A TRAPPING SURVEY FOR DEEPWATER SHRIMP (DECAPODA : NATANTIA) IN WESTERN SAMOA

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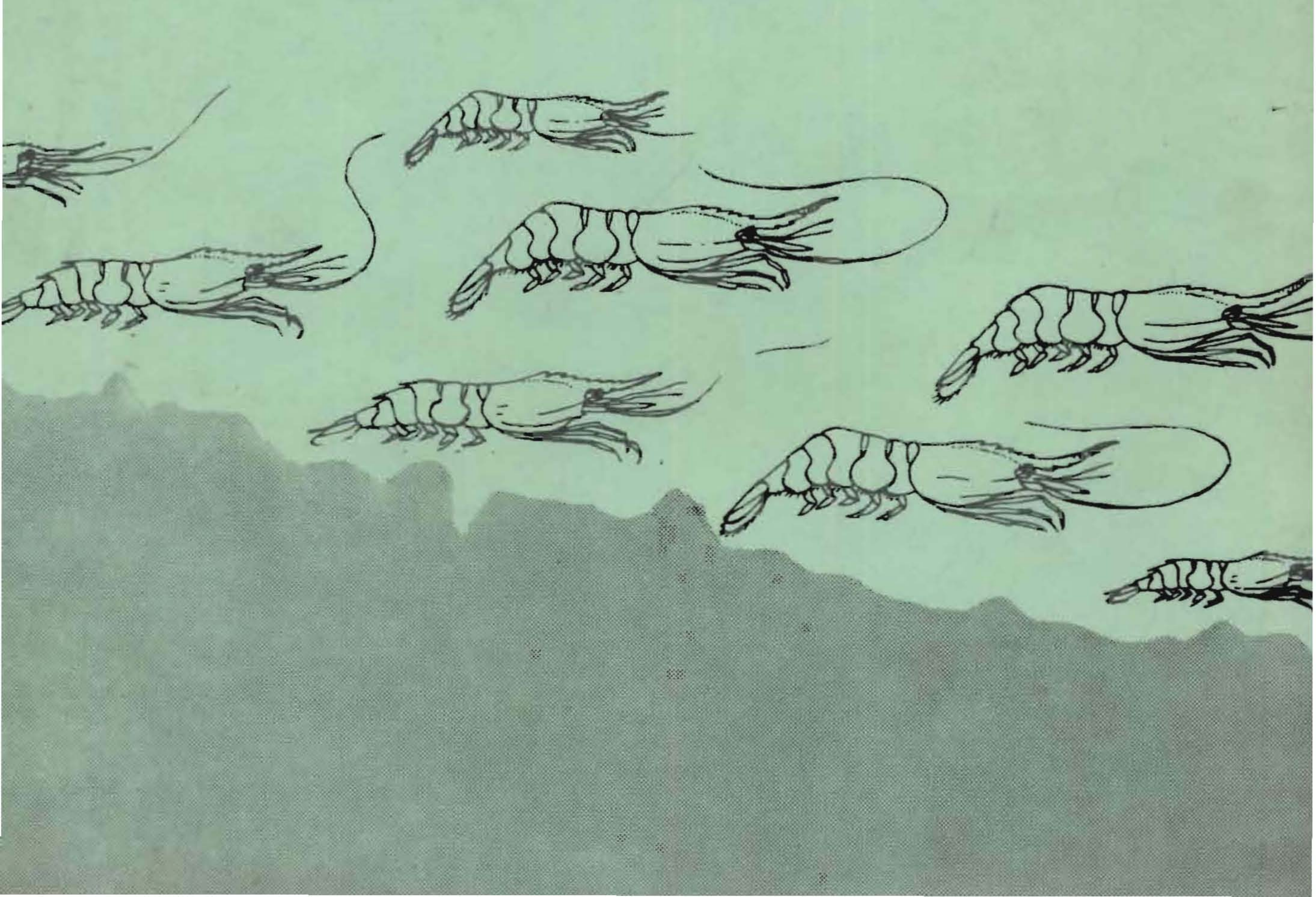

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A project undertaken by the Institute of Marine Resources and funded by the Hanns Seidel Foundation from the Federal Republic of Germany.

THE UNIVERSITY OF THE SOUTH PACIFIC,
SUVA, FIJI.

ABSTRACT

King M. G. (1980), A trapping survey for deepwater shrimps (*Decapoda: natantia*), in Western Samoa.

Report of the Institute of Marine Resources. The University of the South Pacific. Suva, Fiji.

Baited traps were used to carry out a survey for deepwater shrimps in Western Samoa in the South Pacific. Two-entrance conical traps, baited with tuna heads (*Katsuwonus pelamis*), were set in depths from 306 m to 846 m in waters out from Apia harbour. Mean catch rates were 0.9 kg per trap in the shallowest depths and reached a maximum of 1.4 kg per trap in the 500 to 600 m depth range. Six species of carid and one penaeid shrimp were provisionally identified from the catch; in terms of abundance, the carid shrimps, *Heterocarpus ensifer* and *H. laevigatus*, had the greatest commercial potential.

CONTENTS

1. INTRODUCTION

The crustaceans commonly known as prawns or shrimps, represent one of the world's most commercially valuable group of marine species. This group (the natantian decapods) consists of two large subgroups; the penaeid prawns, which form the basis of valuable trawl fisheries in many tropical and subtropical countries, and carid shrimp which are more widely distributed but less commonly exploited. A recent development however, has been the interest shown in the exploitation of deepwater carid shrimp.

The biology of carid shrimps is not well known, although a few species, which form the bases of commercial fisheries, have been studied. Many carids are deepwater, benthic species living on the sea floor and may make vertical diel migrations up into the middle water masses. The females carry the eggs externally (in contrast to penaeid shrimp) under the abdomen on the pleopods, which are specially adapted for the purpose. Eggs are present in a large proportion of the population throughout the year and the life-cycle appears to be more extended than that of penaeids (unpublished data). Carid shrimps are caught commercially in Alaska (Barr, 1970), North America (Dahlstrom, 1970) and Chile (Hancock and Henriquez, 1968). In several other countries, experimental trawling and trapping for deepwater shrimps is being conducted. These include several Pacific island countries including Hawaii (Struhsaker and Aasted, 1974), Guam (Wilder, 1977), New Caledonia (Intes, 1978), Fiji (Brown and King, 1979) and Vanuatu; formerly the New Hebrides, (King, 1980).

The distribution of deepwater carids in the above countries suggests that similar resources may exist in other Pacific Islands with suitable offshore bathymetry. Samples of carid shrimp have previously been obtained in Western Samoan waters by the French Research Vessel "Coriolis" (Anon, 1977) and the present survey was undertaken in September 1980, to investigate deepwater shrimps as a potential fishery.

Western Samoa consists of the two main islands of Savaii and Upolu which lie in the Pacific Ocean approximately at latitude 14° South of the equator and 172° west of Greenwich (figure 1). For practical reasons the preliminary survey was confined to the waters adjacent to Apia, the capital of Western Samoa. Apia harbour is situated in an inlet in the fringing coral reefs on the northern side of the island of Upolu. Two leading lights marking the entrance to the harbour (Pacific Islands Pilot vol. 11) were used to define the transect, along which, the trapping survey was conducted (see section 2e, figure 4). It is stressed that this survey was of a preliminary nature and was carried out over a restricted time, from 5 September to 16 September, 1980, and in a small area.

