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SUMMARY OF SPC WORK IN THE DEVELOPMENT OF SMALL-SCALE FISHING GEAR AND TECHNIQUES

I. INTRODUCTION

1. The Fourteenth Regional Technical Meeting on Fisheries (1982) recommended that 'greater emphasis on gear development' be incorporated into the existing framework of the Deep Sea Fisheries Development Project. A number of individual countries have also requested project visits with major gear development components, underlining the growing importance which SPC member countries attach to the development of their coastal fishery resources. Of particular interest to many countries is the development of gears and techniques to harvest fish associated with fish aggregation devices (FADs). The activities of the project have been concentrated in this field, and several innovations by the SPC Master Fishermen have given promising results. Controlled experimentation has also been conducted on some established fishing methods, and a number of potential improvements identified. Fishing techniques receiving attention in the past twelve months (1 August 1982-31 July 1983) include:

- Vertical longlining
- Bait traps
- Ika-shibi fishing
- Shark-lining
- Gill netting
- Trolling

2. The following paragraphs outline this work.

II. VERTICAL LONGLINING ON FADs

3. The relative simplicity of the gear and handling procedures required to operate small vertical longlines around FADs makes this a very promising technique for small-scale fishermen. The Commission has thus concentrated considerable effort on developing this method during trials in Niue, Vanuatu and the Cook Islands. A wide variety of gear configurations and variations in technique have been employed.

4. Vertical longline trials in Niue were carried out on two FADs, one about a quarter of a mile, and the other about a mile, off Alofi. Twenty-nine fishing trips, averaging six hours fishing time per trip, were made, twenty-three in a 12-foot aluminium dinghy and six in a 28-foot aluminium 'alia' catamaran. The longline was either tied off to the FAD, or tied to the boat, which itself would be moored to the FAD. On one trip, nine other dinghies were moored to the FAD, so the boat and longline were allowed to drift.

5. The longline, illustrated in Figure 1, consisted of a vertical mainline of 7 mm diameter Kuralon longline cord equipped with a sinker and float, and a horizontal leader line used to tie it off. Ten (10) to twenty (20) snoods, each bearing a single Mustad tuna circle hook, were attached to the mainline, using longline clips, at 10-20 m intervals, variations being made in order to fish specific depths, conserve bait or allow for operating conditions.

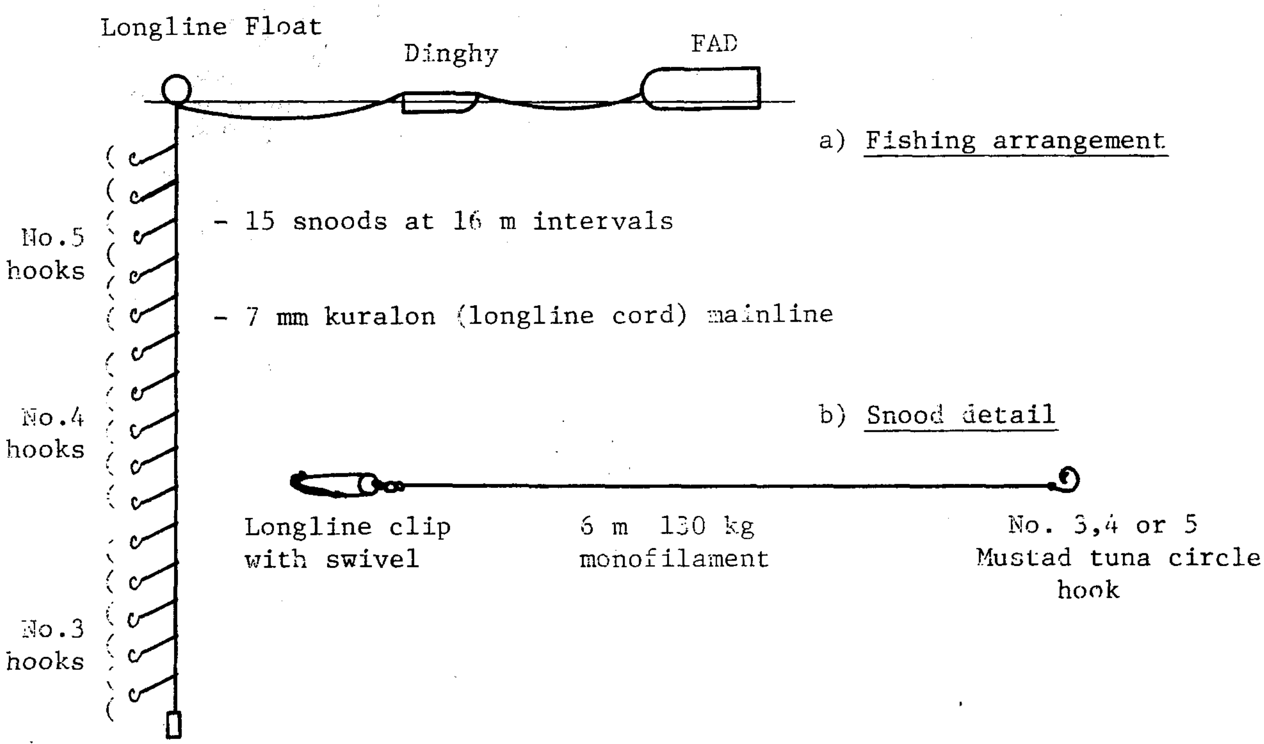

Figure 1: Longline used during trials in Niue

6. Several sets of the longline were made at night, but most were made around dawn, with fishing continuing well into the day. One hundred and seventy-four (174) fishing hours were completed, producing 86 fish with a total round weight of 918 kg. This gave a return of 5.3 kg per hour's fishing - a rate comparable to that obtained by bottom fishing activities in some areas. The bulk of the catch comprised yellowfin and albacore tunas, as shown in Table 1.

