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Results of trawl count surveys on juvenile salmon and attendant fish species along southern Sakhalin Island (southwestern Sea of Okhotsk) performed by RV “Dmitry Peskov” in July 2006–2008

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ABSTRACT

The results of oceanographic and trawl count surveys in Aniva Bay and along southeastern Sakhalin Island (southwestern Sea of Okhotsk) in July 2006–2008 are considered. A total of 280 oceanographic and 263 trawl stations were performed, and 2834 juvenile pink and chum salmon and 846047 fish of other species were sampled. Profiles of temperature distribution along standard transects in Aniva Bay, graphic data of horizontal temperature distribution over the sea surface and at 10- and 20-m horizons in the study areas, maps of catch distribution patterns for juvenile salmon and attendant fish species and their size-weight characteristics are given in this report. It is mentioned that in Aniva Bay juvenile pink and chum salmon stay for a long time (to 1.5-2.5 months) in a coastal zone after their appearing in sea waters. Juveniles' migration from a shore to the open waters of the bay takes place independently of the dates when specimens enter sea waters. This migration is brief and usually happens in the first half of July. As a rule, by the 20s of July, all juvenile pink and chum salmon leave the bay area. Then they concentrate along southeastern Sakhalin and stay there up to the end of July. The results of studies of juvenile salmon migration from southern Sakhalin in 2004–2008 are summed up. Besides salmonids, a total of 47 fish species from 22 families enter the ichthyocenoses composition of the upper epipelagial of Aniva Bay and shelf area of southeastern Sakhalin. Juvenile pink and chum salmon make up only 0.02-0.76% of the total fish sampled. Attendant fish species were represented mainly by fry, underyearlings and immature small specimens. The predatory fish that could consume salmon juveniles were either absent or not abundant in the ichthyocenoses composition.

INTRODUCTION

The SakhNIRO studies of early sea life period of juvenile pink and chum salmon on the shelf of eastern Sakhalin and southern Kuril Islands began in 2002 aboard RV “Dmitry Peskov” using the mean-size pelagic trawls. When performing trawl stations in 2002 and 2003, an extensive approach was used: after a series of trawl hauls in Aniva Bay, trawl operations were done on the shelf area of southeastern Sakhalin, then in Terpeniya Bay (or near southern Kuril Islands), further along northeastern Sakhalin. However, such approach did not allow us to find aggregations of juvenile salmon at the phase of their migration from a shore (Shubin et al., 2003; Kovalenko et al., 2004). Since 2004, an intensive approach has been used: a surveyed area was restricted by Aniva Bay, and trawl hauls were performed in two or three stages for the same

scheme of stations. As a result, in the first half of July, dense juvenile pink and chum salmon aggregations migrating from a shore were first found in Aniva Bay. In 2005, the results of the 2004 surveys were verified (Shubin et al. 2005, 2007). In 2006-2008, these studies were continued in order to ascertain the dates of migration and habitat status, and also to follow migratory ways of juvenile salmon after their leaving Aniva Bay.

MATERIALS AND METHODS

A southwestern part of the Sea of Okhotsk (shelf area of southern Sakhalin – Aniva Bay), La Perouse Strait, and southeastern Sakhalin coast (Fig. 1) have been investigated by the SakhNIRO RV “Dmitry Peskov” in July 2006–2008. The target objects were juvenile pink, chum and masu salmon (*Oncorhynchus gorbuscha*, *O. keta* and *O. masou*) and other fish species from the upper epipelagic shelf zone. The trawl survey has been performed according to the elaborated scheme of stations and particular tasks, which are given in the basic part of the report. The stations were always located along the latitude transects above the isobaths of 30 m, 50 m, 75 m, 100 m, 150 m, and 200 m and above the depth slope. In 2006, the trawl survey was conducted in Aniva Bay and La Perouse Strait by three stages (Table 1) according to the same scheme of stations. A total of 21 trawl hauls were done in Aniva Bay and 6 trawl hauls in La Perouse Strait and east of it (Fig. 2A). In 2007, the trawl survey was performed in Aniva Bay by three stages as well (Table 1) according to the same scheme of stations. All of 30 trawl hauls were done in Aniva Bay (Fig. 2B). In 2008, a total of 22 trawl hauls were done in Aniva Bay between 13 and 17 July. Later the trawl operations were performed along southeastern Sakhalin by two stages. At the first stage (18–27 July), a total of 56 trawl hauls were done between Cape Aniva and str. Sovetskoye, including 30 trawl hauls near Tonino-Anivskiy Peninsula (18–21 July). At the second stage (28–29 July), a total of 12 trawl hauls were done between Cape Levenorn and Cape Aniva and one more trawl haul in Aniva Bay near Cape Aniva (Fig. 1, 2C). The second stage of survey was performed in order to ascertain feeding duration of juvenile salmon along the shore of Tonino-Anivskiy Peninsula. In total, 263 trawl stations were performed in 2006–2008; 2834 juveniles of pink and chum salmon and 846047 fish of other species were sampled (Table 1).

In 2006–2007, fish sampling was accomplished with a mid-water rope trawl (54.4/192 m). The trawl codend was created of the set of nets with 9 mm mesh. Its vertical opening was about 27-28 m and horizontal about 40-44 m. In 2008, a mid-water rope trawl of 48/200 m with

the 12-mm mesh was used. Its vertical opening was about 26-28 m and horizontal about 36-40 m. A peculiarity of the 48/200 m trawl construction was that its codend divided into two “sleeves”: the upper “sleeve” sampled fish from the 0–13(14) m layer and the lower one from 14(15)–28 m. The V-shape boards of 4.0 m² were used for the horizontal opening of the trawl. For each of trawl hauls, a head line of the trawl was brought out to 0-horizon using a rubber shield of 3.35-3.5 m². A front part of the trawl was 270 m off the vessel stern. The layer sampled was 0–28(30) m, mean towing speed 4.4 knots, and duration of a trawl towing 0.5 of an hour. Trawl operations were performed only during daylight. The area sampled was about 0.15-0.17 km² per a trawl haul. The caught fish from each trawl haul were sorted by species; majority of juvenile pink and chum salmon were used for biological analyses (fork length and body weight). The species belonging to juvenile pink and chum salmon were identified by the number of gill rakers on the first gill arch. Fish frequency and mean catches were calculated for the total number of stations performed.

To measure oceanographic parameters, a sounder ICTD № 1356 produced by the company FSI was used. Sounding was conducted up to 100 m or to the bottom at smaller depths. In Aniva Bay, oceanographic data were collected from four standard transects at 24 stations (Fig. 2D). Of them, the century-old transect IV (Cape Aniva – Cape Anastasiya) has the most complete statistical data. The sea condition was characterized by the calculated temperature and salinity anomalies along the standard transects by layers. The computer program “Mean long-term characteristics of hydrologic-hydrochemical parameters of the shelf zone of Sakhalin Island (NiroPRO)”, created on the data-base of “Oceanographic atlas of the shelf zone of Sakhalin Island” (Pischalnik, Bobkov, 2000) was used for calculation. In 2008, oceanographic measurements along southeastern Sakhalin were conducted as accompanying a trawl survey; oceanographic stations were performed before and after each of trawl hauls.

Within our report, a “coastal zone” is an area between the shore line and depths of 28-30 m, from which we began trawling; a “near-surface sea layer” is an upper quasihomogeneous layer and upper part of a seasonal thermocline up to the depth of the 4-6°C isotherm (usually it is a 0-15(20) m layer).

The following abbreviations occur in the text, Tables, and Figures: SST – sea surface temperature, °C, σ – root-mean-square deviation, M – arithmetic mean, N – number of specimens in a sample, CPUE – catch per unit effort.

RESULTS OF SURVEYS

Distribution of oceanographic characteristics

2006 In early summer, a vertical distribution of oceanographic indices in the upper sea layers was characterized by significant negative anomalies. At the first stage of the survey, statistically significant negative temperature anomalies reaching 3°C were recorded at the transect Cape Aniva – Cape Anastasiya in the 0-30 m layer. The positive salinity anomalies, equal or exceeding σ , were recorded in the upper layers. The values of anomalies declined rapidly with the depth increase (Table 2). The noticeable anomalies of temperature and salinity were also recorded in the upper layers at the rest three stations of the standard transect of the bay. SST on the bay area varied from 14-15°C in northern part to 10-11°C in the southeastern part. At the 10-m horizon the water temperature varied from 3 to 7°C, at 20 m from 0.5 to 3.5°C, and at 50 m from 0.5 to 1.2°C (Fig. 3). Salinity was 31.7-32.2‰ at the sea surface and 32.5-32.8 ‰ at the 30-m horizon. Later, at the second and third stages of survey, a vertical distribution of seawater temperature in the upper layers of the bay did not change appreciably, and on the whole, in early summer 2006 they were unusually low.

2007 In early summer, the upper sea layer temperature in Aniva Bay was close to a standard, but salinity of these layers was characterized either by significant negative anomalies (first stage of survey) or proximity to a standard (third stage of survey). The important feature of the temperature and salinity field in the bay was its spatial heterogeneity. In the beginning of survey the waters of the upper layer were warmer and less saline in the western part of the bay than in its eastern part. At the end of survey the situation has changed: the upper layer waters of the eastern part of the bay were warmer and less saline. At the first stage of survey, significant (close to σ) positive temperature anomalies and significant (close to 2σ) negative salinity anomalies were recorded at the transect Cape Aniva – Cape Anastasiya in the layers of 0-20 m and 0-30 m (Table 2). The same distribution pattern for oceanographic indices in these layers was observed for the neighbor transect III. In the northern part of the bay (transects I and II), insignificant (much less than σ) negative temperature anomalies and significant salinity anomalies were observed in the upper layer. SST on the bay area varied from 15-16°C in western part to 12-13°C in the southeastern part. At the horizon of 10 m the water temperature varied from 11-14°C in western to 6-9°C in the eastern part of the bay; at 20-m horizon from 3-4°C in northern part to 10-11°C in a zone of weakly expressed anticyclone vortex on the open boundary

of the bay. At the horizon of 50 m the water temperature nowhere was lower than 0°C (Fig. 4). Salinity at the water surface was 31.4-31.7‰, and 31.4-32.1‰ at the 20-m horizon. The repeated measurements, performed in 10 days, showed that the anticyclone vortex in the southern part of the bay became stronger. A cyclone ring with colder and more saline waters was formed in the southwestern part of the bay. Due to this, the negative anomalies of temperature and salinity were recorded in the upper layers at the transect Cape Aniva – Cape Anastasiya, although their statistical significance was not high. On the rest bay area, only insignificant positive temperature and negative salinity anomalies were recorded in the upper layers. However, a spatial distribution of oceanographic parameters changed greatly: waters of the upper sea layer were warmer and less saline in the eastern part of the bay that is a rare phenomenon in this region.

2008 In early summer, a vertical distribution of oceanographic indices was close to a standard in the upper sea layers of Aniva Bay; the exception was the area of the outmost northern part of the bay. In mid July, an insignificant positive temperature anomaly was recorded in the layer of 0-10 m at the transect Cape Aniva – Cape Anastasiya, and insignificant negative temperature and positive salinity anomalies in the layer of 0-50 m; the values of anomalies increased with the depth (Table 1). The central part of the bay (transects III and II) had a close pattern of vertical distribution of oceanographic indices in the upper sea layer. In the northern part of the bay (transect I) the statistically significant negative temperature anomaly (2.5°C) and positive salinity anomaly (0.3‰) were observed in the 0-50 m layer. SST on the bay area varied from 15-16°C in northwestern to 11-12°C in its southeastern part. At the horizon of 10 m, water temperature varied mainly from 10 to 12°C, and at 20-m horizon from 6 to 8°C. The lowest temperatures (3 to 5°C) were recorded along the eastern shore of the bay that is common for this region. At the horizon of 50 m, water temperature varied from 0 to -0.5°C (Fig. 5A, 6). Salinity was 31.5-32.0‰ at the water surface and 32.3-32.5 ‰ at the 20-m horizon. Along southeastern Sakhalin, coastal waters warmed up greater compared to the western part of Aniva Bay in mid July. A temperature distribution along Tonino-Anivskiy Peninsula was rather unusual. SST was high all over the area, ranging between 13.5 and 16°C (14-15°C at major stations). Deepening of the warm waters with lower salinity, apparently related with such a rare for this region phenomenon as downwelling, was observed along Tonino-Anivskiy Peninsula. At the coastal stations of this site, the 10°C isotherm was located deeper (15-18 m horizon) than on the rest area, and at some stations it was located at 25-30 m. North of Mordvinov Bay and to the southern part of Terpeniya Bay the 10°C isotherm at the coastal stations was located at lesser depths (10-12 m, rare 16 m). Above the mid and offshore parts of southeastern Sakhalin shelf, the water

temperature usually did not exceed 10°C at the 10-m horizon. Along Tonino-Anivskiy Peninsula, the water temperature at the coastal stations was 10-12°C at the 20-m horizon, and 6-8°C above the mid and offshore parts of the shelf zone; northward the temperature at this horizon changed from 3-4 to 6°C (Fig. 5B-5D, 6). Salinity was 31.5-32.3‰ at the sea surface and 32.0-32.5 ‰ at the 20-m horizon.

Distribution, abundance and size-weight characteristics of juvenile salmon

2006 The aim of trawl survey in Aniva Bay was to ascertain timing of the mass juvenile pink and chum salmon migration from the bay shore depending on the temperature of the near-surface sea layer. Since earlier (2004-2005), the survey was conducted in the first half of July (Shubin et al. 2005, 2007), in 2006 it was carried out in the same time period. At the first stage of the survey, juvenile pink salmon were observed only at a single station (frequency 4%, 3 fish sampled, mean catch over the region 0.1 fish/trawl). The frequency of juvenile chum salmon was low as well (11%), although higher than pink salmon. Its catches varied from 1 to 9 fish/trawl, (average 0.5 fish/trawl); a total of 14 chum salmon were sampled (Fig. 7A, 8A). At the second stage of survey, frequency and catches of juvenile salmon remained low. Pink salmon juveniles were observed only at a single station (frequency 4%, 14 fish sampled, mean catch 0.5 fish/trawl). The frequency of juvenile chum salmon was 15%, its catches varied from 2 to 6 fish/trawl (average 0.5 fish/trawl); a total of 14 specimens were sampled (Fig. 7B, 8B). At the third stage of the survey, frequency and catches of juvenile salmon continued to be low. Pink salmon juveniles were observed only at two stations (frequency 7%, 9 and 15 fish sampled, mean catch 0.9 fish/trawl). Chum salmon juveniles were observed at four stations (frequency 15%). Their catches varied from 1 to 4 fish/trawl, average 0.4 fish/trawl; a total of 8 fish were sampled (Fig. 7C, 8C). The size-weight characteristics of juvenile pink salmon were similar: fork length 5-8 cm (average 6.7 cm), body weight 0.9-4.4 g (average 2.3 g). The size-weight characteristics of juvenile chum salmon ranged widely: fork length 6.9-19.8 cm (average 14.5 cm), body weight 2.3-73.7 g (average 33.9 g) (Fig. 9).

2007 The aim of trawl survey was the same as in the prior year. Taking into account the experience of 2006, the survey was conducted a little later: since 8 through 23 July (Table 1, Fig. 2B). At the first stage of the survey, juvenile salmon aggregations were mainly observed nearby the open boundary of Aniva Bay. The frequency of juvenile pink salmon comprised 30% and chum salmon 33%.

The catches of juvenile pink salmon varied from 1 to 102 fish/trawl (average 8.9 fish/trawl); a total of 268 specimens were sampled. The catches of juvenile chum salmon varied from 1 to 155 fish/trawl (average 11.3 fish/trawl); a total of 339 specimens were sampled (Fig. 10A, 11A). At the second stage of the survey, pink salmon dominated in catches. Its frequency was 29%, catches varied from 1 to 164 fish/trawl (average 10.4 fish/trawl); a total of 325 specimens were sampled. It should be noted that the main aggregations of juvenile pink salmon were observed in the eastern part of the bay, where they were absent five days earlier. The frequency of juvenile chum salmon was low (7%), catches did not exceed 2 fish/trawl (average 0.06 fish/trawl); a total of 4 specimens were sampled (Fig. 10B, 11B). At the third stage of the survey, juvenile pink salmon dominated in catches as well. Its frequency composed 20%, catches varied from 1 to 101 fish/trawl (average 4.1 fish/trawl); a total of 123 specimens were sampled. The main aggregations of juvenile pink salmon were observed on the same areas as before – along the eastern coast of Aniva Bay, but the aggregation core has shifted to the south (outlet of the bay). Juvenile chum salmon were not frequent (7%); their catches varied from 1 to 8 fish/trawl (average 0.3 fish/trawl), a total of 9 specimens were sampled (Fig. 10C, 11C). The size-weight characteristics of pink juveniles were similar at all of three stages. Their fork length ranged between 4.8 and 9.6 cm (average 7.6 cm) and body weight between 1 and 10.3 g (average 3.5 g); 98-99% of specimens were 6 to 9 cm in length and 1 to 6 g in weight (Fig 12). In contrast to pink salmon, the size-weight characteristics of chum juveniles varied widely: fork length 6.2 -13.4 cm (average 10.1 cm) and body weight 1.9-22.1 g (average 9.4 g). Of them, 90% of specimens had weights more than 8 g (Fig. 13).

2008 The trawl survey performed in 2008 had two aims: (1) to determine location of juvenile pink and chum salmon after they leave Aniva Bay; (2) to continue investigations along the southeastern Sakhalin coast started in 2002-2004, in order to evaluate a distribution pattern of the juvenile salmon migrating from rivers and hatcheries in this region. In Aniva Bay, juvenile salmon were observed only in the southeastern part, nearby the open boundary of the bay. The base of catches (69%) was composed of pink juveniles. Their frequency was not high (18%), catches varied from 1 to 124 fish/trawl (average 6.5 fish/trawl); a total of 143 specimens were sampled. One third of juvenile salmon catches was composed of chum salmon, which were less frequent (9%) than pink salmon. The chum catches varied from 8 to 56 fish/trawl (average 2.9 fish/trawl); a total of 64 specimens were sampled (Fig. 14A, 15A). The size-weight characteristics of juvenile pink salmon were similar. Their fork length ranged between 6.9 and 9.7 cm (average 8.1 cm) and body weight between 2.2 and 8.0 g (average 4.5 g). The dominants

were specimens of 8 to 9 cm in length and 4 to 6 g in weight. The size-weight characteristics of juvenile chum salmon were more diverse compared to pink salmon. Their fork length varied from 6.8 to 14.0 cm (average 8.4 cm) and body weight from 2.5 to 25.2 g (average 5.7 g). Distribution of these indices had a bimodal character. The first group (89%) included juveniles of 7 to 10 cm in length and 3 to 9 g in weight; the second group (11%) included juveniles of 12 to 14 cm in length and 18 to 26 g in weight (Fig. 16).

At the first stage of the survey along southeastern Sakhalin, juvenile salmon were observed to be unevenly distributed: all of pink juveniles and almost all of chum juveniles (96%) were sampled along the coast of Tonino-Anivskiy Peninsula. The base of catches was formed by pink juveniles (89%). In general, their frequency was not high over the region (25%), catches varied from 1 to 442 fish/trawl (average 17.3 fish/trawl); a total of 966 specimens were sampled. Along the coast of Tonino-Anivskiy Peninsula, the frequency and mean catch of juvenile pink salmon were significantly higher (43% and 32.2 fish/trawl, respectively). The majority of pink juveniles (95%) were caught above the isobaths of 30 to 150 m. Juvenile chum salmon comprised only 11% of the total salmon catch on the shelf area of southeastern Sakhalin. Their frequency (23%) was almost the same as for pink salmon, but catches were significantly lower. They varied from 1 to 50 fish/trawl (average 2.4 fish/trawl); a total of 133 specimens were sampled. The majority of chum juveniles (84%) were caught above the isobaths of 50 to 200 m, and the rest specimens above the depth slope (Fig. 14B, 15B). The size-weight characteristics of juvenile pink salmon were similar. Their fork length ranged between 4.5 and 10.5 cm (average 8.5 cm) and body weight between 1.0 and 9.4 g (average 5.2 g). The dominants were specimens of 9 to 10 cm in length and 6 to 8 g in weight. These indices were a little greater than those from juveniles sampled earlier in Aniva Bay (1.1 times greater by length and 1.2 times by weight). The size-weight characteristics of juvenile chum salmon were not similar as those observed earlier in Aniva Bay. The fork length of specimens varied from 6.5 to 17.6 cm and body weight from 1.8 to 56.4 g. There were polymodal and bimodal patterns for length and weight distributions (Fig. 16).

