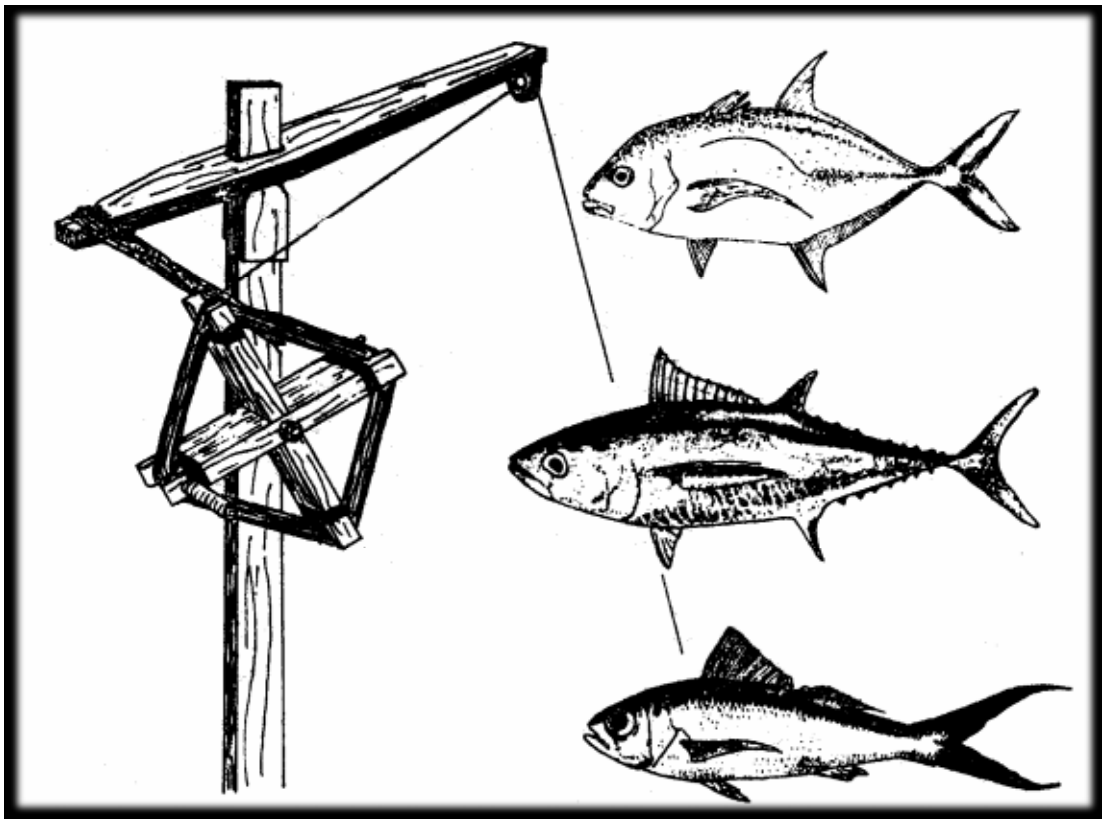
DEEP SEA FISHERIES DEVELOPMENT PROJECT

Report of third visit to

TONGA

6 September 1980 — 7 May 1981



SOUTH PACIFIC COMMISSION
NOUMEA, NEW CALEDONIA

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by

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SUMMARY

The South Pacific Commission's Deep Sea Fisheries Development Project operated for the third time in the Kingdom of Tonga between 6 September 1980 and 7 May 1981, under the supervision of SPC Master Fisherman Paul Mead, with assistance from SPC Master Fisherman Pale Taumaia. The objectives of the visit were to evaluate the suitability and effectiveness of several prototype sailing and motor-sailing craft being produced as fishing vessels by a joint FAO/UNDP/Tonga Government boatbuilding project. Ancillary objectives were to demonstrate and provide training in outer reef slope fishing techniques and related subjects, and to assess the potential of two simple fishing methods bottom longlining, and the use of fish traps — which might be used in place of or in conjunction with those already in use by the Project.

A detailed programme of sea-trials, alternating with on-shore vessel improvements and modifications, was undertaken by the SPC Master Fisherman (in conjunction with the staff of the Tonga Fisheries Division and the FAO/UNDP Boatbuilding Project), for several of the boatyard's designs. The evaluation of the vessels concerned was thus mainly carried out by a process of consultation. The vessel evaluations presented in this report contain only summary information on the most important characteristics and problems of each vessel. Nevertheless, they serve to illustrate the considerations to be taken into account in the design of a good fishing vessel, and underline some of the problems facing small boat construction projects.

Ancillary to the main objective was the training of Fisheries Division staff, local fishermen and others in a variety of fishing and seagoing skills. This was not a formal part of the Project's work programme, but was carried out on an opportunistic basis, in conjunction with vessel appraisal or experimental fishing trips.

Also ancillary to the main objective was the experimental use of bottom longlines and fish traps as a possible supplement to the Project's standard bottom fishing activities. Both techniques were carried out several times on a trial basis, and the results are presented in full in this report. The general conclusion was that, under certain conditions, bottom longlining showed potential as a possible secondary fishing activity to deep bottom fishing. The fish trapping trials were considered a failure, confirming the experience of several other Pacific island countries.

CONTENTS

1. INTRODUCTION

The South Pacific Commission's Deep Sea Fisheries Development (DSFD) Project is a mobile village-level rural development project which operates in Pacific island nations at specific government request, and which has the following broad objectives:

– To promote the development or expansion of artisanal fisheries throughout the region based on fishery resources which are at present under-utilised, and in particular the deep-bottom resources of the outer reef slope;

– To develop and evaluate new simple technology, fishing gear and techniques suitable for use by village fishermen, which will enable fishermen to substantially increase catches while reducing dependence on costly imported fuels;

– To provide practical training in appropriate fishing techniques to local fishermen and government fisheries extension workers.

The main aim of this Project visit was to examine the suitability and effectiveness of the various prototype sailing and motor-sailing craft being produced by the FAO/UNDP project "TON/77/002: Prototype Fishing Vessel Construction and Evaluation" in Nuku'alofa. Other objectives were to demonstrate and provide training in outer reef slope fishing techniques, basic small boat seamanship, coastal navigation and boat and engine maintenance. It was planned to carry out some of this work in conjunction with the Ha'ano Fishermen Society in the Ha'apai island group, but unforeseen delays in the construction of the Society's 30-foot motor-sailing vessel prevented this. Instead one 8-day trip was made to Ha'apai, and two shorter trips to Eua.

The Project was based in Nuku'alofa from 6 September 1980 to 7 May 1981, under the supervision of SPC Master Fisherman Mr Paul Mead. In March a second SPC Master Fisherman, Mr Pale Taumaia, joined the Project, to assist in gear trials which were to be carried out, until the first week of May. In that portion of the visit, objectives in addition to those already listed were to experiment with other simple fishing methods which might be used in place of or in conjunction with those already in use by the Project. These were bottom longlining, and the construction and setting of fish traps.

During the Project's stay in Tonga, approximately 70 days were spent assisting in construction and alterations to the new prototype vessels, 15 days on gear construction, and over 50 days at sea.

2. BACKGROUND

2.1 General

The Kingdom of Tonga, which lies between 15°S and 24°S latitude and l73°W and l77°W longitude, comprises a widely scattered group of 169 islands, 45 of which are inhabited, lying in a generally north-north-easterly direction (Figure 1). The country is divided into three main groups of islands: Tongatapu, on which the capital Nuku'alofa

lies, with adjacent islands in the south; Ha'apai, a far-flung archipelago of low coral islands in the centre, and Vava'u in the north. With a limited total land area of 699 square kilometres, the Kingdom's 200-mile exclusive economic zone encompasses 677,000 square kilometres of ocean (SPC estimate). The population in mid-1980 was estimated to be 94,760, with over 57,400 living on Tongatapu (Kingdom of Tonga, 1981).

Tonga's exports, valued in 1980 at T$7.2 million, are mainly agricultural products, of which by far the most important are coconut products (T$4.9 million). From 1970 to 1980, the balance of trade underwent a marked deterioration, with the trade deficit growing from T$2.9 million to T$23 million during the period. In 1980, imports totalled T$30.1 million, with 24 per cent of this total comprising food stuffs. Part of the growth in food imports, particularly of canned and other fish, and mutton flaps, (totalling T$1.9 million) is attributed to the current shortfall in the supply of fresh fish, despite some growth in local fish production up to 1980 (Kingdom of Tonga, 1981).

2.2 Existing fisheries

Domestic fishing activities are mainly traditional in nature, and are often carried out for subsistence purposes. Rand collection of reef invertebrates, spearing, netting, handlining and the use of traps constructed from stakes and wire netting are all common. A total of 1,700 fishermen were recorded in a survey carried out by the Fisheries Division in 1973, although much fishing is also done by women (Kingdom of Tonga, 1976). The government Central Planning Department estimated the artisanal fishing fleet to number some 770 boats, ranging from canoes (450) to inboard-powered motor boats (20) (Kingdom of Tonga, 1981).

Most commercial fishing is carried out around Nuku'alofa, by part- or full-time fishermen whose main fishing method is handlining in the shallow (up to 60 m) water within the lagoons. However, since the two previous visits by the DSFD Project (Mead, 1979, and Mead, 1980), the deep-bottom droplining technique, using wooden handreels, has become more widely adopted, particularly by the operators of the larger vessels.

Commercial fish production in 1977 was estimated at 1,293 tonnes, of which 54 per cent was landed in Tongatapu (Kingdom of Tonga, 1981). Although a government fish market was in operation at the time of this visit, most fishermen still prefer to sell their catch on the shore or roadside where possible. Prices fluctuate widely according to supply and demand, but tend to be much higher in Tongatapu than in other localities.

3. PROJECT OPERATIONS

3.1 General

A total of 19 fishing trips, some involving two vessels, were carried out in the three island groups. Much time was also spent in modifying and improving the fishing vessels and other activities as detailed in Table 1.

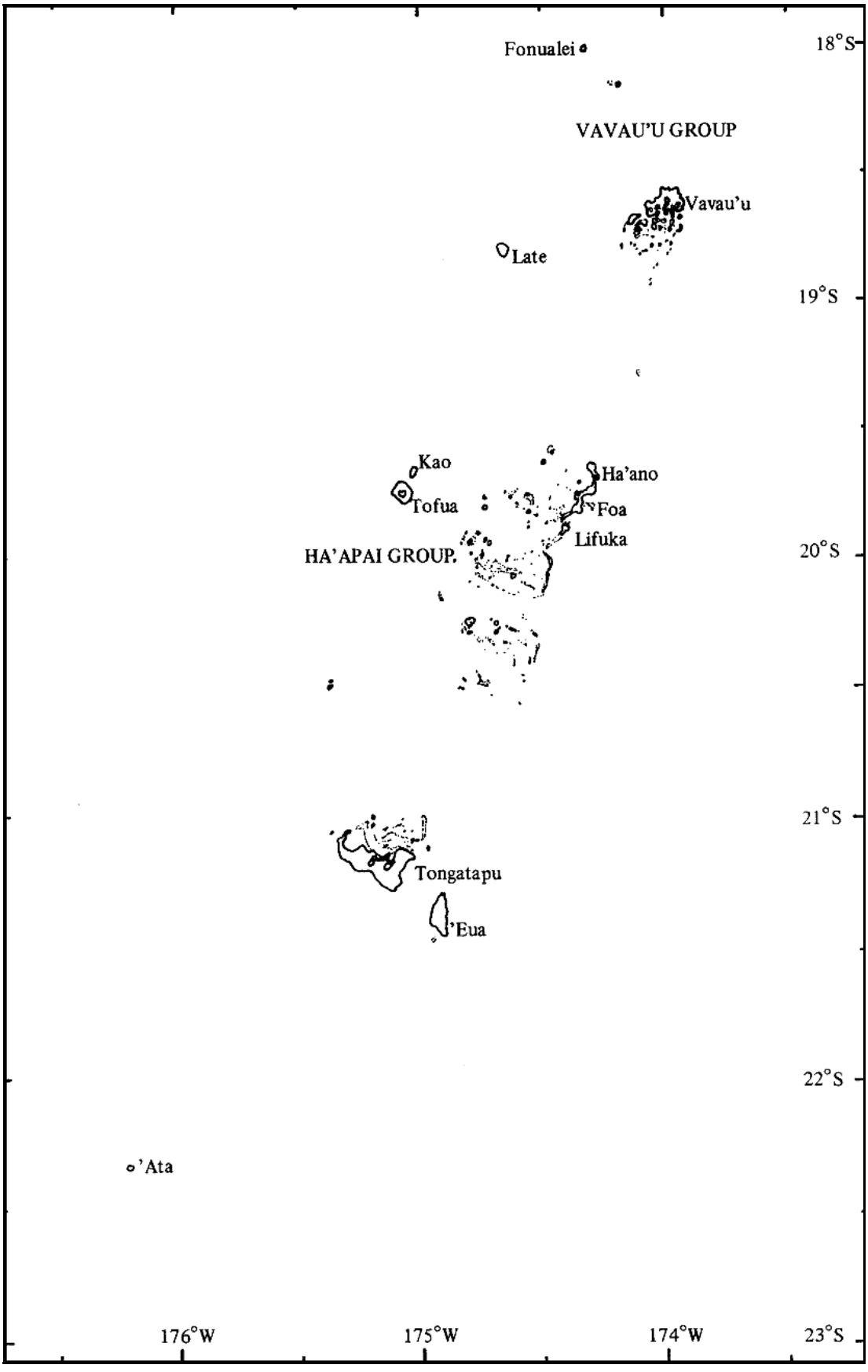


Figure 1: Main islands and reef areas in Tonga.

Table 1: Summary of Activities

Date	Activities
Sep 06 – Sep 16	Arranged housing, finance, unpacking and preparation of gear. Heavy rain every day.
Sep 17 – Oct 29	Worked on trimaran *Malolo* and catamaran *Fafakitahi*. Sailing trials and modifications to trimaran.
Oct 30 – Nov 11	Fishing *Malolo*, modifications after each trip.
Nov 12 – Nov 21	Fishing local whaleboat.
Nov 22 – Dec 15	Modification and repair of *Fafakitahi*. Construction of fishing reels.
Dec 16 – Jan 14	Christmas holidays, further repairs and modifications to *Fafakitahi* after a fishing trip to Hunga. Stripped out all the insulated holds and redecked most of the boat.
Jan 15 – Jan 18	Hurricane warning and rough weather.
Jan 19 – Jan 24	Waterproofed cabins, modified hatches, rerigged the mast and rigging.
Jan 25 – Jan 28	Short sailing trip, followed by further modifications to sail and rigging. Epitarred hull planking.
Jan 29 – Jan 31	Fishing trips to Hunga.
Feb 01 – Feb 04	Hurricane warning, rough seas.
Feb 05 – Feb 09	Heavy rain and strong winds. Worked on a fish trap and construction of fishing reels.
Feb 10 – Feb 20	Fishing trip on catamaran *Fafakitahi*.
Feb 21 – Feb 28	Meeting and fishing trips with SPC Fisheries Adviser, Assistant Fisheries Officer, and other Master Fishermen.
Mar 03 – Mar 04	Bottom longlining from *Fafakitahi*.
Mar 09 – Mar 27	Sea trial, mounting of gear, and extended trip to Ha'apai aboard motor powered catamaran *Tui Punga* with trainees from Tuvalu.
Mar 30 – Apr 03	Construction of fish traps.
Apr 06 – Apr 28	Fishing aboard *Fafakitahi*.
Apr 29 – May 07	Sorting catch records, packing gear.

