Planktological Study on the Warm Tsushima Current Regions—I

Plankton Properties and Their Relation to Oceanographic Conditions of Noto Peninsula-Sado Island Region in the Autumn of 1950.

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I Introduction

There is considerable reason for beliebing that the oceanographic conditions in the waters named in the title have much bearing upon the condition of fishing of our coastal fishery on the Sea of Japan, because those waters lie across the migration rout of mackerel, sardine, saury, squids and other migratory fishes upon which the fishery is largely dependent. But little has been known of oceanography, especially of planktological properties, of these waters. In the present study, the plankton in those waters was investigated in relation to physical and chemical conditions of the sea, in the hope that studies of this kind, when continued systematically, will lead us to a better understanding of the relationship between the oceanographic conditions and the availability of fish, and to a more effective fishing operations.

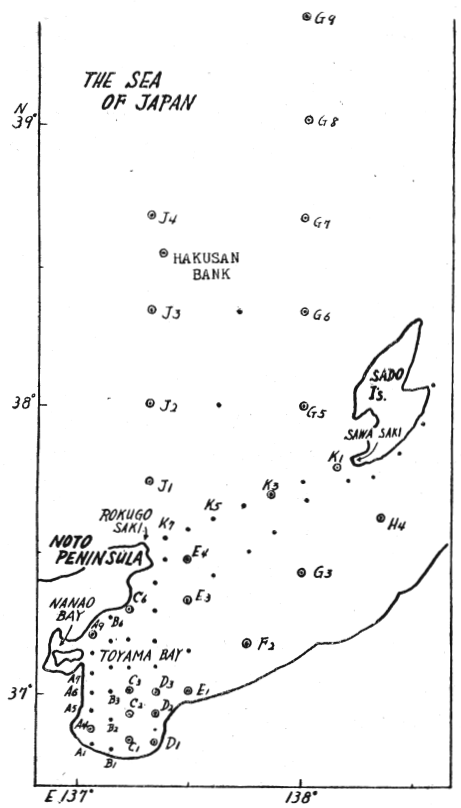

Fig. 1 The positions of observation stations. (Mark ◉ indicates the positions that the specific composition of plankton was idendified and recorded in the Appended Table.)

The material for this study was collected during the oceanographic observation of those waters conducted over the period September 9–20, 1950 on board the "Hakusan Maru", research vessel of the Ishikawa Prefecture Fisheries Institute. Positions of the stations are shown in Figure 1. At every station, plankton was collected by a vertical haul through the uppermost 25-meter layer, and physico-chemical observation was made as indicated bellow:

Items — water-temperature, chlorinity, oxygen content, silicate content, hydrogen ion concentration,

transparency and color of sea water, and meteorological observations.

Observation layers (in meter) — 0, 10, 25, 50, 75, 100, 150, 200, 250, 300, 400, 600, 800, 1,000.

Method of collecting plankton: Plankton was collected by the vertical haul with the Kitahara's net. The net was lowered to the point where the submerged length of the wire reached 25 m, and then hauled up to the surface. The inclination of the wire varied at different stations. as indicated in the Appended Table added at the end of this thesis. The filtering cone of the net was made of XX No. 13 silk bolting cloth (corresponding to Müller gauze No. 13) and provided with a small bucket (glass tube) having a cock at the bottom. Its mouth measured 20 cm. in diameter.

Measuring the settling volume: Since the main purpose of this investigation was to know the general feature of plankton distribution, no attempt was made to take the count of plankton organisms. So that, the settling volume of the catch was measured and used as an index of the abundance of plankton. The whole catch at each station (i. e. zooplankton and phytoplankton not segregated) was washed in the 50 cc. measuring cylinder graduated every 0.1 cc., and the volume was read after being left undisturbed for 24 hours. But the identifcation of specific composition of plankton was carried only at 27 stations as shown in Figure 1 (mark ⊙) and in the Appended Table.

Before proceeding further, I wish to express my sincere gratitude to Mr. R. Sugano, Director of the Ishikawa Prefecture Fisheries Institute, who kindly arranged so that this investigation could be made on the maiden voyage of the "Hakusan Maru". My hearty thanks are also due to Mr. K. Miyata, Mr. S. Kasahara and the crew of the "Hakusan Maru" for their assistance during the cruise.

II Plankton

Quantitative analysis of plankton: The settling volume of plankton (Fig. 2) varies between 11.0 cc. (St. D_1) and 0.1 cc. (St. K_2). Generally it is large in neritic regions such as Toyama Bay, the waters around Sado Island, and north of 39°N. In these areas settling volume always exceeds 1 cc.. In the waters between Noto Peninsula and Sado Island it is small, usually less than 0.5 cc.. In the north of 39°N the settling volume increases gradually with latitude, and reaches the maximum of 8.0 cc. at St. G9.

Geographical distribution of the settling volume coincides well with that of transparency of sea water (Figs. 2 and 3).

In either zooplankton or phytoplankton, no single species is overwhelmingly dominant. In most localities, the settling volume of phytoplankton is considerably small. Relatively dominant species are listed below for each region.

