Planktological Study on the Warm Tsushima Current Regions —II

Plankton Properties and Their Relation to Oceanographic Conditions of the Central Japan Sea in the Summer of 1951.

Toshimasa SHIMOMURA

I Introduction

Knowledge on the horizontal and vertical distribution of plankton is indispensable for the prediction of fishing condition and for the study of marine ecology. The vertical distribution of zooplankton, in particular, is studied very intensively in these years in relation to the deep sea scattering layer.

This paper, however, is concerned with more basic phases of plankton study, and describes the abundance and composition of the plankton in the euphotic zone of the offshore region of the Japan Sea off central Honshu, Japan, with reference to the relation between these planktological properties and physical and chemical conditions of the sea.

Little has been known on the oceanography, especially, of the waters named above. The plankton of the offshore region of the Japan Sea has been studied only by Marukawa (1928) and Aikawa (1934), while the production and distribution of plankton in its neritic regions have been studied in conciderable details by Yanagisawa (1938), Kokubo (1940), Furuhashi (1951, 1952, a, b, c), Fukase and Furuhashi (1952), and Shimomura (1953).

The material for this study was collected during two observation cruises. The first cruise covered the waters from Noto Peninsula to Sado Island (Observation lines L, I, g, M and N) during July 6 - 14, 1951, and the second, the waters from Noto Peninsula to Oki Islands (Observation lines a, b, and C) during July 28 - August 5, 1951 (Fig. 1).

In these observations the stations totaled 86; at 52 stations (mark ●), only the surface observations of physical and chemical factors were taken; at the other 34 (mark ⊙), plankton was collected and vertical observations of physical and chemical factors were made to the 400-meter layer.

The author was aided by Mr. K. Miyata, Mr. M. Mukai and other persons in collecting the material at sea and in the chemical analysis of water samples at land. He was aided also by the crew of the research ship "Daini Asahi Maru" in the laborious and time-consuming work on board. To all these gentlemen the author wishes to express his hearty thanks.

Method of collecting plankton: Plankton sample is collected by the vertical haul with the Kitahara's plankton net. The net is lowered until the submerged length of

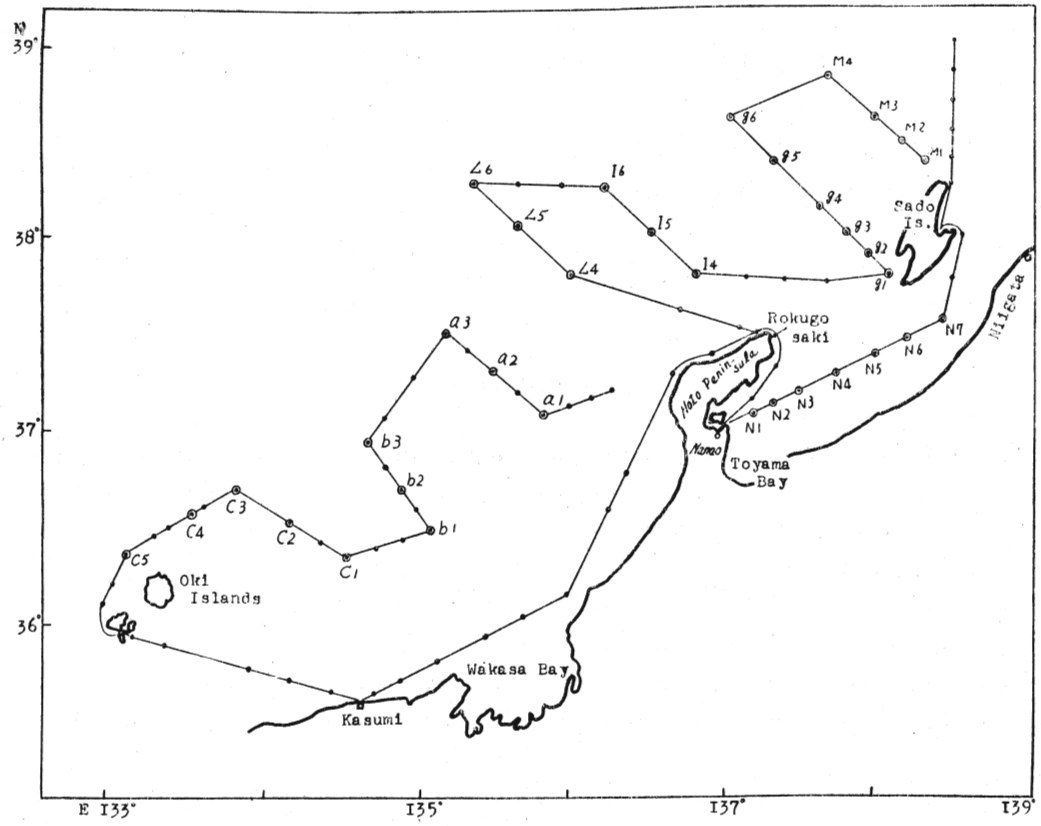

Fig. 1 The track and the positions of stations.

the wire reaches 25 m, and then hauled up roughly vertically to the surface. The filtering cone of the net consists of XX No. 13 silk bolting cloth (corresponding to Müller gauze No. 13), and is provided at the bottom with a small bucket (glass tube) having a cock. The mouth of the net measures 22 cm. in diameter.

Quantitative examination of plankton sample: The material is diluted with water about five times as much as its settling volume, and 1 cc. of the diluted sample is poured into a counting chamber, measuring 22 mm by 27 mm inside and 1.6 mm deep, with a glass bottom sectioned at 0.5 mm intervals. The chamber is made by fastening its brass sides to the glass bottom with Canada balsam. Counting is made under microscope, usually on the whole area of the chamber.

II Plankton

Number of species: A total of 120 species are identified, comprising 70 animal and 50 plant species. A complete list of these species is given in the Separate Table. Table 1 gives the number of the species belonging to various classificatory groups. Except for those stations where conditions are extremely neritic (Sts. C4, C5 and N1),

Table 1 The numbes of species.

Phytoplankton	50	Zooplankton	70
Cyanophycea	2	*Protozoa*	3
Dinoflagellata	19	*Copepoda*	33
Diatomaceae	28	*Phyllopoda*	3
.....		*Mollusca*	3
Chaetoceros	8	*Amphipoda*	2
Rhizosolenia	8	*Larval Form*	12
Other Diatomaceae	12	*Chaetognatha*	8
.....		*Thaliaceae*	2
Chlorophyceae	1	*Others*	4

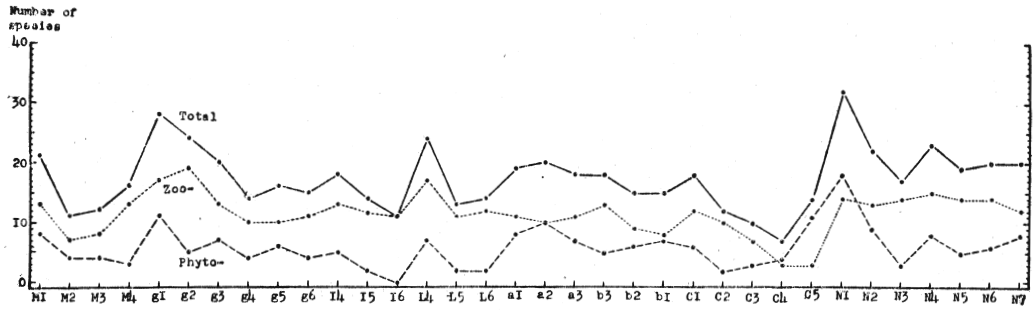

Fig. 2 Number of species constituting the total, zoo-, and phyto-plankton at each station.

