Survey of the Deep Water Shrimp Resources of the Northern Gilbert Islands, Kiribati

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I. inTRODUCTION

Bottom-living penaeid shrimps of the family Pandalidae are known to occur in the deep (200 - 700+ metres) waters of the outer reef slope in many if not all Pacific Island countries. Surveys have established the presence of Heterocarpus and several other genera in Fiji (Brown and King 1979), Vanuatu (King 1981a: De Riviers et al., 1982), Guam (Wilder 1977), Western Samoa (King 1980), Papua New Guinea (King 1982), New Caledonia (intes 1978: Crutz, unpublished data) and French Polynesia(CNEXO, 1979). King (1986) provides a useful summary of survey work carried out in the region to date.

An economically important trap fishery for Heterocarpus laevigatus and related species exists in Hawaii, although it appears to have recently undergone a decline. Attempts to develop local fisheries based on deep-water shrimp resources in other Pacific Island countries have so far met with very limited success.

in April 1985 the Government of Kiribati requested the South Pacific Commission to undertake a preliminary assessment of deep-water shrimp resources in the waters around the Gilbert Islands, in order to assess the commercial potential of these resources under prevailing local conditions. After an extended period of correspondence and discussions with the Kiribati Fisheries Division, the following specific activities were identified as the main aims of the survey:

to determine the presence of commercially valuable species of deep water shrimp in Kiribati waters by a programme of trial trap fishing in selected areas around the Island of Tarawa and possibly other areas in the Gilbert Islands group;

to provide a comparative assessment of the nature and abundance of local deep-water shrimp resources;

to evaluate the commercial potential of the resource;

to demonstrate appropriate methods of gear construction, fishing and catch handling method to members of the Kiribati Fisheries Division and other

Preparations for the execution of the survey were initiated in mid-1986 and the appropriate fishing and other gear purchased and shipped to Kiribati. The actual survey programme, which lasted for six weeks, commenced in February 1987, after several postponements due to mechanical problems with the survey vessel, unseasonal bad weather in the Gilberts group, and the absence of key Fisheries Division personnel overseas. All practical work associated with the survey was supervised by consultant deep-water fisherman Bernard Crutz, with assistance during the first three weeks from SPC Assistant Fisheries Officer Garry Preston. The first half of the programme was spent in gear construction and preparation for fishing. 13 days were spent fishing during the second half of the survey, with the remaining time spent repairing or replacing fishing gear. The report was prepared at SPC headquarters in Noumea, New Caledonia after completion of the survey, and the final draft forwarded for comments by the Kiribati Fisheries Division in June 1987.

2. FISHING GEAR

2.1 Trap types

2.1.1 General

Two different trap types were used during the survey (figure 1). Most were small traps of a size selected for two reasons: to make efficient use and minimise wastage of the materials from which they would be constructed, which were delivered in standard sizes; and so that catch rates would be comparable with those obtained from earlier surveys, which used traps of similar dimensions, in other Pacific Island countries. The small traps were set 1n strings (usually of between four and eight traps per string) equally spaced along a bottom line, which was attached by one end to a hauling line.

Experience in the Hawaiian commercial fishery and elsewhere indicate that larger traps outfish smaller ones by a factor of five or more to one. A small number of larger traps were therefore built and set alongside the small ones to allow a comparison between the effectiveness of different trap sizes. The large traps were not set in strings but individually, and were attached directly to the hauling line.

Some consideration was given to making the large traps to a design similar to one seen in the Hawaiian commercial fishery. This design is a truncated pyramid, about 1 m square around the base 8nd 1 m high, with a single entrance at the top. This plan was ultimately rejected on the grounds that a fairer comparison of the effectiveness of the two trap sizes would be obtained if both were built to similar designs.

2.1.2 Small traps

A total of 30 small traps (type 1) were constructed. These were box-shaped, 70cm x 70cm square by 40cm high (0.196 cubic metres) and fitted with a hinged access door, 35cm x 70cm, on the top surface (figure 1). The frames were made of 10mm diameter steel rod, bent and welded as described in section 2.2.1, and covered with half-inch (13mm) mesh galvanised chicken wire.

A hauling bridle consisting of a 2.5m length of 8mm diameter polypropylene rope was attached to each trap by tying the ends of the rope through the two corners of the trap frame opposite the door. A heavy-duty longline clip was attached to the bridle, slightly off-centre, and used to fix the trap to the bottom line (see section 2.3.4).

Each trap had four conical entrances, about 20cm in diameter at the outer end and tapering down to 5cm diameter at the inner end, one on each vertical face. The entrances were of the same galvanised chicken wire as the cover and were made by cutting a hole in the cover and attaching a roughly semicircular piece of chicken wire rolled to form the cone. The entrances were positioned at the ends of the trap walls in such a way that they did not directly oppose each other.

2.1.3 Large traps

Five large traps (type 2a) were constructed, These were also box-shaped, about 160cm long by 120cm wide x 80cm (1.44 cubic metres) high and fitted with a hinged access door 75cm square on the top surface (figure 1). The frames were made of 12mm diameter steel rod and covered with the same half-inch (13mm) mesh galvanised chicken wire. An inferior quality chicken wire made it necessary to cover some of the large traps twice to provide enough strength.

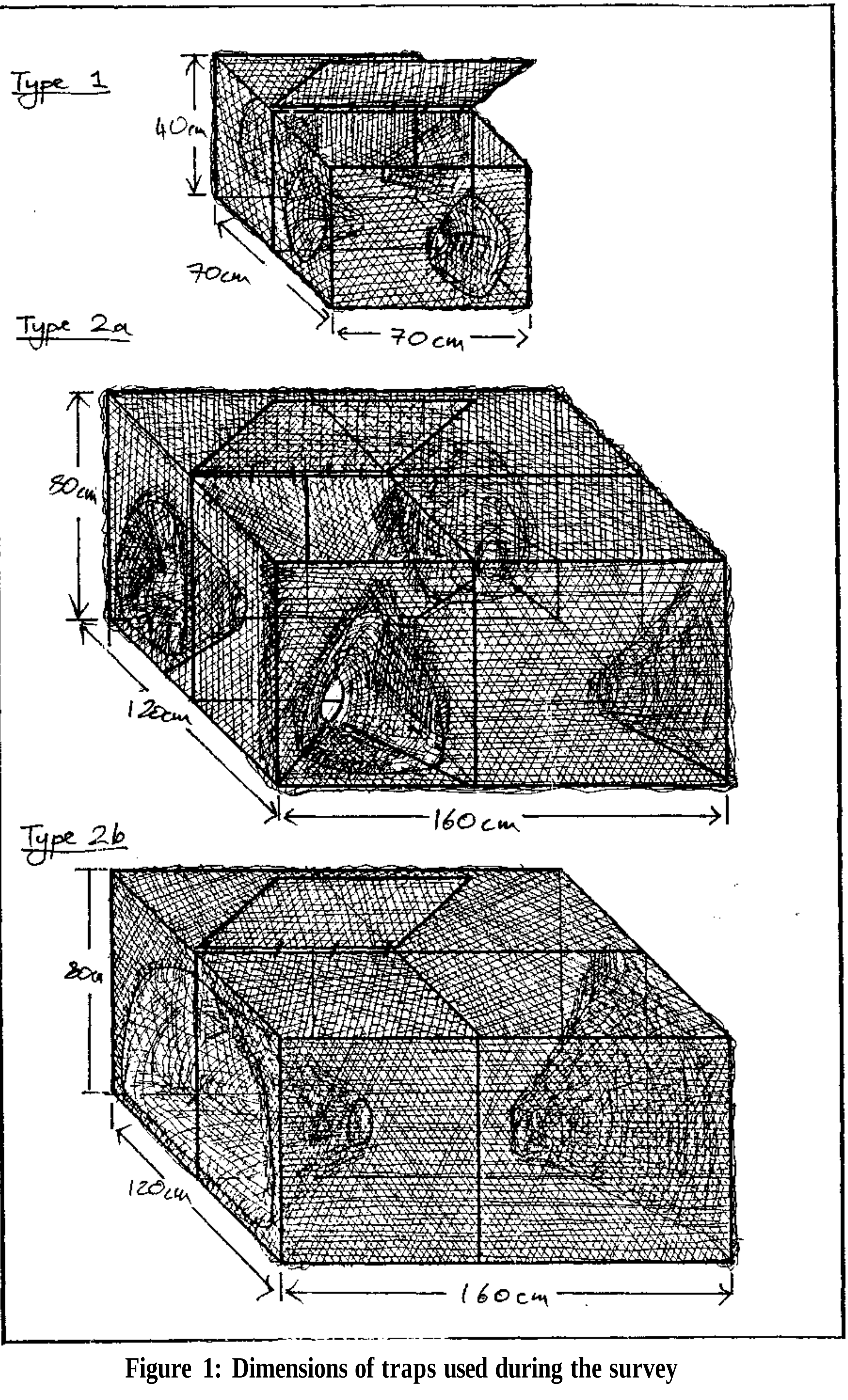

Figure 1: Dimensions of traps used during the survey

Four separate 1.4m lengths of 8mm diameter polypropylene rope were used as a hauling bridle, one being tied through each corner of the trap frame. The ropes were tied to the hauling line independently of each other to avoid trap loss in the event of one or more of them being cut or broken during hauling,

Each large trap was initially made with four conical entrances, about 45cm in diameter at the outer end and tapering down to 5cm diameter at the inner end, as for the small trap type, However, once the fishing trials started it quickly became clear that these traps were yielding poor results, and the entrances were therefore altered on one trap to try to improve its performance. The original entrances were removed, the trap walls re-covered, and two much larger entrances made, one in each of the trap's smaller vertical faces (ends). This trap (type 2b) performed much better than its predecessors and was subsequently the only one used for fishing.

Figure 2: **Final checking of a large trap**

2.1.4 Fish traps

At the request of the Kiribati Fisheries Division, two fish traps were also made and occasionally set during the shrimp trapping operations. These were Z-traps approximately 200cm by 140cm by 120cm high (3.4 cubic metres) and were made from 12mm steel rod and covered in 2-inch cyclone weldmesh. The entrances, also made of weldmesh, were large conical types which pointed upwards to minimise fish escapement. These traps were not intended to catch shrimps and are not discussed further in this report.

2.2 Trap Construction Techniques

2.2.1 Frames

Both trap types had frames made from plain steel rod, of the type sometimes used for reinforcing cement. The rod was purchased in 6m lengths and cut to size according to a pre-calcuiated cutting plan using an oxy-acetylene welding torch.

To minimise the time spent making the frames, a jig was made by welding short (5cm) lengths of 18mm diameter steel rod onto an approximately 2m x 1 m sheet of half-inch (13mm) thick steel plate (figure 2). Using a special bending tool, also made from 18mm diameter steel rod, part of each trap frame could be made by bending longer pieces of steel rod around the jig, rather than welding large numbers of short pieces together. For the welding that was necessary, electric arc welding equipment was used and the negative electrode left permanently clamped to the steel plate of the jig. By resting the trap frame on the jig, it was usually possible to obtain an electrical contact good enough to allow spot welding without the time consuming task of repeatedly clamping on and removing the negative electrode for each fresh piece of steel.

