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Distribution of Benthic Organism and Their Remains at the Entrance of Tokyo Bay, in Relation to Submarine Topography, Sediments and Hydrography[1]

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1) Presented at the *Tenth Pacific Science Congress* of the Pacific Science Association, held at the University of Hawaii, Honolulu, Hawaii, U. S. A., 21 August to 6 September, 1961, and sponsored by the *National Academy of Sciences, Bernice Pauahi Bishop Museum*, and the *University of Hawaii.*

Abstract

The Tokyo Submarine Canyon cuts into the shelf in Uraga Strait which connects Tokyo Bay with the open ocean. The canyon terminates rather abruptly midway in the strait, not reaching the main basin of the bay. The canyon head and the bay are connected by a narrow, corridor-like submarine channel, having a remarkably flat floor. Some 120 dredging stations cover the whole area of the strait together with the bay mouth, ranging from 5 to 600 m in depth, including soft bottom areas within the canyon and on the shelf, and also a few hard bottom areas on the shelf-edge. The distribution of the benthos and their remains is influenced both by the water masses and by the submarine topography. The former affects organisms directly as their surrounding medium, and the latter indirectly through water movements and nature of the bottom.

Within the canyon, deep sea (bathyal) molluscs were found along with numerous ophiurans, indicating the influence of the cold Intermediate Water. Although benthic assemblages of the shelf-edge are similar to those of the canyon in the predominance of ophiurans, they are rather distinguishable from those of both the canyon and the shelf, including several characterizing species. Hard bottom facies was found at a few stations where a strong current might be inferred. Remains of characterizing species of such a habitat was found on a level bottom at the foot of the slope, indicating the transportation of sediments within the canyon.

On the shelf, outer and inner sublittoral regions are recognized, the former being occupied predominantly by polychaetes and pelecypods, and latter by small sized crustaceans. Each region has an individual set of dominant, characteristic and exclusive species. The boundary roughly corresponds to the 20 m isobath, which is also that between silty and clean sand. This is clearly seen on the west side of the strait, where flat plaines of different depths are found, while the boundary is less obvious on the east side, where the bottom deepens gradually and the silt-clay content of the sediment is appreciably higher than at the corresponding depth on the other side.

Within the submarine channel, characterizing species of both the shelf-edge and the outer sublittoral were found together. This habitat is a peculiar region on the shelf, where the oceanic water enters the bay through the submarine channel beneath the coastal water, and the tidal current is also strong. The higher figures in species and individual numbers might be understood as an edge effect in an ecotone in two senses between two sets of major habitats: the deep- and the shallow sea systems on the one hand, the open sea and the enclosed bay on the other.

I. INTRODUCTION

The study of bottom dwellers in the waters surrounding Japanese islands showed a steady progress in its earlier history at the end of the last century, although it was mainly confined to taxonomic works. In the beginning of the 1920's, interests of marine biologists in the bottom fauna provided the impetus for the "Survey of the Continental Shelf Bordering Japan", which was carried out during 1925–1930 on board the research vessel Sôyô-maru (Aikawa, '36). This was a major undertaking, covering an extensive part of Japanese waters. But, on the other hand, the vastness of the surveyed area reduced the number of stations per unit area so that an intensive ecological investigation of a particular region was rather difficult from the data of this survey. It is regrettable that both the taxonomic and ecological studies of the collected materials is incomplete.

From the early 1930's, the study of the bottom fauna has been shared by marine geologists. Among them, Niino ('43, '50, '55, etc.) has dredged extensively in various localities, but his chief interest, besides marine geology, has been the larger and more conspicuous organisms. In 1938, Miyadi ('40, '41a, b, '42, etc.) began an extensive study of marine benthic communities, using a bottom-sampler with a definite opening area. Subsequently, Habe ('52, '56 etc.), G. Yamamoto ('50, '55 etc.) and others also made use of the quantitative methods in the ecological surveys of bottom dwellers. Although the areas they surveyed were numerous, the majority of them were enclosed bays less than 50 m deep, and containing predominantly the coastal water. The ecological investigation of benthos in a particular region, which contains all sorts of habitats from the shallow water to the deep seas bathed in three different waters, coastal, oceanic and intermediate, has remained practically untouched in this country.

In the summer of 1959, the author had an opportunity to work with geologists, dredging in the environment of the Tokyo Submarine Canyon at the entrance of Tokyo Bay. The survey had been planned by Prof. T. Sakamoto and Prof. N. Nasu of the University of Tokyo for the geological investigation of the area, as a part of the "Intensive Research Project for the Fisheries in Yokosuka Region" conducted by the Fisheries Section, Kanagawa Prefectural Office (Yokohama), and carried out both by the Kanagawa Prefectural Fisheries Experimental Station (Misaki) and by the Kanagawa Prefectural Advising Office for Fisheries (Odawara & Kawasaki). Some 120 dredging stations[1], ranging from 5 to 500 m in depth, covered a sufficiently large area to include several sorts of submarine topography, sediments and water masses. The sampling apparatus used mainly in this survey was a kind of drag bucket. Since the scooped sediments were fairly well protected from the washing away of the finer materials, even animals of minute size could be collected, and it was possible to study, at least semiquantitatively, the distribution patterns of animals and the community make-up in terms of percentage of both the total individual number, and the total wet weight of the animals in each haul. The results of two other little surveys, made on the shelf-edge and the slope in this area under the direction of Prof. H. Niino of the Tokyo University of Fisheries, are also discussed.

In a previous paper (Horikoshi, '57), the author attempted to give a tentative causal explanation for the distribution of the molluscan assemblages in Sagami Bay and its adjacent waters, discriminating in different habitat types from the bay head to the open ocean, as well as from shallow water to deep seas, in relation to the submarine topography, the sediments and the hydrography. From the results of the present survey, the area covered by which lies in the closest contact with Sagami Bay, it becomes possible to describe in more detail the faunas and facies concerning all the animal groups of benthos except micro-organisms[2]. Recently, the author has discussed the topographical aspects of the study on bottom fauna ('60a), and has commented that the bottom configulation exerts strong influence on the distribution of benthos through the sediments and the movement of water. To know the topographical situation of each dredging station of the present survey, a detailed chart showing the submarine topography was contoured by the author from sixteen original survey sheets made by the Hydrographic Division, Maritime Safety Bureau,

1) Based on the materials of this dredging operation, cooperative geological and biological studies were made. A series of papers (in Japanese with English abstract), in which the outlines of these studies as well as the hydrography of the surveyed area are mentioned, has been prepared under a common subtitle of the "Cooperative Survey at the Entrance of Tokyo Bay in 1959". These papers are now in press, and will appear in the Journal of the Oceanographical Society of Japan, The 20th Anniversary Volume, 1962. The title and authors are as follows: I. General aspect of the cooperative survey (T. Sakamoto & N. Nasu); II. Submarine topography (N. Nasu, H. Kagami & M. Horikoshi); III. Hydrography (S. Koganéi & M. Horikoshi); IV. Submarine geology (N. Nasu, H. Kagami & J. Chûjô); V. Modal size distribution of the bottom sediments and the depositional conditions (H. Kagami); VI. Clay minerals in the sediments (K. Oinuma & K. Kobayashi); VII. Distribution of benthic animals and their remains (M. Horikoshi).

The 3rd and the last articles, together with a part of the 2nd, are the summaries of the present paper. The details of the 5th article have already been published (in English; see reference).

2) Studies on foraminifers (by Dr. T. Uchio) and ostracods (by Dr. T. Hanai) are in progress.

Japan (Tokyo), and the sedimentary data were compiled on the same chart from the bottom notations in the same original sheets. From the results of the "mechanical analysis" of the sediment obtained by Prof. N. Nasu and Dr. H. Kagami of the University of Tokyo, cumulative curves of grain size distribution were drawn by the author. These curves were studied as an indicator of the physical environments. To know the submarine climate in different habitats, the hydrographical data were analysed. These data had been obtained from the observations at the fixed stations surveyed by the Research and Survey Section of the Kanagawa Pref. Fishr. Exp. St. during 1958–1961 under the direction of Mr. S. Koganéi. Trying to bring all these into a coherent body, the author has intended in this paper to formulate what might be called a "*biological oceanography of the sea floor*". In the same time, an effort has been made to establish a sound base-line for the future ecological surveys, in which a collecting device with a definite opening will be used to permit a full quantitative analysis of the samples.

Acknowledgements

The author takes this opportunity to express his deepest gratitude to Professor Fuyuji Takai of the Gelogical Institute, University of Tokyo, Professor Kiyoshi Takewaki of the Zoological Institute, University of Tokyo and Professor Ichirô Tomiyama, Director of the Misaki Marine Biological Station, for their continuous encouragement and criticism of the manuscript.

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II. PHYSICAL ENVIRONMENT

A. General Description of Tokyo Bay and Uraga Strait

Tokyo Bay is situated in the central part of the Japanese main island, Honshû, on its Pacific side. The bay is enclosed by two peninsulas, the Miura Peninsula on the west, and the Bôsô Peninsula on the east. It is connected with an open ocean at the mouth of Sagami Bay by a narrow strip of water, Uraga Strait (Fig. 1).

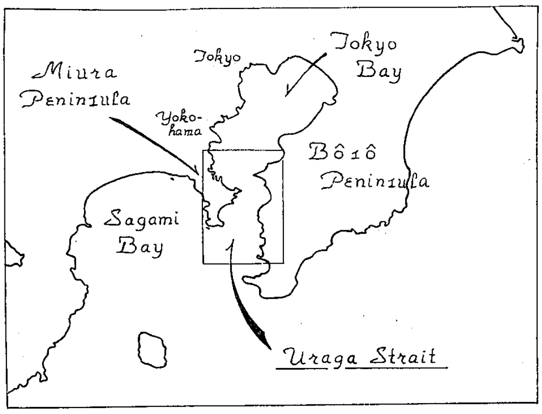

Fig. 1. Sketch map showing the surveyed area at the entrance of Tokyo Bay.

A hidden gorge, well-known as the Tokyo Submarine Canyon, cuts deeply into the shelf in the strait (Fig. 2; see also Attached Chart). It starts from the eastern rim of the main basin of Sagami Bay[1)] at the south of the Miura Peninsula (1,000 m in depth), goes around the south-eastern tip of the peninsula (800–600 m), and then comes into the strait in between the Miura and Bôsô Peninsulas (500–400 m). The canyon does not reach the main basin of Tokyo Bay, and terminates rather abruptly midway in the strait, where it gets narrower and shallower (300–100 m).

1) Shepard, F. P., '48, pp. 218–220, fig. 74; Mogi, A. '55, '58; Horikoshi '57, fig. 1. chart I.

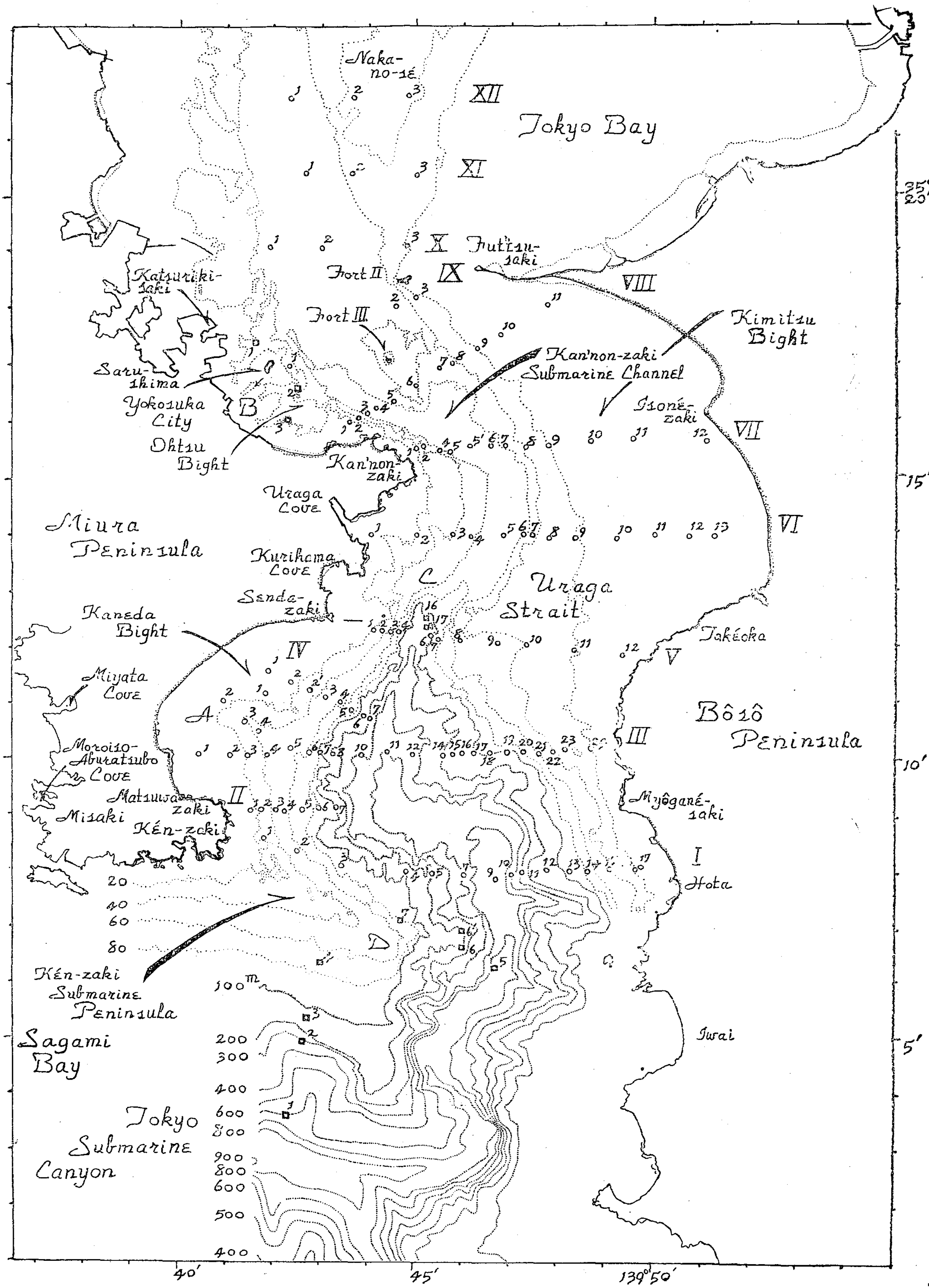

Fig. 2. Locations of dredging stations. Circles: drag bucket; rectangles: Niino dredge.

The canyon head and the bay are connected by a narrow corridor-like underwater ditch, which has a remarkably flat floor (ca. 80 m). It runs along the western quarter of the strait, and turns around an eastward protrusion of the Miura Peninsula, coming nearest to the coast line at the cape of Kan'non-zaki. A new name "*Kan'non-zaki Submarine Channel*" is proposed here for this peculiar submarine topography.

The main basin of Tokyo Bay is said to be restricted by a line drawn between two capes, Katsuriki-saki on the Miura Peninsula (Yokosuka) and Fut'tsu-saki on the Bôsô Peninsula (Suda et al., '31; Takagi, '58). It is fairly large among the enclosed bays in Japan (1,187 km^2), while its depth dose not exceed 50 m. Tokyo, Yokohama and other cities, which stand upon the northern and the western border of the bay, pour their sewage into the basin, partly enriching and partly polluting the water.

B. Submarine Topography and Sediments

Tokyo Submarine Canyon: Prior to a description of the canyon, it will be necessary to refer to a submarine peninsula which separates the inner part of the canyon from the outer. The submarine peninsula extends south-eastward from the southeastern corner of the Miura Peninsula. Since this is also hitherto unnamed, although several reefs on its top have their own names, a new name "*Ken-zaki Submarine Peninsula*" is proposed after the name of a promontory on the southeastern extremity of the Miura Peninsula.

Between the truncated tip of the submarine peninsula and the shelf along the Bôsô Peninsula, the canyon runs in a sinuous course. The floor of the canyon is filled with muddy sediment, and is flat even in the area where it is narrowed by the submarine peninsula[1] as well as in the inner part (Attached Chart). The western canyon-wall of the inner part is rather precipitous with rock exposures and gravelly bottom areas, while the more gently sloping eastern wall is

1) It is interesting to find a sandy belt across the canyon in a place where the canyon-walls approach each other more than elsewhere right under St. D-6 (Attached Chart & Fig. 25a-Profile-D (upper)). There is no available data to determine whether the convergence of tidal currents, or the oscillatory movement of bottom water at a node of an internal wave within the canyon, or both, is responsible. An example of coarser sediments found at the nodes of an internal wave within an embayment was described by Revelle ('39) and Munk ('41) from the Gulf of California. An isolated coarse-sedimented area with a benthic community indicating the water movement was reported by the author from Moroiso-Aburatsubo Cove (Horikoshi, '55). Unpublished supplementary data indicate that a maximum horizontal velocity near the nodes of a standing wave is responsible for the peculiar distribution of benthic animals as well as that of sediments. A future survey within the canyon on this respect is strongly hoped for.

almost entirely covered with sediments. On the slope of the canyon-wall, the sand content of the sediment is a little higher ("clayey Silt-Sand"), than on the canyon-floor (" clay-sandy Silt ")[1] although a fine-grained sediment similar to that of the floor is found within an embayment on the western wall (Sts. III–8, 10) (Fig. 3).

At its northern-most limit, from a depth of about 400 m, the canyon becomes narrower and shallower rather quickly, losing the flatness of its floor, until it shows a prominent break in slope at the depth of the neighbouring shelf-edge (90–95m : Fig. 5). This suggests that the canyon terminates here in the middle of Uraga Strait, off Kurihama Cove, more abruptly than what would have been expected from an early report (Shepard, '48, pp. 218–220, fig. 74) based on meager sounding data. The canyon-head is constricted by protrusions of the shelf from both sides so that a kind of vestibule is formed.

Shelf-edge: On the west side of the canyon, the shelf-edge is defined more clearly than on the east side by a marked break in slope. It is found at a depth of 105 m outside the submarine peninsula, 100 m inside the submarine peninsula on the west side of the canyon, and 90–95 m on the canyon-head. On the east side, a less conspicuous break in slope seems to be found at a depth around 140 m. The shelf-edge and the marginal area of the shelf around the inner part of the canyon is covered with muddy sediments, mostly of " Silt-Sand ", and in some places with " clayey Silt-Sand ". Gravel is found in several localities, but this is considered by Drs. Nasu & Kagami[2] to be " the sediment of earlier generation " (Shepard, '39, p. 228 ; Revelle & Shepard, '39, pp. 269, 270). There are two rock areas on the shelf-edge, where the rocky bottom is indicated by many bottom notations of " rock ". One area is found on the tip of the submarine peninsula and the other is found on the wall around the canyon head vestibule. In both localities, rock fragments were actually dredged in this survey (Sts. D–6, 6′, C–16, 17). The absence of the mantle of sediment seems to be due to strong currents, the presence of the latter being inferred from the topographical characteristics of the localities, e. g. the exposed tip of the submarine ridge, and a sharp break in slope lying within the course of strong tidal currents, respectively.

Ken-zaki Submarine Peninsula: Although the tip of the submarine peninsula, demarcated by the shelf-edge, is a broad rectangle in outline, the 40 m isobath contour encircles a series of rocky reefs extending from the cape of Ken-zaki as far as the tip of the submarine peninsula in a wedge-like shape. The series of reefs forms a secondary

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1) For the explanation of sediment types, see p. 102.

2) The paper was read at the annual meeting of the Geological Society of Japan (April, 1951 ; Tokyo).

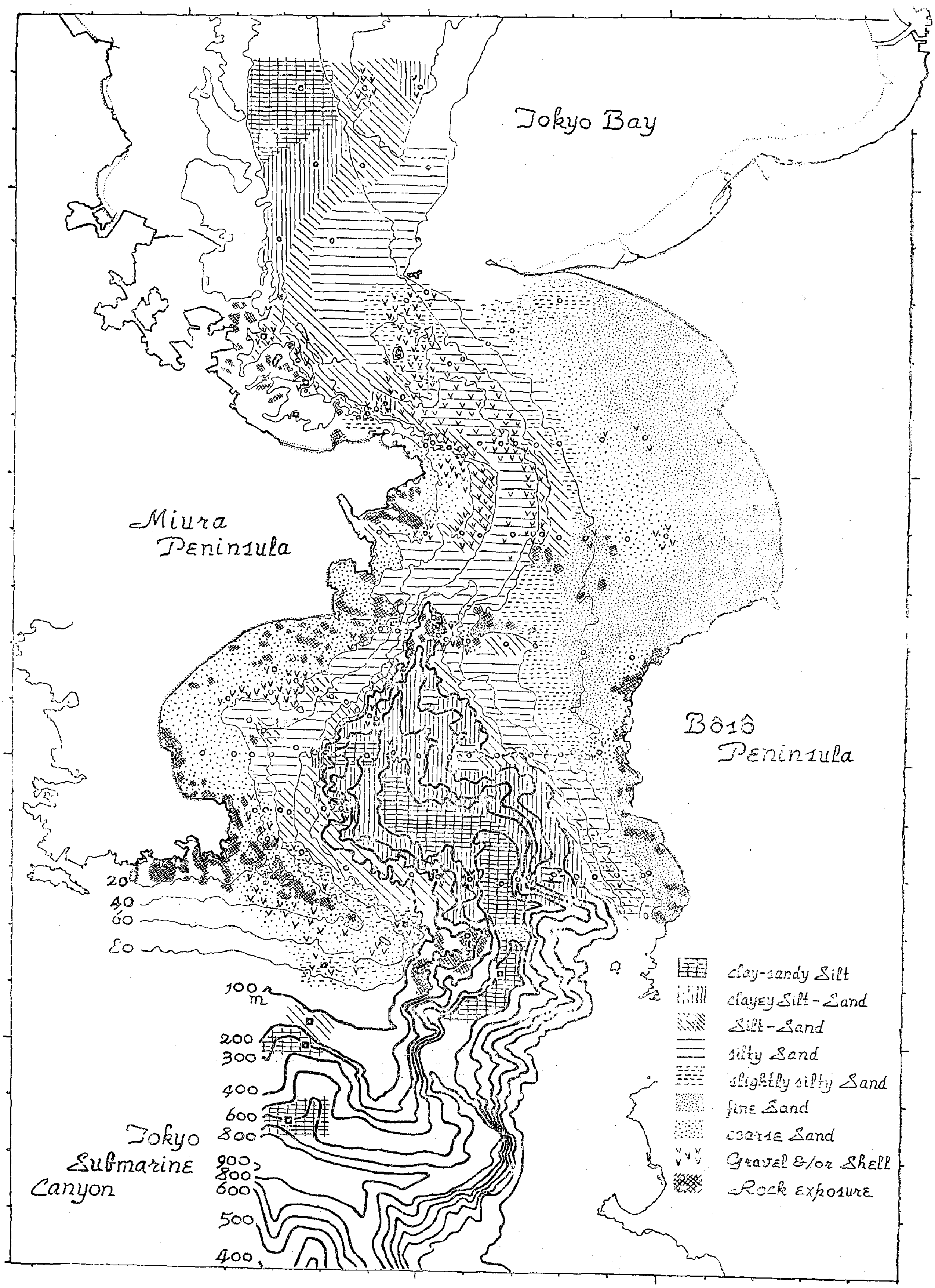


Fig. 3. Distribution of the bottom sediments at the entrance of Tokyo Bay.

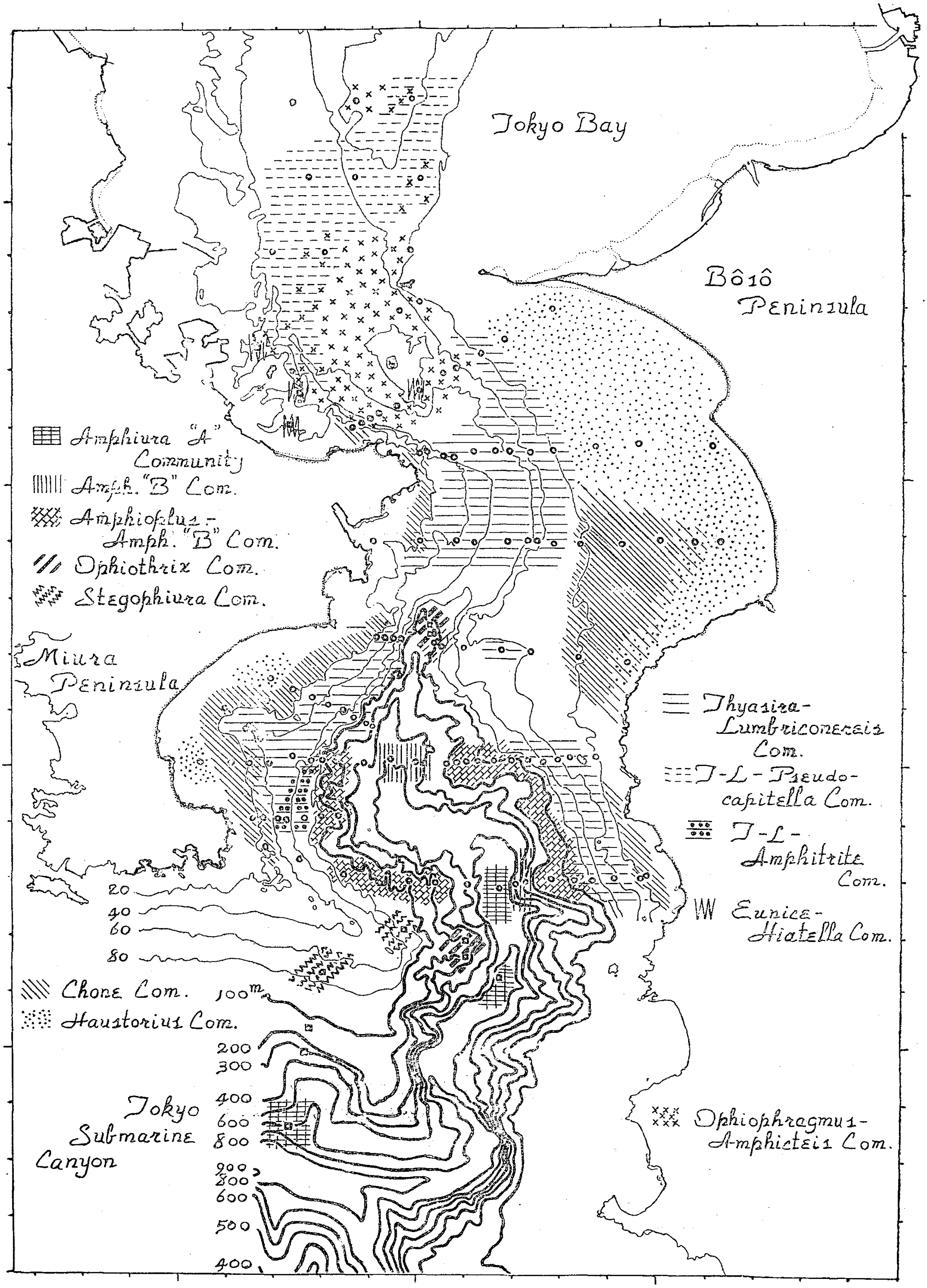


Fig. 4. Distribution of benthic communities at the entrance of Tokyo Bay.

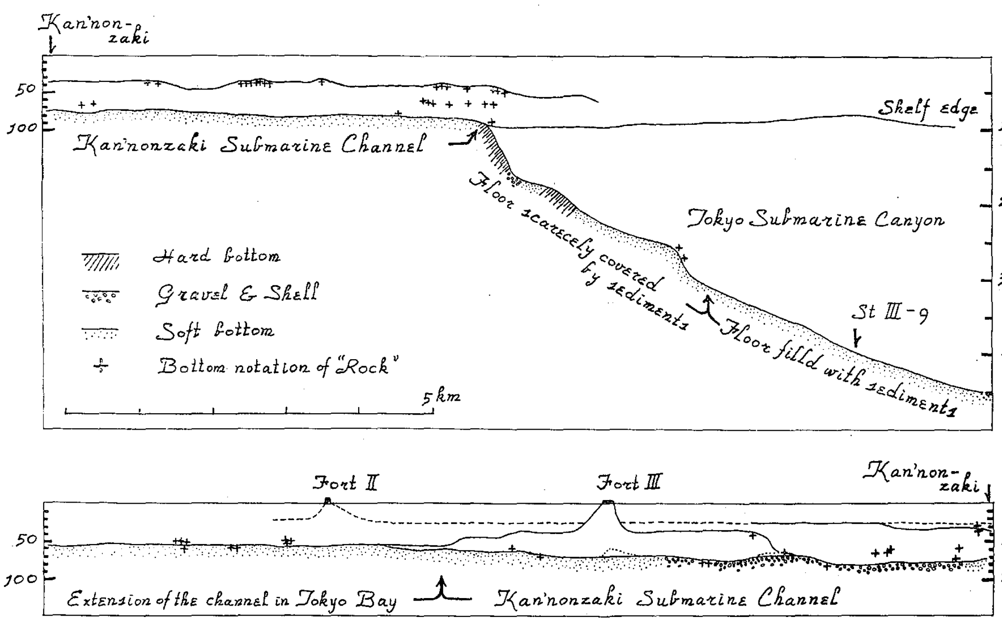


Fig. 5. Projected profiles along Tokyo Submarine Canyon and Kan'non-zaki Submarine Channel. Note a break in slope at the junction of the canyon and the submarine channel; and the remarkably flat floor of the submarine channel.

ridge, dividing the top of the ridge into two parts, the outer and inner flats (fig. 25a-Profile-D(lower)). On the outer flat, which slopes more gently than the inner, the boundary between the finer sediments and the coarse sediment with gravel and shell fragments runs roughly parallel to the direction of the secondary ridge, crossing the iso-bath contours more or less diagonally (Attached Chart). This seems to suggest the influence of the wave and current action against the submarine peninsula[1] on one hand, and the function of the secondary ridge as a natural breakwater on the other. In this connection, it is interesting to find that the sediment in the lower part of the shelf at the protected inner foot of the submarine peninsula is more fine-grained (Sts. II–3∼5) than it is in the corresponding depth of the neighbouring locality.

