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Zooplankton Community of the Water Adjacent to Umashima Strait, the Western Inland Sea

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Around the water adjacent to Umashima Strait, the Western Inland Sea, net plankton was collected monthly for two years(1987 and 1988). Carrying out holizontal hauls of Naikai type net there on account of the shallow water of a few meters depth, we sampled 89,928 individuals of 17 aminal taxa and 103,270 of 19 taxa in 1987 and in 1988 respectively.

In both years, the most dominant was fish in egg and larva phase, and next to it were copepod and cladoceran. Other than the typical holoplanktons such as appendicularian, copepod and cladoceran, the meroplanktons which subsume nekton such as fish mentioned above, and benthos as macruran, brachyuran or polychaete, in their ontogenetically incipient stage appeared frequently.

The holoplanktons showed sparse occurrence in winter, temporary proliferating in eary spring when the ambient water suffered the minimum temperature and successive enhancement in occurrence thereafter. Within the meroplanktons, fish indicated pronounced oscilation peaking around summer when many miscellaneous zooplankton taxa also appeared profuse, whereas polychaete appeared steady but meagerly, and macruran and brachyuran also occurred yearround but in quite different aspects each year; no periodicity is distinct among the other benthos larvae except a few.

1 Introduction

Tana Marine Biological Station(T.B.S.), set up in 1952, has been prospecting the biota of waters adjacent to Umashima Strait, the Western Inland Sea, where T.B.S. locates[1-9]. This area abounds with many kinds of aquatics and some have yielded the resources for the coastal aquaculture and various fisheries. In order to reveal an aspect of the dynamics in the biological structure on the productive process there, we investgated the zooplankton community monthly for two annual cycles. Here we will emphasize upon treating fish egg and larva as typical zooplankton

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as natant invertebrates, since some fishes in the buoyant phase have been recounted to be marred or fed, in lacustrine as well as marine condition, by these invertebrates[10-13] and vice versa, which infers that they may be an ingredient of a food web in littoral areas.

2 Method

The equipment we collected zooplankton specimens was a larva net of Naikai type, which has $0.4m^2$ gape (71.4cm in diameter) and 2.9m flank, and is made of GG28 nylon netting and GG38 in the former and in the latter half respectively. We towed it for 5 minutes horizontally without any depressor by R.V. Nagisamaru II of T.B.S. The bottom underneath the sampling point is a few meters depth (Fig. 1) and is stratified with muddy-sand material (Mdϕ :1.25-1.46). Monthly collections were executed through two hauls a run before noon on a day round spring tide period. While towing, we adjasted the gear speed at 2 knots and the surface water was bucketed to measure the temperature. Each collection from which abandoned trash, allochthonous organisms, macroalgae and macroplankton, as hydrozoan, were manually eliminated aboard was transferred to T.B.S. and reserved in 5% formalin solution. After measuring the bulk of the sediment gravitated for 24 hours, under a dissecting microscope we identified huddles of zooplankton belonging to certain taxonomic entities such level as order or class (Table 1). Thereafter counting the number of individuals of each zooplankton taxa occurred in the sample and calculating the volume of the water mass filtered, we estimated numerical density collected *in situ*.

