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Results of trawl counting juvenile salmon and attendant fish species along the southern Sakhalin coast (south-western part of the Okhotsk Sea) in July-August 2005 during the R/V "Dmitry Peskov" survey

by

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ABSTRACT

Since July 6 through August 18, 2005, distribution and habitat conditions of juvenile salmon have been studied in three phases in Aniva Bay and La Perouse Strait (southwestern part of the Okhotsk Sea). A midwater rope trawl (54.4/192 m) was used to count juveniles. A total of 88 trawl operations were performed according to the elaborated map of stations. Dense aggregations of juvenile pink salmon were found at the first phase of survey. Juvenile chum salmon were rare in catches. At the second phase of survey, a density of juvenile salmon aggregations was characterized by low indices. At the third phase of survey, juvenile salmon were not observed. In total, 31 fish species from 19 families entered the ichthyocenosis composition of the upper epipelagial of Aniva Bay, La Perouse Strait and adjoining waters in summer 2005. Immature capelin, arabesque greenling fingerlings, juvenile Bering wolffish, sea raven, rockfish and others were the most abundant. The thermohaline characteristic of the study regions, maps of catch distribution of juvenile salmon and attendant fish species and data on their size-weight indices are given.

INTRODUCTION

In the 2002-2003, SakhNIRO began studying the early sea life period of juvenile salmon along the shores of eastern Sakhalin and southern Kuril islands. A total of 289 trawl operations have been performed in June-July 2002-2003 along the eastern Sakhalin and southern Kuril islands. Among other species, 86 juvenile pink and 325 juvenile chum salmon were sampled. This survey showed that in the second half of June and in July the juvenile salmon were absent in catches or they were very few. We suggested that low catches of the native-origin juvenile salmon are associated with the fact that in June (in some regions in July as well) they do not move from the shore farther than a 30-m isobath, where we have started trawling (Shubin et al., 2003; Kovalenko et al., 2004). In this connection, in such regions of the eastern Sakhalin as Aniva Bay and a coastal zone of the southeastern part, we decided to conduct a two-phase survey in 2004 (June and July). If in June juveniles actually do not move deeper than a 30-m isobath, a probability of their occurring in catches out of this line later (in July) increased significantly. The survey, conducted in the second half of June 2004 in Aniva Bay and along southeastern Sakhalin, proved the 2002-2003 results. As before, juvenile salmon were not numerous from catches. The second survey conducted in Aniva Bay in early July showed the existence of juvenile salmon dense aggregations. In mid-July 2004, the dense aggregations of juvenile pink and chum salmon were also found along the southeastern Sakhalin coast. Thus, there was elucidated that before migration from the shore juvenile salmon stay in the coastal zone (up to the 30-m isobath) during 1.5-2.5 months. Juveniles' moving to the shelf area is not gradual (as far as fish are growing), but on the contrary, it happens simultaneously (in a short space of time) (Shubin et al., 2005). Are the observed data accidental, and to what extent is a scheme of juvenile salmon migration from the southern Sakhalin shore, marked in 2004, constant? To elucidate this question, studies have been continued in 2005. We decided to carry them out mainly in Aniva Bay by three phases (early and late July, and mid-August). The objective to divide the survey into phases is to reveal and evaluate a length of period for the mass juvenile pink salmon migration from the shore.

MATERIAL AND METHODS

Accounting works have been conducted aboard the research vessel "Dmitry Peskov" since July 6 through August 18, 2005. Aniva Bay and La Perouse Strait were a study area surveyed in three phases according to the map of sampling stations elaborated in advance. During the first phase of survey (from 6 through 11 July), a total of 25 trawl sets were performed in Aniva Bay. During the second phase of survey (from 20 through 25 July), a total of 25 trawl sets were performed in Aniva Bay (by the same scheme) and 5 trawl sets in La Perouse Strait. During the third phase of survey (from 11 through 18 August), a total of 25 trawl sets were performed in Aniva Bay, 5 trawl sets in La Perouse Strait and, additionally, 3 trawl sets along the transect Cape Svobodniy – Cape Terpeniya (southeastern Sakhalin) (Table 1, Fig. 1).