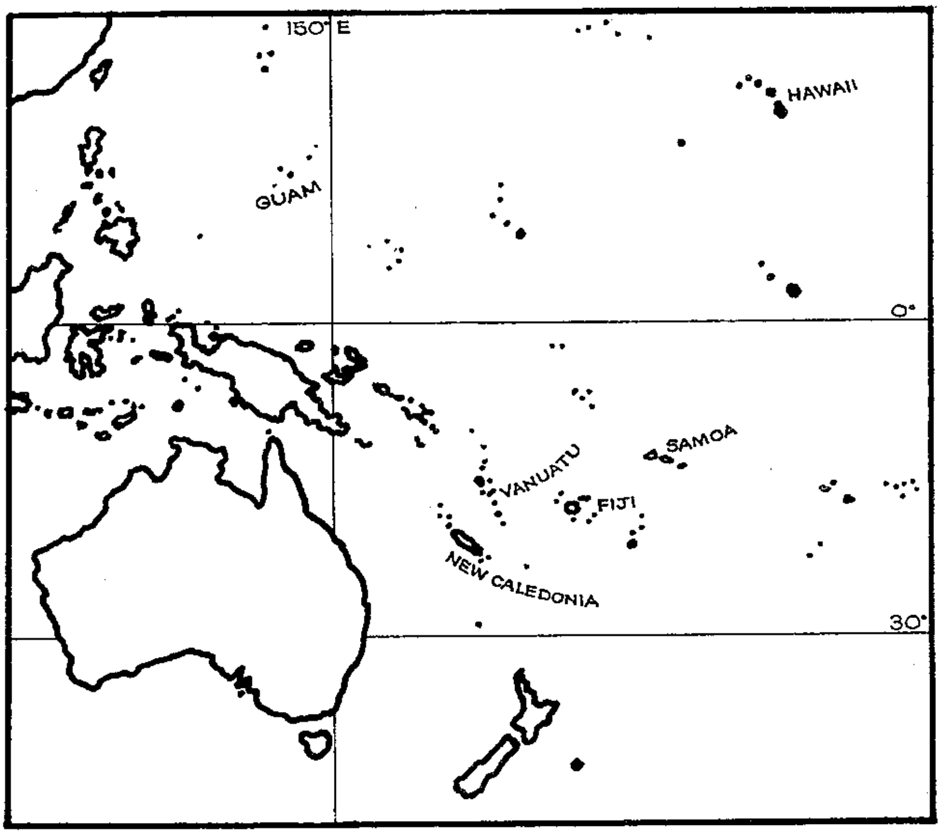

FIGURE 1 : The Pacific Ocean showing the position of Samoa and other Island countries mentioned in the text.

2. FISHING GEAR AND METHODS

a. The traps:

The steel frames of disused fish traps were altered for use in the present survey. The trap design was that of a 60 cm high truncated cone with a base diameter of 90 cm and a top diameter of 60 cm (figure 2). The trap frame was made from steel reinforcing rod and covered with 1 cm square galvanised wire mesh.

The two entrance cones were made from the same wire mesh and fitted at opposite sides of the trap; the cones extended about 20 cm into the interior of the trap and the inner opening was about 12 cm square. An access gate was hinged below one of the entrances to allow for the placement of bait and the removal of the catch. The gate was secured in a closed position with short lengths of wire. A 3 m rope bridle was spliced onto the steel frame at the top of each trap.

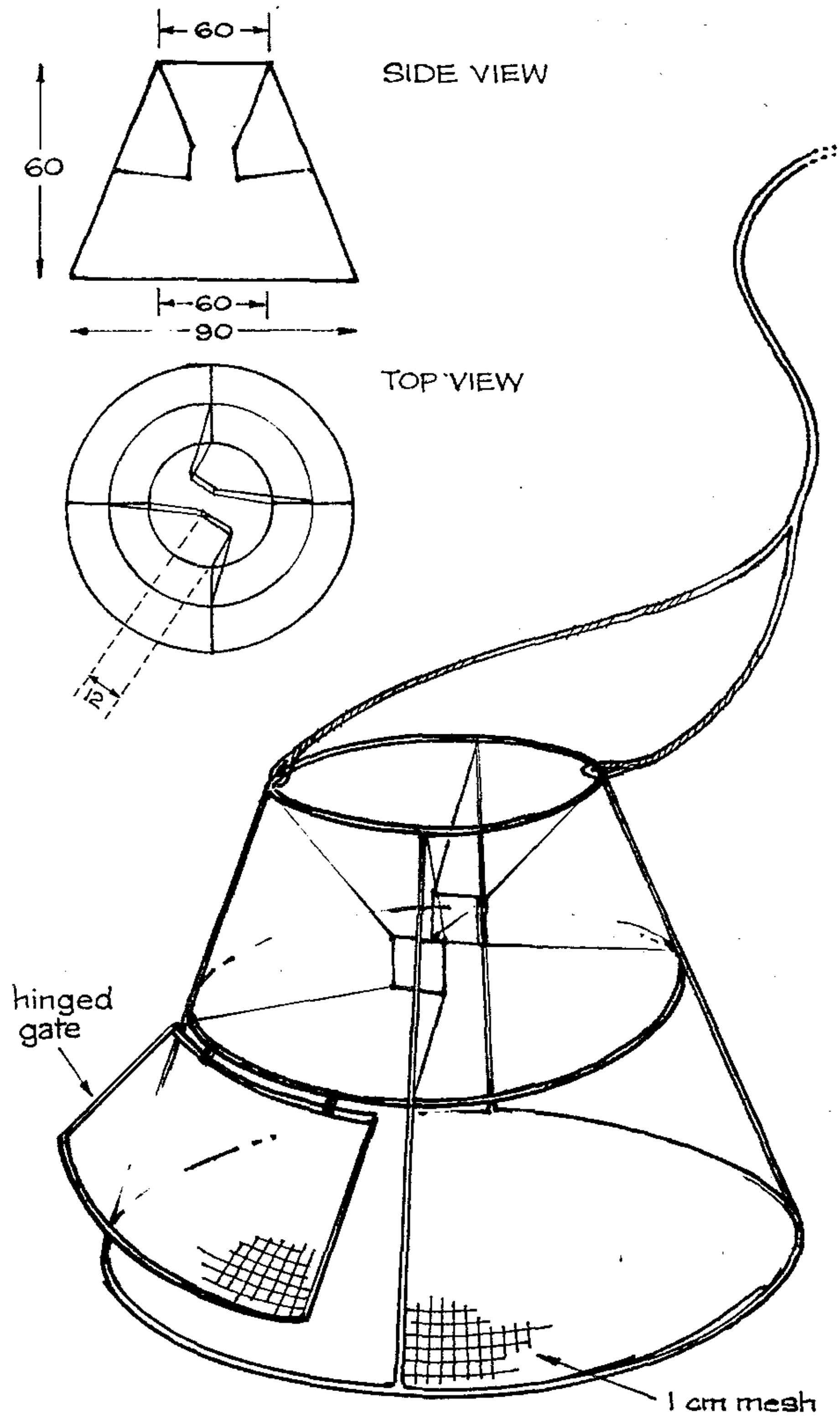

FIGURE 2: The shrimp trap used in the survey. The two entrances were made from the wire mesh (without any frame work) and were offset (see top view) so that the inner openings were not directly opposite each other. Drawings not to scale; measurements given in centimetres.

b. The fishing rig:

The trap fishing line consisted of two parts, viz. a drop line from the marker buoys and a bottom line from which the traps were strung (figure 3). The top of the drop line was attached to a 30 cm diameter buoy, which was itself attached to a second marker buoy. The second marker buoy was lashed to a 3 m wood or bamboo pole fitted with a brightly coloured flag and a 4 kg scrap metal weight as shown in figure 3.

The dropline was of 8 mm diameter polypropylene and was made from separate coils (approximately 220 m in length) which were joined together as necessary. At one end of the bottom line, four loops were formed into the rope at 15 m intervals, the last loop being an eye-splice at the end of the rope. This spacing was considered necessary to avoid competitive effects between the traps. The end three loops were used to attach the trap lines and from the fourth loop, a 10 kg scrap iron weight was attached via a short length of rope. The weight was to prevent the traps being lifted by the pressure of wind and current against the floats and rope.

c. The fishing vessel and equipment:

The boat made available for the trapping survey in Western Samoa was a 8.5 m aluminium and plywood, F.A.O. "Alia" catamaran powered by a 25 h.p. (18.7 kw) outboard engine. The winch was a portable unit consisting of a 3 h.p. (2.3 kw). Briggs and Stratton 4-stroke engine, which powered a geared trap hauler via a belt drive. The trap hauler pulley was similar to the type used in the Australian rock lobster trapping fishery - i.e. in which the trap line is firmly gripped by the pulley and stripped off by a metal peeler.

A "Skipper" model 603 echo sounder fitted with a narrow beam ferrite transducer was used to obtain depth profiles and measure the depth at each trap drop. The echo sounder was rigged as a portable unit with a separate 12 volt lead/acid battery and the transducer was mounted at the end of a length of pipe. A hand-bearing compass was used to fix the position from shore marks at locations along the transect.

d. The bait:

During the period of the survey, skipjack tuna (*Katsuwonus pelamis*) were regularly being caught and landed at Apia. Many of these fish were being stored in deep freeze units. Tuna heads were separated from the frozen carcasses with an electric saw and used as bait throughout the survey. Two frozen heads were suspended by wire in the middle of each trap.