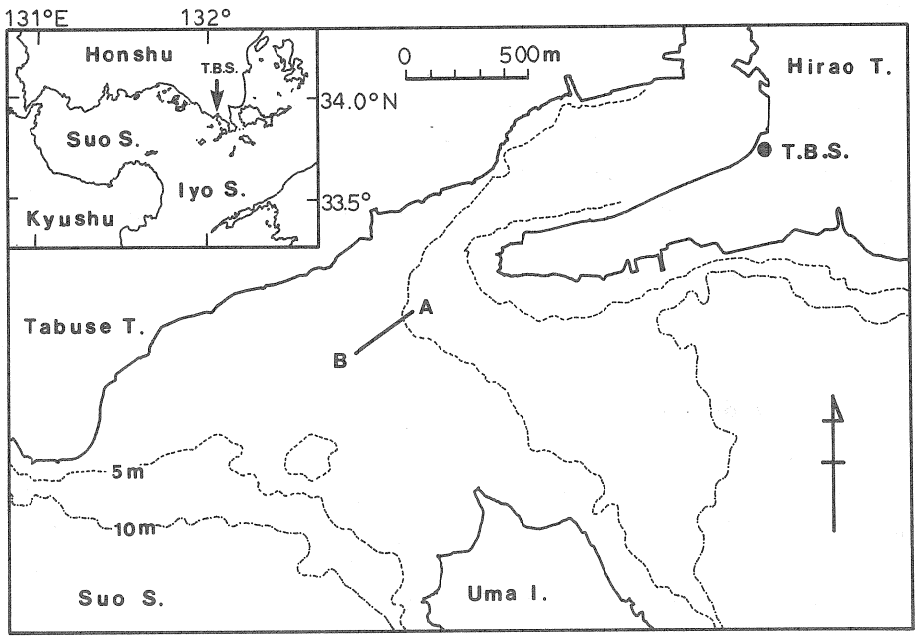

Fig. 1. Sampling location. Hauls were executed between A and B.

Table 1. List of the abbreviations for zooplankton taxa cited in this study

abbreviation	taxon name
Pi	fish
Ap	Appendicularia
Ec	Echinodermata
Ch	Chaetognatha
St	Stomatopoda
Br	Brachyura
An	Anomura
Ma	Macrura
Am	Amphipoda
Is	Isopoda
My	Mysidacea
Ba	Thecostraca
Co	Copepoda
Os	Ostracoda
Cl	Cladocera
Ce	Cephalopoda
Bi	Bivalvia
Ga	Gastropoda
Po	Polychaeta

3 Results and Discussion

We sorted 89,928 individuals of 17 animal taxa and 103,270 of 19 taxa in 1987 and in 1988 respectively. In late summer of each year we observed manifold congeries which comprised the largest assemblage of all the animal taxa except a few that were sorted twice (2 months) or more a year. In early spring there was also another transient aggregation of less taxa than above mentioned.

A brief description of the monthly change in the assemblages of the 1987 series is as follows (Figs. 2 and 3, Table 2): In January and February Co (*vid.* Table 1 on abbreviations hereafter) greatly dominated and Ap followed it, with rather barren ingredients. In March the abundance, slightly less than half of which was Ap and the other half was Co, was reduced to the minimum of this annual series, and consecutively the other miscellaneous zooplankton never or little co-occurred. In April Cl became dominant but the total abundance still remained sparse. In May Pi would multiply abruptly there, therefore, it affected the increment in the total number. In June there came a successive replenishment with Pi to the previous month, and this resulted in its maximum of the 1987's occurrence. From July to September a variety of taxa was observed, and it suggests the largest potential in their proliferating abilities. Cl, together with Co, Ma, Br, Ch and Pi were prevalent then. Co swelled conspicuously in October, but the other miscellaneous taxa appeared to have decreased or been dissipated. In November and December Co and Ap occurred densely and Br predominated in December.

In the 1988 series Ec and Os were additionally recorded to the 1987's (Figs. 2 and 3, Table 3): Ap and Co continued to occur numerically dominant but Br deminished in January. There was a relative paucity of zooplankton in February, however, it had a similar heterogeneity to that of the previous month. Co and Cl seemed to upserge in March, with which the total abundance of this month became replete by two orders of magnitude consequently. Ap recurred to be major and Co together with Cl deceased in number in April, and so was the total abundance. About a half of the assemblage in May was Ap again and next to it was Pi. Ensuingly, Pi accounted for more than 91.3% and 81.0% of all the specimen in June and July respectively. Cl would thrive in August, and the other miscellaneous taxa appeared to coincide with it, which indicates the maximum of 1988's total abundance. September's assemblage, the abundance and heterogeneity of which fell, would be almost trisected into Br, Co and Cl. In the serial reduction in the total abundance from October forth, Co was in the most flourish in October after March and then faded away. Cl predomin-

