THE ZOOGEOGRAPHICAL ASPECTS OF THE JAPAN SEA PART I[1)]

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With 15 Text-figures

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1. Introduction

It seems that the studies on the animal distribution in the Japan Sea have been conducted in two ways; one is the way traced by taxonomists and the other is that pursued by fisheries biologists. Many taxonomists engaged in taxonomic or faunistic studies of the animal groups in the Japan Sea used to close their studies with a zoogeographical consideration on respective groups; and in most cases, these were done in the method of regional zoogeography and their main concern seemed to remain in establishing some demarcation lines of a certain zoogeographical significance. Thus, their treatment might be highly abstract or their analyses were apt to be non-dynamic, without paying full attention to the vertical structure and the seasonal or secular variation of animal distribution, and the effects of envi-

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ronmental factors governing the distribution pattern of animals were often overlooked.

Chief interests of fisheries biologists, on the other hand, concerned in the dynamic processes and structures in distributional phenomena such as horizontal and vertical migrations or fluctuations and successions of populations in the sea under consideration. Thus, they have contributed to enrichment of our knowledge concerning the relationships between the animal distributions and the environmental factors, although their works were usually confined to the distributional mechanism of a single or a few selected species or to the distribution pattern of animal communities only within certain limited areas.

On the knowledges accumulated in these ways, we are now familiar with many facts pertaining to the fauna of the Japan Sea including its qualitative and, to a lesser degree, quantitative composition and its distributional characteristics. In addition, there are a considerable amount of informations which have been obtained by fishermen during their professional workings and must be very helpful in studying the zoogeographical characteristics of the Japan Sea. Most of these facts and informations are, however, found only fragmentarily in so many different literatures or left unrecorded, and yet no effort has ever been made to gather and compact them into a form of synthetic knowledge.

Needless to say that physical oceanographic data are indispensable in explaining biogeographical phenomena in the sea. Contrarily, it is possible that the studies of some biogeographical phenomena suggest the significance of certain physical processes hitherto neglected by physical oceanographers or even the existence of certain new hydrographic phenomena in the sea.

In the present paper it is intended to show dynamic and structural aspects of the animal distributions in the Japan Sea from an ecological point of view on the basis of the collection of all kinds of available data and informations from various sources. In doing this, a particular attention is paid to the relationships between the distributional patterns of animals and their environment, and discussions are made to elucidate the mechanisms effecting the characteristic distributional patterns of animals realized in this marginal sea in the Far East.

Acknowledgement

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2. Short Review of Previous Works; Mainly concerning the Regional Zoogeographical Divisions of the Japan Sea

The scientific research of the fauna of the Japan Sea was opened as early as toward the end of the eighteenth and the beginning of the nineteenth centuries, when some expedition ships of west European countries and Russia ploughed the northern districts of the Pacific Ocean.

For instance, the French fleet *Boussole* and *Astrolabe*, commanded by F. G. DE LA PÉROUSE, investigated the western and northern parts of the Japan Sea in 1787, and in 1805 the Russian ship *Nadezhda* commanded by J. KRUSENSTERN and accompanied by the famous naturalist G. TILESIUS cruised through the Japan Sea, surveying the coasts of Japan, especially that of the Island of Yezo (Hokkaido). In 1829, the hydrographic research ship *Actaeon* of Great Britain made soundings and dredgings at some points in the Japan Sea and A. ADAMS, naval surgeon to that ship, brought a large amount of biological samples to his mother country. Another important scientific expedition in the middle of the nineteenth century was that made by L. SCHRENCK of Russia; he chiefly dealt with the coasts of the northern Japan Sea and Sakhalin and obtained quite extensive and diverse collections from all kinds of sea animals, primarily molluscs. The beginning of the present century is marked by several famous expeditions undertaken by American and Russian scientists: the investigations by the United States Fisheries steamer *Albatross* and the oceanographic expedition by *Vitiaz* under the commandership of Admiral S. O. MAKAROV were indeed of great significance in the early history of scientific research of the Japan Sea. In 1900–01, expeditions were made by P. SCHMIDT, celebrated Russian ichthyologist, in the northern Japan Sea as well as on Japanese and Korean coasts.

Studies on the material collected and brought by these expeditions were focussed mainly to the taxonomical and morphological ones, and it was not until the twenties and thirties of the present century that systematic surveys of the distributional pattern of the faunas, including the deep-water fauna, with the precise measuring of their environments began with the works by K. M. DERJUGIN and his colleagues of the U. S. S. R. and with the expedition by the R. V. *Sôyô Maru* of the Imperial Fisheries Institute of Japan under the leadership of H. MARUKAWA. As results of these works and expeditions many aspects of the conditions and biology of the Japan Sea came to light for the first time.

In 1949 the Institute of Oceanology of the Academy of Sciences of the U. S. S. R. sent the R. V. *Vitiaz* to the Far Eastern seas and since then the ship surveyed the areas quite systematically and thoroughly: in 1950 the ship made cruises to the central and northern parts of the Japan Sea and undertook quantitative biological samplings down to the depth of 3500 m. In 1953–57, the Fisheries Agency of Japan carried out a large-scale investigation of the Tsushima current region of the Japan Sea with co-operation of the Seikai, Japan Sea and Hokkaido Regional Fisheries Research Laboratories and many prefectural fisheries experimental stations along the west side of the Japanese Islands including Hokkaido and Kyushu, and many important facts of the distribution of marine resouces and hydrography of that area of the Japan Sea have been clarified throught this investigation.

Based on the material collected in these or other ways, the fauna and its distribution in the Japan Sea have been worked out steadily by numerous biologists, chiefly taxonomists, and nowadays we can imagine some distinct ideas regarding the distributional characters of certain animal groups in this marginal sea. Of these biologists, the following names are particularly distinguished for their significant contributions in respective animal groups or research fields: D. S. JORDAN, S. TANAKA, P. SCHMIDT, Tamezo MORI, A. Y. TARANETZ, G. U. LINDBERG, M. KATAYAMA and Y. HONMA (fishes); T. TOKIOKA (ascidians, appendicularians and chaetognaths); A. M. DJAKONOV and R. HAYASHI (echinoderms); L. SCHRENCK, W. H. DALL, T. KURODA, K. M. DERJUGIN, S. NOMURA, K. HATAI and K. KIKUCHI (molluscs); H. BALSS, M. J. RATHBUN, Z. T. KOBJAKOVA, Y. YOKOYA, T. SAKAI, T. KAMITA, L. VINOGRADOV and S. MIYAKE (decapod crustaceans); E. F. GURJANOVA (amphipods and isopods); A. I. BULYCHEVA (amphipods); H. UTINOMI (caprellids, cirripeds and pantopods); C. ZIMMER, N. B. LOMAKINA and S. GAMÔ (cumaceans); W. M. TATTERSAL and N. II (mysids); L. PONOMAREVA and Y. KOMAKI (euphausiids); T. KOMAI (stomatopods); Takamochi MORI, K. A. BRODSKY and O. TANAKA (pelagic copepods); L. K. LOZINA-LOZINSKY and I. W. HEDGPETH (pantopods) K. HATAI and E. D. KONZHUKOVA (brachiopods); Y. OKADA, K. SAKAKURA and H. I. ANDROSOVA (bryozoans); H. SATÔ and V. V. MAKAROV (gephyreans); I. G. ZACHS, N. P. ANNENKOVA and P. V. USCHAKOV (polychaetes); T. UCHIDA (coelenterates); I. ZACHS, K. M. DERJUGIN, O. MOKIEVSKY, P. A. MOISEEV, H. AIKAWA, T. WATANABE and A. OUCHI (distribution of benthos including demersal fishes); H. MARUKAWA, H. AIKAWA, T. YAMADA, T. TOKIOKA, I. YAMAZI, K. FURUHASHI, S. MOTODA, M. ANRAKU, T. SHIMOMURA, H. FUKATAKI, K. UCHIDA, T. SENTA, K. A. BRODSKY, I. MESHCHERYAKOVA and L. A. PONOMAREVA (distribution of plankton including pelagic fish eggs and larvae); A. G. KAGANOVSKY, S. ITO, S. NISHIMURA and I. OKACHI (distribution of nekton including pelagic reptiles and cetaceans); etc.

Zoogeographical contributions made by these researchers, especially by many of the taxonomists, were mostly limited to the regional zoogeography: animal species were divided mainly into the southern or tropical-subtropical Indo-West Pacific elements and the northern or arctic-subarctic elements, and the distributions of these elements in respective localities were examined. Such treatments lead naturally to the establishment of some zoogeographical subdivisions, each characterized by certain prevailing element, and then to the drawing of some border lines between different subdivisions. Many of such attempts are met with in literatures on several animal groups inhabiting the Japanese or the Far Eastern seas including the Japan Sea; for instance, among the recent contributions, those of VINOGRADOV (1946) on decapod crustaceans and of UTINOMI (1955) on shallow-water cirripeds may deserve special merits.

However, there is found a bewildering divergence among the conclusions reached in these previous zoogeographical works. To put various ideas in order and find out the real level of our present knowledge on the zoogeography of the Japan Sea, a short historical sketch on the problem is to be given below. In Fig. 1 are shown the positions of the boundary lines proposed by previous authors for distributions of various animal groups in the Japan Sea. Apparently, widely different views have been presented by different authors, occasionally even by the same authors at different dates.

It was JORDAN (1901, 1902) who, on the basis of the fish distribution, divided for the first time the waters adjacent to Japan into several zoogeographical subregions and discussed the faunistic aspects of each subregion. According to him, the Japan Sea coast of Hokkaido and that of Hondo or Honshu north of the Noto Peninsula are included in his *Hokkaido District*, adjoining to the *Middle Hondo* or *Honshu District* which occupies the coast south of the same peninsula, and the coasts of Karafuto (Sakhalin), though not explicitly touched by this author, are seemingly to be included in the *Kurile* (*Chishima*) *District*. Thus, he marked two boundary lines in the west of the Japanese Islands: one around the Noto Peninsula and the other through the Sôya (La Pérouse) Straits. JORDAN's conclusion, especially regarding his idea showing the importance of the Noto Peninsula as a barrier within the Japan Sea dividing the northern and southern regions has later raised much debates among marine zoogeographers and ichthyologists; for instance, TANAKA (1912), celebrated ichthyologist of Japan, opposing to JORDAN's opinion, presented a view that the boundary between the northern and southern regions in the Japan Sea should be sought off Niigata Prefecture or a little further north, although he admitted to some extent an innegligible role of that peninsula on the distribution of marine animals in this marginal sea. Either UCHIDA (1929) stated that he could not admit any significance of the line at the Noto Peninsula as a zoogeographical boundary. On the other hand, NOMURA & HATAI (1936) ascertained that a very important demarcation in faunal facies of several invertebrate taxa including the molluscs and brachiopods could be

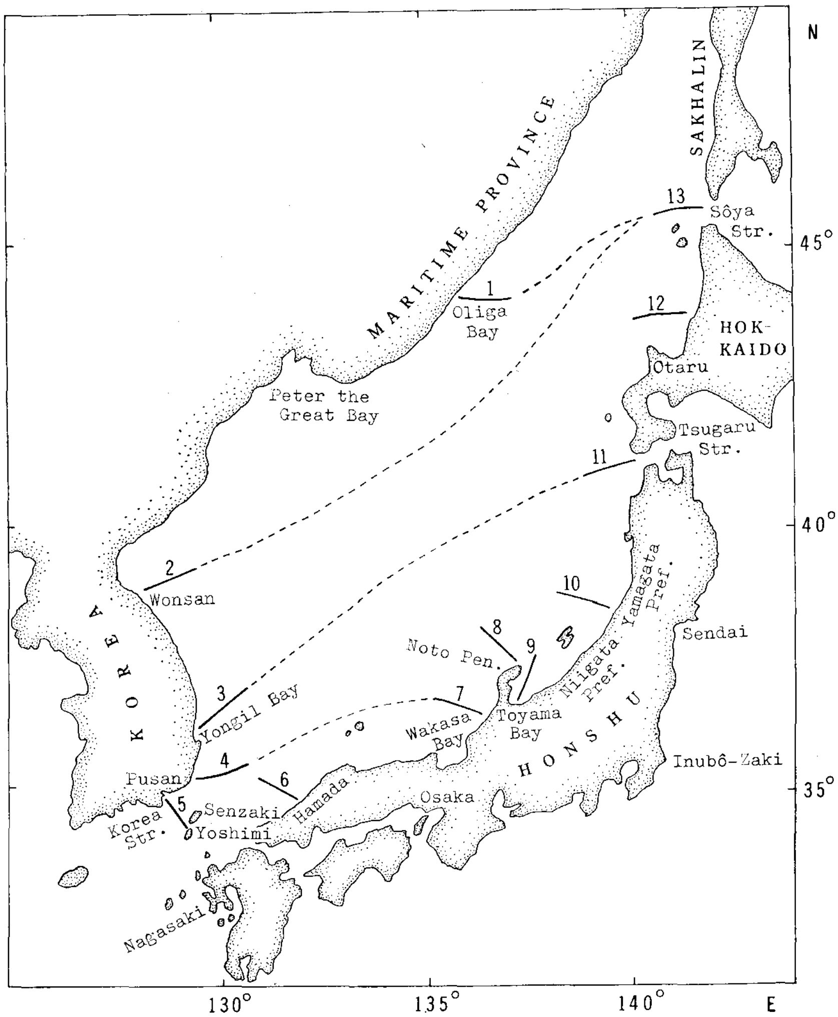

Fig. 1. Boundary lines proposed by previous authors for distributions of various animals in the Japan Sea. 1—13. LINDBERG (1925) ; VINOGRADOV (1946, 1948). 2—13. SCHMIDT (1904, 1926, 1950) ; JORDAN & METZ (1913). 3—11. UTINOMI (1955). 4—7. VINOGRADOV (1946, 1948). 5. UCHIDA (1935) ; KAMITA (1941) ; EKMAN (1953). 6. TANAKA (1921, 1926, 1929, 1931, etc.) ; TANAKA (1936) ; YOSHIDA & ITO (1957). 7. BALSS (1924). 8. JORDAN (1901, 1902) ; NOMURA & HATAI (1936) ; UTINOMI (1955) ; YOSHIDA & ITO (1957) ; ANDROSOVA (1958). 9. KIKUCHI (1937) ; UEKI (1943). 10. TANAKA (1912). 12. TANAKA (1936). For the nature and implications of respective lines, see the text.

found in the region of the Noto Peninsula, dividing the eastern Japan Sea into the northern *Uetsu Province* and the southern *Noto-San-in Province*. A similar view had in fact expressed already by BALSS (1924) on the distribution of decapod crustaceans, noticing a difference in the faunal composition between the Noto Peninsula and Wakasa Bay. This view was later corroborated by the Soviet carcinologist VINOGRADOV (1946), and according to him, the northern limit of the Indo-West Pacific region could be drawn from the middle of the area covering the Noto Peninsula and Wakasa Bay on the east side to a point between the Korea Straits and Yongil (Geijitsu or Unkovsky) Bay on the west side of the sea. In this connection, it may be of some interest to note that KIKUCHI (1937) and UEKI (1943), studying mainly the distributions of molluscs and decapod crustaceans, once insisted that the boundary between the northern and southern faunas in the Japan Sea should be moved a little eastward than ever believed by JORDAN, NOMURA, HATAI and others, namely, to the center line dividing Toyama Bay. Later, however, this boundary, called KIKUCHI's line, was rejected by UEKI (1957) who stated that such a line was of no major zoogeographical significance but of only a limited importance for the local distribution pattern of marine animals within Toyama Bay.

