fishery. Japanese vessels fishing in joint ventures averaged catches of nearly 30,000 t annually between 1971 and 1981. The fishery was suspended in 1982 following a downturn in the economics of the industry.

A major offshore fishery continues with foreign purse-seine vessels fishing under licence in PNG's 200-mile Declared Fishing Zone (Figure 1). Purse-seining began in the early 1970s and increased dramatically in the early 1980s. Catches have exceeded 200,000 t annually in recent years (SPC, 1992).

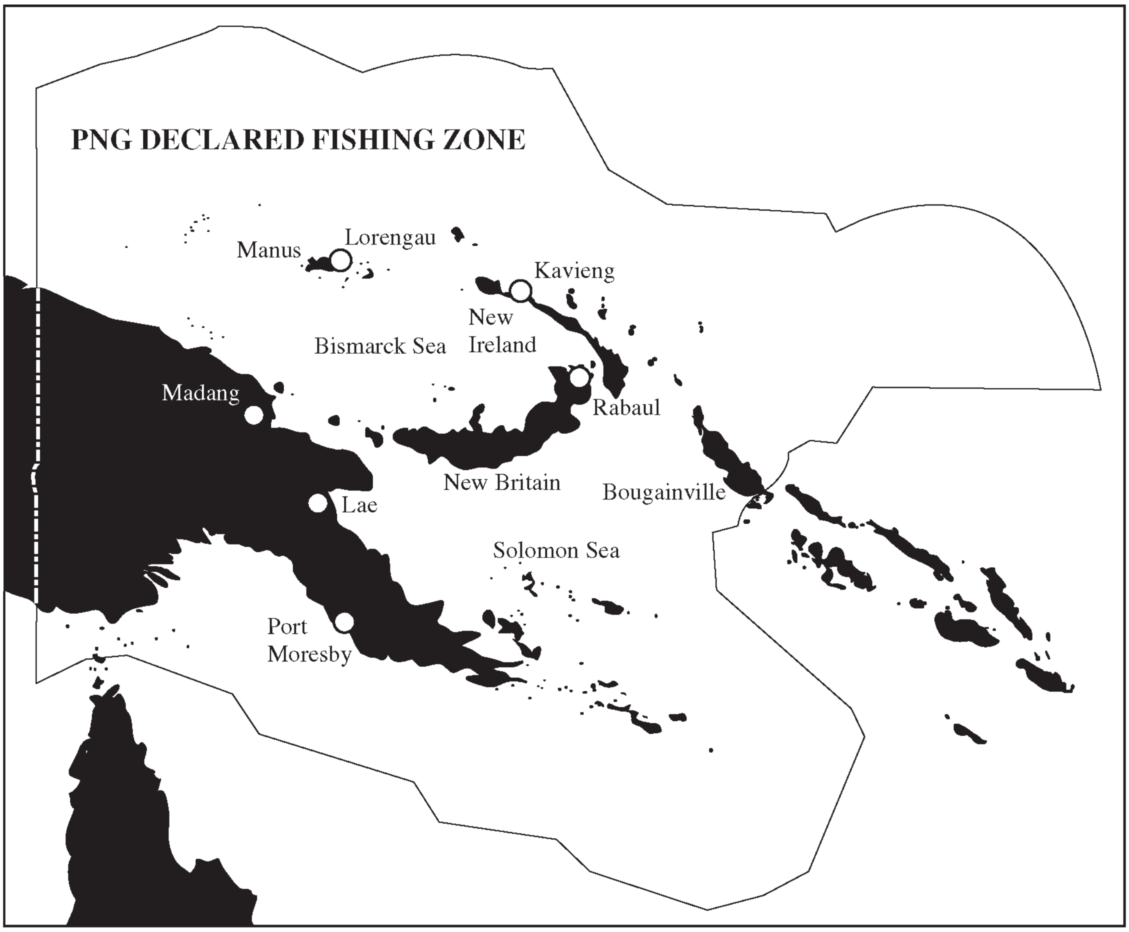


Figure 1: PNG declared fishing

Joint-venture prawn and lobster fisheries have also operated in thee Gulf of Papua. Other commercial exploitation of local marine resources is limited but in recent times has included a joint-venture shark longline fishery and the export of live groupers and lobsters. A number of coastal fisheries stations are maintained by government. Catches collected at these stations have been shipped to coastal urban centres or to Highland settlements where there is generally a shortage of affordable protein foodstuffs. Some of the coastal fisheries stations have exported quantities of reef fish and barramundi fillets and at others the collection and sale of crabs .and lobsters is important Demand for fisheries products exceeds supply in most areas. Some K$34.5 million was expended on fisheries product imports in 1989, of which the largest component by far was canned fish (Philipson, 1991).

2.3 Artisanai fisheries in the National Capital District

Most of the fresh fish supplied to Port Moresby's urban population originates in an artisanal fishery centred on five communities situated west of the city, the most important of which, in terms of production, is Daugo Island (Fisherman's Island). Daugo is a low-lying coral and sand island about 2.5 m long by 0.5 m wide situated on the outer reef about four miles west-south-west of Port Moresby. It is sparsely covered with vegetation and produces no crops other than a few coconuts. Some pigs and chickens are raised in the village, but everything else, including water, is brought in from Port Moresby. In common with several other fishing communities adjacent to Port Moresby, the Daugo Island community originated elsewhere in Papua New Guinea and lacks land tenure. This, together with the few opportunities for agriculture on Daugo Island, leaves the inhabitants dependent on the sea for their subsistence and livelihood.

A fleet of about 50 boats and canoes fish the reefs and lagoon and the offshore waters around Daugo Island by trolling, handlining netting and spearing. Apart from that portion of the catch retained for subsistence use, most is carried to Port Moresby's Koki Market for sale. The Daugo Island fishery has produced as much as 215 t annually (Lock, 1986). Almost 1 t of assorted fish was seen at Koki Market on a visit made during this assignment, while the market's annual throughput of fresh fish is estimated at around 400 t landed by almost 300 commercial artisanal fishermen (Philipson, 1991). The fresh fish market has been dominated by small reef and lagoon species known to be popular with consumers. However, some 10 per cent of catches has comprised tunas and Spanish mackerel (Lock, 1986).

The Port Moresby area fishery is believed to be in decline with both reef and lagoon fish stocks thought to be overfished, abetted by destructive fishing practices such as the use of explosives and extensive gill-netting. For these reasons DFMR has seen a need for a programme that encourages diversification of fishing effort away from stressed inshore fishing grounds in favour of more effort offshore, particularly towards pelagic fishes such as tunas.

The tuna resource in the area, particularly skipjack and yellowfin, is thought to be abundant and underexploited. Other pelagic species commonly occurring include dolphinfish (mahimahi), rainbow runner, dogtooth tuna, and shark. It is hoped that the deployment of FADs in the area will promote diversification towards fishing for these species.

The active sport fishery in Port Moresby, centred on the Port Moresby Game Fishing Club, would probably benefit from FAD deployment. This might be expected to contribute to the development of sports fishing tourism.

3. SURVEY VESSEL AND EQUIPMENT

Upon arrival in Port Moresby, the 6onsultant found that DFMR's research vessel MV *Melissa* which had been assigned to the pilot FAD project was not available. However, a suitable alternative, the FV *Kikori Tamate*, was provided. This DFMR research vessel is a 15 m Yamaha-built (1991) fishing research boat powered by a six-cylinder Yanmar diesel engine. She came equipped 48-mlle Furuno radar unit, a Furuno colour echo-sounder, SSB and VHF radios, and a 12 VDC/24 VDC power supply. The vessel was not equipped with an autopilot.

In order to provide for efficient and accurate FAD site survey work the consultant carried to PNG three items of OFD Project survey equipment: a 2000 m range Furuno FV 362 colour echo-sounder, a portable transducer mounting, and a JRC JLR-4110 Global Positioning System (GPS) receiver/plotter. Installing these units on board the *Kikori Tamate* was relatively simple. Ample room was available on the chart table in the wheelhonse just behind the steering station for mounting the echo-sounder. The GPS unit was mounted on top of the echo-sounder by drilling holes in the sounder display housing and fixing the GPS unit's mounting bracket to it with stainless steel machine screws. This arrangement enabled monitoring of both instruments simultaneously and also reduced the number of holes that had to be made in the chart table. Both units were connected to the vessel's 12 VDC/24 VDC power supply using power leads with in-line fuse holders for protection from power surges.

SPC's portable transducer mounting fabricated in welded aluminium (Figure 2) was mounted to the side of the *Kikori Tamate* aft of one-third of the vessel's length back from the bow, this being the position where turbulence would least affect performance. The pole of the aluminium transducer housing was first secured to a 2 m length of 100 x 50 mm (4 x 2 in) rectangular steel tubing using U-bolts. Holes were then drilled in the steel tubing and a clamp was made to fix this unit to the hull of *Kikori Tamate*. In order to avoid damaging the vessel unnecessarily, three bolts were removed from the rub rails and these holes were then used to fix the transducer pole. A rope forestay was also added to reduce vibrations. This arrangement worked well at vessel speeds to four knots At higher speeds interference from Vibration and bubbles caused clutter on the sounder's display screen.

The GPS unit's antenna was mounted on the ship's foremast with the bracket and clamps provided. Both the GPS antenna connection lead and the transducer cable were fed into the wheelhouse via a ventilation cowling in the overhead. This allowed the wheelhouse to be secured while in port and avoided drilling a hole. Nylon cable ties were used to keep everything tidy.