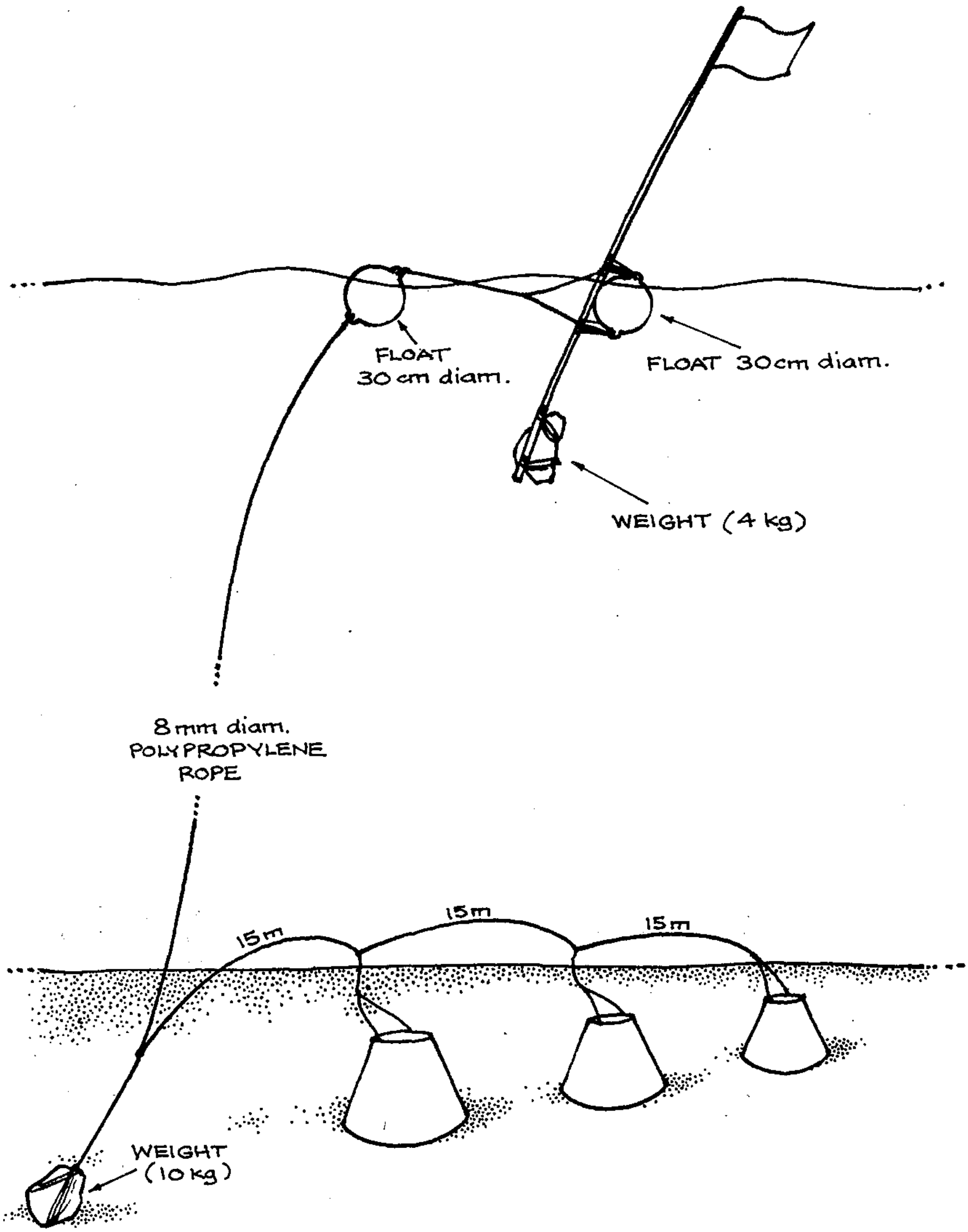

FIGURE 3: The arrangement of the traps used in the survey. The length of dropline used (i.e. between buoys and bottom weight) was equivalent to the depth of water plus a minimum of 25% excess rope.

e. The survey area and method:

After taking a series of echo-soundings, a transect was chosen in line with the leading lights at the entrance to Apia harbour (figure 4). This transect ran offshore on a bearing of 14° T with the two lights in line (chart 1339).

Each set of three baited traps was set overnight at various depths along the transect. It was intended to set a string of traps over each night at depth intervals of 50 m, between 250 and 700 m; however it proved difficult to set traps in predetermined depths due to the steep slope of the sea floor. In one instance, the traps appeared to slide down the slope and were eventually set, beyond the proposed limit of the survey, in 846 m.

At each set location, the depth was recorded at the time of setting and, on the following day, at the time of hauling up; the mean of these two readings was used to define the "estimated fishing depth". Depths, shore bearings, setting and hauling times and other details were recorded at sea on a pre-prepared daily log sheet.

The catch from each individual trap was placed in a labelled plastic bag for handling in a shore laboratory. All shrimp were separated according to species and into ovigerous (egg-bearing) and non- ovigerous groups before being counted and weighed. A large sample, usually the catch from one trap in each set, was set aside for measuring. Shrimp measurements were recorded, to the nearest millimetre, as carapace lengths (distance between the post-orbital eye socket and the posterior median edge of the cephalothorax; see figure 6).

f. The fishing operation:

At each dropping location, the traps and weight were lowered over the windward side of the boat. With the motor off, the boat would drift off to leeward with the trap acting as a sea-anchor during the drop. Pressure was always kept on the drop line as the rope was let out to avoid tangling the traps. During the drop, additional coils of rope were successively added to the drop line to provide sufficient rope for the depth of water (equivalent to the depth of water plus a minimum of 25%). At the end of the final coil, the float buoy and marker buoy were attached and cast off from the boat.

Each string of three traps were left in the sea overnight and located for hauling in on the following morning. Using the 3 h.p. motor and geared winch, the line was hauled in at the rate of about 25 m per minute and flayed down loosely into the catamaran floats. Once the traps were on deck they were emptied into separate labelled plastic bags, before being rebaited and reset in a new location.

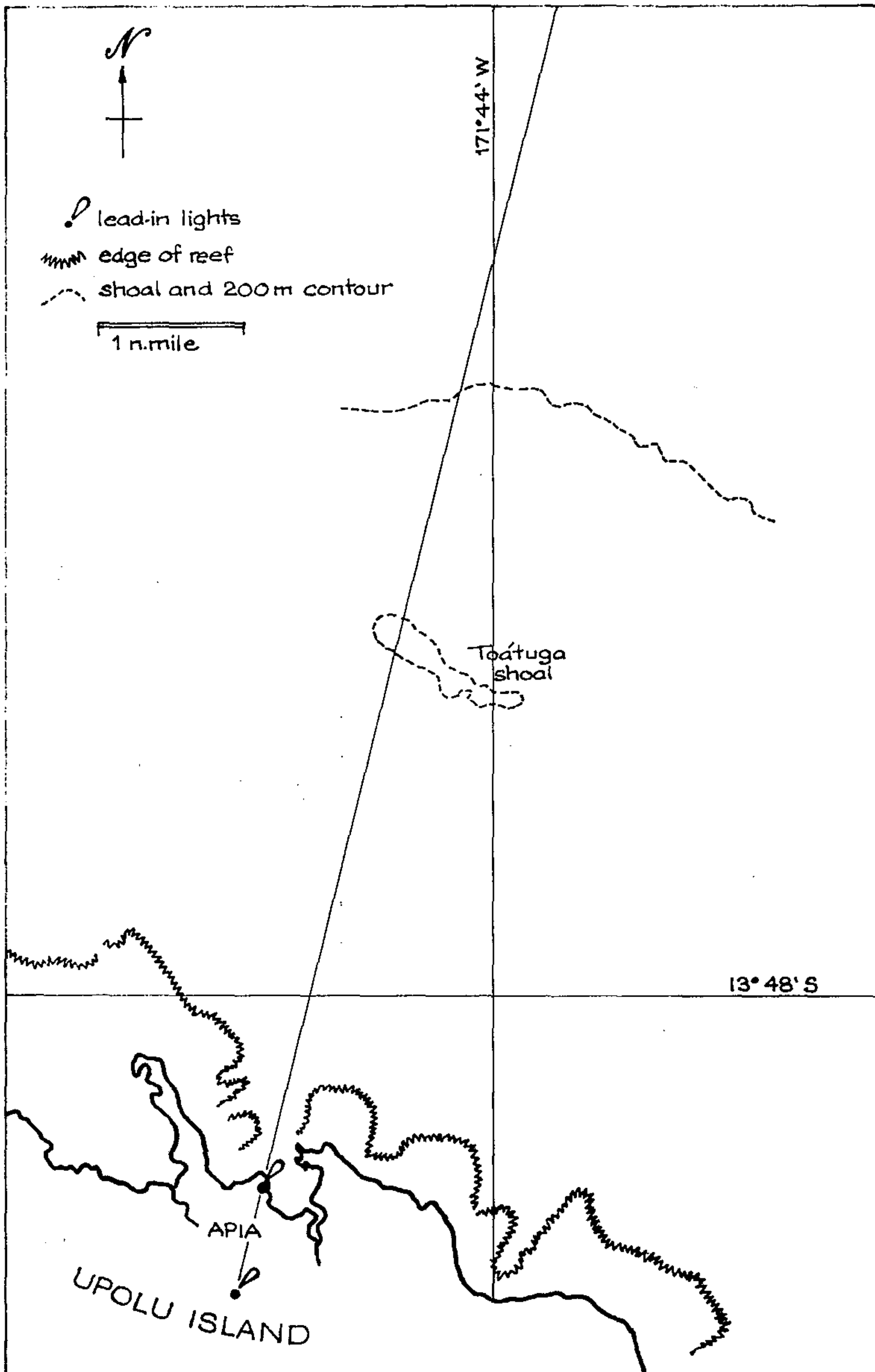

FIGURE 4: The preliminary survey area near Apia, Western Samoa. Traps were set along the transect beyond the 200 m contour line and in line with the two lead -in lights into Apia Harbour.