I) Toyama Bay — *Oncaea venusta, Corycaeus japonicus, Corycaeus lautus, Chaetoceros coarctatus.*

II) South of Sado Island — *Oncaea venusta, Creseis acicula, Ceratium carriense f. ceylanicum.*

III) Off Noto Peninsula — *Creseis acicula, Diphyes appendiculata, Rhizosolenia styli-*

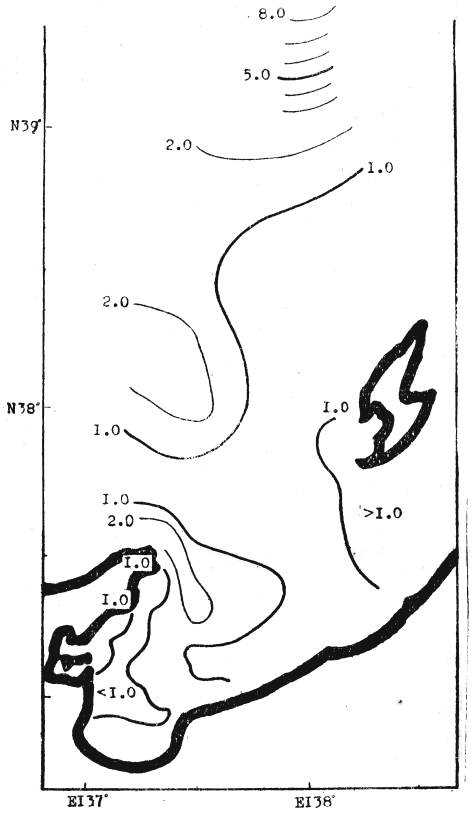

Fig. 2 Geographical distribution of settling volume (cc.) of total plankton organisms.

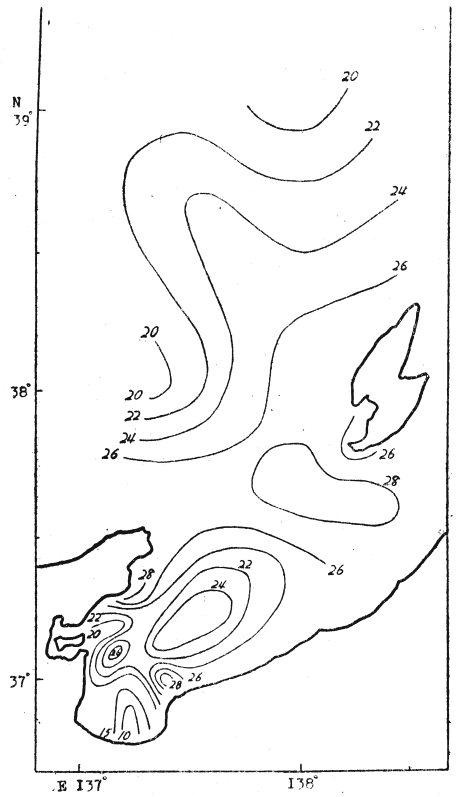

Fig. 3 Geographical distribution of transparency of sea water (m.).

formis var. latissima.

IV) North of 39°N — There occurs no dominant species. Phytoplankton usually exceeds zooplankton in settling volume, in contrast with other regions.

V) Between Noto Peninsula and Sado Island — *Creseis acicula, Sticholonche zanclea, Oncaea venusta, Setella gracilis,* Genus *Ceratium.*

Relation between settling volume and sea conditions : As stated before, the settling volume of plankton is great in neritic regions and in the outside of Tsushima Current. Toyama Bay and the waters fringing Sado Island belong to the former category, and the low temperature region off Toyama Bay belongs to the latter. In the open sea, large settling volume is associated with relatively low water temperatures below 24°C. Even in such low temperature regions plankton is composed exclusively of warmth-loving forms.

In Figure 4 the main and branch flows of Tsushima Current are indicated respectively by thick and fine arrows. The region of low plankton abundance (volumetri cally) between Noto Peninsula and Sado Island corresponds to the path of Tsushima Current. It may well be said that the path of Tsushima Current is represented by the region in which settling volume is less than 1 cc. and usually 0.5 cc. so. Although the settling volume differs so conspicuously between the regions of high and low abundances, the species constituting the plankton hardly differ in the two regions.

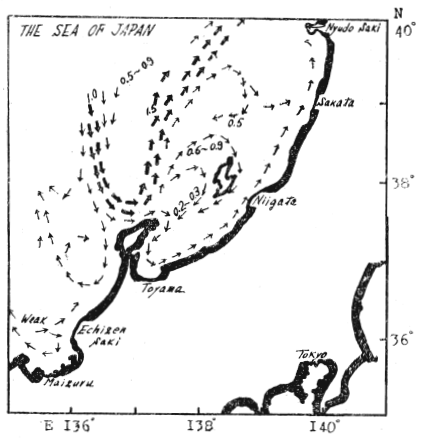

Fig. 4 The path and its velocity (knot) of Tsushima Current during the observation period. (by Yoshida)

Toyama Bay receives fresh water from Nanao Bay and from various rivers such as Jintsu River, Sho River, Kurobe River etc.. Accordingly, the chlorinity is very low in the upper layer of the innermost part of the bay. For example, the diluting effect of Sho River is traceable northwards along the observation line A, and that of the Nanao Bay water is recognized at St. A9 (Fig. 5), because the chlorinity in the 0–5 m layer is below 18.00‰ in the south of St. A5. But even in those regions where the diluting effect is strong, no purely freshwater forms occur in the plankton.

