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Midwater Fishes off the Pacific Coast of Boso Peninsula, Central Japan: Species Composition, Abundance, Biomass, and Zoogeographic Affinities

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Abstract Midwater fishes were collected by oblique hauls between the surface and an average depth of 1290 m, using a 10-ft Isaacs-Kidd midwater trawl, at seven stations off the Pacific coast of Boso Peninsula, central Japan. A total of 1860 fishes (excluding larvae), representing 19 families and 66 species, were collected, with a mean abundance and biomass of 565 inds and 278 g (wet weight) per 100 m^2 of ocean surface in the upper 1000 m water column, respectively. Gonostomatids were most numerically abundant (75%), followed by myctophids (20%), melamphaids (1.4%) and sternoptychids (0.9%), while myctophids dominated in total biomass (47%), followed by gonostomatids (42%), melamphaids (3.1%) and bathylagids (3.1%). Of these, the gonostomatid, *Cyclothone atraria*, ranked top in both total abundance (52%) and biomass (26%). Zoogeographic grouping of the 66 species on the basis of centers of distributions/abundance in relation to water masses indicated that tropical-subtropical species were the most numerous overall (43 spp.), followed by wide-ranging (10 spp.), subarctic (6 spp.), pseudoceanic (6 spp.) and transitional species (1 sp.). Except for the transitional species, all zoogeographic groups were represented by at least one of the six most abundant species. Size-frequency distributions and other available information suggested that the study area was located at an interface between peripheral breeding populations of the tropical-subtropical, subarctic and pseudoceanic species, being a consequence of both the adjacent land mass and hydrographic conditions of the area, where cold, less saline waters originating from the subarctic region advected below the more saline, warm Kuroshio current flowing northeastward along the peninsula.

Aspects of reproduction, age and growth of Japanese midwater fishes have been studied for many relatively dominant species in the past three decades, including bathylagids (Miya, 1994b, 1995), gonostomatids (Kawaguchi and Marumo, 1967; Kawaguchi, 1973; Miya and Nemoto, 1985, 1986a, b, 1987a, b, 1991), sternoptychids (Okiyama, 1971) and myctophids (Odate and Ogawa, 1961; Odate, 1966; Go et al., 1977a, b), in addition to advances in taxonomic understanding of major taxa, such as gonostomatids (Kawaguchi, 1971; including photichthyids), sternoptychids (Haruta, 1975 for *Argyropelecus*; Haruta and Kawaguchi, 1976 for *Sternoptyx*) and myctophids (Kawaguchi and Aioi, 1971 for *Myctophum*; Kawaguchi and Shimizu, 1978 for *Diaphus*). In contrast, more comprehensive information on the midwater fish assemblages, of which the above are a part, including species composition, abundance, biomass, horizontal and vertical distribution patterns, and zoogeographic affinities, have not been documented to date, being available only for a group of specific taxa. Such one was myctophid investigation in Suruga Bay, central Japan, by Kawaguchi (1977), in which he detailed some of these biological aspects of the constituent species.

This paper reports species composition, abundance, biomass and zoogeographic affinities of the midwater fishes off the Pacific coast of Boso Peninsula, central Japan. The study site was chosen because, while midwater fish faunal composition has been investigated for typical subarctic (Pearcy et al., 1979) and tropical-subtropical areas (Parin et al., 1976) adjacent to Japanese waters, there has been no such study in a transitional zone between the two

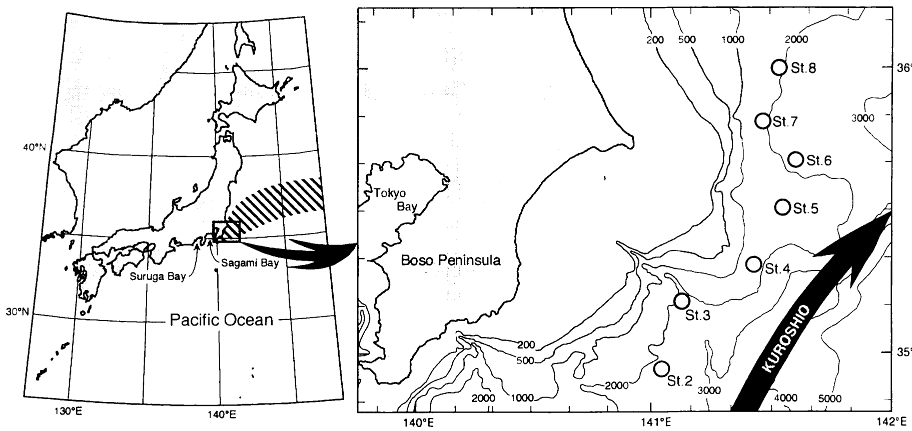

Fig. 1. Locations of the sampling stations. Hatched area indicates an approximate boundary between Subarctic Water Mass and Central Water Mass in the Pacific Ocean (Sverdrup et al., 1942). The course of the Kuroshio current is superimposed on the basis of a weekly report (Kaiyô Sokuhô) provided by the Hydrographic Department, Maritime Safety Agency of Japan. Depth contours in meters.

major areas, which broadly corresponds to waters off the Pacific coast of central Japan. Waters off Boso Peninsula, in particular, are located along the edge of the transitional zone, where the warm western boundary Kuroshio current prevails at the surface over colder, less saline subarctic waters advected from the north (Yang et al., 1993). The study was based on 1860 adult fishes taken by oblique-hauls utilizing a 10-foot Isaacs-Kidd midwater trawl at seven stations off the peninsula, which primarily consisted of meso- and upper bahtypelagic micronektonic fishes.

Materials and Methods

Midwater fishes were taken at a series of seven stations (Sts. 2–8), situated off the Pacific coast of Boso Peninsula, central Japan (Fig. 1), on 4 and 5 September 1991, during cruise KT-91-13 of the R/V *Tansei Maru*, Ocean Research Institute, University of Tokyo.

A single oblique haul was made at each station, using a 10-ft Isaacs-Kidd midwater trawl (10-ft IKMT) with a mesh opening of 5.0 mm and mouth area of 7.3 m^2 (Table 1). Wire (3000–4000 m) was paid out at a speed of 0.8–1.0 m/sec and retrieved at the same speed. The ship speed was 2.0–2.5 knots while the net was sinking and 1.0–1.5 knots during retrieval. The volume of water filtered, monitored by a flow meter mounted near the center of the mouth, ranged from 45,720 to 70,680 m^3, with a mean volume of 60,650 m^3. The maximum depths fished by the nets were estimated from the records of the Time-Depth meter equipped with a temperature sensor (Tsurumi Seiki Co., Ltd, Yokohama, 2000-m model), or if such were unavailable, from the relationships between wire length and angle during

Table 1. Summary of 10-ft IKMT oblique-haul data

Station	Latitude	Longitude	Date	Time	Period*	Max. depth (m)
2	34°56.7′N	141°02.0′E	4 Sept. 1991	2328–0127	night	1310
3	35°10.8′N	141°07.9′E	5 Sept. 1991	0440–0650	crepuscular	1200
4	35°19.1′N	141°26.5′E		0900–1105	day	1150
5	35°30.2′N	141°32.6′E		1253–1434	day	1230
6	35°41.3′N	141°37.1′E		1610–1820	crepuscular	1240
7	35°49.6′N	141°27.9′E		2028–2237	night	1460
8	35°59.2′N	141°32.4′E		0316–0519	crepuscular	1470

* Crepuscular periods are defined as 1 h before and after sunrise (0514) and sunset (1800). Those tows made exclusively between these two crepuscular periods are considered as day- and nighttime tows, while all others considered as crepuscular.

towing (Miya, unpubl. data). The maximum depths varied from 1150 to 1470 m, with an average depth of 1290 m. Along with the trawl samples, CTD casts were made at the seven stations, and also at St. 9 (37°00′N, 142°00′E), from the surface to 1000 m.