Table 1: Vertical longline catches from 2 FADs in Niue

Species	Catch No.	Catch Weight (kg)
Thunnus albacares, yellowfin tuna	51	459
Thunnus alalunga, albacore tuna	16	300
Thunnus obesus, bigeye tuna	14	82
Katsuwonus pelamis, skipjack tuna	2	22
Coryphaena hippurus, dolphin fish	1	9
Ruvettus pretiosus, oilfish	1	13
Prionace glauca, blue shark	1	33
Total	86	918

7. The capture of albacore in substantial quantities is of particular significance as these do not occur often in catches taken by other fishing methods in Niue.

8. Considerable work was done to identify those variations in technique which increase productivity. In particular, the effects of fishing depth and bait type or quality were closely examined, and modifications to both these factors were made frequently. Different fishing depths proved to yield very different catches, both in quality and type. The depth of capture of each fish was estimated by noting the approximate depth of the hook on which it was taken, and this information then used to derive the estimates of catch per unit of effort (c.p.u.e.) by depth shown in Table 2. The effort unit used is ten hook-hours, indicating a 10-hook longline set for 1 hour, or a 20-hook line set for half an hour, etc.

Table 2: Vertical longline catches by depth from 2 FADs in Niue

Depth range (metres)	Hook-hours	Catch No.	Catch Weight (kg)
0-100	824	21	126
100-200	1150	29	259
200-300	754	32	461
300+ *	113	4	72
Total	2841	86	918

* Maximum fishing depth 350 m.

9. As can be seen, substantially higher catch rates were obtained from depths below 200 m than from the upper part of the water column. Differential catch rates also occurred for different species, with albacore dominating in deeper waters, as shown in Figure 2.

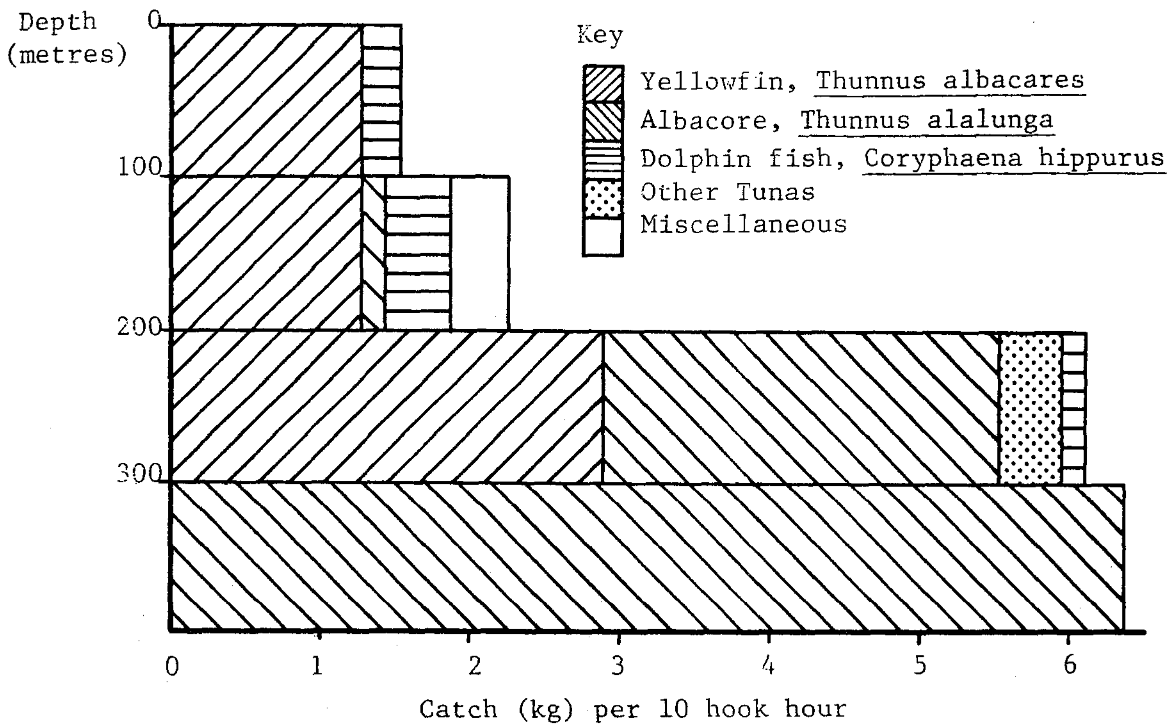

Figure 2: Vertical longline catch rates by depth range

Bait type and quality also significantly influenced catches. Traps were installed on the FADs (see Section II) to catch scads (*Decapterus* sp.) and atule (*Selar crumenophthalmus*) after initial longlining trials using cut tuna, frozen New Zealand mackerel, and other bait types, produced poor catches. These improved production considerably, as shown in Table 3.

