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# Surface water type and distribution of juvenile fishes and cephalopods in Pacific coast waters of Hokkaido and the Kuril Islands in summer, 1989

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## Abstract

The purpose of this report is to present the relationship between the distribution of fish and cephalopod species and surface water type in the coastal and offshore waters on the Pacific side of Hokkaido and the Kuril Islands based on the survey of R/V Wakashio-maru in summer 1989. Fishes of 27 species and cephalopods of 6 species were collected with finemeshed purse seine, dip-net, and surface trawl net. The results of oceanographic observations showed that Oyashio Water (Kuril Current Water) occupied almost the entire research area. The authors divided the area surveyed into three types of regions characterized by the temperature and salinity at the surface. The three water regions were 1) the coastal water, 2) the surface warm water, and 3) the cold water. In the coastal waters, 12 fish and cephalopods species were observed, and juvenile chum salmon (*Oncorhynchus keta*) showed high abundance. In the surface warm waters, 26 species were observed, and both juveniles and adults of true sardine (*Sardinops melanosticta*), Japanese anchovy (*Engraulis japonica*) and Pacific saury (*Cololabis saira*) occurred in abundance. In the cold waters, 19 species were observed, and *Gonatus middendorffi* (juvenile) were plentiful.

## Introduction

It is well-known that the Oyashio Water have high primary production and is running southwestward along the Kuril Islands and Hokkaido (Kawai 1972). As reported in several studies (Fukushima 1979; Sablin and Pavlychev 1979; Nagasawa 1984), adults of Pacific saury and Japanese sardine feed in this area. It is also believed that juvenile chum salmon utilize this area as

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a northward migration route (Irie 1985).

The authors conducted the survey to compare the distribution of juvenile chum salmon, other fishes, and cephalopods with oceanographic observations in this area. The survey was conducted aboard the R/V Wakashio-maru under the mutual agreement of the 1989 U.S.S.R.-Japan composite committee of fisheries as part of the U.S.S.R.-Japan cooperative research.

The purpose of this report is to present the basic relationship between the distribution of collected species and oceanographic conditions and describes some biological characteristics of each species in this area.

## Materials and methods

The survey was conducted from July 11 to August 4, 1989 in the coastal and offshore waters on the Pacific side of Hokkaido and the Kuril Islands by the research vessel Wakashio-maru (199. 51 GRT). The sampling was carried out, in principle, from the coast to the offshore area, however the coastal waters (within 12 mile zone) of the Kuril Islands were not included in the sampling area (Fig. 1).

