Distribution and biology of epipelagic animals in the northern North Pacific Ocean and adjacent seas-I. Fishes and squids in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in the autumn of 1993

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Abstract

A surface-trawl survey was conducted by the R/V *Kaiyo maru* in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in October and November 1993. The distributions and abundances of the species caught are described and discussed. Twenty-four fish species (1 lamprey, 1 shark, and 22 teleosts) and one squid species were identified. Juvenile Pacific salmon (6 species of the genus *Oncorhynchus*) were the most abundant, followed by myctophids, juvenile arabesque greenling (*Pleurogrammus azonus*), and gonatids including boreopacific gonate squid (*Gonatopsis borealis*) and probably schoolmaster gonate squid (*Berryteuthis magister*). Northern smoothtongue (*Leuroglossus schmidti*) were also abundant. Juvenile arabesque greenling were abundantly taken in the Okhotsk Sea in October but disappeared from the surface waters in November because they settled on the bottom. There were marked differences in the oceanic distribution of arabesque greenling and Atka mackerel (*P. monopterygius*), suggesting that these species segregate their habitats. Northern smoothtongue mostly occurred in the Okhotsk Sea, and myctophids were caught in the North Pacific Ocean.

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We conclude that the surface layer of the southern Okhotsk Sea provides favorable habitats for the feeding and growth of juvenile salmonids, arabesque greenling, and other epipelagic migratory species from summer to mid-autumn but ends its role in late autumn with decreasing sea-surface temperatures.

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

Introduction

The southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands support many important fisheries resources such as Pacific salmon (*Oncorhynchus* spp.), walleye pollock (*Theragra chalcogramma*), Pacific saury (*Cololabis saira*), arabesque greenling (*Pleurogrammus azonus*), and Japanese flying squid (*Todarodes pacificus pacificus*). Various aspects of the fishery biology of these species have been studied extensively in this region, but most of research was confined to a limited period which corresponds to their fishing seasons, i.e., from early summer to early autumn. Little information is yet available about the distribution and abundance of fishes and squids in surface waters in other seasons, although some research was done by Russian scientists (e.g., Birman, 1969 ; Shuntov *et al.*, 1986 ; Shuntov, 1989, 1994).

The Fisheries Agency of Japan's research vessel *Kaiyo maru* conducted a surface-trawl survey from mid-October to late November in 1993, as a Japan-Russia-Canada cooperative project, in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in order to clarify the distribution and migration of juvenile Pacific salmon originating in Japan (Anon., 1993).

The purpose of the present paper is to describe the distribution of epipelagic fishes and squids, excluding salmonids, caught by the *Kaiyo maru* in that region. For salmonids, their distribution and biological features (age, size, food, origin, and physiological conditions) have been described elsewhere (Ueno *et al.*, 1994, 1995 ; Ogura, 1995 ; Tamura, 1995 ; Azuma, 1995 ; Startsev, 1995 ; Naito and Ueno, 1995). Phyto- and zooplankton distributions and oceanographical characteristics also have been reported (Kawasaki and Kono, 1995 ; Kono and Kawasaki, 1995 ; Shiomoto and Yamanaka, 1995 ; Shimizu *et al.*, 1995 ; Seki *et al.*, 1995).

Materials and Methods

Capture of fishes and squids

The *Kaiyo maru* (2,630 gross tons), a 96-m stern trawler, used a surface trawl ("spider net", 208-m long, 63.2-m headrope, 63.2-m groundrope, and cod end with 11-mm knotless mesh) in order to catch juvenile salmonids and other epipelagic species. Fishing operations were conducted at 31 stations along 5 transects in the southern Okhotsk Sea (20 stations) and along 4 transects in the western North Pacific Ocean (11 stations) from mid-October to late November in 1993 (Fig. 1). Station numbers were designated according to locations along the transects. For example, Station

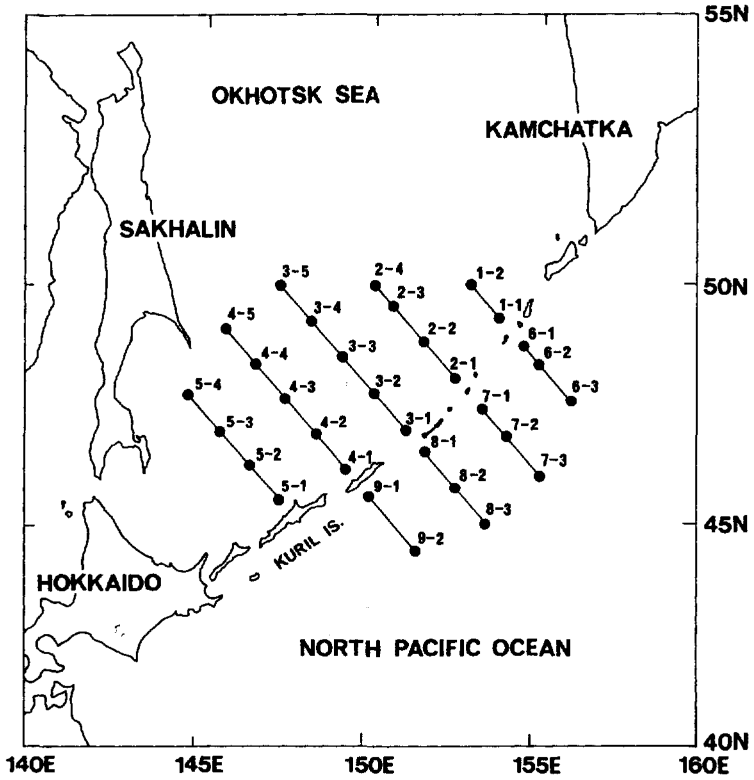

Fig. 1. Location of stations sampled by the R/V *Kaiyo maru* in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in October and November 1993.

2-2 is the second station from the southeast along Transect 2 in the Okhotsk Sea, and Station 8-3 is the third station from the northwest along Transect 8 in the North Pacific Ocean.

The survey consisted of two cruises which were from October 15 to November 2 for the first cruise and from November 8 to 26 for the second cruise. All stations were sampled for each cruise. The trawl with ca. 400-m warps was towed from the surface to ca. 50 m at a mean speed of 5.5 knots (range : 3.9-6.3) for one hour. Tows were usually made at two stations per day. Catch per unit effort (CPUE) was calculated as the number of fish or squid caught by the trawl per hour.