At the second stage of the survey, the base of juvenile salmon catches continued to be composed of pink (91%). Their frequency was high (54%), catches varied from 1 to 260 fish/trawl (average 26.7 fish/trawl); a total of 347 specimens were sampled. The majority of pink juveniles were sampled above the isobaths of 50 to 100 m. Juvenile chum salmon constituted only 9% of the pink catches. Their frequency was 39%, catches varied from 1 to 19 fish/trawl (average 2.8 fish/trawl); a total of 36 specimens were sampled. The majority of chum juveniles

were sampled above the isobaths of 50 to 100 m too (Fig. 14C, 15C). The fork length of juvenile pink salmon ranged between 7.2 and 11.6 cm (average 9.0 cm) and body weight between 2.7 and 14.1 g (average 6.4 g). The pink salmon were larger by weight than those sampled earlier in Aniva Bay and along southeastern Sakhalin at the first stage of the survey (1.4 and 1.2 times, respectively). The size-weight characteristics of juvenile chum salmon were not similar: fork length ranged between 7.2 and 15.5 cm and weight between 3.3 and 33.9 g (Fig. 16).

In conclusion we are to mention that about 95% of juvenile pink and chum salmon sampled in July 2008 were taken from the upper “sleeve” of the 48/200 m trawl codend, whereas other fish species were taken from both “sleeves”. In our opinion, such distribution of juvenile salmon between the codend “sleeves” is related with their main habitats in the near-surface layer (0-13(14) m).

Besides juvenile pink and chum salmon, juvenile masu of the N.0+ age group occurred in our catches. In July 2006, a total of 13 masu specimens were sampled in Aniva Bay and 5 specimens in 2007 (Table 3). The fork length of juvenile masu salmon varied from 12.4 to 30 cm and body weight from 19.5 to 300 g. In July 2008, juvenile masu salmon were not found in Aniva Bay (Table 3). Along the southeastern Sakhalin coast, a total of 23 specimens were sampled. The maximal masu catches (to 9 fish/trawl) were recorded nearby the open boundary of Terpeniya Bay (Fig. 17). The fork length of masu salmon ranged between 15 and 28 cm and weight between 39 and 266 g. The masu specimen, caught on 27 July 2008 (47°30' N and 144°15' E), was without both pectoral fins (tag ?); its fork length was 27 cm and weight 245 g. All masu salmon, sampled in 2008, fed actively; their diet consisted mainly of juvenile Pacific sand lance.

Pre-spawning pink and chum salmon, feeding chum salmon

The pre-spawning pink salmon were the most abundant in Aniva Bay in the first half of July 2006, and along southeastern Sakhalin in the second half of July 2008 when their maximal catches reached 13-40 fish/trawl. Pink salmon fed actively; besides euphausiids, their diet consisted of juvenile arabesque greenling, Pacific capelin, saffron cod (to 40 ind.), sea raven, *Podothecus sp.* (to 60 ind.) and *Lumpenus sp.* (to 20 ind.), juvenile squid, and larval crab opilio (*Chionoecetes opilio*). Chum salmon were represented in catches both by the pre-spawning (age groups 0.3+ and 0.4+) and feeding (age group 0.1+) specimens. All specimens (3) of the pre-spawning chum salmon were caught between 11 and 19 July 2007 in Aniva Bay. They were males (67-70 cm, 4.2-5.6 kg, gonado-somatic index 0.08-0.15%). As for the feeding chum

salmon, a total of 6 specimens were caught: 5 fish in Aniva Bay in the first half of July 2006 and 1 fish south of Cape Aniva in the second half of July 2008. In the first case the fork length of fish ranged between 34.3 and 38.0 cm and weight between 470 and 680 g. In the second case the fork length was 34.5 cm and weight 485 g (Fig. 17, Table 4).

Other fish species

Besides salmonids, a total of 38 fish species from 21 families have been found in ichthyocenoses of the upper pelagial of Aniva Bay, La Perouse Strait, and southeastern Sakhalin shelf area in July 2006–2008 (Table 5). In Aniva Bay a total catch of these fishes amounted to 366241 ind. in 2006, 138950 ind. in 2007, and 30828 ind. in 2008; along southeastern Sakhalin 309710 ind. in 2008. Totally, 845729 specimens were sampled (Table 1). In Aniva Bay, the arabesque greenling (*Pleurogrammus azonus*) was steadily abundant. In 2006, Pacific capelin (*Mallotus villosus*) dominated in the ichthyocenosis. Pacific herring (*Clupea pallasii*) was also abundant in that time. But in 2007 the mean catch of capelin and that of herring were 22 and 18 times (respectively) as low than in the prior year. In 2008, the mean catch of capelin declined 137 times, and herring were absent in the bay. In 2006–2007, Japanese anchovy (*Engraulis japonicus*) occupied an appreciable place in the ichthyocenosis; in 2008, its mean catch declined 44–49 times. Such species as *Lumpenus sp.*, sea raven (*Hemitripterus villosus*), Bering wolffish (*Anarhichas orientalis*), and *Hemilepidotus sp.* have steadily been met in the ichthyocenosis. Their mean catches were maximal in 2006 (173, 94, 55, and 11 fish/trawl, respectively). Bering wolffish was very frequent being at the level or even higher than arabesque greenling. *Podothecus sp.* and saffron cod (*Eleginus gracilis*) were usually low-abundant (the first species was more abundant in 2006, and the second one in 2008). Walleye pollock (*Theragra chalcogramma*) was also low-abundant in 2006–2007. Its maximum catch (13846 fish/trawl) was recorded only in 2006 at the station near Cape Aniva (46°05' N, 143°23' E). In 2008, walleye pollock were not observed in the bay. In that year, Pacific sand lance (*Ammodytes hexapterus*) was very frequent, and Greenland halibut (*Reinhardtius hippoglossoides matsuurae*) and quill-fish (*Ptilichthys goodei*) relatively frequent on the bay area (50, 27, and 14%, respectively); however, the catches of sand lance did not exceed 9 fish/trawl, and halibut and quill-fish 1–2 fish/trawl. The mean catches of these species were only 1.5, 0.3, and 0.2 fish/trawl, respectively (Table 6). Salmon shark (*Lamna ditropis*) occurred in catches only in 2007. Despite a low frequency, it played an important role in forming fish biomass in the ichthyocenosis. The rest fish species occurred rare and in small numbers in the Aniva Bay catches. Thus, a single

specimen of the northern swellfish (*Takifugu porphyreus*) was sampled on 29 July 2008 near Cape Aniva (46°00' N, 143°19' E) above the depths of 83-91 m.

Along southeastern Sakhalin, in the second half of July 2008, saffron cod was a dominating species in the ichthyocenosis (frequency 61%, mean catch 3354 and maximal catch 36250 fish/haul). Saffron cod were distributed everywhere, but their densest aggregations were observed above the depths of 30 to 75 m. Arabesque greenling, Pacific capelin, Pacific sand lance, Bering wolffish, and *Podothecus sp.* were very abundant. Arabesque greenling were widely distributed near Tonino-Anivskiy Peninsula, but they were less frequent northward; their catches shifted from the coastal zone to the depth slope. The mean catch of arabesque greenling was 460 and maximal 3600 fish/haul. The catches of capelin and sand lance in this region were more significant than in the same (2008) year in Aniva Bay. The mean catch of capelin was 515 and that of sand lance 38 fish/haul (maximal catches 15324 and 1700 fish/haul, respectively). The capelin concentrated mainly in Mordvinov Bay above the depths of 30-100 m, and sand lance were distributed everywhere, including the area of depth slope nearby the open boundary of Terpeniya Bay. Bering wolffish (93%) was the most frequent among fishes of the upper epipelagic southeastern Sakhalin shelf. This species was distributed all over the shelf area with the largest concentrations near Tonino-Anivskiy Peninsula. There its maximum catch reached 118 fish/haul (average 13 fish/haul for the entire area). Salmon shark were low-frequent (by 1 individual at 4 stations). In 2008, along southeastern Sakhalin, as in Aniva Bay, Greenland halibut and quill-fish were relatively frequent (19 and 20%, respectively). Greenland halibut catches composed 1-41 fish/haul (average 1.3 fish/haul) and quill-fish catches 1-10 fish/haul (average 0.5 fish/haul) (Table 6). Greenland halibut occurred in catches above the depths of 30 to 120 m; its maximum catch was recorded above the depth of 110-120 m. Quill-fish occurred in catches above 30-110 m depth; its maximum catch was recorded above the depth of 30-50 m (Fig. 18-28).

Arabesque greenling was represented in catches exclusively by underyearlings. Their fork lengths ranged widely (6 to 19 cm), being related with the mixture of fishes originated on different spawning grounds of Sakhalin, western Hokkaido and southern Kuril Islands. Bering wolffish was also represented by underyearlings (3 to 20 cm). The two-year-old specimens (8 to 12 cm) prevailed in the Pacific capelin catches; yearlings and three-year-old specimens (5-8 and 13-17 cm, respectively) were rare. Pacific herring in 2006 was represented mainly by yearlings (7-12 cm), and in 2007 by specimens of the 3+ and 4+ age groups (17-26 cm). In 2008, along southeastern Sakhalin, the two-year-old specimens (13-17 cm) prevailed in herring catches (Fig.

29). Quill-fish and *Lumpenus sp.* were represented by larvae with body lengths of 10-17 and 2-6 cm, respectively. Sea raven, saffron cod, Pacific sand lance, and Greenland halibut were at a fry stage of maturity. Their lengths were 2.3 to 8.5 cm (Fig. 30-31). Adult saffron cod (22-27 cm) were rare in catches. Japanese sandfish (*Arctoscopus japonicus*), halibut-like flounder (*Hippoglossoides robustus*), great sculpin (*Myoxocephalus polyacanthocephalus*) and *Triglops sp.* were also represented by juveniles with 1.6 to 4 cm in length. Walleye pollock was usually represented by juveniles with 5-7 cm in length. The exception was the 2006 catch at the station near Cape Aniva where the second-year fish (9-15 cm) dominated (Fig. 32). Sometimes adult walleye pollock (to 60-64 cm) occurred in trawl catches. *Podothecus sp.* and *Tillesina sp.* were represented by juveniles with 3-3.5 cm in length. Adult Gilbert's seapoacher (*Podothecus sturioides*) with the body length of 12-14 cm were rare in catches. Crested sculpin (*Blepsias bilobus*) was represented by juveniles with 3.5-7.2 cm in length, rarely by adult specimens (16-22.5 cm); small rockfish (*Sebastes minor*) by juveniles and adults (3-19.7 cm); species of the genus *Pleuronectes* by juveniles (3.9-4.1 cm) and adults (to 28.5 cm); species of the genus *Eumicrotremus* by juveniles and adults (3-12 cm), spiny dogfish (*Squalus acanthias*) and salmon shark (*Lamna ditropis*) by adults (61-64 and 170-205 cm, respectively). The rest fish species presented in Table 5 were represented only by adult specimens as well.

DISCUSSION

The data collected during the RV "Dmitry Peskov" surveys in Aniva Bay in July 2004 and July–August 2005 showed that after appearing in sea waters juvenile pink and chum salmon stay for a long time in a coastal zone. They begin migrating from this zone only in the first half of July when the sea surface temperature reaches 14-16°C, and 10°C at the 10-m horizon. By the 20s of July, almost all juveniles leave the bay (Shubin et al. 2005, 2007). The 2006-2008 surveys allowed us to specify the data and to determine location of juvenile pink and chum salmon after they leave Aniva Bay. Thus, the survey conducted in the first half of July 2006 showed an extremely low density of juvenile salmon in Aniva Bay: mean pink salmon catch per a trawl haul was only 0.5 and mean chum catch 0.4 fish/trawl. The situation was like that observed in 2002-2003 when the survey was conducted too early, before the beginning of juvenile mass migration from the coastal zone (Shubin et al., 2003; Kovalenko et al., 2004). Perhaps, it happened because juveniles stayed too long in the coastal zone due to the abnormal low warming of the near-surface sea layer in Aniva Bay recorded in the first half of July 2006. However, the 2006 situation most probably is the exception, because usually the temperature conditions, which are

necessary for juvenile mass migration, are being formed in the near-surface sea layer of Aniva Bay by the end of the first ten days of July. Judging from juvenile pink distribution over the bay on 8-13 July 2007 and on 13-17 July 2008, mainly along its southern boundary, their major part had already left the bay, and we observed only the end part of their grouping. The same is referred to the major part of the chum salmon grouping. Its rest part had not migrated from the southern Sakhalin shore, but moved there from the adjoining waters (this will be reported below). Along with that, in July 2007, we have found one more important peculiarity of juvenile salmon migration from the bay shore: if a near-surface sea layer temperature in the western part of the bay is higher than in the eastern one, juveniles first migrate from the western shore of the bay. Such a feature of juvenile migration proves once again a role of temperature in regulation of this process.

The local origin of juvenile pink salmon sampled in Aniva Bay in 2006-2008 is beyond doubt. In the bay rivers, juvenile pink and chum salmon begin migrating downstream and entering sea waters since late April or early May through early or mid June, and a “peak” of migration takes place in the first–third decades of May. The dates of juvenile salmon release from hatcheries are usually coincide with the period of their mass downstream migration. Hence, by early or mid July they may stay in a sea from 1 to 2.5 (maximum 2.8) months. From our data, the size-weight characteristics of juvenile pink salmon migrating from Aniva Bay in early or mid July 2006-2008 were 4.8-9.7 cm and 1-10.3 g that is common for juveniles feeding in a sea from 1 to 2.5-2.8 months. Distribution of these indices was always monomodal. Observations for juvenile chum salmon showed a different situation. Their size-weight characteristics ranged widely (from 6.2 to 19.8 cm and from 1.9 to 73.7 g) that is common for juveniles occurring in a sea from 1.5 to 3.5-4 months. Distribution of these indices was always bimodal or polymodal. About 60% of specimens were to 10 g, about 36% - 11-25 g, and about 4% - 26-75 g in weight. We suggest that all juvenile chum salmon to 10 g in weight, sampled in Aniva Bay and La Perouse Strait, were of the local origin (from rivers and hatcheries of Aniva Bay). The rest juveniles are from the adjacent waters, because local chum juveniles can not stay in sea water more than 2.5-2.8 months. Thus, they have not migrated from the southern Sakhalin shore, but moved to it.

In 2008, following the small aggregations of juvenile salmon in the southeastern part of Aniva Bay, their large aggregations were found along the coast of Tonino-Anivskiy Peninsula, restricted in the north by the latitude of Cape Svobodniy. What origin were pink juveniles that occurred in this region? Obviously, majority of them were related to Aniva Bay. There are the

following arguments for this hypothesis. As mentioned above, the main bulk of juvenile pink salmon leave Aniva Bay by mid July. Along with that, the end part of their grouping is still staying in the southeastern part of the bay. So a “core” of migrating group may be somewhere nearby (in adjacent waters), that we actually observed along Tonino-Anivskiy Peninsula between 18 and 21 July. At this site, juveniles have migrated from the shore, but not approached to the shore from the open waters of the Okhotsk Sea, because their distribution was related just with the inner and mid parts of the shelf area. Besides, juveniles from these two regions were close by the size-weight characteristics, which also indicate their common origin. Along with that, pink juveniles along Tonino-Anivskiy Peninsula between 18 and 21 July were 1.2 times as large by weight as those sampled earlier in Aniva Bay. Later, since 28 July, they were 1.4 times larger by weight; the polymodal elements occurred in their distribution. In this connection we may suggest that pink salmon aggregations along Tonino-Anivskiy Peninsula included a little mixture of specimens from the adjacent waters with longer staying in seawater compared to the Aniva Bay juveniles. We cannot exclude a hypothesis that pink juveniles sampled along Tonino-Anivskiy Peninsula originated from the rivers of just this peninsula. But this is possible only for a very insignificant part of the relatively small juveniles, because the river spawning areas of the peninsula comprises only 2.8% (20,6 thousand m²) of the total river spawning area of southeastern Sakhalin, and juveniles migrate downstream later in this region than in Aniva Bay. Actually, on 21 July, about 17% of specimens caught at the station with coordinates 46°30' N and 143°42' E were unusually small in size (4.5-6.0 cm in length and 0.99-1.92 g in weight) that was never observed in Aniva Bay. They comprised only 1.7% of the total juvenile pink salmon catch at the first stage along southeastern Sakhalin. The size-weight characteristics of juvenile chum salmon ranged widely at both stages of the survey along southeastern Sakhalin, and their distribution was bimodal or polymodal. We suggest that 75 to 80% of these chum juveniles, which weighed up to 10 g, have originated from Aniva Bay, and the rest specimens were related with the adjacent waters. The latter included all of five individuals sampled above the depth slope north of Cape Svobodniy. Mixing of the Sakhalin origin juvenile salmon with those from the adjacent waters is a usual phenomenon near Tonino-Anivskiy Peninsula. During 15-25 July 2004, the dense aggregations of pink and chum juveniles were also observed in this area. The body weight of juveniles in those aggregations was 1.8-1.9 times as great than on 7-12 July in Aniva Bay (Shubin et al., 2005).

Except for five chum juveniles, we failed in catching juvenile salmon in the second half of July 2008 north of Cape Svobodniy. And this happened despite the fact that many large

spawning rivers flow into the sea along the southeastern Sakhalin coast between Cape Svobodniy and stn. Sovetskoye. Besides, several hatcheries are located in this area. Obviously, the absence of juvenile salmon in our catches in this area was caused by the high temperature of the near-surface sea layer. So, juveniles have migrated from the coastal zones out of the shelf area before the beginning of our survey.

In 2006-2008, we sampled 41 juvenile masu salmon and 222 pre-spawning pink salmon in Aniva Bay and along northeastern Sakhalin. The occurrence of juvenile masu salmon and pre-spawning pink salmon near southern Sakhalin in July is common, related with the mass entrance of masu salmon into seawater (Nikiforov et al., 2006) and beginning of the pink salmon spawning run.

Sometimes the pre-spawning autumn chum salmon occur in Aniva Bay since late June and also in July. Thus, in 2004, we sampled 1 autumn chum salmon in the bay on 23 June and 1 specimen on 5 July. Their lengths were 67 and 75 cm and weights 3.5 and 5.3 kg. In 2005, we sampled 1 autumn chum salmon on 7 July and 2 specimens on 25 July. In the first case, the specimen was 64 cm long and 3.7 kg weigh, in the second case the mean length of specimens was 68.5 cm and mean weight 4.4 kg. So, the catch of 3 autumn chum salmon in July 2006 is not an exception. The feeding chum salmon of 0.1+ age group occurred rarely in catches (5 fish in 2006 and 1 fish in 2008). In late July 2008, a total of 30 feeding chum salmon of the 0.1+ age group occurred also in one of the trap nets along the western coast of Aniva Bay (oral information of the SakhNIRO scientist A.A. Antonov). In August, such specimens were not observed in this trap net.

On the whole, a list of attendant fish species, found during the 2006-2008 surveys, is rather common for this region and time period, as well as fluctuations in quantitative indices for the mass fish species (Shuntov et al., 1994; Lapko, 1996; Radchenko et al., 1997, 2002; Velikanov, 2004; Velikanov et al., 2005; Shubin et al., 2007). The unusual events were a finding of dense aggregations of juvenile saffron cod along southeastern Sakhalin and relatively high catches of juvenile Greenland halibut and larval quill-fish in July 2008. Earlier these species were considered to be occasional (saffron cod) or rare (Greenland halibut, quill-fish) in ichthyocenosis of the upper epipelagic zone (Radchenko et al., 2002; Shubin et al., 2003, 2005, 2007, Kovalenko et al., 2004). However, on the continental slope of southeastern Sakhalin, Greenland halibut is a dominating species (Balanov, 2002), and its juveniles have a pelagic life history (Fadeev, 2005). In our opinion, the relatively high catches of juvenile Greenland halibut in July 2008 are related with the effectiveness of trawl (48/200 m), constructed just for catching

juvenile fish. Quill-fish was a single fish species whose larvae, due to their particular morphology (snake-like shape), clutched at the net lines of the trawl sac. So, numbers of the larvae found depended greatly on careful examination of the trawl meshes. In fact, larvae of quill-fish are also common along southeastern Sakhalin. They even enter a diet for the mostly distributed fish species (Bering wolffish in particular). Because of the new data, now we do not consider juvenile saffron cod to be occasional, and juvenile Greenland halibut and larval quill-fish rare elements of ichthyocenosis of the upper epipelagic southeastern Sakhalin zone.