In the offing, the region of high plankton abundance starts from the position where the thickness of the warm and less saline surface layer sharply decreased —— for example, St. J2 (Fig. 6). It is indicated in Figure 6 that the 20°C isotherm lies at the depth of about 75 m in Toyama Bay, but

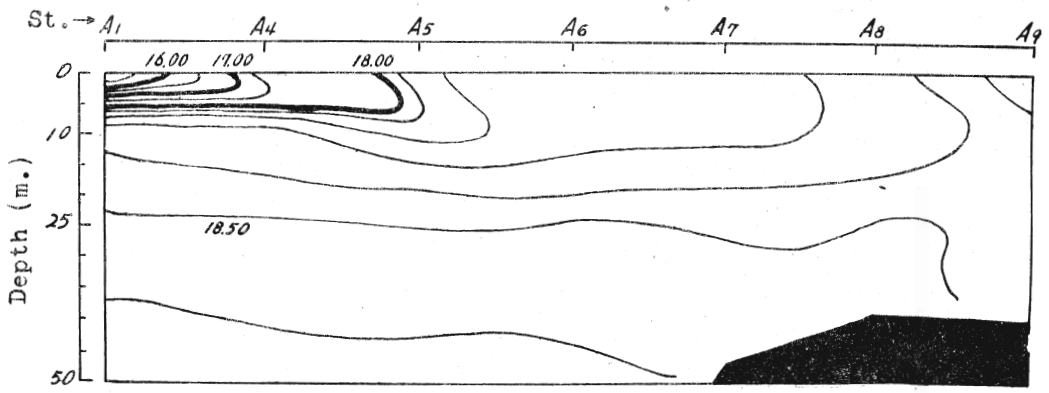

Fig. 5 Vertical distribution of chlorinity along the observation line A in Toyama Bay.

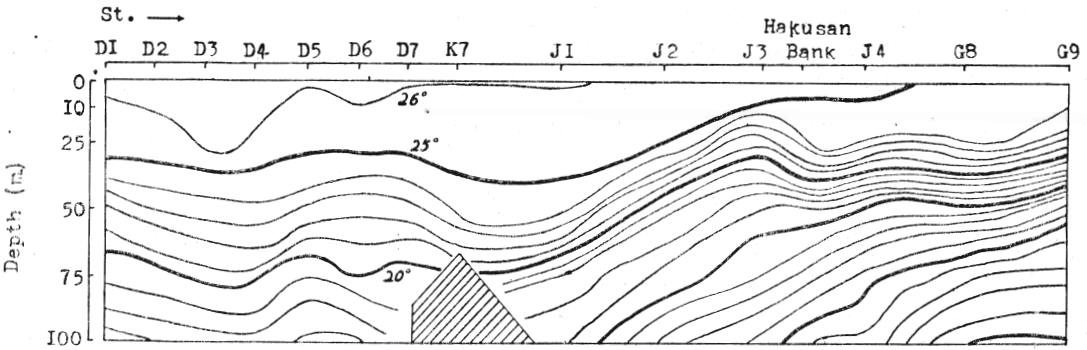

Fig. 6 Vertical distribution of temperature of sea water from the innermost part of Toyama Bay to the offing.

at 25m in the north of St. J3, where the first discontinuity of water temperatnre lies between 25 m and 50 m layer. The profile of chlorinity shows the similar tendeney. Oxygen content increases gradually with latitudes; for example, it is 5.5 cc/L at St. G3, but at St. G9 it exceeds 7.0 cc/L from surface down to 100-meter layer. Silicate content is considerably uniform, usually about 0.5 mg/L.

After all, we come to conclusion that in the offing high plankton abundance is associated with sharp decrease in the thickness of Tsushima Current. In other words, plankton is abundant in such regions where the surface water of the cold current from north is laterally mixing with the surface water of the warm Tsushima Current from south (Shimomura, T. and K. Miyata, 1953). At Sts. G8 and G9 there is tendency that plankton abundance increases, as the thickness of warm surface layer is reduced and the strength of the current velocity increases. Hence, the high abundance of plankton at these stations is probably due, to considerable extent, to the accumulation action of the warm surface current.

Number of species: A total of 104 species are identified, comprising 48 animal and 56 plant species. A complete list of the species appears in the Appended Table. Table 1 gives the number of these species for different classificatory groups. *Copepoda* and

Table 1 Number of species

Zooplankton	48	Phytoplankton	56
Protozoa	4	*Cyanophyceae*	2
Coelenterata	2	*Dinoflagellata*	23
Copepoda	21	*Diatomaceae*	30
Phyllopoda	2	*Chaetoceros*	11
Mollusca	3	*Rhizosolenia*	9
Amphipoda	1	*Other Diatoms*	10
Larval Form	10	*Chlorophyceae*	1
Miscs.	5		

larval forms account for the majority of animal species. The majority of plant species belong to *Diatomaceae* or *Dinoflagellata*, and only few, to *Cyanophyceae* or *Chlorophyceae*. The majority of the *Copepoda* species belong to Suborder *Podoplea*. More *Dinoflagellata* species belong to Gen. *Ceratium* than to any other genus.

Mention should be made to the fact that at any station more *Dinoflagellata* species occur in phytoplankton than the species of Gen. *Chaetoceros* or Gen. *Rhizosolenia*. This feature is to be regarded as a remarkable characteristics of the plankton population with which this study is concerned, becaus in the phytoplankton population so far reported from the adjacent waters of Japan there were always found lesser *Dinoflagellata* species than *Chaetoceros* species.