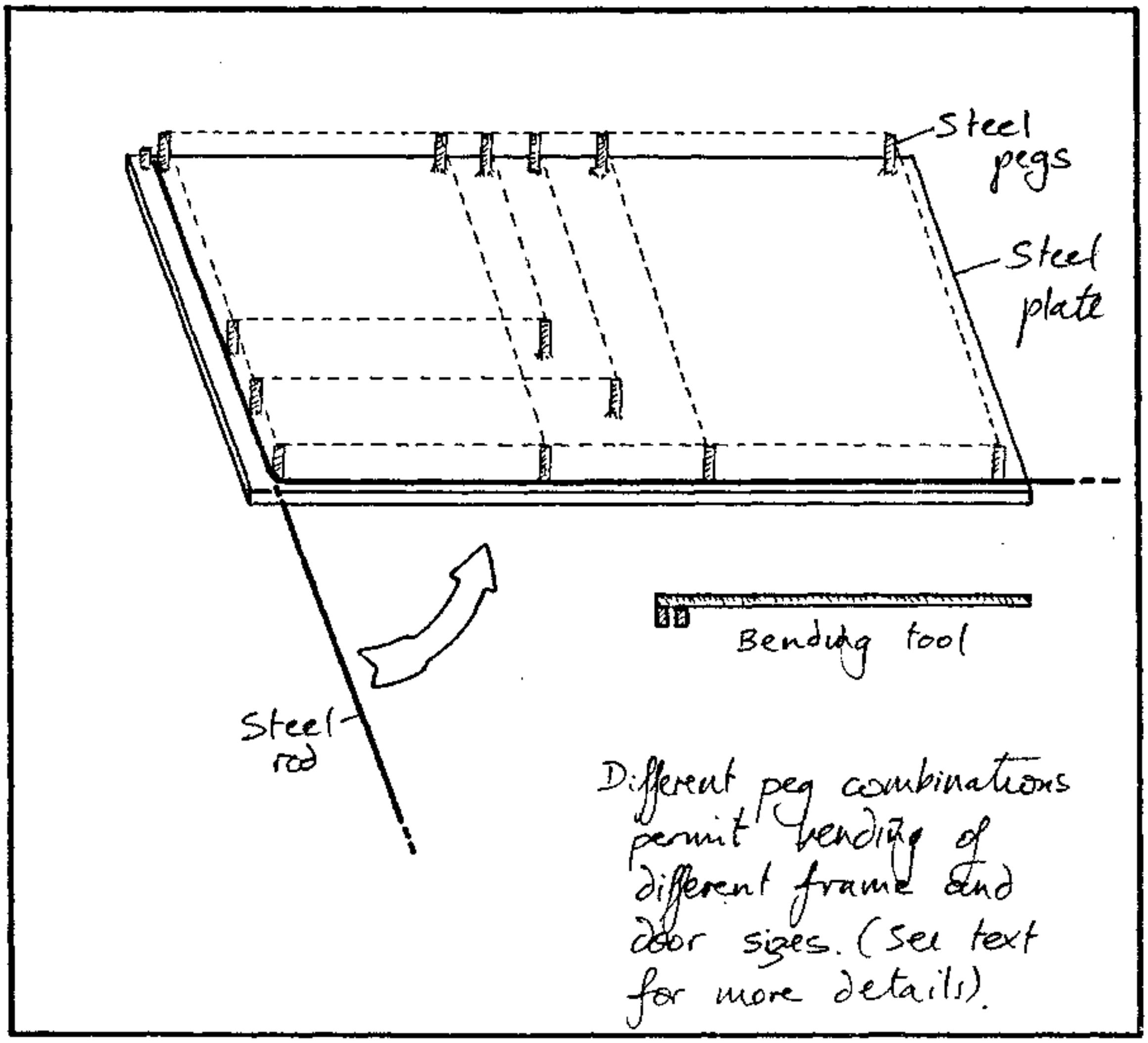

Figure 3: The jig used for bending and welding the trap frames

2.2.2 Doors

Each trap was fitted with an access door on its top surface. The frame of the door was made of the same steel rod as the trap frame, and in the same way, by bending the rod around the jig and then welding the two ends together. Once both frame and door had been covered with wire mesh, the door was attached to the frame using several twists of galvanised steel tie wire, which acted as hinges. The open end of the door was held shut by two fasteners which could be quickly and easily removed and replaced. Each fastener consisted of a loop of rubber cut from an old tractor inner tube with two hooks made of scrap 12-gauge (about 3mm diameler) galvanised steel fence wire bent into It.

2.2.3 Covers

The trap frames and doors were covered with half-inch (13mm) mesh galvanised chicken wire mesh, This material was supplied in rolls 90cm wide by 50m long, and was cut to pieces of the required size using tinsnips. The mesh was attached to the frame using 1.5 inch (38mm) stainless steel fence rings, applied with special crimping pliers. The supply of fence rings proved to have been underestimated and was insufficient for the number of traps being built. On the last few traps the wire mesh was therefore attached by the more usual but time-consuming method of twisting short lengths of galvanised steel tie-wire around the frame members and strands of the mesh.

2.2.4 Entrances

Entrances for the small traps were made by cutting roughly semicircular pieces of chicken wire with a radius of about 40cm, and folding them into cones which were then inserted into the trap walls through cross-shaped holes cut in the chicken wire cover. This method of cutting the trap cover created four triangular flaps which acted as anchor points to which the entrance cone could be attached. Attachment was by means of half-inch galvanised steel fence rings, again fixed in place using special pliers. As with the larger rings, these ran out before all the traps had been completed and the last few entrances were attached using twists of tie-wire.

The original entrances of the large traps were bigger but were made in a similar fashion. However these did not perform well and one trap was subsequently altered. The original entrances were removed and the holes closed, then new holes cut in the ends of the trapsand much bigger entrances inserted. The new entrances occupied the whole of the end wall of the trap and gave vastly improved results (see section 4.3.3).

2.2.5 Bait containers

Bait containers for the traps consisted of folded rectangular pouches made from the same galvanised wire mesh as the trap covers, For the small traps, the pouches were about 15cm square and when filled with bait held about 0.5kg: for the large traps, they were about 20cm square and held about 0.75kg of bait. All bait containers were held in place in the centre of the trap by tying using two lengths of tie-wire. The containers could be easily removed for emptying and rebaiting by untwisting the ends of the tie-wire.

2.3 Trap Lines

2.3.1 General

The configuration of the trap lines is shown in figure 3. All traps were set and retrieved using a hauling line, which was fixed by one end to a series of floats spaced along a float line. The other end was attached to the traps. in the case of the large traps, which were set singly, the hauling line was attached directly to the trap bridle (see section 2.1.2). For the smaller traps, which were set in strings, the hauling line was attached to one end of a bottom line (section 2.3.4) along which the traps were evenly spaced.

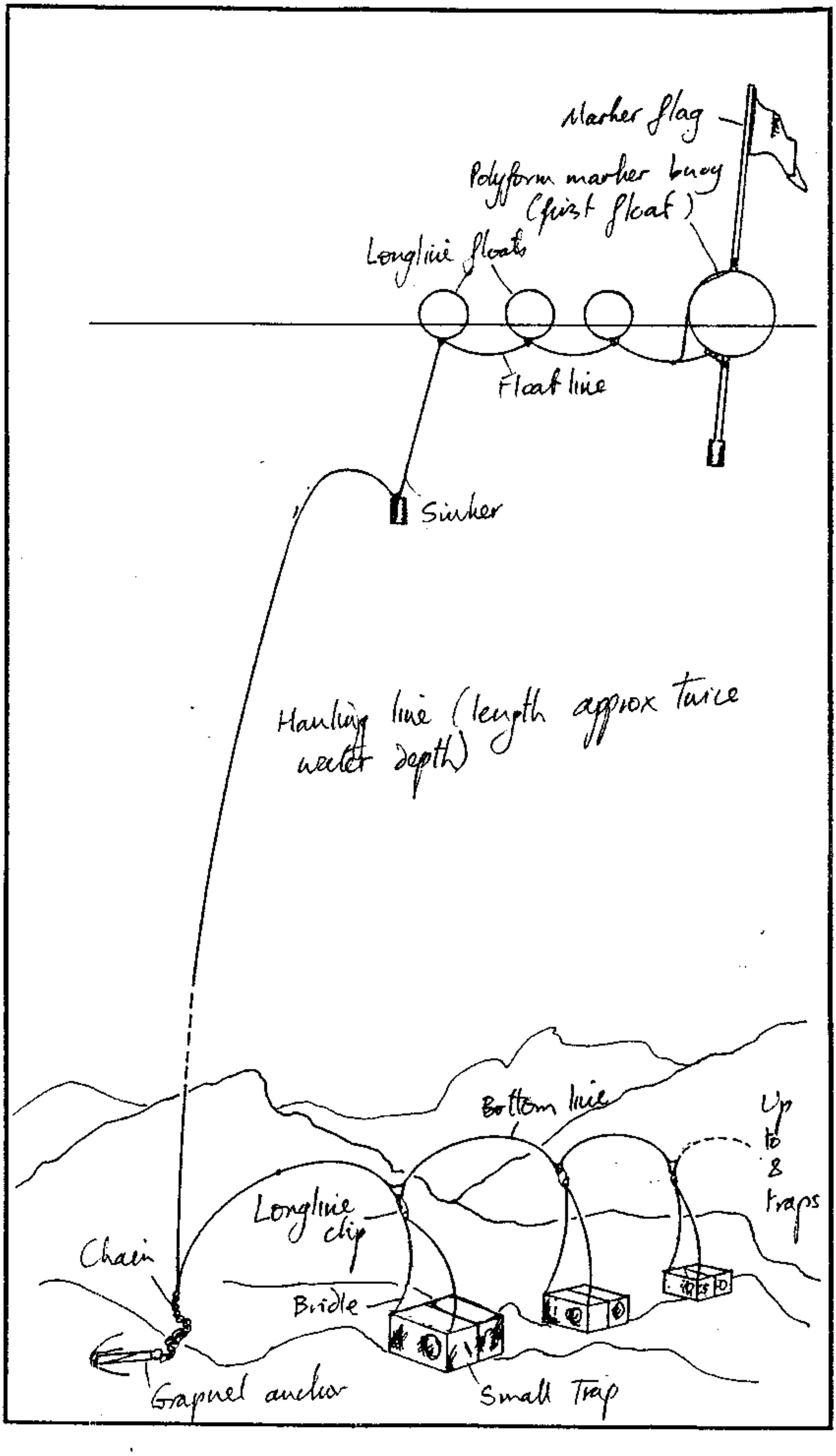

Figure 4: Typical trap and line configuration

2.3.2 **Hauling lines**

The hauling lines were of 10mm diameter 3-strand polyethylene rope, which was delivered in 220m coils. Before the days fishing operations began the ropes were adjusted by cutting and splicing so that the length of the hauling line was approximately double that of the water depth in which the traps were to be set (see section 3 for more detail).

A 2kg scrap iron weight was attached to the hauling line about 50m from the upper end. This acted to prevent any slack line floating to the surface and fouling the vessels propeller during trap retrieval.

Figure 5: **First (flagpole) floats stored on deck prior to attachment to floatlines**

A small grapnel anchor, made from welded and bent 12mm diameter steel rod and fitted with about 2m of 12mm galvanised steel chain, was attached to the hauling line about 20m from the bottom end. This served to anchor the traps and reduce the possibility of their dragging along the bottom after setting.

2.3.3 Float lines

The float line comprised an approximately 20m length of 10mm diameter polypropylene/ polyethylene rope to which four floats on short lengths of rope were tied. The first (distal) float was an approximately 70cm diameter inflatable marker buoy carrying a flagpole. The other three floats were hard plastic pressure-resistant longline balls about 40cm in diameter, which would retain their buoyancy if submerged by currents.

2.3.4 Bottom lines

Bottom lines were used only for the small traps, which were set in strings rather than singly. Each bottom line consisted of a 200m length of 8mm diameter white polyethylene rope. A loop was made in the bottom line every 40m by splicing in both ends of a short (about 20 cm length of blue 8 mm diameter polypropylene rope. The loops were easily visible and served as attachment points for the traps, which were fixed on using heavy duty longline clips (see section 2.1.2).

A 6-10kg scrap iron weight was attached to the free end of the bottom line to help the traps; sink properly, and to reduce the likelihood of trap movement after setting.

2.4 Costs

2.4.1 Materials

Table 1 shows the actual costs of the materials used during the survey, including shipping and other charges where applicable. Since many of the thems required for the survey were either not normally available, or inordinately expensive, in Kiribati itself, most of the materials were purchased overseas and shipped to Tarawa prior to the survey.

2.4.2 Labour

The fact that trap construction is a slow and labour-intensive activity has been documented elsewhere (e.g Mead 1986) and was taken into account in planning this survey. A number of labour-saving devices, particularly the construction of a jig for bending the trap frames (see sectfon2.2.1) and the use of fence rings rather than tie-wire for attaching the chicken wire to the frames (see sect1on2.2.3), were adopted, and it was estimated that these reduced the time taken to complete the traps by at least 50%.

Despite this, trap construction still took longer than expected (3 weeks instead of 2), partly because of late delivery of some of the materials, and repeated electrical power cuts during the welding phase. Records were kept of the hours worked by each of the nine men involved in cutting materials, welding, attaching wire mesh to the traps, or otherwise assisting with their construction, A total of about 450 man-hours went into the trap construction, at an average cost of A$1.8O/man-hour, giving a total labour cost of about A$810. it was estimated that the large traps took about half as long again to construct as the small ones (17 man-hours as opposed to 12) although this was a somewhat subjective assessment given that many Jobs were going on at the same time.