CONCLUSION

The following facts were ascertained by the results of the 2004-2008 surveys on the early sea life history of juvenile pink and chum salmon in Aniva Bay. After appearing in seawater, juvenile pink and chum salmon stay for a long time (to 1.5-2.5 months) in the coastal zone. Their migration from a shore to the open waters of the bay occurs independently of the timing when specimens enter seawater, not gradually, as far as they grow, but in contrast, simultaneously (“volley” character). As an exception, individuals and small groups may appear in the open waters of the bay earlier (in June). Usually, mass migration of juvenile pink and chum salmon from the shore is observed in the first half of July when a near-surface sea layer temperature is close to the upper limit of the temperature optimum for their feeding (14-16°C on the sea surface and about 10°C at the 10-m horizon). Under the lower temperature, juveniles do not leave a coastal zone, and under the higher temperature they leave the bay area. The interannual fluctuations in timing for juvenile salmon migration, which are determined by the actual hydrological conditions in the bay, are possible. During migration from the shore, juveniles form dense aggregations on the bay area. Within these aggregations catches per trawl haul reach hundreds and thousands of specimens. When juveniles begin migrating from the bay’s shore, they do not stay on the area and usually leave the bay completely by the 20s of July. After leaving Aniva Bay, juveniles concentrate along Tonino-Anivskiy Peninsula (southeastern Sakhalin) where occur up to the end of July. All, or almost all of pink salmon, sampled in Aniva Bay, are of the local origin, and chum juveniles are of mix origin (local and from the adjacent waters). Obviously, juveniles’ distribution in the open waters of Aniva Bay and southeastern Sakhalin is related exclusively with the layer of 0-15 m. Besides salmonids, the ichthyocenosis composition of the upper epipelagic of Aniva Bay and adjacent waters of southeastern Sakhalin included 38 fish species from 21 families (47 species from 22 families, including the 2004-2005 surveys). Juvenile pink and chum salmon occupied a subordinate position in ichthyocenosis of

the upper epipelagic zone by the quantitative indices. In Aniva Bay they comprised 0.02% of the total number of fish sampled in 2006, 0.76% in 2007, and 0.67% in 2008; along southeastern Sakhalin, 0.48% in 2008. Usually, arabesque greenling, Pacific capelin, Pacific herring, Bering wolffish, sculpins of the genus *Hemilepidotus*, walleye pollock, saffron cod, Pacific sand lance, *Lumpenus sp.*, and *Podothecus sp.* were the most abundant in the ichthyocenoses. The attendant fish species were represented mainly by fry, underyearlings, and immature small specimens. In this connection, we may assert that absence or small numbers of predators that may consume juvenile salmon are common for ichthyocenoses of these regions.

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Table 1 – Numbers of performed trawl stations aboard RV “Dmitry Peskov” and numbers of sampled fish by time periods and sampling areas in 2006-2008

Year	Area	Time period	Stations performed	Juvenile salmon sampled, ind.		Other fish species sampled, ind.
				pink	chum	
2006	Aniva Bay	1-5.07	27	3	14	366338*
	Aniva Bay	6-10.07	27	14	14	
	Aniva Bay	11-15.07	27	24	8	
2007	Aniva Bay	8-13.07	30	268	339	138974**
	Aniva Bay	14-18.07	31	325	4	
	Aniva Bay	18-23.07	30	123	9	
2008	Aniva Bay	13-17.07	22	143	64	30829***
	Southeastern Sakhalin	18-27.07	56	966	133	309906****
	Southeastern Sakhalin – Aniva Bay	28-29.07	13	347	36	
Total:			263	2213	621	846047

* - including juvenile masu salmon (13 ind.), 0.1+ chum salmon (5 ind.), and pre-spawning pink salmon (79 ind.)

** - including juvenile masu salmon (5 ind.), pre-spawning chum salmon (3 ind.), and pre-spawning pink salmon (16 ind.)

*** - including pre-spawning pink salmon (1 ind.)

**** - including juvenile masu salmon (23 ind.), 0.1+ chum salmon (1 ind.), and pre-spawning pink salmon (173 ind.)

Table 2 – Anomalies of seawater parameters along the transect Cape Aniva – Cape Anastasiya in July 2006-2008 by layers (above the line) and mean square deviation σ (under the line) calculated relatively to the mean long-term estimates

Layer, m / Parameter	0-20	0-30	0-50	0-100	20- 100	30- 100	50- 100
3 July 2006							
Temperature, °C	<u>-2.61</u> 1.86	<u>-2.94</u> 1.95	<u>-2.80</u> 1.88	<u>-2.04</u> 1.49	<u>-1.86</u> 1.38	<u>-0.56</u> 1,25	<u>-1.07</u> 1,01
Соленость, S‰	<u>+0.27</u> 0.27	<u>+0.33</u> 0.26	<u>+0.34</u> 0.26	<u>+0.25</u> 0.25	<u>+0.24</u> 0.24	<u>+0.21</u> 0.24	<u>+0.13</u> 0.24
12 July 2007							
Temperature, °C	<u>+1.83</u> 1.96	<u>+2.01</u> 2.07	<u>+1.44</u> 2.00	<u>+0.75</u> 1.58	<u>+0.08</u> 1.33	<u>-0.13</u> 1.05	-
Salinity, S‰	<u>-0.46</u> 0.24	<u>-0.46</u> 0.24	<u>-0.38</u> 0.24	<u>-0.20</u> 0.23	<u>-0.07</u> 0.23	<u>+0.02</u> 0.23	-
13 July 2008							
Temperature, °C	<u>-0.37</u> 2.02	<u>-1.03</u> 2.14	<u>-1.51</u> 2.10	<u>-1.26</u> 1.76	<u>-1.58</u> 1.66	<u>-1.41</u> 1.51	<u>-0.81</u> 1.15
Salinity, S‰	<u>+0.15</u> 0.27	<u>+0.18</u> 0.26	<u>+0.19</u> 0.25	<u>+0.19</u> 0.24	<u>+0.21</u> 0.23	<u>+0.21</u> 0.22	<u>+0.20</u> 0.21

Table 3 – Indices of juvenile masu salmon abundance from catches during the cruise of RV “Dmitry Peskov” in July 2006-2008

Index	2006	2007	2008	
	Aniva Bay – La Perouse Strait	Aniva Bay	Aniva Bay	Southeastern Sakhalin
Frequency, %	7.4	3.3	-	14.7
Limits of catches, fish/trawl	1-6	1-2	-	1-9
Mean catch, fish/trawl	0.16	0.05	-	0.33
Total fish caught	13	5	-	23

Table 4 - Indices of pre-spawning pink salmon (above the line), feeding and pre-spawning chum salmon (under the line) from catches during the cruise of RV “Dmitry Peskov” in July 2006-2008

Index	2006 Aniva Bay – La Perouse Strait	2007 Aniva Bay	2008	
			Aniva Bay	Southeastern Sakhalin
Frequency, %	29.6/6,2*	7.7/2.2**	8.7/-	44.2/1.4*
Limits of catches, fish/trawl	1-13/ 1	1-2/1-2	1/-	1-40/1
Mean catch, fish/trawl	0.8/0,06	0.1/0,03	0.1/-	2.2/0.05
Total fish caught	62/5	8/3	2/-	150/1

* - specimens of the 0.1+ age group

** - pre-spawning specimens

Table 5 – Fish frequency (%) in the upper epipelagic zone of Aniva Bay, La Perouse Strait, and southeastern Sakhalin shelf area in July 2006-2008

Species	2006	2007	2008	
	Aniva Bay – La Perouse Strait	Aniva Bay	Aniva Bay	Southeastern Sakhalin shelf
1. Petromyzontidae <i>Lethenteron camtschaticum</i>	1.2	6.6	-	-
2. Lamnidae <i>Lamna ditropis</i>	-	5.5	-	5.9
3. Squalidae <i>Squalus acanthias</i>	-	2.2	-	-
4. Engraulidae <i>Engraulis japonicus</i>	17.3	46.2	13.6	18.8
5. Clupeidae <i>Clupea pallasii</i> <i>Sardinops melanostictus</i>	79.0 1.2	9.9 3.3	- -	7.2 -
6. Osmeridae <i>Mallotus villosus catervarius</i>	77.8	31.9	18.2	21.7
7. Salmonidae <i>Oncorhynchus gorbuscha(j)</i> <i>O. gorbuscha(a)</i> <i>O. keta(j)</i> <i>O. keta(a)</i> <i>O. masou(j)</i>	4.9 21.0 13.6 6.2 7.4	26.4 7.7 15.4 2.2 3.3	21.7 8.6 13.0 - -	27.9 44.2 25.0 1.4 14.7
8. Gadidae <i>Theragra chalcogramma</i> <i>Eleginus gracilis</i>	7.4 7.4	6.5 12.1	- 68.2	- 60.9
9. Gasterosteidae <i>Gasterosteus aculeatus</i>	1.2	2.2	4.5	13.9
10. Scorpaenidae <i>Sebastes minor</i> <i>S. schlegeli</i>	17.3 1.2	14.3 -	22.7 -	37.7 -
11. Hexagrammidae <i>Pleurogrammus azonus</i>	78.0	82.4	86.4	66.7
12. Cottidae <i>Myoxocephalus polyacanthocephalus</i> <i>Hemilepidotus sp.</i> <i>Triglops sp.</i> <i>Enophrys diceraus</i> <i>Gymnocanthus sp.</i>	8.6 22.2 2.5 - -	- 12.1 - - 1.1	- 68.2 - 4.5 -	- 14.5 - - -
13. Hemitripterae <i>Hemitripterus villosus</i> <i>Blepsias bilobus</i>	35.8 3.7	40.7 9.9	86.3 18.2	30.4 21.7

Table 5 (continued)

14. Agonidae				
<i>Podothecus sp.</i>	8.6	3.3	27.3	43.5
<i>Tilesina sp.</i>	-	-	18.2	13.0
15. Cyclopteridae				
<i>Eumicrotremus taranetzi</i>	-	-	-	10.1
<i>E. orbis</i>	21.0	2.2	4.5	-
<i>E. pacificus</i>	1.2	5.5	4.5	-
<i>E. sp.</i>	-	-	4.5	2.9
16. Stichaeidae				
<i>Lumpenus sagitta</i>	14.8	7.7	18.2	17.4
17. Anarhichadidae				
<i>Anarhichas orientalis</i>	75.3	59.3	91.0	92.8
18. Ptilichthyidae				
<i>Ptilichthys goodie</i>	-	-	13.6	20.3
19. Trichodontidae				
<i>Arctoscopus japonicus</i>	-	-	4.5	-
20. Ammodytidae				
<i>Ammodytes hexapterus</i>	1.2	-	50.0	46.4
21. Pleuronectidae				
<i>Pleuronectes asper</i>	1.2	-	-	-
<i>P. sakhalinensis</i>	-	1.1	-	-
<i>P. sp.</i>	3.7	-	9.1	-
<i>Hippoglossoides robustus</i> <i>Reinhardtius</i>	-	-	-	1.4
<i>hippoglossoides matsuurae</i>	-	-	27.3	18.8
22. Tetraodontidae				
<i>Takifugu porphyreus</i>	-	-	-	1.4

- - a species was not found from catches

j – juvenile specimens

a – adult specimens

Table 6 – Mean (above the line) and maximum (under the line) catches of some fish species (fish/trawl) in the epipelagic zone of Aniva Bay, La Perouse Strait, and southeastern Sakhalin shelf area in July 2006-2008 from the cruise data of RV “Dmitry Peskov”

Species	2006	2007	2008	
	Aniva Bay – La Perouse Strait	Aniva Bay	Aniva Bay	Southeastern Sakhalin
<i>Pleurogrammus azonus</i>	687/11685	1280/16510	1293/11517	460/3600
<i>Mallotus villosus catervarius</i>	2894/30435	131/4523	21/450	513/15324
<i>Clupea pallasii</i>	339/3975	19/1560	0.0/0.0	0.7/45
<i>Engraulis japonicus</i>	44/1785	40/968	0.9/16	1/44
<i>Anarhichas orientalis</i>	55/510	5/157	14/64	13/118
<i>Theragra chalcogramma</i>	185/13846	0.2/9	0.0/0,0	0.0/0.0
<i>Eleginus gracilus</i>	0.1/3	0.3/6	14/192	3354/36250
<i>Hemitripterus villosus</i>	94/1470	8/250	18/119	2/30
<i>Hemilepidotus sp.</i>	11/480	1/45	21/165	0.7/10
<i>Ammodytes hexapterus</i>	0.1/5	0.0/0.0	2/9	38/1700
<i>Podothecus sp.</i>	20/570	0.03/1	1/18	81/1754
<i>Lumpenus sp.</i>	173/7230	0.2/6	0,4/4	69/337

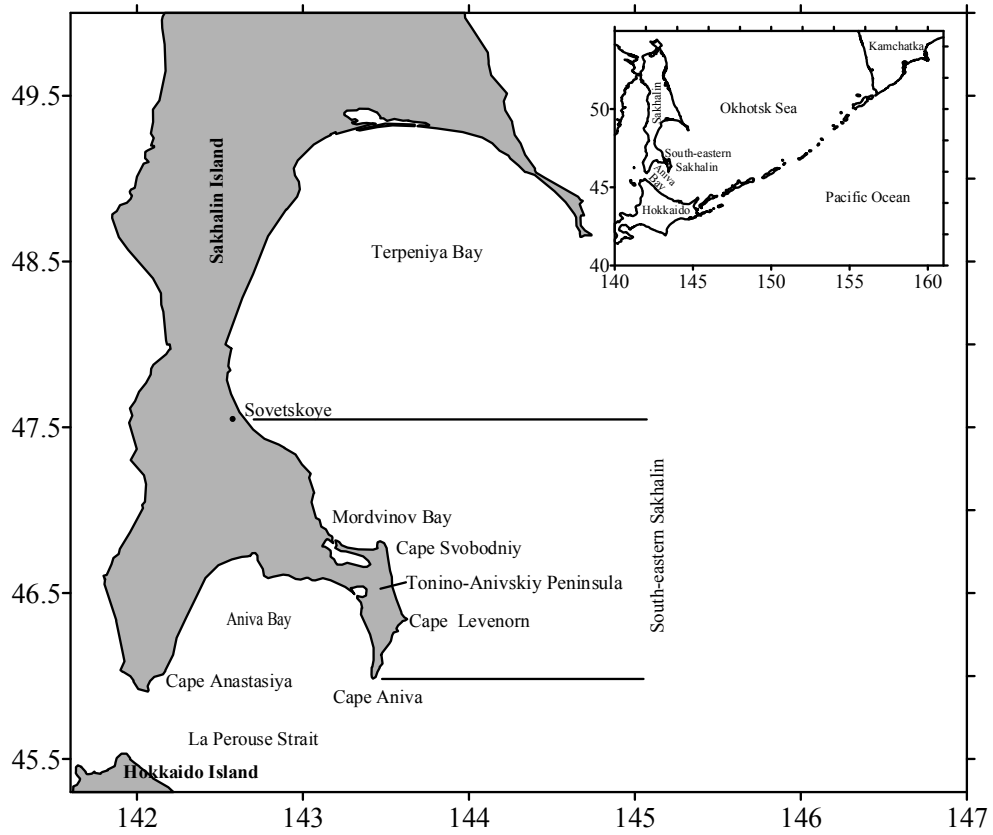


Fig. 1- Map of the study region along southern Sakhalin Island

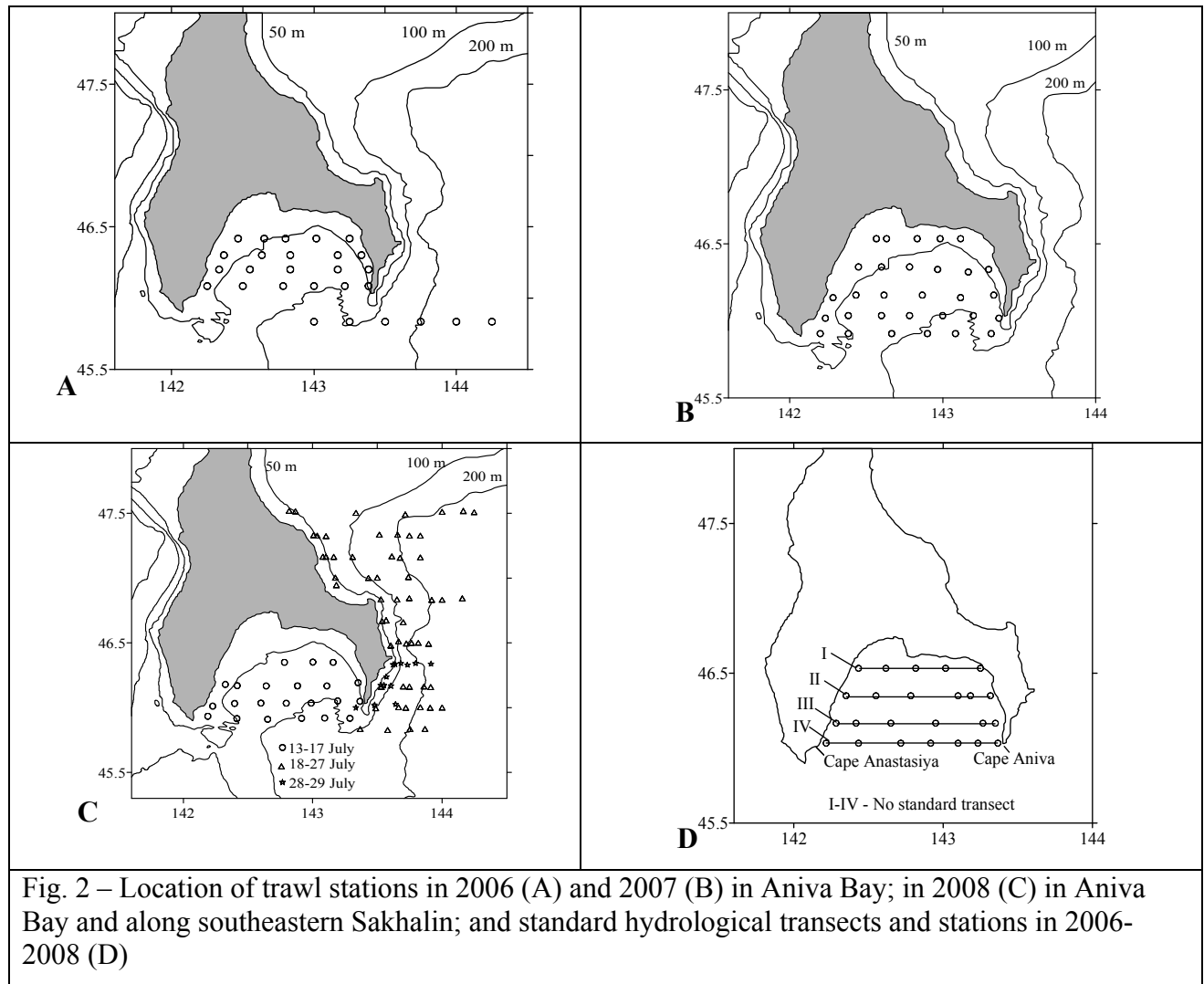


Fig. 2 – Location of trawl stations in 2006 (A) and 2007 (B) in Aniva Bay; in 2008 (C) in Aniva Bay and along southeastern Sakhalin; and standard hydrological transects and stations in 2006-2008 (D)

