COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION of FISHERIES and OCEANOGRAPHY

Report No. 93

A PUMP NET SAMPLER TO EXAMINE THE SPATIAL DISTRIBUTION OF ROCK LOBSTER LARVAE

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Reprint No. 994

Marine Laboratory
Cronulla, Sydney
1978

ISBN 0 643 002106 X

Printed by CSIRO, Melbourne

78.237-600

A PUMP NET SAMPLER TO EXAMINE THE SPATIAL DISTRIBUTION OF ROCK LOBSTER LARVAE

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Abstract

The design of a pump net sampler to study the size and horizontal distributions of patches of the early stage phyllosoma larvae of the western rock lobster *Panulirus longipes cygnus* George is described and its performance evaluated.

The sampler had a 1.6 m diameter mouth and an overall length of 7.08 m, with a filtering surface of 1.05 mm mesh. The sampler filtered approximately 120 m^3 of water min^{-1} when towed at 1 m s^{-1}. A suction hose attached to a cod-end funnel was used to pump the plankton from the codend to the deck of the vessel. Pumping was continuous, a series of subsamples being obtained at short intervals by directing the pump discharge into a series of mesh-bottomed buckets on deck.

The sampler could be towed at a specified depth for the desired length of time and at the desired speed, and still retain a good filtration capability. However, the subsamples pumped from the codend did not contain a representative proportion of the phyllosoma entering the net because almost all the phyllosoma adhered to the mesh of the net. The pumped subsamples did contain a relatively large proportion of euphausiids whenever they were encountered and it is possible that the sampler, in its present form, could be used to examine the spatial distribution of some species with compact, relatively dense body forms such as euphausiids. The net by itself with a conventional codend fitted would be a suitable sampler for obtaining large volume plankton samples.

INTRODUCTION

The majority of planktonic organisms are not distributed randomly in the water but exhibit pronounced aggregation of individuals (e.g. Haeckel 1890; Hardy 1936, 1955; Bainbridge 1957; Cassie 1963; Cushing 1962; Wiebe 1970). Large variation in the density estimates of early phyllosoma larvae of the western rock lobster *Panulirus longipes cygnus* George was found between stations sampled during 1974 and 1975 (Rimmer, unpublished data). These results indicated that the distribution of the early larvae was highly contagious and that the sampling technique used did not integrate the patchiness to a degree where reliable estimates of density over a broad geographical area could be obtained.

An attempt was made to try to understand the nature of the patchiness of the phyllosoma larvae and the mechanisms responsible for it. The approach was to design a horizontal sampler taking a continuous series of small discrete subsamples along a transect long enough to encompass one or more patches of phyllosoma. In this paper a brief description is given of the sampler which was developed and the results of the tests made to evaluate it are discussed.

The greatest densities of early stage phyllosoma are present during the summer months (December through February) at a depth of about 10 m, during darkness, in waters near the edge of the continental shelf in Western Australia (Rimmer, unpublished data). The sampler was tested under these conditions at about latitude 32°S using the 44 m vessel *R.V. Sprightly*.