Prior to a test run, the GPS had to he initialised and corrections entered. Since the chart used for the survey (*AUS 379, Kerema Bay to Port Moresby*, Hydrographic Branch, Department of the Navy, Australia) was drawn to the Australian Geodetic System, this system was selected during initialisation. Corrections were made by noting the chart position for the vessel's mooring at DFMR's Marine Base wharf and comparing this with the GPS readout. A longitude adjustment had to be made with a shift of 0.4 nm E (0.40 minutes [0.40'] of longitude). No latitude correction was necessary. Other GPS users in Port Moresby were consulted and reported similar findings. During the trial run a position check was made at Basilisk Beacon; the GPS readout matched the vessel's position on the chart.

4. FAD SURVEY ZONE SELECTION

Before commencing the bathymetric survey to select a FAD site several factors had to be considered: and the site had to be within reach of the Daugo Island fishermen, within a potentially productive fishing ground, in an area that would not interfere with shipping or violate local maritime regulations.

The consultant and DFMR masterfisherman Rakwa Leka visited Daugo Island to consult with representatives of the fishing community. On the day of the visit most of the fisherman were either out fishing or attending a council meeting in Port Moresby, but two village elders present indicated that while most fishing is done inside the reef and along the outer reef edges, most of the fishermen are capable of fishing further offshore. They reported that trips were occasionally made out of sight of land and that wind and swell directions were used to navigate back to land. Most of the fibreglass skiffs in use, known locally as 'banana boats', are equipped for trolling as well as for bottom fishing.

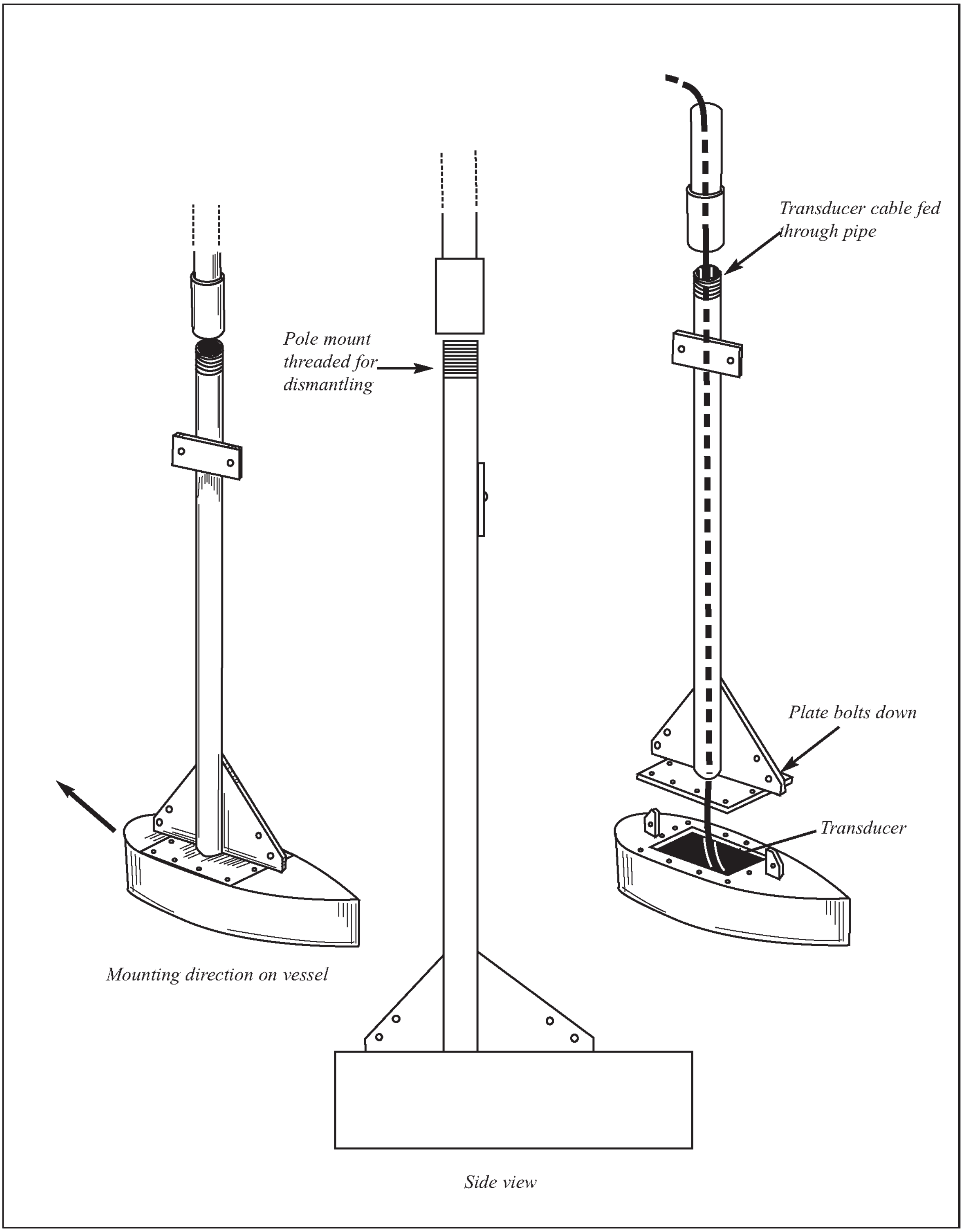


Figure 2: SPC's portable transducer mounting fabricated in welded aluminium.

Experience elsewhere in the region suggests that FADs are often more effective when deployed well offshore (3—5 nm); it was considered that survey zone could extend this far without the eventual site selection and deployment unduly taxing the abilities of the Daugo Island fleet to reach the FAD and to land catches at Port Moresby's Koki Market.

Consultation with DFMR staff, as well as with Daugo Island fishermen landing fish at Koki Market, indicated that virtually all areas offshore of Daugo Island and the Port Moresby area are productive grounds for troll fishing with yellowfin and skipjack tuna common. This view was reiterated by members of the Port Moresby Game Fishing Club.

A meeting arranged with the Port Moresby Harbourmaster indicated that any activity outside of the harbour demarcation was beyond his jurisdiction, but that the NCD Department of Transport might have some regulations covering FAD buoys. Consultation with the Superintendent of NAVAIDS at the Department of Transpprt, Mr Laurie Duncan, revealed that a FAD could be sited anywhere, except in the channels leading into the harbour, without formal authorisation or issue of a permit. The Department of Transport required only that written notification be supplied soon after deployment, giving details of position, buoy description and light characteristics for inclusion in subsequent 'Notices to Mariners'.

In consideration of this information, and after referring to the chart (AUS 379), it was decided to conduct survey in an area west of Daugo Island between 09˚30'—09˚35 S latitude and 146˚55'—147˚ 02' E longitude (Figure 3). The chart showed that the 1000 m contour passes diagonally from left to right through area. As experience elsewhere has shown that 1000 m minimum site depths commonly result in effective FADs, it was expected that a suitable deployment site would be found there.

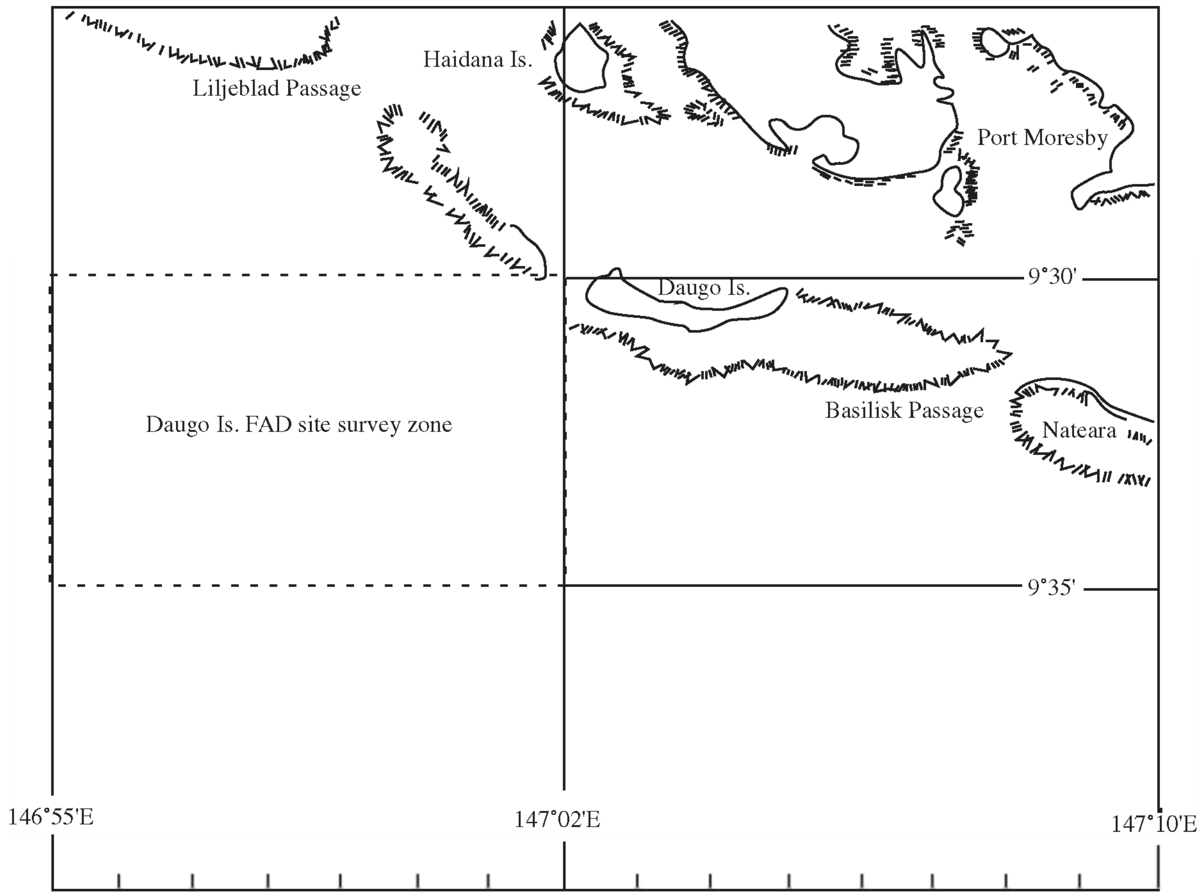


Figure 3: Daugo Island FAD site survey zone.