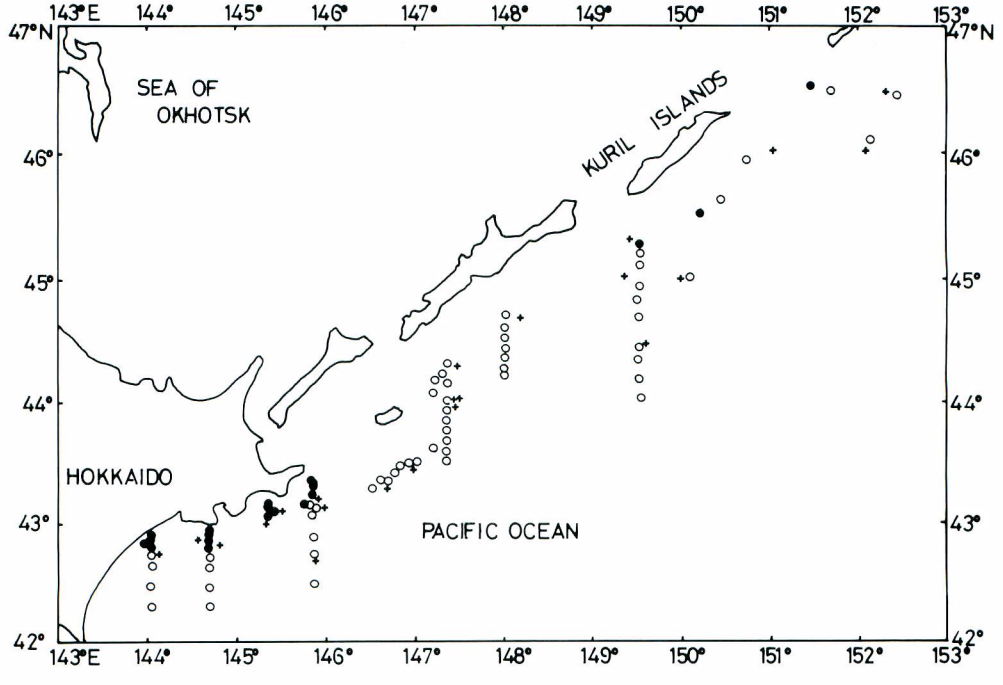


**Fig. 1.** Location of sampling stations in the coastal and offshore waters of Hokkaido and the Kuril Islands, summer 1989. Sampling methods are purse seine (open circle), surface trawl net (solid circle), and dip net (cross).

Oceanographic observations were also conducted in principle at fish sampling points from the surface to 500 m using a smart CTD. The results of these observations were analyzed by T-S diagram.

Fifty-nine fine-meshed purse seine operations was made for sampling of fishes and cephalopods during the survey. The purse seine was about 273 m long and 44 m deep. The mesh size was 18 mm (stretched knot to knot measure), with 5 mm mesh in the bunt section (final fish-retaining section). In the shallow area (i.e. less than 50 m in depth), thirty operations of the surface trawl net were made instead of the purse seine. It had 6.6 m mouth width, 4.5 m mouth height, and 19 m in length with a cod-end of 5 mm mesh size. Both purse seine and surface trawl net operations were made in the daytime. When the research vessel was adrift at night, the dip-net was used for collecting fishes and cephalopods which were attracted by the fishing lamp. Twenty two samplings by the dip-net were made during this survey.

Some samples caught were measured aboard the vessel and others preserved in formalin to examine at the laboratory. Measurement of body length was generally made for all individuals sampled. However, when a large number of individuals of a single species was caught, 30 individuals were randomly collected and measured.

## Results

*Distribution of water mass and surface water type*

All data (surface to 500 m depth) of water temperature and salinity which were obtained in the present survey were plotted in the temperature-salinity diagram (Fig. 2). This showed that the characteristics of the mid and deep water mass (from 50 m to 500 m depth) were intermediate between the Okhotsk sea waters and the central waters of the western subarctic region. This suggests that the Oyashio water mainly occupies this area, because the Oyashio Water is known to have two origins - the Okhotsk Sea water and the central water of the western subarctic region (Hirano 1956 and Yoshida 1988). However, the temperature and the salinity of the surface layer waters (surface to 30 m depth) varied widely (Fig. 2). The surface water temperature ranged 4 °C to 17 °C and the surface salinity renged 30.9 to 33.6.

The distributions of temperature and salinity at the surface are shown in Fig. 3. At the surface, there was warm water (higher than 10 °C) off the southeastern coasts of Hokkaido and south Kuril Islands, while cold water (lower than 10 °C) off the coast of the mid Kuril Islands, and extremely low salinity water (between 30.9 and 32.7) off the coast of southeastern Hokkaido.

In order to breakdown the surface water type, authors used 10 °C isotherm and salinity of 32.8 which was reported as a minimum value of northwestern Pacific Ocean and Okhotsk Sea in summer (Hirano 1958). The criteria of each water type which the authors adopted are as follows :