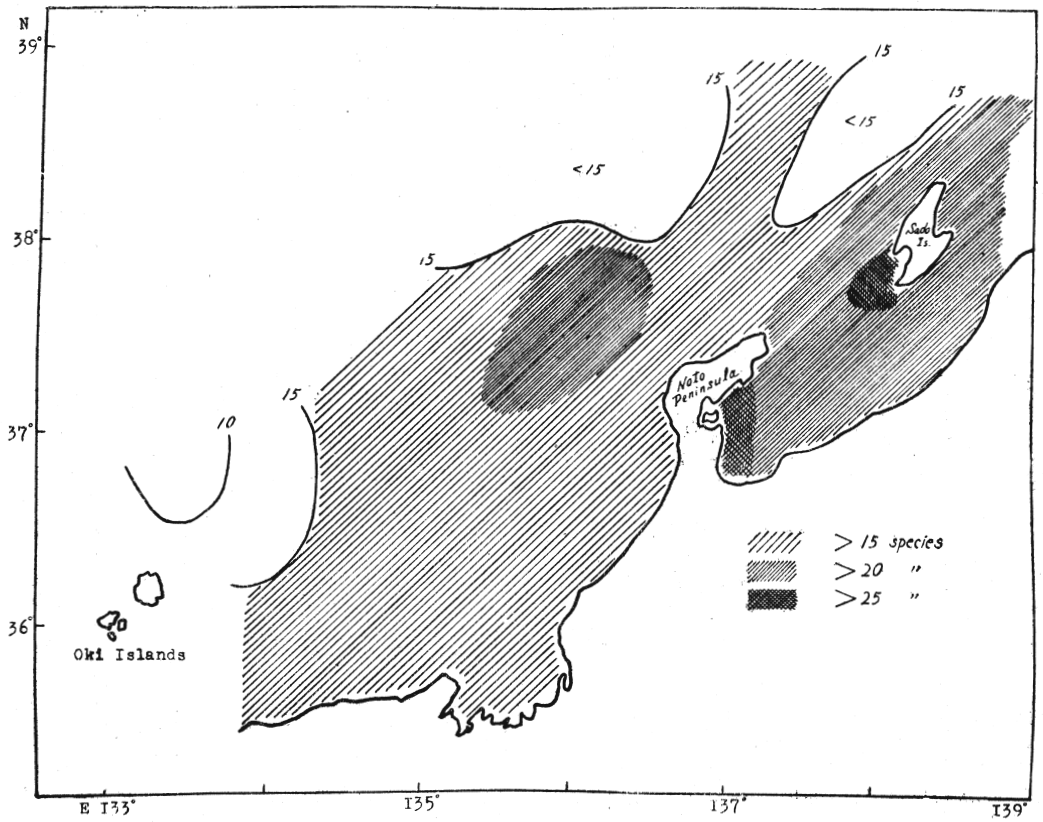

Fig. 3 Geographical distribution of the number of total species including zoo- and phyto-plankton.

there are found more zooplankton species than phytoplankton species at one locality (Fig. 2). Usually more than 10 animal species occur along with less than 10 plant species at one locality. Number of the constituent species varies according to station from the minimum of 7 to the maximum of 32. The number usually ranges between 10 and 20 in the offshore, but is considerably great at the stations very close to land (Sts. g1 and N1).

In Figure 3 is shown the geographical distribution of this number. It is indicated in the figure that the plankton is composed of more than 15 species of organisms in the flow of Tsushima Current, but of less than 15 species on the offshore side of Tsushima Current.

Within the path of Tsushima Current there are regions where the plankton is constituted by more than 20 species; for example, Toyama Bay and the north-western offing of Noto Peninsula. The numbers of zooplankton and phytoplankton species are 15 and 8 in the former region (St. N4), and 17 and 7 in the latter (St. L4) (see Separate Table). In either region, plankton is composed exclusively of neritic forms. And such species as *Noctiluca scintillans*, *Calanus helgolandicus*, *Oithona nana*, *Oncaea venusta* are common to both regions. Therefore, it may be said that the specific composition of plankton is very much alike in the two regions. A closer examination of the Separate Table shows that the increase of the constituent species is due to the occurrence of various larval forms (including nauplii) and *Thaliaceae* in Toyama Bay, and to that of such neritic forms as larvae, *Calanidae* and *Diatomaceae* in the other region.

The plankton samples for this study consisted exclusively of purely warmth-loving forms. It should be remembered in this connection that the whole area covered by this study was free from the direct influence of the cold oceanic current from the north during the observation period, and that the net was hauled only through the uppermost layer of the sea (0–25m. zone).

Number of plankton organisms: The abundance of plankton varies between 2,609/m^3 and 463,000/m^3 according to stations. The minimum is recorded at St. N3, where the plankton is composed of 73% of zooplankton (of which *Oikopleura* is dominant) and 27 % of phytoplankton (mostly *Trichodesmium*). The maximum is encounted at St. C4, where only 0.2% of the plankton population is represented by zooplankton and 98.8% by phytoplankton (of which *Climacodium biconcavum* is preponderant).

As is shown in Figure 4, plankton is most abundant at Sts. b3 and C4 off Wakasa Bay, and considerably abundant in the north of Noto Peninsula (Sts. I4–I6). But the abundance is comparatively low (i.e. 3,000–6,000/L) in Toyama Bay (Sts. N2 and N3).

Figure 5 shows the percentages of zooplankton and phytoplankton to the total plankton for each station. Fig. 5, together Fig. 4, shows that in the waters from the north-west of Noto Peninsula eastwards (i. e. Stations of M, g, I, L and N series) variation in the abundance of plankton is not always associated with the variation in phytoplankton abundance. In the west of Noto Peninsula, however, the abundance of plankton is primarily determined by that of phytoplankton. In this region *Climacodium*

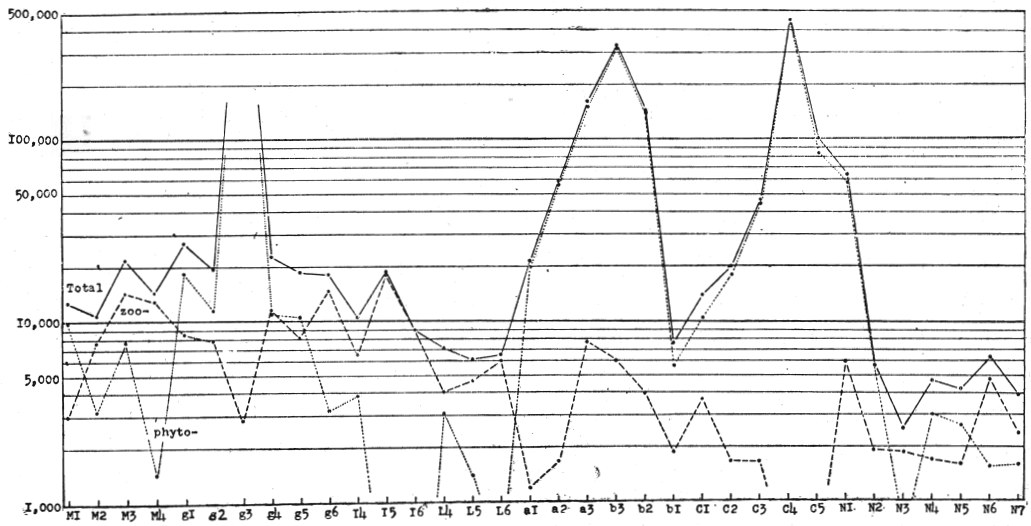

Fig. 4 Number of total, zoo- and phyto-plankton organisms per cubic meter of sea water at each station. (It is impossible to count number of phytoplankton organisms at St. g3, due to colony forming of Gen. *Trichodesmium*.)

