PLANKTON INVESTIGATION IN INLET WATERS ALONG THE COAST OF JAPAN

XIX. REGIONAL CHARACTERISTICS AND CLASSIFICATION OF INLET WATERS BASED ON THE PLANKTON COMMUNITIES[2)]

ISAMU YAMAZI

Seto Marine Biological Laboratory, Sirahama

With Plates XVI–XXIII, 4 Text-figures and 3 Tables

CONTENTS

Introduction

Although a large number of works have already been published on the productivity and ecology of plankton in various bays or inlet waters, no extensive investigation on the classification of the inlet waters based on the peculiarities of their plankton

1) Contributions from the Seto Marine Biological Laboratory, No. 275.

communities has been made as yet. The works of YOSHIMURA (1934–1936 and 1943) on the classification of inlets with references to the composition of fishes and benthic animals and those of MIYADI (1938–1942) and MIYADI *et al.* (1944, 1947, 1952 and 1954) from the standpoint of the benthic community are the most useful studies available to the biology of the inlet waters in our country. Seasonal changes of plankton composition at regular stations in some inlets along the coast of Japan were

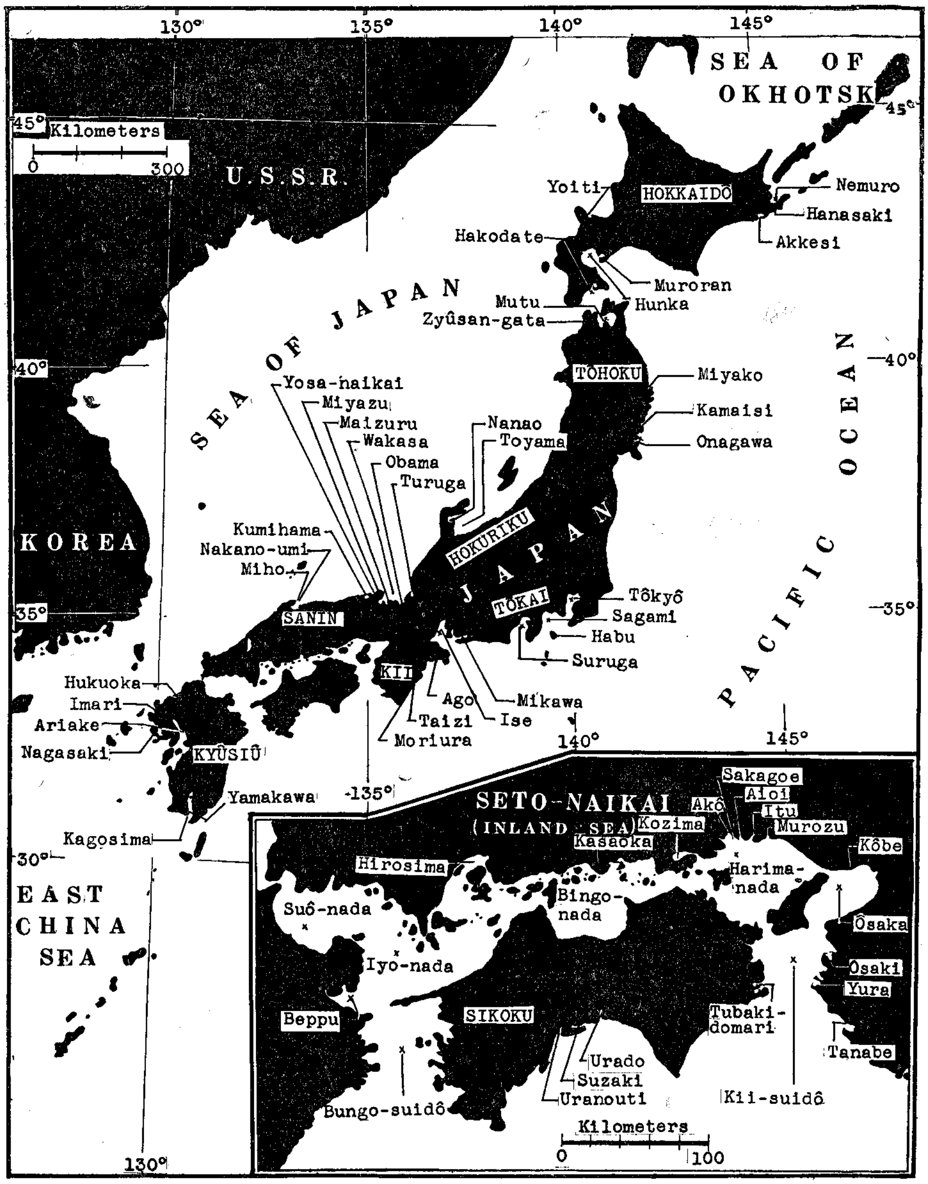


Fig. 1. Map showing the bays and inlets mentioned in this article.

also discussed by many authors (KOKUBO, 1931–1952; SHIMOMURA, 1953; KADO, 1954; ASAOKA, 1955). These works deal chiefly with phytoplankton, but very briefly with zooplankton, and consequently it is difficult to learn from these studies the general indication on the relative abundance of the whole plankton community and its seasonal changes. There are some foreign works which lasted over several years and clarified the seasonal succession of zooplankton. However, the results of these works cannot be compared with the present study, because they do not contain detailed distribution types of plankton within the inlets.

The planktological studies of inlet waters have hitherto been made by the writer (YAMAZI, 1950–1955) intended chiefly to make clear the distribution of plankton in relation to hydrological environments. In this paper, the writer will try to summarize the results of his studies on the plankton communities in Japanese inlet waters with special reference to their regional characteristics and the classification of inlets.

Table 1. Sources of biological and hydrological data quoted in the present study.

Names of Inlets	Location	Authors
Ago	Kii Peninsula	MIYADI (1941); MORISHIMA (1948 b, 1950); TOKIOKA *et al.* (1950 a, b)
Aioi	Inland Sea	KOBE MARINE OBSERVATORY (1935 a, 1937)
Akô	Inland Sea	KOBE MARINE OBSERVATORY (1935, 1937)
Akkesi	Hokkaidô	YAMAZI (1950); MORISHIMA (1955)
Ariake	W. of Kyûsyû	KOBE MARINE OBSERVATORY (1938 c, 1951)
Bungo-suidô	Inland Sea	KOBE MARINE OBSERVATORY (1951)
Habu Harbour	Tôkai Region	MASUI (1941)
Hakodate	Hokkaidô	HABE (1955); HAKODATE MARINE OBSERVATORY (1950); TANITA *et al.* (1950); YAMAZI (1951)
Hirosima	Inland Sea	KOBE MARINE OBSERVATORY (1930, 1936); UDA & WATANABE (1933); YAMAZI (1952)
Hukuoka	N. of Kyûsyû	AIKAWA (1930); MIYADI *et al.* (1942); KOBE MARINE OBSERVATORY (1942)
Hunka	Hokkaidô	KOBE MARINE OBSERVATORY (1934); MURORAN MUNICIPAL OFFICE (1950); TAMURA (1947, 1950); YAMAZI (unpubl.)
Imari	NW. of Kyûsyû	AIKAWA (1930); YAMAZI (1953 a)
Ise	Tôkai Region	KOBE MARINE OBSERVATORY (1933)
Itu	Inland Sea	KOBE MARINE OBSERVATORY (1935, 1937)
Zyûsangata	W. of Tôhoku Dist.	KOKUBO and SATO (1947)
Kagosima	S. of Kyûsyû	KOBE MARINE OBSERVATORY (1933); MIYADI & MASUI (1942); YAMAZI (unpubl.)
Kamaisi	E. of Tôhoku	YAMAZI (1953)
Kii-suidô	E. of Sikoku	KOBE MARINE OBSERVATORY (1930, 1938, 1951–1953)
Kôbe Harbour	Inland Sea	KOBE MARINE OBSERVATORY (1942)
Kozima	Inland Sea	YAMAZI (1954)
Kumihama	San'in District	MIYADI *et al.* (1948, 1950); TATIBANA (1952); YAMAZI (1954); YOSHIMURA (1938)

Names of Inlets	Location	Authors
Maizuru	San'in District	MIYADI *et al.* (1950, 1954); MORISHIMA (1950); YAMAZI (1953 a); FURUHASHI (unpubl.)
Mikawa	Tôkai Region	KOBE MARINE OBSERVATORY (1933 a)
Miho	San'in District	MIYADI *et al.* (1952, 1954)
Miyako	E. of Tôhoku	YAMAZI (1954 a)
Miyazu	San'in District	MAIZURU MARINE OBSERVATORY (1949); MIYAZAKI (1952); HABE & YAMAZI (1955); YAMAZI (1955 a)
Moriura	Kii Peninsula	YAMAZI & HORIBATA (1955 d)
Muroran	Hokkaido	HABE (1953); YAMAZI (MS)
Murozu	Inland Sea	KOBE MARINE OBSERVATORY (1935)
Nagasaki	W. of Kyûsyû	AIKAWA (1930); YAMAZI (1952)
Nakano-umi	San'in District	CHIBA (1948); KURASIGE & KITAMURA (1933); KOBE MARINE OBSERVATORY (1931 b); MIYADI & HABE (1945); MIYADI *et al.* (1952, 1954)
Nanao	Hokuriku Region	HABE (1952); MIYADI *et al.* (1942 c); SHIMOMURA (1953); YAMAZI (1952 d)
Nemuro	Hokkaido	YAMAZI (1950)
Obama	San'in District	HABE *et al.* (1945, 1946); MORISHIMA (1948); YAMAZI (1954)
Sagami	Tôkai Region	AIKAWA (1936); MARUMO *et al.* (1951); MARUMO (1951)
Sakagoe	Inland Sea	KOBE MARINE OBSERVATORY (1935 b)
Seto-naikai (Inland Sea)	Inland Sea	KOBE MARINE OBSERVATORY (1930 b, 1936 b, 1937, 1942, 1952); MURAKAMI (1954); MAEKAWA *et al.* (1953)
Suruga	Tôkai Region	KOBE MARINE OBSERVATORY (1939 a); AIKAWA (1936)
Suzaki	S. of Sikoku	UEDA (1950)
Taizi	Kii Peninsula	YAMAZI & HORIBATA (1955 d)
Tanabe	Kii Peninsula	YAMAZI(1955c & unpubl. data); MIYADI(1940–41)
Tôkyô	Tôkai Region	AIKAWA (1936); FUJIYA (1952); HANAOKA *et al.* (1947–1950, 1952); K. M. O. (1931); MASUI (1943); SIMAZU *et al.* (1948); SHIMOMURA (1953); FISHERIES AGENCY (1952 a, b); YAMAZI (1955 b)
Toyama	Hokuriku Region	KOBE MARINE OBSERVATORY (1938); AIKAWA (1936)
Tubaki-domari	E. of Sikoku	KOBE MARINE OBSERVATORY (1936, 1939)
Turuga	San'in District	YAMAZI (1954 d); KOBE MARINE OBSERVATORY (1939)
Urado	S. of Sikaku	UEDA (1950); MIYADI *et al.* (1944)
Uranouti	S. of Sikoku	MIYADI *et al.* (1944); UEDA (1949)
Wakasa	San'in District	MAIZURU MARINE OBSERVATORY (1949); MAÉDA (1952, 1953 a, b); MIYADI *et al.* (1947, 1949, 1952); MIYAIRI (1952); TATIBANA (1952); YAMAZI (1949); YOSHIMURA (1938)
Yoiti	Hokkaidô	ANRAKU (1953); YAMAZI (1951)
Yura	Kii Peninsula	HABE *et al.* (1945); YAMAZI (unpubl. data)
Yamakawa	S. of Kyûsyû	MIYADI *et al.* (1942); HABE (1943)

The author's grateful thanks are due to Prof. Dr. D. MIYADI, Dr. H. UTINOMI and Dr. T. TOKIOKA for their advices and encouragement as well as for their kindness in reading the manuscript. It should be recorded also that this series of investigations was much promoted by the financial aid of the Ministry of Education.

Some of the data about the plankton, benthos, nekton as well as the hydrological environments appearing in this series of reports were cited from the authors listed in Table 1. The locations of inlets mentioned in this paper are shown in Fig. 1.

I. Characteristics of Japanese Inlets

a. Characteristics of Inlet Waters

The complicate coastline of Japan presents a wide variety of environmental conditions, forming shallow and enclosed lagoons on one hand and bays with deep and wide entrances on the other hand. In these bays and inlet waters, the salinity ranges from brackish to oceanic concentration, and the temperature fluctuates from nearly freezing in winter, as on the coast of Hokkaidô, to 29°C or more in summer. The water of the inlets has many important characteristics common to all. Generally it is more variable regionally, seasonally and annually than the open sea water in such characters as transparency, water color, dissolved oxygen contents, hydrogen ion concentration, amount of phosphates and silicates, catalytic activity of sea water, tidal range, degree of stagnancy, salinity and temperature.

Along the coast of the Japan Sea, there are many lagoons isolated from the open sea by sand-bars. The hydrological conditions of these lagoons are more or less peculiar or abnormal as biological environments, e.g. the basin is somewhat deeper than the threshold between the open sea and often holds an azoic zone near its bottom, especially distinctly in the summer season. The summer stagnation is very stable, because the much diluted and heated surface water prevents the vertical circulation, though the degree of stability varies in different inlets or in the different portions of the same lagoon. MIYADI and HABE (1954) classified such disharmonic inlets chiefly on the basis of the "thriving" or "nonthriving" of some indicator animal species, viz. (1) permanent azoic, (2) summer azoic and (3) slightly disharmonic types. The lakes of Hiruga and Suigetu on the Japan Sea coast belong to type 1, the lagoons of Kumihama, Yosanai-kai and Nakano-umi are of type 2. The type 3 is represented by the inner regions of many inlets, e.g. the innermost regions of many inlets near large cities or of lagoons. The deposits of these inlets are often jet black in color and smell of intolerable odour of hydrogen sulphide (YOSHIMURA, 1938, MIYADI *et al.*, 1950; YAMAZI, 1954).

The deepest bays of Japan are Sagami, Suruga and Toyama bays, each having a basin with a depth of about 1500 meters and characterized by the poor development of coastal indentations and the littoral zone. To the bays with basins deeper than 50 meters belong such large ones as Hunka, Aomori, Wakasa and Kagosima as well as main basins of the Inland Sea (Seto Naikai). Most of the shallow inlets less than 50 meters deep, such as the bays of Tôkyô, Ariake, Ise, Ôsaka, Hirosima and other many small bays or inlets, are characterized by the well development of the beach. Inlets of the last category may be met with most commonly in our country.

The size of Japanese inlets is generally small. Even the largest ones, Iyo-nada and Harima-nada of the Inland Sea, are about 3500 Km^2 in extent. The area of other larger bays is shown in YOSHIMURA's paper (1934).

The bottom texture differs widely in different bays and their different parts. Near the mouth or in the channel where the current is vigorous, the bottom is covered chiefly with gravels, sand and shell fragments. On the contrary, in the inner region where the current is weak, the bottom consists of mud. The innermost region of many bays near cities, and the deeper basin of enclosed lagoons or caldera bays sometimes hold black deposits.

Before going further into the plankton distribution, it may be of some use to give here short sketches of some hydrological characteristics of our inlet waters.

Salinity: Salinity is the best indicator to determine the mixing degree of the sea-water with the fresh-water. And ecologically, the salinity is an important factor limiting the distribution of most plankters and keeping the characteristic inlet plankton community. Generally a fairly clear salinity gradients both horizontally and vertically are observable in most inlet waters, especially markedly in the rainy season from spring to autumn. In some inlets, however, the salinity gradient may be obliterated almost completely in the winter season. In the inlets along the Pacific coast, where the tidal influence is very strong, the vertical stratification of salinity is relatively smaller than that in those along the Japan Sea coast, where the vertical tidal mixing is slight. In the latter inlets, the summer stratification may often persist till winter.

Temperature: The daily and annual cycles of the surface temperature follow rather closely those of the atmospheric temperature at the same location (YAMAZI, 1955 c and d). The studied inlets are located under the influence of either the Kurosio or the Oyasio current area (Fig. 1), i.e. between 31°N (Kyûsyû) and 43°N (Hokkaidô). The average monthly temperature in the south, for example, ranges from about 15°C to 29°C in Kurosio current area, and in the north from about 1°C to 20°C in the Oyasio current area.

Generally the summer surface temperature is the lowest at the mouth part of the inlets and increases towards the inner region, and it is reverse in the case of the winter season. Although the vertical difference of some degrees may be generally observable in the innermost region, it is less pronounced in most of the inlets along the Pacific coast than in those along the Japan Sea, where the thermal stratification is more defined. The high temperature and the low salinity due to the inflows of land drainage caused by heavy rainfalls are the chief characteristics of the summer environment.

Transparency and water color: Both transparency by SECCHI's disc and water color by FOREL's scale differ in different parts of inlets; the water is generally less transparent and yellowish in color in the inner region, because of the inflow of the land drainage carrying sewage and debris of various sources as well as rich plankton growth. The highest transparency, about 40 meters, was measured in Toyama Bay, where of course the color is bluish.

Dissolved oxygen: The amount of dissolved oxygen is strongly influenced by biological processes. The surface water of the area from the middle region, which is occupied by *Oithona—Paracalanus* community with rich diatoms, to the mouth of bay, where the water is turbulent, is almost supersaturated with oxygen. On the other hand, the oxygen is generally in subsaturation in the innermost region with *Acartia —Oithona nana* community, due probably to the increase of organic matter in the water. In some enclosed inlets, the oxygen demand by organic matters is so high in summer that almost complete absence of oxygen may be observed in the bottom layer.

Hydrogen ion concentration: Usually the horizontal distribution of pH accords well with that of the dissolved oxygen, being higher in the outer region of inlets and lower in the innermost or estuarine regions. The bottom water generally keeps lower pH; this fact is associated with less contents of oxygen, especially distinctly in summer.

Phosphate: The inflow from the mountain region contributes only a small amount of phosphate, while that from the field or cities brings a large quantity of phosphate. The phosphate content is in general higher in the inner region of the inlet than in the outer region, and especially high in strongly stagnant water of enclosed inlets.

Silicate: The silicate content of the inlet water is generally higher than that of of the open sea water. The amount of silicate is a good indicator of the land drainage as well as the salinity and catalytic activity. Actually these three characters are closely related with one another both vertically and horizontally. In deeper layers the amount of silicate is usually small and almost invariable both regionally and seasonally.