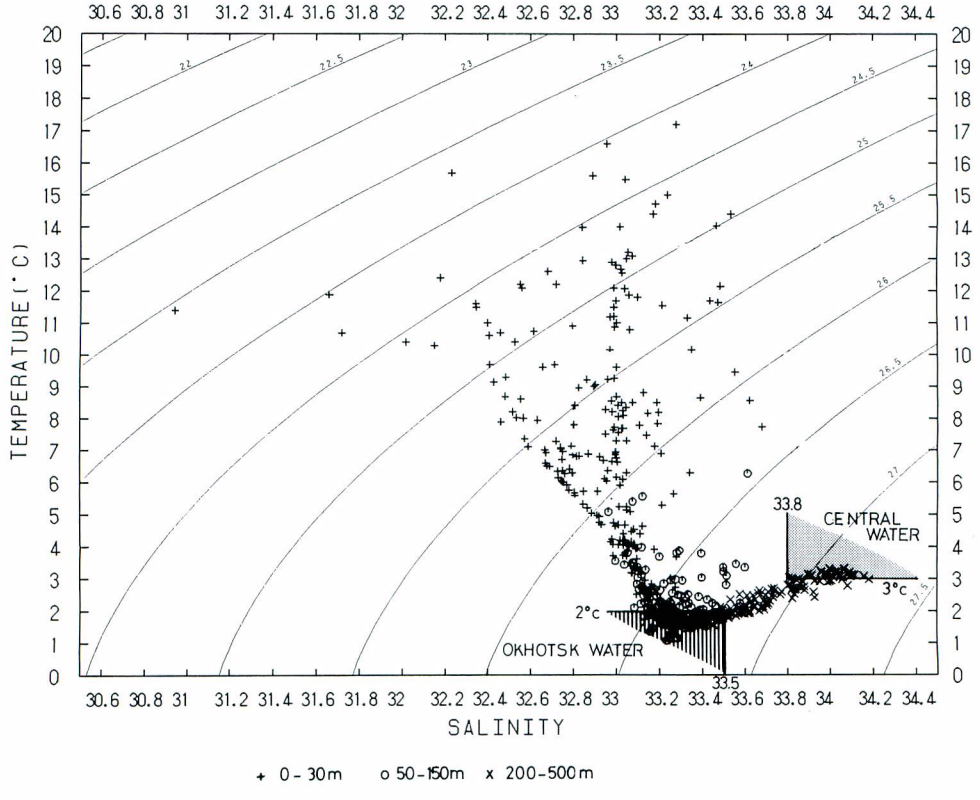


**Fig. 2.** Temperature-salinity relationship in the survey area. The plus signs indicate surface to a depth of 30 m. The open circles indicate a depth of 50 m to 150 m. Crosses indicate a depth of 200 m to 500 m.