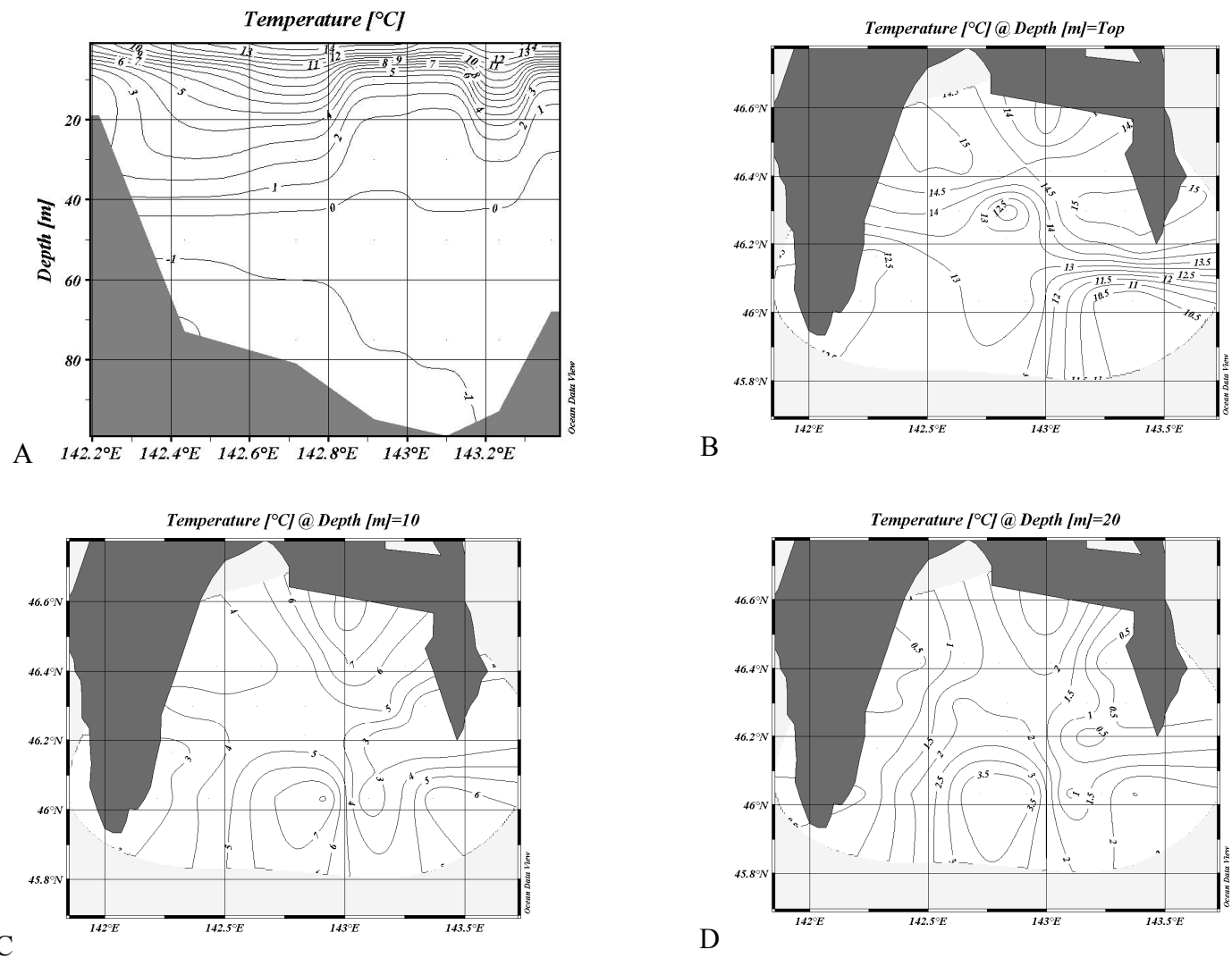


Fig. 3 – Temperature profile along the transect Cape Aniva – Cape Anastasiya on 3 July 2006 (A) and temperature distribution in Aniva Bay at the sea surface (B), 10-m (C), and 20-m (D) horizons between 1 and 5 July 2006

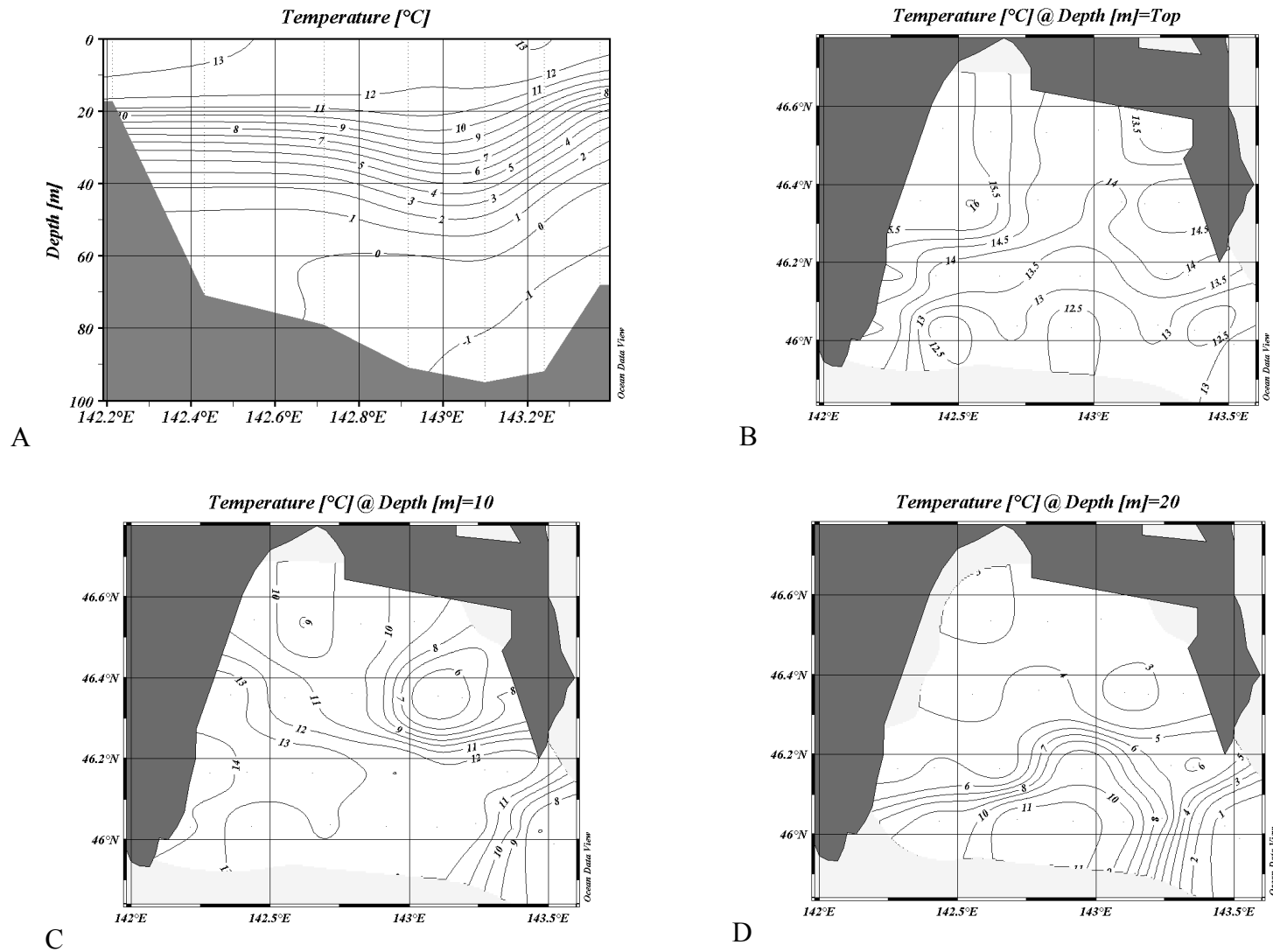


Fig. 4 - Temperature profile along the transect Cape Aniva – Cape Anastasiya on 12 July 2007 (A) and temperature distribution in Aniva Bay at the sea surface (B), 10-m (C), and 20-m (D) horizons between 8 and 12 July 2007

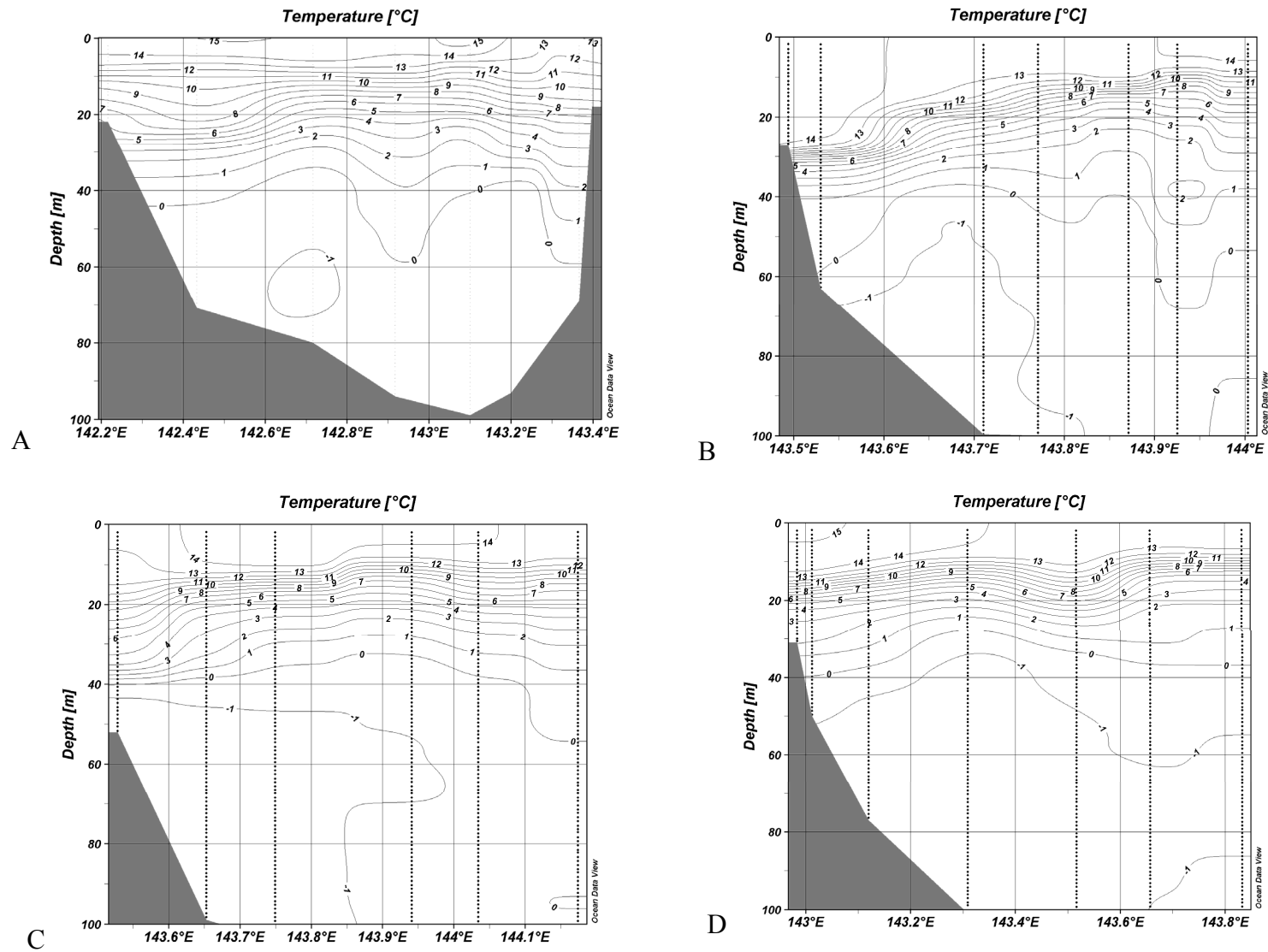


Fig. 5 - Temperature profile along the transect Cape Aniva – Cape Anastasiya on 13 July 2008 (A) and along the southeastern Sakhalin transects: 46°10' (B), 46°50' (C), 47°20' (D) N between 20 and 26 July 2008

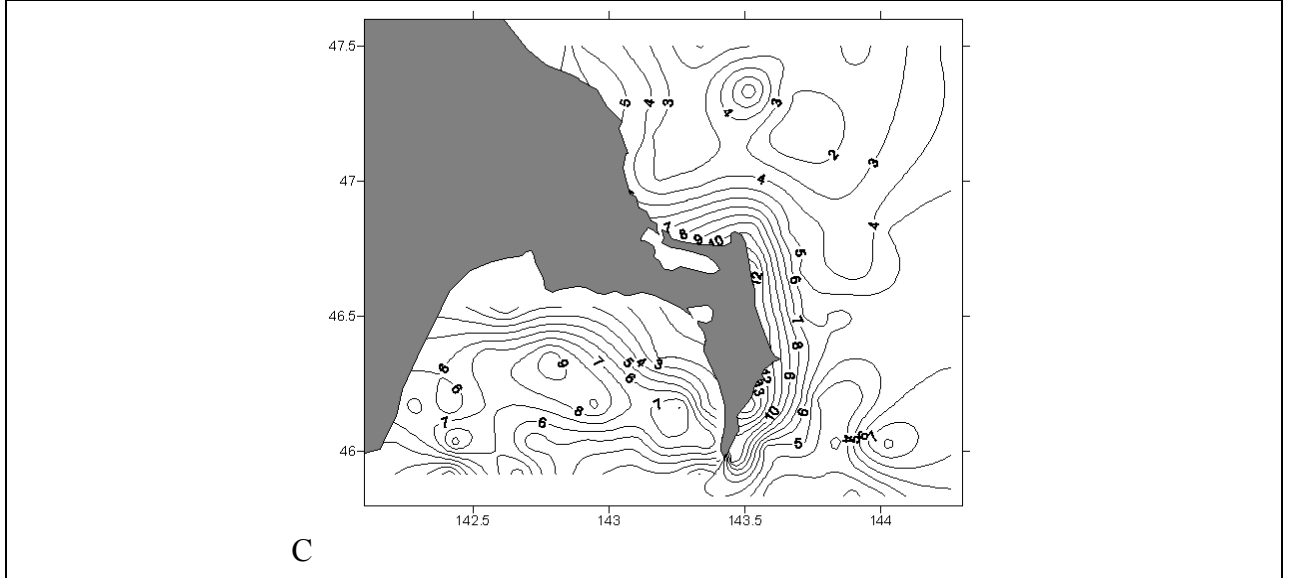
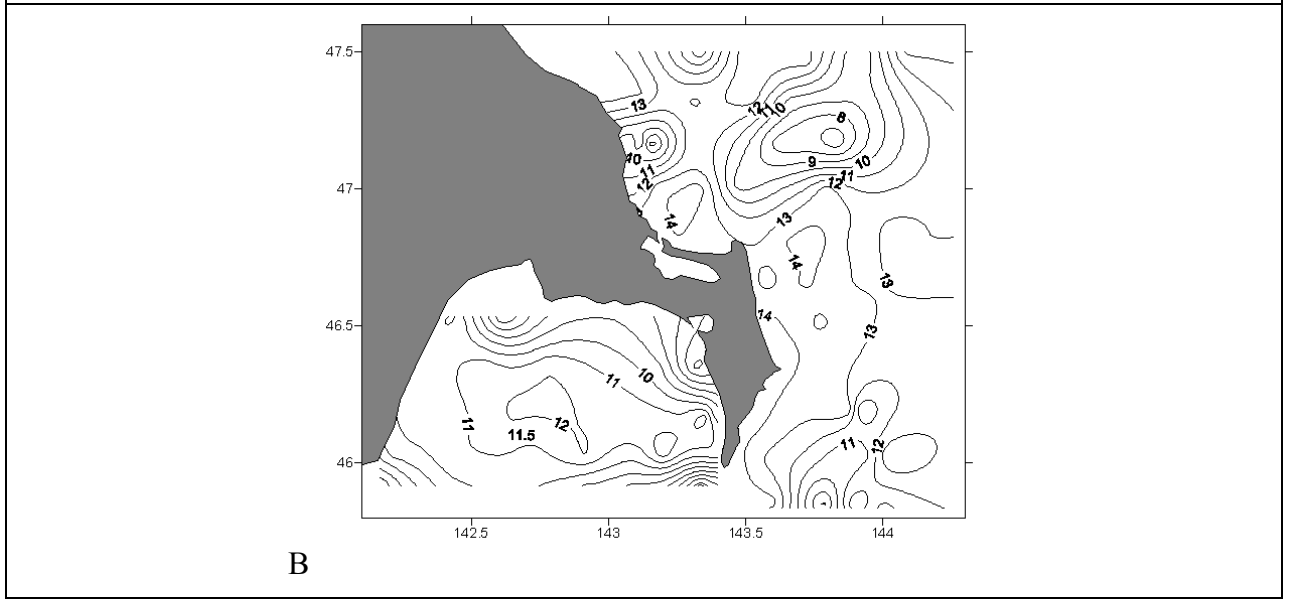
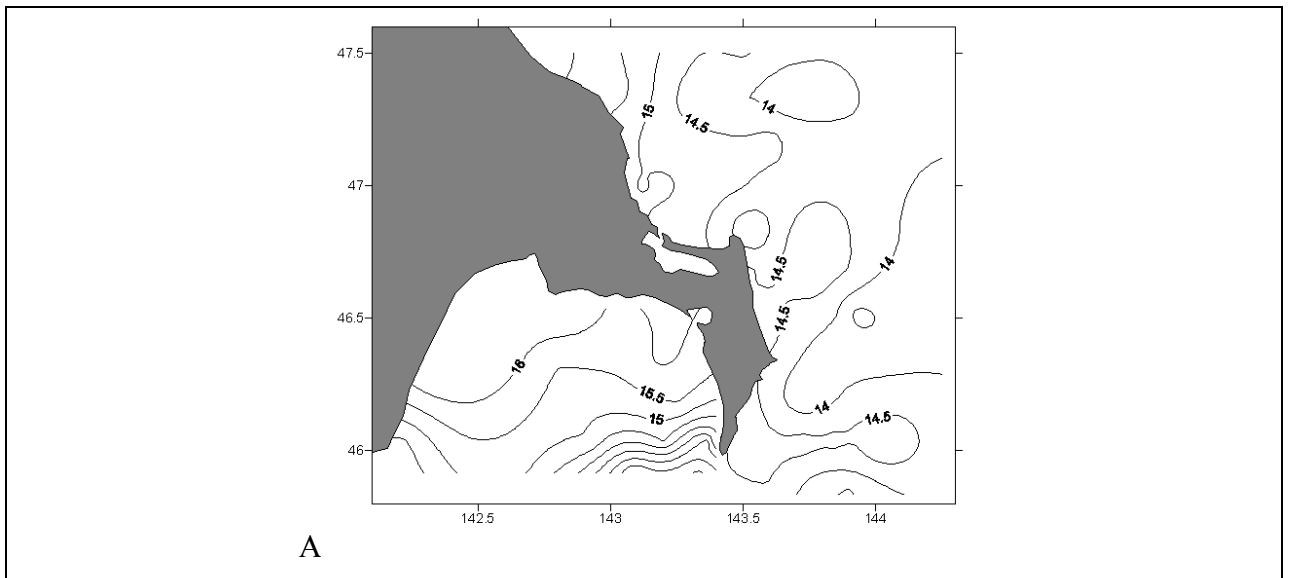


Fig. 6 – Horizontal temperature distribution in Aniva Bay between 13 and 18 July and along southeastern Sakhalin between 19 and 27 July 2008 at the sea surface (A), 10-m (B), and 20-m (C) horizons