Throughout the text, seasons are defined as: summer (June-August), autumn (September-November), winter (December-February), and spring (March-May).

Examination of fishes and squids

Soon after net retrieval, animals caught by the trawl were brought to the laboratory of the *Kaiyo maru,* where they 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 were measured, according to species, for standard length (SL), total length (TL) or scaled body length (SCL), and squids were measured for dorsal mantle length (ML). They were then weighed individually and frozen at $-40°C$ in covered aluminum trays for subsequent laboratory examination.

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.

Results and Discussion

Distribution of sea-surface temperature

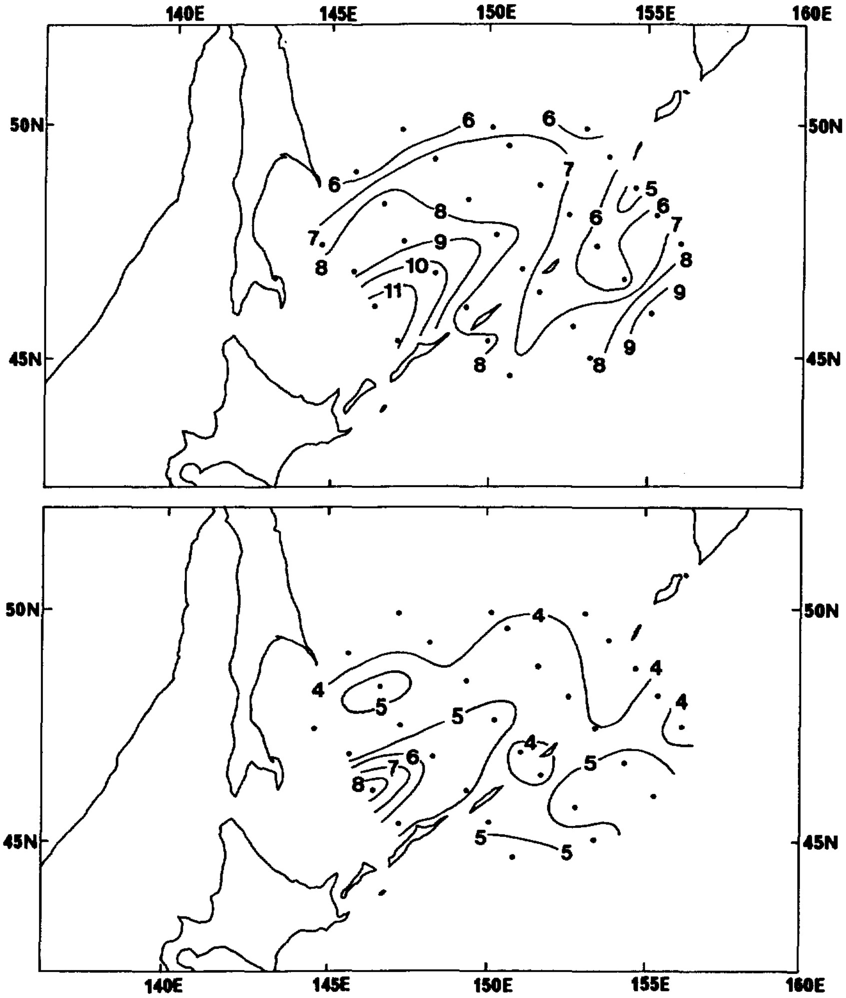

Fig. 2. Sea-surface temperatures (°C) in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands from October 15 to November 2 (top) and from November 8 to 26 (bottom) in 1993.

The October and November distributions of sea-surface temperature (SST) are shown in Fig. 2. During the first cruise (October 15 to November 2), SSTs ranged from 5°-11°C in the Okhotsk Sea and from 4°-9°C in the North Pacific Ocean. Warm water between 10° and 11°C, probably originating from the Soya Current, occurred off northwestern Iturup Island, and water over 7°C extended to the central Okhotsk Sea. Colder water (Oyashio Current) was distributed along the Kuril Islands. During the second cruise (November 8 to 26), SSTs decreased, ranging from 3°-9°C in the Okhotsk Sea and from 3°-5°C in the North Pacific Ocean, but warm and cold waters showed a similar distribution to those observed during the first cruise.

Abundance of fishes and squids caught

A total of 45,994 individuals of fishes and squids were caught. Twenty-four fish species (1 lamprey, 1 shark, and 22 teleosts) and one squid species were identified to the species level (Table 1). Pacific salmon (6 spp., pink salmon *Oncorhynchus gorbuscha* [n=20,280 ; 44.09%], chum salmon *O. keta* [n=4,133 ; 8.99%], sockeye salmon *O. nerka* [n=87 ; 0.19%], coho salmon *O. kisutch* [n=54 ; 0.12%], masu salmon *O. masou* [n=49 ; 0.11%], and chinook salmon *O. tshawytscha* [n=39 ; 0.08%]) were the most predominant (n=24,642 ; 53.58% of the total catch), followed by myctophids (n=9,819 ; 21.35%), arabesque greenling (*Pleurogrammus azonus*) (n=3,698 ; 8.04%), unidentified gonatids (probably schoolmaster gonate squid *Berryteuthis magister* [n=2,510 ; 5.46%]), and boreopacific gonate squid (*Gonatopsis borealis*) (n=2,033 ; 4.42%). Northern smoothtongue (*Leuroglossus schmidti*) (n=931 ; 2.02%) were also abundant. The catches of these species (n=39,271) comprised over 85% of the total catch. The remaining species were quite low in abundance. Salps and jellyfish were sometimes collected abundantly. No marine mammals and seabirds were captured.

Distribution and abundance of fishes and squids

The fishes discussed below are arranged systematically (Nakabo, 1993).

Arctic lamprey (*Lethenteron japonicum*)

One fish was caught at St. 5-4 off the southeast coast of Sakhalin Island in the Okhotsk Sea on November 9. The fish was 431 mm TL.

The Arctic lamprey is anadromous but few oceanic records exist. From coastal waters off Hokkaido (i.e., Ishikari Bay and Abashiri Bay), this species was occasionally taken in spring (Anon., 1979, 1980 ; Mishima and Shimazaki, 1980a, 1980b). As far as we know, the present collection is the first autumn record of the oceanic capture of Arctic lamprey from the southern Okhotsk Sea. Similar epipelagic occurrence has been noted for the Pacific lamprey (*Entosphenus tridentatus*, as *Lampetra tridendata*) (Larkins, 1964).

