THE ZOOGEOGRAPHICAL ASPECTS OF THE JAPAN SEA PART IV[1]

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CONTENTS

3. Peculiarities of Animal Distribution in the Japan Sea (continued)

3.11. Horizontal and Vertical Ranges of the Bottom Communities

In the preceding section (*Section 3.10* in Part III), it is stated that, in the south-eastern part of the Japan Sea, up to seven bottom communities of different faunistic and ecological characteristics are noted during the warmer season of the year, viz. *okaba communities I, II, III, IV* and *taraba communities I, II* and *III*. Such a pattern of vertical arrangement of bottom communities is, however, not always observable throughout the entire sea basin nor all the year round.

As mentioned previously (*Section 3.1*), a number of tropical-subtropical animals stop their northward distribution along the east coast of the Japan Sea at the Tsugaru Straits; and it is an interesting fact that the majority of those animals are members of the okaba communities I and II. The few southern animals ever recorded from the waters north of the Tsugaru Straits are mostly pelagic species (for intance, *Katsuwonus pelamis, Auxis tapeinosoma, Coryphaena hippurus, Xiphias gladius* among fishes, *Argonauta argo* and *Thysanoteuthis rhombus* among cephalopods) or the species which have a pelagic phase in the early stage of life (for instance, *Upeneus bensasi* and *Diodon holacanthus* of fishes). Similarly, southern animals have not infrequently been recorded from the continental side of the northern Japan Sea, from Peter the Great

1) Contributions from the Seto Marine Biological Laboratory, No. 478.

Bay for instance; and most of them are migratory or pelagic animals as already noted by SCHMIDT (1926).

The members of the warm-water bottom communities, on the other hand, may be represented, but quite poorly, in the northerly waters mentioned above. This stands especially good for the okaba community II; typical species of this community such as *Döderleinia berycoides*, *Niphon spinosus*, *Evynnis japonica*, *Cepola schlegeli*, *Zeus japonicus*, *Tanakius kitaharai* of fishes, *Stereocidaris japonica* and *Parastichopus nigripunctatus* of echinoderms, *Doryteuthis kensaki*, *Acila divaricata Dosinella penicillata* (*Dosinia angulosa* sic) of mollusks, *Latreillia phalangium*, *L. valida*, *Carcinoplax longimanus*, *C. vestitus* and *Munida japonica* of crustaceans are entirely absent in those northerly waters. Much the same seems to hold for the okaba community I, too, except for the existence of a certain number of its member species extending their distribution somewhat considerably to those northerly waters[2)].

Much less remarkable development of the okaba community IV in the region north of southern Hokkaido or southeastern Korea may be shown by the distribution pattern of the two important constituent species of that community, the deep-sea smelt *Glossanodon semifasciatus* and the pearlsides *Maurolicus muelleri*. Along the east coast of the Japan Sea, the former species was stated to be distributed south of Toyama Bay by MATSUBARA (1955) and TOMIYAMA & ABE (1958), but according to the recent information by KATOH (1956), its range seems to extend more northward, at least to the coast of Akita Prefecture near the Tsugaru Straits. While, the latter species is also considered to have its northern distributional limit in the region including Akita and Aomori Prefectures or a little more north[3)]. On the continental side, on the other hand, *Maurolicus muelleri* is recorded by MORI (1952) from northeastern Korea but not known from Peter the Great Bay according to LINDBERG (1947), while *Glossanodon semifasciatus* is recorded only from the south Korean waters (MORI 1952). *Glossanodon* is better adapted to the demersal life than *Maurolicus* so that the distribution of the former is almost restricted to the edge of the continental shelf fringing Honshu and South Korea, while that of the latter is often extended to the pelagic region. Occasionally, shoals of *Maurolicus* are observed coming up near the sea surface around the Yamato Bank in the central part of the Japan Sea. Among the

2) This seems to be noted at the least as to fishes and crustaceans: *Callionymus beniteguri*, *Oplegnathus fasciatus*, *Girella punctata*, *Mustelus manazo*, etc. of fishes, and *Hemigrapsus sanguineus*, *Goetice depressa*, *Charybdis japonica*, *Ovalipes punctatus*, *Portunus trituberculatus*, *Squilla oratoria*, etc. of crustaceans, all belonging to the okaba community I, are recorded from the vicinity of Oshoro, west Hokkaido (KOBAYASHI 1962; ICHIKAWA & YAMADA 1957). The similar trend seems recognizable also along the continental coast of the Japan Sea (cf. LINDBERG 1947; KAMITA 1941).

3) According to a personal information from Mr. O. SANO dated Oct. 2, 1957, then a member of the Hokkaido Regional Fisheries Research Laboratory, a small number of pelagic eggs of this gonostomatid fish have been collected off Cape Erimo on the Pacific coast of southeastern Hokkaido in late September. This may suggest either that the pelagic eggs have been drifted out of the Japan Sea to the Pacific through the Tsugaru Straits or that the spawning adult population, even though it is very small, is actually distributed in the waters off southeastern Hokkaido.

invertebrates of this community, *Watasenia scintillans* (Cephalopoda) and *Euphausia pacifica* (Crustacea) may be mentioned. By surface towing of a plankton net, pelagic eggs of a certain squid with a very characteristic appearance are commonly collected in the Japan Sea. And these eggs are generally believed to belong to the above-mentioned luminescent cephalopod or its close allies. According to YAMADA (1937) and SHIMOMURA & FUKATAKI (1957), the eggs occur abundantly from spring to summer in the areas affected by the warm Tsushima current, such as Toyama Bay, Wakasa Bay, off San'in District and off the southeastern to eastern Korea, though they are distributed sparsely in the cold-water areas more northerly located, too. According to PONOMAREVA (1955, 1963), *Euphausia pacifica* is most abundant in the southern part of the Japan Sea as well as the Pacific area south of the Kurile Islands. The southern part of the Japan Sea mentioned by PONOMAREVA seems to include the region south of the line connecting Peter the Great Bay and the Sôya Straits. In this region, *E. pacifica* is not only distributed abundantly but also breeds vigorously; it is not rare to collect a large amount of pelagic eggs and larvae of this euphausiid at certain localities along the central and west Honshu, such as Toyama Bay and Wakasa Bay. In the northern part of the Japan Sea, *E. pacifica* is rather sparse and does not breed; the population found there is seemingly allogenetic and brought there by ocean currents from more southerly regions (PONOMAREVA 1963).

The foregoing instances of the members of the okaba community IV show apparently a tendency that the more demersal they are, the more strictly their geographical ranges are limited; *Glossanodon semifasciatus*, the most demersal member, is restricted to the continental edge in the southeastern part of the Japan Sea, whereas other less demersal members extend their distribution respectively to northerly waters in various degrees. Anyhow, the waters off Honshu and southeastern Korea may be regarded as the center of distribution or their natal place for the members of the okaba community IV.

Thus, it may be concluded that the horizontal distributions of the bottom communities okaba I, II and IV are essentially limited to the southeastern part of the Japan Sea; the northern boundary of their occurrences will be shown by the line through the southeastern corner of Korean Peninsula on the west and the western entrance to the Tsugaru Straits on the east. This line is nothing but the well known boundary zone beyond which the number of warm-water animal species declines abruptly (see Fig. 2 in Part I). This coincidence is no wonder, since the constituent members of the bottom communities mentioned above all belong to the southern warm-water species and that these communities are the most luxuriant as regards the species composition of the animal communities with southern affinity found in the Japan Sea. The sharp drop of the number of southern elements beyond that boundary must be substantially brought forth by the disappearence or the scarcity of the members of the above-mentioned bottom communities in the northerly waters.

Table 2. Frequency of occurrence (f) and number of individuals caught per haul (i/h) of bottom fishes at various depths off the coast of Yamagata Prefecture, September to October, 1961.
Catch by trawl; modes in respective values in bold type. Based on the reports by Yamagata Pref. Fish. Exper. Stat. (1962).