During the first part of this Project visit the weather in Tonga was characterised by strong but variable winds, moderate to rough seas, and extended periods of heavy rain. These continued from November through January, gradually improving during February. In March and April, the wind was mostly light east to southeast with extended periods of calm seas and clear skies.

3.2 Boats and equipment

Four different vessels, all belonging to the Fisheries Division, were used and were continually modified during the course of the Master Fisherman's stay, in line with the programme of continuous assessment and development specified as the main objective of the Project visit. The vessels, which are fully described in Section 4, were:

(a) *Malolo*: a 26-foot (7.8 m) sailing trimaran with a l5-horse power longshaft auxiliary engine;

(b) Sailing whaler: an open 30-foot (9.0 m) gaff-rigged whaleboat without auxiliary engine;

(c) *Fafakitahi*: a 33-foot (9.9 m) sailing catamaran with a 30-hp longshaft auxiliary outboard engine;

(d) *Tui Punga*: a 30-foot (9.0 m) motor-sailing catamaran, equipped with a lightweight 6-hp Petter diesel inboard in each hull.

The Master Fisherman also participated in sea trials of a fifth vessel, a 29.5-foot (8.9 m) motor-sailing monohull. A brief appraisal of this vessel is included in Section 4.

The fishing gear and equipment carried aboard each vessel depended on the objective of the trip. Four fishing techniques — trolling, deep-bottom line fishing, bottom longlining and trapping — were carried out, the latter two on a trial basis, and the gear and techniques used in each are described in Section 5. Details of the operations of each vessel are shown in Appendix 1.

Additional to actual fishing equipment, a JMC-707 portable battery-powered echo-sounder with a range of 0—420 metres, used for locating suitable depths for fishing on the outer reef slope, was carried on all trips.

All vessels were equipped with suitable anchoring gear for deep-bottom fishing as illustrated in Figure 2. This comprised: a simply constructed grapnel anchor made of four 1.5 m (approximately) lengths of 3/8" (9 mm) reinforcing bar, welded together and bent into a grapnel shape; a 5 m length of 1/2" (12 mm) chain shackled to the anchor; approximately 440 m of polypropylene anchor rope, of a diameter appropriate to the size of the vessel (generally 12 mm), and fitted with a "no-return" barb made of 4 mm galvanised fence wire; and an inflatable buoy of 75 kg or greater flotation, fitted with a snap shackle or short rope eye which could be loosely clipped or shackled to the anchor rope so as to slide freely along it.

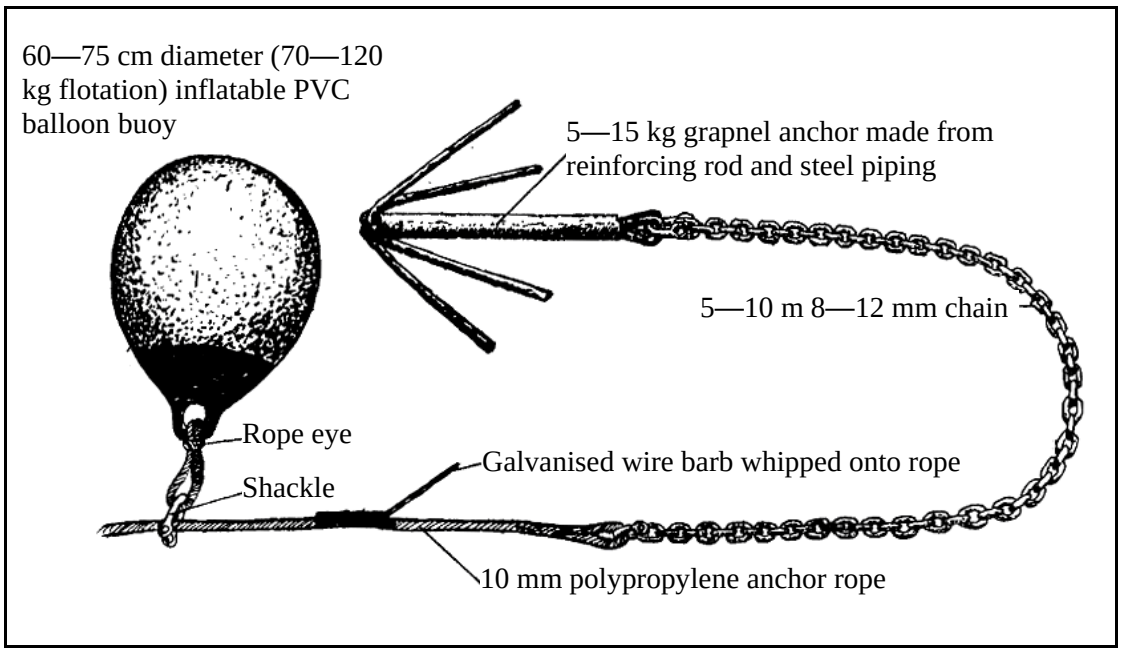


Figure 2: 'Self-hauling' anchor gear.

A simple technique was used to retrieve the anchor after fishing (Figure 3), greatly reducing the effort involved in hauling. By motoring rapidly forward the anchor was broken out and towed until it streamed behind the boat. Still under way, the buoy, shackled onto the line and released, would be forced back along the rope until, close to the anchor, it was trapped by the no-return barb (refer Figure 2). One crewman on the boat could then easily flake the floating rope onto the deck as the boat was slowly steered back, following the rope to the anchor, which, suspended by the buoy at the sea surface, could be easily recovered.

3.3 Fishing techniques

Several different fishing techniques were practised in order to permit thorough vessel evaluations under a variety of fishing conditions, and in line with the secondary objective of experimenting with simple fishing methods to supplement normal project activities. The main techniques used were:

— deep-bottom line fishing, by hand-held line or by using the FAO-designed Western Samoan wooden handreel;

— bottom longlining;

— setting of fish traps;

— trolling.

The fishing techniques and results are described and discussed in Section 5.

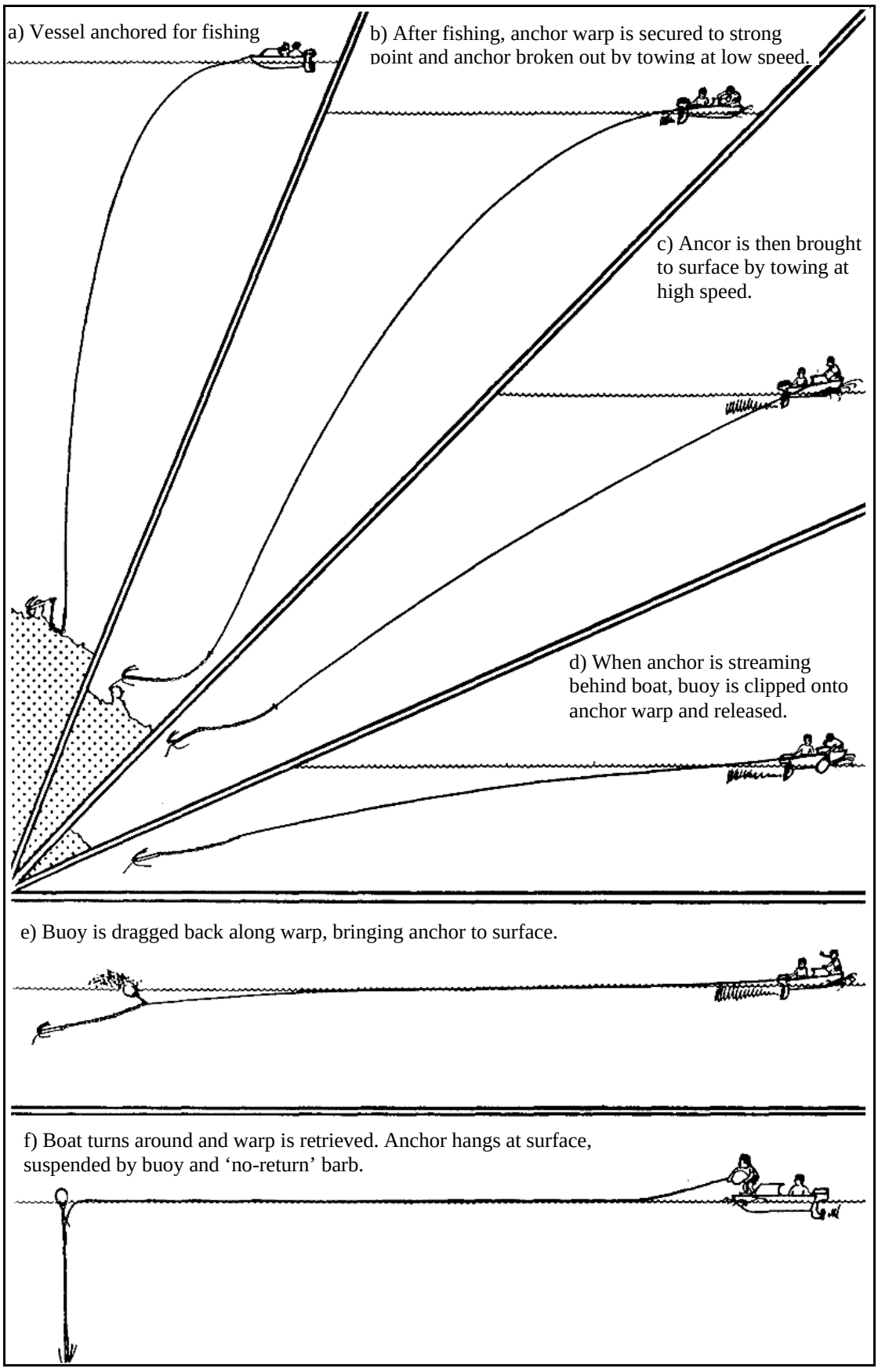


Figure 3: Method of hauling anchor after deep-bottom fishing.

3.4 Data collection

SPC Master Fishermen use a standard logsheet (shown at Appendix 2) to record catch, effort and other data, and make detailed notes of their daily activities and of any supplementary information required. During this Project visit, data collected for each trip comprised: time spent travelling, anchoring and fishing; fishing area, fishing depth or depth range; number of crew; quantity and type of fishing gear, fuel and bait used; the specific identity of each fish caught, where this could be determined; and the total number and weight of each species taken by each fishing method.

3.5 Training activities

Conducted for the most part informally under fishing conditions, the training of government staff and interested local fishermen covered general seamanship and safe handling of a small boat at sea, the rigging and maintenance of fishing gear, deep-bottom fishing techniques, use of the Samoan handreel, the maintenance and operation of outboard engines, and the handling and icing down of the catch.

Priority was given to the training of government personnel who could continue to train local fishermen in deep-bottom fishing techniques following the Project's departure. Additionally, three Tuvaluan Fisheries Officers visited Tonga for several weeks to take delivery of the motor-sailing catamaran *Tui Punga*, which had been constructed for the Tuvalu Government by the Tongan Fisheries Division boat yard. The three Tuvaluans joined the Master Fisherman as trainees between 9 — 21 March, and numerous interested fishermen from the various islands visited were able to fish with the Project for short periods or single trips.

4. EVALUATION OF FISHING VESSELS

4.1 General

The main aim of the Project visit was to examine the suitability and effectiveness of various prototype sailing and motor/sailing craft being produced by the FAO/UNDP boatbuilding project. Due to various, mostly unavoidable, delays in construction, it was not possible to complete trials on all models as was originally planned. To complete fair fishing trials on all the different models being produced by the FAO/UNDP project, allowing sufficient time to redesign and correct recognised faults, would have required at least a full year.

The SPC Master Fisherman fished aboard four different boats, three built by the FAO/UNDP project and the fourth a locally built 30-foot (9.0 m) sailing whaleboat. All three of the FAO/UNDP vessels were multi-hull prototypes — a 26-foot (7.8 m) sailing trimaran (*Malolo*), a 33-foot (9.9 m) sailing catamaran (*Fafakitahi*), and a 30-foot (9.0 m) motor-sailing catamaran (*Tui Punga*). In addition, the FAO/UNDP project produced a 29.5-foot (8.9 m) monohull motor-sailer which was given limited sea trials in which the Master Fisherman participated. This craft seemed applicable to developing artisanal fisheries in several areas of the SPC region and is included in this report although not actually given fishing trials.

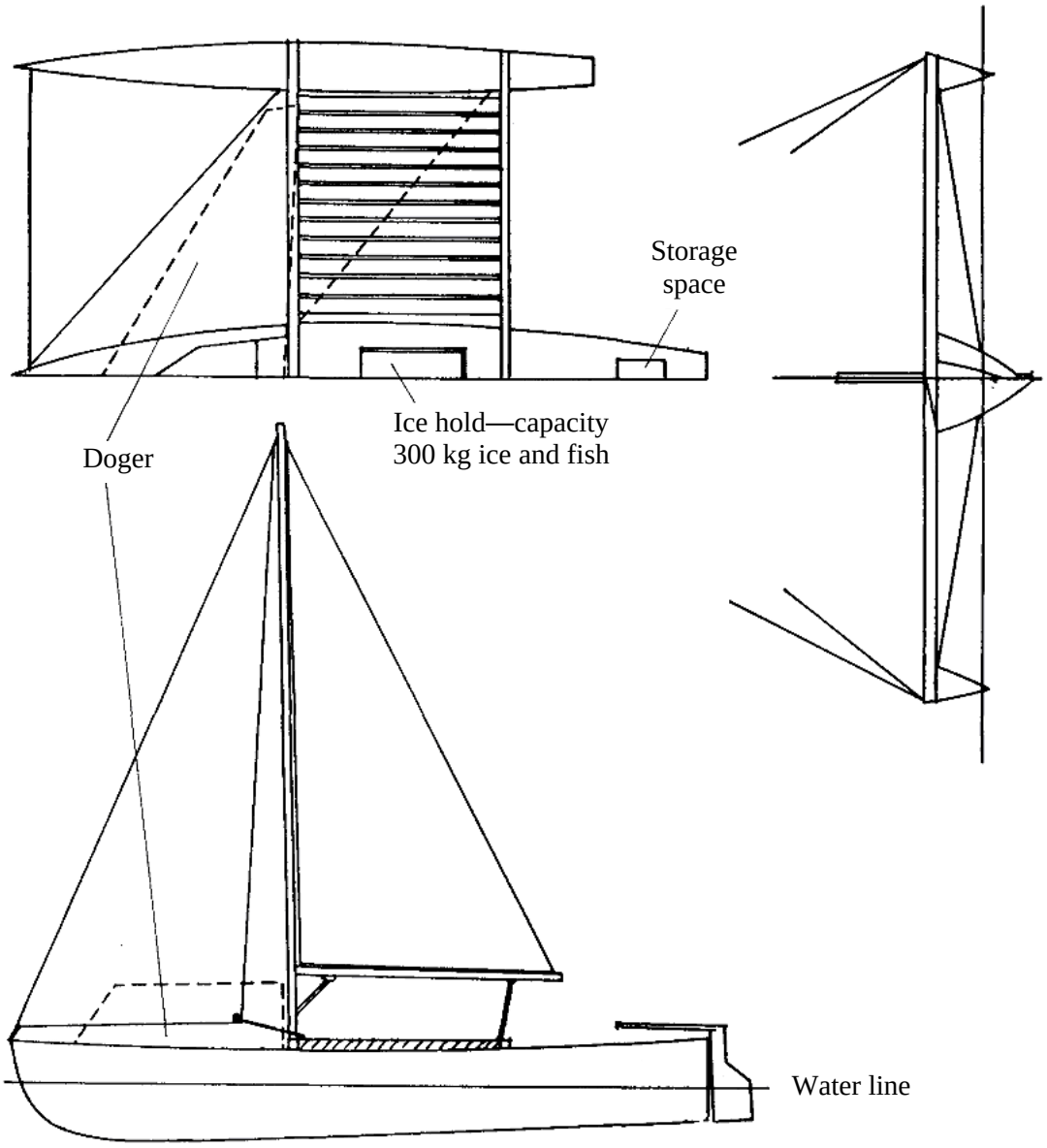
As the Master Fisherman had little previous sailing experience the following

comments deal only with the more obvious features observed during the limited trials.