A midwater rope trawl (54.4/192 m) was used to sample juvenile salmon and attendant fish species. A vertical trawl opening is about 27-28 m, horizontal 40-44 m. During each trawling a head line was set in the 0-m horizon. The trawl was located at a distance of about 275 m from the ship stern. A sampling layer was 0-30 m. In half an hour (duration of one trawl haul) an area of 0.17 km^2 was swept; a volume of water filtered was 0.05 km^3. Trawl operations were carried out in daylight.

The trawl catches were sorted by species. Majority of caught juvenile pink and chum salmon were used for biological analysis. A total of 3863 specimens of juvenile pink and chum salmon were caught during the survey period; of them, about 2000 specimens were taken for biological analysis. Fork length and body weight were measured when performing biological analysis. Species belonging of juvenile salmon was determined by the number of gill rakers on the first gill arch.

The sea parameters were measured at each station before and after a trawl operation using the undulator NU-SHUTLE and sonde ICTD#1356 by the standard methods. In order to calculate sea temperature and salinity anomalies at standard transects, "Mean long-term characteristics of hydrologic-hydrochemical parameters of the Sakhalin Island shelf zone (NiroPRO)" (Pischalnik, Bobkov, 2000a, b) were used.

The following abbreviations are accepted in the text and tables: SST – sea surface temperature (ºC); CPUE - catch per unit effort, σ – mean-square deviation, M – mean arithmetic, N – number of individuals.

RESULTS

Hydrologic environmental conditions. The maps of temperature and salinity distribution at the sea surface and at 20-m horizon are given to analyze oceanologic conditions by the phases of survey (Fig. 2-11). SST in Aniva Bay at the first phase of survey was 13-14°C. The inflow of the relatively cold waters from the Okhotsk Sea was observed around the Cape Aniva; SST in this region varied from 9 to 13°C (Fig. 2). At the 20-m horizon the temperature varied from 4 to 7°C in the southern part of the bay (anticyclonic vortex zone) and from 1 to 3°C in the rest part (Fig. 3). At the 50-m horizon the water temperature everywhere was about 0^0C. Salinity in the surface layer of Aniva Bay was 31.8‰; only in its southern part and in La Perouse Strait the increase in salinity up to 32‰ was observed. In the southeastern part of the bay the salinity gradient ranged from 31.9 to 32.2‰ (Fig. 4). At the 20-m horizon, salinity was 32‰ in the anticyclonic vortex zone, and 32.5‰ out of it (Fig. 5).

At the second phase of the survey, SST in Aniva Bay and La Perouse Strait ranged from 14 to 15°C. Just as at the first phase of survey, the temperature gradient was observed in the southeastern part of the bay (from 8 to 13°C) (Fig. 6). At the 20-m horizon a core of warm waters with the maximum 8°C was observed in the southern part of the bay; in the rest part the water temperature was 1-2°C at this horizon (Fig. 7). Salinity distribution in the surface layer and at 20-m horizon of Aniva Bay was similar to that at the first phase of survey. At the 50-m horizon the temperature varied from 0 to 2°C.

At the third phase of survey, SST in Aniva Bay ranged from 17 to 19°C; the temperature gradient from 12 to 18°C was recorded in its southeastern part. In La Perouse Strait, SST varied from 12 to 20°C (Fig. 8). At the 20-m horizon a core of warm waters with the maximum 11°C was observed in the southern part of the bay as before (Fig. 9). At the 50-m horizon the water temperature varied from 0 to 2°C. The Aniva Bay surface layer salinity remained at the level of 31.8-32.0‰. In the western part of La Perouse Strait it was higher (33.5‰) than in the eastern part (31.8‰) (Fig. 10). At the 20-m horizon, salinity in the bay was 32.5‰, and in La Perouse Strait it increased and reached the maximum (33.9‰) in its western part (Fig. 11). Temperature and salinity vertical distributions at the transect Cape Aniva – Cape Anastasiya are given in Fig. 12-13. The negative statistically significant temperature anomaly was recorded at this transect

(0-30 m layer) that indicates a heat deficit. No statistically significant salinity anomaly was recorded by the transect layers (Table 2-3).