Water depth (m)	40		50		80		100		150	
Number of hauls	11		12		10		12		5	
	f	*i/h*	*f*	*i/h*	*f*	*i/h*	*f*	*i/h*	*f*	*i/h*
Leiognathus rivulatus	**0.55**	**288**	0.33	1.0	0.1	0.1	0.08	0.2	0	0
Upeneus bensasi	0.82	150	**1.00**	**217**	0.4	172	0.17	47.5	0.20	3.6
Stephanolepis cirrhifer	**0.91**	**33.9**	0.58	1.3	0	0	0	0	0	0
Evynnis japonica (young)	0.73	**24.6**	**0.75**	8.3	0.3	0.8	0.08	0.3	0.20	0.2
Chrysophrys major (young)	0.73	9.0	**0.83**	**16.3**	0.2	0.4	0.08	0.3	0.20	0.4
Sillago japonica	0.64	**8.5**	**0.75**	8.0	0	0	0.08	0.1	0	0
Navodon modestus	0.45	6.0	**0.83**	**16.6**	0.8	1.9	0.25	4.5	0	0
Lagocephalus lunaris	**0.64**	**5.6**	0.58	3.8	0.2	0.5	0	0	0	0
Chelidonichthys kumu	**0.73**	**3.5**	0.67	2.8	0.1	0.1	0.08	0.3	0	0
Saurida undosquamis	**0.36**	**4.0**	0.33	0.5	0	0	0	0	0	0
Sphyraena schlegeli	**0.18**	0.4	0.08	**0.5**	0	0	0	0	0	0
Nemipterus virgatus	**0.09**	0.1	0.08	**0.3**	0	0	0	0	0	0
Argyrosomus argentatus	**0.09**	**0.5**	0.08	0.1	0	0	0	0	0	0
Areliscus joyneri	**0.09**	**0.6**	0.08	0.4	0	0	0	0	0	0
Zebrias zebra	**0.09**	**0.2**	0.08	0.1	0	0	0	0	0	0
Rhinoplagusia japonica	**0.09**	**0.5**	0	0	0	0	0	0	0	0
Cynoglossus robustus	**0.09**	**0.2**	0	0	0	0	0	0	0	0
Caranx equula	**0.09**	**0.1**	0.08	0.1	0	0	0	0	0	0
Platycephalus indicus	**0.09**	**0.9**	0.08	0.6	0.0	0.2	0	0	0	0
Trachinocephalus myops	0	0	**0.08**	**0.3**	0	0	0	0	0	0
Fugu vermiculare porphyreum	0	0	**0.08**	**0.4**	0	0	0	0	0	0
Mustelus manazo	0.27	1.3	**0.33**	1.3	0.2	**3.1**	0	0	0	0
Oplegnathus fasciatus	**0.18**	**1.4**	0	0	0	0	0	0	0	0
Plectorhynchus cinctus	**0.36**	**0.4**	0.08	0.1	0	0	0	0	0	0
Lepidotrigla microptera	0.36	0.6	0.50	9.9	**1.0**	**86.3**	0.9	55.8	1.0	23.6
Trachurus japonicus	0.36	4.3	0.75	52.8	**0.8**	**996**	0.7	84.7	0.2	11.0
Pseudorhombus pentophthalmus	0.09	0.1	0.25	1.5	**0.7**	**2.0**	0.4	0.5	0	0
Callionymus lunatus	0.09	0.2	0.16	5.2	**0.7**	6.6	0.5	**7.7**	0	0
Zeus japonicus	0	0	0.42	1.6	**0.9**	**6.9**	0.5	2.6	0.2	0.4
Chaeturichthys sciistius	0	0	0	0	**0.1**	0.2	0.08	**0.4**	0	0
Cepola schlegeli	0	0	0	0	**0.1**	**0.4**	0.08	0.1	0	0
Eopsetta grigorjewi	0	0	0.08	0.4	0.9	10.5	**1.0**	**23.7**	1.0	17.8
Tanakius kitaharai	0	0	0.08	0.3	0.7	5.9	0.8	**9.1**	**1.0**	1.5
Uranoscopus japonicus	0	0	0.08	3.3	**0.7**	**5.3**	0.42	2.2	0.2	0.4
Niphon spinosus	0.09	0.1	0.08	0.3	**0.7**	2.8	0.67	**3.7**	0.2	1.6

Table 2 (continued).

Water depth (m)	40		50		80		100		150	
Number of hauls	11		12		10		12		5	
	f	*i/h*	*f*	*i/h*	*f*	*i/h*	*f*	*i/h*	*f*	*i/h*
Döderleinia berycoides	0	0	0.08	1.8	**0.9**	11.8	0.83	**22.2**	0.4	19.8
Neobythites sivicolus	0	0	0.08	1.0	**0.9**	**3.6**	0.42	1.4	0.4	0.8
Branchiostegus japonicus	0	0	0.08	0.1	**0.6**	**6.4**	0.25	0.3	0.2	1.4
Parapercis sexfasciatus	0	0	0.08	0.2	**0.4**	**3.1**	0.17	0.2	0	0
P. pulchella	0	0	0.08	0.1	**0.2**	0.5	0.17	**3.3**	0	0
Raja sp. (?=*R. tengu*)	0	0	0.08	0.3	**0.5**	**1.1**	0.25	0.4	0	0
Lophius litulon	0	0	0.08	0.3	0.5	3.5	0.75	6.3	**0.8**	**27.0**
Hexagrammos otaki	0	0	0.08	0.1	0.1	**0.5**	0	0	**0.4**	0.4
Limanda yokohamae yokohamae	0.09	0.1	0	0	0.6	1.2	0.67	**1.7**	**1.0**	1.0
L. herzensteini	0	0	0	0	0.1	1.2	0.42	4.8	**0.8**	**20.8**
Enedrias nebulosus	0	0	0	0	0	0	0.08	0.1	**0.8**	**4.2**
Glossanodon semifasciatus	0	0	0	0	0.5	408	0.58	**889**	**0.8**	833
Liparidae sp.	0	0	0	0	0.2	0.3	0.25	0.5	**0.6**	**2.8**
Cottidae sp.	0	0	0	0	0	0	0.25	1.3	**0.8**	**156**
Cottiusculus schmidti	0	0	0	0	0	0	0.17	0.8	**0.2**	**2.8**
Occa iburia	0	0	0	0	0	0	0.08	0.5	**0.6**	**13.2**
Glyptocephalus stelleri	0	0	0	0	0	0	0	0	**0.6**	**2.8**
Squalus acanthias suckleyi	0	0	0	0	0	0	0	0	**0.2**	**48**
Gymnocanthus herzensteini	0	0	0	0	0	0	0	0	**0.2**	**11.4**
Gadus morhua macrocephalus	0	0	0	0	0	0	0	0	**0.2**	**35.0**
Theragra chalcogramma	0	0	0.08 (young)	0.1	0	0	0	0	**0.4**	**2.2**

Our attention is now focussed on the depth range and its regional difference of these communities. First, as to the okaba community I, some informations are available from the works done by Ouchi (1960), Ouchi & Ogata (1960a) and the Yamagata Prefectural Fisheries Experimental Station (1962) for the region off the Hokuriku coast extending from Niigata to Yamagata Prefectures and from those carried out by the Shimane Prefectural Fisheries Experimental Station (1963) for the coastal region of the southern Japan Sea. In Tables 2 and 3 are summarized the results of the works by the Fisheries Experimental Stations of Yamagata and Shimane Prefectures. It is apparent that off the coast of the Yamagata-Niigata region occurrences of the species of the okaba community I are mostly confined to the upper 50–60 m layer, with the boundary between this community and the okaba II at about 60–70 m. Off the Shimane coast, on the other hand, the constituent species of the okaba community I are found mostly within the upper 100 or 130 m, with the center of abundance in the surface 50 m. Thus, the vertical range occupied by the okaba community I in the southern region of the sea is nearly twice as thick as in the

Table 3. Frequency of occurrence (f) and catch in kilograms per haul (c/h) of bottom fishes at various depths off the coast of Shimane Prefecture, April to September, 1962.
Catch by trawl; modes in respective values in bold type. Based on the reports by Shimane Pref. Fish. Exper. Stat. (1963).

Water depth (m)	50		100		130		150	
Number of hauls	15		16		16		14	
	f	c/h	f	c/h	f	c/h	f	c/h
Rhinobatus schlegeli	**0.67**	**4.29**	0.06	0.20	0	0	0	0
Nemipterus virgatus	**0.67**	**5.86**	0.38	0.17	0	0	0	0
Stephanolepis cirrhifer	**0.60**	**0.98**	0.25	0.03	0	0	0	0
Chelidonichthys kumu	0.87	**5.63**	**0.94**	4.03	0.56	0.32	0.14	0.03
Saurida undosquamis	0.87	**8.50**	**0.94**	1.66	0.56	0.32	0.14	0.03
Callionymus virgis	**0.67**	**0.57**	0.31	0.02	0.50	0.02	0.14	0.00
Leiognathus rivulatus	**0.53**	0.02	0.50	**0.67**	0.06	0.00	0	0
Heteromycteris japonicus	**0.53**	0.02	0.38	**0.03**	0.13	0.00	0.07	0.03
Sillago japonica	**0.47**	**0.16**	0.19	0.03	0	0	0	0
Caranx equula	0.47	**0.78**	**0.56**	0.32	0.13	0.00	0	0
Areliscus interruptus	**0.27**	**0.01**	0.19	0.01	0.13	0.00	0	0
Pseudorhombus cinnamoneus	**0.67**	**1.39**	0.19	0.79	0.06	0.00	0	0
Trachinocephalus myops	**0.13**	**0.13**	0.06	0.01	0.12	0.03	0	0
Navodon modestus	**0.20**	**0.02**	0.19	0.01	0	0	0	0
Chrysophrys major (young)	**0.47**	**0.59**	0.19	0.00	0.13	0.01	0.07	0.02
Evynnis japonica (young)	**0.67**	**0.22**	0.50	0.04	0.13	0.00	0	0
Mustelus manazo	**0.33**	0.49	0.31	**0.54**	0.13	0.03	0.14	0.09
Upeneus bensasi	0.87	5.01	**1.00**	**6.01**	0.44	0.16	0.14	0.01
Zeus japonicus	0.67	**0.71**	**0.94**	0.40	0.63	0.41	0.57	0.63
Parapercis sexfasciatus	0.20	0.02	**1.00**	**2.71**	0.69	0.13	0.07	0.00
Lepidotrigla microptera	0.73	0.98	0.81	1.93	**0.88**	**2.99**	0.64	0.20
Taius tumifrons	0.33	0.17	**0.81**	**6.75**	0.50	0.15	0.21	0.03
Branchiostegus japonicus	0.07	0.01	0.44	0.06	**0.63**	**0.25**	0	0
Eopsetta grigorjewi	0.20	0.12	0.56	0.12	**0.88**	1.25	0.86	**3.31**
Tanakius kitaharai	0.07	0.00	0.25	0.02	0.44	0.29	**0.64**	**1.51**
Hoplobrotula armata	0.13	0.00	0	0	**0.69**	0.11	0.29	**0.40**
Champsodon snyderi	0.27	0.02	0.56	0.03	0.69	**0.22**	**0.93**	0.16
Congridae sp.	0.13	0.21	0.06	0.25	0.50	0.47	**0.72**	**2.53**
Döderleinia berycoides	0	0	0	0	**0.94**	2.38	0.79	**4.72**
Niphon spinosus	0	0	0	0	0.19	**0.19**	**0.21**	0.03
Glossanodon semifasciatus	0	0	0	0	**0.94**	1.41	0.79	**12.6**
Cleisthenes pinetorum herzensteini	0	0	0	0	0.13	0.04	**0.86**	**8.08**
Liparis tanakai	0	0	0	0	0	0	**0.21**	**0.01**

