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Autumn Distribution of Epipelagic Fishes and Squids in the Okhotsk Sea and Western North Pacific Ocean off the Kuril Islands and Southeast Hokkaido

Kazuya NAGASAWA*[1], Yasuhiro UENO*[1], Junko SAKAI*[1,2], and Junta MORI*[1]

Surface-trawl surveys were conducted in the central and southern Okhotsk Sea and in the western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late November in 1996. A total of 33 fish species (one lamprey, two sharks, and 30 teleosts), 13 squid species, and some other unidentified species were collected. This paper describes and discusses the distribution patterns of abundant species. Salmonids (six species of the genus *Oncorhynchus*) were the most abundant (27% in number and 51% in weight of total catch), followed in number by mackerel (*Scomber* sp.), juvenile walleye pollock (*Theragra chalcogramma*), myctophids, juvenile arabesque greenling (*Pleurogrammus azonus*), and Japanese anchovy (*Engraulis japonicus*). Over 98% of the salmonids collected were ocean-age 0 juveniles. Pink (*O. gorbuscha*) and chum (*O. keta*) salmon juveniles predominated. Northern smoothtongue (*Leuroglossus schmidti*), Japanese sardine (*Sardinops melanostictus*), and various gonatid squids were also abundant. In early autumn (August to September), juvenile salmonids, juvenile arabesque greenling, and migratory warm-water species were segregated according to sea surface temperature (SST) in the Okhotsk Sea: the salmonids occurred in more northern waters than did the others. With decreasing SST during mid- and late autumn (October to November), most of the warm-water species migrated southerly to the North Pacific Ocean and juvenile arabesque greenling moved to coastal waters. Juvenile salmonids moved southward but remained in the Okhotsk Sea. Vertically migrating myctophids and bathylagids were abundant in the evening. Gonatid squids were also numerous in the evening catches. We conclude that the surface water of the Okhotsk Sea is constantly utilized by the species vertically migrating from deep waters and also provides habitats for feeding and growth to various warm-water species and juvenile arabesque greenling from summer to autumn and to juvenile salmonids from summer to autumn or winter.

Key words: ocean distribution, Pacific salmon, epipelagic fishes and squids, Okhotsk Sea, North Pacific Ocean

Introduction

Scientists of the National Research Institute of Far Seas Fisheries (NRIFSF) have been interested in the migration of juvenile Japanese salmonids (*Oncorhynchus* spp.) because the oceanic life of the fish after leaving coastal waters of northern Japan is poorly understood (cf. Irie, 1990). In the autumn of 1993, the first large scale surface-trawl survey was conducted in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands by the NRIFSF scientists on board the Fisheries Agency of Japan (FAJ) research vessel *Kaiyo maru*, and much information was obtained on the distribution and biology of salmonids in this region (Fisheries Agency of Japan, 1995). However, the survey period was confined to mid- and late autumn (from mid-October to late November), and more information was needed to fully understand the migration of Japanese salmonid juveniles from summer to autumn, especially in early autumn. Thus the NRIFSF scientists conducted the second large scale surface-trawl surveys using two FAJ research vessels, *Shunyo maru* and *Kaiyo maru* from late August to late September and from early October to late November in 1996, respectively, as a Japan and Russia cooperative project, in the central and southern Okhotsk Sea and in the western North Pacific Ocean off the Kuril Islands and southeast Hokkaido.

During these cruises, we collected many epipelagic fishes and squids as well as salmonids (Ueno and Sakai, 1997). The aims of the present paper are to clarify the distribution patterns of the epipelagic species based on the data collected from the early to late autumn of 1996 and to discuss the significance of the surface water of the Okhotsk Sea as habitats of the species collected.

Materials and Methods

Capture of Fishes and Squids

The survey period was divided into two seasons; early autumn (from late August to late September) and mid- and late autumn (from early October to late November). Catch per unit effort (CPUE) was calculated as the number of fish or squid caught by the trawling per hour to illustrate the distribution patterns of the species collected. Although Russian scientists

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*[1] National Research Institute of Far Seas Fisheries; 7-1, Orido 5-chome, Shimizu-shi, Shizuoka 424-8633, Japan.
*[2] Present address: National Research Institute of Fisheries Engineering; Ebidai, Hakachi-machi, Ibaraki 314-0421, Japan.

(e.g., Shuntov et al., 1986, 1988, 1996) used various catch coefficients for estimation of fishes, squids, and jellyfishes caught in trawls from the Okhotsk Sea and Pacific waters off the Kuril Islands, we did not apply such catch coefficients to the present study because exact values of those coefficients are unknown. Tows were usually made at two stations per day from the morning to the evening. No collection was made at night.

1. Early autumn cruise

The R/V *Shunyo maru*, a 47.8-m stern trawler (387 gross tons), used a surface rope trawl (NST-99-K1, 86 m long, 30-m headrope, 30-m groundrope, and cod end with 17-mm mesh). Fishing operations were conducted at 11 stations in the western North Pacific Ocean from September 7 to 11 and 25 to 30 and at 31 stations in the central and southern Okhotsk Sea from August 29 to September 7 and from September 11 to 21 (Fig. 1A). The trawl was towed horizontally in a layer ranging from the surface to ca. 30 m at ca. 5 knots for one hour.

2. Mid- and late autumn cruise

The R/V *Shunyo maru*, a 96-m stern trawler (2,630 gross tons), used a surface rope trawl (NST-60-K1, "spider net", 222 m long, 63.2-m headrope, 63.2-m groundrope, and cod end with 12-mm mesh). Fishing operations were conducted at 18 stations in the western North Pacific Ocean from October 6 to 15 and at 31 stations in the central and southern Okhotsk Sea from October 22 to November 31 (Fig. 1B). The trawl was towed horizontally in a layer from the surface to ca. 60 m at a mean speed of 5.8 knots (range: 5.2-6.5) for one hour.

Examination of Animals Caught

Soon after net retrieval, animals caught by the trawl were sorted by species, counted, and weighed. When a species was too abundant to count, its entire catch was weighed and the number was then estimated from a subsample. Fishes and squids were measured for standard length (SL) and dorsal mantle length (ML), respectively. The animals measured were weighed individually and frozen at -20℃ or -40℃ in covered aluminum trays for subsequent examination at the institute.

Scientific names used herein follow those recommended by Nakabo (1993) for fishes and Okutani (1991) for squids. English common names follow those given by Robins et al. (1991) and Amaoka et al. (1995) for fishes and Roper et al. (1984) for squids.

Oceanography

Oceanographic data were collected at all stations using CTD (0-500 m during the early autumn cruise, and 0-1,500 m during the mid- and late autumn cruise) or XCTD (0-1,000 m during the mid-and late autumn cruise). Additionally, XBT casts (0-760 m or 0-1,820 m) were made during the mid- and late autumn cruise.

Results and Discussion

Distribution of Sea Surface Temperature

During early autumn, sea surface temperature (SST) ranged from 11℃ to 18℃ in the western North Pacific Ocean off the Kuril Islands and southeast Hokkaido and from 11℃ to 16℃ in the Okhotsk Sea (Fig. 2A). Warm water higher than 15℃ (Soya Current) widely occurred off the southeast coast of Sakhalin. Relatively cold water between 11℃ and 14℃ (Oyashio Current) was distributed along the Kuril Islands. Another relatively cold water lower than 13℃ occurred in the central Okhotsk Sea.

During mid- and late autumn, SST markedly decreased in the Okhotsk Sea, ranging from 5℃ and 11℃ (Fig. 2B). Relatively warm water higher than 10℃ was restricted to the region off southeast

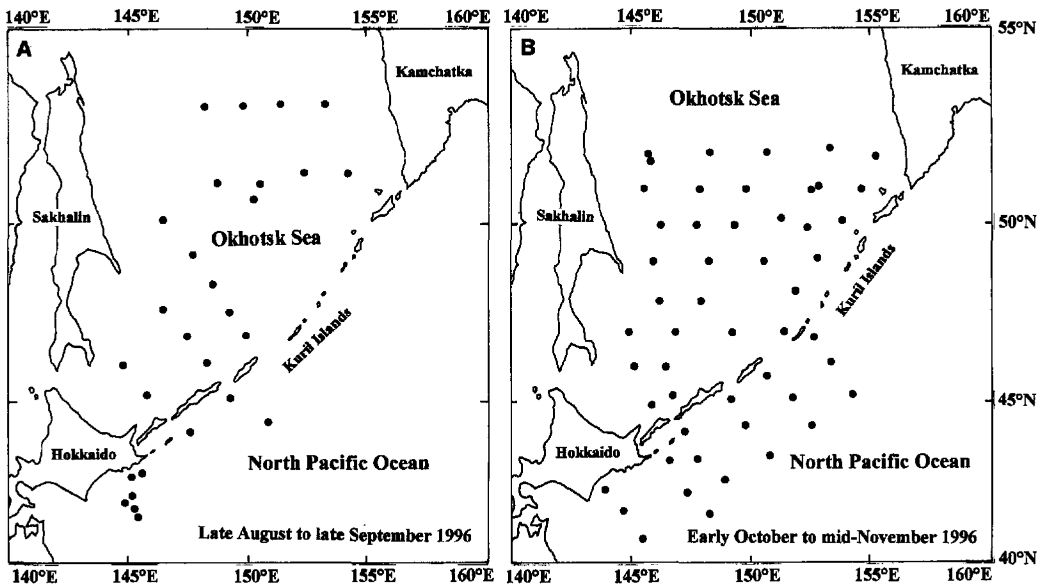

Fig. 1. Location of stations (closed dots) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido sampled by the R/V *Shunyo maru* from late August to late September (A) and by the R/V *Kaiyo maru* from early October to mid-November (B) in 1996.