In his monograph of Japanese fishes (part I) published in 1921, TANAKA presented his new idea of the zoogeographical subdivisions of the surrounding seas of Japan from an ichthyological view-point, an idea considerably different from his previous one (TANAKA 1912) regarding the treatment of the Japan Sea. In this monograph, the south Karafuto (Sakhalin), north and middle Hokkaido and northeast Korea were included in his *Nemuro District*, the south Hokkaido, west coast of Honshu down to Hamada in San'in District and east Korea in the *Sendai District*, and the Japan Sea coast of Honshu west of Hamada and southern coast of Korea in his *Osaka District*; thus, the effort to seek a zoogeographical demarcation on the middle part or thereabout along the west coast of Honshu had been completely abandoned here. The same author published a further modified opinion in a series of subsequent papers (1926, 1929, 1931, 1933 a, etc.), mentioning that the Japanese coasts should be divided into two, *North* and *South*, regions with the boundary on the Japan Sea side in the west of Hamada in San'in District whilst that on the Pacific side around Cape Inubô-Zaki. Here, the *North Region* is termed as an area distributed by both arctic and temperate fishes and the *South Region* is an area occupied by both tropical and temperate fishes. In a later work published in 1934, however, TANAKA told that although the boundary between the *North* and *South Regions* is clearly defined on the Pacific side of Japan it is quite vague on the Japan Sea side, noting that over an extensive area along this, west coast of Japan fishes of both the *North* and

South Regions occur alternately with seasons. The reasoning culminated in his opinion expressed in his 1936 and later publications (1939, 1943, etc.), where he proposed to establish the *Middle Region* in addition to the *North* and *South Regions* in the zoogeographical subdivision of the west coasts of Japan as embracing the area stretching from Hamada in San'in District to near Otaru faced to Ishikari Bay or further north on the west coast of Hokkaido. According to this author, the *Middle Region* defined in this way is inhabited not only by temperate fishes but also by many tropical and arctic fishes, thus it may be regarded rather as a transition area between the *North* and *South Regions*. A view supporting the above opinion was presented by HONMA (1952, 1957 d), who compared the fish fauna of Niigata Prefecture and its environs with those of other districts along the west coast of Honshu, noticed that the distributional patterns of both northern and southern forms change gradually with latitudes and reached the conclusion that it does not seem proper to draw any boundary of major zoogeographical significance in the middle region of the eastern Japan Sea. Against to this, YOSHIDA & ITO (1957) recently proposed a boundary to be set in the middle waters of the eastern Japan Sea, although they admitted the basic trend that the number of species of southern fishes decreases and that of northern fishes increases with latitudes. Following to these authors, the coastal waters of the sea on the Japan side should be divided into three regions, but in a way somewhat different from that of TANAKA (1936), namely, the *Southern Area* comprizing Yoshimi and Senzaki Districts, both in Yamaguchi Prefecture, the *Middle Area* along Shimane Prefecture and the *Northern Area* north of Toyama Prefecture.

The idea to regard the greater part of the Japan Sea, at least the waters off the Honshu coast of Japan, as a transition area inhabited by both northern and southern forms has been also presented by several researchers of the invertebrates; for instance, YOKOYA (1933) and SAKAI (1940) manifested from their studies on the distributions of respectively decapod crustaceans in general and brachyurans a similar view, showing that certain warm-water elements are distributed northward up to the Tsugaru Straits or off Shônai Province in Yamagata Prefecture at the least, while some cold-water elements reach southward near Nagasaki or further south along the continent even to Amoy on the southeast coast of China. UTINOMI's (1955) study on the distribution of shallow-water cirripeds added another similar conclusion; he placed the entire west coast of Honshu and the south coast of Korea under the temperate region or *Northern Japan Province* inhabited by both warm-water and cold-water species in addition to temperate species and bordered north by the subarctic region or *Hokkaido-Tisima Province* with the boundary extending from the western entrance of the Tsugaru Straits to the southeast corner of the Korea Peninsula. However, he also admitted the zoogeographical significance of the Noto Peninsula as a demarcation of the fauna on a lesser degree, dividing the region into two subprovinces. In contrast to these, ANDROSOVA (1958) is peculiar in stating that the Noto Peninsula constitutes the southern limit of distribution for many of the arctic-subarctic bryozoans of the order Cheilostomata although the same peninsula does not seem to delimit the dispersal of subtropical species.

Similar diversity is found, too, regarding the zoogeographical divisions of the northern and northwestern parts of the Japan Sea. SCHMIDT (1904, 1926, 1950) divided on ichthyological data the Japan Sea into two parts by a line roughly stretching from Wonsan (Genzan) on east Korea to west Hokkaido and designated the northern part as the subarctic region or *North Japan Sea* and the southern part as the subtropical region or *South Japan Sea*. Actually, JORDAN & METZ (1913) showed that the fish fauna off east Korea north of Wonsan is similar to that near Sakhalin. On the other hand, BALSS (1924) noticed that not a few southern elements of decapod crustaceans are distributed in Peter the Great Bay together with northern elements, and LINDBERG (1925) observed the same trend in fish distribution around the bay, which made him draw a boundary line through Oliga Bay on the southern Maritime Province and the Sôya Straits to divide the northern and southern regions of the Japan Sea. It is true, many more southern forms were later added to the fish fauna of Peter the Great Bay and its environs by many investigators including LINDBERG (1928), TARANETZ (1937, 1938) and RUMYANTZEV (1947) (see *Section 3.1*); and the same enrichment of southern forms in the fauna may undoubtedly have been recorded for other animal groups, too. Thus, LINDBERG's view was accepted by VINOGRADOV in his discussions on the distribution of decapod crustaceans (1946) and again on the zoogeographical zonations of the Far Eastern seas (1948), where he regarded the above boundary as separating the north-boreal from the south-boreal region and defined the latter region as bordered south with the subtropical region by a line stretched from a point between the Korea Straits and Yongil Bay to the area covering the Noto Peninsula and Wakasa Bay. Further, LINDBERG (1947) treated Peter the Great Bay as an independent region of unique zoogeographical characteristics, while MOISEEV (1953) regarded the bay as a transitional area, but somewhat inclined to the north-boreal, as many north-boreal and several south-boreal species of the demersal fishes, notably flatfishes (Pleuronectina) are distributed together in that area. Thus, there have been much debates and considerable confusions in treating zoogeographically the northwestern waters of the Japan Sea and especially the area of Peter the Great Bay and its environs.

As to the zoogeography of the area along the east and south Korean coasts, on the other hand, the following works are to be noted. UCHIDA (1935) presented in his short report on the fish distribution a view that a demarcation is noted around Chinhae Bay near Pusan, dividing the east Korean from the south Korean waters. KAMITA (1941) showed that the northerly distribution of many southern crabs are stopped off Pusan. VINOGRADOV (1946, 1948) set, as mentioned above, a boundary at an intermediate position through the Yongil Bay and the Korea Straits and regarded this line as the northern limit of the Indo-West Pacific region, namely the boundary between the south-boreal and the tropical-subtropical regions. EKMAN (1953) also is inclined to regard the Korea Straits roughly the northern limit of the Indo-West Pacific region on the eastern coast of the Asiatic mainland. UTINOMI (1955) proposed, on the distribution of littoral cirripeds, a demarcation passing roughly through Yongil Bay, slightly north of the Korea Straits; however, this demarcation was regarded by him as the boundary between the sub-arctic (*Hokkaido-Tisima Province*) and the temperate (*Northern Japan Province*) region.

As seen above, there still remain considerable confusions, both in terminology and ideas expressed by various authors concerning the zoogeographical divisions of the Japan Sea. Several causes are responsible for such a state: specialities of the animal groups treated; inadequate or insufficient covering of the areas and depths in sampling or in discussion; different levels of taxonomic and ecological knowledges on respective animal groups; disagreement in terminology; etc. But the most important cause seems to be found in that most authors could not pay full attention to the dynamic and structural aspects of the animal distributions in relation to the dynamic hydrographical processes in this marginal sea.

It is a fact that, in such a confused state, some recent authors, including YOKOYA (1933), TANAKA (1936), SAKAI (1940), HONMA (1952, 1957d), MOISEEV (1953) and UTINOMI (1955), tend to agree at the least in regarding the greater part of the Japan Sea as a transition area between the typically flourishing regions of respectively northern and southern faunas and in designating it as *middle, boreal* or *temperate region.* And actually the greater part of this sea, including the waters off west Hokkaido or even southwest Sakhalin and the area of Peter the Great Bay or further north and those off the southernmost coasts of the surrounding lands, is occupied by northern arctic-subarctic elements as well as southern tropical-subtropical ones, though the proportion of these two elements varies with the localities and seasons; and undoubtedly this has been partly responsible for so much diverse views in the zoogeographical divisions of the Japan Sea[2]. The so-called "transition area" theory seems

2) On the Pacific coasts of Japan, the "transition or intermingling area" of northern and southern elements is rather sharply delimited and hence the zoogeographical divisions are defined without much controversies.

to have been proposed first as a compromise between those earlier conflicting views, and since then has been accepted by increasing supports. This can be an accomodation relieving the confusions, but it cannot be accepted as the final solution of the problem in the zoogeography of the Japan Sea. It must be of an essential importance to explain *why* the northern and southern elements are "intermingled" or "coexist" in so a wide area in the Japan Sea.

3. Peculiarities of Animal Distribution in the Japan Sea

When the zoogeographical characteristics of any marine environment are discussed, this is generally made smoothly in the following process. First the faunal peculiarities and striking distributional patterns of the animals in the environment are enumerated, and then they are interpreted in relation to the hydrographical, climatological and geographical features of the area under consideration. This process is followed here, and in this chapter any significant zoogeographical peculiarities of the Japan Sea are given as far as I am aware.

3.1. Distribution Patterns of Northern and Southern Elements

It has long been known that both northern arctic-subarctic and southern tropical-subtropical animals are found existing together in the greater part of the Japan Sea; and this "overlapping" of distributional ranges of both elements in so a wide latitudinal extent (34° N. to 42°–45° N., or further north in some animals) has been regarded as one of the most prominent characters of this marginal sea (YOKOYA 1933; SAKAI 1940; OKADA 1947; KOMAI 1948; etc.) This forms a striking contrast to the situation on the Pacific side of Japan, where the distributions of northern and southern elements are rather sharply separated from each other and the overlapping transitional area is limited within a narrow latitudinal range (35° N. to 38° N.) (HORIKOSHI 1962).

In fact, a considerable number of tropical-subtropical forms are found penetrating even into the northernmost part of this sea basin, while many subarctic and some arctic species are extending their distribution down almost to the southernmost area of the sea. Needless to say of various tropical-subtropical species of pelagic reptiles (sea turtles and snakes), fishes, cephalopods, decapod crustaceans, copepods, dinoflagellates, etc. reported now and then from Ishikari Bay and its environs on the west coast of Hokkaido (SASAKI 1929; NAKAGAWA & TAKAHASHI 1934; KINOSHITA & IMAI 1936; KINOSHITA 1939; NISHIMURA, Sh. 1939; IIZUKA 1949, 1950; ANRAKU 1953; NISHIMURA 1958, 1964; UENO 1964 a, 1964 b; etc.), there are further records from the more northern or northwestern colder regions as shown next. In Peter the Great Bay and adjacent waters, a considerable number of tropical fishes such as *Ilisha elongata, Chirocentrus dorab, Auxis tapeinosoma, Histiophorus* *orientalis*, *Coryphaena hippurus*, *Alectis ciliaris*, *Trichiurus lepturus*, *Diodon holacanthus*, *Mola mola*, etc. and subtropical fishes such as *Prionurus microlepidotus* (=*Xesurus scalprum*), *Oplegnathus fasciatus*, *Ablennes anastomella*, etc. have been reported respectively more than once (LINDBERG 1928; TARANETZ 1937, 1938; RUMYANTZEV 1947; NOVIKOV 1957a); and according to SVETOVIDOV (1952) the number of such southern species attained 32 in the late twenties and 45 in the late thirties of this century. NOVIKOV (1957b) states that the ocean sunfish *Mola mola* is not uncommon along the Maritime coast and records an occurrence of the porcupinefish *Diodon holacanthus* even in Amur Bay (53° N.) According to ISAHAYA (1936), the bluefin tuna *Thunnus thynnus* has ever migrated near to southern Sakhalin in shoals large enough to support a local commercial fishery. TARANETZ (1937) refers to a leatherback turtle *Dermochelys coriacea* caught in Ruinda Bay (44°50′ N.) in central Maritime Province. *Pelamydrus platurus*, a sea snake of the tropical seas, was once recorded from Possiet Bay (43°40′ N.) near Vladivostok (NIKOLSKY 1916). Tropical or subtropical crabs such as *Leucosia rhomboidalis*, *Hemigrapsus sanguineus* and *Charybdis japonica* are listed by SAKAI (1940) and KAMITA (1941) in the fauna of Vladivostok and Peter the Great Bay; *Hemigrapsus sanguineus* is also recorded from Moneron (Kaiba) Island, south Sakhalin (SAKAI 1940).

On the other hand, numerous typically subarctic or even arctic animals are caught in a sufficient quantity from more or less deep waters of the southern part of the Japan Sea off San'in District, among which the following deserve a special attention: *Hippoglossoides elassodon dubius*, *Glyptocephalus stelleri*, *Cleisthenes pinetorum herzensteini*, *Theragra chalcogramma*, *Arctoscopus japonicus* and many species of the families Zoarcidae, Liparidae and Cottidae among fishes, *Ctenodiscus crispatus*, *Crossaster papposus japonicus* and *Pentametrocrinus* sp. among echinoderms, *Chionoecetes opilio elongatus*, *Crangon dalli* and *Pandalus borealis* among crustaceans, the molluscan genera *Buccinum*, *Volutopsius*, *Neptunea* and so forth (WATANABE et al. 1958; WATANABE et al. 1960). Moreover, according to SAKAI (1940) and KAMITA (1941), most of the subarctic crabs inhabiting the northern Far Eastern seas are extending their distributions along the continent down to the Korea Straits or further southward. The Camchatkan king crab *Paralithodes camtschatica* is occasionally found down to Yamaguchi Prefecture along Honshu Island and to the Korea Straits along the continent (KAMITA 1958). Typical subarctic crustaceans such as *Pandalus hypsinotus*, *P. kessleri*, *Pagurus ochotensis* and *Chionoecetes opilio elongatus* were once recorded even from near Nagasaki of west Kyushu (VINOGRADOV 1946). Further, MATSUBARA (1934) and YOSHIDA & ITO (1957) state that the salmon *Oncorhynchus keta* and the sea-run form of *O. masou* occasionally migrate southward beyond the southern limit of the Japan Sea to the northwestern waters of Kyushu.

The above-cited examples are all plainly supporting that the coexistence of northern and southern elements prevails extensively within the Japan Sea. Then, this point will be examined more precisely on the statistical bases of certain animal groups.

On Table 1 are shown the results of studies by several authors on the marine fish fauna of various localities along the Japan Sea coasts; fishes are taken here up as they are considered to be sampled rather thoroughly both horizontally and vertically at respective localities. In allotting respective species to the northern (N), southern (S) and temperate (T) groups, cautions were paid along the standard base given by KATOH (1956), regardless of the arrangements adopted by respective authors[3]. Apparently the fish fauna at respective localities is not investigated at the same level, and therefore the direct comparison of raw datum figures is not feasible. We can only compare the faunas of different localities by weighing the figured faunal assemblages of respective localities by unequal factors. But this method holds valid under the assumption that fishes were collected quite randomly as regards the geographical groups at respective localities. The analysis of the data shown on Table 1 was made in this way and the following points were made clear.

