DEEP SEA FISHERIES DEVELOPMENT PROJECT

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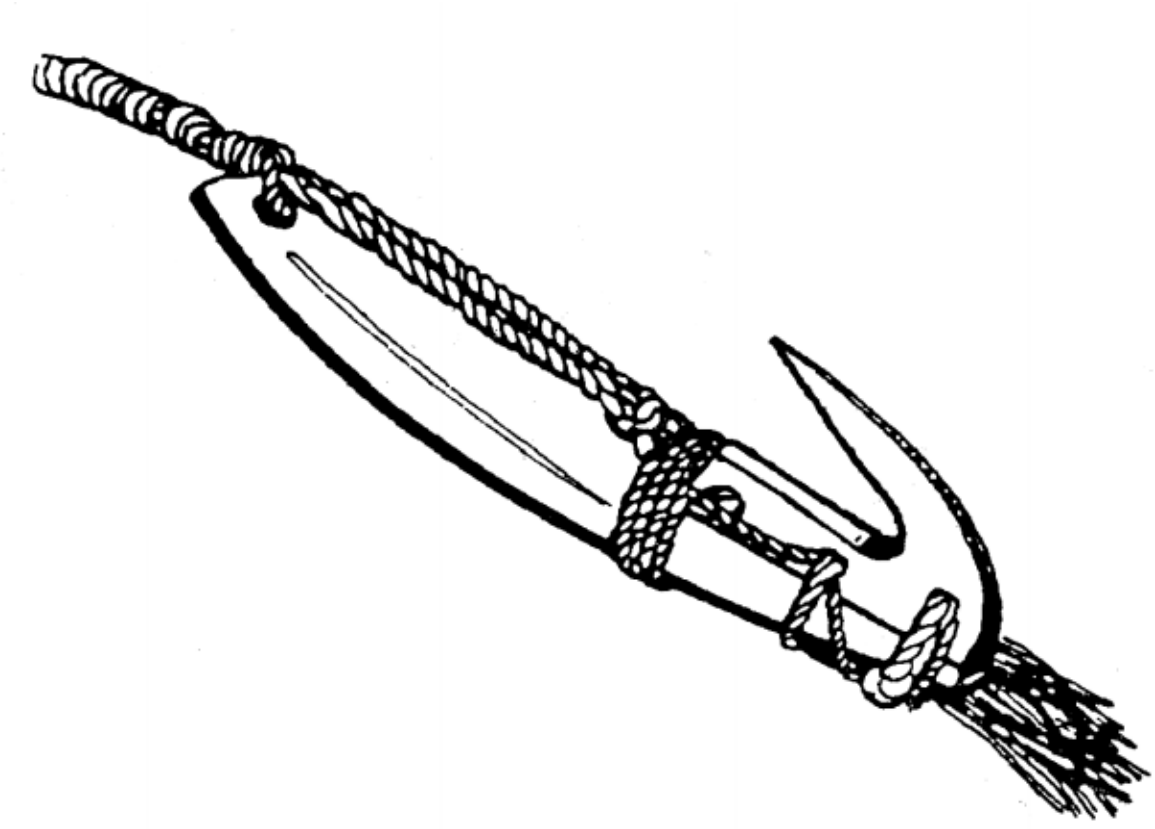

REPORT ON SECOND VISIT TO TOKEALU

13 August — 22 December 1986

South Pacific Commission
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SOUTH PACIFIC COMMISSION

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by

P. Taumaia

Masterfisherman

and

P. Cusack

Fisheries Development Officer

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SUMMARY

The South Pacific Commission's Deep Sea Fisheries Development Project operated provided field-based technical fisheries assistance to Tokelau for the second time between 13 August and 22 December 1986, under the supervision of SPC Masterfisherman Pale Taumaia.

The primary aim of the visit was to conduct fishing trials and demonslrations with small-scale vertical longlining gear under development by the Project which has proven effective elsewhere in capturing deep-swimming tunas associated with fish aggregation devices (FADs). Fishing was to centre on two FADs in the Territory, one of which had been in place off Nukunono atoll for 18 months and the other newly deployed off Atafu.

Secondary fishing activities included further training of local fishermen in deep-bottom fishing using wooden handreels, as well as trolling and a variety of baitfishing activities.

The ten-hook vertical longline in use, most often baited with mackerel scad *(Decapterus* spp.), was set off Nukunono for a total of 49 hours over 9 fishing trips and produced a catch of 11 fish with a combined weight of 218.3 kg, all of which was saleable. Six of the fish taken were yellowfin tuna *(Thunnus albacares), the* target species, which averaged around 22 kg in weight. Illness in the Masterfisherman's family required his return to Western Samoa during the period of the scheduled project operations at Atafu. Only a few demonstration sets of the vertical longlining gear were therefore made there under the supervision of Tokelau counterpart officer Mr Solomona Aleta. Although the catch rate (CPUE) recorded during the limited fishing trials completed was only moderate at 4.1 kg/took-hour, it is considered that the technique could be adopted to good effect by Tokelauan fishermen and may well prove to be more productive than traditional mid-water fishing techniques, especially as the gear may be left unattended and other fishing activities conducted concurrently.

Trolling was particularly productive during this visit, numerous schools of skipjack tuna *(Katsuwonus pelamis)* being common in the area at the time. Trolling was conducted both to capture bait supplies in support of deep-bottom fishing and to land catches for community consumption. The wooden handreels, handlines, and traditional tuna poles rigged with pearlshell lures were employed for a total of 67 hours of fishing effort which produced a catch of 240 fish weighing 630.0 kg in all. The CPUE figure recorded for trolling with handreels and handlines was 8.8 kg/reel- on line-hour, and for pole-trolling 15.5 kg/pole-hour.

Deep-bottom droplining was also conducted, using both handreels and handlines, for a total of 119 hours of fishing effort. The catch of 171 fish with a combined weight of 315.0 kg resulted in a CPUE figure of 2.6 kg/reel- or line-hour. If sharks (which are not eaten in Tokelau) are excluded from calculations, the CPUE falls to 1.9 kg/reel- or line-hour. These catch rates correspond closely to the low productivity recorded by this fishing technique during the previous Project visit to Tokelau in 1982.

Fourteen fishing trips were completed over the course of the visit, each of which involved an average of 8 hours directly engaged in one or more fishing methods. The catch by all methods totalled 500 fish with a combined weight of 1,171.3 kg.

It was concluded that, in spite of adequately abundant near-shore and oceanic fish resources and seasonal abundance of particular species, Tokelau's remoteness, social organisation and meagre material resources would probably restrict fishing activities to subsistence level ih the foreseeable future.

It was recommended, therefore, that future development in local fisheries should be directed toward increasing the efficiency of local fisheries efforts in order to maximise productivity for fuel and labour expended. Improved gear, such as the vertical longline demonstrated during this visit, an ongoing FAD programme, and improved, simple catch preservation techniques were seen as some means of achieving this aim.

ACKNOWLEDGEMENTS

The South Pacific Commission acknowledges with gratitude the friendly co-operation and assistance afforded the Deep Sea Fisheries Development Project during its stay in Tokelau. Deserving of special thanks are the official Secretary for Tokelanan Affairs Mr Adrian Massey, Director of Agriculture and Fisheries Mr Foua Toloa, and counterpart fisheries officer Mr Solomona Aleta. In addition, thanks are offered to the **taupulega** and **pulenuku** of Nukunono and Atafu, as well as the communities of the two atolls, whose support played a large part in the Project's success.

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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, 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 them 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.

A previous DSFDP visit to Tokelau in 1982 was concerned with conducting preliminary surveys of the deep-bottom fish resources of the outer reef-slopes at each of the three atolls in the group, and the demonstration of deep-bottom fishing techniques and gear developed by the Project during previous operations in 16 other Pacific countries or territories.

The report of the visit (Taumaia & Preston, 1985) concluded that the relatively poor catch rates recorded (averaging 2.1 kg/reel-hour, excluding sharks) and the limited extent of suitable deep-bottom fishing grounds noted would probably prove inadequate to support substantial development of this fishery.

he report noted too that 'lack of infrastructure, poor communications, and the social organisation of the islands, will constrain any commercial development, [but that there is] merit in encouraging local fishermen to exploit this resource and development activities aimed at improving the effectiveness, ease, and safety of subsistence fishing activities an the islands'.

The 1986 visit described in this report followed a request to the SPC by the Tokelau Administration for the services of a Masterfisherman to conduct fishing trials and demonstrations of vertical longlining, employing gear and techniques developed by the DSFDP which target deep-swimming tunas associated with fish aggregation devices (FADs), and to evaluate the effectiveness of this fishing technique in comparison to traditional Tokelauan mid-water tuna fishing methods. A secondary objective of the visit was to conduct further training in deep-bottom fishing.

In response to this request SPC Masterfisherman Pale Taumaia, who had supervised the earlier DSFDP visit to Tokelau, was assigned to work at the atolls of Nukunono and Atafu between August and December 1986. This assignment was the 47th country visit made by the DSFDP.

2. BACKGROUND

2.1 General

Tokelau is a remote group of three atolls with a combined land area of little more than 12 sq km. Nukunono is 4.7 sq km, Fakaofo 4 sq km, and Atafu 3.5 sq km (see Figure 1). Although the islands are well out of sight of each other, they may all be enclosed by a circle with a radius of less than 90 km, having its centre approximately 500 km north of Western Samoa.