Table 3: Vertical longline catches by bait type from 2 FADs in Niue

Bait type	Hook-hours	Catch No.	Catch Weight (kg)	C.p.u.e. (kg/10 hook-hours)
Scad and atule	2168	81	857	4.0
Fresh and Salted tuna, mackerel and flying fish	673	5	61	0.9
Total	2841	86	918	3.2

10. The five fish taken on the inferior bait included an oilfish and a shark, the only two unsaleable fish caught.

11. Longlining trials carried out in Vanuatu used similar techniques but produced very different results. Longlines were set from a 28-foot wooden 'alia' catamaran, either constructed as shown in Figure 3a and tied to the FAD or, in later trials, modified as shown in Figure 3b and set so as to drift close by the raft. Fourteen (14) fishing trips were conducted from Port Vila, giving a total of 75 fishing hours. Sixteen (16) fish weighing 264 kg were caught, yielding catch rates of 19 kg/trip, 3.5 kg/fishing hour, or 1.6 kg/10 hook-hours. These catch rates are lower than those experienced in Niue, and the catch itself contained a very high proportion (over 75%) of sharks (see Table 4) which are abundant around Vanuatu's FADs. As well as being difficult to handle, these disrupted fishing operations by biting off hooks and traces (and on one occasion a large portion of the mainline), tangling the longline around the FAD mooring, and attacking other hooked fish.

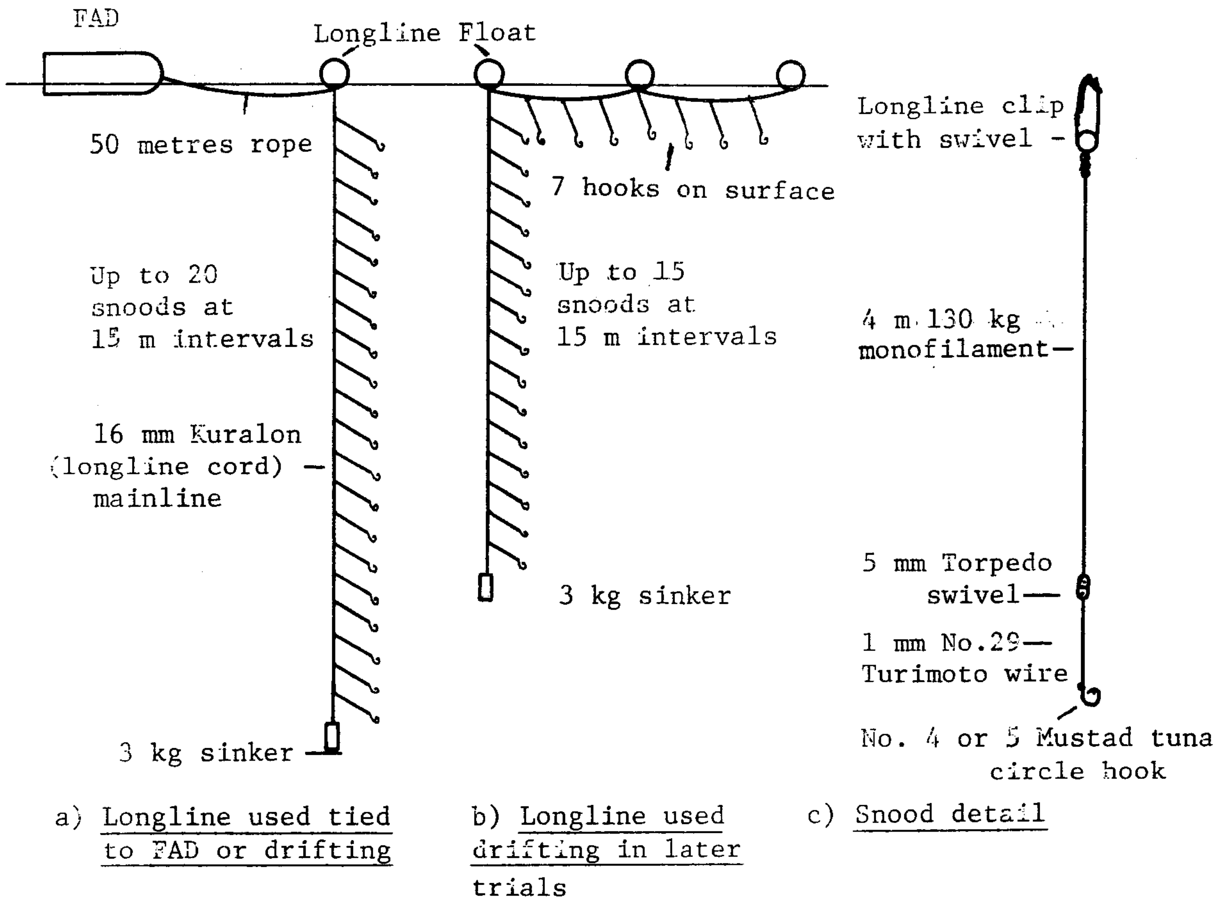

Figure 3: Longlines used during trials in Vanuatu

Table 4: Vertical longline catches around 2 FADs in Vanuatu

Species	Catch No.	Catch Weight (kg)
Thunnus albacares, yellowfin tuna	5	39
Coryphaena hippurus, dolphin fish	1	10
Elegatis bipinnulatus rainbow runner	4	13
Carcharhinus falciformes, silky shark	5	156
Sphyrna sp., hammerhead shark	1	46
Total	16	264

12. Table 5 shows that catches were clearly demarcated as to depth, with most fish being hooked in less than 100 m (sometimes while the line was being set) and nothing caught below 200 m - the converse of the situation in Niue.