4.2 Trimaran *Malolo*

This vessel was a 26-foot (7.8 m) sailing trimaran (Figures 4 and 5) carrying a 15-hp longshaft petrol-driven auxiliary outboard motor and with a built-in insulated ice/fish hold. Over 200 man-hours were spent working on the trimaran after it was "finished" by the boat builders before it was ready for its first fishing trip. In all, four trips were made aboard the boat, with numerous hours being spent on repairs and alterations between trips.

Figure 4: **Malolo.**



Main particulars

Length overall: 26 feet (7.8 m)
Beam overall: 26 feet (7.8 m)
Depth moulded: 3 feet (0.9 m)
Propulsion: auxiliary 10 hp longshaft outboard engine

Figure 5: **Malolo** ***general arrangement.***

A number of problems were encountered, the main ones being:

(1) The deck was too close to the surface of the sea, was not strong enough to stand the shock of waves striking underneath, and was always awash in any wind of over 10 knots;

(2) The boat had low carrying capacity;

(3) The boat was heavy and difficult to push through the water under outboard power alone;

(4) Although it sailed reasonably well in fair winds, the *Malolo* would not sail in light wind conditions, and was unsafe in strong winds or heavy seas.

Assessment

This boat never approached the minimal standards required of a fishing boat in Tonga.

4.3 Sailing whaleboat

This was an open 30-foot (9.0 m) gaff rigged whaleboat (Figure 6) with no auxiliary power, built locally and previously used for whaling until this activity was banned by the government. When sailed by its owner, it proved to be a seaworthy but not sea-kindly platform for bottom fishing as it had a tendency to roll badly at anchor in even a moderate chop.

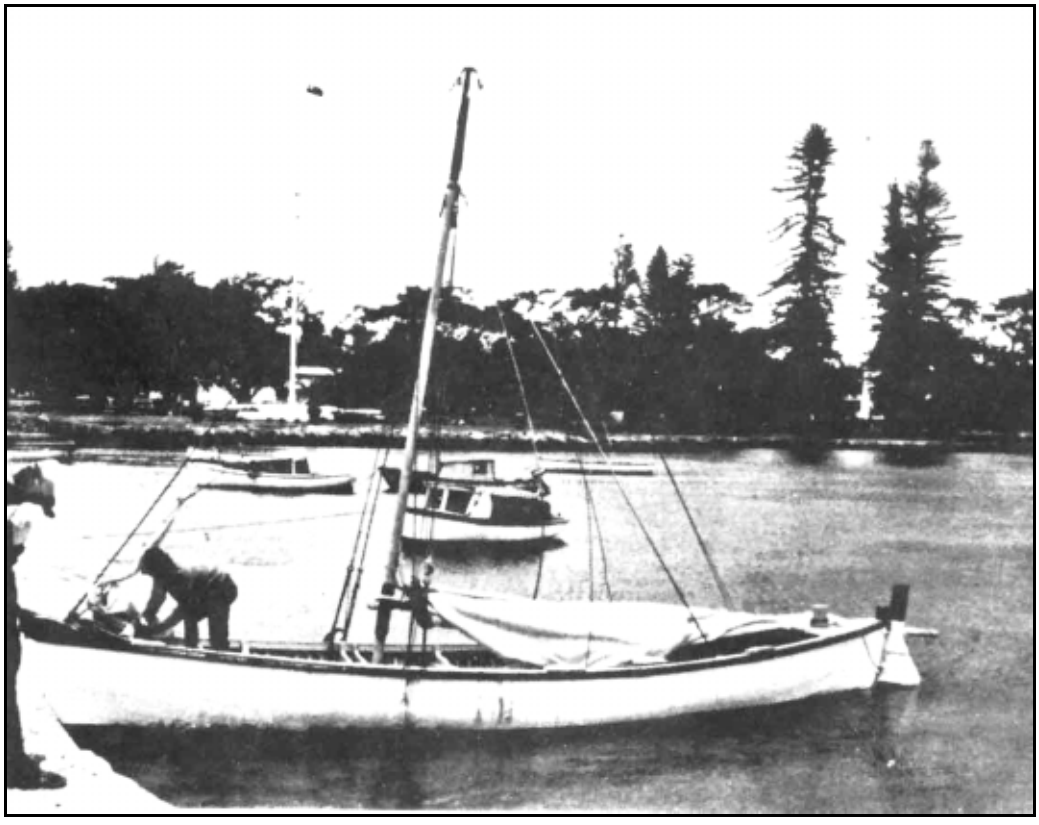


Figure 6: Sailing whaleboat.

This type of boat, besides being a much better sea boat than the *Malolo* had a higher load carrying capacity. Two bottom fishing trips were made aboard the boat, both in moderate to rough sea conditions, the last being a two-day trip covering over 100 nautical miles and resulting in a catch of over 150 kg of marketable fish.

The problems encountered were:

(1) The boat rolled badly when anchored;
(2) The interior of the boat was cluttered and space was wasted due to overbracing as it was built as a whaling platform;
(3) There was no auxiliary power. After being becalmed in the early morning hours on the return leg of the second trip, it took 8 hours to cover the last five miles;
(4) There was no shelter from sun or seas.

Assessment

Whaleboats such as this one have been used in Tonga for years. They are safe, strong sea boats, capable of carrying good loads cheaply over reasonable distances in the right wind and sea conditions, and are familiar and readily acceptable to local fishermen. However, to make a more reliable fishing boat, they need auxiliary power (outboard or preferably a small diesel) to be fitted, along with removable ice boxes. To provide a larger uncluttered working area, some of the cross braces (needed for whaling but not for fishing) should be removed and some type of simple floorboards installed.

4.4 Sailing catamaran *Fafakitahi*

This vessel was a 33-foot (9.9 m) planked catamaran (Figure 7) with hulls of a simple, deep-V configuration. A cabin was built into each hull forward of midships and insulated ice/fish boxes were built into the hull space from the rear of the cabin towards the stern. A 30-hp longshaft petrol outboard was used for auxiliary power. Eleven different fishing trips, most of at least two days' duration, were made on this boat.

The main problems encountered were:

(1) The original engine was underpowered for the weight of the boat, and prove adequate for manoeuvering only in light sea conditions. Fuel consumption was financially prohibitive when motoring over any distance, even under ideal conditions;

(2) The original sail support system was inadequate: the mast and boom were of insufficient strength and incorrectly stayed while most fittings were poorly constructed. There were not enough cleats and those present were small and improperly mounted;

(3) The original steering system was weak and poorly designed, and fell apart on the first trip;

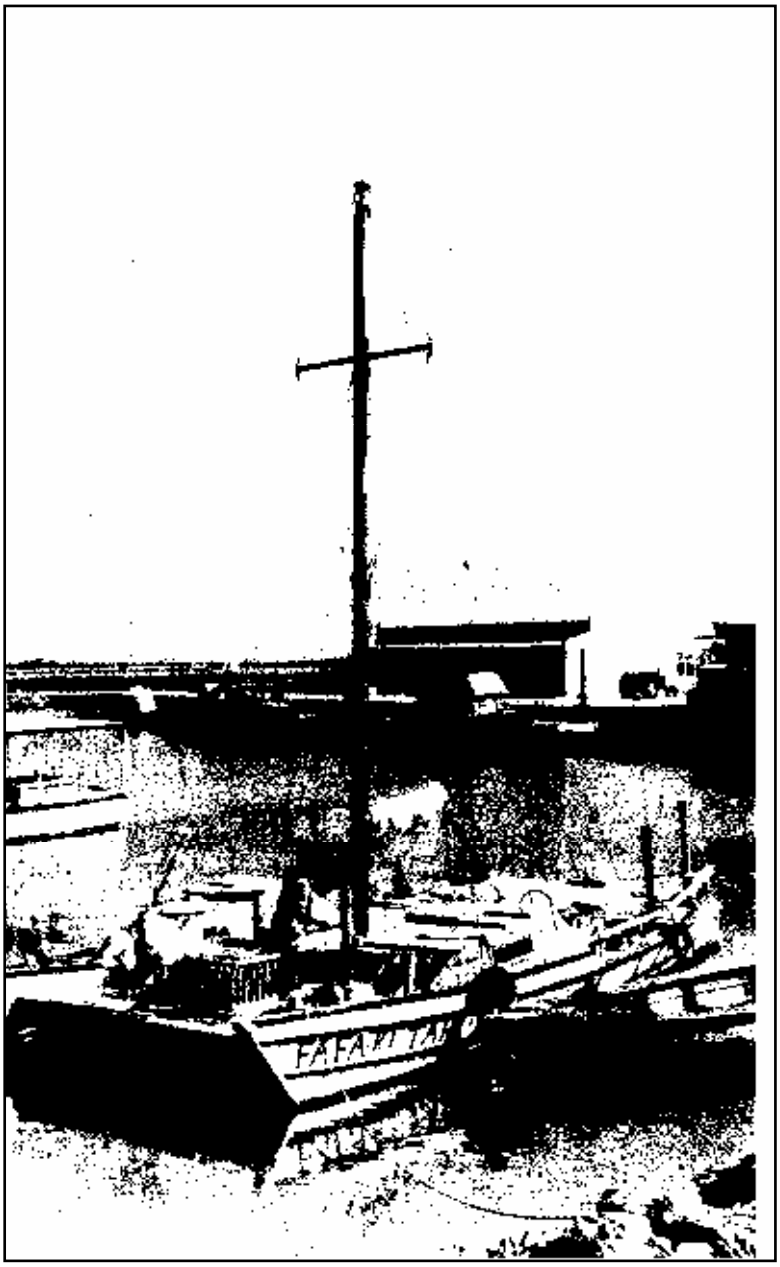


Figure 7: **Fafakitahi.**

(4) All tops, sides, windows, and doors leaked due to poor design, placement and construction;

(5) The solid foredeck did not shed water, and the slotted after-deck allowed jets of water to shoot through every time a wave struck the hulls or broke underneath;

(6) The decks over the hulls leaked badly as they had been built of a very poor quality green timber and were full of holes. Similar problems were encountered with the hull planking which quickly became waterlogged for the same reason;

(7) Even though both the hulls and the decks leaked badly the boat was nearly impossible to bail as no limber holes had been cut through the frames;

(8) All the built-in ice boxes had been poorly installed and had to be torn out after the first trip as they became water-logged and would not hold ice.

Assessment

Despite the many problems experienced, this was an excellent sea boat capable of sailing safely, after improvements had been made, over good distances. As a sailing craft, it was easy to handle and able to tack fairly effectively into a head wind. Unfortunately, its full potential was never realised because of a plague of problems, most of which were due to faulty construction and poor timber. The 30-hp outboard did not have the power to move the boat economically over any distance or into a head sea, but this was in large part due to the water-logged condition of the hulls. The uncluttered working area, combined with exceptional stability, made this craft easy to fish from, even at anchor in moderate seas. The increased stability also made fishing and being at sea on the boat a less strenuous task and more energy could be used in the actual work of fishing. If the crew are able to sleep, move about, and work in a stable, comfortable boat, they are more likely to be willing to spend more time at sea.

This boat has the potential to be a good economical fishing craft if more care is taken in construction, all fittings made and attached properly, and the hull covered with good 3/8" (9 mm) marine plywood and sheathed in fibreglass instead of planking. As the boat is capable of spending up to one week at sea, it should be fitted with two well-insulated ice/fish boxes, one for each hull, which are set into the hulls but are not a part of the hull structure. It is essential that boats of this type be fitted with some form of reliable propulsion, preferably diesel.