middle region of the sea; undoubtedly, the change in the thickness of the layer occupied by this community must be gradual from the south to the middle of the sea, and in all likelihood to near the western entrance to the Tsugaru Straits.

As regards the vertical range of the okaba community II, there are some evidences indicating that the community ranges from about 100 m to 150 m off San'in District and from 60–70 m to approximately 150 m off the Hokuriku coast. According to WATANABE et al. (1958), the layer from 100 m to 150 m off the coast of Tsuiyama in San'in District is almostly invariably occupied by the bottom community characterized by rich occurrences of the fishes *Lepidotrigla microptera, Taius tumifrons* and *Raja pulchra*, occasionally accompanied by *Trachurus japonicus, Zeus japonicus, Eopsetta grigorjewi, Dasyatis akajei, Raja kenojei*, etc., all being typical fish members of the okaba community II. Similarly, off the coast of Niigata and Yamagata Prefectures, vertical distributions of the representative fish members of the same community, such as *Döderleinia berycoides, Eopsetta grigorjewi, Tanakius kitaharai, Pseudorhombus pentophthalmus, Uranoscopus japonicus, Trachurus japonicus* and *Zeus japonicus*, virtually fall at 150 m; in a few species the lower limit of their distribution is shown at a somewhat lesser depth, viz. 120 m (Fig. 24 in Part III). Thus, the lower limit of the vertical range of the okaba community II seems to be found at 120–150 m throughout the greater part of the area of its occurrence in the Japan Sea, or only slightly shallower in the northerly (Hokuriku) waters than in the southerly (San'in) waters. Although the exact depth range may differ to a certain extent according to seasons and hydrographic or topographic conditions, this presents a noticeable contrast to the okaba community I which changes its lower limit rather considerably with latitudes as mentioned already.

As to the vertical range of the okaba community IV, it is noteworthy that most members of this community undergo a marked diel vertical migration. NISHIMURA (1960d) once supposed that they may be partly responsible for the deep scattering layers of supersonic sounds which are widely observed in the Japan Sea (TABATA 1958; KATO & SHIMOMURA 1959). According to the study of TABATA (1958) made in the central and southeastern areas of the sea, the D.S.L. rises to 50 m at night and sinks down to 200–300 m in the daytime. The main organisms responsible for the observed D.S.L. were supposed by this author to be *Parathemisto japonica* (hyperiid amphipod), *Enoploteuthis chunii* (cephalopod) and *Maurolicus muelleri* (teleost), all belonging to the okaba community IV. Meanwhile, the pelagic eggs of *Maurolicus* are collected in large numbers in the areas with the water depth of 200–300 m at the fringe of the continental shelf or a little offshore beyond it (ITO et al. 1951; NISHIMURA 1959c), and populations of the adult fish are supposed to thrive at the depths below 150–160 m, particularly in the range 250–300 m, from the analyses of occurrences of this tiny teleost in stomach contents of various predatory fishes in the Japan Sea (NISHIMURA 1957a). Another important teleostean member *Glossanodon semifasciatus* is distributed on the outer part of the continental shelf, mainly in the depths around

150 m, throughout the entire southeastern region of the Japan Sea (WATANABE 1956a). Likewise, the shrimp *Pasiphaea sivado* is known to be abundant in the depths around 180 m on the continental slope in Toyama Bay, though occasionally it appears in much lesser depths (NAKAZAWA 1947). The adult forms of *Euphausia pacifica* are believed to occur in the middle layer around 200 m or more in the daytime in the offshore area of the sea (KOMAKI & MATSUE 1958), but there are some evidences suggesting that they are sometimes living on the sea bottom about 150 m deep on the outer part of the continental shelf (NISHIMURA 1959d). In this connection, the finding of WATANABE et al. (1958) that *Euphausia pacifica* constitutes together with *Parathemisto japonica*, another crustacean member of the okaba community IV, the staple food for many typical demersal fishes such as *Arctoscopus japonicus, Allolepis hollandi, Glyptocephalus stelleri, Hippoglossoides dubius*, etc. will be especially interesting. Throughout the data presented above, the members of the okaba community IV are considered to be distributed mainly around 150–180 m on the edge of the continental shelf, but also in considerably deeper (200–300 m) layers in the pelagic region off the shelf edge. And, of course, most of them undergo a diel vertical migration and may be caught in much shallower layers under certain favorable conditions.

As mentioned already in *Section 3.10* in Part III, the upper and lower belts of the okaba community IV are penetrated respectively by the animals belonging to the communities of okaba III and taraba I. The members of the okaba community III are believed to have their center of geographical distribution in the sublittoral zone of the temperate districts such as Honshu, southern Hokkaido and south to southeast Korea, though the minority of the community is also found penetrating into further northerly waters like Peter the Great Bay (cf. MOISEEV 1953)[4]. The

4) The geographical ranges of some typical members of the okaba community III are given below:

Hexagrammos otaki—Throughout Japan; south and west Korea.

Agrammus agrammus—Southern Hokkaido to Kyushu; south and west Korea. Rather abundant along the Pacific coast of southern Japan.

Pseudoblennius spp.—Mainly northern Honshu to Kyushu; south Korea. Abundant on the Pacific coast.

Ammodytes personatus—Throughout Japan and Korea. Particularly abundant along the coasts of southwestern Hokkaido, Sanriku District, the Seto Inland Sea, west Kyushu, etc.

Dictyosoma bürgeri—Throughout Japan; south Korea.

Sebastes inermis—Southern Hokkaido to Kyushu; south Korea. Rather abundant on the southern coasts.

Limanda yokohamae yokohamae—Southern Hokkaido to Kyushu; south and east Korea; the East China Sea.

Asterias rollestoni—Pacific side of Honshu, south and west Kyushu and the southern Japan Sea.

Loligo edulis—Pacific coast of southern Honshu, Kyushu and the southern Japan Sea.

Pugettia quadridens—Southeastern Hokkaido to Kyushu, the Japan Sea; Korea; China.

The animals of this community are apparently more flourishing on the Pacific side of southern Japan than in the Japan Sea. It is supposed that they have been differentiated in the coastal waters on the Pacific side of the Japanese Islands and in the area which is now the East China Sea during the glacial stages of the Quaternary period, and later have penetrated into the Japan

Continued to next page

members of the taraba community I, on the other hand, are flourishing in the sublittoral zone of the more northerly, subarctic districts such as northern Hokkaido, west Sakhalin, the southern Okhotsk Sea, northeast Korea and Peter the Great Bay to the Maritime Province.

The taraba community I seems to be divided into two groups according to the pattern of geographical distribution of its constituent species (Fig. 28). The *group 1*, including such species as *Clupea harengus pallasi, Pleurogrammus azonus, Sebastes taczanowskii, S. nivosus, S. thompsoni, S. steindachneri, Aptocyclus ventricosus, Limanda aspera, Microstomus achne*, etc. of fishes and *Strongylocentrotus nudus, Yoldiella johani, Nucula tenuis,*

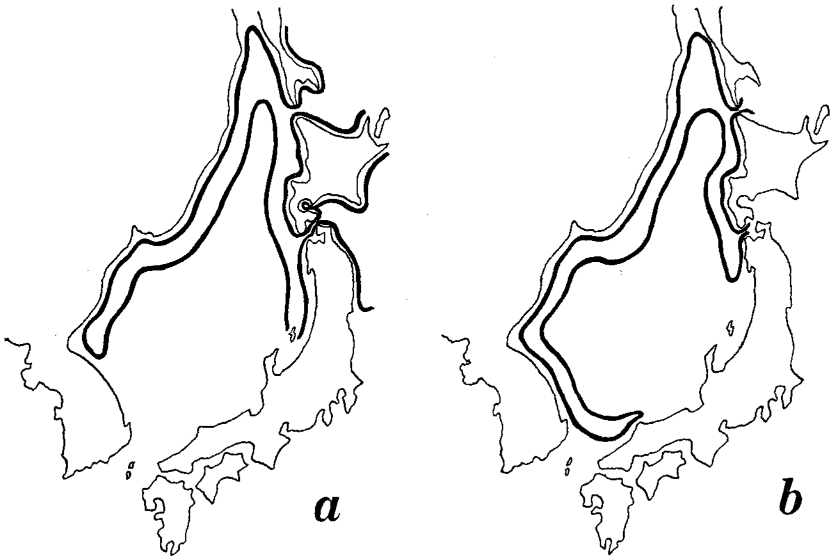

Fig. 28. Distribution pattern of two groups of the taraba community I. a.-Distribution of the group 1, with denser population in the southern Okhotsk Sea and the northwestern North Pacific; b.-Distribution of the group 2, with its center in the northwestern region of the Japan Sea.