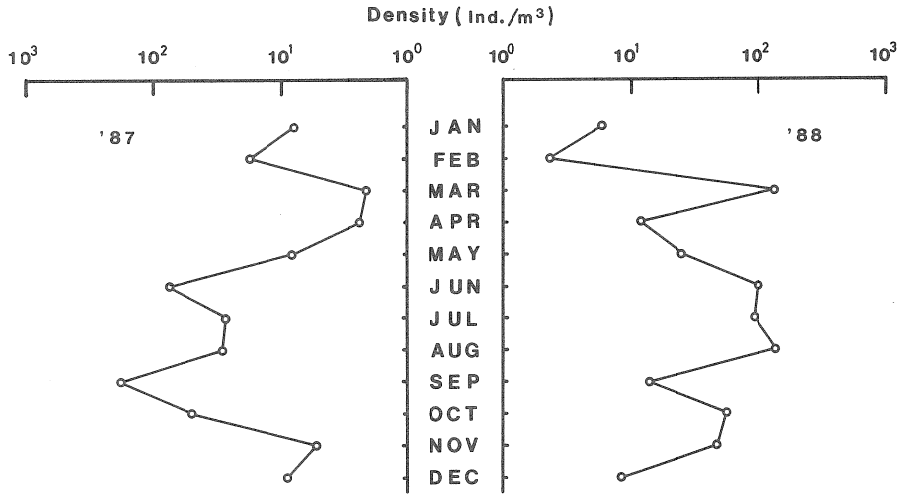

Fig. 2. Summation of the density of all the animal taxa monthly occurred in 1987 (left) and 1988 (right) series.

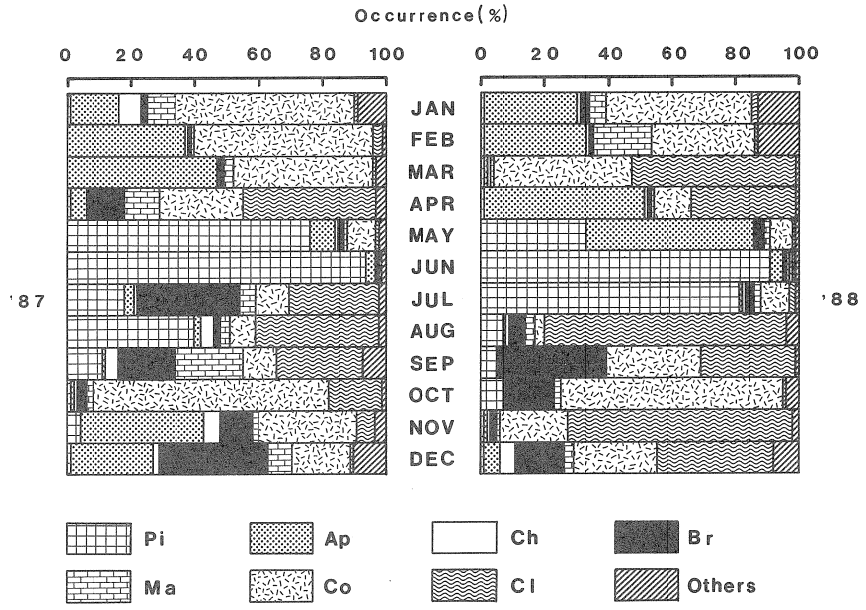

Fig. 3. Taxonic component of major zooplankton monthly occurred in 1987 (left) and 1988 (right) series.
vid. Table 1 on abbreviations.