Table 1. Estimated material and related costs for the survey*

ITEM	NUMBER OF PIECES	UNIT COST		TOTAL COST		TOTAL COST (A$)
Trap construction						
10mm ø steel rod, 6m lengths	66	F$	1.89	F$	124.74	163.41
12mm ø steel rod, 6m lengths	25	A$	3.50	A$	87.50	87.50
13mm mesh chicken wire, 30m rolls	4	F$	69.00	F$	276.00	361.56
13mm mesh chicken wire, 30m rolls	2	A$	54.60	A$	109.20	109.20
1.5 inch stainless steel fence rings, approx 178 **rings/lb**	111b	US$	6.00	US$	66.00	98.34
0.5 inch galvanised steel fence rings, approx 500 rings/lb	41b	US$	2.10	US$	8.40	12.52
Fence pliers, large	2	US$	16.20	US$	32.40	48.28
Fence pliers, small	2	US$	9.50	US$	19.00	28.31
Galvanised tie-wire, 100m rolls	2	A$	20.13	A$	40.26	40.26
0.5-inch steel **plate,** 2m by 1m (approx)	1	A$	110.00	A$	110.00	110.00
Various electric welding rods	-		---	A$	50.00	50.00
Freight charges (USA)	-		---	US$	135.75	202.27
Wharfage and storage charges (Kiribati)	-		---	A$	34.59	34.59
SUB-TOTAL - Trap construction						1346.24
Other costs						
Polyform buoys	10	NZ$	80.70	NZ$	807.88	638.22
Longline floats	30	A$	17.50	A$	525.00	525.00
8mm ø polyethylene rope, 200m coils	5	CFP	2675	CFP	13375	171.47
10mm ø polyethylene rope, 200m coils	36	F$	28.35	F$	1020.60	1336.99
Heavy duty longline clips	77	CFP	100	CFP	7700	98.72
Documentation charges (Fiji)	-		—	F$	40.00	52.40
SUB-TOTAL-Other costs						2822.80
TOTAL						4169.04

2.4.3 Cost per trap

Based on the known material costs and estimated labour inputs, the cost of constructing each trap type is shown below.

* Currency conversions based on SPC exchange rates in January 1987:

A$ 1,00 =	F$	0.7634
	US$	0.6711
	NZ$	1.2658
	CFP	78

Table 2. Estimated trap construction inputs

INPUT PER TRAP	TRAP TYPE SMALL	LARGE	TOTAL inPUT
Labour (man-hours)	12	17	450
Labour cost (A$)	20.75	31.25	810.00
Material cost (A$)	24.93	99.72	1346.24
Cost per trap(A$)	45.68	130.97	-
Number built	30	6	36
Total cost (A$)	1370.40	785.82	2156.22*

*Does not tally exactly due to rounding.

It is possible that labour costs could be cut down over the longer term, but subsequent discussions in this report are based on actual costs only.

3. FISHING OPERATIONS

3.1 General

The period available for fishing was less than expected (3 weeks instead of 4) because the trap construction took longer than anticipated. 13 days were spent fishing, with some days spent repairing or modifying some of the traps. No time was lost due to bad weather, althouhg one fishing day was lost due to mechanical problems with the survey vessel, Nei Tewenei.

Figure 6: Large traps stored on the upper deck of the Project vessel Nei Tewenei

The traps, floats, lines and other fishing materials were progressively loaded on board the Nei Tewenei during the first three weeks of the survey programme. Shallow water prevented the vessel approaching too closely the locality of the workshops in which the traps were being assembled. The vessel was therefore moored in the lagoon some distance away and loading done using a flat-bed truck and an 8m outboard powered fibreglass skiff. All gear was subsequently left on board until the completion of the survey programme. Traps which needed to be repaired or altered were fixed on board.

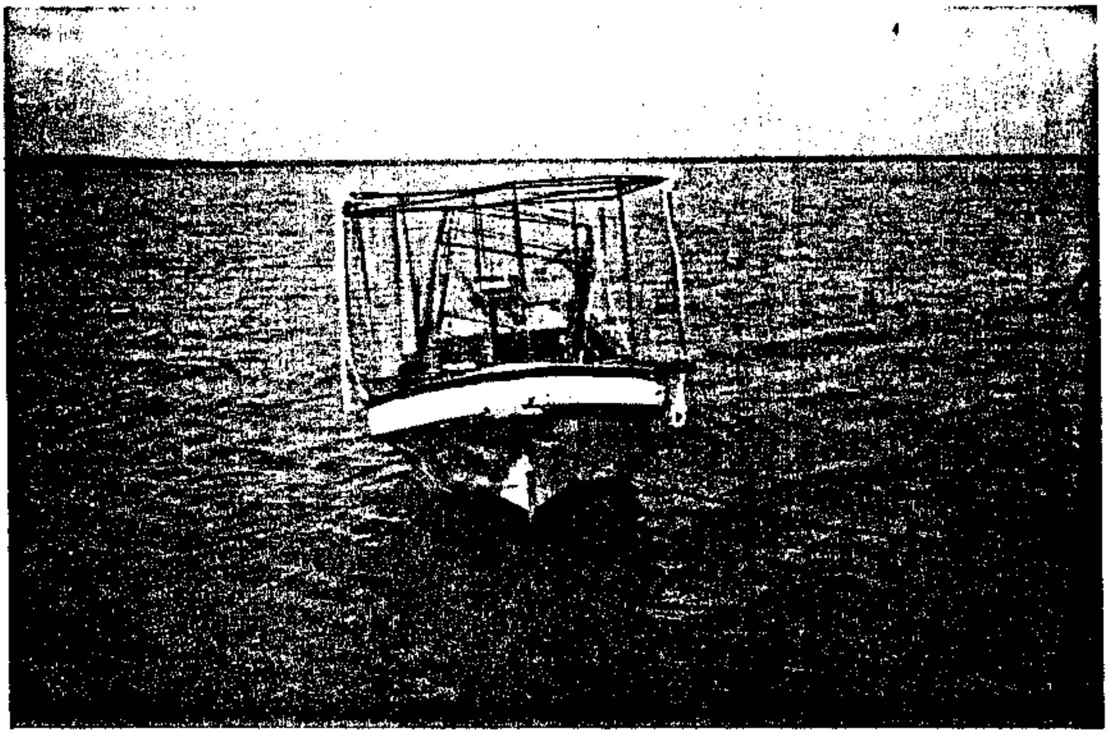

Figure 7: Using an outboard-powered skiff to transport traps

3.2 Boat and equipment

The Fisheries Division's vessel Nei Tewenei, a 15.2m LOA x 4.8m beam steel boat originally built for prawn trawling in Australia, was used exclusively during the survey. The vessel was manned by a skipper and six crew (plus the consultant), all of whom were involved fully in the fishing operations.

Nei Tewenei had a large working deck space (approximately 3.6m x 4.0m) as well as an upper deck of 3.6m x 2.6m which was used for trap storage. Equipment on the vessel that was used in the survey included the following:

a roughly cubic ice box, about 1.5 m long on each side, positioned in the forward centre part of the working deck. The box, which was partitioned into three equal-sized compartments, was used for storing some of the hauling lines. The rest were stored in empty oil drums carried especially for the purpose;

a Furuno NC-50 paper echo-sounder capable of sounding to depths of over 5000m.

a horizontal-sheave longline hauler with a load capacity of about 800kg. The hauler was positioned in the forward starboard area of the working deck and allowed lines to be pulled over the starboard side of the boat using a pivoting guide roller mounted on the gunwale. This arrangement was used for hauling all the traps;

Figure 8: The horizontal sheave hauler and gunwale line roller used for hauling the trap lines. The rope is being flaked into an empty oil drum

3.3 Fishing Techniques

3.3. f Fishing regime

Fishing was carried out on a daily basis. The normal daily routine involved picking up bait, which was frozen low-grade skipjack and yellowfin tuna obtained from the national fishing company Te Mautari, in the morning, then leaving port and locating the trails that had been set the previous day. These were hauled and the catches bagged and placed on ice. Soundings were then carried out in and around the next area chosen for fishing. Once the bottom had been thoroughly investigated, the lines were spliced to the right length for the depths to be fished, and the traps readied and set. On most days six or seven sets were made, five or six of strings of small traps and one of a large trap. All sets were overnight, the traps being dropped in the late morning or early afternoon of one day and recovered as early as possible the following day. All sets were of between 17 and 24 hours duration, except for one day when the traps were left out for 48 hours due to a mechanical problem with Net Tewenel.

The boat normally returned to port in Betio, Tarawa, after the completion of each days fishing, usually by late afternoon. The remainder of the day was spent in sorting the catch, recording fishing data, and carrying out gear repairs.

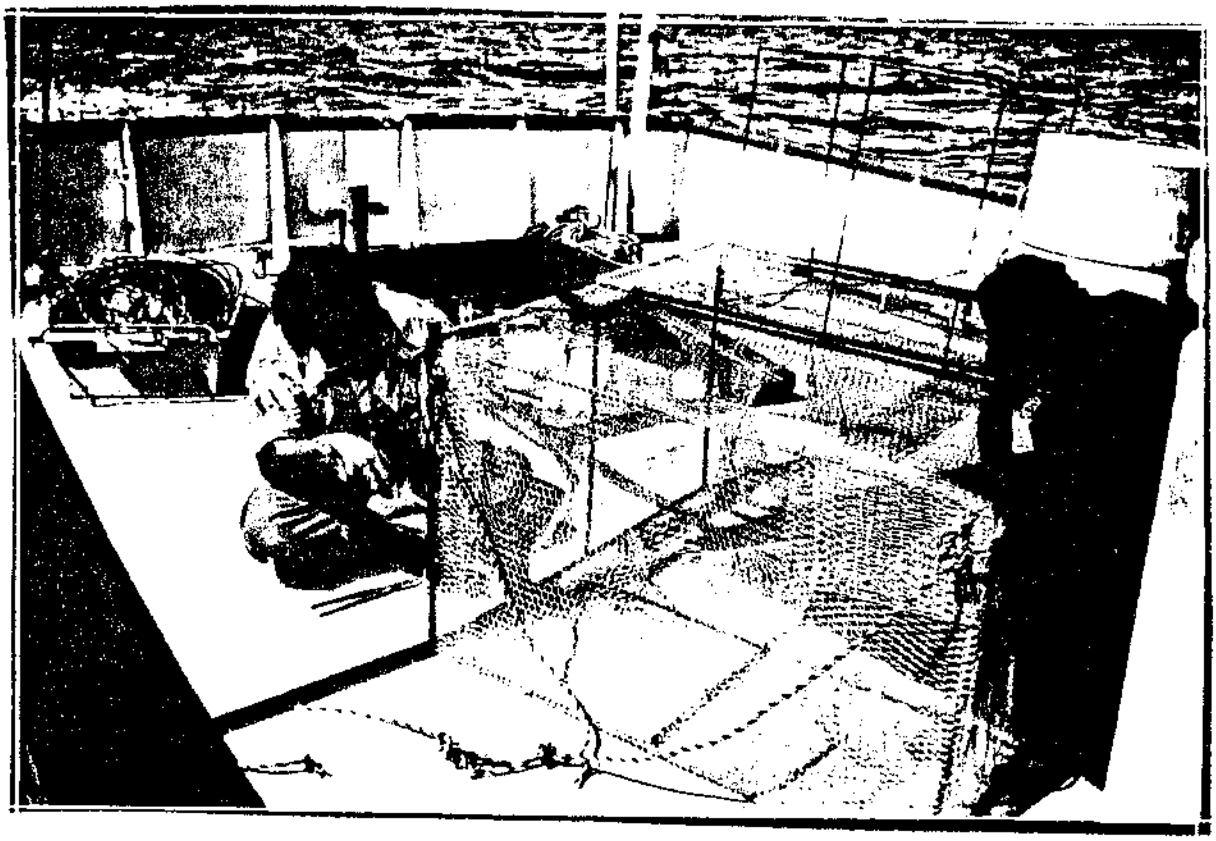

Figure 9: Carrying out trap repairs between trips

3.3.2 Setting procedure

Prior to setting the traps, the sea bed in the area where the set would be made was investigated using the echo-sounder to determine the depth, bottom profile, and, if possible, bottom type. Once the approximate setting location was decided, the hauling lines were adjusted to a length approximately twice that of the water depth. This high safety factor in the length of the hauling line was necessary to allow for the extreme bottom irregularities and strong currents expected in some parts of the survey zone.