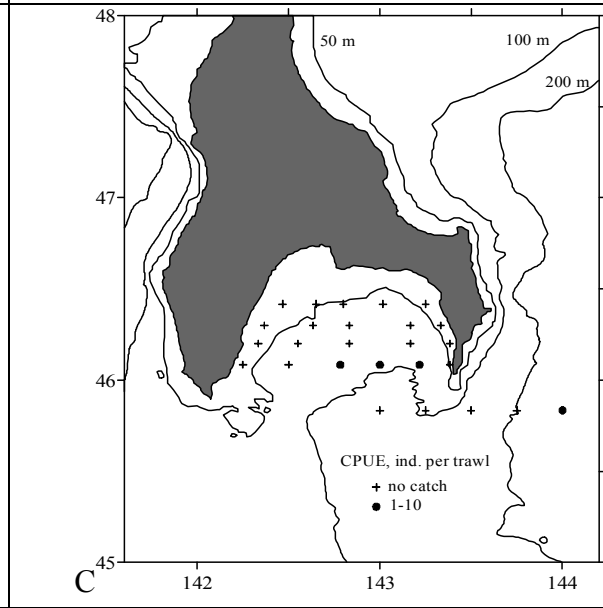
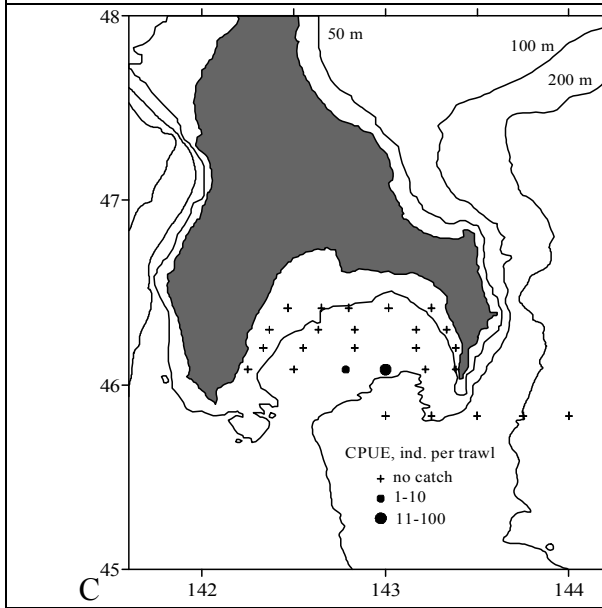
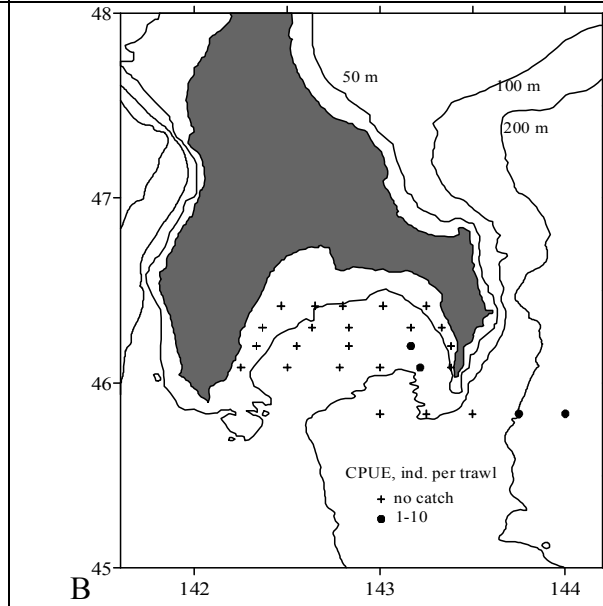
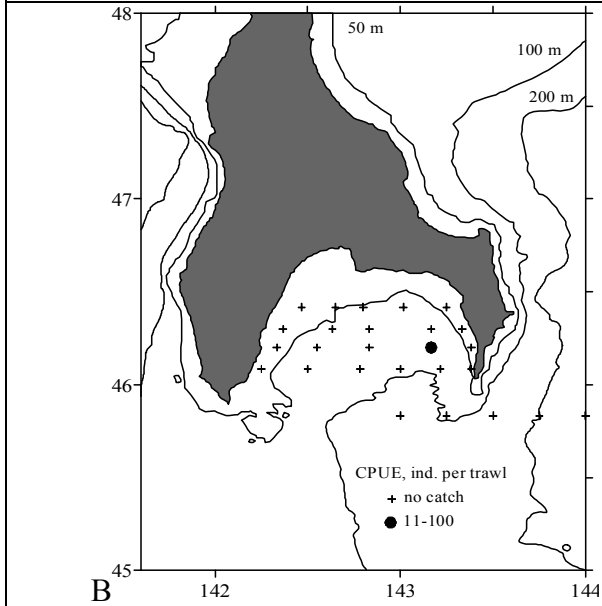
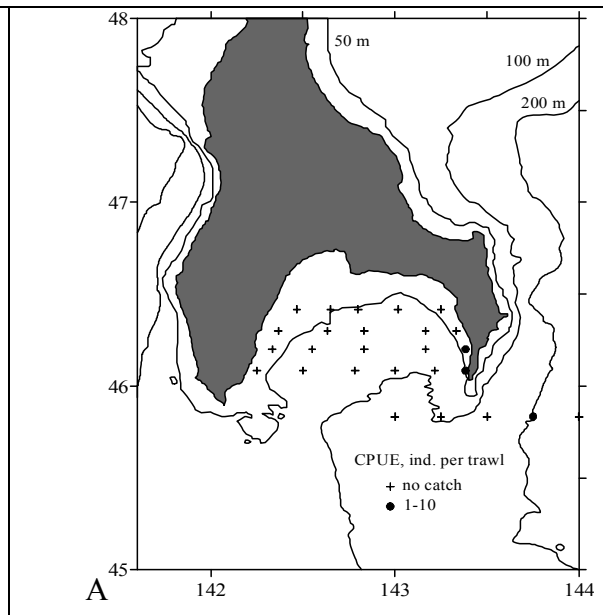
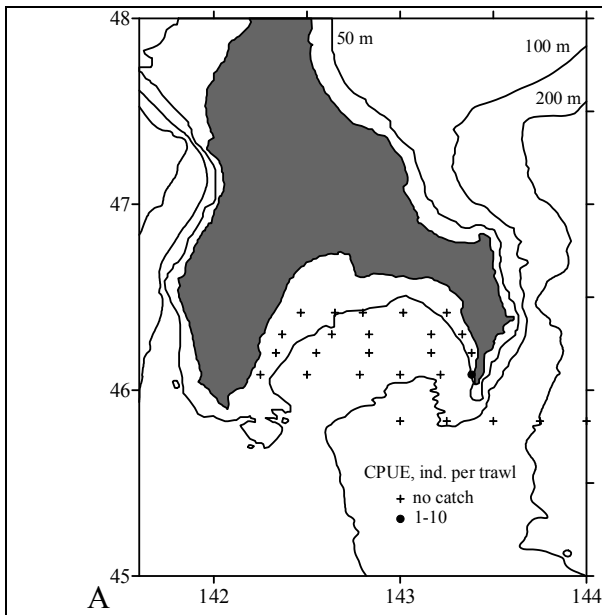


Fig. 7 – Distribution of juvenile pink salmon catches in Aniva Bay in 2006: 1-5 July (A), 6-10 July (B) and 11-15 July (C)

Fig. 8 - Distribution of juvenile chum salmon catches in Aniva Bay in 2006: 1-5 July (A), 6-10 July (B) and 11-15 July (C)

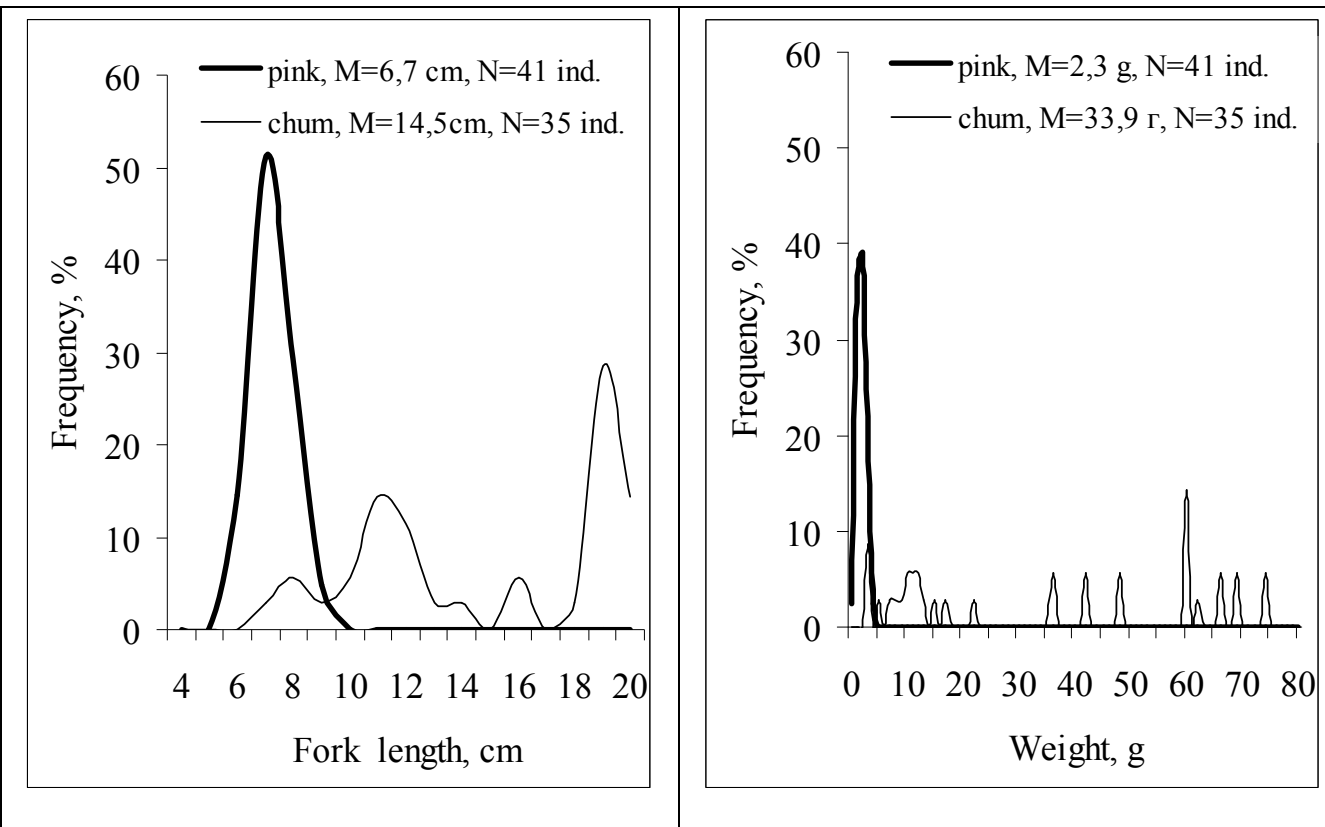


Fig. 9 – Length and weight distribution of juvenile pink and chum salmon in Aniva Bay and La Perouse Strait between 1 and 14 July 2006

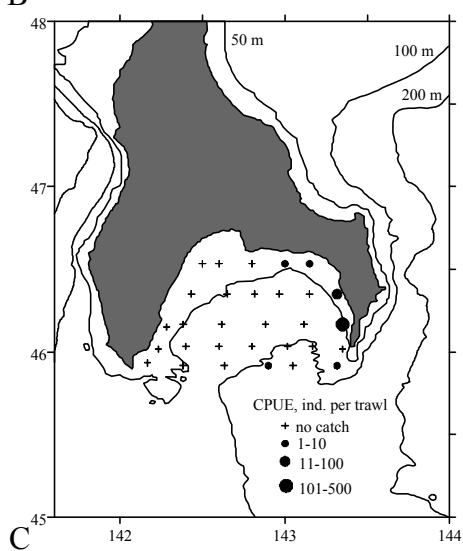
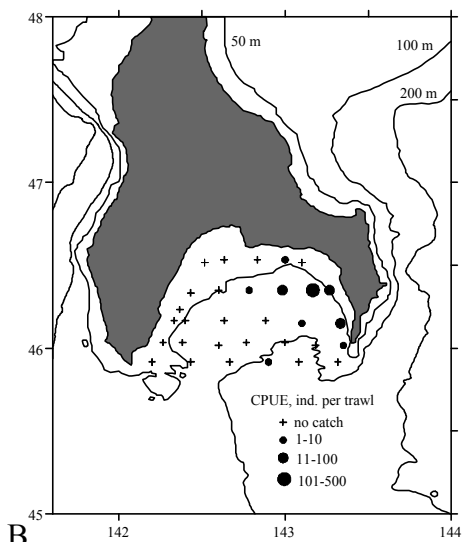
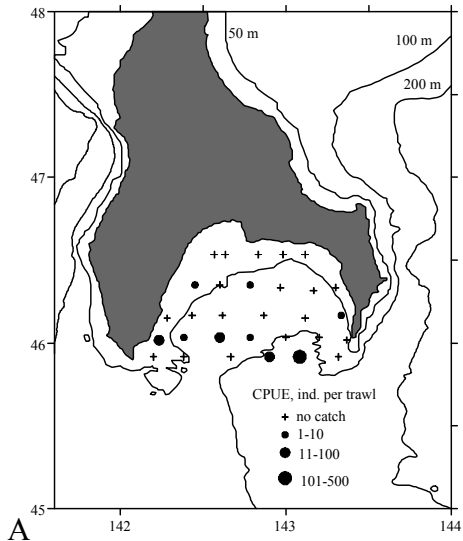


Fig. 10 - Distribution of juvenile pink salmon catches in Aniva Bay in 2007: 8-13 July (A), 14-18 July (B) and 18-23 July (C)

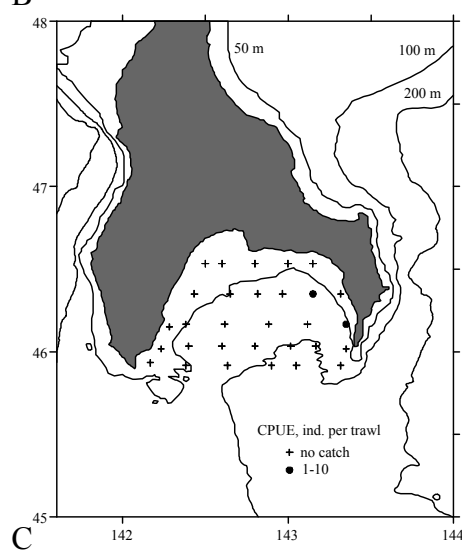
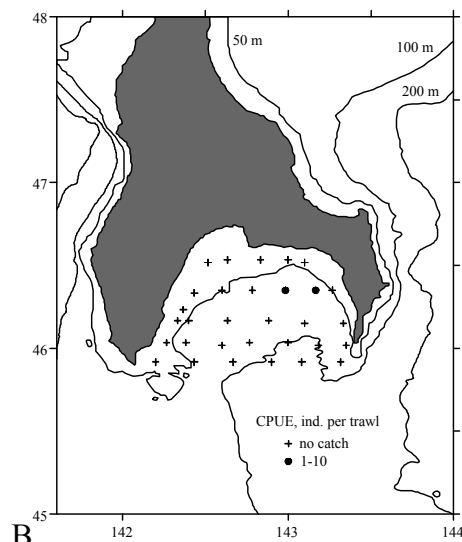
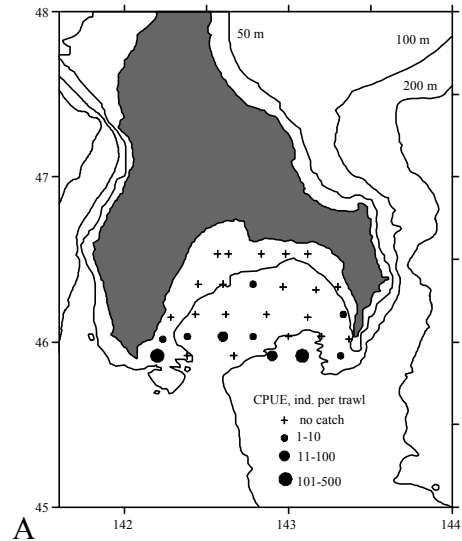


Fig. 11 - Distribution of juvenile chum salmon catches in Aniva Bay in 2007: 8-13 July (A), 14-18 July (B) and 18-23 July (C)

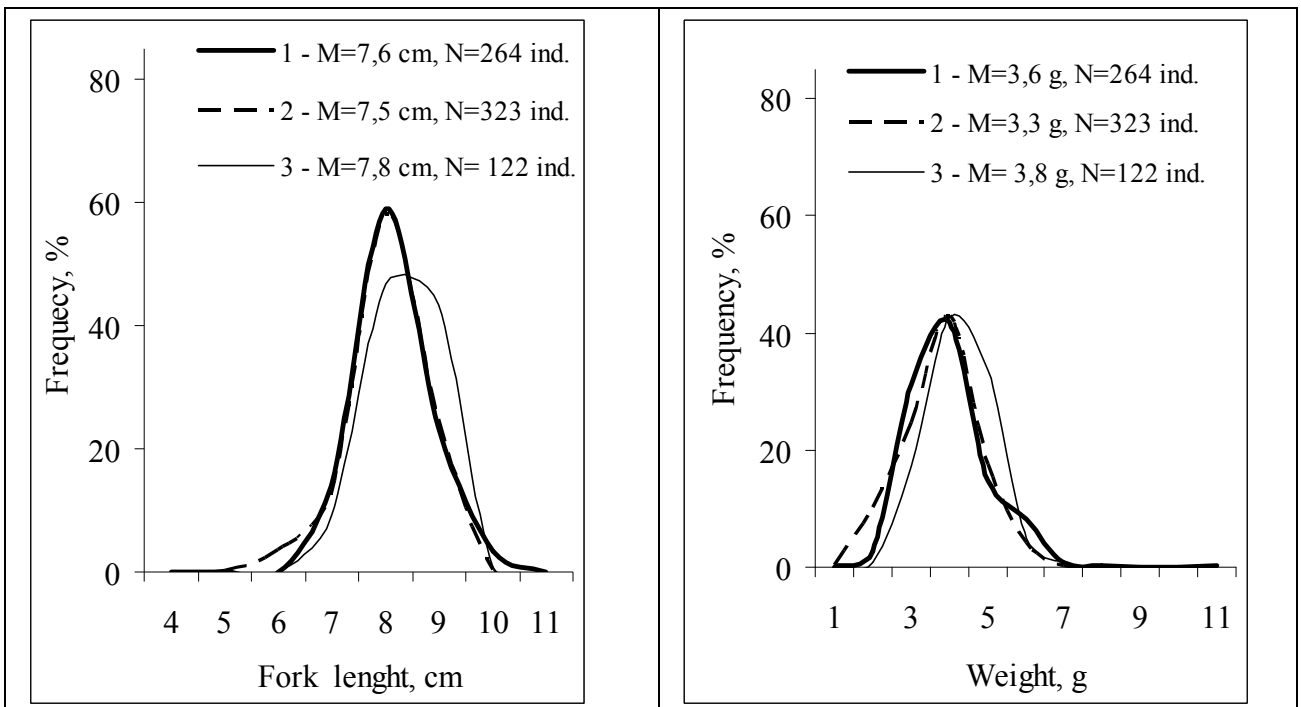


Fig. 12 - Length and weight distribution of juvenile pink salmon in Aniva Bay in 2007: 8-13 July (1), 14-18 July (2), and 18-23 July (3)

