DRAGONET II, AN OPENING-CLOSING QUANTITATIVE TRAWL FOR THE STUDY OF MICROVERTICAL DISTRIBUTION OF ZOOPLANKTON AND THE MEIO-EPIBENTHOS[1)]

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With 11 Text-figures and 6 Tables

Scientists, in their efforts to reduce the difficulties of studying the marine benthos, have produced an abundance of bottom sampling instruments. These have been reviewed recently by HOLME (1964) and HOPKINS (1964). In recent years most emphasis has been placed on corers and grabs which, if used properly, give the most precise samples of bottom sediments and their biocontents. Trawls have slipped somewhat into disrepute, but nevertheless many naturalists still use them surreptitiously. In order to determine the microdistribution of zooplankton near the bottom, and of epibenthic animals just above the sea floor, we here add a super-gadgeted trawl to the over-long list of bottom sampling devices. Where depth, visibility and other factors permit, diving and manual manipulation of collecting apparatus as described by FAGER, FLECHSING, FORD, CLUTTER and GHELARDI (1966) can eliminate many of the errors that attend the use of remotely controlled apparatus including trawls, and we have used that approach with this apparatus whenever feasible. However, the Dragonet is primarily designed for remote operation. Some may recognize Dragonet II as a modification of the EBD's and EBTOC's (epibenthic dredge, epibenthic trawl, opening closing) built by BRADSHAW and BIERI some years ago (GUNTER, 1957). Although there are several new features in this trawl, its two unique characteristics are a changing bridle attachment and an *in situ* sorter. While lowering, the bridle is attached above the center of gravity. This assures that the trawl will land right side up and thus permits the design of an asymmetrical trawl. When the trawl reaches bottom, the suspension point shifts forward and lower, for towing over the bottom. The lower and forward towing position reduces drag during

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retrieval. The *in situ* sorter removes much of the collected sediment from the lighter, more delicate organisms concentrated in the net, thus reducing the damage to fragile animals. We named this trawl after the Flathead Dragonet, *Calliurichthys japonicus* (HOUTTUYN) or Yomegochi in Japanese.

Features of the Trawl

The trawl is shown closed for lowering in Text-fig. 1, and open in Text-fig. 2. Text-fig. 3 gives the dimensions of the trawl. These can be modified to suit local needs. It is made of a black-iron rod frame mounted on two thin galvanized iron runners. For use in very soft sediments the runners should be doubled in width. The sides and doors are also made of thin galvanized iron. The entire assembly weighs 35 kg in air. The doors are opened and closed by a gravity actuated lever on the stern. This lever arrangement has the advantage of low drag and immediate closing if, during the trawling operation a sudden increase in speed pulls the trawl off the bottom.

Glued to the upper door is a thin plastic tube (Text-fig. 2) that jams the flow meter of the upper net so the propeller can only rotate while the doors are open. We use a Rigosha flow meter with the anti-reverse mechanism removed and the propeller glued to the shaft. The meter is held to the dividing shelf by twisted copper wire.

The lower door has a wire whisker that releases a VAN DORN type water bottle when the trawl is ten cm above the bottom (Text-fig. 4). The tubular guide for the whisker is slotted so that the bottle can be cocked while the doors are closed. The bottle is used to take a bottom salinity and phytoplankton sample. We have used a thermometer inside the bottle to get a crude estimate of the bottom temperature, but a BT or other independently operated device would be better.

The nets are attached to a wire frame by means of buttons. The frame and nets are quickly slipped in and out of their guide slots to facilitate rinsing. Several kinds of frames can be made to allow the use of two, three, four or more nets at one time.

As mentioned above, the unique feature of the trawl is a bridle release system which assures that the trawl will land right side up on the bottom. When on the bottom, Dragonet is towed from low in front in the traditional manner (Text-fig. 6), but while it is being lowered, the bridle is fed back to two releases at the center of the trawl doors. Figure-eight shaped rings are welded to a ten mm diameter iron spreader which is attached to the releases (Text-fig. 5). When the trawl strikes the bottom, the spreader with rings is released and the towing point shifts to the front of the trawl. Thus during lowering the center of gravity of the trawl is well below the point of attachment of the bridle. For work deeper than 50–100 m the first release point can be shifted to the top of the doors, but in this case a weight should be tied to the stern release lever so that it hangs a foot or two below. This is needed

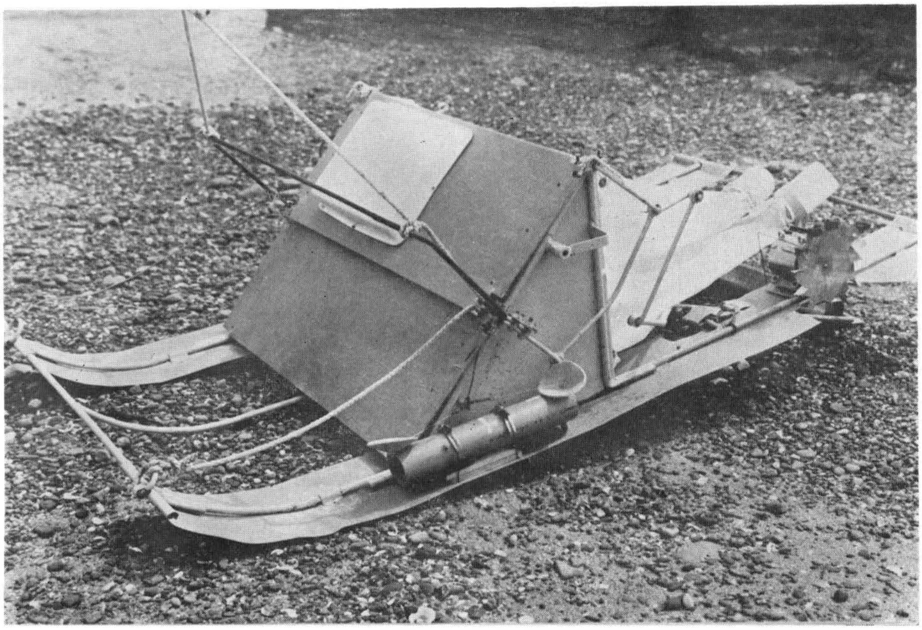

Fig. 1. Dragonet in closed position ready for lowering. White tray bolted to the upper door allows for the installation of an automatic camera.