Table 2. Monthly occurrence of zooplankton taxa in the 1987 series

taxon	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pi	R			R	C	CC	C	CC	CC	+	+	R
Ap	C	C	+	+	+	C	+	+	+	R	C	C
Ch	+	R			RR		R	C	C	+	+	R
St							R		C			
Br	+	R	R	+	+	C	C	+	CC	C	+	C
An					RR		R	RR	+	RR	RR	
Ma	+	+	R	+	R	+	C	+	CC	C	+	+
Am	R		R		R		R	+	C	+	R	+
Is							R	RR	R	R		
My						R		RR			R	
Ba	+	R	RR			R	R	R	+		R	+
Co	C	CC	+	+	+	+	C	C	CC	CC	C	C
Cl	+	+	R	C	+	+	C	CC	CC	C	+	RR
Ce									RR			
Bi	R		R		R		R	RR			R	
Ga	R					RR	+	R	+	RR		
Po	+	R	R	R	R	RR	R	+	+	+	R	+

RR: 0.001–0.01, R: 0.01–0.1, +: 0.1–1.0, C: 1.0–10, CC: 10–100 (ind./m^3).

ated in the last two months.

Some differences between the two annual series of zooplankton communities are detected as such (Figs. 2 and 3, Tables 2 and 3): In March of 1988 there is the throng of Co which appears a month later, and that of Cl which is more densifed than this period of the previous year. The analogous aspect of the Cl occurrence is also shown in the November assemblages. Cl, however, has the reveasal relation in September, which is indicated in Co, Ma, Br and Pi. Nearshore and shallow water subsist a great variety of aquatics under peculiar interaction which is explicitly defferent from those of offshore or oceanic zone.[14] Various phases of intra- and/or inter-specific relations among them suffer the spatio-temporal alterlation in rather small scales.[15,16] The observation with such time scales as twice a month or more must enable us to detail the proliferation of the zooplankton community there.

According to the occurrence patterns as shown among these aminal taxa of both years, such as Pi, Ap, Br, Ma, Co, Cl and Po, the last five of which had been throughout noted down, seem to be distinguished from alternative ones by their perennial occurrence. These taxa were classified into a few subtypes depending upon the Simpson's indices of concentration (λ) on the monthly density numbers (Table 4): The first is the fluctuant subtype such as Pi and Cl whose λ is around 0.40 or more. The second is the quasisteady subtype as Po whose λ is around 0.15. The third is, as Ap and Co, intermediate between them. Besides λ corroborates that Br and Ma occurred differntly each year. Another conspicuous disposition of the perennial type is the semiannual hordes in Co and Cl; transitory one in spring and rather long-term one in late summer respectively. It alludes to the variety of

Table 3. Monthly occurrence of zooplankton taxa in the 1988 series

taxon	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pi	RR	R	R	R	C	CC	CC	CC	+	C	+	R
Ap	C	+	+	C	CC	C	C	+		RR	+	+
Ec								C				R
Ch	R	RR	+	R			+	C		+	+	+
St							R	+		RR		
Br	+	R	R	R	+	+	C	C	C	C	C	C
An						RR	R	+		R		
Ma	+	+	+	+	+	C	C	C	+	+	+	+
Am	+	R	R	RR	R	R	R		RR	R	R	+
Is		RR	R	RR	RR			R	R	R	R	RR
My					R							
Ba	RR	+	RR	RR		R	R	+	R	C	+	R
Co	C	+	CC	C	C	C	C	C	C	CC	C	C
Os			R							R		
Cl	R	R	CC	C	+	+	C	CCC	C	+	CC	C
Ce										RR		
Bi												R
Ga	RR	R	R	R		R	R	R			RR	R
Po	+	R	+	R	+	+	R	R	R	+	+	+

RR:0.001-0.01, R:0.01-0.1, +:0.1-1.0, C:1.0-10, CC:10-100, CCC:100-1000 (ind./m^3).

the species that have different life histories within the taxon. This issue is a consideration in any taxa that appeared across seasons.

Only a third part of all the animal taxa obtained in this study belongs to holoplankton and the others, to meroplankton that subsumes nekton and benthos in their ontogenetically initial stages. On the annual basis, however, the holoplanktons such taxa as Ap, Ch, Co and Cl occurred more abundantly than meroplanktons; their subsistence had been observed the whole time. Accordingly the structure of the zooplankton community investgeted here was basically constituted by the holoplanktons, though their occurrences, and hence the taxonic components, were altered with the lapse of time.