Spiny dogfish (*Squalus acanthias*)

Two fish were caught: one each at Sts. 6-2 and 7-3 in the North Pacific Ocean on October 27 and 29. The fish were 90 and 100 (mean 95) cm TL. There was no catch in the Okhotsk Sea.

This species is known to conduct a seasonal north-south migration around northern Japan

Table 1. Fishes and squids collected with a surface trawl in the southern Okhotsk Sea and western North Pacific Ocean in October and November 1993.

Scientific name	English common name	Japanese common name	Percent abundance		
			1st cruise (n=19,073)	2nd cruise (n=26,921)	total (n=45,994)
Lethenteron japonicum	Arctic lamprey	kawa-yatsume	0.00	<0.01	<0.01
Squalus acanthias	spiny dogfish	abura-tsunozame	<0.01	0.00	<0.01
Engraulis japonicus	Japanese anchovy	katakuchi-iwashi	0.15	<0.01	0.06
Leuroglossus schmidti	northern smoothtongue	togari-ichimonji-iwashi	4.26	0.44	2.02
Liolagus ochotensis	Okhotsk deepsea smelt	sokoiwashi	0.00	0.11	0.06
Bathylagidae	unidentified deepsea smelt	sokoiwashi-rui	0.00	0.03	0.02
Oncorhynchus nerka	sockeye salmon	benizake	0.20	0.18	0.19
Oncorhynchus keta	chum salmon	sake	13.58	5.73	8.99
Oncorhynchus gorbuscha	pink salmon	karafutomasu	39.66	47.23	44.09
Oncorhynchus kisutch	coho salmon	ginzake	0.27	0.01	0.12
Oncorhynchus tshawytscha	chinook salmon	masunosuke	0.06	0.10	0.08
Oncorhynchus masou	masu salmon	sakuramsu	0.17	0.06	0.11
Paralepis atlantica atlantica	duckbill barracudina	kusabiuroko-eso	0.00	0.01	<0.01
Anotopterus pharao	daggertooth	mizu-uo-damashi	0.01	0.01	0.01
Tarletonbeania taylori	North Pacific lanternfish	hokuyou-hadaka	<0.01	0.00	<0.01
Myctophidae	unidentified myctophids	hadakaiwashi-rui	2.29	34.85	21.35
Theragra chalcogramma	walleye pollock	suketoudara	0.34	0.02	0.15
Cololabis saira	Pacific saury	sanma	0.01	0.00	<0.01
Gasterosteus aculeatus aculeatus	threespine stickleback	itoyo	0.00	0.01	<0.01
Anoplopoma fimbria	sablefish	gindara	0.00	<0.01	<0.01
Pleurogrammus azonus	arabesque greenling	hokke	19.38	<0.01	8.04
Pleurogrammus monopterygius	Atka mackerel	kitano-hokke	2.52	1.14	1.72
Blepsias bilobus	crested sculpin	hokake-anahaze	0.03	0.01	0.02
Scorpaeniformes	unidentified scorpionfish	fusakasago-rui	0.00	0.01	<0.01
Scorpaenidae	unidentified scorpionfish	fusakasago-rui	0.00	0.01	<0.01
Aptocyclus ventricosus	smooth lumpsucker	hoteiuo	0.02	0.02	0.02
Anarhichas orientalis	Bering wolffish	ookamiuo	0.00	<0.01	<0.01
Zaprora silenus	prowfish	bouzu-ginpo	0.01	0.01	0.01
Pleuronectidae	unidentified flounder	karei-rui	0.00	<0.01	<0.01
Teleost	unidentified fish juvenile	koukotsugyo-rui	<0.01	0.00	<0.01
Gonatopsis borealis	boreopacific gonate squid	takoika	2.46	5.81	4.42
Berryteuthis magister ?	schoolmaster gonate squid ?	tsumeika ?	9.50	2.59	5.46
Gonatidae	unidentified gonatids	tsumeika-rui	5.05	1.59	3.02

(Inukai and Sato, 1934 ; Kojima, 1957). In late autumn, spiny dogfish, which resided in northern waters in summer months, migrate southward to the coastal waters of Honshu for overwintering. Those southward-migrating fish are usually over 110 cm long (Inukai and Sato, 1934). Considering such information, our specimens are thought to have been captured on the way to their southern overwintering area.

Japanese anchovy (*Engraulis japonicus*)

Twenty-nine fish were caught in the southwestern Okhotsk and Pacific waters (Sts. 5-1, 5-2, 8-3, 9-2 : most of them (28 fish) were taken in October. The fish consisted of two size groups, ranging from 43-50 (mean 47) mm SCL and 86-143 (mean 120) mm SCL.

Juveniles and adults of this species recently have been reported to occur in coastal Okhotsk and Pacific waters off Hokkaido and the Kuril Islands (Ueno *et al*., 1990, 1992 ; Yamaguchi and Yamagishi, 1991 ; Mihara, 1994). Since this species can spawn in July-August in waters off southeastern Hokkaido (Mihara, 1994), the small fish sampled can be regarded as juveniles which hatched there or in adjacent waters.

Northern smoothtongue (*Leuroglossus schmidti*) and other bathylagids

Of 931 northern smoothtongue caught, 926 (99.5%) fish were caught at Sts. 1-2 and 3-1 on October 26 and 19, and St. 4-3 on November 10 in the Okhotsk Sea. Only one fish was taken in the North Pacific Ocean (St. 8-1) on October 3. The fish ranged from 101-151 (mean 125) mm SL. Some other bathylagids, including Okhotsk deepsea smelt (*Lipolagus ochotensis*), were also collected in small numbers ($n=36$).

According to Shuntov *et al*. (1990, 1993b), northern smoothtongue are abundant in the upper layer of the central and southern Okhotsk Sea. Balanov and Il'inskii (1992) also found that this species is predominant in the mesopelagic waters of the Okhotsk Sea. Shuntov *et al*. (1993b), however, did not comment on its occurrence in the western North Pacific Ocean. This information, together with the results of the present study, indicates that the abundance of northern smoothtongue is much higher in the Okhotsk Sea than in the western North Pacific Ocean.

Duckbill barracudina (*Paralepis atlantica atlantica*)

Two fish were caught at St. 8-3 in the North Pacific Ocean on November 24. They were 434 and 453 (mean 444) mm SL.