The three coral atolls comprise a cluster of more than 100 islets, or **motus**, which vary in length up to 6 km and in width from a few metres to 200 m. Maximum elevation is between 3 and 5 m. The reefs extend only a short distance from the shore and then descend into very deep waters. There is no access for large vessels into the lagoons. The atolls have sandy, rubbly, coral soils particularly suited to coconut palms. Soils in moist hollows

are augmented with organic material to support subsistence gardening. Cultivated plants include banana, papaya, a coarse variety of taro, and breadfruit.

The climate of the group is warm and humid, with temperatures averaging 20° annually and rarely exceeding 28° Rainfall is heavy but irregular. Occasional short droughts can occur, as can wet periods when daily average rainfall averages 80 mm or more. December to February is the wettest period. Winds are characteristically light and typically from the South-east quarter. However around October mild to strong north-east winds sometimes occur, which can develop into severe storms or cyclones which have in recent history caused considerable damage and some loss of life (Seluka, 1982).

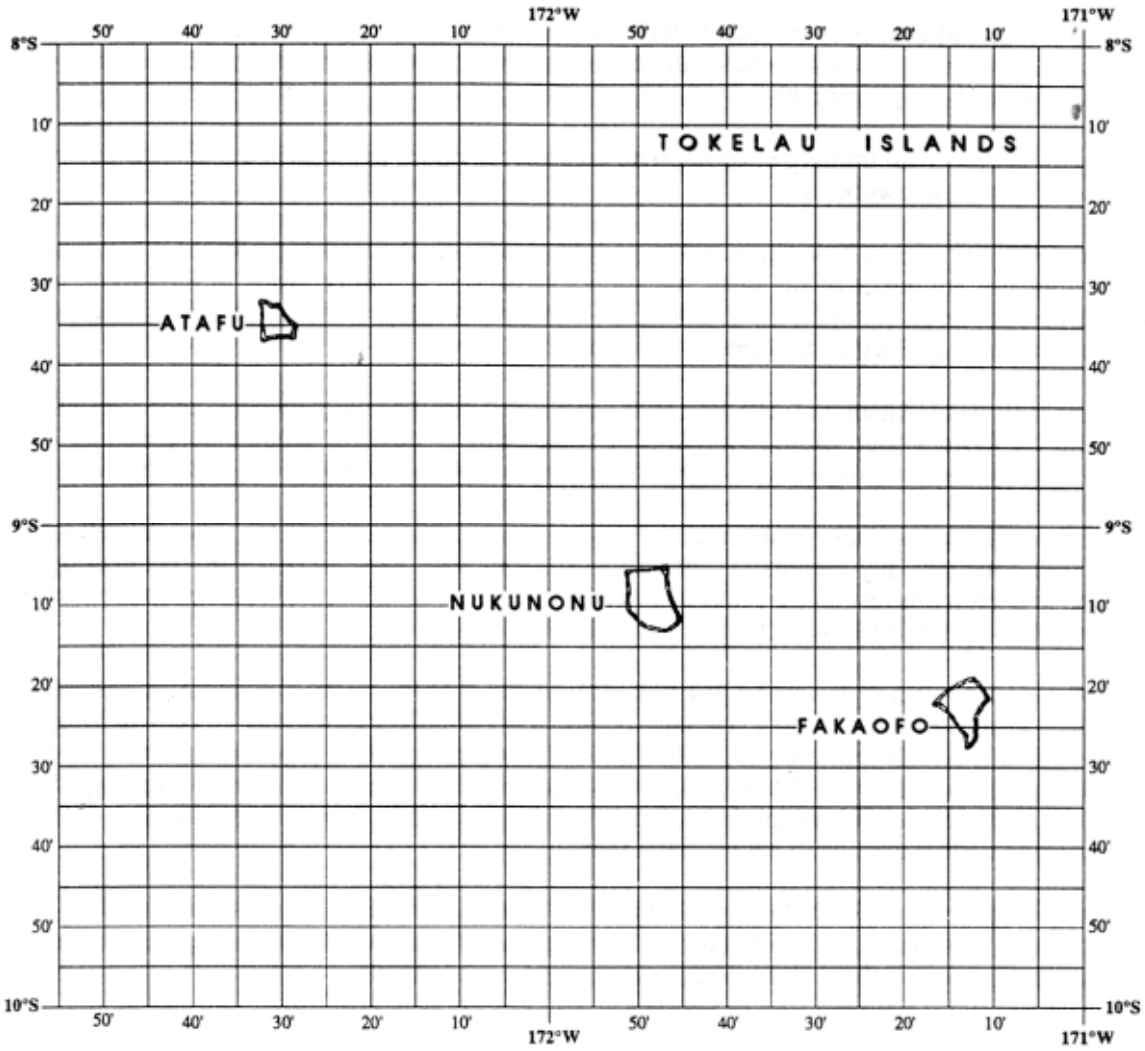

Figure 1: The Tokelau Islands

The people of Tokelau are Polynesian and probably originated from Samoa (Hooper & Huntsman, 1973). To some extent the people retain cultural ties with Samoa, but the culture is distinctly influenced by the atoll environment which has its closest parallel in Tuvalu, with which there are also linguistic, kinship, and cultural affinities. A 1986 census recorded a total population of 1,690:603 on Atafu, 421 on Nukunono, and 661 on Fakaofo (Anon:, 1986). This figure represents an increase of 7.5 per cent over the 1981 census figure and indicates a stabilising of the population level after a general decline throughout the 1960S and 1970s. Emigration from the atolls was facilitated by a New Zealand Government resettlement programme initiated in 1963, after Western Samoa became independent and thereby effectively ceased to provide an outlet for Tokelans over-population, or a source of economic opportunity. This programme ceased in 1976, by which time there were some 1,600 Tokelauans living in New Zealand (Peat & Conly, 1984).

The administration of Tokelau, formerly part of the British Crown Colony of the Gilbert and Ellice Islands, was assumed by New Zealand in 1925, and in 1948 the islands became a New Zealand Territory. Tokelauans are New Zealand citizens but by residency regulations are not entitled to social welfare benefits which apply in the New Zealand mainland. Because of the small size and remoteness of the atolls, and the consequent difficulties of internal and international communications, the group's administrative centre, the Office for Tokelau Affairs, is located at Apia in Western Samoa. The appointed Administrator of Tokelau is based in Wellington, but in practice his powers are invested in the Official Secretary, who resides in Apia.

The channel for formal contact between the Administration and the Tokelau community is by way of **faipule** who represent the crown and the Administrator, and **pulenuku** who represent the island councils (**taupulega**) of elders and family heads, at each of the three atolls. Appointment to the administrative posts is by popular vote, the term of tenure being three years. The **taupulega** control village affairs, allocate community work and resources, and communicate with the Administration through the **faipule** and the **pulenuku**.

True economic activity in Tokelau is very limited. Exports are restricted to small amounts of copra and handicraft items, and income is largely derived from salaries paid by the Administration and remittances from Tokelauans working overseas. The practice of sharing food and material resources, known as **inati**, means that the cash economy of the group has remained of secondary importance to the traditional principle of redistribution to ensure equal shares for all. The average per capita share of the group's food import bill was less than A$ 100 in 1983 (Anon., 1984), demonstrating that the bulk of food consumed is still produced or grown locally.

At the time of this visit the atolls were supplied by the cargo and passenger vessel *MV Wairua,* under charter to the Tokelau Administration to complete an approximately monthly shipping service between the atolls and Western Samoa. The lack of reef passages requires all loading and unloading to be conducted at high tide with small boats serving as lighters.

2.2 Existing fisheries

Tokelauans have traditionally looked to the sea as their main source of protein. Although there are no full-time fishermen, most Tokelauans are, of necessity, regularly occupied in a diverse range of fishing methods which harvest the lagoons, reef flats or open ocean. Fishing may be directed toward providing food for individual families or, under the supervision of the **taupulega**, toward gathering a communal catch to be shared under the **inati** system.

Although the lagoons are relatively large and their area far exceeds that of the land available for agriculture, all three are closed, and appear to be fairly unproductive (Hinds, 1971; Tuna Programme, 1983). For this reason outer reef and open-water resources have historically been of great importance to the Tokelauans. Tokelau's 200 nautical mile EEZ was declared by New Zealand in 1980 and encompasses some 318 876 sq km of ocean (SPC estimate). Some foreign fishing vessels have operated in Tokelauan waters fishing for tunas; revenues derived from licensing fees for these vessels accrue to the Territory.

Traditional fishing methods have been retained in Tokelau to a greater extent than in many of the more developed Pacific islands, although modem fishing gear, including steel hooks nylon lines and nets, and the use of outboard motors, has largely replaced traditional gear and sail. Techniques commonly in use include:

– **Makomako** fishing for bottom species at depths between 30 m and 120 m along the outer reef-slopes. A terminal rig bearing up to seven baited hooks is lowered to the bottom from a drifting boat and not hauled until a number of fish have been hooked. This technique is occasionally used at greater depth and local fishermen are familiar with, and have names for, many deep-bottom species;

– Mid-water handlining for tunas, wahoo, and sharks using a heavy line (typically 130—150 kg test monofilament nylon) and heavy wire trace, with **ulihega** *(Decapterus* spp.) or skipjack as bait;

– Trolling outside the reef for tunas wahoo, and barracuda using artificial lures or flying fish dressed as bait;

– Fishing for **ulihega** with short handwood rods (**hikaki**) rigged with small baited hooks on light line. This technique is conducted outside the reef with the fishermen in the water alongside their boats scattering a chum of grated coconut flesh or minced fish to attract the school;

– Capturing flying fish at night using storm lanterns to attract and blind the fish and scoop nets to take them from the water.