Catalytic activity of sea water: The catalytic activity of sea water, which is expressed by the reaction velocity of decomposing hydrogen peroxide, is usually lower in the inner region than in the outer region of inlets; the lower values are generally associated with the larger amount of land drainage. Vertically the values in the surface and bottom layers are lower than those in the middle layer.

b. Quantity of Plankton

The settling volume, number and composition of plankton vary from the inner to the outer part of inlet, because each plankter has its favourable hydrological and topographical conditions. The volume is usually far larger in the middle region than in the innermost or the outer region of inlet. The population of zooplankters, especially of copepods, increases towards the inner region, being the densest in the innermost region. On the contrary, the numbers of phytoplankters, especially diatoms, are fewer in the innermost region than in outer region, and richest in the middle region where the open sea water and the inlet water rich in nutritive elements are mixed together. The differences of hydrological environments, such as the water movement, salinity and temperature, cause directly or indirectly the local variation in the distribution of inlet plankton.

c. Composition of Plankton

Among the inlet zooplankton, copepods are always the most predominant constituent, though some other animals may sometimes occur in a considerable amount. Larvae of bottom animals, cladocerans, tintinnids and pelagic tunicates are important next to copepods, and chaetognaths, medusae and ostracods occur less numerously or occasionally (Plates XVI–XXIII).

Some of the copepods occur in a considerable number regularly at a certain region and in a definite season. The following species are more important ones because they show typical distribution in the inlet: i.e. *Sinocalanus tenellus*, *Pseudodiaptomus inopinus*, *Acartia clausi*, *A. spinicauda*, *Oithona nana*, *O. rigida*, *Paracalanus parvus* minor form, *Oithona similis*, *Microsetella rosea*, *M. norvegica*, *Centropages* sp., *Temora* sp., *Euterpe acutifrons*, *Oncaea media*, *O. venusta*, *Corycaeus* spp., and some oceanic copepods. The occurrence of *Sinocalanus* and *Pseudodiaptomus* is restricted to estuary or brackish water area of enclosed inlets, where the typical marine copepods are scarce, for instances, the innermost regions of the bays of Kozima, Kumihama and Nakano-umi. The community composed of these two forms is replaced by that of *Acartia* and *Oithona nana* in the adjacent region. *Acartia clausi* and *A. spinicauda* are found in the innermost area, where the water is not so brackish as in the area mentioned above, and decrease steadily towards the outer area of the inlet. These two Acartians are found in same areas but in different seasons. The main area of distribution of *Oithona nana* is the inner region of the inlet, although it may be seen throughout the whole area of the inlet. The minor type of *Paracalanus parvus*, too, occurs more abundantly in the inner and middle regions than in the outer region. *Oithona similis* and *Microsetella* spp. are more important in the outer part than in the inner part of the inlet. *Oncaea* spp., *Corycaeus* spp. and other neritic and oceanic copepods are the inhabitants of the outermost region of the inlet.

Cladocerans of bays are represented by *Penilia schmackeri*, *Evadne tergestina* and *Podon* sp. They are most abundant in the inner and middle parts during the season from early summer to autumn. The inlet chaetognaths *Sagitta delicata*, *S. crassa* and its forma *naikaiensis* occur most abundantly in the inner region from spring to autumn. A pelagic tunicate, *Oikopleura dioica*, is found commonly in the inner region from early summer to early autumn. Tintinnids such as *Tintinnopsis radix*, *Tintinnopsis beroidea*, *Favella taraikaensis*, *Favella ehrenbergii* and *Helicostomella longa* are found in the inner region.

The occurrence of many larval forms of benthic animals such as Echinodermata, Polychaeta, Mollusca, Cirripedia, etc. is one of the characteristic features of the inlet plankton. They appear numerously during spring and summer, although they may be found all the year round.

Doliolums, salpas, oceanic copelates, chaetognaths, and other animals and plants occur chiefly in the outer region of the inlet, where the components of plankton differ widely from those of the inner region.

d. Ecological Notes of Some Indicator Copepods

Acartia clausi GIESBRECHT

Acartia clausi is a littoral copepod widely distributed from estuarine to somewhat sheltered waters close to the land (BIGELOW, 1926; DEEVEY, 1946; WELLS, 1938; WIBORG, 1940; WILSON, 1932 a, b). In the inlet of Taizi near our laboratory, this species occurs from January to June, the maximum occurrence being in the spring season from April to May, and disappearing when the temperature rises above 25°C or so (YAMAZI and HORIBATA, 1955 d). It is the most important copepod in the innermost part of inlets on our coast (YAMAZI, 1951–1955), and may be regarded as a littoral or brackish water form being capable of surviving in waters of various salinities, as low as about 10‰. The water temperature seems to control the occurrence of this species in the inlet. In Taizi bay, the temperature was 13°C and the salinity was about 30‰ in January. In June, the former rose up to 23°–25°C and the latter ranged between 23 and 31‰. It is evident that *Acartia clausi* stands a wide range of temperature and salinity as indicated in my previous papers, although temperature higher than 25°C gives a deliterious effect on this plankton, thus the species disappears completely or is reduced to a very small number in hot summer. *Acartia clausi* is considered to have only one generation in a year and its developmental period is relatively long. The slow development of this species has already been described by DEEVEY (1948). I am not sure whether a small number of this copepod survives under adversity. However, the prosperity of *A. clausi* in spring was replaced by that of *A. spinicauda* in summer. This alternation of copepod fauna was observed in two successive years, and it may be considered as a regular successional phenomenon to be observed in the inlets on the Pacific coast, or at least near Kii Peninsula.

Acartia spinicauda GIESBRECHT

Acartia spinicauda is abundant in the warmer seasons from summer to autumn, occurring in the innermost parts of inlets. It begins to appear when the temperature rises beyond 25°C and continues to thrive till it falls below 20°C. This is a littoral and brackish water form being capable of surviving in waters of relatively low salinity (YAMAZI, 1951–1955). KOKUBO *et al.* (1947) found this species in a brackish inlet, Zyûsan-gata in Tôhoku District. In Kozima Bay, it was found in the water with the salinity of as low as 12‰ and above 30‰, and the maximum occurrence was from August to October, decreasing in November and December. As is shown above, this species differs strikingly from *Acartia clausi* in its seasonal occurrence, though their distribution in the inlet is quite similar. The variation of salinity in a wide range do not act effectively on its distribution. *A. spinicauda* seems to be more euryhaline and warm stenothermal than *Acartia clausi*. The observed range was from 20°C to 30°C.

Oithona nana GIESBRECHT

Oithona nana is a small copepod and represents the most abundant and important crustacean in our inlets. Its large stock always contains nauplii and copepodids, besides adults. Although this species is found numerously throughout the year, the number rises sharply during the period from summer to winter. The density of the stock varies from area to area in the inlet. Although it may be found sparsely in the open sea waters close to the land and with higher salinity, it is more common in inlet or estuarine waters of lower salinity. As a whole, its center of distribution is in strongly stagnant water, where *Acartia clausi* and *A. spinicauda* occur, too. LOHMANN (1908) reported the occurrence of this species in the area of low salinity of Kiel Bay and WIBORG (1940) found it in Oslo Fjord in the period from June to February. FARRAN (1911) found it to be common in the coastal waters of the North Sea and the English Channel. The maturation seems to come very rapidly in this species under favourable conditions. TESCH (1915) found that this species had a life cycle of 6–7 weeks along the Dutch coast of the North Sea. MURPHY (1923) pointed out that under experimental conditions, this species had a life cycle of ten weeks.

Oithona rigida GIESBRECHT

Judging from the records of Taizi and Tanabe Bay (YAMAZI, 1955 c; YAMAZI and HORIBATA, 1955 d), this species seems to be an inlet or coastal form. It occurred in the season from late August to December, and began to increase in September to attain the maximum during the period from October to November. Its dense population was found in the inner area rather than in the outer part of the inlet. Thus, this species may take the place of *Oithona nana* during the period when the salinity becomes too high for the latter species.

Paracalanus parvus (CLAUS)

This species is a cosmopolitan. It has been recorded from the tropical and temperate regions of European waters (WIBORG, 1940) and from the tropical and subtropical waters in the west Pacific (MORI, 1937). In Japanese waters two distinct morphological (TANAKA, MS) and ecological types are distidguished in this species, one is the minor form which thrives in inlet waters and the other is the major form found in outer regions of inlets or in neritic coastal waters (YAMAZI, 1955 c and d; FURUHASI, MS).

The minor form thrives mostly in early summer and autumn, especially remarkably at the inner area of the bay, although it may be found everywhere all the year round (YAMAZI, 1951–1955). In Taizi Bay it occurs in the outer part throughout the year, but most numerously in the summer season. In the bays of Tanabe and Moriura the center of dense population of this species lies in the outer area rather than in the inner part. Thus this species is rather euryhaline; its large population is, however, generally found in more saline areas than in cases of *Acartia* and *Oithona nana.* It seems to tolerate the embaymental environments better than *Oithona similis* does.

Microsetella spp.

Microsetella is one of the common species occurring in the border area between the inlet and the open sea waters, for instance, in the central parts of Tôkyô Bay (YAMAZI, 1955 b) and Hirosima Bay (YAMAZI, 1952 c), where it was found more numerously than in the outer part near the mouth. Although it was found all the year round, the highest density was attained in the summer and autumn (YAMAZI, 1955 d), and the lowest value was found during the season from late spring to early summer. This species is eurythermal, but relatively stenohaline on the Pacific coast, as shown by the fact that it has not been found in abundance or is quite absent in the water of lower salinities, which holds large populations of *Acartia*, *Oithona nana* and *Paracalanus.* Although this species is distributed widely in the oceanic water, its abundant occurrence is restricted to the coastal or inlet waters. *Microsetella rosea* (DANA) is a common warm water form and *Microsetella norvegica* (BOECK) is adapted somewhat to lower temperature than *Microsetella rosea.*

Euterpe acutifrons (DANA)

This species is a neritic and tropical-subtropical form occurring both in the inlets, even in their inner regions, and in the open sea. It is strongly euryhaline and eurythermal; it was found throughout the year in surveyed inlets but the population was always relatively small.

Oithona similis CLAUS

Oithona similis is found in relatively large numbers in the coastal waters or in the outer part of the bay, where this copepod occupies higher percentage of plankton animals than in the inner region. In inlets, a relatively large population occurs during the period from winter to early summer. In general it disappears in the inner region of various inlets, where *Acartia* and *Oithona nana* communities are found. In the northern Atlantic, *Oithona similis* occurs in abundance in inlets for the greater part of the year (WILSON, 1932; WIBORG, 1940; DIGBY, 1950; DEEVEY, 1952; FISH, 1936; MARSHALL, 1949), and repeats the spawning three or four times a year. It may become adult within two months in favourable conditions. This species is more stenohaline than the preceding species *E. acutifrons*, being never recorded in abundance in the innermost parts with lower salinities. Thus it is considered as a coastal form with a fairly narrow salinity tolerance; the emergence of this species in the inlet is usually attributable to the inflow of the open sea water.

Oncaea spp.

Oncaea occurs sporadically in inlets and is more stenohaline than *Microsetella* and *Oithona similis*. It is distributed widely in the oceanic water, but is more abundant near the coast than in offshore waters. Although it is found all the year round in Japanese waters, it thrives more in summer and autumn. *Oncaea media* GIESBRECHT and *Oncaea venusta* PHILIPPI are the common members of the genus, of which the former is more numerous than the latter. They are carried into the inlets by the inflow of the offshore waters and increase there while the salinity is kept high, but never occur in abundance in the water of low salinity.

Corycaeus spp.

Corycaeus spp. may occupy a higher percentage in total copepods at the entrance of some inlets than any other forms. They are stenohaline and inhabit in the oceanic as well as the coastal water. Usually they are very scarce in inlets throughout the year, excepting occasional appearance in quantity. The abundant occurrence is usually restricted to summer and autumn seasons.

Other Copepods

Other inlet copepods may be grouped as follows: (1) local stock confined chiefly in the inlet and (2) the copepods derived from the open sea or brackish water stocks (YAMAZI, 1955 d). The warm oceanic species are carried into the inlet by currents derived from Kurosio on the Pacific coast or from Tusima Current on the Japan Sea coast. They are numerous in the summer and autumn seasons when the oceanic influx is strong. The cold water species of the inlets originate from the Oyasio on the eastern coast of Hokkaidô and from the Liman Current on the western coast of Hokkaidô during the cold season. The stray copepods from the brackish waters are represented by two important species *Sinocalanus tenellus* KIKUCHI and *Pseudodiaptomus inopinus* BRUCKHARDT; they were found in the innermost region of bays of Kozima, Kumihama and Nakano-umi (YAMAZI, 1954 e).

All the copepods mentioned in this paragraph are quantitatively insignificant in the inlet waters.

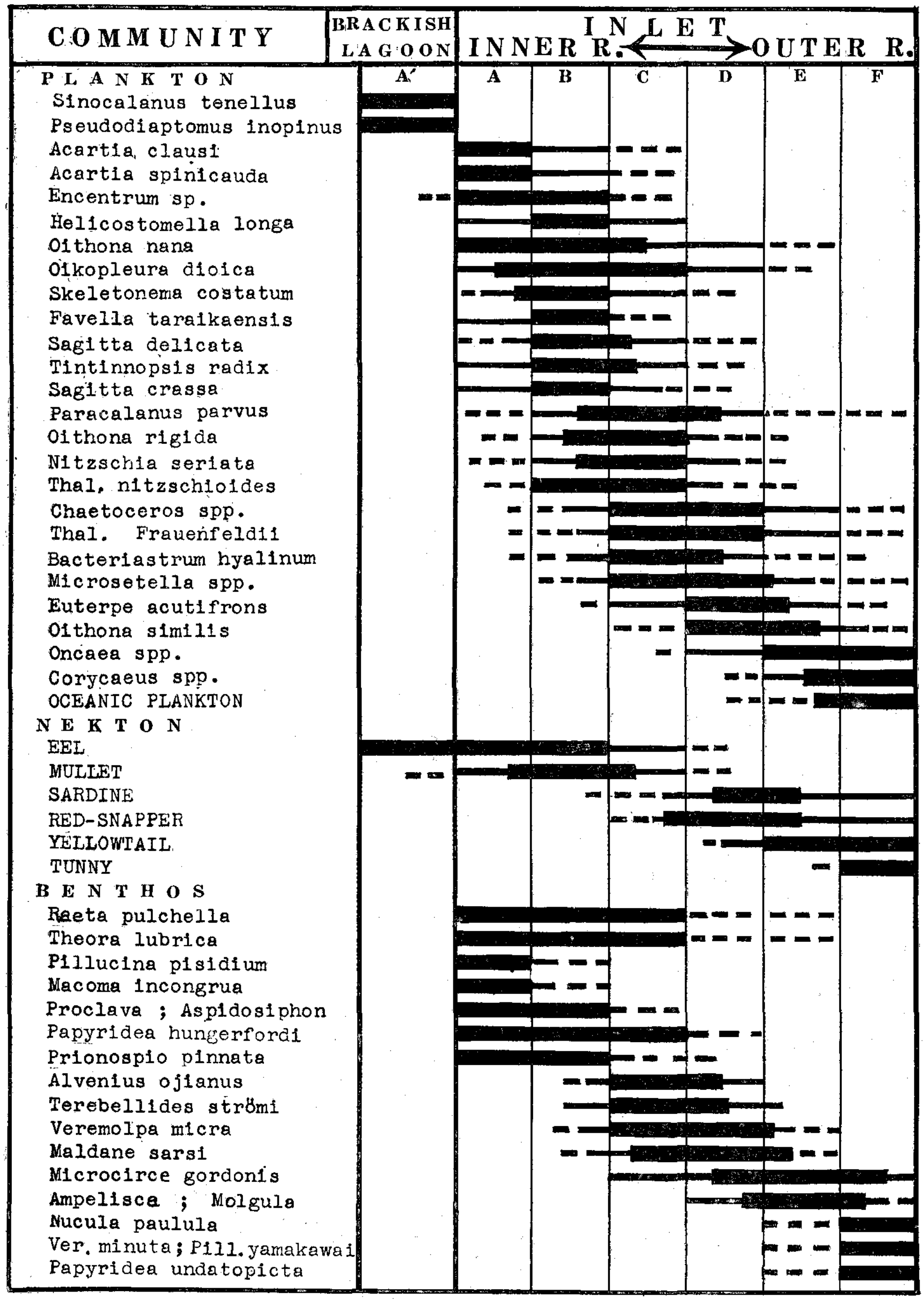
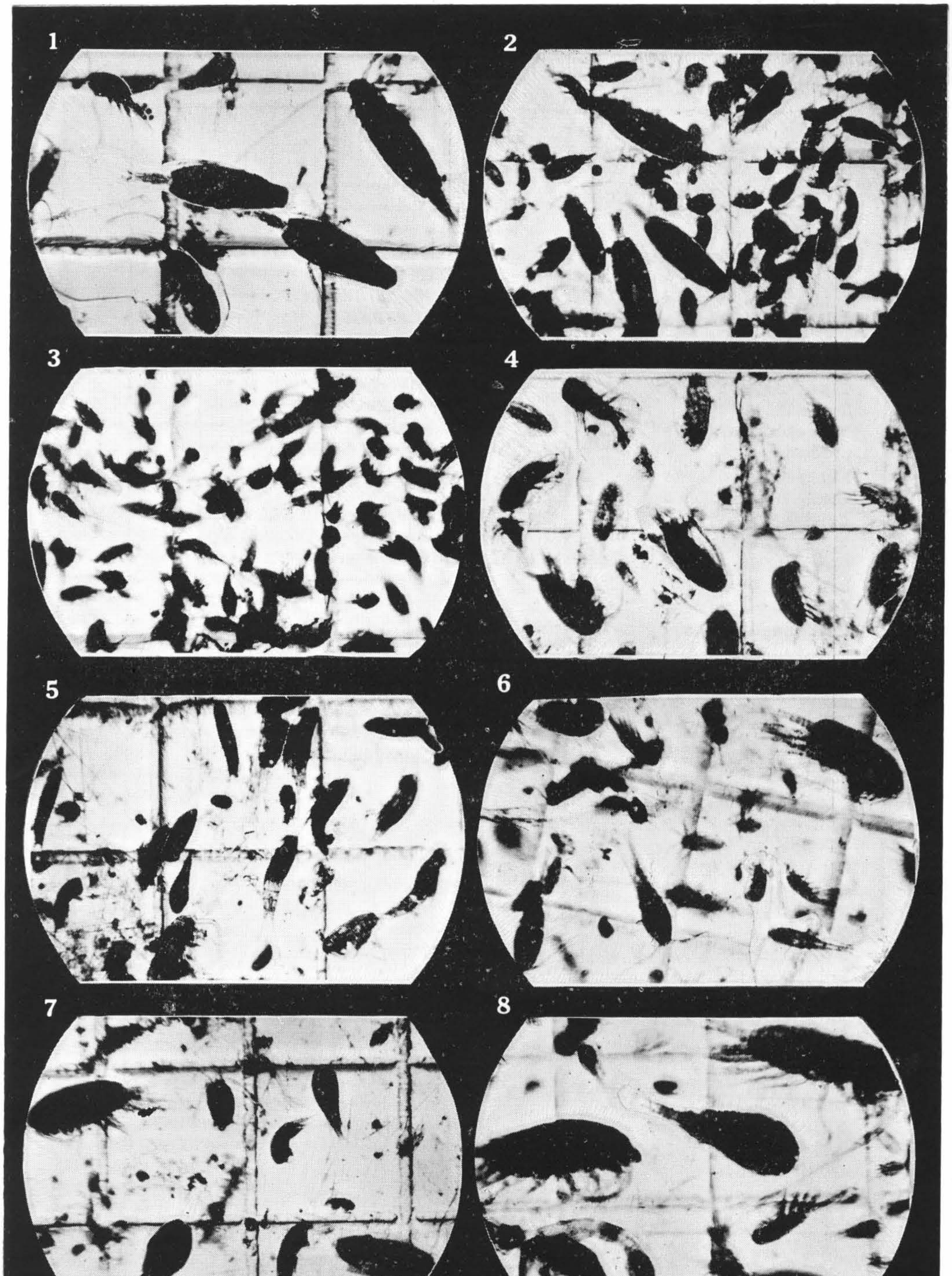


Fig. 2. Distribution of important inlet water organisms.