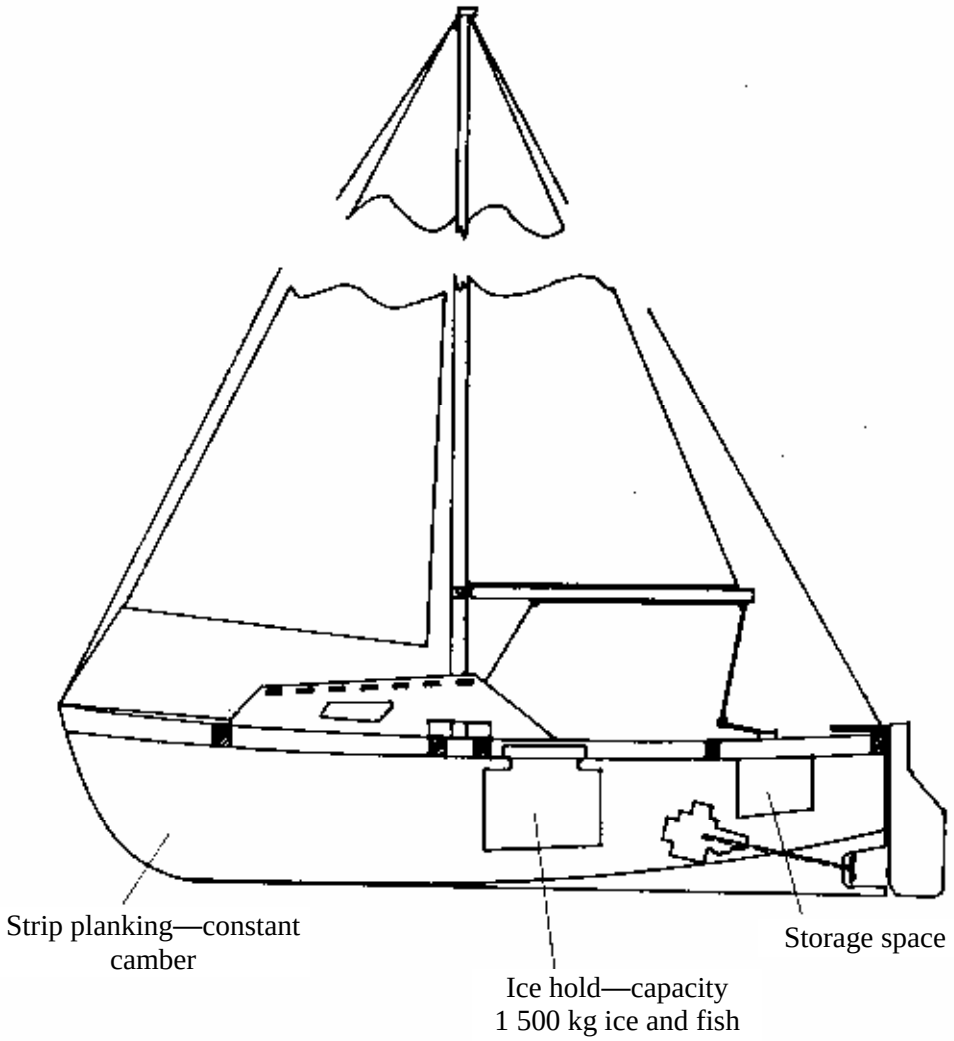
4.5 Motor-sailing catamaran *Tui Punga*

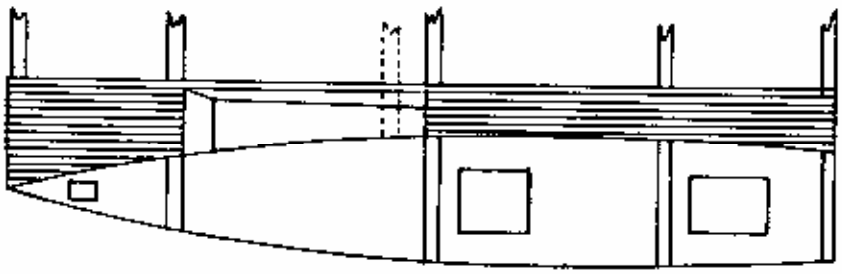
This craft (Figures 8 and 9) was a 30-foot (9.0 m) motor-sailor with a more beamy, rounder hull configuration than the *Fafakitahi*. A small lightweight 6-hp Petter diesel was mounted low in each hull. Well-insulated fish holds, mid-way between the engine compartment and cabins, provided space for approximately 1.5 tonnes of fish and ice. A cabin in each hull, just forward of the ice hold, was fitted with sleeping accommodation for four, plus cooking facilities.

The SPC Master Fisherman made two trial fishing trips aboard this vessel, the second being a 7-day trip covering a total distance of over 330 miles (610 km) in which several different sea conditions were experienced from flat calm to very rough.

The main problems encountered were:

(1) The engines were too small and unable to push the boat into even a moderate sea;





Main particulars

Length overall: 30 feet (9.0 m)
Beam overall: 15 feet (4.5 m)
Depth moulded: 3 feet 10 inches (1.2 m)
Propulsion: 2 x auxiliary 6 hp Petter diesel inboard engine

Figure 8: **Tui Punga** ***general arrangement.***

(2) The engines were poorly mounted (both engines broke loose from their mounts), and too low in the bilges (bilge water was picked up by the coupling and thrown over the engine and batteries);

(3) Both hulls leaked and were difficult to bail or pump;

(4) The steering system was poorly designed;

(5) The boat could not sail effectively into a head wind.

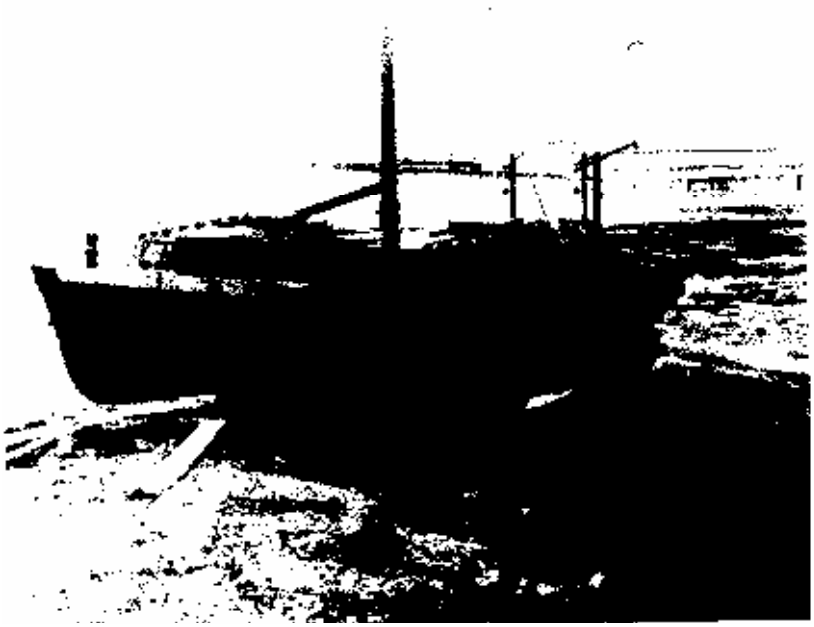


Figure 9: **Tui Punga.**

Assessment

Like the *Fafakitahi*, the *Tui Punga* never realised her full potential on either of the trips in which the Master Fisherman took part, mainly because of poorly fitted and designed sails and careless workmanship when mounting the engines. The sails were nearly always useless in any wind, except that, coming from the stern, and on the second trip both engines came loose from their mountings. As well as being incorrectly mounted, the engines were underpowered, being barely able to make headway into even a moderate sea and winds of 15—20 knots when running at 3/4 revs. Both hulls leaked through the bottom, probably due to striking rocks and coral heads in the area used for launching. Again it was difficult to pump or bail as some frames did not have limber holes. The steering system worked but would jam at times and seemed too complicated, although there was a workable backup tiller system which could be used in emergencies. Like the *Fafakitahi*, despite its many problems, the basic boat had the potential to be an excellent fishing platform. Although more bouncy than the *Fafakitahi*, it had good stability, a large clean working area, was reasonably comfortable to work on, highly manoeuverable with both engines operating, and the built-in insulated ice boxes were able to keep fish and ice mixed in equal weights for over four days. With just a few improvements a crew of 3—5 could comfortably stay at sea and fish for up to a week.

4.6 Motor-sailing monohull

This craft (Figure 10) was a 29.5-foot (8.9 m) monohull with a gaff rigged sail plan and a 20-hp Yanmar 2QM diesel inboard engine. It was capable of carrying approximately 2 tonnes of fish and ice in insulated holds which were built into the boat.

The Master Fisherman made only two short trips aboard this craft, both in sheltered water, and the following comments must be viewed with caution.

Some problems encountered were:

(1) As in the multi-hull prototypes, the sail plan needed modification;

(2) The deck was too cluttered and there was comparatively little clean working area for the size of the boat;

(3) The steering system was poorly designed;

(4) The decks and cabin leaked, mainly because of the poor quality of timber used.

Assessment

The deck layout on this boat was broken and uneven, with a limited amount of working room for the size of the deck area. Movement about the deck, such as from the tiller to the cabin, was difficult even while cruising in sheltered water because of the awkward placement of well decks, insulated ice boxes, engine compartment, etc. It would seem that a straight, even deck with the cabin built over the engine and two or three portable lift-out insulated ice boxes would have been cheaper and easier to

build. Like the other boats produced by the FAO/UNDP boatbuilding project, the basic vessel could have been good, but it was plagued with many of the same unnecessary problems, most of which could have been eliminated by closer supervision during construction.

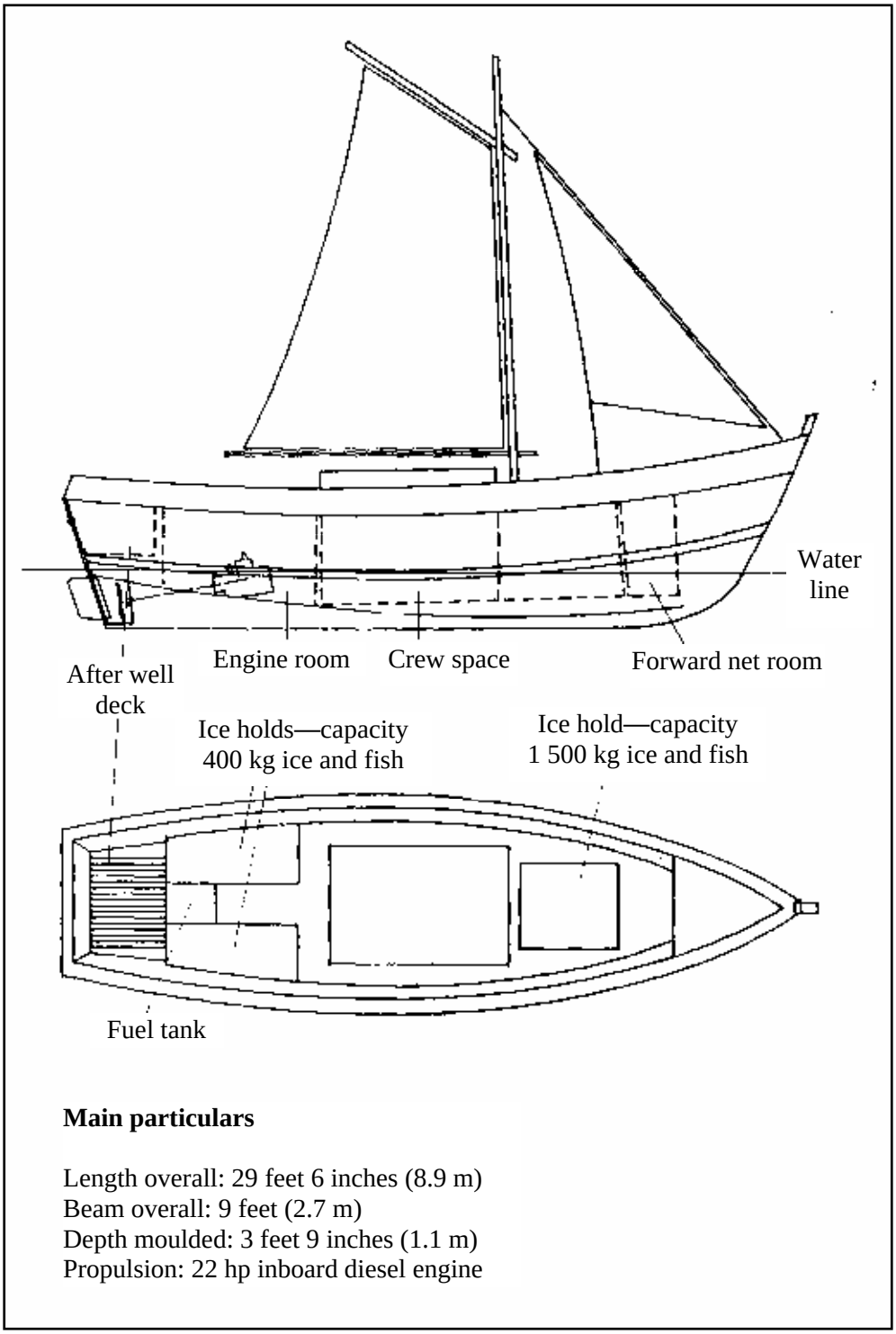


Figure 10: Motor-sailing monohull general arrangement.

4.7 Summary of vessel evaluations

(a) *26 ft (7.8 m) trimaran,* Malolo. Almost any simple catamaran or monohull would give a safer, more economical performance.

(b) *30 ft (9.0 m) whaleboat*. Variations of this boat have been used for many years by Tongans for transportation of people and produce, whaling, and part-time fishing. At the present time a number of these boats are sitting idle due to a ban on whaling. It is recommended that some form of low interest loan package be made available to their owners. This should not be in the form of money but a complete package put together by the Fisheries Officer, and consisting, at the bare minimum, of an outboard for auxiliary power, basic fishing gear, wooden fishing reels, insulated ice boxes, and anchoring gear consisting of anchor rope, chain, anchor, and float large enough to pull the anchor.

(c) *33 ft (9.9 m) sailing catamaran* Fafakitahi. Although most of the many problems associated with this vessel could easily be solved, it is not recommended that this boat be made available to Tongan fishermen at the present time. The vessel has good potential sea-going ability, but it is strongly recommended that further work and carefully monitored fishing trials be carried out prior to producing more of these boats.

(d) *30 ft (9.0 m) motor-sailing catamaran* Tui Punga. This vessel was originally built for the Fisheries Division of Tuvalu, a nation of nine small islands stretching in a generally north-south direction over miles of open ocean. Unlike Tonga, as it is much closer to the equator, there are long periods of light to no winds with flat calm seas between May and September when sails alone would be nearly useless. In conditions such as this, if the boat is to travel and fish effectively between islands, it is essential that it has both a well-designed sail plan and sufficient reliable engine Further work on the design is therefore essential power.

(e) *29.5 ft (8.9 m) motor-sailing* monohull. It is the Master Fisherman's belief that at this stage of fisheries development in Tonga this is the best boat of those evaluated for the more serious and capable Tongan fisherman, if it is constructed properly. This craft should have the range and carrying capacity to exploit most of the bank and seamount areas in Tongan waters.

Basic safety equipment should be provided on all boats produced by the FAO/UNDP project and each individual boat should be given a shakedown cruise of at least two days in unsheltered waters and faults corrected before being turned over to their owners, who are usually not experienced engineers or carpenters and do not generally have their own tools. It is also strongly recommended that prototype vessel designers and construction supervisors make at least one overnight fishing trip on each prototype produced before the boat is turned over to the buyer fisherman, in order to experience first hand the features needed in a good fishing boat.

5. FISHING ACTIVITIES AND RESULTS

5.1 General

Fishing activities, and therefore the gear and techniques used, varied from trip to trip, depending on the vessel and onboard equipment, trip objectives, weather and other operating conditions. Trolling, deep-bottom dropline fishing, bottom longlining, and the setting of fish traps were all carried out in a variety of combinations, the latter two methods on an experimental basis. Appendix 1a details the operational aspects of the 19 fishing trips conducted from the 4 different vessels described in Section 4, and Appendix 1b summarises fishing activities by trip.

The areas fished ranged over a distance of 100 miles, from Kallau and the south-west of ‘Eua in the south to the volcanic island of Kao in the north, and from the western edge of Tongatapu in the west to parts of the Ha’apai group in the east. Areas fished are shown in Figure 11.