Ichthyocenosis structure of upper pelagial. During the survey period in Aniva Bay, La Perouse Strait and along southeastern Sakhalin, a total of 31 fish species form 19 families occurred in catches. The phase survey revealed significant temporary changes in ichthyocenosis structure related to decline in fish abundance and biomass, and dominants substitution. In early July a total of 20 fish species occurred in ichthyocenosis. Immature capelin *Mallotus villosu catervarius,* fingerlings of arabesque greenling *Pleurogrammus azonus*, juvenile Bering wolffish *Anarhichas orientalis*, sea raven *Hemitripterus villosus*, pink salmon *Oncorhynchus gorbuscha,* and Gilbert's seapoacher *Podothecus gilberti* were the most frequent from catches. The same species formed the base of ichthyocenosis by abundance and biomass. The total catch accounted 43233 individuals; of them, juvenile pink salmon composed 8.4%. In the second half of July the fish species diversity decreased a little (17 species were found). Except for the juvenile pink salmon, the ichthyocenosis base was formed by the same fish species as before. However, their abundance in this period decreased almost as much as 3 times; the total catch was 14517 individuals, and the juvenile pink salmon percentage decreased to 1%. Bering wolffish was the dominant by frequency. Other species occurred in catches from less than a half of stations performed. Arabesque greenling and sea raven were the most frequent. As before, capelin and arabesque greenling remained the dominants by abundance and biomass from catches. By mid-August the ichthyocenosis structure changed significantly. None of fish species was found from more than a half of trawl catches; juvenile rockfish *Sebastes sp*. and immature capelin were the most frequent (47% and 40%, respectively). The rest fish were found from less than 20% of trawl catches (usually, 10 individuals per a trawl haul). Only at some stations the catches of juvenile *Hexagrammos sp*. and sand lance *Ammodytes hehapterus* amount 20-100, and capelin to 825 individuals per a trawl haul. Compared to July, no juvenile pink and chum salmon (*Oncorhynchus),* immature herring *Clupea pallasi*, Japanese anchovy *Engraulis japonicus,* and juvenile walleye pollock *Theragra chalcogramma* were found in the ichthyocenosis structure. At the same time, there appeared such new ichthyocenosis elements as threespine stickleback *Gasterosteus aculeta*, juvenile *Ptilichthus goodei,* and *Hexagrammos sp*., crested sculpin *Blepsias bilobus*, Greenland halibut *Reinhardtius hippoglossoides matsuurae*, and a rockfish that occupied a dominant place by abundance. Mature pink salmon dominated by biomass in the ichthyocenosis. The total fish catch in August was 18874 individuals; of them, juvenile rockfish composed 17529 individuals (Tables 4-7).

Juvenile pink salmon. At the first phase of survey in Aniva Bay, pink salmon frequency was 56%, CPUE varied from 1 to 2867 individuals per a trawl haul. A total of 3617 individuals were caught (8.4 % of the total fish numbers from catches). Major juveniles were caught in the western part of the bay above the depths of 34-36 m (Fig. 14). Their fork lengths varied from 5.1 to 9.7 cm, weights from 1.1 to 6.6 g. The mean length was 7.3 cm, weight 2.9 g (Fig. 15). The mean size-weight indices of juveniles differed insignificantly by stations (Table 8). At the second phase of survey in Aniva Bay and La Perouse Strait, the pink salmon frequency declined to 13%; CPUE varied from 1 to 151 individuals per a trawl haul; in total, 159 individuals were sampled. Major juveniles were caught above the isobaths of 90-100 m in La Perouse Strait (Fig. 14). In Aniva Bay, the fish fork length varied from 7.6 to 9.7 cm, weight from 3.3 to 7.0 g, averaged 8.8 cm and 4.9 g, respectively. In La Perouse Strait, the pink salmon size-weight indices ranged wider (5.9-10.4 cm and 2.2-9.0 g). The fish were larger (9.0 cm and 6.0 g) than in Aniva Bay (Fig. 16). The pink salmon caught at the second phase in La Perouse Strait exceeded by their size-weight indices the juvenile fish caught at the first phase in Aniva Bay (1.2 times by length and 2 times by weight) (Fig. 17). At the third phase of survey, pink salmon were not observed in Aniva Bay and adjoining waters.