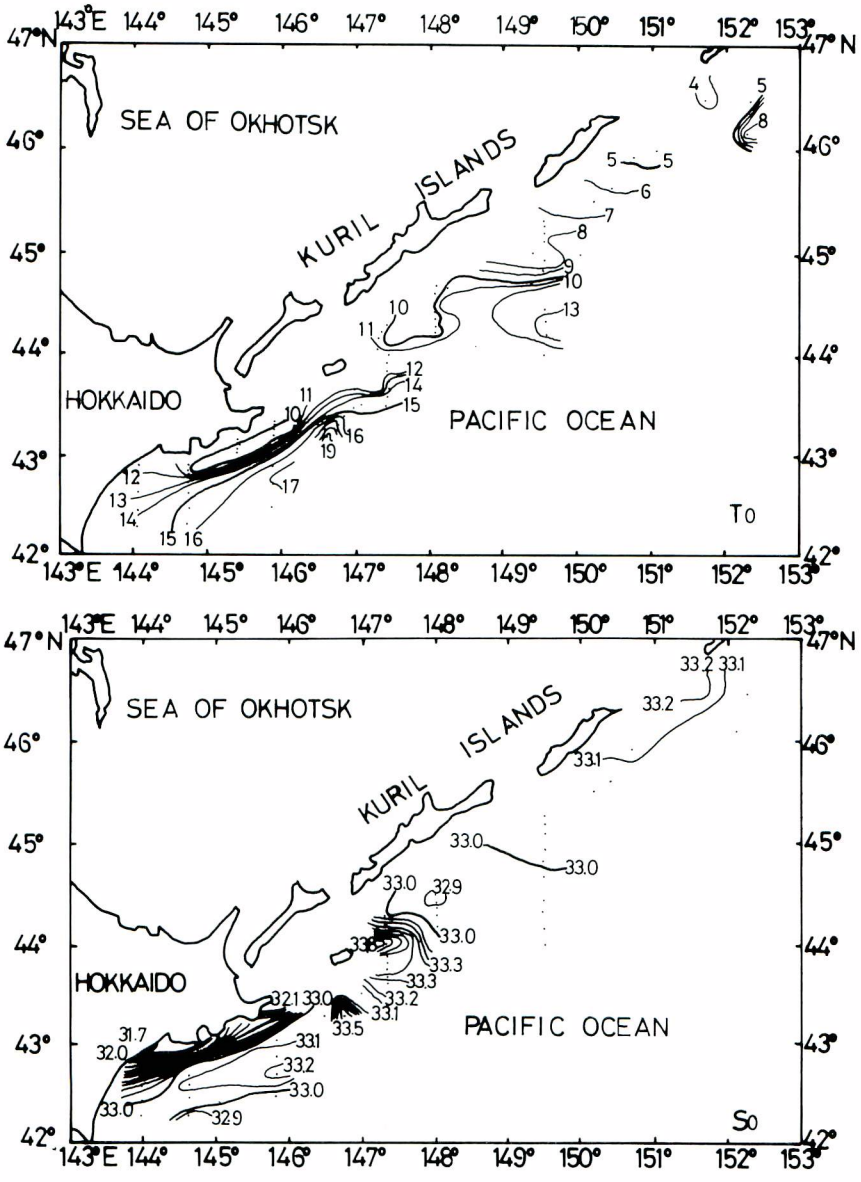


Fig. 3. Horizontal distribution of water temperature (°C) and salinity at the surface in summer 1989 in the survey area.

a. The coastal water :

The salinity is lower than 32.8. It seems to be affected by freshwater flowing from Hokkaido and Kuril Islands. Such an extreme low salinity is not normally observed in the offshore waters in summer.

b. The surface warm water :

The salinity is higher than 32.8 and temperature is higher than 10 °C. It is considered to be formed as a result of heating up the surface water of the Oyashio water (Hirano 1958).

c. The cold water :

The salinity is higher than 32.8 and the temperature is lower than 10 °C.

The schematic distribution of three surface water types is shown in Fig. 4. The coastal waters were distributed in the coastal area of Hokkaido, and the cold waters in the coastal and offshore areas of the mid Kuril Islands and a small part of the offshore area of Hokkaido. The surface warm waters were distributed in the southeastern offshore areas of Hokkaido and the south Kuril Islands.

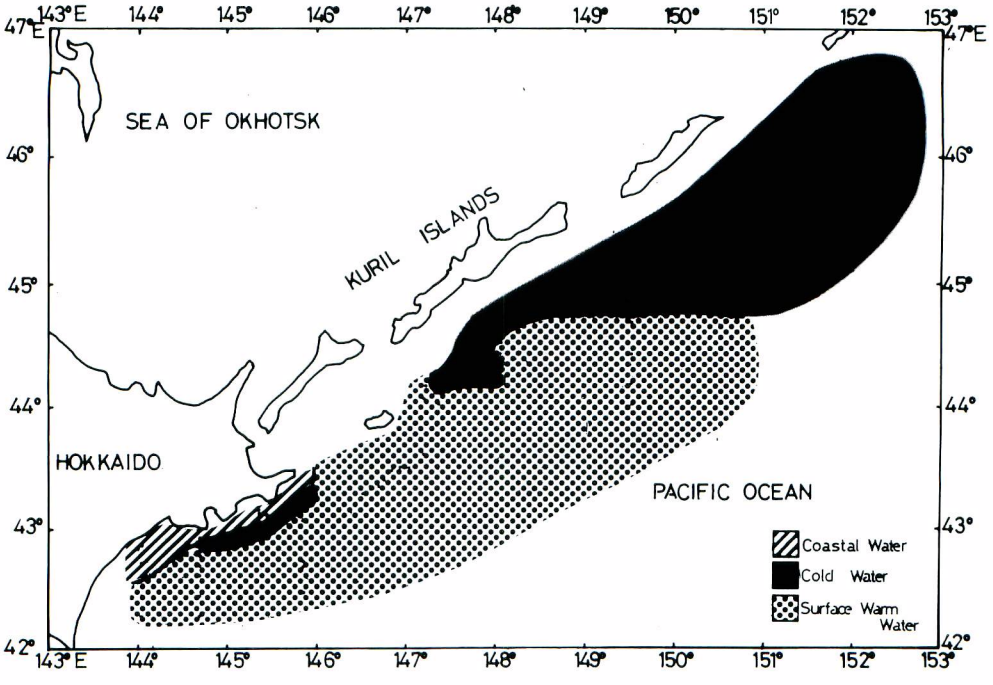


**Fig. 4.** Schematic distribution of three types of surface water. The type of water is categorized by surface water temperature and salinity. The coastal water : The salinity is lower than 32.8. The surface warm water : The salinity is higher than 32.8 and temperature is higher than 10 °C. The cold water : The salinity is higher than 32.8 and temperature is lower than 10 °C.