A good deal of fishing was conducted around Tongatapu, and at the islands of Hunga Tonga and Hunga Hapai. Despite being persistently hampered by adverse weather conditions, all trips to the two Hunga islands gave good fishing, as in the two previous visits to Tonga by the Project (Mead, 1979; Mead, 1980).

5.2 Bottom fishing

Bottom fishing in deep or shallow water using a multiple-hook terminal rig hauled by hand or reel was carried out on all 19 fishing trips. On the first six trips, handlines of 20—40 kg test monofilament nylon fitted with wire terminal rigs and three tuna circle hooks (as shown in Figure 12) were used. During November, the wooden Western Samoan handreels, used as standard equipment by the Project and shown in Figure 13, were constructed and fitted to the *Fafakitahi*, and were used on the next ten trips. On the last three trips, the crew reverted to handline fishing in lagoon waters in between other activities such as the setting and hauling of traps.

The bottom fishing technique is basically similar regardless of whether handreels or handlines are used, and of depth. Suitable fishing grounds are selected, target depths of around 200 m being located by using the echo-sounder when fishing the outer reef slope. Where possible, the anchor is dropped in water shallower than the chosen fishing spot, in a position selected so that the prevailing winds and current will carry the boat back over the deeper areas as the anchor warp is paid out. At many of the reef slope locations, the fished during this visit, however seabed was of moderate gradient, and the boat frequently had to be anchored in deep water. On some occasions, conditions dictated that bottom fishing be carried out inside lagoon areas.

Once the boat is resting at anchor, bottom fishing is conducted using the handreels or handlines fitted with terminal rigs and a sinker of up to 2 kg in weight, depending on water depth and current strength. The sinker is lowered to the bottom and thereafter the line kept tight by hand, to allow the fisherman to respond to bites by striking, and to reduce the possibility of tangling with other lines. Because of the length and elastic properties of the line, which make rapid striking difficult when fishing in deep water,

much reliance is placed on the effectiveness of the self-hooking tuna circle hooks used.

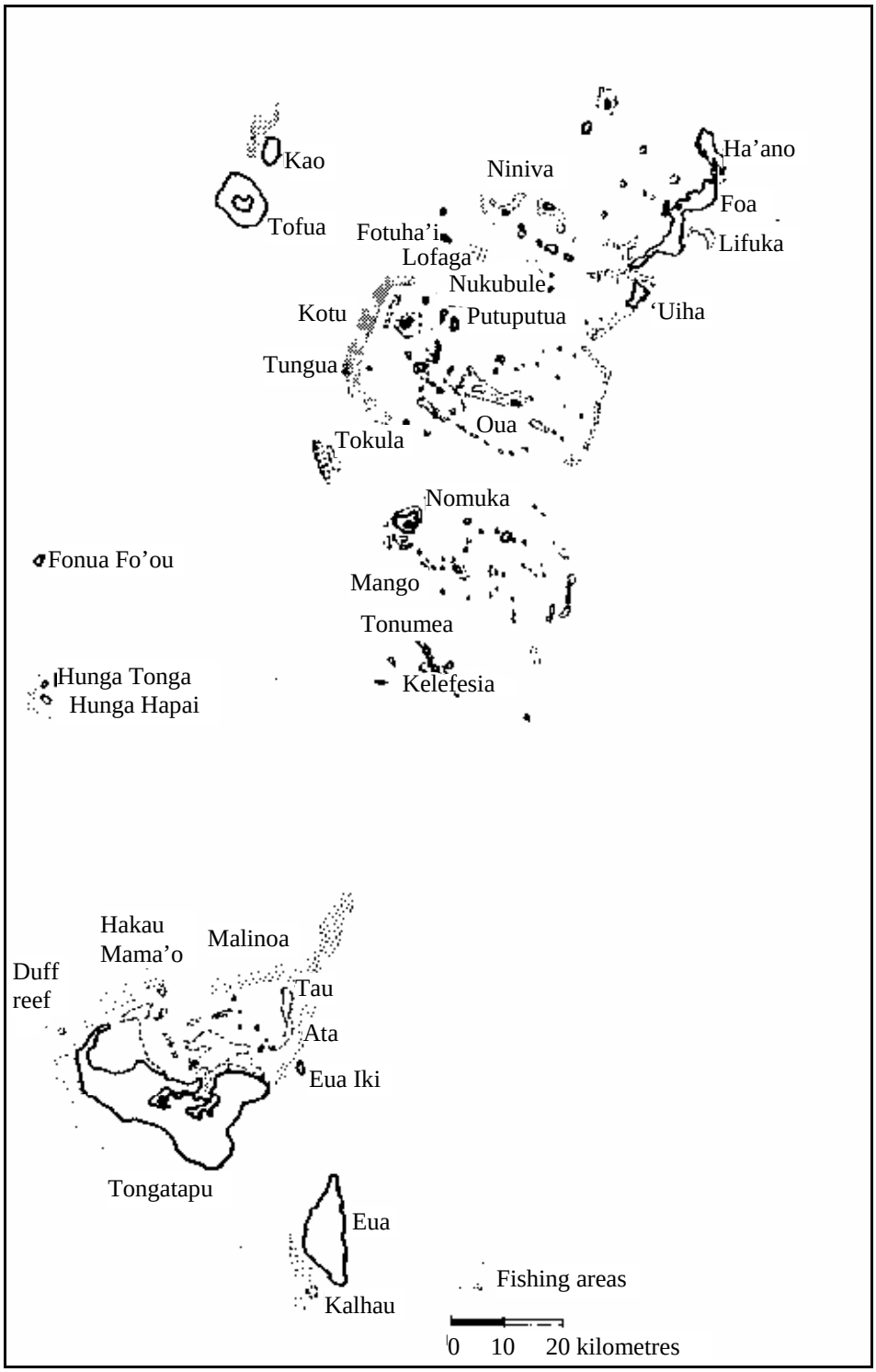


Figure 11: Sketch map showing areas fished during the Project visit.

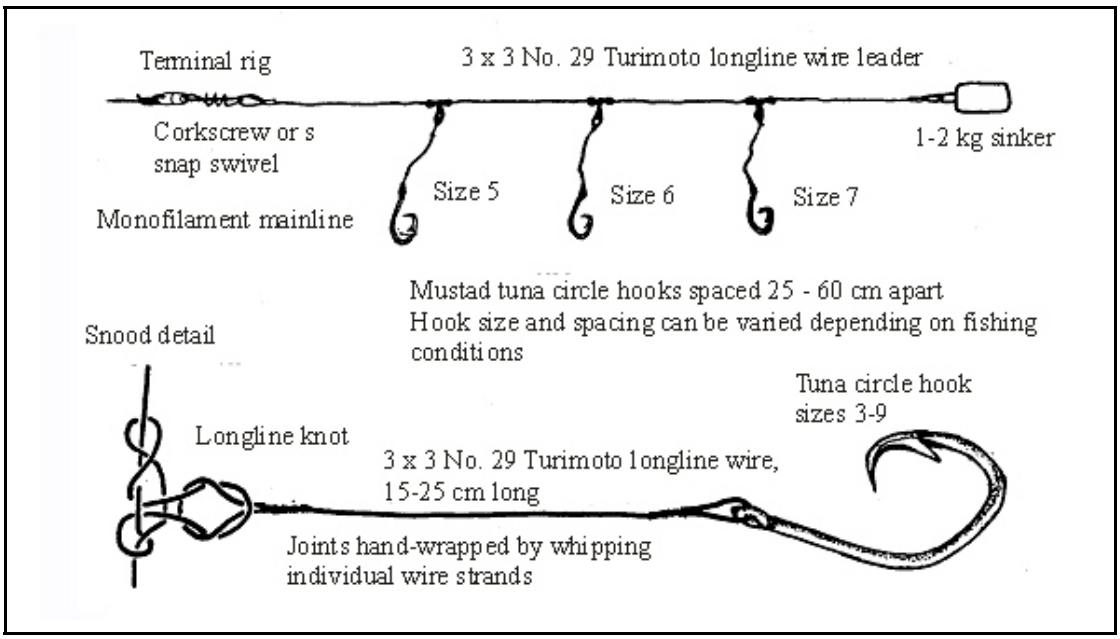


Figure 12: Typical terminal gear for bottom fishing.

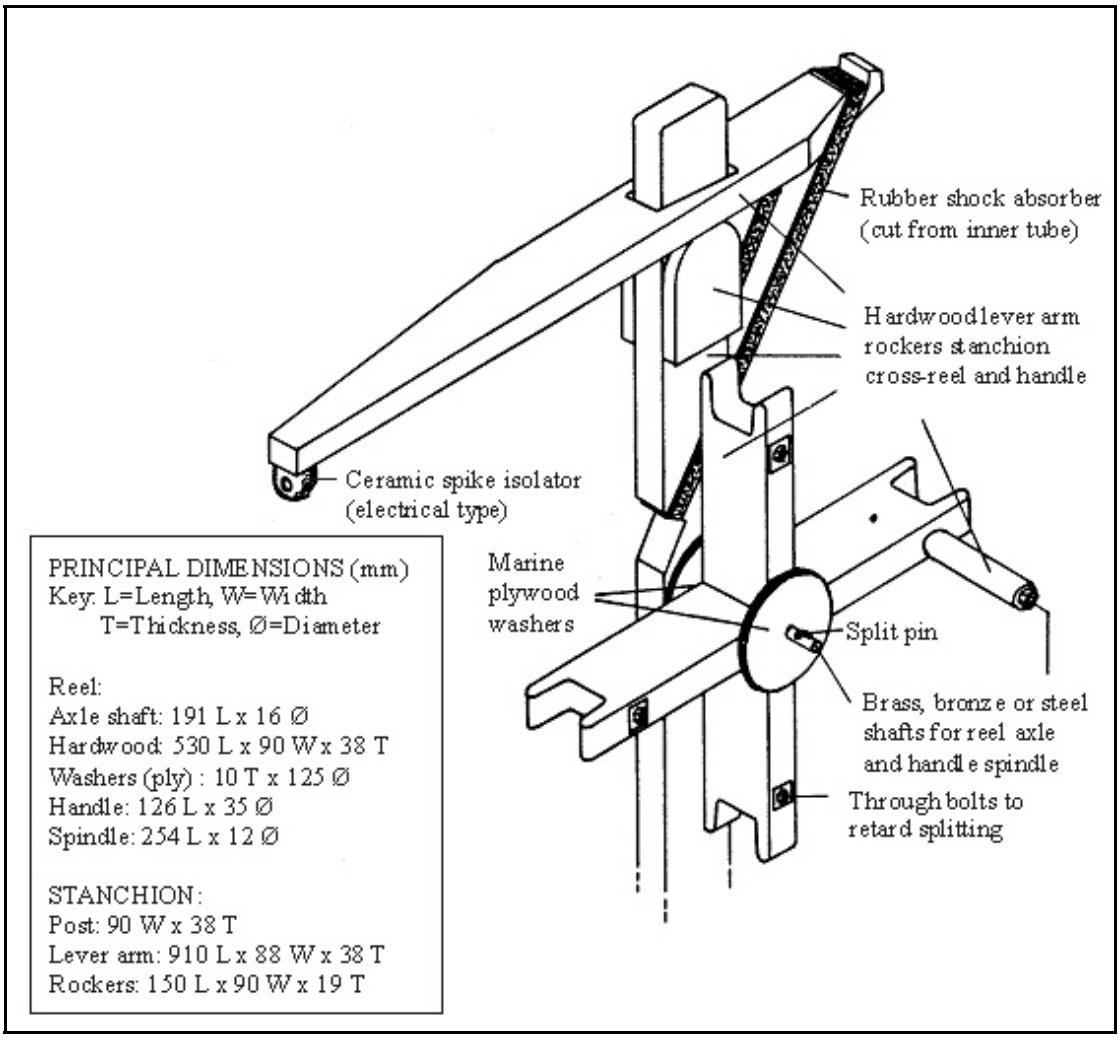


Figure 13: The wooden handreel used by the Project.

The preferred bait for deep bottom fishing is skipjack, and this or other tuna was used when available. On about half the trips, however, other baits had to be used. These included sardines, mackerels and commercial longline saury.

A total of 126 hours were spent in bottom fishing, using from 2 to 4 reels or lines and yielding a total fishing effort of 341 line-hours. This produced a catch of 572 fish weighing 905.8 kg, a catch rate of 2.7 kg/line-hour. Handreels and handlines gave markedly different catch rates (3.3 kg/reel-hour vs. 2.4 kg/line-hour). If sharks are excluded the catch rates are reduced to 3.0 kg/reel-hour and 2.0 kg/line-hour respectively. The species composition of the two catches were also different. The handreel catch showed a much higher proportion, both numerically and by weight, of deep water snappers (family *Lutjanidae*: sub-families *Etelinae* and *Apsilinae*) than the handline catch, which was dominated by emperors (family *Lethrinidae*) and shallower water snappers (family *Lutjanidae*; sub-family *Lutjaninae*). This was to be anticipated, as much handlining was carried out when the vessels operated in shallower lagoon water. Further information on the species composition of these catches can be found in Appendix 3.

Bottom fishing using the Western Samoan handreel is the Project's standard fishing method and has been carried out in a number of Pacific island nations. Table 2 gives catch rates for a number of Tonga's neighbouring locations where the Project has operated. Catch rates are quoted from previous DSFD Project reports, in some cases after recalculation due to inconsistencies which made the original values incomparable. A full list of published DSFD reports can be found inside the back cover of this document.

Table 2: Deep bottom catch rates achieved by the DSFD Project in selected Pacific countries and territories

Locality	Year and report (see inside back cover)	Deep-bottom catch rate (kg/reel-hour)	
		Total	Excluding sharks
Tonga (this visit)	1980/81 (22)	3.3*	3.0*
Tonga	1979 (13)	7.6	5.7
Tonga	1978 (7)	–	3.6**
Fiji	1979/80 (17)	14.1***	9.3
Wallis	1980 (19)	9.3	8.7
Futuna	1980 (19)	5.6	5.2
American Samoa	1978 (6)	–	4.9
Western Samoa	1975 (2)	–	4.1
Niue	1978 (8)	–	2.8
Niue: Niue Island	1979 (14)	8.5	7.0
Niue: Beveridge reef	1979 (14)	6.1	5.6

* Handreel fishing only (excludes handlining).
** Estimate only — excludes *Lutjanus bohar*.
*** Recalculated.

Catch rates during this visit to Tonga were lower than those obtained in previous visits, and for the surrounding area as a whole. This is at least partly attributable to crew morale. Frequently uncomfortable fishing conditions and the need on many occasions for continual bailing or other work often greatly detracted from the fishing operations.

5.3 Trolling

Trolling was conducted while travelling to and from areas selected for other fishing activities, using 1—3 lines variously arranged depending on the vessel, and artificial feather or plastic lures. During 352 hours travelling, 58 hours trolling were carried out for a total fishing effort of 114 line-hours. On many occasions, the crew were preoccupied with bad weather or difficulties with the vessel, and no troll lines were fished.