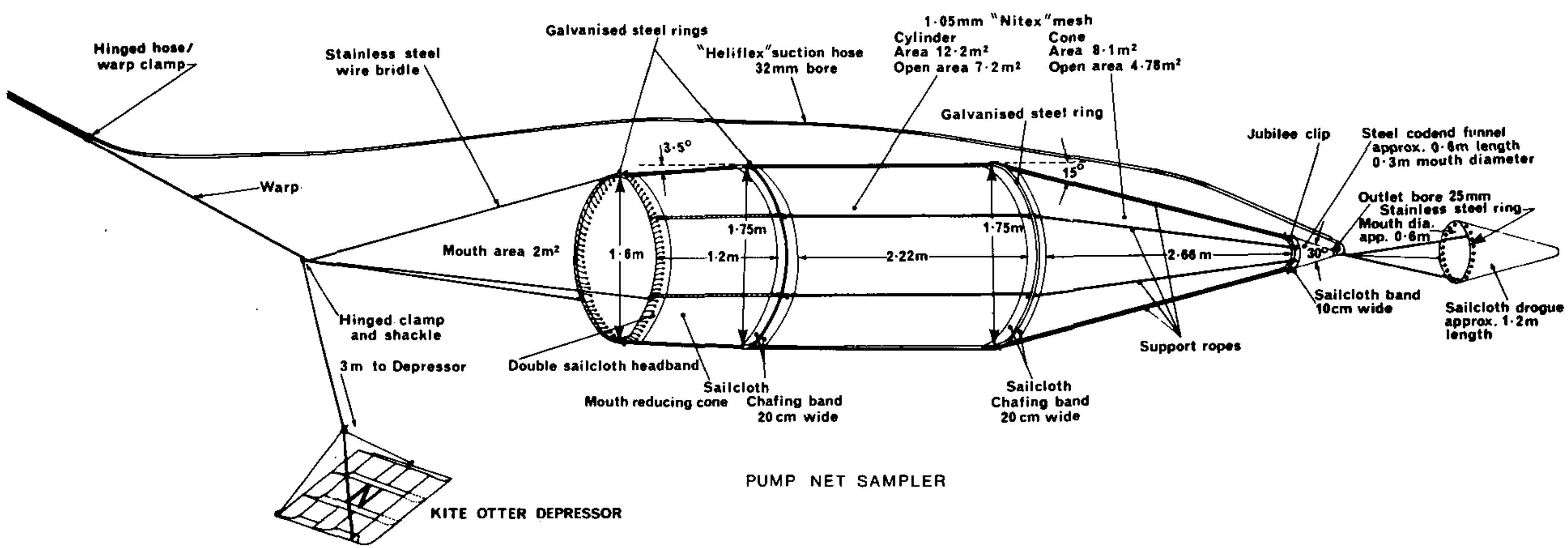

Figure 1. Pump net sampler in operational position showing construction details.

METHODS

Sampler Design

Considerations

The most important consideration taken into account was the overall sparseness of early stage phyllosoma larvae in the plankton. Data for Stage I phyllosoma larvae from the 1974-75 sampling programme (Rimmer, unpublished data) gave an unweighted arithmetic mean density at a depth of 10 m at night of approximately 35 (0-181) range larvae per 1000 m^3 of water filtered. The low density of these larvae in the plankton precluded the use of a Longhurst-Hardy type sampler (Longhurst *et al.* 1966) or a pump by itself, because the volume of water sampled would be too small to have any probability of catching larvae in numbers adequate for analysis. At the time, it appeared the best solution was to use a large net to filter most of the water and a pump to transfer the catch from the codend of the net to subsampling buckets on the deck of the vessel.

Because of the low density of larvae and the need to make the distance travelled for each subsample as short as possible for better definition of patch size, a volume of 200 m^3 of water was considered the minimum to be filtered for each subsample, with an estimated potential catch of about seven larvae.

The Net

A circular mouth plan was chosen as being the strongest for a lightweight design. The mesh used was 1050 μ monofilament "Nitex" with a porosity of 0.59. The design of the net was based on data and suggestions in the UNESCO monograph "Zooplankton Sampling" (1968). The filtration efficiency was intended to be as near as possible to 100% and the net was to be capable of being towed for at least one hour at 1.0 m s^{-1} without serious reduction in filtration efficiency through clogging. An open area ratio of 6:1 was selected. A mouth reducing cone and a large cylindrical section of mesh were incorporated to increase and sustain filtration efficiency. The details of assembly and materials are shown in Fig. 1.

Codend Attachments

The fore end of the codend funnel was a metal collar (0.3 m diameter) which fitted inside the codend of the net. Loops welded around the collar provided attachment points for the support ropes which took the strain off the mesh. Behind the collar, the steel sides tapered down at the same angle as the net's side angle, to an inside diameter of 25 mm. A tube leading from the end was curved around so the suction hose connected parallel to the net's side angle. Cam-lock fittings were used for quick attachment and release. A small conical drogue was attached to keep the codend from sinking under its own weight and collapsing the net. Results of the initial sampling trials suggested the steel codend funnel was unsatisfactory and the codend was modified by replacing the funnel with a framework of steel rods and extending the mesh of the net right down to the suction hose intake.