Within the nekton in the early development Pi, especially in egg phase, appeared overwhelmingly from late spring to autumn when the water temperature was rather high (Fig. 4). During this period its density often increased to be approximate to or over the holoplankton's one that also became enhanced. This facet of community structure demonstrates the experimental area functions as a spawning and nursery ground for fish. Another nekton Ce appeared sparsely but punctually in autumn.

Several taxa of benthos in the incipient stage also occurred sequentially or sporadically: St and An appeared in late summer or early autumn and Is in October, whereas no periodicity is distinct among the other benthos larvae except a few. The occurrence of Br, Ma and Po classified above as the perennial subtype suggest that they

Table 4. Simpson's indices (λ) of concentration on the monthly density number for the zooplankton taxa

taxon	λ	
	1987	1988
Pi	0.419	0.391
Ap	0.205	0.279
Ec	—	0.995
Ch	0.570	0.325
St	0.987	0.834
Br	0.497	0.202
An	0.469	0.509
Ma	0.740	0.197
Am	0.809	0.237
Is	0.390	0.205
My	0.374	1.000
Ba	0.246	0.372
Co	0.284	0.294
Os	—	0.494
Cl	0.432	0.340
Ce	1.000	1.000
Bi	0.247	1.000
Ga	0.451	0.180
Po	0.157	0.146

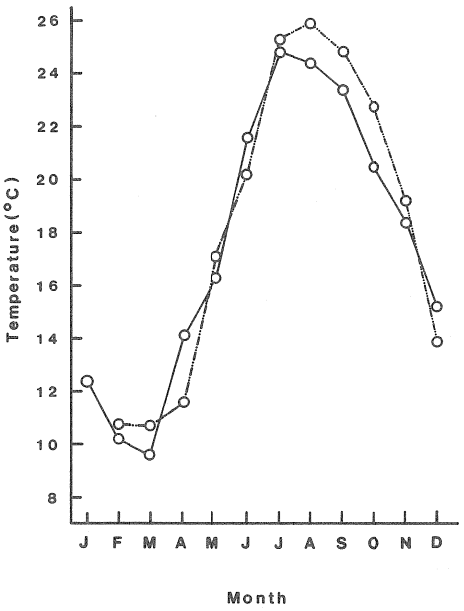

Fig. 4. Surface water temperature measured on sampling date. solid line: 1987 and chain line: 1988. Datum of January 1987 is missing.

are endowed with continual or overlapped procreation. To ascertain their fecundity, more elucidation on taxonomy or ecology of them is requisite, which is another aspect of our consideration mentioned above.

Some idiosyncrasies were documented on zooplankton fauna of several locations throughout the Inland Sea.[17-20] It was evidenced that Co, Cl and Ap occurred monthly with four digits or more per cubic meter and there Co almost always predominated. From our notice, however, it was induced that every monthly summation of the density of all the animal taxa *per se* was one to three orders of magnitudes below those and Co underwent the predominant taxon only several times. On the annual basis of ours, Pi resulted in the most densely occurrent taxon and Co or Cl, in the secondary to it therefore. This difference in the dominant taxon between them perceived here has some implication for that in the local abundance of zooplankton.

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馬島水道付近の動物プランクトン群集

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山口県熊毛郡田布施町沖の馬島水道付近の浅海域で1987年１月から２年間，表層域に分布する動物プランクトンを内海型稚魚ネットの水平曳によって月別採集した。採集された動物プランクトンの密度は1987年・1988年とも2.11-180個体／m^3の間で増減し，いずれも６月から９月にかけて高く，１月・12月は低かった。1987年では17動物群が，1988年では19動物群が採集され，このうち魚類（卵・稚仔）および原索類・短尾類・長尾類・橈脚類・枝角類などが優占した。採集されたいくつかの動物群はほとんど終年出現し，それぞれの季節的消長に特徴が認められた。