(1) On both the Japanese and continental sides, the percentage and quite probably the number, too, of the northern elements increase, while those of the southern elements decrease, with latitudes.

(2) The rate of increase or decrease is not always constant; at certain localities there are drastic changes of the faunal composition.

(3) Such a drastic change occurs for the northern elements between the San'in-Oki and the Shimonoseki-Senzaki region on the Japanese side; a marked drop in the number of the northern species in the latter region (i.e. reduced to in all probability less than 15% of the number in the former region) cannot be denied in spite of the possibility that the fish fauna is studied in the former region probably two or three times more comprehensively than in the latter region, as is presumed from the comparison of the number of temperate and southern elements between the two regions. On the continental side of the sea, on the other hand, such an abrupt change is not observable; instead, the change takes place rather gradually from the richer northern fauna in the Maritime Province and in Peter the Great Bay

3) One of the errors frequently made by authors is that the temperate species may be regarded erroneously as "southern" forms by workers familiar with northern fauna, while they may be erroneously labelled as "northern" forms by students familiar with southern fauna.

Table 1. Distributions of northern (N), temperate (T) and southern (S) elements of fishes in the Japan Sea (exclusive of anadromous and catadromous species).

I. On the Japanese side.

Regions	Shimonoseki and Senzaki	San'in and Oki	Toyama Bay	Niigata and Yamagata	West coast of Hokkaido	West coast of Sakhalin and Tartary Str.
Sources	YOSHIDA & ITO (1957)	YANAI (1950); HAMABE & SHIMAMURA (1954); MORI (1956)	KIKUCHI (1931); KATAYAMA (1940, '42)	SUGIHARA (1944); HONMA (1952, '54, '55a–e, '56a–b, '57a–c, '59a); OUCHI & OGATA (1960)	HIKITA & MISU (1952); KOBAYASHI (1962)	LINDBERG (1947, '59)
Number of species and subspecies recorded	N 5(2%)	N 94(18%)	N 79(19%)	N 122(25%)	N 69(63%)	N 140(90%)
	T 32(15%)	T 94(18%)	T 85(20%)	T 95(19%)	T 26(24%)	T 13(8%)
	S 172(83%)	S 325(64%)	S 252(61%)	S 272(56%)	S 14(13%)	S 2(1%)
	Total 209	Total 513	Total 416	Total 489	Total 109	Total 155

II. On the continental side.

Regions	Quelpart Isl. to Pusan	Tongnae to Yongil Bay	Kangwen	Wonsan to Unggie	Peter the Great Bay	Maritime coast
Sources	MORI (1952)	MORI (1952)	MORI (1952)	MORI (1952)	LINDBERG (1947)	LINDBERG (1947)
Number of species and subspecies recorded	N 27(5%)	N 10(14%)	N 10(33%)	N 67(58%)	N 124(65%)	N 140(84%)
	T 93(18%)	T 22(30%)	T 12(40%)	T 25(22%)	T 35(18%)	T 14(8%)
	S 401(77%)	S 41(56%)	S 8(27%)	S 23(20%)	S 31(16%)	S 13(8%)
	Total 521	Total 73	Total 30	Total 115	Total 190	Total 167

down to the poorer one in southern Korea[4]. It is, moreover, to be noted that a considerable portion (not less than 20%) of the northern elements found in the Wonsan-Unggie region or even in Peter the Great Bay have penetrated into the most southerly region of Korean waters, namely the Quelpart Island-Pusan region.

(4) For the southern elements, a remarkably abrupt change is discernible on each of the Japanese and the continental sides. A notable reduction in the number of southern species occurs between the Niigata-Yamagata and the West Hokkaido region; in this discontinuous belt, about 240 species or more than 35% of the southern members recorded in the former region are blocked their way toward the north beyond the Tsugaru Straits. Although the fish fauna of the West Hokkaido region is investigated rather poorly, possibly at the level of about a half of that in the Niigata-Yamagata region, as presumed from the mutual comparison of the number of northern elements among the former and adjoining northern and southern regions, this feature must be accepted as a general one. A similar marked reduction is found between the Quelpart Island-Pusan and the Tongnae-Yongil Bay region of the Korea Peninsula; no less than 200 species or more than 50% of the southern members occurring in the southern coastal waters of the peninsula appear to cease the distribution beyond Pusan. This aspect is to be admitted in spite of the fact that the fish fauna on the east Korean coast is investigated still insufficiently. Another less marked reduction may also occur between the Tongnae-Yongil Bay and the Kangwen region.

(5) The temperate elements show a distributional tendency rather similar to that of the southern elements, although the changes are generally not so abrupt as in the case of the latter elements.

(6) The Wonsan-Unggie region and Peter the Great Bay region share a similar relative composition of the fish fauna, and especially it is interesting that the Peter the Great Bay region appears to hold almost the same numbers of southern as well as temperate elements compared with the Wonsan-Unggie region in spite of its far northerly situation.

(7) Among the three regions along the west coast of Honshu Island, the San'in-Oki, the Toyama Bay and the Niigata-Yamagata region, the relative composition and the number of species of respective elements appear to be all very resembling one another.

Similar conclusions can be drawn out from the results of the studies on

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4) If the point of the less marked change is sought, however, on the continental side, it should possibly be set between the Wonsan-Unggie and the Kangwen region. This may be admitted even if we accept an insufficient level of investigations in the Wonsan-Unggie region, especially the Kangwen region, as compared with that in Peter the Great Bay or the Maritime coast.

certain animal groups other than fishes, although the available data are much insufficient compared with the case of fishes. For instance, the faunistic and distributional studies of various authors on the crabs in the Japan Sea and adjacent waters, the data of which are covering fairly thorough ranges, both horizontally and vertically, present the following results.

Of the 56 brachyuran species of the southern group including the genuine Indo-Pacific species, the species peculiar to the Indian Ocean and the tropical Pacific species as defined by SAKAI (1940) which have penetrated into the Japan Sea, 46 reach Fukui to Ishikawa Prefecture, 41 are known from Toyama Bay, and 30 are recorded from the Niigata-Yamagata region (SAKAI 1940; OUCHI 1960). Around the Oga Peninsula, Akita Prefecture, 24 of such species are known (NAGATA & NISHIMURA 1960). Thus, at least up to the Oga Peninsula the number of southern crab species decreases rather gradually. Then, on the west coast of Hokkaido, only a single southern species, *Hemigrapsus sanguineus*, is known with certainty (NISHIMURA, Sh. 1939), and thus it is apparent that a distinct distributional gap is discerned for southern elements between this region[5] and the Oga Peninsula region. *Hemigrapsus sanguineus* represents the single southern element also in the brachyuran fauna of the west coast of Sakhalin (KOBJAKOVA 1958, 1959). On the continental side of the Japan Sea, KAMITA (1941) records 52 species of southern crabs from the southern coast of Korea and 10 of such crabs from the eastern coast, while KOBJAKOVA (1958) records three southern crabs from Peter the Great Bay. Thus, a prominent gap is apparently found between the southern and eastern coasts of the Korea Peninsula.

The northern crabs, on the other hand, show a rather uniform distribution throughout the greater part of the Japan Sea. Off the west coast of Hokkaido, 10 of the northern species are known, 9 of which are distributed further south near to the Honshu coast of the Tsushima Straits (SAKAI 1940; and additional informations obtained recently), but only two species reach the waters off the west Kyushu (KAMITA 1941). KOBJAKOVA (1958) lists seven northern crabs from Peter the Great Bay, and KAMITA (1941) records eight of the same element in the waters off the east coast of Korea, of which three species are distributed further south beyond Yongil Bay. On the other hand, SAKAI (1940) lists five of these species from the Yellow Sea and Gulf of Pechihli (Po-Hai), but it is unknown whether these occurrences are continuous to or disjunctive from the main populations living in the Japan Sea. It may thus be concluded that the southernmost region of the Japan

5) In the list of marine invertebrates of Hokkaido compiled by YAMAGUCHI & YAMADA (1955), there are recorded 7 southern crabs; but this list includes the members from the coast along the Tsugaru Straits and southeast Hokkaido, and thus the exact number of species of southern crabs from the Japan Sea coast of this island cannot be deduced from this list.

Sea is the place where a change occurs in the distribution of northern brachyurans, the change being very clear on the Japanese side of the sea, but not so pronounced on the continental side; and this distributional pattern conforms quite well to that of the northern fishes.

As to the temperate elements, comprizing the Sino-Japanese species and those endemic to Japan as defined by SAKAI (1940), a considerable number of them are distributed northward to the northwestern part of Honshu Island: SAKAI (1940) mentions that the majority of temperate brachyuran species recorded from the Japan Sea (30 out of 36 species) are extending their distribution up to Toyama Bay on middle Honshu, and the recent data show that no less than 21 species are found around the Oga Peninsula near the northwestern corner of Honshu (NAGATA & NISHIMURA 1960; T. NISHIMURA's personal communication of December 23, 1964). The number of the temperate species decreases rapidly in further north; only 3 species are known to reach west Hokkaido and southwest Sakhalin. On the continental side of the sea, the number of species of the temperate crabs drops abruptly around the southeastern corner of the Korea Peninsula; of about 50 species occurring on the southern coast, only 3 or 4 species extend their distribution to the eastern coast of the peninsula. Thus, the distributional pattern of the temperate brachyurans resembles closely that of the southern species just like in the case of fishes.

From the discussions made above, it may be generalized that in the Japan Sea the northward distributions of a great number of southern and temperate marine animals are blocked somewhere between northwest Honshu and west Hokkaido on the eastern, Japanese side and between the southern and eastern coasts of the Korea Peninsula on the western, continental side, whereas the southward distributions of a large part of northern animals are limited off the westernmost region of San'in District on the Japanese side, but on the continental side the diminution of the number of northern elements is not so marked as on the Japanese side and a considerable number of them are found along the southern coast of the Korea Peninsula or distributed further south to the Chinese coasts.

In Fig. 2 are shown the situations of the discontinuity belts in the distributions of those elements, thus supposed. Evidently, the discontinuity belt for the northern elements coincides with the boundary between the *North* and *South Regions of Japan* as proposed by TANAKA (1926, etc.), the name being later changed by the same author (1936) to the boundary between the *Middle* and *South Regions*, or with the demarcation between the *Middle* and *South Areas* of YOSHIDA & ITO (1957), whilst the discontinuity belt for the southern elements is close to the boundary between the *Hokkaido-Tisima* (*subarctic*) and the *Northern Japan* (*temperate*) *Province* of UTINOMI (1955), though its position on the continental side is to be shifted a little more south and thus approaches the demarcation between the *Eastern* and *Southern Regions* of Korea as proposed by UCHIDA (1935) and KAMITA (1941). The area embraced by these two discontinuity belts, involving the vast waters off the greater part of the west coast of Honshu Island, is regarded as maintaining a "coexistence" of rich northern and southern elements together with temperate elements, if

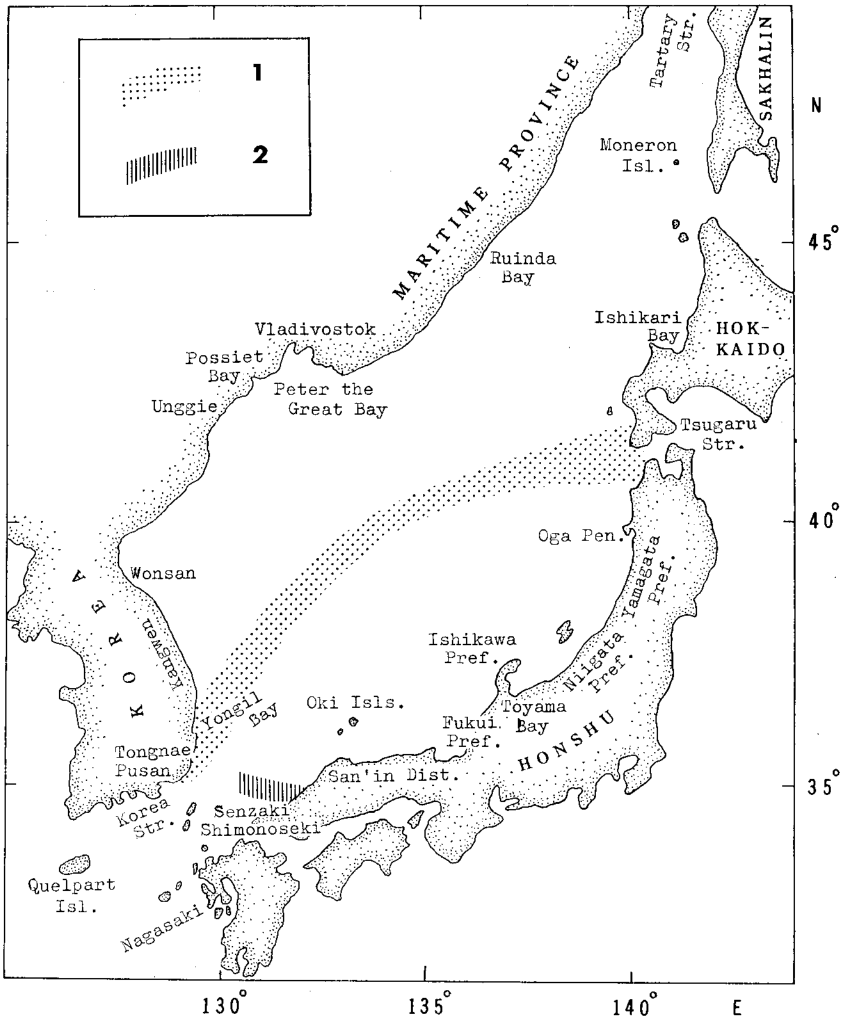

Fig. 2. The discontinuity belts of distribution of southern and northern elements of marine animals in the Japan Sea. 1. The belt where an abrupt change occurs in the number of species of the southern elements. 2. The belt where an abrupt change occurs in the number of species of the northern elements (no markedly abrupt change is sought on the continental side).

the vertical segregation of these three elements is put outside the consideration for the moment.

The boundary set off Wonsan on the east Korean coast by SCHMIDT (1904, 1926, 1950) and JORDAN & METZ (1913) for the fish distribution may be accepted as showing the tendency that further distributions of a considerable number of northern fishes are checked beyond Wonsan. While, the boundaries off middle Honshu proposed by many authors (JORDAN 1901, 1902; TANAKA 1912; BALSS 1924; NOMURA & HATAI 1936; KIKUCHI 1937; UEKI 1943; YOSHIDA & ITO 1957; etc.) are obviously tenable no longer so far as the faunistic or qualitative distributional aspects are concerned. TANAKA's (1936) proposition setting a boundary between the *Middle* and *North Regions* of Japan in the waters off Ishikari Bay or a little more north on the west coast of Hokkaido remains without being wholly judged. Really, a certain number of southern and temperate elements occur in Ishikari Bay and its environs and do not extend further north over there; but the faunistic difference between this region and the northern adjoining region, namely, the west Sakhalin-Tartary Straits region, is never greater than that between this region and the northwest Honshu region.

3.2. Occurrences of Southern Elements on the Japan Sea Coast of Middle to West Honshu in Winter

It is very strange that many southern elements of marine animals are caught in the winter season instead of the warmer seasons of the year on the Japan Sea coast of middle to west Honshu. The most remarkable ones of such animals are pelagic forms such as the young of the porcupinefish *Diodon holacanthus* and its related species and certain sea turtles.