Table 5: Vertical longline catches by depth on 2 FADs in Vanuatu

Depth Range (metres)	Catch No.	Catch Weight (kg)	C.p.u.e. (kg/10 reel-hours)
0-100	12	173	3.1
100-200	4	91	1.3
200-300	0	0	0
300+ *	0	0	0
Total	16	264	1.6

* Maximum fishing depth 325 m.

13. Either frozen saury (industrial longline bait), which was sometimes salted to harden it, or fresh tuna, were used as bait, depending on availability. Most tuna were caught on saury, and most sharks on tuna, but no detailed analysis of bait effectiveness was performed. Scad and atule were unavailable and it is not known whether catch rates would be improved by their use.

14. In addition to the problems caused by sharks, large numbers of oceanic triggerfish (probably *Canthidermis maculatus*) proved a nuisance by picking the bait from the hooks when the line was set too close to the FAD. To avoid these two hindrances, several sets on a total of eight trips were conducted with the longline adrift after it had been released in a position where wind and current would carry it close by the FAD.

15. As can be seen from Table 6, this practice appeared to improve catches of desirable species, while reducing the incidence of sharks and associated problems, and loss of bait to the triggerfish. Elimination of sharks from the catch naturally resulted in a drastic reduction of the overall catch rate.

Table 6: Catches from vertical longlines tied to and drifting around 2 FADs in Vanuatu

	Catch							C.p.u.e. (kg/10 hook-hours)		
	Hook hours	Sharks n.	Sharks kg	Others n.	Others kg.	Total n.	Total kg	Sharks	Other	Total
Drifting longlines	763	1	20	9	58	10	68	0.3	0.8	0.9
Longlines tied to FAD	914	5	182	1	4	6	186	2.0	0.1	2.0
Total	1677	6	202	10	62	16	264	1.2	0.4	1.6

16. The modifications to the drifting longline shown in Figure 3b were made towards the end of the Vanuatu trials in order to concentrate effort in the shallower waters where most of the earlier catch occurred. Insufficient trials have been conducted to allow assessment of this gear.

17. These results illustrate both the potential of the technique and some of the many varied problems to be overcome. Vertical longlining on FADs is seen as one of the most promising new fishing methods for small-scale fishermen, and development of the technique will continue to assume a high priority in the Deep Sea Fisheries Development Project's work.

III. BAIT TRAPS ON FADs

18. Principal target species on FADs are tunas of various types and other pelagic fish. Some techniques (described in Sections II and IV) aimed at capturing these species require for bait very fresh small fish of certain types which may be locally difficult to obtain.

19. In Niue, small schools of scad and atule (Decapterus and Selar spp) were frequently seen while diving around FADs, and box traps were hung from three rafts to capture these. A typical trap (illustrated in Figure 4) consisted of a weighted rectangular wooden frame, about 6' x 3' x 3', panelled with chicken wire and with a conical entrance on both ends.

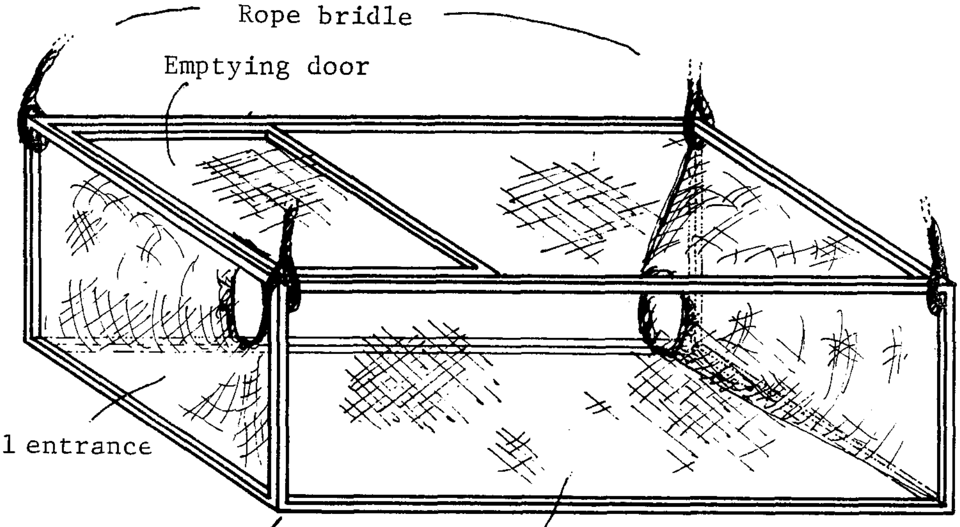

Figure 4: Typical bait trap used in Niue and Vanuatu

The trap was suspended on a rope bridle 15' below the raft and was not baited in any way. Nevertheless, fish frequently entered and, although there was nothing to prevent them escaping through the entrances, usually reacted to the process of hauling the trap by staying inside it. At other times, when the trap was not disturbed, they could sometimes be observed leaving and re-entering via the entrances. Escaping could probably be further discouraged by setting the entrances at an angle, to take advantage of the natural inclination of scad to swim downward.