The traps to be set were placed at the stern of the boat. The trap bridles were clipped into the eyes on the bottom line, care being taken to ensure that the traps were in the sequence in which they would go into the water, and the bottom line tied to the other end of the hauling line. (in the case of large traps, which were set singly, no bottom line was used, the trap being attached directly to the hauling line using the four short lengths of rope tied to the corners of the trap). The sinker and grapnel anchor were attached to the hauling line at the appropriate points and the float line tied to the other end. The bait containers were filled and tied in place in the centre of the traps using tie-wire, and the doors hooked shut using the fasteners.

The boat was then motored slowly over the setting area until the desired setting location or depth was found. The traps were tot go one at a time over the stern, then the boat motored full ahead so that the hauling line was paid out and the floats pulled over the side.

Figure 10: Small traps stacked on deck prior to setting

3.3.3 Hauling procedure

When hauling the traps, the marker floats were approached from downwind and the float line retrieved by one of the crew with a boathook. The floats were brought aboard on the starboard side of the vessel, the hauling line placed in the line hauler sheave, and the hauler started. Once a reasonable amount of line was on board the float line was untied from the hauling line and the floats put aside. The hauling line was flaked into the deck ice box or an empty oil drum as it came aboard, one end being tied off to a convenient point so that it could be easily found again for the next set.

The hauler was stopped at the appropriate points to allow removal of the sinker tied onto the hauling line about 50m from the upper end, and of the grapnel anchor tied about 20m from the lower end. When the end of the hauling line was reached the knot connecting it to the bottom line was helped around the hauler sheave by one of the crew to prevent it slipping. Hauling continued at a slower speed, stopping each time a trap came up against the side of the boat while the trap was manhandled aboard and unclipped. This process continued until all the traps had been recovered.

Figure 11: Recovering a large trap

Considerable care was required in manoeuvering the boat during the hauling process to avoid breaking the hauling line, which happened on several occasions. it was necessary to keep the boat as close as possible to its original station and counter the drifting caused by wind and current, both of which were strong on some occasions. The use of a heavier hauling line was not possible since the 10mm diameter rope already in use was the largest size that would fit in the Ne1 Tewenei's hauler sheave. However, since the hauling line is the most valuable part of the fishing gear, it would be desirable in a commercial situation to use larger diameter rope to minimise the chance of breakage and consequent rope loss. This is in fact the practice in the Hawaiian fishery, where hauling lines of up to 20mm diameter are commonly used (B. R. Smith, personal communication).

As each trap was brought on board the catch was emptied out, the bait container removed and any unused bait thrown away. The bait containers were refilled with fresh bait and replaced if the traps were to be reset again straight away.

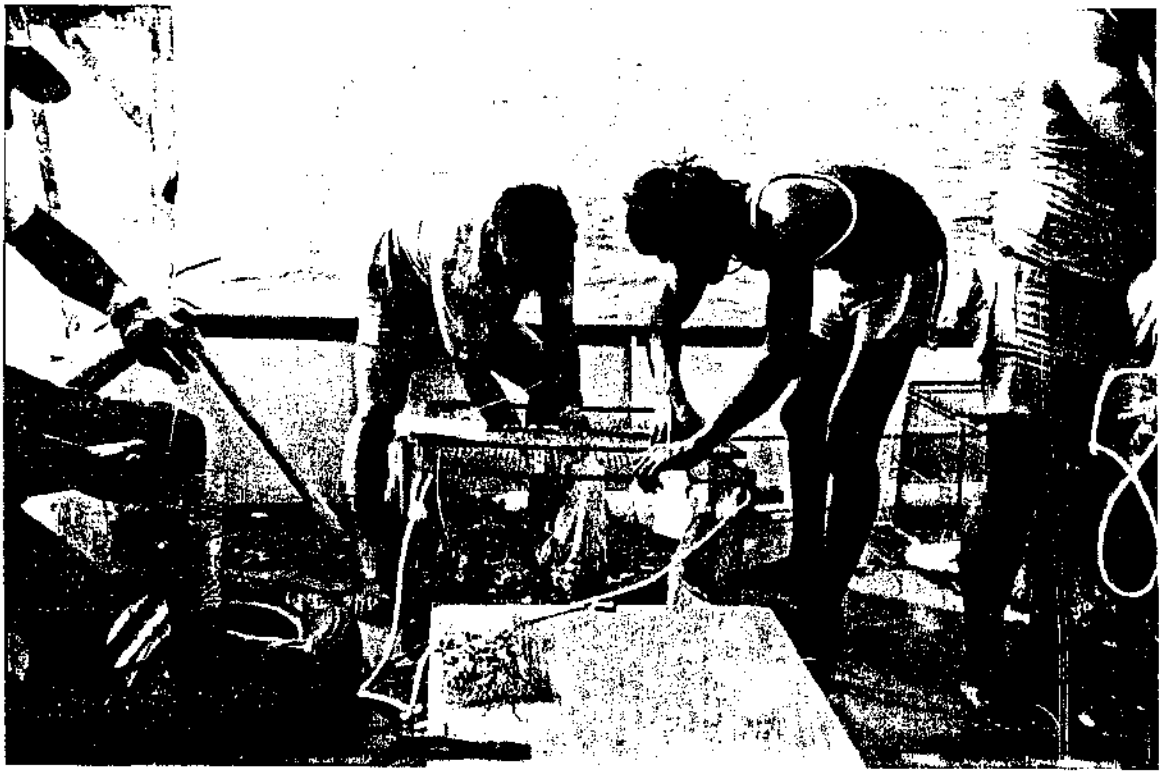

Figure 12: Emptying a freshly-hauled small trap

3.3.4 Catch handling

As each trap was brought aboard its catch was emptied into a plastic bag marked with an Identification code, and placed on ice for later sorting. When the vessel returned to port at the end of the days fishing, the catches were sorted according to size and species and the relevant catch data was recorded. Several specimens of each major shrimp species, plus any unusual or unidentified specimens, were preserved in 90% alcohol for later identification by taxonomic specialists, The rest of the shrimps were replaced in plastic bags and frozen in a domestic chest freezer at the Fisheries Division's headquarters. Several samples were sent by the Fisheries Division for evaluation by potential buyers in Australia and Fiji. The results of these evaluations were not available at the time of compiling this report. Any fish or other non-shrimp catches were given to the crew.

3.3.5 Data collection

A variety of information on the fishing operations was collected using a mixture of standard forms, maps and charts, and ordinary note-taking. For each set, records were kept or notes made of the following information: fishing location; water depth (measured at the times of both setting and hauling); bottom profile or topography; time, date and position of setting and hauling; number and type of traps in each set; total catch weight from each trap; identity and approximate percentage composition (by weight) of dominant species in each trap catch; and size composition of samples of dominant species.

Figure 13: Weighing individual trap catches

in addition, some estimates were made of the recovery rate (ratio between tail weight and whole weight) from different size classes of the more Important species in the catch.

5.4 Fishing locations

Suitable areas for deep-water shrimp trapping in the Gilbert islands group are few and limited in extent. The steep gradients of the outer reef slopes in most areas limit the habitat for the shrimps (water depths of 200 to somewhere over 700m) to a narrow band several hundred metres outside the reef.

It was originally intended to carry out trial fishing in the three areas, selected because they appeared to be of suitable depths for deep water shrimp fishing and were reasoanbly accessible from Tarawa, where the survey vessel was based. These areas (shown in figure 14) were: the leeward (western) reef slopes of Tarawa atoll; the Maiana banks, a saddle of (relatively) shallow water running between Tarawa and Maiana island; and, if time permitted, small ledge areas off the islands of Abaiang and Maiena. However, because construction of the traps took longer than anticipated, there was insufficient time to adequately cover all these areas, and the fishing plan was subsequently revised to exclude the Abaiang ledge and Maiana bank areas.

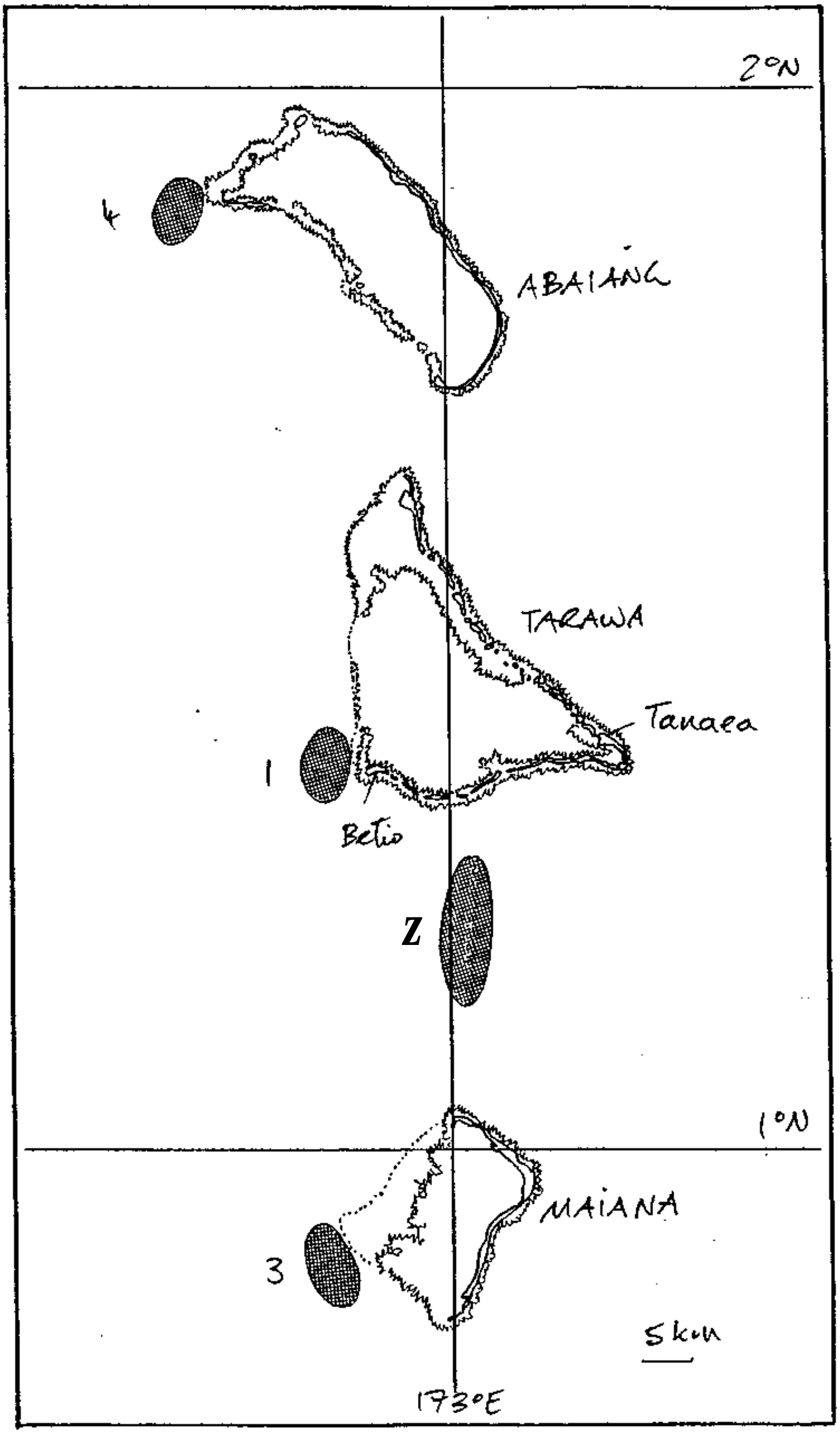

Figure 14: Planned survey fishing areas. Areas 3 end 4 were were ultimately dropped from the survey and area 2 only partly fished due to heavy gear losses

4. FISHING RESULTS

4.1 Fishing zones

4.1.1 Areas

Trial fishing was carried out in two general areas: the Malaria banks, a saddle running south from the southern end of Tarawa; and the outer reef slope of the south western part of Tarawa. Figure 15 shows the locations in which traps were set.