Other fishing methods include fishing from the reef edge with bamboo poles and light line, gill-netting and spearfishing within the lagoons, and the hand collection of reef invertebrates, both by day and by the light of storm lanterns at night. Only limited handlining is conducted within the lagoons, at depths to around 90 m.

Pole-trolling for skipjack tuna *(Katsuwonus pelamis)* using traditional pearlshell lures is still practised in Tokelau and in the right fishing conditions can be quite productive. Skipjack remains a very important food resource and a good deal of cultural significance and lore is attached to the skipjack fishery. The better part of the estimated annual catch of 18 t of skipjack (Tuna Programme, 1983) is now taken by trolling with modern lures from outboard-powered craft.

A variety of fishing craft are in use throughout the group, all of which are necessarily of shallow draught to enable them to pass between the lagoons and the open sea at high water. Traditional outrigger canoes, or **vaka atafaga**, up to 10 m in length, are still commonly in use. These craft are constructed from a local hardwood, **kanava**; the short planks being shaped and then sewn together with sennit fibre or synthetic twine. Aluminium dinghies around 4—5 m in length are now increasingly popular and each atoll has an 8.9 m aluminium catamaran, built in Western Samoa to the FAO 'alia' design and supplied under a UNDP assistance programme.

Many brands of outboard motors, usually o f 5—6 hp, but ranging up to 25 hp, are used to power the imported dinghies and those of the canoes which have been fitted with engine mounting boards between the hull and the outrigger; however lack of spare parts and maintenance skills has rendered many of these motors inoperative. Most craft are family-owned, though the alias are owned and operated by the communities under the supervision of their **taupulega**.

Fish storage facilities at each atoll are extremely limited, confined to a small number of private and communal domestic chest freezers (15 at Nukunono), the effectiveness of which is restricted by the short hours of public power generation. Ice is not generally available. The fresh fish supply therefore varies irregularly due to weather and sea conditions, the seasonality of some species, the availability of fuel, and other factors such as communal work obligations which limit fishing activities. Fish is sometimes of deteriorating quality by the time it is consumed.

A fish aggregation device (FAD) deployment programme has been undertaken; at the time of this visit one FAD had been in position off Nukunono for approximately 18 months. A second FAD was deployed off Atafu from the *MV Wairua* during the voyage which transported the Project Masterfisherman to Tokelau.

3. PROJECT OPERATIONS

3.1 General

The Project was first assigned to work at Nukunono to conduct fishing operations centred on the FAD in position offshore of the atoll's main settlement. Fourteen fishing trips were completed there between 25 August and 21 October.

The second stage of the visit was scheduled for Atafu, however the Masterfisherman was called to Western Samoa due to illness in his family and took passage there aboard the *MV Wairua* on the voyage which carried

the Project's gear to Atafu. During his absence, fishing trials and demonstration trips were conducted at Atafu by the Masterfisherman's Tokelauan counterpart officer, Mr Solomona Aleta. Upon the return of the Masterfisherman aboard the first available transport from Western Samoa, a severe fuel shortage at Atafu determined that only enough fuel to conduct one exploratory trip to the recently deployed FAD was allocated for Project use by the **taupulega**.

Moderate north-easterly winds predominated during the 10 weeks of operations at Nukunono, in hot and dry conditions. Seas were generally good, particularly along the western lee shore where the FAD was positioned, and where most fishing was conducted. Fishing operations were occasionally hampered during periods of low water by difficulty in taking the alia across the reef from the lagoon to the open sea.

Weather conditions deteriorated during the latter part of operations conducted at Atafu by the counterpart officer. Strong westerly blows and rough seas restricted offshore fishing considerably.

3.2 Boats and equipment

All fishing trips were conducted aboard the communally-owned 8.9 m aluminium-hulled alia catamarans which were made available for Project use by the **taupulegu** at both Nukunono and Atafu.

The Nukunono alia (Figure 2) was powered by a 35 hp Johnson outboard motor and carried a 20 hp Johnson as a standby. This craft was rigged by the Masterfisherman with a canvas awning between the cabin and the stern to serve as a sunshade and a robber skirt was fitted around the outboard leg to prevent seawater splashing up onto the motor through the outboard well opening in the deck.

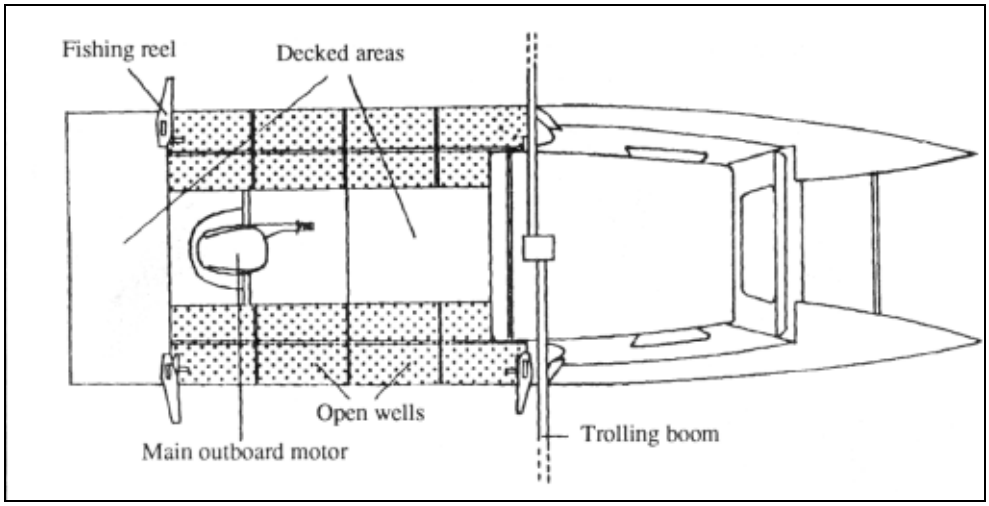

Figure 2: Deck layout of the alia catamaran used by the Project at Nukumono

Three of the Project's FAO, Western Samoa-design wooden handreels (Figure 3) were mounted on the alias and were variously employed for deep-bottom fishing, trolling, and vertical longline setting. Other fishing gear carried on occasion included handlines of monofilament nylon wound on handcasters, which are commonly used for bottom fishing in Tokelau, flying fish scoop nets, and poles and pearlshell lures for pole-trolling. In addition, the Project's Koden SR 657 echo-sounder, with a depth range to 525 m, was carried to locate bottom-fishing sites.

Anchoring gear comprised a simple grapnel constructed from 6 m of 10 mm diameter steel reinforcing rod bent into shape and lashed together with wire; a 5 m length of 12 mm galvanised steel chain shackled to the anchor eye; approximately 440 m of 10 mm diameter polypropylene anchor rope with a 'no-return' barb of galvanised fencing wire whipped in place near the chain connection; and an inflatable buoy of 75 kg or greater flotation, fitted with a snap-shackle on a short rope eye, which could be clipped to the anchor warp to slide freely along it. This gear is illustrated in Figure 4.

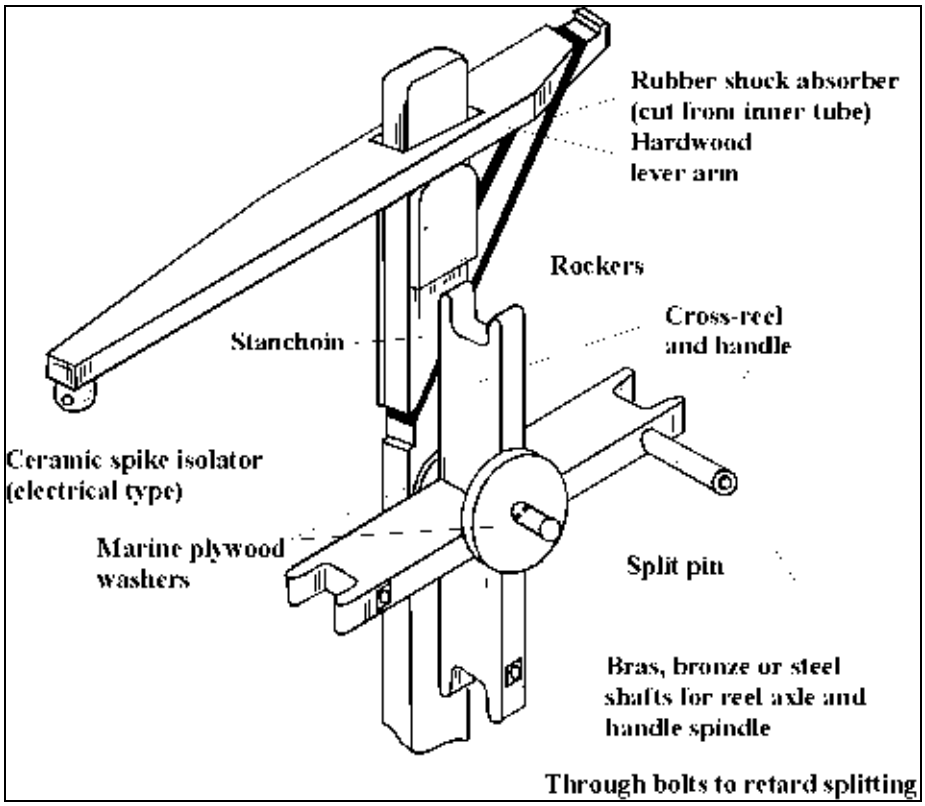

Figure 3: FAO, Western Samoa-design wooden handreel rigged for bottom-fishing and trolling