20. The trap was checked on every trip and the contents were seen to be very variable. Extended periods of time occurred during which no scad could be seen in the trap or around the raft, while at other times fairly large schools were present. Table 7 shows the bait taken by the project in this way.

Table 7: Catches from bait traps on a FAD in Niue

Date	Decapterus sp.		Selar crumenophthalmus		Other	
	No.	kg	No.	kg	No.	kg
20/11/82	20	4	10	2	1	5*
6/12/82	120	20	18	3	-	-
10/12/82	40	6	24	3	-	-
13/12/82	40	5	20	2.5	-	-
21/ 1/83	30	5 (est)	-	-	-	-
	250	40	72	10.5	1	5

* Yellowfin tuna, Thunnus albacares

21. As can be seen, only a small number of hauls were made. This was because the trap had usually been emptied by other fishermen, whose catch far exceeded that of the project. Several more yellowfin and a dolphin fish are also known to have been taken from the trap.

22. Damage to the trap occurred on many occasions and necessitated repair or replacement. Predatory fish frequently tore holes in the wire netting in attacking the baitfish sheltering inside. At other times, trolling or handlines caught on the trap, ripping it or pulling it out of position.

23. A similar trap was installed on a FAD in Vanuatu but was lost due to strong currents after two weeks, during which time no suitable bait was caught. However, 25 oceanic triggerfish (possibly Canthidermis maculatus) were taken from the trap in two hauls. These are a nuisance during fishing operations as they pick the bait from hooks but are themselves very difficult to catch. Traps may therefore offer a way of keeping their numbers down to a tolerable level.

IV. IKA-SHIBI FISHING

24. The ika-shibi fishing technique aims to capture deep-swimming tunas using a weighted line carrying a single baited hook on a trace and, sometimes, a chum-bag or basket. The line is used in conjunction with an underwater light which attracts the tuna (or small baitfish, which in turn attract the tuna) to the vicinity.

25. Fifty-nine hours were spent in preliminary trials of the technique during seven overnight fishing trips in Niue. The lines used were as shown in Figure 5, and were fished from a 28-foot aluminium 'alia' catamaran in depths from 16 to 480 metres with the boat variously anchored, at a sea anchor, or freely adrift. Up to five lines were used at any one time.

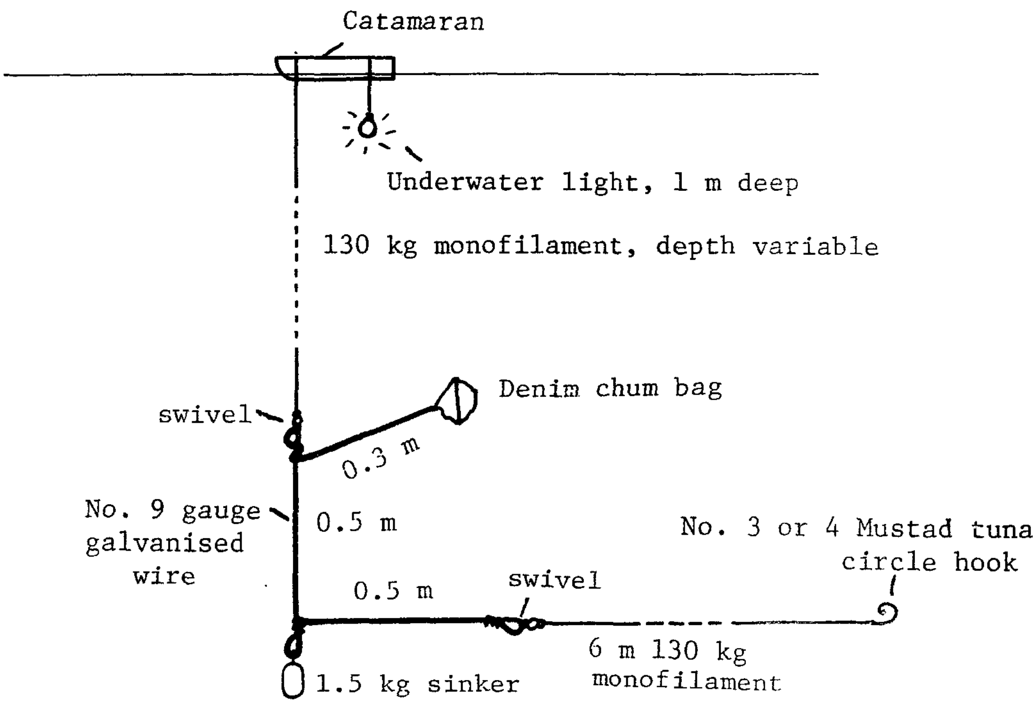

Figure 5: Ika-shibi line used during trials in Niue

26. A total of 6 fish, weighing 87 kg (3 yellowfin tuna 25 kg; 2 oilfish 57 kg; 1 dog shark 3 kg) were caught, yielding a catch rate of 1.4 kg per fishing hour. Few problems were experienced in the use of the underwater lights, but a good deal of work remains to be done in identifying optimum baits, gear configurations, fishing depths and anchoring arrangements.