The suction hose was a 160 m continuous length of 32 mm (1¼ inch) bore "Heliflex" (Nylex Corp., Australia) with transparent walls.

A deck mounted KL-Bornemann (Kelly and Lewis Pty. Ltd., Australia) eccentric helical rotor pump with variable speed drive and a 2 HP 440 V, 3 phase motor in a waterproof casing was used. The delivery rate was 59.1 ℓ (13 gal) min^{-1}.

TABLE 1

CATCHES OF EARLY STAGE PHYLLOSOMA

Haul	Duration of haul (min)	No. of 2 min sub-samples	No. of sub-samples with larvae	Total No. of larvae in sub-samples	No. of larvae in net residue	Vol. of euphausiids in subsamples	Vol. of euphausiids in net residue
(a) From Seven Hauls using Pump Net with Steel Codend, January-February 1976.							
1	60	30	9	12	290	-	-
2	60	30	0	0	170	-	-
3*	46	23	0	0	no sample	-	-
4	30	15	6	7	1599	-	-
5	60	30	0	0	2531	-	-
6	30	15	0	0	489	-	-
7	46	23	0	0	921	-	-
			TOTAL	19	6000		
			% OF TOTAL	0.3%	99.7%		
* Suction hose broke off codend about 8 min after commencement of this haul - subsamples taken with pump only.							
(b) From Five Hauls using Pump Net with Modified Mesh Codend, December 1976							
8	60	30	2	3	43	1979	1120
9	60	30	4	4	149	1311	1300
10	60	30	1	1	61	1366	1435
11	60	30	4	6	1255	9228	9590
12	60	30	15	24	2285	1008	700
			TOTAL	38	3793	14892	14145
			% OF TOTAL	.1%	99%	51%	49%

The subsamples were collected on deck by directing the delivery hose for 2 minutes in turn into each of a series of mesh bottomed buckets. The bottom of each bucket was removable to permit preliminary examination of the subsample under a magnifying lamp before it was preserved.

A kite-otter (Colton 1959) was used to depress the warp. The net was attached to the warp about 3 m above the depressor. The hose was attached to the warp at intervals of about 3 m with modified hinge clamps (Griffiths and Rimmer 1977) which had a hinged cylindrical section welded to one side which clamped around the hose.

Initial sampling with the pump net was carried out in January and February 1976. At that time the sampler was fitted with the steel codend funnel. Modifications were made and further sampling trials were carried out in October and December 1976 with the modified codend assembly.

The slowest practicable towing speed (about 1 $m\ s^{-1}$ or 2 knots) was used to allow a minimum distance to be covered by each subsample. At that speed, and with a net mouth area of 2 m^2, a volume of 240 m^3 would be filtered in 2 minutes while covering a distance of 120 m. A transect of approximately 3600 m (nearly 2 nautical miles) would be covered in an hour.

For each haul the net was towed in a direction diagonal to the wind, so that if patchiness was due to windrows, the sampler would be cutting across them diagonally. As soon as the net stabilized at depth, the pump was started and allowed to run for 1 minute to clear the hose before the subsamples were taken. A continuous series of 2 minute subsamples was obtained over sampling periods ranging from 30 minutes to 60 minutes. Subsamples were examined on board for the presence of early stage phyllosoma larvae then preserved for later examination. At the end of each haul the pump was shut off and the sampler recovered. The net was then washed down and all residual material from the net preserved. A total of 18 hauls were made during trials of the sampler.

RESULTS

The sampler was awkward to handle over the stern of the vessel when launching and recovering, but behaved satisfactorily once submerged, and all equipment functioned correctly. The net was able to sustain its filtering capability throughout a one hour haul at 1 $m\ s^{-1}$ as evidenced by lack of clogging in the cylindrical section of the net.