Juvenile chum salmon. At the first phase of survey in Aniva Bay, the chum salmon frequency composed 20%; CPUE varied from 1 to 133 individuals per a trawl haul; in total, 140 individuals were sampled (Fig. 14). Major chum salmon were caught in the western part of the bay above the depths of 34-36 m. The chum salmon fork length varied from 5.8 to 13.1 cm, weight from 1.5 to 18.8 g (average 7.9 cm and 4.1 g, respectively) (Fig. 18). The mean length of chum salmon was similar to pink salmon, and weight as much as 1.4 times (Fig. 19). At the second phase of survey, chum salmon was found only at a single station (1 specimen 8.6 cm long and 5.1 g weigh). At the third phase of survey, no chum salmon was observed in Aniva Bay and adjoining waters.

Mature pink and chum salmon. Besides juveniles, 118 mature pink and 5 chum salmon were caught. At the first phase of survey in Aniva Bay, 1 pink and 1 chum salmon were sampled. Their size-weight indices were: 50 cm and 1.87 kg (pink salmon); 64 cm and 3.72 kg (chum salmon). At the second phase of survey, the total pink salmon catch composed 12 individuals and chum salmon 2 individuals. Major pink salmon were caught in the northwestern part of Aniva Bay. Their fork length varied from 39 to 46.5 cm, weight from 0.86 to 1.15 kg. The mean indices of chum salmon were 68.5 cm and 4.55 kg. At the third phase of survey the total pink salmon catch increased significantly (105 ind.), and only 2 chum salmon were sampled. A total of 42 pink salmon were sampled in the open waters of the southeastern Sakhalin along the external border of Terpeniya Bay. Fish length varied from 38.5 to 52 cm, weight from 0.75 to 2.0 kg. Chum salmon were caught along the external border of Terpeniya Bay as well. The mean indices of chum salmon constituted 64.8 cm and 3.65 kg.

Walleye pollock. Walleye pollock was represented by juveniles found in July during the first and second phases of survey; CPUE did not exceed 1 individual per a trawl haul. In total, 6 specimens were sampled (4 - at the first phase and 2 - at the second phase). Fish were from 7 to 7.5 cm and from 8 to 19 cm long, respectively.

Arabesque greenling. During the first and second phases of survey, arabesque greenling was one of fish species that dominated by frequency, abundance and biomass. At the first phase of survey its frequency composed 96%. This species occupied the second place by abundance from catches (28%); mean CPUE was 9.1 kg (4834 ind.) per a trawl haul; a total weight was 226.6 kg from catches (56% of the total biomass). The maximum catch was recorded within 46°17'N and 142°38'E above the depths up to 70 m making 118.3 kg (6572 ind.) (Fig. 20). Fish length varied from 9 to 20 cm; one specimen was 32 cm long. The 12-16 cm fish formed the base of catches (74%); mean fork length was 13.9 cm (Fig. 21). At the second phase of survey, arabesque greenling was less frequent (2 times) compared to the first phase (47%) (Table 4). Along with a general decline in fish abundance from catches, the arabesque greenling abundance declined as well (20%), but by biomass it occupied the leading position, being at the second place after immature capelin (39%). The mean CPUE of arabesque greenling was 2.8 kg (97.2 ind.) per a trawl haul under the total capture of 84.2 kg (2915 ind.). The maximum catch constituted 30 kg (1000 ind.) and was recorded within 46°30'N and 143°07'E above the depth of about 40 m (Fig. 22). Fish length varied from 12 to 19 cm. The dominants were fish from 13 to 15 cm long (58 %) (Fig. 23). At the third phase of survey, arabesque greenling was not found in Aniva Bay. At the external border of Terpeniya Bay, only 19 specimens were sampled during 3 trawl operations. Fish length varied from 16 to 20 cm.