V. SHARK LINING

27. Due to the disruption to gill net, vertical longline and troll fishing caused by sharks in Vanuatu, some effort was directed toward reducing their numbers by fishing specifically for them using a single-hook line equipped with large floats and lightweight chain, as illustrated in Figure 6. Sharks caught in this way can be left to fight the buoy until exhausted or dead: the handling problems are therefore much less than those encountered with one or more sharks on a longline. It is also less likely that damage will occur to one of these heavier lines, and if it does it is less serious than the loss of part or all of a longline carrying up to twenty-five traces.

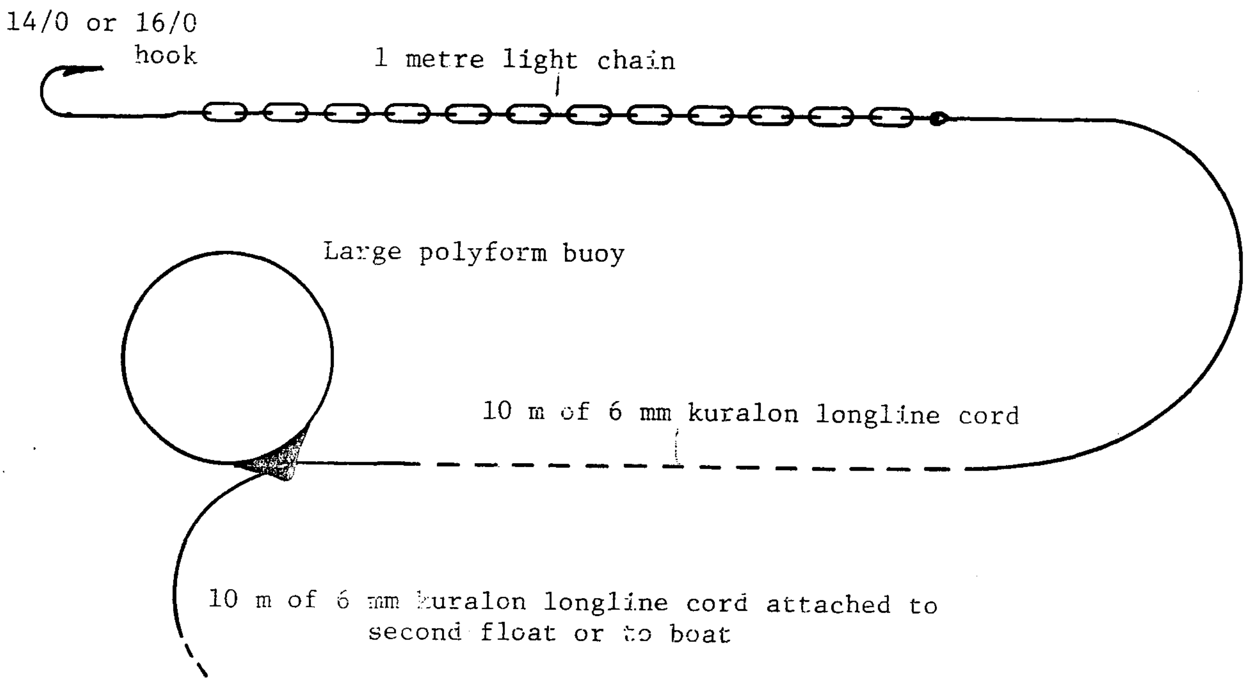

Figure 6: Shark line used in Vanuatu

28. Single hook shark lines were set for a total of 29.5 hours in 7 trips, 5 from Port Vila and 2 from Luganville, and yielded 5 silky sharks (Carcharhinus falciformes) with a total weight of 166 kg. The fish were generally hooked within one to two hours of the lines being set but were left to swim around for several hours, so the true fishing time is in fact substantially less than the 29.5 hours for which the hooks were immersed.

29. Although generally considered unsaleable in the past, improved methods of handling and presentation are doing much to increase the acceptability of shark meat in a number of locations. In these areas, shark fishing can be profitable, even if prices are low, due to the large average weight of these fish. This type of fishing will thus probably find increasing application, both to catch sharks for sale and to reduce their numbers in areas where they hinder other fishing operations.

VI. GILL NETTING ON FADs

30. Trials of a pelagic gill net were conducted on a FAD in Vanuatu during March 1983 to assess the method's potential in catching surface schooling tunas and other pelagic fish. The net comprised four panels of 6" stretched mesh nylon multifilament netting hung as shown in Figure 7.