The porcupinefish, a tropical species of the Tetraodontida, is supposed to spawn in the coastal areas of Luzon, Formosa, the Yayeyama Islands and vicinities in the early half of the year, probably February through July (NISHIMURA 1960 a, 1961 b), and the young are driven into the Japan Sea by warm currents. The porcupinefish has long been noted by the people of the Japan Sea coastal districts of Honshu and north Kyushu for its young shoals approaching the coasts and being stranded in great numbers in rough winter days. This phenomenon was studied by NISHIMURA (1958 a, 1958 b), who revealed that the approach or stranding of the shoals occurs earlier in the northern districts than in the southern region, namely, from summer to autumn in Hokkaido and the Tsugaru Straits, from autumn to winter in middle Honshu and from winter to next early spring in west Honshu and north Kyushu, and that the mass stranding occurs most frequently and in the largest scale along the Japan Sea coast of middle to west Honshu and the northern coast of Kyushu. The amount of the stranded porcupinefish sometimes attains an astonishing number, for instance, as great as 2,000 individuals at a spot (NISHIMURA 1958 b). At certain localities of middle to west Honshu such as the Sado Strait, Toyama Bay and San'in District, the porcupinefish is ocassionally caught in early summer, too, but in much smaller quantity than in winter (NISHIMURA 1958 b, 1961 b).

The leatherback turtle *Dermochelys coriacea* affords another example. It is known that this turtle is caught or stranded almost exclusively in winter

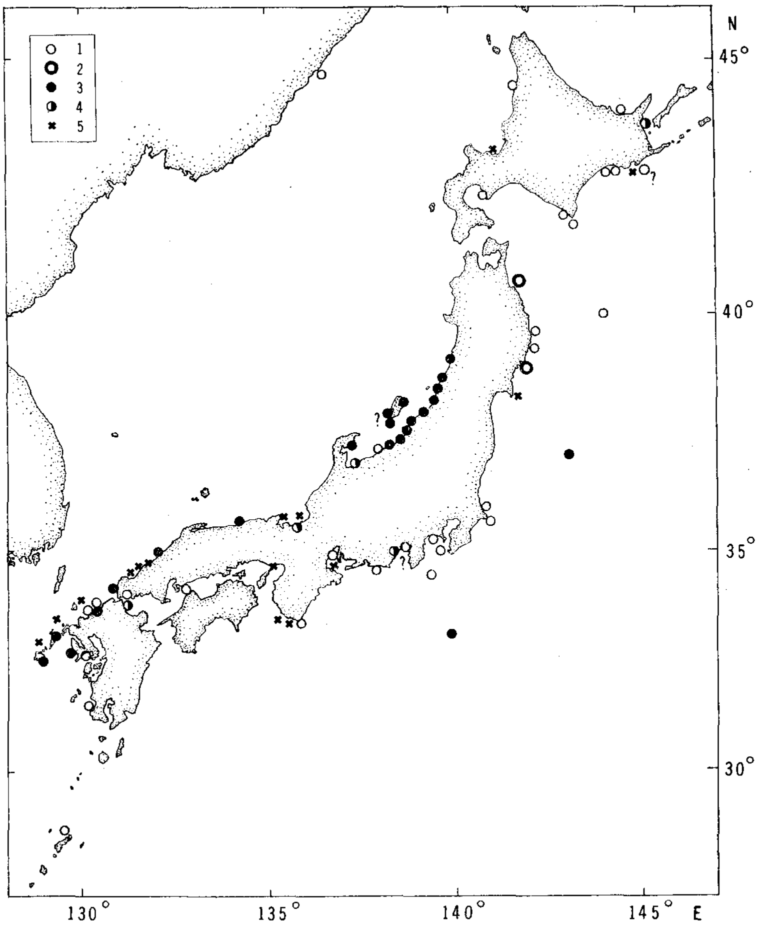

Fig. 3. Occurrences of the leatherback turtle *Dermochelys coriacea* in the Japanese waters. 1. The occurrence of a single turtle in the warm season of the year (May to September). 2. The locality with records more than once in the warm season. 3. The occurrence of a single turtle in the cold season of the year (November to next March). 4. The occurrence of a single turtle in the temperate season of the year (April and October). 5. The occurrence of a single turtle of unknown date. The question mark indicates uncertain specific identification.

along the Japan Sea coast of Honshu as is shown in Fig. 3, where all leatherback turtle captures in the Japanese waters are recorded (NISHIMURA 1964 a, 1964 b). In contrast with the occurrences in winter on the Japan Sea coast of Honshu, the occurrences on the Pacific side of Honshu and Hokkaido are concentrated in the warm season.

Similar occurrences are known for the hawksbill *Eretmochelys imbricata*. This tropical turtle has ever been captured on the coasts of Tottori (KIYOMATSU 1956), Ishikawa (HUZIO 1952) and Niigata Prefecture (NISHIMURA & MIZUSAWA 1962; I. MATSUDA's personal communication of March 12, 1962) in midwinter. Besides, there are five records in the old document named "*Sado Nendaiki*" (*The Chronicle of Sado Island*); of the five hawksbills recorded in the 18th and 19th centuries, the three with respectively a definite date of capture were all obtained in midwinter. Furthermore, the loggerhead turtle[6], is occasionally caught along the Japan Sea coast of Honshu in midwinter (NISHIMURA & MIZUSAWA 1962); this turtle is, however, caught there in the warm season, too.

Another citation concerns a species of sea snakes (Hydrophiidae). ABE (1907) recorded that the sea snake was caught not infrequently on the coast of of Izumo Province in Shimane Prefecture during the season from late autumn to early winter. According to his description, this sea snake is considered to be a tropical oceanic species, *Pelamydrus platurus*. Recently, KAMITA (1962) compiled the records of this snake on the coast of Izumo Province for the period from 1930 to 1960 and found that the occurrences were concentrated in November to December. *Pelamydrus platurus* seems to be adapted most effectively to the pelagic life and frequently goes out into the oceanic waters (NAKAMURA 1947). Also it has been caught at times on the west coast of middle Honshu in winter (NISHIMURA & MIZUSAWA, MS.) It may reach north as far as Hokkaido and the Maritime Province (NAKAMURA 1947, 1957; NIKOLSKY 1916), but unfortunately the season of its occurrence at these localities is not known.

In addition, the species listed below may be included in the southern animals showing a similar occurrence on the Japan Sea coast of Honshu; that is, they occur much more frequently and in larger quantity in winter than in summer (NISHIMURA 1958 f, 1959 a, 1960 b, 1960 c; OKACHI 1958).

Pisces

Mola mola	*Thunnus thynnus*
Masturus lanceolatus (Fig. 4)	*Histiophorus orientalis*
Ostracion tuberculatus	*Makaira mazara*
Boesemanichthys firmamentum	*Iso flos-maris*
Canthidermis rotundatus	*Prionurus microlepidotus*
Auxis tapeinosoma	*Siganus fuscescens*

6) It is as yet not precisely known whether the loggerhead turtles caught in the Japan Sea are *Caretta caretta* or *Lepidochelys kempii* or include both species.

Pterophryne spp.
Cephalopoda
Argonauta argo
Thysanoteuthis rhombus
Scyphozoa
Stomolophus nomurai

In this connection, it must be noted that such southern animals are caught on the northernmost coast of Honshu and on the Hakkaido coasts almost exclusively in summer or autumn, namely, a few to several months earlier

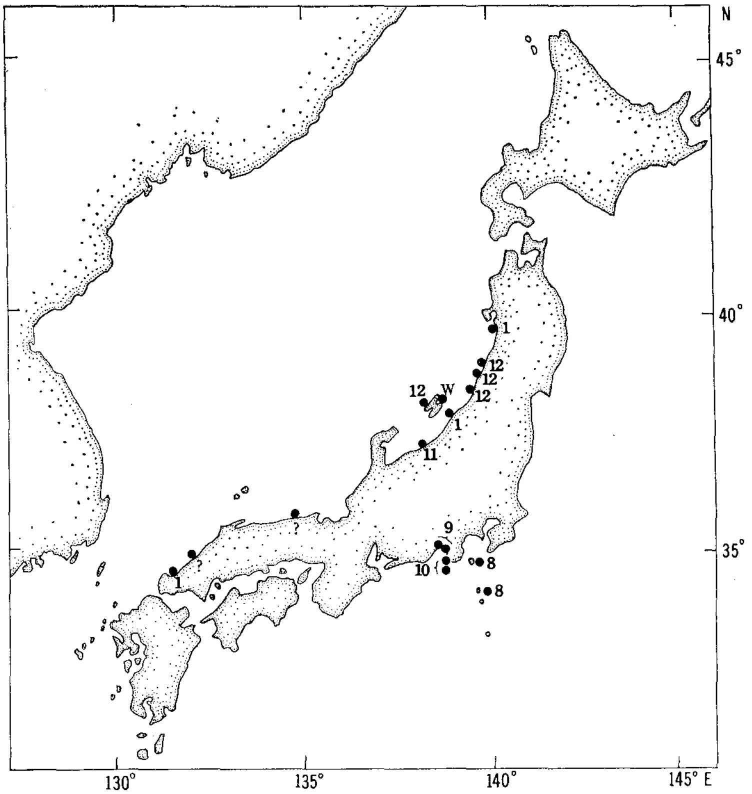

Fig. 4. Occurrences of the sharptail ocean sunfish *Masturus lanceolatus* in the Japanese waters. The numerals indicate the month of capture. In Ryotsu Bay of Sado Island, it has been caught several times in winter (W). Records without definite date are indicated with a question mark.

than in the region along the Japan Sea coast of middle to west Honshu. For instance, the porcupinefish appears, as mentioned above, in summer to autumn in Hokkaido and the Tsugaru Straits in contrast to the conspicuous occurrence in midwinter in middle to west Honshu. The leatherback turtle is caught from late July to middle October, mostly in August, on the Hokkaido coasts (NISHIMURA 1964 a, 1964 b), and the same may be true for other sea turtles (NISHIMURA 1958 e). Besides, there are records of the ocean sunfishes (*Mola* or/and *Masturus*) occurring in summer in the southern Hokkaido waters (NISHIMURA 1958 e). This phenomenon must appear strange at a glance, because the warm currents are believed to transport those pelagic animals from the south to the higher latitudes after they have swept off the Japan Sea coast of west and middle Honshu.

3. 3. Occurrences of Neritic Animals in Offshore Regions

It is another striking feature of the animal distribution in the Japan Sea that neritic animals are commonly found distributed or drifted in a considerable distance from the coast, almost in the central part of the sea, as noted already by some authors.

TOKIOKA (1951) mentioned the occurrences of the forms *typica* and *naikaiensis* of *Sagitta crassa*, a chaetognath of the strongly neritic nature, and a considerable number of *Oikopleura dioica* known as a neritic appendicularian in the offshore waters around the New Yamato Bank (36°50′ N., 134°40′ E.; now called the Oki Bank). He stated in the same work that the frequent occurrence of *Oikopleura dioica* in the offshore waters seemed to be a characteristic feature of the appendicularian fauna of the Japan Sea, differing from that on the Pacific side of Japan.

SHIMOMURA (1954 b) showed that a zooplankton community dominated by neritic forms such as *Oithona nana*, *Calanus sinicus* and *Noctiluca scintillans* was prevailing widely in the offshore region as far as 100 nautical miles from the coast of middle Honshu in July to August, 1951. Of the zooplankters mentioned above, *O. nana* is particularly noted because it is known as a regular and most important member in the plankton community developed in the inner part of many bays on the Japan Sea coast of Honshu (YAMAZI 1956).

Further, SHIMOMURA (1957 c) reported that a rather dense distribution of larvae of the anchovy *Engraulis japonica* was found in the central part of the Japan Sea during the survey in the summer of 1955 (Fig. 5). The anchovy spawning in the surrounding waters of Japan is made mostly within a narrow coastal belt, generally less than 10 nautical miles from the shore (NAKAI et al. 1955), and this is also true for the Japan Sea (YAMANAKA & ITO 1957). It has been, however, known that the anchovy does spawn under special circumstances in far offshore regions, for instance, in the waters hundreds of miles off Sanriku District or southeast Hokkaido in summer on the Pacific side (NAKAI et al. 1955; ODATE 1957); and in the Japan Sea, too, a few anchovy eggs were actually sampled at positions as far as 80 to 350 nautical miles from the coast during the above-mentioned survey (Fig. 5). Since the anchovy egg hatches out in a very short time under higher water temperature in summer, the occurrence of eggs must necessarily indicate that they were actually laid in near-by the same spots, but not carried there from any coastal places. The results of H. FUKATAKI's analysis of many years' data of the anchovy spawning surveys in the Japan Sea must be noted in this respect. According to his unpublished data[7], a rich anchovy spawning is observed in the coastal regions of Honshu in the season from spring to early summer, but the spawning is found also in the very offshore waters, some two hundred miles or more from the coast in the midsummer (August) when the coastal spawning

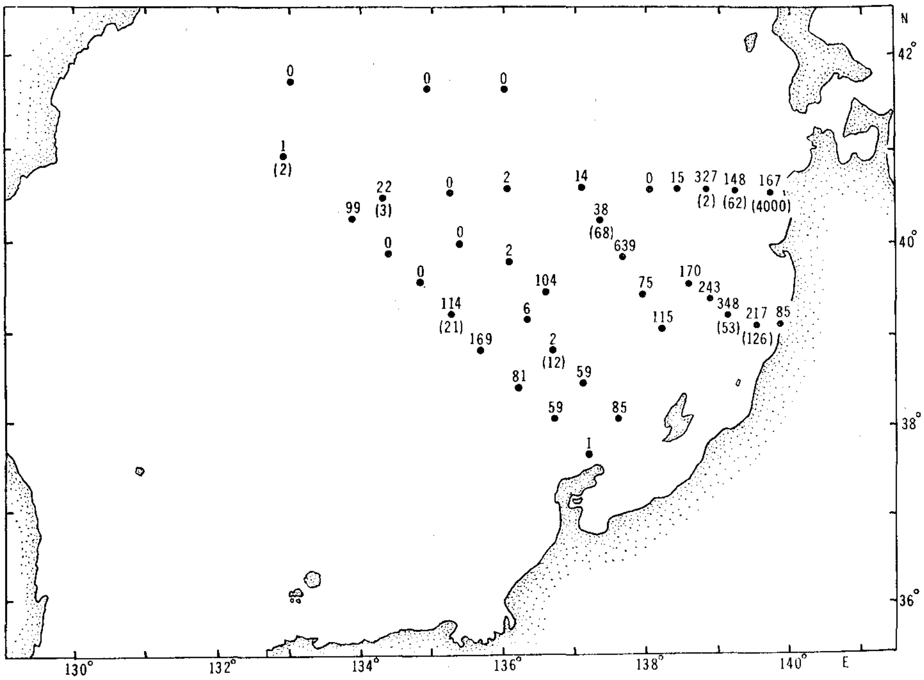

Fig. 5. Distribution of the pelagic larvae and eggs of the anchovy *Engraulis japonica* in August, 1955 (After SHIMOMURA 1957c). Numerals indicate respectively the number of larvae and eggs (in parentheses) collected by surface tows of a conical larva-net (mouth diameter 150 cm) for 10 minutes at a speed of about 2 knots.

runs down (Fig. 6). Thus, though it is not impossible that the anchovy larvae including specimens up to 57 mm in total length which were reported by SHIMOMURA (1957 c) from the central part of the sea consisted partly of individuals derived from the spawning in the coastal waters, it seems more probable that the anchovy spawns and the spawned eggs give rise to viable larvae in the very offshore area of the Japan Sea in the summer months. It is thus suspected that the conditions favorable to the neritic fish to carry

7) For the previledge to quote the unpublished data, I express here my cordial thanks to him.

out the reproduction are presented in the offshore region of this marginal sea in the warmest month of the year at least.