5. FAD SITE SURVEY

5.1 Method

As the Kikori Tamate was not equipped with an autopilot, it had to be steered along transects. Starting at the northernmost and easternmost position of the site survey zone, the helmsman was directed to steer due west (about 263˚C allowing for magnetic variation). On this course the readout for latitude on the GPS should not vary by much. The first transect was run on a line 09˚30.00'S. (The resolution of latitude and longitude was set at '0.001' rather than '0.01' for greater accuracy.) In reality, slight adjustments to the course had to be made along each transect, depending on whether the boat had drifted south or north of the desired course.

While following such a course, the GPS and the colour echo-sounder were constantly monitored simultaneously. At each 0.250 minute of longitude interval on the GPS screen (0.25 nm) the depth in metres was recorded. After one transect was run in this way the vessel was steered south to the next transect at 09˚30.250'S and the process was repeated going in an easterly direction. This method eliminated the need to enter waypoints into the GPS and would have been simplified even further had the vessel been equipped with an autopilot (Figure 4).

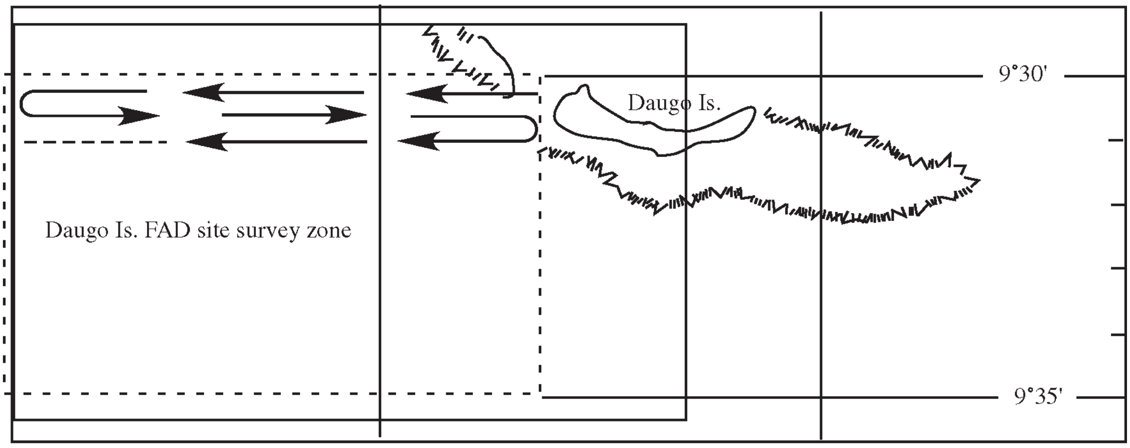


Figure 4: Path of vessel running echo-sounding transects in Daugo Island FAD survey zone

A log sheet was prepared prior to each day's survey work with latitude and longitude filled in, so that only depth data and any observations (e.g. steep bottom, birds in area) had to be recorded.

5.2 Results

About the survey of the first zone it became apparent that the transects were starting to
that the south-west portion of the zone could probably be eliminated as it FAD parameters. Transects were subsequently run in a north-south direction starting in the shallowest area (east) and shifting towards the west. The north-south transects were continued until the sounder began 'running out of bottom' in the south-west corner of the survey zone. Recorded depths were later transferred to a grid using 41 x 57 cm graph paper as a plotting sheet. Intervals in 100 m increments were determined by extrapolation and contour lines were drawn for each 100 m contour (Figure 5). The resulting bottom contour configuration indicated that the seabed in the survey zone consists of a series of ridges and valleys, with some relatively steep inclines and some flat areas on the ridges. These features were particularly evident in the shallower areas of the zone (300—500 m).

A FAD site (Site A) indicating a dense substrate bottom and with an acceptable extent of regular depth was selected on one of the flat riges lying between two valleys. The site lay in proximity to canyons or valleys which might be expected to produce upwellings and contribute to fish abundance. The site depth was 900 m.

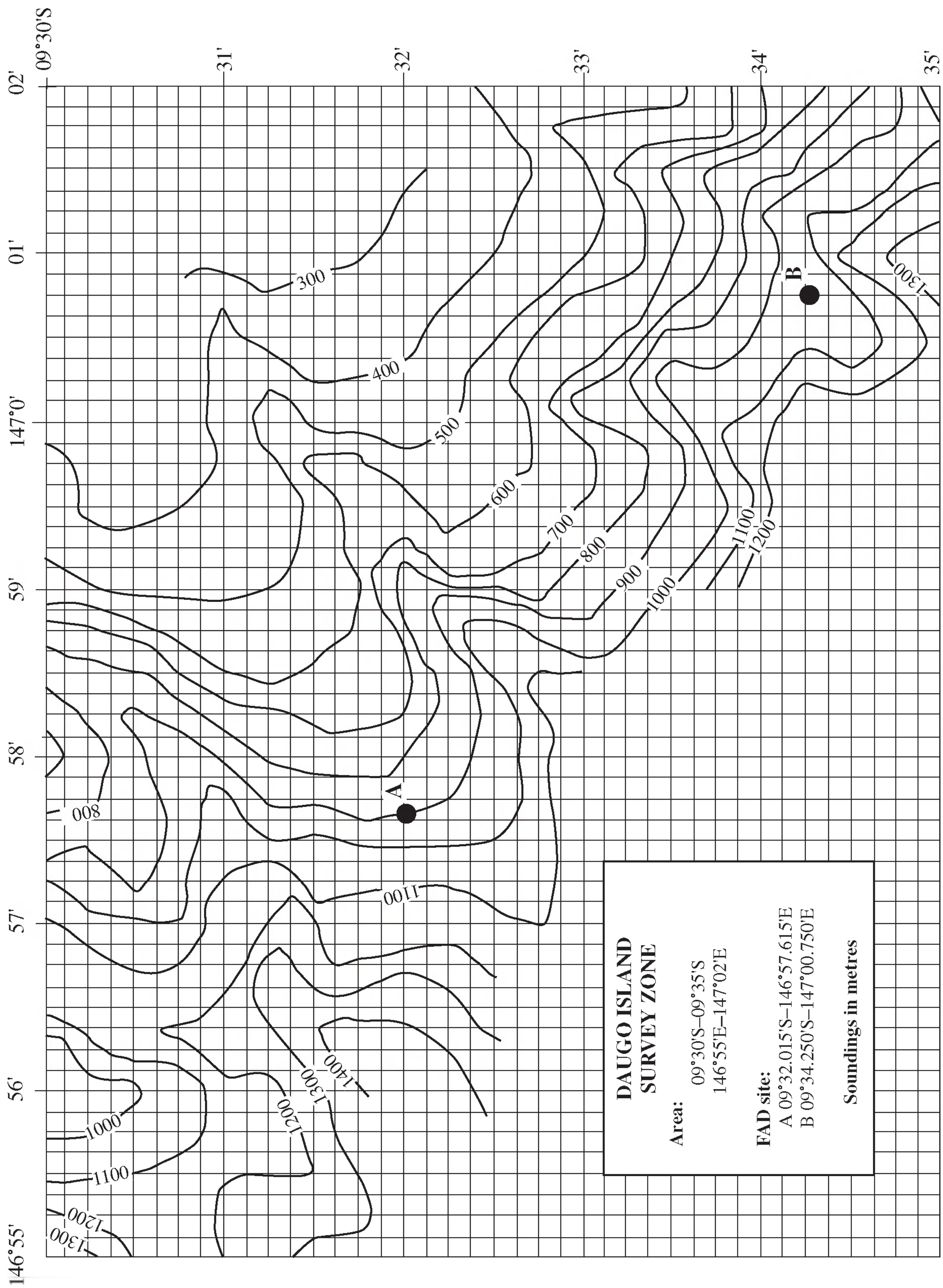


Figure 5: Daugo Island FAD site survey zone bathymetry and selected FAD sites A and B.

An alternative site (Site B) was also selected in this survey zone, as shown in Figure 5. This site was chosen in the middle of an approximately half-mile square area of regular depth around 1000 m. Site B lies approximately 3.5 nm from Site A.

During the latter part of the consultant's stay, in response to reports by both DFMR stuff and members of the Port Moresby Game Fishing Club of a productive tuna fishing ground to the south of Basilisk Passage, an additional survey zone, bounded by 09°35'—09°37'S latitude and 147°06'E—147°08'E longitude, was surveyed, to provide DFMR with a possible future alternative FAD site. The survey zone and FAD site (Site C) selected are shown in Figure 6, Figure 7 shows the bathymetry of the zone.