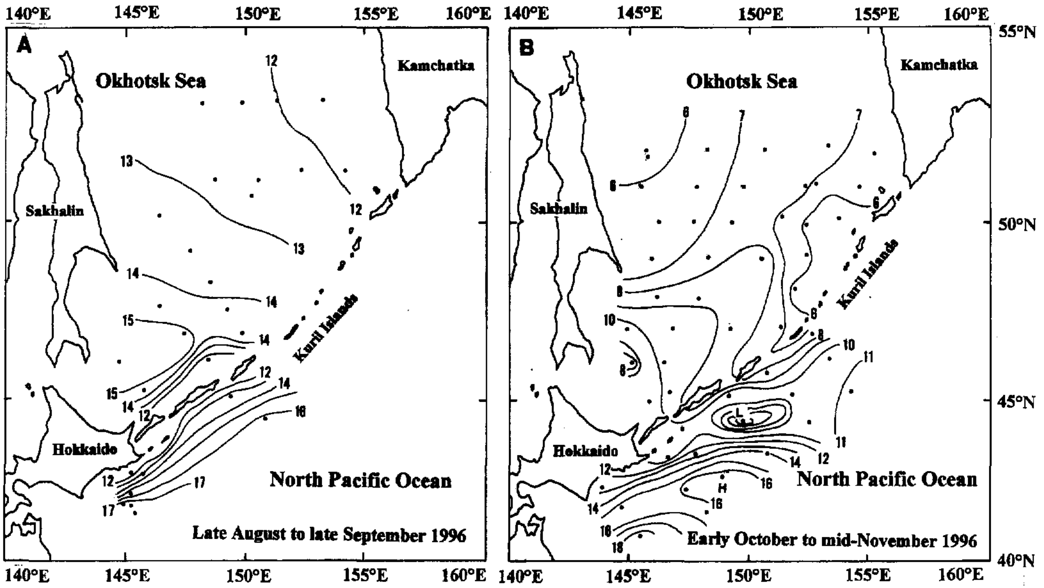

Fig. 2. Sea surface temperature (℃) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

Sakhalin. SST of the western North Pacific Ocean did not change as much as that of the Okhotsk Sea.

Abundance of Fishes and Squids

A total of 100,598 animals, excluding jellyfishes, were caught during the two cruises. Thirty-three fish species (one lamprey, two sharks, and 30 teleosts) and 13 squid species were identified to the species level (Appendix tables 1 and 2). The total catch weight (including jellyfishes) from the two cruises was 11,117.4 kg. No marine mammals and seabirds were captured.

Based on the number of individuals caught, salmonids (six species of the genus *Oncorhynchus*, see below) were the most numerous (n=26,853; 26.69% of the total catch), followed by mackerel (*Scomber* sp., n=16,864; 16.76%), walleye pollock (*Theragra chalcogramma*, n=16,262; 16.17%), myctophids (three species, n=14,163; 14.08%), arabesque greenling (*Pleurogrammus azonus*, n=7,172; 7.13%), and Japanese anchovy (*Engraulis japonicus*, n=7,090; 7.05%)(Appendix table 1). Northern smoothtongue (*Leuroglossus schmidti*, n=4,274; 4.25%), Japanese sardine (*Sardinops melanostictus*, n=2,440; 2.43%), and various gonatid squids (seven species, n=2,851; 2.83%) were also numerous. The catch of these numerous species (n=98,969) comprised over 98% of the total catch. In addition to these species, commercially important species, e.g., Pacific saury (*Cololabis saira*, n=1,427; 1.42%), Japanese flying squid (*Todarodes pacificus pacificus*, n=260; 0.26%), and neon flying squid (*Ommastrephes bartrami*, n=126; 0.13%), were caught.

Based on the weight of individuals caught, salmonids (six species combined) reached 51.02% of the total weight (Appendix table 2). Mackerel were the second most abundant (2,008.8 kg, 18.07%), followed by walleye pollock (823.3 kg, 7.41%) and arabesque greenling (518.0 kg, 4.66%). Jellyfishes (1,007.3 kg, 9.06%) were also abundantly collected, in particular in early autumn. Due to their small size, the percentages of myctophids, Japanese anchovy, northern smoothtongue, and gonatid squids remained at low levels, although these species were numerous in the catches.

General Distribution Patterns of Epipelagic Species

In early autumn, juvenile salmonids and other fishes occurred in different areas (Fig. 3): the salmonids were restricted to northern cold waters (SST<13℃) in the Okhotsk Sea off the west coast of Kamchatka, but juvenile arabesque greenling were distributed south of the cold waters (SST=13℃-15℃). Migratory warm-water species, such as mackerel, Japanese anchovy, Japanese sardine, and Japanese flying squid, occurred abundantly in the southern Okhotsk Sea off northeast Hokkaido and in the North Pacific Ocean off southeast Hokkaido and the Kuril Islands. This is apparently due to differences in preferred water temperature between the species.

With decreasing SST during mid- and late autumn, most of the warm-water species migrated southerly to the North Pacific Ocean and juvenile arabesque greenling moved to coastal waters. Juvenile salmonids moved southward but remained in the Okhotsk Sea. According to Ueno and Sakai (1997), the salmonids were widely distributed in the central and southern Okhotsk Sea (SST= 4℃-15℃, mostly <8℃).

Distribution of Abundant Species

Salmonids (*Oncorhynchus* spp.)

Six species of salmonids were collected: pink salmon (*O. gorbuscha*) were the most numerous (n=18,392; 18.28% of the total catch), followed by chum salmon (*O. keta*, n=7,740; 7.69%), sockeye salmon (*O. nerka*, n=479; 0.48%), coho salmon (*O. kisutch*, n=95; 0.09%), masu salmon (*O. masou masou*, n=80; 0.08%), and chinook salmon (*O. tshawytscha*, n=67; 0.07%). Most of the salmonids collected were ocean-age 0 juveniles (n=26,319; 98.01% of the