1
2
3
4
5
6
7
8
1 mm

II. Important Plankton Communities and their Distribution in the Inlet

Although the constituent species of inlet plankton are nearly the same in all inlets of our country, different areas of inlets with different salinities keep their own characteristic plankton communities. Being based upon the results of my previous investigations, the plankton in Japanese inlets may be classified ecologically into the following communities (in each community copepods occupied more than 50% of the total number of zooplankton) and their fasciations (Fig. 2 and Plates XVI–XXIII).

A scheme of the regional distribution of these communities and the relation between them and the hydrological environments are shown respectively in Fig. 3 and Table 2.

***Acartia* community:** This community occupies the innermost region of inlets, adjacent to the brackish water area or the estuary. *Acartia* community (which is dominated with *A. clausi* from spring to early summer and with *A. spinicauda* from summer to autumn) is associated usually with *Oithona nana* and *Paracalanus parvus*, and may be subdivided into fasciations according to the relative abundance of these associates. Other associates are *Sagitta delicata*, *S. crassa*, *S. crassa* f. *naikaiensis*, *Oikopleura dioica* and a small number of brackish water copepods *Sinocalanus tenellus* and *Pseudodiaptomus inopinus*. In the area of this community the animal productivity is relatively high, but the plant productivity is much lower than that in outer areas.

The water is highly stagnant, often yellowish brown in color and of a very small transparency. Both the salinity and catalytic activity of sea water are the lowest here than in the rest of the inlet. Important animals of this area are *Theora lubrica*, *Raeta pulchella*, *Brachidontes senhausia*, *Macoma incongrus*, *Fulvia hungerfordi*, *Pillucina*, *Paphia* and shrimps among the benthos, and eel (*Anguilla japonica*) and mullet (*Mugil cephalus*) among fishes. All these animals are characteristic forms of the area of strongly stagnant water.

***Oithona nana* community:** The population of this community is very dense. It borders with the *Acartia* community along its outer side. It is associated with *Acartia clausi* (from spring to early summer) or *Acartia spinicauda* (from summer

---

Fig. 3. Microphotographic representation of various plankton communities in inlet waters.

1. *Acartia* community, associated with *Oithona nana* and *Paracalanus parvus* (minor form).
2. *Oithona nana* community, associated with *Acartia spinicauda*.
3. *Oithona nana* community, associated with its nauplii.
4. *Paracalanus parvus* minor form community, associated with *Oithna nana*.
5. *Microsetella* community, associated with *Paracalanus parvus* (minor form) and copepod nauplii.
6. *Oithona similis* community, associated with *Oithona nana*, *Microsetella*, *Paracalanus parvus* (major form) and copepod nauplii.
7. *Oncaea* community, associated with *Paracalanus parvus* (major form), *Oithona similis* and copepod nauplii.
8. Oceanic copepod community.

to autumn), a large number of larval forms, especially copepod nauplii, *Sagitta crassa* f. *naikaiensis* (in summer), *Sagitta crassa* (in winter), *S. delicata, Oikopleura dioica, Tintinnopsis radix, Favella taraikaensis, Helicostomella longa*, and diatoms such as *Skeletonema costatum, Nitzschia seriata, Leptocylindrus danicus, Thalassiothrix Frauenfeldii* and *Chaetoceros* spp. In the intermixing area along its outer region, it is associated with *Paracalanus parvus* and *Oithona similis*. This community is very stable throughout the year as compared with other communities situated more outward. The plankton productivity of the area occupied by this community is very large, although the constituents of this association are somewhat less than those of other communities of outer parts of the inlet. This community may become more monotonous in its composition in the inner region of some lagoons on the coast of Japan Sea or in some secondary baylets in the Inland Sea.

The water holding this community is characterized by high stagnancy, yellowish brown color, small transparency, lower salinities, lower content of phosphates and silicates than in outer areas. Low values of pH and catalytic activity of sea water and the subsaturation of dissolved oxygen are also observed in this part. The benthic animals in this area are *Theora lubrica, Raeta pulchella, Brachidontes senhausia, Macoma incongrua, Fulvia hungerfordi, Pillucina* and *Paphia*, and the nekton is represented by mullet.

***Paracalanus* community:** This community occupies the outer side of the *Oithona nana* community, and borders with *Oithona similis* (or *O. similis* with *Microsetella*) community in its outer part. Other associates are *Euterpe acutifrons, Sagitta delicata, Sagitta crassa, Oikopleura dioica, Encentrum* sp., and diatoms such as *Chaetoceros* spp., *Bacteriastrum hyalinum, Thalassiothrix Frauenfeldii* and *Thalassionema nitzschioides*. The area holding this community can be regarded as an intermixing zone between the inner and outer communities of the inlet. The plankton productivity is the highest and the number of constituents of the community is the largest here throughout the inlet. The water shows higher transparency and salinity, lower water color, less phosphates and silicates, and higher catalytic activity of sea water than in the inner areas. The benthos of the area occupied by this community is characterized by such mollusks as *Alvenius ojianus* and *Veremolpa micra* and the nekton is represented by sardines (*Amblygaster melmosticta, Engraulis japonica* and *Etrumeus micropus*), red-snappers (*Pagrosomus major* and *Evynnis japonica*) and mullet.

***Oithona similis* community:** The representative copepod of the community of the area outer than those mentioned above is *Oithona similis*. The other members are *Paracalanus parvus, Microsetella, Oncaea, Corycaeus*, oceanic copepods and other pelagic animals and plants. The plankton productivity is small here. The water is more saline and transparent than in the preceding areas, but the water color is lower than that of the more outer areas of the bay. Among important associated benthos are such mollusks as *Alvenius ojianus, Veremolpa micra, Nucula paulula, Microcirce*

Table 2. Hydrological characteristics in different areas of the inlet.

Inner Area	Middle Area	Outer Area
Strong Embaymental Conditions	Middle Embaymental Conditions	Weak Embaymental Conditions
(1) Hydrological conditions, especially the salinity, are affected seriously by fresh-water discharge and vary in a wide range.	(1) Temperature and salinity vary greatly according to seasons, but their average values are not much different from those in the outer region.	(1) Hydrological conditions, especially, salinity, temperature, catalytic activity, amount of silicates and other nutrient salts are all subjected to the seasonal cycle prevalent in the adjacent open sea.
(2) Salinity shows the maximum vertical variation.	(2) Vertical variation of salinity is slight.	(2) Nearly constant salinity.
(3) Quite independent from direct influences of the open sea.	(3) Slightly affected by the direct influences of open sea.	(3) Vigorous oceanic influences.
(4) Shallow water.	(4) Relatively shallow water.	(4) Deep water.
(5) Least oxygen contents.	(5) Maximum oxygen contents.	(5) Moderate oxygen contents.
(6) Lowest transparency.	(6) Relatively high transparency.	(6) Highest transparency.
(7) Yellowish brown water.	(7) Yellowish green water.	(7) Bluish water.
(8) Large amount of silicates (SiO_2) and phosphates (P_2O_5).	(8) Moderate content of SiO_2 and P_2O_5.	(8) Lowest contents of SiO_2 and P_2O_5.
(9) Lowest value of catalytic activity of sea water.	(9) Relatively high catalytic activity.	(9) Highest catalytic activity.
(10) Strong stagnancy of water.	(10) Medium stagnancy.	(10) Weak stagnancy.

gordonis, and *Pillucina yamakawai*, and among nekton are sardine, red-snapper and yellowtail (*Seriola quinqueradiata*).

***Microsetella* community:** In the middle to the outer region of the bay, where the stagnant water of the inner part and the oceanic water are mixed with each other, an outbreak of abundant *Microsetella* may be observed occasionally. This community is accompanied by *Oithona nana*, *Paracalanus parvus*, *Oithona similis*, *Oncaea* spp., *Oikopleura dioica* and often by a dense mass of diatoms consisting of *Chaetoceros* spp., *Thalassiothrix*, *Thalassionema*, etc.

***Oncaea* and *Corycaeus* community:** The area exterior to the areas occupied by preceding communities is characterized by abundant occurrence of these species. This community is accompanied by variable amounts of *Paracalanus parvus*, *Oithona nana*, *Oithona similis*, oceanic copepods and other animals and plants. Here, the plankton productivity is small, because the water is less stable and the water movement is rapid. The main benthos found in this area are *Nucula paulula*, *Microcirce gordonis*, *Veremolpa minuta*, *Papyridea undatopicta*, *Pillucina yamakawai* and *Veremolpa micra* and the important nektons are sardine, red-snapper and yellowtail.

Oceanic community: The outermost area of the inlets is occupied chiefly by oceanic animals, diatoms, dinoflagellates and less numerously by some neritic forms. The plankton productivity is very small. The water is very turbulent and characterized by high salinity, high catalytic activity of sea water and low transparency in comparison with those of the inner areas. The water color is bluish, and silicates and phosphate contents are small. The chief associated molluscs are *Nucula paulula*, *Microcirce gordonis*, *Veremolpa minuta*, *Papyridea undatopicta* and *Pillucina yamakawai*, and among nektons are yellowtail, tunny, bonito, etc.

III. Characteristics of Plankton Communities of Japanese Inlets with References to Hydrological Conditions

The biological characteristic of an inlet is closely related with the topographical and hydrographical characteristics. And reversely, the biological characteristics of an inlet are the indicators of the topographical and hydrographical characteristics of the bay. My idea is that the biological characteristics of inlets may be represented by various combinations of plankton communities, which are denominated after some dominant copepods. As indicator copepods were selected common species which occurred widely either in inlet or in the open sea along the coast of Japan. Among such copepods there were some which appeared regularly throughout the year quite indifferently to the environmental conditions, and other which showed regular seasonal succession. Besides copepods, such animals as *Sagitta*, *Oikopleura*, Cladocera, Rotifera, tintinnid ciliates (*Tintinnopsis*, *Favella*, *Helicostomella*) and larvae of invertebrates, and such plants as various diatoms and dinoflagellates are also useful as complementary indicators of regional characteristics of the inlets. In the following I wish to describe some characteristic combinations (Table 3 and Fig. 4).

Table 3. Combination types of the plankton communities.

	A. clausi or *spinicauda* Community	*O. nana* Community	*P. parvus* Community	*O. similis* or *O. similis* with *Microsetella* Community	*Oncaea* and *Corycaeus* Community	Oceanic copepod Community	Combination types
	A	B	C	D (or D′)	E	F	
More Oceanic ↑ ↓ Stronger Embayment	A	B					A—B
	A	B	C				A—B—C
	A	B	C	D			A—B—C—D
	A	B	C	D (or D′)	E		A—B—C—D (or D′)—E
	A	B	C	D (or D′)	E	F	A—B—C—D (or D′)—E—F
			C	D (or D′)	E	F	C—D (or D′)—E—F
	More Oceanic ——→ ←—— Stronger Embayment						

1. *Acartia—Oithona nana* (**A—B**) type

Most of the secondary baylets of large inlets, many lagoons on the Japan Sea coast, the inlets having narrow mouths, and shallow estuarine regions near the inner parts belong to this type. These areas are occupied by *Acartia* community consisting of *Acartia clausi* (from winter to early summer) and *A. spinicauda* (from summer to autumn) as well as *Oithona nana* (all the year round) community. *Oithona similis* seldom appears there, except a few individuals which originate from more exterior waters. Occasionally a small number of brackish water copepods, *Sinocalanus tenellus* and *Pseudodiaptomu insopinus,* join these communities. Such inlets having communities dominated by *Acartia* and *Oithona* may be called as A—B type. The inlets of this type are more numerous on the Japan Sea coast than on the Pacific coast. The water belonging to this type are characterized by low transparency, low salinity, low dissolved oxygen content, low catalytic activity of sea water, rich silicates and nutrient salts and high stagnation of water in comparison with that of other types. Even the complete disappearance of oxygen during long summer season may be observed in deeper layer of strongly embayed inlets, where *Oithona* often makes a monotonous community in the upper layer. In the summer season *Paracalanus parvus* is found associated with *Oithona nana* community, as observed in the outer part of Kumihama Bay and Yosa-naikai. In such disharmonic inlets, diatoms, especially *Chaetoceros,* occur only sporadically, although the nutrient salts are very rich. Zyûsan-gata on the Japan Sea coast and the secondary baylets of the Inland Sea may also be classified in this type, although the latter assumes different aspects during the summer season.

2. *Acartia—O. nana—Paracalanus* (**A—B—C**) type

In the inlets of this type, *Acartia* and *Oithona nana* communities occur in the inner region, while in the outer region the minor form of *Paracalanus parvus* and *O. nana* are found numerously. Besides the following characteristic associates, there occur a large number of larval forms, especially copepod nauplii and pelecypod veligers: viz. chaetognaths *Sagitta delicata, S. crassa* and its forma *naikaiensis*, pelagic tunicate *Oikopleura dioica* and rich diatoms such as *Skeletonema costatum, Leptocylindrus danicus, Nitzschia seriata, Thalassionema, Thalassiothrix, Chaetoceros* and *Bacteriastrum.* Among all the population of plankton *Oithona nana* is the densest. The water is rich in nutrients, and the phytoplankton flourishes occasionally under favourable condition. The region of lower salinity at the innermost part sometimes keeps a small number of brackish water copepods such as *Sinocalanus* and *Pseudodiaptomus.*

The water of this type is characterized by high stagnancy, yellowish brown color, small transparency, low salinity, high contents of phosphates and silicates, and low pH. The dissolved oxygen is in subsaturation. Similar environments are seen in some secondary inlets of the Inland Sea (the baylets of Matunaga, Akô, Aioi, Sakagoe, Itu, Murozu, Kasaoka and Kôbe Harbour), the western baylet of Nanao, and the bays of Uranouti, Urado, Obama, Ôsaki, etc. Lagoons of Nakano-umi and Kumihama may also belong to this type, although the oxygen content near the bottom decreases remarkably or disappears in summer. Prodigious outbreak of diatoms is seen in some favourable seasons.

The inlets of this type are not always defined by the topographical or hydrological characteristics. There are also some inlets which show intermediate characteristics between A—B—C type and A—B type at some regions and in some seasons.

3. *Acartia—O. nana—Paracalanus—O. similis* (**A—B—C—D**) type

Acartia clausi (or *spinicauda*), *O. nana, Paracalanus* and *O. similis* communities are arranged in this order from the inner to the outer part of the inlet. This combination type of plankton communities is found in large inlets which are connected with the open sea through relatively small entrances or in some secondary baylets of large bays. It is seldom found in small inlets with wide mouth or in bays with large tidal range. The above mentioned circumstance is found more often on the Japan Sea coast, where the tidal range is very small and the water movement is comparatively weaker than on the Pacific coast. The bays of Maizuru, Miho, Akkesi, Nemuro, Muroran and Tubaki-domari are examples of this type.

In the inlets of this type nutrient salts are rich in the inner region. The larger parts of such inlets are occupied by dense A—B—C communities or by intermixed ones of these communities. The density of the population of *Oithona similis* is small. The productivity of diatoms such as *Chaetoceros*, *Bacteriastrum*, etc. and dinoflagellates is prodigious in some favourable seasons. The inner part of the area occupied by A—B—C communities is shallow and rather high in oxygen contents. Associates of this community type are *Oikopleura dioica*, *Sagitta crassa*, *S. delicata*, *Penilia*, *Evadne*, numerous pelagic larvae of polychaetes, decapods, cirripeds, starfishes, sea-urchins, pelecypods and gastropods. The inlets of this type on the Japan Sea coast differ from those on the Pacific coast in having wider inner A—B—C community area and narrower *O. similis* area.

4, a. *Acartia*—*O. nana*—*Paracalanus*—*O. similis*—*Oncaea* and *Corycaeus* (**A—B—C—D—E**) type

4, b. *Acartia*—*O. nana*—*Paracalanus*—*O. similis* with *Microsetella* —*Oncaea* and *Corycaeus* (**A—B—C—D′—E**) type

Dense population of *Acartia*, *O. nana*, *Paracalanus*, *O. similis* (or *O. similis* with *Microsetella*) occupies the larger parts of the inlets of this type, except a narrow outer area near the entrance, where *Oncaea* and *Corycaeus* appear in a small number. Following subtypes may be recognized:

A—B—C—D—E type: The arrangement of plankton communities in the area inner than *Oithona similis* community is quite similar to that of the preceding type. The narrow outer part of the bay, however, is occupied by coastal copepods (*Oncaea* and *Corycaeus*), other animals and plants, which are thriving in the open sea water. In such inlets, the water is turbulent in the outer region, where the plankton productivity is relatively small. The area of respective community is nearly equal with one another, no major community being found.