Pandalus kessleri, etc. of invertebrates, is found along the coast of Maritime Province and the west coasts of Sakhalin, Hokkaido and nothern Honshu, but much more vastly outside the Japan Sea, i.e. in the southern Okhotsk Sea and on the Pacific side of Hokkaido and northern Honshu. On the other hand, the *group 2* which consists of such forms as the species of the Percinae of the family Agonidae (sea-poachers) and of the Stichaeinae and Opisthocentrinae of the family Stichaeidae (pricklebacks),

Sea (NISHIMURA 1966). But originally they were boreal forms and then migrated from the northern North Pacific down to the Japanese waters (NISHIMURA 1964e). In this respect, they differ markedly from the animals of the okaba communities I and II, which are mostly Indo-West Pacific species or their direct descendants, and also from those of the okaba community IV, which are ancient warm-water mesopelagic forms or their derivatives, often showing world-wide distribution on the generic or sometimes even on the specific rank.

Cleisthenes pinetorum herzensteini, Glyptocephalus stelleri, Limanda yokohamae schrencki, L. punctatissima punctatissima, etc. of fishes and *Asterias amurensis, Ophiura sarsi* var. *vadicola, Diamphiodia craterodmeta, Cucumaria japonica* (=*C. frondosa* var. *japonica*), etc. of invertebrates appears to have the center of distribution within the Japan Sea off the coast of southern Maritime Province, from where the distribution is extended down along the east coast of Korea to the coast of San'in District of west Honshu in the west and to the west coast of northern Honshu through west Sakhalin and Hokkaido in the east[5].

As to the vertical range of the okaba community III and the taraba community I, it is already shown in *Section 3.10* that the former is generally occupying the depths about 100–150 m off Hokuriku District and about 100–200 m off San'in District, while the latter occupies the 150–250 m belt, with the center at about 200 m, thoroughout the southeastern region of the Japan Sea. It has been stated that the boundary between the so-called okaba and taraba grounds is seen approximately around 200 m (OKACHI 1954) or 150–200 m (WATANABE et al. 1958); the former depth was deduced from the surveys made off Hokuriku District, while the latter from the data of studies made off San'in District. And three bottom communities, i.e. the okaba III, the okaba IV and the taraba I, are situated around the above-mentioned boundary level. It is very striking that up to three distinct communities are included in such a narrow vertical range. The boundary referred to above might correspond to a large-scale contact zone of different environments and thus with a sharp intergradation within the animal populations living there. On this point, further discussions will be made in Part V of this paper. Anyhow, the boundary may shift the depth to a certain extent with regions and seasons so that it is impossible to give the exact depth of its level throughout the Japan Sea. Nevertheless, it is noteworthy that the depth of the boundary is maintained almost similarly even in two remote regions such as Hokuriku and San'in Districts.

Below this boundary layer exists the taraba community II, which extends roughly in the depth range 200–300 m possibly throughout the southeastern Japan Sea, and in the depths greater than 300 m is flourisihing the taraba community III. Such a pattern of bathymetric distribution of the bottom communities in the lower part of the taraba ground seems to be found thoughout the entire southeastern region of the sea (WATANABE et al. 1958; OUCHI & OGATA 1962; ITO 1967; OKIYAMA 1967. Refer also Fig. 24 in Part III).

Summarizing the foregoing discussions, the following scheme is presented to

5) Certain species of the group 2 actually occur off the west coast of middle Honshu, e.g. Niigata and Toyama Prefectures, but it is doubtful whether they are maintained there autogenetically. Even for the populations of *Cleisthenes pinetorum herzensteini* and probably also of *Glyptocephalus stelleri* off the San'in coast, it is supposed that the main spawning is concentrated in the westenmost part of this offshore area near the southeast Korean coast (OUCHI 1954; WATANABE 1956b, 1958) and that their populations in other parts of the area are maintained by larvae transported from that main spawning ground (WATANABE 1958).

show the bathymetric distribution of the bottom communities in the southeastern region of the Japan Sea as observed in the warm season:

	San'in District	Hokuriku District
Okaba community I	0 to 100–130 m	0 to 60–70 m
〃 II	100 to 150 m	60–70 m to 120–150 m
〃 III	100 to 200 m	100 to 150 m
〃 IV	150 to 200 m	150 to 200 m
Taraba community I	ca. 200 m	ca. 200 m
〃 II	200 to 300 m	200 to 300 m
〃 III	Deeper than 300 m	Deeper than 300 m

There is seen a general trend that the communities composed of warm-water elements such as the okaba communities I, II and III show deeper situations or greater vertical ranges in the southerly San'in waters than in the northerly Hokuriku waters, but the communities of cold-water species such as the taraba communities I, II and III occupy essentially the same level off both San'in and Hokuriku Districts.

In the median-latitudinal region on the continental side of the Japan Sea, in Peter the Great Bay for instance, the communities corresponding to the okaba I, II and IV are considered substantially absent as mentioned already in regard to the northern limit of their distribution; this is also suspected from the fact that there some fish representatives of the okaba community III and those of the taraba community I such as *Limanda yokohamae*-group, *L. herzensteini*, *Cleisthenes pinetorum herzensteini* and

Table 4. Main living spaces of some bottom fishes in Peter the Great Bay. Mainly after MOISEEV (1953) and OGATA (1960).

	In summer	In winter
Limanda aspera	5–60 m	150–250 m
L. punctatissima	5–30 m	170–250 m
L. yokohamae yokohamae	5–20 m	180–240 m
L. herzensteini	10–50 m	150–200 m
Cleisthenes pinetorum herzensteini	5–60 m	180–230 m
Glyptocephalus stelleri	20–50 m	150–250 m
Acanthopsetta nadeshnyi	40–150 m	200–500 m
Hippoglossoides dubius	40–150 m	300–400 m
Gadus morhua macrocephalus	50–150 m	150–250 m

Glyptocephalus stelleri are occupying together the same shallow layers, coming up to at least 5 m below the surface (Table 4)[6]. The lower limit of the vertical distribution of these fishes is found at about 40–50 m in the warm season, and below this level

6) The tropical-subtropical animals, especially those with a pelagic habit or with a pelagic phase in the larval stage, which are occasionally found in these northerly waters (see pp. 45–36 in Part I), and the warm-water neritic plankton which becomes temporarily predominant there in summer (see p. 87 in Part II) are supposed to occur in the very shallow layers, presumably within the upper 5–10 m, where the water is warmed considerably in summer. It is as yet doubtful, however, whether or not there is developed in these waters a distinct bottom community with southern affinity, corresponding to the above-mentioned warm-water pelagic populations.

there is flourishing the fish fauna of the taraba community II characterized by such species as *Gadus morhua macrocephalus*, *Hippoglossoides dubius* and *Acanthopsetta nadeshnyi*, which extends down to about 150 m during the warm season. Meanwhile, *Allolepis hollandi*, the most characteristic fish of the taraba community III, is said by SCHMIDT (1950) to be found at the depths 200–300 m off the Maritime coast throughout the year. As to the invertebrate bottom fauna, on the other hand, the results of investigations made in Peter the Great Bay by DERJUGIN and his collaborators (DERJUGIN 1939; DERJUGIN & SOMOVA 1941; etc.) seem to show that at least three bottom communities are defined there according to respective biogeographical characters: the first, which occupies the floor shallower than 45–50 m, is composed of temperate and subarctic sublittoral forms with some admixture of subtropical elements; the second occupies the floor about 50 m to 200 m and includes many cold-water species characteristic of the taraba community II defined in this paper; and the last is formed of the members of the taraba community III and occupies the bottoms from about 200 m down to 2000 m or more.

Thus, at least three life zones are discernible on the sea floor off the continental coast of median latitudes. And it seems especially noteworthy that members of the okaba community III and the taraba community I occur essentially at the same shallow levels in this region without any clear segregation between them.

A similar aspect is found off the west coasts of Hokkaido and Sakhalin. HIKITA

Table 5. Occurrences of fishes of respective bottom communities off the west coast of middle to northern Hokkaido, May to October, 1951. Depth and number of individuals caught (in parentheses) are given. Compiled from the data presented by HIKITA & MISU (1952).

Okaba I species:
Mustelus manazo 80 m (1 specimen).

Okaba II species:
Raja pulchra 78 (2), 80 (1); *Lepidotrigla microptera* 54 (4).

Okaba III species:
Hexagrammos otaki 94 (1); *Limanda herzensteini* 54 (1), 78 (1), 80 (2); *Platichthys stellatus* 54 (1), 150 (2).