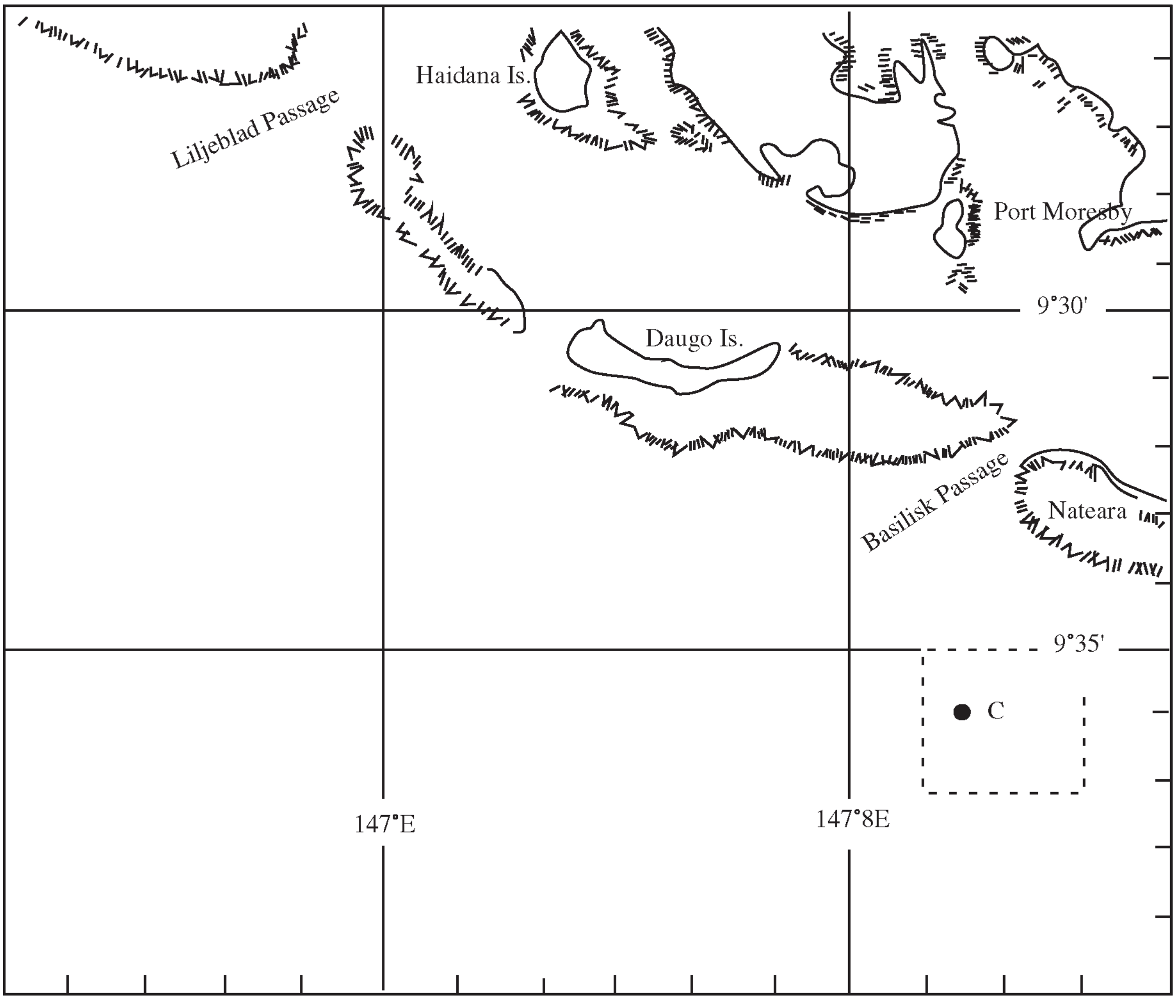


Figure 6: Basilisk Passage survey zone bathymetry and selected FAD site C

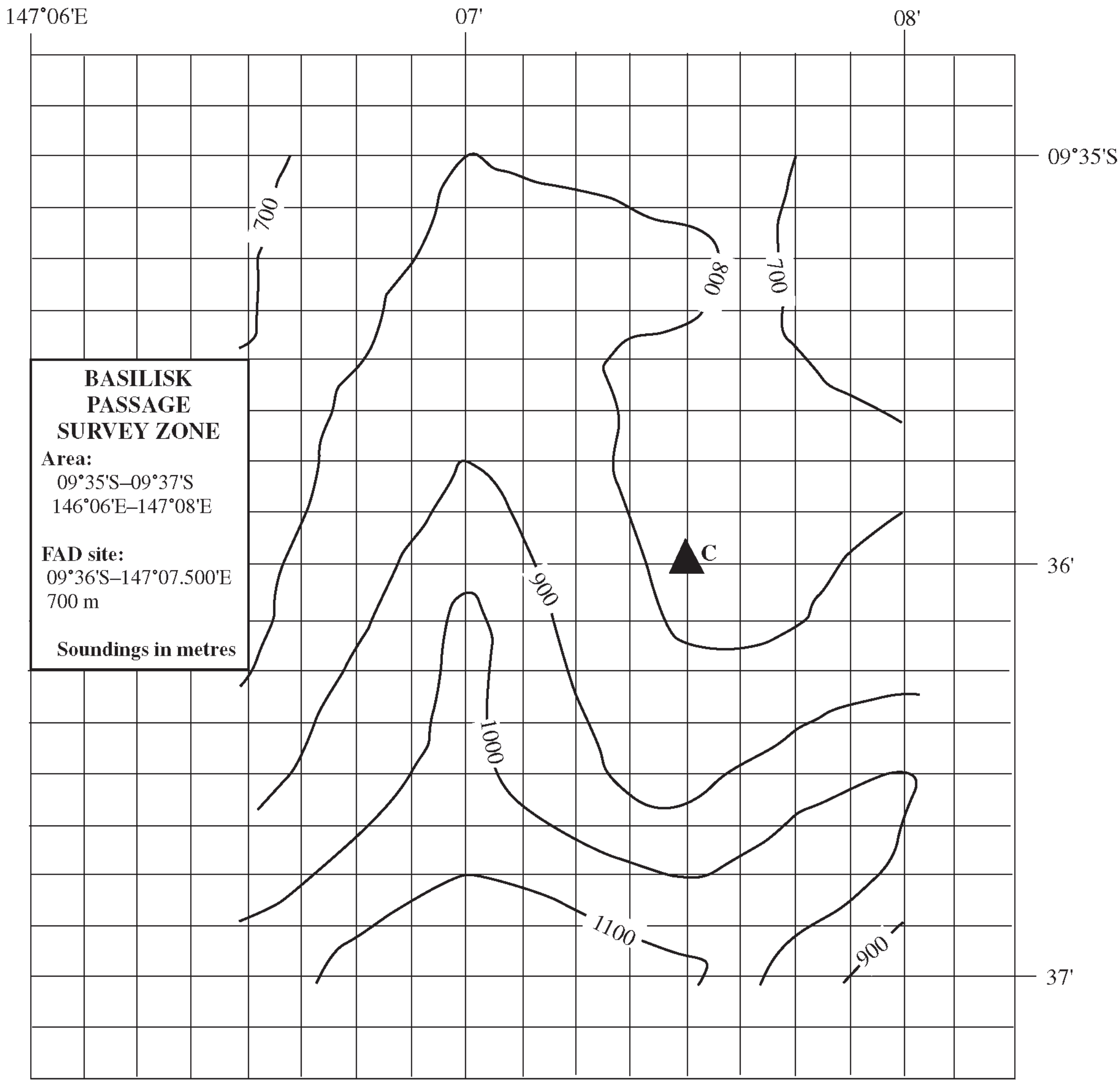


Figure 7: Basilisk Passge survey zone bathymetry and selected FAD Site C.

6. FAD ASSEMBLY AND RIGGING

6.1 Raft (buoy)

A steel FAD buoy, based on a design prepared for SPC by Lieutenant Commander R. Boy of the United States Coast Guard, an authority on deep-sea moorings, was fabricated according to SPC-supplied specifications (Figure 8) by a local engineering company. Ordering of the buoy and procurement of most other FAD hardware required was undertaken by a Port Moresby commercial fishing supply company, The Net Shop. The completed buoy was found to be professionally constructed and appeared to be sound and seaworthy. The buoy was slightly modified from the standard design by the replacement of the 12 mm (1/2 in) thick steel padeye, by which the buoy is linked to the upper mooring chain, with a 25 mm (1 in) thick padeye. This necessitated the use of a 25 mm shackle to make they buoy/chain connection. This shackle was fitted so that the shackle bolt would take the wear on the padeye and the bolt was welded to the shackle bow so that it could not work loose (Figure 9).