Fishing on the Maiana banks was very unsatisfactory. The saddle of the sea floor appears to have a venturi effect on the south equatorial current which flows strongly in this area, reaching average speeds of at least three knots and with violent surface and subsurface eddies. The seabed is highly irregular and appears to be composed of steep pinnacles and gullies which, combined with the effects of the current, made it very difficult to position the traps with any precision, and caused serious problems with hauling the strings of small traps. The first three days were spent fishing on the Maiana banks, during which time 12 smell traps were lost (47% of the total of 26 small traps which were lost during the survey. The trap loss problem did not occur with the large traps, which were always set singly rather than in strings). These losses were considered too heavy and no further fishing was carried out in this area.

Fishing conditions on the south-western outer reef slope area of Tarawa were better, although still far from ideal. The seabed sloped downwards with a steep gradient (about 400m vertical drop for each nautical mile of distance from the reef, or a gradient of over 1 in 5 (22%)). The seabed was less irregular than on the Maiana banks, and currents were weaker, being generally between 0 and 1 knot. Most fishing was carried out in this area.

4.1.2 Depths

The steeply sloping and often irregular seabed made it very difficult to accurately ascertain the true depth in which a given trap had been fishing. The depth measured at the time of setting would often differ from that measured when hauling, because of the effects of depth variation within the cone of sensitivity of the echo-sounder, and because of differences in the position of the boat relative to the traps on the bottom. it also seems likely that different traps within a string would have been fishing at somewhat different depths.

in practice, depth measurements at the time of setting and hauling were averaged, and this value assumed to be the depth at which all traps in a given string were fishing. Depth data presented in this report are therefore the best estimates it was possible to obtain but should not be regarded as being precise measurements.

Traps were set in depths varying between 200 and 760m. The first sets were made systematically in 100m increments throughout the depth range which had yielded catches of deep-water shrimps in other Pacific island countries (200, 300, 400, 500, 600 and 700m). As the trials progressed those depths which consistently gave low catches were progresively abandoned in favour of those where the returns were better. This was done in order to optimise catches and be able to make realistic estimates of yields under a commercial fishing situation. Towards the end of the survey, most fishing was being carried out in the most productive depth range, between 400 and 500m, although occasional sets were still made in other depths.

Although only a limited amount of successful fishing was carried out in the Maiana banks area, there did not appear to be significant differences from the south-west Tarawa area in either the amount or the composition of the catch.

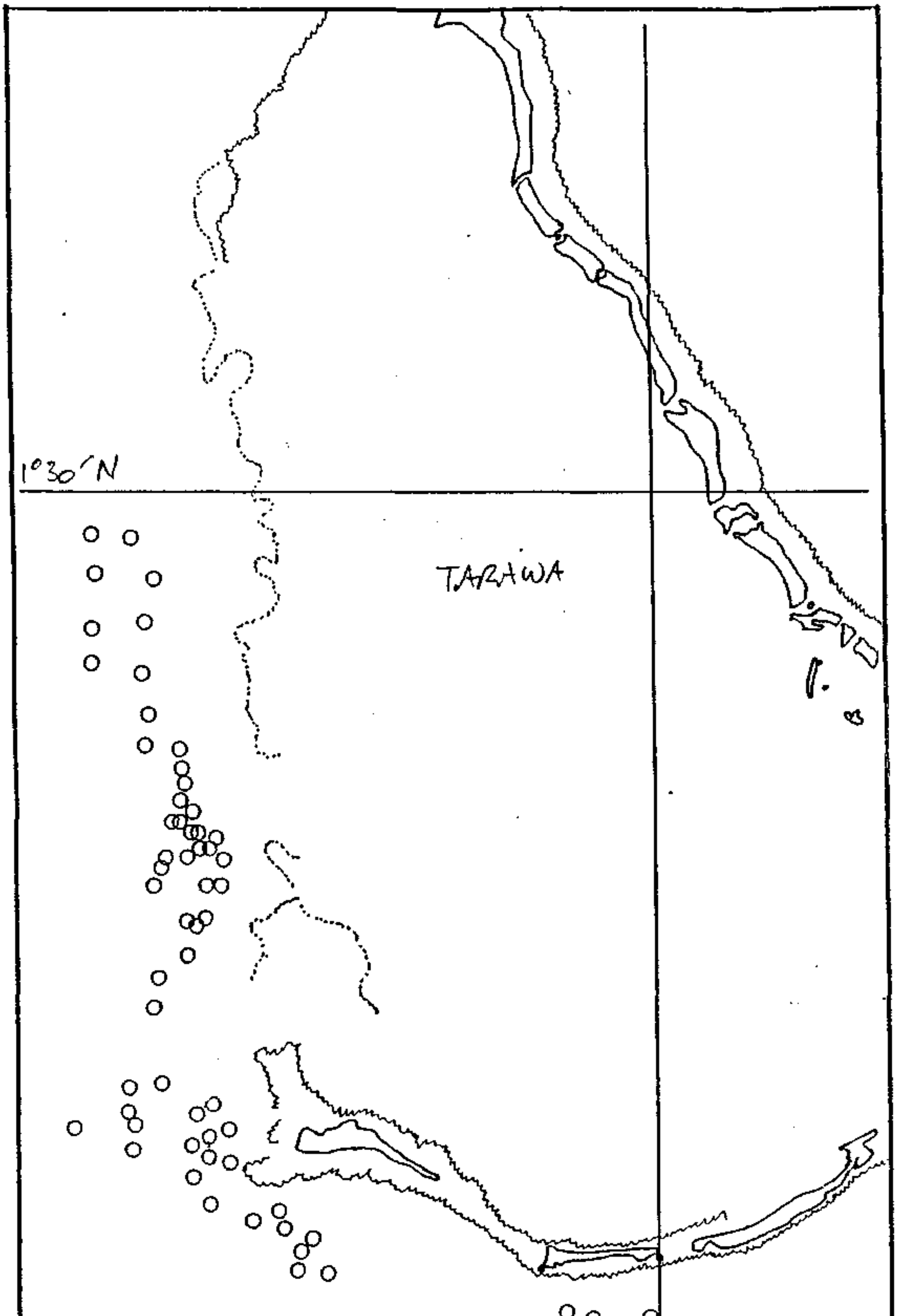

Figure 15: Distribution of trapping effort during the survey

4.2 Catch and effort

4.2.1 Effort

13 days were spent in effective fishing, during which time, a total of 280 traps (265 small traps and 15 large ones) were dropped. 26 of the small traps were lost due to entanglement on the bottom, and have therefore been excluded from the catch and effort results in the discussions which follow. The first 7 of the large trap sets were ineffective due to faulty entrance construction, these too have been excluded from the results. The remaining 8 large trap sets were made after the entrances had been modified.

The effective fishing was therefore 239 small trap sets and 8 large trap sets, mostly of between 17 and 24 hours duration (14 small trap sets and 1 large trap set lasted for48 hours). Of this effort, 40 small trap sets were in the Maine banks area, the remainder (199 small trap sets and 8 large trap sets) being in the south-west Tarawa area.

4.2.2 Catch rates

Small trap catches ranged from zero to a maximum of 4.31 kg/trap. The overall average catch rate for the small traps was 0.72kg, increasing to 1,04kg for the optimum fishing zone (400 to 500m).

Figure 16: Typical small trap catch

The large traps did not initially work, apparently because the entrances were not functioning correctly. One large trap was subsequently modified (see section 2.2.4) and its entrances improved, after which it worked effectively. Of the 15 large trap sets, 8 were made using this modified trap, and these are the only results considered in this report.

The aim of using large traps was to obtain an indication of the effects of trap size on catch rates. The large traps were therefore set only in the optimum fishing zone (400 to 500m). Catch per trap ranged from zero to a maximum of 9.30kg, with an average of 4.04kg, or about 4 times the catch of the small traps in the same depth zone.

4.2.3 Total catch

The total catch from all areas and depths was 201.4kg of deep water shrimps, plus occasional eels, fish, crabs and other animals which entered the traps but were of no commercial significance. 165.8kg of the catch was taken in small traps, the remainder (35.6kg) in large traps.

Figure 17: A pike-eel (f. Muraenesocidae) taken from one of **the** traps

in some locations cannibalism among trapped shrimps has been noted in traps left on the bottom for times exceeding 12 hours (King 1986). When cannibalism occurs 1t is evident from the numbers of empty thoracic carapace segments which remain in the trap. These were not numerous in the catches taken during this survey, and it therefore appears that cannibalism did not occur to any significant degree even though the traps were being soaked for relatively long periods of time.

4.2.4 Catch variation with depth

Fishing was carried out throughout the depth range between 200 and 760m. Figure 18 shows the depth distribution of total catch per small trap. Overall, the highest catches were obtained in depths of 400 to 500m.

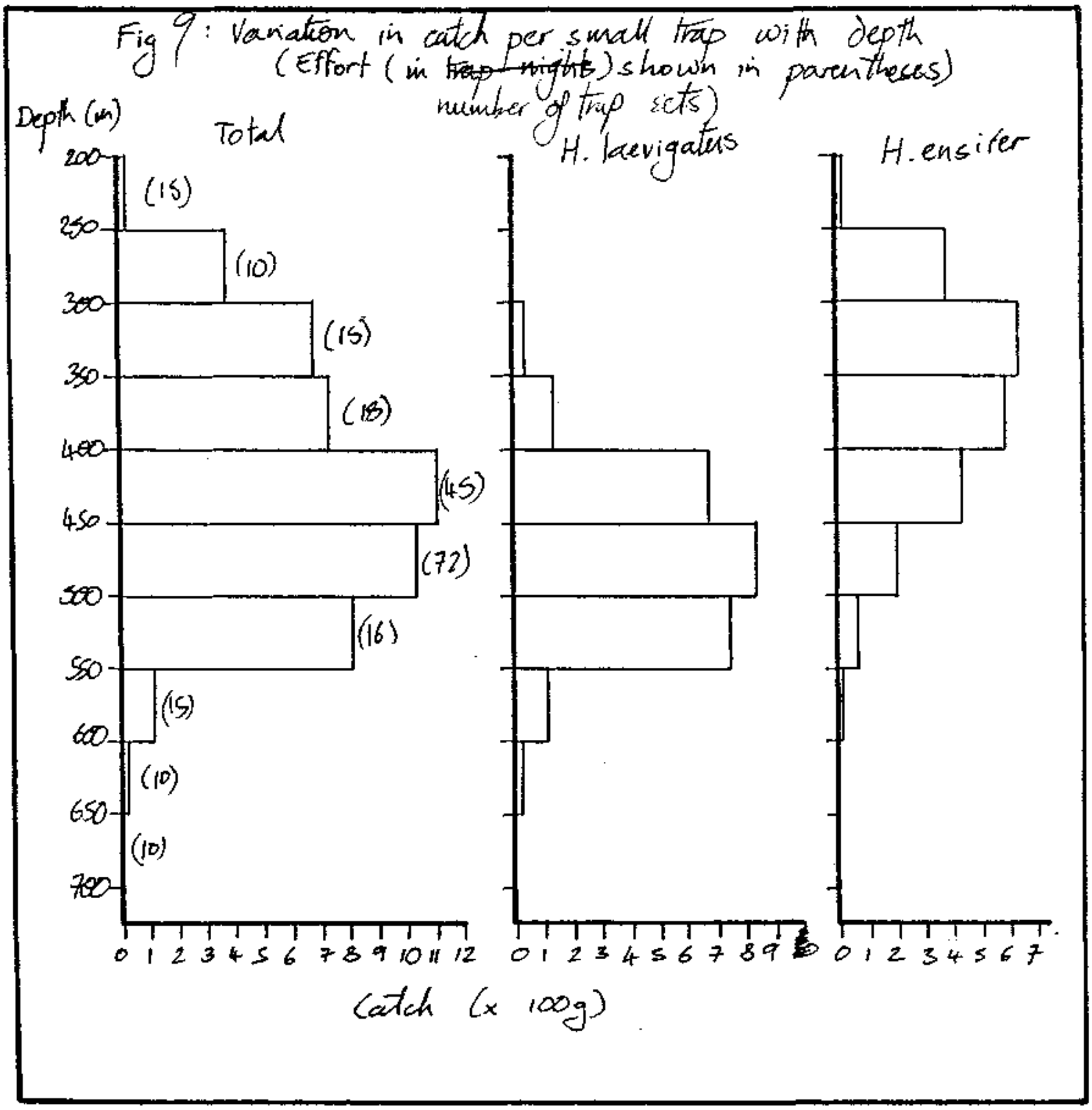

Figure 18: Variation in catch per small trap with depth. Effort (in number of trap sets) is shown in parentheses

4.2.5 Bait

The bolts used were frozen skipjack and yellowfin tuna. No differences in the effectiveness of these two baits were detected from the catches obtained.