Taraba I species:
Clupea harengus pallasi 135 (1), 170 (1), 230 (1); *Pleurogrammus azonus* 270 (2); *Sebastes taczanowskii* 54 (3); *Tilesina gibbosa* 80 (2); *Podothecus sachi* 80 (3); *Limanda punctatissima* 54 (7); *Cleisthenes pinetorum herzensteini* 54 (1), 80 (3), 170 (1); *Glyptocephalus stelleri* 170 (2), 230 (2); *Lepidopsetta mochigarei* 135 (1), 230 (1).

Taraba II species:
Arctoscopus japonicus 215 (2), 250 (2), 350 (1); *Sebastes owstoni* 230 (4); *Hippoglossoides dubius* 215 (1), 230 (3); *Gadus morhua macrocephalus* 170 (3), 230 (2); *Theragra chalcogramma* 170 (2), 300 (1), 350 (1).

Taraba III species:
Breviraja smirnovi 550 (1), 700 (7), 800 (1); *Icelus spiniger* 320 (1), 350 (2); *Malacocottus gibber* 800 (1); *Liparis rhodosoma* 700 (4); *Crystallias matsushimae* 360 (2), 550 (1); *Petroschmidtia toyamensis* 330 (3), 350 (1), 360 (2), 700 (1), 800 (1); *Lycodes nakamurai* 350 (1); *L. schmidti* 330 (3), 350 (1), 360 (2); *L. tanakai* 550 (1); *Allolepis hollandi* 300 (2), 350 (4).

& MISU (1952) examined the material obtained by experimental trawling made off the middle and northern Hokkaido in May to October, 1951. The results of their examination (Table 5) indicate clearly the existence of the taraba community III at the depths greater than ca. 300 m, while the layers 50–200 m and 200–300 m were occupied respectively by the members of the taraba communities I and II. Moreover, the members of the okaba communities I and II, when any occurs, were found mingled with the members of the okaba community III in the layers shallower than ca. 100 m. The aspect off the west coast of Sakhalin seems to be intermediate between those in Peter the Great Bay and off the west coast of Hokkaido: according to the results of investigations made by the Hokkaido Fisheries Experimental Station in the summer of 1956 (Table 6), the upper 100 m was occupied by the members belonging to the okaba community III and simultaneously also by those belonging to the taraba community I, while the 100–200 m layer was inhabited by the members of the taraba community II. As to the taraba community III, the data are inadequate; but in all probability it will be found below about 200 m. The okaba communities I and II seem to be virtually absent in this region.

Table 6. Vertical biomass distribution of some bottom fishes off the west coast of Sakhalin, July to November, 1956.
Catch by trawl, in kilograms per haul. Based on the reports by Hokkaido Fish. Exper. Stat. (1956).

	Depth range			
	50–99 m	100–149 m	150–199 m	>200 m
Limanda yokohamae yokohamae	2.2	0	0	0
L. herzensteini	8.3	0	0	0
Clupea harengus pallasi	1.1	0	0	0
Cleisthenes pinetorum herzensteini	39.0	0	0	0
Lepidopsetta mochigarei	21.0	0.4	0	0
Limanda aspera	27.7	1.5	0	0
Pleurogrammus azonus	34.1	1.5	0	0
Glyptocephalus stelleri	100.7	41.6	64.8	37.5
Pleuronectes pallasi	10.9	36.0	18.7	0
Acanthopsetta nadeshnyi	53.6	272.8	65.7	0
Theragra chalcogramma	2.6	2.6	8.6	37.5
Gadus morhua macrocephalus	129.7	61.9	151.6	75.0
Hippoglossoides dubius	13.5	142.0	151.2	37.5

Summarizing the discussions given so far, the pattern of vertical distribution of the bottom communities and their bathymetric ranges in the northern and northwestern regions of the Japan Sea, as observed during the warm season of the year, can be formulated as follows:

	West Hokkaido	West Sakhalin	Peter the Great Bay
Okaba community I	0 to ca. 100 m	Virtually absent	Virtually absent
" II			
" III		0 to 100 m	0 to ca. 50 m
Taraba community I	50 to 200 m		
" II	200 to 300 m	100 to ca. 200 m	ca. 50 to 200 m
" III	Deeper than 300 m	Deeper than ca. 200 m	Deeper than 200 m

Along the eastern side of the Japan Sea, any same bottom community occupies shallower depths with the increasing latitude (compare the aspect off San'in and Hokuriku Districts with that off the west coasts of Hokkaido and Sakhalin), and possibly the same trend along the western side of the sea, attaining the extremity in Peter the Great Bay (or more likely off the Maritime coast). The above-mentioned pattern of vertical distribution of the bottom communities and its geographical change is schematically presented in Fig. 29.

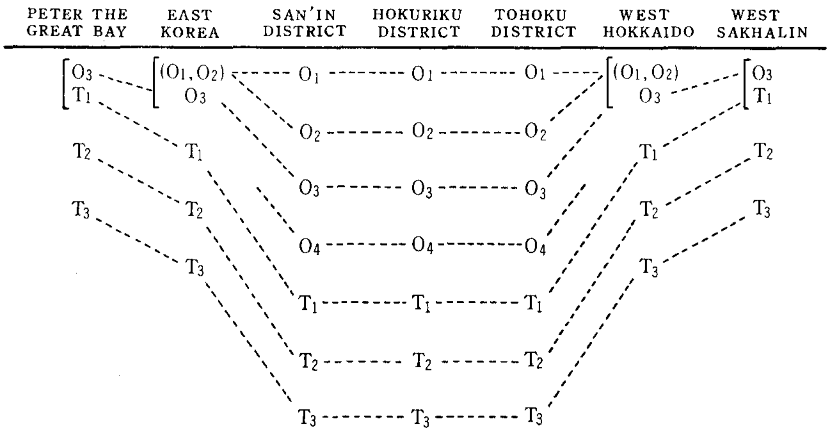

Fig. 29. Schematic representation of the vertical pattern of the bottom communities and its horizontal succession in the Japan Sea.

O_1-Okaba community I; O_2-Okaba community II; O_3-Okaba community III; O_4-Okaba community IV; T_1-Taraba community I; T_2-Taraba community II; T_3-Taraba community III. The communities in parentheses are represented in respective areas in a very reduced state and the communities grouped by bracket are found in a more or less intermingled state.

It is shown that the community structure becomes simpler and the levels of respective communities are raised with increasing latitude.

A similar pattern of geographical changes can be expected for the vertical distribution of pelagic populations, too, though the available data are less complete. In the southeastern region of the Japan Sea, the plankton community is divided into three groups (cf. pp. 369–370 in part III): the surface tropical-subtropical population including many neritic forms and inhabiting the upper 100–150 m; the mid-water, subtropical population occupying the depths from about 100 m to 250 m; and the deep-water subarctic-arctic population thriving at the depths greater than 150–200 m (YAMAZI 1953; FURUHASHI 1953; etc.) In the northwestern region of the sea, on the other hand, most of the warm-water plankters disappear, but several forms, mostly eurythermal, are distributed in the upper 50–75 m, with the uppermost 10–20 m or so being marked by the thriving of neritic forms, while the layers deeper than 50–75 m are wholly occupied by the arctic-subarctic plankton (BRODSKY 1937, 1941, 1957, 1959; PONOMAREVA 1959; MESHCHERYAKOVA 1960).

Thus, the boundary between the distribution of the warm-water and cold-water planktons is clearly much shallower in the northern region of the Japan Sea than in the southern region and the depth of its level roughly coincides with that of the boundary between the distributions of the okaba and taraba communities in the bottom environment. The warm-water and cold-water planktons mentioned above may respectively be the inhabitants of distinct water masses and then the okaba and taraba communities must be respectively the inhabitants at different levels on the sea floor washed by these water masses (Fig. 30). More precisely saying, the following correspondence may be plausible to postulate between the pelagic and the bottom

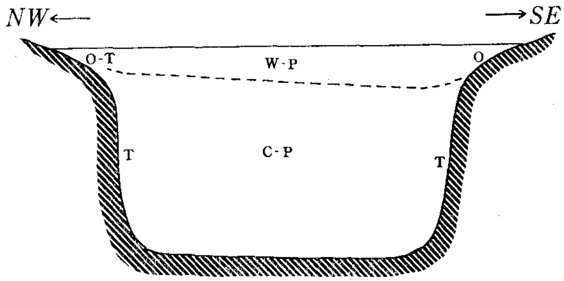

Fig. 30. Schematic representation of a vertical section of the Japan Sea in the direction of NW-SE, showing the relation between the distribution of the bottom communities and that of the pelagic communities.

O.-Ground of the okaba communities; T.-Ground of the taraba communities; W-P.-Domain of the warm-water pelagic communities; C-P.-Domain of the cold-water pelagic communities.

On the shallow bottom of the northwestern coast of the sea, some intermingling occurs between certain elements of the okaba communities and the taraba communities (O-T).

animal communities: the surface plankton including many neritic forms to the okaba community I in the southeastern region and to the okaba community III plus the taraba community I with the addition of a few members of the okaba community I in the northwestern region; the mid-water subtropical plankton to the okaba community II in the southeastern region; and the deep cold-water plankton to the taraba communities II and III throughout the Japan Sea[7].