Trolling produced 21 fish, weighing 170.4 kg, at a catch kg/line-hour. This consisted of both open water species such as dolphin fish, and reef-associated species such as mackerels, dogtooth trevally. Species composition details can be found in Appendix 3.

5.4 Trials of bottom longlines

Single bottom longlines, or trotlines, were deployed on the outer reef slope on 5 trips, in order to make a preliminary assessment of the potential of this fishing method and the possible problem areas involved. These consisted of a weighted mainline bearing numerous baited hooks on short traces, and connected to one or more floatlines tied off to surface buoys.

The first version of the bottom longline to be tested, was made wholly out of 6 mm kuralon (staple fibre polyvinyl alcohol) rope. The mainline was of 230 — 350 m in length, bearing 150 hooks, with a floatline at each end, as shown in Figure 14a. Difficulties in hand hauling and experience with gear loss on rock and coral slopes led to the number of hooks being reduced to 40—50, set along a mainline of used Japanese tuna longline of 100—150 m in length. A stronger single floatline of kuralon was attached to one end only (Figure 14b).

In this arrangement, it was intended that snagging or tangling on the bottom would cause breakage of the mainline before the floatline, thus avoiding the loss of the whole line.

By the last trip on which a longline was set, an acceptably workable system had been developed whereby a longline of this type could be set in about 5 minutes, and hand-hauled in 15—30 minutes depending on depth, catch and bottom type. Deployment depths ranged from 190—320 metres.

Over the 5 trips, 22 longline sets were made, resulting in a fishing time (soak time) of 39.8 hours and an effort (as defined in the notes to Appendix 1b) of 2,675 hook-hours. The total catch by this method was 119 fish weighing 281 kg, a catch per unit effort of 7.1 kg/hour or 1.1 kg/10 hook-hours. It was felt that improvements to the gear and handling techniques significantly improved the efficiency of this fishing method as the project progressed, and that continued development would have resulted in higher long-term catch rates.

An average time for one longline set over the 5 trips was 1 hour 50 minutes, comprising 10 minutes setting time, 65 minutes soak time, and 35 minutes for hauling. Catches averaged 12.8 kg/set, which was equal to the production on average

of 4 hours' handreel fishing. However, there is no reason why several longlines could not be set and hauled in sequence or, alternatively, why other fishing activities could not be carried out during the hour or so the longline is on the bottom. This would improve the efficiency of the method considerably, and under the right conditions make bottom longlining a useful supplement to other fishing activities.

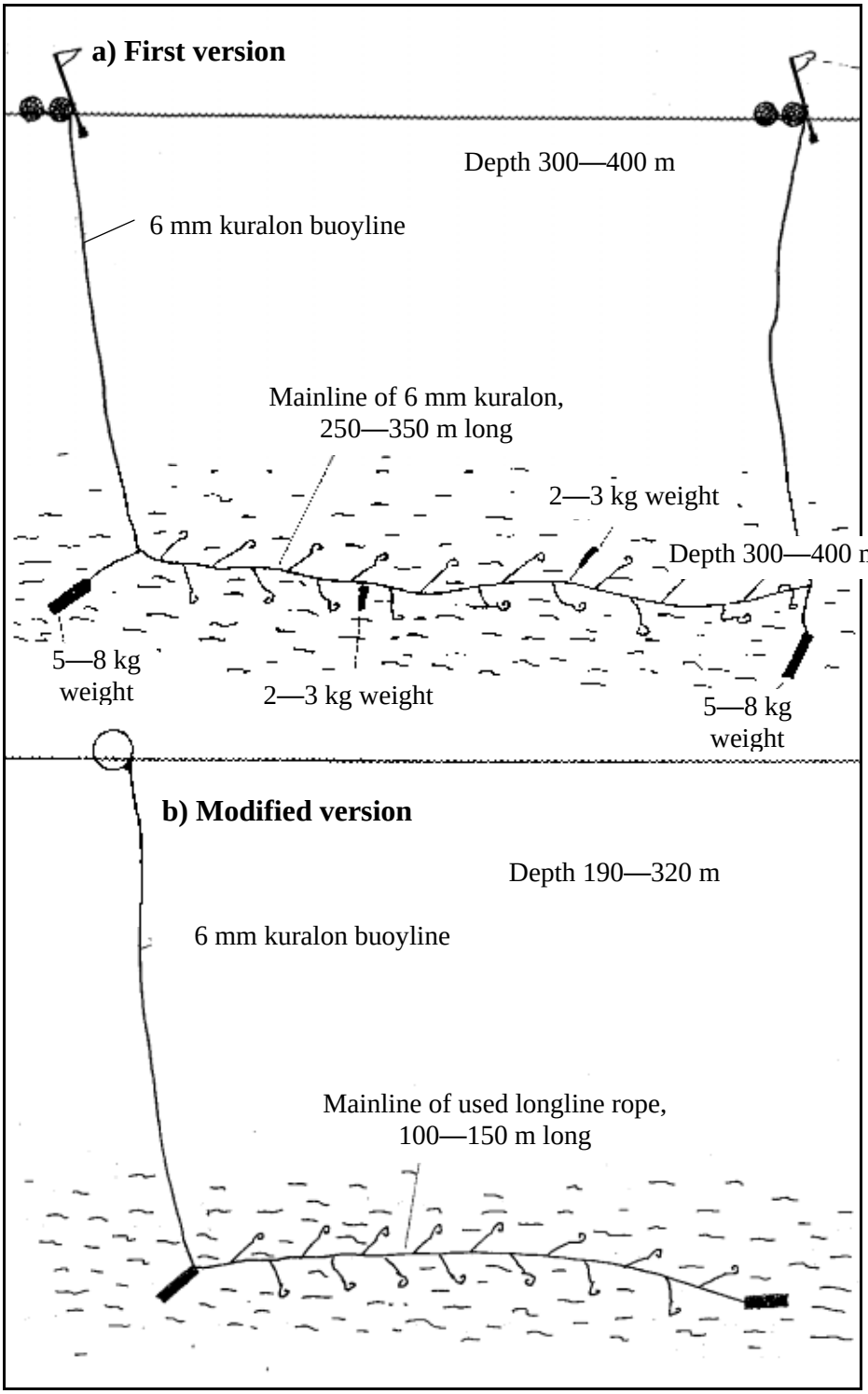


Figure 14: Bottom longline types used during the Project visit.

Of the 119 fish, weighing 281.5 kg, caught on bottom longlines, 59 (118.5 kg) were deep water snappers (family *Lutjanidae*: sub-family *Etelinae*). Other major components of the catch were groupers (family *Serranidae*) and sharks (families *Carcharhinidae, Mustelidae*, *Squalidae*). Further details can be found in Appendix 3.

5.5 Trials of fish traps

Between 23 March and 3 April 1981, three Z-traps of dimensions l m x 1.5 m x 2.5 m were constructed of l" (2.5 cm) mesh galvanised chicken wire over a frame of 1/2" (12 mm) steel reinforcement rod (see Figure 15). All trap frames were cut, bent and welded together, the galvanised mesh being lashed over the frame with 120 kg monofilament line in place of tie wire, which was unavailable.

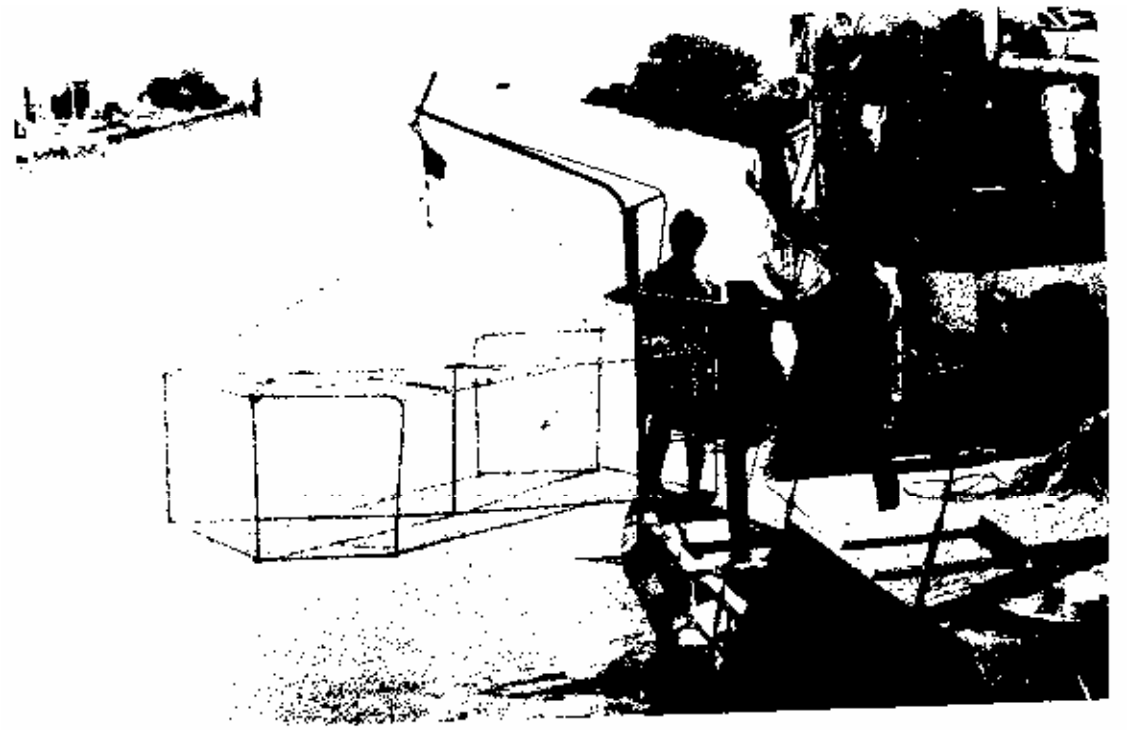


Figure 15: Z-trap used in trapping trials.

Each trap had a conical entrance with an external diameter of 0.6 m. Construction of the traps was time consuming with approximately 128 man-hours being needed to complete the first one. Construction time decreased considerably on the second and third traps through experience and practice and the third trap took only 24 man-hours to complete. Twenty man-hours would be a reasonable time estimate for the construction of one Z-trap by experienced workers.

Cost of materials in construction of one 1 m x 1.5 m x 2.5 m fish trap (Z type) were as follows:

25 metres of 115 cm wide galvanised chicken wire half inch (13 mm) mesh	$T	22.00
40 metres of half-inch (13 mm) dia. reinforcement rod	$T	10.00
Monofilament line	$T	1.00
	$T	33.00

The *Fafakitahi* was fitted with a davit and snatch block prior to trip 16, and three sets of the traps were subsequently made, all setting and hau1ing being done by hand. On the first set, the three traps were dropped in 22, 16 and 12 metres depths, each trap having a surface float attached to it by the hauling rope. The deeper trap was "baited" by the attachment of a chemical light stick, the middle trap by placing pieces of fish inside, and the shallowest left unbaited. The traps were soaked overnight for 13 hours and on hauling had caught no fish, despite the fact that two hours' handlining nearby produced 16 fish. Hand hauling was extremely strenuous work and required the full effort of all four people on board.

Due to the difficulties in hauling, the traps were reset in shallower water, 6 m deep, in a channel through a small reef patch, and were left to soak, unbaited, for a full week. On hauling, only 8 small reef fish were caught, and the traps were replaced for another week-long soak. Again, only small reef fish were trapped. Details of the species caught can be found in Appendix 3.

Fish traps have been fished on a trial basis in a number of Pacific island countries, and almost without exception, abandoned as unsuitable for use in small-scale fisheries for a variety of reasons, the most commonly stated of which are low productivity, handling problems, theft, and shark attack. The results of the present trials, while limited in scope and duration, were consistent with the above and demonstrated the difficulties of handling such large bulky traps from small fishing boats, and in particular the problem of hauling such traps from any depth without mechanical assistance.

5.6 Species composition of the catch

Deep water snappers (family *Lutjanidae*: sub-family *Etelinae*) were the target group of species for much of the fishing carried out during this Project visit, and made up 27 per cent of the catch weight. Shallow water snappers (family *Lutjanidae*: sub-family *Lutjaninae*) and emperors (family *Lethrinidae*) also comprised a substantial portion of the catch (together 29.3% by weight) due to the amount of fishing carried out in shallower waters. Groupers (family *Serranidae*) were caught at all depths and made up 13.2 per cent of the catch weight. Sharks were numerous (7.7% by number) but had a relatively low average weight (3.1 kg) and thus constituted only 12.8 per cent of the total catch weight. This is in contrast to results obtained by the Project in many other countries where sharks, despite being caught in small numbers, have often made up a high proportion of the catch weight because of their generally large size. Oilfish and snake mackerels (family *Gempylidae*) are also often a major component of the catch, but in this visit comprised only 0.9 per cent of the catch weight.

Full details of the catch composition are shown in Appendix 3.

6. CONCLUSIONS AND RECOMMENDATIONS

The main aim of the Master Fisherman's visit was to provide an evaluation of the vessels being produced by the Tonga-based FAO/UNDP boatbuilding project. The main conclusion from this evaluation is that the FAO/UNDP boatbuilding project catamaran and monohull designs show potential as commercial artisanal fishing vessels, but considerably more thought needs to go into a number of specific design aspects, as described, and far more stringent quality control needs to be enforced.

The main recommendations relating to the boatbuilding project which arose from those assessments were discussed with the Principal Fisheries Officer and the UNDP Boatbuilder prior to the Master Fisherman's departure, and many have now been implemented. These recommendations are:

(1) That further development of the design of the trimaran *Malolo* be suspended or assigned very low priority;

(2) That the modifications suggested in Section 4.4 be incorporated into the *Fafakitahi* catamaran design, following which further carefully monitored fishing trials be carried out prior to producing more of these boats;

(3) That the *Tui Punga* catamaran design (Section 4.5) be modified to incorporate larger engines and a more efficient sailplan, and also undergo further evaluation;

(4) That development of the motor-sailing monohull design (Section 4.6) be given the highest priority by the FAO/UNDP project. Of the four designs, this appears most appropriate to the needs of Tonga's small fishermen;

(5) That considerably more stringent practices be adopted in the selection of materials for these vessels, and in supervising their construction;

(6) That the FAO master boat builder participate in fishing trials of the vessels so as to experience first hand the requirements of a good fishing boat;

(7) That all vessels produced by the Project be given a trial of at least two days in unsheltered waters under actual fishing conditions before being turned over to their purchasers;

(8) That basic safety equipment be provided with the vessels;

(9) That a scheme be implemented to enable and encourage the conversion of whaleboats and other vessels currently lying idle to take up commercial fishing. This should include the provision of fishing gear and auxiliary equipment.