Capelin. At the first phase of survey, immature capelin along with juvenile arabesque greenling and Bering wolffish occupied a leading position in ichthyocenosis by frequency (92%), abundance (55%), and biomass (37%) (Tables 4-7). The mean capelin CPUE composed 4.1 kg (950 ind.) per trawl haul. In total, 102.1 kg (23752 ind.) of capelin were captured during this period. The maximum capture - 28 kg (5479 ind.) was recorded within 46°31'N and 143°09'E above the depth of about 40 m (Fig. 24 A). Capelin length varied from 6 to 11 cm, averaged 9.8 cm (Fig. 25 A). At the second phase of survey, an abrupt decline in capelin frequency (17%) from catches was recorded. However, at one of stations (46°33'N and 142°30'E), capelin capture constituted 90 kg (10000 ind.) above the isobath of 32 m. So, in general, it occupied the leading position by abundance (74%) and biomass (45%) from catches among the epipelagic fishes of the bay. The mean capelin CPUE was 3.2 kg (359 ind.) per a trawl haul. In total, 97.0 кг (10783 ind.) of capelin were captured (Fig. 24 B, Tables 4-7). Fish length varied from 8.5 to 12 cm, averaged 10.5 cm, that is a little longer than at the first phase of survey (Fig. 25 B). At the third phase of survey, capelin frequency increased up to 40%, but its abundance and biomass were insignificant (5 and 7%, respectively). The maximum CPUE was 5.6 kg (825 ind.) (Fig. 24 Г). The total catch composed 6.5 kg (943 ind.) (Table 4-7). Fish length varied from 8.5 to 14 cm, averaged 11.4 cm, that is longer than at the first and second phases of survey (Fig. 25 Г).

Bering wolffish. During the first and second phases of survey, juvenile Bering wolffish was one of the most frequent fish species. At the second phase of survey, along with capelin, it occupied the second place by frequency (92%), conceding only to the arabesque greenling (96%) (Tables 4-7). Despite the high frequency, its abundance and biomass were not high (2.7 and 2.8 %, respectively). The mean Bering wolffish CPUE was 0.5 kg (46 ind.) per a trawl haul. In total, 11.8 kg (1177 ind.) of Bering wolffish were captured during this period. The maximum catch – 2 kg (200 ind.) was recorded within 46°17'N and 142°38'E above the depth of 52 m (Fig. 26). Fish length varied from 8 to 14 cm; the base of catches was formed by fish with 11-13 cm in length, (91%); the mean length of fish was 11.8 cm (Fig. 27). At the second phase of survey, Bering wolffish dominated by frequency (87%), however, as at the first phase of survey, its abundance and biomass were low (0.9 and 1.5%, respectively). The mean CPUE was 0.1 kg (4.5 ind.) per a trawl haul; maximum 0.6 kg (20 ind.) (Fig. 28). In total, 3.3 kg (136 ind.) of Bering wolffish were captured (Tables 4-7). Fish length varied from 10 to 20 cm and weight from 15 to 43 g; the dominants were fish 15-17 cm long (65%); mean length was 15.4 cm (Fig. 29). At the third phase of survey, frequency of Bering wolffish decreased almost as much as 7 times (13%); abundance and biomass decreased as well (0.1 and 0.4%, respectively). The maximum CPUE was 0.19 kg (4 ind.). The total catch composed 0.36 kg (8 ind.) (Tables 4-7). Fish length varied from 13 to 21 cm.