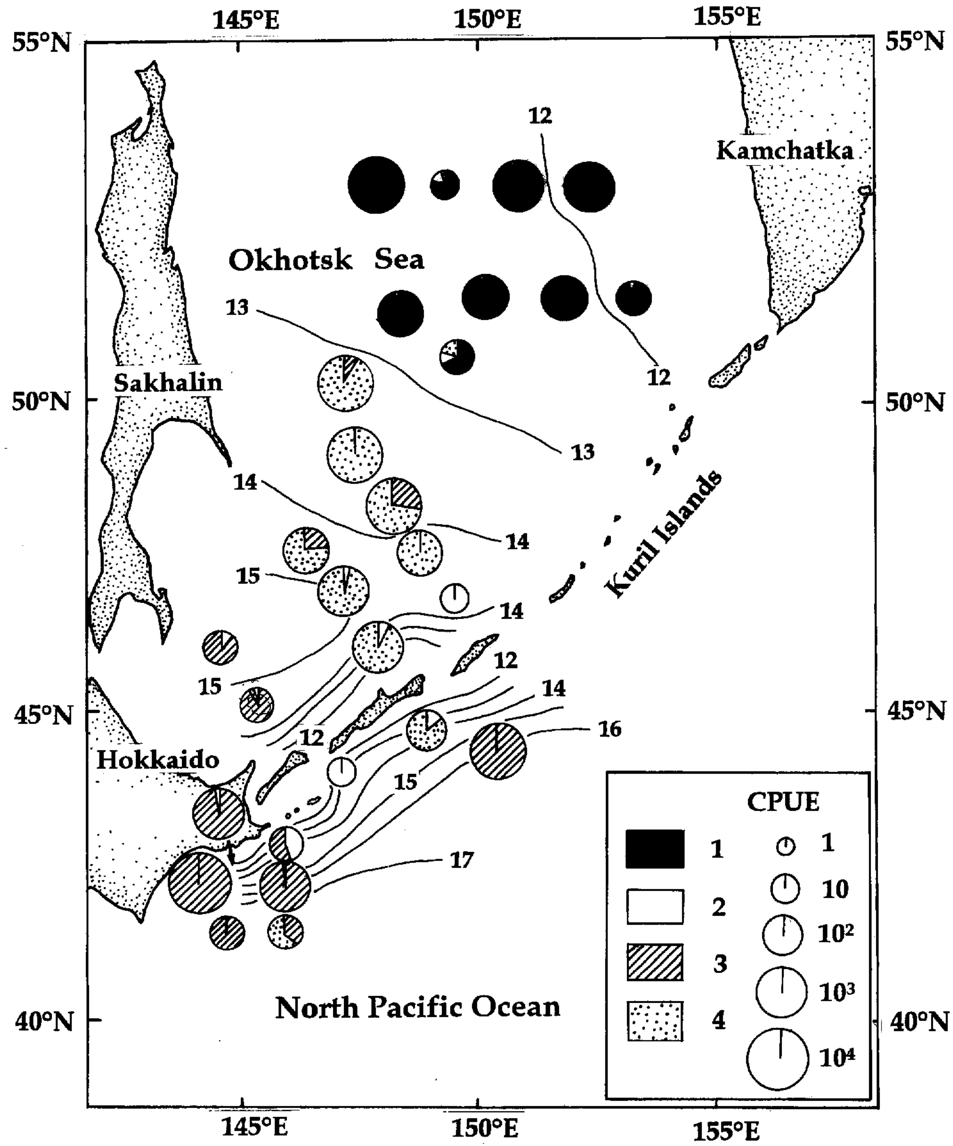

Fig. 3. Sea surface temperature (℃) and CPUE distribution (number of fish caught per hour) of epipelagic species in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September in 1996. 1, juvenile salmonids (*Oncorhynchus* spp.); 2, immature and adult salmonids; 3, migratory warm-water species (mackerel [*Scomber* sp.], Japanese anchovy [*Engraulis japonicus*], Japanese sardine [*Sardinops melanostictus*], Pacific saury (*Cololabis saira*), Japanese flying squid [*Todarodes pacificus pacificus*], neon flying squid [*Ommastrephes bartrami*]); 4, arabesque greenling (*Pleurogrammus azonus*) and others.

salmonid catch). Pink and chum salmon reached 28.29% and 19.56% in weight of the total catch, respectively. Salmonid juveniles were collected only in the Okhotsk Sea.

The distribution of the salmonids has been reported by Ueno and Sakai (1997): juvenile chum, pink, coho, and masu salmon occurred in the central and southern parts of the Okhotsk Sea, whereas juvenile sockeye salmon were found off southwest Kamchatka. Detailed information on the SST-related occurrence, abundance, and fish size of each species is available from Ueno and Sakai (1997). Salmonid juveniles are known to occur in offshore waters of the Okhotsk Sea from summer to autumn or winter (Birman, 1969; Takagi et al., 1981; Machidori and Kato, 1984; Shuntov, 1989, 1994; Naito and Ueno, 1995; Ueno and Ishida, 1996; Lapko and Startsev, 1996; Radchenko et al., 1997).

Japanese sardine (*Sardinops melanostictus*)

In early autumn, the species was abundantly collected at two stations of Pacific waters off southeast Iturup Island and Hokkaido but was not taken in the Okhotsk Sea (Fig. 4). No fish were captured in mid- and late autumn.

Annual changes in population size of Japanese sardine in the Far East have affected its distribution and abundance in the western North Pacific Ocean and southern Okhotsk Sea. When its abundance was high, the species was collected numerously off southeast Hokkaido (Kenya, 1982; Wada, 1988) and in the southern Okhotsk Sea (Yamaguchi and Yamagishi, 1990). With decreasing abundance, however, the species was not found in the Okhotsk Sea, whereas it occurred in coastal Pacific waters along the Kuril Islands (Shuntov et al., 1993, 1994, 1996).

The fact that Japanese sardine were not caught in

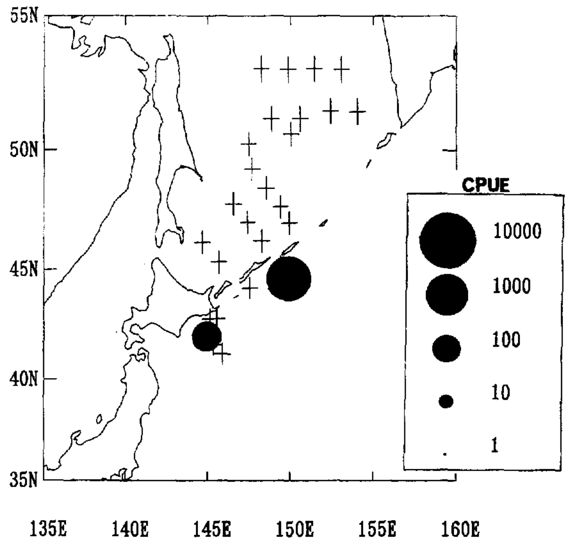

Fig. 4. CPUE distribution (number of fish caught per hour) of Japanese sardine (*Sardinops melanostictus*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September in 1996.

mid- and late autumn was caused by the southward migration of Japanese sardine to southern waters. Nagasawa (1984a, 1984b) indicated that this species moves southerly off the southeast coast of Hokkaido in October.

Japanese anchovy (*Engraulis japonicus*)

The species was abundantly caught off southeast Hokkaido in both early and mid/late autumn, and some fish were taken along the Kuril Islands (Fig. 5A, 5B). No fish were captured in the offshore Okhotsk Sea (Fig. 5B).

Nagasawa et al. (1996) collected this species using a surface trawl net of the research vessel *Kaiyo maru* at nearly same locations in October 1993. There are some other previous records of the species from coastal Okhotsk and Pacific waters off Hokkaido and the Kuril Islands (Ueno et al., 1990, 1992; Yamaguchi and Yamagishi, 1990; Shuntov et al., 1993, 1994, 1996; Mihara, 1994; Chuchukalo et al., 1995). Shuntov et al. (1994, 1996) reported that the species was more abundant in coastal Pacific waters than in the coastal Okhotsk Sea. It feeds mainly on euphausiids in the southern Okhotsk Sea (Chuchukalo et al., 1995).

Northern smoothtongue (*Leuroglossus schmidti*)

The species was collected in mid- and late autumn in the Okhotsk Sea, especially abundantly in the northern part of the survey area (Fig. 6A). The fish collected ranged from 40 to 155 mm SL. No fish were collected in the North Pacific Ocean.

It is known that this species is very abundant in the southern Okhotsk Sea (Gorbatenko and Cheblukova, 1990; Shuntov et al., 1990, 1993, 1994; Balanov and Il'inskii, 1992; Lapko, 1995; Nagasawa et al., 1996). The species occurs in the western North Pacific Ocean as well, but its abundance is much higher in the Okhotsk Sea (Shuntov et al., 1994; Nagasawa et al., 1996).

Samplings were made at different times of day, excluding night, during the present study. The species was caught only in the evening. This is probably because the species migrates from deep to surface waters in the evening. Sobolevskii and Sokolovskaya (1993) caught the species in epipelagic waters off the Pacific coast of Kamchatka in the evening and at night.