4.5 Species composition

4.3.1 Major species

The following seven species of deep-water caridean shrimp were found in the trap catches:

Heterocarpus laevigatus (smooth nylon shrimp)
Heterocarpus ensifer (armed nylon shrimp)
Heterocarpus qibbosus (humpback nylon shrimp)
Heterocarpus sp. (unidentified)
Plesionika martia (golden shrimp)
Plesionika carinata?
Parapandalus sp. (unidentified)

Specimens of each species were carried to Noumea after the conclusion of the survey and the identifications confirmed by taxonomic specialists at the Noumea headquarters of the French research institute ORSTOM. Specimens of the two unidentified species were forwarded to the Musée Nationale d'Histoire Naturelie in Paris for further examination, the results of which were not yet available at the time this report was prepared.

Heterocarpus laevioatus and H. ensifer together made up about 995? of the catch weight (64% H. laevigatus. 3551 H. enslfer) and were the only two species likely to have any commercial significance. Heterocarpus gibbosus. which made up a substantial portion of the catch during surveys carried out in Fiji (King 1984) was only occasionally noted during this survey. The other species, which are of less commercial interest than the Heterocarpus genus because of their generally smaller sizes, were also only found in small quantities, a feature which was consistent with most other surveys carried out in the region.

4.3.2 Species variation with depth

Figure 9 shows the depth distribution of small trap catches of the two principal species, Heterocarpus laevioatus and H, ensifer. respectively. Heterocarpus laevigatus showed a peak of (abundance from 450 to 550m (0.81 kg/trap), H, enslfer at 300 to 400m (0.61 kg/trap).

4.4 Size composition

4.4.1 Average size per trap

in marketing shrimps of any sort, size 1s an Important factor affecting their value. During this survey, individual shrimp size varied greatly both within and between species. Some attempt was therefore made to assess the size distribution of shrimps in the catch.

The average weights of the catch of Heterocarpus enslfer and H, laevioatus from each trap were determined by dividing the total weight of each species in the trap by the total number of individuals. Average weights obtained in this way for H. ensifer varied from 3.6g to 9.0g, but for the most part lay close to 6.6g. For H, laevigatus the average weight per trap varied between 4.7g and 46.6g, with a mean of 14.5g (see also section 4.4.2).

4.4.2 Size variation with depth

As with the species composition, size composition varied with depth. This was assessed only in a subjective fashion. in general, for both Heterocarpus species the smallest individuals were found in the shallowest depths. For H. laeviaatus in particular it was noticeable that the sets made at the lower end of the species' depth range (550-650m) contained higher proportions of larger individuals, although the catches themselves were lower.

4.4.3 Grading of Heterocarpus species

Catches of the two most Important Hetflrocarpus species were graded according to the three size categories used by King (1986) as indicators of value on the Hawaiian market: large (less than 25 shrimps/kg, or weights greater than 40g/1nd1v1dual); medium (between 45 and 25 shrimps/kg, or between 22 and 40g/1nd1v1dual); and small (more than 45 shrimps/kg, or less than 22g/1ndividual). Overall proportions, by number and weight, of the three sizes in the total catch were as follows;

Table 3: Proportions of size grades in the Heterocarpus catch

	Heterocarpus laevigatus (%)		Heterocarpus ensifer (%)	
	number	weight	number	weight
Large (>40g)	6.4	12.7	0	0
Medium (22-40g)	30.2	33.2	0	0
Small (<22g)	63.4	54.1	100	100

Figure 19: Grading of Heterocarpus species by size

4.4.4 Recovery rates

Samples of a variety of sizes of the two dominant Heterocarpus species were weighed whole and then beheaded and re-weighed, to obtain an estimate of the recovery rate, I.e. the proportion of the body weight which is made up of saleable tall meat. Recovery rates were measured with the shell on and varied very little among the different size classes, averaging 45% for all sizes combined.

5. DisCUSSION

5.1 The resource

5.1.1 Fishing grounds

It was fairly clear before the survey started that the extent of deep water shrimp habitat around the islands of Kiribati is not great. Suitable depths for the shrimps are limited to narrow bands around most of the islands and atolls of the group, and a small number of shelving areas such as the Maiana banks. The coverage and density of soundings marked on navigational charts of the group are not adequate to enable a precise estimate to be made of the area of seabed which would provide a suitable habitat for the shrimps. However, a very rough estimate for the three islands of Tarawa, Maiana and Abaiang would be approximately 630 sq km of seabed between 200 and 700m, of which about 208 or 125 sq km lies 1n the optimum fishing depth of between 400 and 500m. The estimated distribution of deep water shrimp habitat around the three islands is shown in figure 20.

Survey fishing results demonstrated that within this limited habitat area further limitations were Imposed by difficult fishing conditions. Deep water shrimp trapping during the survey was extremely challenging, certainly far more difficult than in other countries where the authors had been involved in similar trials (New Caledonia and Fiji). Major problems were experienced in accurately setting the traps at the desired depths, and there was a high incidence of gear loss for traps that were set in strings (although this was subsequently reduced by limiting fishing to the easier grounds). Rough bottom conditions and very strong currents effectively made fishing Impossible on the Maiana banks, one of the larger grounds where deep water shrimps could be expected. in the south-west Tarawa area, much care was needed to select precise areas of seabed which were not too steeply sloping and did not prevent too great a threat of trap fouling.

Available navigational charts do not provide much information on the nature ami slope of the seabed around the Gilbert islands. What information there is, however, indicates that potential deep water shrimp grounds in other parts of the group are probably similar in nature to those around Tarawa.

5.1.2 Comparative abundance

Part of the aim of this survey was to provide a comparative assessment of the abundance of Kiribati's deep water shrimp resources. Effort was taken to ensure that the trap design used would give results which could be compared to those obtained from earlier surveys or trapping experiments carried out in the region.

Table 4 shows broadly comparable catch rates achieved during surveys in other Pacific island countries using traps of less them 0.3 cubic metres volume in local optimum fishing depths. The level of catches achieved during this survey, about 1.0kg per small trap, were somewhat below the average of those obtained elsewhere.

When making a direct comparison of catch rates in this way it should be borne in mind that both environmental conditions and fishing techniques differed substantially between locations. Differences in such factors as the type of bait used, or apparently minor aspects of trap design, can have an important influence on catch rates. The above figures should therefore be regarded as indicative only. Substantial further research work aimed specifically at resource assessment is needed to refine these estimates to the point where they can be considered truly representative of the Gilberts group.

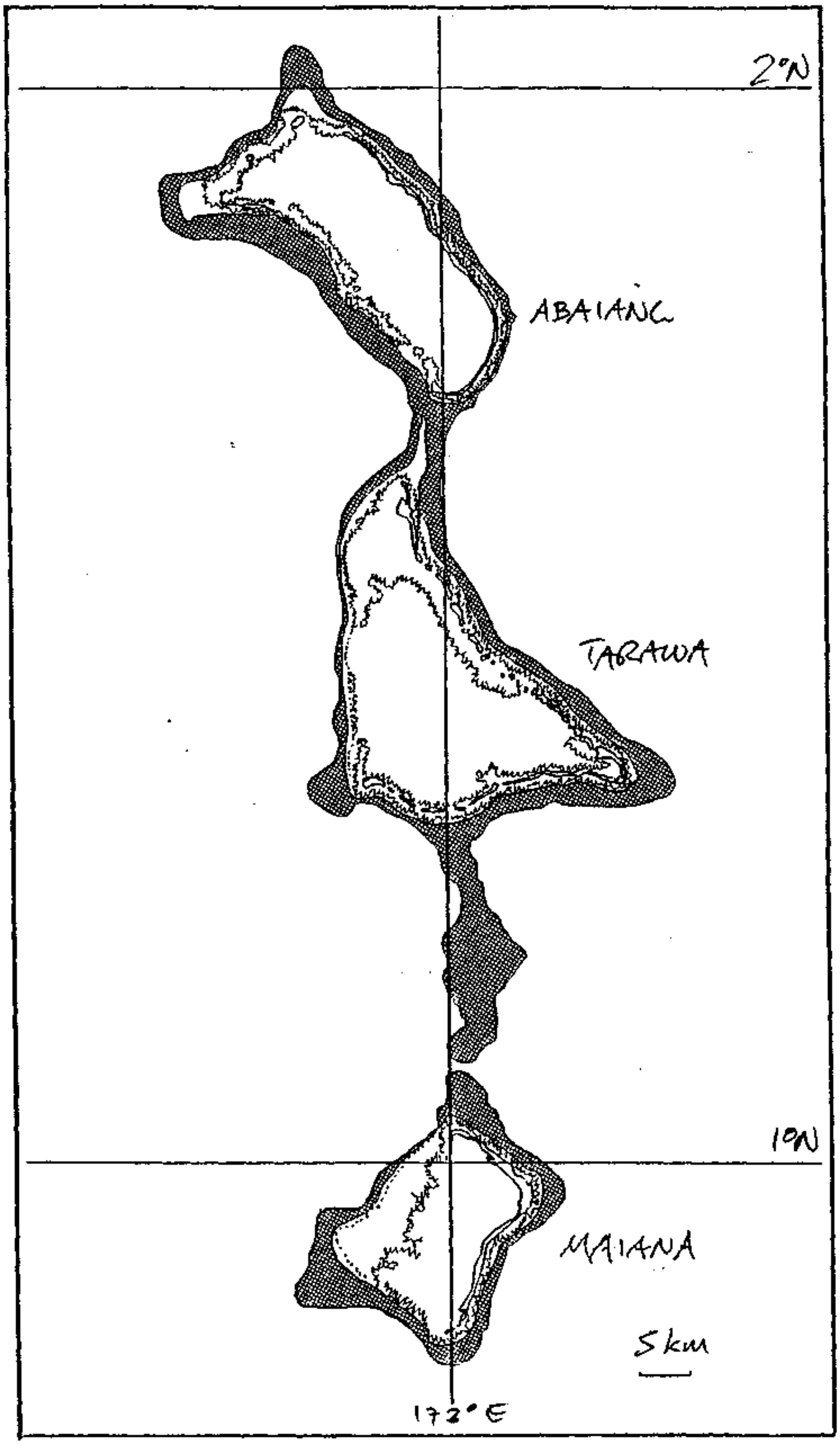

Figure 20: Estimated extent of deep-water shrimp habitat (area between 200m and 700m depth contours) around Tarawa, Maiana and Abaiang. Total area = approx. 630 sq. km.

Table 4. Catch rates obtained from deep water shrimp trapping trials in other Pacific island countries.
(Modified from King 1986)

COUNTRY	OPTIMUM FISHING DEPTH (m)	AVERAGE CATCH PER TRAP (kg)	REFERENCE
Hawaii (Northwest group)	550-600	2.9	Gooding 1984
Guam (west coast)	440-680	2.1	Wilder 1977
Western Samoa (near Apia)	500-600	1.4	King 1980; King 1984
Tonga (near Nukualofa)	600-700	0.6	King 1981b; King 1984
Fiji (near Suva)	450-650	1.2	King 1984
Vanuatu (near Port Vila)	500-600	2.8	King 1981a; King 1984
Vanuatu (north-west Efate)	450-500	1.1	de Riviers et al, 1982
New Caledonia (Loyalty islands)	800	2.0	Intes 1978
New Caledonia (Mainland)	350-450	0.6	Crutz, unpublished data
Northern Marianas	550-800	1.0	Polovina et al, 1985
Kiribati	400-500	1.0	This survey

Catch rates from the larger traps was greater than from the smaller ones by a factor of about four. This 1s consistent with experience elsewhere and is one of the reasons why most vessels in the Hawaiian deep water shrimp fishery ultimately opted to use small numbers of large traps rather than more numerous small traps. (Other reasons include the cost of the traps themselves: in Kiribati, labour is relatively cheap but in locations such as Hawaii where this is not the case, there are significant construction cost savings to be made by using large traps).

in discussing catch rates, it is worth noting that short trap sets (of about 6 hours duration) hauled during the hours of darkness have been found to give substantially better catches of Heterocarpus laevigatus than longer sets, hauled in daylight, in the same location (Wilder, 1977). The suggested reason is that this species undertakes a diurnal migration into deeper waters, and is usually caught in traps when it returns to relatively shallower waters during the night. Whatever the reason may be, the apparent increase in catchability of H. laevigatus during the night would be worth investigating since it represents a possible means both of increasing total catches and possibly also the proportion of large grade shrimps in the catch.