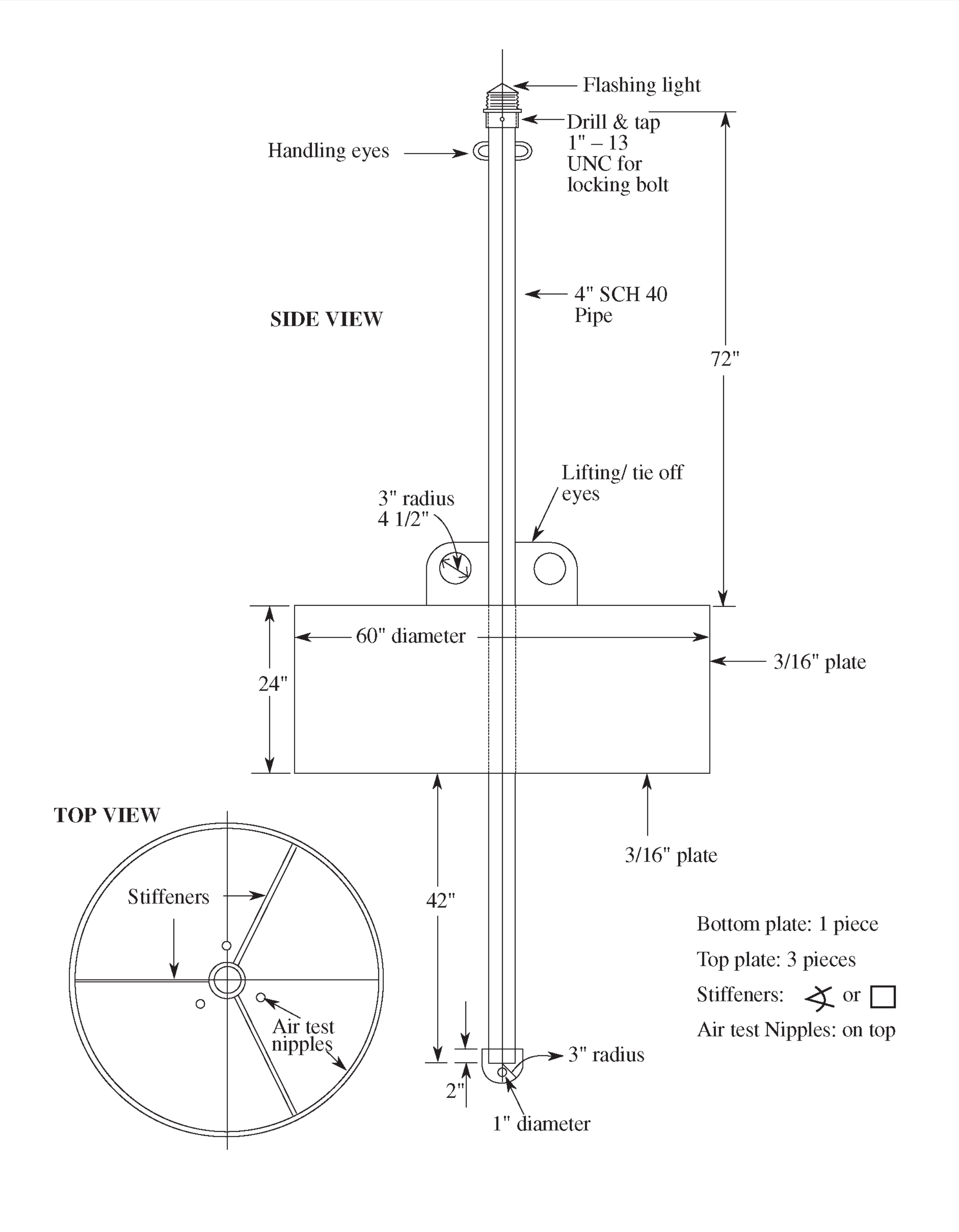


Figure 8: Steel spar-buoy FAD raft designed by Lt. Cmdr R. Boy

Figure 9: Padeye at lower end of spar (counterweight) showing the 25 mm shackle, with bolt welded in place

The only other modification made to the buoy was the addition of raised lettering '**DFMR FAD #1**' in welded bead on the radar reflector for identification.

A battery-powered Mc Dermott buoy light with a daylight switch was installed in the spar. The light was red against theft by a patent tamper-proof bolt. The light had an amber fresnel lens and the light characteristics were ten-mile, flashing, two-second. Reflective tape was also applied to the spar just below the light to help locate the FAD at night should the light malfunction or be damaged.

6.2 Hardware

Hardware for the FAD mooring was procured by The Net Shop and comprised both new materials ordered in for the project and items on hand from various sources in Port Moresby. Three types of shackles were thus used: the 25 mm mooring shackle already described, to make the buoy/upper chain connection; 16 mm (5/8 in) galvanised screw pin shackles; and safety anchor shackles supplied with patent Nylite rope connectors. Screw pin shackles are not recommended for FAD moorings because of the danger of the bolt working free. To guard against this all shackles were welded closed and finished with a tar sealant containing corrosion inhibitors (Brushable Hydroseal by Pabco Products, Australia).

Korean-made 16 mm (5/8 inch) galvanised anchor chain was used for both the upper and lower mooring sections, while the swivel used was a sealed bag-bearing type made by Garukan, Japan. Four pairs of sacrificial zinc button anodes were attached at intervals on the upper chain to guard against corrosion of the hardware. These were drilled out to take a larger bolt than that supplied and the nuts were tack-welded (Figure 10).

Figure 10: Tack-welding a zinc button anode to the upper chain to guard against corrosion

6.3 Rope

Two types of rope had been procured for the FAD mooring. The nylon rope for the upper (sinking) portion of the mooring was two-in-one (sheath and core) braided 20 mm rope. The polypropylene rope for the lower (floating) section of the mooring was two-in-one braided 22 mm rope; both ropes by Namyang, Korea. Two-in-one braided rope is not recommended for FAD moorings because of the difficulty of splicing them successfully in the field and because the different constructions in the sheath and core may cause necking (Boy & Smith, 1984). As these ropes had inadvertently been procured for the FAD project the options were to proceed with them or dispose of them and wait for new rope to be delivered. It was decided in consultation with DFMR to make the best use of the rope on hand.

Neither DFMR staff nor the consultant had any experience splicing two-in-one rope. Three references were invaluable in educating everyone involved. The Net Shop provided a video tape (Sabella, 1991) and two splicing manuals were on hand (Merry, 1988; Anon., 1983). After repeated attempts, acceptable eye-splices and end-to-end splices could be made in the polypropylene rope. The nylon rope, however, proved almost impossible to splice. The eye-splice could never be closed completely and the end-to-end splice joining the nylon and polypropylene sections was completely unsatisfactory. The 20 mm nylon fitted easily into the 22 mm polypropylene but the polypropylene would not fit back into the smaller nylon. Even the fabrication of a special tubular rid by DFMR staff did not solve the problem (Figure 11).

The ropes could not be joined with knots because this would potentially lower the mooring's break-strength by as much as 50 per cent. Another plan was to form eye-splices at either end of the nylon and polypropylene rope sections and connect the two ropes with Nylite rope connectors and shackles. The weight of this added hardware would, however, alter the performance of the catenary curve by acting as a counterweight with the potential to draw the nylon and polypropylene lines together in such a way that they might foul. Finally it was decided to abandon the nylon rope altogether and rig the complete mooring from polypropylene rope. This, of course, still required the use of PP rope of greater length than the site depth in order to create sufficient scope for the mooring and some means of preventing the excess line (usually held in an inverse catenary curve by the differing properties in seawater of nylon and polypropylene ropes) floating to the surface where it would be vulnerable to damage by boats, fishing gear or vandals.

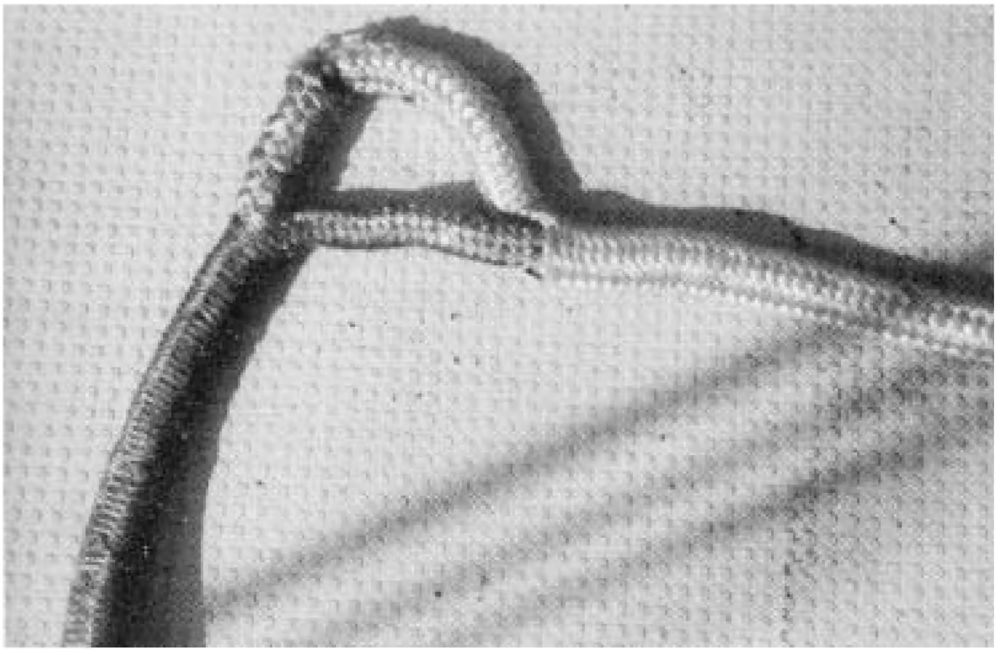


Figure 11: Unsuccessful attempt to end-splice the nylon and polypropylene lines

It was decided then to rig a counterweight-type mooring by interspersing a length of chain in the mooring line at the point where a catenary curve would normally be placed. The only rope joins required would be eye-splices which DFMR staff were by this stage proficient in.

All splices were done according to *The splicing handbook* (Merry, 1988), the easiest to follow of the three references mentioned above. In all, four eye-splices and one end-to-end splice joining two coils were made. All eye-splices were protected with Nylite rope connectors (Figure 12). Each splice was cross-sewn with 1 mm nylon cord and whipped with 2.5 mm nylon cord (Figure 13). In addition 1.5 m of reinforced PVC hose was sheathed over the rope on either side of the chain counterweight section to guard against chafing.

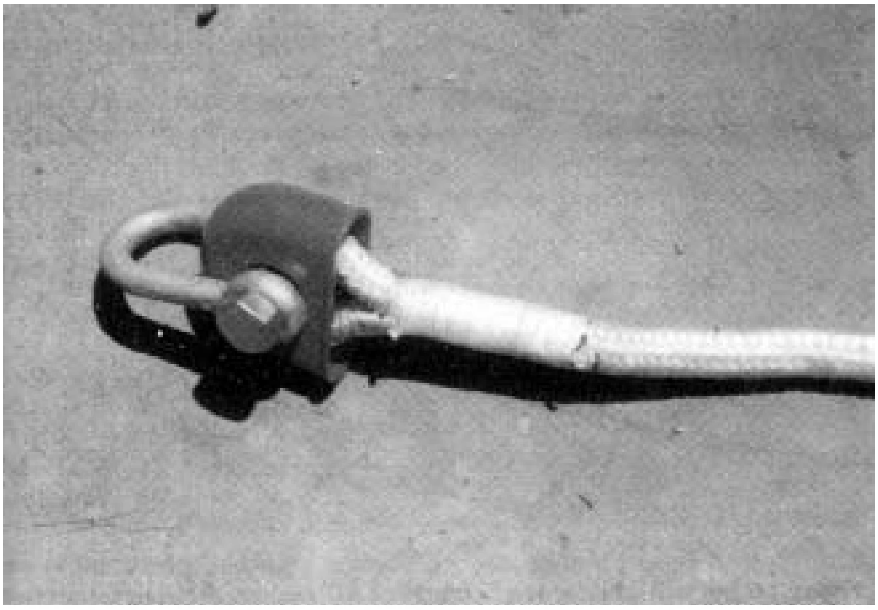


Figure 12: Eye-splice, complete with nylite rope connector.