3. RESULTS

a. Offshore bathymetry:

The depths in several areas offshore from Apia were recorded using the echo-sounder. The sea bottom profile along the sampling transect shown in figure 4 is presented in figure 5, which was drawn from the echo-sounder recording paper. A shallow shelf of less than about 90 m depth extends out from Apia harbour for about 5.5 nautical miles. At approximately 3.5 nautical miles from the harbour, Toatuga bank rises to about 20 m from the surface. Beyond 5.5 n. miles from the harbour entrance the sea floor drops away steeply at a slope of about 1 in 3.4.

b. Species caught:

During the survey, six species of carid shrimp and one penaeid prawn were caught. At least two carid genera, *Plesionika* and *Heterocarpus* are represented. In common with other deepwater shrimp, they are all characteristically coloured pink to deep red and the females often carry blue/grey to bright blue eggs.

The seven shrimp found in the present survey are listed below in approximate order of increasing size. Scientific names, where given, are provisional; vernacular working names are from King (1980) and Brown and King (1979).

- *Plesionika longirostris* (stars and stripes shrimp)
- Species D - Single broad spine on dorsal side of abdomen
- *Plesionika martia*
- *Heterocarpus* sp. c - three spines on dorsal side of abdomen
- *Heterocarpus ensifer* – (two spined shrimp)
- *Heterocarpus laevigatus* - (red tipped shrimp)
- *Penaeid* sp.

Many of the species, in particular the *Heterocarpus* species, are so variable in aspects of their morphology (e.g. rostrum shape) that species separation is difficult. As an aid to identification, the known species are included in a tentative illustrated key in figure 6.

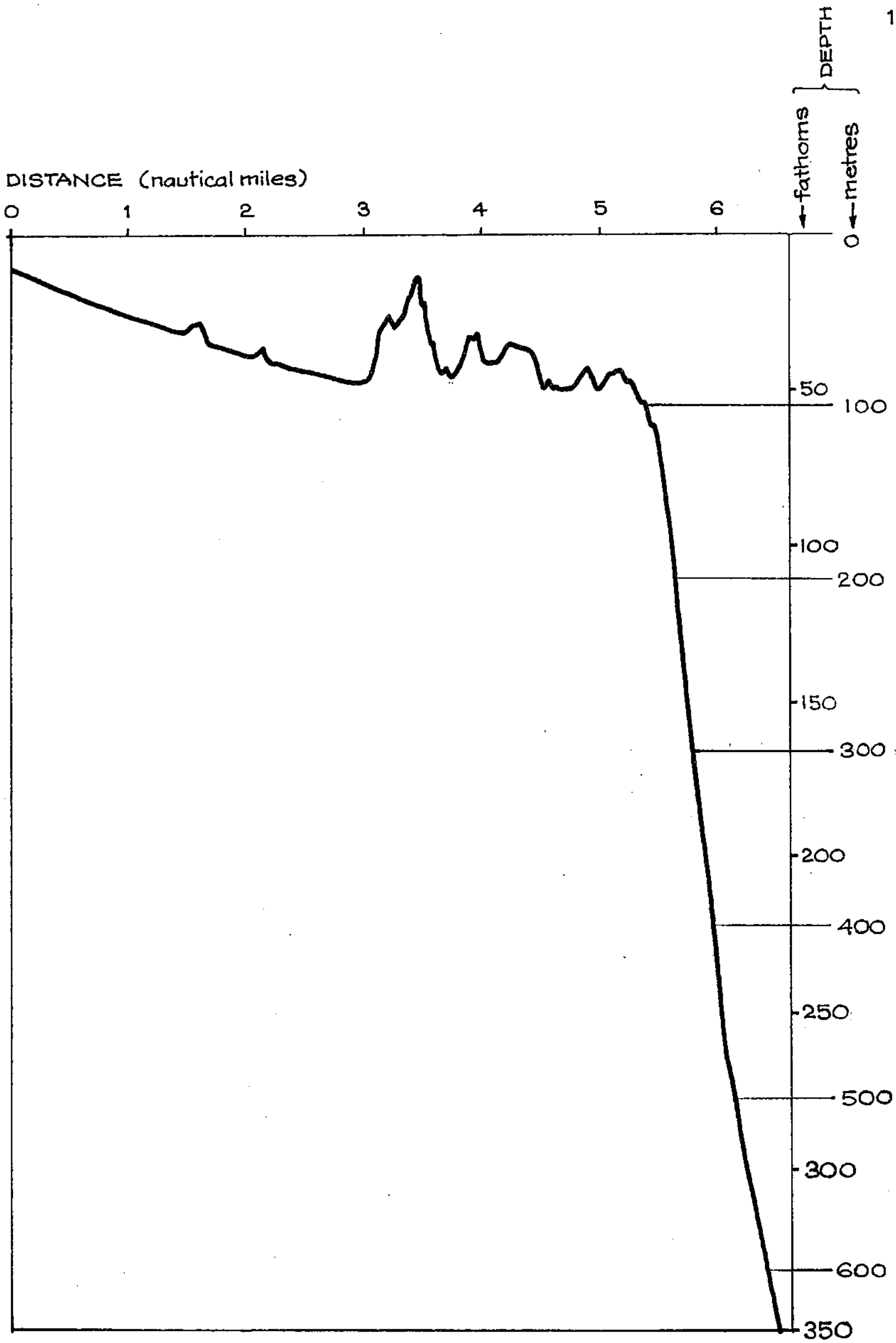

FIGURE 5: The depth profile, measured by an echo-sounder trace, of the transect line indicated in figure 4; i.e. on a bearing of 14° TRUE out from Apia harbour