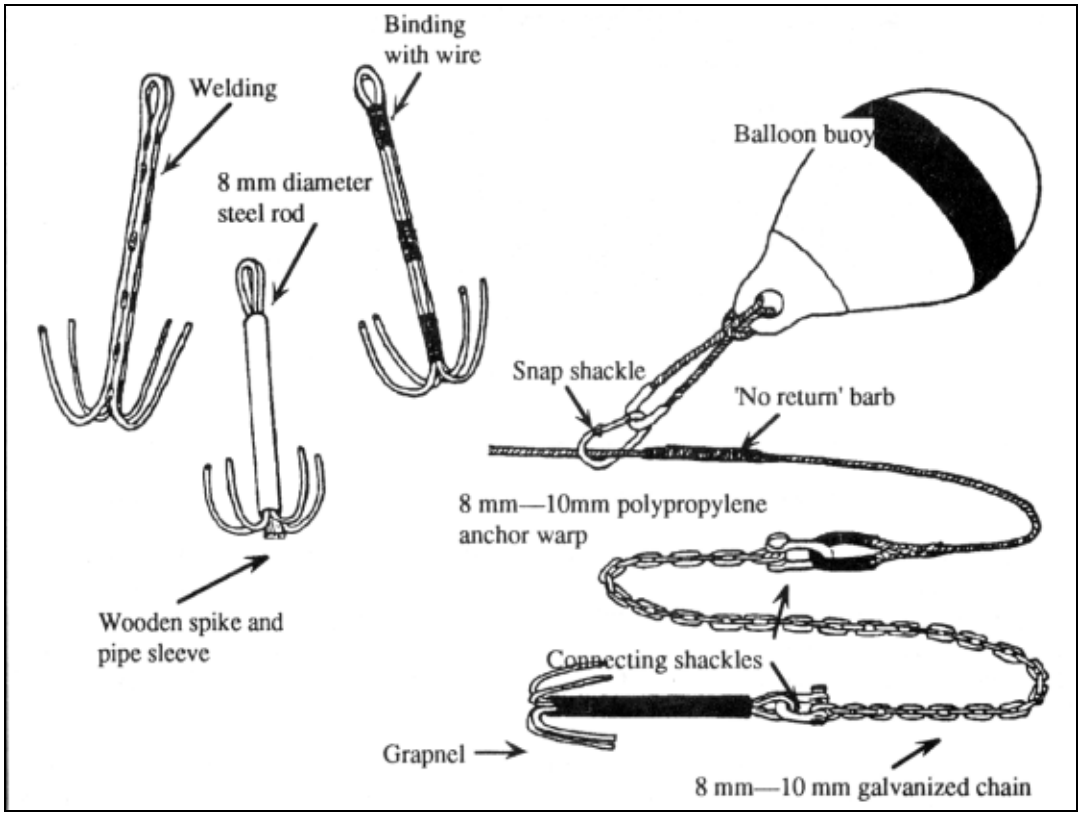

Figure 4: Self-hauling anchor gear used for deep-bottom fishing and Vertical longlining along the outer reef-slope

3.3 Training activities

Although not scheduled as a formal activity, the demonstration of vertical longlining became an important aspect of the fishing trips conducted, in response to the considerable interest in this technique expressed by local fishermen. Further training in deep-bottom fishing and anchoring technique, and in the construction of the FAO wooden handreels, was also conducted. All training was informal and, with the exception of handreel construction, carried out at sea under actual fishing conditions. A total of 11 fisheries staff or private fishermen participated in training trips and took an active role in whatever fishing activities were being conducted, including the capture of baitfish for use during vertical longlining.

Tokelauan counterpart officer Mr Solomona Aleta participated in 12 of the 14 trips made at Nukunono; in the absence of the Masterfisherman during the early part of the Atafu visit, he demonstrated vertical longlining to fishermen there. Mr Paulino Sakaria, a Nukunono Fisheries Division staff member, participated in each trip conducted there under an agreement whereby he and other assigned fishermen were to receive a share of the catch.

3.4 Disposal of the catch

After the agreed share of the catches landed by the Project had been distributed among participating crew, the remainder became the property of the local Fisheries Division and was offered for sale at NZ $1.00/ kg. However, a good part of the gross catch was deemed by the **taupulega** to be subject to the customary laws regarding **ika ha**, or fish which by tradition must be shared among the community. Catches subject to this convention include turtles, billfish, and catches by individual boats of more than 20 skipjack.

3.5 Data collection

SPC Masterfishermen use a standard logsheet (shown in Appendix 1) to record catch effort and other data and make detailed notes of their daily activities and of any supplementary information required. During this visit, data collected for each trip included: time spent travelling, anchoring, and engaged in each type of fishing; fishing depth or depth range; number of crew/trainees; quantity and type of fishing gear (in the case of vertical longlining the number of hooks set); 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.

4. FISHING ACTIVITIES AND RESULTS

4.1 General

Fourteen fishing trips were completed at Nukunono (Figure 5), for which detailed trip records were kept (see Appendix 2). Catch and effort data for fishing trips at Atafu supervised by the counterpart officer, and the one FAD inspection trip made there under the Masterfisherman's supervision, are not included in this report.

Figure 5: Nukunono atoll, showing sites fished during this visit

The 14 fishing trips completed occupied 152 hours at sea, during which vertical longlining was conducted for 49 hours over 9 trips; bottom droplining for 31 hours over 10 trips; trolling with handlines or handreels for 25 hours over 13 trips; pole-trolling with traditional pearlshell lures for 4 hours over 4 trips; and scoop netting for flying fish for 5 hours over 2 trips.

Each trip combined a variety of fishing methods, the use of a particular technique being determined by the requirements of the demonstration programme; the need to capture bait supplies; weather, sea, and tide conditions; and the occasional requirement that, at the direction of the **taupulega**, the Project vessel fish for the community.

The catch by all methods comprised 500 fish with a combined weight of 1,171.3 kg. The contribution to this catch by each of the fishing methods is detailed in the following sections, along with a description of the techniques and gear employed, and CPUE (catch per unit of effort) rates recorded.

4.2 Vertical longlining

Vertical longlining demonstration and fishing trials were centred on the FAD situated offshore from Nukunono village on Vao istet, in an area which generally lies in the lee of prevailing winds. At the time of this visit the FAD had been in place for about 18 months. The longline used was made up from 275 m of 230 kg test monofilament nylon, with ten heavy-duty swivels crimped in place along the line to serve as attachment points for snoods. Two additional swivels were fitted, one to the head of the line and one to the foot, for attaching a supporting buoy and a 4 kg sinker, respectively. The ten individual snoods were rigged from 5.5 m lengths of 135 kg test monofilament nylon fitted with a longline clip at one end and a no. 3, 4, or 5 tuna circle hook at the other. The swivels fitted for snood attachment were spaced at 13 m intervals. An additional 100 m length of line was attached to the head swivel and was used either for the attachment of a second, larger buoy or to tether the longline to the FAD. The rigging arrangement of this line is illustrated in Figure 6.