**Table 1.** Total number of individuals caught and range of body length for each species, and the mark of occurrence by water types. SCL is scaled length ; FL is fork length ; KL is knob length ; STL is standard length ; and ML is mantle length. Occurrence rate is the percentage of sampling stations where the species was occurred.
− : Occurrence rate is 0 %. + : Occurrence rate is less than 10 %. ++ : Occurrence rate is 10 % to 20 %. +++ : Occurrence rate is more than 20 %.

| Scientific Name | Total Number of Catch | Range of Body Length (mm) | The coastal water | The surface warm water | The cold water |
|---|---|---|---|---|---|
| **Fishes** | | | | | |
| *Sardinops melanosticta* | 974 | 42-241 : SCL | + | +++ | + |
| *Engraulis japonica* | 1735 | 23-164 : SCL | + | +++ | − |
| *Oncorhynchus gorbuscha* (adult) | 37 | 392-536 : FL | − | + | +++ |
| *Oncorhynchus keta* (abult) | 1 | 630 : FL | − | + | − |
| *Oncorhynchus keta* (juvenile) | 255 | 80-139 : FL | +++ | + | + |
| *Cololabis saira* | 672 | 9-348 : KL | + | +++ | + |
| *Gasterosteus aculeatus aculeatus* | 4 | 70 : STL | − | + | + |
| *Brama raii* | 9 | 418-485 : FL | − | + | − |
| *Scomber japonicus* | 23 | 32-395 : FL | − | + | − |
| *Scomber tapaeinocephalus* | 3 | 198-209 : FL | − | + | − |
| *Trachurus japonicus* | 2 | 47- 71 : SCL | − | + | − |
| *Ammodytes spp.* | 5175 | 27- 55 : STL | − | ++ | + |
| *Anarhichas orientalis* | 3 | 56- 62 : STL | − | + | + |
| *Anoplopoma fimbria* | 1 | 29 : STL | − | − | + |
| *Hexagrammos stelleri* | 31 | 43- 55 : STL | ++ | − | + |
| *Hexagrammos lagocephalus* | 9 | 78- 87 : STL | − | − | ++ |
| *Hexagrammos octogrammus* | 13 | 39- 52 : STL | ++ | + | + |
| *Plurogrammus azonus* | 37 | 68-166 : STL | − | + | + |
| *Hemilepidotus gilberti* | 25 | 24- 34 : STL | + | ++ | + |
| *Blepsias cirrhosus draciscus* | 43 | 27- 47 : STL | ++ | + | − |
| *Blepsias bilobus* | 1 | 30 : STL | − | + | − |
| *Hemitripterus villosus* | 2 | 38- 41 : STL | + | − | − |
| *Myoxocephalus stelleri* | 1 | 16 : STL | + | − | − |
| *Aptocyclus ventricosus* | 1 | 224 : STL | − | + | − |
| *Atheresthes evermanni* | 13 | 30- 40 : STL | − | ++ | + |
| *Pholidae spp.* | 1 | 31 : STL | + | − | − |
| *Lumpenella nigricans* | 1 | 47 : STL | − | + | − |
| *Briozoichthys lysimys* | 30 | 28- 37 : STL | − | + | + |
| **Squids and Octopus** | | | | | |
| *Todarodes pacificus* | 53 | 88-190 : ML | − | ++ | − |
| *Onychoteuthis banksii* | 1 | 284 : ML | − | + | − |
| *Gonatus middendorffi* | 355 | 8- 68 : ML | − | ++ | +++ |
| *Gonatus madokai* | 69 | 10- 80 : ML | + | + | + |
| *Berryteuthis magister* | 3 | 9- 15 : ML | − | + | + |
| *Japetella diaphana* | 1 | 60 : ML | − | − | + |
| Number of Species | — | | 12 | 26 | 19 |

*The fish and cephalopods species encountered and their distribution*

Twenty-seven species of fishes and 6 species of cephalopods were collected with three Kinds of sampling gear during the survey.