Number of the total species (i. e. the species constituting phytoplankton and zooplankton) varies from station to station between 12 (St. C6) and 35 (St. G3). As is indicated in Figure 7 which is deprived from the Appended Table, the geographical variation in number of the total species generally coincides well with the variation in the percentage of animal species to total species; in other words, number of the total

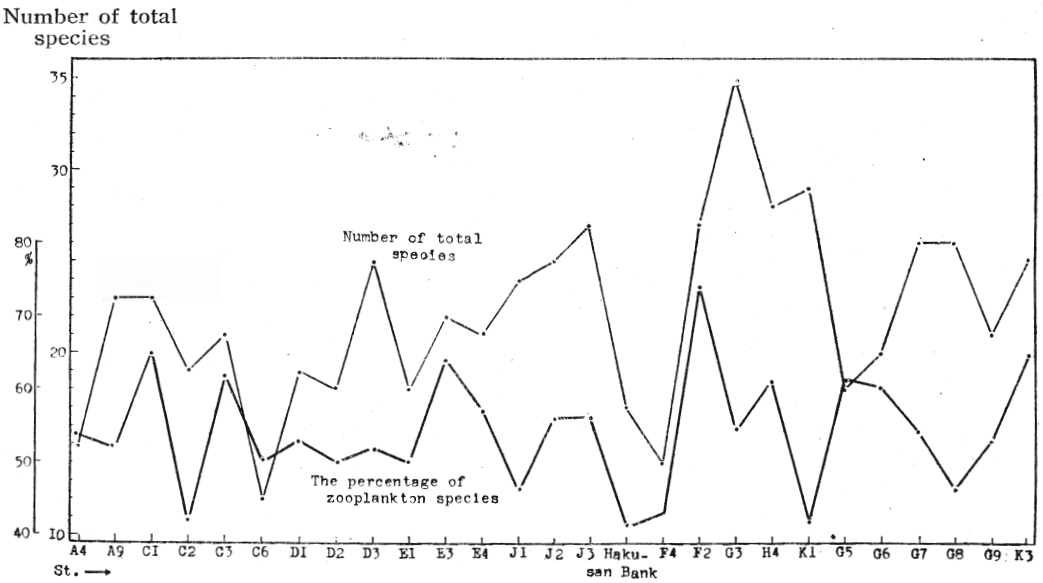

Fig. 7 Number of total species and the percentage of number of zooplankton species to number of total species.

species varies in proportion to that of zooplankton species. In Toyama Bay, and along the northernmost observation line G5–G9 (respectively shown in the left and right end of Fig. 7), this relationship does not hold, and the variation in number of total species is associated with the change in number of phytoplankton species more closely than with the change in number of zooplankton species.

At any station, zooplakton is constituted of 6 to 20 species, of which one third to one half belongs to *Copepoda*. More than 16 species constitute the zooplankton of the neritic region. But the number decreases towards the offshore: between 10 and 15 in thc flow of Tsushima Current and below 10 on Hakusan Bank and in its vicinity (St. J4).

Number of the phytoplankton species to be found at one station varies from 6 (St. C6) to 17 (St. K1), according to the position of the station. With a few exceptions, these species all belong to *Diatomaceae* or *Dinoflagellata.*

Relations between number of the total species and sea conditions: Figure 8 shows the distribution of number of the total species and the path of the warm Tsushima Current during the observation. As is cleary indicated in Figure 8, the path of Tsushima Current —— the main flow as well as the branches —— coincides with the region where the plankton is composed of 20 to 25 species of organisms. In other regions the number of species either exceeds 25 or is smaller than 20. Figure 8 shows that there are three such regions where plankton is composed of more than 25 species of organisms and that two of them are situated near the turns of the course of Tsushima Current and partially surrounded by the flow of the current. No striking difference exists in the species that are constituting the plankton of the two regions, all the species being

warmth-loving. One of the regions where plankton is constituted of less than 20 species of organisms lies in the vicinity of Hakusan Bank, in the north of the main flow of Tsushima Current. In this region, too, plankton is constituted only of warmth-loving species, and purely cold-loving forms are not found.

Another remarkable feature of Figure 8 is the region south-west of Sado Island, where plankton shows much diversified specific composition. This region lies outside the neritic region, but is not situated in the turning area of Tsushima Current, like other two regions of divesified plankton composition. Why the composition of plankton is far more diversified in this region than in other neighboring regions?

Explanation may be found in the distribution of Current. In the west of Sado Island, two branches leave the main flow of Tsushima Current. One branch proceeds clockwise along the east and south coast of Sado Island; the other proceeds counterclockwise along the coast of Toyama Bay. Thence, the two flows again meet in the region in question.

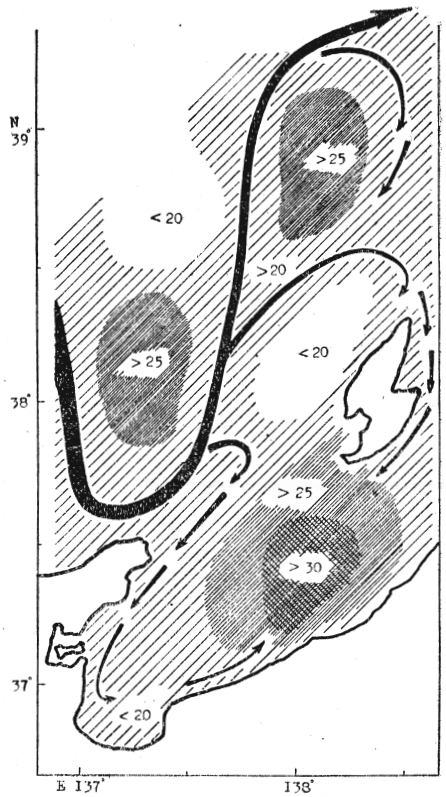

Fig. 8 Relation between the distribution of number of total species and the path of the warm Tsushima Current during the period Sept. 9–20, 1950.