The secondary aim of the Project visit was to conduct trials of alternative fishing gears, and this work is detailed in Sections 5.4 and 5.5. From the results of trial bottom longlining and trap fishing it is concluded that the former technique has potential for further development while the latter shows very little promise.

Standard deep bottom fishing produced a catch rate which is low compared to the rates achieved previously in Tonga and neighbouring countries. However, this is partly attributable to difficult fishing conditions and could doubtless be improved upon by an experienced fishing crew operating regularly from a well laid-out vessel. For deep bottom droplining, wooden handreels gave higher catch rates than ordinary handlines.

Additional recommendations relating to fishing gear development are as follows:

(10) That further gear development work carried out by the Fisheries Division should concentrate on improving bottom longlining techniques as an alternative or supplement to deep bottom line fishing;

(11) That local fishermen be encouraged to use wooden handreels, rather than handlines, for deep bottom fishing.

7. ACKNOWLEDGEMENTS

The South Pacific Commission gratefully acknowledges the support and friendly assistance of the staff of the Fisheries Division during the Deep Sea Fisheries Development Project's stay in Tonga. Deserving of special mention are Peace Corps Volunteer Extension Officer Jack Martin who worked closely with the Master Fisherman, and vessel skipper Mr Luhama Fuapau. Principal Fisheries Officer Mr Cliff Ratcliffe and Fisheries Biologist Mr Tony Hopson also provided invaluable administrative and logistic support.

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APPENDIX la: Summary of operational aspects of fishing trips

Trip number	Date	Vessel	Number of crew (Note 1)	Trip duration (hours)	Hours spent travel-ling (Note 2)	Fuel type and amount used (litres)	Hours spent fishing (Note 3)	Catch (kg)	Catch/ hour spent fishing (kg) (Note 4)	Catch/ man-hour spent fishing (kg)	Bait used (kg)
1	29-31/10/80	Malolo	3	44	15	Petrol, 32	14.0	41.2	2.9	1.0	4
2	07-08/11/80	Malolo	3	25	7	Petrol, 14	11.0	33.6	3.1	1.0	5
3	10-11/11/80	Malolo	2	21	7	Petrol, 14	7.0	30.2	4.3	2.1	3
4	13-14/11/80	Whaleboat	3	23	5	0 (sail)	8.0	21.0	2.6	0.9	2
5	19-21/11/80	Whaleboat	4	43	32	0 (sail)	25.0	179.0	7.2	1.8	5
6	01-02/12/80	Malolo	4	22	6	Petro1, 9	15.0	77.7	5.2	1.3	4
7	17-20/12/80	Fafakitahi	4	62	42	Petrol, 55	9.0	86.0	9.6	2.4	5
8	29-31/01/81	Fafakitahi	5	47	23	Petro1, 5	16.0	19.0	1.2	0.2	1
9	10-12/02/81	Fafakitahi	3	58	33	Petro1, 18	12.0	82.5	6.9	2.3	10
10	18-19/02/81	Fafakitahi	3	29	13	Petrol, 1	10.0	42.5	4.3	1.4	5
11	25/02/81	Fafakitahi	7	9	6	Petrol, 32	4.3	46.0	10.7	1.5	6
12	26/02/81	Fafakitahi	7	7	4	Petro1, 32	4.3	40.0	9.3	1.3	7
13	03-04/03/81	Fafakitahi	4	24	7	Petrol, 32	10.4	94.0	9.0	2.3	7
14	05-06/03/81	Tui Punga	5	27	22	Diesel, 27	5.0	57.0	11.4	2.3	5
15	10-17/03/81	Tui Punga	5	161	96	Diesel, 165	40.6	216.0	5.3	1.1	15
16	08-10/04/81	Fafakitahi	4	48	11	Petro1, 50	18.2	122.0	6.7	1.7	12
17	15-16/04/81	Fafakitahi	5	24	9	Petro1, 36	9.0(+167)	130.0	14.4	2.9	14
18	22-23/04/81	Fafakitahi	4	20	7	Petrol, 36	4.0(+170)	26.5	6.6	1.7	2
19	24-25/04/81	Fafakitahi	3	21	7	Petrol, 36	3.0	22.0	7.3	2.4	1
Total			-	715	352	-	225.8(+337)	1366.2	6.1	1.5	113

Notes: (1) Number of crew includes the Master Fisherman and all persons on board, including observers.

(2) Hours spent travelling including both sai1ing and motoring time. These are not separable as on many occasions both were used simultaneously.

(3) Hours spent fishing includes all fishing time, plus time spent trolling while travelling.
Soak time for fish traps (trips 17 and 18) is in parentheses due to the long periods involved.

(4) Excludes soak time for fish traps.

APPENDIX 1b: Catch and effort summary by fishing trip

Trip Number	Fishing method (Note 1)	Fishing hours (Note 2)	Units of gear (Note 3)	Effort (Note 4)	Catch		Catch (kg) per unit effort
					Number	Weight	
1	Handline	13.0	3	39.0	18	41.2	1.1
	Troll	1.0	2	2.0	0	0.0	0.0
	Total	**14.0**	**-**	**-**	**18**	**41.2**	**-**
2	Handline	11.0	2	22.0	25	33.6	1.5
3	Hand1ine	7.0	2	14.0	6	30.2	2.2
4	Handline	7.0	3	21.0	22	21.0	. 1.0
	Troll	1.0	2	2.0	0	0.0	0.0
	Total	**8.0**	**-**	**-**	**22**	**21.0**	**-**
5	Handline	10.0	3	30.0	40	125.6	4.2
	Troll	15.0	1	15.0	5	53.4	3.6
	Total	**25.0**	**-**	**-**	**45**	**179.0**	**-**
6	Hand1ine	15.0	3	45.0	51	77.7	1. 7
7	Handreel	5.0	2	10.0	18	66.0	6.6
	Troll	4.0	1	4.0	1	20.0	5.0
	Total	**9.0**	**-**	**-**	**19**	**86.0**	
8	Handree1	6.0	3	18.0	9	15.0	0.8
	Troll	10.0	3	30.0	1	4.0	0.1
	Total	**16.0**	**-**	**-**	**10**	**19.0**	**-**
9	Handreel	6.0	2	12.0	18	65.5	5.5
	Troll	6.0	2	12.0	2	17.0	1.4
	Total	**12.0**	**-**	**-**	**20**	**82.5**	**-**
10	Handreel	6.0	3	18.0	34	42.5	2.4
	Troll	4.0	3	12.0	0	0.0	0.0
	Total	**10.0**	**-**	**-**	**34**	**42.5**	**-**
11	Handree1	1.0	3	3.0	9	22.0	7.3
	Longline (1)	3.3	150	50.0	5	24.0	0.8
	Total	**4.3**	**-**	**-**	**14**	**46.0**	**-**
12	Handree1	1.0	3	3.0	12	13.0	4.3
	Longline (1)	3.3	150	49.5	12	27.0	0.5
	Total	**4.3**	**-**	**-**	**24**	**40.0**	**-**
13	Handreel	4.0	2	8.0	5	33.0	4.1
	Longline (4)	6.4	40	25.7	16	61.0	2.4
	Total	**10.4**	**-**	**-**	**21**	**94.0**	**-**
14	Handree1	2.0	3	6.0	14	21.0	3.5
	Troll	3.0	3	9.0	3	36.0	4.0
	Total	**5.0**	**-**	**-**	**17**	**57.0**	**-**

APPENDIX 1b: Catch and effort summary by fishing trip (continued)

Trip Number	Fishing method (Note 1)	Fishing hours (Note 2)	Units of gear (Note 3)	Effort (Note 4)	Catch		Catch (kg) per unit effort
					Number	Weight	
15	Handree1	12.0	2-3	34.0	49	69.0	2.0
	Longline (10)	14.6	40-60	85.1	52	107.0	1.3
	Troll	14.0	2	28.0	9	40.0	1.4
	Total	**40.6**	**-**	**-**	**110**	**216.0**	**-**
16	Handree1	1.0	2	2.0	10	23.5	11.8
	Hand1ine	5.0	3	15.0	48	36.01	2.4
	Longline (6)	12.2	45-150	57.2	34	62.5	1.1
	Total	**18.2**	**-**	**-**	**92**	**122.0**	**-**
17	Hand1ine	8.0	4	32.0	145	128.5	4.0
	Trap	1.0(+167)	2	3.3	8	1.5	0.5
	Total	**9.0(+167)**	**-**	**3.3**	**153**	**130.0**	**0.**5
18	Hand1ine	3.0	3	9.0	25	19.5	2.2
	Trap	1.0(+170)	1	1.7	21	7.0	4.1
	Total	**4.0(+170)**	**-**	**-**	**46**	**26.5**	**-**
19	Handline	3.0	2	6.0	14	22.0	3.7
TOTAL	Handree1	44.0	2-3	114. 0	178	370.5	3.3
	Hand1ine	82.0	2-4	233.0	394	535.3	2.3
	Long1ine	39.8	40-150	267.5	119	281.5	1.0
	Troll	58.0	1-3	114 .0	21	170.4	1.5
	Trap	2.0(+337)	1-2	5.0	29	8.5	1.7
GRAND TOTAL		**225.8(+337)**			**741**	**1366.2**	

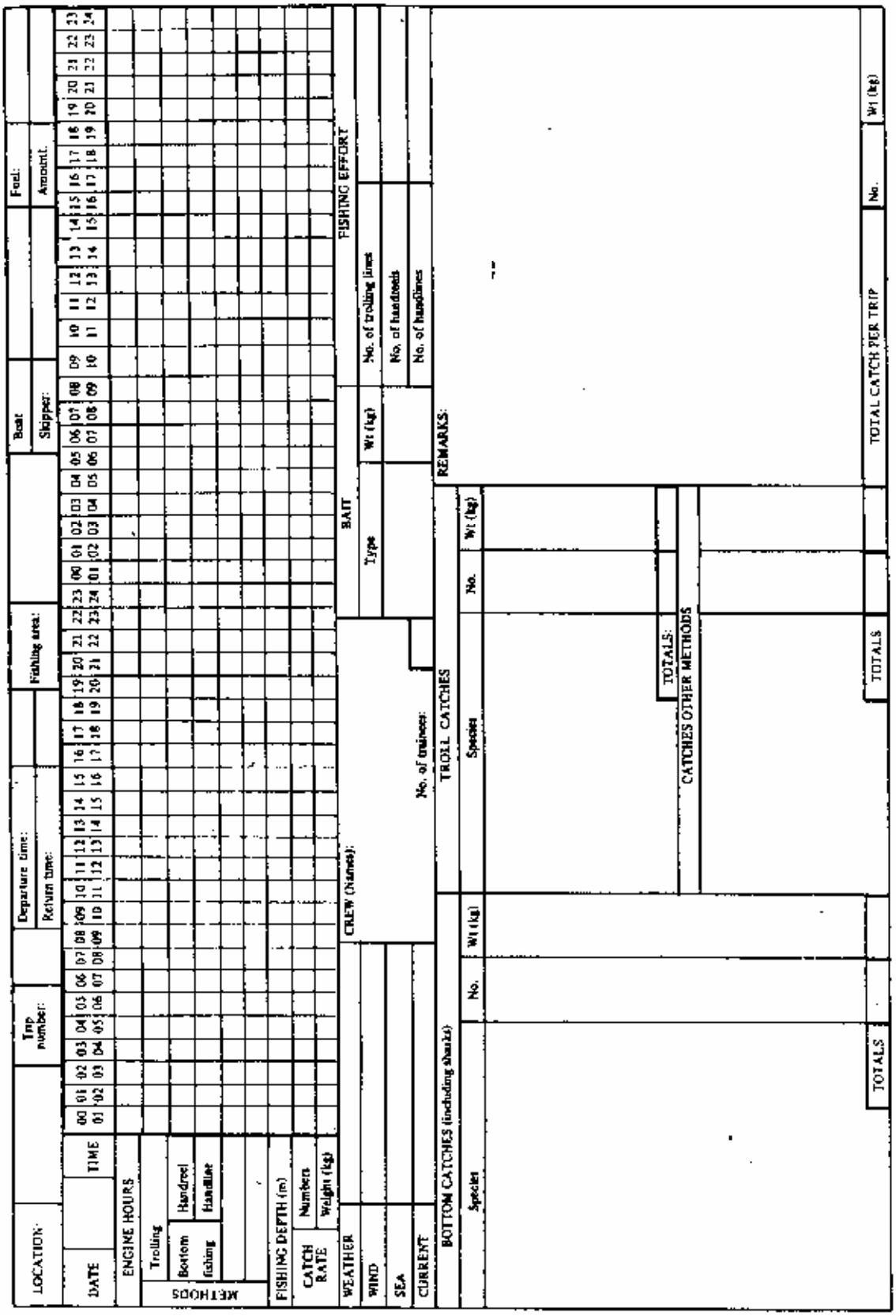
Notes: (1) Fishing method: numbers in parentheses after "longline" indicate number of sets.

(2) Hours spent fishing includes both "active" fishing time spent in handree1 fishing, and the setting and hau1ing of bottom longlines and traps, plus "passive" fishing time (during which the fisherman is not continuously occupied in operating the gear), such as soak-time of long1ines and traps, and trolling while travelling. For traps, soaktime is recorded separately in parentheses due to the long periods involved.

(3) Units of gear: for handree1, handline and troll fishing, refers to number of lines; for bottom long1ine, number of hooks; and for trapping, number of traps.

(4) Effort: units used for handree1, hand1ine and troll fishing are number of lines x number of fishing hours; for bottom longlining, number of hooks/10 x number of hours fished (including setting and hauling times); and for traps, number of traps x number of hours fished/10.

APPENDIX 2: Standard fishing data collection form



APPENDIX 3: Species composition of the catch by fishing method
Classification of *Lutjanidae* and *Lethrinidae* follows Johnson, G.D., 1980.