Daggertooth (*Anotopterus pharao*)

Five fish were captured in the North Pacific Ocean : one each at Sts. 6-3 and 8-2 in the first cruise and at Sts. 6-2, 7-2, and 8-1 in the second cruise. The fish ranged from 760-814 (mean 789) mm SL. There was no catch in the Okhotsk Sea.

Based on a surface-trawl survey in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands, Shuntov *et al*. (1993b) found that daggertooth occurred mainly in Pacific waters. Shuntov *et al*. (1993a) also collected this species off the southeast coast of Kamchatka.

Nagasawa (1992) reported that daggertooth were incidentally caught in salmon surface-gillnets in the North Pacific Ocean.

Myctophids

Myctophids were caught, mainly in the evening, in the North Pacific Ocean. These myctophids consisted of about three species but since most fish were heavily damaged, no species identifications were made, except for one North Pacific lanternfish (*Tarletonbeania taylori*). Myctophids were the second highest in abundance (Table 1).

In the oceanic North Pacific Ocean off the Kuril Islands, several myctophid species (*Diaphus*

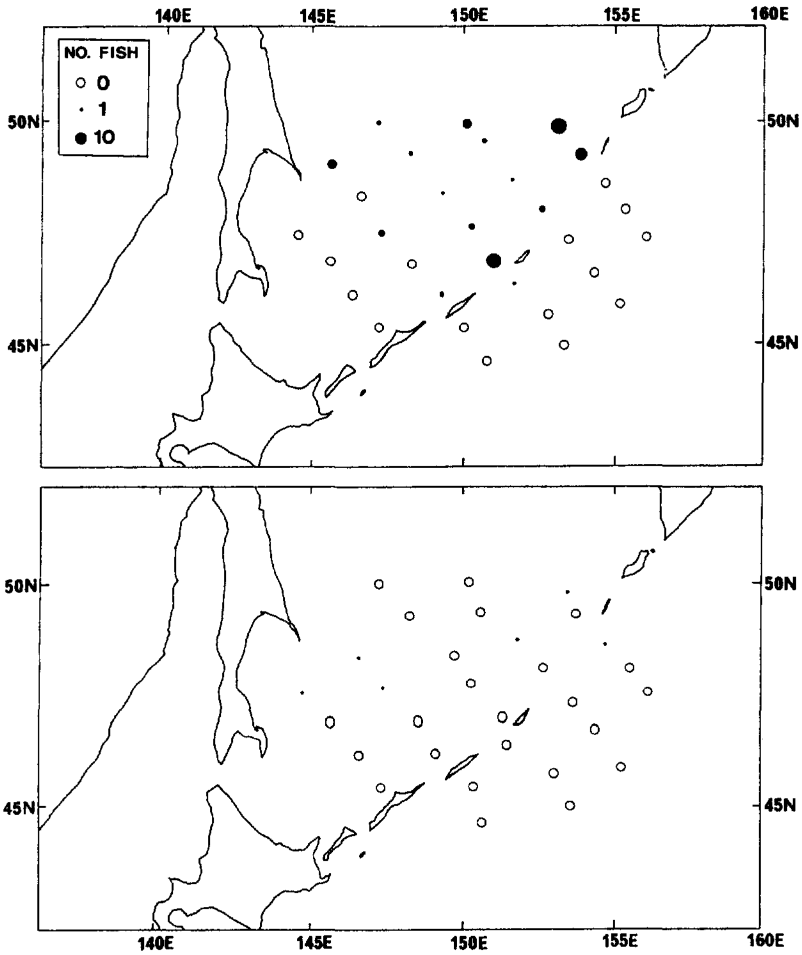

Fig. 3. Distribution (number of fish caught per hour) of walleye pollock (*Theragra chalcogramma*) in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands from October 15 to November 2 (top) and from November 8 to 26 (bottom) in 1993.

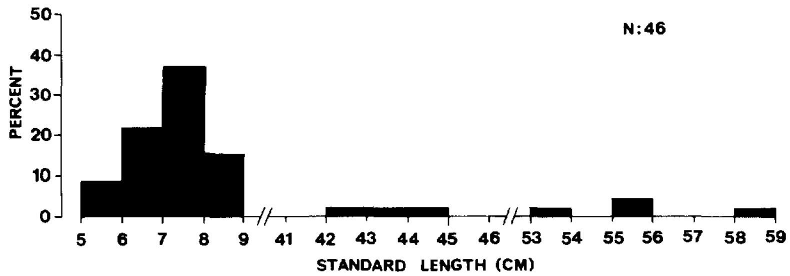

Fig. 4. Length frequency distribution of walleye pollock (*Theragra chalcogramma*) caught in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in October and November 1993.

theta, Stenobrachius leucopsarus, Notoscopelus japonicus, Ceratoscopelus warmingi, and *T. taylori* [as *T. crenularis*]) have been reported from the upper epipelagic layer in the twilight and at night (Shuntov *et al*., 1993b). The myctophids caught in the present study may include these species.

Walleye pollock (*Theragra chalcogramma*)

Seventy-one fish were caught during the survey: 69 fish (97.1%) were collected in the Okhotsk Sea while only two fish was collected from the North Pacific Ocean (Fig. 3). The majority of fish ($n=65$) was taken during the first cruise. The fish consisted of two size groups, ranging from 56-88 (mean 73) mm and 428-584 (mean 494) mm SL (Fig. 4).

Ishino (1993) has suggested, based on vertebral counts, that southwestern Okhotsk Sea walleye pollock comprise at least two stocks, i.e., the western Okhotsk Sea stock and the Nemuro Strait stock. Thus, the fish caught may belong to both or either of these stocks.

Pacific saury (*Cololabis saira*)

Two fish were caught at St. 9-2 off Iturup Island in the North Pacific Ocean on November 2. They were 219 and 245 (mean 232) mm SCL. Since this species overwinters in southern Japanese waters (Kobayashi *et al*., 1968), the fish caught are thought to be on the way to their overwintering area.

Threespine stickleback (*Gasterosteus aculeatus aculeatus*)

Two fish were caught: one each at Sts. 3-4 and 5-4 in the open Okhotsk Sea off the southeast coast of Sakhalin on November 13 and 9, respectively. They were 43 and 64 (mean 54) mm SL. No fish were taken in the North Pacific Ocean.