To this subtype belong the inlets of Suzaki, Imari, Moriura, Yura and Hakodate.

A—B—C—D′—E type: The arrangement of the plankton communities is quite similar to that of the preceding subtype, excepting the addition of abundant *Microsetella rosea* or *M. norvegica* in the area between the inner and outer regions, just outside of C or D. The plankton productivity of this subtype is very large, *Chaetoceros* and *Thalassiothrix* being found in quantities in this D′ area; while the productivity drops rapidly in the area outside of the area of *Microsetella*, where many oceanic forms occur in turn. The inlets of this type are usually very complex topographically as well as hydrographically, the water movement being relatively stronger than in the former subtype. The water is transparent, highly saline and very rich in dissolved oxygen throughout the year, especially in the outer region of the inlet. The water of the inner region is characterized by relatively rich nutrient salts.

The bays of Ago, Hirosima, Nagasaki, Tôkyô, Miyazu, Hukuoka, Ariake, Turuga, Mikawa and the larger basins of Inland Sea belong to this subtype.

5. *Acartia—O. nana—Paracalanus—O. similis* (or *O. similis* with *Microsetella*)—*Oncaea* and *Corycaeus*—Oceanic copepod (**A—B—C—D (or D′)—E—F**) type

In many large bays with deep basins and wide entrances, plankton animals, dinoflagellates and diatoms of the coastal and oceanic origin are numerously distributed and occupy a wide area reaching to the central region. The inner part with stagnant water and small secondary baylets of this type are left for A—B—C communities. The population is usually thinner than that of the foregoing types. The bays of Tanabe, Miyako, Ise, Kagosima, Ôsaka, etc. belong to this type.

The water of the inlets of this type shows a great variability from the inner to the outer region. Chemical and physical factors undergo much greater diurnal and seasonal variations in the inner region than in the outer region. In the north baylet of Nanao Bay, bays of Kamaisi, Wakasa and Onagawa, and other baylets with small area, *Acartia* and *Oithona nana* occur in their innermost parts. The main parts of these bays are occupied by C—D (or D′)—E—F communities.

6. *P. parvus—O. similis* (or *O. similis* with *Microsetella*)—*Oncaea* and *Corycaeus*—Oceanic copepod (**C—D (or D′)—E—F**) type

The main part of the bay of this type is occupied by oceanic or coastal water copepods such as the major form of *P. parvus*, *O. similis*, *Microsetella*, *Oncaea* and *Corycaeus*, chaetognaths, tunicates, protozoans, diatoms and dinoflagellates, which are the inhabitants of the warm Kurosio or Tusima current. These forms stay there and establish an oceanic community which are maintained for a considerably long period or being continuously supplied from the coastal or oceanic areas. Larvae of various benthic animals, *Acartia clausi*, *Oithona nana* and their associates are absent, except in the narrow coastal belt of the bays or baylets. The deeper layers of the deep basins of the bays of Toyama, Hunka, Suruga, etc. have the communities of the cold water. The hydrological properties in the main basin, especially salinity, temperature, transparency, water color, amount of nutrient salts, etc. are similar to those in the neritic or oceanic waters, which do not show a great seasonal variation. The plankton productivity is generally low as in the adjacent open sea.

The main basins of Suruga, Hunka (surface layer less than 40 m), Toyama (surface layer less than 100 m), Kii-suidô, Bungo-suidô and Sagami belong to this type which is dominated by oceanic species.

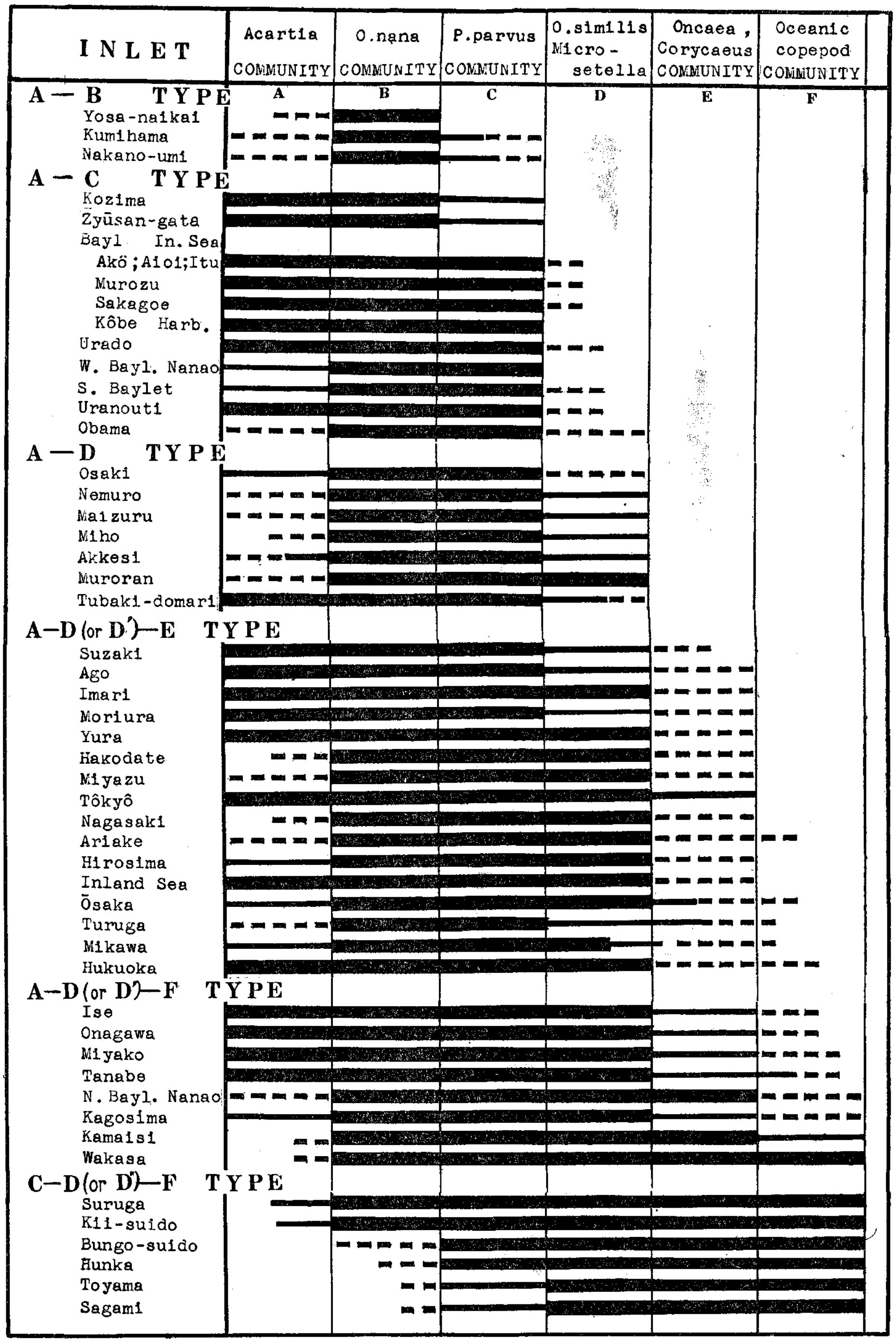


Fig. 4. Combination types of plankton communities found in some bays and inlets on Japanese coasts.

IV. Classification of Japanese Inlets Based on Plankton Communities

As explained in Chapter III, six combination types of plankton communities, being represented by dominant copepods are found in our inlets. In each inlet one of these combination types develops quite regularly, which corresponds to topographical and hydrological conditions, especially the differences of the oceanic influence. These types of combination of important plankton communities are shown schematically in Fig. 3.

V. Fluctuations in Plankton Composition

Seasonal Fluctuation: The regional distributions of plankton, nekton and benthos are influenced by various hydrological and topographical factors. As was shown in my previous papers, among inlet communities, the inner ones such as *Acartia* and *Oithona nana* communities are very stable both seasonally and annually, while those of the outer region such as *Paracalanus parvus* and *Oithona similis* communities are relatively variable, because of the turbulence caused chiefly by the low atmospheric pressure, the southerly summer and northerly winter winds. (YAMAZI, 1955 c and d).

Successional change: The planktological types of inlets naturally change with change in long-run of the topographical and hydrological conditions. As is shown in the inlets of Kumihama, Yosa-naikai, Nakano-umi and Kozima Bay (MIYADI, 1952 and 1954 a; YAMAZI, 1954 a, e), the disharmonic condition which harbours *Oithona* or *Oithona—Paracalanus* communities is related closely with the narrow channel connecting the inlet with the open sea. Most of these bays are lagoons made by the development of sand-bars, and the water is diluted by the strong inflow of freshwater. The influences of either of fresh water or of open sea water change with the development of the sand-bar damming the lagoon. The transformation of the community types in these lagoons from A—B—C—D or A—B—C—D′ to monotonous A—B or A—B—C corresponds to the transition of the embaymental conditions of the inlet from the widely opened bay to the enclosed brackish lagoon, which even holds some brackish water plankters. And finally the transition from the marine communities, i.e. *Oithona similis—Paracalanus—Oithona nana* and *Acartia* community to the brackish water community *Pseudodiaptomus—Sinocalanus* community may be regarded to indicate the increase of the stagnation degree of the inlet water.

VI. Origin of Inlet Plankton

The inlet plankton comes from two sources: (1) a local autogenetic stock and (2) an allogenetic population consisting of both oceanic and coastal forms, i.e. the plankton of warm Kurosio and Tusima current around Honsyû and of cold Oyasio and Liman currents around Hokkaidô. The second population may be brought into the inlet by the inflow of oceanic water. The following forms are the noticeable warm water autogenetic plankters in Japanese inlets: *Acartia clausi* and *spinicauda*, *Oithona nana* and *rigida*, *Paracalanus parvus* minor form, *Microsetella rosea* and *norvegica* among copepods; *Penilia schmackeri* and *Evadne tergestina* among cladocerans; *Sagitta delicata*, *crassa* and its forma *naikaiensis*, *Oikopleura dioica*; *Tintinnopsis radix* and *beroidea*, *Favella taraikaensis* and *Helicostomella longa* among protozoans; *Skeletonema costatum*, *Chaetoceros* spp., *Thalassiothrix Frauenfeldii*, *Thalassionema nitzschioides*, *Nitzschia seriata*, *Leptocylindrus danicus*, *Biddulphia* spp., *Asterionella japonica* among diatoms, etc. These inlet forms decrease towards the outer region of the inlet, although they may be observed in a small number in coastal waters of the open sea. Several cold water autogenetic forms such as *Chaetoceros socialis* and *Ch. debilis*, etc. may appear in the inner part of the inlets of the warm region during the short period from winter to early spring.

The allogenetic oceanic or coastal water copepods, pelagic tunicates, chaetognaths, radiolarians and other animals and plants generally decrease toward the inner part of the inlets. Excepting some neritic forms they can not thrive there. The allogenetic warm water species occur more abundantly, during the warm seasons from summer to autumn when the oceanic influx is very strong and the inlet water is renewed in a large scale. The occurrence of cold water oceanic forms is restricted to the cold season except in the inlets of Hokkaidô.

VII. Types of Inlets Based on Plankton Community and their Relation to Those Based on Nekton and Benthos

Historically, KOLKWITZ and MARSSON (1908) established an ecological system for freshwater phytoplankters, which were classified into polysaprobe, α- and β-mesosaprobe and oligosaprobe, according to their reaction to polluted water. LEVANDER (1918) and VÄLIKANGAS (1926) supplemented this system brackish and salt water forms. BRAARUD and BURSA (1939) followed the similar lines of classification as LEVANDER and VÄLIKANGAS, and classified three phytoplankton types in Oslo Fjord, in relation to the contamination of the water, namely polysaprobe (*Eutreptia Lanowi*), mesosaprobe (*Skeletonema costatum*, *Pontosphera Huxleyi*, *Ceratium fusus*, *C. tripos* and *Peridinium trichoideum*) and oligosaprobe (*Nitzschia delicatissima*). NAUMANN (1919) established an ecological system of the freshwater phytoplankton, which corresponds to the chemical characters of the environment, and classified the water into oligotroph, eutroph and heterotroph, and later this system was developed to his classification of lakes from the plant physiological point of view (NAUMANN, 1932). It is natural, however, that the plankton distributions in various inlets on Japanese coasts are different in many ways from those in the freshwaters or Scandinavian fjords. The inlets are always directly connected with the open sea, and this fact is the most important point for the ecological classification of marine plankton, because the environments of freshwater plankton usually form more or less closed system. Thus, for the establishment of biological types of inlets, there should be other view-points than those for lakes.

MIYADI, MASUI and HABE (1944) studied the distribution of the benthic animal communities, and HABE (1952) discussed on the dead shell accumulations in Japanese inlets from the geographical and ecological points of view. They distinguished three major characteristics in the inlets—strong, middle and weak embaymental characteristics, although the classification of inlets are left for the future. They recognized following facts: the benthic communities characteristic to strong embaymental conditions are the *Terebellides—Maldane* community in the main basin of Tanabe Bay, the mouth region of Ago Bay and the wide area of Gokasyo Bay, the *Cylichna* community in the southern baylet of Nanao Bay and the shallow basins of bays of Ise and Tôkyô, and the *Prionospio* community in the middle region of Ise Bay and the eastern region of bays of Tôkyô and Beppu. With these benthic communities are related usually the shell acumulation consisting of *Alvenius ojianus*, *Veremolpa micra*, *Raeta pulchella* and *Theora lubrica* and *Fulvia hungerfordi*. The weak embaymental conditions sustain such communities as the *Molgula—Caprella* community in the main basin of Matoya Bay, the mouth of Hukuoka Bay, the north and south (at the mouth region) baylets of Nanao Bay, the mouth region of Yura Bay, the *Caprella—Ampelisca* community in the south region of Tôkyô Bay, and the *Ampelisca* community in the channels of Akasi and Yura in Ôsaka Bay and Sakurazima Channel of Kagosima Bay. These communities are associated with the shell accumulation consisting of *Nucula paulula*, *Microcirce gordonis*, *Veremolpa minuta*, *Laevicardium undatopictum* and *Pellucina yamakawai*.

YOSHIMURA (1934–36, 1943) established a comprehensive classification of Japanese Bays on the basis of the distribution of useful nekton and benthos, besides their hydrological conditions. He classified the bays into three major types, namely the shrimp—mullet type (for instance Ariake Bay), the redsnapper—sardine type (Aomori Bay) and the yellowtail type (Sagami Bay). The shrimp—mullet type is subdivided into a) shrimp—sardine subtype to which belong to the bays of Ise and Mikawa, b) laver—mollusca—shrimp subtype to which belong to the bays of Tôkyô, Ariake, Nakano-umi and Matusima, c) eel subtype to which belong Hamana Lake. The red-snapper—sardine type is represented by Kii-suidô, the Inland Sea, Bungo-suidô, bays of Yatusiro, Hukuoka and Aomori. The yellowtail type is subdivided into two subtypes: a) yellowtail—tunny subtype represented by bays of Sagami and Suruga, and b) yellowtail-sardine subtype represented by bays of Toyama, Wakasa and Kagosima. This classification does not include other biological communities.

The communities of *Oithona nana* and *Acartia clausi* or *A. spinicauda* share the same area with the strong embaymental community of MIYADI *et al.*, and YOSHIMURA's fauna characterized by eel, clam, taps, oyster, laver, mullet, shrimp and gilthead. They are frequently accompanied by *Sagitta delicata*, *Oikopleura dioica*, *Tintinnopsis* *beroidea* and *T. radix*, *Favella taraikaensis*, *Helicostomella longa*, *Skeletonema*, *Nitzschia*, *Leptocylindrus*, *Thalassionema*, etc.

Paracalanus parvus, *Oithona rigida* and *similis*, *Microsetella* spp., and *Euterpe* occur in the area occupied by MIYADI's middle embaymental community or YOSHIMURA's red-snapper—sardine community. *Oithona nana*, *Sagitta delicata*, *Oikopleura dioica*, *Chaetoceros* spp., *Thalassiothrix*, *Thalassionema*, *Nitzschia* and *Bacteriastrum* are the pelagic associates in this area.

Oncaea media and *venusta*, *Corycaeus* spp., calanoids and other oceanic animals and plants appear in the area characterized by MIYADI's weak embaymental community comprising mackerel horse-mackerel, yellowtail, bonito and tunny.

Thus the distributions of plankton, nekton and benthos in the bay are in good agreement with one another. There is, however, a difference between YOSHIMURA's classification and YAMAZI's one. YOSHIMURA classified the types of relatively large bays or inlets according to the kinds of catches of useful nekton and benthos from their entire area, but payed little consideration to the regional differences in quantity and quality of catches.

Thus, the relation between the inlet types proposed by the two authors may be shown as follow: The inlets of A—B to A—B—C types correspond to A—D or A—D′—E types to the laver—shellfish—shrimp or shrimp—sardine subtypes of the same type, the inlets of A—F type to the sardine subtype of the red-snapper—sardine type or yellowtail—sardine subtype of the yellowtail type, and the inlets of C—D (or D′)—F type to the yellowtail—sardine or yellowtail—tunny subtype of the yellowtail type.

VIII. Inlet Plankton Communities as Indicators

a. As Indicators of the Stagnation Degree of the Inlet Water

As the occurrence of various plankton organisms is regarded as the synthetical result of influences of different environmental factors, the plankton community may be used safely as one of the foremost biological indicators for the nature and circulation of the water mass. The value of the plankton as indicators of the coastal water movements has been discussed by many workers (FRASER, 1952; REDFIELD, 1941; REDFIELD and BEALE, 1940; RUSSELL, 1935 and 1936; SØMME, 1933, 1934; WIBORG, 1954).

The inlets afford a rich variety of hydrological conditions, which are also affected by oceanic influx. The distribution of plankton in the inlet is correlated to the mixing degree of the open sea water with the stagnant water in the inner parts of the inlets (YAMAZI, 1955 a, b, c and d). The inlet waters on Japanese coasts by Kurosio and Tusima Current are characterized by the presence of some warm inlet-water species, which may be used as indicators for pursuing the water masses originated in the inlets. In fact, the courses of water movement as indicated by the distribution of plankton communities agree well with those traced by drift bottles. Frequently the indicator plankton can suggest of give a clue to the point of dispersion of a certain water mass, where the pursued water is too diluted to be detected by the conventional hydrological methods (YAMAZI, 1955 a and b).

b. As Indicators of the Biological Conditions for Fisheries and Aquiculture

As was shown in our previous paper (YAMAZI and HORIBATA, 1955 d), the yellowtail fishery at the entrance of Taizi Bay is affected strongly by the inflow of the coastal water, which can be ascertained by the existence of a large number of coastal or offshore plankters.