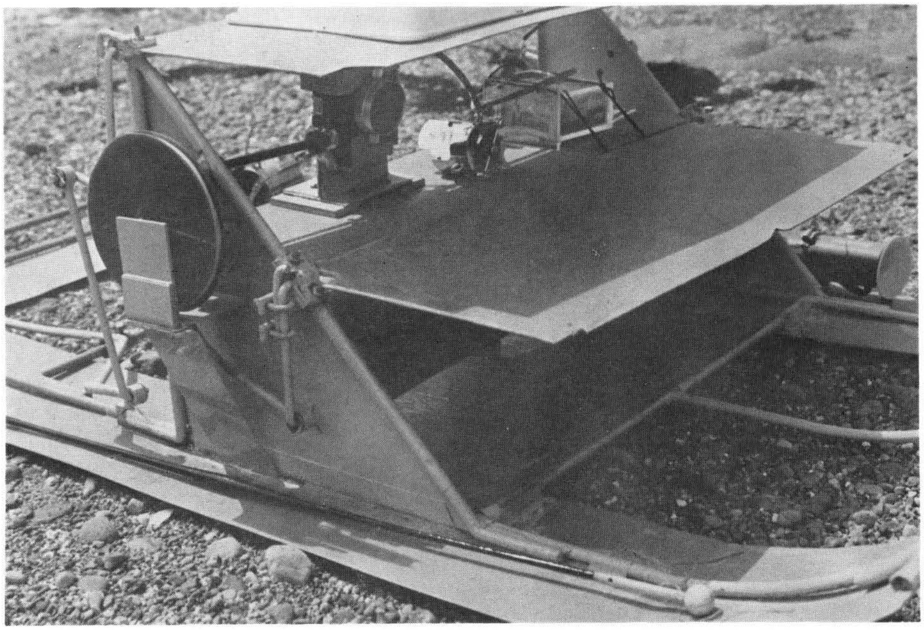

Fig. 2. Dragonet without nets but in open position. Note closed water bottle, flow meter with black plastic jamming rod attached to the upper door, and shelf inserted to divide the lower door compartment into two ten cm levels. In this picture the trawl is equipped with an automatic camera and strobe.

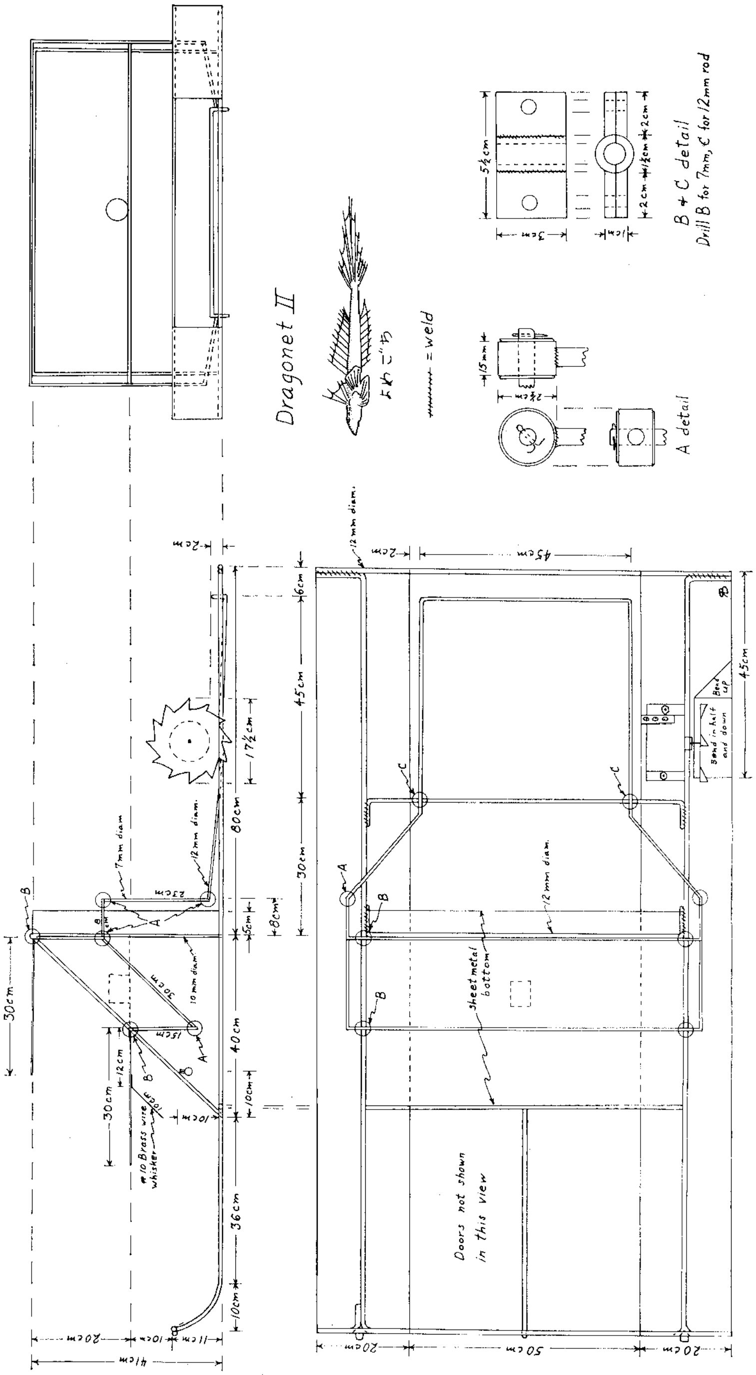

Fig. 3. Detail drawing of Dragonet II.