family PANDALIDAE - key to genera

1. Carapace with strong lateral keels ---------- *Heterocarpus*

   Carapace lacking keels ------------------------------ 2

2. Rostrum about twice length of carapace------ *Plesionika*

   Rostrum more than twice length of carapace---*Parapandalus*

Genus *Heterocarpus*

1. Abdomen with 2 dorsal spines------*ensifer* (?)-----*sibogae* (?)

   Abdomen without dorsal spines-------------------------2

2. Post rostral spines on high dorsal ridge----------*gibbosus*

   No high dorsal ridge on carapace------------------*laevigatus*

Genus *Plesionika*

1. Dorsal rostral teeth (4 to 8)? only on base of rostrum----*martia*
   (one dorsal spine on third abdominal segment ?)

   Dorsal rostral teeth along length of rostrum---------- *longirostris*

Genus *Parapandalus*

1. Many fine dorsal and ventral rostral teeth -----------*serratifrons*

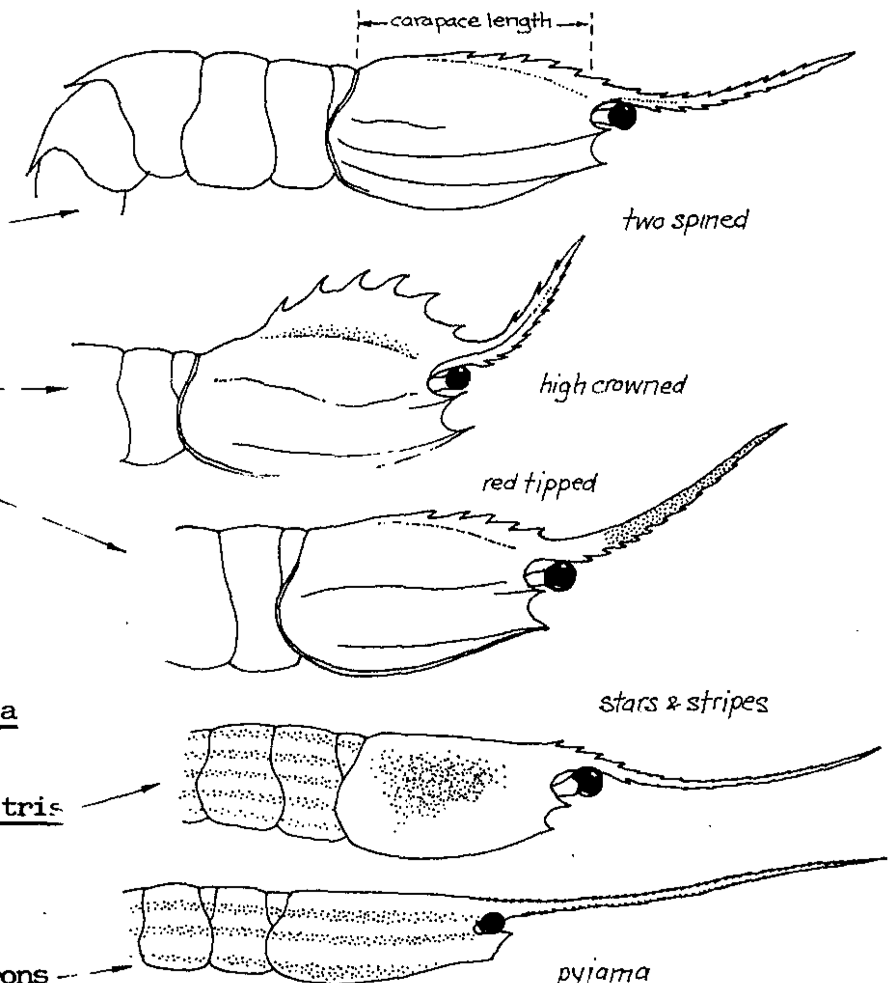

FIGURE 6: A tentative key to the deepwater shrimp found in a preliminary trapping survey in Western Samoa (from King, 1980 - *Heterocarpus gibbosus* was not found in the Western Samoan survey)

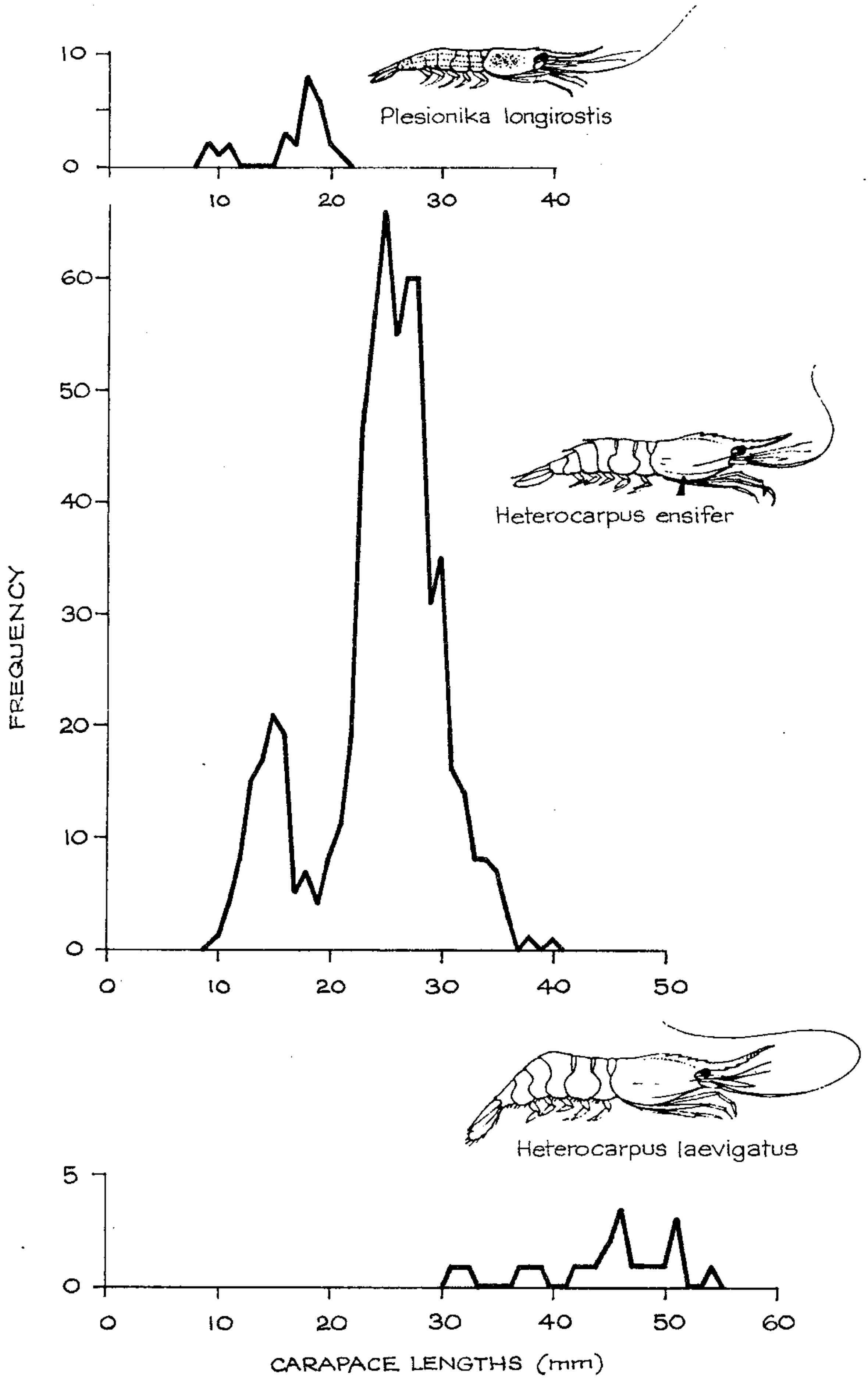

FIGURE 7: Length-frequency diagrams of the three most abundant species of deepwater shrimp (samples from all depths combined)

Of the species found, only three were in sufficient trap abundance to be of possible commercial interest. These are *Plesionika longirostris*, *Heterocarpus ensifer* and *H. laevigatus*. *H. laevigatus* is the largest of these with a mean carapace length of about 45 mm (approximately 160 mm total length). The length frequency data from all three species are shown in figure 7.

c. Variation in catch rate with depth

Traps and bait used in all depths were similar and all traps were left set for a similar time period (15 to 20 hours); traps were set before sunset and retrieved after sunrise on the following day. It is, therefore, possible to use the catch weight per trap, as an index of the trap abundance of shrimp in various depth zones.

Catch data from the survey were grouped in 100m depth ranges and the results are presented as a histogram in figure 8. The figure shows that total mean catches of shrimp were lower in shallower water at 0.9 kg per trap but increased with depth, to a maximum of 1.4 kg per trap in the 500 to 600 m depth range. In deeper water, catches were low but because of the limited nature of the survey, these data may not indicate the situation in other areas of Western Samoa, or at other times of the year.

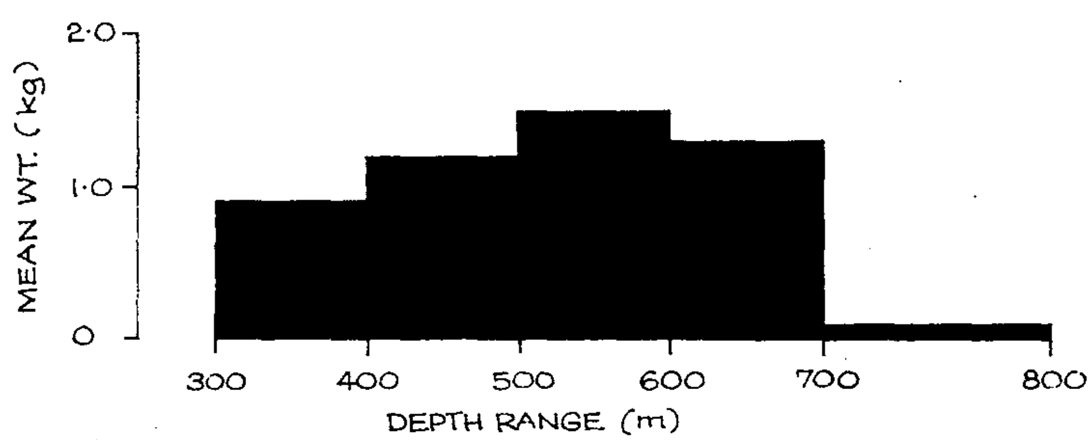

FIGURE 8: Histogram showing the mean catch weight (kg) per trap in various depth ranges.

d. Distribution of species with depth:

Catch data from the survey was used to calculate the contribution of various shrimp species to the total catch at each depth. These contributions, expressed as percentages, are given in table 1. The four species which occurred in low trap abundance are grouped together as "other species".