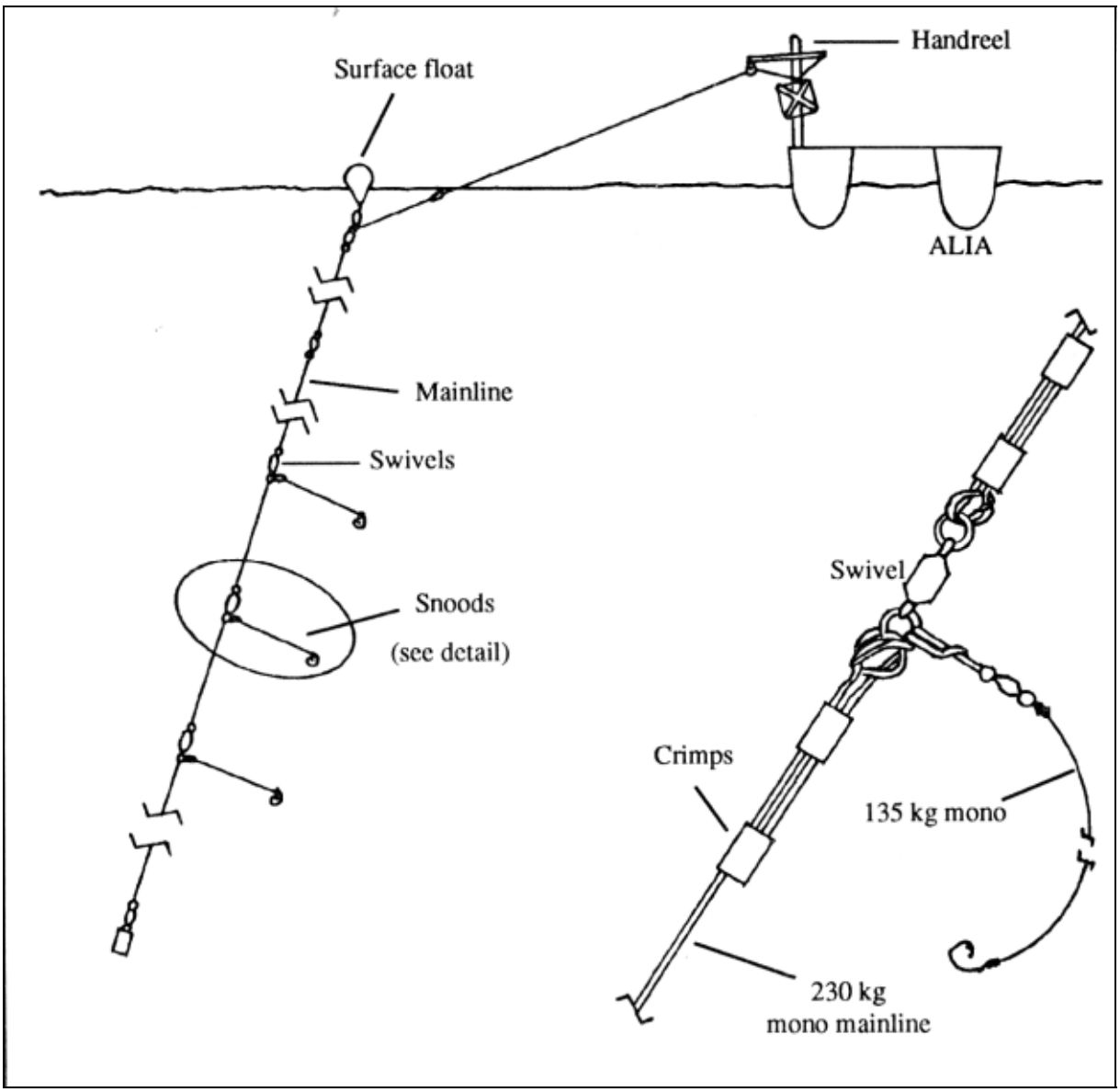

Figure 6: Rigging arrangement of vertical longline

The mainline was wound on a modified version of the FAO wooden handreel, with the usual ceramic line-guide replaced by a nylon pulley-wheel bolted to the reel arm. The pulley reduced friction and allowed the free passage of the swivels crimped into the line. Snoods were stored, wound hook to longline clip, on a handcaster. The line was set by first attaching the sinker to the bottom swivel and then lowering the mainline directly from the handreel, baited snoods being attached to successive swivels as they appeared off the reel. Lowering speed was maintained at about the natural sinking rate of the baits in order to reduce the tendency for snoods to stream upwards and perhaps tangle on the mainline The smaller of the two buoys, attached to the head of the mainline, served to support the line, while the second, at the end of the horizontal tether line, was fitted to provide the extra resistance which might be required to tire large fish or in the event of multiple hook-ups.

The baitfish most favoured for mid-water tuna fishing in Tokelau are the mackerel scads *(Decapterus* spp.), known locally as **ulihega**, and these were most often used to bait the longline. Supplies of **ulihega** were irregularly available from local fishermen or were occasionally captured by the alia's crew using the traditional technique of chumming the fish and hooking them with short rods, with the fishermen in the water alongside the boat. Other baits used whole were halfbeaks (*Hemiramphus* spp.), and fiying fish (*Cypselurus* spp.). These species were captured at night, using pressure lanterns to attract and blind the fish and long-handled scoop nets to take them from the water. Halfbeaks were taken in the lagoon and flying fish in the open sea. Strips of cut skipjack were also used occasionally, in order to gauge this bait's comparative effectiveness in attracting strikes.

When fresh baits were to hand, the longline was most often set at the beginning of the fishing trip and left to soak while other fishing, such as trolling or bottom droplining, was conducted.

The vertical longline catch comprised eleven fish, including six individuals of the target species, yellowfin tuna *(Thunnus albacares)*. These fish averaged 22 kg in weight. The other significant capture was an unspecified billfish weighing 70 kg. The species composition of the vertical longline catch is detailed in Appendix 3.

The productivity of vertical longline fishing may be expressed as a CPUE figure, with the standard unit of effort designated 'hook-hours' and representing 10 hooks set for one hour of fishing or 'soak' time. On this basis the total fishing effort by this method was 53 hook-hours and the total catch of 218.3 kg of fish resulted in a catch rate (CPUE) of 4.1 kg/hook-hour, as shown in Table 1.

Table 1: Summary of catch and effort by vertical longlining

Location	No. of trips	Fishing hours	Effort (reel-hours)	Catch				Total (kg)	CPUE (kg)
				Saleable		Unsaleable			
				No.	Wt (kg)	No.	Wt (kg)		
Nukunono	9	49.0	53.0	11	218.3	0	0.0	218.3	4.1

4.3 Deep-bottom droplining

Deep-bottom droplining along the outer reef-slope was conducted during 10 of the fishing trips undertaken. Most of these trips targeted areas along the atoll's western reef which were not extensively surveyed during the Project's previous deep-bottom fishing investigation in 1982. This fishing technique was most often employed only after one or two vertical longlines had been set at the FAD and left to soak, and was always dependent on having a supply of suitable fresh bait available. The preferred bait for deep-bottom fishing was fresh skipjack. If chilled bait was not available from the previous day's fishing, it was usual to troll for skipjack before attempting deep-bottom fishing. Suitable fishing sites were located by echo-sounding, the target depth being around 200 m. The anchor was then dropped in water shallower than that of the fishing spot, in a position selected so that prevailing wind or current would carry the boat back over the fishing site while the anchor warp was paid out. In calm conditions, or when fishing over a bottom slope of only moderate gradient, it was

sometimes necessary to anchor in water of the same depth as that of the fishing site, or even in deeper water.

Once the boat was resting at anchor, bottom fishing was commenced using both the wooden handreels and handlines wound on handcasters to lower and haul a baited multiple-hook terminal rig (illustrated in Figure 7). The sinker was lowered to the bottom and thereafter the line kept taut by hand to allow the fisherman to respond to bites by striking, and reduce the possibility of fouling other lines. Because of the elasticity of the long lengths of line in use, much reliance is placed on the 'self-hooking' qualities of the tuna circle hooks.

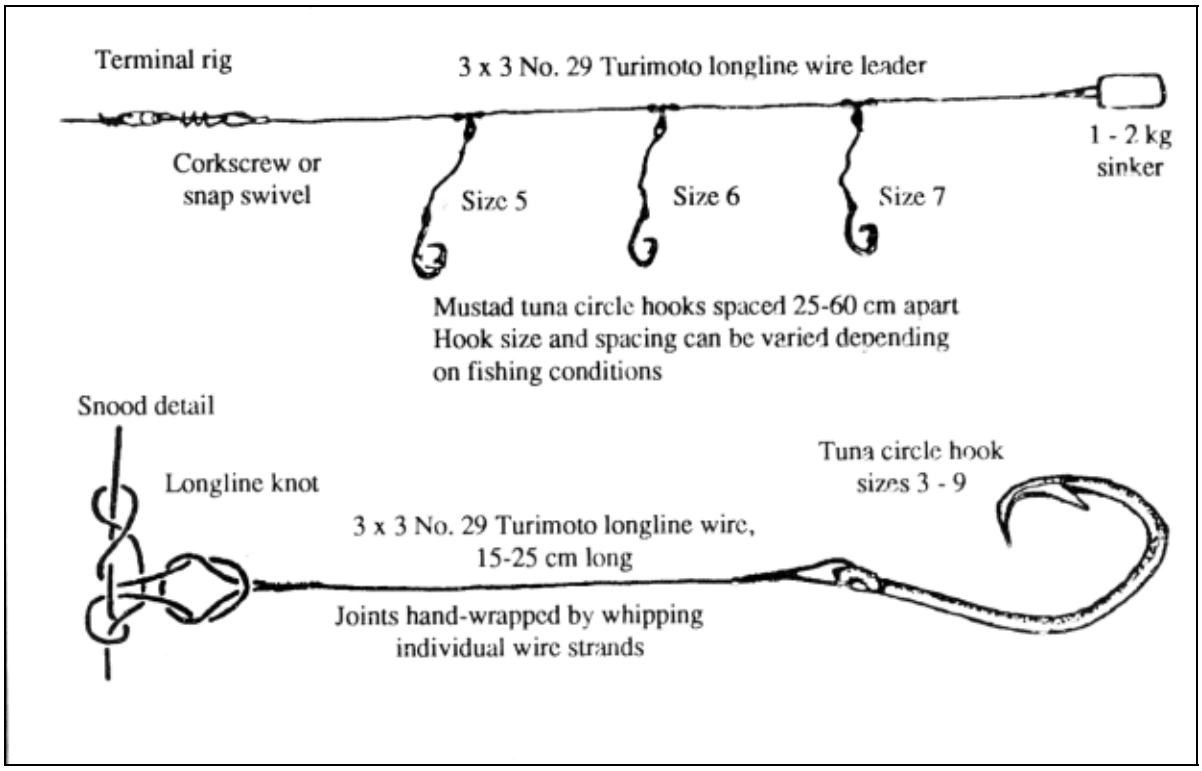

Figure 7: Typical terminal rig for deep-bottom fishing

At the conclusion of fishing, or preparatory to moving to another fishing site, the anchor was hauled using a simple technique which greatly reduced the effort required in hauling by hand by motoring rapidly forward, the anchor was broken out and then towed until it streamed on the surface behind the boat. The inflatable buoy was then dipped over the anchor warp, using the attached snap-shackle, and released. Water resistance forced the buoy back along the warp until it became trapped by the 'no-return' barb whipped onto the line near the chain connection. The boat was then motored slowly back toward the buoy with the floating anchor warp being fed inboard by hand, and the chain and anchor, suspended at the surface by the buoy, could be easily recovered. This technique is illustrated in Figure 8.