Shelves bordering the canyon: On the west side of the canyon, the coast line of the Miura Peninsula recedes slightly between two headlands, Matsuwa-zaki on the south and Senda-zaki on the north. Within this embayment, Kaneda Bight, are found two flats of different depths, the upper (2–20 m) and lower (40–50 m), which are covered predominantly with different sorts of sediments, clean sand and silty sand respectively. A small shelf valley notches the upper flat slightly in the central part of the bight. On the upper flat, north of the valley, there are many reefs and several coarse-sedimented areas with gravel and shell fragments. Beyond the margin of the lower flat,

1) A rough sea is actually found in this locality in high southerly wind.

the sea-floor slopes moderately down towards the shelf-edge. The sediment is a little more muddy ("Silt-Sand") than on the lower flat.

On the east side of the canyon, the inclination of the sea-floor atop the shelf is comparatively moderate, and uninterrupted by flats. Although the general pattern of the sediment distribution on the east side is not so different from that on the other side, the sediment from depths below 20 m is more muddy, showing a slightly higher content of silt-clay (Fig. 3), and is more patchy in its distribution pattern (Attached Chart).

Kan'non-zaki Submarine Channel: As already referred to, a corridor-like submerged hollow, Kan'non-zaki Submarine Channel, runs from the canyon-head into Tokyo Bay, scoring the shelf.[1] The channel is divisible into two parts, northern and southern, by a line drawn eastwards from the cape of Kan'non-zaki, at which it shows a sharp bend. In the southern part, it has a remarkably flat floor with a depth of 75–80 m (Fig. 5), bordered by steep sidewalls, and has a practically invariable width of about 1.5 km. Since the upper margins of the side-wall are found in depths of about 40 or 50 m, the channel is entirely submerged. In the north of the cape, it is bifurcated by a bank having a depth of 40 m, which carries an islet, Fort No. 3 (Dai-san Kaiho), in its center. In the south-western main course, the floor of the channel is separated into a few shallow basins by bars lying across the course; while in the north-eastern branch, the channel is interrupted by a sill, the top of which lies at a depth of 45 m, between the bank and the northeastern side-wall of the channel. An extension of the channel, encircled by the 40 m iso-bath contour, runs as far north as off Yokohama, reaching the main basin of Tokyo Bay. The submarine channel, however, loses its peculiar corridor-like feature as it proceeds beyond a line drawn between an island off Yokosuka, Saru-shima, and another islet off the cape of Suno-saki, Fort No. 2 (Dai-ni Kaiho), through the truncated northern end of the bank around Fort No. 3 (Fig. 3; Fig. 25b–Profile-IX).

The sediment within the submarine channel is muddy (silty Sand) except in the northern-most part, where it is still more silt-clayey in the western half, and gravel and shells are found along the side-wall in the southern part of the channel, and are as abundant on the channel-floor around the cape of Kan'non-zaki as they are along the wall and on the bank. In the north of Kan'non-zaki, tho south-

1) The submarine channel seems to be classified into the category of "shelf channel" with other examples like those off Delaware and Chesapeake Bays and off New York (Keunen, '50, p. 481; Shepard, '48, p. 110) Disregarding the difference in dimensions, it is similar to the last, the Hudson Channel, which scores the shelf for a great distance from the head of the Hudson Canyon (Keunen, ibid, figs. 202, 209 & 224).

western side-wall of the channel is straight for some distance, and is so precipitous that it might be called a submerged cliff. Some rock exposures are found on the cliff.

In the north-west of the cape of Kan'non-zaki, the coast line recedes slightly forming an embayment, Ohtsu Bight, in which the bottom configuration is strikingly complicated with banks and shoals. The island of Saru-shima stands on the top of the largest bank in the bight. In the south-east of the bank around Saru-shima, the 30 and 40 m iso-bath contours come into the bight, forming a diverticulum of the submarine channel. The bank around Saru-shima seems to be so exposed that it is covered with sandy sediment only, while on the other banks and shoals, muddy sediments are also found (Attached Chart).

Shallow flat in Kimitsu Bight: Along the coast of the Bôsô Peninsula, the shallow flat less than 20 m deep is comparatively narrow in the southern part of the surveyed area, while it occupies a broad area between the submarine channel and the slightly receding coast line from Takéoka on the south and the cape of Fut'tsu-saki on the north. This embayment between Takéoka and Fut'tsu-saki was named Kimitsu Bight by Dr. H. Kagami[1]. In this area, the sea-floor has a very gentle inclination from a depth of 5 to 15 m, beyond which it slopes down to the upper rim of the submarine channel. The sediment is sandy on the flat, and is muddy (silty Sand or slightly silty Sand) on the outer slope.

The sediment in the south of the cape of Fut'tsu-saki is slightly silty even on the flat (Sts. VIII-10, 11), and the sandy sediments is not so clean as it is in the southern part of the area. This is probably caused by a slacking of water movement accompanied by a small eddy seen here, the presence of which is further confirmed by the recovery of the drift bottle (Kubo, '57, fig. 1).

Naka-no-sé, a bank in Tokyo Bay: On the eastern border of the extension of the submarine channel in Tokyo Bay, there stands a bank, Naka-no-sé, having a depth of 18-20 m. It is separated by a narrow elongated hollow containing a small basin about 25 m deep, from the shallow flat less than 20 m deep, which extends towards the center of the bay in the north of the cape of Fut'tsu-saki. On the top, the bank is almost flat except for slight undulations, while it slopes down from the easily recognized margin of the top rather abruptly, especially on the west side. The bank is covered by gravel and muddy sediments containing a fairly large amount of silt-clay

1) Personal information; the name will appear in "Nasu, Kagami & Horikoshi". Co-operative Survey at the Entrance of Tokyo Bay in 1959. II. Submarine Topography (see foot-note on p. 50).

particles. Some fossiliferous rock fragments have been found on the bank (Niino, '43).

In the mouth of Tokyo Bay, the finer sediments tend to be found in the more western and the inner localities. This seems to suggest relationships between the sediments on one hand, and the currents, circulations and tidal currents on the other. As will be mentioned later, a water made turbid by muddy freshwater from run-off flows out of Tokyo Bay along the coast of the Miura Peninsula, while clear oceanic water enters the bay going around the cape of Fut'tsu-saki. Tidal currents are weaker on the western side than on the other.

C. Hydrography

Canyon Water: It was reported (Uda, '37) that, below a water mass of high temperature and high chlorinity (**A**: in Fig. 6), another mass of low temperature (**B**) characterized by a chlorinity minimum at a depth of about 600 m was found in Sagami Bay. The **A** water is derived from the Central Water of the North Pacific brought into Sagami Bay by a branch of the Kuroshio. The **B** water corresponds to what is called the Intermediate Water as distinguished from the

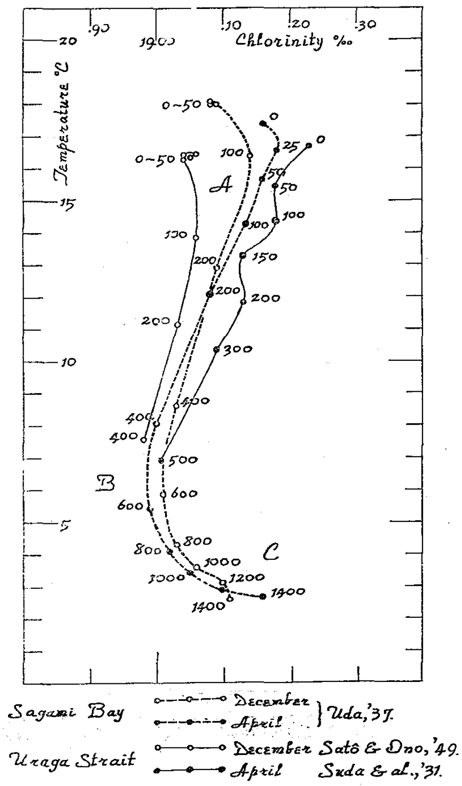


Fig. 6. Temperature-chlorinity curves in Sagami Bay and in Uraga Strait. (Data from Suda et al., '31; Uda, '37; and Satô & Ono, '49.)

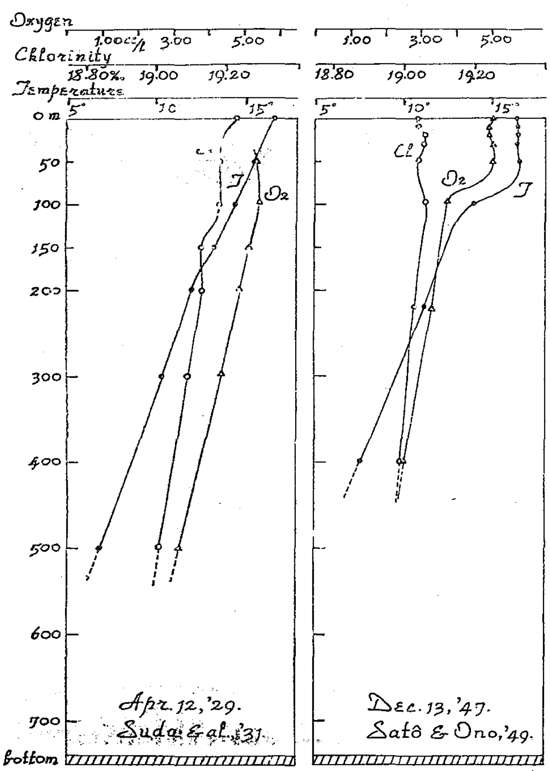


Fig. 7. Vertical distribution of temperature, chlorinity, and O_2 % at the mouth of Uraga Strait. (Data from Suda et al., '31; and Satô & Ono, '49.)

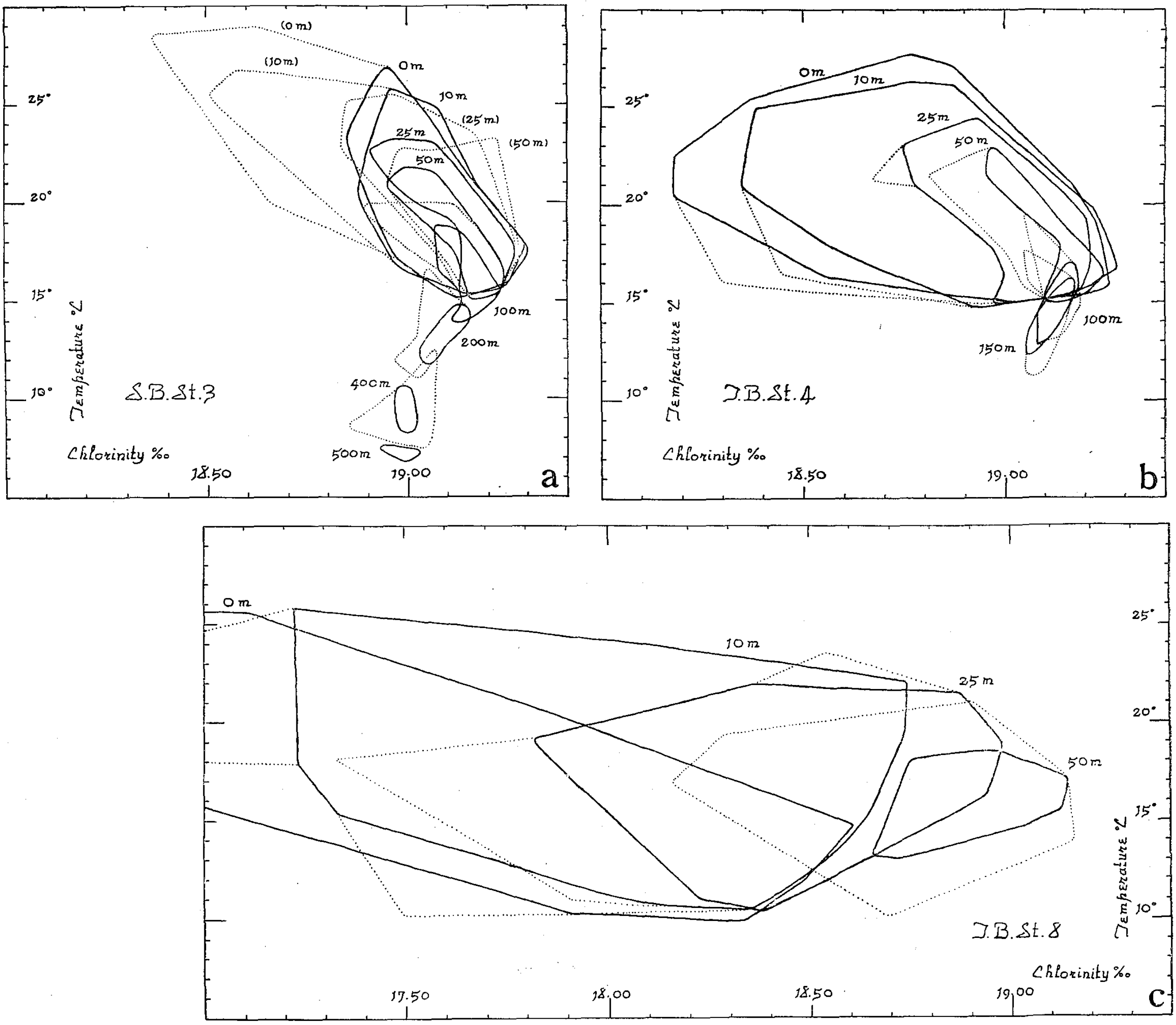


Fig. 8a-c. Submarine climograph at 3 fixed points in Sagami Bay, and in Uraga Strait. Solid lines encircle temperature-chlorinity values at each depth in all seasons of the 4 successive years, 1958-1961; broken lines indicate few anomalous values. a: Sagami Bay St. 3, off Misaki; b: Tokyo Bay St. 4, southeast of Ken-zaki; c: Tokyo Bay St. 8, off Saru-shima.

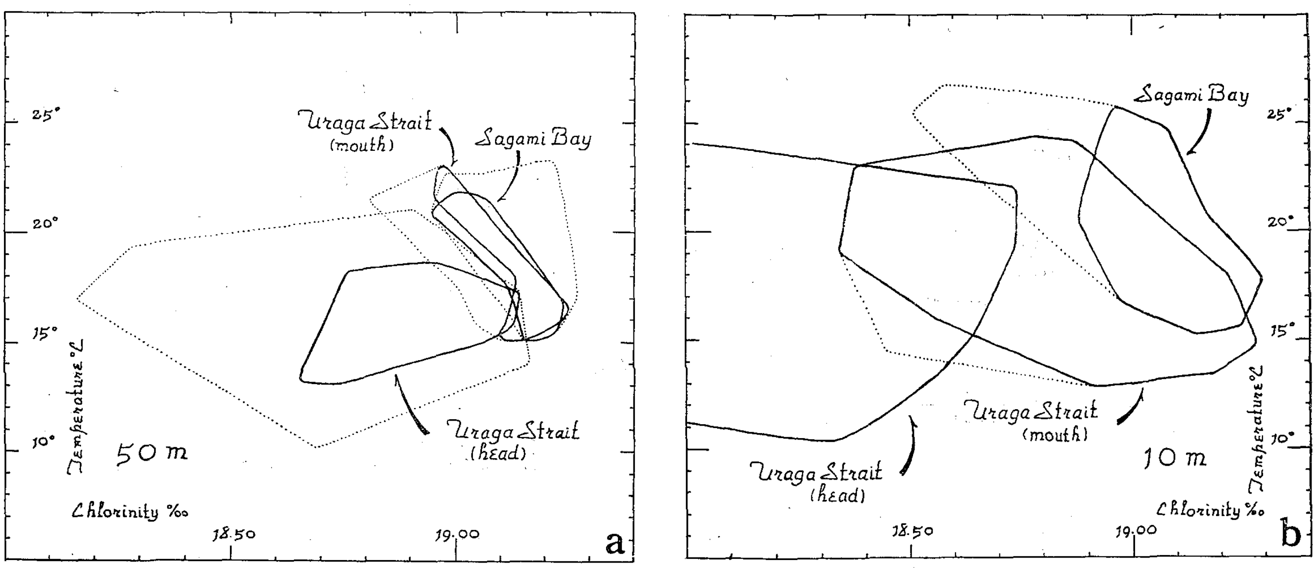


Fig. 9a, b. Submarine climograph at depths of 50 m (a: subsurface layer), and 10 m (b: surface layer), in Sagami Bay, and at the mouth-, and the head of Uraga Strait.

third, the Deep Water (**C**), which occurs in greater depths, and is higher in chlorinity and still lower in temperature.

In the mouth of Uraga Strait, two types of water, upper and lower, can be recognized from the vertical distributions of temperature, chlorinity and saturation percentage of oxygen (Fig. 7). Since a layer of transition between these two waters seems to be found at depths between 100–200 m which roughly corresponds to the depth of the shelf margin, the Tokyo Submarine Canyon is considered to be entirely filled by the lower water. In Fig. 8a, the data obtained from several depths at a fixed station (S. B. St. 3)[1] off Misaki, the southwestern extremity of the Miura Peninsula (Fig. 10), are plotted in relation to temperature and chlorinity. The group of T–Cl values at each depth in all seasons for four years (1958–1961) being encircled by a solid line, with dotted lines indicating the small number of anomalous values found at the several depths. Such a diagram will be called in this paper as a "submarine climograph". From the diagram, it is known that T–Cl relations of the waters below 200 m

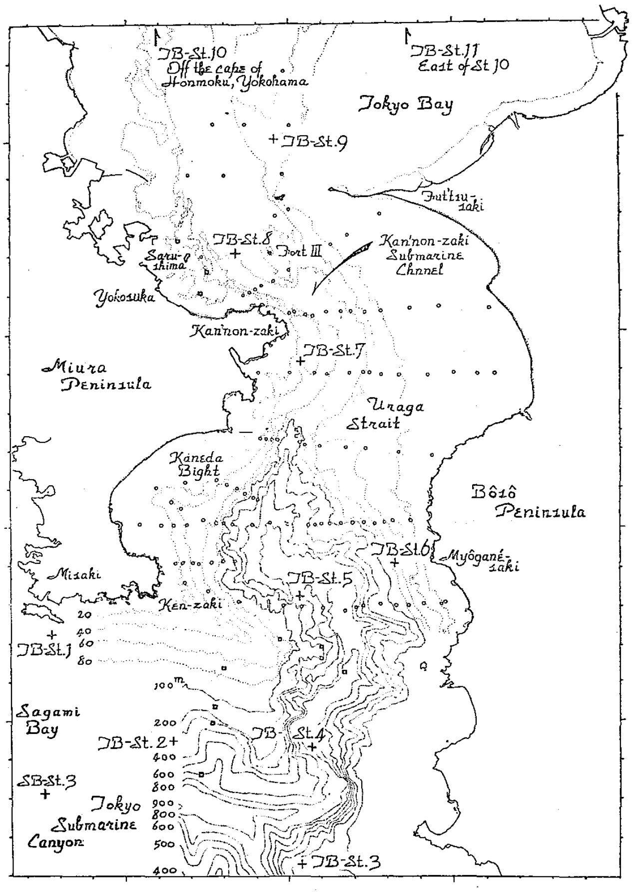


Fig. 10. Locations of hydrographical stations. SB St.=Sagami Bay Station; TB St.=Tokyo Bay Station. TB Sts. 10, 11 are situated outside of this map in the directions of arrows.

1) Sagami Bay Station: Kanagawa Pref. Fisher. Exp. St.

are not only different from those above this depth all the year round, but also show comparatively narrow ranges of variation. Because of the lack of available data, it is still unknown whether there is a chlorinity minium from depths below 500 m, but T–Cl relations at depths within the canyon are quite similar to those at corresponding depths in Sagami Bay (Fig. 6). Hence, it can be understood that the water within the canyon is at least under the influence of the Intermediate Water of the western North Pacific, if indeed it is not this water itself. This cool and less saline water with little seasonal variation can be called here the "Canyon Water".

Oceanic, or Kuroshio Water: Although it seems possible to consider from what was mentioned above that the water atop the shelves in the mouth of Uraga Strait is the "upper water", the season in which the data for Fig. 7 were obtained was the time of convection (winter & early spring), when a rather homogeneous water tended to be seen in the upper 100 or 200 m. In the season of stratification (summer), the matter is somewhat more complicated, since the upper water is divided into two layers, *surface* and *subsurface.* This is clearly seen in Fig. 12e–h, which shows the seasonal variations in the vertical distribution of chlorinity during four successive years observed at a fixed station (T. B. St. 5)[1] east of Kenzaki, the south-eastern extremity of the Miura Peninsula. Disregarding the year to year change in details, waters of low chlorinity always appear in the surface layer during summer and sometimes in winter or spring. In the subsurface layer, there tends to be found a chlorinity maximum at a depth of around 100 m especially in summer season. It is interesting to find that the pattern of variation in the high chlorinity water (shaded in Fig. 12e–h (f, g)) seems to be comparable to that of the Kuroshio Water in an open ocean during summer (Fig. 11: from Suda, '43); the high chlorinity water at the Kenzaki station is known to be derived from the Central Water of the western North Pacific, or the Kuroshio Water in the offing of the Japanese islands. In Sagami Bay and in Uraga Strait, the property of the water has been altered by mixing so that it may not be called precisely the Kuroshio Water. It will be referred to merely as oceanic water, but when necessary, it will be called the "Kuroshio" Water in its restricted sense to indicate

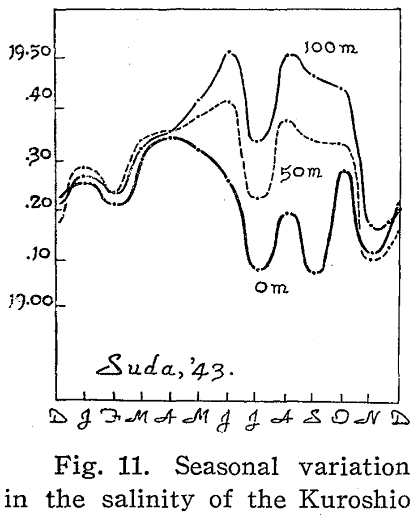


Fig. 11. Seasonal variation in the salinity of the Kuroshio water, off Shio-no-misaki, Kii Peninsula. (From Suda, '43).

1) Tokyo Bay Station: Kanagawa Pref. Fisher. Exp. St.

the source of derivation.

Coastal, or Tokyo Bay Water: In order to understand the properties and their seasonal variation in the surface water at the mouth of Uraga Strait, it is necessary to understand the water in Tokyo Bay proper. One of the outstanding features of the bay is the influx of large quantities of freshwater from run-off and the resulting low chlorinity. According to Suda et al. ('31), the catchment area for the run-off is 9 times greater than the bay itself. This figure is comparatively higher than that of Osaka Bay (8 times) or that of the Inland Sea (2 times). The physiography of the bay, having a bottle-necked mouth, is responsible for emphasis of these hydrographical characteristics. In the time of "*winter-convection*"[1] (Figs. 15 a–b, 16 a–d : both from Suda et al., '31), the colder less saline water within the bay comes into contact with the warmer and more saline water, found in the southern part of Uraga Strait, at a narrow water-way between the capes of Kan'non-zaki and Suno-saki on the head of the strait. In this locality, rather steep horizontal gradients of temperature and chlorinity are found (Suda et al., '31 ; Satô & Ono, '49). In the time of "*summer-stratification*", the warmed, less saline water within the bay flows out rather freely into the strait spreading over the cooler and more saline oceanic water, without showing such a steep gradient (Matida, '50, fig. 2).

At T. B. St. 8, east of the island of Saru-shima off Yokosuka on the head of the strait, the seasonal variation of the surface water, with respect to temperature and chlorinity, is more regular from year to year than in the mouth of the strait. The chlorinity of the surface water is reduced three times a year, slightly in winter, moderately in early summer, and heavily in late summer or early autumn, while the temperature is slightly lower than that of the subsurface water in winter, and is increased during summer. Comparing the climographs of the surface layer (10 m) in the head and the mouth of the strait with that of Sagami Bay (T. B. Sts. 8 & 4 near 5, S. B. St. 3) (Fig. 9b), it can be seen that the water flowing out of Tokyo Bay is quite different from the surface water in Sagami Bay, and that the water in the mouth of the strait shows an influence of the water of Tokyo Bay. The out-flowing water from Tokyo Bay is a kind of coastal water, much influenced by solar-radiations, run-off and the atomosphere (Murray & Hjort, '12, pp. 240–241 ; Moore, '58,

1) More precisely, the water is slightly stratified during the winter (January–March) by means of the chilling from the surface, while in the late autumn (November) and spring (April), it is practically homogeneous from the surface to the bottom. For the sake of simplification, all these seasons are summarized here under a term of the time of "*winter convection*".

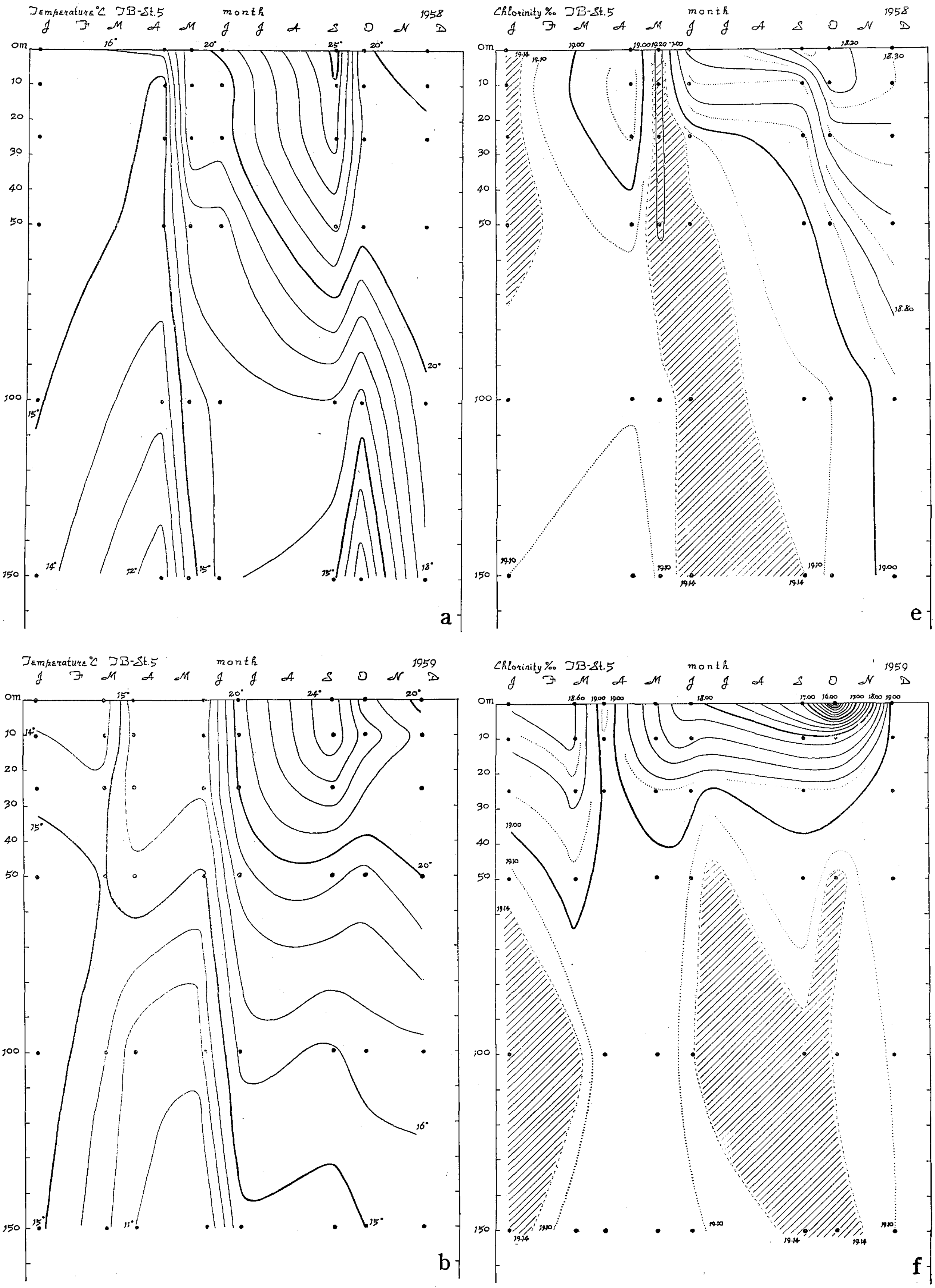
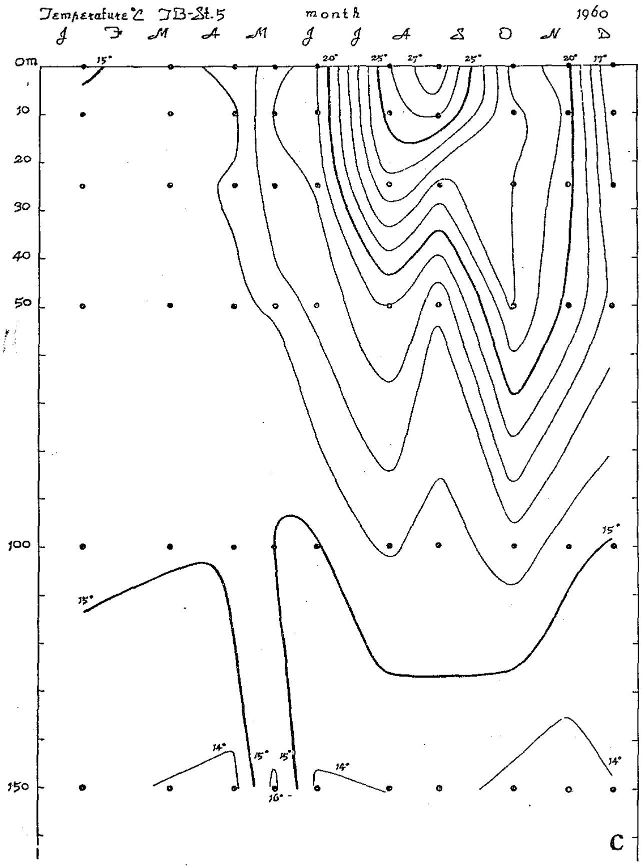
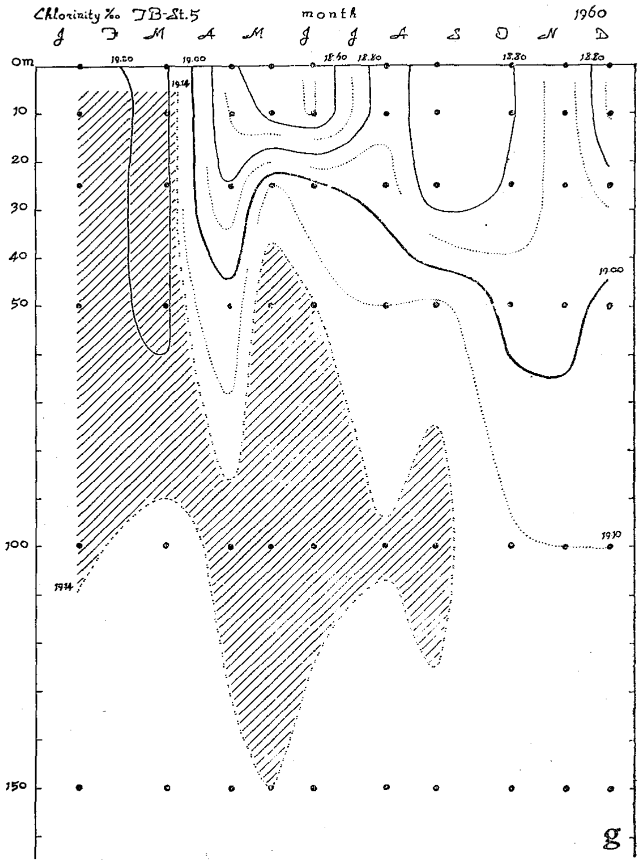
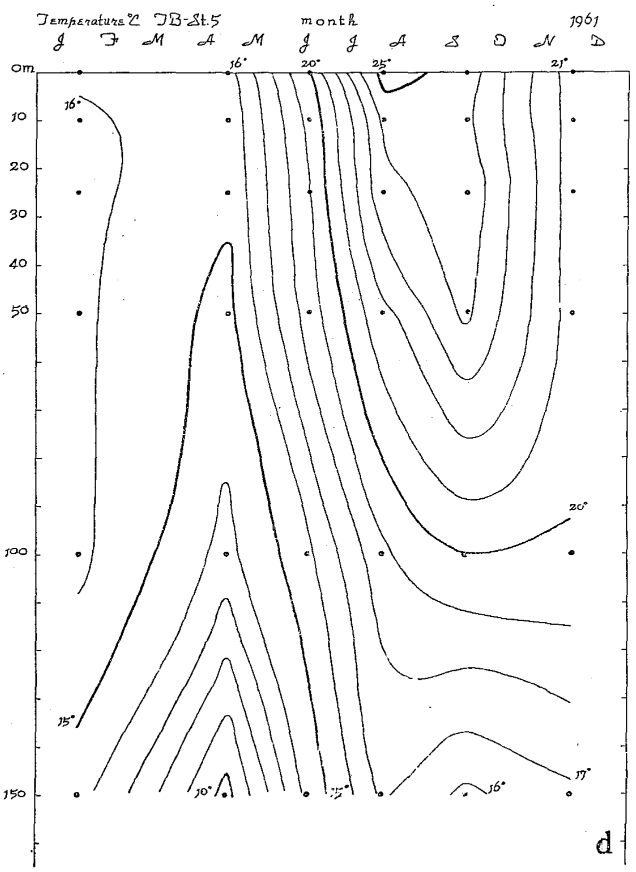


Fig. 12a–h. Seasonal variations in the vertical distributions of temperature (a–d) and chlorinity (e–h) during the 4 successive years, 1958–1961, at the mouth of Uraga Strait (TB St. 5, east of Ken-zaki). (Shaded area: high chlorinity, demarcated arbitrarily by 19.14‰ iso-chlorine).