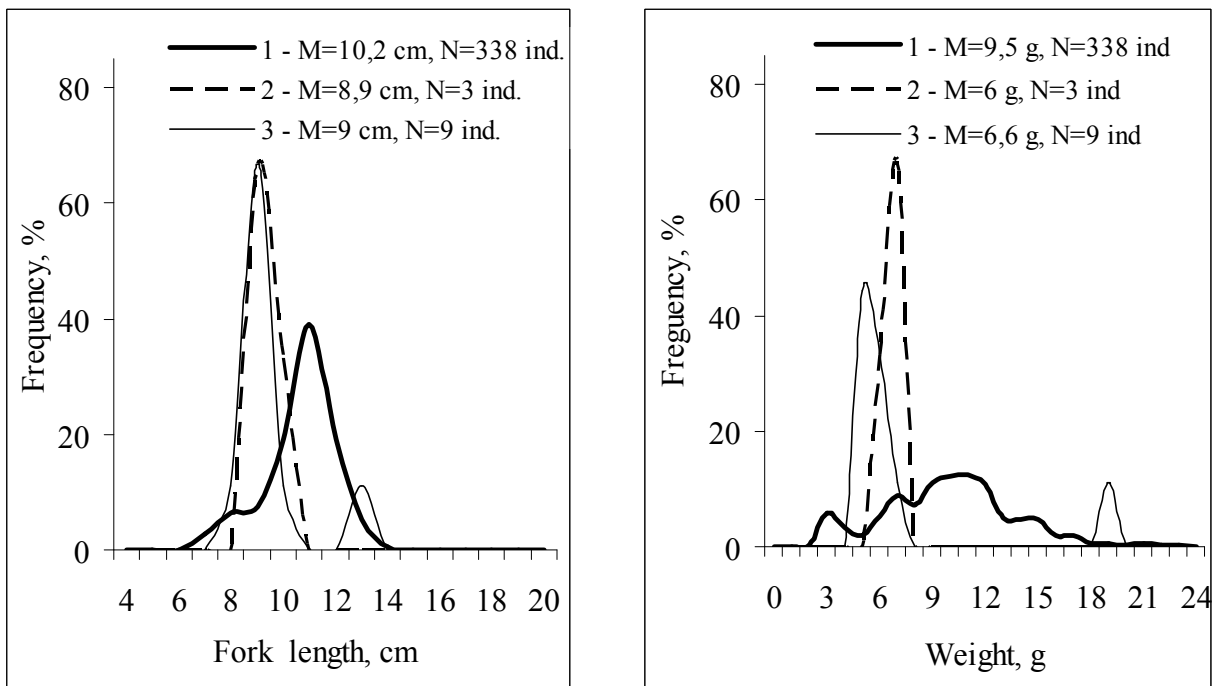


Fig. 13 - Length and weight distribution of juvenile chum salmon in Aniva Bay in 2007: 8-13 July (1), 14-18 July (2), and 18-23 July (3)

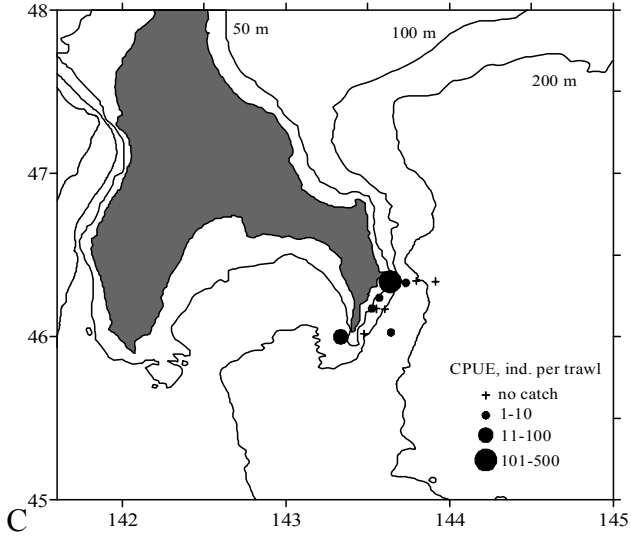
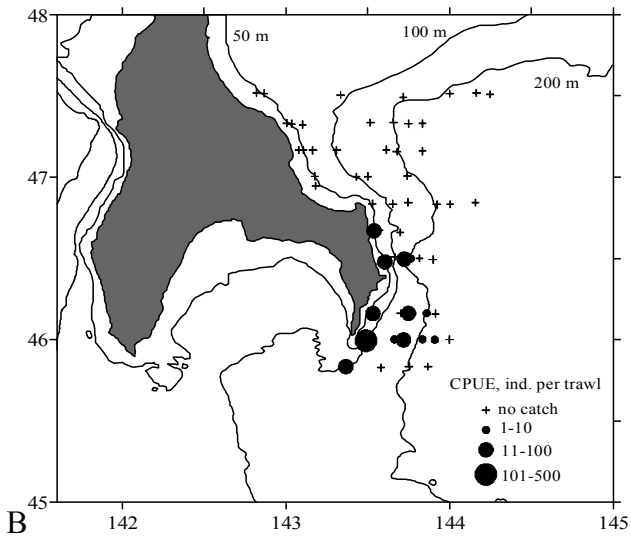
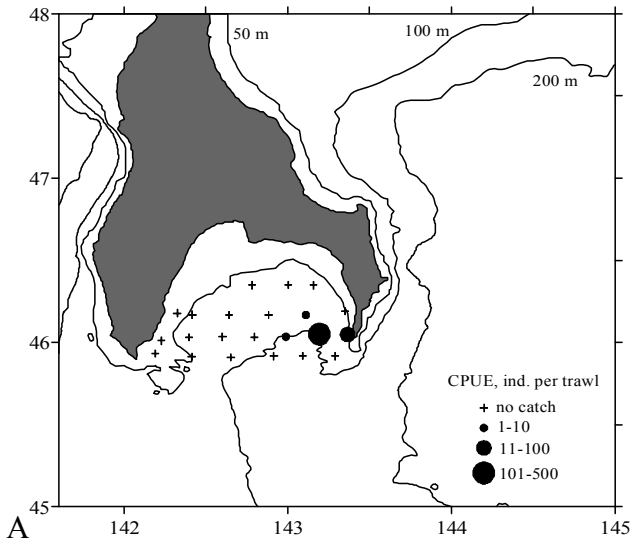


Fig. 14 - Distribution of juvenile pink salmon catches in Aniva Bay and along southeastern Sakhalin in 2008: 13-17 July (A), 18-27 July (B) and 28-29 July (C)

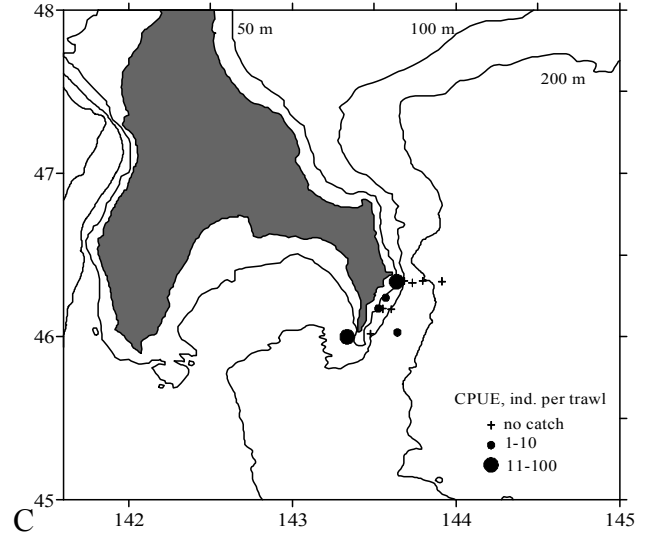
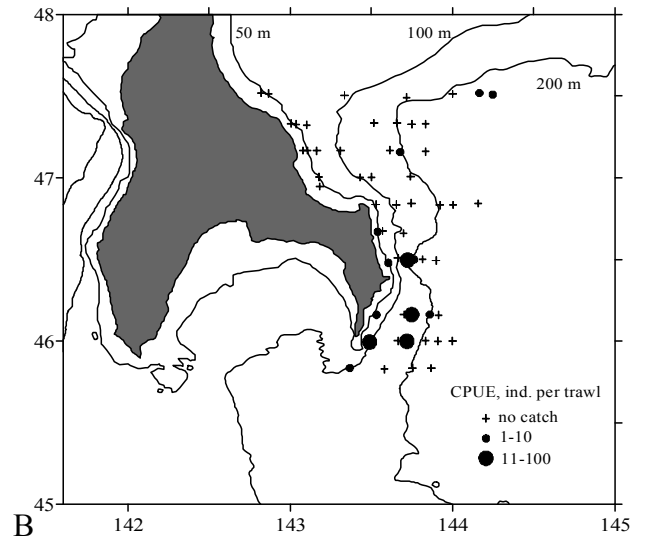
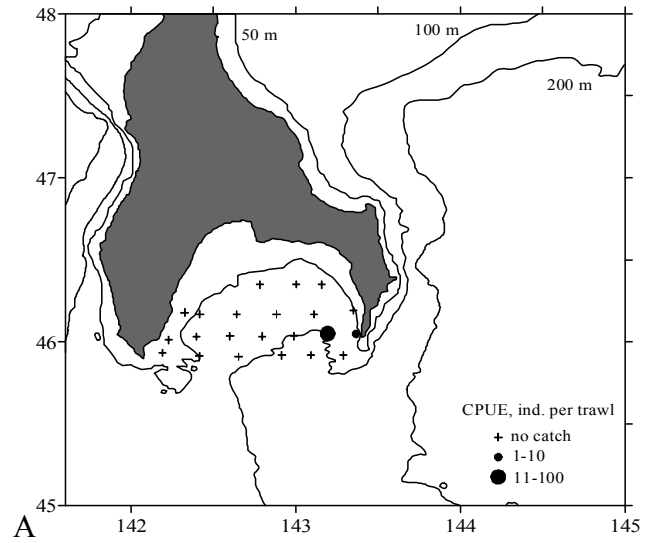


Fig. 15 - Distribution of juvenile chum salmon catches in Aniva Bay and along southeastern Sakhalin in 2008: 13-17 July (A), 18-27 July (B) and 28-29 July (C)

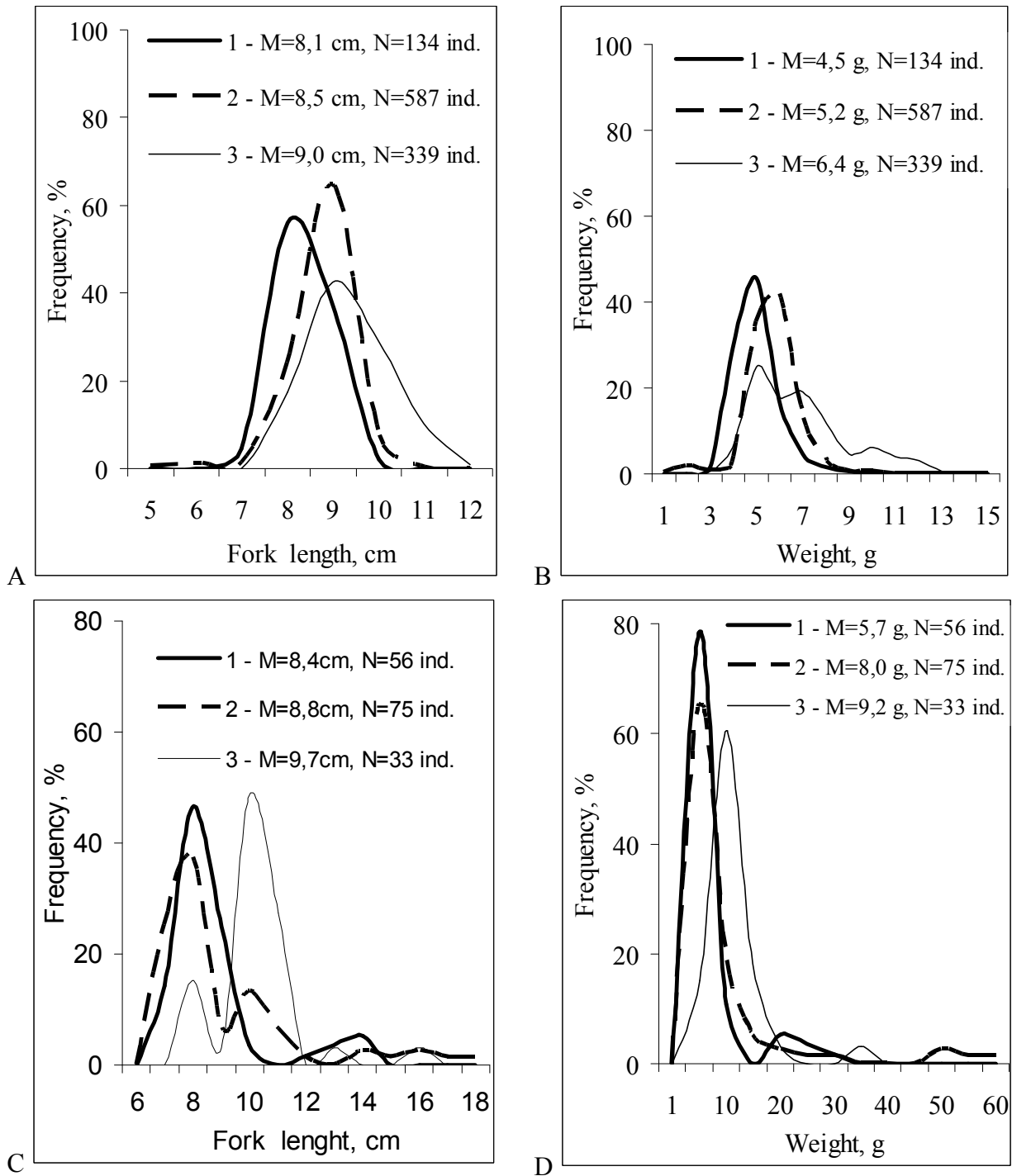
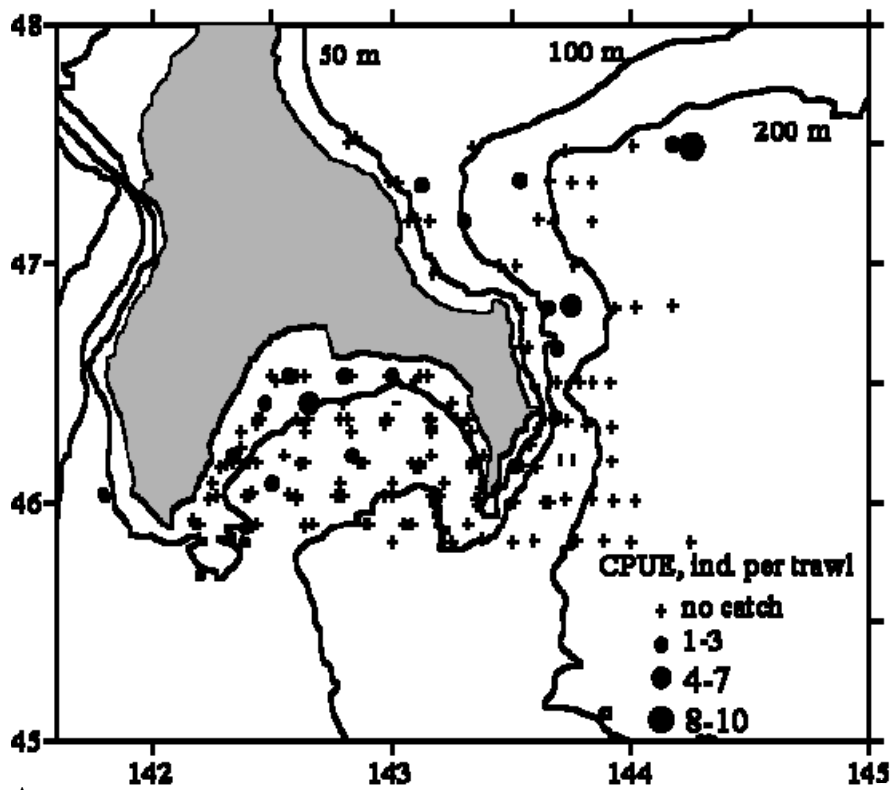
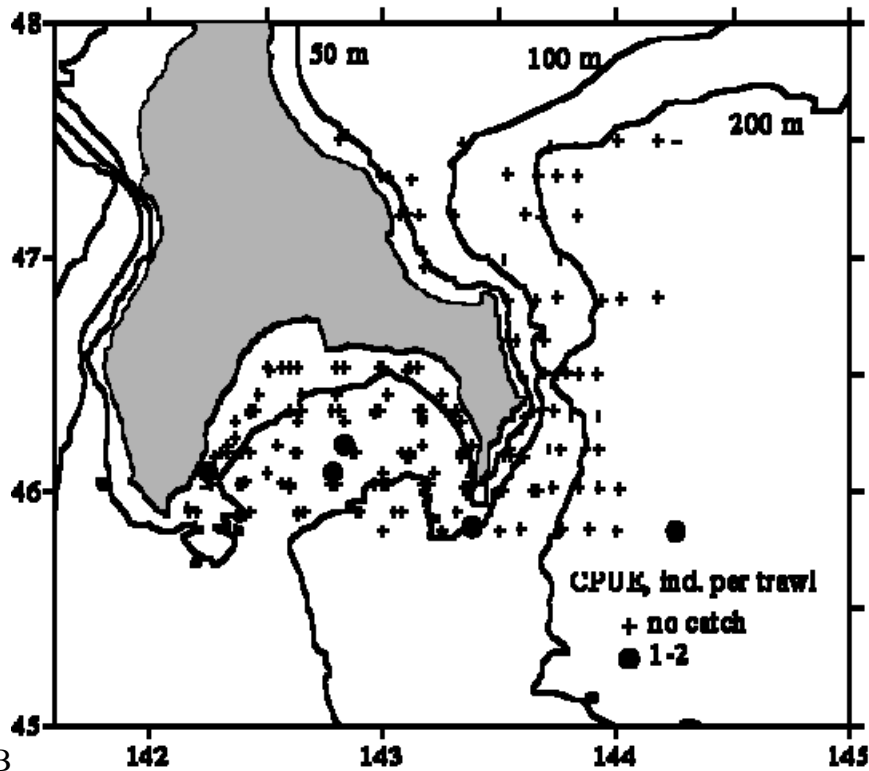


Fig. 16 – Length and weight distribution of juvenile punk (A, B) and chum (C, D) salmon in Aniva Bay between 13 and 17 July (1), along southeastern Sakhalin between 18 and 21 July (2), and along southeastern Sakhalin and in Aniva Bay between 28 and 29 July 2008 (3)



A



B

Fig. 17 – Distribution of catches of N.0+ juvenile masu salmon in July 2006-2008 (A) and 0.1+ chum salmon in July 2006 and 2008 (B)