SHIMOMURA (1957 b) refers to the occurrence of *Penilia avirostris* (=*P.*

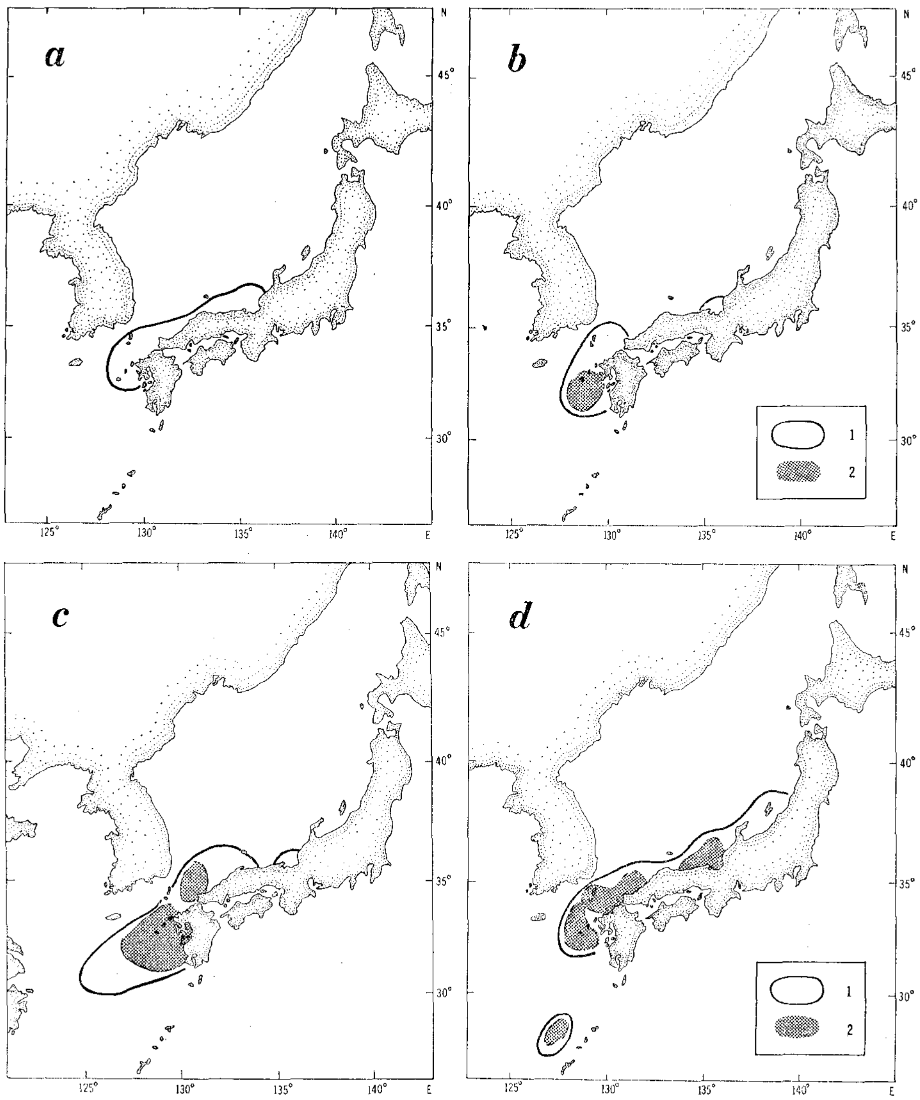

Fig. 6. Monthly succession of the distribution of anchovy eggs in the Japan Sea and its adjacent waters (After the unpublished data of H. FUKATAKI). The abundance is indicated by a mean of the numbers of eggs hauled in each 1°×1° square in the way shown in the explanation of Fig. 5 in the years 1952 to 1958.
a.—January ; b.—February ; c.—March ; d.—April. 1.—Less than 10 eggs per haul ; 2.—10 or more eggs per haul.

schmackeri), a cladoceran of highly neritic habit, at stations as far as 100 to 120 nautical miles off the coast in the same cruise of 1955, although the main population was found in the coastal waters.

During the offshore fishing experiments carried out in the summer of 1960, a considerable number of pufferfish were angled in quite offshore waters

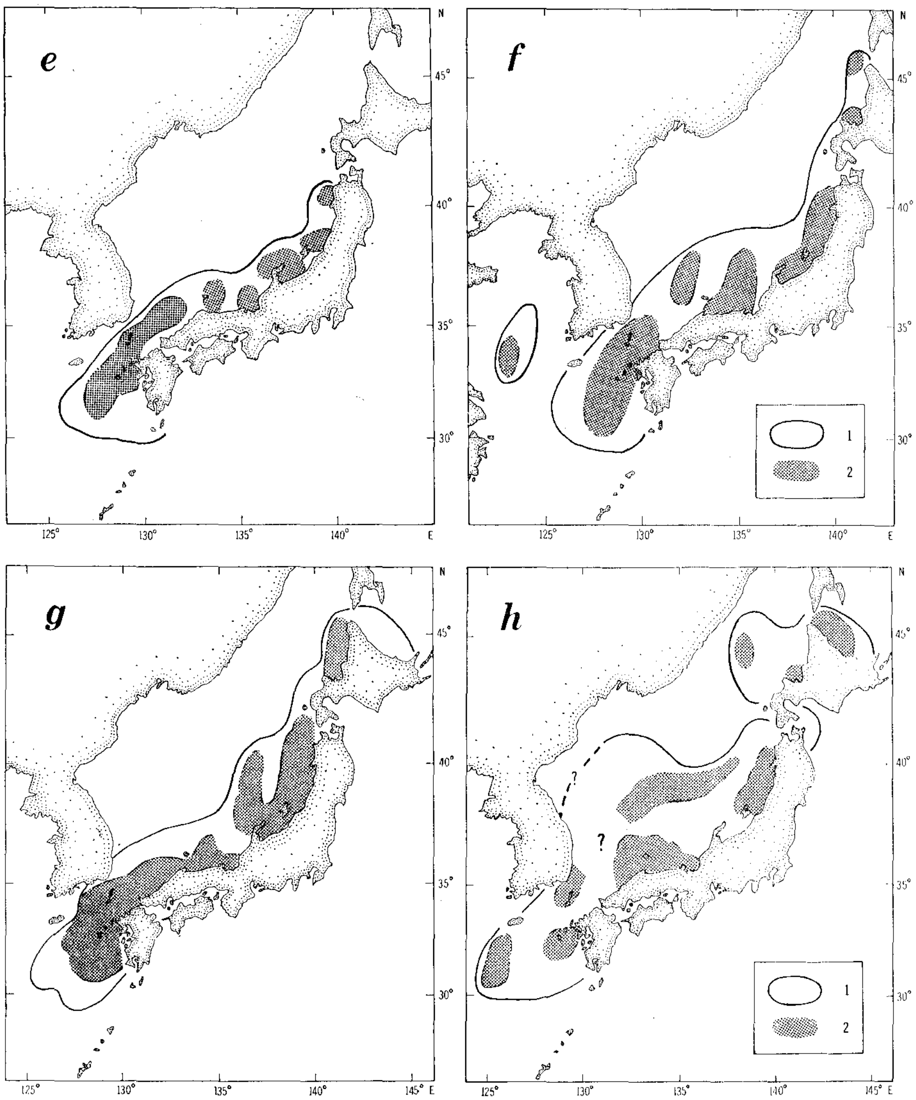

Fig. 6 (continued).
e.—May ; f.—June ; g.—July ; h.—August. 1.—Less than 10 eggs per haul ; 2.—10 or more eggs per haul.

of the Japan Sea (Japan Sea Reg. Fish. Res. Lab. & Toyama Pref. Fish. Exper. Stat. 1961) and similar experience was repeated in the following years. In Fig. 7 are shown the sites of offshore occurrence of the pufferfish based on these and other data. This pufferfish was identified with *Fugu vermicularis porphyreus*, a member of the neritic origin. The specimens caught were all

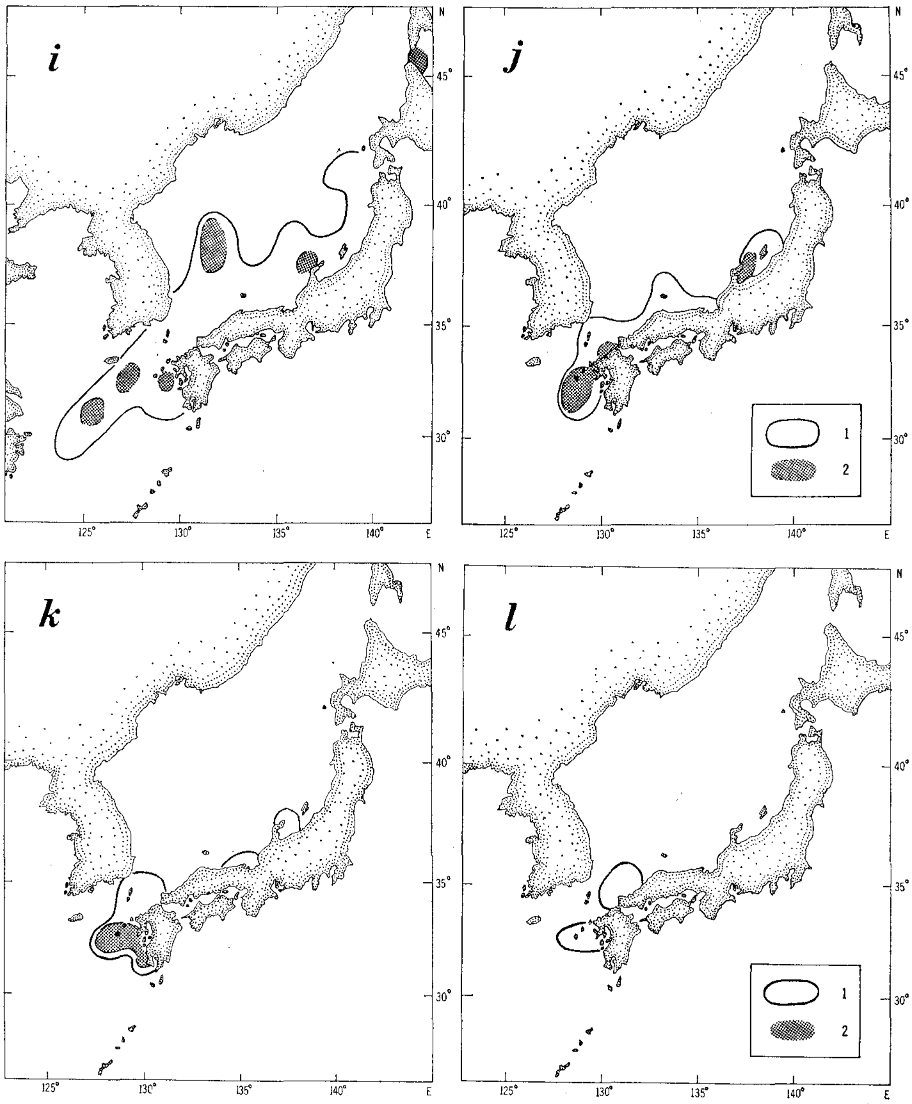

Fig. 6 (continued).
i.—September ; j.—October ; k.—November ; l.—December. 1.—Less than 10 eggs per haul ; 2.—10 or more eggs per haul.

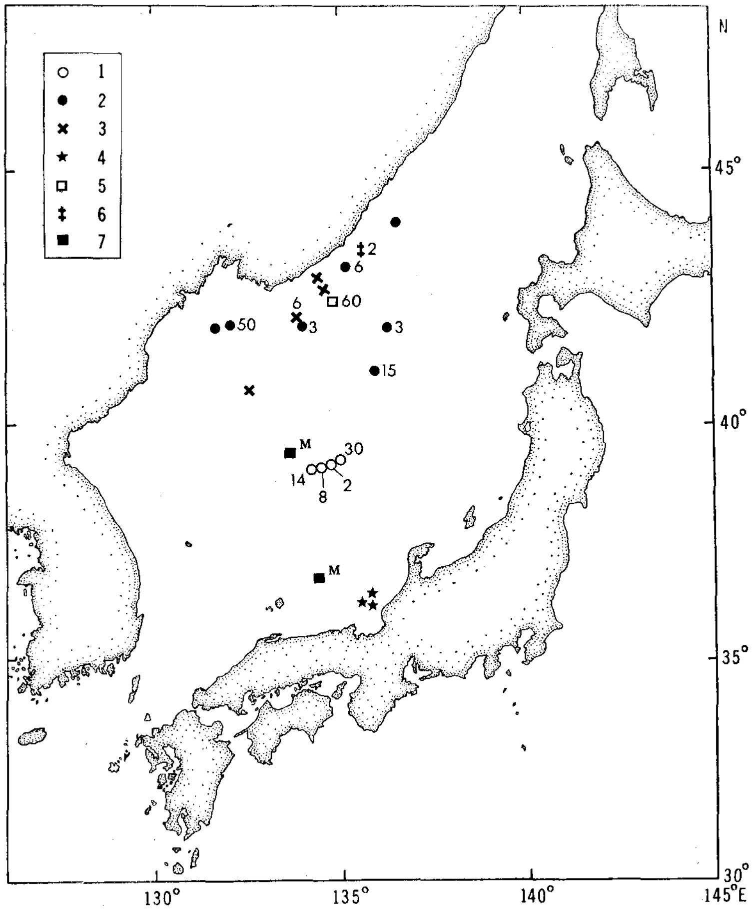

Fig. 7. Occurrences of the pufferfish *Fugu vermicularis porphyreus* in the surface layer of the Japan Sea recorded during the offshore fishery surveys (Compiled from Fisheries Agency, Japan 1958 a, 1962 a, 1962 b; Japan Sea Reg. Fish. Res. Lab. & Toyama Pref. Fish. Exper. Stat. 1961 ; etc.) Numerals indicate the number of fish caught ; the record by a single individual is shown without numeral indication ; and *M* shows that many individuals of this fish were found gathering under a fishing lamp. Codes for respective institutions taking charge of those fishery surveys are : 1.—June 1953 by Fukui Prefectural Fisheries Experimental Station ; 2.—June to July 1960 by Japan Sea Regional Fisheries Research Laboratory and Toyama Pref. Fish. Exper. Stat. ; 3.—June to July 1961 by Fukui Pref. Fish. Exper. Stat. ; 4.—April to May 1961 by Kyoto Pref. Fish. Exper. Stat. ; 5.—July 1961 by Kyoto Pref. Fish. Exper. Stat. ; 6.—July 1961 by Toyama Pref. Fish. Exper. Stat. ; 7.—June 1962 by Shimane Pref. Fish. Exper. Stat.

of a considerable size (ca. 30 cm in body length), presumably at or near the adult stage. Although the spawning habit and early life history of this species are not yet worked out, seven species and subspecies of the same genus, *Fugu rubripes*, *F. niphobles*, *F. stictonotus*, *F. vermicularis radiatus* and others, are known unexceptionally to lay demersal and highly adhesive eggs (UCHIDA et al. 1958). It is therefore likely that the present pufferfish might also lay such demersal adhesive eggs during the spawning possibly confined in the coastal waters. In this respect, it is rather surprising to find adult shoals of this fish in such an offshore region of the Japan Sea.