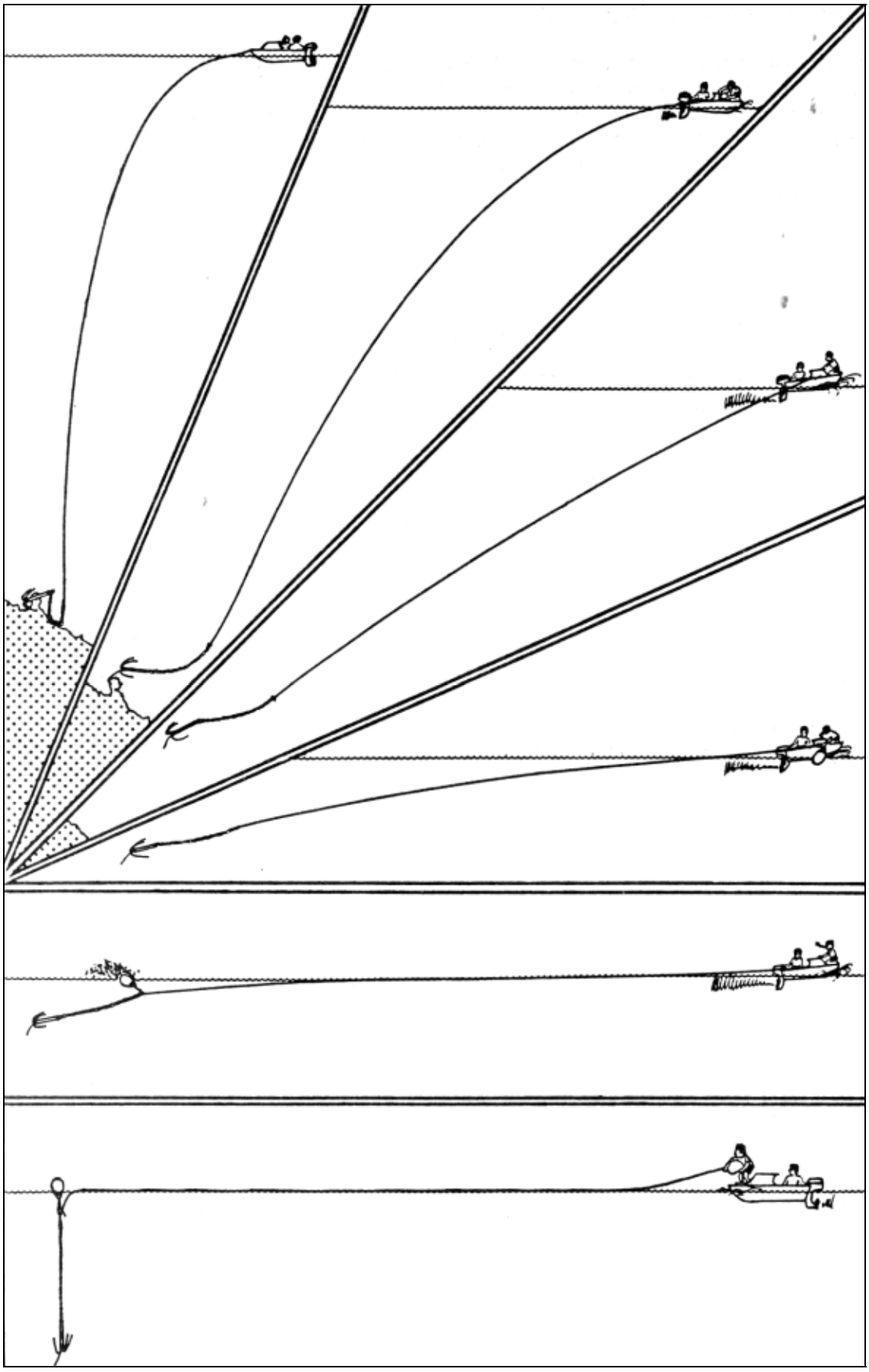

Figure 8: Anchor recovery method

Although the alia was fitted with three handreels the number of crew fishing on occasion required that some fishermen use their customary handlines wound on handcasters. The average fishing effort over the 31 hours engaged in bottom-droplining was therefore 3.8 reels or lines in use per hour of fishing time, or 119 reel- or line-hours overall The catch comprised 171 fish with a combined weight of 315.0 kg, giving a catch rate (CPUE) of 2.6 kg/reel- or line-hour. Nearly 29 per cent by weight of the Catch was unsaleable, made up of three grey reef sharks weighing 91.0 kg in all. When sharks are excluded from the calculation of catch rate, the figure recorded for saleable species only was 1.9 kg/reel- or line-hour (see Table 2).

Table 2: Summary of eater and effort by deep-bottom droplining

Location	No. of trips	Fishing hours	Effort (reel-hours)	Catch Saleable No.	Catch Saleable Wt (kg)	Catch Unsaleable No.	Catch Unsaleable Wt (kg)	Total (kg)	CPUE (kg)
Nukunono	10	31.0	119.0	168	224.0	3	91.0	315.0	2.6

Note: If sharks and other locally unsaleable species are excluded from the catch, CPUE = 1.9 kg.

The catch was dominated by **tafauli**, or black trevally *(Caranx lugubris),* which species was both the most numerous taken and that recording the highest individual species weight (115.5 kg). Most of this catch was taken over three consecutive trips fishing at depths between 100 m and 200 m in an area just north of Nukunono village. These trips may have coincided with a period of seasonal local abundance of this species which is reported to occur annually in Tokelau. **Tafauli** accounted for 51.6 per cent by weight of the saleable catch.

Deep-water snappers of the Etelinae sub-family were the next most important component of the saleable catch, the 16 individuals taken, with a total weight of 35.5 kg, accounting for 15.8 per cent by weight of the catch. The most common species in this group was the **palusega**, or small-tooth jobfish *(Aphareus rutilans)*. Other significant components of the saleable catch included 28.8 kg of groupers and cods (Serranidae) and 20.5 kg of emperors (Lethrinidae). The species composition of the overall deep-bottom catch is detailed in Appendix 4.

4.4 Trolling

Trolling was conducted during 13 of the 14 trips undertaken, in most cases specifically to capture skipjack to use as deep-bottom fishing bait or as a means of maximising catches for time Spent at sea. The final two trips were devoted exclusively to trolling, in response to direction by the **taupulega** that the alia fish for the community by what was then the most productive means, skipjack being abundant in the area at the time.

Lines were trolled directly from the wooden handreels, with appropriate monofilament nylon leaders or wire traces fitted to the reels' mainlines by means of corkscrew or snap swivels. Local fishermen also occasionally used their own trolling lines which are typically of heavy monofilament nylon wound on handcasters.

During four of the trips traditional tuna poles and pearlshell lures were used to capture skipjack. Pole-trolling with this traditional equipment is still practised in Tokelau when schools of skipjack are feeding freely at the surface and it can be an extremely efficient small-boat fishing technique in the right conditions.

The six hours engaged in this fishing method produced the highest catch rate recorded during the visit at 15.5 kg/pole-hour (pole-hours = the use of one tuna pole over one hour of fishing), as indicated in Table 3. It should be borne in mind, however, that pole-trolling was conducted only in optimum conditions; it is unlikely that such a catch rate would be sustainable over extended trolling operations.

Table 3: Summary of catch and effort by pole-trolling

Location	No. of trips	Fishing hours	Effort (reel-hours)	Catch Saleable No.	Catch Saleable Wt (kg)	Catch Unsaleable No.	Catch Unsaleable Wt (kg)	Total (kg)	CPUE (kg)
Nukunono	4	4.0	6.0	35	93.0	0	0.0	93.0	15.5

Trolling by handreel and handline, although recording a lower CPUE figure (8.8 kg/line-hour) than pole-trolling, was quite productive (see Table 4). Small plastic lures were most often used, rigged on light monofilament nylon leaders, designed to capture the small schooling tunas then abundant in the area. Much of the catch of 196 skipjack and 9 yellowfin in the 2—5 kg weight range was taken in the vicinity of the FAD. In most cases trolling was discontinued once sufficient skipjack had been taken to ensure the day s bait supply for deep-bottom fishing.

Table 4: Summary of catch and effort by handreel and handline trolling

Location	No. of trips	Fishing hours	Effort (reel-hours)	Catch Saleable No.	Catch Saleable Wt (kg)	Catch Unsaleable No.	Catch Unsaleable Wt (kg)	Total (kg)	CPUE (kg)
Nukunono	13	25.0	61.0	205	537.0	0	0.0	537.0	8.8

The species composition of the troll catch by both methods is detailed in Appendix 5.

4.5 Scoop netting

Scoop netting for flying fish *(Cypselurus* spp.) was conducted during two overnight fishing trips, in instances to capture fresh bait for vertical longline sets made at first light. The catch taken over 7 net-hours (the use of one scoop net for one hour) amounted to go fish with a total weight of 8.0 kg. This indicates the capture of juvenile fish not normally targeted by scoop-netting; however these small sizes were ideal for bait. Although the CPUE figure of 1.1 kg/net-hour, as shown in Table 5, indicates low productivity, this fishing technique was quite productive in terms of producing whole baits. An average of nearly 12 fish was captured per net-hour and the total catch was sufficient to fully bait eight longline sets.