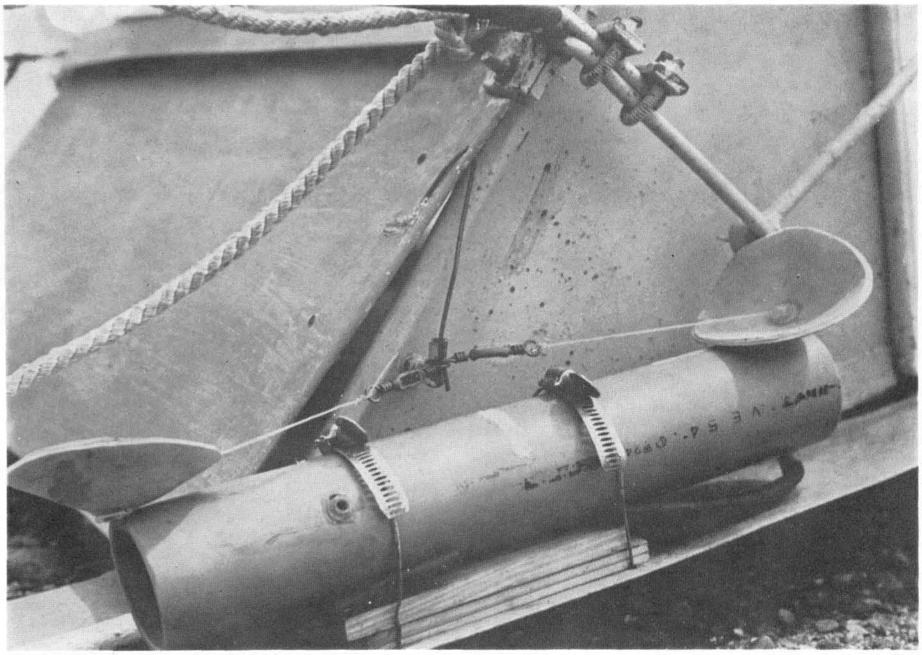

Fig. 4. VAN DORN type water bottle showing whisker release.

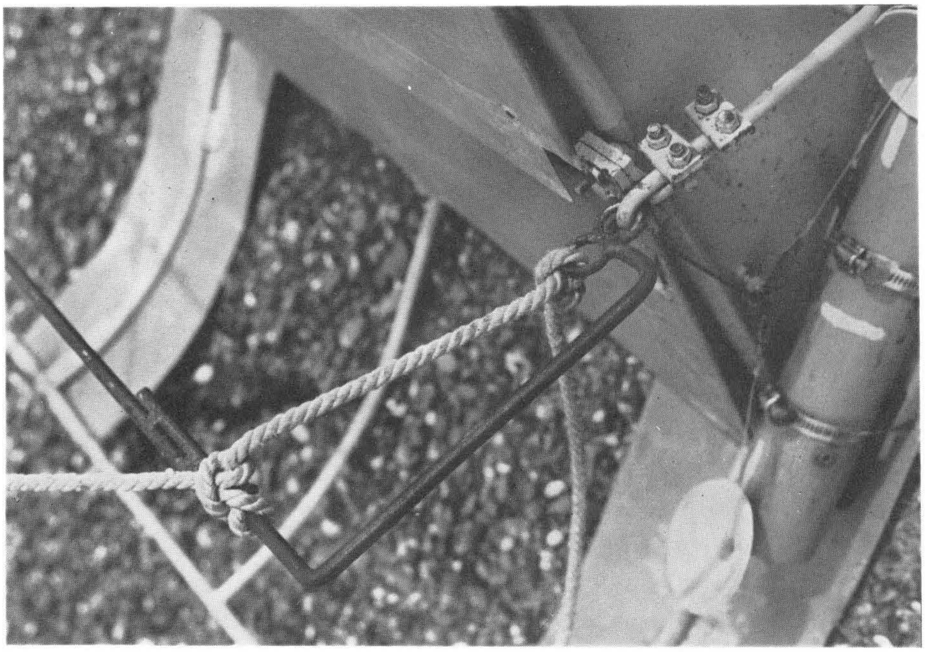

Fig. 5. Detail view of the bridle spreader and center release.