In the latter half of 1958, an unexpected outbreak of a giant rhizostome medusa, *Stomolophus nomurai*, was observed throughout a wide range of the Japan Sea and its adjacent waters (SHIMOMURA 1959; NISHIMURA 1959 a, 1961 a). As is shown in Fig. 8, abundant occurrences were noted even in the central part of the Japan Sea. Rhizostomaeans are generally believed to reproduce in littoral embayments or estuaries, and it is very probable that the present medusa reproduces in similar environments, though its early life history remains to be worked out. I have already suggested that the coastal region from south to southwest Korea furnished with a great number of islets and embayments may be a main birth-place of this medusa and next the western coastal waters of Kyushu, and that the medusa may be drifted out to the open sea from these regions (NISHIMURA 1959 a, 1961 a). Similar outbreaks of this medusa were recorded three or four times, at least, prior to the 1958 outbreak (KISHINOUYE 1922; TANAKA 1930). Anyhow, it is strange that a littoral form like this rhizostomaean is found in large swarms in the very central region of the Japan Sea.

It is well known that *Sagitta bedoti* represents the dominant constituent of the chaetognath fauna of the Tsushima current region in the Japan Sea (TOKIOKA 1959; FURUHASHI 1958). According to TOKIOKA (1959), this chaetognath shows a characteristic distribution: in the Pacific, it is found solely in the coastal, semi-closed, or mixing areas. He discriminated the water mass characterized by dominant occurrence of *S. bedoti* and distinct from the far oceanic waters of the North Pacific, and called it "*bedoti*-water". He showed further that the water mass is maintained prominently in the East China Sea, the southern Yellow Sea, the southeastern Japan Sea and the northeastern waters of Honshu (cf. Fig. 35 of TOKIOKA 1959). In fact, *S. bedoti* may constitute 100% of the chaetognath population at some positions in the Japan Sea, for instance, along the boundary between the Tsushima and the Liman currents (TOKIOKA 1959). FURUHASHI (1958) supposed that the population of *S. bedoti* in this marginal sea may be the immigrants from the East China Sea where the species is flourishing, but later he abandoned this supposition (FURUHASHI 1959). TOKIOKA's (1959) view of separating a particular water mass for explaining the characteristic distribution of *S. bedoti* may be interesting in its own way; and although this chaetognath is stated as quite euryhaline and eurythermal and its distribution is considered not necessarily bound to the coastal region, its flourishing occurrence in the Japan Sea, particularly along the offshore polar front, may be regarded as a remarkable zoogeographical feature, and this may not contradict to the fact that various

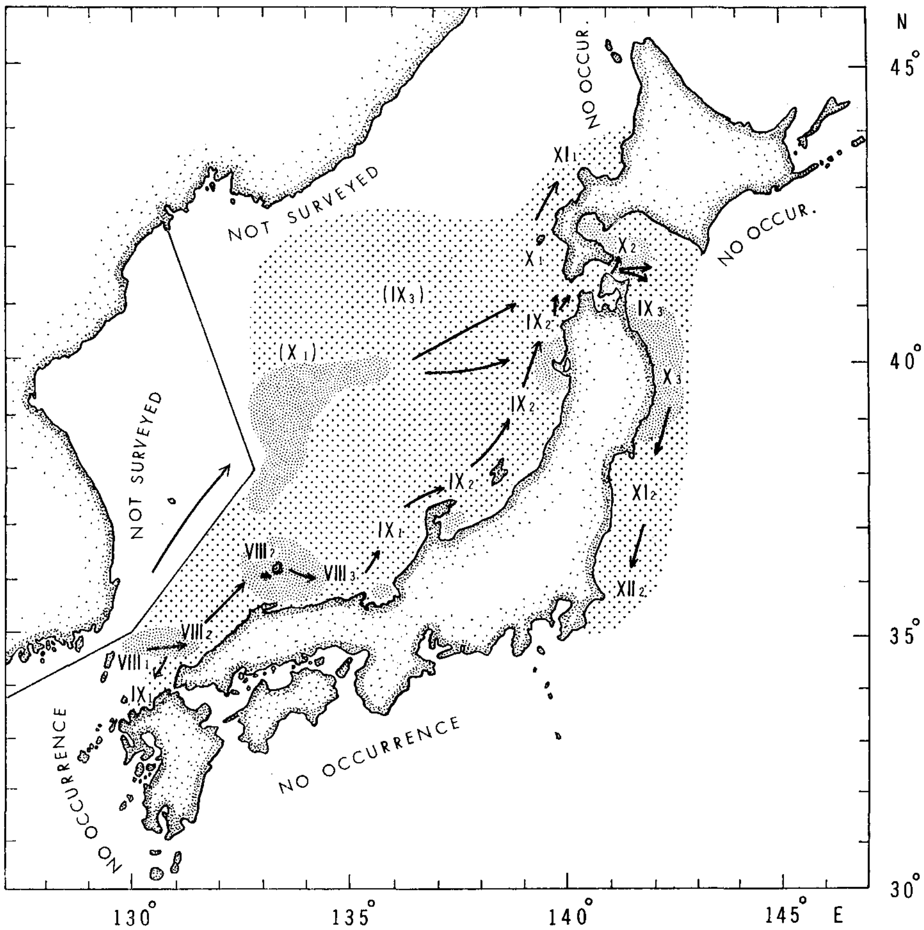

Fig. 8. Distribution of a giant rhizostomaean medusa *Stomolophus nomurai* in the latter half of 1958 (After SHIMOMURA 1959 ; slightly modified). The Roman figure indicates the month of the first appearance of the medusa at respective areas, with the suffixed numerals 1 to 3 respectively showing the first, the second and the third part of the month. Arrows indicate the probable drifting routes. In the central part of the Japan Sea, the dates of the earlier appearances were not known ; the medusae were already distributed densely there in the period from late September to early October.

animals of coastal water origin are found distributed frequently and sometimes in large quantities in the offshore region of this sea basin.

At last, a brief reference is made to the offshore occurrence of pelagic larvae of some coastal fishes. UCHIDA & DOTSU (1958) published the maps showing that the larvae of *Upeneus bensasi, Dasson trossulus, Stephanolepis cirrhifer* and other fishes, all typically coastal in the adult stage, occur in the offshore waters as well, say, as far as more than 100 nautical miles from the Honshu coast. Most of these larvae are known to gather in small shoals under the floating *Sargassum* and to be transported over long distance by the surface ocean current, as is mentioned by HOMMA & SUGIHARA (1963) on *Dasson trossulus* occurring around the coast of Sado Island in the eastern Japan Sea.

3. 4. *Fewer Stenohaline Oceanic Elements*

As compared with the fauna on the Pacific side of Japan, that on the Japan Sea side is distinct in having much fewer stenohaline oceanic elements.

For instance, of the five species of the subfamilies Thunninae and Katsuwoninae commonly caught on the Pacific side, only the bluefin tuna *Thunnus thynnus* is caught in the Japan Sea in the quantity comparable to that on the Pacific side. While, the skipjack *Katsuwonus pelamis* and the yellowfin tuna *Neothunnus albacora* are both rare and fished only sporadically in certain years, the albacore *Thunnus alalunga* is an extremely rare visitor and the occurrence of the big-eye tuna *Parathunnus obesus* in this marginal sea is very doubtful (MATSUBARA 1955)[8]. According to KAWASAKI (1958, 1960), the tuna-like fishes mentioned above are defined as follows on their adaptability to salinity:

Bluefin..............................Neritic; euryhaline, rather adapted to lower salinity.
Skipjack ....Adapted to a wide range of environments; euryhaline.
Yellowfin..........................Reef or insular form; euryhaline.
Albacore and Big-eye.........Oceanic; stenohaline, adapted to higher salinity.

Thus, the Japan Sea maintains a considerably large population of a single species well adapted to lower salinity and minor populations of other euryhaline species but the stenohaline species adapted to higher salinity and thus to the oceanic life are shut out from this sea basin.

In connection with the tuna and skipjack distributions, it may be interesting to note the distribution patterns of some pelagic copepods. A number of species belonging to the genera *Sapphirina* and *Copilia* of the Corycaeidae,

8) OHTSURU (1955) recorded the big-eye tuna on the table of fishes commercially caught by small motor trawler in the northern Japan Sea, and this was transcribed by KATOH (1956) in his list of marine fishes of the Japan Sea. Probably, however, OHTSURU's record is attributable to a misprint or an erroneous information.

Cyclopoida, are distributed abundantly in the Pacific waters and regarded as the characteristic copepods of the warm water mass in the Pacific Ocean (BRODSKY 1955); especially in the surface layer on the skipjack fishing ground, the water mass furnished with the iridescence produced by these copepods is called "*tama mizu*" (jewel water) by Japanese fishermen and affords an indicator of effective operations (UDA 1960). However, these copepods are found only rarely and in much smaller quantities in the Japan Sea, although a few of them have penetrated into the considerable north in the sea; and, of course, no "*tama mizu*" is observed there. Similar distributions are known for the members of *Rhincalanus* and *Mecynocera* of the Eucalanidae, Calanoida, too. *Rhincalanus* is a markedly stenohaline oceanic warm-water genus (TANAKA 1957), and the same holds for *Mecynocera* (cf. FURUHASHI 1961). Two species of the former genus, *R. cornutus* and *R. nasutus*, and a single species of the latter genus, *M. clausi*, are known in the Japanese waters. They are commonly found on the Pacific side, particularly in the Izu region (TANAKA 1956; HONJO et al. 1957; NAKAI et al. 1957), but are decidedly rare in the Japan Sea.

Flying-fishes afford another example. According to PARIN (1960), there are 23 species of flying-fishes in southern Japanese waters including the Ryukyu and the Ogasawara (Bonin) Islands, which consist of 12 neritic and 11 oceanic forms. Of these, only seven or less than one third are known in the Japan Sea, namely, five neritic forms and two oceanic forms. These are assigned, according to PARIN (1960), respectively to the following ecological groups:

Parexocoetus brachypterus brachypterus *Cypselurus poecilopterus* *C. starksi*	Neritic; tropical.
C. heterurus döderleinii *C. hiraii*	Neritic; subtropical.
Exocoetus volitans	Oceanic; tropical.
Prognichthys (Danichthys) rondeletii	Oceanic; subtropical.

Of these seven species, only two neritic and subtropical ones (*Cypselurus heterurus döderleinii* and *C. hiraii*) are found in a sufficient number to support commercial fisheries in the Japan Sea (OKACHI 1958), while other five are caught only rarely. Thus, the reduction in number of species as well as in the size of population, particularly for oceanic forms, is rather striking in spite of the existence of an influential branch current of the Kuroshio flowing into the Japan Sea.

Some oceanic whales and sharks are also poor or missing in the Japan Sea. For instance, the sperm whale *Physeter catodon*, distinguished for its oceanic life, is neither caught nor observed in the Japan Sea proper (MATSUURA 1935b; KIMURA 1956); this toothed whale seems not to venture to migrate into this marginal sea. The same whale is said to be rare even in the vicinity of the Tsushima Islands and southeast Korea[9] and quite missing in the Yellow Sea (MATSUURA 1935 a). The sei whale *Balaenoptera borealis*, likewise an oceanic inhabitant as defined by NEMOTO (1959), shows a similar distribution. It is caught in a large number on the Pacific side of Japan but never in the Japan Sea; its records in this sea basin are quite doubtful according to MATSUURA (1935e). OMURA & NEMOTO (1955) and OMURA (1959) consider that this whale comes near only to the Pacific coast of Japan. The Bryde's whale *Balaenoptera edeni*, another oceanic inhabitant (NEMOTO 1959), is distributed nearly in a similar way, but takes a slightly wider range than the preceding species: it approaches to south and west Kyushu, the Tsushima Islands and south Korea besides the Pacific coast of Japan (OMURA 1959; NEMOTO 1959), but strangely it does not seem to go far into the Japan Sea proper (Fig. 9). The whales which have ever been caught in considerable amounts in the Japan Sea are as follows (KUZUU 1903; OMURA & SAKIURA 1956; KIMURA 1956; OMURA et al. 1957; NISHIMURA 1961c)

Fin whale, *Balaenoptera physalus*
Lesser rorqual, *B. acuto-rostrata*
Humpback whale, *Megaptera novae-angliae*
Gray whale, *Eschrichtius glaucus*
Right whale, *Eubalaena glacialis*

Of these, the last two have been markedly reduced by over-hunt in the late decades of last century, and they are today very rare throughout the Far Eastern seas. These five species are all coastal inhabitants and go into the coastal waters (TAGO 1922; MATSUURA 1935 a, 1935 c, 1935 d, 1936). NEMOTO (1959) assorted baleen whales as follows on their ecological habitats: the lesser rorqual, Gray whale and humpback whale are coastal members in the group of "ocean and marginal sea denizens", and the fin whale and right whale are pelagic members in the same group, whilst the blue, sei and Bryde's whales are included in the group of "ocean denizens".

The whale shark *Rhincodon typus* enters occasionally into the Japan Sea and goes north as far as the west coast of Hokkaido, although it is extremely rare within this sea. On the Pacific side of Honshu, however, this high-sea shark is rather frequently observed off Sanriku District swimming around with shoals of skipjack (KIMUKA 1954; KURODA 1955). In such a case, the

9) KUROZAWA (1937) mentions that in the autumn of 1936 a few sperm whales migrated to off Ulsan in southeast Korea together with many sei whales (probably Bryde's whale; see further lines in text) and an individual was caught for the first time ever since the Ulsan whaling ground had been opened in 1903. The author further shows that the Tsushima current was unusual in the region in that season and suggests that the immigration of sperm whales was caused by this unusual hydrographic condition.

skipjack shoal accompanying a whale shark is called by fishermen "*same-tsukigun*" (shoal attending to shark) which promises a good catch.

Then, it must be noted that most of previously mentioned oceanic species are epipelagic forms inhabiting the surface layer of the oceanic region. On the other hand, the mesopelagic animals or those living in a middle layer of the same region (cf. BRUUN 1955, 1957; HEDGPETH 1957) are by no means rare in the Japan Sea; rather some of them are found or caught more frequently and in larger numbers in this marginal sea than on the Pacific side of Japan as will be shown later. This striking difference found in the

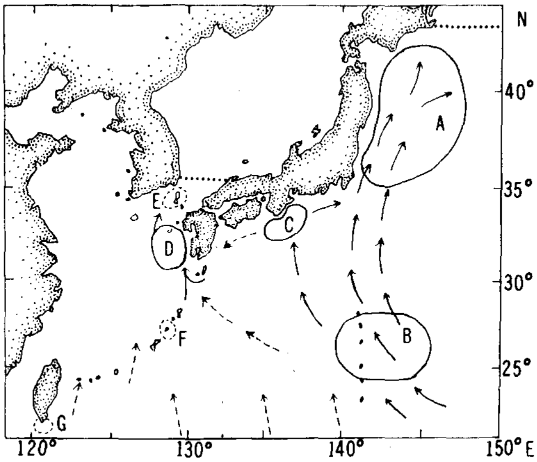

Fig. 9. Probable migration routes and the whaling grounds of the Bryde's whale *Balaenoptera edeni* in the adjacent waters to Japan (After NEMOTO 1959). A, B, C, D—Recent whaling grounds; E—Former whaling ground before 1945; F, G—The areas suspected of the migration of the whale before 1945. Dotted lines indicate the northern limits of distribution.

feature of occurrence between the epipelagic and mesopelagic oceanic animals in the Japan Sea is seemingly attributable to the peculiar hydrography of this marginal sea.