Threespine sticklebacks are anadromous. They migrate to the sea as juveniles but little is known about their oceanic life. In coastal waters off Hokkaido, this species was collected in spring (e.g., Mishima and Shimazaki, 1980a, 1980b). Ueno *et al*. (1990, 1992) also sampled threespine sticklebacks in Pacific and Okhotsk waters off the Kuril Islands in summer. Quinn and Light (1989) found that this species widely occurs on the high seas of the North Pacific Ocean. Sticklebacks also have been recorded from the stomachs of coho salmon, steelhead trout (*Oncorhynchus mykiss*), and thick-billed murres (*Uria lomvia*) from offshore waters of the North Pacific Ocean (Ogi, 1980 ; Quinn and Light, 1989). It is unknown whether offshore-dwelling sticklebacks can return to fresh water.

Sablefish (*Anoplopoma fimbria*)

One fish, 177 mm SL, was caught at St. 2-2 in the Okhotsk Sea on November 16. This fish is regarded as age-0 juvenile (Beamish and Chilton, 1982).

It is worthy to note this juvenile occurrence in the Okhotsk Sea. Sablefish juveniles are known to occur in surface waters along the Aleutian Islands and coastal waters off British Columbia

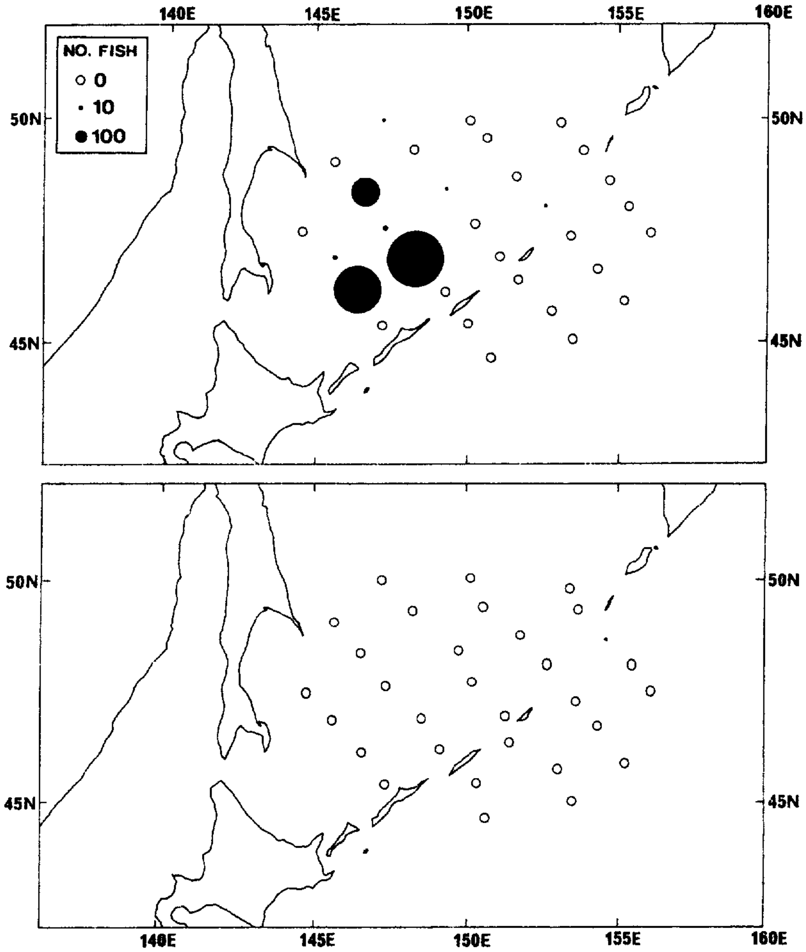

Fig. 5. Distribution (number of fish caught per hour) of arabesque greenling (*Pleurogrammus azonus*) in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands from October 15 to November 2 (top) and from November 8 to 26 (bottom) in 1993.

(Kobayashi, 1957 ; Mason *et al.*, 1983). Although there is no record of juveniles larger than 30 mm in surface waters on the Asian side of the North Pacific Ocean (Sasaki, 1985), Novikov (1994) reported that sablefish occurs in the Okhotsk Sea as well as in the western and eastern North Pacific Ocean and Bering Sea. Inada and Ishido (1988) also noted the occurrence of young sablefish (25-33 and 43-47 cm in fork length) off the Pacific coast of northern Honshu, Japan, and suggested that this species reproduces in Asian waters.

Arabesque greenling (*Pleurogrammus azonus*)

There was a marked difference in the abundance and distribution of arabesque greenling between the first and second cruises (Fig. 5). During the first cruise, this species was caught abundantly (n=3,697) with a mean CPUE of 462 (range : 1-1,712) at 8 (25.8%) of 31 locations in the Okhotsk Sea, especially in its southwestern area (Sts. 4-2, 4-4, 5-2), but it never occurred in the North Pacific Ocean. During the second cruise, only one fish was taken from one Pacific location (St. 6-1) near the northern Kuril Islands and no fish were captured in the Okhotsk Sea. SSTs at the stations with high juvenile catches were over 8°C in the Okhotsk Sea (Fig. 2).

The fish caught ranged from 175-215 (mean 195) mm SL (Fig. 6) and, based on the growth curve for this species calculated by Kyushin (1957), these are thought to be juveniles and nearly one year