It is as yet unknown whether or not the layers predominated by the cold-water

7) It is a point of debate whether the floating members of the okaba community IV, such as *Euphausia pacifica*, *Parathemisto japonica* and *Metridia pacifica*, should be included in the warm-water plankton or in the cold-water plankton. Most Japanese planktologists regard them as cold-water species, while most Russian scientists treat them under the headings of warm-water, subtropical or temperate species. Anyhow, it seems that the layer of their densest distribution spreads along the surface of contact of the warm and cold water masses.

plankton can be split into two, upper and lower, zones respectively corresponding to the levels of the taraba communities II and III. Many of those cold-water zooplankters are quite eurybathyal and penetrate down into greater depths. But really there are certain species that are confined to the deeper zone of the water layers in question. According to BRODSKY (1937, 1941, 1957) and VINOGRADOV (1960), three species of copepods *Gaidius brevispinis, G. variabilis* and *Gaetanus simplex,* the ostracod *Conchoecia* spp., the mysid *Meterythrops microphthalma,* the ctenophore *Beroë* sp., the siphonophore *Dimophyes arctica* and a few radiolarians of the families Challengeridae and Aulosphaeridae are almost confined to the layers below 200 m and most abundant in the depth from 500 m to 1000 m in the northwestern part of the Japan Sea. It is noticeable that the upper limit around 200 m for the vertical distribution of these deep-water plankters coincides well with the boundary between the taraba communities II and III in the northwestern Japan Sea.

3.12. Characteristics of the Deep Water Communities (1). Fishes

Although the deep water communities of the Japan Sea has been studied only inadequately so far, the available data suggest their marked peculiarities differing from those found in the deep waters off the Pacific side of Japan. We shall be first concerned with the fish fauna.

The anacanthine fishes of the family Macrouridae, or Coryphaenoididae as used by some authors, are generally accepted as the most numerous deep sea fishes with regard to both species and individuals. This seems to be best applicable to the Philippine, the Sulu and adjacent sea basins (HUBBS 1954).

The same is also true for the deep waters off the Pacific side of Japan. Nearly 50 species of the macrourids are known from there, particularly from off southern Japan (TOMIYAMA & ABE 1958), and some of them are fished commercially in an extremely large amount by deep-water long line and motor trawl. The following species are of a special importance because of their huge population (KAMOHARA 1949; MATSUBARA 1955): *Abyssicola macrochir, Hymenocephalus kuronumai, H. striatissimus, Coryphaenoides garmani, Coelorhynchus multispinulosus, C. tokiensis, C. japonicus,* etc. Further, there are evidences suggesting that the macrourids likewise occupy a very important place in the fish community in the deep waters off the Pacific side of northern Honshu and southern Hokkaido (Hachinohe Branch, Tôhoku Regional Fisheries Research Laboratory 1952, 1954); there the predominant species is *Nematonurus acrolepis,* followed by *Coelorhynchus parallelus* (probably mis-identified *C. multispinulosus*; see MATSUBARA 1955), *C. anatirostris* and *C. gilberti.*

Turning to the Japan Sea, we are impressed by a decided poverty of the macrourid fauna in this sea basin. Early in the history of ichthyological investigation of the Japan Sea, GILBERT & HUBBS (1916) drew attention to the total absence of the macrourid fish in the material collected by the U.S. Fisheries Steamer *Albatross* and laid much stress on it as an astonishing feature of the deep water fauna of this sea basin. However, their conclusion was later proved to be partly erroneous. In 1931, KIKUCHI recorded for the first time a species of this anacanthine family from the Japan Sea by listing *Coelorhynchus japonicus* in his faunal review of Toyama Bay, and the same species was again recorded by KATAYAMA (1940) in his catalog of the fishes of the same bay. However, these records are now taken as doubtful in regard to identification. It was not until 1942 that a well defined species of the Macrouridae was formally described from the southeastern Japan Sea: KATAYAMA described it as new to science under the name *Coelorhynchus multispinulosus*, and at present this species is considered the only member of the macrourid fauna throughout the Japan Sea (MATSUBARA 1955; TOMIYAMA & ABE 1958). The macrourid ever recorded as *Coelorhynchus japonicus* by KIKUCHI (1931) and KATAYAMA (1940) from Toyama Bay may possibly be identical with *C. multispinulosus*. As stated already, this macrourid is one of the most abundant species off the Pacific coast of Japan. *Coelorhynchus parallelus* listed by YANAI (1950) from off San'in District also might be mis-identified *C. multispinulosus* (cf. MATSUBARA 1955). Later, MORI (1956) recorded the occurrences of *C. japonicus* and *C. multispinulosus* in the deep waters off San'in District; it is impossible, however, to confirm the validity of his identification of the first species. The same can be said also as to *C. japonicus* from Pohang of southeastern Korea and from Senzaki near the west end of San'in District reported respectively by MORI (1952) and by YOSHIDA & ITO (1957). Anyhow, it can be safely concluded that the macrourid fauna of the Japan Sea is extremely simple.

The poverty is applied also to the quantity: there is not even a single information telling any abundant occurrence of the macrourid in the Japan Sea[8)] except for its southernmost region where somehow frequent occurrences of this fish are not impossible. Nothing is mentioned as to the occurrence of the macrourid on the fish lists of the waters off Niigata Prefecture, Yamagata Prefecture and west Hokkaido, respectively compiled by HONMA (1952 and later articles), SUGIHARA (1944) and HIKITA & MISU (1952). I myself and also a considerable number of my acquainstances working at various fisheries research stations situated on the Japan Sea coast of middle to north Honshu have never seen nor heard of any catch of macrourid fish either by investigational or by commercial fishery operations. The unique species of the family, *Coelorhynchus multispinulosus*, itself is considered to be quite rare in the Japan Sea by its finder (Dr. M. KATAYAMA's personal information of February, 1955).

The report by YANAI (1950) may be the only exception of the conclusion given above as regards the numerical distribution of the macrourid fish in the Japan Sea;

8) Once, ITO et al. (1951) reported from Toyama Bay and its adjacent waters abundant occurrence of the so-called "*Macrurus* egg". This pelagic egg, quite distinguished for its characteristic appearance, had been assigned to a certain species of macrourid fishes. Consequently, rich occurrences of this egg were thought by these authors to allude to the possibility of the distribution of a large population of some macrourid fish in the Japan Sea. Later, however, the mistake in identifying this egg was pointed out and it was then assigned to the pearlsides *Maurolicus muelleri*, an extremely abundant teleost in the Japan Sea (NISHIMURA 1957a); this new identification seems now to be generally accepted (HATTORI et al. 1957; MITO 1961, 1966).

it is stated that *Coelorhynchus parallelus* (probably mis-identified *C. multispinulosus*) is rather common off Shimane Prefecture of San'in District[9]. It is as yet unknown, however, whether this macrourid is really autogenetic in that region or not. We cannot reject the idea that some individuals of this fish are transported by ocean currents from some more southerly region, presumably the East China Sea, during its early pelagic stage and settle down to the bottom off San'in District, growing to the demersal adults. Because, it is a well known fact that most macrourid fishes spend a pelagic life during the early stage of development (HUBBS 1954; MARSHALL 1955), and it is well established that there are distributed several species of macrourids in the East China Sea and some of them are so abundant as to play an important bio-economical role in the bottom community of that sea, as mentioned below. AOYAMA (1953) and MISU et al. (1955) state that *Coelorhynchus japonicus* (specific identification somewhat dubious and ? including more than one species) is frequently ingested by various bottom fishes such as *Saurida tumbil, Muraenesox cinereus, Nibea nibe, Uranoscopus japonicus* and *Lophius litulon* in the East China Sea, and particularly remarkable is the fact that the same fish constitutes a very important portion of food for the medium-sized lizardfish *Saurida tumbil* in the central region of that sea.

A similar relation is seen between the lanternfish fauna of the Japan Sea and that off the Pacific side of Japan. The family Myctophidae is represented by about 33 species on the Pacific side of Japan, some being so abundant as to contribute greatly to the bio-economy in that area (Fisheries Agency, Japan 1954; OGAWA 1961; etc.) In the Japan Sea, on the contrary, merely two species, *Diaphus coeruleus* and *Notoscopelus elongatus* (=*Macrostoma japonicum*), have hitherto been recorded only rarely from its southern region (YANAI 1950; MORI 1956). And again for the occurrences of these myctophids off San'in District, the larval transportation from the East China Sea can be supposed.

According to the view of ANDRIASHEV (1935) and SCHMIDT (1935), the deep sea fish populations consist of two groups of different origins; one includes 'primary' or 'ancient' deep sea fishes belonging to the special families that have a long history of adaptation to the deep sea life and are often provided with peculiarly-built organs such as luminous glands, telescopic eyes, elongated appendages and so on. Moreover, these forms generally occupy the lower positions in the phylogeny of fishes. While, the other group consists of 'secondary' or 'young' deep sea species that, belonging to the families common with the fishes living on the shallow continental shelf, have invaded the deep waters rather recently and thus without any specially developed organs. The following fish groups are enumerated in the 'primary' deep sea fish fauna other than the most predominant groups Macrouridae and Myctophidae: the

9) However, Mr. Y. IMAOKA of the Shimane Prefectural Fisheries Experimental Station informed me in his personal communication of June, 1962 that *Coelorhynchus multispinulosus* is occasionally caught in his district by trawl but in only insignificant quantity; merely two individuals of almost adult size were found in catches made by nearly 70 operations of investigational trawling in 1961.

orders Bathyclupeiformes, Ateleopiformes, etc., the suborders Opisthoproctoidei, Stomiatoidei, Ceratioidei, etc., and the families Alepocephalidae, Oncocephalidae, etc. (ANDRIASHEV 1953).