Various hydrological and planktological studies have been made in many inlets in relation to such problems as the spat-falling and fattening of rock oysters, pearl oysters and mussels. Judging from the regional distribution of inlet communities, the spawning and fattening seem to be governed by biological and environmental conditions, which are indicated by the plankton communities. For instance, the rock oysters are naturally found in the areas of *Acartia, Oithona nana* and their mixed communities which flourish mostly in inlet of lowest salinity. While the pearl oysters are abundant in the areas where plankton communities are dominated by *Paracalanus*, *O. similis* and *Oncaea*, their geographical distribution in our waters is limited by low temperatures of sea water. According to YAMAMOTO (1953), the spawning of the scallop is related closely to the change of plankton communities, following the sudden seasonal changes in water temperature. The regionally different plankton communities, thus, serve as indicators in finding out the favourable aquicultural conditions for various animals and plants.

IX. Summary

1. In this paper are dealt with the chief features of plankton and hydrological conditions as well as their mutual relationships in the inlet waters along the coast of Japan.

2. The plankton is studied both quantitatively and qualitatively, with special references to the composition of zooplankton in which copepods are always the most important constituents.

3. The distribution types of chief plankton communities of inlet waters on one hand and principal hydrological properties on the other corresponds well with each other, and on these bases we can provide a schematic diagram by which various inlets may be classified biologically.

4. The planktological and hydrological observations in some bays and inlets show that the compositions of zoo- and phytoplankton communities are much influenced by the water movements.

5. A classification of Japanese inlets is attemped here on the bases of plankton communities.

6. The seasonal succession and annual fluctuation of plankton in the inlet waters are studied both quantitatively and qualitatively, and then the regional distributions of plankton communities are discussed. The plankton communities are generally more stable, in all seasons, in the inner region of the inlet than in the outer region. The annual fluctuations in plankton population and specific composition are much larger in the outer region than in the inner region.

7. The inlet plankton originates in two sources: 1) An autogenetic inlet stock and 2) an allogenetic population, the latter of which may be divided into the coastal water forms and the oceanic forms thriving in Kurosio, Tusima Warm Current, Oyasio and Liman Cold Current. The amount of plankton which drift out of the inlets into the adjacent coastal waters seem practically negligible for the most part of Japanese coasts.

8. The relation between the distribution of plankton communites and those of nekton and benthos is discussed in various inlets.

9. The feature of the regional distribution of the inlet plankton communities is useful as an indicator for the stagnation degree or degree of embaymental condition on inlet water. It may be of use for judging the biological conditions for various fisheries or aquiculture.

REFERENCES

AIKAWA, H. 1930. The plankton of the southern sea of Japan, considered with references to their hydrography. Rec. Ocean. Wks. Japan, 3 (1), pp. 17–34.

——— 1934. On the quantitative analysis of plankton associations in the seas surrounding Japan, II. Jour. Imp. Exp. Fish. Station, no. 5 (In Japanese with English abstract).

——— 1936 a. On the quantitative analysis of plankton associations in the seas surrounding Japan, VI. Ibid., no. 7 (In Japanese with English abstract).

——— 1936 b. On the diatom communities in the waters surrounding Japan. Rec. Ocean. Wks. Japan, 8, pp. 1–159.

ALLEN, W. F. 1927. Quantitative studies on inshore marine diatoms and Dinoflagellata of southern California in 1921 and in 1922. Bull. Scripps Inst. Oceanog., Tech. Ser., (2), pp. 19–29, (3), pp. 31–38.

——— 1928. Quantitative studies on inshore marine diatoms and Dinoflagellata in southern California in 1924. Ibid., 1 (15), pp. 347–356.

——— 1930. Quantitative studies of surface catches of marine diatoms and dinoflagellates. Ibid., 2 (10), pp. 389–399.

ANRAKU, M. 1953. Seasonal distribution of pelagic copepods at Oshoro Bay, West Coast of Hokkaido. Bull. Fac. Fish., Hokkaido Univ., 3 (3), pp. 187–192.

ASAOKA, O. 1955. On the variation of the composition of plankton diatoms and the sea at a pier on Jôgasima Island in the period from March 1952 to May 1953. Jour. Ocean. Soc. Japan, 11 (2), pp. 69–74 (In Japanese with English abstract).

BIGELOW, H. S. 1926. Plankton of the offshore waters of the Gulf of Maine. Bulletin, U. S. Bur. Fish. (1924), 40 (2), pp. 1–509.

BRAARUD, T. & A. BURSA. 1939. The phytoplankton of the Oslo Fjord, 1933-34. Hvalrådets Skrifter, nr. 19.

CHIBA, T. 1950. A limnological survey of the Nakano-umi and Lake Sinji in the coast of the Japan Sea. II. On the plankton of Nakano-umi in summer (1949). Bull. Jap. Soc. Sci. Fish., 16 (5) (In Japanese with English abstract).

——— 1952. On the plankton of Nakano-umi in summer, 1948. Jour. Shimonoseki Coll. Fish. 2 (1).

DEEVEY, G. B. 1948. The zooplankton of Tisbry Great Pound. Bull. Bingham Oceanogr. Coll., 12 (1), pp. 1-44.

——— 1952 a. A survey of the zooplankton of Block Island Sound, 1943-1946. Ibid., 13 (3), pp. 65-116.

——— 1952. Quantity and composition of the zooplankton of Block Island Sound, 1949. Ibid., 13 (3), pp. 120-164.

DIGBY, P. S. B. 1950. The biology of the small planktonic copepods of Plymouth. J. Mar. Biol. Ass. U. K., N. S. 29, pp. 393-438.

FARRAN, G. P. 1910 and 1911. Copepoda. Bull. trim. Cons. Perm. int. pour l'explor. de la mer. Résumé Planktonique. I and II Cph.

FISH, C. J. 1936. The biology of *Oithona similis* in the Gulf of Maine and Bay of Fundy. Biol. Bull. Woods Hole, 70, pp. 193-216.

FRASER, F. H. 1952. The Chaetognatha and other zooplankton of the Scottish area and their value as biological indicators of hydrographical conditions. Scottish Home Dep., Mar. Res. 1952, no. 2.

FUJIYA, M. 1952. On the seasonal variation of diatoms in Tôkyô Bay. Bull. Naikai Reg. Fish. Res. Lab., no. 2 (In Japanese with English abstract).

GRAN, H. H. & T. BRAARUD 1935. A quantitative study of the phytoplankton in the Bay of Funday and the Gulf of Maine. Jour. Biol. Bd. Canada, 1 (5), pp. 279-467.

HABE, T. 1943. The second survey of the benthic communities of the Yamakawa-ko, with special reference to the deep reduction layer. Jour. Ocean. Soc. Japan, 2 (4), pp. 17-25. (In Japanese).

——— 1944. The studies on the benthos and *Littorina* communities on the tidal zone of Uragami Bay. Ibid., 4 (1) (In Japanese).

——— 1946. Benthic communities of Katuura Bay. Kyôto-daigaku Seiri-Seitai Kenkyû Gyôseki, no. 54 (In Japanese).

——— 1949. Benthic communities and molluscan thanatocoenoses of Tanabe Bay. Bull. Jap. Soc. Sci. Fish., 15 (5) (In Japanese).

——— 1952 a. Benthic communities and molluscan thanatocoenoses of the Nanao Bay. Special Publ. Japan Sea Reg. Fish. Res. Lab. on the 3rd Anniv. of its Founding, pp. 59-64.

——— 1952 b. Molluscan thanatocoenoses of Tôkyô Bay. Bull. Jap. Soc. Sci. Fish., 17 (5) (In Japanese).

——— 1952 c. The accumulation of molluscan shells of the inlet. Tikyû Kagaku, no. 7.

——— 1953. The accumulation of molluscan shells in the bays Hunka and Muroran. Sinseidai no Kenkyû, no. 18 (In Japanese).

——— 1954. The distribution of molluscs in the inlet waters. Zool. Mag., 63 (11 & 12), pp. 483-484.

——— 1955. Molluscan thanatocoenoses of Hakodate Harbour. Sinseidai no Kenkyû, no. 21 (In Japanese).

HABE, T. & YAMAZI, I. 1955. Bio-oceanographical characteristics of the Miyazu-wan. Bull. Biogeogr. Soc. Japan, 16-19.

HABE, T. *et al.* 1945 a. Marine benthic communities of Ôsaki Bay. Kyôto-daigaku Seiri-Seitai Kenkyô Gyôseki no. 21 (In Japanese).

T. HABE *et al.* 1945 b. On the benthic studies of the inlets of the Sea: Benthic communities and molluscan thanatocoenoses of Matunaga Bay. Ibid., no. 22 (In Japanese).

——— 1945 c. The molluscan thanatocoenoses of Obama inlet of Wakasa Bay. Ibid., no. 32 (In Japanese).

——— 1946. Benthic communities of Yura Bay. Ibid., no. 56 (In Japanese).

HAKODATE MARINE OBSERVATORY, 1950. The report of the oceanographical observation in the Hakodate Harbour. Jour. Oceanogr. H. M. O., no. 2.

HANAOKA, T. 1952. On the indicator of production from a water area. Bull. Naikai Reg. Fish. Res. Lab., no. 1 (In Japanese with English abstract).

HANAOKA, T. *et al.* 1947–1950. Res. Rep. Productivity of Inland Sea. Central Fish. Exp. Sta. Tôkyô, nos. 1–8 (In Japanese).

KADO, Y. 1954. The seasonal change of plankton and hydrography of the neighbouring sea of Mukaishima. Jour. Sci. Hirosima Univ., Ser. B, Div. 1, 15 (6).

KAWAGUCHI, M. 1945. Biological studies on the Inland Sea, II. Benthic communities of Kasaoka Bay during the spring. Kyôto-daigaku Seiri-Seitai Kenkyû Gyôseki, no. 17.

——— 1946. Records on the benthic community of Tôkyô Bay. Ibid., no. 58 (In Japanese).

KAWAGUCHI, M. & SIRAI, K. 1944. Biological studies on the Inland Sea, I. Benthic communities of Kasaoka Bay. Ibid., no. 8.

KÔBE MARINE OBSERVAYORY, 1930 a. Results of the oceanographical observations in Kii Suidô on board the R. M. S. "Syunpu Maru" in winter 1927–28. (1) (2). Jour. Ocean. 1 (1), pp. 1–20; (2), pp. 77–111.

——— 1930 b. Results of the second oceanographical observations in the Ôsaka Wan (Bay) on board the R. M. S. "Syunpu Maru" in 1928. Ibid., 1 (3), pp. 173–367.

——— 1930 c. The results of the oceanographical observations on board R. M. S. "Syunpu Maru" in the Setonaikai (the Inland Sea) in the year 1928, 1929–1930, (part 1) and (part 2). Ibid., 2 (2), pp. 335–433; (4), pp. 537–643.

——— 1931 a. The results of the oceanographical observations on board R. M. S. "Syunpu Maru" in the Tôkyô-wan in the spring, 1929. Ibid., 3 (1), pp. 1–119 (In Japanese with English résumé).

——— 1931 b. The results of the oceanographical observations on board R. M. S. "Syunpu Maru" in the Nakanoumi in the summer, 1929. Ibid., 3 (1), pp. 120–153.

——— 1933 a. The reports of the oceanographical observations on board R. M. S. "Syunpu Maru" in the Ise-no-umi and the Mikawa-wan in Oct., 1929. Ibid., 5 (1), pp. 1–97.

——— 1933 b. The reports of oceanographical observations of the Kagosima-wan and limnological observations of the Ikeda-ko in March 1930. Ibid., 5 (2), pp. 285–396.

——— 1934. Report of the oceanographical observations on board R. M. S. "Syunpu Maru" in the Hunka-wan (Volcanic Bay), Hokkaidô (August, 1932). Ibid., 6 (2), pp. 209–240.

——— 1935 a. Report of the oceanographical observations taken on board R. M. S. "Syunpu Maru" in the Ômura-wan in November and December, 1931. Ibid., 8 (1), pp. 1–164.

——— 1935 b. Report of the oceanographical observations off the Uotukerin (maritime woods for luring fishes) in Nov. 1934. Ibid., 8 (2), pp. 201–212.

——— 1936 a. Report of the oceanographical observations taken on board R. M. S. "Syunpu Maru" in Ôsaka-Wan in April 1935. Ibid., 8 (3), pp. 263–311.

——— 1936 b. Report of the oceanographical observations on board R. M. S. "Syunpu Maru" in the western half of the Seto-Naikai (Inland Sea of Japan) in the winters 1930, 1932 and 1933. Ibid., 9 (2), pp. 101–270.

——— 1937. Results of the oceanographical observations on board R. M. S. "Syunpu Maru" in the Seto-Naikai (Inland Sea of Japan) in the severe winter, February, 1936. Ibid., 10 (1), pp. 45–76.

——— 1938 a. Report of the regular monthly oceanographical observations on board the R. M. S. "Syunpu Maru" in the Ôsaka-Wan and Kii-Suido (1934–1935). Ibid., 11

(2), pp. 221–362.
KOBE MARINE OBSERVATORY, 1938 b. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the Toyama-Wan (1936). Ibid., 11 (3), pp. 509–534.
——— 1938 c. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the Ariake and Yatusiro-Kai (1936). Ibid., 11 (2), pp. 535–610.
——— 1939 a. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in Suruga-Wan (Oct.–Nov., 1936). Ibid., 12 (1), pp. 37–72.
——— 1939 b. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in Turuga-Wan (Sep.–Oct., 1933). Inbid., 12 (1), pp. 73–78.
——— 1939 c. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the regions close to Uotuke-Hoanrin (1935–1937). Ibid., 12 (2), pp. 175–234.
——— 1941. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the Ariake and Yatusiro-Kai (1936). Ibid., 13 (2), pp. 211–285.
——— 1942 a. The diatoms collected on the oceanographical observations (1934–1935) in Ôsaka Bay. Ibid., 13, pp. 594–638.
——— 1942 b. The dinoflagellates collected on the oceanographical observation (1934–1935) in Ôsaka Bay. Ibid., 13, pp. 639–652.
——— 1942 c. The silicoflagellates collected on the oceanographical observations (1934–1935) in Ôsaka Bay. Ibid., 13, pp. 1100–1128.
——— 1942 d. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the Hukuoka-Wan in April–May, 1940. Ibid., 13 (3), pp. 481–548, (3), pp. 928–969.
——— 1942 e. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the Seto-Naikai (Inland Sea) 1938–1939). Ibid., 13 (4), pp. 801–865.
——— 1942 f. Report of the oceanographical observations on board the R. M. S. "Syunpu Maru" in the Kobe Harbour in April, 1941. Ibid., 13 (4), pp. 928–969.
——— 1951–1953. Report of the oceanographical observation on board the R. M. S. "Syunpu Maru" in Kii-Suido. Ibid., 2nd Series, 1–4.
——— 1951–1953. Results of the regular monthly oceanographical observations on board the R. M. S. "Syunpu-Maru" in the Ôsaka Wan. Ibid., 1–4.
——— 1952. Meteorology and oceanography in the Seto Inland Sea. Bull. Kobe Marine Observatory, no. 161.
——— 1951–1952. Report of the Plankton. Huyû-Seibutu Sokuhô no. 5–8.
KOKUBO, S. 1931–1940. Planktological Review, no. 1–15, Nat. Res. Council of Japan (In Japanese).
——— 1932. Quantitative studies on microplankton in Aomori Bay during 1929–1930. Rec. Ocean. Wks. Japan, 4 (1), pp. 171–244; Jour. Fish., no. 35 (In Japanese).
——— 1945–1949. Bulletin of the marine Biological Station of Asamushi. vols. 1–5.
——— 1950. On the plankton of Mutu Bay. Reg. Fish. Rec. Aomori Prefecture, 1, pp. 99–122.
——— 1952. Results of the observations on the plankton and oceanography of Mutu Bay during 1950. Reference being made also to the period 1946–1950. Bull. Mar. Biol. Station, Asamushi, 5 (1–4), pp. 1–54.
KOKUBO, S. & T. TAMURA 1934. On the seasonal and vertical distribution of the plankton of Aomori Bay. Sci. Rep. Tôhoku Imp. Univ., 4th Ser., Biol., 8 (4), pp. 297–333.
——— & ——— 1938. Observations on the plankton and hydrographic conditions of Aomori Bay. During the period 1933–1935. Rec. Ocean. Wks. Japan, 10 (1), pp. 1–15.
KOKUBO, S. & S. SATO 1947. Planktons in Jû-san Gata. Physiol. and Ecol., 1 (4).
KOLKWITZ, R. & M. MARSSON 1908. Ökologie der pflanzlichen Saprobien. Ber. d. deutsch. Bot. Ges. 1908., 26 a.
KURASIGE, H. & K. KITAMURA 1933. On the "Akasiwo" caused by diatom at the Nakano-umi.

Jour. Meteor. Soc. Japan, 2nd Ser., 12 (6), pp. 287-300 (In Japanese).

LEVANDER, H. 1918. Meddelande om Helsingfors hamnplankton. Meddel. Soc. Fauna & Flora Fennica, 44, Helsingfors.

LOHMANN, H. 1910. Untersuchungen zur Feststellung des vollständigen Gehaltes des Meeres an Plankton. Komm. Wissenschaftl. Meeresunt. Biol. Anst. Helgoland, Abt. Kiel., 10.

MARSHALL, S. M. 1949. On the biology of the small copepods in Loch Striven. J. Mar. Biol. Assoc. U. K., N. S. 28, pp. 45-122.

MAÉDA, H. 1952. Studies on Yosa-Naikai. 1. On the over-saturation of dissolved oxygen and vertical changes of pH in winter. Umi to Sora (Sea and Sky), 29 (5/6), pp. 89-95 (In Japanese with English summary).

——— 1953 a. Ditto. 2. Considerations upon the range of the saturation and the influences by the river Noda and the open Sea. Jour. Shimonoseki Coll. Fish., 3 (2), pp. 133-140.