FAMILY, species, English name, Tongan name (where known)	Handreel Number	Handreel Weight (kg)	Handline Number	Handline Weight (kg)	Bottom longline Number	Bottom longline Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
LUTJANIDAE (sub-family *ETELINAE, APSILINAE*)												
Aphareus rutilans Small-tooth jobfish, palu polosi, paluila, palu hala nifo	-	-	8	37.6	1	2.0	-	-	-	-	9	39.6
Aprion virescens Green jobfish, utu	-	-	21	40.3	-	-	1	2.0	-	-	22	42.3
Etelis carbunculus Short-tailed red snapper, palu malau	1	11.0	5	6.9	5	11.0	-	-	-	-	11	28.9
Etelis coruscans Ribbon-tailed red snapper, palu tavake palu kula	6	25.0	1	6.4	12	41.0	-	-	-	-	19	72.4
Pristipomoides amoenus Large-eye flower snapper	7	3.0	4	1.0	9	4.0	-	-	-	-	20	8.0
Pristipomoides filamentosus Rosy jobfish, palu	7	8.0	8	17.0	2	3.0	-	-	-	-	17	28.0
Pristipomoides flavipinnis Yellow jobfish, palu	24	24.5	18	19.3	17	19.5	-	-	-	-	59	63.3
Pristipomoides multidens Large-scale jobfish, palu	8	20.0	-	-	9	35.0	-	-	-	-	17	55.0
Pristipomoides zonatus Banded flower snapper	3	2.0	-	-	4	3.0	-	-	-	-	7	5.0
LUTJANIDAE (sub-family *APSILINAE*)												
Paracaesio kusakarii Saddled fusilier, palu mutu mutu	14	62.3	1	6.8	-	-	-	-	-	-	15	69.1
Sub-total: Deep-water snappers	**70**	**155.8**	**45**	**95.0**	**59**	**118.5**	**1**	**2.0**	**0**	**0**	**196**	**411.6**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, Eng1ish name / Tongan name (where known)	Handreel Number	Handreel Weight (kg)	Handline Number	Handline Weight (kg)	Bottom longline Number	Bottom longline Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
LUTJANIDAE (sub-family *LUTJANINAE*)												
Lutjanus argentimaculatus Mangrove jack	6	43.8	1	3.5	-	-	-	-	-	-	7	47.3
Lutjanus bohar Red bass, fangamea	-	-	3	12.5	-	-	-	-	-	-	3	12.5
Lutjanus caeruleovittatus	1	1.0	3	1.1	-	-	-	-	-	-	4	2.1
Lutjanus fulvus	-	-	2	1.0	-	-	-	-	-	-	2	1.1
Lutjanus gibbus Paddletail, koanga kula	-	-	5	3.5	-	-	-	-	-	-	5	3.5
Lutjanus kasmira Blue-lined snapper, fate	15	6.0	46	11.7	-	-	-	-	-	-	61	17.7
Lutjanus monostigma One-spot snapper	-	-	1	2.0	-	-	-	-	-	-	1	2.0
Lutjanus rufolineatus Rufous seaperch, fate	2	1.0	6	2.4	-	-	-	-	-	-	8	3.4
Lutjanus russelli Moses seaperch	3	1.5	19	6.1	-	-	-	-	2	0.5	24	8.1
Macolor niger Black-and-white seaperch	-	-	2	4.5	-	-	-	-	-	-	2	4.5
Sub-tota1: Other snappers	**27**	**53.3**	**88**	**48.4**	**0**	**0**	**0**	**0**	**2**	**0.5**	**117**	**102.2**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handree1 Number	Handree1 Weight (kg)	Handline Number	Handline Weight (kg)	Bottom longline Number	Bottom longline Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
LETHRINIDAE												
Gymnocranius griseus Sea bream, mu	-	-	3	3.5	-	-	-	-	-	-	3	3.5
Gymnocranius japonicus Pearl-eyed sea bream, mu	1	2.0	10	9.5	-	-	-	-	-	-	11	11.5
Gymnocranius lethrinoides Sea bream, mu	2	4.0	16	20.0	2	3.0	-	-	-	-	20	27.0
Gymnocranius robinsoni Sea bream, mu	-	-	6	6.9	-	-	-	-	-	-	6	6.9
Lethrinus chrysostomus Sweetlips emperor, manga	12	30.0	20	38.8	3	7.0	-	-	-	-	35	75.8
Lethrinus mahsena Yellow-tailed emperor	-	-	11	12.3	-	-	-	-	-	-	11	12.3
Lethrinus miniatus Long-nosed emperor, ngutu kao	-	-	3	14.0	-	-	-	-	-	-	3	14.0
Lethrinus nebulosus Spangled emperor	-	-	4	6.5	-	-	-	-	-	-	4	6.5
Lethrinus reticulatus Reticulated emperor	-	-	3	0.7	-	-	-	-	-	-	3	0.7
Lethrinus variegatus Variegated emperor, ngu ngu toa, manga	14	12.0	81	48.3	-	-	-	-	-	-	95	60.3
Lethrinus spp. unident Emperor	1	1.0	-	-	-	-	-	-	-	-	1	1.0
Sub-total: Emperors	**30**	**49.0**	**157**	**160.5**	**5**	**10.0**	**0**	**0**	**0**	**0**	**192**	**219.5**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handreel Number	Handreel Weight (kg)	Handline Number	Handline Weight (kg)	Bottom longline Number	Bottom longline Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
SERRANIDAE												
Cephalopholis aurantias Orange rock-cod	1	2.0	-	-	-	-	-	-	-	-	1	2.0
Cephalopholis sexmaculatus Rock cod	-	-	1	1.1	-	-	-	-	-	-	1	1.1
Cephalopholis urodelus Flag-tail rock cod	1	0.2	1	0.3	-	-	-	-	-	-	2	0.5
Epinephelus areolatus Yellow spotted grouper, ngatala	8	5.0	-	-	3	2.5	-	-	-	-	11	7.5
Epinephelus corralicola Coral rock cod	-	-	6	5.0	-	-	-	-	-	-	6	5.0
Epinephelus fasciatus Black-tipped grouper	5	1.3	6	2.2	-	-	-	-	-	-	11	3.5
Epinephelus hoedti Purple rock cod, ngatala	1	3.0	2	12.9	-	-	-	-	-	-	3	15.9
Epinephelus maculatus Trout cod	1	3.0	5	19.7	-	-	-	-	-	-	6	22.7
Epinephelus merra Wire netting cod	-	-	3	0.7	-	-	-	-	-	-	3	0.7
Epinephelus morrhua Curve-banded grouper, ngatala popo	6	13.8	-	-	8	18.5	-	-	-	-	14	32.3
Epinephelus septemfasciatus Seven-banded grouper	1	21.0	1	8.5	6	45.0	-	-	-	-	8	74.5
Epinephelus truncatus Orange rock cod	2	3.7	1	1.0	-	-	-	-	-	-	3	4.7
Saloptia powelli Grouper	1	1.0	-	-	-	-	-	-	-	-	1	1.0
Variola louti Lunar-tailed cod, ngatala kula	1	1.0	7	8.5	-	-	-	-	-	-	8	9.5
Sub-total: Groupers, cods	**28**	**55.0**	**33**	**59.9**	**17**	**66.0**	**0**	**0**	**0**	**0**	**78**	**180.9**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handree1 Number	Handree1 Weight (kg)	Hand1ine Number	Hand1ine Weight (kg)	Bottom long1ine Number	Bottom long1ine Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
CARANGIDAE												
Carangoides fulvoguttatus Gold-spotted trevally	-	-	l	5.0	-	-	-	-	-	-	l	5.0
Caranx sexfasciatus Bigeye trevally	1	5.0	-	-	-	-	-	-	-	-	1	5.0
Megalaspis cordyla Finny scad	-	-	-	-	-	-	1	1.0	-	-	1	1.0
Seriola rivoliana Deep-water amberjack, valu moana	2	11.1	-	-	2	20.0	-	-	-	-	4	31.1
Uraspis helvo1i Banded jack, lupo	-	-	2	2.9	-	-	-	-	-	-	2	2.9
Sub-tota1: Trevallies, jacks	**3**	**16.1**	**3**	**7.9**	**2**	**20.0**	**1**	**1.0**	**-**	**-**	**9**	**45.0**
SCOMBRIDAE												
Acanthocybiun solandri Wahoo, valu louniu	-	-	-	-	-	-	1	22.4	-	-	1	22.4
Euthynnus affinis Mackerel tuna	-	-	-	-	-	-	2	3.0	-	-	2	3.0
Grammatorcynus bicarinatus Double-lined mackerel	-	-	-	-	-	-	1	1.0	-	-	1	1.0
Gymnosarda unicolor Dog-tooth tuna, valu tonga, valu puku	-	-	-	-	-	-	5	52.0	-	-	5	52.0
Katsuwonus pelamis Skipjack tuna, 'atu	-	-	-	-	-	-	1	4.0	-	-	1	4.0
Thunnus albacares Yellowfin tuna, takuo, kahikahi	-	-	-	-	-	-	3	21.7	-	-	3	21.7
CORYPHAENIDAE												
Coryphaena hippurus Dolphin fish, mahimahi	-	-	-	-	-	-	5	60.2	-	-	5	60.2
Sub-total: Mackerels and tunas	**0**	**0**	**0**	**0**	**0**	**0**	**18**	**164.3**	**0**	**0**	**18**	**164.3**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name, Tongan name (where known)	Handreel Number	Handreel Weight (kg)	Handline Number	Handline Weight (kg)	Bottom longline Number	Bottom longline Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
SPHYRAENIDAE												
Sphyraena barracuda Great barracuda, hapatu	-	-	-	-	-	-	1	3.1	-	-	1	3.1
Sphyraena flavicauda Short-jawed seapike	-	-	1	0.5	-	-	-	-	-	-	1	0.5
Sphyraena forsteri Forsters seapike, hapatu	-	-	4	6.5	-	-	-	-	-	-	4	6.5
Sphyraena jello Slender seapike	3	4.0	-	-	-	-	-	-	-	-	3	4.0
Sphyraena qenie Dark-finned seapike	-	-	4	7.1	-	-	-	-	-	-	4	7.1
Sub-total: Barracudas, seapikes	**3**	**4.0**	**9**	**14.1**	**0**	**0**	**1**	**3.1**	**0**	**0**	**13**	**21.2**
GEMPYLIDAE												
Promethichthys prometheus Snake mackerel	6	4.8	1	0.3	-	-	-	-	-	-	7	5.1
Ruvettus pretiosus Oilfish, valu maka	-	-	1	6.8	-	-	-	-	-	-	1	6.8
Sub-total: Snake mackerels	**6**	**4.8**	**2**	**7.1**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**11.9**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handree1 Number	Handree1 Weight (kg)	Hand1ine Number	Hand1ine Weight (kg)	Bottom long1ine Number	Bottom long1ine Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
MURAENIDAE (Morayeels)												
Gymnothorax goldsboroughi Moray eel	-	-	-	-	2	2.0	-	-	-	-	2	2.0
Gymnothorax leucostigma Moray eel	-	-	-	-	2	1.0	-	-	-	-	2	1.0
Gymnothorax richardsoni Richardson's moray eel	1	1.0	-	-	-	-	-	-	-	-	1	1.0
Gymnothorax sp. unident Moray eel	-	-	1	1.5	-	-	-	-	-	-	1	1.5
MURAENESOCIDAE (Pike eels)												
Muraenesox cinereus Arabian pike-eel	-	-	1	5.5	-	-	-	-	-	-	1	5.5
HAEMULIDAE (Sweetlips)												
Plectorhyncus picus Painted sweetlips	-	-	1	2.8	-	-	-	-	-	-	1	2.8
TETRAODONTODAE (Puffer fishes)												
Pleuranacanthus sceleratus Giant toadfish	-	-	1	3.0	-	-	-	-	-	-	1	3.0
ECHENEIDAE (Remoras)												
Remora remora Remora	-	-	2	2.0	-	-	-	-	-	-	2	2.0

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handree1		Hand1ine		Bottom long1ine		Troll		Trap		Total	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
HOLOCENTRIDAE (Squirrel fishes)												
Adioryx spinifer Armoured squirrel fish	-	-	6	1.7	-	-	-	-	-	-	6	1.7
Myripristis amanaeus Big-eye soldier fish	-	-	3	0.5	-	-	-	-	-	-	3	0.5
Osteichthys japonicus Squirrel fish	-	-	-	-	2	2.0	-	-	-	-	2	2.0
MULLIDAE (Goatfishes)												
Mul1oidichthys pflugeri Orange goat fish	-	-	1	1.0	-	-	-	-	-	-	1	1.0
Parupeneus chryserydris Bright-saddled goat fish	-	-	1	0.5	-	-	-	-	-	-	1	0.5
BALISTIDAE (Trigger fishes)												
Sufflamen frenatus Trigger fish	1	1.5	1	0.5	-	-	-	-	-	-	2	2.0
CHAETODONTIDAE (Butterfly fishes)												
Chaetodon auriga Threadfin butterfly fish	-	-	-	-	-	-	-	-	7	1.1	7	1.1
Chaetodon citronella Speckled butterfly fish	-	-	-	-	-	-	-	-	1	0.1	1	0.1

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handree1 Number	 Weight (kg)	Handline Number	 Weight (kg)	Bottom longline Number	 Weight (kg)	Troll Number	 Weight (kg)	Trap Number	 Weight (kg)	Total Number	 Weight (kg)
ACANTHURIDAE (Surgeon fishes)												
Acanthurus nigrofuscus Spot-cheeked surgeon fish	-	-	-	-	-	-	-	-	3	0.3	3	0.3
Acanthurus olivaceus Orange-epaulette surgeon fish	-	-	-	-	-	-	-	-	1	0.2	1	0.2
Zebrasoma scopas Blue-lined brown tang	-	-	-	-	-	-	-	-	3	0.3	3	0.3
SCARIDAE (Parrot fishes)												
Scarus frenatus Fall parrot fish	-	-	-	-	-	-	-	-	1	1.0	1	1.0
Scarus venosus Banded parrot fish	-	-	-	-	-	-	-	-	11	5.0	11	5.0
Sub-total: Miscellaneous bony fishes	**2**	**2.5**	**18**	**19.0**	**6**	**5.0**	**0**	**0**	**27**	**8.0**	**53**	**34.5**

APPENDIX 3: Species composition of the catch by fishing method (continued)

FAMILY, species, English name Tongan name (where known)	Handree1 Number	Handree1 Weight (kg)	Hand1ine Number	Hand1ine Weight (kg)	Bottom long1ine Number	Bottom long1ine Weight (kg)	Troll Number	Troll Weight (kg)	Trap Number	Trap Weight (kg)	Total Number	Total Weight (kg)
CARCHARHINIDAE (Whaler sharks)												
Carharhinus albimarginatus Silvertip shark, anga	-	-	3	24.0	1	2.0	-	-	-	-	4	26.0
Carharhinus melanopterus Blacktip reef shark	-	-	3	5.0	-	-	-	-	-	-	3	5.0
Triaenodon obesus Whitetip reef shark	6	24.0	4	21.0	21	42.0	-	-	-	-	31	87.0
HEXANCHIDAE (Six-gill sharks)												
Hexanchus griseus Bluntnose six-gill shark	-	-	2	17.7	-	-	-	-	-	-	2	17.7
MUSTELIDAE (Smooth hounds)												
Mustelus griseus Spotless smooth hound	-	-	3	5.6	4	9.0	-	-	-	-	7	14.6
Mustelus manuzo Smooth hound	-	-	3	9.9	-	-	-	-	-	-	3	9.9
SQUALIDE (Spiny dog fish)												
Squalus sp. unident Spurdog	3	6.0	-	-	4	9.0	-	-	-	-	7	15.0
Sub-total: Sharks	**9**	**30.0**	**18**	**83.2**	**30**	**62.0**	**0**	**0**	**0**	**0**	**57**	**175.2**
TOTAL	**178**	**370.5**	**394**	**535.4**	**119**	**281.5**	**21**	**170.4**	**29**	**8.5**	**741**	**1366.2**

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