The relationship between the surface water type and the occurrence of species is summarized in Table 1. Twelve species were observed in the coastal waters, 26 species in the surface warm waters, and 19 species in the cold waters. The largest number of species and individuals was collected in the surface warm water.

The body lengths frequencies of 5 of the most abundant species are shown in Table 2. Horizontal distributions of these species are shown in Fig. 5.

**Table 2.** Body length of main species for all sampling areas. FL is fork length. SCL is scaled length. KL is knob length. ML is mantle length.

| length (mm) | *Oncorhynchus keta* (FL) | *Sardinops melanosticta* (SCL) | *Engraulis japonica* (SCL) | *Cololabis saira* (KL) | *Gonatus middendorffi* (ML) |
|---|---|---|---|---|---|
| 0-10 | 0 | 0 | 0 | 2 | 1 |
| -20 | 0 | 0 | 0 | 5 | 0 |
| -30 | 0 | 0 | 82 | 7 | 13 |
| -40 | 0 | 0 | 150 | 22 | 60 |
| -50 | 0 | 2 | 32 | 23 | 96 |
| -60 | 0 | 6 | 36 | 49 | 15 |
| -70 | 0 | 1 | 21 | 15 | 2 |
| -80 | 1 | 0 | 13 | 15 | 0 |
| -90 | 10 | 0 | 2 | 15 | 0 |
| -100 | 84 | 0 | 0 | 7 | 0 |
| -110 | 104 | 0 | 0 | 12 | 0 |
| -120 | 47 | 1 | 0 | 6 | 0 |
| -130 | 10 | 0 | 4 | 12 | 0 |
| -140 | 1 | 0 | 24 | 9 | 0 |
| -150 | 0 | 0 | 19 | 2 | 0 |
| -160 | 0 | 0 | 6 | 2 | 0 |
| -170 | 0 | 0 | 1 | 1 | 0 |
| -180 | 0 | 2 | 0 | 0 | 0 |
| -190 | 0 | 34 | 0 | 2 | 0 |
| -200 | 0 | 88 | 0 | 5 | 0 |
| -210 | 0 | 82 | 0 | 3 | 0 |
| -220 | 0 | 29 | 0 | 1 | 0 |
| -230 | 0 | 8 | 0 | 4 | 0 |
| -240 | 0 | 2 | 0 | 1 | 0 |
| -250 | 0 | 1 | 0 | 1 | 0 |
| -260 | 0 | 0 | 0 | 3 | 0 |
| -270 | 0 | 0 | 0 | 2 | 0 |
| -280 | 0 | 0 | 0 | 1 | 0 |
| -290 | 0 | 0 | 0 | 0 | 0 |
| -300 | 0 | 0 | 0 | 0 | 0 |
| -310 | 0 | 0 | 0 | 1 | 0 |
| -320 | 0 | 0 | 0 | 2 | 0 |
| -330 | 0 | 0 | 0 | 1 | 0 |
| -340 | 0 | 0 | 0 | 1 | 0 |
| -350 | 0 | 0 | 0 | 1 | 0 |
| Total | 256 | 390 | 245 | 257 | 187 |