If the variegated specific composition of the plankton of this region result from the contact of the two currents, it should contain the species found in one current as well as the forms found in the other. In Table 2 is given the complete list of species constituting the plankton in the waters in question (St. G3), and whether a species occur

Table 2 Comparison of the specific composition of the plankton south-west of Sado Island (St. G3), north of Sado Island (St. G6), and in Toyma Bay (St. E1).

	Species captured in the waters south-west of Sado Island (G_3).	North of Sado Island (G_6)	Toyama Bay (E_1)
Phytoplankton	*Trichodesmium contortum*	+	−
	〃 *Thiebauti*	−	−
	Ceratocorgs horrida	+	+
	Ceratium inflexum	+	−
	〃 *carriense f. ceylanicum*	−	+
	〃 *Humile*	−	−

	Species captured in the waters south-west of Sado Island (G_3).	North of Sado Island (G_6)	Toyama By (E_1)
Phytoplankton	*Ceratium macroceros gallicum*	−	−
	〃 *pulchellum*	+	−
	〃 *tripos*	−	−
	〃 *sumatranum*	−	−
	Rhizosolenia alata	−	−
	Chaetoceros coarctatus	−	+
	Dactyliosolen tenuis	−	−
	Thal'x Frauenfeldii	−	−
	Biddulphia sinensis	−	−
	Peridinium falutipes	−	+
Zooplankton	*Globigerina bulloides*	+	−
	Sticholonche Zanclea	+	+
	Eucalanus giesbrechti	−	−
	Temora discaudata	+	−
	Setella gracilis	+	+
	Oncaea venusta	+	+
	Corrycaeus japonicus	−	+
	Euterpe acutifrons	+	−
	Evadne tergestina	−	−
	Penilia Schmackeri	−	+
	Amphipoda	+	−
	Creseis acicula	+	−
	Planktomya Henseni	−	−
	Oikopleura	+	+
	Sagitta	+	+
	Doliolum nationalis	+	−
	Polychaeta larva	+	+
	Gastropoda larva	−	−
	Ophiopluteus larva	−	−

(+) or not occur (−) in the north of Sado Island (St. G6), and in Toyama Bay (St. E1) is indicated. Sts. G6 and E1 are regarded as representing the waters where the currents in question have passed. At St. G3 phytoplankton is constituted of 16 species and the zooplankton of 19 species. Of the 16 plant species, one is common to the three stations, 8 are found only at St. G3, and the other 7 are common to St. G3 and one of Sts. G6 and E1. Of the 19 animal species, 6 are common to the three stations, 5 limited to St. G3, and 8 common to St. G3 and one of the other two stations. Such being the case, the species found at St. G3 may be regarded as being composed of the species originating from St. G6 and St. E1.

It then follows that the region south-west of Sado Island which is characterized by the plankton of diversified specific composition is probably formed by the contact of the southward flow along the southern coast of Sado Island with the north-eastward

flow along Japan Proper (Honshu). In Table 2 there are one common species in phytoplankton to these three stations and six in zooplankton —— the former is *Ceratocorgs horrida*, the latter are *Sticholonche zanclea, Setella gracilis, Oncaea venusta, Oikopleura, Sagitta, Polychaeta larva.* In phytoplankton, 8 species —— *Trichodesmium Thiebauti, Ceratium Humile, Cerat. macroceros gallicum, Cerat. tripos, Cerat. sumatranum, Rhizosolenia alata, Thalassiothrix Frauenfeldii, Biddulphia sinensis* ——, and in zooplankton, 5 species —— *Eucalanus giesbrechti, Evadne tergestina, Planktomya Henseni, Gastropoda larva, Ophiopluteus larva* —— occur at St. G3, but not at St. G6 and St. E1.

Of the thirteen species that are not found at Sts. G6 and E1, 7 species —— *Trichodesmium Thiebauti, Ceratium Humile, Cerat. macroceros gallicum, Cerat. sumatranum, Biddulphia sinensis, Eucalanus giesbrechti, Ophiopluteus larva* —— are characteristic to St. G3, i. e. they are not found at other stations of the present observation. Other 5 species of the group, namely *Ceratium tripos, Thalassiothrix Frauenfeldii, Evadne tergestina, Gastropoda larua, Planktomya Henseni,* are found only in Toyama Bay and its neighborhood, but scarcely in the vicinity of St. G6.

On the basis of the scheme of current system and the foregoing analysis of the specific composition of plankton, it may be concluded that the region south-west of Sado Island which is characterized by the plankton of diversified specific composition has resulted from the contact of two currents, namely, the south-westward flow along the southern coast of Sado Island and the north-eastward flow from Toyama Bay.

It then follows that, in the present observation, the plankton of diversified specific composition (i. e. more than 25 constituent species) is found either in the waters partially surrounded by the turning flow of Tsushima Current, or in the mixing region, as mentioned previously.

No purely cold-loving species are found. Some neritic forms, such as *Gastropoda larva,* occurred only in the neritic region, but such regularity is only occassionally found in the distribution of other forms. For example, *Ceratium inflexum, Trichodesmium contortum, Doliolum nationalis* etc. occur chiefly in the offing. Following six species are not found in the north of Hakusan Bank, where the influence of the northern cold water mass is relatively strong.

Peridinium falutipes	*Oithona nana*
Globigerina bulloides	*Oithona decipiens*
Oncaea venusta	*Oithona similis*

In the foregoing paragraphs, reference has been made to the number of total species.