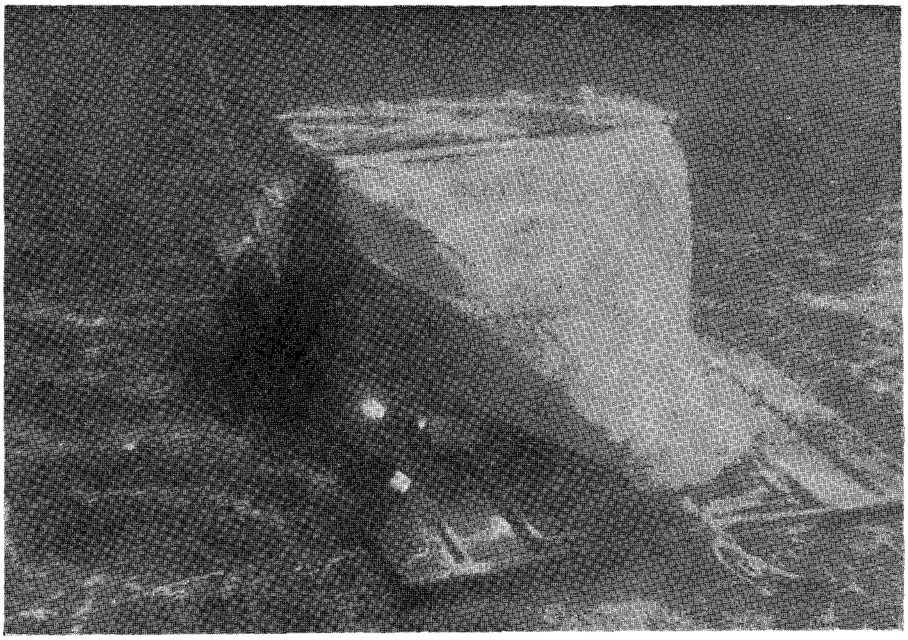

Fig. 6. Dragonet in operation on a gravel bottom. Water sample has been taken. Note that the nets are tied to the stern cross bar.

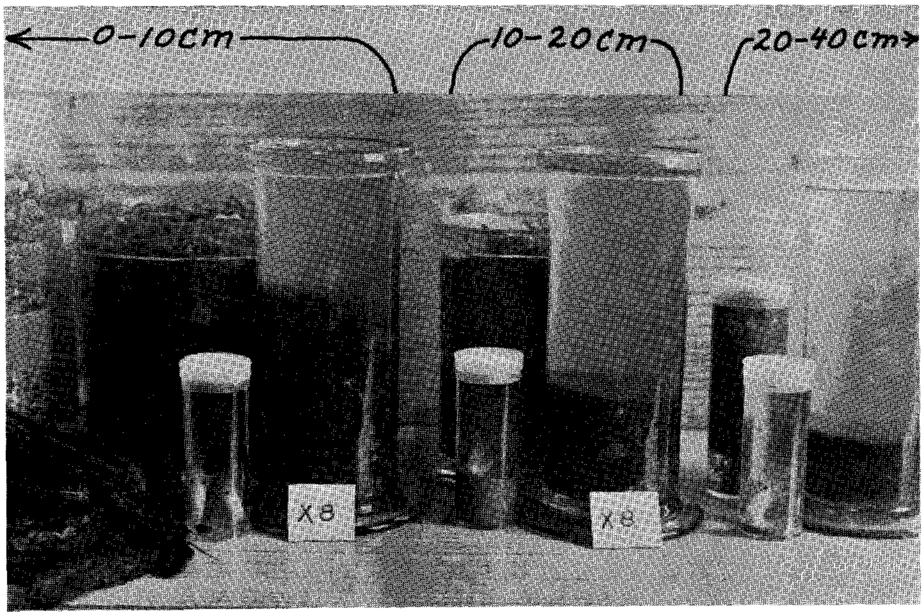

Fig. 7. Three samples from a single tow over a coarse-sand and gravel bottom showing the different amounts of sediment; detritus larger than five mm; smaller detritus with smaller animals; and shrimp taken from 25 square meters. The lower net collected

to keep the trawl in a "nose up" position while lowering and to insure that the stern of the trawl strikes bottom first. The bridle release system could possibly be used on other trawls to give a depressor action during lowering and a low drag configuration during retrieval.

The sheet metal shelf between the bottom net and the lower front door is faced with two iron rods. The shallow pan formed by this arrangement (Text-fig. 2) acts as a catching tray for sand, shells, rocks and other heavy components. The material collected in the pan is saved and examined for heavier animals such as pelecypods and ostracods. This *in situ* sorting helps prevent damage to the more delicate bottom organisms during trawling.

The bottom walker (Text-fig. 1) is made from a T.S.K. flow meter in order to keep the friction of the counter to a minimum and thus reduce the slippage of the blades in different kinds of sediments. The front bearing is removed and replaeed by a plastic tube. The paddle wheel, cut from thin sheet metal, is held to the propeller shaft by screwing into a plastic sleeve. All anti-reverse fittings of the meter are removed. The walker has a jammer made of thin brass rod attached to the stern release lever (Text-fig. 1). This prevents the wheel from turning except when the trawl is on the bottom.

We have been using the trawl in a very rocky region and thus have put a cross bar and dividing bar at the front of the trawl to help carry it over large rocks. However, in areas where rocks are not a hazard, these bars could be left out. In this case the front runners should be stiffened by the addition of an extra iron rod down the center of each runner. This would decrease the disturbance in front of the nets and probably increase the catch of the more agile animals.

Operation of the Trawl

The bottom walker is calibrated in place on the trawl, complete with nets, by towing by hand over a measured course in shallow water. The trawl and walker should be observed continuously to see that everything is working correctly. Over a 60 m course in coarse gravel the bottom walker made 52 revolutions and in hard packed sand 58 revolutions. At the same time the flow meter recorded 270 and 150 revolutions respectively. The tide was ebbing during the calibration and produced the difference in the flow meter readings. The upper flow meter is calibrated in the usual way by towing it without nets at speeds of one-quater to three knots in an enclosed tank.

On board ship the bottom walker and flow meters are zeroed. The bridle is set in the center releases and a stick is placed between the stern cross bar and the

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Fig. 7. Continued
several pieces of waterlogged pine bark shown at the left. Note that the amount of smaller detritus and smaller animals shown for the lower two levels is only one-eight of the total taken.

stern release lever until the trawl is ready to put over the side. The water bottle is set. With the boat moving at slow speed, the trawl is lifted over the side, slipped in stern first and allowed to stream astern for a few moments to see that all is in correct position. The trawl is then lowered to the bottom while the boat maintains its slowest forward speed. It is left on the bottom for two to four minutes then retrieved. We use nine mm diameter nylon rope for the bridle and towing line. A weak link of 5 mm polyester line is used on one side of the bridle.