The samples were fixed in 5–10% buffered seawater formalin immediately after collection. All midwater fishes were sorted in the laboratory, counted and identified to species where possible. Standard lengths (SL) were measured to the nearest millimeter. Sorted species were blotted and weighed to the nearest 0.1 g on an electronic balance. Larval fishes were excluded from the analyses because the mesh size of the trawl would have undoubtedly allowed many to escape.

Abundance and biomass per 100 m^2 of ocean surface standardized for the upper 1000 m water column were estimated by the following equations:

$$\text{Abundance} = \text{N} \times \frac{100\ \text{MD}}{\text{VWF}},$$

$$\text{Biomass} = \text{W} \times \frac{100\ \text{MD}}{\text{VWF}}$$

where N is the number of individuals, W is wet weight (g), MD is the maximum depth reached by the net (m), and VWF is the volume of water filtered by the net (m^3). These calculations assume that all depths were sampled equally. Although oblique IKMT tows generally sample much volumes of water around the maximum depths, this assumption was satisfied in the upper 1000 m water column because all tows were made deeper than 1000 m (see Table 1).

In order to establish zoogeographic characteristics of the study area, the fish species were classified into the following five zoogeographic categories, according to their centers of abundance or distribution in relation to water masses and affiliation with the land mass. The first four categories are those for oceanic species, while the last one for land-associated species for which no attempts were made to divide northern or southern components. Information on geographic distributions was taken from published records in original/review articles for specific taxa, but not from the secondary sources, such as regional synopses (for information source, see Table 2). Definitions for water masses in the Pacific Ocean follow Sverdrup et al. (1942). 1) Subarctic species (SA): those occurring abundantly or exclusively in the Subarctic Water Mass and rarely or never taken in the Central Water masses; 2) tropical-subtropical species (TS): those occurring abundantly or exclusively in the Central Water masses or more to the south (or Kuroshio waters) and rarely or never taken in the Subarctic Water Mass; 3) wide-ranging species (W): those not limited to a single water mass, but occurring abundantly across several water masses, with the centers of abundance or distribution not lying in the transitional zone between the above two water masses; 4) transitional species (TS/SA): those occurring abundantly in the transitional zone between the Subarctic Water Mass and the Central Water masses; 5) pseudoceanic species (P): those occurring abundantly along the upper slope of the land mass. Since the first four categories (SA, TS, W, TS/SA) are based on the water mass distributions demonstrated by Sverdrup et al. (1942), there are no "temperate" species in this zoogeographic scheme despite the fact that the study area is climatologically temperate and is located in the "northern Temperate" region as biogeographically defined by Backus (1986). The latter (P), on the other hand, corresponds to those comprising the "mesopelagic boundary community," recently defined by Reid et al. (1991).

Results

Hydrography

The study area was greatly affected by the course of the Kuroshio current, which was flowing northeastward along the southeastern side of the transect on which the seven stations lay, during the study period (September 1991; Fig. 1). Effects of the Kuroshio could be detected as higher temperature contours at the surface (≥24°C) and higher salinity contours between 50 and 150 m (≥34.4‰), extending from Sts. 2 to 8 (Fig. 2), below which subarctic waters, characterized by a salinity minimum layer of 34.0–34.2‰, advected in the upper mesopelagic zone (300–600 m) from the north (Fig. 2). A strong salinity front occurred somewhere between Sts. 8 and 9 (Fig. 2), the latter being located about one degree north of the former. No traces of newly-formed or decaying cold-core rings were detected.

Species composition, abundance and biomass

Definite latitudinal changes in species composition, abundance and biomass were found to be lack-

Table 2. Summary of the catch data and zoogeographic affinity of the midwater fishes taken at a series of the seven stations off the Pacific coast of Boso Peninsula during a KT-91-13 cruise