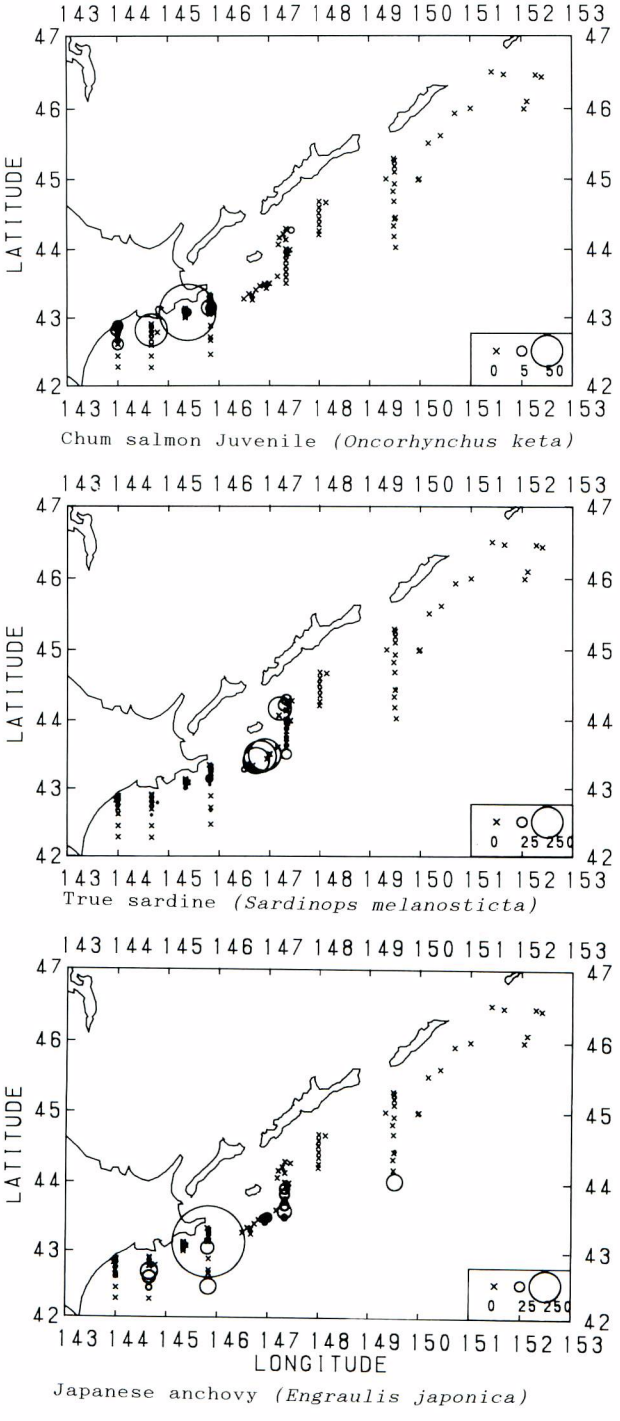


**Fig. 5.** Distribution and catch in numbers per operation for 5 main species.

a. Chum salmon, *Oncorhynchus keta* (juvenile)

Juvenile chum salmon were abundant in the coastal waters off Hokkaido, but only two individuals were caught from the surface warm water off the south Kuril Islands. The fork length ranged from 80 mm to 139 mm.

b. True sardine, *Sardinops melanosticta*

A great part of this species occurred in the surface warm water area off the south Kuril Islands, and a few individuals were found in the other two water areas. The body length of the greater portion of true sardine fell within a 180 mm to 250 mm range in scaled length. Accordingly, the greater portion of this species is considered to belong to the adult stage (Kondo *et al.*, 1976). A few juveniles (50 mm to 120 mm) were also collected.