Samples Collected by the Trawl

We have used the trawl with good results down to 100 m. The analysis of these collections will be reported later in detail, but Table 1 shows the degree of separation achieved in a tow made over a sand bottom in a small pocket beach on the south shore of Tanabe Bay in the middle of March, 1966. Two nets were used, each sampling a 20 cm thick layer. A considerable amount of the zooplankton was very close to the bottom (0–20 cm) and would not have been adequately sampled with the usual vertical or oblique net tow.

Table 1. Number of individuals per 5 m^2 of bottom or one m^3 of water.

Organism	Lower Net (0–20 cm)	Upper Net (20–40 cm)
Gammarids	800	5
Mysids	33	1/2
Harpacticoid copepods	38	1/2
Cumaceans	19	0
"micro" Calanid copepods	43	1
Decapod larvae	29	1
Nematodes	19	0
Ostracods	100	0
Ophioplutei	3	0
Larvaceans	10	0
Chaetognaths	2	2
Noctiluca	400	6×10^3
Coscinodiscus	80	1×10^3
Algal detritus	7 ml	0.2 ml

In another series of tows in shallow water the bottom net was replaced by two nets each sampling a 10 cm thick layer. The mixed sand and gravel bottom had large, scattered clumps of algal detritus but even so, there was good separation in the lower nets as shown in Table 2 and Text-fig. 7. One unexpected result was the collection of loose detritus. The Dragonet may be a useful device for the quantitative study of macro-detritus.

To show a part of the effective results obtained by Dragonet, the qualitative

Table 2. Number of individuals per 10 m^2 of bottom or one m^3 of water, May 7, 1966; 10 a.m.

Organism	Lower Net (0–10 cm)	Middle Net (10–20 cm)	Top Net (20–40 cm)
Gammarids	440	57	20
Mysids	26	15	2
Harpacticoid copepods	188	6	6
Cumaceans	116	6	0
"micro" Calanid copepods	45	270	820
Nematodes	19	3	2
Shrimp	2	0	0
Caprellid amphipods	52	0	6
Tanaids	13	0	0
Flatworms	6	0	0
Chaetognaths	6	120	2
Coscinodiscus	0	3	20
Noctiluca	trace	trace	2 ml
Zooplankton and zooepibenthos	5.3 ml	2.3 ml	0.6 ml
Macro-detritus	42 ml	2.5 ml	2 ml
Sand	12 ml	2 ml	0.2 ml

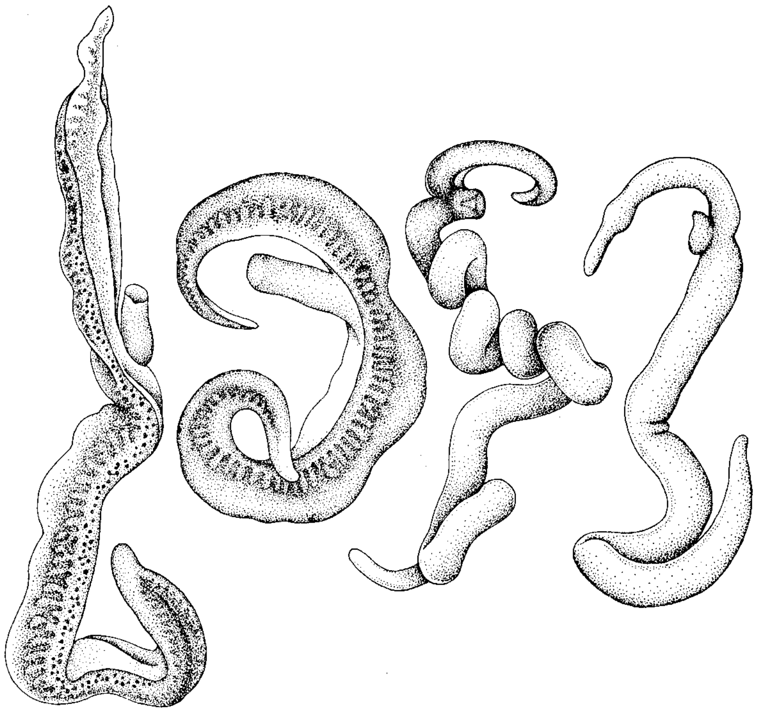

Fig. 8. Two monocelidid turbellarians found abundantly at St. NS-1, ×35.

analyses of near-bottom plankton and meio-epibenthos in some trawl catches are given roughly below.

Nearshore Samples 1 and 2: The Dragonet was trawled in a small pocket beach on the north coast of the cape occupied by the laboratory on March 12, 1966. Of the two trawls, the first (NS, No. 1) was made at 10.00 h for 60 m distance on a gravel bottom 1.5 m deep about 7 m from the water's edge. The last (NS, No. 2) was

Table 3. Plankton composition of nearshore samples.