Species	*N*	Size range (mm in SL)	Abundance (inds/100 m²) Mean±SD (%)	Biomass (g/100 m²) Mean±SD (%)	Zoogeo-graphic affinity[a]	Source of information on geographic distributions
Nemichthyidae						
Nemichthys scolopaceus	2	330–672	0.5± 0.9 (0.1)	1.9± 4.3 (0.7)	TS	Nielsen and Smith (1978)
Bathylagidae[b]						
Bathylagus ochotensis	4	26–59	1.2± 1.1 (0.2)	0.8± 1.2 (0.3)	P	Kobyliansky (1985)
Bathylagus pacificus	5	29–146	1.7± 2.9 (0.3)	6.9±16.9 (2.5)	SA	Rass and Kashkina (1967)
Leuroglossus schmidti	1	30	0.3± 0.7 (0.0)	0.0± 0.1 (0.0)	P	Borodulina (1968)
Alepocephalidae						
Bajacalifornia megalops[c]	2	24–57	0.7± 1.2 (0.1)	0.2± 0.5 (0.1)	W	Miya and Markle (1993)
Platytroctidae						
Holtbyrnia innesi	1	47	0.3± 0.7 (0.0)	0.1± 0.2 (0.0)	W	Matsui and Rosenblatt (1987)
Gonostomatidae						
Cyclothone alba	45	15–27	14.5±16.6 (2.6)	0.6± 0.7 (0.2)	TS	Mukhacheva (1974)
Cyclothone atraria	957	14–55	294.0±54.8 (51.9)	71.1±15.4 (25.6)	W	Mukhacheva (1974)
Cyclothone pallida	50	20–61	14.2± 7.5 (2.5)	2.7± 1.3 (1.0)	TS	Miya (1994c)
Cyclothone pseudopallida	101	12–50	31.7±29.5 (5.6)	2.7± 3.1 (1.0)	TS	Miya (1994a)
Gonostoma elongatum	2	23–63	0.8± 2.0 (0.1)	0.2± 0.5 (0.1)	TS	Mukhacheva (1972)
Gonostoma gracile	244	20–119	73.8±18.7 (13.0)	40.9±17.3 (14.7)	W	Mukhacheva (1972)
Sternoptychidae						
Argyropelecus aculeatus	2	26	0.5± 0.9 (0.1)	0.2± 0.5 (0.1)	TS	Haruta (1975)
Argyropelecus hemigymnus	1	18	0.3± 0.9 (0.1)	0.0± 0.1 (0.0)	TS	Haruta (1975)
Maurolicus muelleri	1	23	0.4± 1.1 (0.1)	0.1± 0.2 (0.0)	P	Okiyama (1971)
Sternoptyx diaphana	13	10–30	3.6± 2.7 (0.6)	1.5± 2.3 (0.5)	TS	Haruta and Kawaguchi (1976)
Phosichthyidae						
Ichthyococcus elongatus	2	21–26	0.6± 1.7 (0.1)	0.1± 0.3 (0.0)	TS	Mukhacheva (1980)
Vinciguerria nimbaria	3	18–29	1.0± 1.2 (0.2)	0.2± 0.3 (0.1)	TS	Gorbunova (1972)
Chauliodontidae						
Chauliodus sloani	8	28–150	2.6± 1.8 (0.5)	4.7± 6.6 (1.7)	W	Parin and Novikova (1974)
Stomiidae						
Macrostomias pacificus	1	245	0.3± 0.7 (0.0)	1.6± 4.2 (0.6)	W	Shcherbachev and Novikova (1976)
Stomias nebulosus	1	57	0.3± 0.7 (0.0)	0.1± 0.2 (0.0)	TS	Shcherbachev and Novikova (1976)
Astronesthidae						
Astronesthes indica	2	33–34	0.6± 1.5 (0.1)	0.2± 0.5 (0.1)	TS	Sokolovsky and Sokolovskaya (1981)
Melanostomiidae						
Opostomias mitsuii	1	57	0.3± 0.7 (0.0)	0.1± 0.4 (0.1)	W	Parin and Sokolovsky (1976)
Notosudidae						
Scopelosaurus hoedti	1	48	0.3± 0.7 (0.0)	0.1± 0.2 (0.0)	TS	Bertelsen et al. (1976)
Paralepididae						
Lestrolepis intermedia	2	68–93	0.6± 0.9 (0.1)	0.2± 0.4 (0.1)	TS	Rofen (1966)
Paralepis atlantica	3	48–76	0.8± 1.5 (0.1)	0.4± 0.7 (0.1)	TS	Rofen (1966)
Myctophidae						
Benthosema suborbitale	5	18–30	1.6± 1.2 (0.3)	0.2± 0.2 (0.1)	TS	Kawaguchi (1977)
Ceratoscopelus warmingi	98	23–56	30.2±29.3 (5.3)	11.7±11.5 (4.2)	TS	Kawaguchi (1977)
Diaphus garmani	106	14–37	30.3±29.4 (5.4)	3.2± 2.5 (1.1)	P	Kawaguchi and Shimizu (1978)
Diaphus kuroshio	3	58–62	0.9± 1.1 (0.2)	2.0± 2.5 (0.7)	TS	Kawaguchi and Shimizu (1978)
Diaphus mollis	13	15–29	3.5± 5.0 (0.6)	0.6± 0.8 (0.2)	TS	Kawaguchi and Shimizu (1978)
Diaphus parri	1	24	0.3± 0.9 (0.1)	0.1± 0.2 (0.0)	TS	Kawaguchi and Shimizu (1978)
Diaphus perspicillatus	12	19–36	3.4± 5.2 (0.6)	0.4± 0.5 (0.1)	TS	Kawaguchi and Shimizu (1978)
Diaphus regani	1	22	0.3± 0.7 (0.0)	0.0± 0.1 (0.0)	TS	Kawaguchi and Shimizu (1978)
Diaphus signatus	1	18–32	0.3± 0.7 (0.0)	0.1± 0.2 (0.0)	TS	Kawaguchi and Shimizu (1978)
Diaphus suborbitalis	2	15–19	0.6± 1.5 (0.1)	0.0± 0.1 (0.0)	P	Kawaguchi and Shimizu (1978)
Diogenichthys atlanticus	4	17–19	1.1± 2.1 (0.2)	0.1± 0.1 (0.0)	TS	Wisner (1976)
Hygophum proximum	2	19	0.7± 1.2 (0.1)	0.1± 0.1 (0.0)	TS	Wisner (1976)
Hygophum reinhardtii	1	22	0.3± 0.7 (0.0)	0.0± 0.1 (0.0)	TS	Wisner (1976)
Lampadena luminosa	4	20–25	1.1± 2.3 (0.2)	0.1± 0.2 (0.0)	TS	Wisner (1976)
Lampanyctus alatus	3	24–26	0.9± 2.3 (0.2)	0.1± 0.2 (0.0)	TS	Kawaguchi (1977)
Lampanyctus jordani	12	12–125	3.4± 2.3 (0.6)	50.8±54.3 (18.3)	SA	Wisner (1976)
Lampanyctus nobilis	16	27–42	4.6± 2.9 (0.8)	1.1± 0.5 (0.4)	TS	Wisner (1976)
Lampanyctus niger	3	37–38	0.9± 1.5 (0.2)	0.1± 0.2 (0.0)	TS	Kawaguchi (1977)

Table 2. (Continued)

Species	N	Size range (mm in SL)	Abundance (inds/100 m²) Mean±SD (%)	Biomass (g/100 m²) Mean±SD (%)	Zoogeographic affinity[a]	Source of information on geographic distributions
Lampanyctus tenuiformis	1	53	0.3± 0.7 (0.0)	0.2± 0.5 (0.1)	TS	Wisner (1976)
Myctophum asperum	7	22–40	2.3± 2.9 (0.4)	0.6± 0.9 (0.2)	TS	Kawaguchi et al. (1972)
Myctophum nitidulum	2	26–28	0.6± 1.5 (0.1)	0.1± 0.3 (0.0)	TS	Kawaguchi et al. (1972)
Myctophum orientale	2	22–23	0.5± 1.3 (0.1)	0.1± 0.2 (0.0)	P	Kawaguchi (1977)
Notoscopelus resplendens	5	46–60	1.6± 2.3 (0.3)	1.6± 2.3 (0.6)	TS	Fujii and Uyeno (1976)
Stenobrachius leucopsarus	1	95	0.3± 0.7 (0.0)	2.1± 5.6 (0.8)	SA	Wisner (1976)
Stenobrachius nannochir	51	49–104	15.5± 3.8 (2.7)	51.4±17.3 (18.5)	SA	Wisner (1976)
Symbolophorus evermani	8	20–68	2.4± 2.0 (0.4)	1.3± 2.5 (0.5)	TS	Wisner (1976)
Symbolophorus californiensis	1	25	0.3± 0.8 (0.1)	0.0± 0.1 (0.0)	TS/SA	Wisner (1976)
Taaningichthys bathyphilus	1	28	0.3± 0.8 (0.1)	0.0± 0.1 (0.0)	TS	Wisner (1976)
Taaningichthys paurolychnus	1	48	0.3± 0.7 (0.0)	0.2± 0.4 (0.1)	TS	Wisner (1976)
Taaningichthys minimus	1	58	0.3± 0.7 (0.0)	0.3± 0.8 (0.1)	TS	Wisner (1976)
Bregmacerotidae						
Bregmaceros japonicus	2	44–55	0.7± 1.2 (0.1)	0.3± 0.6 (0.1)	TS	Masuda and Ozawa (1979)
Macrouridae						
Caelorinchus tokiensis	1	30+	0.4± 1.0 (0.1)	0.3± 0.8 (0.1)	TS	Nakabo (1993)
Coryphaenoides cinereus	1	75+	0.4± 1.1 (0.1)	1.1± 2.8 (0.4)	SA	Nakabo (1993)
Oneirodidae						
Chirophryne xenolophus	1	64	0.4± 1.0 (0.1)	1.6± 4.3 (0.6)	TS	Pietsch (1978)
Bertella idiomorpha	1	55	0.3± 0.7 (0.0)	0.7± 1.9 (0.3)	SA	Pietsch (1973)
Oneirodes eschrichtii	2	12–13	0.6± 1.0 (0.1)	0.1± 0.1 (0.0)	W	Pietsch (1974)
Puck pinnata[d]	1	11	0.3± 0.7 (0.0)	0.0± 0.1 (0.0)	TS	Pietsch (1978)
Melamphaidae						
Poromitra crassiceps	1	105	0.3± 0.7 (0.0)	4.7±12.5 (1.7)	W	Ebeling and Weed (1973)
Scopeloberyx spp.[e]	25	13–35	7.3± 4.1 (1.3)	2.8± 2.0 (1.0)	TS	Ebeling and Weed (1973)
Parabrotulidae						
Parabrotula plagiophthalma	2	34–43	0.5± 1.4 (0.1)	0.1± 0.2 (0.0)	W	Nielsen et al. (1990)
Total	1860		564.7±51.1	278.2±69.6		