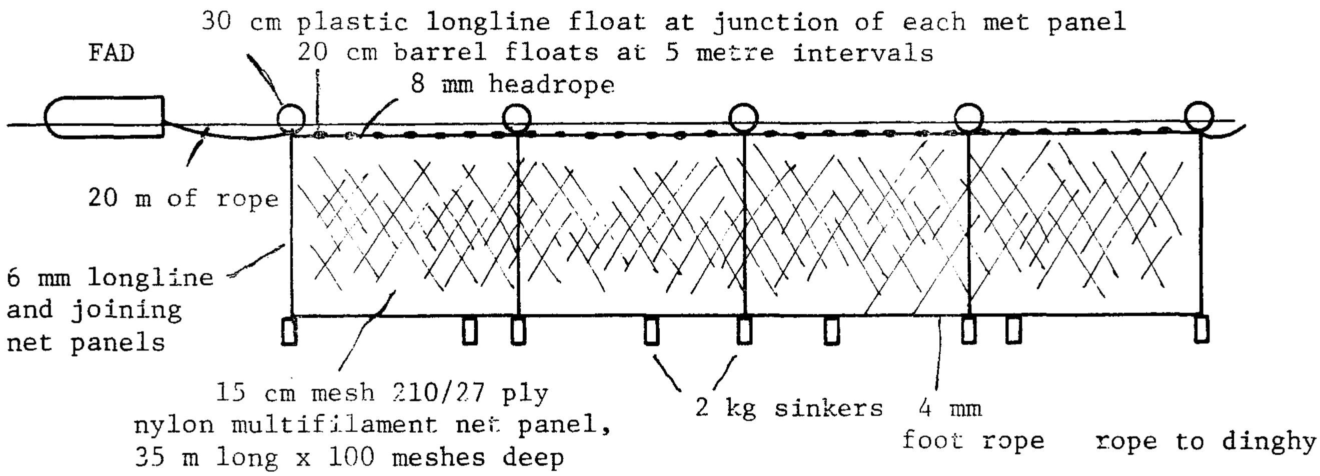

Figure 7: Gill net used during trials in Vanuatu

31. Three overnight sets were made using an 8.5 or 10.5 metre catamaran as a mother boat to carry the net and tow a 4.5 m dinghy to the FAD. The net was stacked in the dinghy and set before dark by tying one end of the headrope off to the raft on a line about 30 m long and paying out the net as the dinghy drifted down-current. The dinghy was then left tied off to the down-current end of the headrope while the 'mother boat' conducted bottom fishing or other activities. Flashing buoy lights placed on the raft and dinghy enabled the net to be relocated in the dark, and hauling commenced immediately prior to sun-up.

32. Continual difficulties were caused by currents and wind. On the first trip the net tangled during setting, but was replaced by a second net which was successfully set. On the second trip the current, which was moderate during setting, dropped during the night, allowing the wind to blow the net and dinghy back towards the raft. This permitted a meshed hammerhead to swim around the FAD mooring chain several times, causing a tangle which took some hours to free. On the third trip the current increased after setting, breaking the headrope and tearing the net down to the leadline. The net was therefore retrieved shortly after setting, and the trip abandoned.

33. Thus, only the first two trips produced catches, which are detailed in Table 8.

Table 8: Catches from gill netting on a FAD in Vanuatu

Species	Trip 1 (7-8/3/83)		Trip 2 (14-15/3/83)		Total	
	No.	kg.	No.	kg	No.	kg
Katsuwonus pelamis (skipjack tuna)	7	11	-	-	7	11
Thunnus albacares (yellowfin tuna)	-	-	2	13	2	13
Elegatis bipinnulatus (rainbow runner)	1	3	1	4	2	7
Coryphaena hippurus (dolphin fish)	-	-	1	4	1	4
Carcharhinus falciformes (silky shark)	8	250	4	140	12	390
Carcharhinus albimarginatus (silvertip shark)	-	-	1	6	1	6
Sphyrna spp. (hammerhead sharks)	-	-	2	102	2	102
	16	264	11	269	27	533

34. 6.5 per cent of the catch weight was of the target species group, the rest comprising various sharks which appear to attack enmeshed fish and become enmeshed themselves in the process. Almost every pelagic fish caught had a shark within 10 feet of it, or a large hole in the net where one had presumably torn away. Other holes were also scattered at intervals around the net. These were much more numerous on the first set, when a strong current stretched the net tight, than on the second, when the net hung slack.

35. These initial results are far from discouraging but make it clear that much more work is needed to reduce net damage and increase the catch of desirable species while reducing the incidence of sharks, which are difficult to handle and frequently unsaleable. Future trials will include attempts to set the net adrift up-current of the FAD where tuna concentrations are felt to be greater. Drifting with the current may avoid some of the damage caused by the action of fish or currents on the tightly stretched net, and may also help reduce the phosphorescence which appears to be increasing when water flows across the net, and which sometimes makes the net stand out clearly. Improvements will also be made to the rigging of the net, particularly in the leadline which will be made of heavier rope fitted with smaller sinkers placed closer together.

VII. TROLLING

36. Trolling is an expensive fishing method due to the high fuel consumption involved, but can be very effective in several situations, such as in the capture of surface schooling tunas, or pelagic species associated with the outer reef slope. Minor improvements in techniques or catch rate can significantly improve operating economics. Troll fisheries, particularly around FADs but also for coastal pelagic species, are developing in a number of Pacific countries and the Commission attaches high priority to the refinement of trolling techniques.

37. Troll catches fluctuate widely in conjunction with the target species' seasonal or local abundance, daily feeding regime or reproductive cycle. The type of bait used and the manner in which it is presented greatly influence its attractiveness, and this, too, appears to vary both with the condition of the fish and from species to species. For this reason it is difficult to make broad generalisations, and it should be borne in mind that improvements identified under a particular set of conditions may have little effect when those condiitions no longer prevail.

38. Trial fishing carried out in Niue aimed to quantitatively assess the effects of bait type and the depth at which they were fished on the catch taken by inshore trolling around the island. In comparing bait effectiveness, synthetic rubber 'octopus' lures of varying colours and sizes, but mainly red or red and white, were trolled simultaneously or separately with flying fish dressed as bait. The catches and catch rates obtained are shown in Table 9.