TABLE 1: Species composition by weight expressed as a percentage of the total shrimp catch at each depth range.

DEPTH RANGE (M)	PLESIONIKA LONGIROSTRIS	HETEROCARPUS ENSIFER	HETEROCARPUS LAEVIGATUS	OTHER SPECIES
300-399	9	90	0	1
400-499	0	97	2	1
500-599	0	61	36	3
600-699	0	62	36	2
700-899	0	0	44	56

The distribution of each species of shrimp with depth was estimated by using the mean catch weight per trap as an index of relative abundance. Based on these limited data, the distribution of the three major species is shown in figure 9.

Plesionika longirostris only occurred in the shallowest depth sampled where it accounted for 9% of the total catch of the 300 to 399 m range. It is possible that this species is more abundant in shallower depths. The two-spined shrimp, *Heterocarpus ensifer* occurred over all but the deepest of the sampled depths and in the range 400 to 499 made up 97% of the total catch.

In depths of over 500 m the proportion of the large red tipped shrimp, *Heterocarpus laevigatus* increased to reach a maximum trap abundance at about 500 m to 700 m depth. At the greatest depth sampled (846 m) several specimens of an as yet unidentified *Heterocarpus sp.*, as well as a single specimen of a penaeid shrimp were caught.

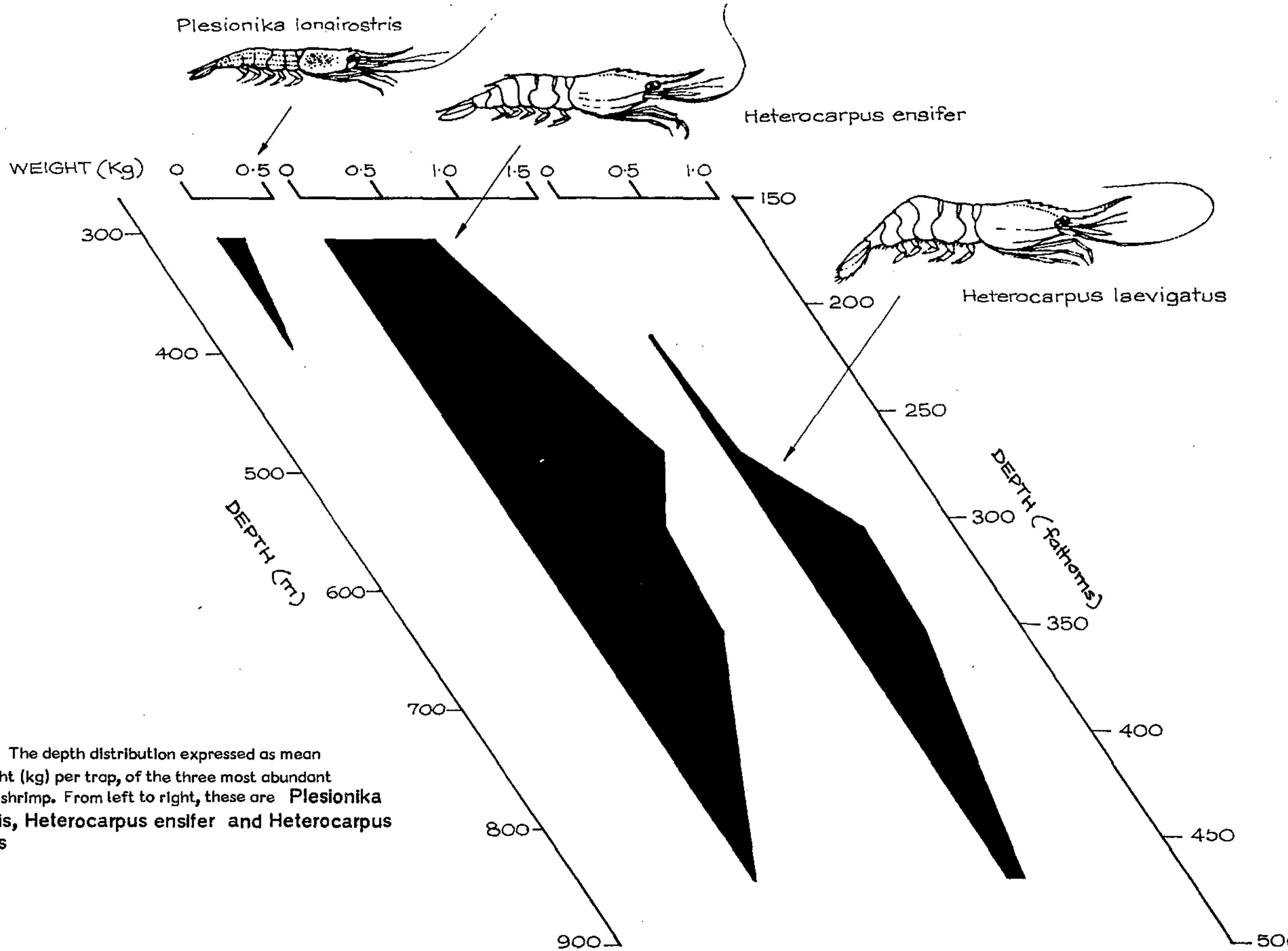

FIGURE 9: The depth distribution expressed as mean catch weight (kg) per trap, of the three most abundant deepwater shrimp. From left to right, these are **Plesionika longirostris, Heterocarpus ensifer and Heterocarpus laevigatus**

e. Variation in shrimp size with depth:

The length-frequency data were examined to determine whether the size of shrimp altered with depth. As *Heterocarpus ensifer* occurred over the widest depth range, this species was chosen for analysis. Length frequency data from various depths are shown in figure 10. This figure shows that shrimps are distributed in distinct size groups in most depths. From figure 10 and the total-length frequency diagram presented in figure 7 (samples from all depths combined), at least three size groups are evident; these groups approximately fall into the carapace length categories ≤19 mm, 20 to 30 mm and ≥31 mm. The number of shrimps in each of these categories, expressed as a percentage of the total sample at each depth, is shown in table 2.

At least 60% of the catch in each depth consisted of shrimp from the middle size group, which has an approximate modal length of 26 mm. The data are insufficient to detect possible trends in shrimp size with change in depth but these trends have been noted in other countries. Surveys in Hawaii (Struhsaker & Aasted, 1974) and in Vanuatu (King, 1980) indicated that a greater proportion of large shrimps are found in the middle of the species depth range; smaller individuals are more common in the shallower and deeper areas of the depth range.

TABLE 2: The number of *Heterocarpus ensifer* (expressed as a percentage of the number in the total sampled at each of the depths listed) in each of the three carapace length groups ≤19 mm, 20 to 30 mm and ≥31 mm.

Depth (m)	≤19 mm	20 to 30 mm	≥31 mm
306	6	86	8
387	6	82	12
486	28	67	5
545	17	75	8
635	24	60	16