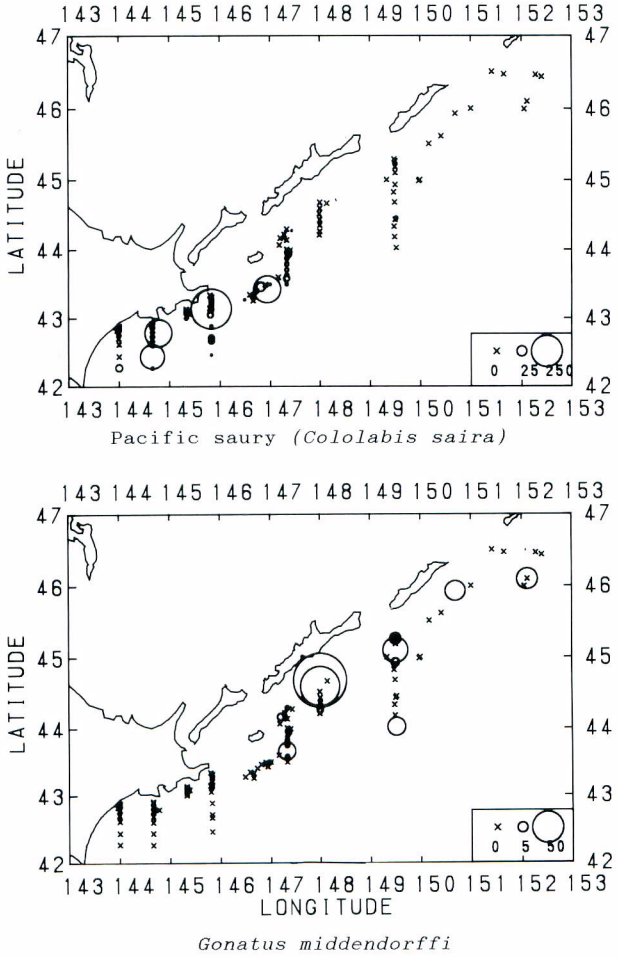


**Fig. 5.** (continued)

c. Japanese anchovy,
*Engraulis japonica*

The distribution of juveniles of this species occurred widely over the surface warm water area, and a few were found also in the coastal waters. The length range of juvenile Japanese anchovy was within 30 mm to 90 mm in scaled length. A few adults of 120 mm to 170 mm were also found.

d. Pacific saury,
*Cololabis saira*

This species was most abundant in the surface warm waters, with a few individuals found in the other two waters. All the life stages juvenile, young and adult appeared because individuals collected were between 9 mm and 348 mm in knob length.

e. *Gonatus middendorffi*

The greater part of this squid occurred in the cold water area, but a considerable number was also present in the surface warm water area. This squid was reported to be distributed in cold water area such as the northwentern Pacific Ocean, Okhotsk Sea and Bering Sea (Kubodera and Okutani 1981). The body length fell within the 8 mm to 68 mm range in mantle length. This revealed that all individuals collected in this survey belonged to the stage of juveniles.

## Discussion

*Migration of chum salmon juveniles*

Chum salmon juveniles which originated from the rivers in Japan have been commonly understood to migrate to the northern part of the North Pacific Ocean or Bering Sea (Neave *et al.*, 1980). In previous reports (Irie 1985 ; Hashiguchi and Matsushita 1988), the juveniles were encountered along the coastal belt of Hokkaido and the north part of Honshu at least by early-July. It is also known that the juveniles migrate northward relatively near the shore from June to September off the Pacific coast of North America (Hartt and Dell 1986). In the present survey, almost all juveniles were found in the coastal waters off Hokkaido, while few juveniles were caught near the Kuril Islands. These facts indicate the possibility that the juveniles occurred off the Pacific coast of Hokkaido migrate northward along the close coastal area of the Kuril Islands, although the coastal area within the 12 mile zone of the Kuril Islands was not investigated.

*Occurrence of Japanese anchovy*

The distribution of juveniles of Japanese anchovy has been reported to be in the south of Hokkaido and the coastal waters of Honshu, but has not been reported in the present survey area (Kondo 1971, Kobayashi and Abe 1962). Accordingly, there is the possibility that Japanese anchovy expanded their habitat into this area (the surface warm water area) beause a number of individuals was collected and the range of scaled length of juveniles was also comparatively wide.

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# 1989年夏季の北海道及び千島の太平洋側沿岸域における海況と幼魚及び頭足類の分布

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## 摘　要

さけ幼魚及びその他の重要魚種の幼魚の分布と海洋条件との関係を明らかにすることを目的として，1989年，夏季に北海道及び千島の太平洋側の沿岸域及び沖合域でまき網，表層曳き網及びたも網を用いて漁獲試験を行った。この調査で，27種の魚類及び6種の頭足類が採集された。また，同時にCTDによる海洋観測を実施した。中下層水の性質から，調査水域は概ね親潮水域に属すると判断された。表面水の水温と塩分から，調査水域をさらに沿岸水域，表層暖水域及び冷水域に分割したところ，各水域と生物の分布との間に良い対応が見られた。沿岸水域では，全部で12種が採集され，特にさけの幼魚が多く分布した。また，表層暖水域では，全部で26種が採集され、特にマイワシ，カチクチイワシ，サンマ(幼魚から成魚まで)の分布が多く見られた。冷水域では，全部で19種が採集され，特にカムチャツカテカギイカ（幼いか）が多く漁獲された。