——— 1953 b. Ditto. 3. Analytical observation of the influence of the river Noda and the benthic communities. Ibid., 3 (2), pp. 141-149.

MAEKAWA, K. *et al.* 1953. On the seasonal change of oceanographical condition and the plankton in Suho Nada. Naikai Exp. Fish. Stat. Yamaguti Prefecture, 5 (1) (In Japanese).

MAIZURU MARINE OBSERVATORY 1949. The results of the oceanographical observation on Miyazu Bay and Yosa-Naikai. Oceanographical Data, no. 10.

——— 1952. The report of the oceanographical observation in the western part of Wakasa Bay on board the R. M. S. "Kurosio Maru" (Feb. 29-March 2, 1952). Ibid., 1 (3/4), pp. 71-81 (In Japanese with English abstract).

MARUMO, T. *et al.* 1951 a. On the diurnal variation of planktological conditions at the centre of Sagami Bay. I, II and III. Oceanogr. Rep. Centr. Meteor. Obs., 2 (1) (In Japanese with English abstract).

——— 1951 b. On the planktological conditions of Sagami Bay from September, 1947 to July, 1948. Ibid., 2 (1).

MASUI, T. 1941. The benthic communities of the Habu-ko with special reference to the sulphides in sediments. Jour. of Fish., no. 49, pp. 66-71 (In Japanese with English résumé).

——— 1943. The benthic communities of Tôkyô Bay. Jour. Ocean. Soc. Japan, 3 (2), pp. 130-141 (In Japanese).

MATSUDAIRA, C. 1940. Seasonal change of chemical composition of sea water and phytoplankton in the Bay of Ise. Suisan Gakukaihô, 8 (2), pp. 148-162 (In Japanese).

MIYADI, D. 1938. Quantitative studies on the benthic communities of the Ôsaka Wan, I. Umi to Sora (Sea and Sky), 18, pp. 172-184.

——— 1938. Preliminary reconnaissance on the benthic communities of the Tanabe-wan. Bull. Jap. Soc. Sci. Fish., 7, pp. 176-178 (In Jap. with Engl. synopsis).

——— 1940. Quantitative studies on the benthic communities of the Ôsaka-wan, II. Nippon Gakuzyutu-kyôkai Hôkoku, 15 (3).

——— 1940. Marine benthic communities of the Ôsaka-wan. Jour. Ocean., 12 (2), pp. 371-385.

——— 1940. Marine benthic communities of the Tanabe-wan. Annot. Zool. Japon, 19 (4).

——— 1941a. Indentation individuality of the Tanabe-wan. Mem. Imp. Mar. Observ., 7 (4).

——— 1941b. Marine benthic communities of the Beppu-wan. Ibid., 7 (4).

——— 1941c. Marine benthic communities of the Ise-wan and the Mikawa-wan. Ibid., 7 (4).

——— 1941.d. Ecological survey of the benthos of the Ago-wan. Annot. Zool. Japon., 20 (3).

MIYADI, D. *et al.* 1942 a. Marine benthic communities of the Kagosima-wan and Yamakawa-kô. Jour. Ocean., 13 (3) (In Japanese).

——— 1942 b. Marine benthic communities of the Hukuoka-wan. Umi to Sora, 22 (7), pp. 232-251 (In Japanese).

——— 1942 c. Studies on the benthic communities of the Nanao-wan. Jour. Ocean.

Soc. Japan, 2 (1) (In Japanese).

MIYADI, D. *et al.* 1944 a. On the correlation between the embaymental degree and the distribution of the benthos on the bottom and tidal zone of Uranouti Bay. Ibid., 3 (4), (In Japanese).

——— 1944 b. The embaymental degree of Urado Bay. Ibid., 4 (1) (In Japanese).

——— 1944 c. On the relation between the embaymental degree and distribution of the communities. Kyôto-daigaku Seiri-Seitai Kenkyû Gyôseki, no. 3.

——— 1945. Benthic communities and thanatocoenoses of Nakano-umi. Ibid., no. 31, pp. 1–24.

——— 1947. On the thanatocoenoses of bays. Physiol. and Ecol., 1 (2), pp. 110–124 (In Japanese with English résumé).

——— 1947 a. On the hydrographical succession of the Yosa-naikai and the decline of its fisheries. Zool. Mag., 57 (9), pp. 147–151 (In Japanese with English summary).

——— 1949. Studies on the Yosa-Naikai, its oceanographic conditions and their improvement for fisheries purposes. Bull. Jap. Soc. Sci. Fish., 14 (5), pp. 244–250 (In Japanese with English abstract).

——— 1950 a. On the benthos and shell deposits of Kumihama Bay ; a lagoon on southwestern Japan Sea coast. Stud. Aquat. Anim. Japan, I, pp. 25–32, (5)–(6) (In Japanese with English summary).

——— 1950 b. Benthonic biocoenoses and thanatocoenoses of the Maizuru Bay. Ibid.

——— 1952. The biological studies of bays of Miho and Nakano-umi (I). Kyôto-daigaku, Seiri-Seitai Kenkyû Gyôseki, no. 76 (In Japanese).

——— 1954 a. Idem. (2). Ibid., no. 78 (In Japanese).

——— 1954 b. Biological succession in disharmonic bays and lagoons, and their improvement for fisheries purposes. Proceedings Seventh Pacific Science Congress, 4.

MIYAIRI, T. 1952. Studies on the constituents of the water and fisheries status in the Inland Sea of Yosa. Special Publ. Japan Sea Reg. Fish. Lab., on the third Anniv. Found., pp. 193–202 (In Japanese with English abstract).

MIYAMOTO, H. *et al.* 1954. Fishing situations of the yellowtail in the Pacific coast, 1950–1951 through 1952–1953 seasons. Bull. Tôkyô Reg. Fish. Res. Lab., no. 8 (In Japanese with English abstract).

MORISHIMA, M. 1947. The accumulation of foraminiferal tests in the inlets of Obama and Maizuru. Physiol. and Ecol., 2 (3).

——— 1948 a. The accumulation of foraminiferal tests in inlets of Wakasa Bay on the Inland Sea of Japan. Rep. Com. Treat. Mar. Ecol. Paleoecol., Nat. Res. Coun., Washington, no. 7.

——— 1948 b. Foraminiferal thanatocoenoses of Ago Bay, Kii Peninsula, Japan. Ibid., no. 8.

——— 1955. Foraminiferal thanatocoenoses of Akkeshi Bay and its vicinity. Memoirs Coll. Sci. Univ. Kyôto, Ser. B, 20 (2), pp. 113–117.

MORI, T. 1937. The pelagic Copepoda from the neighbouring waters of Japan. Yôkendo Co., Tôkyô.

MURAKAMI, A. 1954. Oceanography of Kasaoka Bay in Seto Inland Sea. Bull. Naikai Reg. Fish. Res. Lab., no. 6 (In Japanese).

MURPHY, H. 1923. The life cycle of *Oithona nana*, reared experimentally. Univ. California Publ. Zool. 22 (13).

MURORAN MUNICIPAL OFFICE 1950. Reports of Oceanographical Observations taken in the Funka Bay, during the period 1948–1950.

NAIKAI REG. FISH. RES. LAB. 1951–1955. Report of Inland Sea Fish. Co-oper. Investig. Ser. A, no. 1–11 (In Japanese).

NAUMANN, E. 1919. Några synspunkter angående limnoplanktons ökologi med särskild hänsyn till fytoplankton. Svensk Bot. Tidskr., 13 (2).

———— 1932. Grundzüge der regionalen Limnologie. Die Binnegewässer. Bd. XI, Stuttgart.

OKITSU, T. 1953. Observation on the seasonal changes of phytoplankton in Aomori Bay during 1951. Bull. Mar. Biol. Stat. Asamushi, 6 (1-4).

REDFIELD, A. C. 1941. Effects of the circulation of water on the distribution on the calanoid community in the Gulf of Maine. Biol. Bull., 80, pp. 86-110.

REDFIELD, A. C. *et al.* 1940. Factors determining the distribution of populations of chaetognaths in the Gulf of Maine. Ibid., 79, pp. 459-487.

RUSSELL, F. S. 1935. On the value of certain plankton animals as indicators of water movements in the English Channel and North Sea. Jour. Mar. Biol. Ass. U. K., N. S., 20 (2), pp. 309-332.

———— 1936. Observations on the distribution of plankton animals made on Col. E. T. Peel's Yacht "St. George" in the mouth of English Channel, July, 1935. Ibid., 20, pp. 507-522.

———— 1939. Hydrological and biological conditions in the North Sea as indicated by plankton organisms. Jour. du Conseil, 14 (1), pp. 171-192.

SHIMAZU, T. & K. YAMANE 1948. Studies on the benthos of Tôkyô Bay (1). On the seasonal changes of temperature of bottom with reference to the benthos. Bull. Jap. Soc. Sci. Fish., 14 (1), pp. 51-55 (In Japanese with English synopsis).

SHIMOMURA, T. 1953. A study on the production and distribution of the microplankton and their relation to oceanographic conditions. I, II and III. Bull. Japan Sea Reg. Fish. Res. Lab., no. 3 (In Japanese with English abstract).

———— 1953. Planktological study on the propriety of culture or multiplication in Nanao Bay, Ishikawa Pref., Ibid., no. 3 (In Japanese with English abstract).

———— 1954. Planktological study on the warm Tushima Current region. I and II. Ann. Rep. Japan Sea Reg. Fish Res. Lab. no. 1.

TAMURA, T. 1947. The report of the oceanographical observation in Hunka Bay. Jour. Oceanogr. H. M. O. no. 2, pp. 144-167 (In Japanese).

———— 1950. Annual change of occurrence of plankton in the vicinity of Muroran. Report on the oceanographical observations of Volcano Bay, Hokkaido Muroran Municipal Office, pp· 63-83 (In Japanese).

———— 1951. On the seasonal change of the plankton making their appearance in the vicinity of Funka-Bay. Sci. Pap. Hokkaido Fish. Sci. Inst. no. 8, pp. 26-38 (In Japanese).

TANAKA, O. 1956. The pelagic copepods of the Izu region, middle Japan. Systematic account, I. Calanidae and Eucalanidae. Publ. Seto Mar. Biol. Lab., 5 (2), pp. 251-272.

TANITA, S. *et al.* 1950. Studies on the environmental conditions of shellfish field. 1. In the case of Hakodate Harbour. Bull. Fac. Fish., Hokkaidô Univ., 1 (1), pp. 1-10.

TESCH, J. J. 1915. Quantitative Untersuchungen über das Vorkommen des Copepoden und ihrer Entwicklungsstadien im Plankton beim Haaks-Feuerschiff (1912). Mit einem Anhang. Rapp. Verhandl. Rijksinst Visscherijonderz. I, 3, Helder.

TOKIOKA, T. 1939. Notes on chaetognaths and pelagic tunicates of Ôsaka Bay. Umi to Sora, 19, pp. 152-160 (In Japanese).

TOKIOKA, T. & I. YAMAZI, 1950. Studies on the pearl fishing ground of Ago Bay. II and III. Kyôto-daigaku Seiri-Seitai Kenkyû Gyôseki, no. 70, pp. 5-18 and no. 71, pp. 19-61 (In Japanese).

TOKIOKA, T., I. YAMAZI & S. FUSE, 1951. Idem. V. Estimation of the hydrographical and hydrobiological influences of Hukaya Channel upon Hunakosi baylet in Ago Bay. Ibid., no. 73, pp. 19-61 (In Japanese).

TSUJITA, T. 1953. A marine ecological study on the Bay of Ômura. Jour. Ocean. Soc. Japan, 9 (1), pp. 23-31 (In Japanese with English abstract).

UDA, M. *et al.* 1934. The catch of kiddle nets in two fishing grounds on the coast of Nagasaki

Prefecture and Izu Peninsula. Bull. Jap. Soc. Sci. Fish., 2 (4), pp. 190–198 (In Japanese with English summary).

UEDA, M. 1949. Hydrological observation on the Uranouchi Bay. Ibid., 15 (4), pp. 190–198 (In Japanese with English summary).

——— 1950. Biological and limnological conditions in Urado Bay and Suzaki Bay. Hirooka Agric. High School, in Kôti Prefecture (In Japanese).

VÄLIKANGAS, I. 1926. Planktologische Untersuchungen im Hafengebiet von Helsingfors. 1. Über das Plankton insbesondere das Netz-Zooplankton des Sommerhalbjahres. Acta zoologica Fennica 1. Helsingfors.

WELLS, A. L. 1938. Some notes on the plankton of the Thames estuary. J. Anim. Ecol., 7, pp. 105–124.

WIBORG, K. F. 1940. The production of zooplankton in the Oslo Fjord in 1933–1934 with special reference to the copepods. Hvålradets Skrifter., no. 21, pp. 1–85.

——— 1954. Investigations on zooplankton in coastal and offshore waters of western and northwestern Norway. With special reference to the copepods. Rep. Norw. Fish. and Mar. Inv., 11 (1).

WILSON, C. B. 1932 a. The copepods of the Woods Hole region, Massachusetts. Bull. U. S. Nat. Mus., no. 158, pp. 1–635.

——— 1932 b. The copepod crustaceans of Chesapeake Bay. Proc. U. S. Nat. Mus., 80 (15), pp. 1–54.

WILSON, D. P. 1951. A biological differences between natural sea waters. Jour. Mar. Biol. Assoc. U. K., 30 (1).

YAMAMOTO, G. 1951 a. Ecological note on transplantation of the scallop, *Pecten yessoensis* Jay, in Mutu Bay, with special reference to the succession of the benthic communities. Sci. Rep. Tôhoku Univ. 4th Ser. 19, pp. 11–16.

——— 1951 b. Benthic communities of Mutu Bay. Bull. Jap. Soc. Sci. Fish., 16 (16).

——— 1952. Further study on the ecology of spawning in the scallop, in relation to luner phases, temperature and plankton. Ibid., 19, pp. 247–254.

——— 1953. Ecology of the scallop, *Pecten yessoensis* Jay. Ibid., 20 (1), pp. 11–32.

YAMAZI, I. 1950. Plankton investigation in inlet waters along the coast of Japan. I. Introductory notes and the plankton of Akkesi Bay, Hanasaki Inlet and Nemuro Harbour. Publ. Seto Mar. Biol. Lab., 1 (3).

——— 1951. Idem. II. The plankton of Hakodate Harbour and Yoichi Inlet in Hokkaidô Ibid., 1 (4).

——— 1952 a. Idem. III. The plankton of Imari Bay in Kyûsyû. Ibid., 2 (2).

——— 1952 b. Idem. IV. The plankton of Nagasaki Bay and Harbour in Kyûsyû. Ibid., 2 (2).

——— 1952 c. Idem. V. The plankton of Hirosima Bay in the Seto-Naikai (Inland Sea). Ibid., 2 (2).

——— 1952 d. Idem. VI. The plankton of Nanao Bay. Bull. Japan Sea Reg. Fish. Rea. Lab. Special vol.

——— 1952 e. Seasonal succession of the plankton at the shell-fish ground of Ariake Bay, Hukuoka Prefecture. Senkai Zôsyoku Tyôsa Hôkoku, Fish. Agency. no. 1.

——— 1953 a. Plankton investigation in inlet waters along the coast of Japan. VIII. The plankton collected during the cruises to the New Yamato Bank in the Japan Sea. Publ. Seto Mar. Biol. Lab., 3 (1).

——— 1953 b. Idem. IX. The plankton of Onagawa Bay on the eastern coast of Tôhoku District. Ibid., 3 (2).

——— 1953 c. Idem. X. The plankton of Kamaisi Bay on the eastern coast of Tôhoku District. Ibid., 3 (2).

YAMAZI, I. 1954 a. Idem. XI. The plankton of Kozima Bay in the Seto-Naikai (Inland Sea). Ibid., 3 (3).

——— 1954 b. Idem. XII. The plankton of Miyako Bay on the eastern coast of Tôhoku District. Ibid., 3 (3).

——— 1954 c. Idem. XIII. The plankton of Obama Bay on the Japan Sea coast. Ibid., 4 (1).

——— 1954 d. Idem. XIV. The plankton of Turuga Bay on the Japan Sea coast. Ibid., 4 (1).

——— 1954 e. Idem. XV. The plankton of Yosa-Naikai and Kumihama Bay, enclosed bays on the Japan Sea coast. Ibid., 4 (1).

——— 1955 a. Idem. VIII. The distribution of plankton in Miyazu Bay in relation to the water movement. Ibid., 4 (2).

——— 1955 b. Idem. XVI. The plankton of Tôkyô Bay in relation to the water movement. Ibid., 4 (2).

——— 1955 c. Idem. XVII. Seasonal succession of zooplankton in the inner area of Tanabe Bay from June to October, 1954. Ibid., 4 (2).

YAMAZI, I. & T. HORIBATA 1955 d. Idem. XVIII. Seasonal succession of plankton in Taizi Bay in the years 1951–1953. Ibid., 4 (2).

YASUI, Z. 1930. Topographical features of the Inland Sea. Umi to Sora, 10, pp. 181–185.

YOSHIMURA, S. 1931. Vertical distribution of sulphide in Suigetu-ko and Hiruga-ko, Hukui. Jap. Jour. Limnol., 1 (1), pp. 44–46 (In Japanese).

——— 1934–1936. General oceanographical studies of inlets: A comparison between inshore feature and offshore feature. Chiri Kyôiku, 20 (1), pp. 22–29; (2), pp. 160–165; (4), pp. 415–422; (5), 515–519; 21 (1), pp. 46–51; (3), pp. 285–290; (6), pp. 645–649; 23 (1), pp. 43–50; (4), pp. 404–410; (5), pp. 528–530 (In Japanese).

——— 1934 a. Oceanographical classification of the Japanese inlet. Geogr. Rev. Jap., 10 (6), pp. 533–535 (In Japanese).

——— 1934 b. The areas and depths of inlet waters in the main land of Japan. Jour. Geography, 46 (543), pp. 245–246 (In Japanese).

——— 1943. A system of inlets in the main land of Japan based on the catches of coastal fisheries: A general oceanographical investigation. (1). Papers Ôtuka Geogr. Soc., no. 3, pp. 113–136 (In Japanese).