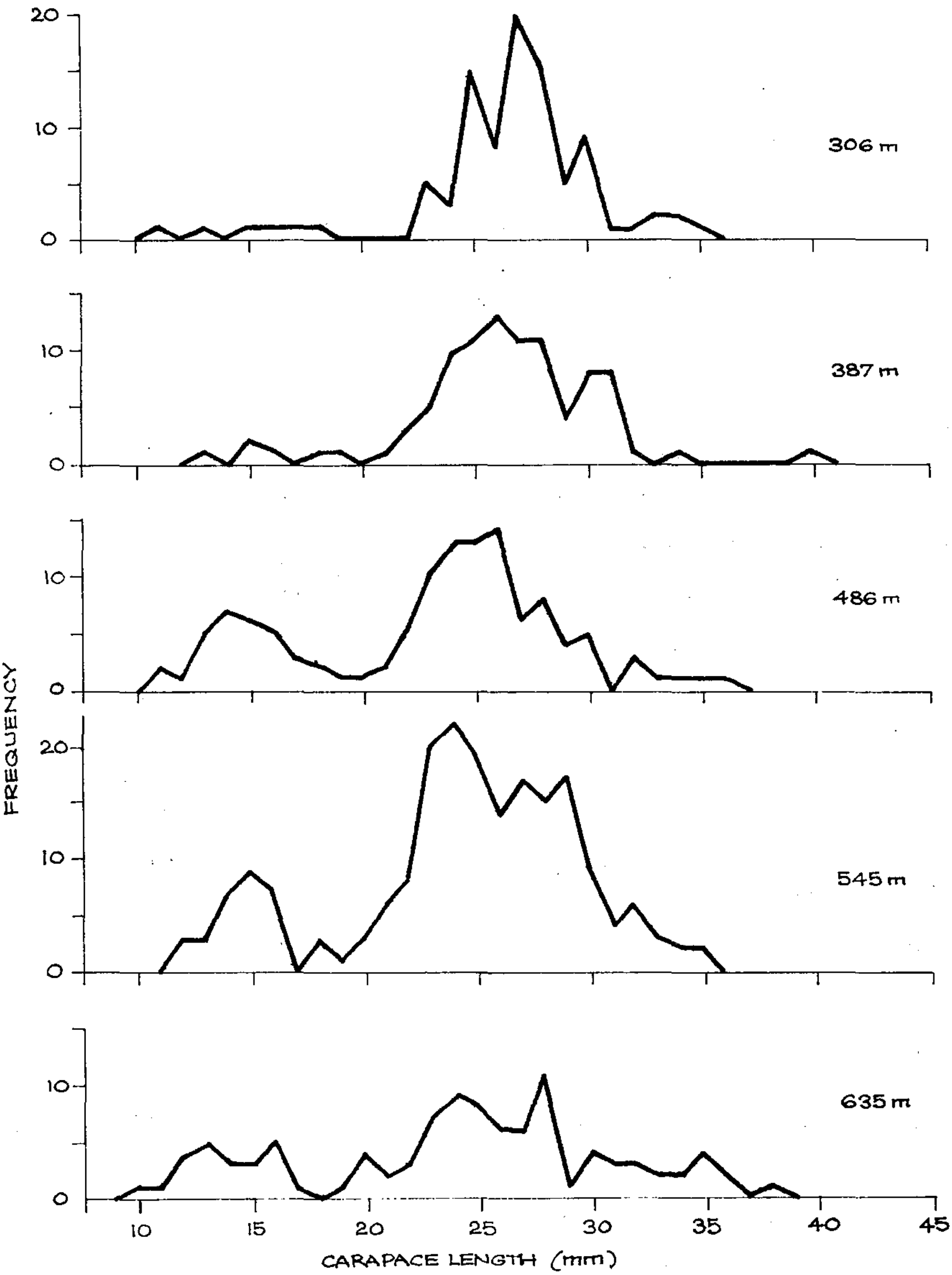

FIGURE 10: Length frequency distributions of **Heterocarpus ensifer** from different depths. The depth (m) is indicated at the right of each graph.

f. Sexuality:

As specimens of *Heterocarpus ensifer* were obtained over a large size range (10 to 40 mm carapace length) it was possible to determine the proportion of ovigerous (egg bearing) individuals in each size class for this species. Figure 11 was constructed by combining data from samples taken at all depths (n=608) and shows the number, in each millimetre size class. This figure shows that at about 28 mm carapace length, half the population consists of ovigerous females and at 36 mm carapace length and over, the population consists entirely of ovigerous females. Both *Heterocarpus ensifer* and *H. laevigatus* appear to be protandrous hermaphrodites - that is, existing initially as small males before changing sex to become females. Eggs are carried externally and work in Fiji (King - unpublished data) indicates that the eggs may go through a series of colour changes associated with development.

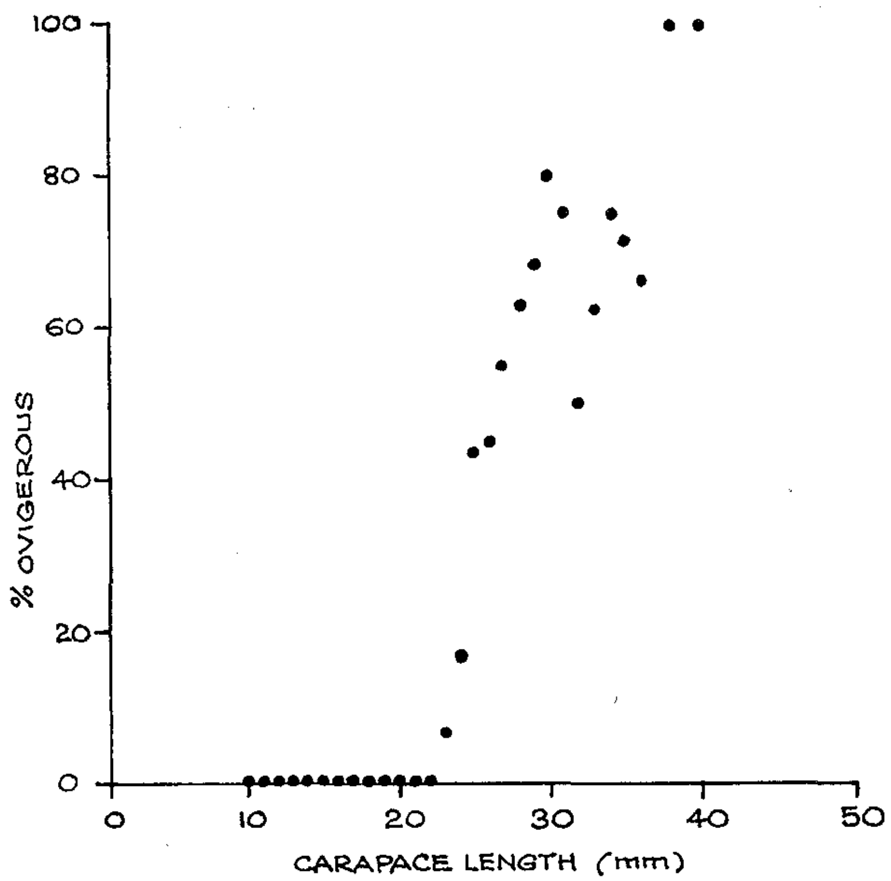

FIGURE 11: The percentage of ovigerous females in each mm size class, expressed as a percentage of the total sample (all depths combined; n=608)

4. DISCUSSION

A total of seven species of deepwater shrimp was found in the Western Samoan survey. This total includes six carid shrimps and one penaeid prawn species. Several of these species have been found in other Pacific island countries including Hawaii (Struhsaker & Aasted 1974), Guam (Wilder 1977), New Caledonia (Intes 1978), Fiji (Brown & King 1979) and Vanuatu (King 1980). Many of the smaller shrimps from depths less than 450 m are not referred to in this literature. Most of the published work refers to the distribution and biological aspects of the two larger carid shrimp, *Heterocarpus ensifer* and *H. laevigatus*; because of their sizes these two species are generally regarded as having the best commercial potential. Another large *Heterocarpus* species, *H. gibbosus*, which accounts for a substantial proportion of the catches in Fiji (in approximately 400 m to 500 m depth) was not found in the Western Samoan survey.

Heterocarpus ensifer and *H. laevigatus*, are found in all of the above countries and their reported depth distributions are shown in figure 12. The distribution of *H. ensifer* in Western Samoa (i.e. greatest abundance between 350 m and 650 m) is similar to its distribution in other Pacific countries. The depth distribution of *H. laevigatus* however appears to be more variable; in Western Samoa the species was found in greatest abundance between 500 m to 600 m.

Although the present survey was limited, the mean catches of 1.4 kg of shrimp per trap in the 500 to 600 m depth range were sufficient to encourage a further examination of the fisheries potential. Further studies over extended time periods are necessary, for example, to determine any seasonality in shrimp abundance. Surveys should also be extended to other areas of Western Samoa. The slope of the seafloor in the area examined during the present survey was very steep, which made setting traps in predetermined depths difficult. The steep seafloor slope is also likely to make anchoring the traps difficult; for example, during the survey one set of traps appeared to slide down the slope into deeper water until the buoys and marker flag were dragged beneath the sea surface.

Although the larger *Heterocarpus* species appeared to be more abundant than the other species, additional surveys are needed to assess the trap abundance of other shrimps. *Plesionika longirostris*, for example, is often abundant in Fiji in depths of about 350 m. This species has a higher "recovery rate" (the weight of high value tail meat expressed at a percentage of total weight) than the other species and is obtained in shallower water where fishing costs are obviously less. During the present survey, however, catches of *P. longirostris* were less than 0.3 kg. per trap. Further work is needed to determine the trap abundance and depth distribution of this species in shallower waters.