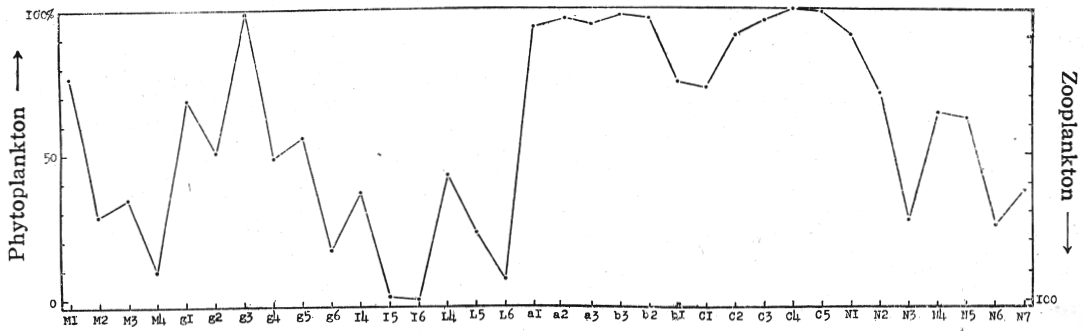

Fig. 5 Numerical percentage of zoo- and phyto-plankton organisms in total plankton at each station.

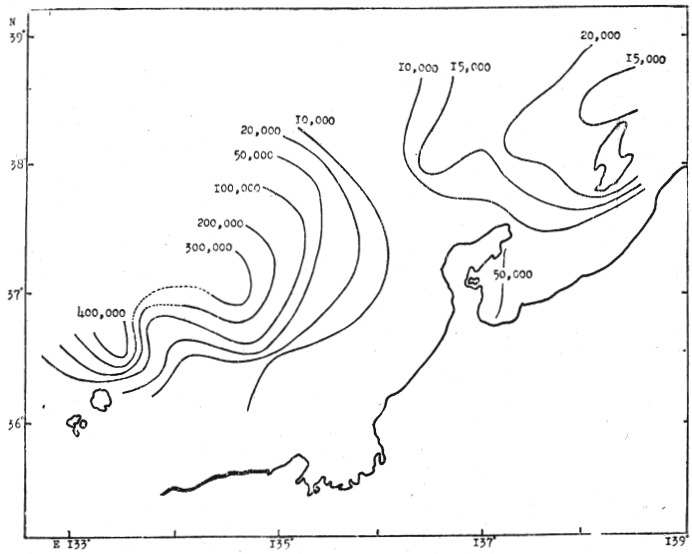

Fig. 6 Geographical distribution of the number of total plankton organisms per cubic meter of sea water.

biconcavum is found in high concentrations and constitutes the major part of phytoplankton. The maximum concentration of this diatom is recorded 408,388/m³ at St. C4.

As is indicated in Figure 6, plankton is abundant in two regions: one is located in the north-western offing of Wakasa Bay and protruding south-east towards the mainland; the other is located in the offing of Sado Island and extending from the north-east to the south-west. In the first region plankton is twenty to thirty times as abundant as in the second. These two regions and Honshu (Japan Proper) are isolated from one another by a region of low plankton abundance, usually below 10,000/m³; this region represents the path of the main flow of Tsushima Current.

Figures 7 and 8 show the geographical distribution of the abundance of zooplankton and phytoplankton, respectively. It is indicated in Figure 7 that zooplankton is abundant (over 5,000/m³) in the offshore region ranging from the north of Sado Island south-west to the offing of Wakasa Bay. In these waters *Oithona nana* and *Oithona larvae* are dominant in zooplankton, except in the offing of Wakasa Bay (Sts. a3 and b3) where *Gastropoda larvae* and *Oncaea venusta* are the dominant forms. Zooplankton occurs in the greatest abundance and outnumbers phytoplankton in the north and north-west of Sado Island. In the west of Wakasa Bay, zooplankton is scarce, and the density falls below 500/m³ in the vicinity of Oki Islands. In the main flow of Tsushima Current, too, zooplankton is relatively scarce, usually less than 3,000 organisms per cubic meter of sea water.

Geographical distribution of the abundance of phytoplankton (Fig. 8) is just reverse to that of zooplankton. Phytoplanton is very abundant from the north of Oki Islands eastwards to the offing of Wakasa Bay. In the north-east of this region, phytoplankton is comparativeIy scarce. In the north-west of Sado Island phytoplankton is relatively

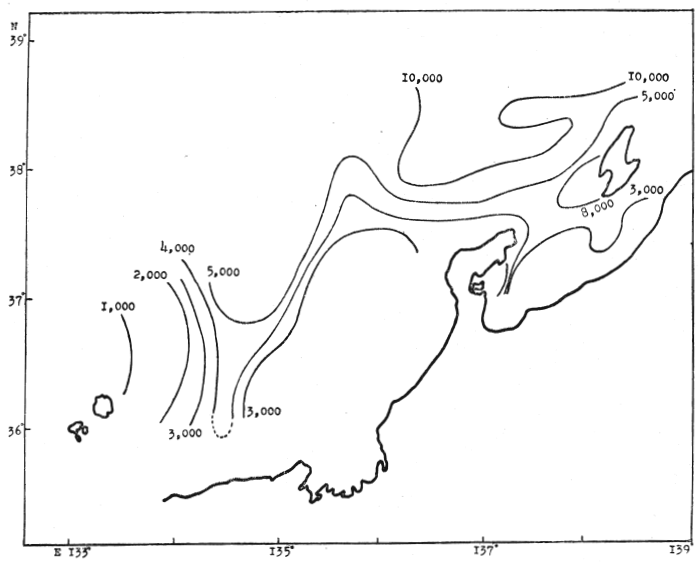

Fig. 7 Geographical distribution of the number of zooplankton organisms per cubic meter of sea water.