EXPLANATION OF PLATES XVI–XXIII

PLATE XVI

Fig. 1. *Pseudodiaptomus inopinus* BRUCKHARDT, female, dorsal and lateral sides. ×40.
Fig. 2. *Sinocalanus tenellus* KIKUCHI, female, dorsal and lateral sides. ×40.
Figs. 3 A–C. *Acartia spinicauda* GIESBRECHT. A, Female, dorsal side. ×40; B, 5th feet of female. ×240; C, Male, dorsal side. ×40.
Figs. 4 A & B. *Acartia clausi* GIESBRECHT. A, Female, dorsal side. ×40; B, Male, dorsal side. ×40.
Fig. 5. *Paracalanus parvus* (CLAUS), minor form, female, lateral side. ×40.
Figs. 6 A & B. *Oithona nana* GIESBRECHT. A, Male, dorsal side. ×40; B, Female, dorsal side. ×40.

PLATE XVII

Figs. 1 A & B. *Oithona rigida* GIESBRECHT. A, Female. ×40; B, Male. ×40.
Figs. 2 A & B. *Oithona similis* CLAUS. A, Female. ×40; B, Male. ×40.
Fig. 3. *Oithona decipiens* FARRAN, female. ×40.
Figs. 4 A & B. *Euterpe acutifrons* DANA. A, Male. ×40; B, Female. ×40.
Fig. 5. *Microsetella rosea* DANA, male (above) and female (below). ×40.
Fig. 6. *Oncaea venusta* PHILIPPI, female. ×40.
Fig. 7. *Corycaeus speciosus* DANA, male. ×40.
Fig. 8. *Oncaea media* GIESBRECHT, female, dorsal and lateral sides. ×40.
Fig. 9. *Limnocaea genuina* KOKUBO female. ×40.

PLATE XVIII

Fig. 1. *Paracalanus parvus* (CLAUS), major form, female, lateral side. ×40.
Fig. 2. *Corycaeus consinnus* DANA, female. ×40.
Fig. 3. *Corycaeus flaccus* GIESBRECHT, female. ×40.
Fig. 4. *Oithona plumifera* BAIRD, female. ×40.
Fig. 5. *Oithona robusta* GIESBRECHT. ×40.
Fig. 6. *Calanus pauper* (GIESBRECHT), female. ×20.
Fig. 7. *Acrocalanus gibber* GIESBRECHT, female. ×20.
Fig. 8. *Setella gracilis* DANA, female. ×40.

PLATE XIX

Fig. 1. *Stegosoma magnum* LANGERHANS. ×40.
Fig. 2. *Oikopleura dioica* FOL. ×40.

Fig. 3. *Oikopleura longicauda* VOGT. ×40.
Fig. 4. *Oikopleura fusiformis* FOL. ×40.
Fig. 5. *Oikopleura rufescens* FOL. ×40.
Fig. 6. *Oikopleura cophocerca* GEGENBAUR. ×40.

PLATE XX

Fig. 1. *Fritillaria tenella* LOHMANN. ×40.
Fig. 2. *Fritillaria borealis* f. *sargassi* (LOHMANN). ×40.
Fig. 3. *Fritillaria haplostoma* FOL. ×40.
Fig. 4. *Fritillaria venusta* LOHMANN. ×40.
Fig. 5. *Fritillaria formica* f. *digitata* LOHMANN & BÜCKMANN. ×40.

PLATE XXI

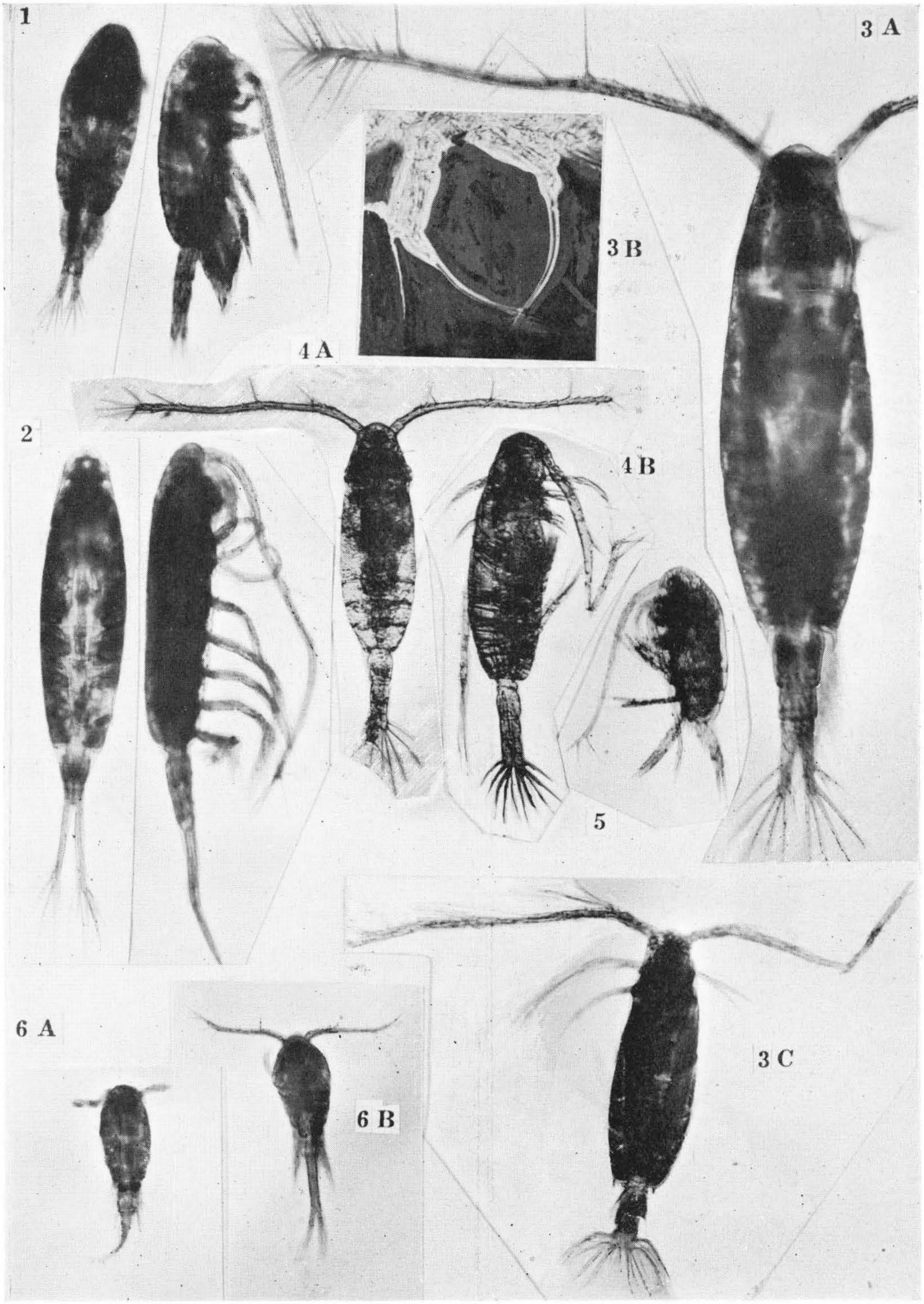
Fig. 1. *Sagitta robusta* DONCASTER. ×12.
Fig. 2. *Sagitta bipunctata* KROHN. ×12.
Fig. 3. *Sagitta serratodentata* KROHN. ×12.
Fig. 4. *Sagitta enflata* GRASSI. ×6.
Fig. 5. *Sagitta delicata* TOKIOKA. ×24.
Fig. 6. *Sagitta minima* GRASSI. ×24.
Fig. 7. *Sagitta crassa* f. *naikaiensis* TOKIOKA. ×24.
Fig. 8. *Sagitta crassa* TOKIOKA. ×12.
Fig. 9. *Sagitta regularis* AIDA. ×12.
Fig. 10. *Sagitta neglecta* AIDA. ×12.
Fig. 11. *Evadne tergestina* CLAUS. ×24.
Fig. 12. *Podon* sp. ×24.
Fig. 13. *Penilia schmackeri* RICHARD. ×24.
Fig. 14. *Evadne nordmanni* LOVEN. ×24.

PLATE XXII

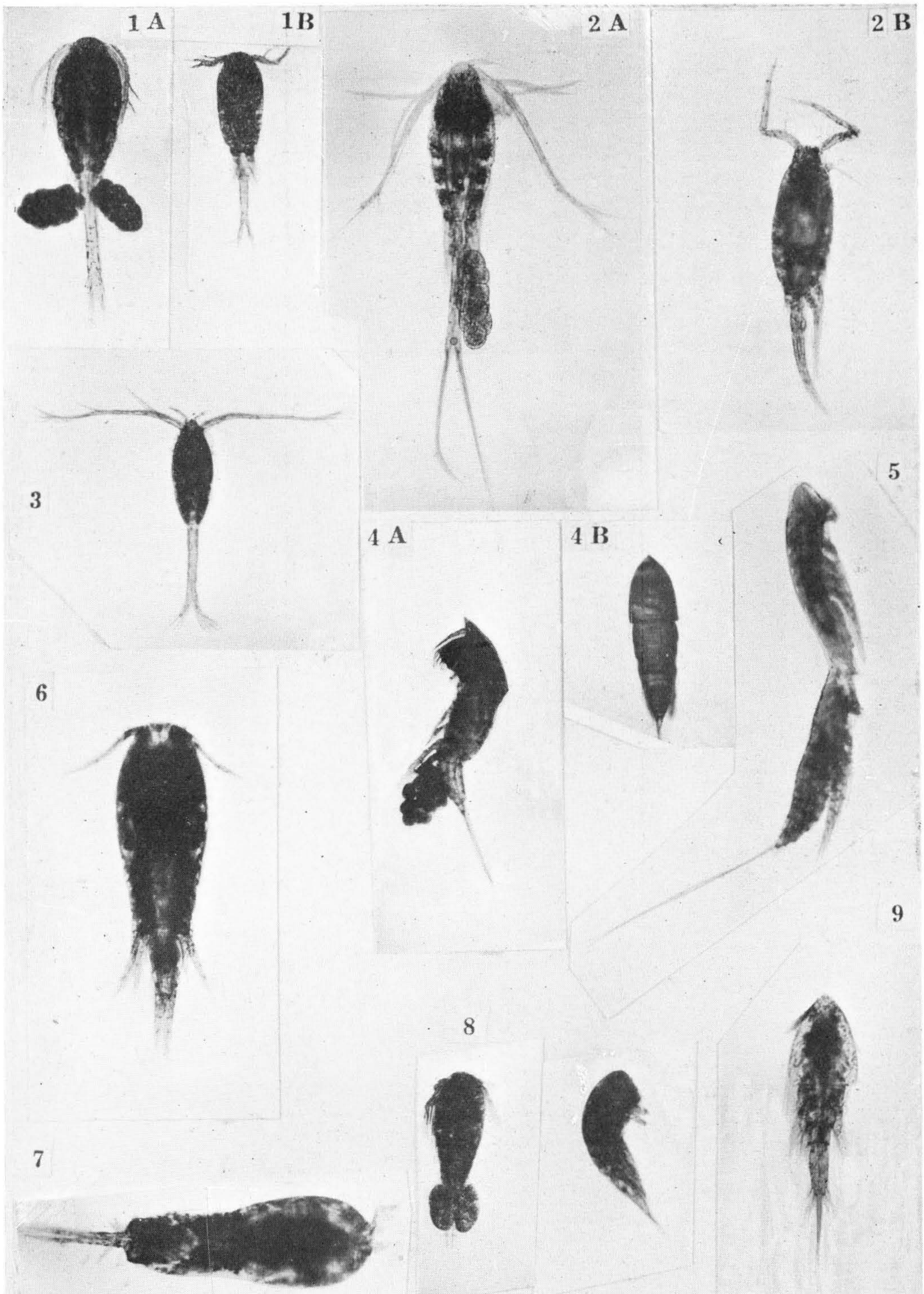
Fig. 1. *Skeletonema costatum* CLEVE. ×240.
Fig. 2. *Leptocylindrus danicus* CLEVE. ×240.
Fig. 3. *Nitzschia seriata* CLEVE. ×240.
Fig. 4. *Thalassionema Nitzschioides* GRUNOW. ×240.
Fig. 5. *Thalassiothrix Frauenfeldii* GRUNOW. ×240.
Fig. 6. *Bacteriastrum hyalinum* LAUDER. ×240.
Fig. 7. *Ditylium Brightwellii* GRUNOW. ×240.
Fig. 8. *Dactyliosolen antarcticus* CASTRACANE. ×240.
Fig. 9. *Eucampia Zoodiacus* EHRENBERG. ×240.
Fig. 10. *Rhizosolenia setigera* BRIGHTWELL. ×240.
Fig. 11. *Biddulphia sinensis* GREVILLE. ×120.

PLATE XXIII

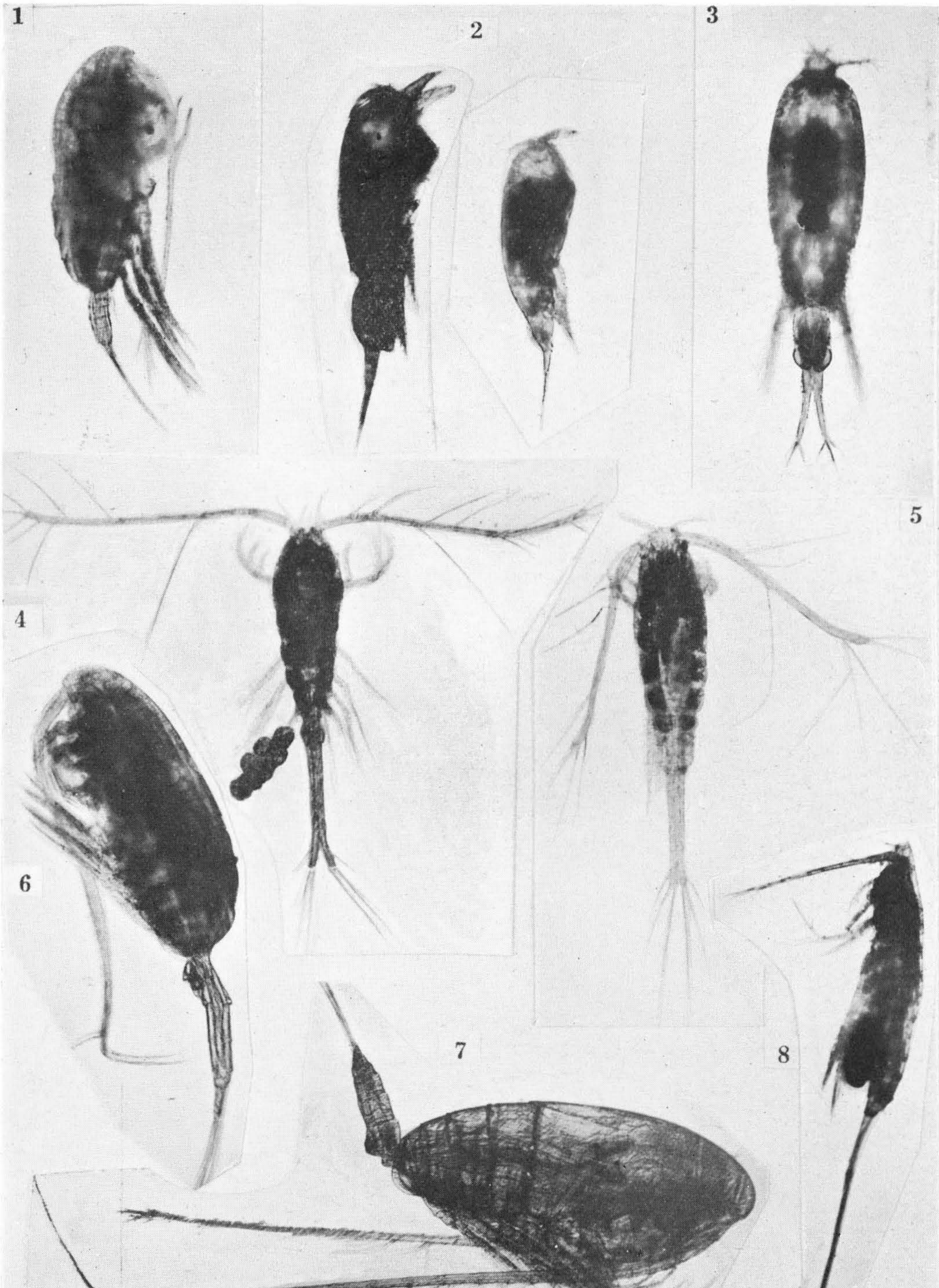
Fig. 1. *Chaetoceros socialis* LAUDER. ×240.
Fig. 2. *Chaetoceros decipiens* CLEVE. ×240.
Fig. 3. *Chaetoceros distans* CLEVE. ×240.
Fig. 4. *Chaetoceros didymus* var. *protuberans* EHRENBERG. ×240.
Fig. 5. *Chaetoceros debilis* CLEVE. ×240.
Fig. 6. *Chaetoceros laciniosus* SCHÜTT. ×240.
Fig. 7. *Chaetoceros curvisetus* CLEVE. ×240.
Fig. 8. *Chaetoceros compressus* LAUDER. ×240.
Fig. 9. *Chaetoceros affinis* LAUDER. ×240.
Fig. 10. *Chaetoceros Van Heurcki* GRAN. ×480.