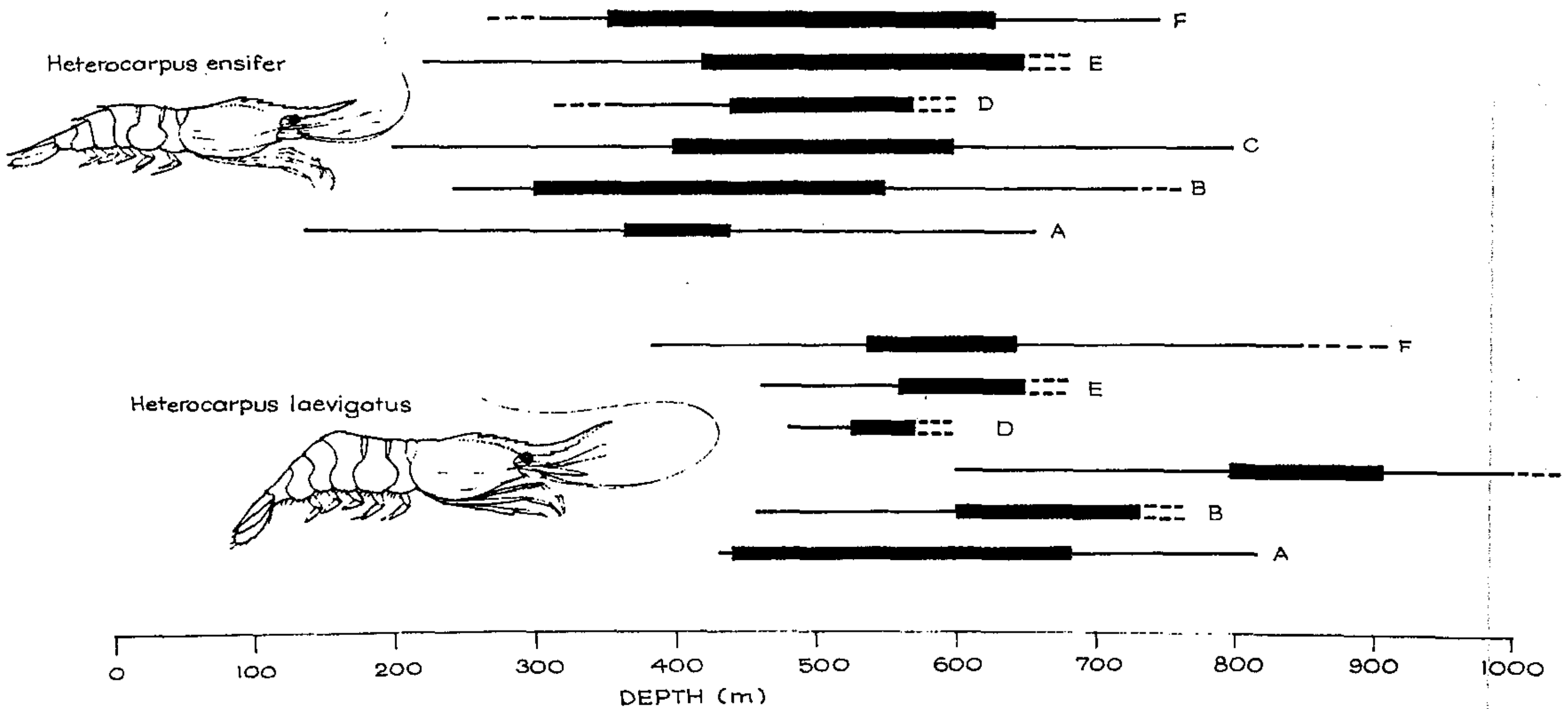

FIGURE 12: The depth distribution (light line) and depth of greatest abundance (heavy line) of **Heterocarpus ensifer** and **Heterocarpus laevigatus.** References are: (A) Hawaii, Struhsaker & Aasted, 1974,

(B) Guam; Wilder, 1977,

(C) New Caledonia; Intès, 1978,

(D) Fiji; Brown & King, 1979,

(E) Vanuatu (Formerly New Hebrides); King 1980

(F) this report.

Dotted lines indicate the limits of the respective surveys.

The present preliminary survey has established that deepwater carid shrimp can be trapped in Western Samoan waters in sufficient quantity to consider carrying out commercial trials. Further work is necessary to elucidate several points regarding the biological, economics, handling and marketing aspects of the proposed fishery. To this end, a suggested programme for further research is attached to this paper as an appendix.

5. ACKNOWLEDGEMENTS

I wish to thank the Chief Fisheries Officer of Western Samoa, Mr. Alphonso Philipp, for providing the facilities of the Fisheries Department for the project. The success of the survey was mainly due to the help of the ALIA "Tautai Nouei" crew, Milo Pualo, Peleti Paia, Talosaga Leapepe and, especially, Japanese aid (J.O.C.V.) gear technologist, Hiroshi Kinuta.

At the Institute of Marine Resources, I acknowledge the support of the Director, Dr. U. Raj and the assistance of Mr. Nand Ram. Drs. Leon Zann and Michael Capra kindly read the manuscript.

Financial support for the project was provided by the Hanns Seidel Foundation. Specimens of all shrimps collected were kindly forwarded, by Dr. D. Popper, to Dr. C. Lewinson of Tel Aviv University.

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7. APPENDIX - RECOMMENDATIONS:

The following is a recommended outline of further research, the aim of which is to investigate the possibility of establishing a deepwater shrimp trapping fishery in Western Samoa.

a. Extended surveys:

Trapping surveys could usefully be extended over time and area. Surveys should be carried out down the sea-floor slope at regular intervals (e.g. monthly) in a particular area. This sampling procedure would need to be continued for at least 12 months to examine the possibility of any seasonal fluctuations in catch rates.

Surveys should also be extended to other areas where the sea floor slope is more gradual than the one in the preliminary survey area of Apia. In selecting other areas to carry out surveys the following criteria should be considered. The area should.....

(i) have a moderate sea floor slope (ideally less than 1 in 8) in the depth range 350 m to 650 m.

(ii) preferably be on the leeward, and therefore more sheltered, side of the two main islands.

(iii) have adjacent shore facilities for fuel, ice etc.

Standard procedures, as reported in this paper, should be followed in all future surveys so that results can be readily compared and assessed. Standard traps with identical bait (tuna heads?) should be used and traps set at 50 m depth intervals down the sea-floor slope from about 300 m to 700 m. Data should be collected on standard forms to simplify the assessment of species distribution and trap abundances.

b. Trap and bait trials:

It is suspected that the traps used in the preliminary survey were not the most efficient for catching deepwater shrimps. For example, results in Fiji (unpublished) have shown that 4 -entrance box traps were more successful than types similar to those used in the survey. With the facilities and expertise available in the Western Samoan Fisheries Department, different trap designs could easily be built and the efficiency tested in controlled experiments.

Although tuna heads (*Katsuwonus pelamis*) were successfully used in the preliminary survey, a variety of cheap and locally available baits should be tested (using tuna heads as a control). Possibilities include fish oil with flour or small fish. The shrimp are cannibalistic and trials using shrimp "heads" (cephalothorax) from previous catches have had some success; however, oily bait such as tuna has proved to be the most efficient in initial trials in Fiji. (King, unpublished data).

c. The prospects of a fishery.

In examining the prospects for a shrimp trapping fishery, several items need to be carefully examined. These include the economics of the operation, catch handling and marketing.

The most suitable size and the type of vessel is usually of prime importance in any fishery. However, in Western Samoa large numbers of the F.A.O. "Alia" 8.5 m catamaran have been built and supplied to local fisherman. These aluminium catamarans are sold complete with a main (25 h.p.) and an auxilliary (8 h.p.) outboard engine as well as all line fishing gear for less than Aust $5.000. This type of vessel has been successfully used in shrimp trapping surveys in both Western Samoa and Vanuatu (King 1980). Their high initial stability and large deck area contribute to the catamaran's suitability. However to set the number of traps required for commercial operation (say a minimum of 50 traps) it would be necessary to relay strings of about 15 traps out to the fishing grounds at a time (a distance of about 12 n. miles return trip in the case of Apia). It may also be possible to develop folding or collapsable traps for the fishery.

Other than the fishing boat itself, there are two other expensive items of fishing equipment required - namely an echo-sounder capable of detecting the depths involved and a mechanical or hydraulic trap-hauling winch. It would be possible to use shore bearings in place of the echo-sounder to determine fishing locations and depths but this method would depend on the availability of charts with accurate soundings; the method would be less reliable where the sea bottom profile has as steep a slope as that obtained during this survey. Any examination of the costs involved, should include special reference to the increase of costs with fishing depth and the likely incidence of trap loss due to heavy weather, shark attack etc. The cost of bait may also be considerable.

The handling of deepwater shrimp requires considerable care - more so than, say, scale fish. Immediately after being caught, shrimp must be placed in crushed ice or chilled brine. Sodium metabisulphite, used as a dipping solution, may be a useful means of extending the cold storage life of the shrimp. Cooking time for deepwater shrimp must be kept short; 2 to 3 minutes in boiling water usually being sufficient.