The volume sampled during a one hour haul was in the order of 7200 m^3 which appeared to have been adequate to provide a sufficient number of early stage phyllosoma. The result of catches of early stage phyllosoma in January-February 1976 and December 1976 and also of euphausiids in December 1976 are given in Table 1. Total catches of early stage phyllosoma (combining net residue and subsamples) for one hour hauls in a single location within a three day time span in January-February 1976 ranged from 170 to 2531 phyllosoma per haul. In a similar location over two days in December 1976 the range in total catch per haul was 46 to 2309 phyllosoma. Assuming that all the phyllosoma appeared in the subsamples and each of the 30 subsamples contained an equal proportion of the total catch, then the catch per subsample would have ranged from 5.7 to 84.4 in the January-February 1976 hauls and 1.5 to 77.0 per subsample in the December 1976 hauls. When subsamples and net residues were examined, it was found that almost all phyllosoma had adhered to the net and that only a very small percentage of the phyllosoma entering the net actually appeared in the subsamples.

It was obvious from the results of the first trials that the sampler was not functioning as expected. It was suspected that the steel codend funnel produced a "barrier" of slow moving water which prevented plankton from entering the suction hose. It was calculated that if the opening to the funnel was not obstructed a volume of 4.24 $m^3\ min^{-1}$ would pass through it when towed at

TABLE 2

SETTLED VOLUMES (cm^3) OF PLANKTON IN PUMPED SUBSAMPLES FOR EACH QUARTER OF THE HAULS

Haul	8	9	10	11	12	13 *	15	16	17*	Quarterly totals
First quarter	851.5	196.6	268.0	1298.0	1.7	0.2	4.5	12.0	<0.1	2632.5
Second quarter	644.5	433.0	375.0	2196.0	289.1	0.1	32.0**	7.5	<0.1	3977.2
Third quarter	321.5	347.0	523.0	2731.5	308.0	0.1	1.2	12.3	<0.1	4244.6
Fourth quarter	161.5	334.0	200.0	3002.5	409.0	0.0	1.3	7.2	<0.1	4155.5
Haul Total	1979.0	1310.6	1366.0	9228.0	1007.8	0.4	39.0	39.0	<0.1	14969.8

* Pump only, with inlet towed at same depth as for samples with net.

** Comprising mostly a single seaweed specimen.

1 m s $^{-1}$. The pump was removing only 0.059 m^3 min^{-1}: thus the codend funnel must have been "rejecting" 4.18 m^3 min^{-1}. The "rejected" water would then have to pass through the meshes. It was thought that the "rejected" plankton would adhere to the mesh and clog it immediately in front of the funnel. As the haul went on the clogged area would enlarge thus progressively increasing the "hang-up" of plankton in the net. To examine this hypothesis the codend was modified so that the mesh extended right down to the hose intake. If this "barrier effect" was taking place, then one would expect a consistently higher volume of plankton to be picked up by the pump near the beginning of a haul when the meshes would be clear than towards the end when they would be clogged. However, this was not in any way evident (Table 2) and comparison with the data in Table 1 showed that there was no significant improvement in the proportion of phyllosoma appearing in the subsamples after the codend was modified. Clogging occurred no matter which system was used.

During the December 1976 trials large numbers of euphausiids were encountered, and hauls 8 to 12 were composed almost exclusively of euphausiids. In each of these five hauls the ratio of the euphausiids in the subsamples to euphausiids in the net residues was very close to 50:50 (Table 1). This was a vastly better result than that achieved for phyllosoma in the same hauls where the average proportion of numbers in subsamples to numbers in net residues was only 1:99.

Two hauls made with the suction hose detached from the codend were compared with other hauls with the sampler intact to see if a greater amount of plankton would be washed out of the net through the opening in the codend than was taken out by pump when the hose was attached. The amount of plankton residual in the sampler after the first open codend haul, which occurred accidentally when the hose broke off the codend, was not detectably different from the amount in other hauls made the same night. The second open codend haul actually yielded a higher volume of plankton residue than any of the other four hauls done at the same location within two nights (Table 3).