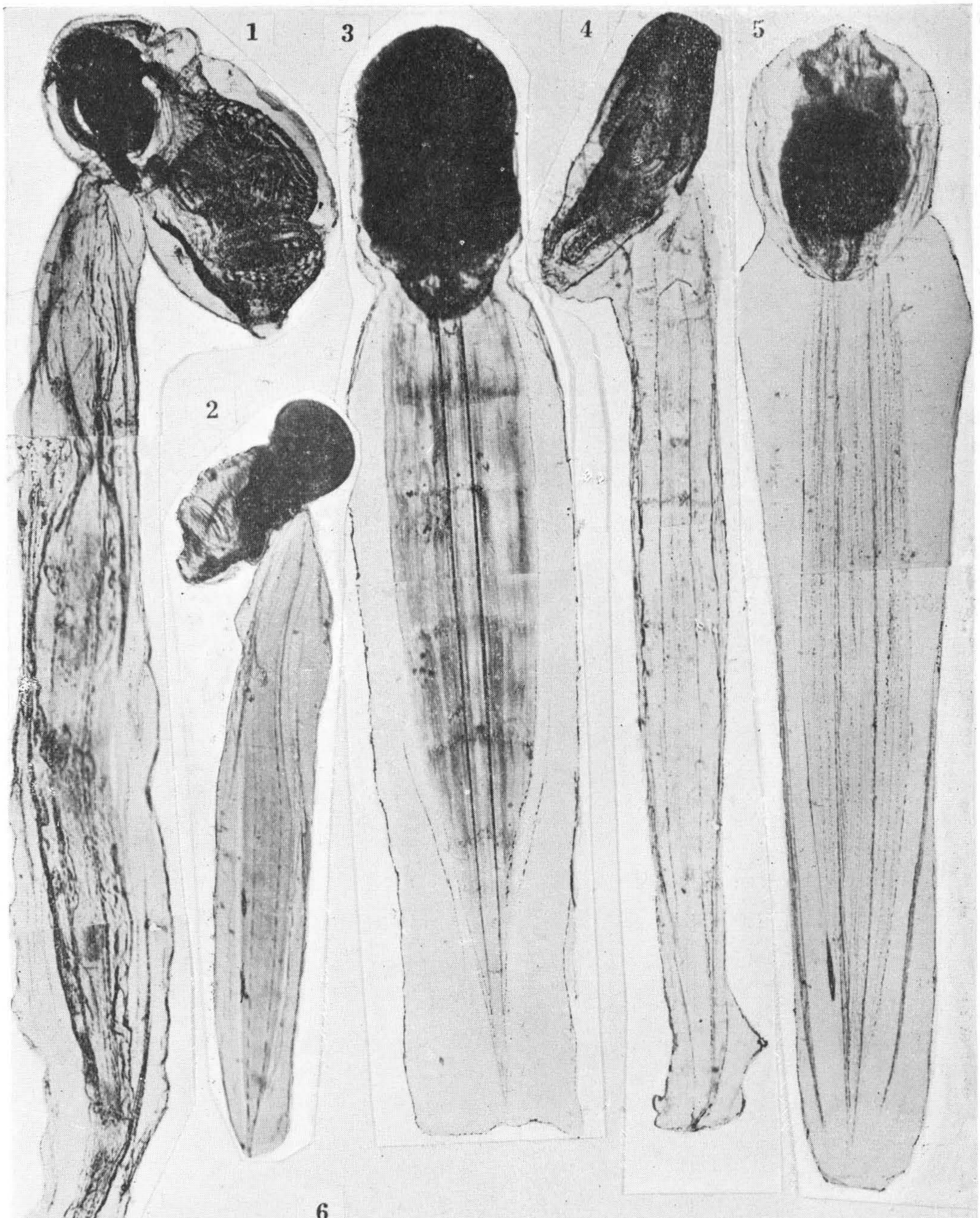
I. YAMAZI: PLANKTON INVESTIGATION IN INLET WATERS, XIX.



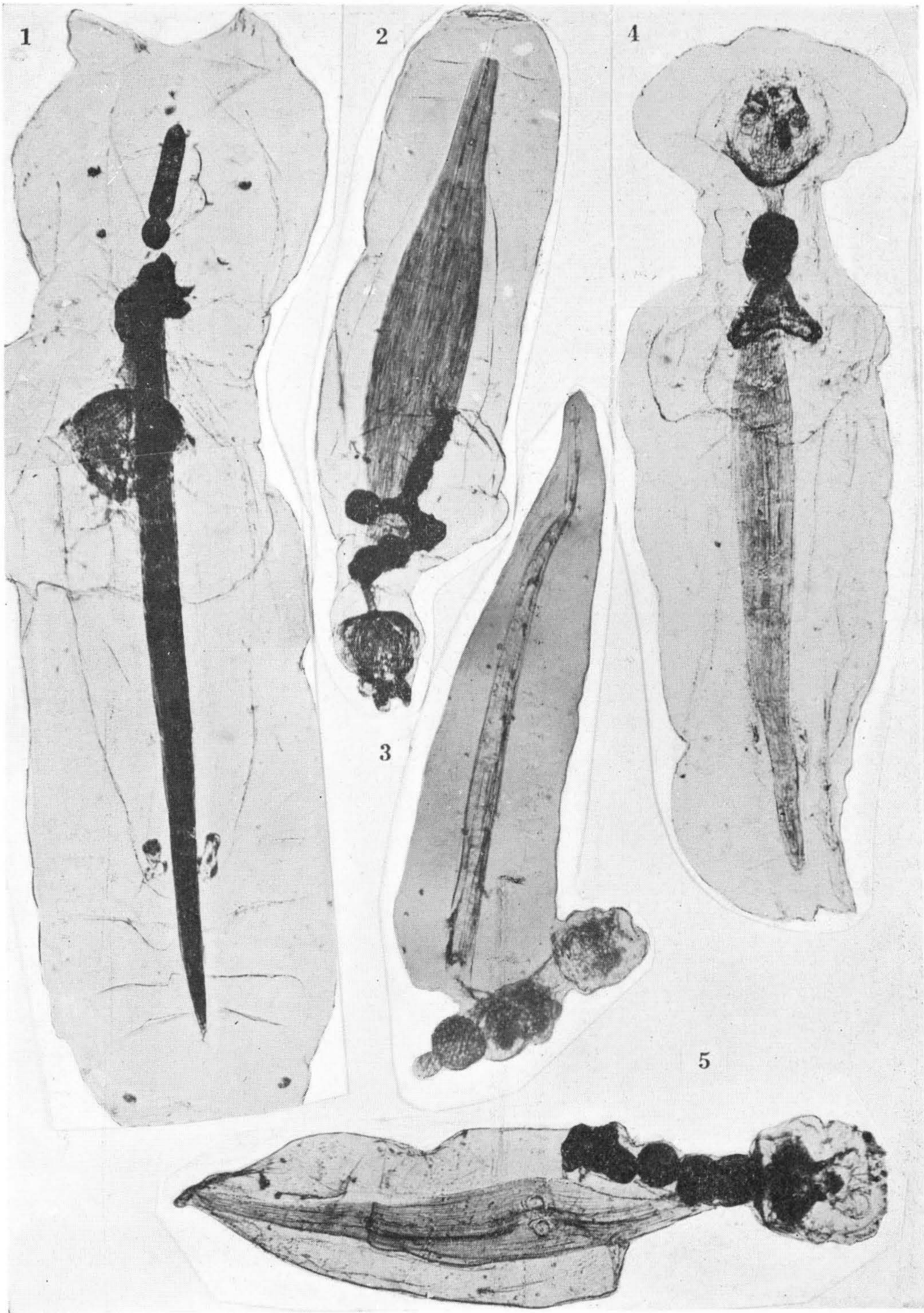
I. Yamazi: Plankton Investigation in Inlet Waters, XIX.



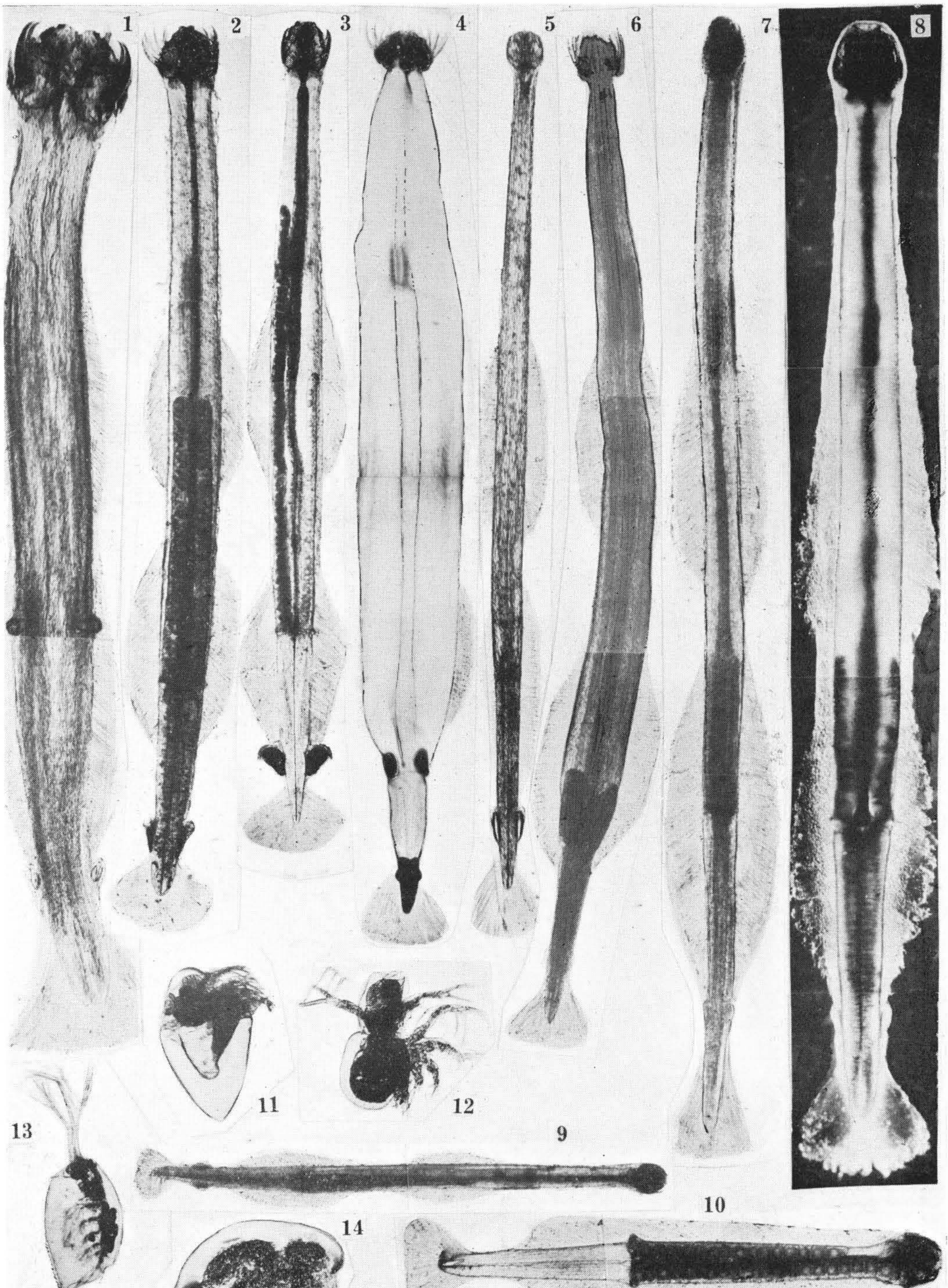
I. YAMAZI: PLANKTON INVESTIGATION IN INLET WATERS, XIX.

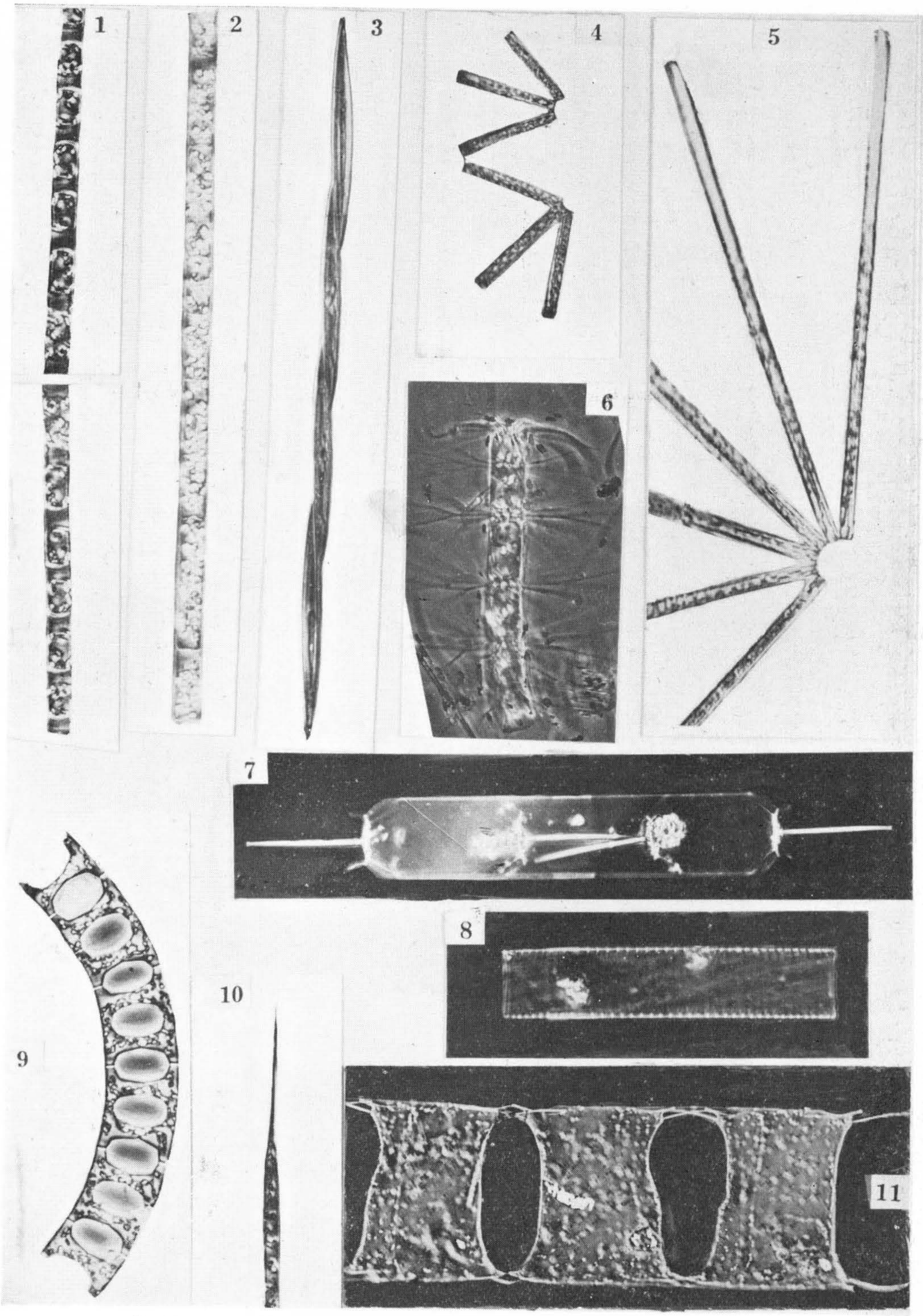


I. YAMAZI: PLANKTON INVESTIGATION IN INLET WATERS, XIX.

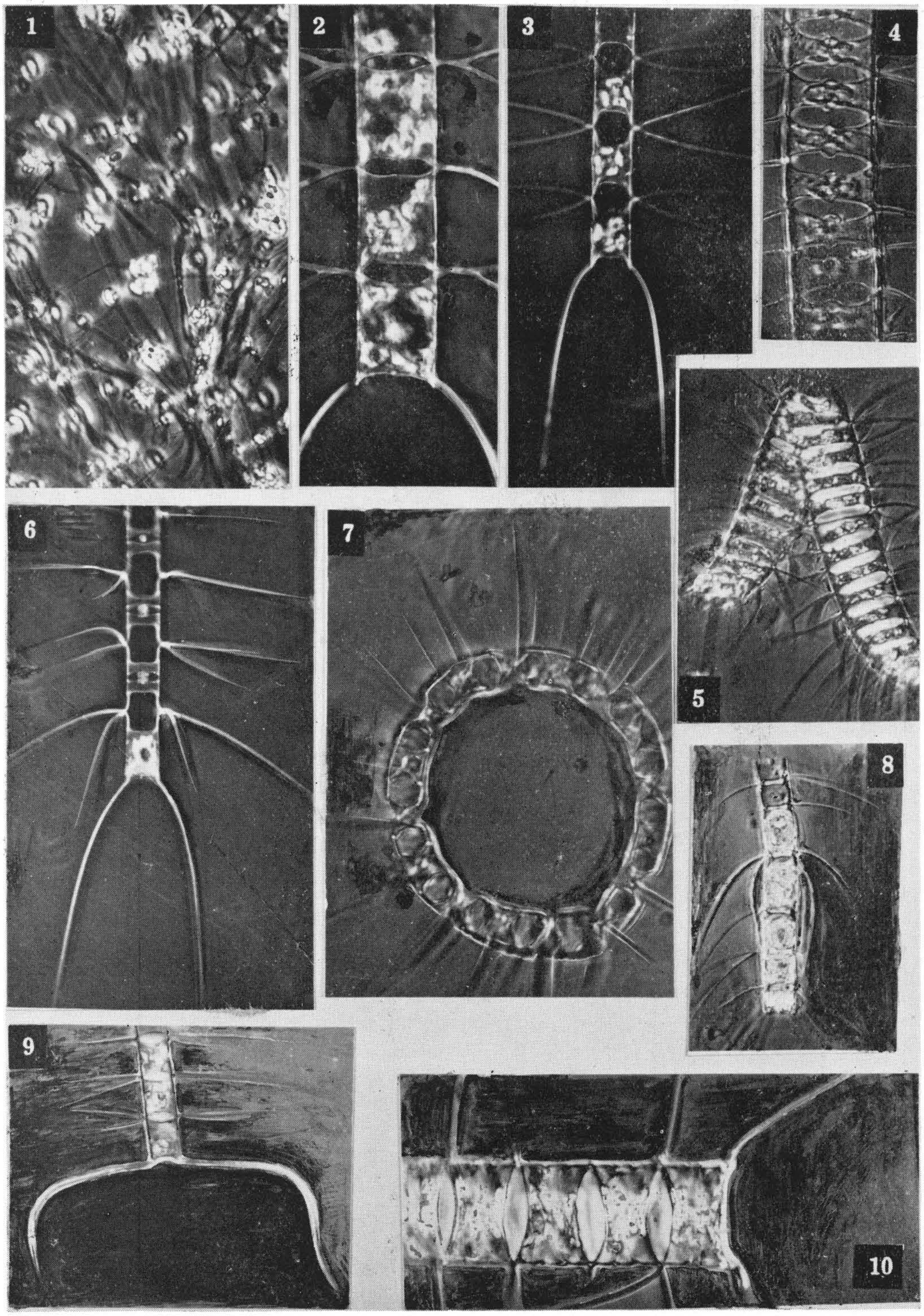


I. YAMAZI: PLANKTON INVESTIGATION IN INLET WATERS, XIX.


1
2
3
4
5
6
7
8
9
10
11
12
13
14



I. YAMAZI: PLANKTON INVESTIGATION IN INLET WATERS, XIX.



I. YAMAZI: PLANKTON INVESTIGATION IN INLET WATERS, XIX.