Samples / Animals	NS Sample No. 1		NS Sample No. 2	
	Top net sample	1/2 of bottom net sample		Top net sample
Siphonophora	13	2	3	7
other hydromedusae	37	6	3	7
Pleurobrachia sp.				1
Cyphonautes			1	1
Actinotrocha	1			
Penilia		1		
Evadne nordmanni	39 } 57	12 } 14	4 } 10	10 } 21
Evadne tergestina	18	1	6	11
Conchoecia sp.		1		1
Acartia spp.	5	17	52	32
Paracalanus spp.	16	7	7	3
Oithona spp.	25 } 80	3 } 43	7 } 76	6 } 58
Corycaeus spp.	26	5	6	14
other copepods	8	11	4	3
Crustacean larvae	11	4	1	6
Creseis spp. (empty shell)	(3)	(2)	1 (1)	
Littorinid egg	1			
Ophioplutei	7			8
Serratosagitta pacifica	9 } 29	2 } 6	1 } 5	1 } 3
other chaetognaths	20	4	4	2
Oikopleura longicauda	2		1	1
other oikopleurids	6 } 42	4 } 23	1 } 16	5 } 44
Fritillaria pellucida	31	18	14	38
other fritillarians	3	1		
Doliolum nationalis			1	
Ascidian larvae	3	1	1	1
Fish eggs	5	2	2	1
Fish larvae		1		1
Eggs unident.			1	
Larvae unident.	1			2

made at 11.00 h for the same distance on a sand bottom 1.8 m deep only 10 meters offshore the course paralleling the first trawl. Large amounts of detritus of brown algae were found in both catches. The plankton composition seen in these two samples was the same as shown in Tables 1 and 2, with dense *Noctiluca* and a significant amount of *Coscinodiscus*. The differences between the top and bottom net plankton samples and between the No. 1 and No. 2 trawl plankton samples may be seen in Table 3. Even in such shallow places, some slight vertical differences are noticed in quantity. The composition of meio-epibenthos in those samples is given in Table 4. Of foraminiferous shells of NS No. 1 sample, *Planorbulina acervalis*,

Table 4. Meio-epibenthos composition of nearshore samples.

Samples / Animals	NS Sample No. 1				NS Sample No. 2			
	Top net sample		1/2 of bottom net sample				Top net sample	
Foraminifera (mostly empty shells)	391		534		80		184	
Monocelidids	9		385		2			
Nematoda	61		335		141		22	
Polychaeta	11		8		12		5	
miscellaneous vermes including larvae			6		3			
Harpacticoid copepods	55		92		112		27	
Ostracoda (live)	4		10		22		6	
(empty shells, unpaired)	46		57		42		19	
Proneomysis tenuiculus			92	92	83	94	1	2
Gastrosaccus kojimaensis					11		1	
Pontocrates altamarinus	2	13	27	78	702	971	12	26
Pontogeneia rostrata	5		28		38		3	
Urothoe sp.			4		186		9	
other gammarid amphipods	6		19		45		2	
Caprella acutifrons f. *neglecta*	3	5	1	2	7	11		
other caprellids	2		1		4			
Anatanais normani	2		1				1	
Sphaeroma sp.			6	8		1		
Munna sp.			2		1			
Cumacea (*Bodotria similis*)	12		12		26		2	
Crustacean larvae	5		3		2		2	
Pontarachnid (*Litarachna* sp.)			1					
small Lamellibranchia (live)	3		11		1		6	
(empty shells, unpaired)	9		9		11		5	
small Gastropoda (live)	1		4		2		1	
(empty shells)	7		19		10		8	
small nudibranch			1					

Elphidium spp. and *Amphisorus* sp. were predominant. Of ostracod shells, *Bairdia* sp. was the most abundant.

The abundant occurrences of two monocelidid turbellarians in NS No. 1 and the big catch of gammarid amphipods, especially of *Pontocrates altamarinus* and *Urothoe* sp., in NS No. 2 are noticeable. In such nearshore places near the surf, small epibenthonic animals, without significant motility, seem to be stired up more easily by the violent water movement than larger animals with stronger swimming ability such as amphipods and mysids which keep their bottom situations.

50 m Sample 1: The Dragonet was trawled for 15 min. in 10.00–11.00 h on June 13, 1966 on the 50 m deep sand bottom about 1.2 km west of Cape Setozaki, south of the laboratory. In this case, the net frame was slipped out a little on retrieval, as the nets were pushed by the water current. The top net sample was thus much contaminated and put aside in formal examination. The bottom net scraped 3.2 ml of sand and 1 ml of minute organic detritus, in which the following plankton and meio-epibenthos shown in Tables 5 and 6 were caught.

The paddle wheel of the bottom walker was found lost when the Dragonet was retrieved. The flow meter did not seem to show the exact volume of water through the top net during the bottom trawl, because the doors were found flapping in a strong current on retrieval. The results of the analyses of both the plankton and meio-epibenthos shown in Tables 5 and 6 are, therefore, significant only qualitatively. Of microplankton found in the sample, only *Noctiluca* and *Ceratium sumatranum* were found in a significant density. Most of foraminiferous shells were empty. Of foraminifers, greenish specimens of live *Operculina ammonoides* as large as 4 mm in diameter were the most remarkable. Probably this foraminifer, mysids and *Spadella* are the most characteristic elements of meio-epibenthos at this station.

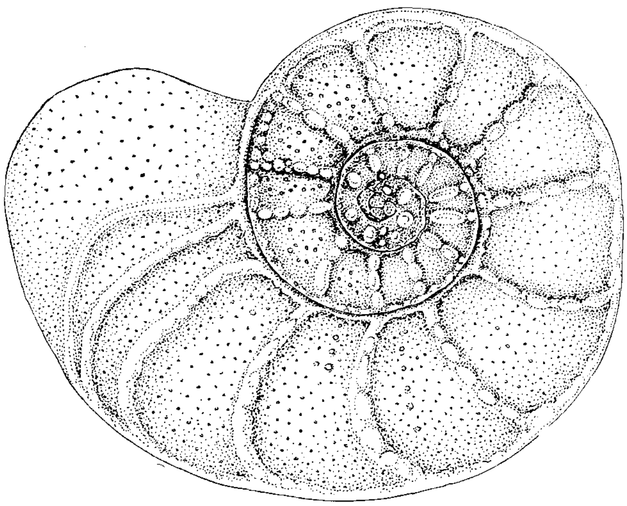

Fig. 9. *Operculina ammonoides* (GRONOVIUS) from St. 50–1, ×45.