Sea raven. By frequency, sea raven occupied the second and third places in July along with such common fish species as arabesque greenling, capelin and Bering wolffish. At the first phase of survey, sea raven frequency was 76%, however, its abundance and biomass were not high (4.6 and 0.7%, respectively) (Tables 4-7). The mean CPUE was 78.8 ind. per a trawl haul; the maximum catch composed 344 ind. (0.94 kg) (Fig. 30). The total catch was 3.94 kg (1970 ind.). Fish length varied from 4 to 7 cm. At the second phase of survey, sea raven frequency remained relatively high (47%), but its abundance and biomass decreased significantly (0.4 and 0.06%, respectively). The mean CPUE was 1.6 ind. per a trawl haul, and the maximum catch amounted to 15 ind. (Fig. 31). At the third phase of survey, a total of 5 specimens between 5.5 and 6.5 cm long were sampled.

Rockfish. At the first two phases of survey, *Sebastes sp.* was not found from catches. At the third phase of survey, rockfish dominated by frequency along with capelin in the Aniva Bay epipelagic zone (47%). It occupied the leading position by abundance (93%). The mean CPUE of rockfish was 584 ind. per a trawl haul. The maximum catch of 1 kg (10000 ind.) was recorded at the station with coordinates 45°49'N and 143°01'E above the depth of 110 m. The total catch composed 17529 ind. (2.29 kg). The rockfish was represented exclusively by juveniles ranged from 1.5 to 3.5 cm in length and from 0.1 to 0.2 g in weight. So, its biomass was low (2.6%) (Fig. 32, Tables 4-7).

***Salmon shark* (*Lamna ditropis*)**. At the first phase of survey, two individuals of *Lamna ditropis* were caught (180 and 200 cm long). At the third phase of survey, three individuals of *Lamna ditropis* were caught (between 186 and 195 cm long). All of them were males.

RESULTS AND DISCUSSION

In 2002, SakhNIRO began trawl counting of juvenile salmon in the epipelagic shelf zone of eastern Sakhalin and southern Kuril Islands. Taking into account that the juvenile salmon harvest by their main reproductive areas in Sakhalin-Kuril Region composes hundreds of millions specimens (Shubin et al., 2003; Kovalenko et al., 2004), we expected the catches to be at the level of dozens and even hundreds specimens per unit effort during our survey. However, the actual situation appeared to be quite different, especially concerning pink salmon (Radchenko et al., 2002). During June and July 2002-2003, a total of 36 juvenile pink salmon were sampled in Aniva Bay, La Perouse Strait, and along south-eastern Sakhalin. Because juveniles were not abundant and had different sizes, perhaps, they were not the advanced-migrating, but accidentally carried-away specimens. No juvenile pink salmon were observed in Terpeniya Bay; they were not found along the northeastern Sakhalin, except for 36 individuals at a single station. In July 2003, only 10 juvenile pink salmon were sampled along the southern Kuril Islands. Compared to pink, juvenile chum salmon were sampled much more (325 ind.). The size-weight indices of chum salmon were extraordinary great along the eastern Sakhalin south of 49ºN and near Kunashir Island (southern Kuril Islands).

In total (in June-July 2002-2003), we have sampled 407 juvenile pink and chum salmon along the eastern Sakhalin and southern Kuril Islands, that is more than in all the previous expeditions in the shelf zone in this time period (Birman, 1985; Shershnev et al., 1982; Shuntov, 1989). Nevertheless, the results of cruises were quite unexpected – no aggregations of the native-origin juvenile salmon were found on the shelf area. Partially, this was related to the trawl low efficiency, which is usually 0.01 for fish juveniles (Shuntov et al., 1994). Another reason was, perhaps, that not only in June, but in some regions also in July juvenile salmon do not leave in mass the near-shore line to the 30-m isobath, from where we began trawl operations. In this connection, we decided to conduct a survey in 2004 in Aniva Bay by two phases – in the second half of June and first half of July, and along the southeastern Sakhalin in the second half of June and July.