Myctophids

Myctophids were the third highest in number caught in mid- and late autumn (Appendix table 1), although only four fish were collected in early autumn. The myctophids collected in mid-autumn were identified as three species, i.e., northern lampfish (*Stenobrachius leucopsarus*), North Pacific lanternfish (*Tarletonbeania taylori*), and California headlightfish (*Diaphus theta*). The most abundant species was northern lampfish, which occurred in the Okhotsk Sea (Fig. 6B). The fish ranged from 40 to 88 mm SL. North Pacific lanternfish and California headlightfish were collected in the western North Pacific Ocean off the central Kuril Islands (Fig. 6C, 6D), and the latter species was taken

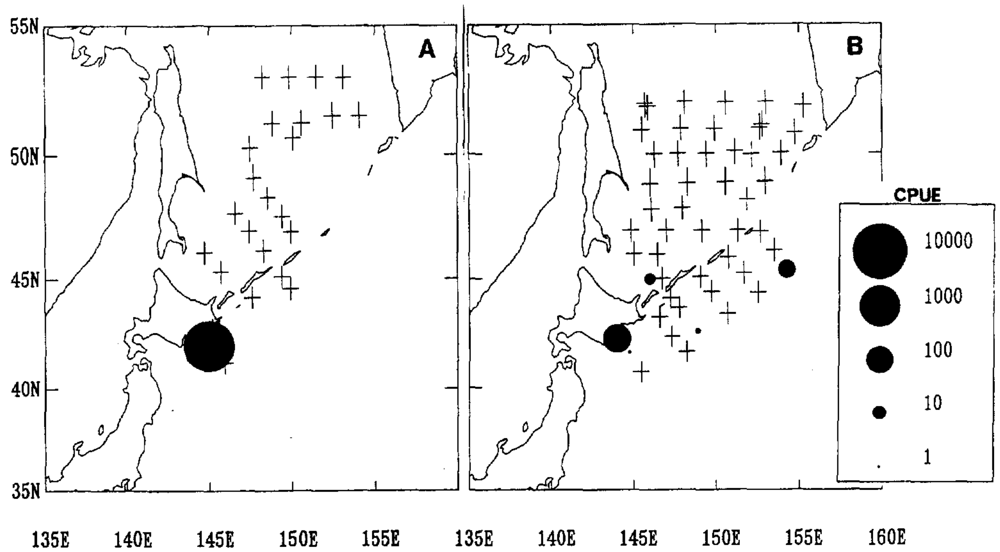

Fig. 5. CPUE distribution (number of fish caught per hour) of Japanese anchovy (*Engraulis japonicus*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

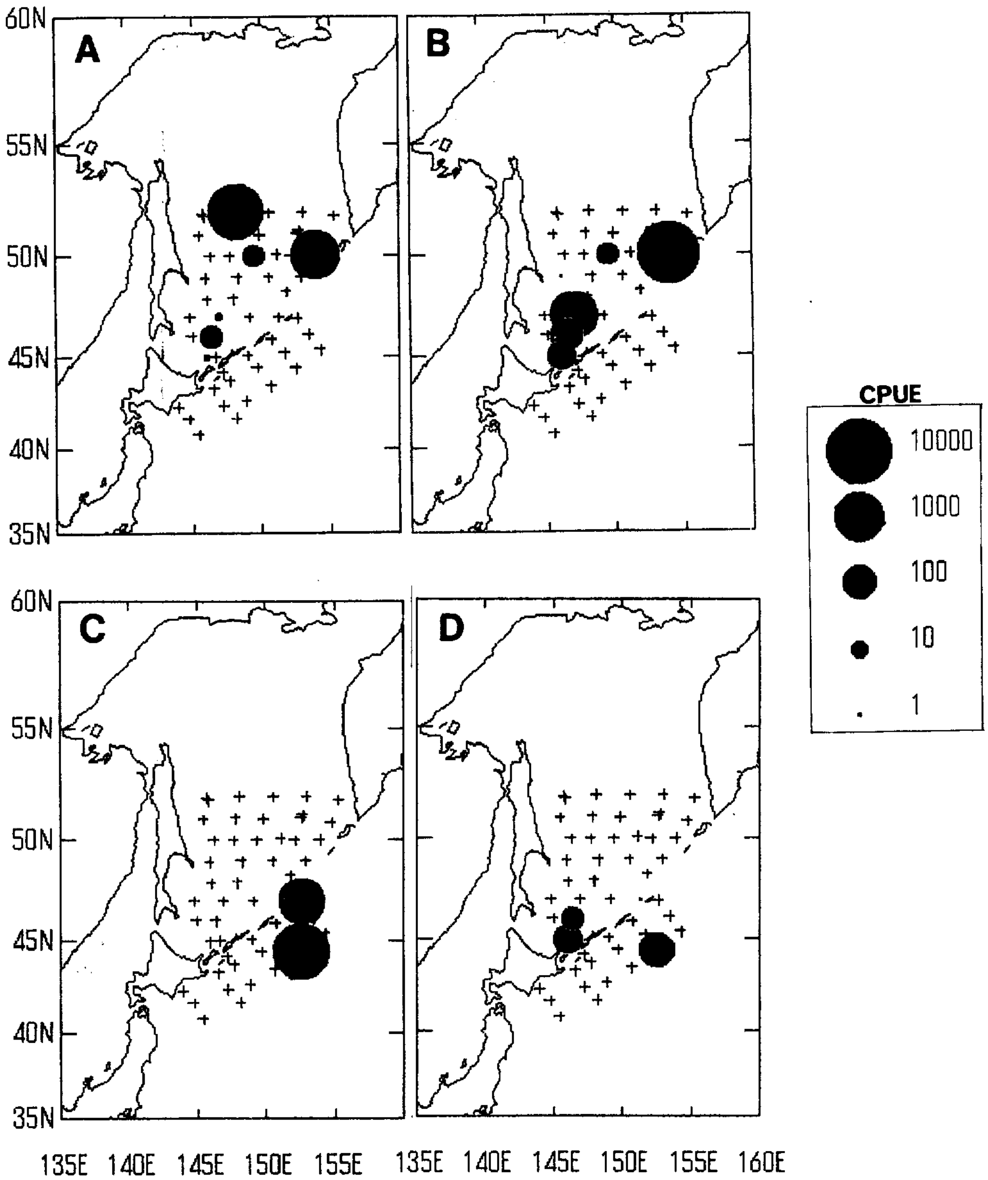

Fig. 6. CPUE distribution (number of fish caught per hour) of bathylagids and myctophids in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from early October to mid-November in 1996. A, northern smoothtongue (*Leuroglossus schmidti*); B, northern lampfish (*Stenobrachius leucopsarus*); C, North Pacific lanternfish (*Tarletonbeania taylori*); D, California headlightfish (*Diaphus theta*).

in the southernmost region of the Okhotsk Sea as well (Fig. 6D). As myctophids were caught mainly in the evening, due to the diel vertical migration to surface waters, it is highly likely that these distribution patterns were biased by sampling time of day.

Myctophids are extremely abundant in the study region (Shuntov et al., 1993, 1994, 1996; Lapko, 1995; Ivanov, 1997). Several species, including *S. leucopsarus, D. theta, T. taylori* [as *T. crenularis*], *Notoscopelus japonicus*, and *Ceratoscopelus warmingi*, are known to occur in trawl catches from surface waters of the western North Pacific Ocean off the Kuril Islands (Shuntov et al., 1993). The age and growth of California headlightfish caught from this region has been reported by Ivanov and Lapko (1993).

Walleye pollock *(Theragra chalcogramma)*

Although only three walleye pollock were taken in early autumn, the species was abundantly collected in mid- and late autumn. Fish occurred in waters lower than 7℃ SST at five stations off southwest Kamchatka and at one station off east Sakhalin (Fig. 7). In particular, over 16,000 fish were collected only at one station off southwest Kamchatka, where the fish were exclusively juveniles (150-210 mm SL). Some large fish (450-610 mm SL) were collected at other stations. No fish were captured in the western North Pacific Ocean.

Walleye pollock were exclusively predominant in epipelagic waters of the Okhotsk Sea in 1980s, especially in waters from 50° N to 55° N (Gorbatenko and Cheblukova, 1990; Shuntov et al., 1990). However, our catch from the epipelagic waters was small, indicating that the population size currently has decreased and remained low, which also has been suggested by Russian scientists (e.g., Lapko, 1995;

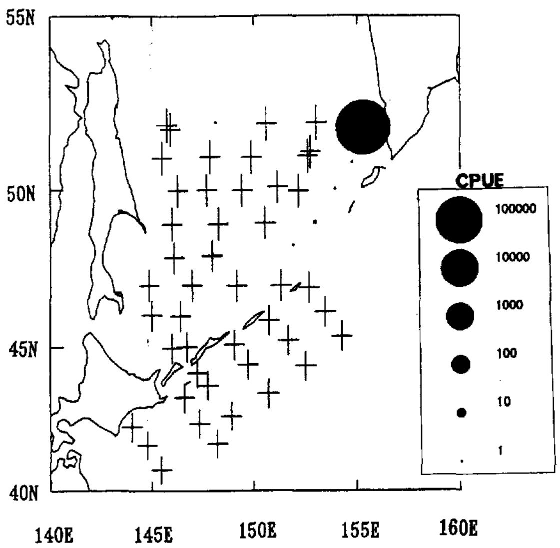

Fig. 7. CPUE distribution (number of fish caught per hour) of walleye pollock (*Theragra chalcogramma*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from early October to mid-November in 1996.

Shuntov et al., 1996). On the other hand, the observed high abundance of juvenile walleye pollock occurring off southwest Kamchatka is in accordance with the past reports by Temnykh (1989, 1990).