Table 9: Coastal trolling catches by bait type, Niue

Bait type	Effort (line-hour)	Catch no.	Catch kg	C.p.u.e. (kg/line-hour)
Artificial lures	479	85	1072	2.2
Flying fish	135	10	106.5	0.8
Total	614	95	1178.5	1.9

39. As can be seen, the artificial lures proved roughly three times as effective as the natural bait and were also more convenient to store and handle.

40. Three line configurations were used to assess the effects of depth on trolling success. Ordinary 130 kg monofilament lines result in the bait being trolled between the surface and a depth of about 2 m. Incorporation of a 0.5 kg lead sinker on a short length of wire at the point of attachment of the trace increases this depth to about 5m, while the use of 3/64" branded stainless steel wire as a mainline results in a fishing depth of about 10-12 m. These depths are approximate and vary both with trolling speed and the type of bait used. Table 10 shows the catches obtained using these different arrangements.

Table 10: Coastal trolling catches by fishing depth, Niue

Line type	Approximate Fishing depth (m)	Effort (line-hours)	Catch no.	Catch kg	C.p.u.e (kg/line-hour)
Normal monofilament	0-2	155	8	95.5	0.6
Weighted monofilament	2-5	133	11	137.5	1.0
Stainless steel wire	10-12	326	76	945.5	2.9
Total		614	95	1178.5	1.9

41. Catches were clearly higher using the heavier, deeper fishing lines.

42. Consideration of the above information indicates that the use of a combination of wire lines and artificial baits ought to give the best catch rates. Table 11, which shows c.p.u.e. figures for the six different combinations of line and bait used, confirms that this was the case. Figures in brackets are the number of line hours on which the adjacent c.p.u.e. values are based.

Table 11: Troll c.p.u.e. by bait and line type, Niue

Bait type	Line type: Surface monofilament	Line type: Weighted monofilament	Line type: S.S. wire	Total
Artificial lures	0.77 (108)	1.29 (102)	3.19 (269)	2.2 (479)
Flying fish	0.26 (47)	0.19 (31)	1.55 (57)	0.8 (135)
Total	0.60 (155)	1.0 (133)	2.9 (326)	1.9 (614)

43. The c.p.u.e. values show a fairly steady progression from the combination of flying fish on a surface line, which give a catch rate of 0.26 kg/line-hour, to artificial lures on a wire line, which produced over twelve times as much.

44. Although a limited number of yellowfin (Thunnus albacares), barracuda (Sphyraena barracuda), and dogtooth tuna (Gymnosarda unicolor), were caught, the greater portion of the sub-surface catch was wahoo (Acanthocybium solandri). Catch composition probably reflected more the depth and/or distance offshore worked rather than the species available to be caught around the coast. When trolling specifically for wahoo, the vessel was most often run at a constant speed of 4-6 knots paralleling the coast from 100-200 metres off the reef or cliff. Trolling this distance offshore also produced the occasional yellowfin and dogtooth tuna, usually just after sunrise.

45. The average catch rate obtained by coastal trolling in Niue was 1.9 kg/line-hour. Monofilament surface lines used with small octopus lures in coastal areas, under similar conditions in Vanuatu, produced a rate of 0.6 kg/line-hour. These catch rates do not compare well with those which can be obtained by other methods such as bottom fishing, but nevertheless are substantially higher than the catch rates usually obtained when trolling is conducted in open offshore waters. In this environment good catches depend on the presence or absence of surface tuna schools, and trolling is often uneconomic because of the large amounts of time and fuel spent in searching for them. One of the most obvious benefits of FADs to small-scale fishermen is that they reduce this wastage to a minimum by concentrating local tuna schools into a known small area.

46. In an attempt to quantify the catch rate improvements generated by FADs, controlled trolling, using the same gear and techniques, was carried out in Vanuatu in three distinct situations:

(a) as a primary fishing activity around FADs. Schools were chased and catches maximised by moving from school to school and FAD to FAD as occasion demanded;

(b) as a secondary fishing activity while travelling to bottom fishing grounds. As the troll catch was required for bait, every attempt was made to fish promising spots, troll through nearby schools and make a second run through a productive area, provided no great loss of bottom fishing time was involved. Most of this trolling was conducted in inshore waters;

(c) purely incidentally en route to a FAD. Only very occasional deviations from the path of travel were made when a school was very nearby and looked particularly promising. This mostly involved trolling in offshore areas or very deep water.

47. Table 12 shows the catches obtained in these ways.

Table 12: Comparison of troll catches by three different fishing regimes, Vanuatu

Trolling regime	Effort (line-hours)	Catch no.	Catch kg	C.p.u.e. (kg/line-hour)
(a) Around FADs	237	863	1859	7.8
(b) Travelling to and from bottom fishing grounds	122.5	42	78	0.6
(c) Travelling to and from FADs	378	19	56	0.15
Total	737.5	924	1993	2.6

48. As can be seen, trolling around FADs yielded a catch more than ten times that from the relatively productive coastal waters and over fifty times that obtained by undirected trolling in open water.

49. The species composition of the catches also varied, in that skipjack and yellowfin tuna together made up 90 per cent of the catch weight in category (a) and 89 per cent of that in category (c), but only 32 per cent in category (b), where a variety of other species, typical of a more near-shore environment, dominated.