Some five species of these groups have hitherto been recorded from the Japan Sea (RASS 1953). Of these, *Glossanodon semifasciatus* of the Opisthoproctoidei and *Maurolicus muelleri* of the Stomiatoidei are extremely abundant around the continental edge as mentioned previously, but others seem to be very rare. *Alepocephalus umbriceps* of the Alepocephalidae was ever described by JORDAN & THOMPSON (1914) on a single specimen obtained at Aomori near the northern end of Honshu, but no other specimen has been obtained since. UENO (1965) is of the opinion that the type and the only specimen of this species might really be caught off either Sanriku District of northeast Honshu or the Pacific coast of Hokkaido and landed at Aomori for market. The real distribution of this fish in the Japan Sea is considered doubtful. The record of *Cryptopsaras couesi* of the Ceratiidae from off Tsuchizaki, Akita Prefecture was made by OSHIMA (1934a, 1934b) on a single specimen deposited in a local museum at Sendai, but no further occurrence has been recorded in the Japan Sea since; there is even some doubt as to the locality of that specimen[10]. *Halieutaea stellata* of the Oncocephalidae is occasionally caught in the southeastern region of the Japan Sea from the bottom occupied by the okaba community II, therefore the level of its occurrence is not so deep in the Japan Sea. Moreover, as in the cases of macrourids and myctophids, it is very likely that the *Halieutaea* population in this marginal sea is recruited by larvae transported from the East China Sea as suggested by NISHIMURA & YAMAZAKI (1961b).

After all, only two species of the primary deep sea fishes are maintained autogenetically in the Japan Sea, and they are thriving as the constituents of the okaba community IV at a relatively shallow level in this sea basin.

In contrast to the poverty of the primary deep sea fishes, the so-called 'secondary' or 'young' deep sea fishes are remarkably flourishing in the Japan Sea. These consist in this sea basin of members of the families Cottidae, Liparidae, and especially Zoarcidae. They are regarded as 'secondary' or 'young' because (1) they are not markedly differentiated in morphology from their closely-related forms which are living in shallow-water environments, and (2) generally they belong to the phylogenetically young groups of fishes and are devoid of any archaic characters (ANDRIASHEV 1953). These fish groups are represented richly in the deep basin of this marginal sea not only in the number of species but also in the biomass as shown below.

The family Zoarcidae is represented by 10 genera and 23 species in the Japan Sea, of which the following eight are truly deep sea forms:

10) There is an odd inconsistency as regards the present specimen. OSHIMA (1934a) cited this specimen as Specimen No. 1150 in the collection of the Saitô Hô-on Kai Museum, Sendai, but in another paper (1934b) as Specimen No. 5426.

Lycodes nakamurai	**Lycodes teraoi*
L. macrolepis	**Petroschmidtia toyamensis*
**L. tanakai*	*Derjuginia ochotensis* (=*Gengea japonica*)
**L. japonicus*	*Allolepis hollandi*

Especially, the last one is distinguished because of its extremely large population. There are some reports of surprisingly big catches of this fish made by trawl on deeper bottoms of the Japan Sea. OUCHI (1955, 1963) and OUCHI & OGATA (1962) state that *Allolepis hollandi* is very abundant on the sea floor beyond 300 m off Niigata Prefecture and it is often inevitable to discard the trawl net because of unusual weight of this zoarcid caught in it. Similar experiences are expressed by INOUYE (1955), RYÔKE & ASANAKA (1958), DOI (1958) and others in different regions of the southern Japan Sea. Many of the remaining seven species are fairly common, too.

Twenty-eight genera and some 70 species of the Cottidae (including Psychrolutidae) are recorded from the Japan Sea, of which about 12 are deep water forms:

**Artediellus auriculatus*	*Triglops scepticus*
**Cottiusculus minor*	**Ricuzenius toyamensis*
C. gonez gonez	*R. pinetorum*
C. gonez schmidti	*Dasycottus japonicus*
**Icelus spiniger cataphractus*	**D. longipinnis*
**I. uncinalis stenosomus*	**Malacocottus gibber*

Similarly, the Liparidae is represented by 4 genera and 34 species in this marginal sea, of which at least the following 16 species are regarded as deep sea inhabitants:

Liparis rhodosoma	**Careproctus entomelas*
L. tessellatus	*C. colletti*
Paraliparis entochloris	**C. entargyreus*
**Careproctus sinensis*	**C. furcatus*
C. pellucidus	*C. segaliensis*
**C. acanthodes*	*C. rhodomelas*
C. rastrinus	**C. batialis*
**C. trachysoma*	**C. puniceus*

Some of these cottid and liparid fishes are fairly common on the deep floor; especially, *Dasycottus longipinnis* (*D. longidorsalis* sic), *Malacocottus gibber, Liparis tessellatus, Careproctus sinensis* and *C. puniceus* are rather richly distributed off San'in District (WATANABE et al. 1958), and *D. japonicus, M. gibber, Icelus spiniger, Triglops scepticus* and *L. tessellatus* are common near Sado Island (OUCHI & OGATA 1962; OUCHI 1963).

Some of these deep water fishes are endemic to the Japan Sea (marked with asterisk on the above-given list), while others are common to the Okhotsk and Bering Seas or the North Pacific off northern Japan. Most of the endemic species, however, have respectively their twin in the adjacent waters: *Lycodes brevicauda* for *L. tanakai, Petroschmidtia albonotata* for *P. toyamensis, Ricuzenius nudithorax* for *R. toyamensis, Icelus spiniger spiniger* for *I. spiniger cataphractus, I. uncinalis uncinalis* for *I. uncinalis stenosomus,* all from the Okhotsk or the Bering Sea. *Dasycottus longipinnis* might even be synonymous with *D. japonicus* from the Pacific side of northern Japan, and again *Cottiusculus minor* might be identical with *C. gonez gonez* from the Okhotsk Sea and the northern Japan Sea. It is a well known fact that the teleostean genera mentioned so far are the representative constituents of the fish fauna of the North Polar seas (ANDRIASHEV 1953b). Undoubtedly, the deep water fauna of the Japan Sea may have been derived from the cold water fish fauna in northern seas.

At all events, the deep water fish fauna of the Japan Sea is almost devoid of the so-called 'ancient' deep sea forms, and instead it is composed thoroughly of the so-called 'young' deep sea forms with the northern origin or affinity. In this respect, the deep water fauna of the Japan Sea is very distinct from that of the Pacific area just east and southeast of Japan. Such a feature of the deep water fish fauna seems at least partly responsible for the supposition held by some authors that the deep basin of the Japan Sea is a geologically young structure.

However, when we turn our attention to the invertebrate fauna, we obtain a somewhat different conclusion as regards the characteristics of the deep water fauna of the present marginal sea, as will be discussed next.

3.13. Characteristics of the Deep Water Communities (2). Invertebrates

It cannot be denied that many of the 'ancient' deep water invertebrate forms thriving on the Pacific side of the Japanese Archipelago are absent from the Japan Sea as in the case of fishes mentioned just previously.

For instance, primitive forms of echinoderms such as Echinothuriidae of the Echinoidea and Isocrinidae and Millericrinida of the Crinoidea are known from the deep waters off the Pacific coasts of middle to southern Japan, but entirely absent in the Japan Sea. The archaic deep-water forcipulate sea-stars of the family Brisingidae (FISHER 1911; BELYAEV in ZENKEVITCH & BIRSTEIN 1960) are not infrequently caught from the depths off the Pacific side (SUYEHIRO et al. 1962; BELYAEV 1966), but quite unknown from the Japan Sea. Polychelidae and Homaridae of the Decapoda Reptantia, very ancient families which can be traced back to the Jurassic, are fairly common in the deep waters off the Pacific coasts of middle to southern Japan, and some representatives, *Thaumastocheles, Nephrops* and *Nephropsis* for instance, of the last family are even fished commercially in these waters. In the Japan Sea, on the contrary, members of these families are totally absent or represented very poorly only in its southernmost area[11]. The same is true for the deep water forms of Penaeidae, the most primitive prawn family. *Bentheuphausia* of the Euphausiacea and *Gnathophausia*

11) Once, BALSS (1914) reported ? *Pentacheles* (=*Polycheles*) nov. sp.? from the Japan Sea, based on a single right chela collected by FRANZ DOFLEIN from off Maizuru. Later, however, it was revealed that the chela was not of *Polycheles* but of *Ctenocheles balssi,* a remarkable new species of the anomuran family Callianassidae (KISHINOUYE 1926). The anomuran species, which is collected not infrequently in the Japan Sea, resembles *Thaumastocheles* significantly in the external appearance. Therefore, it seems very likely that '*Thaumastocheles japonicus*' occasionally reported from the Japan Sea (e.g. SUZUKI 1963) is a mis-identified *Ctenocheles balssi.*

of the Mysidacea, the most primitive existing genera of respective groups, are inhabitants of the great depths of the world oceans, but never recorded from the Japan Sea. Many further examples may be saved to avoid being tedious.