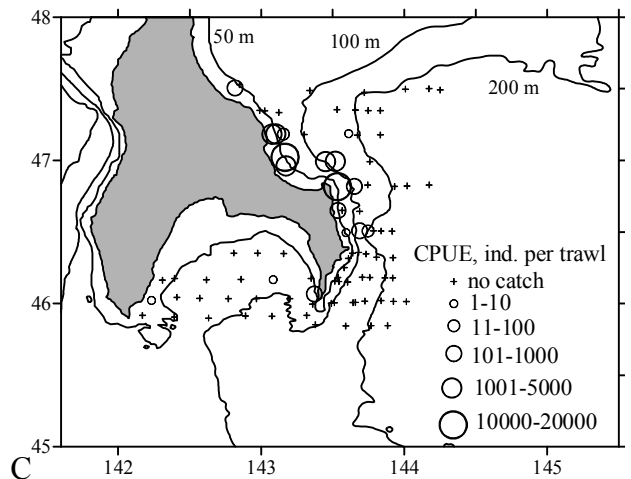
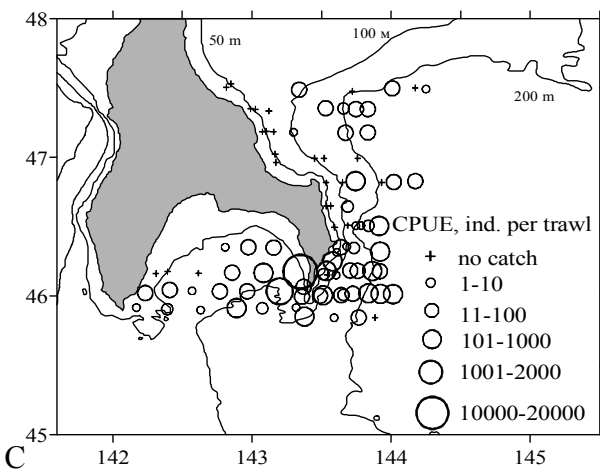
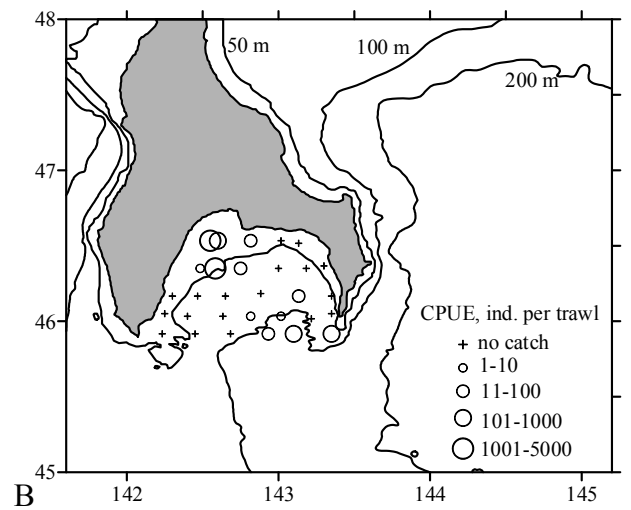
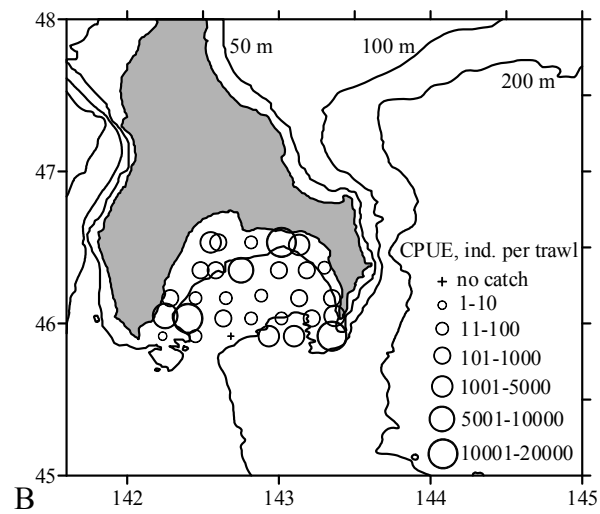
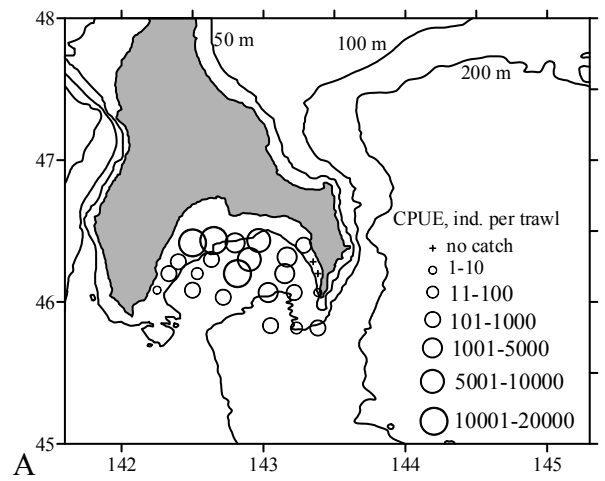
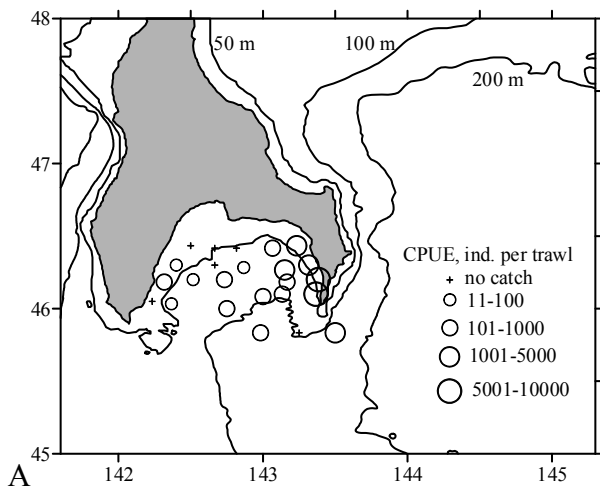


Fig. 18 – Distribution of *Pleurogrammus azonus* catches: 1-5 July 2006 (A), 8-13 July 2007 (B) and 13-29 July 2008 (C)

Fig.19 - Distribution of *Mallotus villosus catervarius* catches: 1-5 July 2006 (A), 8-13 July 2007 (B) and 13-29 July 2008 (C)

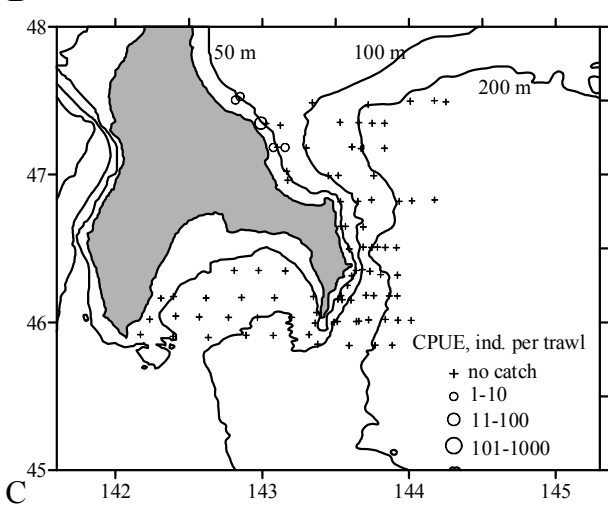
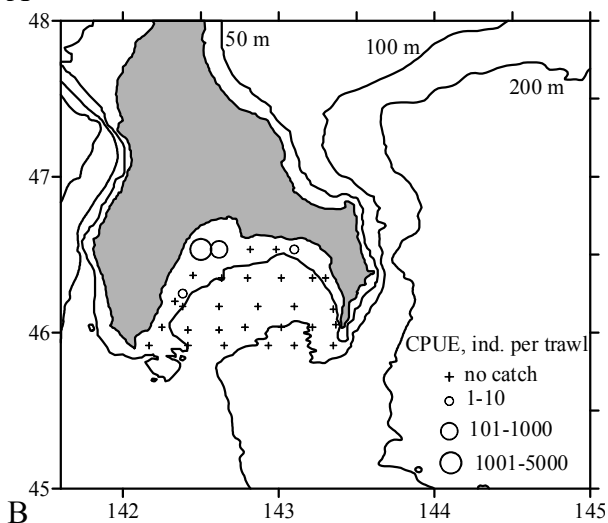
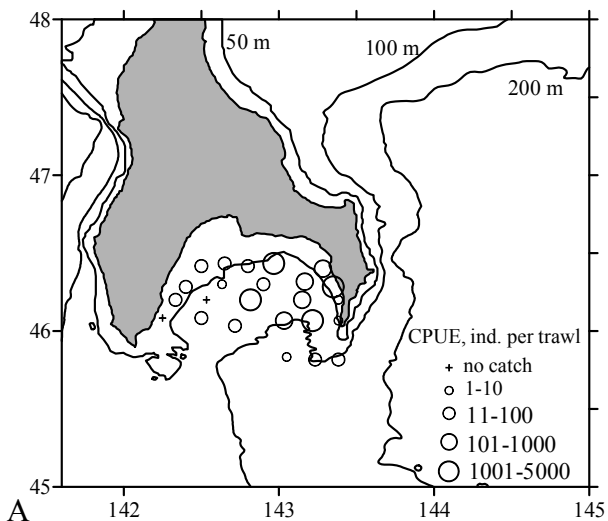


Fig. 20 - Distribution of *Clupea pallasii* catches: 6-10 July 2006 (A), 13-18 July 2007 (B) and 13-29 July 2008 (C)

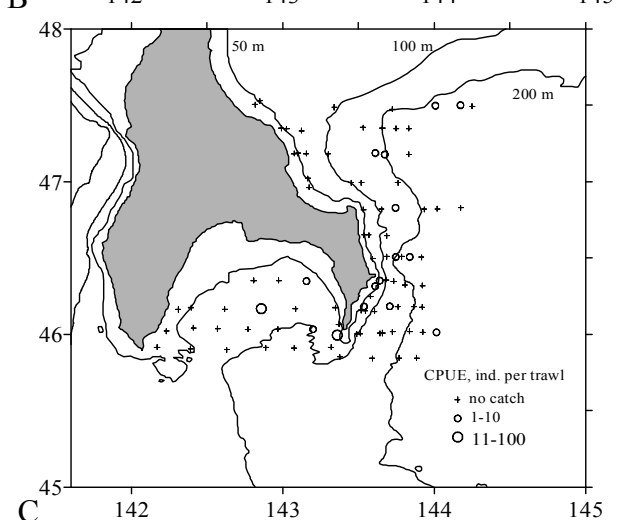
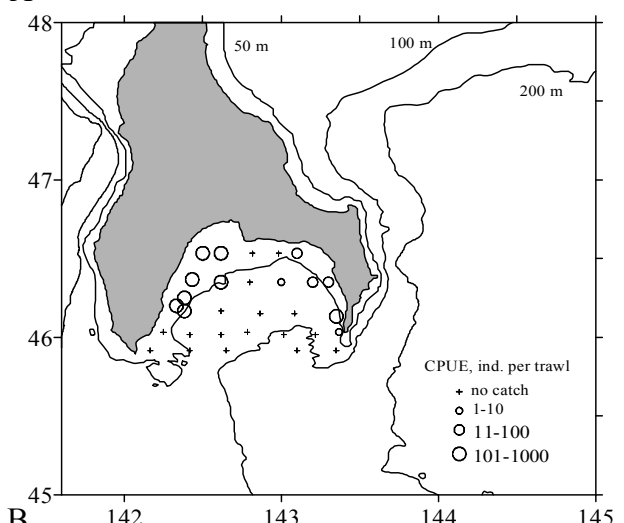
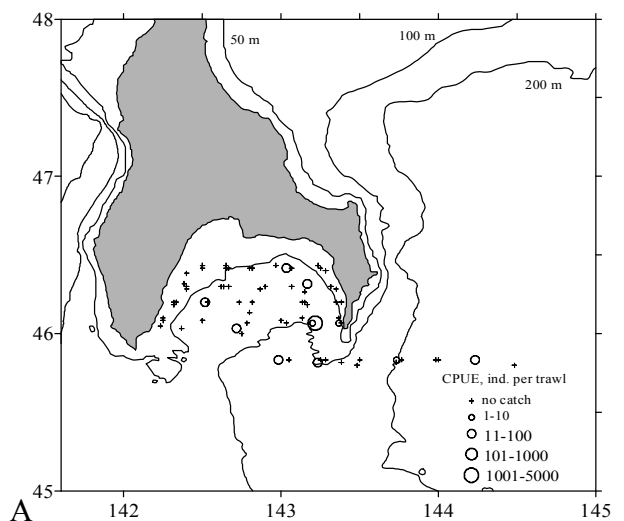


Fig. 21 - Distribution of *Engraulis japonicus* catches: 1-15 July 2006 (A), 13-18 July 2007 (B) and 13-29 July 2008 (C)

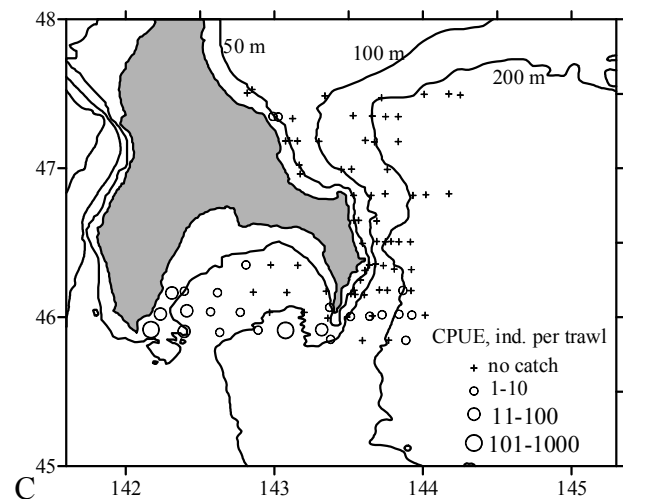
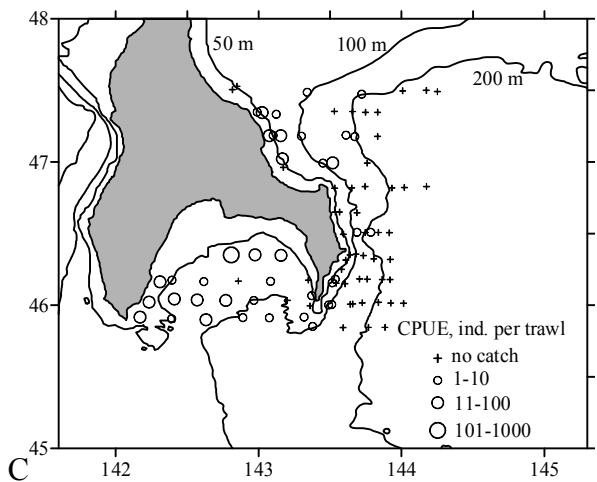
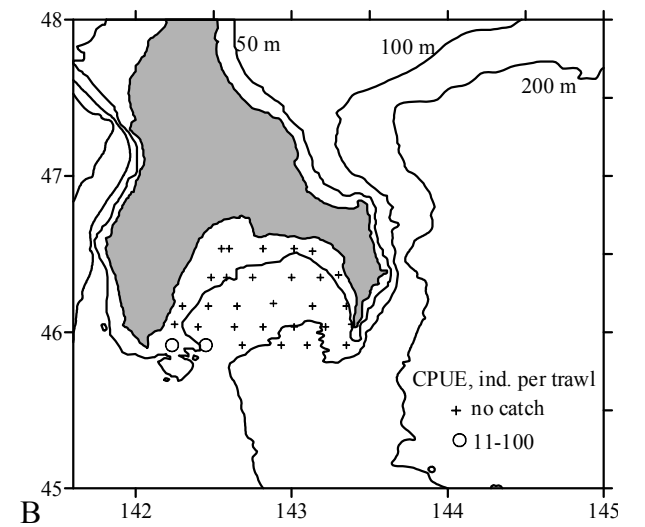
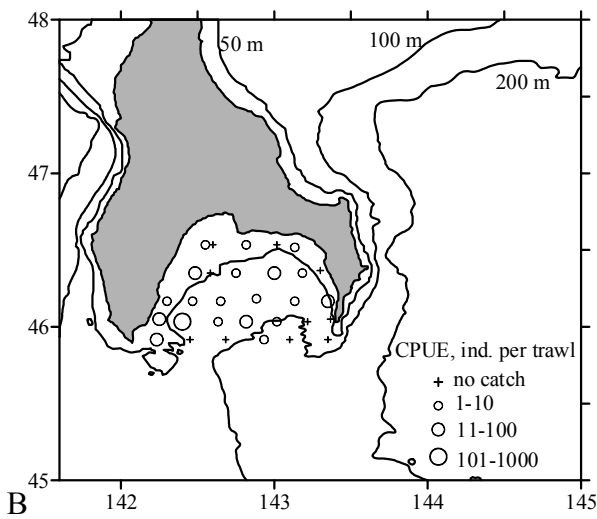
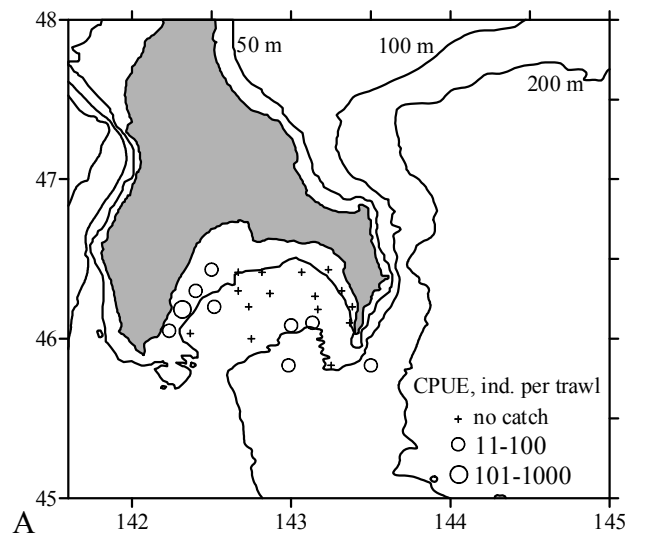
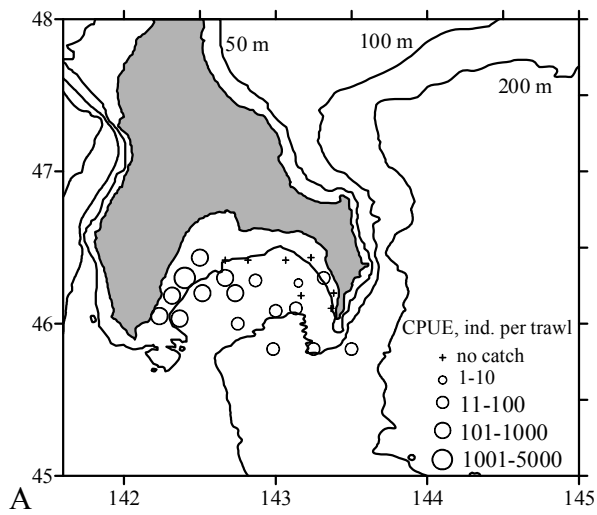


Fig. 22 - Distribution of *Hemitripteris villosus* catches: 1-5 July 2006 (A), 8-13 July 2007 (B) and 13-29 July 2008 (C)

Fig. 23 - Distribution of *Hemilepidotus* sp. catches: 1-5 July 2006 (A), 8-13 July 2007 (B) and 13-29 July 2008 (C)