Table 5: Summary of catch and effort by scoop netting

Location	No. of trips	Fishing hours	Effort (reel-hours)	Catch Saleable No.	Catch Saleable Wt (kg)	Catch Unsaleable No.	Catch Unsaleable Wt (kg)	Total (kg)	CPUE (kg)
Nukunono	2	5.0	7.0	80	8.0	0	0.0	8.0	1.1

5. DISCUSSION AND CONCLUSIONS

Tokelau is a remote territory of small communities where the distribution of food and material resources is still largely determined by the traditional concept of communal sharing, and where a market economy, although having a steadily increasing influence, is still relatively unimportant. There is, therefore, despite ample demand, little scope for a cash-based trade in fish. There are only very limited facilities for even the short-term storage of fish and at present no opportunities to export fresh or frozen fish. Significant quantities of salted/sun-dried

fish are regularly freighted to Western Samoa; some small quantities even reach the Tokelauan community in New Zealand, but these shipments are given to friends and relatives rather than sold.

Fishermen are directly handicapped in their fishing efforts by a lack of support services and materials including engine maintenance and repair facilities and expertise, spare parts, stocks of suitable fishing gear, and ice. It is unlikely, therefore, that in spite of at least seasonally abundant fish resources, Tokelauan fisheries offer scope for any significant development as a means of generating cash income. The exception may be in developing export markets for processed fish products, particularly salted/sun-dried fish. The production of this item on any significant scale would, however, almost certainly require much-improved refrigerated storage facilities so that seasonal peak captures of particular species could be held over a period of several days to allow for eventual processing.

Tokelau's lagoons are typical of the closed-atoll type and are relatively unproductive. Outer reef-slope fishing during this and the previous DSFD Project visit indicated that local deep-bottom resources, while not exploited to any great extent, were likely to yield only poor catch rates in comparison to some other areas in the Pacific. Trolling catch rates during this visit were quite high, but the productivity of this fishery is known to decline during the 'off' season for tunas; this fishing technique, even when productive, also involves high fuel consumption.

The limited vertical longlining trials conducted in the vicinity of Nukunono's FAD, while indicating that this technique may provide an effective means for capturing deep-swimming tunas and billfish gathered at FADs, were not extensive enough to conclude whether or not the technique would be more productive than traditional Tokelauan mid-water tuna fishing methods. Vertical longlining has, however, proven more efficient and productive than single-hook mid-water fishing techniques during DSFDP trials conducted elsewhere in the Pacific (Chapman, in press). The particular benefit to Tokelauan fishermen might be that they could conduct other fishing activities in the interval between setting vertical longlines and hauling them.

The future successful development of vertical longline fishing in Tokelau will depend largely on the survival of the FADs, and on their being replaced if lost. The early replacement of FADs in Tokelau is likely to present difficulties particular to the area's remoteness, shipping schedules, and the likelihood that funding for such replacement would have to be sought from an aid agency.

It therefore appears uulikely that Tokelauan fisheries will develop beyond subsistence level in the foreseeable future.

However, because modern subsistence fishing activities consume fuel and expendable fishing supplies, and still require labour, any increase in their efficiency is likely to be significant for small communities with only limited manpower and material resources. The aims for future fisheries development in Tokelau should therefore be to develop more efficient and productive techniques and gear, to develop the support facilities required for small-boat fishermen, and to derive maximum value from catches landed. The following recommendations have been drafted with these alms in mind.

6. RECOMMENDATIONS

The government trading stores on Nukunono and Atafu should be stocked with a range of at least basic fishing gear at reasonable prices so that fishermen on these atolls have readier access to gear supplies than having to order them from Fakaofo, or further afield. In addition to trolling lures and hooks, and supplies for reef fishing, the stocks should include items required for vertical longlining, mid-water handlining and deep-bottom fishing, such as tuna circle hooks, heavy-duty swivels, longline clips, and long lengths of heavy monofilament nylon fishing line.

Public Works mechanics presently responsible for outboard motor maintenance and repair services should be equipped with a range of spare parts to suit one appropriate make and model of outboard motor. It is probably impractical to attempt to keep spares for a range of outboard motor makes and models. Stocking single-make spares should encourage the use of that make and thereby facilitate servicing and spare part supply.

Manufacturers or agents might be consulted to determine which would offer the most satisfactory supply service at the best prices.

A FAD inspection and maintenance programme should be initiated, in consultation with the donor agency which supplied the units already deployed. Detecting early signs of wear to the upper fittings, damage to rafts, or loss of appendages, will help extend FAD life and effectiveness. Replacement parts, including rafts and swivels, should be held so that repair or replacement can be done when necessary.

Monitoring of FAD-associated catches and the compilation of catch records will assist in determining the local effectiveness of the FADS and enable informed decisions to be made concerning the desirability or otherwise of devoting limited resources or aid grants to further FAD deployment.

Studies should be made on the feasibility of improving both reef landing channels and channels giving access to the open sea from the lagoons. Any such improvement work should take into account expert advice on the possible environmental effects of such undertakings.

Efforts should be made to encourage improved, simple fish processing procedures such as salting, drying, and smoking, so that seasonal abundances of particular species may be better exploited, and the supply of consumable fish better regulated. Improved processing may produce a product with wider local consumer acceptability, which may also have some export market potential. It would be useful to conduct marketing. trials with the salted/sun-dried fish already produced. Such trials could be conducted in Western Samoa in the first instance.

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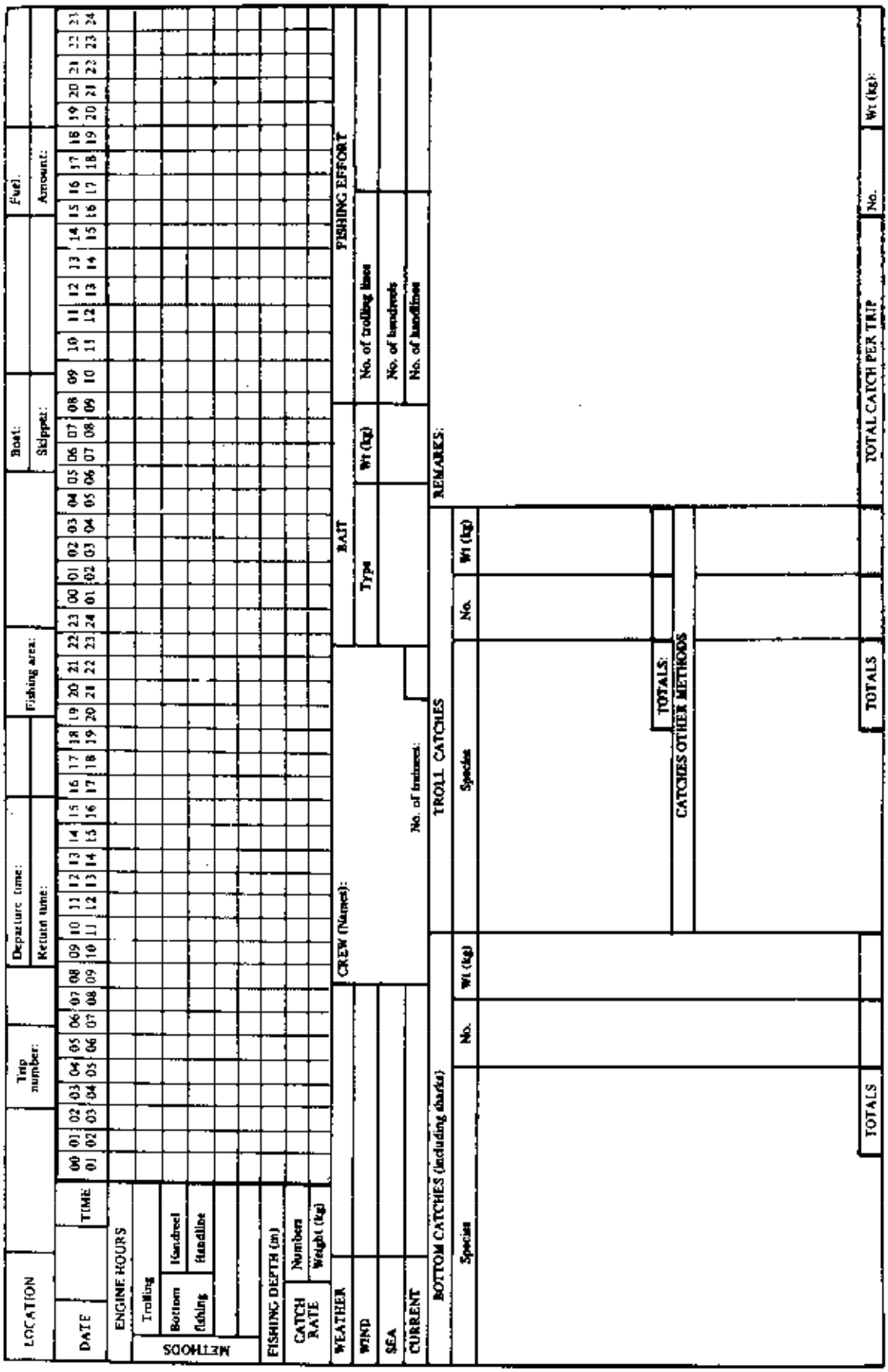
APEENDIX 1