Like number of total species, the number of the phytoplankton species or the zooplankton species to occur one station is also correlated to the oceanographic conditions, although the correlation becomes obscure in the order named (Figs. 9 and 10). The number of the species constituting phytoplankton ranges between 10 and 15 in the main flow of Tsushima Current, but remains below 10 in the branch flows of Tsushima Current and in the offing beyond Tsushima Current. The number of zooplankton species in the main and the branch flows of Tsushima Current fluctuates between 10 ~ 15

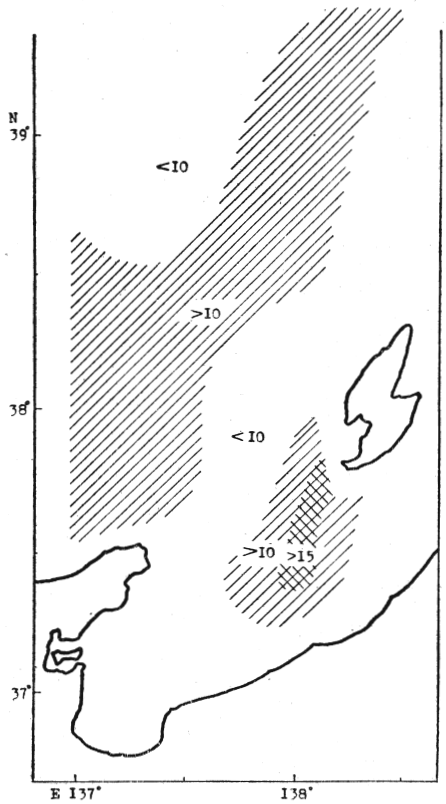

Fig. 9 Geographical distribution of the number of phytoplankton species.

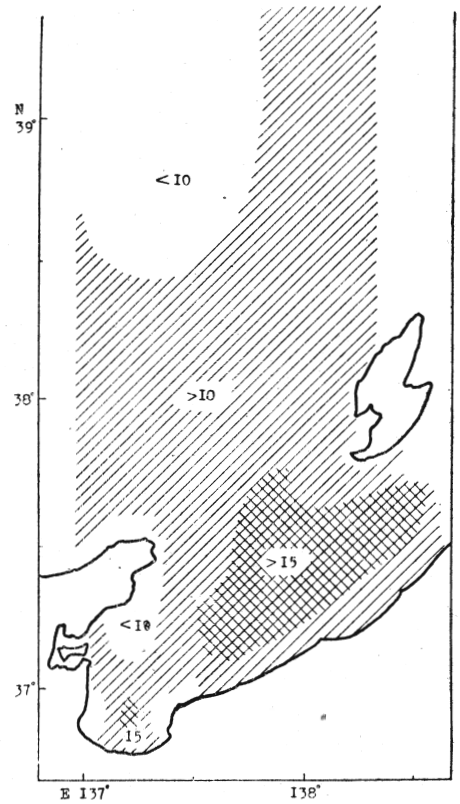

Fig. 10 Geographical distribution of the number of zooplankton species.

species, and falls below 10 in the north of Hakusan Bank. The waters south-west of Sado Island is characterized by the diversified composition of phytoplankton as well as zooplankton species, being constituent of more than 15 species.

After all, the conclusion is arrived at that the distribution of the number of phytoplankton species shows better the path of Tsushima Current in comparison with that of zooplankton species. The number of total species, including phytoplankton and zooplankton, however, indicates most strictly the relation between the sea conditions and the geographical distribution of the number of species. In conclusion the path of Tsushima Current is far better indicated by plotting the number of total species than plotting the number of phytoplankton species or zooplankton species.

So far as the present study concerns, the indicator species of the main flow of Tsushima Current are *Ceratium trichoceros* and *Diphyes appendiculata.*

III Summary

1) This study is concerned with the geographical distribution of microplankton and its relation to the flow of Tsushima Current, in the waters off Noto Poninsula and

Sado Island during the period September 9 – 20, 1950. It is to be the first step to a complete planktological investigation of that low temperature region which occurs in these waters and exerts great influence upon the coastal fishing in the northern Japan Sea.

2) The settling volume of total microplankton varies with geographic position from 0.1 (St. K2) to 11.0 cc. (St. D1). On the basis of the geographical distribution of this volume, three regions are distinguished in the present waters: namely, the neritic region, the path of Tsushima Current, and the offshore region. Within the flow of Tsushima Current the settling volume is less than 1 cc., and usually about 0.5 cc., while it exceeds 1 cc. in the other regions.

3) The list of species for separate stations indicates that the specific composition (irrespective of the relative abundance of each species) of the phytoplankton shows two peculiarities: (1) at any locality, more *Dinoflagellate* species are found than the species belonging to Gen. *Chaetoceros* or *Rhizosolenia*; (2) species of Gen. *Ceratium* account for the greatest part of *Dinoflagellate* species.

4) Number of the species occurring at one station varies between 12 (St. C6) and 35 (St. G3). It is quite noteworthy that the number differs markedly in the three regions mentioned in 2). In the neritic region it is always bellow 20; in the main and branch flows of Tsushima Current it increases over 20; in further offing the number again falls below 20. Number of the plant species, and that of the animal species that occur at one station also differ in the three regions, but the difference becomes less considerable in the named order.

As stated in 2) the settling volume also shows marked decrease in the path of Tsushima Current, but the decrease is not so remarkable in branch flows as in the main flow. It, therefore, follows that of the four measures mentioned above, the number of total species (animal and plant combined) is best correlated with the path of Tsushima Current.