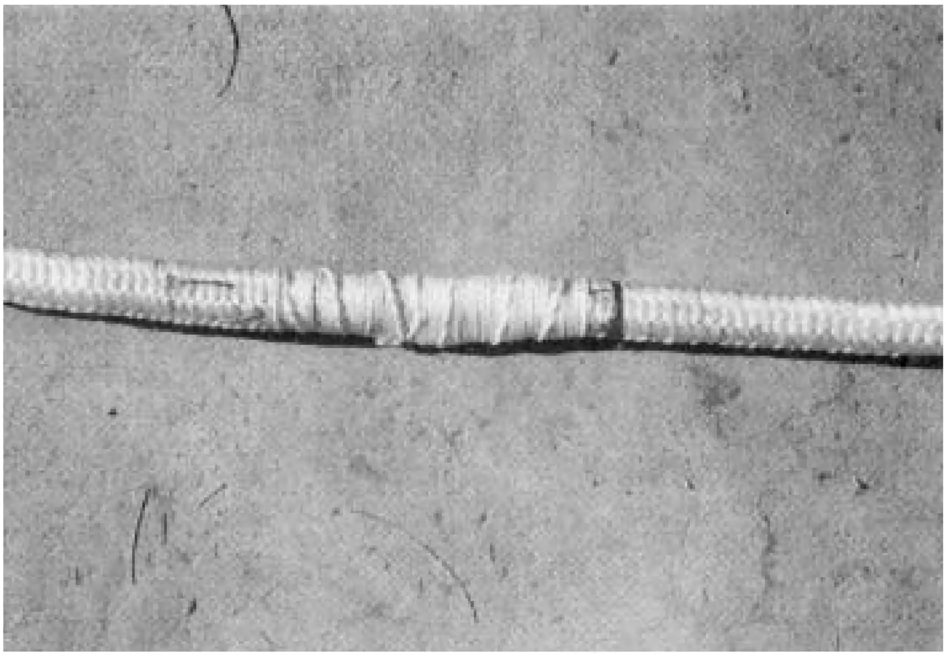


Figure 13: End-to-end splice in polypropylene rope showing cross-sewing and whipping

6.4 Anchor

The anchor used in the mooring, donated by a local company, was a surplus counterweight from a forklift. It was reported to weigh 2 t and, although this was not verified, the boom truck employed to set it on the deck of FV *Kikori Tamate*, with its crane rated at 3 t lift at 2 m extension, had some difficulty in hoisting it. A length of 16 mm (5/8 in) chain was run through the vent hole in the anchor and joined with shackles to the main anchor chain (Figure 14); all shackles were welded and coated.

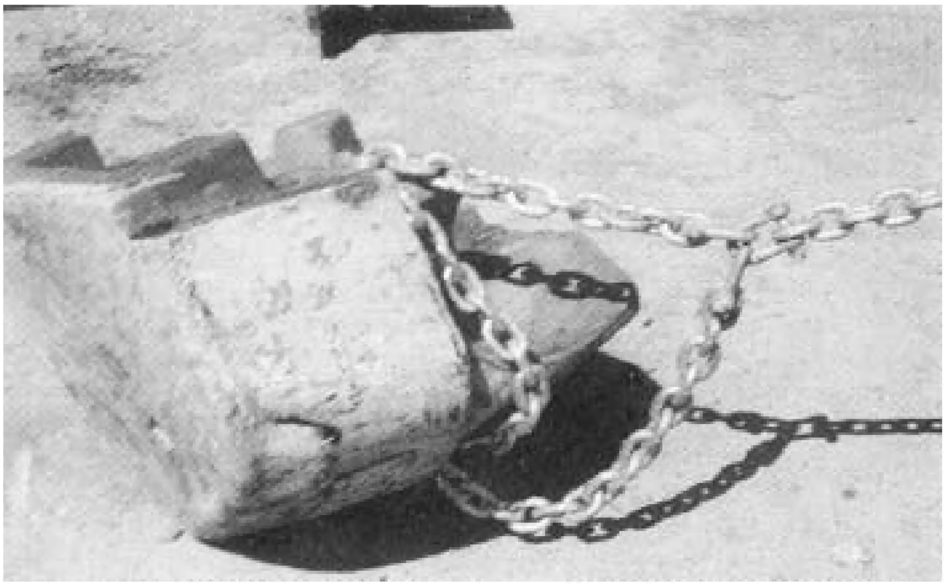


Figure 14: Forklift counterweight used as FAD anchor, showing connection to the FAD mooring's lower chain.

6.5 Aggregator (appendage)

As is normal practice with most FADs, aggregating material was rigged to sling beneath the raft in the hope of enhancing the aggregation process. The aggregator in this case was fabricated by The Net Shop. It comprised a 10 m length of 12 mm (1/2 in) polyethylene 3-strand rope with various bits of small stuff woven into its lay. Wire rope thimbles were eye-spliced into each end for easy attachment to the upper mooring chain. The finished product resembled a large hula skirt (Figure 15). It was attached to the middle third of the upper mooring chain by 12 mm (1/2 m) screw pin shackles moused with wire. It was positioned in such a way that it could not interfere with the swivel at the lower end of the top chain.

Figure 15: Preparation of the aggregator (appendage) line

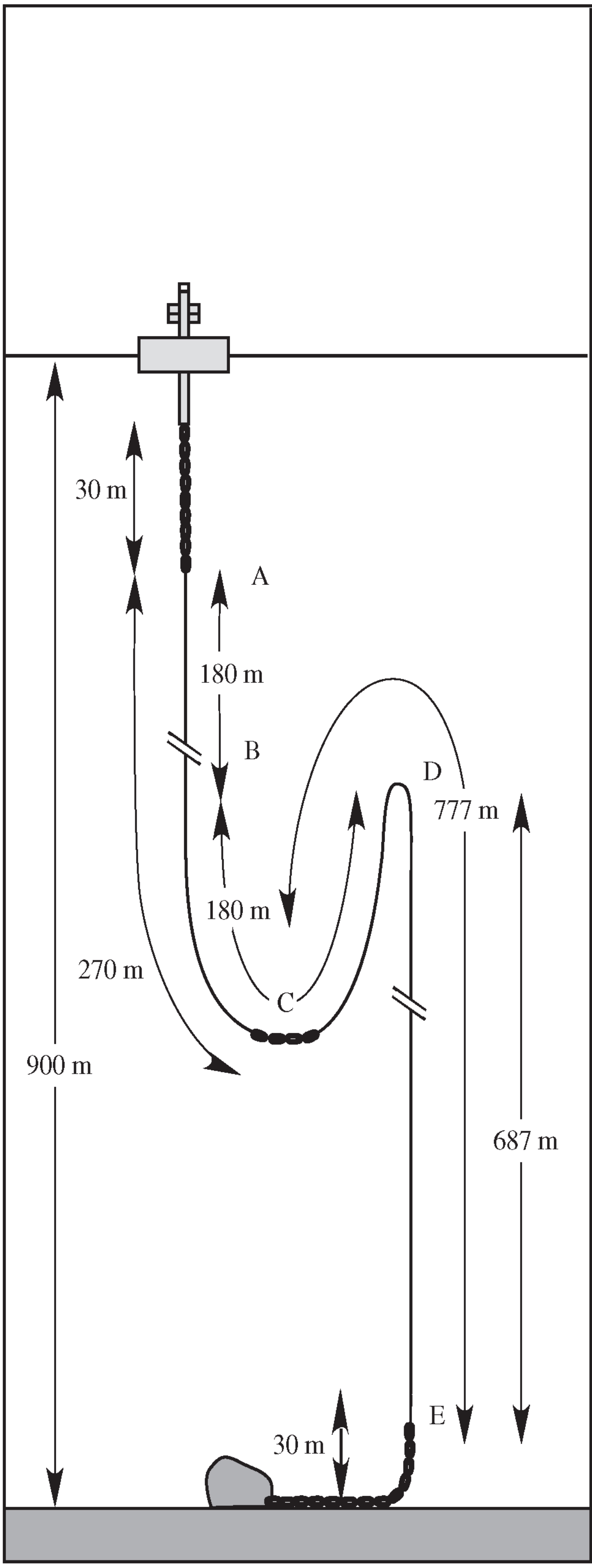
7. MOORING CALCULATION

As the nylon rope was abandoned, the calculations normally used to ascertain the comparative lengths of sinking (nylon) and floating (PP) ropes required to form a submerged inverse catenary curve in the mooring were not valid. Instead it had to be calculated how much PP rope would be required and how the counterweight would be placed in order to hold the reserve line away from the surface. The calculations re made as follows:

Preliminary information

Site depth	:	900 m
Upper chain length	:	30 m
Lower chain to be lifted off the bottom	:	3 m
Weight of 3 m of chain/hardware in air	:	22 kg
Buoyancy of rope PP (0.24 kg/m x 0.116)	:	0.02784 kg/m
Weight of steel in sea water	:	Weight x 0.869