3.5. Frequent Occurrences of Some Mesopelagic Animals

It is to be noted that there are some oceanic animals caught on the Japan Sea side of Honshu more frequently and more abundantly than on the Pacific side. Such are the oarfish *Regalecus russellii*, the dealfish *Trachipterus ishikawai* and other fishes living in the middle layer of the oceanic region. This phenomenon is very strange, because every oceanic animal is naturally considered to appear more frequently in the extensive open ocean like the Pacific than in the semi-closed marginal basin such as the Japan Sea, as actually seen in the cases of the epipelagic oceanic animals.

The oarfish is a taeniosomous teleost supposed to inhabit the middle layer of the ocean (NISHIMURA 1962 b). As it is the creature of a quite unusual appearance, its occurrence, mostly found stranded after a rough weather, has never failed to raise a local sensation which is then recorded in some way. In Fig. 10, the occurrences of this fish hitherto recorded are shown on the map. It is seen clearly that the occurrence is more frequent

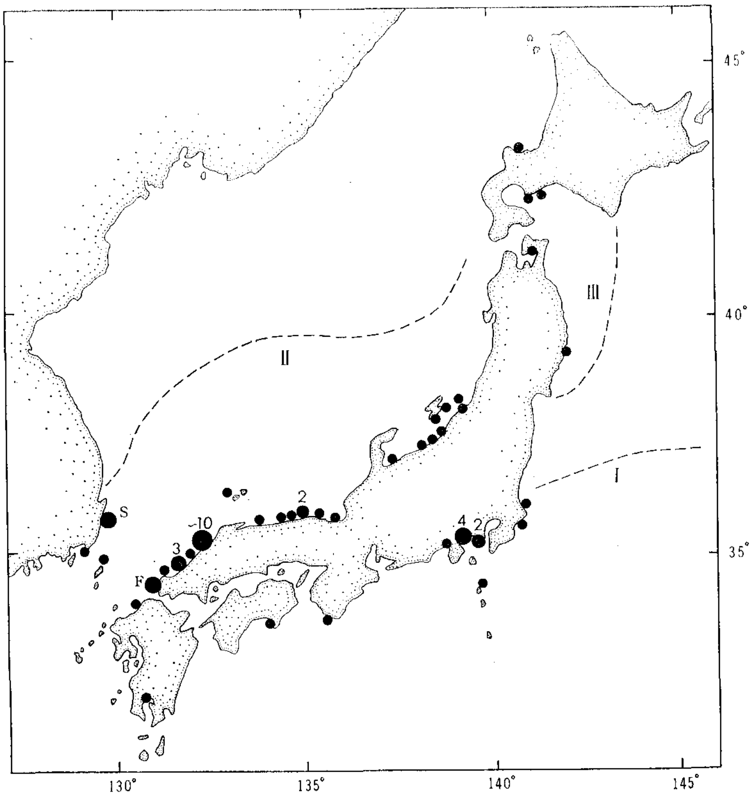

Fig. 10. Occurrences of the oarfish *Regalecus russellii* in the Japanese waters. The smallest solid circles indicate the record of a single individual ; the numerals attached to larger circles show the number of specimens ever recorded in respective localities ; and *S* and *F* are used respectively to mean several and a few individuals for records without exact numerical data. The boundaries between the warm and cold currents are shown by broken line ; I between the Kuroshio and the Oyashio, II between the Tsushima and Liman currents and III between the Tsugaru current and the Oyashio.

on the Japan Sea side than on the Pacific coast, or more precisely, more occurrences in the Tsushima-Tsugaru current region than in the Kuroshio region. A simiar phenomenon is also noted for *Trachipterus ishikawai*, another taeniosomous fish of a mesopelagic life (Fig. 11). This teleost is considered rare on the Pacific side of Japan, as it has been recorded there only a dozen times or thereabout in these fifty years after the first description was made in 1901 (NISHIMURA 1962 a). Contrarily, on the Japan Sea coast, it is fairly

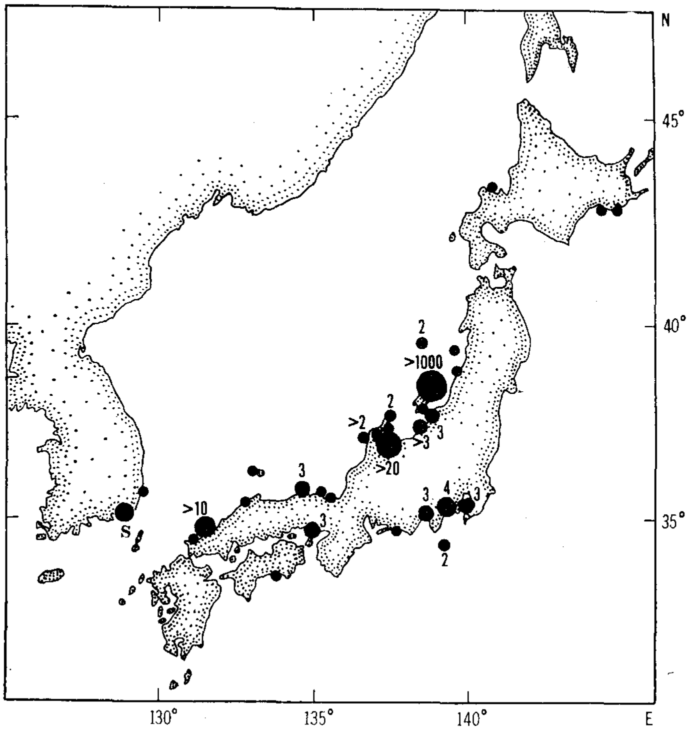

Fig. 11. Occurrences of the dealfish *Trachipterus ishikawai* in the Japanese waters. The smallest solid circles indicate the records of a single individual ; the numerals attached to larger circles show the number of specimens ever caught in respective localities ; and *S* means that uncertain but several individuals have been caught at the locality.

common and there are so many records at such localities as Ryotsu Bay of Sado Island, Echigo Province, Toyama Bay, Noto Peninsula and San'in District (NISHIMURA 1962 a, 1963). The occurrences of these taeniosomous fishes are concentrated mainly in winter to spring in the Japan Sea in spite of their subtropical nature. In San'in District, however, another peak of occurrences is seen in early summer for the oarfish (NISHIMURA 1962 b ; KAMITA 1962).

Certain species of the family Molidae also show a similar occurrence. For instance, the sharptail ocean sunfish *Masturus lanceolatus* is rare on the Pacific side, but rather common in the Japan Sea (Fig. 4). The ocean sunfish *Mola mola* is also commonly caught in this marginal sea[10]. This species has been regarded by some authors (NORMAN 1931; NORMAN & FRASER 1937; SUYEHIRO 1951; SMITH 1961) as an ocean surface denizen; but TANAKA (1933 b) suggested that it must rather be an inhabitant of the middle layer of the ocean and makes appearance on the sea surface only occasionally, because it is met with on the sea surface much less abundantly and less frequently than it is expected from the frequent occurrences of its young individuals in the stomach of carnivorous fishes like tunas. I am of the same opinion with TANAKA in considering that the peculiar features of this fish with the remarkably developed gelatinous subdermal tissue, soft and watery muscles and poorly ossified skeletons (KURODA 1949; ARAKAWA & MASUDA 1961) may be adaptations to the mesopelagic life in the ocean. Probably the same is true for the sharptail ocean sunfish[11]. These animals are considered to be sent into the Japan Sea through the East China Sea and the Tsushima Straits in the middle or deep layer, then carried to the surface layer and at last drifted ashore to be stranded or caught. The occurrences of these fishes are mostly confined in winter in the Japan Sea just like the cases of the taeniosomous fishes.

The porcupinefish *Diodon holacanthus* may well be noted by its similar occurrence pattern. As mentioned in *Section 3.2*, young shoals of this fish appear in great quantities along the Japan Sea coast of Honshu and northwest Kyushu in the winter season; but their occurrence is rather sporadic on the Pacific coast (NISHIMURA 1958 a, 1958 b). For a long time, it has been thought strange that the young porcupinefish are caught only very rarely and in quite small numbers by the surface tow of nets in the southern seas of Japan in spite of their expected distribution in large numbers there; and this led NISHIMURA (1965) to suppose that the shoals of young porcupinefish might be driven by warm currents not in the very surface layer but in somewhat deep layers and in this way enter the Japan Sea in a large popu-

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10) For instance, in the winter of 1960–61 alone, four individuals of *Mola mola* were stranded on the coast of Niigata Prefecture (NISHIMURA & MIZUSAWA 1962), and it is said that ocean sunfish is caught not infrequently by set nets in Ryotsu Bay of Sado Island in every winter. Further, NOVIKOV (1947b) mentions this species being by no means rare along the Maritime coast.

11) YABE (1950) obtained seven young specimens of *Masturus* from the gut of an individual of the wahoo *Acanthocybium solandri*, caught at an offshore station in the Pacific; and this seems to suggest the mesopelagic life of this moline fish. KURODA (1949) mentions that the muscular constitution of this species is very like that of *Mola mola*.

lation. When the surface water is chilled in late autumn to winter, the shoals might rise to the shallower layer and then be carried to the coast to be stranded or entangled in the set nets by large numbers. On the Pacific side, on the other hand, the hydrographic conditions are considered not to be favorable to the rising and subsequent drift to the coast of the shoals.

3.6. Southward Dispersal of Surface-Living Animals of the Northern Coastal Origin in Winter

There are not a few animals breeding in the coastal waters or in the inland waters of the northern districts such as Siberia and Sakhalin whose offspring populations are dispersed in the winter season to an extensive area in the central region of the Japan Sea or even to the southernmost part of the sea off west Honshu. These are the pink salmon *Oncorhynchus gorbuscha* and the Atka mackerel *Pleurogrammus azonus*, several species of whales and seals (the subfamily Phocinae), the northern fur seal *Callorhinus ursinus*, etc.

It has long been known and recently clarified precisely that shoals of the pink salmon with maturing gonads regularly migrate into the waters stretching from off the middle and north Honshu to Hokkaido during the seasons from winter to early summer and are fished abundantly there. The areas of occurrence and relative abundance of this salmon in one of the recent years are shown in Fig. 12. In this life stage, the fish migrate through a shallow layer of the sea and are caught efficiently by surface drift gill-net; Fig. 12 is prepared based on the results of this fishery. The shoals are composed of the fish of a single age group, that is, one year and half old when they appear in the southeastern region of this marginal sea, and believed to belong to the stocks of the Maritime, Amur and Sakhalin rivers, especially of the Amur and its tributaries (MIYAUCHI 1957, 1959; SHIMOMURA 1960; FUKATAKI et al. 1961). Meanwhile, no prominent run of the pink salmon is known today in any rivers or streams of Honshu, and probably of Hokkaido, either[12]. Thus, it is evident that these salmon shoals, descended their home streams to the sea in the spring to summer of the previous year, have dispersed to off the west coasts of Hokkaido and Honshu across the Japan Sea by the beginning of the following spring. The

12) Though it is reported that some runs of the pink salmon have ever (presumably in the years 1930 to 1934) been observed in certain streamlets of the west part of Sado Island (HONMA 1959b), no run is now observed in this island. According to MATSUBARA (1955), the pink salmon were occasionally caught in the Chitose-Gawa, the upper reaches of the River Ishikari-Gawa in west Hokkaido, although it is doubtful whether the run was of the scale large enough to be regarded of a commercial significance; but at present any thriving run is not recorded from that river. Of the rivers and streams of Hokkaido pouring into the Japan Sea, only the northernmost, the Teshio-Gawa, receives some runs of the pink salmon in recent years, and actually a small number of the fish are caught there annually for the hatchery (Hokkaido Hatchery Stat. 1959, 1960).

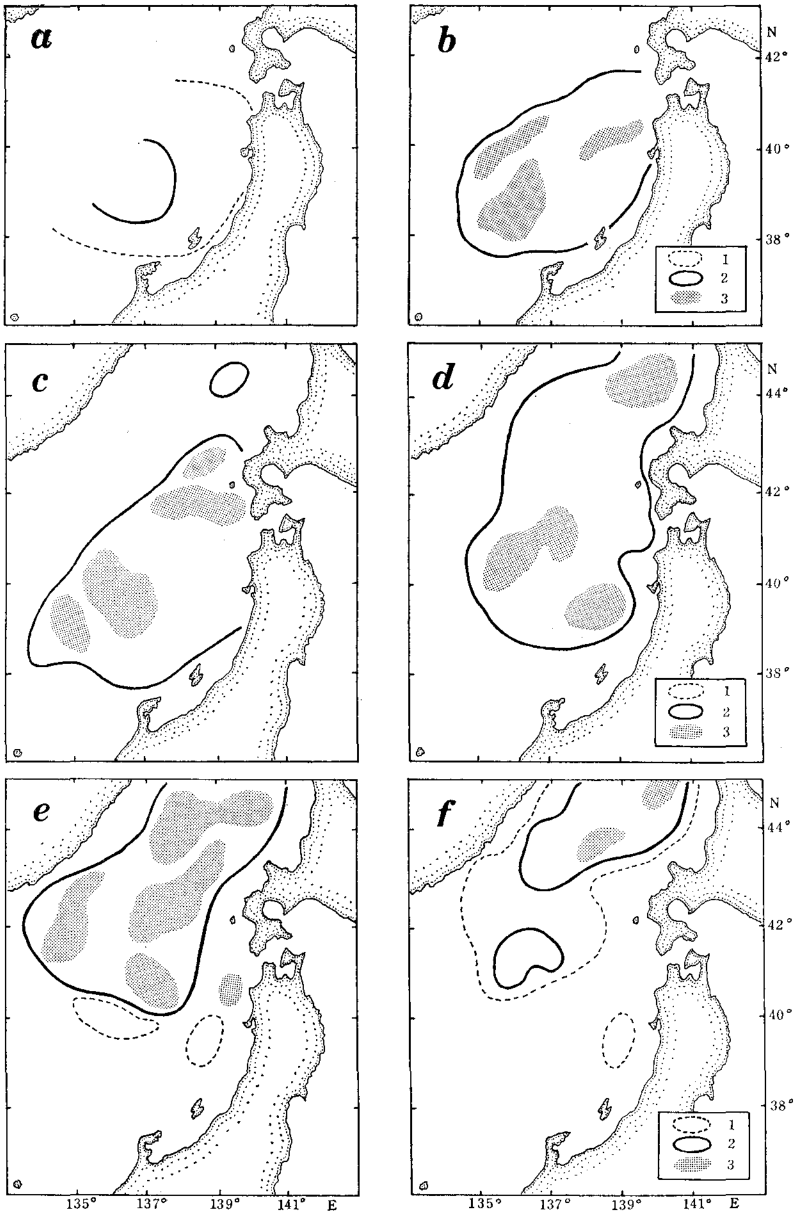

Fig. 12. Occurrences and relative abundance of the pink salmon *Oncorhynchus gorbuscha* in the Japan Sea in 1960. The relative abundance is indicated by a mean of the numbers of salmon caught per *tan* (Japanese unit of the length of the drift net) for each 1/3°×1/3° square. a.—Early March ; b.—Middle April ; c.—Early May ; d.—Late May ; e.—Early June ; f.—Middle June. 1.—Less than one salmon per *tan* ; 2.—One to five salmon per *tan* ; 3.—More than five salmon per *tan*.

wintering area of the pink salmon in its marine life stage is not yet known, but it might be found somewhere in the high-sea region of the Japan Sea as suggested by SHIMOMURA (1960b, 1961). This southward dispersal in the autumn to winter season displayed by the juvenile pink salmon of the continental origin is really noteworthy not only from the biological stand-point but also from the hydrographical aspects, as it is not yet determined whether this dispersal is an active migration or merely a passive drift.