[a] *TS*—tropical-subtropical; *SA*—subarctic; *W*—wide-ranging; *P*—pseudoceanic; *TS/SA*—transitional species (for definitions, see Materials and Methods). [b] Generic arrangement follows Dunn (1983). [c] Senior synonym of *Bajacalifornia erimoensis* Amaoka and Abe (Sazonov and Ivanov, 1980). [d] Recorded for the first time from Japanese waters (identified by T. W. Pietsch). [e] Including two forms, *Scopeloberyx ophisthopterus* and *S.* sp, the latter of which is an undescribed species, being a more abundant in the study area (Y. Sato, pers. comm.).

ing, probably owing to the relatively homogeneous hydrographic features of the study area (see above). This resulted in noticeably higher values of the percent similarity (PS) indices (Whittaker and Fairbanks, 1958) between the species composition of the seven stations (21 pairs; mean±SD=73.8±6.4; range, 60.0–83.2). Since such values greatly exceeded those obtained within the same zoogeographic zones for vertically migrating midwater fishes in the central equatorial Pacific (mean, 42.3–53.7; Clarke, 1987), all samples were assumed to be taken from the same zoogeographic unit in the following biological account. Furthermore, since there were no statistically significant differences in overall abundance (Kruskal-Wallis test; $p=0.507$) and biomass ($p=1.000$) among day (Sts. 4 and 5), night (Sts. 2 and 7) and crepuscular (Sts. 3, 6 and 8) periods of tows, all samples were treated in the same manner (see also Maynard et al. [1975] and references therein for general lack of diel related avoidance).

A total of 1860 fishes, representing 19 families and 66 species, were collected at the seven stations (Table 2). Myctophids were most speciose (30 spp.), followed by gonostomatids (6 spp.), sternoptychids (4 spp.) and oneirodids (4 spp.).

Mean abundance (inds/100 m²) and biomass (g/100 m²) among the seven stations were 565± 51 SD and 278±70 SD, respectively (Table 2). Gonostomatids were most abundant (75%), followed by myctophids (20%), melamphaids (1.4%) and sternoptychids (0.9%), the four families comprising 97% of the total sampled, while myctophids dominated in total biomass (47%), followed by gonostomatids (42%), melamphaids (3.1%) and bathylagids (3.1%), the four families comprising 95%. Of these, the gonostomatid, *Cyclothone*

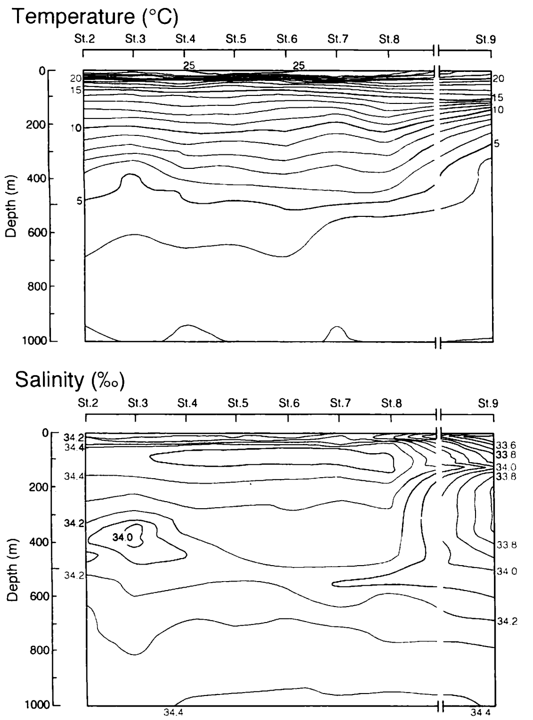

Fig. 2. Temperature and salinity contours along a transect from Sts. 2 to 9. For locations of the stations, see Figure 1.

atraria, ranked top in both total abundance and biomass, comprising 52% and 26%, respectively, with *Gonostoma gracile* being 2nd (13%) in abundance and 4th (15%) in biomass. The myctophids, *Stenobrachius nannochir* and *Lampanyctus jordani*, also contributed significantly to biomass, being 2nd (19%) and 3rd (18%), respectively. Other species did not contribute greatly to the total catch, all comprising less than 6% in both abundance and biomass.

Zoogeographic affinities

Zoogeographic grouping of the 66 species indicated that tropical-subtropical species were the most numerous overall (43 spp.), followed by wide-ranging (10 spp.), subarctic (6 spp.), pseudoceanic (6 spp.) and transitional species (1 sp.) (Table 2).

Discussion

Among the 66 species off the Pacific coast of Boso Peninsula, the rare oneirodid midwater fish, *Puck pinnata*, was recorded for the first time in Japanese waters. Although there exist no comparable faunal lists for the study area, the species list is probably accurate for all but rarely encountered species. The total number of species recorded for the first time from Sts. 2 through 8 showed a dramatic decrease (22→13→10→9→7→3→3), indicating that most of the more common midwater species of the region were represented in the collections. In addition, the study took place during the season (fall) when abundances of tropical-subtropical coastal and midwater fishes are highest in the peninsula region (Miya et al., 1994a, b) and in Sagami Bay (Miya and Yamaguchi, unpubl. data; see Fig. 1 for bay location). Furthermore, the number of myctophid species recorded in the present study (30 spp.) were close to those recorded in Suruga Bay (37 spp.), where extensive samplings have been undertaken (Kawaguchi, 1977).