Pacific saury (*Cololabis saira*)

There was a marked difference in distribution of Pacific saury between early and mid/late autumn: the species was found in offshore waters (SST>13℃) of the Okhotsk Sea in early autumn (Fig. 8A), but there were a few catches in the southern Okhotsk Sea in mid- and late autumn, when it was abundant in Pacific waters off the Kuril Islands (Fig. 8B). The fish collected in the latter season ranged from 160 to 310 (mostly 200-280) mm SL.

The disappearance of Pacific saury from the Okhotsk Sea in mid- and late autumn is the result of its southward migration to the North Pacific Ocean with decreasing SST (Kobayashi et al., 1968).

Arabesque greenling (*Pleurogrammus azonus*) and Atka mackerel (*P. monopterygius*)

Arabesque greenling were caught only in the Okhotsk Sea. Fish occurred in offshore waters in early autumn (Fig. 9A) but were found mostly in coastal waters in mid- and late autumn (Fig. 9B). SSTs at the stations with high catches were 13℃-15℃ for early autumn and 8℃-10℃ for mid- and late autumn. The fish collected in mid- and late autumn were juveniles of 175-230 (mostly 200-220) mm SL.

Nagasawa et al. (1996) found that the species occurred in surface waters of the Okhotsk Sea from mid-October to early November but subsequently disappeared from the waters. The authors suggested that the species moves to the continental shelf with decreasing SST. Shimazaki and Kyushin (1982) made a similar suggestion. Mel'nikov (1996) also reported based on trawl surveys that juvenile arabesque greenling occur in surface waters of the southern Okhotsk Sea in summer and move to bottom waters in autumn. It thus appears that the distributional shift of the species from early to mid/late autumn found in the present study is due to its migration from offshore to coastal waters before settlement on the continental shelf.

It has been suggested that the population size of arabesque greenling in the Okhotsk Sea remained at a low level in the 1980s (Nagasawa et al., 1996) but has increased in the 1990s (Mel'nikov, 1996). Nagasawa et al. (1996) suggested a possibility to estimate a possible coastal catch of the species in Hokkaido waters based on its offshore abundance. The species is known to feed heavily on copepods in the southern Okhotsk Sea (Chuchukalo et al., 1995).

Although Atka mackerel were caught in the autumn of 1993 (Nagasawa et al., 1996), a small number of fish were taken during the present study. The stomach contents of this species from waters off the northern Kuril Islands were currently reported by Orlov (1997a) and Onishchik (1997).

Pacific pomfret (*Brama japonica*)

The species was caught in coastal waters of

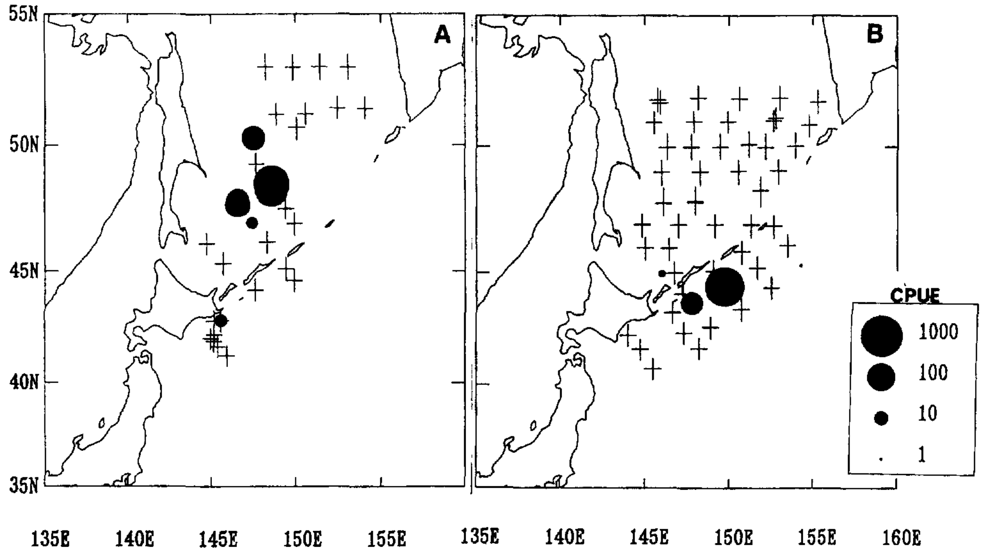

Fig. 8. CPUE distribution (number of fish caught per hour) of Pacific saury (*Cololabis saira*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

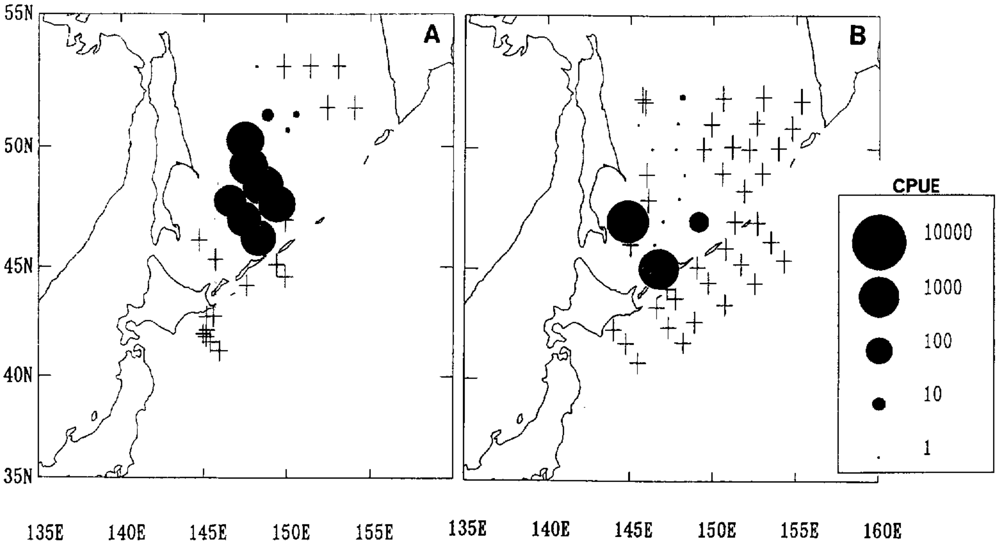

Fig. 9. CPUE distribution (number of fish caught per hour) of arabesque greenling (*Pleurogrammus azonus*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

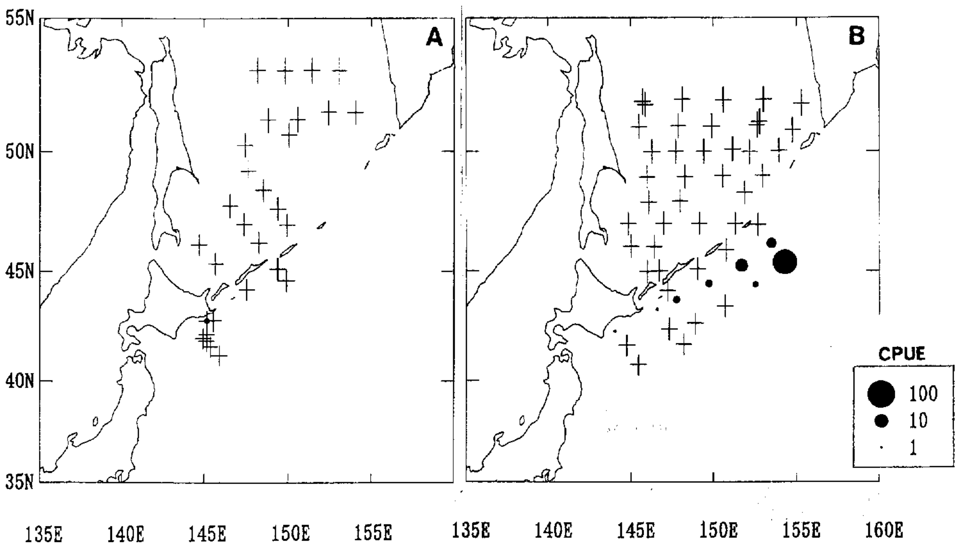

Fig. 10. CPUE distribution (number of fish caught per hour) of Pacific pomfret (*Brama japonica*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

southeast Hokkaido in early autumn (Fig. 10A) and in neritic Pacific waters near the Kuril Islands in mid- and late autumn (Fig. 10B). No fish were taken in the Okhotsk Sea.

It has been reported that Pacific pomfret are abundant in Pacific waters off the Kuril Islands in summer (Shuntov et al., 1993, 1994, 1996). The species is a seasonal migrant between subtropical and subarctic waters and arrives in coastal waters of southeast Hokkaido and the Kuril Islands in August and September (Machidori and Nakamura, 1971; Wada and Murata, 1985; Savinykh, 1994). The food of Pacific pomfret caught in the western North Pacific Ocean was reported by Wada and Honda (1992) and Savinykh and Chuchukalo (1996).