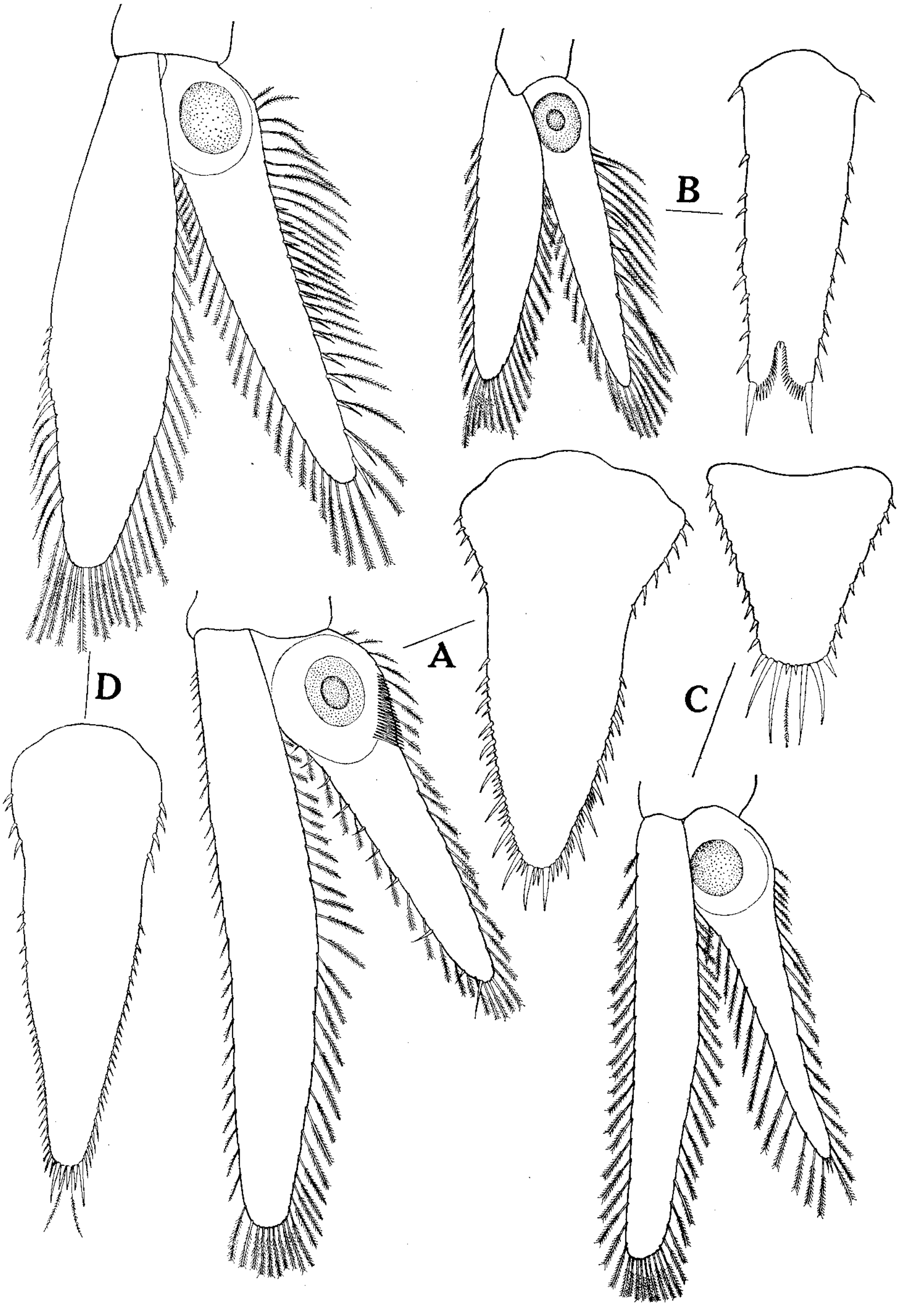

Fig. 10. Mysids found in the present material, male telson and left uropod, dorsal; ×50. A—*Proneomysis tenuiculus*, B—*Gastrosaccus kojimaensis*, C—*Hypererythrops spinifera*, D—*Siriella trispina*.

Table 5. Plankton composition of deep-water samples.

Samples / Animals	50 m Sample 1		100 m Sample 1	
Acanthometra sp.			1	
other radiolarian	1?			
Siphonophora	88		1	
other hydromedusae	22			
Cyphonautes	2			
Penilia	1274			
Evadne nordmanni	2	90		
Evadne tergestina	88			
Podon sp.	7			
Cirripedia nauplii	30		1	
Acartia sp.	25			
Paracalanus sp.	94			
other calanoid copepods	309		87	
Oithona sp.	80	712	10	135
Corycaeus spp.	33		38	
Oncaea spp.	167			
other copepods	4			
Copepoda nauplii	96		1	
Sergestes sp.	1			
Macrura nauplii	1			
Macrura zoeae	21			
Phyllosoma	1			
Brachyura zoeae	28			
Megalopa	1			
Echinospira	2			
Ophioplutei	3			
Zonosagitta bedoti	81	108		
other chaetognaths	27		4	
Oikopleura longicauda	327		4	
other oikopleurids	151	481	6	10
Fritillarians	3			
Doliolums	5			
Fish eggs	26		1	
Fish larvae	14			
Eggs unident.	1		4	
Larvae unident.	6		6	

Table 6. Meio-epibenthos composition of deep-water samples.