Comparable data for midwater fish biomass only exist for the area, estimated by Gjøsæter and Kawaguchi (1980). They were based on oblique-haul collections using a large-conical plankton net (ORI net; mouth diameter, 1.6 m). Gjøsæter and Kawaguchi (1980) estimated an average midwater fish biomass in adjacent water north of the Kuroshio current to be 550 g/100 m^2, almost twice that of the present estimate (278 g/100 m^2). The former estimate, however, had been multiplied by 2.6, a coefficient calculated empirically from catch comparisons between the ORI net and a 10-ft IKMT (Gjøsæter and Kawaguchi, 1980), the latter of which is a more effective sampling gear for larger midwater animals. Therefore our present estimate (278 g/100 m^2) is much closer to that of their original, plankton-net based data (210 g/100 m^2), although the effects of various factors, such as differences in sampling methods, time and season cannot be identified. The mean abundance was apparently an underestimation, because of possible net avoidance and escapement through meshes, as exemplified by Gartner et al. (1988). The latter should have occurred for small, abundant fishes, such as *Cyclothone alba* (ranked 7th in abundance in the present study; maximum size, 29 mm SL; Miya and Nemoto, 1991), because it was far more abundant than its larger congener, *C. pseudopallida* (ranked 3rd), in Sagami Bay, when estimated by a 10-ft IKMT with a mesh size of 0.50–0.69 mm (463 vs. 277 inds/100 m^2; Miya and Nemoto, 1991).

The results of the zoogeographic groupings could have been readily anticipated owing to the location of the study area (60–80 km offshore; bottom depth, 1560–2120 m; Fig. 1) and the prevailing hydrographic features, being influenced by both the adjacent land mass and the warm Kuroshio current originating in the equatorial Pacific and prevailing at the surface, above the colder, less saline subarctic waters advected from the north (Fig. 2). Species of tropical-subtropical affinities are abundant due to the warming effects of the Kuroshio offshore, while subarctic species are present due to cold waters at depth and inshore. As evidence of this, considerable numbers of boreal fishes have been collected in Suruga Bay (see Fig. 1 for bay location) and off Kumanonada, in deep waters to the south of the study area (Kubota, 1972; Kodama et al., 1986), and a few species (ca. 7%) taken in bottom-trawl catches off Choshi, northern part of the peninsula (Miya et al., 1995), whereas coastal fishes taken from set-net catches off the southernmost parts of Boso Peninsula have comprised predominantly tropical-subtropical species (ca. 70%; Miya et al., 1994a, b).

Rather than being considered simply a heterogeneous assemblage, it should be noted that, except for the transitional species, all of the zoogeographic groups included in the midwater fish fauna off the peninsula were represented by at least one of the six most abundant species (Table 3), which together comprise 83% of the total abundance. The two most abundant species were wide-ranging (W), protandrous gonostomatids, *Cyclothone atraria* and *Gonostoma gracile*, both of which are endemic to the western North Pacific and which have been shown to have complete life cycles in Sagami Bay or adjacent waters (Kawaguchi and Marumo, 1967; Miya and Nemoto, 1987b). The third most abundant species, the gonostomatid *Cyclothone pseudopallida*, a tropical-subtropical species (TS) broadly distributed in the world oceans north of 30°S, also has a complete life cycle in Sagami Bay (Miya and Nemoto, 1986a). The following three ranks were occupied by myctophid fishes, each affiliated with different zoogeographic groups: the fourth most abundant was the tropical-subtropical (TS) cosmopolitan species, *Ceratoscopelus warmingii*, fifth was the pseudoceanic *Diaphus garmani* (P), and sixth, the subarctic *Stenobrachius nannochir* (SA). None of these are known to complete their life cycles in the study area or adjacent waters, which suggests that, in the Boso Peninsula region, species of strongly cold (SA) or warm affinities (TS) may be at the edges of their zoogeographic range. Data on size-frequency distributions, minimum size at maturity (size of the smallest gravid females reported in the literature) and maximum size of four species representing the four zoogeographic affinities support this idea (Fig. 3).

The size-frequency distribution of the protandrous *Gonostoma gracile* encompassed a broad spectrum, in which juveniles and subadults (20–40 mm SL), males (40–70 mm SL) and females exceeding minimum size at maturity (80 mm SL; Kawaguchi and Marumo, 1967), were well represented as definite size classes, being typical resident species with complete life cycles. Such should be the case for the other two dominant species, *Cyclothone atraria* and *C. pseudopallida*, although their small size classes (< 30 mm SL) were not well represented in the present samples due probably to escapement through large meshes of the trawl (5.0 mm).

On the other hand, the above three myctophid species exhibited patterns notably different from that

Table 3. The top six abundant midwater fishes off the Pacific coast of Boso Peninsula: relative abundance, zoogeographic affinity, minimum size at maturity and maximum size

Rank	Species	Relative abundance (%)	Zoogeographic affinity*	Min. size at maturity (mm SL)*	Max. size (mm SL)*	Source of minimum size at maturity and maximum size recorded
1	*Cyclothone atraria*	51.9	W	33	59	Miya and Nemoto (1991)
2	*Gonostoma gracile*	13.0	W	80	133	Kawaguchi and Marumo (1967); Mukhacheva (1972)
3	*Cyclothone pseudopallida*	5.6	TS	25	48	Miya and Nemoto (1991)
4	*Diaphus garmani*	5.4	P	40	60	Nafpaktitis et al. (1977)
5	*Ceratoscopelus warmingi*	5.3	TS	53	75	Badcock and Araújo (1988); Wisner (1976)
6	*Stenobrachius nannochir*	2.7	SA	80	110	Miya (unpubl. data); Wisner (1976)

* For definitions, see text.

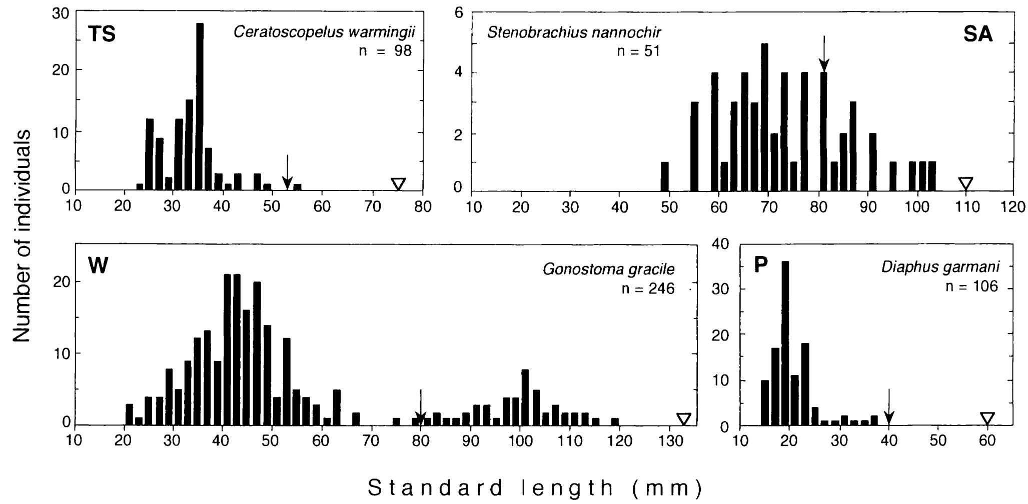

Fig. 3. Size-frequency distributions of the four of the six most abundant species, representing the four zoogeographic groups (TS, SA, W and P). Arrows and triangles indicate minimum size at maturity and maximum size recorded, respectively (for definitions, see text; for source of information, see Table 3).

of *G. gracile*, although differential net avoidance or escapement through net meshes might occur. *Ceratoscopelus warmingii* (TS) exhibited two distinct modes of smaller size classes (ca. 25 mm and 35 mm SL) were recognized, with only a single individual (55 mm SL, sex indeterminate) having attained minimum size at maturity (53 mm SL; Badcock and Araújo, 1988). Since the maximum size of this species was reported as ca. 75 mm SL (Wisner, 1976; Nafpaktitis et al., 1977), the present sample appeared to comprise exclusively immature fishes, as did those of *Diaphus garmani* (P), no specimens having attained the minimum size at maturity (40 mm SL; maximum size recorded, 60 mm SL; Nafpaktitis et al., 1977). Because larval and juvenile specimens of the two species have been recorded but mature adults never collected in the central part of Sagami Bay (Miya and Yamaguchi, unpubl. data), their recruitment may have resulted from transport by the Kuroshio current during earlier life history stages from more southern or more coastal populations. It should be noted that abundant occurrences of similarly small and immature tropical-subtropical species have been noted in the northern Sargasso Sea (30–32°N) myctophid fish assemblage, where the effects of the warm western boundary current, the Gulf Stream, are similarly pronounced along the coast (Gartner et al., 1989).