Mackerel (*Scomber* sp.)

The species caught in the present study was exclusively chub mackerel (*Scomber japonicus*). From the body color pattern and the number of dorsal fin rays, however, it is likely that the fish collected included another species, spotted mackerel (*Scomber australasicus*). Thus we herein use *Scomber* sp. as a scientific name.

Mackerel were collected in the North Pacific Ocean off southeast Hokkaido and the Kuril Islands in early autumn (Fig. 11A). Fish were very abundant off southeast Hokkaido in mid- and late autumn (Fig. 11B). No fish were captured in the Okhotsk Sea.

Chub mackerel are known to conduct a seasonal migration and to stay and feed in waters near Hokkaido and the Kuril Islands in summer and autumn (Usami, 1973; Murakami, 1978). However, due to its low abundance in waters around Japan, the species was not commercially caught in the 1980s and early 1990s in the study region. Russian scientists also did not list this species in their reports from surveys conducted in early 1990s in Pacific waters off the Kuril Islands (Shuntov

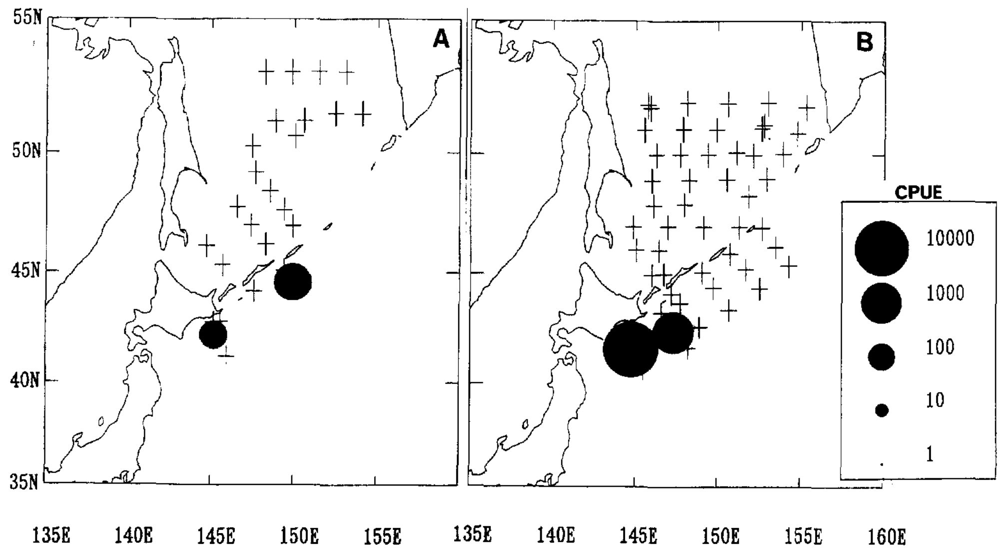

Fig. 11. CPUE distribution (number of fish caught per hour) of mackerel (*Scomber* sp.) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

et al., 1993, 1994, 1996). Our present collection shows that some fish migrate north to waters near Hokkaido and the Kuril Islands even though the population level of the species remains at a low level.

Boreopacific gonate squid (*Gonatopsis borealis*) and other gonatids

Squids of the family Gonatidae were abundantly caught in mid- and late autumn. Boreopacific gonate squid were caught, mainly in the evening, in the Okhotsk Sea (Fig. 12A). The squid ranged from 35 to 135 mm ML. Other gonatids included *Gonatus middendorffii, G. berryi, G. onyx, Gonatopsis makko, Berryteuthis magister*, and *B. anonychus*. These gonatids were collected in the North Pacific Ocean off the Kuril Islands but some were taken in the Okhotsk Sea (Fig. 12B). The gonatids (species combined) ranged from 60 to 165 mm ML.

Boreopacific gonate squid is a subarctic species found in the northern North Pacific Ocean and adjacent seas (Okutani et al., 1988). It has been reported from the Okhotsk Sea (Naito et al., 1977; Shuntov et al., 1993; Nagasawa et al., 1996) and Pacific waters off the Kuril Islands (Naito et al., 1977; Shuntov et al., 1993). Ivanov (1997) found that the species is extremely abundant in mesopelagic Pacific waters off the Kuril Islands. He recognized nine known and two uncertain species of gonatids from this region.

Japanese flying squid (*Todarodes pacificus pacificus*) and neon flying squid (*Ommastrephes bartrami*)

Japanese flying squid were collected in the southern Okhotsk Sea and off southeast Hokkaido in early and mid/late autumn (Fig. 13A, 13B). In early autumn, one squid was caught as far north as 50°15'N in the Okhotsk Sea (Fig. 13A). Neon flying squid were taken in the North Pacific Ocean off Iturup Island in early autumn. There was no catch of this species in the Okhotsk Sea.

The Japanese flying squid is a typical seasonal

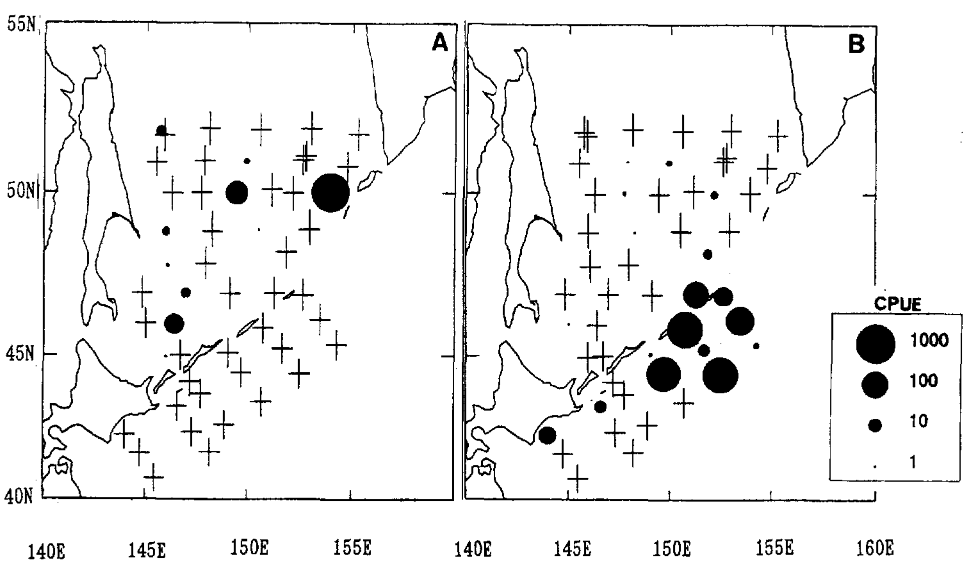

Fig. 12. CPUE distribution (number of squid caught per hour) of gonatids in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from early October to mid-November in 1996. A, boreopacific gonate squid (*Gonatopsis borealis*); B, other gonatids.

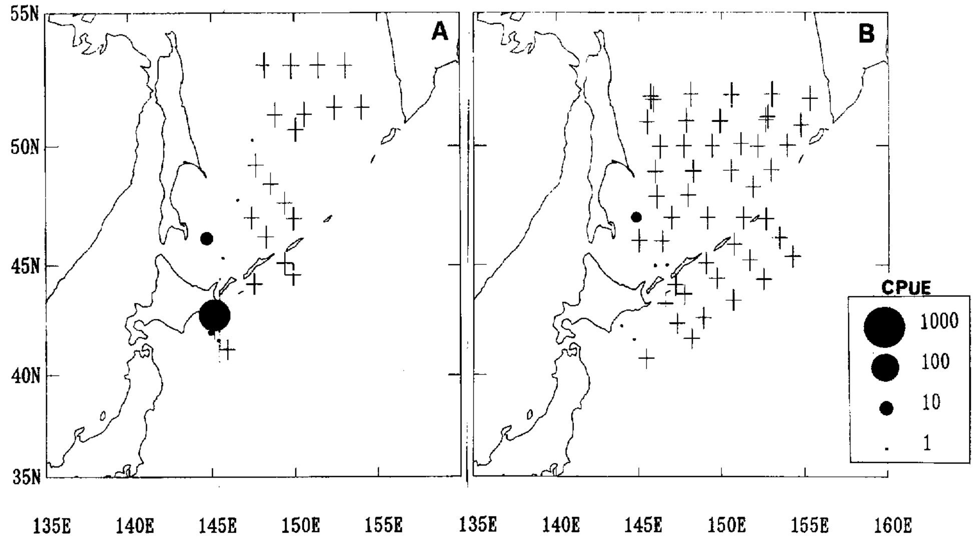

Fig. 13. CPUE distribution (number of fish caught per hour) of Japanese flying squid (*Todarodes pacificus pacificus*) in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands and southeast Hokkaido from late August to late September (A) and from early October to mid-November (B) in 1996.

migrant. Northward migrating immature squid enter the Okhotsk Sea in summer and, with decreasing SST in autumn, return to the Japan Sea or the North Pacific Ocean for spawning (Araya, 1967). Unlike this species, the neon flying squid does not migrate to the Okhotsk Sea. Biological information on the latter species from the western North Pacific Ocean is available from Murata (1990).