For purposes of these calculations the mooring line was divided into working sections as shown in Figure 16.



$$DE = \frac{\text{Weight of hardware to be lifted}}{\text{Buoyancy of rope}}$$
$$= \frac{22 \text{ kg} \times 0.869}{0.02784 \text{ kg/m}}$$
$$= 686.7 \text{ Or } \mathbf{687 \text{ m}}$$

AB = Site depth – (DE + 30 m + 3 m)
= 900 m – 720 m
= **180 m**

BCD = Site depth x 0.20
= 99 x 0.20
= **180 m**

$$ABC = AB + \frac{BCD}{2}$$
= 180 m + 90 m
= **270 m**

$$CDE = \frac{BCD}{2} + DE$$
= 90 m + 687 m
= **777 m**

ROPE SECTIONS		VERIFICATION	
Upper chain	30 m		
AB	180 m	Site depth	900 m
BCD	180 m		
DE	687 m	Catenary	
Lower chain	3 m	curve	180 m
TOTAL	**1080 m**	**TOTAL**	**1080 m**

Counterweight caluculation

The counterweight was required to be of sufficient weight to prevent rope section ABCD (360 m) from floating to the surface. The weight required, comprising chanin and connecting shackles, is calculated as follows:

Rope buoyancy:
= 360 m x 0.02784 kg/m

Weight required to counteract buoyancy of rope section ABCD = 10.02 kg

Weight of steel in seawater = weight in air x 0.869

So, $\frac{10.02}{0.869}$ = weight in air of required hardware
= **11.5 kg**

Figure 16: Configuration of the mooring, showing division into working sections for rope length calculation

A counterweight consisting of four shackles (two for the chain and one for each Nylite rope connector) and 1.1 m of 16 mm (5/8 inch) galvanized chain weighed 11.5 kg. The extra length added to the mooring was considered negligible in overatl calculation of the mooring lengths.

The mooring was thus rigged according to these calculations at DFMR's Marine Base.

8. DEPLOYMENT

Before loading the FAD materials onto the *Kikori Tamate*, a wooden workbench was lashed into place at the stern at rail height (see Figure 17). A ramp of sorts was also constructed by DFMR staff to facilitate launching of the buoy. Both the anchor and the buoy were loaded by boom truck at a slipway in Port Moresby; care was taken to secure both for safe steaming.

Figure 17: Loading the FAD anchor onto the deployment bench lashed in place at the* Kikori Tamate's *stern

In loading the mooring the rope was faked down on the afterdeck between where the anchor and buoy were stowed. The rope had previously been faked from the coils in figure-eights to remove kinks. The 'anchor-last' method for deployment, generally recommended for safe small-vessel deployments, was to be used.

Upon nearing the deployment site the vessel was slowed to an idle going into the sea and current. Before launching the buoy the upper chain with attached appendage line was faked over the rail. The same was done with the anchor chain just before launching. After ensuring that the vessel was on station the buoy was launched. The anchor line was paid out from the stern as the boat proceeded slowly past the drop site. The boat was turned around in a circle heading back toward the buoy while continuing to pay out line. When all the line was out the boat was turned back into the sea, effectively laying the line out in a large 'S'. The anchor was then dropped at a position about one-third of the depth, up-current from the site as recommended (Boy & Smith, 1984). The method used for deploying the anchor was similar to that used by the DSFDP during a FAD assistance project in the Cook Islands (Desurmont, 1992), the difference being that manpower rather than a chain-block was used to jettison the anchor (see Figure 18).

Figure 18: Launching the anchor using levers and manpower

The buoy was observed for 45 minutes, after which time it had settled in a position about 0.1 nm north-west of the anchor site.

At this time two Daugo Island skiffs were spotted trolling nearby. They were approached and the FAD was pointed out to them (see cover photograph). Soon afterwards the crew of the *Kikori Tamate* landed two yellowfin tuna by trolling (20—25 kg) and it was thus considered that the FAD was in range of the fishermen it was intended to benefit and that tuna could be found in the area.

The *Kikori Tamate* returned to the FAD some two hours after the deployment to find that the buoy now lay about 0.35 nm from the intended anchor site. By this time of day the wind off Port Moresby usually picks up to 10—15 knots and current increases accordingly. The first conclusion was that the anchor might have been dragging. However, calculating the radius of swing from the scope of anchor line and the depth showed that the buoy could be displaced one-third of a nautical mile (617 m) horizontally from the anchor at full extension of the mooring, without taking account of any stretch in the mooring.

Using the Pythagorean theorem to verify this yields:

900 (site depth) squared	=	810,000
1090 squared	=	1,188,100
square root of difference	=	614

Plotting back to the drop site from its last observed position and measuring one-third of a nautical mile along this plot gives the most probable location of the anchor (09˚32.015'S—146˚57.615'E). This is 0.04 nm from the intended site (Figure 19).

[Note: Soon after deployment of the Daugo Island FAD DFMR staff designed and distributed a catch record form. During a visit by SPC's Inshore Fisheries Scientist in early 1993 advice was given on modification of the form. The form currently in use is shown in Appendix A. It is understood that DFMR staff will also establish a database to enable analysis of the FAD's productivity.]

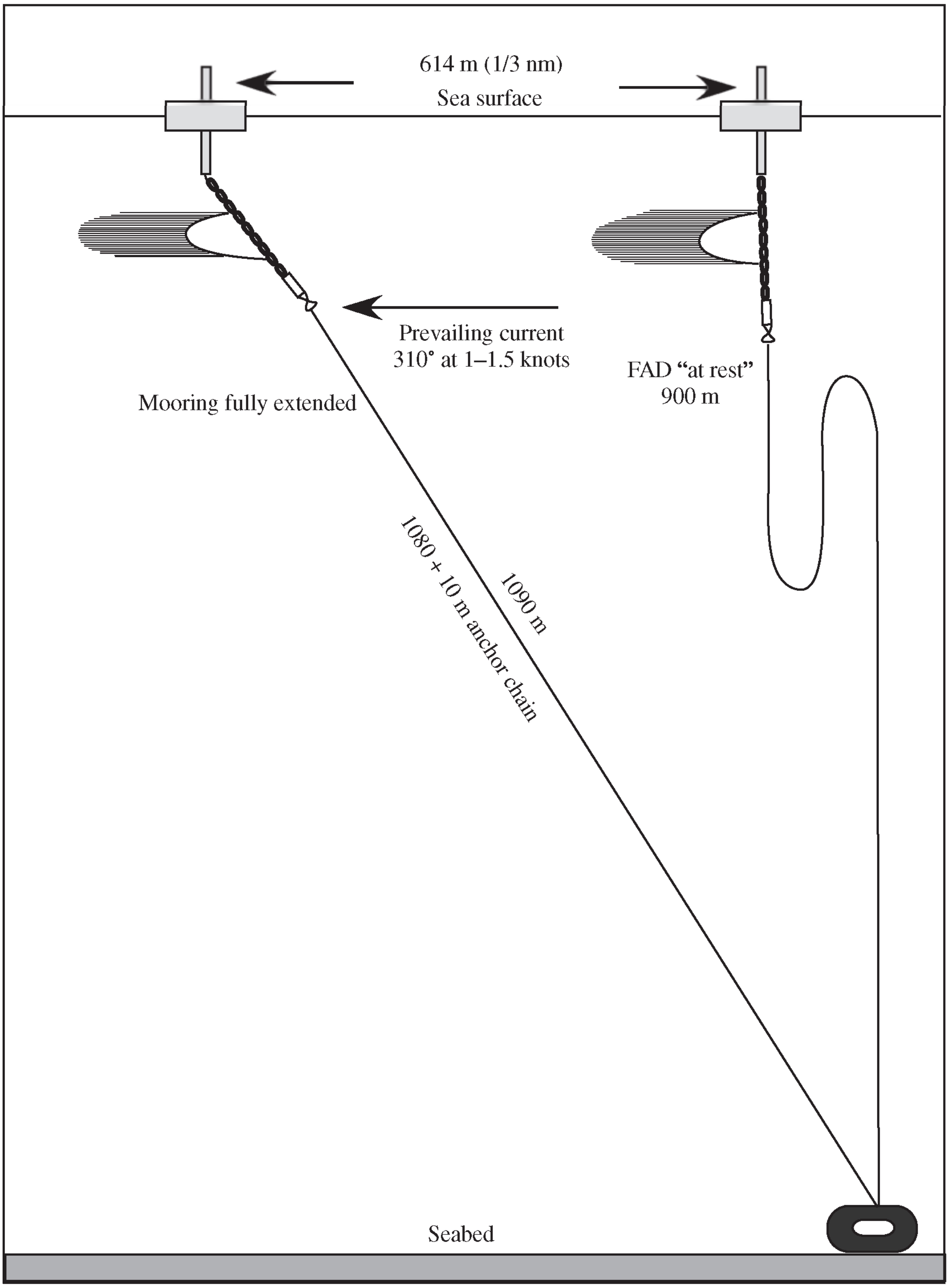


Figure 19: The theoretical displacement of the FAD raft from the anchor site under the effect of current and/or wind.

9. RECOMMENDATIONS

9.1 Specific

- It is likely that the Daugo Island FAD will, if successful, generate requests by other fishing communities for FADs to be deployed adjacent to their landing sites. Expansion of the FAD programme in Port Moresby will require continued outside technical assistance in the medium term. Although the staff at DFMR and the crew of the support vessel were all enthusiastic and eager to learn skills such as chart plotting and GPS operation, survey techniques cannot be mastered in a short time. In the case of this programme, only the captain of FV *Kikori Tamate* had a firm grasp of the concepts of latitude and longitude and an understanding of wheelhouse electronics in general.