In contrast, the size-frequency distribution of *Stenobrachius nannochir* (SA) was inclined to relatively large fishes, this can be seen in Figure 3, a considerable number having attained minimum size at maturity (80 mm SL; Miya, unpubl. data) and the largest (106 mm SL) being close to the maximum size recorded in the literature (110 mm SL; Wisner, 1976). Furthermore, no larvae and few juveniles (ca. 20 mm SL) have been recorded in Sagami Bay, these facts together suggesting that, unlike *C. warmingii* (TS) and *D. garmani* (P), *S. nannochir* (SA) is actively or passively transported only during subadult and adult stages of its life history. Their adult occurrences, therefore, does not necessarily indicate that it has a complete life cycle in the study area. It might be possible that the adult *S. nannochir* were expatriates, as exemplified in *Myctophum punctatum* populations in the western North Atlantic, which were composed exclusively of very large individuals with no indications of sexual maturation and lacking post-larvae (Zurbrigg and Scott, 1972).

The three patterns of occurrence discussed here, which were reflected in the size-frequency distributions of the relatively dominant species, may be the case for most of the other, less abundant species, although the small number of specimens and lack of relevant biological information precluded more meaningful comparisons. Because some relatively wide-ranging tropical-subtropical gonostomatids, *Cyclothone alba* (Miya and Nemoto, 1986b) and *C. pseudopallida* (Miya and Nemoto, 1986a), and subarctic bathylagids, *Bathylagus pacificus* and *B.*

milleri (Miya, 1994b), are known to reproduce in Sagami Bay, it is clear that having a complete life cycle or otherwise in the study area, is an individual species' characteristic rather than that of a zoogeographic group. Nevertheless, it appears that the study area was located at an interface more or less between the peripheral breeding populations of the tropical-subtropical, subarctic and pseudoceanic species, the location of which may shift according to spatial/temporal variations in large scale hydrographic conditions. Future, more extensive seasonal surveys of life histories will reveal whether or not these midwater fishes with various zoogeographic affinities are characterized by having complete life cycles in the study area.

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Literature Cited

Backus, R. H. 1986. Biogeographic boundaries in the open ocean. Pages 9–13 *in* A. C. Pierrot-Bults, S. van der Spoel, B. J. Zahuranec and R. K. Johnson, eds. Pelagic biogeography. Unesco Tech. Papers in Mar. Sci. 49. Paris.

Badcock, J. and T. M. H. Araújo. 1988. On the significance of variation in a warm water cosmopolitan species nominally *Ceratoscopelus warmingii* (Pisces, Myctophidae). Bull. Mar. Sci., 42: 16–43.

Bertelsen, E., G. Krefft and N. B. Marshall. 1976. The fishes of the family Notosudidae. Dana Rep., (86): 1–114, pl. 1.

Borodulina, O. D. 1968. Taxonomy and distribution of the genus *Leuroglossus* (Bathylagidae, Pisces). Probl. Ichthyol., 8: 1–10.

Clarke, T. A. 1987. The distribution of vertically migrating fishes across the central equatorial Pacific. Biol. Oceanogr., 4: 47–81.

Dunn, J. R. 1983. Development and distribution of the young of northern smoothtongue, *Leuroglossus schmidti* (Bathylagidae), in the northeast Pacific, with comments on the systematics of the genus *Leuroglossus* Gilbert. Fish. Bull., 31: 23–40.

Ebeling, A. W. and W. H. Weed III. 1973. Fishes of the western North Atlantic. Part 6. Order Xenoberyces (Stephanoberyciformes). Mem. Sears Found. Mar. Res., (1): 397–478.

Fujii, E. and T. Uyeno. 1976. On three species of the myctophid genus *Notoscopelus* found in western North Pacific. Japan. J. Ichthyol., 22: 227–233. (In Japanese with English abstract.)

Gartner, J. V., Jr., W. J. Conley and T. L. Hopkins. 1988. Escapement by fishes from midwater trawls: a case study using lanternfishes (Pisces: Myctophidae). Fish. Bull., 87: 213–222.

Gartner, J. V., Jr., P. Steele and J. J. Torres. 1989. Aspects of the distribution of lanternfishes (Pisces: Myctophidae) from the northern Sargasso Sea. Bull. Mar. Sci., 45: 555–563.

Gjøsæter, J. and K. Kawaguchi. 1980. A review of the world resources of mesopelagic fish. FAO Fish. Tech. Pap., 193: 1–151.

Go, Y. B., K. Kawaguchi and T. Kusaka. 1977a. Ecologic study on *Diaphus suborbitalis* Weber (Pisces, Myctophidae) in Suruga Bay, Japan—I. Method of aging and its life span. Bull. Japan. Soc. Sci. Fish., 43: 913–919.

Go, Y. B., K. Kawaguchi and T. Kusaka. 1977b. Ecologic study on *Diaphus suborbitalis* Weber (Pisces, Myctophidae) in Suruga Bay, Japan—II. Growth pattern. Bull. Japan. Soc. Sci. Fish., 43: 1411–1416.

Gorbunova, N. N. 1972. Systematics, distribution and biology of the fishes of the genus *Vinciguerria* (Pisces, Gonostomatidae). Trudy Inst. Okeanol., 93: 70–109. (In Russian with English summary.)

Haruta, C. 1975. Taxonomy and geographical distribution of the genus *Argyropelecus* (family Sternoptychidae) from the western North Pacific Ocean. Japan. J. Ichthyol., 22: 83–96. (In Japanese with English abstract.)

Haruta, C. and K. Kawaguchi. 1976. Taxonomy and geographical distribution of the fishes of the genus *Sternoptyx* (family Sternoptychidae) from the western North Pacific Ocean. Japan. J. Ichthyol., 23: 143–152. (In Japanese with English abstract.)

Kawaguchi, K. 1971. Gonostomatid fishes of the western North Pacific. Japan. J. Ichthyol., 18: 1–16.

Kawaguchi, K. 1973. Biology of *Gonostoma gracile* Günther (Gonostomatidae). II. Geographical and vertical distribution. J. Oceanogr. Soc. Japan, 29: 113–120.