The fact that at least one experimental study has found catches to vary during the day/night cycle in this way supports the contention among many people who have been involved in deep water shrimp trapping, including these authors, that there is substantial movement of shrimps into and out of the traps as they rest on the bottom. The implication of the above study is that shrimps which enter the trap during the night are easily able to leave it again at daybreak. Escapement also influences the maximum catch achievable by a given trap. Ralston (1986) notes that the presence of shrimps, particularly large ones, already in the trap may inhibit the entry of more shrimps. Once a certain density is reached, either no more shrimps will enter the trap, or, more likely, the quantity entering roughly equals the quantity leaving. This effectively sets a maximum limit on the amount of shrimps a trap is able to catch, and it seems reasonable to suppose that this limit is proportional in some way to the size of the trap. in this context, it is of interest to note that during this survey the ratio of the floor surface areas of the large and small traps (1.92 sq.m. to 0.49 sq.m., or 3.92:1) is similar to the ratio of their catches (4:1).

5.1.3 Absolute abundance

King (1986) presents a summary of studies on the biology of Heterocarpus laevigatus which agree that this and probably other deep water shrimp species have low growth rates and high natural mortality rates. These characteristics have Important implications with regard to the yield which can be expected from deep water shrimp stocks. Based on an assumed natural mortality rate of 0.66 and an average catch rate of 2kg per small trap per set, he estimates an annual total yield of deep water shrimps of 200kg per square kilometre. Using somewhat different stock assessment techniques, an annual yield of 200kg per square nautical mile (58kg/sq,km.) has been estimated for the Northern Mariana islands. (Moffitt and Polovina (in press), cited in King 1986).

During an intensive fishing experiment, also in the Northern Mariana islands, Ralston (1986) estimated an exploitable biomass (standing stock) of 5.5kg of deep water shrimp per hectare (550kg/sq.km) in an area where initial catch rates were about 3.0kg per small trap per set. During this 16-day intensive fishing experiment, in which fishing effort totalled 279 effective small trap sets, the deep water shrimp population in the approximately 312 hectare (3.1 sq.km,) experimental fishing area was reduced by an estimated 45.3%.

It is not known whether these figures are representative of the Kiribati situation. if they were to hold for the Tarawa/ Maiana/ Abaiang area, then the habitat area assumptions of section 5.1.1 would produce stock and yield estimates as follows:

Table 5: Deep water shrimp stock and yield extrapolations

	Total for Tarawa/ Abaiang/ Maiana (200-700m)	Optimum Fishing zone (400-500m)
Habitat area (sq.km)	630	125
Standing stock (tonnes) @ 550kg/sq.km	346	69
Annual yield (tonnes) @ 200kg/sq.km	126	25

in fact, even in the optimum fishing zone the catch rates achieved during this survey were substantially lower than those used in both the above projections. it seems highly likely therefore that both standing stock and yield would also be substantially lower than those values proposed by King and Ralston.

5.2 Fishing economics

5.2.1 Equipment costs

The initial cost of equipping the Nei Tewenei with the limited amount of fishing gear required to carry out this survey (excluding any major items of deck equipment) was as follows (see section 2.4.1 for more detail):

Table 6: Actual costs of equipment used in the survey

30 small traps	A$ 1370.40	(includes labour costs)
6 large traps	A$ 785.82	(includes labour costs)
Rope	A$ 1508.46	
Floats	A$ 1163.22	
Other costs	A$ 151.12	
TOTAL	A$ 4979.02	(includes all freight and handling charges)

During the survey, 26 small traps and part of the rope was lost: the total replacement cost for this gear was estimated at A$ 1560. it is possible that some of these losses could have been avoided by not fishing in the Maiana banks area. Growing experience of both the fishing areas and the trap handling techniques by the crew would also reduce the loss rate over the longer term. Nevertheless, a certain amount of gear loss is inevitable: also, traps which are not lost will gradually succumb to damage, particularly to the chicken wire covering, which will therefore need to be fixed. Repairing or replacing fishing gear is a substantial ongoing cost in trap fishing.

5.2.2 **Operating costs**

The operating costs of fishing during the survey are difficult to ascertain. The Nei Tewenei is a government vessel and as such enjoys certain subsidies (e.g. fuel and supplies at government rates). it is not a commercial vessel and its initial value is therefore not being depreciated as an operating cost over its useful life span. The skipper and crew are government employees and as such their conditions of employment may differ from those which would normally be paid to a fishing crew on a small boat. The resources of the government (financial, personnel, and communications) are available in the event of mechanical or other vessel difficulties, a situation that gives many advantages in a location such as Tarawa, where minor problems can disable a vessel for long periods because of poor communication and supply infrastructures. The costs incurred by lost fishing time due to vessel difficulties are therefore not likely to be representative of a true commercial vessel.

The daily operating costs here are therefore "best guesses" based on estimated costs of some items and known costs of others.

Table 7. Estimated dally operating costs of Net Tewenei during deep water trapping trials.

DAILY EXPENSES		A$
Fuel oil		200.00
Crew wages (including skipper)		120.00
Bait (25kg per day @A$0.50/kg)		12.50
ice (50kg per day	@A$0.25/kg)	12.50
Supplies		25.20
Other		20.00
TOTAL		390.20

5.2.3 Economic analysis of fishing operations

Based on the above estimates of initial and operational costs, table 8 gives an economic projection of fishing operations using the Nei Tewenei or a similar vessel. A number of assumptions have been made, as follows:

- the original cost of the vessel is taken to be A$ 100,000, which is amortised over 10 years, the estimated working life of the boat;
- vessel insurance and maintenance costs are as estimated;
- 200 fishing days a year are achieved;
- 200 small traps are set on each fishing day, all in the best fishing zone (400-500m);
- catches 8re the same as those obtained in the best fishing zone during this survey;
- all fishing gear is lost or damaged beyond repair and has to be replaced each year.

Table 8. Economic analysis of deep water shrimp trapping operations in Kiribati using Mel Tewenei.

ITEM	TOTAL COST (A$)	ANNUAL COST (A$)
a) initial investments		
initial vessel cost	100 000	
200 small traps @ A$46/trap	9 200	
Floats and ropes	12 500	
TOTAL inVESTMENT	121 700	
b) Fixed costs		
Crew wages (Skipper and 6 crew)		24 000
Vessel repairs and maintenance		15 000
Amortisation of total initial investment over 10 years		12 170
insurance		10 000
Supplies (A$3.60/man/day)		5 040
TOTAL ANNUAL FIXED COSTS		66210
c) Ooeratina costs		
Trap replacement costs		9 200
Float and rope replacement costs		12 500
Fuel oil (A$200/day)		40 000
ice (200kg/day $ A$0.25/kg)		10 000
Bait (100kg/day $ A$0.50/kg)		10 000
Other Hems		4 000
TOTAL ANNUAL OPERATinG COSTS		85 700
TOTAL ANNUAL COSTS		151 910

d) income

1 .Okg shrimps/trap x 200 traps/day x 200 days/year = 40 OOOkg/year

	Annual income (A$)	Net proftt/loss (A$)
I) @ A$3.00/kg	120 000	-31910
II) @ A$4.00/kg	160 000	8 090
iii) @ A$5.00/kg	200 000	48 090

If costs are as per these assumptions, the break-even cost for the product would be around A$3.79/kg for whole shrimps. Given the recovery rate of 4555 estimated in section 4.4.3, this would rise to $A8.44/kg for tails with the shells on (excluding the cost of any additional labour required in processing),

Since, during the survey fishing, large traps caught on average four- times as much as small ones, it may be possible to substitute 50 large traps for the 200 small traps in the above projection. This would reduce initial trap costs by about 25%. As the large traps would need to be set in short strings rather than singly, trap loss would probably still be significant. Nevertheless the total number lost may be reduced (although this would mean that more traps would succumb to operational wear 8nd tear and would need labour- and material-intensive repair work) and trap replacement costs may therefore diminish by perhaps *25%.* Bait use would be cut from 2kg per four small traps to 0.75kg per large trap, reducing bait costs by about 62%. These savings would have the effect of reducing the total annual expenditure by someA$ 10,850, and break-even prices would accordingly fall to A$3.78 for whole shrimps and A$8.39 for shell-on tails, This option is strictly speculative, since the trials of large traps were not extensive enough to establish either consistent catch rates or efficient methods of handling these unwieldy traps on Nei Tewenei.

It is likely that costs will not be as the above projection assumes. As noted earlier, Nei Tewenei is a government vessel and as such is exempt from many of the normal financial restrictions on a commercial vessel. in particular, all the fixed costs will be borne by central government regardless of the activities of the vessel, and as such there is no real need for them to be recovered from fishing operations. A more realistic assessment of government fishing economics might therefore be to exclude fixed costs and count only the A$85,700 operational costs. in this case, the break-even product price (using small traps) would be around A$2.14/kg for whole shrimps, and A$4.76/kg for shell-on tails.

Further complexities in the economic analysis arise 1f some of the running or gear costs considered here are met as part of other Fisheries Division or overseas aid projects. in this case the fishing operation would be further subsidised and the break-even cost for the product would fall further. The true economics of using the Nei Tewenei for "commercial" deep water shrimp trapping can only be accurately assessed by individuals who are intimate with the financial structure of the whole Kiribati Fisheries Division.

No consideration has been given so far to the possibility of commercial deep water shrimp trapping by vessels other than Nei Tewenei. This is because, apart from Nei Tewenei, there are few vessels in Kiribati which are large enough to have the deck space required for working traps, or which are equipped with a hauler, which is essential for this type of fishing, The only exceptions are several local and international cargo vessels, which presumably would not be able to incorporate the setting and hauling of traps into their routines, and the pole-and-line tuna fishing vessels of the national fishing company Te Mautari. These latter vessels could conceivably be fitted out for deep water shrimp trapping on an occasional basis, such as during periods of poor tuna or bait availability, as a supplement to their normal activities. However, given the inherent flexibility of such arrangements, it is not possible to assess their likely economics in this report.

5.3 Catch marketing

5.3.1 General

The potential for marketing deep water shrimps from Kiribati is completely unexplored. A detailed investigation would be required to Identify appropriate marketing channels and outlets if commercial production was envisaged on anything other than a small scale. Such a study was outside the scope or terms of reference of this survey.

It is nevertheless possible to speculate on potential market opportunities and on deep water shrimp marketing problems in general, as they clearly bear heavily on the commercial potential of the resource.

5.3.2 Product quality

Deep water shrimps are a high quality product, with an attractive deep orange or red colour when fresh, and a firm, sweet-flavoured flesh which has an appealing colour and texture once cooked. The shrimps taken during this survey were kept on ice for periods of 4-10 hours after capture (due to the need to collect biological and other information after fishing), then frozen in a domestic freezer. The product was of medium quality in the assessment of the consultant and of local individuals who were given samples. Without the data collection requirement, the shrimps could probably have been frozen during the fishing day in the Nei Tawenei's small on-board blast freezer.

Several samples were sent by the Fisheries Division for evaluation by potential overseas purchasers. The results of these evaluations had not been received at the time of preparing this report.

5.3.3 Black spot

in other areas of the Pacific, deep water shrimps have presented marketing problems because of "black spot", a condition which causes unsightly blackening of the thorax beneath the carapace and which reduces the value of the product or renders it unsaleable. Black spot occurs 1n a number of shallow water shrimp species and is normally attributed to bacterial degradation of certain compounds in the flesh of the shrimp. Since bacterial action can be minimised by prompt and continued chilling (such as immersion in an ice/brine slurry Immediately on capture), the presence of any blackening 1s normally taken to indicate that the product has been badly handled. Black spot of this type can sometimes be inhibited or prevented from worsening by dipping the affected shrimps in a solution of sodium metabisulphite for 1 -2 minutes.

in deep water carideans the cause of black spot is not necessarily due to bacterial decay, since blackening is sometimes observed 1n living shrimps as the traps are hauled. Dipping in sodium metabisulphite does little, if anything, to Improve the appearance of freshly caught deep water shrimps that are affected with black spot. in addition, some countries (including the USA and Australia) have now introduced legislation that limits or prohibits the use of sodium metabisulphite in the treatment of Imported seafood products. (S. F. Roberts, SPC Fish Handling and Processing Officer, pers. comm.)