Temperature °C TB-St.5
month
1960
J F M A M J J A S O N D
0m
10
20
30
40
50
100
150
15°
20°
25°
27°
25°
20°
17°
15°
15°
14°
15°
15°
16°
14°
14°
c


Chlorinity ‰ TB-St.5
month
1960
J F M A M J J A S O N D
0m
10
20
30
40
50
100
150
19.20
19.00
18.60
18.80
18.80
18.80
19.14
19.00
19.10
19.14
g


Temperature °C TB-St.5
month
1961
J F M A M J J A S O N D
0m
10
20
30
40
50
100
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16°
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21°
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20°
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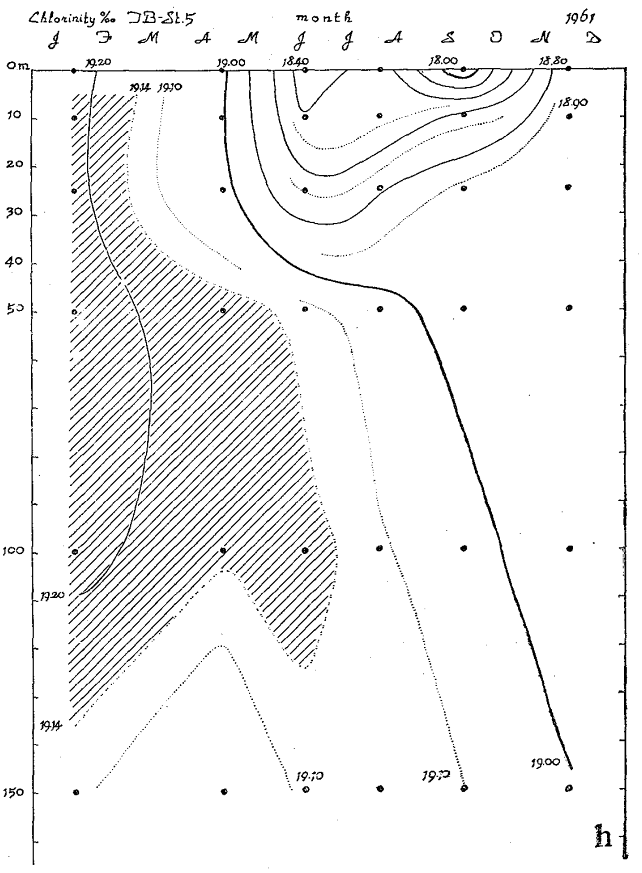
16°
d


Chlorinity ‰ TB-St.5
month
1961
J F M A M J J A S O N D
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19.10
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h

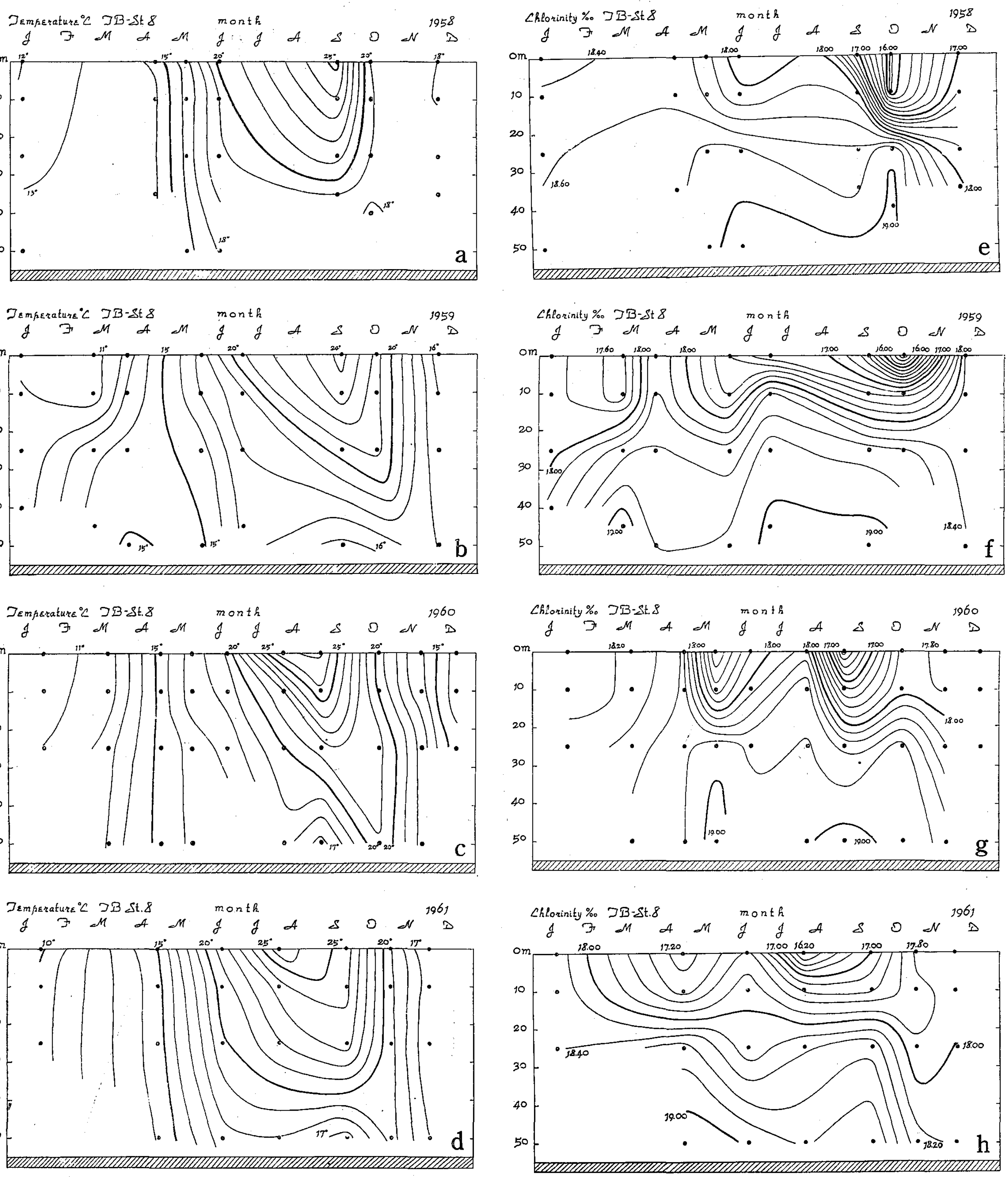


Fig. 13a-h. Seasonal variations of the vertical distributions of temperature (a-d) and chlorinity (e-h) during the 4 successive years, 1958-1961, at the head of Uraga Strait (TB St. 8, between Saru-shima and Fort III).

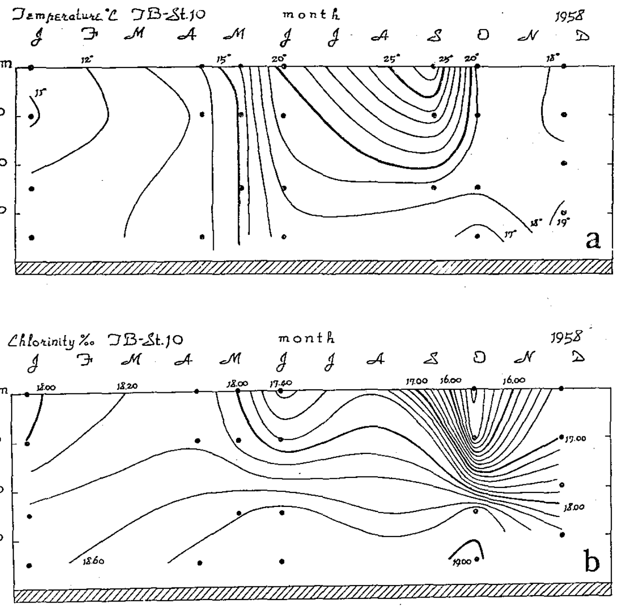


Fig. 14a, b. Seasonal variations of the vertical distributions of temperature (a) and chlorinity (b) in 1958, in Tokyo Bay (TB St. 10, off Honmoku, Yokohama City).

p. 154), and will be called here, after its place of origin, the "Tokyo Bay Water".

Boundary between surface and subsurface waters: It requires only a glance to recognize that the reduction of chlorinity caused by precipitation and especially by run-off is rather suddenly diminished at a depth of about 25 m, on the head of Uraga Strait (Fig. 13e–h) as well as in Tokyo Bay proper (T. B. St. 10 off Honmoku, Yokohama) (Fig. 14b). The effect of heating and chilling at the surface is also somewhat different in the layers above and below this depth (Figs. 13a–d, 14a). On close inspection, it is sometimes found that the chlorinity decreases and temperature increases gradually from the surface to the depth of 25 m; while at other times (Fig. 13, b–Mar., c–Sept., e–Oct., f–Mar. May; Fig. 14, b–Oct.), the water in the upper 10m is practically homogeneous, and the surface and the subsurface waters are separated by a transition layer, within which chlorinity and temperature change so rapidly that the layer has the character of a discontinuity surface. By the term "*depth of the boundary*" is meant in this paper the depth at which surface effects are practically nonexistent, including both cases of gradual and rapid transitions.

In the mouth of Uraga Strait (T. B. Sts. 5, Fig. 12), the boundary can be recognized also around a depth of 25 m. But in this locality, the

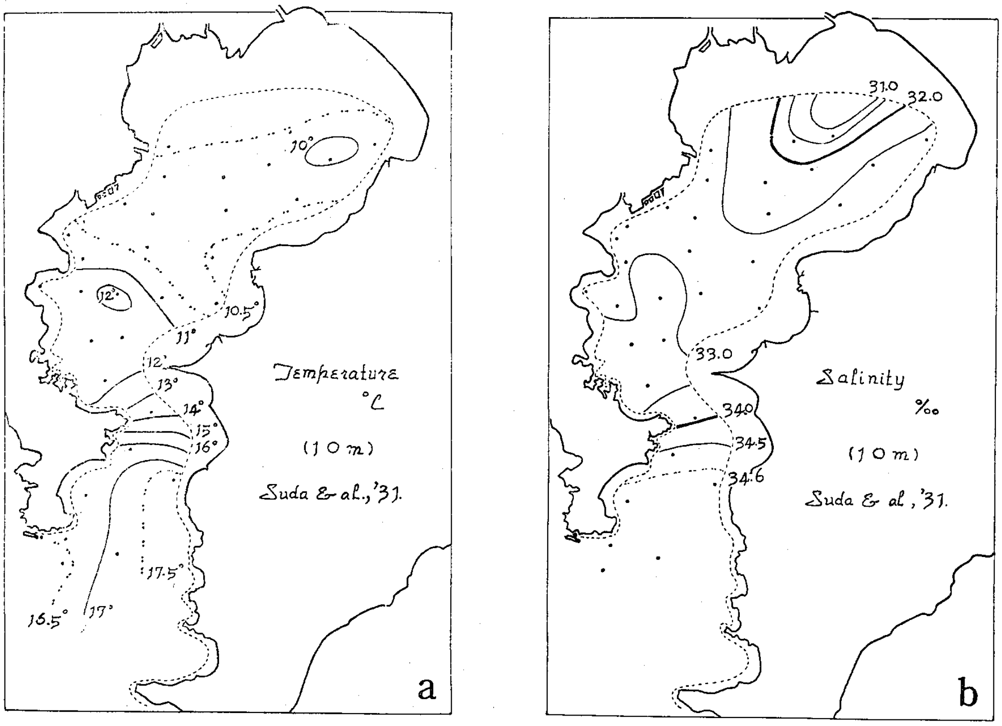


Fig. 15. Distribution of temperature (a) and salinity (b) at a depth of 10 m in Tokyo Bay. Note rather steep gradients found in a narrow water-way betweeen Kan'non-zaki and Fut'tsu-saki. (From Suda et al., '31.)

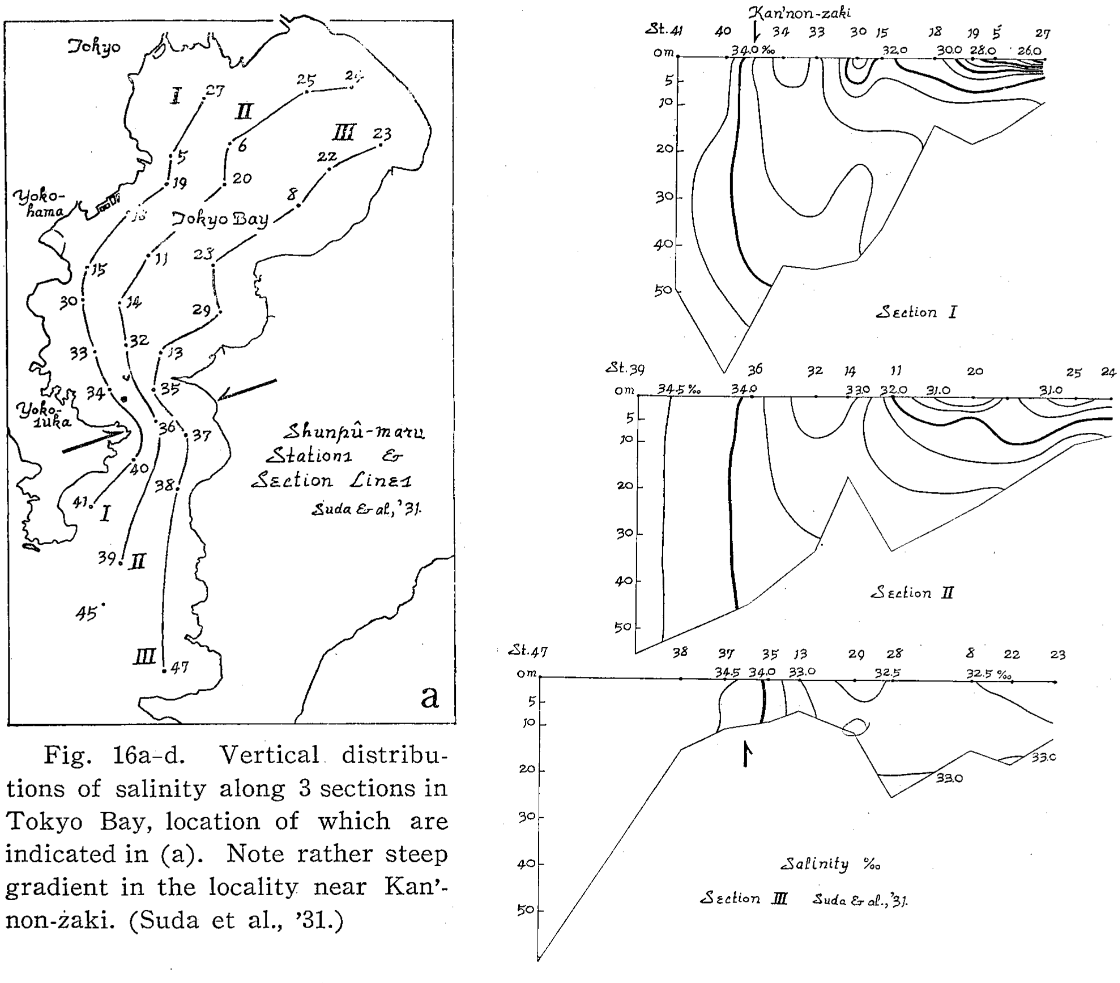


Fig. 16a–d. Vertical distributions of salinity along 3 sections in Tokyo Bay, location of which are indicated in (a). Note rather steep gradient in the locality near Kan'non-zaki. (Suda et al., '31.)

bathimetrical range of the homogeneous water is sometimes extended down to a depth of 25 m (Fig. 12, e–Apr., g–Sept.). Although the irregular and rough intervals of the sampling depths (0, 10, 25, 50 m etc.) does not allow a precise determination of the boundary depth, it can be said that the boundary is situated a little deeper in the mouth of Uraga Strait (25 m or more) than both on the head of the strait and in Tokyo Bay (25 m or less).

Bottom Water in Kan'non-zaki Submarine Channel and in Tokyo Bay: A strong influence of the oceanic water was recognized along the whole area of Kan'non-zaki Submarine Channel, and in some cases even within Tokyo Bay beyond its mouth, based on the distribution pattern of benthos, both living and dead, which will be described subsequently. In spite of this, Suda et al. ('31) and Satô & Ono ('49) suggested only a rather slight indication of the influence along the bottom inside the cape of Kan'non-zaki, but as indicated before, the season of their survey was at the time of "winter-convection". Having analysed the chlorinity data from the fixed stations, it was revealed that, in the time of "summer-stratification", the hydrographical condition of the locality was quite different not only in the upper layer but also in the bottom layer. It is interesting to learn that a discontinuous layer accompanied by an underlying water of oceanic nature was also reported by H. Yamamoto ('58) from a bottle-necked small enclosed bay, Urado Bay, with an excess of run-off. He described the seasonal change of temperature-chlorinity relations in several depths, but did not offer any causal explanation.

Although the seasonal difference in the nature of the subsurface water within the submarine channel, i. e. more oceanic in summer than in winter, can be seen on brief examination of Fig. 13e–h, it is more clearly shown in Fig. 17a–d in which the chlorinity values of both the surface and the subsurface layers at each station are represented on a sketch map of the surveyed area. During "winter" (see sketches for Jan. and Apr.), the subsurface chlorinity values within the submarine channel are lowered in rough proportion to the surface value, while during "summer" (June & Sept.), they show either absence or only a slight sign of reduction in spite of striking decreases of surface chlorinity from the mouth of the strait towards the bay head. At times, strong effects of the oceanic water along the bottom was recognized as far as off Yokohama (Tab. 1: Cct., '58). The difference between waters within the submarine channel and in the mouth of the strait during "winter" is also seen in the submarine climograph of the subsurface water (Fig. 9a).

The seasonal difference in the hydrography of a shallow enclosed bay having a bottle-necked entrance without sill might be summarized

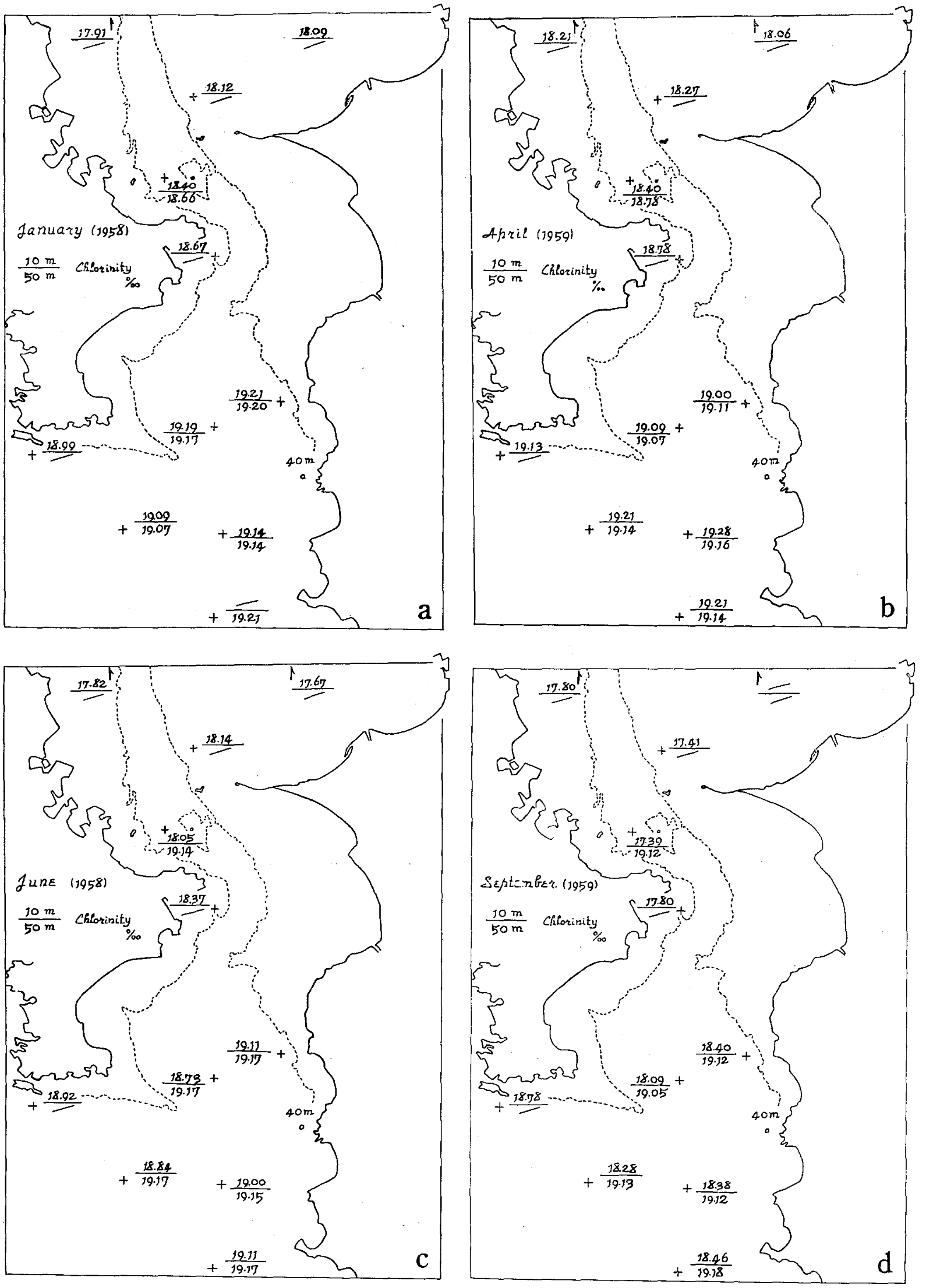


Fig. 17a-d. Distribution of chlorinity in the surface (10 m : above the bar), and the subsurfuce (50 m : below the bar) layers. In the subsurface layer, the chlorinity difference between the mouth and the head of Uraga Strait is very small, or practically non-existent, in the summer season (c: June: d: September), in contrast to the winter season (a: January: b: April).

Table I. Chlorinities in the surface and subsurface layers, in the mouth-(off Myôgané-saki), and on the head (off Saru-shima) of Uraga Strait, and within Tokyo Bay proper (off Hon'moku). In parenthesis, the depths of observation (upper numerals) and sea floor (lower) are indicated.

		off Hon'moku	(chlorinity difference)	off Saru-shima	(chlorinity difference)	off Myôgane-saki
Jan. ('58)	Surface	17.96	(0.31)	18.27	(0.93)	19.20
	10 m	17.97	(0.48)	18.45	(0.76)	19.21
	bottom	18.51 $\left(\frac{35}{40}\text{m}\right)$	(0.15)	18.66 $\left(\frac{50}{55}\text{m}\right)$	(0.57)	19.20 $\left(\frac{50}{70}\text{m}\right)$
Apr. ('59)	Surface	18.15	(0.27)	18.42	(0.61)	19.03
	10 m	18.21	(0.19)	18.40	(0.60)	19.00
	bottom	18.29 $\left(\frac{35}{40}\text{m}\right)$	(0.19)	18.78 $\left(\frac{50}{55}\text{m}\right)$	(0.33)	19.11 $\left(\frac{50}{75}\text{m}\right)$
May ('59)	Surface	17.12	(0.27)	17.39	(0.86)	18.25
	10 m	/		17.61	(0.90)	18.51
	bottom	18.77 $\left(\frac{35}{41}\text{m}\right)$	(0.09)	18.86 $\left(\frac{50}{55}\text{m}\right)$	(0.16)	19.02 $\left(\frac{50}{75}\text{m}\right)$
June ('58)	Surface	17.30	(0.53)	17.83	(0.49)	18.32
	10 m	17.82	(0.23)	18.05	(1.06)	19.11
	bottom	18.94 $\left(\frac{35}{40}\text{m}\right)$	(0.20)	19.14 $\left(\frac{50}{55}\text{m}\right)$	(0.03)	19.17 $\left(\frac{50}{75}\text{m}\right)$
June ('59)	Surface	16.82	(0.32)	17.14	(1.81)	18.95
	10 m	16.88	(1.52)	18.40	(0.71)	19.11
	bottom	18.87 $\left(\frac{35}{42}\text{m}\right)$	(0.16)	19.03 $\left(\frac{45}{50}\text{m}\right)$	(0.13)	19.16 $\left(\frac{50}{60}\text{m}\right)$
Oct. ('58)	Surface	15.17	(0.59)	15.76	(2.39)	18.15
	10 m	15.25	(0.54)	15.79	(2.35)	18.14
	bottom	19.03 $\left(\frac{35}{40}\text{m}\right)$	(0.01)	19.04 $\left(\frac{40}{50}\text{m}\right)$	(−0.07)	18.93 $\left(\frac{50}{75}\text{m}\right)$

diagrammatically as follows (Fig. 18a, b). During the " winter ", when the quantity of the freshwater from run-off is not so great, the water in an enclosed bay is fairly homogeneous in mid-bay (a result of convection) but slightly stratified both in the surface layer on the bay head, and in the bottom layer in the bay mouth ; while the water of an open sea is practically homogeneous, again from convection, which is further promoted by the reduction of flowing out of the low chlorinity water from the bay. The two bodies of water come into contact only in a narrow channel at the entrance of the bay, where rather steep gradients of temperature and chlorinity are found, at least in the upper layer. During the summer, the influx of large quantities of freshwater from run-off lowers the chlorinity of the warmed surface water. In such a stratified condition, a transition layer having the character of a discontinuity surface tends to develop, over which diluted water of the bay flows out to the open sea. The subsurface oceanic water enters far into the bay, perhaps as a compensation current of the out-flow. Thus the exchange of water goes

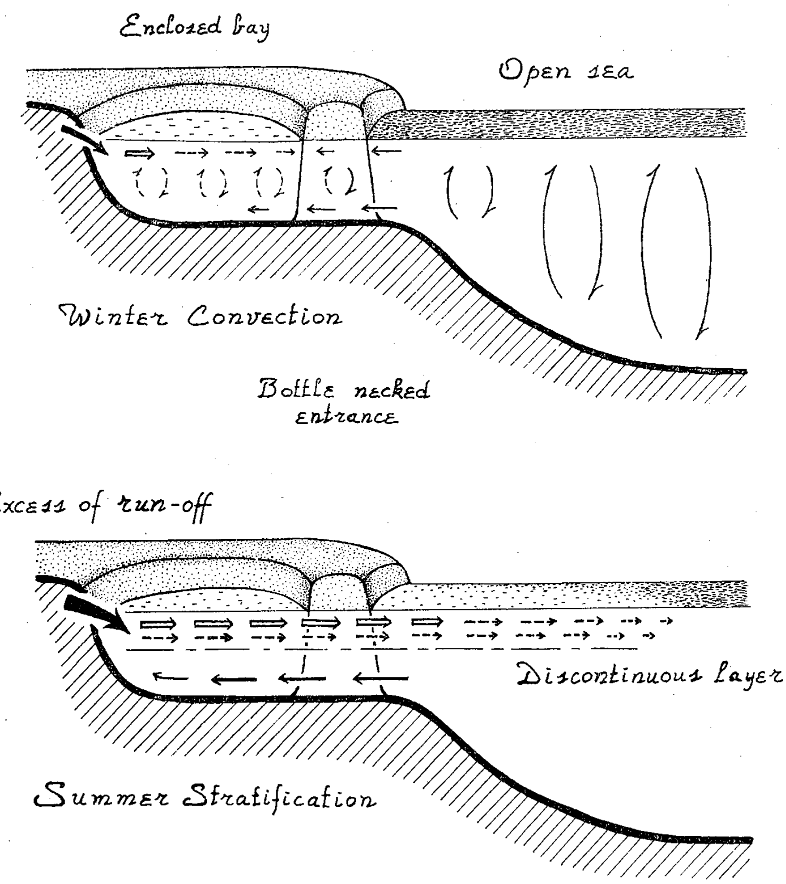


Fig. 18. Diagrammatic representation of the seasonal variation in hydrography of an enclosed bay with a bottle-necked entrance. (Further explanation see text.)

on through the lower depths of the entrance.