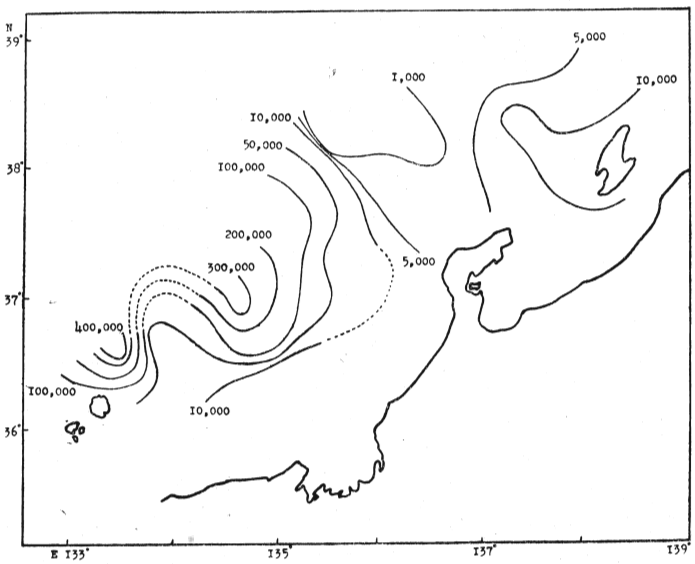

Fig. 8 Geographical distribution of the number of phytoplankton organisms per cubic meter of sea water.

abundant (about 10,000/m³), and its major part is accounted for by *Rhizosolenia alata* and *Rhiz. hebetata f. semispina* in the offshore (St. g4) and by *Ceratium massiliens* (including *Cerat. protrubens*) and *Chaetoceros coarctatus* near the island (St. g3). The density of phytoplankton population in this region, however, is only 1/20 to 1/30 of that off Wakasa Bay.

As previously mentioned, the high abundance of phytoplankton off Wakasa Bay is caused by heavy growth of *Climacodium biconcavum*. In Toyama Bay there is found an isolated region of high phytoplankton abundance (St. N1), where *Chaetoceros affinis* is very abundant (23,455/m³) and represents the major part of phytoplankton. This diatom is known to flourish from September through November in Nanao Bay adjacent to Toyama Bay.

Some characteristics of the plankton population in the offshore region is indicated in Figures 9 and 10. These figures show geographic variation of abundance and composition of plankton along a line connecting the

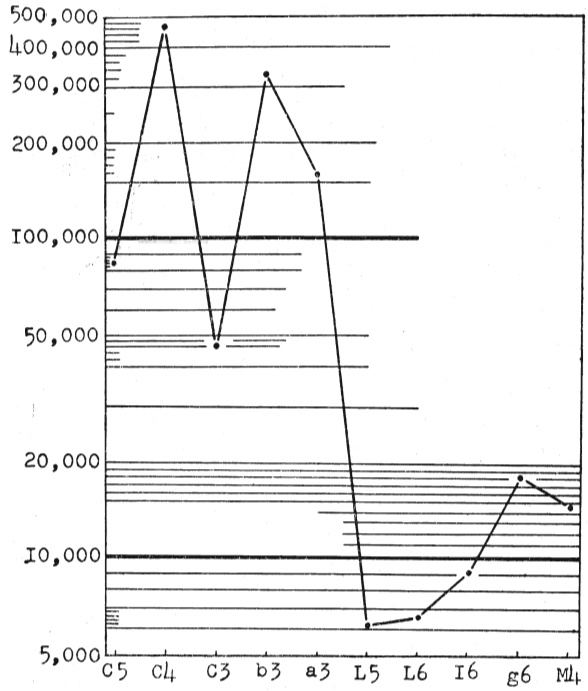

Fig. 9 Number of plankton organisms including zoo- and phyto-plankton at offshore stations.

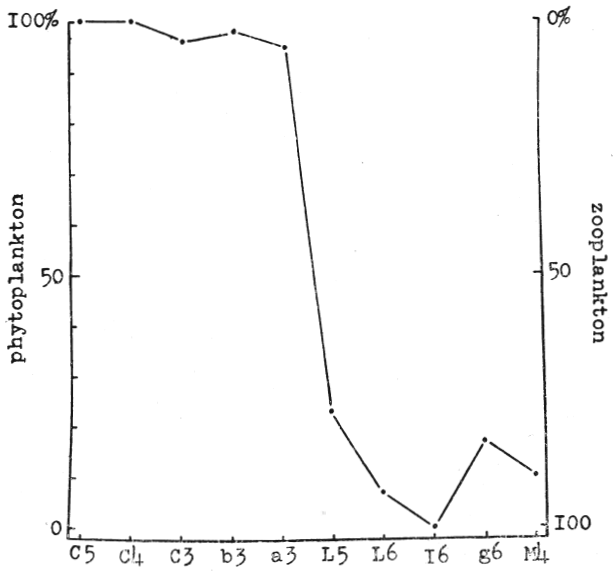

Fig. 10 Numerical percentage of zoo- and phytoplankton organisms in total plankton at offshore stations.

stations most distant from land. This line, running roughly parallel to the coast line of Honshu, is represented by the abscissa in Figs. 9 and 10. At a glance, one will notice that abundance and composition of plankton differs very markedly along the two halves of this line. Plankton is very abundant and composed chiefly of plants along the south-western part of the line (the left half of the graphs), but along the north-eastern part of the line (right half of graphs) plankton is much scarce and animals outnumber plants. Both abundance and composition changes abruptly between St. a3 and St. L5, or in the north-west of Noto Peninsula, indicating that the high abundance of plankton in the offshore waters west of Noto Peninsula caused by the heavy growth of phytoplankton organisms.

In the path of Tsushima Current the abundance of phytoplankton is usually of the order of several thousands per cubic meter of sea water. But it gradually decreases as the flow proceeds north-east, and becomes as low as several hundreds per cubic meter in the offing of Noto Peninsula (Fig. 8), where *Ceratium massiliens*, *Chaetoceros coarctatus* and *Ch. affinis* are major plant species. Abundance of zooplankton is slightly lower in the path of Tsushima Current than in other regions, and the difference is not so remarkable as in the case of phytoplankton. To sum up, Tsushima Current is characterized by low abundance of plankton, particularly of phytoplankton.

Within the waters covered by this study, plankton is adundant in two regions, namely off Wakasa Bay and off Sado Island, it is interesting that both regions are characterized by low water temperature. But it has been indicated that the composition of plankton differs very conspicuously in the two regions; phytoplankton is far dominant over zooplankton off Wakasa Bay, while zooplankton is dominant off Sado Island. Physical and chemical studies indicate that lower water temperature in the two regions is not due to the same factor; it is due to the upwelling in the former region, but in the latter, to the lateral mixing of the intermediate layer of Tsushima Current with the water of the cold Liman Current (Shimomura and Miyata, 1953). Hence. the difference of the plankton population of the two regions may be explained in two ways:

1) The water mass influencing one region is different from that influencing the other. Accordingly, the species to constitute plankton and the phase of their growth are determined independently in each region.

2) Plankton populations of the two regions are principally the same, and have undergone similar succession. Marked difference in abundance and composition indicated by the samples is due to the lag in the sampling period. Actually, the sampling was made during July 7–14, 1951 off Sado Island and during July 28–30, 1951 off Wakasa Bay, with a lag of about two weeks in between.

Probably, these two factors have worked in co-operation.

When Figs. 3, 6, 7 and 8 are compared with each other, it is noticed that the plankton composed of greater number of species does not always occur in greater abundance. Part of this phenomenon is explained by the fact that high abundance often results from the active propagation of one or a few dominant species.