A likely explanation is that the blackening is due to the presence of an ink which is a natural secretion of the shrimp's body. This substance, which has been observed in live shrimps kept in darkened refrigerated aquaria, is luminous at low light intensities (King 1983 cited in King 1986) and possibly serves as a defensive device to confuse predators, in much the same way as the ink of a squid or octopus. it seems probable that most shrimps eject the ink in response to disturbance as the trap is hauled, while some retain larger or smaller traces of it beneath the carapace, where it appears black at the surface. (If the shrimps are subsequently handled badly then additional blackening will of course occur as a result of bacterial action).

in fact, very few of the shrimp caught during this survey were badly affected by black spot, although some showed noticeable traces of blackening. However, the problem is common in other areas and presents marketing difficulties, since the presence of small numbers of blackened shrimps is still taken as an indication by most buyers that the whole batch has been badly handled. The degree to which black spot affects deep water shrimps in Kiribati appeared minimal during this survey. However, its occurrence may vary with season or locality, so this potential problem should not be ignored in considering the commercial future of the fishery.

5.3.4 Local markets

Local markets for shrimps in Kiribati have not so far been seriously investigated. Imports of frozen crustacean meat into Kiribati in 1982 were 107kg, a negligible figure (N. Navuntsaravi, SPC Statistician, pers. comm.) However this may meen little, since a poor supply infrastructure often causes shortages of products which are nevertheless in demand in Kiribati, and particularly in Tarawa where the cash economy is best developed. As well as two hotels with a modest turnover of overseas visitors, Tarawa has a reasonably large number of residents who are salaried employees, including, in 1986, 234 expatriates (M. Day, pers. comm.) These individuals probably represent the largest part of the market for "luxury" seafoods such as deep water shrimps. in fact many foodstuffs token for granted in more metropolitan localities fall into the "luxury" class in Kiribati and command inordinately high prices. Properly handled, good-quality locally caught deep water shrimps sold for the full break-even price of A$3.79/kg would probably compete well with imported meats, chicken, etc. and establish themselves on the local market.

It is impossible to make anything but an intuitive estimate of how much product the local market would or could absorb. in the opinion of the authors, a maximum of 100kg/week could be sold in urban Tarawa. The potential markets on outer islands would be limited or non-existent because of refrigerated transportation difficulties and costs, the less-developed cash economies, and the existence of more extensive subsistence seafood fisheries than on Tarawa.

5.3.5 **Export markets**

in a location such as Kiribati, where the transport infrastructure for highly perishable products such as seafoods is unreliable and expensive, the only export markets worth considering are those on which above average prices can be obtained. Such markets, which exist in several metropolitan countries bordering the Pacific islands region (Japan, US west coast, Australia, New Zealand) are demanding and require consistently high product quality, reliable deliveries, and, often, certain minimum product volumes. Smaller markets, perhaps with somewhat less opportunity for very high prices, exist in a number of Pacific island countries, particularly those where tourism is an important industry (Hawaii, Fiji, Vanuatu, French Polynesia, Guam, New Caledonia).

Export could either be by refrigerated sea transport, or by air. The former is expensive, slow, and may be uneconomic if only small product quantities are involved. Refrigerated cargo vessels can be temperature-unstable and it is possible that wide temperature fluctuations could occur in transit, leading to loss of product quality and value before arrival. Kiribati has direct commercial shipping to Australia, Fiji, and several other Pacific island destinations, in addition, the national shipping company Te Mautari uses its own or chartered reefer vessels to ship frozen tuna to Fiji, American Samoa, Solomon islands and French Polynesia on a variable schedule.

Air transport is more expensive but more appropriate for smaller quantities and for high-value produce, which can arrive at its destination market within hours of being shipped. Air freght is increasingly coming into use worldwide as a means of transporting high-value seafood products. Tarawa has direct air connections with Fiji, Nauru, Tuvalu and the Marshall islands, and access to several other destinations (Australia, New Zealand, Hawaii, Guam and Japan) via these connections.

The choice of export market depends on a variety of factors, particularly the price of the product.Recent commodity prices for headless frozen prawns on the US domestic market ranged from US$ 6.39 - 19.84 (A$ 9.52 - 29.56)/kg depending on species and size (inFOFisH Trade News # 8/87,2 May 1987). However these prices apply to bulk supply and do not refer to the deep water species taken during this survey. These would probably attract prices in the low end of the range because of their generally small sizes. Perhaps a more realistic indicator of export value is the Hawaiian market, where in 1983 prices for fresh chilled _Heterocarpus laevigatus_ were as follows

Table 9: Value of Heterocarpus size grades in Hawaii in 1983:
(from Oishi, 1983)

SIZE CLASS	PRICE ($US)
Small	1.10 - 2.86
Medium	4.40 - 6.60
Large	7.70 - 11.00

in the context of the above prices it is worth noting that of the total catch during the survey only 8.1 % (12.7% of Heterocarpus laevioatus. which itself made up 64% of the total catch) was graded as large. This proportion could probably be increased marginally by fishing the traps a little deeper (550-650m instead of 400-500m), but at the expense of reduced overall catches.

Other factors influencing the choice of market destination include the ease, cost and reliability of transport and the quantities of product involved Of paramount importance is the presence of an agent to receive the produce and ensure it is properly handled when it reaches its destination, and to represent the interests whatsoever over what happens to his produce. Establishing and maintaining contact with a good, reliable agent is one of the most important considerations of all in exporting seafood.

6. CONCLUSIONS

6.1 The resource

The deep water shrimp resource in Kiribati is limited in its natural extent: comparative figures from other areas suggest that the absolute maximum standing stock in the Tarawa/ Maiana/ Abaiang area would be less than 346 tonnes, with a maximum turnover of less than 69 tonnes per year, throughout the shrimps entire habitat range. These values are extrapolated from work done elsewhere and should be viewed both as overestimates, and as being extremely preliminary. Substantial further research work 1s necessary to refine them. However, if they are even remotely accurate, then the resource may not be adequate to support the activities of one boat such as Nei Tewenei fishing 200 traps (which would yield a hypothetical catch of 40 tonnes a year) on a full-time basis.

Access to the resource is further limited by the difficult fishing conditions found 1n Tarawa and probably throughout the Gilbert islands group. These conditions effectively prevent fishing in a large part of the deep water shrimp's habitat, except at the cost of heavy gear losses.

6.2 Commercialisation of trapping operations

in the case of Nei Tewenei, commercialisation could mean several things depending on the extent to which trapping might be subsidised by other activities. True commercialisation, I.e. covering all vessel expenses from trapping activities, would probably be impossible because of the limited stocks close to Tarawa as well as the vessels other commitments. if commercial activities by the Nei Tewenei are considered desirable, an arrangement whereby the vessel fished for sale on a regular occasional basis would be more appropriate.

6.3 Marketing

There appears to be a small potential local market for deep water shrimps which would be relatively easy to access. Given the uncertainty as to the likely volume of production, and the initial difficulties likely to be encountered in exporting, it would be appropriate to try to develop the local market as a first step. if it was considered desirable, export marketing trials could take place simultaneously, However it would be preferable for these to wait until the level and quality of regular production had been established.

The export marketing possibilities for deep water prawns from Kiribati will depend on the quality and quantity of produce, and the transportation routes (which often change) available at the time. A careful investigation into possible marketing options would be necessary if commercial production was envisaged on anything but a small scale.

7. RECOMMENDATIONS

The following recommendations are formulated with the foregoing discussions in mind, and rest on the basic assumption that the Kiribati Fisheries Division wishes to further explore and develop the deep water shrimp resource in Kiribati waters.

The resource in the Tarawa/ Maiana/ Abaiang area appears to be limited in size and extent, and during this survey yielded catch rates which were below average when compared to surveys carried out 1n other parts of the Pacific region. it is doubtful whether the resource would be adequate to support the activities of even a single boat such as Nei Tewenei fishing on a full-time basis. We therefore **recommend against** full-time fishing by the Nei Tewenei.

in any case Nei Tewenei has many other commitments in its role as the Fisheries Division's only extension and fisheries development vessel, and it would probably be unable to adopt a full time deep water shrimp trapping role. Occasional trapping exercises would be more practical, either on a regular scheduled basis, or, more likely, for short spells in between other projects or activities. These could be used to gather additional information on the deep water shrimp resource in Kiribati waters, and to assess the possibility of local market development for this product. We therefore **recommend** that Ne1 Tewenei undertake further deep water trapping trials on an occasional basis as and when opportunities arise.

in planning for any future fishing trials, we **recommend** that two particular avenues for Improving the economic prospects for fishing be explored. These are:

- the benefits of using large traps as opposed to small ones. The survey results demonstrated that large trap catches were in the region of four times that of the small ones, a feature which is consistent with observations elsewhere. The economic projection in section 5.2.3 predicts that some economies may arise from the use of large traps. However these may be offset by the increased difficulties to handling and the extra deck space required for storage during transportation, and require further investigation. Modifications to the shape fo the trap or the positioning of the entrances may further increase their effectiveness or reduce the on-board handling difficulties;

- the possibility of improving catch rates by hauling traps during the hours of darkness. This would require the purchase of additional equipment, specifically lights to enable location of the trap floats in the dark, and some changes to working procedures. Although largely speculative at present, the indications that catches might be Improved (both in size and in the proportion of large Heterocarpus laevipatus taken) by night-time hauling are worth investigating.

Future fishing trials should aim at maximising the most valuable component of the trap catch, i.e. "large" grade shrimps, We therefore **recommend** that all fishing be carried out in the depth range 400-650m and that the following data collection activities be undertaken:

- record the depth and location of each tr.ip set;

- record the total weight of Heterocarpus laevigatus and H. ensifer caught in each trap;

- grade all H. laevigatus into the "large", "medium" and "small" categories defined in section 4.4.2, and record the number and total weight of individual 1n each category for each trap.

Collection and subsequent analysis of this data, even on a sporadic basis, over an extended period of time, will enable fishing effort to be ultimately focussed on that depth zone which produces catches of the greatest value, and will lead to an accumulation of information on which to base more meaningful assessments of the deep water shrimp resource in Kiribati.

The importance of diligent data recording should not be underestimated in any future trapping trials, and neither should the amount of work involved in doing this properly. The collection, analysis and interpretation of the catch records would make a suitable project for a Junior research officer of the Fisheries Division or of the adjacent University of the South Pacific's Atoll Development and Research Unit, which is better equipped for this type of research work. We **recommend** that every effort be made to develop this as a collaborative research activity between these two organisations, with both sides having clearly defined inputs and responsibilities as regards the work to be carried out.

Continued trapping trials will produce quantities of deep water shrimps and we **recommend** that these be put to use in attempting to develop a local market for this product. The catches should be iced, preferably in brine, as soon as possible after capture and handled as carefully as the data collection requirement will allow. After all relevant data has been collected, the shrimps should be re-iced and sold to or via local retail outlets interesting in participating in marketing trials. Every effort should be made to sell the shrimps fresh: freezing is an extra expense which cannot add to the quality of the product but can easily reduce 1t. Freezing should only be carried out if it proves that catches are surplus to immediate local market demand. Concessionary prices may be required in the first few months that the shrimps are offered for sale, although the aim should be to increase the price to cover the break-even cost of catching the shrimps within a year of the start of marketing trials.

We **recommend against** attempts to develop an export market for deep water shrimps from Kiribati, at least until both catch rates and the potential of the local market to absorb this product have been assessed over a reasonable period of time (at least one year). Export buyers require certain minimum quantities and quality standards and it would make sense to ensure that these can be met before attempting to export. Exporting at a premature stage in the development of local deep water shrimp fishing activities would be to risk gaining a reputation as a supplier whose product is of inconsistent quantity and quality, and could be harmful to export prospects in the longer term.

in conclusion, we **recommend against** the Nei Tewenei being involved in deep water prawn trapping on a formal commercial basis, at least until the potential of the resource has been confirmed over at least a year. True commercial fishing by Nei Tewenei is in any case probably not feasible (although a subsidised commercial operation, in which some of the vessels costs are covered by government, may well be). Nevertheless, at least in the first instance, we **recommend** that any future trapping trials be considered as a research activity, albeit one in which a proportion of the costs may ultimately be recovered from catch sales. Too much emphasis placed on the need to cover costs from fishing operations detracts from the real requirements. These are to gather additional information on the resource, and to adopt a "walk before you run" approach to developing a local market for this product, which under current conditions appears to have only marginal economic potential for supporting what can at best be very limited fishing activities.

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