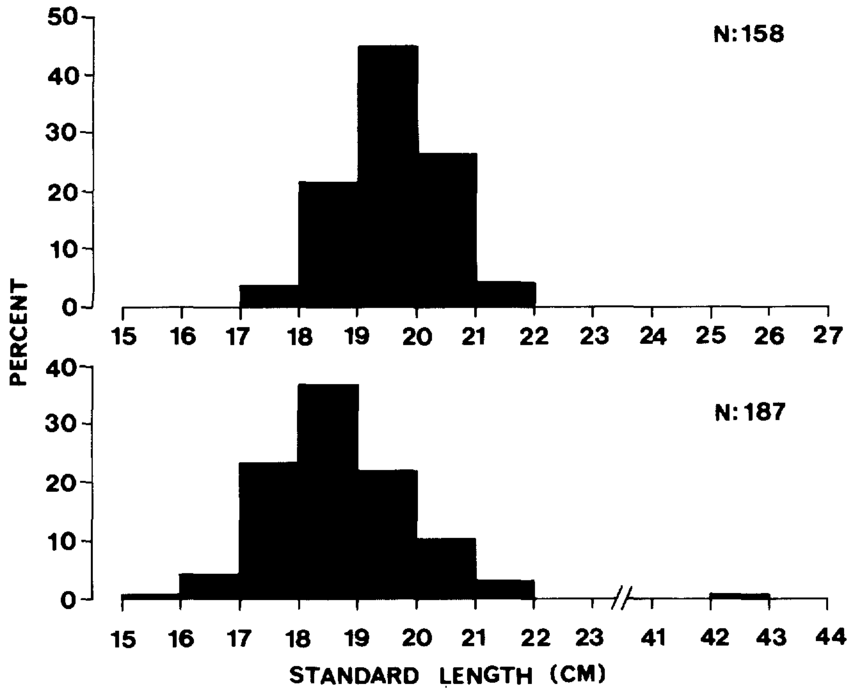

Fig. 6. Length frequency distributions of arabesque greenling (*Pleurogrammus azonus*) (top) and Atka mackerel (*P. monopterygius*) (bottom) caught in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in October and November 1993.

old.

The arabesque greenling spawns in coastal waters of Hokkaido from mid-September to early December (Shimazaki, 1984 ; Torisawa, 1991). Juveniles migrate northward in spring and occur widely in the central and southern parts of the Okhotsk Sea in summer (Shimazaki and Kyushin, 1982). When they grow to 17-20 cm long in autumn, their life dramatically changes and they begin to settle on the continental shelf at depths greater than 50 m. From September to December, these fish are abundantly caught using bottom trawls off the Okhotsk coast of Hokkaido. Therefore, the sudden disappearance of arabesque greenling observed after the first cruise may have resulted from the habitat change of juveniles from the surface layer to the bottom.

Shuntov *et al.* (1986) conducted an extensive surface trawl survey in the Okhotsk Sea in the autumn of 1984 and reported that walleye pollock were the most predominant species, followed by Pacific herring (*Clupea palasii*), young salmon (pink and chum salmon), and capelin (*Mallotus villosus*). However, they gave no comments on arabesque greenling in this region. Shuntov *et al.* (1990, 1993b) also conducted similar trawl surveys in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in the summers of 1988 and 1991, but they provided no information about arabesque greenling. These results are markedly different from those of the present study. The fact that Shuntov *et al.* (1986, 1990, 1993b) did not refer to arabesque greenling in their papers indicates that the abundance of juveniles was quite low during their survey periods. Takayanagi and Maruyama (1993) reported that the abundance of age-0 arabesque greenling in coastal Hokkaido waters was actually at the lowest level in 1984. Therefore, poor commercial catches of arabesque greenling recorded from the Hokkaido coast in 1984-85 could be explained by such juvenile low abundance in 1984.

Atka mackerel (*Pleurogrammus monopterygius*)

Atka mackerel were caught with a mean CPUE of 79 (range : 1-384) in neritic waters along the central and northern Kuril Islands (Fig. 7). The capture locations for Atka mackerel were not overlapped with those for arabesque greenling (see Fig. 5), indicating that these species segregate their habitats.

The fish caught ranged from 155-215 (mean 189) mm SL, except for one fish (428 mm SL) (Fig. 6). Based on the growth curve calculated by Lee (1985), most of the fish are thought to be one year old and the largest fish to be seven years old.

Kobayashi (1958) collected juvenile Atka mackerel (22.0-37.8 mm SL) off the Pacific coast of the Kuril Islands and Kamchatka in June and July. Although Shuntov *et al.* (1986, 1990, 1993b) surveyed the distribution of epipelagic fishes in the Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in the summer and autumn, they did not mention Atka mackerel. According to Lee (1985), this species occurs abundantly in waters near the Aleutian Islands.

Crested sculpin (*Blepsias bilobus*)

Eight fish were caught in the Okhotsk Sea : six were from Sts. 1-1, 2-1, 3-5, 5-2 (2 fish), and 5-3 during the first cruise and two from Sts. 2-1 and 5-3. The fish ranged from 100-168 (mean 135) mm

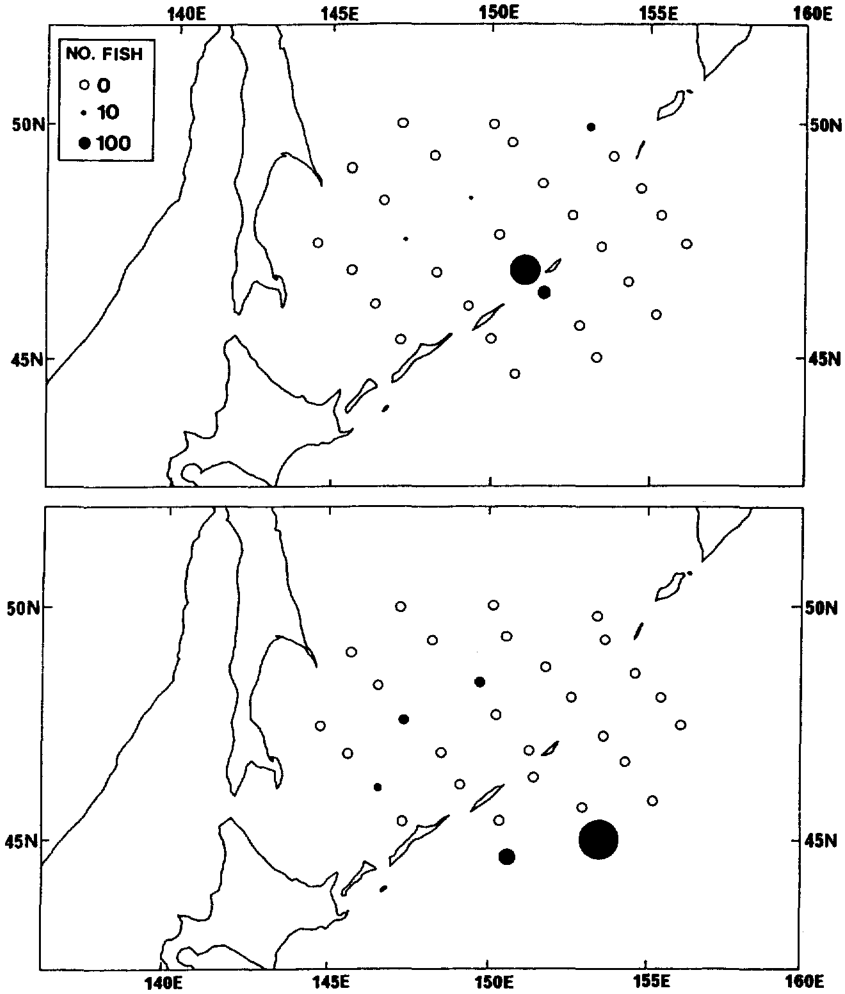

Fig. 7. Distribution (number of fish caught per hour) of Atka mackerel (*Pleurogrammus monopterygius*) in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands from October 15 to November 2 (top) and from November 8 to 26 (bottom) in 1993.