Circulations and currents: It seems to be well established that, in Sagami Bay, a branch of the Kuroshio not infrequently sends an off-shoot towards the mouth of Uraga Strait (Uda, '37; Marumo, '50; Kawada, '57). After entering into the south-eastern corner of the strait, an oceanic water, conveyed by such a current, proceeds northwards along the Bôsô Peninsula. This is confirmed by the recovery of the drift bottle (Uda, '37, fig. 11; Kawada & Iwata, '57, fig. 4).

Suda et al. ('31) reported the circulations and the currents within Tokyo Bay in April as follows (Fig. 19a, b: from the same authors). In the surface layer, the oceanic water enters the bay going around the cape of Fut'tsu-saki. It flows along the east side of the bay, and then turns counterclockwise towards the northwest. The coastal water flows southwards along the coasts of Tokyo and Yokohama Cities, being mixed with the oceanic water until it disappears in a locality around the cape of Kan'non-zaki. These two waters make two eddies, in the southern and the northern parts of the bay respectively. At a depth of 10 m, the oceanic water branches out into three

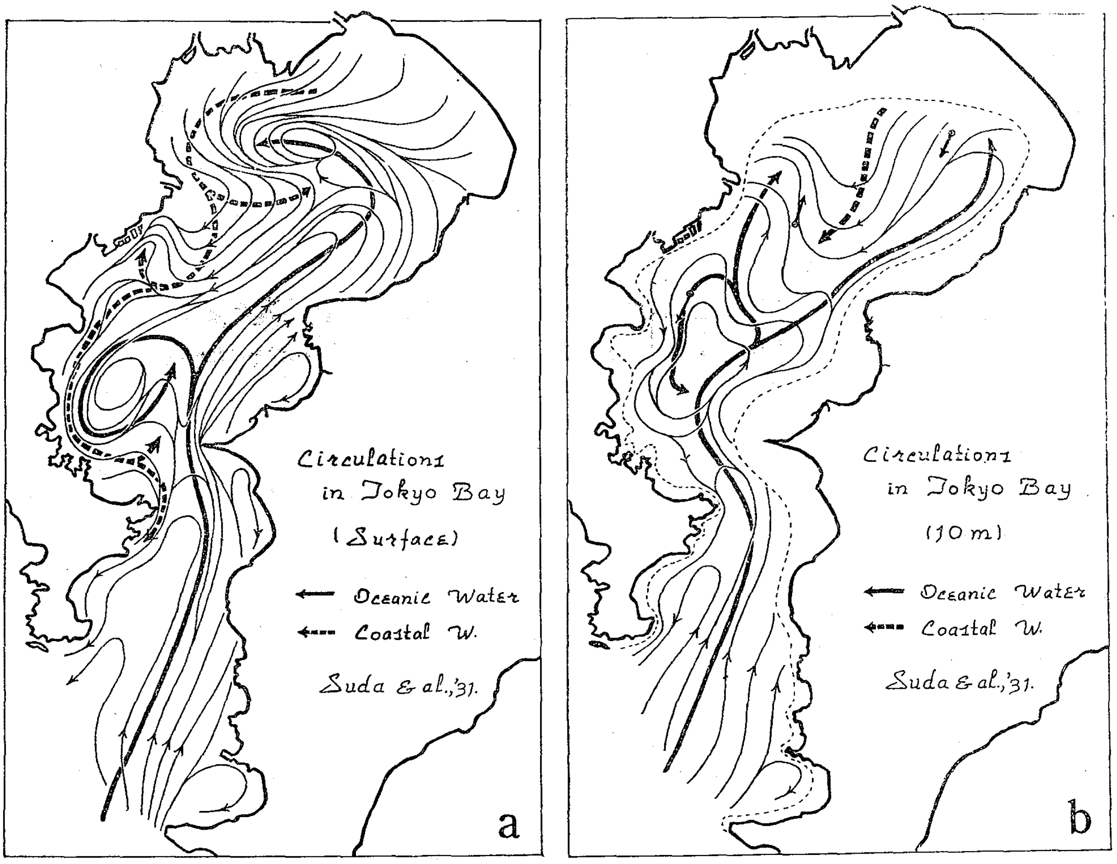


Fig. 19a, b. Circulations in Tokyo Bay at the surface (a), and at the depth of 10 m (b). (From Suda et al., '31.)

offshoots and the coastal water appears only in the northern part of the bay. The different circulation pattern was considered to be due to the different currents at this depth, which as a compensation for the surface current, because the coastal water flowed within a layer around 5 m deep at the time of the survey. It is interesting that the currents at a depth of 10 m can be regarded as those in the subsurface layer, more or less reflecting those in the bottom layer, since there is no available data concerning the bottom current.

Except for a single report (Satô & Ono, '49), water of a more oceanic nature is usually found on the east side of the bay (Suda et al., '31 ; Matida, '50 ; Ono, '51 ; Koganéi, '60), although currents with an inverse (clockwise) circulation pattern have been fonnd in winter (Satô & Ono, '49 ; Ono, '51). These clockwise currents could be induced temporarily by a prevailing wind. Recovery of the drift bottle also suggests the influence of the wind.

In the southern part of Uraga Strait, the currents flow counterclockwise along the iso-bath contours both in the surface and the subsurface layers (Suda et al., '31 ; Satô & Ono '49). According to Koganéi ('60), the coastal, or Tokyo Bay Water, which flows out of the bay along

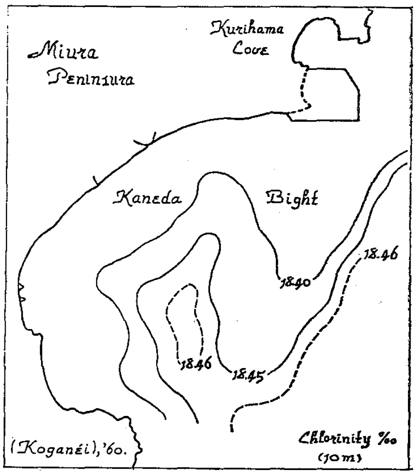


Fig. 20. Distribution of chlorinity at a depth of 10 m in Kaneda Bight. Tokyo bay water of low chlorinity flows southwards off the bight, and the oceanic water of higher chlorinity comes in between the Tokyo Bay water and the coast line. (From Koganéi, '60.)

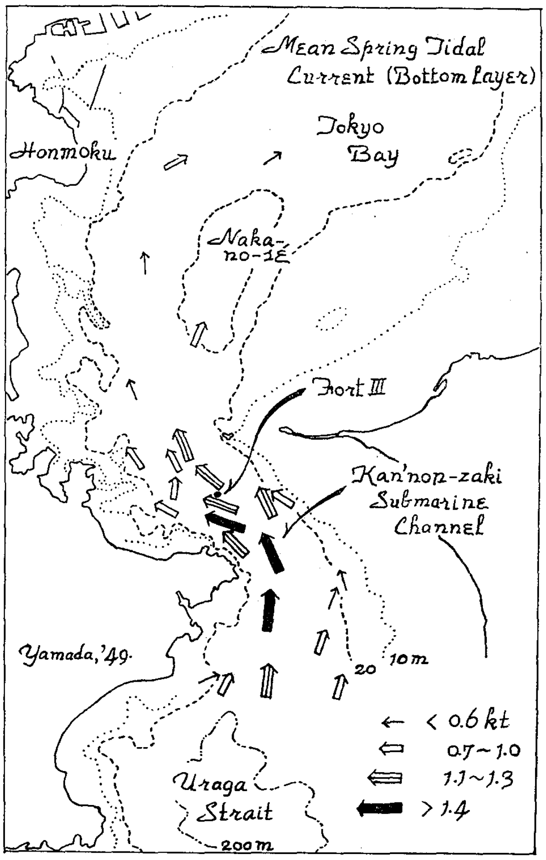


Fig. 21. Tidal currents (mean spring tide) in the bottom layer in the northern part of Uraga Strait and the mouth of Tokyo Bay. (Redrawn from Yamada, '49.)

the coast-line around the cape of Kan'non-zaki, goes straight southward, so that the oceanic water comes into Kaneda Bight between the coast-line of the bight and Tokyo Bay Water (fig. 20 : from Koganéi, '60).

Tidal currents: As can be expected by the physiography, strong tidal currents more than one knot in velocity are found within Kan'non-zaki Submarine Channel (Yamada, '49 ; Ono, '51) (Fig. 21 : redrawn from Yamada, '49). According to Sverdrup et al. ('42, p. 568), the velocity in mid-channel is one third time larger than the average velocity. Although the tidal currents in this submarine channel are in accord with this statement, it is interesting to find that, at the head of the submarine channel the velocity is a little larger on the east side, where the bank around Saru-shima is found, than on the west.

III. BENTHIC ORGANISMS AND THEIR REMAINS

A. Dredging Stations and Methods

The survey made from July 21st to 30th, 1959 on board the research vessel, Enoshima-maru (Kanagawa Pref. Fisher. Exp. St.). The position of the surveying stations was obtained by the compass bearing of three land marks, and the depth was measured with an echo-sounder (24 kc). The majority of the bottom samples were obtained with a dredge, which was an iron cylinder, 20 cm in diameter and 55 cm in length with nine teeth on the front edge. The dredge was towed with a nylon rope, and was hauled by a fishing-line hauler. At a few station (St. B-1～3), the greater amount of samples were obtained by a medium-sized Niino dredge, iron-framed with wire netting and a canvas bag. Besides these, the results of dredging (Niino d.) carried out in July, 1956 (Sts. C-16, 17) and in January, 1959 (Sts. *D*-1～7) on board the research vessel, Shinyô-maru (Tokyo University of Fisheries) are also included in this paper.

On board the vessel, the bottom samples were washed with a sieve of 1 mm standard mesh after a small amount was taken for the studies of micro-biology and marine geology. The washed samples were fixed with formaline neutralized by sodium bicarbonate. In the laboratory, all the macroscopic animals were sorted out of the washed sediments in the fixed samples. They were classified into several animal groups such as ophiurans, crustaceans, polychaetes, molluscs and miscellany. After the wet weight of each animal group was obtained, they were classified further into species, and the individual numbers were counted. The organic remains were also picked up from the washed sediments, classified into species and then counted.

B. Semi-quantitative Aspects of Population

Distribution of rich and poor hauls: As stated above, a fully quantitative analysis of data is not feasible in this research, because of the collecting device which is unsuitable for the estimation of the standing crop. It has been found in the course of this study, however, that there are marked differences in the richness of hauls at the several collecting sites.

A cumulative frequency curve of the numerical population was made (Fig. 22a), by summing up the number of stations plotted against the logarithm of the total number of animals in each haul. From the curve, all the stations were classified into six groups, according to the deviation from the median, i. e. the positive and negative deviations of three grades: the medium, the high and the extreme. Plot-

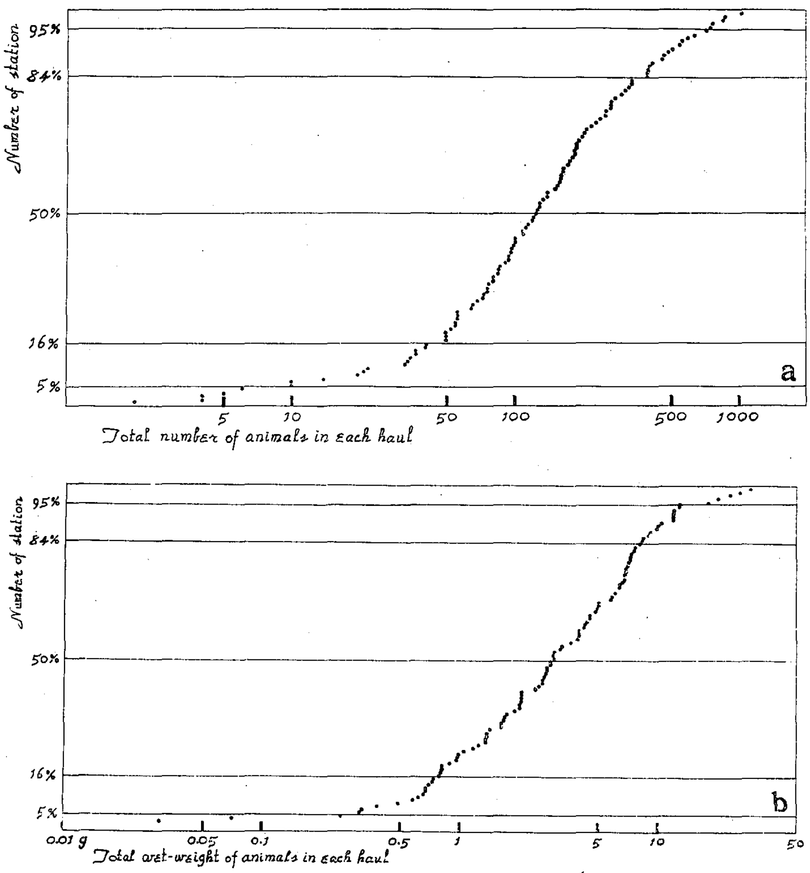


Fig. 22a, b. Cumulative frequency curves of numerical (a), and gravimetrical (b) populations. (Further explanation see text.)

ting the symbols of these six classes on a chart of the surveyed area, distributions of the deviations from the median in the numerical populations can be depicted (Fig. 23a). Concerning the gravimetric population, a cumulative curve of the total wet-weight of the animals in each haul is shown in Fig. 22b. The distributions of the deviations from the median are shown in a chart by a procedure which is similar to that of the numerical aspect of population density (Fig. 23b).

Some ecologically interesting distribution patterns of the deviations can be found by correlating these two separate charts. But, to consider the deviations in both the gravimetric and numerical populations simultaneously, it is more convenient to combine the two symbols plotted on the locality of each station into a single one, which symbolizes what will be called here the "*richness of haul*". The combination of the 6 classes of deviations were regrouped into 5 classes in the richness of haul. They are as follows: the poorest (including extreme negatives of both numerical and gravimetric population distributions), the poor (either high or medium negatives of one distribution with either high or medium negatives of the other), the medium (either high or medium negatives with any of

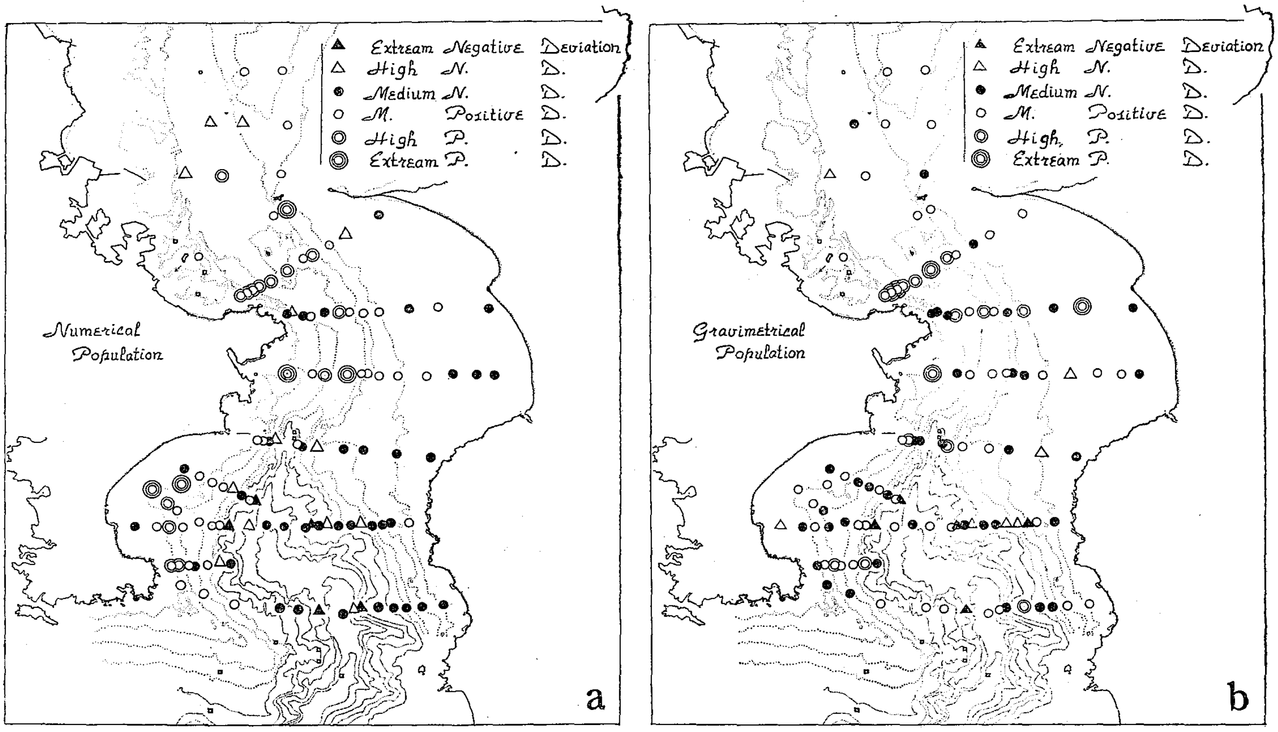


Fig. 23a, b. Distribution of deviations from the medians in the numerical (a), and the gravimetrical (b) populations.

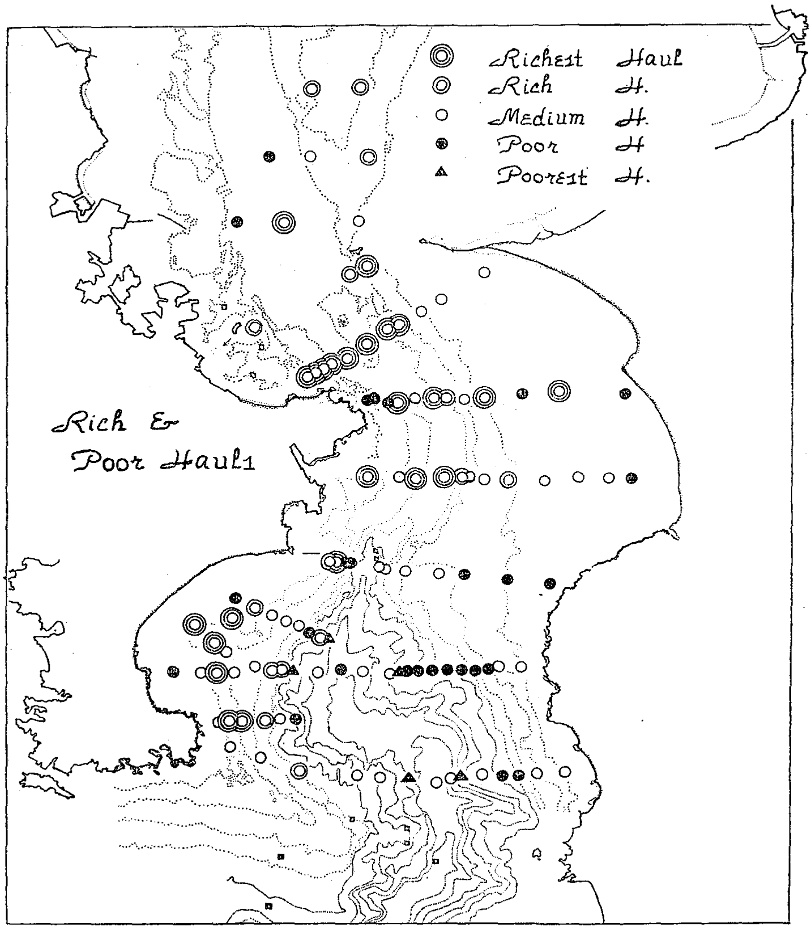


Fig. 24. Distribution of the rich, and the poor hauls at the entrance of Tokyo Bay.

the positives), the rich (both medium positives) and the richest (either high or extreme positive of one distribution with any of the positives of the other). The symbols for these five classes are shown in Fig. 24.

In this figure, it can be seen clearly that the symbols of each class in the richness of haul tend to group with each other in a few localities. The poorest hauls were found only on the steep slope of the canyon-wall, suggesting incomplete sampling. The poor hauls were found in the following localities: (1) within the canyon, (2) on the shelf-edge, (3) in the lower part of the shelf, chiefly on the east side of the canyon, (4) on the shallow flat in Kaneda Bight and in Kimitsu Bight, (5) on the precipitous side-wall of the submarine channels in the north of Kan'non-zaki, and (6) within the extension of the submarine channel in Tokyo Bay. As the ecological meaning of the distribution patterns of the poor hauls will be discussed later, it will suffice here to mention only two localities. In the 4th-named locality, the poor haul was associated with a benthic community which was found in a flat, fine sand-bottomed area, although the locations of the stations were rather distant from each other (Sts. III-1, IV-1, V-12, VI-13 & VII-12). In the 6th-named locality, the poor hauls were found in an area of finer sediments within the extension of the submarine channel (cf. Fig. 3).

The rich hauls were found chiefly in two localities, i. e. in the lower part of the shelf on the west side of the canyon, and around, and on the top of the bank of Naka-no-sé in Tokyo Bay. The richest hauls were concentrated within the submarine channel and in Kaneda Bight.

Semiquantitative distribution of important animal groups: In addition to the observed distribution of rich and poor hauls, the distribution of several groups of animals, such as ophiurans, crustaceans, polychaetes, and molluscs, were found to be closely related to certain localities. These relationships can be seen in Fig. 25a, b, showing the numerical and gravimetric composition of each haul, which are represented in terms of the percentage of population number (upper semi-circle), and of percentage wet-weight (lower semi-circle) respectively. They are depicted beneath the projected profiles of the seafloor to show the topographical locations of the stations a little more clearly than would a contoured plan.

Ophiurans seem to be the prevailing animal within the canyon, occupying more than half of the total wet-weight of a haul (Sts. I-9, 10, III-12), even if they are not the majority in number (St. III-11). On the shelf-edge they still keep their footing, which is lost atop the shelf, except within the submarine channel in the north of Kan'non-zaki (Sts. VIII-1~8, IX-1~3). It is interesting to find in this last locality that they are more numerous on and around the side-walls of the channel than in the middle of the channel-floor (St. VIII-4)[1], since a positive correlation between the abundance of ophiurans and the inclination of the sea-floor has been reported from a submarine ridge in Sagami Bay (Horikoshi, '60a).

Crustaceans tend to be abundant in shallow, more or less exposed localities on the shelf (Sts. I-1; II-1, 2; III-2; A-1, 2; IV-1, 2; V-11; VI-2, 9, 11; VII-10, 12; VIII-10, 11), where the sediment is clean and sandy; either with or without gravel and shell fragments. Polychaetes predominate in the lower part of the shelf, occupying silty sand areas in between the habitats of crustaceans and ophiurans. A good example of such a topographical influence on the frequencies of crustaceans and polychaetes is found in Kaneda Bight (Fig. 25b: Profile-IV+A). In the coarse-sedimented area on the margin of the shallow flat within the bight (p. 58), crustaceans are numerous (Sts. A-1, 2; IV-1, 2), while polychaetes form the majority both in the numerical and gravimetrical populations in the silty sand area within the shelf valley (Sts. A-3, 4). This is in substantial accord with earlier reports, repeatedly confirmed by surveys in many shallow enclosed bays in this country, that crustaceans are conspicuous inhabitants of sandy bottom areas in the outer part of the bay, while polychaetes characterize the muddy sand areas in the middle part of the bay (e.g. Miyadi et al., '42; Horikoshi, '55). The appreciably higher percentage of crustaceans in the numerical population, found on the shelf-edge (Sts. I-4, 5, 12; III-16~19) and on the exposed margin of banks (Sts. V-8; VIII-6), may be attributable to the good oxygen supply resulting from the water movement (which may be inferred from the topography).

In certain places atop the shelf and within the submarine channel, molluscs are as abundant as polychaetes. High frequencies of this group of animals are mostly due to many specimens of either one of two pelecypod species *Thyasira miyadii* Habe (Sts. I-14, 15; III-4; A-4; IV-3, 5; V-9; VI-7, 8; VII-8: see also Fig. 29), or *Anisocorbula venusta* (Gould) (Sts. VI-2, 11; VII-5, VIII-2: See also Fig. 41).

C. Distribution Patterns of Conspicuous Forms

Distribution of living organisms: Through field observations and laboratory works, it became clear that some species would have definite ranges of distribution. The frequency distributions of some conspicuous forms, either abundant or constant in their occurrence

1) St. VIII-6 is a rather exceptional locality within the channel, where epibiose (tube worms) predominate. It is on the top of the bank around Fort No. 3.

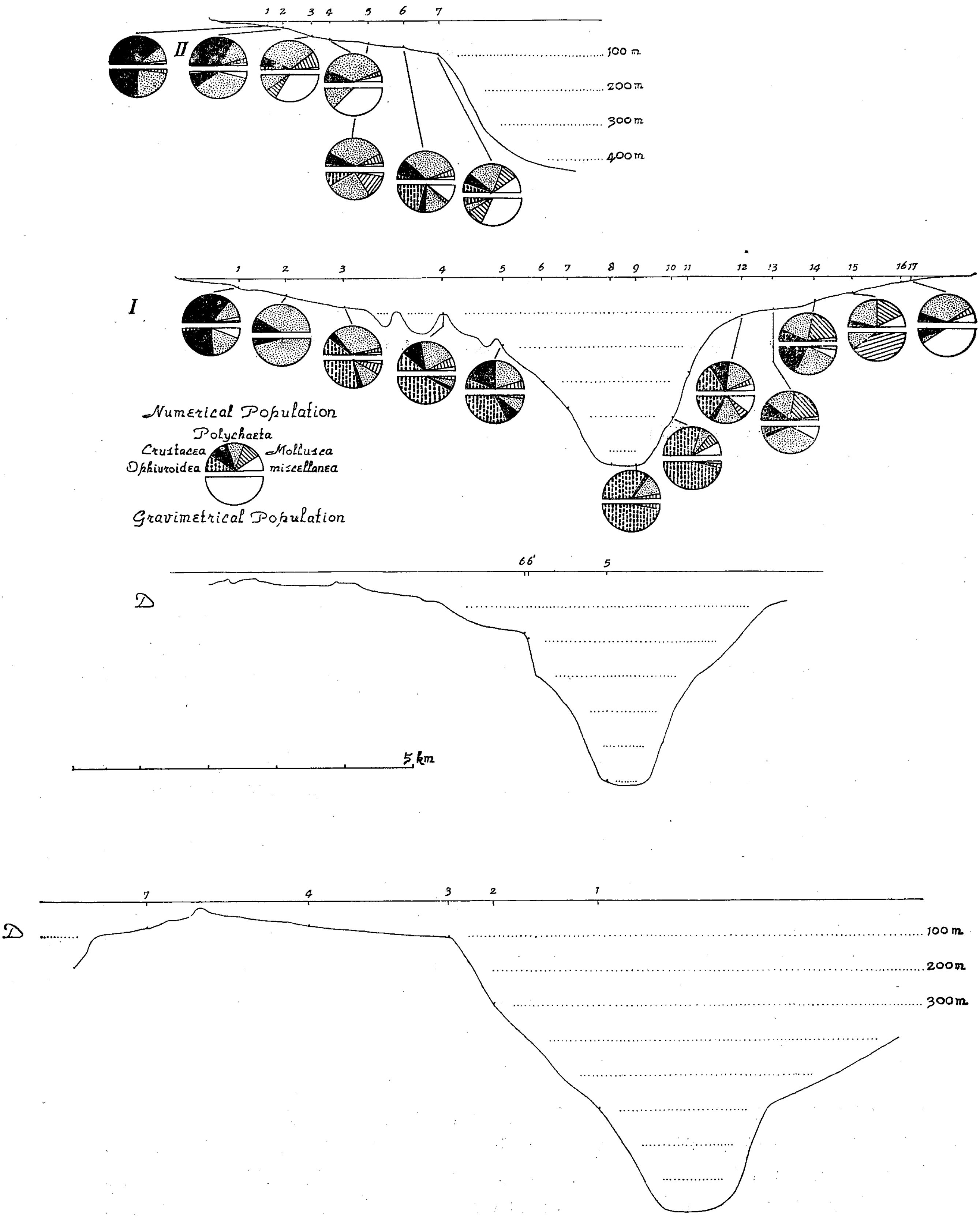


Fig. 25a. Percentages of important animal groups at each station in the numerical- (upper semicircles), and gravimetrical (lower) populations, plotted beneath the projected profile of each section. (For the locations of the sections, see Fig. 2.)