Animals \ Samples	50 m Sample 1		100 m Sample 1	
Operculina ammonoides	206	3804	11	3261
Amphisorus sp.	20		36	
Elphidium spp.	189		106	
Amphistegina lessoni	723		51	
Planorbulina acervalis	92		281	
Cibicides lobatulus	557		247	
other benthonic foraminifers	1849		1549	
Globigerinas and globorotalias	168		980	
Hydrozoa, colony piece			1	
Nematoda	119		33	
Polychaeta	16		6	
Polychaete larvae	2			
Spirorbis nest tubes	25			
other polychaete nest tubes	27		4	
Harpacticoid copepods	6		51	
Eusarsiella sp.	3		45	
other Myodocopa	11		6	
Podocopa (live)	8		5	
Podocopa (empty shells, unpaired)	315		475	
Cypris larvae	9			
Hypererythrops spinifera	46	157		
Siriella trispina	17			
other mysids (juv..)	94			
Pontocrates altamarinus	8	34	6	15
Melphidippa globosa	5			
Rhachotropis sp.			5	
other gammarid amphipods	21		4	
Protomima imitatrix	2	3		
other caprellid amphipod	1			
Munna sp.	2		2	11
Gnathia sp. (juv.)			9	
Cumella spp.	18	40	3	19
Hemilamprops sp.			8	
other cumaceans	22		8	
Pontarachnids			6	
small Brachiopoda (empty shells)	2			
small Lamellibranchia (live)	2			
(empty shells, unpaired)	272		187	
small Gastropoda (live)	1		2	
Pteropoda (empty shells)	23		97	
Atlanta (empty shells)	1		6	
other gastropods (empty shells)	346		76	
Cephalaspidean opisthobranch			1	
small Echinid	1			
Ophiura kinbergi		5		
Aspidophiura forbesi				
Spadella angulata	7			

100 m Sample 1: A trawl with the Dragonet was tried on the 100 m deep sand bottom for 15 min. at 11.00–12.00 h on October 24, 1966, about 6 km west of Cape Setozaki. The same troubles as in the case of 50 m Sample 1 occurred again. Therefore, only the sample caught in the bottom net was analysed qualitatively. The plankton and meio-epibenthos found in the sample are listed in Tables 5 and 6. The much less prominent variety of the plankton is noted at this deeper level. Of the microplankton, only the frustules of *Coscinodiscus*, *Hemidiscus* and *Eucampia* and the empty thecae of *Ceratium macroceros* were found very sparsely. Together with 16.2 ml of sand and 1 ml of organic detritus were caught the meio-epibenthos listed in Table 6. Most of foraminiferous shells were empty. A relative decrease of *Amphisorus* sp., *Elphidium*

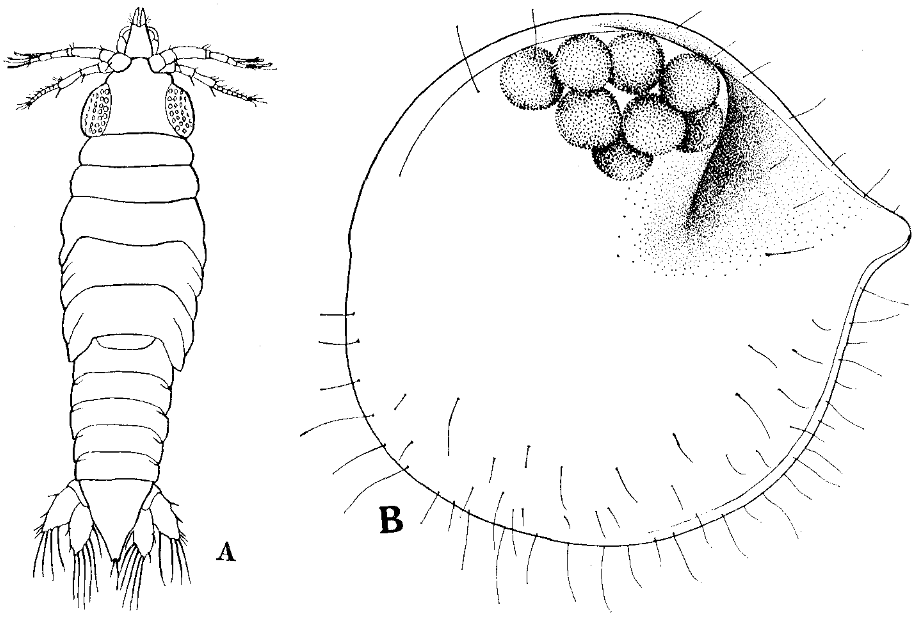

Fig. 11. Prominent animals found in the sample 100–1. A—*Gnathia* sp. (juv.), ×40; (through the courtesy of Mr. S. NISHIMURA),. B—*Eusarsiella* sp., ×55.

spp., and *Planorbulina acervalis* is noted in both of the samples from deeper floors. Especially the rich occurrence of globigerinas and globorotalias in the 100 m Sample 1 is noted. Of the meio-epibenthos, the ostracod, *Eusarsiella* sp. with a nearly spherical body outline, and the isopod, *Gnathia* sp. juv. marked by its red eye spots, were most attractive in the sample examined.

In some crustacean groups, the 100 m population seemed less prominent than the 50 m one. According to NAGATA's observation, 16 species of gammarid amphipods were found in the 50 m sample, but only 6 species in the 100 m sample. According to GAMÔ's examination, the 50 m sample comprised 6 species of cumaceans, while the 100 m sample only 4 of them. It cannot be supposed that the Dragonet scraped the deep floor surface continuously, the quantity of samples caught in the bottom net seemed too small for the effective breadth of the sledge front and for the time of trawling. Very probably the trawl was only on the bottom for a minute or so in those cases, though it is not impossible that this indicates that the sea floor at these deep stations is exposed to a considerably fast water current.

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