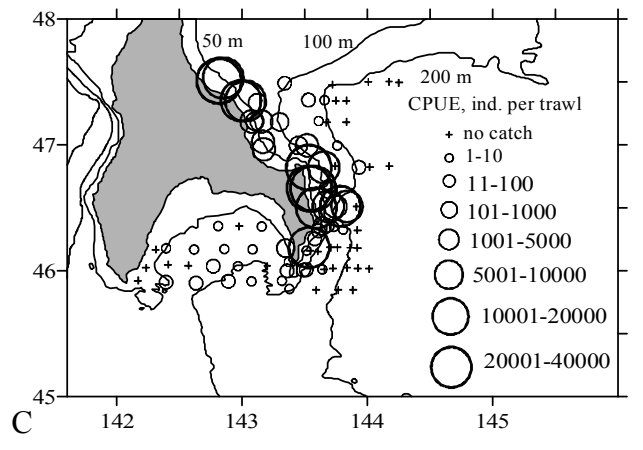
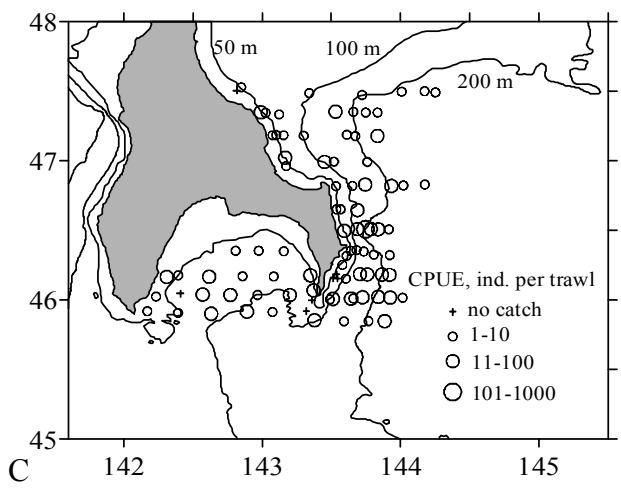
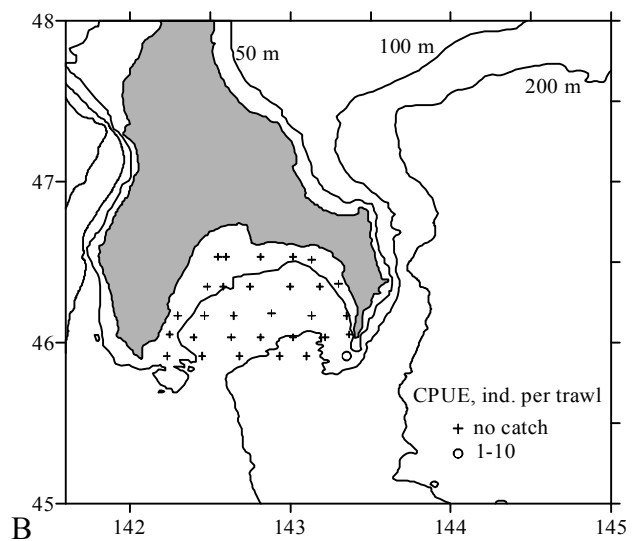
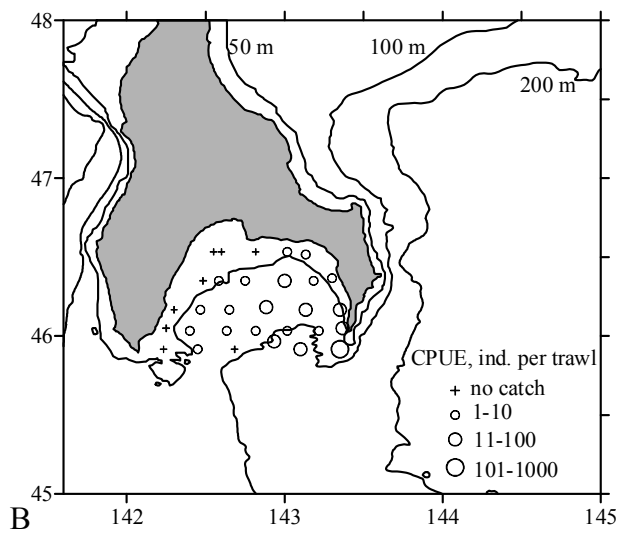
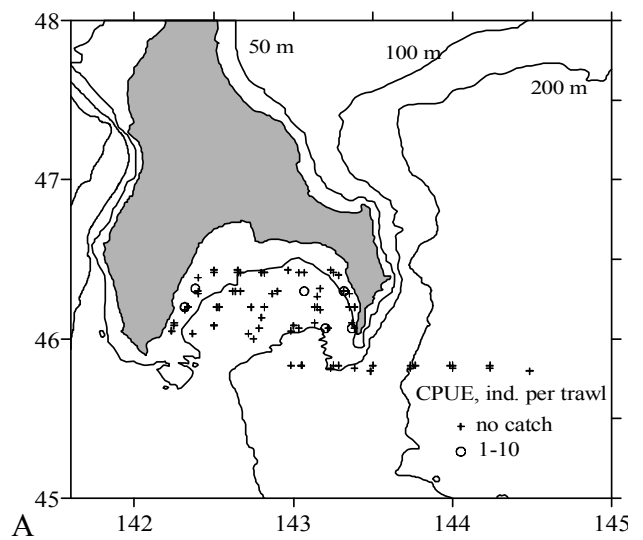
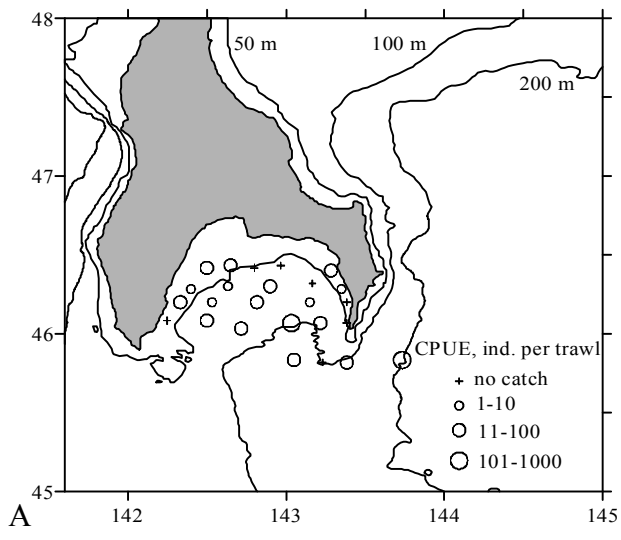


Fig. 24 - Distribution of *Anarhichas orientalis* catches: 6-10 July 2006 (A), 8-13 July 2007 (B) and 13-29 July 2008 (C)

Fig. 25 - Distribution of *Eleginus gracilis* catches: 1-15 July 2006 (A), 8-13 July 2007 (B) and 18-29 July 2008 (C)

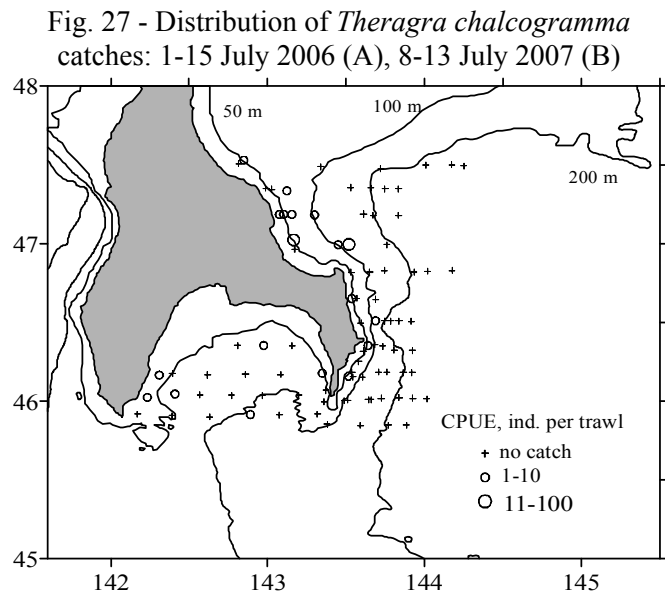
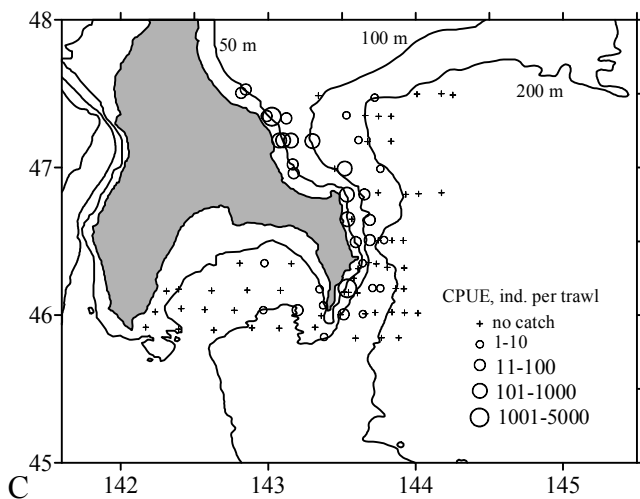
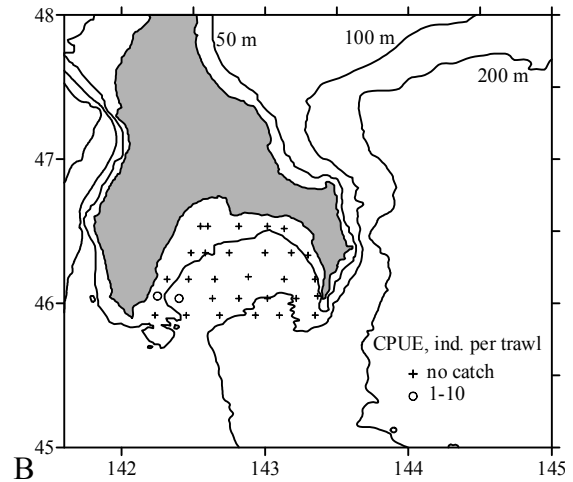
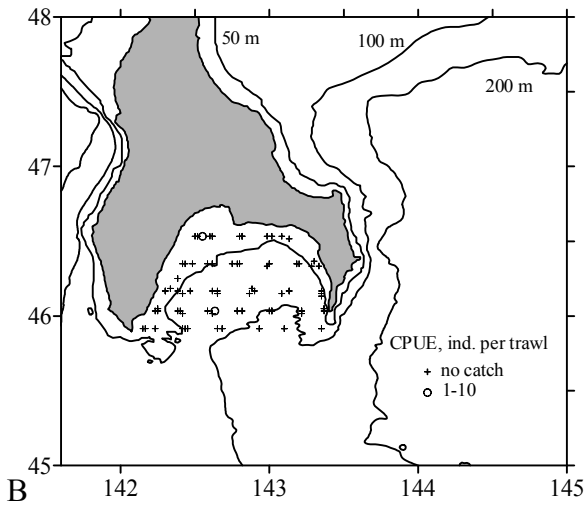
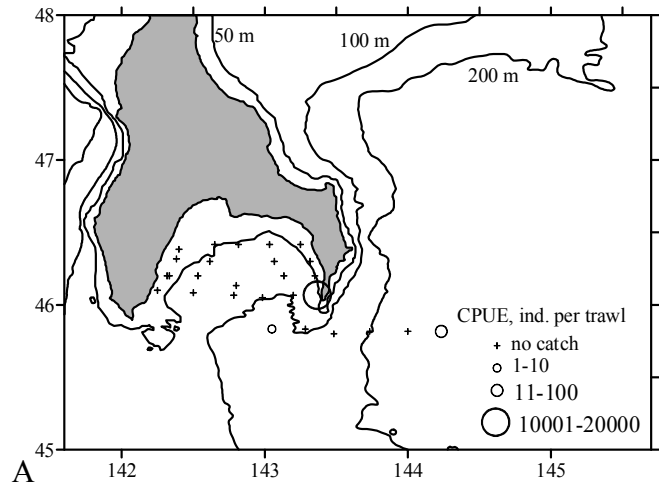
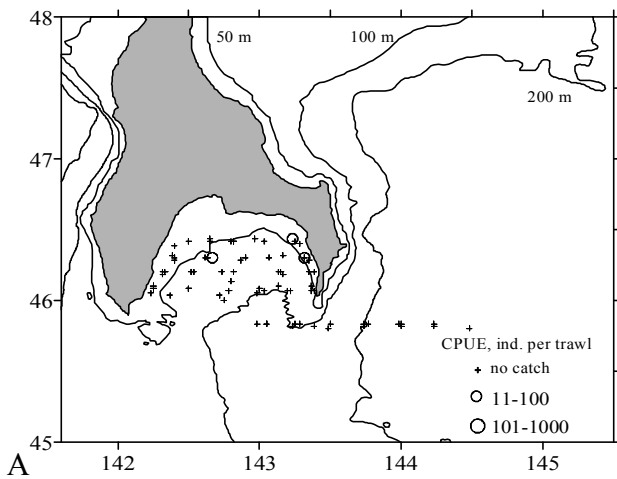


Fig. 26 - Distribution of *Podotheucus* sp. catches: 1-15 July 2006 (A), 8-13 July 2007 (B) and 13-29 July 2008 (C)

Fig. 28 - Distribution of *Reinhardtius hippoglossoides matsuurae* catches: 13-29 July 2008

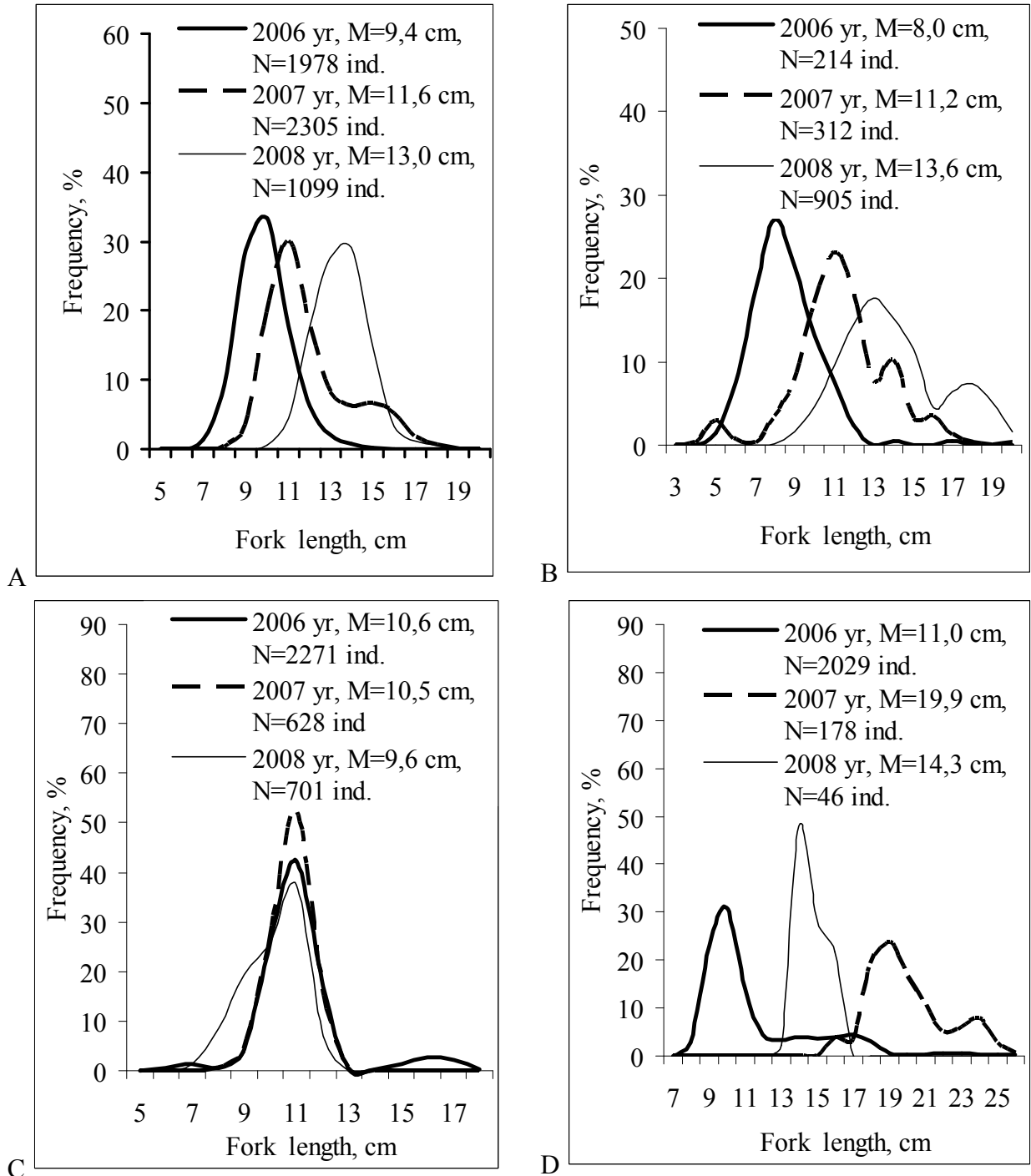


Fig. 29 – Fork length distribution of *Pleurogrammus azonus* (A), *Anarhichas orientalis* (B), *Mallotus villosus catervarius* (C), and *Clupea pallasii* (D)

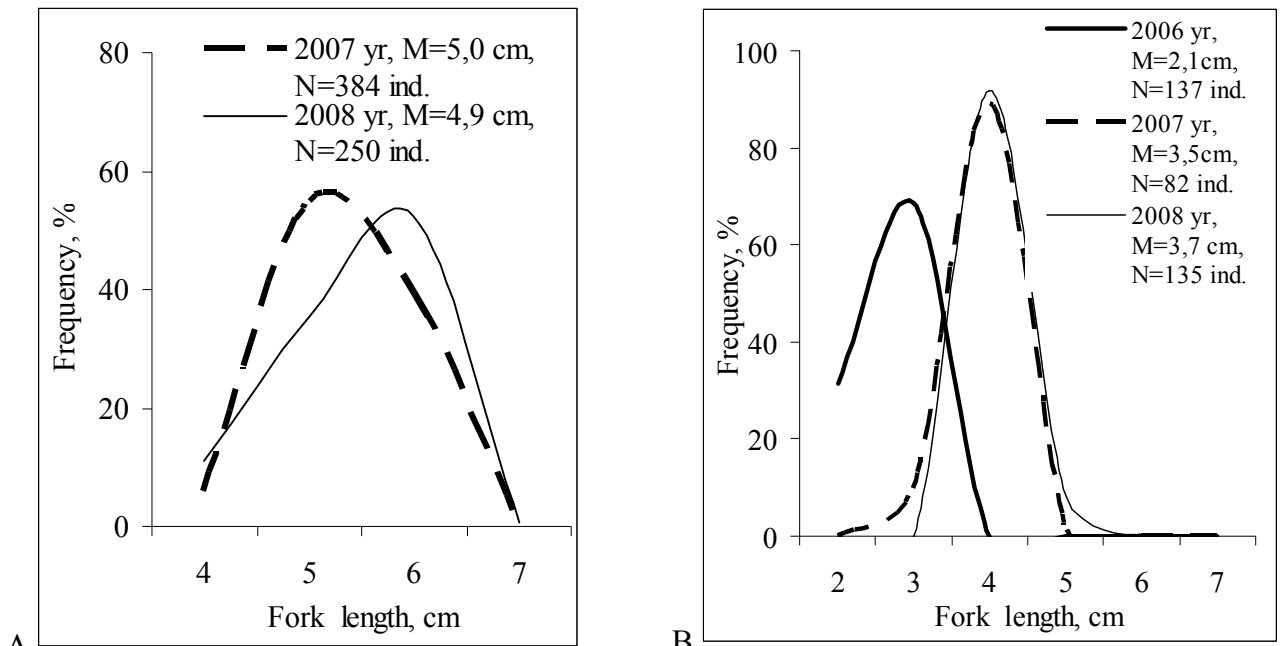


Fig. 30 - Fork length distribution of *Hemitripterus villosus* (A) and *Hemilepidotus sp.* (B)

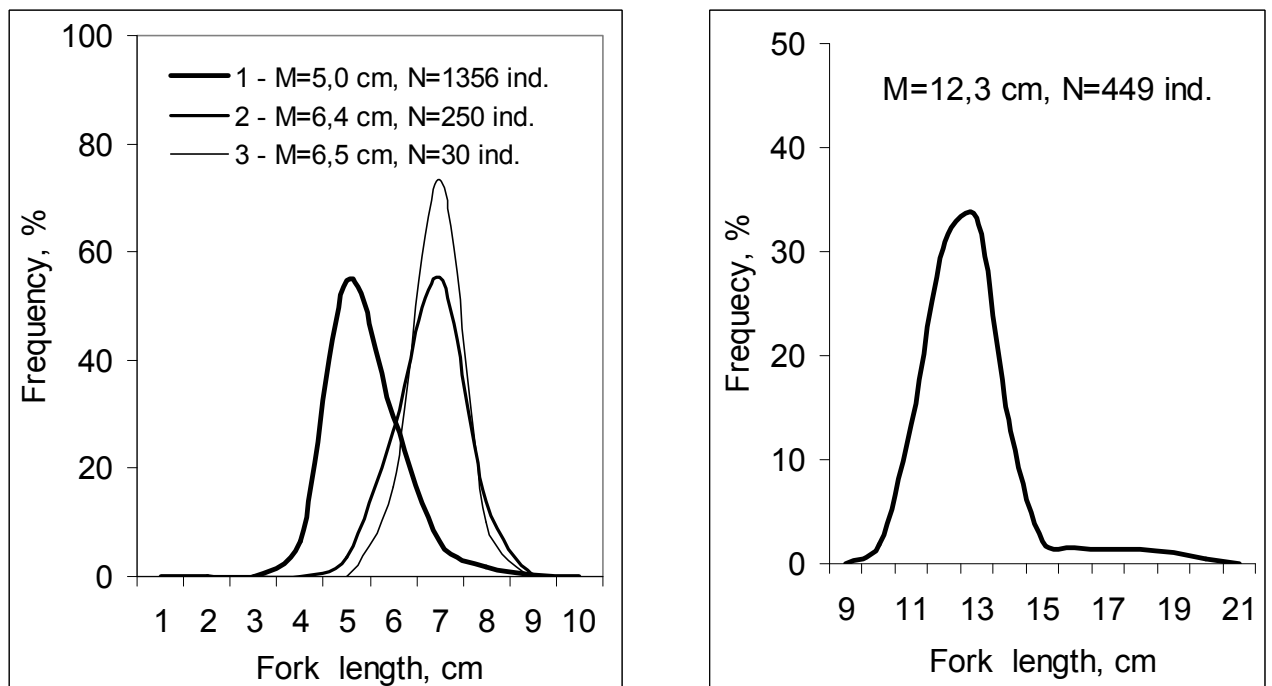


Fig. 31 - Fork length distribution of *Eleginus gracilis* (1), *Ammodytes hexapterus* (2), and *Reinhardtius hippoglossoides matsuurae* (3)

Fig. 32 - Fork length distribution of *Theragra chalcogramma* near Cape Aniva in 2006