- If a productive and sustainable FAD programme is the goal, a FAD team of one or two DFMR staff should be given responsibility for all practical work, including monitoring and maintenance, test fishing, liaison with all fishermen using the FAD(s), FAD catch data collection, and demonstration and training in FAD fishing techniques as required. A log should be kept recording all visits to the FAD and noting any maintenance problems and fishing activity. Divers should periodically check the condition of all hardware down to the swivel (30 m) and the condition of the appendage (aggregator). It has already been noted that on a visit two days after deployment the appendage line was seen to have parted. It is expected that the aggregator will still work in this condition, but divers should add more aggregator material to the top chain as required.

- This team should be provided with the resources necessary (fishing craft, fuel, transport, gear) to conduct this work adequately.

- Management overview of these activities, and planning and implementation of future deployments, should be undertaken by the appropriate branch of DFMR at a senior level. Management responsibilities should include: maintenance of a FAD catch data system; analysis of catch data (along with socio-economic effects and market trends) to determine the potential value and cost effectiveness of further deployments; timely ordering of suitable materials; and ensuring avail-ability of survey and deployment vessels as required.

- DFMR should acquire a colour echo-sounder with sufficient range and power to conduct bathymetric surveys in depths of 1000—2000 m. DFMR should also purchase a GPS unit. A GPS unit will be a valuable tool in ensuring the ease and accuracy of further FAD site surveys and will simplify the location of sites already identified during this project.

- DFMR should continue to build a rapport with the private sector in Port Moresby. During this project, local companies provided, among other things, the anchor, storage facilities, use of a boom truck, transport and use of a pickup track, all at no cost to DFMR or SPC.

- DFMR should establish liaison with the Port Moresby Game Fishing Club. Members of the Club were very interested in the FAD programme and the club is considering deployments at member's cost. Most of the above-mentioned contributions of services were related to club members ties to the local companies. Co-operation in FAD catch reporting should also be sought.

- MV *Melissa* would probably be a more suitable vessel for future FAD programme activities, particularly if it has an autopilot (the *Melissa* was viewed but not inspected).

- Future surveys and deployments should be undertaken in the summer months when the weather is reported to be generally calm. During the pilot project winds of 20—25 knots were not uncommon and seas were often moderate to rough.

•DFMR should consider placing one or more FADs inshore in shallower water. There is a large flat area with depths ranging from 300 to 500 m just off Daugo Island (refer Figure 6). A FAD in this area could prove to be a good aggregator of coastal pelagic species as well as an anchor point for bottom fishing. Several promising fish schools were observed on the echo-Sounder at these depths during the survey: Such a FAD would also be more accessible to Daugo Island canoe fishermen.

9.2 General

Two-in-one (sheath and core) braided rope should be avoided for FAD moorings Aside from the difficulties encountered in splicing it is not considered suitable for FAD moorings as the sheath and the core may react differently to the type of loading experienced in deep-water FAD moorings.

When ordering FAD materials from new sources it is advisable to include illustrations in the order. It is probably better, however, to deal with known suppliers or those recommended by other users, even if it means paying a little more. The money saved in the pilot project by using less expensive Korean rope was more than offset by the time wasted in trying to deal with the landing of the wrong type of rope.

10. REFERENCES

Anon. (undated). *Survey Report of East NewBritain Coastal Fishery Development Project.* Overseas Fishery Cooperation Foundation, Japan.

Anon. 1983. *Splicing manual.* Samson Ocean Systems, Inc.

Boy, R. & B.K. Smith. 1984. *Design improvements to fish aggregation device (FAD) mooring systems in general use in Pacific Island countries.* Handbook no, 24, South Pacific Commission, Noumea, New Caledonia.

Chapman, L. B. and P. Cusack (in press). *Report on third visit to Papua New Guinea, 14 January to 10 July 1984.* Deep Sea Fisheries Development Project. South Pacific Commission Noumea New Caledonia.

Desurmont, A, 1992. F*ish Aggregation Device (FAD) Assistance Programme: Report of visit to the Cook Islands, 23 November to 21 December 1990.* Deep Sea Fisheries Development Project Report, South Pacific Commission, Noumea, New Caledonia.

Frusher, S.D. 1986. 'Utilization of small-scale fish aggregation devices by Papua New Guinea's artisanal fishermen', in J.L. Maclean, L.B. Dizon and L.V. Hostillos (eds) *The First Asian Fisheries Forum*. Asian Fisheries Society, Manila, Philippines. pp. 371—374.

Fusimalahi, T. and J. Crossland 1980. *Report on the SPC Deep Sea Fisheries Development Project in West NewBritain, Papua New Guines,5 September to 14 December 1979.* South Pacific Commission, Noumea. New Caledonia.

Lock, J.M. 1986. *Study of the Port Moresby Artisanal Reef Fishery.* Technical Report 86/1, Department of Primary Industry, Fisheries Division, Port Moresby, Papua New Guinea.

Philipson, P.W. 1991. *Marketing and Credit,* Working Paper No. 12, Fisheries and Coastal Resources Management and Development Project, Asian Development Bank Technical Assistance No.1306 — PNG. Agrodev Canada Inc., Ottawa, Canada.

Sabella, J, 1991. *Braided rope splicing*. A video production. John Sabella & Associates.

SPC. 1992. *Tuna resources of Papua New Guinea waters with particular reference to the so-called Morgado Square (0°30'—3°30'S, 149°—152°E).* Tuna and Billfish Assessment Programme Report. South Pacific Commission, Noumea, New Caledonia.

Wellington, P, and P. Cusack (in press). *Report on fourth visit to Papua New Guinea, 31 March to 23 September 1988.* Deep Sea Fisheries Development Project Report, South Pacific Commission, Noumea, New Caledonia.

APPENDIX A

SMAPLE OF FAD CATCH RECORD FROM DISTRIBUTED BY DFMR

FISH AGGREGATING DEVICE PROJECT

Data collection and questionnaire form

Name of Fisherman: Village: Date:

Time start: Time stop: Total hrs: Vessel type:

Engine size: Amount of fuel used: Total cost of fuel used:

Type of fishing gear used (net, reel and handline etc): Method of fishing (trolling, handline etc):

Number of gears used: handline ________ troll line ________ hand reel ________ net ________

Name of fish	Number of fish	Total weight	Unit price of fish sold

Comment (fishing day, catches, other fishermen seen at the FAD etc):

APPENDIX B

SUMMARY OF DAUGO ISLAND FAD CATCH DATA COLLECTED BY DFMR BETWEEEN JAN/MAR 1993

Month	Effort(hr)	No. of lines	Fuel(l)	Catch No.	Catch (kg)	Catch $K	CPUE(kg/hr)	CPUE(N/Hr)	CPUE($K/hr)
Jan-93	9		40	46		225		5.11	25
	2		44	32		102		16	51
	6		22	25		163		4.17	27.23
	9		40	48		225		5.33	24.94
	9		40	28		115		3.29	13.53
	2		44	18		91		12	60.67
	8		40	14		86		1.75	10.75
	10			82		640		8.63	67.37
	11		40	61		263		5.55	23.91
	7		40	17		69		2.43	9.86
	9		40	34		285		4	33.47
	14		40	37		141		2.74	10.44
	14		40	32		203		2.37	15.04
	10		40	19		92		2	9.68
	8		40	54	133	230	16.63	6.75	28.75
	3	6	40	102	129	181	42.83	34	60.17
	5	6	60	76	78	116	15.6	15.2	23.2
	4	6	30	13	15	20	3.75	3.25	5
	2	6	20	59	79	79	39.5	29.5	39.5
Feb-93	12	6	60	130	197	198	16.42	10.83	16.46
	7	6	50	30	47	124	6.71	4.29	17.71
	3	6	40	57	89	103	29.67	19	34.17
	7	6	55	89	218	307	31.14	12.71	43.86
	4	6	40	54	126	178	31.5	13.5	44.5
	2	6	22	40	85	160	42.5	20	80
	2	6	22	44	92	174	46	22	87
	5	6	50	30	65	120	13	6	24
	2	6	30	108	174	390	87	54	195
	3	6	35	33	95	75	31.67	11	25
	7	6	60	80	150	80	21.43	11.43	11.43
	5	5	10	60	120	180	24	12	36
Mar-93	9	5	15	300	390	600	43.33	33.33	66.67
	4	5	20	12	60	90	15	3	22.5
	6	5	10	93	150	315	25	15.5	52.5
	6	5	20	21	90	120	15	3.5	20
	8	5		20	40	70	5	2.5	8.75
Total	**234**		**1239**	**1998**	**2622**	**6610**	**602.68**	**418.66**	**1325.06**
Average	**6.4**		**36.44**	**55.5**	**119.16**	**183.55**	**27.39**	**11.63**	**36.81**

SPECIES BREAKDOWN FOR RECORD DAUGO ISLAND FAD CATCH BETWEEN JAN/MAR 1993

Common local name	species	Number	%	Cumm %
Skipjack tuna	*Katsuwonus pelamis*	1152	79.07	79.07
Yellowfin tuna	*Thunnus albacares*	88	6.04	85.11
Kingfish	*Acanthocybium solandri and*			
	Scomberomorus commerson	68	4.67	89.77
Finny scad	*Megalaspis cordyla*	49	3.36	93.14
Rainbow runner	*Elagatis bipinnulatus*	42	2.88	96.02
Trevally	*Caranx sp.*	27	1.85	97.87
Dolphinfish	*Coryphaena hippurus*	10	0.69	98.56
Bonito	*Euthynnus affinis and*			
	Auxis thazard	7	0.48	99.04
Barracuda	*Sphyraena spp.*	5	0.34	99.38
Shark		5	0.34	99.73
Unknown		4	0.27	100
Total		**1457**		