In the second half of June 2004, only 2 juvenile pink and 64 chum salmon were sampled along the southern Sakhalin coast. Fish were too large to be of Sakhalin origin. During the repeated survey in Aniva Bay in early July, the juvenile pink and chum salmon were found to be distributed all over the area forming dense aggregations in some places. Judging from pink salmon sizes and taking into account their absence in adjoining waters in June, all fish were of native origin (from Aniva Bay's rivers and hatcheries). Since late April through early July (from 2.5 to 0.8 months, depending on dates of their entering a sea), fish inhabited the near-shore line up to the 30-m isobath, and the bulk of them did not migrate out of it. The same situation is related to majority of chum salmon. A process of native juvenile salmon migration from the near-shore line, their distribution over the Aniva Bay area and moving to the La Perouse Strait was not gradual (as far as fish were growing), but on the contrary, it happened at once, during several days. In the beginning of the second half of July, juvenile pink and chum salmon dense aggregations were observed in the southeastern Sakhalin coastal zone too. The mass migration of juvenile salmon from the shore of southern Sakhalin in July 2004 was related to the increase in SST on the upper border of the optimal-for-feeding temperature (14-15ºC). Apparently, the SST reaching this border became "a signal" for their migration (Shubin et al., 2005).

By the SakhNIRO data, in 2005 a downstream migration of juvenile pink salmon from the Aniva Bay rivers began on 1 May; the main migration was observed since May 25 through June 6 and completion on 15 June. The total amount of downstream migrating fish was 136 million individuals. Juvenile pink and chum salmon were released from hatcheries in late May – early June (pink – 73 million ind.; chum – 15. 6 million ind.). Three trawl surveys conducted in July-August 2005 showed that frequency and density of aggregations for juvenile salmon in Aniva Bay and La Perouse Strait were different by the sampling periods. In early July the migrating-from-shore juvenile salmon were distributed all over the Aniva Bay area forming dense aggregations in some places; the base was formed by pink salmon. The pink salmon sizes proved their native origin (from Aniva Bay's rivers and hatcheries). The same observation is referred to major chum salmon. Juvenile salmon distribution in early July 2005 was close to their distribution in early July 2004. Their size-weight indices and variability ranges were close too (Fig. 33-34). An abrupt decrease in juvenile fish catches in the second half of July, compared to its first half, and their absence in catches in August show that the period of the mass fish migration from the shore and out of Aniva Bay is rather short (not more than 10-12 days). Before their migration from the shore, juvenile salmon stay in the near-shore zone (up to the 30-

m isobath) for a long time (to 2-2.2 months). Their migration is not related to fish reaching the definite size-weight indices. Temperature conditions during the juvenile pink and chum salmon migration from the Aniva Bay shore in 2005 were analogous to those observed in 2004. So, our suggestion that specified SST values is “a signal” for the mass juvenile salmon migration has been proved.

The phase survey performed in summer 2005 showed that a significant intraseasonal variability related to changes in species composition, quantitative indices of fish and dominant substitution is common for ichthyocenosis of the Aniva Bay upper pelagic zone and adjoining waters. In early July 2005, ichthyocenosis was formed by the same fish species as in late June 2002-2003 and early July 2004. They are, for the first turn, arabesque greenling, capelin, Bering wolffish, and sea raven (Table 9). The peculiar feature of 2005 is the lower quantitative indices of immature herring and juvenile *Hemilepidotus sp*., and higher indices of juvenile Gilbert’s seapoachers, compared to the previous years. In the second half of July the base of ichthyocenosis was formed by the same fish species as in its first half, however, their abundance declined abruptly, for the first turn due to sea raven and Bering wolffish, and also capelin and arabesque greenling. As a result, the total catch decreased as much as 3 times. The icthyocenosis has changed greater from the second half of July to mid-August. During this period, the abundance of fish, common for ichthyocenosis in July, continued decreasing, and some fish species (bulk earlier) were not found from catches (e.g. arabesque greenling). As a result, the total catch of the earlier-distributed fish decreased as much as 10 times. Along with that, ichthycenosis was replenished with juvenile rockfish, which occupied the dominating position by abundance. Perhaps, these were fish spawned in spring in the coastal zone to the 30-m isobath. Mature pink salmon dominanted by biomass in August. The intraseasonal variability of the upper pelagic ichthyocenosis is common for Aniva Bay (Velikanov et al., 2004, 2005). However, such great changes as in summer 2005 were marked for the first time. Our long-term studies of ichthyocenosis of the Aniva Bay upper pelagic zone have shown that a significant part of fish catches in this region during the summer period is composed by their fry and fingerlings. In this relation, the epipelagic zone of the region considered has a function of “nursery” for juveniles of different ecological groups (Velikanov et al., 2004).