STANDARD FORM FOR DATA COLLCETION



APPENIX 2

OPERATIONAL APECTS OF FISHING TRIPS

Trip No.	Fishing method	1-Trip hours	Fishing hours	Effort (Note)*	Catch(all species)		Bait kg	Fuel (litres)
					No.	Weight (kg)		
1	Bottom droplining		5.0	15.0	28.0	31.0	5.0	
	Trolling		1.0	2.0	7.0	9.0	0.0	
	Vert. Longlining		2.0	2.0	2.0	2.3	2.0	
	Scoop netting		2.0	4.0	40.0	3.0	0.0	
	Totals	**15.0**	**10.0**		**77.0**	**0.0**	**7.0**	**15.0**
2	Trolling		1.0	2.0	2.0	4.0		0.0
	Vert. Longlining		2.0	2.0	0.0	0.0	1.5	
	Totals	**5.0**	**3.0**		**2.0**	**4.0**	**1.5**	**22.0**
3	Bottom droplining		2.0	8.0	17.0	54.0	1.0	
	Trolling		1.0	3.0	0.0	0.0	0.0	
	Vert. Longlining		7.0	7.0	6.0	50.0	2.0	
	Totals	**10.0**	**10.0**		**23.0**	**104.0**	**3.0**	**30.0**
4	Bottom droplining		2.0	8.0	16.0	100.0	3.0	
	Trolling		3.0	9.0	29.0	68.0	0.0	
	Vert. Longlining		6.0	10.0	2.0	78.0	1.0	
	Totals	**11.0**	**11.0**		**47.0**	**0.0**	**4.0**	**24.0**
5	Bottom droplining		4.0	16.0	22.0	33.0	10.0	
	Trolling		2.0	6.0	10.0	37.0	0.0	
	Totals	**12.0**	**6.0**		**32.0**	**70.0**	**10.0**	**40.0**
6	Bottom droplining		5.0	20.0	20.0	27.0	16.0	
	Trolling		1.0	3.0	28.0	70.0	0.0	
	Vert. Longlining		9.0	9.0	0.0	0.0	1.0	
	Totals	**12.0**	**15.0**		**48.0**	**97.0**	**17.0**	**52.0**
7	Bottom droplining		3.0	15.0	9.0	8.0	10.0	
	Trolling		3.0	9.0	7.0	17.0	0.0	
	Totals	**11.0**	**6.0**		**16.0**	**25.0**	**10.0**	**42.0**
8	Bottom droplining		3.0	12.0	22.0	20.0	10.0	
	Trolling		2.0	6.0	17.0	37.0	0.0	
	Vert. Longlining		2.0	2.0	0.0	0.0	1.0	
	Totals	**11.0**	**7.0**		**39.0**	**57.0**	**11.0**	**38.0**
9	Bottom droplining		4.0	16.0	22.0	21.0	11.0	
	Trolling		1.0	3.0	27.0	56.0	0.0	
	Pole-trolling		1.0	1.0	4.0	10.0	0.0	
	Totals	**10.0**	**6.0**		**53.0**	**87.0**	**11.0**	**27.0**
10	Bottom droplining		2.0	6.0	9.0	9.0	2.0	
	Trolling		1.0	2.0	1.0	2.0	0.0	
	Vert. Longlining		8.0	8.0	1.0	70.0	2.0	
	Totals	**11.0**	**11.0**		**11.0**	**81.0**	**4.0**	**22.0**

APPENIX 2

OPERATIONAL APECTS OF FISHING TRIPS

Trip No.	Fishing method	1-Trip hours	Fishing hours	Effort (Note)*	Catch (all species)		Bait kg	Fuel (litres)
					No.	Weight (kg)		
	Vert. Longlining		3.0	3.0	0.0	0.0	4.0	
	Scoop netting		3.0	3.0	43.0	23.0	0.0	
	Totals	**15.0**	**7.0**		**49.0**	**35.0**	**5.0**	**28.0**
12								
	Vert. Longlining		10.0	10.0	0.0	0.0	3.0	
	Trolling		2.0	2.0	41.0	139.0	0.0	
	Pole-trolling		1.0	1.0	20.0	58.0	0.0	
	Totals	**12.0**	**13.0**		**61.0**	**0.0**	**3.0**	**58.0**
13	Trolling		3.0	6.0	22.0	57.0	0.0	
	Pole-trolling		1.0	2.0	7.0	17.0	0.0	
	Totals	**7.0**	**4.0**		**29.0**	**74.0**	**0.0**	**39.0**
14	Trolling		4.0	8.0	11.0	41.0	0.0	
	Pole-trolling		1.0	2.0	3.0	8.0	0.0	
	Totals	**10.0**	**5.0**		**13.0**	**49.0**	**0.0**	**46.0**
	TOTALS	**152.0**	**114.0**	**0.0**	**500.0**	**1171.3**	**86.5**	**483.0**

Note Effort = - Bottom droplining : reel hours

- Trolling : line/reel hours
- Vertical longling : hook hours (i.e. 10 hooks fished for one hour)
- Scoop-netting : net hours (i.e. one scoop-net in use for one hour)
- Pole-trolling : Pole-hours (i.e. one pole in use for one hour)

APPENDIX 3

SPECIES COMPOSITION OF THE VERTICAL LONGLINE CATCH

GROUP *FAMILY* *Species* English name Tokelauan name (where know)	No.	Weight (kg)
TUNA		
SCOMBRIDAE		
Thunnus albacares Yellowfin tuna Kakahi	6	130.0
BILLFISH		
XIPHIIDAE		
Billfish (unidentified) Tuaniu	1	70.0
SEAPIKES		
SPHYRAENIDAE		
Sphyraena qenie Slender seapike	3	18.0
POMFRET		
BRAMIDAE		
(Possibly) Taratichthys steindachneri	1	0.3
TOTAL	**11**	**218.3**

APPENDIX 4

SPECIES COMPOSITION OF THE BOTTOM CATCH

GROUP *FAMILY* *Species* English name Tokelauan name (where know)	No.	Weight (kg)
DEEP-WATER SNAPPERS		
LUTJANIDAE (sub-family ETELINAE)		
Aphareus rutilans Small-tooth jobfish Palusega	9	21.0
Aprion virescens Green jobfish Utu	2	7.0
Pristipomoides zonatus Banded flower snapper Palu savane	1	1.0
Pristipomoides flavippinis Yellow jobfish	4	6.5
Sub-total	**16**	**35.5**
SHALLOW-WATER SNAPPERS		
LUTJANIDAE (sub-family LUTJANINAE)		
Lutjanus gibbus Paddletail Malai	1	0.5
Lutjanus monostigma One-spot snapper Taira	7	3.0
Lutjanus kasmira Blue-lined snapper Havane	26	3.7
Sub-total	**34**	**7.2**

APPENDIX 4

SPECIES COMPOSITION OF THE BOTTOM CATCH

GROUP *FAMILY* *Species* English name Tokelauan name (where know)	No.	Weight (kg)
EMPERORS		
LETHRINIDAE		
Lethrinus kallopterus Yellow-spotted emperor Hapuki	3	4.5
Lethrinus elongatus Long-nosed emperor Filoa	12	16.0
Sub-total	**15**	**20.5**
GROUPERS AND CODS		
SERRANIDAE		
Cephalopholis sonnerati Tomato rock-cod	8	3.0
Cephalophois sexmaculatus Rock-cod	2	1.0
Cephalopholis spp. Rock cods	2	0.8
Epinephelus microdon Fapuku	25	24.0
Epinepheulus miliaris Fapuku	8	5.0
Sub-total	**45**	**33.8**
CARANGIDAE		
Caranx lugubris Black trevally Tafauli	50	115.5
Seriola rivoliana Deep-water amberjack	1	1.0
Sub-total	**51**	**116.5**

APPENDIX 4

SPECIES COMPOSITION OF THE BOTTOM CATCH

GROUP *FAMILY* *Species* English name Tokelauan name (where know)	No.	Weight (kg)
TUNAS		
SCOMBRIDAE		
Gymnosarda unicolor Dogtooth tuna Tavatava	3	7.0
Thunnus albacares Yellowfin tuna Kakahi	1	8.0
Sub-total	**4**	**15.0**
BARRACUDA		
SPHYRAENIDAE		
Sphyraena barracuda Great barracuda	1	0.5
Sub-total	**1**	**0.5**
SHARKS		
CARCHARHINIDAE		
Carcharhinus amblyrhynchus Grey reef shark	3	91.0
Sub-total	**3**	**91.0**
TOTAL	**171**	**315.0**

APPENDIX 5

SPECIES COMPOSTION OF THE TROLL CATCH BY BOTH METHODS

GROUP *FAMILY* *Species* English name Tokelauan name (where know)	No.	Weight (kg)
A. TROLLING BY HANDLINE AND HANDREEL		
TUNAS		
SCOMBRIDAE		
Katsuwonus pelamis Skipjack tuna Atu	196	488.5
Thunnus albacares Yellowfin tuna Kakahi	9	48.5
Sub-total	**205**	**537.0**
B. POLE-TROLLING		
TUNAS		
SCOMBRIDAE		
Katsuwonus pelamis Skipjack tuna Atu	35	93.0
Sub-total	**35**	**93.0**
TOTAL BOTH METHODS	**240**	**630.0**

APPENDIX 6

SPECIES COMPOSITION OF THE SCOOP NET CATCH

GROUP ***FAMILY*** *Species* English name Tokelauan name (where know)	No.	Weight (kg)
FLYING FISH		
EXOCOETIDAE		
Cypselurus spp. Flying fish	80	8.0
TOTAL	**80**	**8.0**