Distribution of various groups and dominant species of zooplankton: As previously mentioned, zooplankton occurs in the greatest abundance off Sodo Island (Fig. 7). It is abundant and outnumbers phytoplankton also in the north regions, following three groups constitute the major part of zooplankton and are abundant in the named order:

"Larval form" > *"Copepoda"* > *"Copelata"*

And larval forms usually account for more than 50% of zooplankton organisms. In the north of Noto Peninsula quantitative composition of zooplankton varies by stations more considerably than off Sado Island.

In the west of Noto Peninsula and in Toyama Bay, too, above-named three groups constitute the major part of zooplankton. But they do not rank in the foregoing order. *"Copepoda"* take the place of *"Larval form"*, sometimes accounting for more than 50% of zooplankton organisms, and larval forms usually represent about 30%. On the other hand, *Copelata* become relatively abundant; at a station they account for 43% of the zooplankton. In consequence, differences between the relative abundances of the three groups become small in these regions, especially in Toyama Bay where the three major groups of zooplankton rank, according to their relative abundance, in the following order:

"Copepoda" > *"Larval form"* > *"Copelata"*

From the geographical difference in the composition indicated above, one may deduce that the zooplankton association is dominated by larval forms in the north of Noto Peninsula and by *Copepoda* group accompanied by *Copelata* in the offing of Wakasa Bay, and that these two associations are mixed to result the zooplankton of Toyama Bay (Fig. 11).

Oithona nana and *Oncaea venusta* are far more important than other members of *"Copepoda"* group, because they occur more frequently and in far greater abundance. According to conventional theories, both species are typically neritic forms. *Noctiluca scintillans* and *Calanus helgolandicus* rank next to *Oithona nana* and *Oncaea venusta* in their importance. The other animal formes are of little importance, because they occur only occassionally in such small numbers as several hundreds per cubic mether of sea water. Hence, these four species, particulary *Oithona nana* and *Oncaea venusta*, are to be regarded as the major species in the zooplankton of the offshore region of the Japan Sea during summer (Fig. 12).

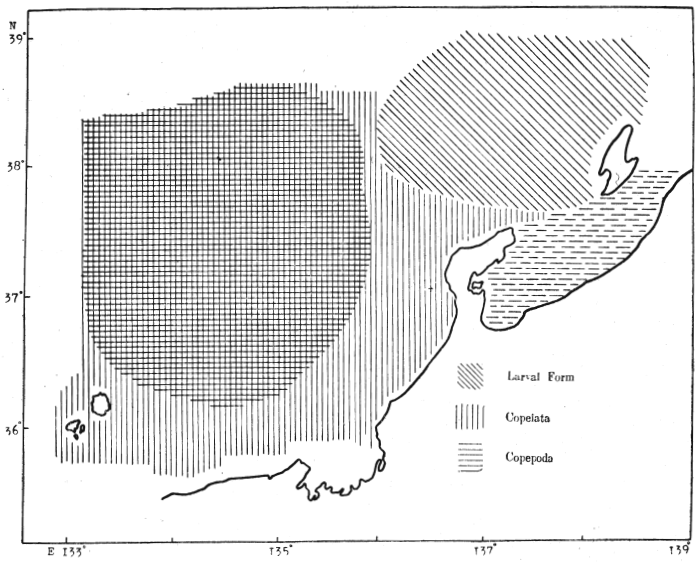

Fig. 11 Geographical distribution of important groups of zooplankton.

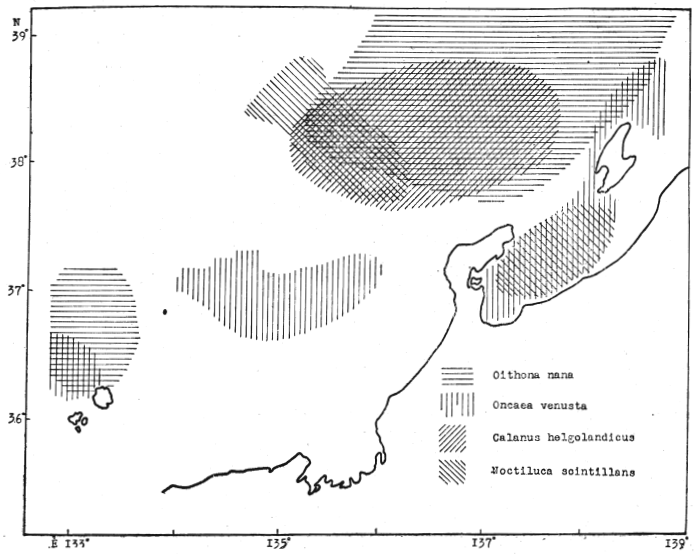

Fig. 12 Geographical distribution of major zooplankton species.

As previously indicated, the zooplankton off Sado Island is composed chiefly of larval forms, but these are mostly *Oithona larvae*. Therefor, it may well be said that a zooplankton population which can be termed *"Oithona community"* is distributing over the whole waters covered by this study, and that the population is modified into *"Oithona Larva community"* in the north and north-east of Noto Peninsula and into *"Oithona Adult community"* in the west of the peninsula.

Distribution of various groups and predominant species of phytoplankton: In the waters coverd by this study, *Cyanophyceae, Dinoflagellata* and *Diatmaceae* constitute the major part of the phytoplankton. Following two points are to be mentioned with

regards to the behavior of these groups.

1) Relative abundance of the three groups varies considerably with geographic positions (Fig. 13) and the variation is due, in most cases, to the heavy variation in the abundance of *Diatomaceae*. It is not uncommon that phytoplankton consists exclusively of this group.

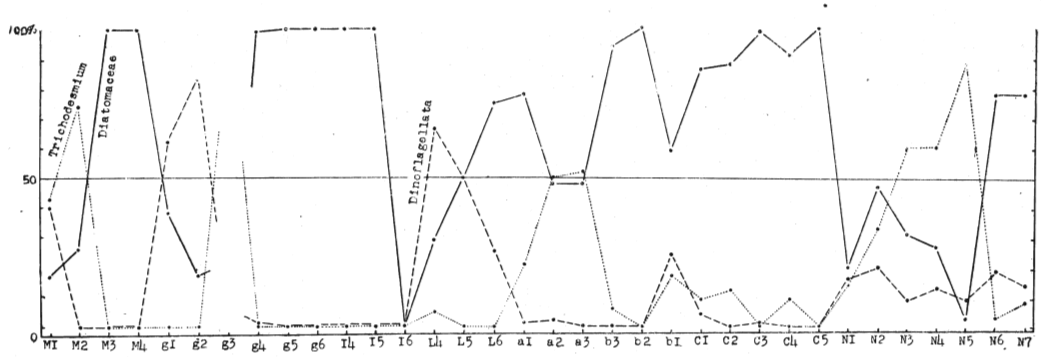

Fig. 13 Percentage abundance of *Diatomaceae*-, *Dinoflagellata*-, and *Cyanophyceae*-group in phyto-plankton at each station.

2) *Cyanophyceae* and *Dinoflagellata* become preponderant only in certain localities, i. e. in Toyama Bay. In this bay, in sharp contrast with other regions, *Cyanophyceae* predominate over other other groups; *Diatmaceae* and *Dinoflagellata* follow in that order respectively accounting for less than 50% and less than 20% of the phytoplankton.