Kawaguchi, K. 1977. Micronekton community—community of myctophid fishes (family Myctophidae) in Suruga Bay, central Japan. Pages 235–268 *in* S. Nishizawa, R. Ishida and T. Kawasaki, eds. Communities and production in the sea. Koseisha-Koseikaku, Tokyo. (In Japanese.)

Kawaguchi, K. and K. Aioi. 1971. Myctophid fishes of the genus *Myctophum* (Myctophidae) in the Pacific and Indian Oceans. J. Oceanogr. Soc. Japan., 28: 161–175.

Kawaguchi, K., H. Ikeda, M. Tamura and S. Ueyanagi. 1972. Geographical distribution of surface-migrating myctophid fishes (genus *Myctophum*) in the tropical and subtropical Pacific and Indian oceans. Bull. Far Seas Fish. Res. Lab., (6): 23–37.

Kawaguchi, K. and R. Marumo. 1967. Biology of *Gonostoma gracile* (Gonostomatidae). I. Morphology, life history and sex reversal. Infor. Bull. Plankt. Japan Commem. No. Dr. Y. Matsue: 53–67, pls. I–II.

Kawaguchi, K. and H. Shimizu. 1978. Taxonomy and distribution of the lanternfishes, genus *Diaphus* (Pisces, Myctophidae) in the western Pacific, eastern Indian Oceans and the southeast Asian Seas. Bull. Ocean Res. Inst. Univ. Tokyo, (10): 1–145.

Kobyliansky, S. G. 1985. Materials for the revision of the genus *Bathylagus* Günther (Bathylagidae): the group of "light" deep-sea smelts. J. Ichthyol., 25: 1–17.

Kodama, K., M. Isotake, H. Kajihara, T. Yamanaka and T. Kubota. 1986. Occurrence of some boreal zooplankton in Kumano-nada, central Japan, in March and May, 1983. Bull. Biogeogr. Soc. Japan, 41: 71–77.

Kubota, T. 1972. Appearance of a boreal lanternfish, *Tarletonbeania taylori*, in Suruga Bay, Japan. Japan. J. Ichthyol., 19: 195–198.

Masuda, S. and T. Ozawa. 1979. Reexamination of the holotypes of *Bregmaceros japonicus* Tanaka and *B. nectabanus* Whitley. Japan. J. Ichthyol., 25: 266–268.

Matsui, T. and R. H. Rosenblatt. 1987. Review of the deep-sea fish family Platytroctidae (Pisces: Salmoniformes). Bull. Scripps Inst. Oceanogr., 26: 1–159.

Maynard, S. D., V. F. V. Riggs and J. F. Walters. 1975. Mesopelagic micronekton in Hawaiian waters: faunal composition, standing stock, and diel vertical migration. Fish. Bull., 73: 726–736.

Miya, M. 1994a. *Cyclothone kobayashii*, a new species of gonostomatid fish (Teleostei: Stomiiformes) from the Southern Ocean, with notes on its ecology. Copeia, 1994: 191–204.

Miya, M. 1994b. Seasonal occurrence of the deep-sea bathylagid fishes in Sagami Bay, central Japan, with notes on their reproductions. Japan. J. Ichthyol., 40: 433–440.

Miya, M. 1994c. First record of *Cyclothone parapallida* (Gonostomatidae) from the Pacific Ocean, with notes on its geographic distribution. Japan. J. Ichthyol., 41: 326–329.

Miya, M. 1995. Some aspects of the biology of *Bathylagus ochotensis* (Pisces: Bathylagidae) in Sagami Bay, central Japan. Bull. Mar. Sci., 56: 173–184.

Miya, M. and D. F. Markle. 1993. *Bajacalifornia aequatoris*, new species of alepocephalid fish (Pisces: Salmoniformes) from the central equatorial Pacific. Copeia, 1993: 743–747.

Miya, M. and T. Nemoto. 1985. Protandrous sex reversal in *Cyclothone atraria* (family Gonostomatidae). Japan. J. Ichthyol., 31: 438–440.

Miya, M. and T. Nemoto. 1986a. Reproduction, growth and vertical distribution of the mesopelagic fish *Cyclothone pseudopallida* (family Gonostomatidae). Pages 830–837 *in* T. Uyeno, R. Arai, T. Taniuchi and K. Matsuura, eds. Indo-Pacific fish biology: proceedings of the second international conference on Indo-Pacific fishes. Ichthyol. Soc. Japan, Tokyo.

Miya, M. and T. Nemoto. 1986b. Life history and vertical distribution of the mesopelagic fish *Cyclothone alba* (family Gonostomatidae) in Sagami Bay, central Japan. Deep-Sea Res., 33: 1053–1068.

Miya, M. and T. Nemoto. 1987a. Some aspects of the biology of the micronektonic fish *Cyclothone pallida* and *C. acclinidens* (family Gonostomatidae) in Sagami Bay, central Japan. J. Oceanogr. Soc. Japan, 42: 473–480.

Miya, M. and T. Nemoto. 1987b. Reproduction, growth and vertical distribution of the meso- and bathypelagic fish *Cyclothone atraria* (Pisces: Gonostomatidae) in Sagami Bay, central Japan. Deep-Sea Res., 34: 1565–1577.

Miya, M. and T. Nemoto. 1991. Comparative life histories of the meso- and bathypelagic fishes of the genus *Cyclothone* (Pisces: Gonostomatidae) in Sagami Bay, central Japan. Deep-Sea Res., 38: 67–89.

Miya, M., E. Higashitarumizu, T. Gonoi, T. Sunobe and K. Mochizuki. 1994a. Fishes of the Boso Peninsula, central Japan—I. Coastal fishes taken by set net off Ainohama, Tateyama. J. Natr. Hist. Mus. Inst., Chiba, 3: 109–118.

Miya, M., E. Higashitarumizu, T. Gonoi, T. Sunobe and K. Mochizuki. 1994b. Fishes of the Boso Peninsula, central Japan—II. Coastal fishes taken by set net off Chitose, Chikura. J. Natr. Hist. Mus. Inst., Chiba, 3: 119–128.

Miya, M., H. Toho and K. Mochizuki. 1995. Fishes of the Boso Peninsula, central Japan—III. Coastal and deep-sea fishes off Choshi. J. Natr. Hist. Mus. Inst., Chiba, 3: 195–215.

Mukhacheva, V. A. 1972. On systematics, distribution and biology of the *Gonostoma* species (Pisces, Gonostomatidae). Trudy Inst. Okeanol., 93: 203–249. (In Russian with English summary.)

Mukhacheva, V. A. 1974. Cyclothones (gen. *Cyclothone*, fam. Gonostomatidae) of the world and their distributions. Trudy Inst. Okeanol., 96: 205–249. (In Russian with English summary.)

Mukhacheva, V. A. 1980. Review of the genus *Ichthyococcus* Bonaparte (Photichthyidae). Voprosy Ikhtiol., 20: 771–786. (In Russian.)

Nafpaktitis, B. G., R. H. Backus, J. E. Craddock, R. L. Haedrich, B. H. Robison and C. Karnella. 1977. Fishes of the western North Atlantic. Part 7. Family Myctophidae. Mem. Sears Found. Mar. Res., (1): 13–265.