On the other hand, numerous invertebrate species of phylogenetically 'young' groups are thriving in the deep waters of the Japan Sea. Representative examples are: *Heliometra* and *Pentametrocrinus*, respectively of the modern or specialized (GISLÉN 1951) unstalked crinoid families Antedonidae and Pentametrocrinidae; snails of the neogastropod genera *Buccinum, Neptunea, Voltopsius*, etc.; prawns of the Pandalidae and Crangonidae; sipunculids *Phascolosoma* and *Physcosoma*; etc.

Subspecies *maxima* of *Heliometra glacialis* is extraordinarily abundant in the deep waters of the Japan Sea; A.H. CLARK (in CLARK & CLARK 1967) vividly depicts the sight of the forward deck of the steamer *Albatross* literally buried under several tons of the trawled individuals of *maxima* in her cruise of 1906 in this marginal sea. *Thaumatometra tenuis*, another deep water species of Antedonidae, is also taken not infrequently together with *H. glacialis maxima*. Comatulids of the genus *Pentametrocrinus* are very common at some places off southern Japan and according to WATANABE et al. (1960), a kind of them occurs in abundance together with the prawn *Pandalus borealis* on the bottoms deeper than 350 m in the southeastern region of the Japan Sea. Richness, not only qualitative but also quantitative, of the gastropods of *Buccinum* and its related genera on the deep floors of the Japan Sea is well known (TERAMACHI 1933; KURODA 1935, 1936) and may not need any further comment here. Various kinds of Pandalidae and Crangonidae are thriving, too; some of them, *Pandalus borealis* and *P. hypsinotus* for instance, are abundantly fished for commercial use (KOJIMA & NAKANO 1961; etc.) and many others including *Pandalopsis japonica, Crangon dalli* and *Nectocrangon toyamensis* form each an important food item for various deep water fishes (WATANABE et al. 1958). Representatives of *Phascolosoma, Physcosoma* and other sipunculid genera are distributed as deep as 1000 m or more in the Japan Sea (MOKIEVSKY 1954).

Such a statement as given above may at first sight appear to reinforce the characteristic feature of the deep water fauna of the Japan Sea as inferred already from the data regarding fish distribution. On the other hand, however, in the invertebrate fauna of the deep waters of the present sea we can notice not a few instances of occurrence of the 'ancient' species, too.

The sea-star *Ctenodiscus crispatus*, one of the most dominant species in the taraba community III, is very abundant throughout the Japan Sea, frequently caught in large numbers together with useful species by commercial trawl net. This sea-star occurs commonly at least down to 1200 m (MOKIEVSKY 1954). The genus *Ctenodiscus* constitutes the subfamily Ctenodiscinae which is currently referred to the family Goniopectinidae of the primitive order Phanerozonia, but sometimes it is placed in the family Porcellanasteridae (e.g. DJAKONOV 1949; GRAINGER 1966), one of the most primitive families within the Phanerozonia and famous for including many abyssal species (MADSEN 1961). Though its exact systematic position is thus somewhat uncertain, there is no doubt in regarding *Ctenodiscus* as one of the primitive seastar groups. Bivalves of the genera *Nuculana, Yoldia* and *Yoldiella* are well thriving both qualitatively and quantitatively on the deep bottoms of the Japan Sea, and constitute quite important food items for many demersal fishes and crustaceans (KIKUCHI 1935; WATANABE et al. 1958; YASUDA 1967; etc.); some of them descend to 1200–1800 m (MOKIEVSKY 1954). These genera belong to the Taxodonta, the most primitive and ancient order of Bivalvia (FILATOVA 1958). Several species of the genus *Thyasira* are recorded from the depths 1900–2850 m in the Japan Sea (MOKIEVSKY 1954); most species of this genus are fairly old, ranging from Paleogene to Recent (e.g. *T. flexuosa, T. disjuncta, T. bisecta,* etc.), and flourished remarkably and widely in Tertiary epoch, suggesting the living members of the genus to represent a kind of 'relict'. The same may be applied to another bivalve genus *Venericardia,* a species of which is known from the depth of 2850 m in the Japan Sea. *Lepidopleurus assimilis* of the most primitive suborder Lepidopleurina of the primitive molluscan class Polyplacophora and *Chaetoderma* sp. also of the very primitive molluscan class Solenogastres have been recorded respectively from the bottom about 1200 m deep in the Japan Sea (MOKIEVSKY 1954). A kind of the curiously-built sea-anemone *Edwardsia* has been collected more than once from the depths of 2300–3200 m in the Japan Sea (DERJUGIN 1939; MOKIEVSKY 1954). CARLGREN (1940) referred this species to *E. arctica. Edwardsia* closely resembles the Middle Cambrian *Mackenzia,* the oldest known hexacoral; and according to CLARK (1913), both genera may belong to the same family, Edwardsiidae. Lastly, mention will be made on the occurrence of a species of the Pogonophora, *Oligobrachia dogieli,* on the bottom 2850 m deep in the northwestern region of the Japan Sea (IVANOV 1963).

Taking into account all these facts, we must admit that the deep water invertebrate fauna of the Japan Sea includes a fair number of 'ancient' forms and that some of them are thriving extraordinarily well there. This stands in contrast with the case of the fish fauna mentioned previously. Whatever may be the cause for this inconsistency, the following trends, the trends applicable, as mentioned already, more or less satisfactorily to the deep water fish fauna as well, seem especially important from a zoogeographical view-point.

First, almost all of these 'ancient' deep water invertebrate forms are cold-water elements showing each a strong relationship, either distributional or phylogenetic, with the northern seas like the Okhotsk, the Bering or the Arctic Sea. Secondly, most of them are distinctly eurybathyal, occurring in a very wide vertical range.

Ctenodiscus crispatus, for instance, is circumpolar, distributed widely in the northern parts of the North Pacific and North Atlantic and the Arctic Ocean; and its recorded depths are 2–2000 m, being found on quite shallow bottoms in the northern waters (DJAKONOV 1958; GRAINGER 1966). A more or less similar situation will hold for many species of the bivalve genera *Nuculana, Yoldia, Yoldiella* and *Thyasira,* too.

Even when the species is endemic to the Japan Sea or to the Far-Eastern seas, they have almost invariably their close relatives in the Arctic or the North Atlantic Ocean. The chiton *Lepidopleurus assimilis* is distributed in both the Okhotsk and Bering Seas outside the Japan Sea and down to the depth of 2000 m (YAKOVLEVA 1955), but the same species is also found in Mutsu Bay of northern Honshu at the level of 30 m (TAKI 1938). As to the Solenogastres *Chaetoderma*, several species are recorded from the northern Far-Eastern seas and the Alaskan waters and their bathymetric range seems to be fairly large (HEATH 1911; OKUDA 1943; IVANOV 1955). The sea-anemone *Edwardsia arctica* was originally described from the North Polar Sea in the bathymetric range 5–120 m (CARLGREN 1921); thus, this species seems to be a quite eurybathyal form with northern affinity. *Oligobrachia dogieli* has hitherto been collected from the Okhotsk Sea and the Kamchatkan waters outside the Japan Sea and, according to IVANOV (1963), it is one of the most eurybathyal pogonophorans, being recorded from 119–2850 m.

There are many more invertebrates of 'ancient' or primitive nature that are thriving in the Japan Sea, though they are not necessarily confined to the deep portion of the sea. Examples are luminous squids such as *Watasenia scintillans, Enoploteuthis chunii* and *E. theragrae*, many species of dentaliids (Scaphopoda) and *Pasiphaea sivado* (macruran Crustacea). Although these invertebrates are generally considered as deep sea forms, their living depths in the Japan Sea are by no means very large. All of the luminous squids mentioned above and *Pasiphaea* are inhabitants of moderate depths around the edge of the continental shelf, belonging to the okaba community IV, just as the 'ancient' deep sea fishes such as *Maurolicus muelleri* and *Glossanodon semifasciatus* do. Many species of dentaliids are recorded from Toyama Bay, and most frequently from the moderate depths around 200 m (KURODA & KIKUCHI 1933). Here, it is decidedly important that these 'ancient' invertebrates mentioned just above are all of the tropical-subtropical origin or affinity, differing from the 'ancient' invertebrates referred to previously which inhabit the truly deep levels of the Japan Sea and which indicate a strong northern affinity.

After all, we may conclude that the deep water fauna, either vertebrate or invertebrate, of the Japan Sea is composed exclusively of the truly cold-water elements of northern affinity, irrespective of their phylogenetic age, and that the 'ancient' deep sea elements of tropical-subtropical affinity which are remarkably flourishing in the deep waters off the Pacific side of Japan, on the other hand, are totally absent on the deep levels of the Japan Sea. The scanty or moderate number of species of the tropical-subtropical 'ancient' deep sea animals that are ever met with in the Japan Sea are distributed almost invariably at rather shallow levels and never in the truly deep waters.

[*To be continued*]