Diatomaceae is further divided into three groups: *"Chaetoceros"*, *"Rhizosolenia"* and *"Other Diatomaceae"*. As in the case of the three major groups of zooplankton, each of these groups consists chiefly of one or a few major species:

"Rhizosolenia" group – *Rhiz. hebetata f. semispina, Rhiz. setigera, Rhiz. alata* (including *f. gracillima*).

"Other Diatomaceae" group – *Climacodium biconcavum.*

"Chaetoceros" group – *Ch. affinis, Ch. coarctatus.*

Figure 14 shows the relative abundance of of these groups at each station in terms

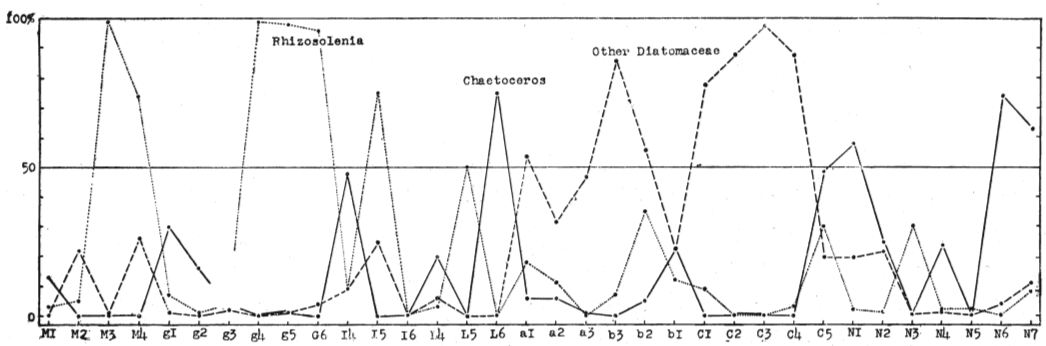

Fig. 14 Percentage abundance of *Chaetoceros*-, *Rhizosolenia*-, and *Other Diatomaceae*-group in phytoplankton.

of percentage to total phytoplankton. As is clear from this graph, *"Rhizosolenia"* and *"Other Diatomaceae"* constitute the major part of phytoplankton in the offshore. In Toyama Bay (Sts. N2–N4), however, none of the three diatom groups amounts to 20% of total phytoplankton, owing to the preponderance of *Cyanophyceae*. *"Chaetoceros"* is preponderant (more than 50% of phytoplankton) in two localities, namely on the east coast of Noto Peninsula (St. N1) and between Honshu and Sado Island (Sts. N6 and N7). In the former region *Ch. affinis* is showing a heavy growth, while *Ch. didymus* and *Ch. coarctatus* occur in great abundance in the latter region.

Figure 15, being deprived from Figure 14, clearly illustrates the characteristics of the geographical distribution of phyto-plankton in the offshore waters covered by this

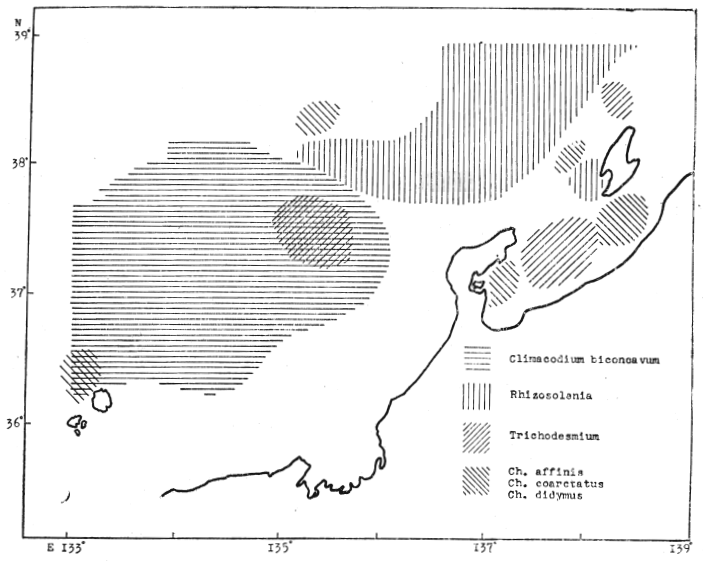

Fig. 15 Geographical distribution of major phytoplankton species.

study. From the north-west of Noto Peninsula north-eastwards *"Rhizosolenia"* group predominates, and in the west of this region *Climacodium biconcavum* is dominant. Distributions of these two phytoplankton associates borders each other north-west of Noto Peninsula. Along the border line there scatter those small isolated regions where *"Chaetoceros"* or *"Cyanophyceae"* (*Trichodesmium*) is dominant in phytoplankton.

III Summary

1) The material for this study was collected during the period July 7–30, 1951, at 34 stations distributing in the Japan Sea off central Honshu, Japan. At each station a vertical haul was made through the 0–25 m. layer. The numerical abundance and quantitative and qualitative composition of plankton are studied upon these samples. And the geographical distributions of these planktological propertios are discussed in relation to physico-chemical conditions of the sea.

2) In the offshore regions, the number of species to occur at one station fluctuates little, usually between 10 and 20, comprising more than 10 animal species and less than 10 plant species.

3) The path of Tsushima Current coincides with the region where the plankton is composed of more than 15 species of organisms. In the further offshore, less than 15 species of organisms are found in the plankton.

4) The abundance of plankton organisms varies with stations between 2,609/m^3 and 463,000/m^3. The regions of high abundance are situated off Sado Island and off Wakasa Bay; in the former region animal species (especially *Oithona nana*) is dominant, but in the latter, plant species (mostly *Climacodium biconcavum*). These regions of high abundance coincide with the low temperature region off Sado Island and that off Wakasa Bay.

5) The path of Tsushima Current coincides with the region of plankton abundance - less than several thousands of organisms per litre of sea water.

6) On the basis of geographical distribution of planktological properties, the waters covered by this study can be divided into the two regions which border each other in the northwest of Noto Peninsula. Abundance as well as composition of phytoplankton differs sharply on the two sides of this line. On the west side, phytoplankton is exceedingly abundant and composed chiefly of *Climacodium biconcavum*. On the northeastern is,dephytoplankton is relatively scarce and "*Rhizosolenia*" group is important.

The abundance of zooplankton is higher in the north-eastern region, but the difference in the two regions is not so remarkable as in the abundance of phytoplankton. *Oithona* is the major constituent of zooplankton in either region, and adult forms of *Oithona* predominate in the western region, while *Oithona* larvae are dominant in the north-eastern region.

7) As far as the present samples concern, the summer plankton population of the middle Japan Sea has comparatively simple specific composition. Two species, namely *Oithona nana* and *Climacodinm biconcavum* are the constituents of primary importance.

The following eight species rank second in importance.

Zooplankton : *Oncaea vdnusta, Noctiluca scintillans, Calanus helgolandicus.*

Phytoplankton : *Rhizosolenia hebetata f. semispina, Rhiz. setigera, Rhiz. alata* (including *f. gracillima*), *Chaetoceros, Ch. coarctatus.*

8) The plankton of Toyama Bay shows peculiar specific composition, as compared with the plankton of other regions. The seasonal and successional chang of the plankton of this bay will be reported in a separate paper.

IV Literature

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Separate Table: The plankton species and each number of organisms per cubic meter of sea water in the central Japan Sea during the period July 7–30, 1951.