SL.

Smooth lumpsucker (*Aptocyclus ventricosus*)

Ten fish were caught in the Okhotsk Sea : four were each at Sts. 2-4, 3-5, 4-1, and 4-3 during the first cruise and six at Sts. 1-1 (3 fish), 1-2, 2-1, and 3-3 during the second cruise. The fish ranged from 260-320 (mean 295) mm SL and 176-238 (mean 203) mm SL in the first and second cruises, respectively. No fish were captured in the North Pacific Ocean.

Epipelagic occurrence of this species has been reported from the central and western parts of the Bering Sea (Yoshida and Yamaguchi, 1985 ; Shuntov *et al.*, 1993a). There are some additional records of smooth lumpsuckers from surface waters of the western North Pacific Ocean (Kobayashi, 1962 ; Ueno *et al.*, 1990). Shuntov *et al.* (1990, table 3) also reported that the "lumpsucker" occurred in the upper epipelagic layer of the Okhotsk Sea in summer, although they did not identify it to the species level.

Bering wolffish (*Anarhichas orientalis*)

One fish, 428 mm SL, was caught at St. 5-4 off the southeast coast of Sakhalin Island in the Okhotsk Sea on November 9.

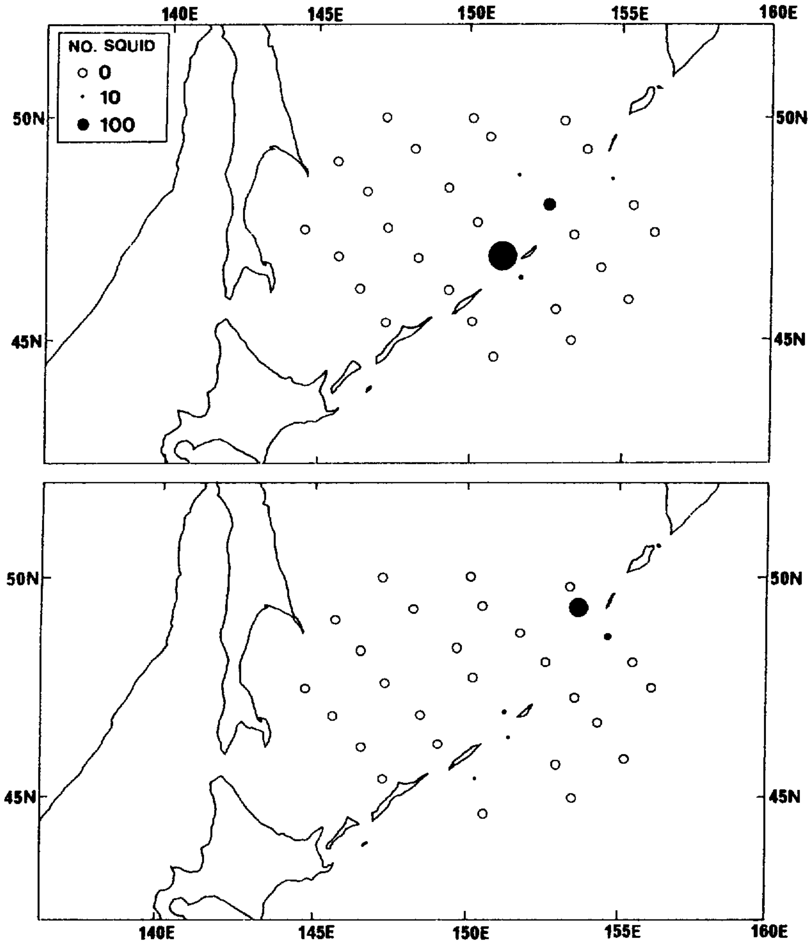

Fig. 8. Distribution (number of squid caught per hour) of boreopacific gonate squid (*Gonatopsis borealis*) in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands from October 15 to November 2 (top) and from November 8 to 26 (bottom) in 1993.

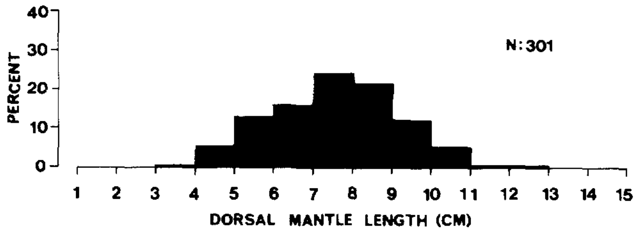

Fig. 9. Length frequency distribution of boreopacific gonate squid (*Gonatopsis borealis*) caught in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands in October and November 1993.