General Discussion and Conclusions

The present study showed that juvenile salmonids, juvenile arabesque greenling, and some migratory warmed-water species occurred in the Okhotsk Sea in early autumn. These species are planktivorous and can utilize abundant zooplankton as prey in the Okhotsk Sea. With decreasing SST in mid- and late autumn, warm-water species migrated southerly to the North Pacific Ocean and juvenile arabesque greenling moved to coastal waters. Juvenile salmonids also moved southward but remained in the Okhotsk Sea. Nagasawa et al. (1996) suggested that the Okhotsk Sea is an important feeding area of various epipelagic fishes and squids from summer to autumn, which was confirmed by the present study. However, as young masu salmon migrate from the Okhotsk Sea to the Japan Sea or the North Pacific Ocean in November (Machidori and Kato, 1984) but juvenile pink salmon occur in the southern Okhotsk Sea even in winter and early spring (December to March)(Shuntov, 1994), it appears that the season when salmonids migrate out of the Okhotsk Sea differs between the species.

Recent works by Russian scientists have greatly contributed to understanding of biological production in the Okhotsk Sea and western North Pacific Ocean (e.g., Shuntov, 1986, 1988; Shuntov et al., 1986, 1988, 1990, 1993, 1994, 1996; Gorbatenko and Cheblukova, 1990; Shuntov and Dulepova, 1991; Dulepova, 1991, 1994, 1996; Lapko, 1994, 1995; Orlov, 1997b; Radchenko et al., 1997). Nevertheless, we need more information about the ocean productivity in this region. For example, vertically migrating myctophids and bathylagids were highly abundant in the surface water in the evening. Gonatid squids were also numerous in the evening catches. A large amount of mesopelagic fishes and squids are known to occur in the North Pacific Ocean off the Kuril Islands (Ivanov, 1997) and some of the species migrate to the surface water at night. The zooplankton consumption by such species in the surface water and energy transfer to deep waters appears quite large (cf. Lapko, 1995). Vertically migrating species are not commercially important, but we should do more work on the species from a viewpoint of ocean ecosystem.

In conclusion, the surface water of the Okhotsk Sea is constantly utilized by the species vertically migrating from deep waters and also provides habitats for feeding and growth to various warm-water species and juvenile arabesque greenling from summer to autumn and to juvenile salmonids from summer to autumn or winter. More work on the vertically migrating species is needed to elucidate their role in the ocean ecosystem of the study region.

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(* These references could not be directly referred to.)

Appendix table 1. Abundance (% in number) of fishes, squids, and other animals collected in surface-trawls in the Okhotsk Sea and western North Pacific Ocean in the early and mid-autumn of 1996.

Scientific name	English common name	Japanese common name	Percent abundance		
			early autumn (n=18,565)	mid-autumn (n=82,033)	total (n=100,598)
Lethenteron japonicum	Arctic lamprey	kawayatsume	0.02	< 0.01	< 0.01
Prionace glauca	blue shark	yoshikirizame	-	< 0.01	< 0.01
Squalus acanthias	spiny dogfish	aburatsunozame	-	< 0.01	< 0.01
Elopiformes (leptocephalus)	unidentified juvenile	karaiwashi-rui	-	< 0.01	< 0.01
Clupea pallasii	Pacific herring	nishin	-	< 0.01	< 0.01
Sardinops melanostictus	Japanese sardine	maiwashi	13.14	-	2.43
Engraulis japonicus	Japanese anchovy	katakuchi-iwashi	37.23	0.22	7.05
Leuroglossus schmidti	northern smoothtongue	togari-ichimonji-iwashi	-	5.21	4.25
Liolagus ochotensis	Okhotsk deepsea smelt	sokoiwashi	-	0.47	0.38
Oncorhynchus nerka	sockeye salmon	benizake	0.01	0.58	0.48
Oncorhynchus keta	chum salmon	sake	5.74	8.14	7.69
Oncorhynchus gorbuscha	pink salmon	karafutomasu	9.59	20.25	18.28
Oncorhynchus kisutch	coho salmon	ginzake	0.02	0.11	0.09
Oncorhynchus tshawytscha	chinook salmon	masunosuke	0.02	0.08	0.07
Oncorhynchus masou masou	masu salmon	sakuramasu	0.05	0.09	0.08
Gonostomatoidei	bristlemouths	yoko-eso-rui	-	< 0.01	< 0.01
Sternoptychinae	marine hatchetfish	mune-eso-rui	-	< 0.01	< 0.01
Paralepididae	barracudina	hadaka-eso-rui	-	0.01	0.01
Alepisaurus ferox	longnose lancetfish	mizu-uo	-	< 0.01	< 0.01
Anotopterus pharao	daggertooth	mizu-uo-damashi	0.01	0.01	0.01
Tarletonbeania taylori	North Pacific lanternfish	hokuyouhadaka	-	5.49	4.48
Stenobrachius leucopsarus	northern lampfish	kohirehadaka	-	11.40	9.30
Diaphus theta	California headlightfish	todohadaka	-	0.38	0.31
Myctophidae	unidentified myctophids	hadakaiwashi-rui	0.02	-	< 0.01
Theragra chalcogramma	walleye pollock	suketoudara	0.02	19.82	16.17
Cololabis saira	Pacific saury	sanma	3.09	1.04	1.42
Gasterosteus aculeatus aculeatus	threespine stickleback	itoyo	-	0.06	0.05
Anoplopoma fimbria	sablefish	gindara	-	< 0.01	< 0.01
Pleurogrammus azonus	arabesque greenling	hokke	24.17	3.27	7.13
Pleurogrammus monopterygius	Atka mackerel	kitanohokke	-	< 0.01	< 0.01
Blepsias bilobus	crested sculpin	hokakeanahaze	0.02	0.01	0.01

Appendix table 1. Continued.

Scientific name	English common name	Japanese common name	Percent abundance		
			early autumn (n=18,565)	mid-autumn (n=82,033)	total (n=100,598)
Eumicrotremus birulai	Siberian lumsucker	konpeito	-	< 0.01	< 0.01
Eumicrotremus sp.	unidentified lumpsucker	ibodangouo-rui	0.01	-	< 0.01
Aptocyclus ventricosus	smooth lumpsucker	hoteiuo	-	< 0.01	< 0.01
Brama japonica	Pacific pomfret	shimagatsuo	0.02	0.12	0.10
Bothrocarina microcephala	silvery eelpout	kamutyakka-genge	-	< 0.01	< 0.01
Anarhichas orientalis	Bering wolffish	ookamiuo	0.01	-	< 0.01
Zaprora silenus	prowfish	bouzuginpo	0.01	0.01	0.01
Scomber sp.	mackerel	saba-rui	4.35	19.57	16.77
Xiphias gladius	swordfish	mekajiki	0.01	-	< 0.01
Pleuronectidae	unidentified flounder	karei-rui	-	< 0.01	< 0.01
Euprymna morseri	mimika bobtail	mimi-ika	-	0.04	0.03
Abralipopsis felis	-*	kariforunia-hotaruika	-	< 0.01	< 0.01
Watasenia scintillans	sparkling enope squid	hotaruika	-	0.01	0.01
Enoploteuthidae	enope squids	hotaruika-rui	-	0.08	0.06
Moroteuthis robustus	robust clubhook squid	nyudoika	-	< 0.01	< 0.01
Gonatopsis borealis	boreopacific gonate squid	takoika	-	1.08	0.88
Gonotopsis makko	mako gonate squid	makko-takoika	-	0.02	0.02
Gonatus onyx	-	tekagi-ika	-	< 0.01	< 0.01
Gonatus berryi	-	Beri-tekagi-ika	-	< 0.01	< 0.01
Gonatus middendorfii	shortarm gonate squid	kamutyakka-tekagi-ika	-	0.10	0.08
Berryteuthis magister	schoolmaster gonate squid	dosuika	-	< 0.01	< 0.01
Berryteuthis anonychus	-	himedosuika	-	< 0.01	< 0.01
Gonatidae	unidentified gonatids	tekagi-ika-rui	0.46	2.27	1.94
Todarodes pacificus pacificus	Japanese flying squid	surumeika	1.33	0.02	0.26
Ommastrephes bartrami	neon flying squid	akaika	0.68	-	0.13
Teuthoidea	unidentified squids	tsutsuika-rui	-	< 0.01	< 0.01
Decapoda	unidentified shrimps	ebi-rui	-	0.02	0.02
Syphozoa	jellyfishes (medusae)	kurage-rui	NC**	NC	NC

* No English name is found in Roper et al. (1984).