St. No.	M1	M2	M3	M4	g1	g2	g3	g4	g5	g6	I4	I5	I6	L4	L5	L6	a1	a2	a3	b3	b2	b1	C1	C2	C3	C4	C5	N1	N2	N3	N4	N5	N6	N7
Location (Latitude (North)	38.27	38.33	38.40	38.54	37.57	38.00	38.16	38.13	38.28	38.41	37.54	38.17	38.21	37.55	38.08	38.23	37.16	37.23	37.37	37.01	36.41	36.33	36.26	36.37	36.48	36.38	36.26	37.09	37.12	37.16	37.22	37.27	37.32	37.38
Location (Longitude (East)	138.22	138.13	138.04	137.46	138.08	138.00	137.51	137.41	137.24	137.07	136.52	136.35	136.17	135.58	135.41	135.23	135.49	135.31	135.13	134.40	134.51	135.06	134.31	134.12	133.38	133.31	132.54	137.11	137.20	137.30	137.45	138.00	138.13	138.26
Date, Time	11/VII. 09.00	11/VII. 07.00	11/VII. 05.00	11/VII. 01.00	10/VII. 06.00	10/VII. 08.00	10/VII. 10.00	10/VII. 12.30	10/VII. 15.30	10/VII. 19.00	8/VII. 03.20	7/VII. 24.00	7/VII. 20.30	7/VII. 04.30	7/VII. 09.00	7/VII. 13.00	28/VII. 09.00	28/VII. 13.30	28/VII. 18.00	29/VII. 04.30	29/VII. 09.00	29/VII. 12.30	29/VII. 19.00	29/VII. 23.00	30/VII. 0.300	30/VII. 06.50	30/VII. 13.30	14/VII. 18.00	14/VII. 16.00	14/VII. 15.00	14/VII. 12.30	14/VII. 09.30	14/VII. 07.00	14/VII. 05.00
Number of total organisms/m³	12,857	10,828	22,085	14,471	27,316	19,525	>6,075	22,812	18,866	18,388	10,534	19,038	9,106	7,236	6,213	6,607	21,360	58,095	159,640	333,374	143,932	7,629	14,179	19,692	47,104	462,925	102,141	65,115	6,849	2,609	4,817	4,322	6,549	4,070
Number of zoopl. organisms/m³	2,978	7,663	14,374	13,043	8,631	7,920	2,801	11,684	8,274	15,174	6,666	18,804	9,106	4,142	4,785	6,131	1,200	1,713	7,680	6,099	3,959	1,917	3,763	1,740	1,680	497	535	6,104	1,967	1,895	1,748	1,644	4,941	2,428
Number of phytopl. organisms/m³	9,879	3,165	7,711	1,428	18,685	11,605	>3,270	11,128	10,592	3,214	3,868	234	0	3,094	1,428	476	20,160	59,382	151,960	327,275	139,973	5,712	10,416	17,952	45,424	462,428	101,606	59,011	4,882	714	3,069	2,678	1,608	1,642
Inclination of wire (°)	40°	47°	0°	10°	40°	0°	0°	0°	0°	10°	0°	0°	0°	0°	0°	0°	52°	49°	35°	38°	52°	45°	49°	0°	10°	0°	24°	15°	0°	24°	20°	25°	10°	0°
Zooplankton																																		
Gazeletta hexanema	–	–	–	–	476	298	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Globigerina bulloides	–	–	95	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Noctiluca scintillans	238	–	–	–	357	298	60	–	–	–	952	–	–	809	500	1,071	–	–	–	–	–	–	–	–	–	–	–	428	179	250	321	214	714	36
Calanus darwinii	–	–	–	–	–	–	–	–	–	119	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36	–	–	–	–
Calanus helgolandicus	–	–	–	190	298	179	–	298	179	476	–	655	595	95	143	238	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	36	–	–	–	–
Acrocalanus gibber	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	321	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Clausocalanus arcuicornis	–	–	–	–	–	–	–	–	–	–	–	–	–	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Clausocalanus furcatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	357	–
Paracalanus parvus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	710	600	1,080	–	–	–	60	–	71	–	119	–
Paracalanus aculeatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36	–	–	–	–
Paracalanus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Euchaeta marina	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Euchaeta longicornis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	107	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Euchaeta sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	–	–	–	–	–
Calanidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	–	–	–	–	–
Temora discaudata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	–
Temora stylifera	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71	–	–	–	–	107	–	–	–	–	–	–
Temora sp.	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Metridia lucens	–	–	–	286	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Labidocera japonica	–	–	–	–	119	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	119	–	–	–	–	–
Centropages bradyi ?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	tr.	–	–	–	–	–	–	–	–	–
Oithona plumifera	–	–	–	286	–	–	–	–	–	–	–	tr.	–	48	250	417	–	71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	119	–
Oithona similis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	143	–	428	428	–	284	60	–	–	–	–	–	–	–	36	–	–
Oithona robusta	–	250	1,047	476	–	–	–	833	60	595	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36	–	–	–	–
Oithona setigera	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	143	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oithona nana	595	2,499	2,285	2,666	476	238	1,071	4,106	2,618	2,440	1,547	2,856	2,618	428	928	1,904	120	286	960	107	–	355	–	–	60	142	107	–	179	36	286	179	286	–
Euterpe acutifrons	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	321	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Idomene furcata ?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Setella gracilis	–	–	–	–	–	–	60	–	–	–	–	–	–	–	–	–	tr.	71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Micosetella rosea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	428	–	142	60	–	–	–	–	–	–	36	–	–	–
Microsetella norvegica	–	–	–	–	60	–	–	–	–	–	–	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corycaeus japonicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oncaea venusta	774	83	–	–	1,845	893	179	119	60	–	417	tr.	119	428	357	595	360	143	240	1,712	1,070	284	497	60	60	–	214	1,607	357	464	71	393	357	143
Corycaeus sp.	–	–	–	–	–	417	60	–	–	–	–	tr.	60	95	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71	36	–	71
Corycaeus flaccus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	–	–	–	–	–	–	–	–	–	–
Evadne tergestina	–	–	–	–	238	–	60	–	–	–	–	–	–	95	–	–	tr.	357	–	107	107	284	213	–	–	–	–	321	–	–	–	–	–	71
Podon leuckarti	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Penilia Schmackeri	–	–	–	–	–	–	–	–	–	–	–	–	–	48	–	–	tr.	–	–	–	–	–	–	–	–	–	–	214	60	–	–	–	–	–
Limacina helicina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	960	–	107	–	71	–	–	–	–	–	–	–	–	–	–	–
Creseis acicula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	284	–	–	–	–	–	–	–	–	–	–	–	–
Planktomya Henseni	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71	–	107	–	–	284	–	–	–	–	–	–	–	–	–	–	–
Paratemisto obiliva	–	–	–	95	–	–	–	tr.	–	tr.	tr.	tr.	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phronima pacifica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–
Nauplius Larva	119	–	190	381	476	1,012	60	417	536	179	–	tr.	238	48	179	238	120	–	480	642	214	213	284	120	180	–	–	750	–	–	71	36	–	36
Calanidae Larva	119	916	4,094	2,094	2,737	1,131	179	1,726	2,142	8,211	2,321	13,150	4,046	476	785	595	–	–	–	–	–	–	–	–	–	–	–	536	–	–	107	71	1,666	–
Metridia Larva	357	1,583	2,094	3,808	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,000
Oithona Larva	–	1,666	4,379	1,714	–	238	–	2,137	1,964	2,023	–	1,250	–	666	–	–	–	–	–	–	107	71	71	240	–	–	–	643	–	107	214	143	476	–
Copepoda Larva	–	–	–	–	–	*774	–	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	300	120	–	–	214	357	36	107	36	•298	–
Gastropoda Larva	–	–	–	95	60	60	–	–	60	–	357	–	60	48	36	60	–	–	3,120	1,284	749	71	142	–	–	142	214	214	–	–	–	–	60	–