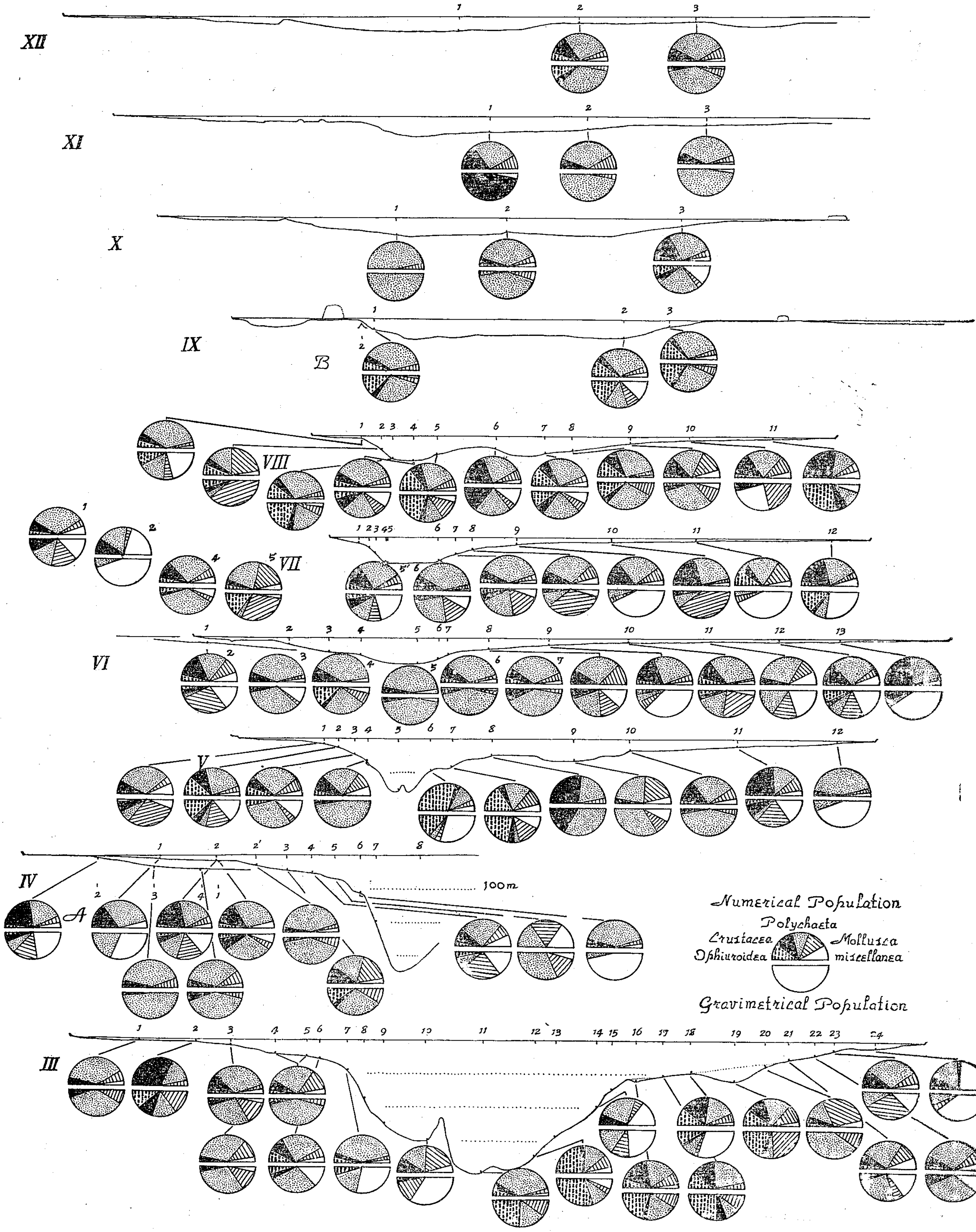


Fig. 25b. Percentage of important animal groups at each station in the numerical- (upper semicircles), and gravimetrical (lower) populations, plotted beneath the projected profile of each sections. (For the location of the sections, see Fig. 2.)

within a habitat, were plotted on separate charts of the surveyed area (Figs. 26–42). Not only several different patterns of distribution could be recognized, but also, at least in some cases, there was no overlapping in ranges of distribution of two neighbouring species, showing a clear boundary between them.

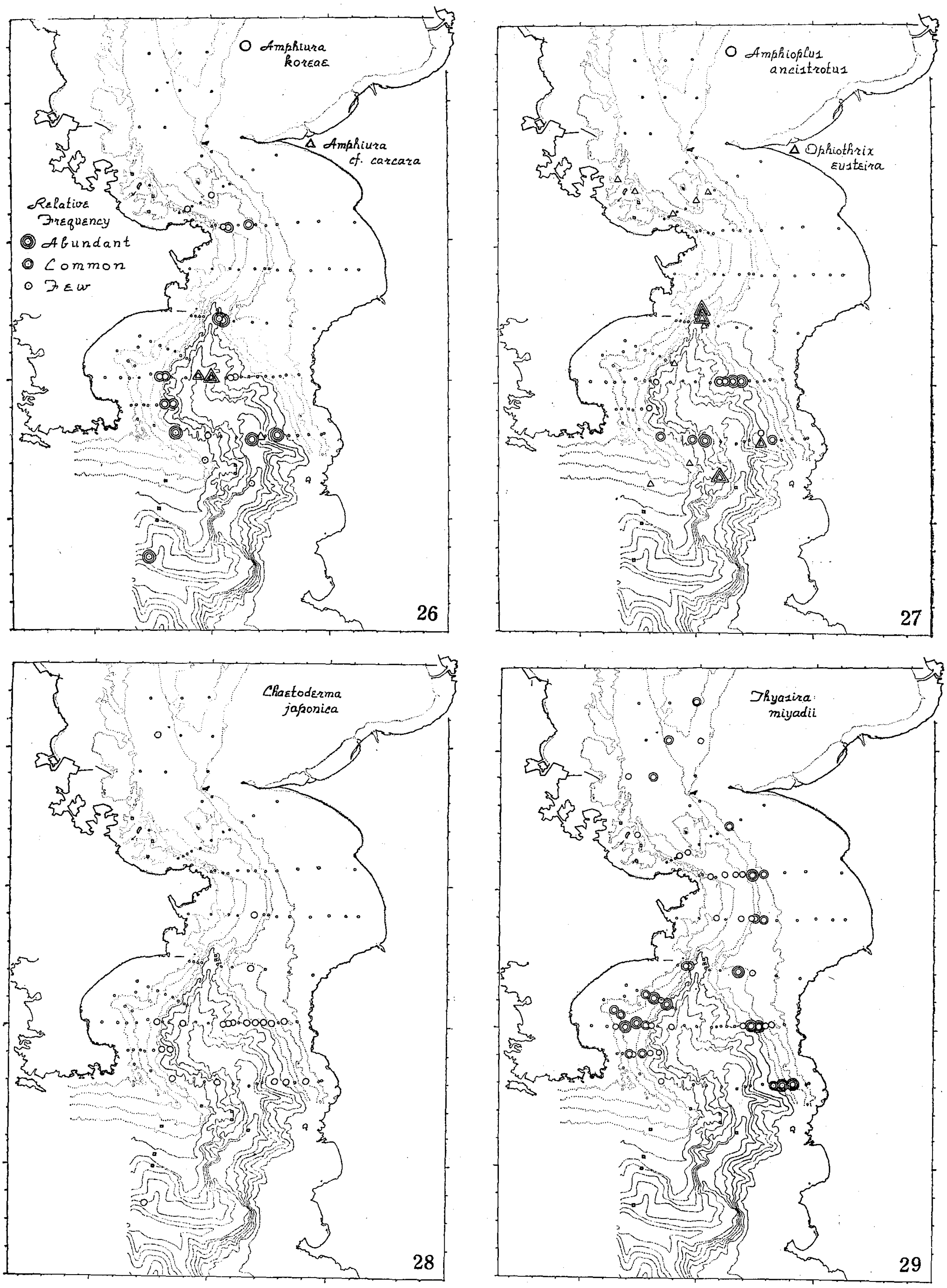
Within the canyon, two species of *Amphiura* were noteworthy both for their abundance and their large size. They showed different ranges of distribution, and were not found together (Fig. 26). *A.* cf. *carcara* was fairly numerous in areas of slightly more sandy sediment, and was confined within the canyon (Sts. I–10 ; III–11, 12) ; while *A. koreae* Duncan, which was abundant within the canyon (Sts. D–1 ; I–9), extended its range onto the shelf-edge. The former species will be called a canyon form, in contrast with the latter, a canyon-shelfedge form. There was also an isolated population of the latter species within the submarine channel to the north of Kan'non-zaki, and it will be discussed subsequently in relation to an ecological characteristic of the channel.

On the shelf-edge, two ophiuran species, in addition to *A. koreae*, were found to be numerous (Fig. 27). They seldom occurred together, *Amphioplus ancistrotus* (H. L. Clark) being distributed in soft bottom areas (Sts. I–3～5, 12, 13, III–16～19), while *Ophiothrix eusteira* H. L. Clark predominated in the hard bottom areas on the tip of the Ken-zaki Submarine Peninsula, as well as on the wall of the canyon-head vestibule (Sts. D–6 ; C–16, 17). The former species will be called a shelf-edge form in its strict sense. On the other hand, an isolated population of the latter species, like *A. koreae*, was found within the submarine channel, although it was most numerous in the rocky area on the shelf-edge. On the west side of the canyon, an aplacophoran mollusc, "*Chaetoderma*" *japonica* Heath (Fig. 28), looked like a shelf-edge form, but it was found also in the lower part of the shelf on the east side, and within the submarine channel as far as off the bank of Naka-no-sé in Tokyo Bay (St. XI–1).

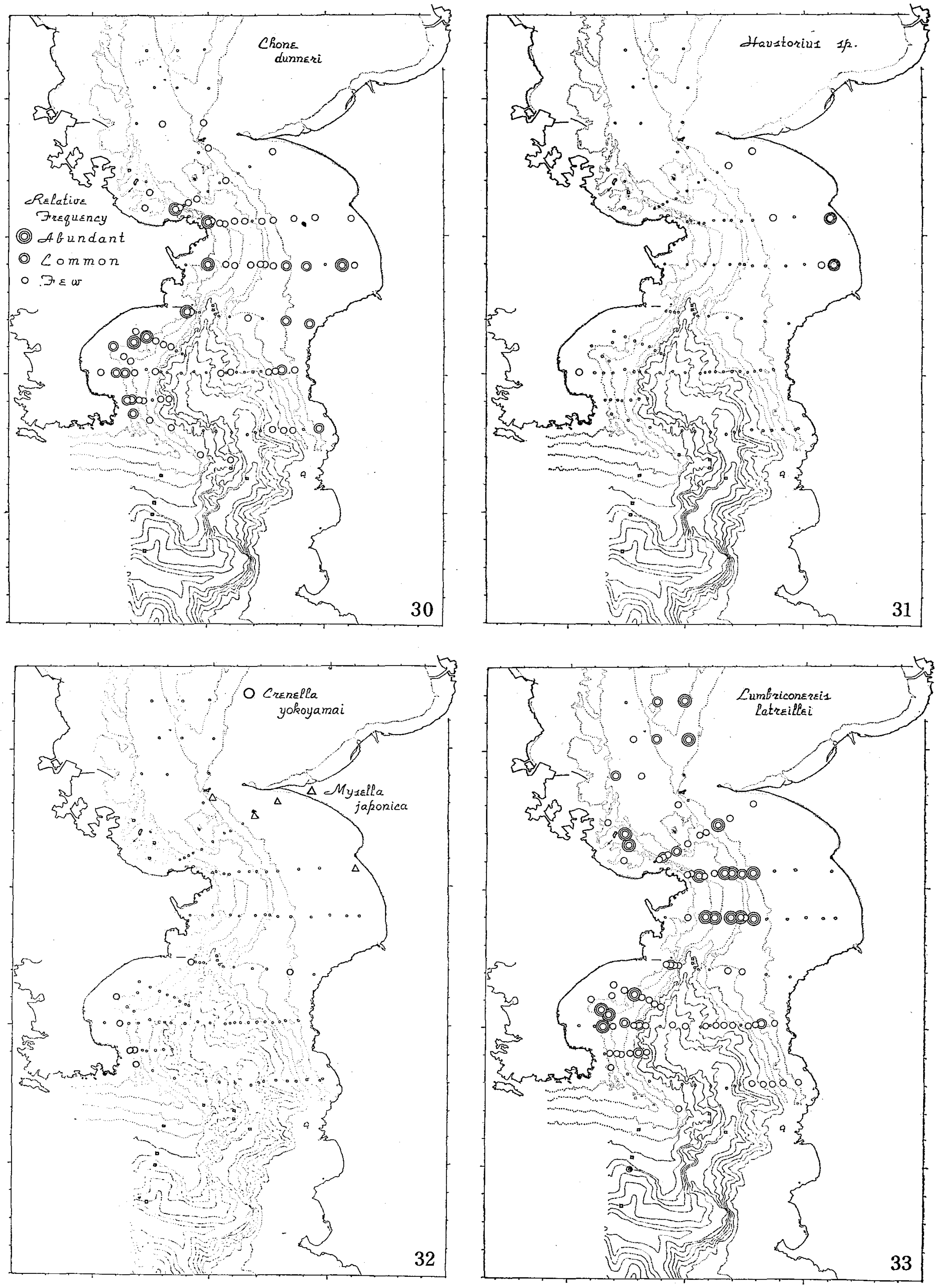
A small pelecypod mollusc, *Thyasira miyadii* Habe (Fig. 29), is an example of the lower-shelf form. (The lower-shelf is that part of the shelf lying below the 20 m contour line.)[1] It was distributed from the shelf-edge to just outside of the lower rims of the upper-shelf areas (the shelf above the 20 m contour),[2] which in turn was inhabited by either one of two minute pelecypods (Fig. 32), *Crenella yokoyamai* Nomura (found in the outer part of the surveyed area), and *Mysella*

1, 2) The lower and the upper parts of the shelf are also called as the *outer* and *inner* parts (Hedgepeth, '57a, b), but the terms *outer* and *inner* are not used here, in order to avoid confusion with the outer (mouth) and inner (Head) parts of the *bay* and *strait*.

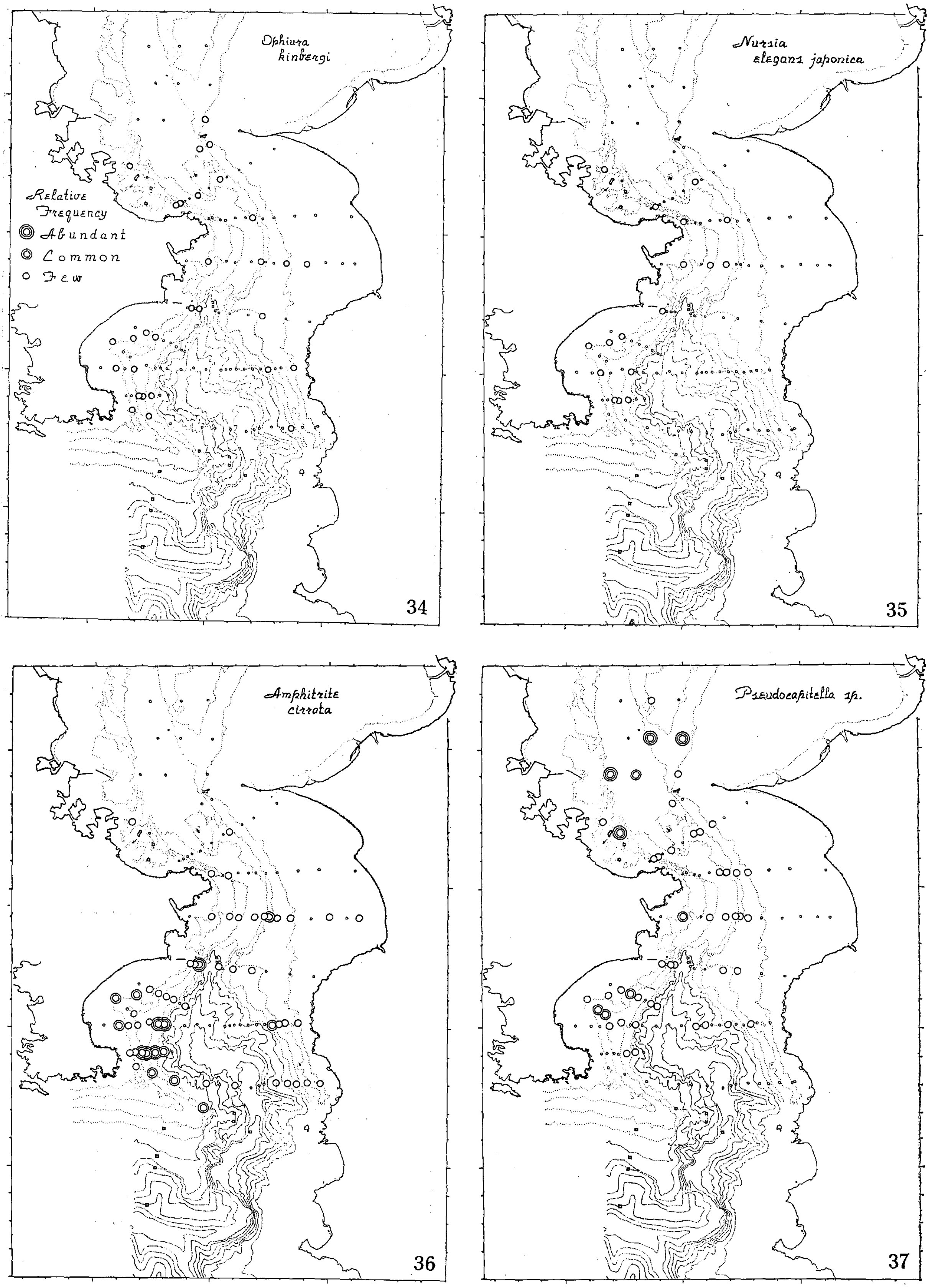
japonica (Yokoyama) (on the shallow flat in Kimitsu Bight). The boundary between these upper and lower regions of the shelf could be recognized by a strikingly clear gap in the distribution of these pelecypod species. A polychaete species, *Chone dunneri* Malmgren (Fig. 30), was abundant only within the upper-shelf region, just inside of this boundary. The distribution of an amphipod, *Haustorius* sp. (Fig. 31), was also restricted to this region. This boundary, however, could not be strictly fit to the distribution of all of the lower-shelf forms. An ophiuran, *Ophiura kinbergi* Ljungman (Fig. 34), and a crab, *Nursia elegans japonica* Sakai (Fig. 35), were found, in certain places, on the lower rim of the upper shelf region. It is interesting to find that neither species could be found on the shelf-edge, thus showing a very similar distribution pattern. So close was parallel, that one chart for one might almost be substituted for the other, except for the absence of the crab on the east side of the canyon. In polychaetes, the distribution tends to be less restricted as in the other animals just mentioned; e. g. *Lumbriconereis latreillei* Audoin & M. Edwards (Fig. 33), *Amphitrite cirrata* (O. F. Müller) (Fig. 36) *Amphicteis gunneri* Malmgren (Fig. 38), and *Pseudocapitella* sp. (Fig. 37) have ranges extended in either direction, deeper and shallower, inhabiting all parts of the shelf from the edge to the most shallow part, and in some species even within the canyon. These polychaetes were much alike in their vertical distribution, but differed not only in their holizontal ranges but also in the location of their centers of distribution. *Lumbriconereis* was quite numerous in only two localities, the middle part of Kaneda Bight and the southern half of the submarine channel; *Amphitrite* was concentrated in the southern-most part of Kaneda Bight; *Amphicteis* was abundant in the eastern part of both the submarine channel and the mouth of Tokyo Bay; and *Pseudocapitella* is common in the shelf-valley within Kaneda Bight and in the mouth of Tokyo Bay. An ophiuran species, *Ophiophragmus japonicus* Matsumoto (Fig. 39), is another example of the shelf forms which have distribution centers in the northern part of the submarine channel (like *Amphicteis*), although it was not found on the shelf-edge. Two shelf forms, *Leptochela gracilis* Stimpson (Fig. 40; a shrimp) and *Anisocorbula venusta* (Gould) (Fig. 41: a pelecypod), seemed to be concentrated in the middle part of the surveyed area. Living specimens of an upper-shelf, minute pelecypod, *Nucula paulula* A. Adams, was not found in Tokyo Bay proper, where is inhabited by a small pelecypod with thin, semi-transparant shell, *Theora lubrica* Gould (Fig. 42).



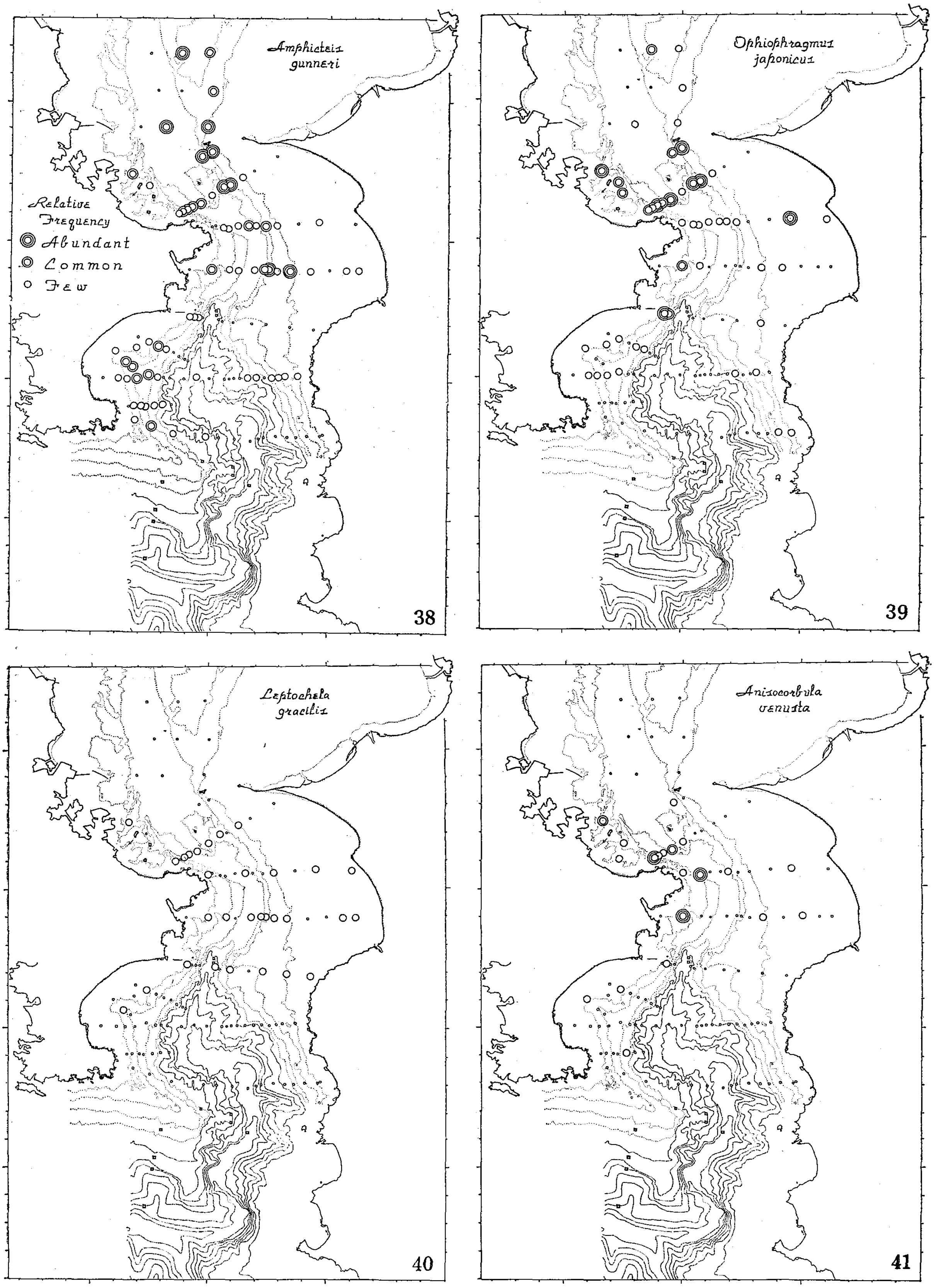
Figs. 26–29. Distribution patterns of living animals in terms of relative frequencies. 26: *Amphiura koreae* (canyon & shelf-edge type; found also in the northern half of the submarine channel), and *A.* cf. *carcara* (canyon type); 27: *Amphioplus ancistrotus* (shelf-edge type s. s.) and *Ophiothrix eusteira* (shelf-edge type s. l.; found also in the northern half of the submarine channel and on the submarine peninsula); 28: "*Chaetoderma*" *japonica* (shelf-edge type s. l.; sporadically found also in the lower-shelf area on the east side of the southern part of the strait, and in the submarine channel); 29: *Thyasira miyadii* (lower-shelf type s. s.; compare with the upper-shelf type s. s. (31: *Crenella* & *Mysella*: opposite)).



Figs. 30–33. Distribution patterns of living animals in terms of relative frequencies. 30 : *Chone dunneri* (concentrated on the edge of upper-shelf areas) ; 31 : *Haustorius* sp. (confined within upper-shelf areas) ; 32 : *Crenella yokoyamai* and *Mysella japonica* (both, upper-shelf type s. s.) ; 33 : *Lumbriconereis latreilli* (concentrated in the lower-shelf area).



Figs. 34-37. Distribution patterns of living animals in terms of relative frequencies. 34: *Ophiura kinbergi* (lower-shelf type s. l.; found also on the edge of upper-shelf areas); 35: *Nursia elegans japonica* (lower-shelf type s. l.; very similar to the preceding species (34), but not found on the east side of the strait); 36: *Amphitrite cirrata* (concentrated in the southern part of Kaneda Bight); 37: *Pseudocapitella* sp. (concentrated at the mouth of Tokyo Bay proper).



Figs. 38-41. Distribution patterns of living animals in terms of relative frequencies. 38: *Amphicteis gunneri* (concentrated around the northern half of the submarine channel); 39: *Ophiophragmus japonicus* (concentrated in the northern half of the submarine channel; rather similar to the preceding species (38)); 40: *Leptochela gracilis* (found chiefly in the northern part of the strait); 41: *Anisocorbula venusta* (concentrated in the northern part of the strait).

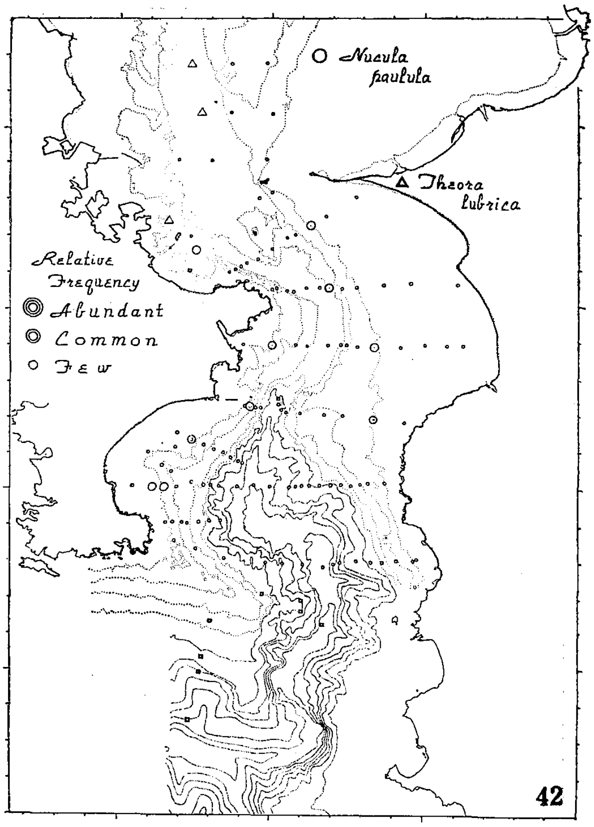


Fig. 42. Distribution patterns of living animals in terms of relative frequencies. *Nucula paulula* (found chiefly in the strait), and *Theora lubrica* (confined within the enclosed bay area in Tokyo Bay proper).

Distribution of molluscan remains: Some differences in patterns of distribution could be found between living organisms and molluscan remains (Figs. 43–55). In cases of empty shells, some transitional types were found both between the shelf-edge and the lower-shelf forms, and between the lower- and the upper-shelf forms. In addition, shelf-edge forms of molluscan remains were present in the southern half of the submarine channel, instead of being restricted to the north of Kan'non-zaki, as were the living forms.

An example of the shelf-edge form, *Polynemamussium intuscostatum* (Yokoyama) (Fig. 43), showed a distribution pattern which was remarkably similar to that of *Amphiura koreae* (see Fig. 26). But, within the submarine channel, this species was more numerous in the southern part. The distribution of two other shelf-edge forms, *Nuculana yokoyamai* (Kuroda) (Fig. 44) and *Sarepta speciosa* A. Adams (Fig. 45), extended as far as the lower-most part of the shelf. It is interesting to find that they are fairly common also at shallower stations only in the southern-most part of Kaneda Bight, (St. II–3, 4), since the sediment contains an appreciable amount of clay particles in this locality, unlike the sediment at the corresponding depths in the neighbouring localities (p. 58, Fig. 3).

Two species of the genus *Limopsis*, *L. azumana* Yokoyama (Fig. 46) and *L. oblonga* A. Adams (Fig. 47) (syn. *L. crenata* A. Adams) were rather similar in their distribution pattern, stretching over both the shelf-edge and lower-shelf. But on closer inspection, details of their distribution patterns are somewhat different from each other: the former species was abundant in the southern part of the submarine channel, and was numerous even in the northern part; while the latter was less numerous within the submarine channel, although common on the lower shelf. Such a difference was also found in the distribution of two lower-shelf forms, *Gibbula japonica* (A. Adams) (Fig. 48) and *Aequipecten vesiculosus* (Dunker) (Fig. 49).

Two examples of the forms intermediate between the lower- and upper-shelf forms are shown in figs. 50 and 51 (*Anisocorbula venusta* & *Alvenius ojianus* (Yokoyama)). Although they were found in both deeper and shallower regions of the shelf, the population density was greatest near the boundary between these two regions. Distribution patterns of some upper-shelf forms, *Lirularia ornata* (Sowerby) (Fig. 52) and *Mysella japonica* (Fig. 53), showed that these species were confined within the limits of the upper-shelf region. In two other species, *Crenella yokoyamai* (Fig. 54) and *Nucula paulula* (Fig. 55), a few specimens were found at deeper stations, especially in two localities, off Kurihama Cove on one hand, and on and around the submarine cliff to the north of Kan'non-zaki on the other, in both of which the inclination of the sea-floor is steep. This may suggest the transportation of empty shells. *Crenella* and *Nuculla* were not common in the northern part of the surveyed area, while *Mysella* was concentrated on the shallow flat in Kimitsu Bight.