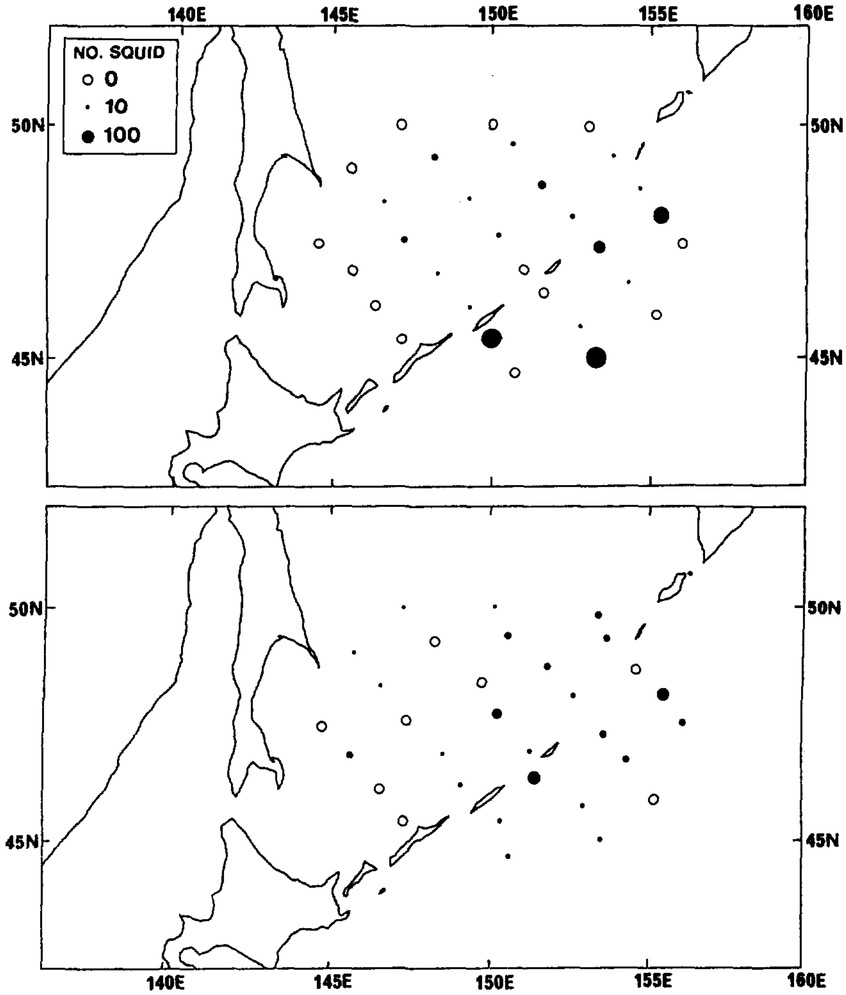

Fig. 10. Distribution (number of squid caught per hour) of unidentified gonatid squids in the southern Okhotsk Sea and western North Pacific Ocean off the Kuril Islands from October 15 to November 2 (top) and from November 8 to 26 (bottom) in 1993.

Bering wolffish are demersal although their juveniles are known to occur in the surface layer of the Okhotsk Sea and western North Pacific Ocean (Kobayashi, 1961 ; Ueno *et al.*, 1990, 1992). Prior to the present report, there appears to be no record of wolffish as large as 428 mm being taken from surface waters. Thus, it is interesting to note that such a large individual was taken in offshore surface waters. The collection site was ca. 120 km distant from the nearest Sakhalin coast and the water depth was ca. 1,500 m.

Prowfish (*Zaprora silenus*)

Four fish were caught : one each at Sts. 2-3 and 6-2 during the first cruise and at Sts. 6-2 and 8-3 during the second cruise. The fish ranged from 175-599 (mean 349) mm SL.

Other fishes

Seven unidentified fishes (5 scorpaenid, 1 pleuronectid, and 1 juvenile) were collected.

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

Boreopacific gonate squid were caught, sometimes abundantly (n=351 and 1,284 at 2 stations), mainly in the evening, with a mean CPUE of 203 (Fig. 8). This species occurred mainly in neritic waters off the central and northern Kuril Islands. They ranged from 30-130 (mean 83) mm ML (Fig. 9). Another species of gonatid, probably schoolmaster gonate squid (*Berryteuthis magister*), was abundantly collected (n=2,510). Some other unidentified gonatid species were also relatively abundant (n=1,391) (Fig. 10) but species identification was impossible because most individuals were heavily damaged. These gonatids ranged from 60-390 (mostly 90-160) mm ML.

General Discussion and Conclusions

The most important finding in the present study is that juvenile fishes, such as salmonids and arabesque greenling, that reside the surface layer of the Okhotsk Sea from summer to mid-autumn, leave there with decreased SSTs in late autumn. Juvenile pink and chum salmon migrate southward to the North Pacific Ocean in November (Shuntov, 1994 ; Ueno *et al.*, 1994 ; Ogura, 1995). Juvenile arabesque greenling finish settling on the bottom in November. Also, juvenile masu salmon are known to migrate from the Okhotsk Sea to Japanese coastal Pacific waters or to the Japan Sea in late autumn (Machidori and Kato, 1984). These results all indicate that in late autumn the surface layer of the Okhotsk Sea ends its role as a region for the feeding and growth of these juveniles. In other words, the Okhotsk Sea provides favorable habitats to juvenile salmonids and arabesque greenling for their feeding and growth only from summer to mid-autumn.

The surface of this sea is covered with drifting ice in winter (Aota *et al.*, 1993) and such cold oceanic conditions appear to be unsuitable for those juveniles. Thus, salmonids and arabesque greenling may have evolved their migration patterns in order to escape from cold waters and to overwinter in areas which are not directly affected by sea ice.

The importance of the Okhotsk Sea as a feeding region during summer to mid-autumn is also applicable to some other migratory species, i.e., spiny dogfish, Japanese anchovy, Japanese sardine (*Sardinops melanostictus*), Pacific saury, Japanese flying squid (e.g., Kojima, 1957 ; Araya, 1967 ; Yamaguchi and Yamagishi, 1990) and also even marine mammals, such as Dall's porpoise (*Phocaenoides truei*) and minke whales (*Balaenoptera acutrostrata*) (Kasuya, 1978 ; Kato and Kasuya, 1992). In late spring and summer, these species migrate from the North Pacific Ocean or the Japan Sea to the Okhotsk Sea, where they stay until late autumn. In the coastal Okhotsk Sea off Hokkaido, there are commercial fisheries for epipelagic fishes and squids in summer and autumn. Dall's porpoise and minke whales go to the Okhotsk Sea probably feed on those migratory fishes and squids.

The present study also has shown that juvenile arabesque greenling were abundantly distributed in the southern Okhotsk Sea in October. As discussed earlier (see the Results and Discussion section), if there is a close quantitative relationship between juvenile abundance in the Okhotsk Sea and commercial catch in Hokkaido, it may be possible to forecast catch level based on oceanic juvenile abundance. Further research is required to evaluate this relationship.

In conclusion, the Okhotsk Sea serves as an important summer-to-mid-autumn feeding area for juvenile salmonids, arabesque greenling, and some other migratory species and ends its role in late autumn. The feeding habits of those epipelagic species and the zooplankton productivity in this sea have been poorly studied to date. Following the pioneering work by Shuntov *et al.* (1986, 1990, 1993b, 1994), more detailed research is needed to evaluate the ocean productivity in the Okhotsk Sea.

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