Cyrripedia-Cypris Larva	–	–	–	–	–	–	–	–	–	–	–	–	–	405	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Zoea Larva	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polychaeta Larva	–	–	–	–	60	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetobranchia Larva	60	–	–	–	179	60	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36	36	71	–	36
Macrurus Egg	60	–	–	–	238	536	238	–	–	–	238	–	–	286	500	238	360	71	240	321	–	–	–	–	–	–	–	107	119	–	–	36	–	–
Fish eggs	–	–	–	–	–	–	–	–	–	tr.	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	◉321	–	–	–	–	–	–
Mysidae	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pteropoda	–	–	–	–	–	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oikopleura longicauda	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	428	–	464	–	–	–	–
Oikopleura spp.	119	666	190	952	119	357	476	1,250	536	1,071	595	893	1,131	–	1,071	655	120	357	720	535	749	355	994	240	180	213	–	–	238	179	179	214	357	250
Fritillaria pellucida	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fritillaria sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	120	–	240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sagitta bipinnata	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sagitta spp.	–	–	–	tr.	298	238	–	–	–	60	60	–	119	48	–	60	–	240	–	107	–	–	–	–	–	–	–	–	–	36	71	36	119	–
Doliolum nationalis	–	–	–	–	–	119	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	119	179	71	36	–	428
Doliolum sp.	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	240	–	–	–	–	–	–	–	–	–	–	–	–	–	60	–
Obelia geniculata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	214	–	–	–	–	–	–
Conchoesia elegans ?	357	–	–	–	595	774	60	–	119	–	119	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71
Phytoplankton																																		
Trichodesmium contortum	3,927	2,332	–	–	–	–	–	–	–	–	–	–	–	143	–	–	4,200	28,190	79,576	21,147	2,014	1,008	1,008	2,176	272	41,688	–	7,818	1,607	428	1,586	2,356	60	143
Trichodesmium erythraeum	–	–	–	–	–	–	3colonies	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Peridinium depressum	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	–
Pyrocystis lanceolata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	120	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium furca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,006	–	–	–	–	–	–	–
Ceratium fusus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	336	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium gracile	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium lunula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,014	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium trichoceros	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	2,014	336	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium pulchellum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	336	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium inflexum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	336	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium deflexum	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	120	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium strictum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium tripos	952	–	–	–	1,250	1,488	238	60	–	–	–	–	–	143	–	–	–	–	–	–	–	1,008	–	–	272	–	–	964	60	–	71	71	–	36
Ceratium longipes	–	–	–	–	–	–	–	–	–	–	–	–	–	–	714	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium gravidum	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium pennatum	–	–	–	–	tr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium macroceros	–	–	–	–	298	298	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	336	–	–	–	–	536	60	–	–	–	–	–
Cerat. macroceros gallicum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cerat. Candelabrum var. dilatatum	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–
Cerat. massiliens var. protuberans	3,035	–	–	–	9,996	7,795	952	–	–	–	1,309	–	–	1,904	–	119	–	–	–	–	–	–	–	–	–	–	–	2,356	833	71	32	179	238	143
Chaeloceros coarctatus	833	–	–	–	3,808	1,845	1,726	–	119	–	893	–	–	619	–	–	1,200	3,692	1,392	tr.	7,049	1,344	–	–	–	–	42,253	tr.	298	–	–	595	–	–
Chaeloceros densus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,570	–	–	143	–	–	–
Chaeloceros pelagicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6,036	5,569	–	–	–	–	–	–
Chaeloceros Lorenzianus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	23,455	536	–	428	–	–	–
Chaeloceros affinis	–	–	–	–	357	–	179	–	–	–	–	–	–	–	–	–	357	–	–	–	–	–	–	–	–	–	–	3,320	357	–	143	–	595	1,035
Chaeloceros didymus	536	–	–	–	1,488	–	–	–	–	–	952	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,012	–	–	–	–	–	–	–
Ch.-Hyalochaete	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia Stolterfothii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	714	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia setigera	–	–	381	95	–	–	–	1,131	595	536	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhiz. alata f. gracillima	–	–	1,904	–	–	–	–	7,557	8,568	1,309	–	–	–	–	–	–	120	–	–	–	–	–	336	–	–	–	6,036	428	–	36	–	–	71	–
Rhizosolenia Bergonii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4,024	–	–	–	–	–	–	–
Rhizosolenia styliformis	298	–	–	–	1,250	179	119	–	–	–	357	–	–	–	–	–	–	1,007	–	–	–	–	–	–	–	8,492	5,030	–	–	–	–	–	–	71
Rhiz. hebetata f. semispina	–	167	5,331	952	–	–	–	2,380	1,250	1,250	–	179	–	–	–	–	–	336	–	–	–	336	336	–	–	–	–	–	–	–	–	–	36	–
Rhiz. styl. var. latissima	–	–	–	–	–	–	–	–	–	–	–	–	–	95	–	–	3,480	4,698	tr.	24,168	48,336	336	336	–	3,860	15,090	321	60	179	71	36	–	–	–
Olimacodium biconcavum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10,440	16,444	69,832	281,960	78,546	1,344	8,064	15,776	44,880	408,388	8,048	6,533	1,071	–	–	–	–	–
Climacodium Frauenfeldianum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	480	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eucampia Zoodiacus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36	–	–	–	–
Thalassiothrix nitzschioides	–	333	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,821	–	–	–	–	–	–
Thalassiothrix longissima	–	–	–	–	–	–	–	–	–	–	357	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3,018	–	–	–	–	–	–	–
Nitzschia seriata	–	333	–	381	238	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,285	–	–	–	–	–	–
Bacteriastrum sp.	–	–	–	–	–	–	–	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–
Pleurosigma affine	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	321	–	–	–	–	–	–
Coscinodiscus radiatus	–	–	–	–	–	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	107
Coscinodiscus excentricus	–	–	95	–	tr.	–	–	–	–	119	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dactyliosolen mediterraneus	–	–	–	–	–	–	–	–	–	–	–	–	–	95	–	–	–	–	–	–	–	–	–	–	–	–	9,054	1,714	–	–	–	–	–	–
Hemiaulus membranaceus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,007	1,160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Licmophora abbreviata	–	–	–	–	–	–	–	–	–	–	–	–	–	95	–	–	–	–	–	–	–	–	–	–	–	–	–	tr.	–	–	–	–	–	–

*including *Labidocera juv.*

◉including *Engraulis japonicus* eggs •including *Saphirina juv.*