D. Benthic Communities, Their Make-up and Their Distribution

By grouping several hauls with similar content, certain assemblages of benthos could be recognized in this research (Fig. 4). Since each of them has its own taxonomic and numerical composition, it seems to be appropriate to describe them as communities, instead of zones and facies, according to a detailed discussion by Jones ('50). On the other hand, it is rather difficult to call them associations which are abstract communities of similar types from various regions in one zoogeographical province (Dice, '52, pp. 18, 43 ; Jones, '50). They are named here after the

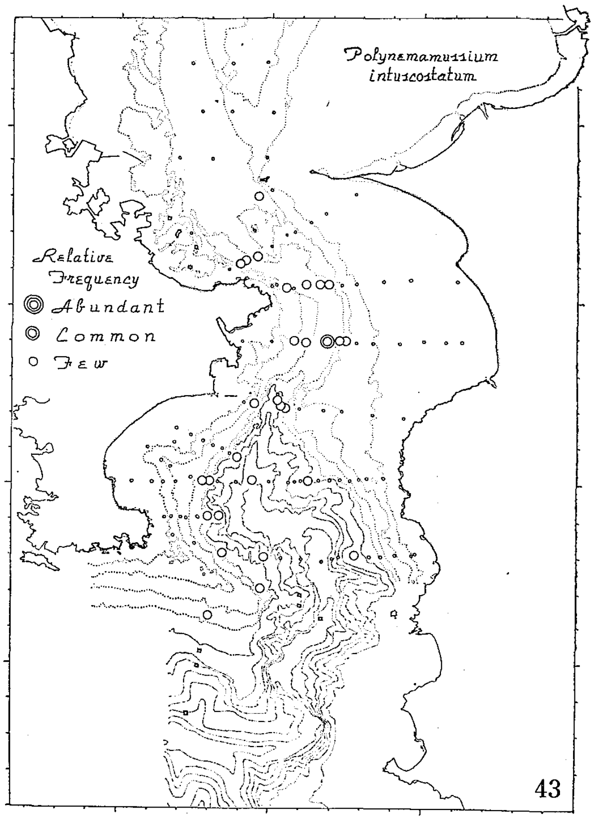
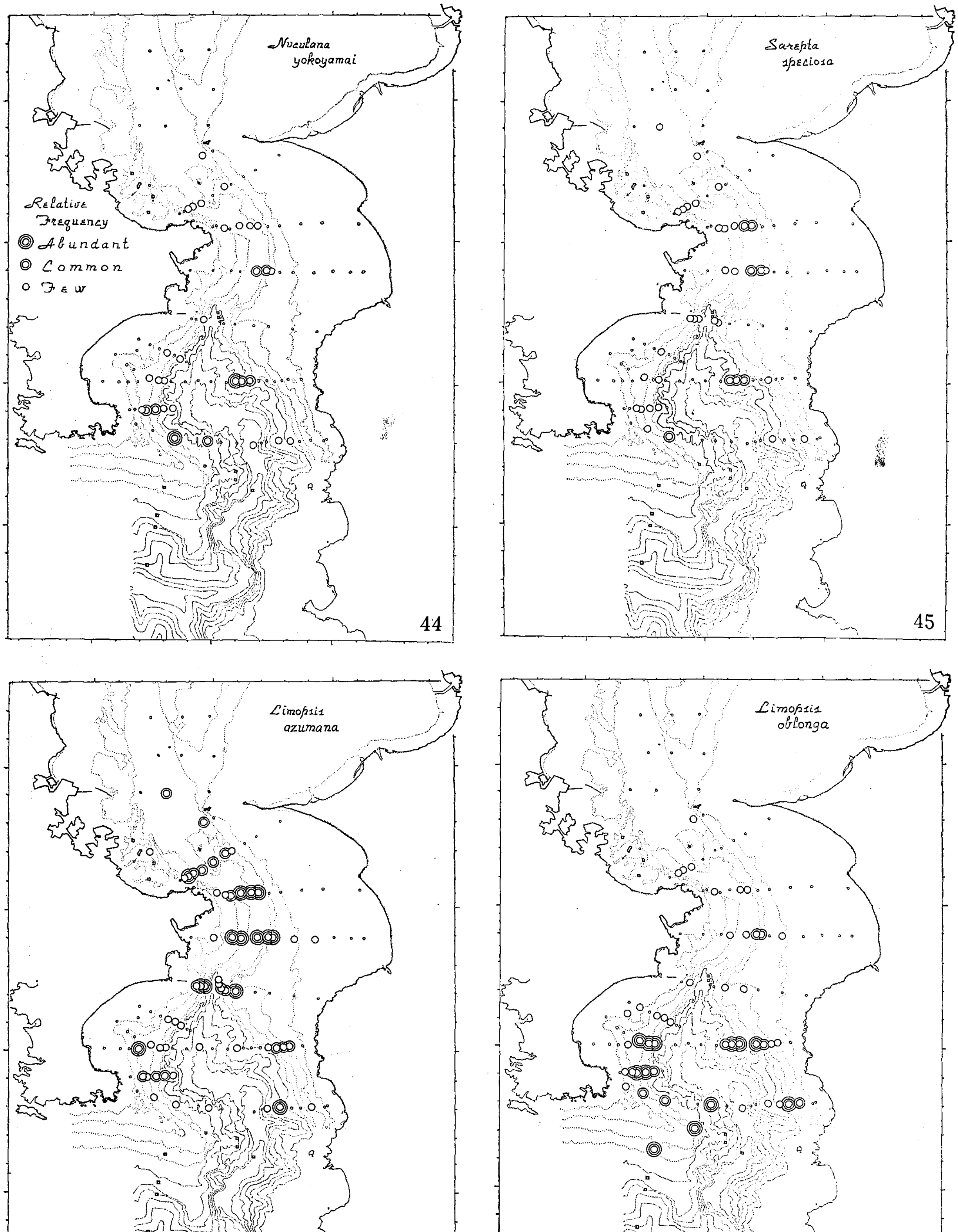
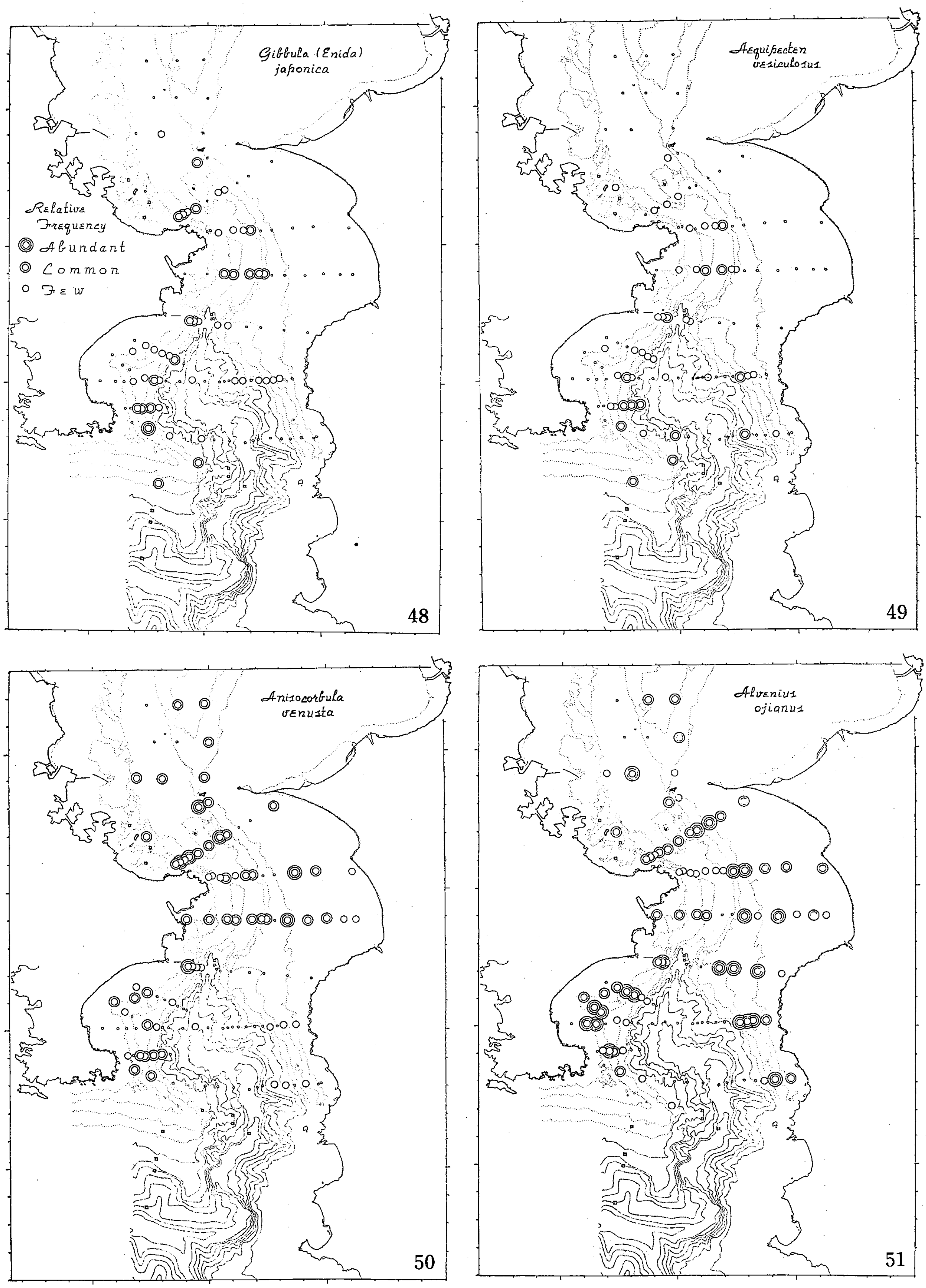


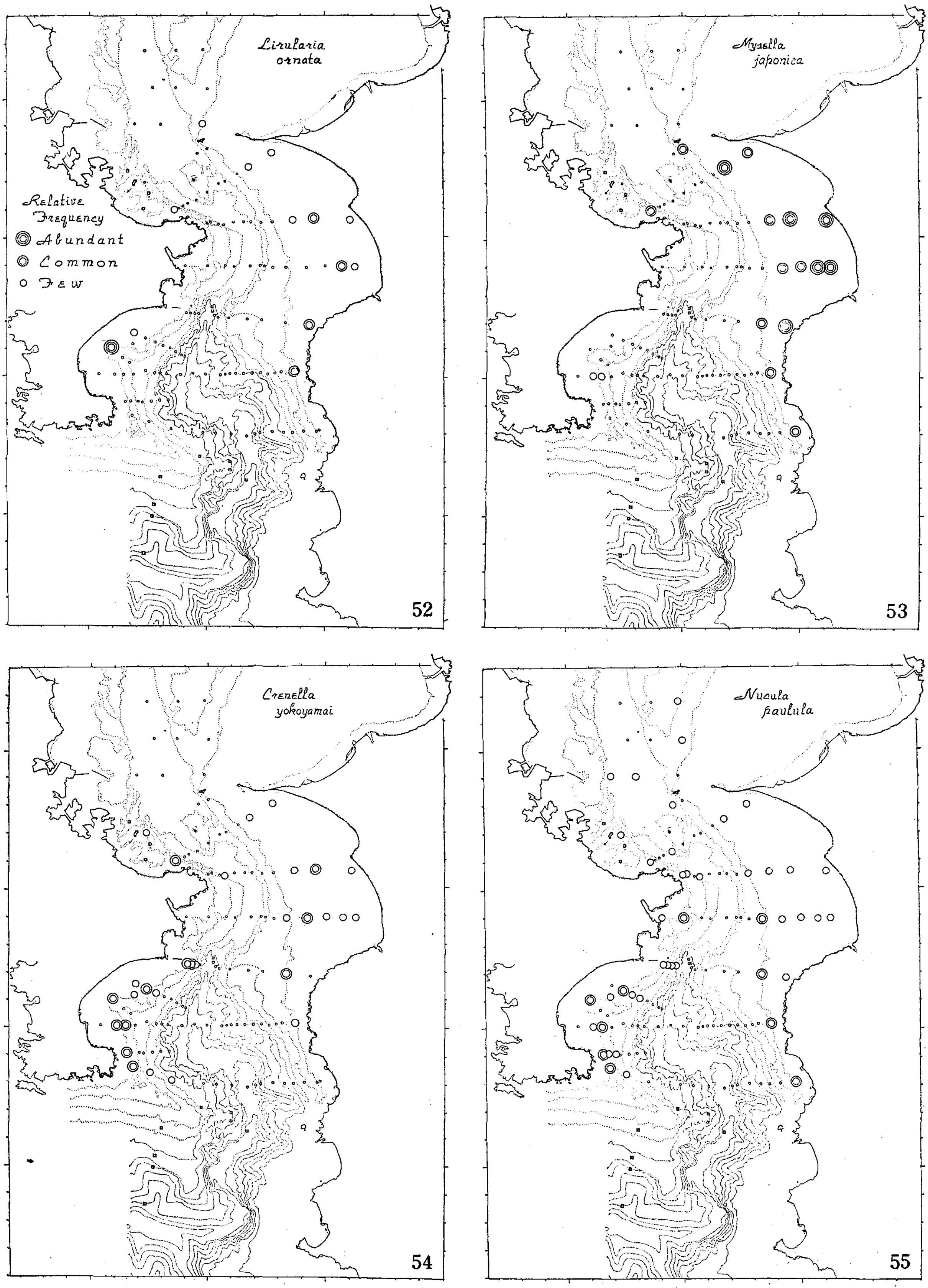
Fig. 43. Distribution pattern of molluscan remains in terms of relative frequencies. *Polynemamussium imtuscostatum* (shelf-edge type s. l.; found also in the submarine channel).



Figs. 44-47. Distribution patterns of molluscan remains in terms of relative frequencies. 44 : *Nuculana yokoyamai* (shelf-edge type s. l.; found also in the lower most part of the shelf, and in the submarine channel) ; 45 : *Sarepta speciosa* (similar to the preceding species (44)) ; 46 : *Limopsis azumana* (stretched over both the shelf-edge and the lower-shelf areas) ; 47 : *Limopsis oblonga* (similar to the preceding species (46), but not so abundant in the submarine channel).



Figs. 48-51. Distribution patterns of molluscan remains in terms of relative frequencies. 48: *Gibbula* (*Enida*) *japonica* (lower shelf type s. s.; note the presence at the foot of a narrow gouge on the canyon head (St. III-11), indicating the transportation of the sediment within the canyon); 49: *Aequipecten vesiculosus* (similar to the preceding species (48), but not so common in the submarine channel); 50: *Anisocorbula venusta* (concentrated along the boundary between the lower and the upper-shelf areas; present at a definite station within the canyon (St. III-11) as in the preceding two species (48 & 49); 51: *Alvenius ojianus* (similar to the preceding species (50), but more abundant in the southern part of the strait).



Figs. 52-55. Distribution patterns of molluscan remains in terms of relative frequencies. 52: *Lirularia ornata* (upper-shelf type s. s.); 53: *Mysella japonica* (upper-shelf type s. s.; concentrated in Kimitsu Bight); 54: *Crenella yokoyamai* (upper-shelf type s. s.; see the distribution of living animals (Fig. 32); note few specimens found in the lower-shelf area, indicating the transportation of empty shells); 55: *Nucula paulula* (similar to the preceding species (54), but the distribution range is a little wider than that).

names of dominant species in place of the names of their habitat, because the species name implies the morphology and the mode of life of that kind of organism, both of which are important from the ecological point of view (Jones, '50, p. 307). Some of the communities found in this survey seems to be "parallel" to those which have been reviewed and discussed by Thorson ('55, '57).

Amphiura "A" & Amph. "B" Communities: Within the canyon, two communities could be recognized, *Amphiura* "A". (*A. koreae*) and *Amphi.* "B" (*A.* sp. cf. *carcara*) communities. In the case of the latter community, the distribution range of the community and that of its dominant species were the same, while the range of the *Amph.* "A" community was confined within the canyon, although smaller populations of the dominant species (*A. koreae*) were found also on the shelf-edge and within Kan'non-zaki Submarine Channel (cf. Fig. 26). It is interesting that specimens of a sessile holothurian, *Psolus squamata* (Koren), were found in the habitat of the *Amph.* "B" community (Sts. I–10, III–12). This seems to indicate a slow and/or slight deposition of clay and silt particles, since this species adheres to stones and rocks on the shelf-edge in Japanese waters (Horikoshi, unpublished; *P. japonicus* Ostergren on the coast of the Japan Sea, Niino, '50, pp. 153, 236), as well as on the continental slope in the Norwegian waters (Murray and Hjort, '12, p. 486). On the other hand, a sedentary polychaete, *Micromaldane* sp., was common at a neighbouring station (St. III–11), at which no *Psolus* was found.

"Parallel" *Amphiura* communities have been known from various countries in the world. (Thorson, '57, pp. 510–513).

Amphioplus-Amphiura Community: On the shelf-edge, two communities were found on two different types of botoom; an *Amphioplus ancistrotus-Amphiura koreae* community on the soft bottom, and an *Ophiothrix eusteira* community on the hard bottom. The former community was characterized hy the presence of either one or both of the dominant species (cf. Figs. 26, 27), as well as by the higher population density of ophiurans (p. 80). One or the other of these 2 species was most numerous among ophiurans at all the stations, except for St. I–4, at which another species of *Amphiura*, (*A. euopla* H. L. Clark) out-numbered the other ophiuran species. The community was found on the shelf-edge and the neighbouring marginal part of the shelf, overlapping with other communities atop the shelf in certain places (Sts. I–13; III–6, 7). A parallel *Amphioplus macraspis* community has been known from soft bottoms at depths more than 100 m deep in Peter the Great Bay, Japan Sea (Deryugin and Somova '40: in Thorson, '57).

Ophiothrix Community: Two rocky areas, in which dominant species of the *Ophiothrix eusteira* community predominated, have already been referred to (p. 84). As had been expected, a juvenile of a large sessile pelecypod, *Lima goliath* Sowerby, was found at St. C–18, and a shell fragment of the same species was collected at St. D–6. This is a characterizing species of the hard-bottom facies of the bathyal (archibenthal) zone in the deep-sea system within Sagami Bay (Horikoshi, '57, p. 59), as *Lima excavata* (which is also large in size) is in Norwegian waters (Murry & Hjort, '12, p. 486 ; Ekman, '53, p. 289). In both localities, an ophiuran, *Ophiochiton fastigatus* Lyman, a brachiopod, *Nipponothyris nipponensis* Yabe & K. Hatai, a sessile pelecypod, *Limopsis azumana* Yokoyama, a pholadid rock-borer, *Nettostomella japonica* (Yokoyama), were found as characterizing species of the community. On the tip of the submarine peninsula, *Psolus* was collected along with a small sized sessile scallop, *Chlamys jousseaumei* Bavay. An identical assemblage of these two species has been found from a hard bottom on the shelf-edge off the south-eastern coast of Bôsô Peninsula (unpublished). On the wall of the canyon-head vestibule, a holothurian, *Amphicyclus japonicus* Bell, replaced these two species. An ecotone (transitional zone) between this and the *Amphioplus-Amphiura* community was found at a station near the canyon-head vestibule (St. V–7).

Stegophiura Community : In the shelly-sanded areas on the top of the Ken-zaki Submarine Peninsula, there was found a community characterized by the presence of two ophiuran species of the genus *Stegophiura*, *S. sterea* H. L. Clark and *S. vivipara* Matsumoto, the distributions of which are restricted to this habitat (although only one solitary specimen of the latter was found at St. III–6). They were not so numerous, but they were found to be constant in their occurrence. One of them, *S. sterea*, has a very conspicuous appearance, being large-sized, short-armed, and vivid red in colour. Two other ophiurans, *Ophiothrix eusteira* and *Ophiopholis mirabilis* (Duncan), were also found constantly, although the former species was not so abundant as in its own community. A community with the same species, *S. sterea*, as the dominant has been reported from depths of 250–300 m off the coast of the Japan Sea (Watanabe et al., in Uchihashi et al., '60, p. 86).

Thyasira-Lumbriconereis Community : Most areas of the lower-shelf region were occupied by one community, the *Thyasira miyadii-Lumbriconereis latreillei* community, except for the northern part of the submarine channel, in which was found another one, the *Ophiophragmus-Amphicteis* community. Not only both of the dominant species of the former community were very constant in their occurrence (cf. Fig. 29, 33), but also one or the other of these two species was most numerous at many stations. In the southern-most part of Kaneda Bight and in the mouth of Tokyo Bay, predominant species were different respectively from those in the main habitat of the community (cf. Figs. 36, 37). But even in these localities, both of the dominant species appeared in appreciable numbers and in addition to this, subordinate species were not very different from those in the main habitat. For these reasons, assemblages of benthos in these two localities might be considered as minor communities, indicating some change of an environmental factor or factors. Adding the name of the predominant species at the end of the community name, these two assemblages will be called *Thyas.-Lumb.-Amphitrite cirrata* community (in Kaneda Bight) and *T.-L.-Pseudocapitella* sp. community (in Tokyo Bay) respectively.

Characterizing subordinate species of the whole community are all polychaete species, and are as follows; *Syllis* sp., *Aricia fimbriata* Moore, *Magelona japonica* Okuda, *Poechilochaetus* sp., *Asychis disparidentata* Moore, *Axiothella harai* (Iizuka), *Praxillella affinis* (M. Sars), *Amphicteis gunneri*, *Amage auricula* Malmgren, *Terebellides straemi* Sars. In the habitat of *T.-L.-Pseudocarpitella* sp. community, *Magelona* was an important species, being reckoned among the dominant group. This species has been found very constantly on a muddy-bottomed area in the lower-shelf (=outer-sublittoral) zone within the western half of Mutsu Bay in the northern-most part of Honshû (unpublished). One of the dominant species, *Lumbriconereis l.*, has been reported to be more abundant in Uraga Strait than in Tokyo Bay (Kitamori, '50). This species has been found to be also numerous in muddy sand areas within 2 coves on the coast of Sagami Bay (Horikoshi, '55, '56). It is interesting to find the name of this genus among the characterizing species of the parallel *Amphiura* community (Thorson, '57) since the *Thyasira-Lumbriconereis* and *Amphioplus-Amphiura* communities were situated side by side in Uraga Strait, showing the overlapping of their distribution ranges in certain places.

Ophiophragmus-Amphicteis Community: In the northern part of the Kan'non-zaki Submarine Channel, i. e. the habitat of the *Ophiophragmus japonicus-Amphicteis gunneri* community, both of the dominant species were almost equally numerous, so that they can be called co-dominants (cf. Figs. 38, 39). Although the subordinate species were not greatly different from those of the *Thyasira-Lumbriconereis* community, these co-dominants far out-numbered the other species at many stations. In addition to this, there were two stations, at which neither of two dominants of the *Thyasira-Lumbriconereis* community were collected (Sts. IX-2; X-3). It can be considered that this was a distinct community rather than another minor component of the *Thyasira-Lumbriconereis* community. An isolated patch of this community was found on the top of the bank of Naka-no-sé in Tokyo Bay. Ecotones between this and the *T.-L.-Pseudocapitella* community were found at several stations (Sts. IX–1 ; X–2 ; XI–3 ; XII–3).

Eunice-Hiatella Community: From tops of banks within Ohtsu Bight, and that of the around Fort No. 3, there was found a community type characterized by the high population density of an errant polycheate species, *Eunice indica* Kinberg, and/or a small, sessile pelecypod *Hiatelle orientalis* (Yokoyama). Since all the localities were on the tip, or the margin of the banks, the habitat of the community was in a more or less exposed place. Among them, St. VIII–6 was situated in a locality which is strongly influenced by tidal currents. At this station, an epibiotic tube worm, *Spirobranchus giganteus* (Pallas), was most numerous along with many crustaceans.

Chone Community: On the shallow flat less than 20 m deep, two communities could be recognized, the *Chone dunneri-*, and *Haustorius* sp. communities. The former was distributed along the margin of the flats (cf. Fig. 31), while the latter was found in the shallower and inshore localities. An exception was found in the northern half of the shallow flat in Kimitsu Bight. As will be discussed subsequently the habitat of the *Haustorius* community in this locality extended towards the marginal part of the flat, bordering on the habitat of one of the lower-shelf communities (*Thyasira-Lumbriconereis* comm.) without having the *Chone* community in between.

In the habitat of the *Chone* community, the population density of the crustaceans was appreciably higher than in the lower-shelf region (p. 81, Fig. 25a, b). Comparatively low wet-weight percentage of this animal group resulted because of the abundance of small-sized crustaceans such as amphipods and isopods. The predominance of amphipods was particularly noticeable in the southern part of Kaneda Bight, where several species of *Corophium* and *Ampelisca* outnumbered the dominant species[1], the latter being both constant and numerous throughout the habitat. *Corophium* was more numerous than *Ampelisca* in shallower localities. This genus has been found in a shallow bottom covered with well-sorted, fine sand within Moroiso-Aburatsubo Cove (unpublished). *Ampelisca diadema* (Da Costa) and *A. naikaiensis* Nagata were common throughout the habitat of the community, while *A. misakiensis* Dahl was fairly common in an ecotone between this and *Thyasira-Lumbriconereis* communities. (St. VI–2). Two minute pelecypods, *Crenella yokoyamai* (cf. Fig. 32) and *Nucula paulula* (cf. Fig. 42), and a polychaete, *Trypanosylis zebra* Grube, were characterizing species in this community. On the margin of the flat within Kaneda Bight,

1) Parallel amphipod communities have been reviewed by Thorson ('57). Whether these facies of the *Chone* community should be regarded as distinct communities, is an open question.

to the north of the shelf-valley, *Eunice indica* appeared in correspondence with the presence of gravel and shell fragments in the sediment (Sts. A-1, 2 ; IV-2 ; VIII-1).

Haustorius Community: As was mentioned above, the richness of the hauls was poor in the habitat of the *Haustorius* community (p. 80, Fig. 24). Among a few animals collected in the habitat, a gammarid, *Haustorius* sp., appeared constantly, although it was never numerous at any station. A spioniform polychaete, *Nerinidea* cf. *papillosus* Okuda, and an unidentified haustoriid (?) amphipod were fairly common, although they were found at several stations in other communities. In the south of Fut'tsu-saki, living specimens of a minute pelecypod, *Mysella japonica,* were collected at several stations (cf. Fig. 32).

IV. FAUNA AND FACIES

A. Three Faunas in the Southern Part of Uraga Strait

Studying the distributions of both individual species and communities in the southern part of Uraga Strait, it becomes clear that 4 groups of benthic organisms are recognized in a vertical sequence, the canyon, the shelf-edge, the lower-shelf and the upper-shelf groups. The deepest group, inhabiting the canyon, includes several deep sea molluscs such as, *Turcicula aeola* (Watson), *Microglyphis noguchii* Kuroda, *Cadulus summa* Kuroda MS, *Malletia inequilateralis* Habe, *M. carinifera* Habe, *Portlandia lischkei* (Smith) and *Macome calcarea* (Gmelin). They were collected either dead or alive, or both, and some of them have been found also in Sagami Bay from the bathyal zone (archibenthal z.) of the deep sea system, indicating the influence of the Intermediate Water (Horikoshi, '57). Since the canyon water has low temperature (less than 10°C) all the year round (see the submarine climograph, Fig. 8a), it is quite understandable to find *Macoma calcarea* and the genus *Portlandia,* both of which are well known as cold water forms in northern Japan (Miyadi, Kuroda & Habe, '54), as well as in European Arctic water (Murray & Hjort, '12, p. 528; Ekman, '53, pp. 125, 172).

It is necessary to refer briefly to the third, or the lower-shelf group, before going to the second, or the shelf-edge group. In contrast to the canyon group, the lower-shelf group contains numerous warm water forms consisting of many endemic species of central (subtropical) Japan, plus a few tropical-subtropical elements. This may be ascribable to the oceanic, or "Kuroshio" Water, bathing the lower part of the shelf. Meanwhile, the taxonomic composition of the shelf-edge group shows an intermediate feature between those of the canyon and the lower-shelf groups, having several species in common with either of these. In the meantime, this shelf-edge group is somewhat similar to the canyon group, at least in the predominance of ophiurans, but it is distinguishable from either the canyon or the lower-shelf groups, containing several exclusive species such as *Amphioplus ancistrotus* and *Polynemamussium intuscostatum*. Similar intermediate features with additional complexities can be found also in the physical environmental factors. The habitat of this benthic group is midway between those of the canyon and the lower-shelf groups. The sea water at corresponding depths also shows properties intermediate between the canyon- and the oceanic waters. The habitat is a little complicated topographically by a break in slope, and it contains the two major types of the sea-floor, hard and soft bottoms. Also the sea water itself is not invariable, e. g. a thermocline is observable at corresponding depths in winter. Thus a question which has been raised by the author ('57, p. 61), whether it can be assumed that this group of benthos has a distinct faunal character (Oyama, '52), rather than an intermediate one peculiar to kind of an ectone between the two major habitats of the sea (the deep- and the shallow sea systems) is still not definitely answered.

In other waters around Japan, similar communities of intermediate character are also found at the corresponding depths. In a locality on the Japan Sea coast, both the benthic invertebrate and demersal fish communities show, in addition to their own special characteristics, intermediate features between the deeper, cold water-, and the shallower, warm water communities (Watanabe et al., '58, '60). On the other hand, it is reported (Hamai & Hashiba, '59) that either the deep water-, or the shallow water community of the demarsal fish appears, in correlation with the alternation of the respective water masses in different seasons at such a depth. Oyama ('51) has explained a mixture of cold and warm water molluscs on the supposition of a change in depth of the thermocline between these two water masses.

In the southern part of Uraga Strait, the lower-shelf group only has one sort of community, except for the minor one. This seems to be in accordance with the monotony of the physical environment. The sea-floor slopes but little, and is covered with a mixed sediment. The properties of the sea water vary only slightly at these depths of the lower part of the shelf.