A similar dispersal is seen also in the juvenile population of the Atka mackerel. The adult of this fish is semi-demersal, inhabiting the shallow coastal waters of the northern Japan Sea and the Okhotsk Sea. The fish breed on rocky or gravel bottom 5 to 30 m deep and several tens to thousands of meters off the beach (HIRANO 1947; Hokkaido Fish. Sci. Inst. 1953; Hokkaido Reg. Fish. Res. Lab. 1956; GORBUNOVA 1958). The breeding season extends from the latter half of August to November on the Maritime coast, from the end of September or the beginning of October to the middle of November off the northwest Hokkaido (around Rishiri and Rebun Islands), and from the first part of November to that of December off the southwest Hokkaido (GORBUNOVA 1958; HIRANO 1947; HIRANO & TAKAHASHI 1943; KAMBARA 1957 b; KAMBARA et al. 1953). While, on the coast of northwest Honshu, the season is estimated to extend from December to February (OGATA 1956). Thus, it is evident that the Atka mackerel spawn much earlier in the northern region than in the southern region. The larva just hatched out after one (GORBUNOVA 1958) to two (HIRANO & KONDO 1948) months' incubation is about 10 mm long (SHIMOMURA & FUKATAKI 1957; YUSA 1957) and colored greenish blue on the dorsal side and silvery on the belly as seen commonly in the fishes adapted to the pelagic life in the sea surface (UCHIDA 1929, 1930). This characteristic coloration is retained till the fish attains at least 150 mm (ABE 1951), and actually only these larval and juvenile individuals are caught at or near the surface of the sea. And here it is noteworthy that the juvenile Atka mackerel occurs at the sea surface not only in the coastal waters but also in the extreme offshore waters of the Japan Sea. In January and February, 1950, the expeditory vessel of the Institute of Oceanology, Academy of Sciences U.S.S.R., caught many young Atka mackerel, 9 to 30 mm in body length, in the central region of the Japan Sea as well as in the coastal areas along southwest Sakhalin and Maritime Province (BETESHEVA 1954)[13], and then in the first to middle parts of April, 1956, numerous young individuals were caught by surface tows at the stations in the central Japan Sea as far as 300 nautical miles from the Honshu coast during the oceanographic survey carrried out by the Japan Sea Regional Fisheries Research Laboratory (Fig.

13) BETESHEVA (1954) referred these specimens to *Hexagrammos otaki*; but apparently this is a mis-identification for the Atka mackerel.

13). In the latter case, it was observed furthermore that the specimens caught were larger of their body size roughly proportionately to the distance

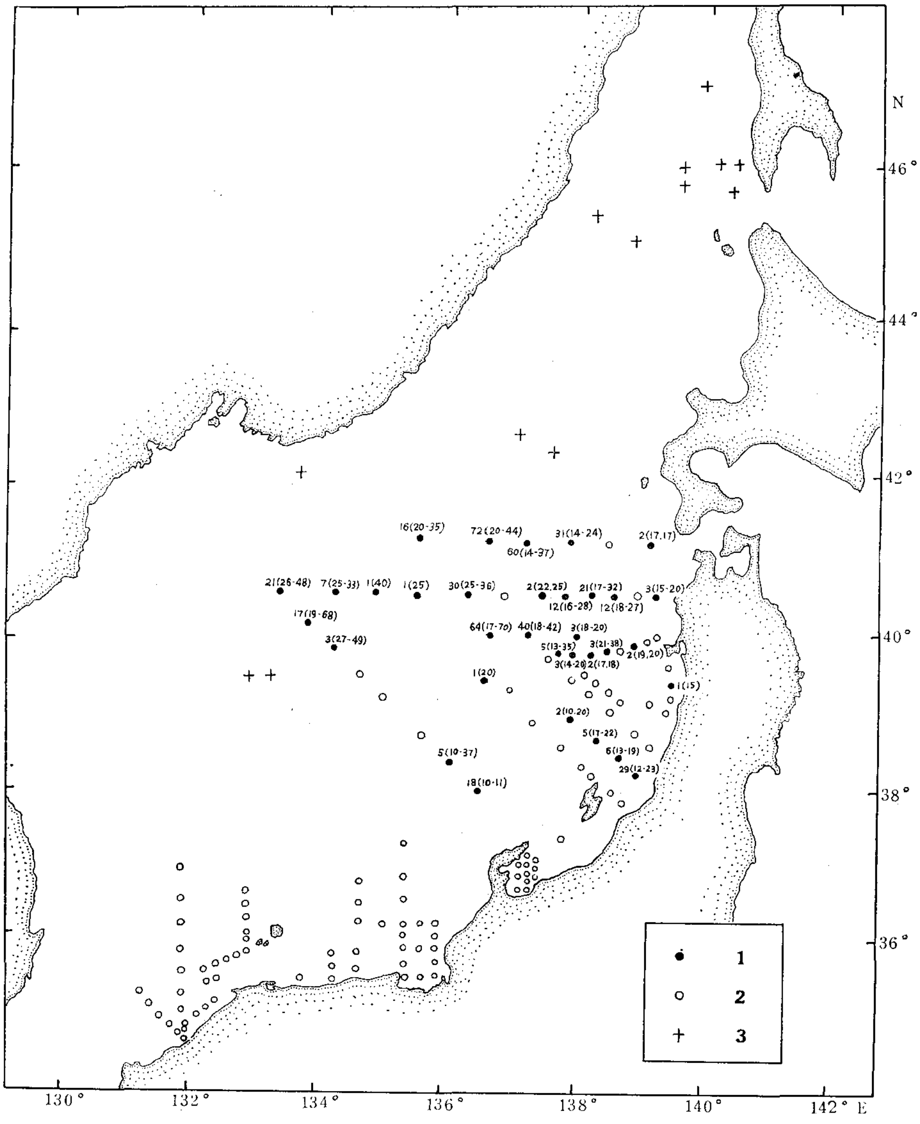

Fig. 13. Distribution of the pelagic young of the Atka mackerel *Pleurogrammus azonus*. 1.—Occurring station by surface tows of a conical larva-net in the first to middle parts of April, 1956 ; figure indicates the number of specimens caught and that in parentheses shows the range of body length in mm. 2.—No pelagic young obtained in the period mentioned in 1. 3.—Occurring station in January to February, 1950. (After SHIMOMURA & FUKATAKI 1957 for the data in the southeastern region and BETESHEVA 1954 for those in the northern region).

from the Honshu coast. Juvenile Atka mackerel may also be found in the stomach contents of some carnivorous fishes caught at sea surface in the offshore region. For instance, OGAWA & NAZUMI (1959) obtained five 93- to 124-mm long specimens from the stomach of the pink salmon fished off the northwest of Sado Island (38°45′ N., 138°12′ E.) in early May, 1958. Also, FUKATAKI (1960) and FUKATAKI et al. (1961) revealed that juvenile Atka mackerel constituted one of the staple foods of the cherry salmon *Oncorhynchus masou*

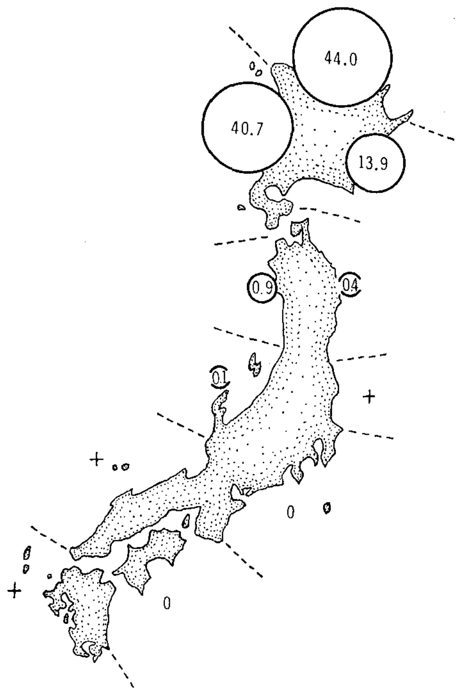

Fig. 14. Percentage distribution of mean landing amount of the Atka mackerel in respective regions, shown separately one another by broken lines, in 1953 to 1955. Cross means the quite sporadic occurrence and 0 the total absence of the species, respectively.

at least in its later stage of marine life in the offshore region in the Japan Sea. The juveniles from the stomach of the cherry salmon fished in the middle of May, 1960, were about 100 mm in body length, and it is stated that the largest specimen ever found in the stomach of the same salmon caught throughout the seasons (May) in the years 1957 to 1960 was 145 mm long (FUKATAKI et al. 1961).

FUKATAKI (1957) explains that these offshore young Atka mackerel are possibly migrating into the cold-water region with rich food plankton from the coasts of the Japanese islands, crossing over the polar front, and coming back again to their birth places in the Japanese coastal waters when the juvenile stage is closed. Probably this opinion was deduced from the fact that the nearer the Japanese coasts, the smaller (or younger) are the individuals collected (see Fig. 13). The same view is supported by OGAWA & NAZUMI (1959), too.

My opinion differs from that proposed by the above-mentioned authors. It seems more likely that the majority of offshore young shoals of the Atka mackerel are derived from the population along the continental (Maritime Province) or northern island (northwest Hokkaido and west Sakhalin) coasts and migrate into the central Japan Sea from their native places in the late autumn to winter seasons. A part of the shoals may even go down to the warm water region across the polar front, but the bulk of them may remain north of the front. This suggestion is supported by the following facts: (1) the growth of the offshore Atka mackerel is quite unusual if they are regarded as the offsprings of the population along the Japanese coasts including south Hokkaido, where the breeding is done two or three months later than in more northern regions (cf. the growth curve of this fish given by SHIMOMURA & FUKATAKI 1957); (2) actually the Atka mackerel is much more abundant in the region north of the polar front than in the region south of it, thus the commercial catch is much larger on the Hokkaido coasts, especially the northwestern and the Okhotsk Sea coasts than on the Honshu coast (Fig. 14), and moreover there are evidences suggesting large populations along the Sakhalin and the Maritime coasts (BELCHUK 1938; ABE 1951; KAMBARA 1957a; ELKINA 1962).

Some 30- to 40-mm long pelagic specimens of *Bathymaster derjugini* were caught by surface tows in the offshore waters in the northern part of the Japan Sea during the above-mentioned cruise of the expeditory vessel of the Institute of Oceanology, Academy of Sciences U.S.S.R. (BETESHEVA 1954). This teleost has ever been recorded only once from Japan by a single adult taken off Nô, Niigata Prefecture (TOMIYAMA 1952). Since the species seems quite rare and may never reproduce in the Japanese coastal water, it is highly likely that the specimen caught near Niigata was an individual drifted there from the coastal waters along Maritime Province or west Sakhalin where the demersal adult population is found during the pelagic young stage in the winter season and grown to the adult size in the Japanese waters (Fig. 15).

Pinnipeds represent another example of the winter dispersal. Seals are occasionally drifted to the Honshu coast down to San'in District (UEKI 1936; NISHIMURA 1960c; KAMITA 1962) in late winter, and these are mostly young individuals. Though the specific identification of these seals is not made sufficiently, they seem to include *Pusa hispida ochotensis* and in a lesser frequency *Phoca vitulina largha*. In addition, the northern fur seal *Callorhinus ursinus* makes a regular appearance in the offshore region of the central to southern Japan Sea in winter to next spring. The herds of this fur seal contain both young and adult individuals and no doubt belong to the stock

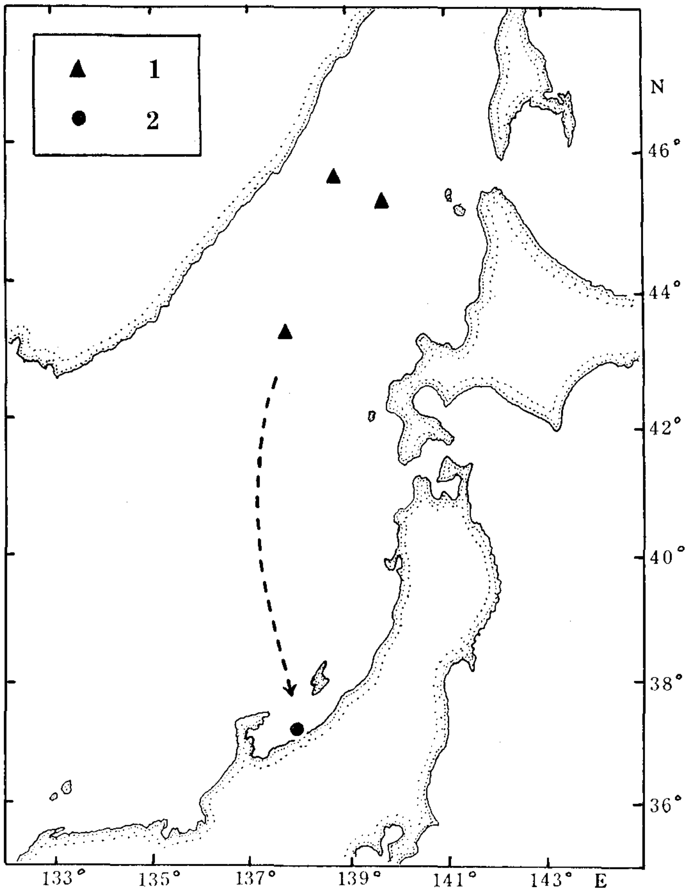

Fig. 15. Offshore occurrences of pelagic youngs of *Bathymaster derjugini* in the midwinter season (1) and the situation of the single record in the Japanese waters (2). Arrow indicates a possible course of drift to the Japanese waters.

of Robben Island, Sakhalin. They are considered to leave Robben Island in October to November after the breading season; a part migrates southward to the Pacific coasts of Hokkaido and northern Honshu, while the remainder enters the Japan Sea through the Sôya (La Pérouse) Straits (MATSUURA 1943). On the other hand, the breeding places of the seals of the Phocinae are not yet precisely known, though it is most likely that they are in the Okhotsk Sea (SCHEFFER 1958), and the young individuals would be drifted into the Japan Sea probably through the Sôya Straits and dispersed across the extensive area of the sea during the late autumn to winter season eventually to reach the coast of Honshu.

Some species of whales seem to show a similar winter migration, namely, to take an offshore course from the northernmost part of the Japan Sea or from the Okhotsk Sea, passing through the Sôya Straits, down to the middle to southern coastal waters of the sea just off southeast Korea or Wakasa to San'in Districts, presumably trepassing the present marginal sea through its central part. And actually it is shown for a species of the beaked whale *Mesoplodon stejnegeri*, a North Pacific form mainly known from the Bering Sea and northwest North America, that this whale may migrate down to the central part of the Japan Sea together with the salmon shoals during the winter season, since it has occasionally been entangled in the surface drift gill-net of salmon fishery in the offshore waters of the sea in early spring (NISHIMURA & NISHIWAKI 1964). It is a remarkable fact that the whales, even their neritic representatives, are neither caught nor observed along the coasts of the intermediate districts between the northern and southernmost parts of the sea (south Hokkaido, Honshu north of Wakasa District, northeast and east Korea) in winter, although they appear regularly and rather frequently in these districts in their northward migration in spring to early summer. More detailed points of the seasonal migration of these whales will be discussed in *Section 3.8.*

All the animals mentioned above in this section are the inhabitants of the surface layer; and the southward dispersal or migration in the winter season commonly seen in these animals seems to suggest the existence of a prevailing southerly surface current in the Japan Sea in that season.

[*To be continued*]