Nakabo, T. (ed.) 1993. Fishes of Japan with pictorial keys to the species. Tokai Univ. Press, Tokyo. xxxiv +1474 pp.

Nielsen, J., J. Badcock and N. R. Merrett. 1990. New data elucidating the taxonomy and ecology of the Parabrotulidae (Pisces: Zoarcoidei). J. Fish Biol., 37: 437–448.

Nielsen, J. G. and D. G. Smith. 1978. The eel family Nemichthyidae. Dana Rep., (88): 1–71, pls. 1–2.

Odate, S. 1966. Study on the fishes of the family Myctophidae in the northeastern sea area along the Pacific coast of Japan. III. Determination of the age and growth of the susukihadaka, *Myctophum affine* (Lütken). Bull. Tohoku Reg. Fish. Res. Lab., (26): 35–43. (In Japanese with English abstract.)

Odate, S. and T. Ogawa. 1961. Study on the fishes of the family Myctophidae in the northeastern sea area along the Pacific coast of Japan. Part II. Susuki-hadaka, *Myctophum affine* Temminck et Schlegel. Bull. Tohoku Reg. Fish. Res. Lab., (19): 90–97. (In Japanese with English abstract.)

Okiyama, M. 1971. Early life history of the gonostomatid fish, *Maurolicus muelleri* (Gmelin), in the Japan Sea. Bull. Japan Sea Reg. Fish. Res. Lab., (23): 21–53.

Parin, N. V. and N. S. Novikova. 1974. Taxonomy of viperfishes (Chauliodontidae, Osteichthyes) and their distribution in the world ocean. Trudy Inst. Okeanol., 96: 255–315. (In Russian with English summary.)

Parin, N. V. and A. S. Sokolovsky. 1976. Species composition of the family Melanostomiatidae in the Kuroshio current zone. Trudy Inst. Okeanol., 104: 237–249. (In Russian with English summary.)

Pearcy, W. G., T. Nemoto and M. Okiyama. 1979. Mesopelagic fishes of the Bering Sea and adjacent northern North Pacific Ocean. J. Oceanogr. Soc. Japan, 35: 127–135.

Pietsch, T. W. 1973. A new genus and species of deep-sea anglerfish (Pisces: Oneirodidae) from the northern Pacific Ocean. Copeia, 1973: 193–199.

Pietsch, T. W. 1974. Osteology and relationships of ceratioid anglerfishes of the family Oneirodidae, with a review of the genus *Oneirodes* Lütken. Nat. Hist. Mus. Los Angeles Co. Sci. Bull., (18): 1–113.

Pietsch, T. W. 1978. A new genus and species of ceratioid anglerfish from the North Pacific Ocean with a review of the allied genera *Ctenochirichthys*, *Chirophryne* and *Leptacanthichthys*. Contr. Sci. Nat. Hist. Mus. Los. Angeles Co., (297): 1–25.

Rass, T. S. and A. A. Kashkina. 1967. Bathylagid fishes of the northern Pacific (Pisces, Bathylagidae). Trudy Inst. Okeanol., 84: 209–221. (In Russian with English summary.)

Reid, S. B., J. Hirota, R. E. Young and L. E. Hallacher. 1991. Mesopelagic-boundary community in Hawaii: micronekton at the interface between neritic and oceanic ecosystems. Mar. Biol., 109: 427–440.

Rofen, R. R. 1966. Fishes of the western North Atlantic. Part 5. Family Paralepididae. Mem. Sears Found. Mar. Res., (1): 205–461.

Sazonov, Y. I. and A. N. Ivanov. 1980. Slickheads (Alepocephalidae and Leptochilichthyidae) from thalassobathyal zone of the Indian Ocean. Trudy Inst. Okeanol., 110: 7–104.

Shcherbachev, Y. N. and N. S. Novikova. 1976. Materials on distribution and taxonomy of the mesopelagic fishes of the family Stomiatidae (Osteichthyes). Trudy Inst. Okeanol., 104: 92–112. (In Russian with English summary.)

Sokolovsky, A. S. and T. G. Sokolovskaya. 1981. Species composition of the family Astronesthidae (Salmoniformes) in the north west Pacific. Voprosy Ikhtiol., 21: 248–252.

Sverdrup, H. U., M. W. Johnson and R. H. Fleming. 1942. The oceans: their physics, chemistry, and general biology. Prentice-Hall, Englewood Cliffs. xii+1087 pp.

Whittaker, R. H. and C. W. Fairbanks. 1958. A study of the plankton copepod communities in the Columbia Basin, southeastern Washington. Ecology, 39: 46–65.

Wisner, R. L. 1976. The taxonomy and distribution of lanternfishes (family Myctophidae) of the eastern Pacific Ocean. NORDA Rep., (3): 1–229.

Yang, S.-K., Y. Nagata, K. Taira and M. Kawabe. 1993. Southward intrusion of the intermediate Oyashio Water along the east coast of the Boso Peninsula. I. Coastal salinity-minimum layer water off the Boso Peninsula. J. Oceanogr., 49: 89–114.

Zurbrigg, R. E. and W. B. Scott. 1972. Evidence for expatriate population of the lanternfish *Myctophum punctatum* in the Northwest Atlantic. J. Fish. Res. Bd. Canada, 29: 1679–1683.

房総半島太平洋岸沖合の中・深層性魚類：種組成，豊度，生物量および生物地理学的特徴

宮　正樹・山口素臣・沖山宗雄

1991年9月に，房総半島太平洋岸沖合の7測点で網口幅3mのアイザックス・キッド中層トロールを用いた中・深層性魚類の傾斜曳採集を各1回行った．その結果，19科66種，計1860個体の魚類（仔魚を除く）が採集され，海面100 m^2 下あたりの豊度（個体数）と生物量（湿重量）はそれぞれ565個体と278gと推定された．これら魚類の圧倒的多数はヨコエソ科が占め (75%)，ハダカイワシ科 (20%)，カブトウオ科 (1.4%) およびムネエソ

科 (0.9%) がそれに続いた．一方，生物量ではハダカイワシ科が最も卓越し (47%)，ヨコエソ科 (42%)，カブトウオ科 (3.1%) およびソコイワシ科 (3.1%) がそれに続いた．これらのうち，ヨコエソ科のオニハダカ *Cyclothone atraria* が豊度と生物量の双方で最も卓越し，それぞれ 52% と 26% を占めた．採集された 66 種の魚類を分布あるいは豊度の中心と水塊との位置関係から，熱帯・亜熱帯種，亜寒帯種，広域種，陸棚種，および移行種に分けたところ，熱帯・亜熱帯種が圧倒的に多く（43 種），広域種（10 種），亜寒帯種（6 種），陸棚種（6 種）および移行種（1 種）がそれに続いた．また，移行種を除くこれら 4 つのすべてのカテゴリーが優占種（豊度）上位 6 種中に出現した．これら 6 種の体長組成と生殖に関する既往の知見を検討した結果，今回の調査海域は，熱帯・亜熱帯種，亜寒帯種，および陸棚種の繁殖個体群の周縁領域であることが示唆された．これは，黒潮の影響が強い表層，その下層にみられる亜寒帯系水の存在，そして陸棚に近いという調査海域の特性に由来するものと考えられた．

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