As was discussed above, the boundary between the habitats of lower- and upper-shelf groups is found at a depth around 20 m (p. 84). This depth roughly corresponds to boundaries between two sets of physical environmental factors (sea floor and sea water) in deeper and shallower parts of the shelf respectively. In the shallower part, there can be seen the flats with a gentle slope, covered with sandy sediments, and bathed with the surface water in summer. The complexity of the sea floor observed on the shelf-edge, but lost in the lower part of the shelf, is again resumed on the shallow flats. The properties of the sea water are highly variable in the surface layer, at least in certain places, so that the water shows characteristics of the coastal water more or less clearly. Parker ('56) has recognized a boundary between the deep and the shallow shelves in the east Mississippi Delta region at a depth of about 13 fms (=23.4 m); a figure which markedly coincides with the results of this survey. He has not described the precise relations between this boundary on one hand, and the topography and the sediments on the other. However, Parker suggests that a difference of water masses could be one of several possible factors.

Inhabitants of this part of the shelf, the upper-shelf group, includes numbers of species which are distributed abundantly throughout the Japanese islands (from Kyûshû to Hokkaidô), e. g. *Anomia cytaeum* Gray, *Dosinia japonica* (Reeve), *Mactra sulcataria* Reeve, *Neverita didyma* (Röding), along with warm, shallow water elements which are confined within the northern limit of the subtropical region of the Japanese waters, (East of the cape of Chôshi: about 36°N.), such as *Paphia vernicosa* (Gould), and *Strombus japonicus* Reeve etc.[1)]

Briefly summarizing what has just been mentioned, there are recognized 1 minor and 3 major groups of benthos in the southern part of Uraga Strait from the canyon floor to the shallowest part of the shelf. The habitat of the canyon group (? including the shelf-edge group), seems to correspond well with the bathyal (archibenthal) zone of the deep sea system recognized in the classification of the marine environments (Hedgepeth, '57a, b). The canyon group can be defined here as the "*cold water, canyon fauna*". The habitats of the lower- and the upper-shelf group correspond to the outer- and inner-sublittorals[2)] of the shallow sea system respectively. They can also be defined as the "*oceanic water, lower-shelf fauna*", and the "*coastal water, upper-shelf fauna*".

B. Facies (Biological Oceanography of the Sea Floor)

In each habitat of all these three faunas, there are found several facies, or local variations of organisms and physical factors. As for the two facies recognized within the submarine canyon (pp. 84, 95), it can only be said that a difference in the distributions of the

1) For lists of molluscs found on the coast of Kurihama Cove and Kaneda Bight, see Okutani, '59 & Horikoshi '60.

2) See foot-note on p. 84.

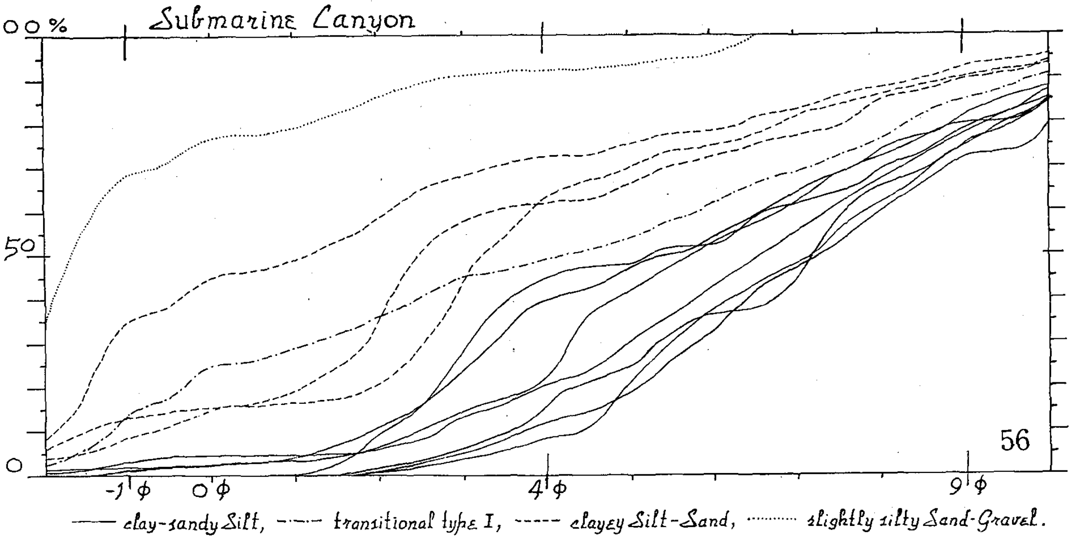
dominants corresponds to a difference in the distributions of the sediments of different sand content, which seems to be affected in turn by the inclination of the sea-floor.

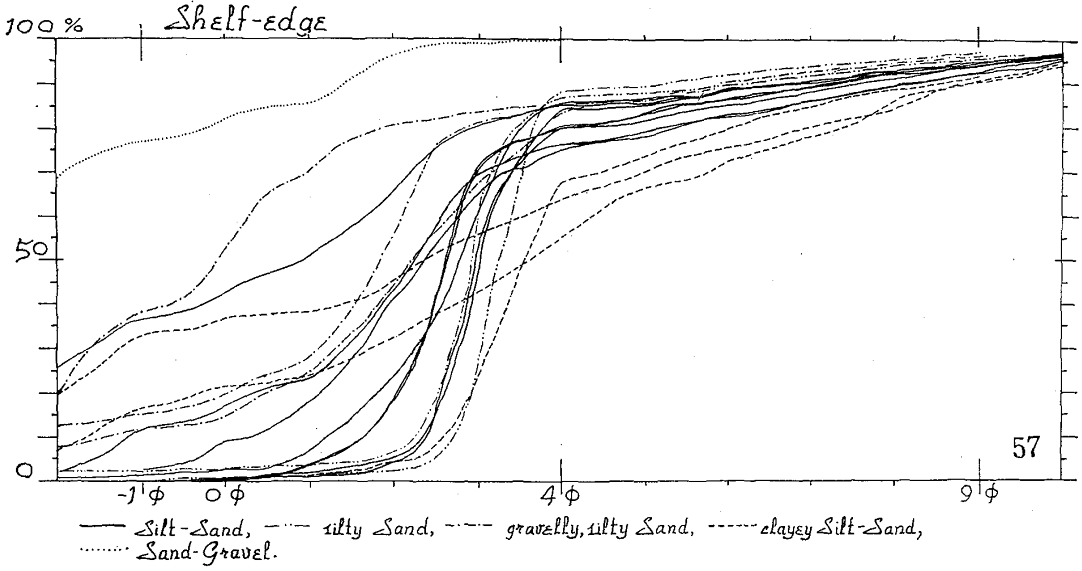
Such a difference in the character of the sediment can be recognized accurately through the graphic representation (Figs. 56–62). The "mechanical analysis" of the sediment (Gripenberg, '39) was carried out by Prof. Nasu & Dr. Kagami in order to know the distribution of particle sizes in a sediment sample at each station, using a set of Tyler standard screens (for particles coarser than 1.0 mm), an Emery settling tube (1.0–0.063 mm), and a "pipette" (finer than 0.063 mm) (Kagami, '61). The results of the analysis were plotted as cumulative curves by the author. These curves are drawn by choosing a size scale along the horizontal axis, and a frequency scale from 0 to 100 per cent along the vertical axis. A logarithmic scale is used for size, but actually the horizontal axis is graduated arithmetically in the ϕ scale ($0\phi = 1.0$ mm, $1\phi = 0.5$ mm, $2\phi = 0.25$ mm etc.) The relations between the discrete classes of the sediment and the diameter in the ϕ scale (in mm) are as follows: gravel $< -1\phi$ (>2.0 mm), sand $= 1 \sim 4\phi$ ($2.0 \sim 0.063$ mm), silt $= 4 \sim 9\phi$ ($0.063 \sim 0.0185$ mm), and clay $> 9\phi$ (< 0.0185 mm). From such a curve, it is possible to read several characteristics of the sediment at each station, not only the percentages of sand, silt, etc., but also the median diameter, the modal size or sizes, the degree of sorting, etc. (Krumbein, '39b). When all the samples are plotted as cumulative curves on a single sheet, the figure resembles a wide dark band, within which zones of several sediment types can be recognized, as has been suggested by Krumbein ('39a). This is more easily seen when the samples are plotted on separate sheets, after the stations have been classified, taking both the fauna and the topography into consideration, into habitat groups: i. e. submarine canyon, shelf-edge, lower-shelf, upper-shelf on the west- and the east sides of the strait, submarine channel, and the mouth of Tokyo Bay proper. As will be mentioned later, these zones are discriminated by the presence of the more or less clear gaps between the bundles of curves, and only few transitional curves are found. They are classified into seven main types and their derivatives, and are named after the grain size composition of the sediment. It is of ecological as well as geological interest to find that each habitat has its representative sediment type, with a few exceptions which indicate the ecological and/or topographical peculiarities of the locality in question. For instance, the sediment on the shelf-edge is predominantly "Silt-Sand", while the lower-shelf area in the southern part of the strait is covered mainly with "silty Sand", and exceptionally with "Silt-Sand" and "slightly silty Sand" in the more protected- and the more exposed localities respectively.

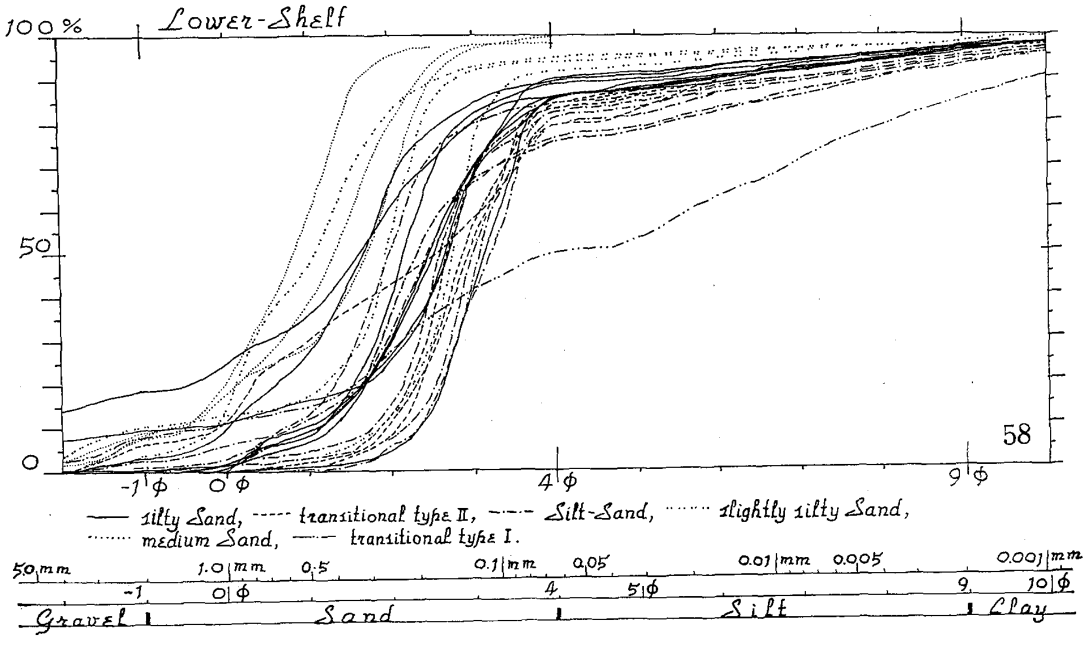
The cumulative curves of the canyon group (Fig. 56) are divisible into two bundles, except for one transitional curve and an additional curve of another sediment type. These two bundles are different not only in the sand content (less than 50% in clay-sandy Silt: solid lines; and more than that in clayey Silt-Sand: broken lines), but also in the content of clay particles (18–28% in the former type, and 7–10% in the latter). It is interesting to known that all the curves of all three stations in the habitat of the *Amphiura* "A" Community are found in one and the same type (clay-sandy Silt), while a curve which is depicted from the only one available datum obtained within the habitat of *Amph.* "B" Community belongs to the other (clayey Silt-Sand).

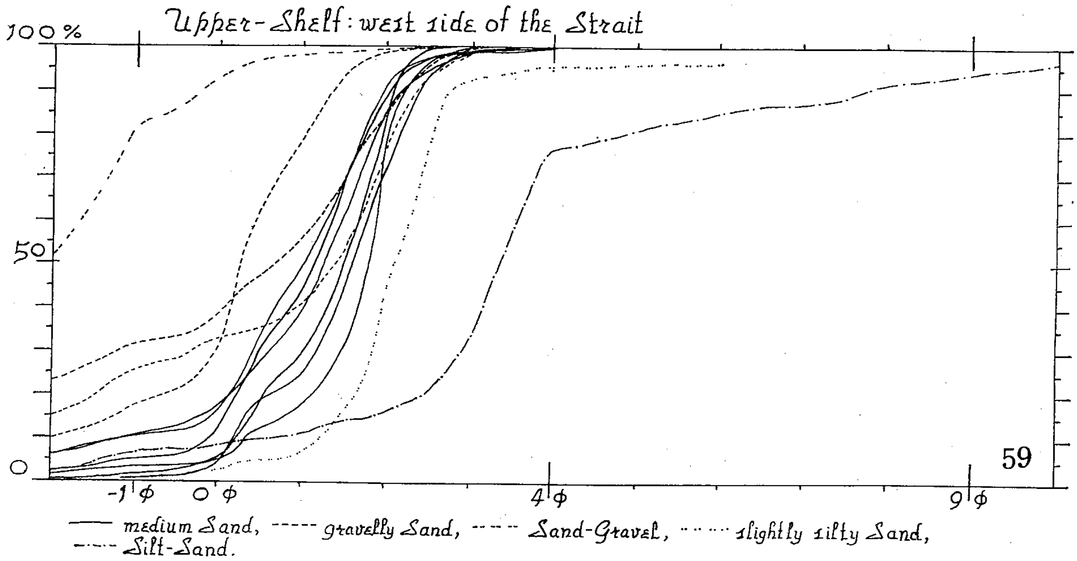
On the muddy flat floor of the canyon at the foot of a narrow gouge on the canyon head (St. III–11), remains of *Lima goliath*, *Cardita nodulosa* Lamarck, *Aniscorbula venusta*, and *Gibbula japonica* were found along with the polychaete species, *Micromaldane*, and several fresh, but empty shells of *Macoma calcarea*, *Marettia inequilateralis*, *Maret. carinifera* and *Cadulus summa*. The former 4 species are the characterizing forms of the shelf-edge and the continental slope on one hand, and the latter 5 are muddy level bottom dwellers on the other. In addition to this, a sessile holothurian, *Psolus*, an indicator of solid substratum, was not collected at this station (p. 95). It may be pertinent to suggest the occurrence of some kind of transportation of sediments within the canyon. It is interesting to note that evidence for transportations along a canyon, including distributions of molluscan remains, have been reported also from the Hudson Canyon (Ericson, Ewing & Heezen, '51).

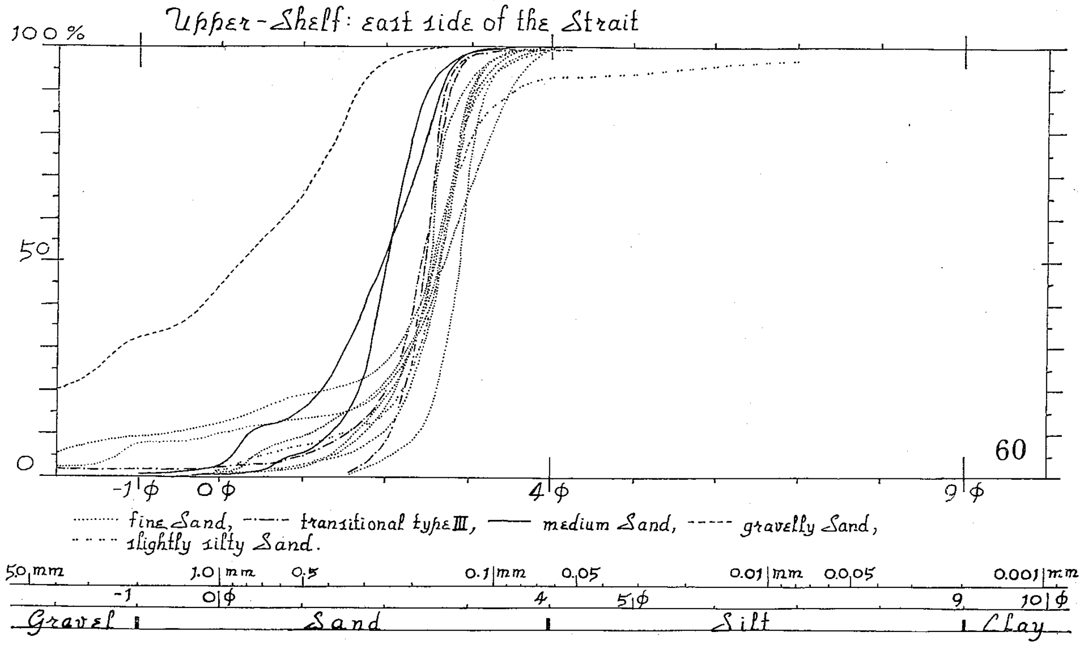
On the *shelf-edge*, two facies in the nature of the sea-floor, hard and soft bottoms, carrying their respective benthic communities, can be recognized (p. 95). In the hard bottom community of *Ophiothrix*, many of the animals are plankton-feeders, and are sessile in their body form and habit. *Psolus* is a very peculiar example among holothurians, and even one ophiuran genus, *Ophiothrix*, has been suggested to be a plankton feeder (Vevers, '56). *Ophiothrix marenzelleri*, the dominant species of the community, has arms provided profusely with thorny spines (hence the Japanese name of Toge-kumohitodé, thorny ophiuran), which are easily imagined being clogged with mud if it were living within soft clayey sediment. Both the predominance of one type of life-forms (sessile plankton-feeders), and the dominance on the hard bottom of an animal having a special morphological character are considered to be related to two environmental peculiarities: the presence of a certain amount of current, bringing a constant supply of plankton, and the resulting scanty deposition of sediment on the


Submarine Canyon
100%
50
0
-1 φ
0 φ
4 φ
9 φ
56
—— clay-sandy Silt, —·— transitional type I, ----- clayey Silt-Sand, ········ slightly silty Sand-Gravel.

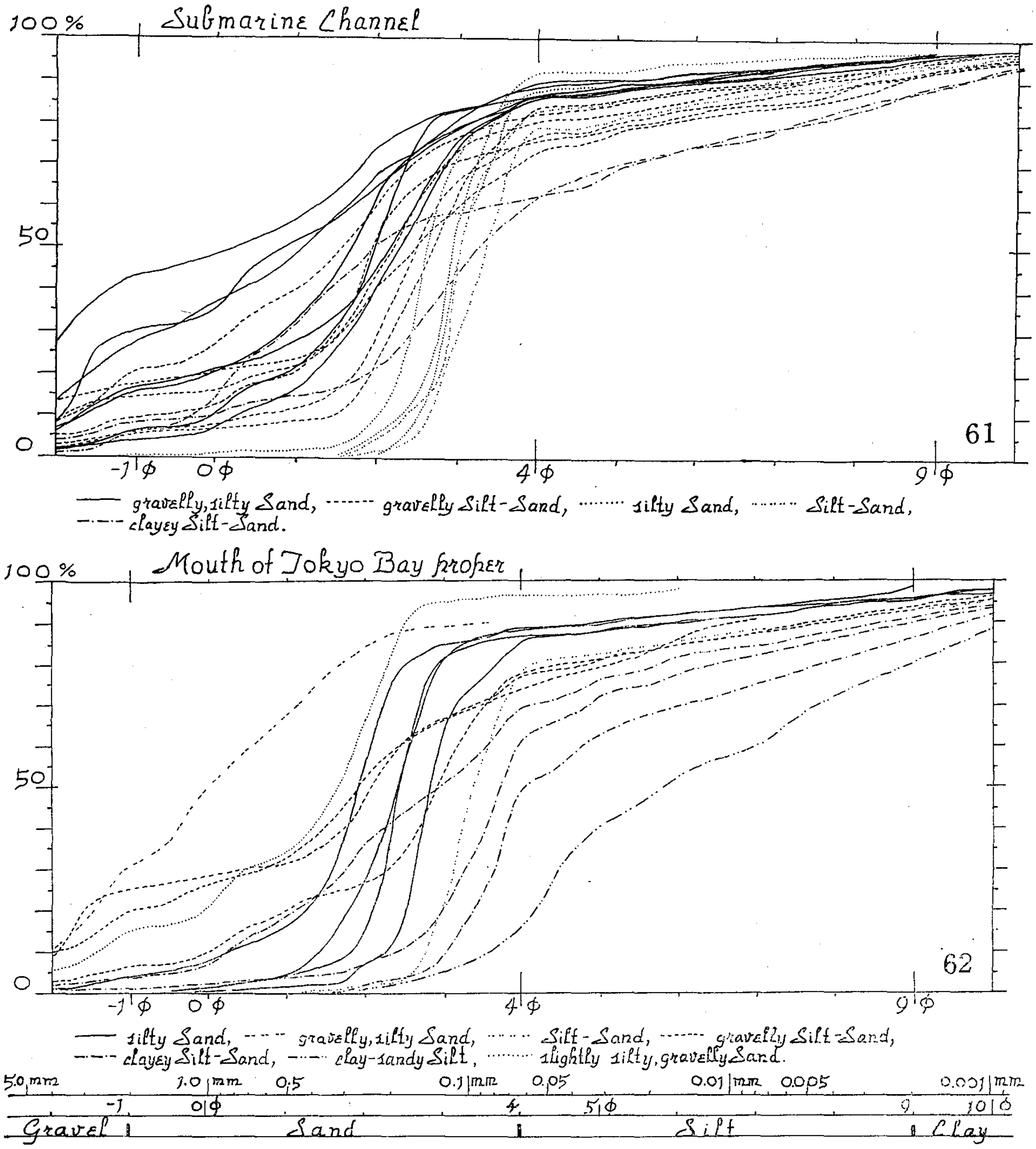

Shelf-edge
100%
50
0
-1 φ
0 φ
4 φ
9 φ
57
—— Silt-Sand, —·· silty Sand, —·— gravelly, silty Sand, ----- clayey Silt-Sand,
········ Sand-Gravel.


Lower-Shelf
100%
50
0
-1 φ
0 φ
4 φ
9 φ
58
—— silty Sand, ----- transitional type II, —·— Silt-Sand, ········ slightly silty Sand,
········ medium Sand, —— transitional type I.
5.0 mm
1.0 mm
0.5
0.1 mm
0.05
0.01 mm
0.005
0.001 mm
-1
0 φ
4
5 φ
9
10 φ
Gravel
Sand
Silt
Clay





Figs. 56-60. Cumulative curves showing the grain size distributions of the bottom sediments at each station. **56: Submarine Canyon;** clay-sandy Silt (Sts. D-1, 2, 5; I-8, 9; III-8, 10), transitional type I. (III-14), clayey Silt-Sand (I-6(gy), 7(gy′); III-11(gy′)), slightly silty Sand-Gravel(I-11). **57: Shelf-edge;** Silt-Sand(D-3; I-3, 4, 5(gy′); II-6(gy′); III-7(gy); III-18, 19), silty Sand(III-16, 17), gravelly, silty Sand (I-12(gy′); II-7; V-6), clayey Silt-Sand(I-13; IV-6(gy′), 7(gy′)), Sand-Gravel(V-7). **58: Lower-shelf;** silty Sand (III-3, 4, 5, 21(gy′), 22; A-3(gy′); V-2(gy′), 4(gy)), transitional type II(I-14, 15(gy′); A-4; IV-3), Silt Sand(II-3, 4, 5; III-20; IV-2′, 5; V-9), slightly silty Sand(I-2(gy); III-23; V-10), medium Sand(D-4(gy′. sl′.), 7(gy′. sl.′); V-8(gy′)), transitional type I. (III-6). **59: Upper-shelf; west side of the Strait,** medium sand(Sts. II-1(gy′), 2; III-1, 2, 24(gy′); IV-1), gravelly Sand(A-2; IV-2; VI-2), Sand-Gravel(A-1), slightly silty Sand(VIII-1), Silt-Sand(VI-1). **60: Ditto: east side;** fine Sand(I-17; V-11; VI-9(gy′), 12, 13; VII-11 (gy′), 12), transitional type III(VII-10; VIII-10(sl′)), medium Sand(V-12; VI-10), gravelly Sand(VI-11), slightly silty Sand(VIII-11). (For the abbreviation see p. 118, Tab. II)



Figs. 61, 62. Cumulative curves showing the grain size distributions of the bottom sediments at each station. **61: Kan'non-zaki Submarine Channel;** gravelly, silty Sand (VI-5(g'), 6; VII-4, 6, 7; VIII-6, 7(gy')), gravelly Silt-Sand(VI-3, 4, 7(gy'); VII-2; VIII-3(gy'), 5(gy')), silty Sand(VII-9(sl); VIII-8, 9), Silt-Sand(VI-8; VII-8), clayey Silt-Sand (VIII-2(gy'), 4(gy')). **62: Mouth of Tokyo Bay proper;** silty Sand(IX-3(gy'); X-2, 3; XI-3), gravelly silty Sand(B-2), Silt-Sand(XI-2), gravelly Silt-Sand(IX-1(gy'); B-1; XII-2), clayey Silt-Sand(X-1; XI-1; XII-3(gy')), clay-sandy Silt(XII-1), slightly gravelly Sand(IX-2). (For the abbreviation see p. 118, Tab. II)

exposed rock surface.

In addition to these two facies, hard and soft bottoms, on the shelf-edge, the habitat of the community of *Stegophiura sterea* on the s u b-m a r i n e p e n i n s u l a will be referred to here. From a merely topographical point of view, it would be included within the lower part of the shelf. However, considering the bathymetrical range of a community having the same species as the dominant off the coast of the Japan Sea (p. 96), along with the presence of other genera and species of ophiurans and that of the remains of a shelf-edge form (*Polynemassium*: Fig. 43) in this locality, it can be suggested that environmental factors on the top of the submarine peninsula differ from those at corresponding depths in other localities. One of the difference in facies is indicated also by the cumulative curve of the sediment. As was mentioned above, the predominant sediment type of the lower shelf depths is silty Sand, with the addition of Silt-Sand and slightly silty Sand, while the sediment is medium Sand in this locality (Fig. 58: another station of this type is situated also in a very exposed locality near the canyon head vestibule). Several characterizing molluscs of the continental slope together with shelf forms, have also been reported from the tops of banks (Oyama, '54; Niino, '55; Horikoshi, '57, pp.57, 61). This suggests that following hydrographical peculiarities, either or both of which could be the cause of the peculiar distribution of organisms: the presence of the agitating influence of waves which otherwise cannot reach the bottom of equivalent depths in other more sheltered localities with the strait; and the presence of the local up-welling of the deeper water (canyon water, or intermediate water), although perhaps not constantly, caused by a barrier obstracting a strong oceanic or tidal current.

In the *lower part of the shelf*, the surveyed area happens to be most extensive from the mouth of Uraga Strait to the periphery of the main basin of Tokyo Bay, so that comparatively numerous facies can be recognized here. To begin with the outer-most locality, the *southern part of Kaneda Bight* is a somewhat peculiar area. As was briefly mentioned in the beginning of this chapter, the predominant sediment types are silty Sand and Silt-Sand, in the lower shelf area and on the shelf-edge respectively (Figs. 57, 58). The two types of sediment differ from each other in their silt-clay content[1] around the value of 15%, being less than that in the former type (10–15%) and more in the latter (15–25%). Such a relationship in the content of the finer particles in the sediment is maintained throughout the whole length of the "tail of silt-clay" (3–4% : 5–7%, at 9ϕ), so that the boundary line drawn between these two sets of curves is not crossed by either of the component curves of the two, except for a very few exceptions found among the "Silt-Sand" type, which has an unusually small value of silt-clay content (broken lines in Fig. 58). In this locality, the clay content of the sediment is appreciably higher (Silt-Sand), than it is at corresponding depths in the neighbouring localities

1) This is the contrary of the value of sand content at 4ϕ (silt-clay %=100−sand-gravel %).

(silty Sand), and the benthic community (the *Thyasira-Lumbriconereis* community) also shows a local variation within its habitat (*T.-L.-Amphitrite* minor community). It seems not to be a mere coincidence to find the peculiar distributions of remains of two pelecypod molluscs, *Nuculana* (Fig. 44) and *Sarepta* (Fig. 45) (p. 90). This locality is situated at the protected foot of Ken-zaki Submarine Peninsula (p. 58).

In the lower part of the shelves bordering the canyon, *the east and west sides* differ from each other in distributions of certain animals. On the west side, an aplacophoran mollusc, "*Chaetoderma*" *japonica*, looks like a shelf-edge form in its distribution, while on the other side its distribution range is extended to shallower places (Fig. 28). A small crab, *Nursia elegans japonica*, is not distributed on the east side (Fig. 35). A difference is also seen in the distribution of the richness of haul, the poor haul being comparatively more numerous on the east side, while rich and richest hauls are seen only on the west side. Whether these differences are due to a difference in the character of sediment (containing slightly larger amount of the finer particles on the east side: Fig. 3, see also Fig. 58) and in the distribution of muddy sediment (more patchy on the east side: Attached Chart), or a difference in the nature of the sea water (enriched Tokyo Bay Water on the west side, and clear oceanic water on the east), or both, seems to be an open question.

Concerning *Kan'non-zaki Submarine Channel*, it will suffice to refer to the following two points, since the ecology of this locality will be discussed subsequently. In the southern part the channel, remains of a pelecypod, *Limopsis azumana* (Fig. 46) out-numbered an allied species, *L.oblonga* (Fig. 47) (p. 90). This may suggest that at least some of the pebbles and shell fragments contained in the sediments of either type of Silt-Sand and silty Sand (Fig. 61), both with appreciable amounts of gravel, are exposed above the surface of the sediment. This in turn may indicate water movement (perhaps seen at the time of spring tide) and resulting in rather slow deposition of fine particles. Living specimens of only *L. azumana* were collected on hard bottoms on the tip of the submarine peninsula and the canyon-head vestibule. Within the channel, several living specimens of this species were collected, actually one of them still attached to a pebble. As was mentioned above (p. 98), the *Eunice* community appeared in exposed localities within the submarine channel and in Ohtsu Bight, suggesting wave and current actions in these localities.