** Not counted.

Appendix table 2. Abundance (% in weight) of fishes, squids, and other animals collected in surface-trawls in the Okhotsk Sea and western North Pacific Ocean in the early and mid-autumn of 1996.

Scientific name	English common name	Japanese common name	Percent abundance		
			early autumn (2,101.6kg)	mid-autumn (9,015.8kg)	total (11,117.4kg)
Lethenteron japonicum	Arctic lamprey	kawayatsume	< 0.01	< 0.01	< 0.01
Prionace glauca	blue shark	yoshikirizame	-	0.33	0.27
Squalus acanthias	spiny dogfish	aburatsunozame	-	0.02	0.02
Elopiformes (leptocephalus)	unidentified juvenile	karaiwashi-rui		-	< 0.01
Clupea pallasii	Pacific herring	nishin	-	< 0.01	< 0.01
Sardinops melanostictus	Japanese sardine	maiwashi	5.09	-	0.96
Engraulis japonicus	Japanese anchovy	katakuchi-iwashi	8.22	0.06	1.60
Leuroglossus schmidti	northern smoothtongue	togari-ichimonji-iwashi	-	0.26	0.21
Liolagus ochotensis	Okhotsk deepsea smelt	sokoiwashi	-	0.0	0.02
Oncorhynchus nerka	sockeye salmon	benizake	0.07	1.56	1.27
Oncorhynchus keta	chum salmon	sake	16.53	20.26	19.56
Oncorhynchus gorbuscha	pink salmon	karafutomasu	7.35	33.18	28.29
Oncorhynchus kisutch	coho salmon	ginzake	0.08	0.44	0.38
Oncorhynchus tshawytscha	chinook salmon	masunosuke	0.14	1.43	1.19
Oncorhynchus masou masou	masu salmon	sakuramasu	0.21	0.36	0.33
Gonostomatoidei	bristlemouths	yoko-eso-rui	-	< 0.01	< 0.01
Sternoptychinae	marine hatchetfish	mune-eso-rui	-	< 0.01	< 0.01
Paralepididae	barracudina	hadaka-eso-rui	-	< 0.01	< 0.01
Alepisaurus ferox	longnose lancetfish	mizu-uo	-	0.01	0.01
Anotopterus pharao	daggertooth	mizu-uo-damashi	0.06	0.04	0.04
Tarletonbeania taylori	North Pacific lanternfish	hokuyouhadaka	-	0.06	0.05
Stenobrachius leucopsarus	northern lampfish	kohirehadaka	-	0.16	0.13
Diaphus theta	California headlightfish	todohadaka	-	0.01	0.01
Myctophidae	unidentified myctophids	hadakaiwashi-rui	< 0.01	-	< 0.01
Theragra chalcogramma	walleye pollock	suketoudara	< 0.01	9.13	7.41
Cololabis saira	Pacific saury	sanma	2.49	0.88	1.19
Gasterosteus aculeatus aculeatus	threespine stickleback	itoyo	-	< 0.01	< 0.01
Anoplopoma fimbria	sablefish	gindara	-	< 0.01	< 0.01
Pleurogrammus azonus	arabesque greenling	hokke	12.33	2.87	4.66
Pleurogrammus monopterygius	Atka mackerel	kitanohokke	-	< 0.01	< 0.01
Blepsias bilobus	crested sculpin	hokakeanahaze	0.01	0.01	0.01

Appendix table 2. Continued.

Scientific name	English common name	Japanese common name	Percent abundance		
			early autumn (2,101.6kg)	mid-autumn (9,015.8kg)	total (11,117.4kg)
Eumicrotremus birulai	Siberian lumsucker	konpeito	-	< 0.01	< 0.01
Eumicrotremus sp.	unidentified lumpsucker	ibodangouo-rui	< 0.01	-	< 0.01
Aptocyclus ventricosus	smooth lumpsucker	hoteiuo	-	0.02	0.02
Brama japonica	Pacific pomfret	shimagatsuo	0.27	2.34	1.95
Bothrocarina microcephala	silvery eelpout	kamutyakka-genge	-	< 0.01	< 0.01
Anarhichas orientalis	Bering wolffish	ookamiuo	< 0.01	-	< 0.01
Zaprora silenus	prowfish	bouzuginpo	0.02	0.02	0.02
Scomber sp.	mackerel	saba-rui	3.60	21.44	18.07
Xiphias gladius	swordfish	mekajiki	4.76	-	0.90
Pleuronectidae	unidentified flounder	karei-rui	-	< 0.01	< 0.01
Euprymna morseri	mimika bobtail	mimi-ika	-	< 0.01	< 0.01
Abralipopsis felis	-*	kariforunia-hotaruika	-	< 0.01	< 0.01
Watasenia scintillans	sparkling enope squid	hotaruika	-	< 0.01	< 0.01
Enoploteuthidae	enope squids	hotaruika-rui	-	< 0.01	< 0.01
Moroteuthis robustus	robust clubhook squid	nyudoika	-	0.01	0.01
Gonatopsis borealis	boreopacific gonate squid	takoika	-	0.46	0.38
Gonotopsis makko	mako gonate squid	makko-takoika	-	< 0.01	< 0.01
Gonatus onyx	-	tekagi-ika	-	< 0.01	< 0.01
Gonatus berryi	-	Beri-tekagi-ika	-	< 0.01	< 0.01
Gonatus middendorfii	shortarm gonate squid	kamutyakka-tekagi-ika	-	< 0.01	< 0.01
Berryteuthis magister	schoolmaster gonate squid	dosuika	-	< 0.01	< 0.01
Berryteuthis anonychus	-	himedosuika	-	< 0.01	< 0.01
Gonatidae	unidentified gonatids	tekagi-ika-rui	0.04	0.46	0.38
Todarodes pacificus pacificus	Japanese flying squid	surumeika	2.86	0.04	0.57
Ommastrephes bartrami	neon flying squid	akaika	5.46	-	1.03
Teuthoidea	unidentified squids	tsutsuika-rui	-	< 0.01	< 0.01
Decapoda	unidentified shrimps	ebi-rui	-	< 0.01	< 0.01
Scyphozoa	jellyfishes (medusae)	kurage-rui	30.41	4.08	9.06

* No English name is found in Roper et al. (1984).

オホーツク海および北海道・千島列島沖合の北西太平洋における表層性魚類とイカ類の秋季分布

長澤和也*・上野康弘*・阪井淳子**・森　純太*

摘　要

水産庁の調査船俊鷹丸と開洋丸により，1996年8月下旬から11月下旬にオホーツク海および北海道・千島列島沖合の北西太平洋において，表層トロール網を用いて表層生物の分布に関する調査を実施した．漁獲された表層生物のうち，種まで同定されたのは魚類33種（ヤツメウナギ類１種，サメ類2種，硬骨魚類30種）とイカ類13種であった．漁獲尾数をみると，サケ・マス類幼魚が最も多く漁獲され，サバ類，スケトウダラ幼魚、ハダカイワシ類，ホッケ幼魚，カタクチイワシが続いた。トガリイチモンジイワシ，マイワシ，テカギイカ類も多く漁獲された．本論文では，これら多獲された魚類とイカ類の分布を記述し，その特性を論じた．秋前期のオホーツク海の表層水には，サケ・マス類幼魚，ホッケ幼魚，サンマ，他の暖海性魚類が海面水温の差に応じて分布していた．秋半ばから後期には，サケ・マス類幼魚はオホーツク海に分布したが、暖海性魚類の多くは南下し，ホッケ幼魚は沖合域から沿岸域に移動した．また夜間の表層水には，深部から移動してきたハダカイワシ類とソコイワシ類，テカギイカ類が多く分布していた．これらの結果から，オホーツク海の表層水は，深部から日周的に移動してくる魚類とイカ類に索餌域を提供するほか，ホッケ幼魚と暖海性魚類に夏～秋季，サケ・マス類幼魚に夏～秋・冬季の生育場を提供すると考えられる．

*遠洋水産研究所（〒424-8633 静岡県清水市折戸5丁目7番1号）
**水産工学研究所（〒314-0421 茨城県波勝町海老台）