5) Because the sampling is confined to the surface layer (vertical hauling from depths of about 25 m up to surface) and the season is warm, no purely cold-loving forms are found in the sample. Hence, it is not possible to correlate the distribution of such species to the flow of Tsushima Current.

6) In the region where the flow of Tsushima Current changes its direction, that is, where it mixes with the cold current from the north, the plankton is composed of more various forms of organisms than in other regions.

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APPENDED TABLE : The plankton species captured in and off Toyama Bay during the period September 9–20, 1950. (◉, ●, ●: dominant species)

St. No.	A4	A9	C1	C2	C3	C6	D1	D2	D3	E1	E3	E4	J1	J2	J3	Hakusan Bank	J4	F2	G3	H4	K1	G5	G6	G7	G8	G9	K3
Location (Latitude (North)	36.52	37.12	36.50	36.55	37.00	37.17	36.49	36.55	37.00	37.00	37.19	37.27	37.45	38.00	38.20	38.32	38.40	37.10.30	37.26	37.38	37.48.30	38.00	38.20	38.40	39.00	39.20	37.42.30
Location (Longitude (East)	137.05	137.05	137.15	137.15	137.15	137.15	137.22	137.22	137.22	137.30	137.30	137.30	137.20	137.20	137.20	137.24	137.20	137.45	138.00	138.21	138.10	138.00	138.00	138.00	138.00	138.00	137.52.30
Date Time	12. 15.00	20. 13.00	13. 15.20	13. 14.00	13. 12.00	9. 07.00	15. 08.30	15. 10.00	15. 12.00	15. 14.30	20. 10.00	20. 08.00	16. 02.30	16. 06.00	16. 11.00	16. 13.30	16. 15.30	10. 24.00	10. 19.00	10. 15.00	17. 10.00	17. 19.00	17. 23.00	18. 03.00	18. 07.30	18. 12.00	17. 06.00
Inclination of wire (°)	4	35	40	20	1	3	0	4	45	40	40	50	10	10	–	20	50	2	2	2	60	30	5	20	45	70	1
Settling volume (cc.) in 24 hours	0.7	2.5	2.4	0.5	0.4	0.8	11.0	0.6	4.3	1.2	2.3	1.8	0.7	2.0	2.0	0.2	1.4	0.7	0.8	1.2	1.6	0.6	0.4	0.8	2.0	8.0	0.6
Zooplankton																											
Clobigerina bulloides	–	●	–	–	–	●	–	–	–	–	●	–	–	●	●	–	–	●	●	–	–	–	●	●	–	–	–
Tripleen	–	–	●	–	●	–	–	–	●	–	●	●	●	●	●	●	●	–	–	–	●	–	●	●	●	●	●
Sticholonche Zanclea	–	–	●	–	●	–	●	●	●	●	●	–	●	●	●	–	–	–	●	●	●	●	●	●	●	●	●
Gazelletta hexanzma	–	–	–	–	●	–	●	–	–	–	–	●	–	–	–	–	●	–	–	–	●	●	–	–	–	–	–
Abyla leuckarti	–	–	–	–	●	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	●	–	●	–
Diphyes appendiculata	–	–	–	–	–	–	–	–	–	–	–	–	●	●	●	●	–	●	–	–	–	–	–	–	●	–	–
Calanus vulgaris	–	●	–	–	●	–	●	–	–	–	●	–	–	–	–	●	–	–	–	●	–	–	–	–	●	●	–
Eucalanus giesbrechti	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–	–	–
Pseudoclanaus elongatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
Temora dišcaudata	–	–	●	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	●
Labidocera acuta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	●	–	–	–	–	–	–	–
Hetzrorhabdus papilliger	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–
Oithona plumifera	–	–	–	–	●	–	–	–	–	–	●	●	–	–	–	–	–	●	–	●	–	–	–	●	–	●	–
〃 *decipiens*	–	–	–	–	●	–	–	–	–	–	–	–	●	–	●	●	–	–	–	●	–	–	–	–	–	–	●
〃 *similis*	–	●	–	–	–	–	–	–	●	–	–	–	●	–	–	–	–	●	–	–	–	–	–	●	●	–	–
〃 *nana*	–	●	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sellla gracilis	●	●	●	●	●	●	●	●	–	●	●	–	●	–	●	–	●	●	●	●	●	–	●	●	●	●	●
Oncaea venusta	●	●	●	●	●	●	●	●	●	●	●	●	–	–	●	–	–	●	●	●	●	●	●	●	–	–	●
Corycaeus japonicus	●	–	–	–	–	–	–	–	–	●	–	–	–	●	●	–	●	–	●	–	–	–	–	–	–	–	●
〃 *lautus*	●	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–
〃 *sp.*	–	–	–	–	–	–	●	●	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	●	●	●	●
Euterpe acutifrons	–	–	●	–	–	–	–	●	●	–	–	–	–	–	–	–	–	–	●	●	–	–	●	–	–	–	–
Copilia mirabilis	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *sp.*	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Candacia catula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
〃 *sp.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–
Sapphirina intestina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–
Evadne tergestina	–	●	–	–	–	–	–	–	●	–	●	–	●	●	–	–	–	●	●	●	–	●	–	–	●	–	●
Penilia schmackeri	●	●	●	●	●	–	●	–	●	●	●	●	–	–	●	–	–	●	●	–	–	–	–	–	–	–	●
Lucifer raynaudii	–	–	–	●	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●
Amphipoda	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	●	–	●	●	–	–	–	●	–	–	–	–
Creseis acicula	●	●	●	●	–	✚	●	–	●	–	●	●	●	●	●	–	–	●	●	●	●	●	●	●	●	●	●
Limacina helicina	–	–	●	●	–	–	–	–	●	–	–	●	–	●	●	–	–	–	–	–	●	–	–	–	–	–	–
Planktomya Henseni	–	–	●	–	–	–	–	–	–	–	–	●	–	●	●	–	–	●	●	●	–	–	–	–	–	–	●
Oikopleura	–	●	●	●	–	–	●	●	●	●	●	–	●	●	–	–	●	●	●	●	●	●	●	–	●	●	●
Sagitta	●	●	●	●	–	–	●	●	●	●	●	●	●	●	–	●	●	●	●	●	●	●	●	●	●	●	●
Doliolum nationalis	–	–	–	–	●	–	–	–	–	–	–	–	●	●	●	●	–	●	●	●	●	–	●	●	●	–	–
Doliolum-Oozoid	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
Brachyura-Zoea	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachyura-Megalopa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–
Polychaeta larva	–	●	●	–	●	–	–	–	●	●	●	–	–	●	–	–	–	●	●	●	●	–	●	●	–	–	–