At the *mouth of Tokyo Bay proper*, distributions of the *Ophiophragmus-Amphicteis* community (on the east side) and the *Thyasira-Lumbriconereis-Pseudocapitella* community (on the west side) roughly correspond to those of the coarse sediments with gravel and finer ones without them (Fig. 3), the latter resulting from currents, circulations and tidal currents in this locality (p. 61). In addition to this, it is noticeable that the presence of certain animal species in this locality is indicative of one of the major habitats of the sea, an enclosed bay, which is different from what is encountered in the southern part of Uraga Strait, an open sea. It has been reported by many authors (Masui, '43 ; Kawaguchi, '46 ; Kitamori, '50 ; Habe, '52), that, among the predominating animals in Tokyo Bay, the following two species can be found : a polychaete, *Prionospio pinnata* Ehler, a characterizing species of a stagnant area in mid-bay (Miyadi, '41a, b), and a thin shelled, small peleycypod mollusc, *Theora lubrica*, a characterizing species of soft-mud area in the inner part of the bay (Miyadi, '40, 41b ; Habe, '56). The former species appeared rather sporadically at several stations in this locality, while the latter was distributed only on the west side (Fig. 42). A relation between population density distributions of *Prionospio* and of *Lumbriconereis* in this locality are similar to what has been depicted in Kitamori's figure ('50, fig. 1). In these connection, it is probable that poor hauls found in a muddy-bottomed area within the extension of the submarine channel (Fig. 24) have certain relations with thin population densities of crustaceans and demersal fishes, which have been reported from the west side of Tokyo Bay proper (Kubo & Asada, '57 ; Takagi, '59).

In the *upper-shelf region*, a difference between distributions of pelecypod molluscs found on the shallow flat (less than 20 m deep) on the *west side*, and those on the *east side of Uraga Strait*, can be recognized. Both living and dead shells of a clam, *Callista chinensis* (Holten), are common in coarse-sedimented areas with gravel and shell fragments (Fig. 59 : gravelly Sand & Sand-Gravel) on the exposed margins of shallow flats along the coast of the Miura Peninsula. Its distribution is extended from the northern edge of the shelf valley in Kaneda Bight as far north as off Uraga Cove. The common occurrence of this clam, based on a beach collection after a typhoon, has been reported from the northern part of the bight (Horikoshi, '60b). This species, however, is not collected on the extensive shallow flat in Kimitsu Bight ; on the other hand, hundreds of remains of the minute pelecypod *Mysella japonica* (Fig. 53), are found in this locality, although the distribution of living specimens were collected only in the northern part of this area. The sediment types are also different in these two areas (Figs. 59, 60), medium Sand (Mdϕ : median diameter in the ϕ scale$=$1–2) is found in Kaneda Bight, together with gravelly Sand and Sand-Gravel distributed along the rim of the shallow flat. On the other hand, fine Sand (Md$\phi$$=$2–3) is predominant in Kimitsu Bight, and both medium Sand and gravelly Sand are found at only a few stations in the more exposed locality in the southern part of Kimitsu Bight (Sts. V–12, VI–10, 11 ; see also Fig. 3). Although these data seem to imply a difference in the wave action, no further causal explanation for the faunal difference can be offered here.

Another aspect of the difference between these two areas is seen in the distribution patterns of the *Chone*- and the *Haustorius* communities (Fig. 4). In Kaneda Bight, the former community is found to occupy the rim of the shallow flat less than 20 m deep, while the latter is found in the shallower and more inshore stations. In Kimitsu Bight, such a topographical arrangement of these two communities is seen only in the southern part. In the northern part, the distribution range of the *Haustorius* community extends to the periphery of the shallow flat, so that the habitat of this community is contiguous with that of a lower-shelf community (*Tyasira-Lumbriconeresis* community), lacking a *Chone* community in between them. Within Kimitsu Bight, similar, but more highly localized variation in the distribution of benthic communities runs parallel to that of the sediment type. In the *northern part of Kimitsu Bight*, the sediment in the marginal part of the shallow flat (Sts. VII–10 ; VIII–10)[1] is " fine Sand ", and neither medium Sand nor gravelly Sand can be found. But closer inspection of the cumulative curves reveals that, although the sediments at these two stations (Fig. 60 : dot-broken lines) have median diameters which are not unlike to those of the ordinary " fine Sand ", the grain sizes of the finer part of the sediments are rather more similar to those of medium Sand (from 2.75 to 2.25ϕ) than to those of fine Sand (from 3.25 to 2.75). Therefore, the sedimentary relationship between the marginal and the inshore parts of a shallow flat is still retained even in the northern part of Kimitsu Bight (the coarser sediment in the margin, and the finer inshore). But the degree of coarseness is very much less in the northern part, and probably accounts for the absence of a coarse sediment community (*Chone* com.).

In spite of what was mentioned above, no definite relations could be found between the *Chone*- and *Haustorius* communities and the particular sediment types. Both communities can be found at stations of either medium or fine sand sediment. As was mentioned before the poor hauls obtained in the habitats of the *Haustorius* community are found on the both sides of the strait (Fig. 24 & p. 80). For these reasons, it seems necessary to take into consideration the distribution of an edible clam, *Mactra sulacataria*, on either sides of the strait (on the coast of Kaneda Bight (Inoue, '60 ; Horikoshi, '60) and Fut'tsu, Takéoka, Hota & Iwai, on the coast of the Bôsô Peninsula (Shimazu, '50)) perhaps in relation to a detailed hydrographical study of the areas.

1) For the details of the submarine topography, see Attached Chart.

A *boundary between the habitats of the upper- and lower-shelf communities* is situated at different depths in physiographically different localities. It is found at a depth of less than 20 m in the northern part of Kimitsu Bight, while in the southern part of Kaneda Bight, the depth is deeper than 20 m. The boundary between sandy and muddy sediments in these two localities corresponds closely with those of the habitats of the two faunas in respective localities (compare Fig. 3 with Fig. 4). It is interesting to find that the local difference in the depth of the boundary between the surface and the subsurface waters (pp. 69, 71) is also parallel to these two sets of local differences (in faunas and in sediments). Although it is not possible to determine here whether the sediments or the properties of water (or both) is responsible for the faunal difference, it may be possible to suggest the occurrence of local differences in the depth of effective wave action in sheltered and in exposed localities. In this connection, it is interesting to note that the boundary has been reported to be found at some depth of 30–40 m near the mouth of Sagami Bay, and 25–30 m on the bay head (Horikoshi, '57, pp. 53–56).

On the *shallow flat around the cape of Fut'tsu-saki* (Sts. VIII–10, 11 ; IX–3 ; X–3), there are found remains of a small-sized pelecypod species, *Anomalocardia micra* (Pilsbry), which has been said to be distributed in an enclosed bay from its middle part to the bay head (for a review see Habe, '56, p. 8), and has been reported from shallow water at the head of Tokyo Bay. This seems to have certain relations with the appreciable amount of the silt-clay content in the sediment (0.8∼13.3% : Figs. 60, 62), and the presence of an eddy in this locality (p. 60), indicating the stagnation and prevalence of coastal water.

C. Ecology and Oceanography of the Kan'non-zaki Submarine Channel

It was expected even during the survey that the influence of the oceanic water may reach the mouth of Tokyo Bay proper as far as off the island of Saru-shima, perhaps running beneath the surface coastal water. This was inferred from the presence of a gorgonian species, *Euplexaura erecta* Kükenthal, collected on a tip of the bank around Saru-shima within Ohtsu Bight (St. B–2), and also from the distributions of several shelf-edge and lower-shelf molluscs along the floor and side-walls of the submarine channel (e. g. *Sarepta speciosa, Aequipecten vesiculosus, Punctrella pelex* (A. Adams) etc.). This is in good accordance with hydrographical observations made by two authors (Masui, '43 ; Koganei, '60) that water of comparatively oceanic nature has been found in and around Ohtsu Bight, in contrast to what would be expected from the physiography.

The laboratory study of the distribution patterns of molluscan remains confirmed this expectation. Distributions of *Limopsis azumana* (Fig. 46) and *Gibbula japonica* (Fig. 48) were extended over the whole length of the submarine channel. Although the other 4 species, *Polynemamussium intuscostatum* (Fig. 43), *Aequipecten vesiculosus* (Fig. 49), *Nuculana yokoyamai* (Fig. 44), and *Sarepta speciosa* (Fig. 45), are less numerous in the northern part of the channel, their distribution range were almost identical with those of *Limopsis* and *Gibbula*, as well as with each other. It is interesting to observe that the limit of the distribution ranges of these molluscan remains fairly well correspond to that of the submarine channel, which is defined from the topographical features (p. 59).

As has been discussed in detail earlier (pp. 71–74), the bottom water within the submarine channel is different from the surface coastal water in the same locality, the former being oceanic in nature, especially during times of excessive run-off. It can be considered that these hydrographical characteristics of the bottom water within the channel account for the peculiar distributions of the shelf-edge and lower-shelf forms.

In addition to these, it is interesting to find the occurrence of a cold-water, deep-sea isopod, *Arctulus brevispina* Richardson, at Sts. VI–3, 6, 5, indicating an influence of the canyon water. It seems possible that the canyon water may be brought into the submarine channel by currents running along the channel, assuming that the canyon water flow out of the canyon-head (perhaps in connection with an internal wave within the canyon). Limbaugh & Shepard ('57, p. 638) have briefly reported the presence of "displacements of gorgonians and certain fishes that reach their shallowest situations on the rim of the canyon", and have suggested a function of the canyon as channel for the ascent of cold water.

It was revealed through laboratory work that rather unexpected isolated populations of shelf-edge ophiurans are restricted to the northern part of the submarine channel (Figs. 26, 27). Two sedentary polychaetes, *Nicomache maculata* Arwidson and *Branchiomma* sp. are other examples of restricted distributions within the northern part of the submarine channel, although the former species was found to be numerous at a few stations on the border between the northern and southern parts of the submarine channel (Sts. VII–5, 6). These distribution patterns of ophiurans and polychaetes in the northern part of the channel are rather similar to those of the co-dominants of the *Ophiophragmus-Amphicteis* community (Figs. 38, 39). It is noticeable that positive relations can be seen between these distributions of benthos and that of the coarse sediments (gravel & shell fragments, and coarse sand : Figs. 61, 62 ; see also Fig. 3 & Attached Chart). In this case, water currents (both tidal and constant) seems to be one of the important factors (pp. 61, 74, 76).

From what has just been mentioned, it will become clear that shallow and deep sea forms are intermingled within this peculiar locality in the lower part of the shelf. It has already been referred to that this locality is situated midway between the open sea and the enclosed bay, not only physiographically but also biologically (p. 109). In addition, one of the co-dominant species of the community which is found within this locality, *Ophiophragmus japonicus*, has been collected at the mouth of an inlet on the coast of Sagami Bay (Moroiso-Aburatsubo Cove : Horikoshi, '55). Hence, in this locality, it is possible to recognize an intermediate zone between two sets of the major habitats : the deep and the shallow sea systems on one hand, and the open sea and the enclosed bay on the other. In its more strict sense, the term "ecotone" cannot be applied to this intermediate zone, because there is a distinct community within the zone instead of a tension zone between two communities (Allee et al., '55). But it may be of practical as well as of theoretical value to recognize in this locality a kind of ecotone (in a broader sence : Dice, '52 ; Odum, '53) between these two sets of major habitats, or major communities. Thus an aggregation of richest hauls within this locality can be understood as an edge effect in a kind of ecotone.

Parker ('56) has described from the east Mississippi Delta region a peculiar assemblage of macro-invertebrates found within shelf valleys ("inlets" or "passes"), which was scored by tidal currents, and connected a very shallow flat ("upper sound": less than 4 m) with another flat of a different depth in the upper part of the shelf ("shallow shelf": less than 23 m). This assemblage includes, besides some species exclusive to this locality, two elements coming from either side of the valley (deeper and shallower), as expected from in- and out-flow of tidal currents. It is interesting to find in his figures (figs. 7, 8-lower), that bottom waters within the shelf valleys are more oceanic in nature (chlorinity more than 18–19%) during the time of maximum river discharge ; these relations which are almost identical with those found within the Kan'non-zaki Submarine Channel. Indeed, topographical, hydrographical and biological situations within this shelf valley seem to be very similar to those within the Kan'non-zaki Submarine Channel, except for a difference in depth which results in some differences in the water masses concerned (lacking the cold water of the deep sea system in Parker's case). The ecology of the Mississippi Delta shelf valley is so closely related to that of the

Kan'non-zaki Submarine Channel, that they can be recognized as parallels.

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Table II. Dredging stations, numerical and gravimetrical (in parentheses: wet weight) populations. (St.=Silt, Sd=Sand, G=Gravel, cy.=clayey, cl.=clay, sty.=silty, sdy.=sandy, gy.=gravelly, f.=fine, md.=medium, sl.=slightly silty; ∼=transitional type; dash denotes small amount).

Station	Depth (m)	bottom sediments	Animal groups %				
			Ophiur.	Crust.	Polych.	Moll.	Misc.
I-1	25	——	1.0% (1.1)	72.8% (29.3)	22.0% (38.3)	1.3% (0.4)	2.9% (2.4)
2	50	(gy) sl. Sd	0.7 (—)	15.2 (5.1)	82.6 (94.2)	1.4 (—)	0 (0.7)
3	85	St-Sd	27.9 (60.1)	11.6 (3.5)	53.4 (28.8)	4.1 (4.8)	2.9 (3.9)
4	102	St-Sd	21.7 (85.5)	21.7 (1.4)	41.7 (9.2)	9.6 (2.8)	5.3 (1.1)
5	205	(gy′) St-Sd	12.5 (68.9)	36.1 (14.8)	40.3 (14.2)	9.7 (2.0)	1.3 (—)
6	310	(gy) cy. St-Sd	—	—	—	—	—
7	370	(gy′) cy. St-Sd	0	0	40.0 (99.9)	60.0 (0.0)	0
8	527	cl-sdy. St	—	—	—	—	—
9	545	cl-sdy. St	69.1 (97.1)	3.1 (0.0)	23.4 (2.9)	2.1 (0.0)	2.1 (0.0)
10	400	——	60.0 (97.1)	—	10.0 (0.2)	10.0 (0.2)	20.0 (2.5)
11	280	sl. Sd-G	0 —	25.0 (0.0)	25.0 (0.0)	0 —	50.0 (99.9)
12	120	(gy′) St-Sd	35.5 (32.5)	19.0 (4.5)	37.2 (33.6)	10.1 (10.0)	8.3 (19.4)
13	94	cy. St-Sd	6.2 (10.1)	15.6 (1.0)	35.9 (76.0)	39.2 (12.8)	3.1 (0.0)
14	72	St-Sd∼sty, Sd	2.9 (0.0)	8.8 (37.8)	45.6 (50.3)	42.7 (9.1)	0.0 (2.8)
15	45	(gy′) St-Sd ∼sty. Sd	2.7 (—)	2.7 (—)	46.7 (19.5)	34.7 (79.5)	13.3 (1.0)
16	20	——	—	—	—	—	—
17	16	f. Sd	1.2 (1.0)	7.1 (9.7)	75.0 (3.4)	4.8 (0.2)	11.9 (85.8)
II-1	15	(gy′) md. Sd	—	77.8 (47.9)	16.1 (46.7)	1.5 (4.1)	3.6 (1.3)
2	25	md. Sd	1.2 (2.4)	66.1 (13.8)	25.6 (74.1)	3.1 (1.3)	3.9 (8.4)
3	47	St-Sd	5.1 (1.1)	8.2 (0.1)	68.4 (19.2)	13.2 (12.0)	5.1 (67.4)
4	56	St-Sd	3.3 (0.7)	10.9 (1.0)	72.4 (23.9)	5.0 (0.2)	8.4 (74.2)
5	70	St-Sd	4.2 (16.7)	10.9 (1.1)	71.2 (51.0)	8.9 (28.3)	4.8 (2.9)
6	79	(gy′) St-Sd	10.3 (43.7)	10.9 (3.6)	69.2 (27.8)	5.4 (1.4)	4.2 (23.5)
7	100	gy. sty. Sd	13.5 (8.3)	9.6 (0.0)	40.4 (8.3)	15.3 (20.9)	21.2 (62.5)

Station	Depth (m)	bottom sediments	Animal groups %				
			Ophiur.	Crust.	Polych.	Moll.	Misc.
III-1	8	md. Sd	—	5.6 (8.1)	79.6 (79.0)	12.9 (12.9)	1.9 (0.0)
2	14	md. Sd	0.6 (22.4)	67.0 (17.4)	26.9 (36.4)	4.2 (23.1)	1.2 (0.7)
3	20	sty. Sd	2.0 (4.5)	17.6 (2.2)	72.4 (40.5)	4.0 (4.8)	4.0 (4.2)
4	45	sty. Sd	2.1 (3.1)	14.7 (2.4)	50.5 (88.1)	28.4 (4.8)	4.2 (1.6)
5	53	sty. Sd	0.5 (0.0)	6.2 (1.9)	68.9 (71.7)	21.5 (23.6)	2.9 (2.8)
6	63	cy. S-Sd ～cl-sdy. St	16.8 (11.1)	17.8 (2.6)	50.3 (60.8)	7.7 (0.9)	7.7 (24.9)
7	100	(gy) St-Sd	5.1 (9.5)	2.8 (0.1)	87.5 (43.1)	1.1 (0.1)	3.5 (47.1)
8	180	cl-sdy. St	—	—	—	—	—
9	240	——	—	—	—	—	—
10	300	cl-sdy. St	—	20.0 (0.2)	30.0 (0.2)	40.0 (33.4)	10.0 (66.2)
11	405	(gy) cy. St-Sd	9.3 (49.9)	4.6 (0.6)	81.5 (32.1)	3.7 (16.6)	0.9 (1.2)
12	345	——	46.3 (65.3)	3.7 (0.0)	27.8 (18.7)	14.8 (5.0)	7.4 (11.0)
13	300	——	—	—	—	—	—
14	205	cl-sdy. St ～cy. St-Sd	—	13.2 (1.4)	48.6 (30.8)	10.5 (3.7)	27.6 (64.1)
15	150	——	33.4	0	50.0	16.6	0.0
16	120	sty. Sd	12.2 (43.8)	33.3 (3.4)	35.6 (35.9)	16.7 (16.8)	2.2
17	100	sty. Sd	21.1 (51.5)	27.3 (9.1)	45.4 (22.7)	6.1 (16.6)	— —
18	98	St-Sd	21.3 (18.5)	32.0 (2.4)	32.0 (17.1)	9.3 (3.9)	5.4 (58.0)
19	122	St-Sd	20.4 (40.5)	20.4 (2.5)	32.7 (10.1)	22.4 (46.9)	4.1 (0.0)
20	75	St-Sd	5.6 (1.5)	5.6 (0.0)	36.1 (80.6)	47.1 (17.9)	5.6 (0.0)
21	55	(gy′) sty. Sd	3.5 (5.4)	14.1 (2.7)	50.6 (52.7)	17.7 (6.7)	14.1 (32.4)
22	41	sty. Sd	4.1 (0.0)	12.2 (12.0)	63.3 (68.0)	12.2 (0.0)	8.2 (20.0)
23	30	sl. Sd	0.8 (0.0)	21.1 (0.7)	61.8 (16.4)	12.2 (61.0)	4.1 (21.8)
24	17	(gy′) md. Sd	4.9 (0.0)	7.6 (1.0)	35.9 (15.2)	1.6 (4.0)	50.0 (79.8)
IV-1	14	md. Sd	—	28.6 (0.0)	63.2 (37.6)	2.0 (0.0)	6.2 62.4
2	16	gy. Sd	1.7 (2.9)	42.4 (3.0)	43.4 (31.8)	4.7 (29.9)	7.8 (29.6)
2′	31	St-Sd	0.4 (1.6)	2.2 (0.4)	89.7 (89.2)	6.0 (7.0)	1.7 (1.7)
3	45	sty. Sd～St-Sd	0.5 (18.6)	22.4 (4.3)	37.5 (62.1)	36.9 (14.3)	2.6 (0.6)

Station	Depth (m)	bottom sediments	Animal groups %				
			Ophiur.	Crust.	Polych.	Moll.	Misc.
4	53	——	2.5 (4.4)	15.0 (1.0)	55.0 (14.8)	15.0 (51.6)	12.5 (28.2)
5	67	St-Sd	—	1.2 (0.0)	32.5 (67.1)	36.2 (25.9)	30.0 (7.0)
6	120	(gy) cy. St-Sd	2.9 (0.0)	5.9 (0.0)	85.3 (6.5)	2.9 (0.0)	2.9 (93.5)
7	200	(gy) cy. St-Sd	25.0 (80.0)	—	25.0 (0.0)	25.0 (18.6)	25.0 (1.4)
A-1	17	Sd-G	1.9 (4.7)	29.0 (13.8)	62.4 (68.2)	1.3 (2.4)	5.4 (10.8)
2	12	gy. Sd	1.4 (4.3)	44.0 (12.4)	43.4 (16.0)	5.7 (26.1)	5.5 (14.1)
3	37	sty. Sd	—	5.1 (3.0)	82.9 (93.5)	11.9 (2.8)	0 (0.7)
4	43	sty. Sd～St-Sd	—	4.1 (7.7)	79.2 (89.4)	15.2 (2.9)	1.5 (—)
V-1	20	——	0.4 (1.3)	14.8 (13.8)	63.8 (13.2)	4.5 (64.0)	16.5 (7.7)
2	31	(gy′) sty. Sd	24.1 (28.2)	18.5 (5.6)	50.6 (7.5)	4.3 (35.0)	2.5 (23.7)
3	51	——	10.0 (5.2)	11.0 (1.1)	58.0 (67.8)	14.0 (2.9)	7.0 (22.9)
4	70	(gy) sty. Sd	5.0 (0.0)	15.0 (2.4)	50.0 (96.3)	20.0 (1.2)	10.0 (0.0)
5	160	——	—	—	—	—	—
6	105	gy. sty. Sd	64.9 (29.2)	3.1 (0.8)	19.5 (6.0)	3.1 (3.2)	9.4 (60.8)
7	83	Sd-G	34.5 (49.0)	7.3 (4.0)	27.3 (3.8)	21.9 (30.6)	9.0 (12.5)
8	52	(gy′) md. Sd	—	52.3 (33.3)	42.8 (66.6)	4.9 (0.0)	—
9	61	St-Sd	—	3.7 (0.0)	47.6 (71.4)	39.2 (14.3)	9.4 (14.3)
10	35	sl. Sd	1.8 (0.0)	23.6 (3.8)	58.2 (91.2)	12.7 (5.0)	3.7 0.0
11	20	f. Sd	0.9 (5.7)	46.8 (18.6)	27.9 (31.4)	18.0 (40.0)	6.4 (4.3)
12	10	md. Sd	0 (—)	3.0 (0.0)	92.9 (12.4)	2.0 (0.8)	2.0 (86.8)
VI-1	15	St-Sd	—	—	—	—	—
2	20	gy. Sd	3.9 (1.7)	29.5 (5.4)	38.0 (5.2)	19.1 (65.9)	9.5 (21.8)
3	41	gy. St-Sd	1.5 (1.5)	7.1 (2.4)	84.6 (74.2)	2.3 (2.4)	4.5 (19.5)
4	50	gy. St-Sd	0.6 (25.6)	11.4 (3.6)	85.9 (55.3)	1.0 (12.6)	1.0 (3.0)
5	74	gy′. sty. Sd	0.1 (0.0)	5.1 (3.2)	92.9 (93.6)	1.1 (1.6)	0.8 (1.5)
6	65	gy. sty. Sd	3.6 (2.4)	16.8 (3.7)	70.9 (89.5)	4.6 (1.9)	4.1 (2.3)
7	52	gy′. St-Sd	5.6 (1.7)	11.1 (11.5)	72.8 (83.6)	7.4 (2.7)	3.1 (0.3)
8	31	St-Sd	0.7 (0.0)	16.9 (8.8)	56.2 (45.8)	25.5 (21.9)	0.7 (23.4)

Station	Depth (m)	bottom sediments	Animal groups %				
			Ophiur.	Crust.	Polych.	Moll.	Misc.
9	20	(gy′) f. Sd	4.8 (2.6)	29.2 (2.6)	59.0 (15.1)	3.6 (7.7)	3.4 (72.0)
10	12	md. Sd	7.5 (7.5)	27.6 (2.9)	61.1 (37.3)	1.5 (49.3)	2.3 (2.9)
11	10	gy. Sd	1.0 (0.5)	6.2 (0.0)	61.9 (31.3)	13.4 (30.0)	17.5 (38.2)
12	8	f. Sd	3.0 (13.7)	22.0 (5.1)	55.0 (18.9)	5.0 (27.6)	15.0 (34.5)
13	6	f. Sd	—	46.2 (7.2)	47.6 (9.3)	1.6 (0.0)	4.6 (83.5)
VII-1	20	——	3.6 (0.0)	12.7 (16.0)	69.1 (25.9)	3.6 (30.8)	11.0 (27.2)
2	30	gy. St-Sd	—	18.2 (0.6)	36.3 (7.7)	4.6 (0.0)	40.9 (91.7)
3	50	——	—	—	—	—	—
4	74	gy. sty. Sd	5.0 (5.4)	21.3 (1.1)	58.7 (77.9)	7.5 (5.4)	7.5 (10.1)
5	71	——	6.7 (29.4)	5.0 (0.3)	25.7 (4.9)	55.9 (62.9)	6.7 (2.5)
5′	74	——	6.7 (4.8)	25.0 (11.4)	52.5 (27.7)	8.3 (14.7)	7.5 (41.3)
6	70	gy. sty. Sd	1.4 (1.0)	15.2 (13.0)	78.9 (56.9)	2.9 (16.2)	1.5 (12.9)
7	55	gy. sty. Sd	3.9 (5.5)	7.9 (6.5)	79.8 (47.8)	4.7 (31.8)	3.6 (8.4)
8	35	St-Sd	0.6 (0.0)	11.5 (1.8)	65.2 (16.8)	19.5 (76.5)	3.1 (4.8)
9	21	sl. Sd	0.7 (0.0)	27.7 (1.0)	50.8 (7.3)	16.7 (3.7)	4.0 (7.9)
10	10	f. Sd∼md. Sd	—	41.9 (1.7)	51.6 (17.1)	2.2 (81.2)	4.3 (0.0)
11	8	(gy′) f. Sd	22.7 (2.5)	9.8 (0.8)	38.0 (1.1)	24.5 (6.1)	4.9 (89.3)
12	6	f. Sd	3.6 (28.7)	38.6 (2.9)	40.9 (13.9)	6.0 (0.7)	10.9 (53.6)
VIII-1	9	sl. Sd	11.4 (17.1)	6.8 (0.7)	76.8 (31.6)	1.9 (7.1)	3.2 (43.5)
2	40	cy. St-Sd	13.6 (12.1)	5.5 (3.3)	30.4 (6.3)	49.3 (77.6)	1.2 (0.6)
3	65	gy′. St-Sd	21.9 (42.3)	6.1 (5.8)	65.9 (41.5)	3.9 (8.7)	2.1 (1.7)
4	70	cy. St-Sd	6.7 (9.6)	7.8 (13.3)	76.2 (41.6)	6.2 (17.0)	3.1 (18.4)
5	55	gy′. St-Sd	29.9 (43.7)	11.4 (3.4)	45.9 (23.1)	9.7 (25.0)	3.1 (4.7)
6	38	gy. sty. Sd	3.1 (2.0)	35.5 (26.1)	47.1 (45.3)	11.4 (6.8)	2.9 (19.7)
7	51	gy′. sty. Sd	24.6 (29.2)	10.5 (6.7)	56.2 (39.5)	3.8 (10.2)	4.8 (14.4)
8	44	sty. Sd	24.3 (21.7)	13.5 (3.8)	58.6 (62.1)	2.0 (10.2)	1.6 (2.2)
9	20	sty. Sd	2.7 (1.9)	19.4 (3.9)	44.9 (72.3)	25.9 (18.9)	7.0 (2.9)
10	10	(sl′) f. Sd ∼md. Sd	2.5 (0.0)	27.5 (9.3)	45.0 (53.1)	17.5 (37.5)	7.5 (0.0)

Station	Depth (m)	bottom sediments	Animal groups %				
			Ophiur.	Crust.	Polych.	Moll.	Misc.
11	5	sl. Sd	2.7 (65.1)	52.1 (6.5)	27.3 (20.1)	8.2 (1.1)	9.6 (7.1)
IX-1	32	gy′. St-Sd	12.4 (27.4)	4.2 (3.1)	79.8 (65.0)	2.1 (2.7)	1.5 (1.6)
2	54	gy. sl. Sd	20.4 (30.8)	6.7 (1.4)	62.5 (30.1)	4.3 (12.7)	6.1 (24.9)
3	23	gy′. sty. Sd	23.3 (30.2)	6.9 (1.1)	59.3 (58.7)	3.6 (7.7)	6.9 (2.2)
B-1	7	gy. St-Sd					
2	15	gy. sty. Sd					
3	8	——					
X-1	50	cy. St-Sd	—	—	94.4 (99.9)	5.6 (0.0)	—
2	40	sty. Sd	2.0 (3.0)	5.4 (0.6)	83.2 (88.3)	7.4 (7.3)	2.0 (0.7)
3	20	sty. Sd	6.6 (16.1)	29.1 (5.8)	54.8 (51.4)	3.5 (5.8)	6.1 (20.5)
XI-1	43	cy. St-Sd	—	28.5 (96.6)	57.1 (3.4)	14.4 (0.0)	—
2	35	St-Sd	—	9.4 (0.0)	75.0 (96.8)	15.6 (3.2)	—
3	23	sty. Sd	1.4 (0.0)	11.4 (0.9)	79.4 (95.1)	6.4 (0.6)	1.4 (3.3)
XII-1	42	cl-sdy. St	—	—	—	—	—
2	19	gy. St-Sd	11.7 (17.3)	15.3 (4.7)	64.8 (73.6)	5.6 (4.4)	2.6 —
3	17	(gy′) cy. St-Sd	0.7 (0.0)	14.9 (3.7)	70.4 (87.8)	12.5 (7.2)	1.5 (1.2)
D-1		cl-sdy. St					
2		cl-sdy. St					
3		St-Sd					
4		(sl′. gy′.) md. Sd					
5		cl-sdy. St					
6		——					
6′		——					
7		(sl′. gy′) md. Sd					
C-16		——					
17		——					