Table 3. Settled volumes (cm^3) of plankton in pumped subsamples and net residues (hauls 7-12: December 1976, hauls 13-17: October 1976)

Haul	Duration of haul (min.)	Vol. of plankton in subsamples (cm^3)	Vol. of plankton residual in net (cm^3)	Gear configuration used
8	60	1979.0	1120.0	Pump net sampler intact
9	60	1310.6	1300.0	" " " "
10	60	1366.0	1435.0	" " " "
11	60	9228.0	9590.0	" " " "
12	60	1007.8	700.0	" " " "
13	60	0.4	no sample	Pump only - net not used
14	40	18.0	34.0	Pump net sampler intact
15	40	39.0	31.0	" " " "
16	40	39.0	350.0	" " " "
17	40	<0.1	no sample	Pump only - net not used
18	40	no sample	1790.0	Net only, codend open - pump not used

Three hauls were made using the pump intake without a net. The first of these occurred when the suction hose broke off the codend. There was a drastic drop in the observed volume of plankton appearing in the subsamples. Volumes measured for the other two hauls showed a similar drop in subsample biomass (Table 3). Not a single phyllosoma larva appeared in any of these subsamples.

DISCUSSION

The most serious problem encountered with the sampler was that of "hang-up" in the net. Hang-up has two effects 1) some organisms adhere to the mesh and fail to find their way to the pump intake, and 2) some organisms do pass from the net mouth to the pump intake but at different rates. The first affects the reliability and the second affects the discreteness of the subsamples. If the rate of passage from the mouth to the codend of the net is not uniform then mixing will have occurred by the time the organisms have reached the pump intake and each subsample will not be a discrete representation of what entered the net mouth during each 2 minute subsample. The extent of the first problem was measured quite easily by comparing amounts of material in the subsamples with amounts residual in the net after each haul. The problem of discreteness is much more difficult to assess and at present there does not appear to be any way of knowing to what extent this is affecting the sampler.

The catches of early stage phyllosoma from the one hour hauls appeared to be large enough to facilitate statistical analysis. If a method could be devised to overcome the "hang-up" problem then the sampler could be a useful tool in studying the horizontal distribution of phyllosoma, at least on a scale where patch size was in the order of about 2000 m or less. Patches larger than this would be too big to encompass in a one hour haul.

The wide range in variability of catch size of early stage phyllosoma larvae from the same location within a short space of time indicates that the hauls are not sampling enough water to fully integrate the effect of patchiness and consequently the sampler could not be used to make reliable quantitative estimates of density of these phyllosoma.

Indications from the sampling described here and from other sampling programmes carried out over the past four years (Rimmer, unpublished data) are that patchiness probably exists on more than one scale and, while the sampler discussed here could be integrating a number of smaller patches in a haul, there are probably much larger patches in the order of tens of nautical miles in dimension which this sampler could not integrate.

Other workers (e.g. Aron 1958; Cassie 1958, 1959) have successfully used pumps to collect plankton samples directly from the water. However, the volumes sampled by their apparatus were relatively small. Aron's pump delivered about 1800 ℓ min^{-1} (400 gal min^{-1}), while Cassie's delivered only 200 ℓ min^{-1} (about 44 gal min^{-1}) and hence the method is only applicable where the organisms being sampled are relatively numerous. The three trial hauls, while sampling directly through the pump intake without the net, were not successful in catching even a single phyllosome after a total of 2 hours 40 minutes pumping as would be expected of such a sparsely distributed organism. The volume sampled by the net was found to be sufficient to provide an adequate sample of phyllosoma. A pump to deliver the same volume would have to have a capacity of 120 000 ℓ min^{-1} (about 26 400 gal min^{-1}) and this is obviously impractical.

The sampler, in its present form, appeared to be successful in sampling euphausiids and it could be useful for studying spatial distribution of these or other organisms with relatively dense, compact body forms, which are less prone to "hang-up" in the net. That is, of course, providing the rate at which these organisms pass down the length of net can be demonstrated to be reasonably uniform.

The net operated well in that it could be towed at the desired depth and speed for the required time while still retaining a good filtering capacity. If fitted with a conventional codend bucket in place of the suction hose and pump it would be a useful piece of gear for obtaining large plankton samples. A fuller description of the sampler is available on application to the authors.

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