Auricularia larva	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
Echinopluteus larva	–	–	●	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gastropoda larva	–	–	●	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–	–	●
Lamellibranchia larva	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ophiopluteus larva	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–	–	–	–
D-shaped larva	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–
Various larva	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–
Phytoplankton																											
Trichodesmium contortum	–	–	–	–	–	–	–	–	●	–	–	–	●	●	●	●	–	●	●	●	●	–	●	●	●	●	●
〃 *Thiebauti*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–	–	–
Trochiscia Clevei	–	–	–	–	–	–	–	–	–	●	●	●	●	–	–	–	–	–	–	–	–	–	–	–	–	–	●
Peridinium depressum	–	●	●	–	–	–	●	–	●	●	●	●	–	●	–	–	–	–	–	–	●	–	●	●	●	–	–
Peridinium falutipes	●	–	–	●	●	●	–	–	–	●	–	–	●	●	●	–	–	●	●	●	–	–	–	–	–	–	●
Ceratocorgs horrida	●	●	–	●	●	●	●	–	●	●	●	●	●	●	●	–	●	–	●	●	●	●	●	●	–	–	–
Amphisolenia bidentata	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	●	–	–	–	–	●	●
Cerat. inflexum	–	–	–	●	–	–	–	–	–	–	●	–	–	●	●	–	–	–	●	●	●	●	●	–	●	–	–
〃 *fusus*	–	●	●	●	–	–	–	–	–	–	–	●	–	●	●	●	●	–	–	–	●	–	–	●	–	–	–
〃 *furca*	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *carriense f. ceylanicum*	●	●	●	●	●	–	–	–	–	●	–	●	●	●	●	●	●	●	●	●	●	●	–	●	●	●	●
〃 *Humile*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
〃 *trichoceros*	–	–	●	●	●	–	●	●	●	●	–	–	●	–	–	–	–	●	–	●	●	–	●	–	–	–	●
〃 *macroceros subsp. gallicum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
〃 *deflexum*	–	●	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	●	–	–	–	●	–
〃 *vultur var. divergens*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–
〃 *pulchellum*	–	–	–	●	–	●	–	–	–	–	–	●	●	–	–	●	–	–	●	–	–	–	●	–	●	–	–
〃 *tripos*	●	–	●	–	–	–	●	●	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
〃 *tenue f. inclinatum*	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	●	–	–	–
〃 *pentagonum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–
〃 *Candelabrum*	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *Candelabrum var. dilatatum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–
〃 *arcuatum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–
〃 *sumatranum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
〃 *sumatranum f. angulatum*	–	–	–	–	–	–	–	–	–	●	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–
〃 *contortum var. saltans*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–
Rhiz. robusta	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *styliformis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	●	●	–	–
〃 *styl. var. latissima*	–	–	–	–	–	●	–	–	●	–	●	●	●	●	●	●	●	●	–	●	●	●	–	●	●	●	–
〃 *Bergonii*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–
〃 *hebetata f. semispina*	●	–	–	–	–	–	–	●	●	–	●	–	–	●	–	–	–	●	–	–	–	–	–	●	●	●	●
〃 *alata*	–	–	–	–	–	●	–	–	–	–	–	–	–	●	–	●	–	–	●	–	–	–	–	–	●	–	–
〃 *Calcar-avis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–
〃 *robusta*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–
〃 *setigera*	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ch. affinis	–	●	–	–	–	–	●	●	●	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	●	●	–
〃 *coarctatus*	●	●	●	●	●	●	–	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	–	●	●	●	●
〃 *borealis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	●	–	–	–	–
〃 *Lorenzianus*	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	●	–	–	–	–	●	–	–	●	–	–	–
〃 *peruvianus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–	–	–	●	–	–
〃 *atlanticus var. neapolitanus*	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *didymus*	–	–	●	●	–	–	–	●	●	●	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–
〃 *curvisetus*	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *socialis*	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *debilis*	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *compressus*	–	●	–	–	–	–	●	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dactyliosolen tenuis	–	–	–	–	●	–	●	–	●	–	–	–	●	–	●	–	–	–	●	–	●	●	–	●	–	●	●
Climacodium biconcavum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–
〃 *Fraueufeldianum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–
Coscinodiscus excentricus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–
Pleurosigma intermedium	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thal'x Frauenfeldii	●	–	●	●	–	–	–	●	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
Bact. delicatulum	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
〃 *hyalinum*	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Asterionlla japonica	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Biddulpha sinensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–	–	–