CONCLUSION

The data obtained during the 2004 survey were proved by the surveys conducted in 2005. It was established that juvenile pink and chum salmon stay in the Aniva Bay near-shore zone during 2-2.2 months up to the 30-m isobath. Fish do not migrate from shore to the shelf area step-by-step (as far as they are growing), but on the contrary, at once, in short terms. The concrete dates of migration are determined (among other causes) by the SST reaching the upper border of the temperature optimum for juvenile salmon feeding. In early July 2005, a species composition of ichthyocenosis of the Aniva Bay upper epipelagic zone was close to that in 2002-2004. The same is referred to quantitative indices of major species except for herring and *Hemilepidotus sp.* A decrease in fish abundance and biomass was observed in the second half of July, and substitution of dominating species in August.

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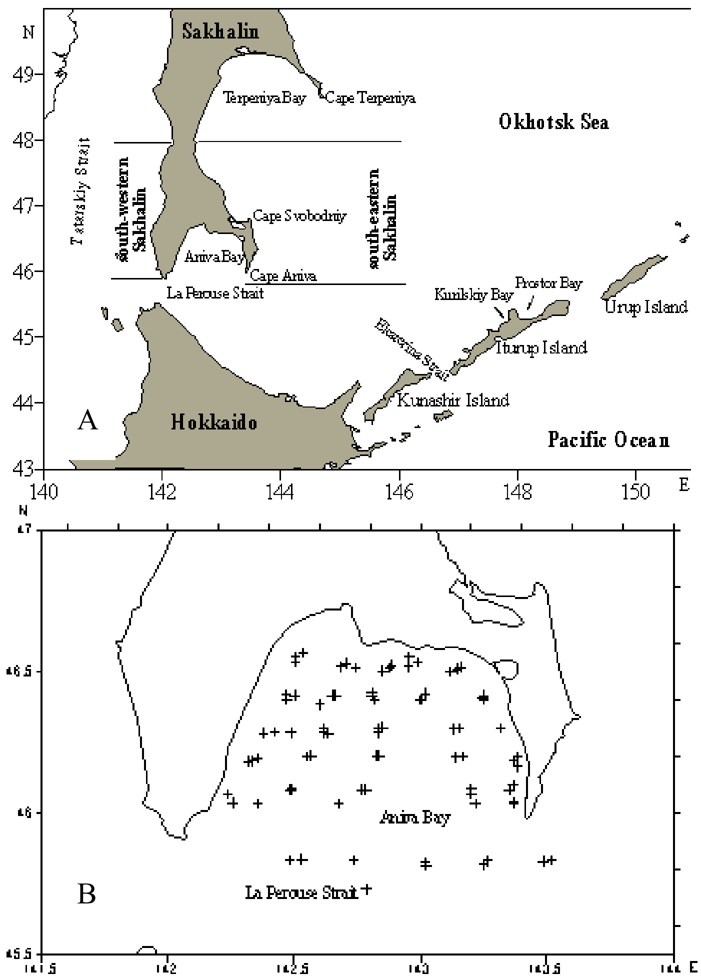

Fig. 1. A map of research are (A) and trawl stations (B) performed during the R/V "Dmitry Peskov" survey in Aniva Bay and La Perouse Strait in July – August, 2005.

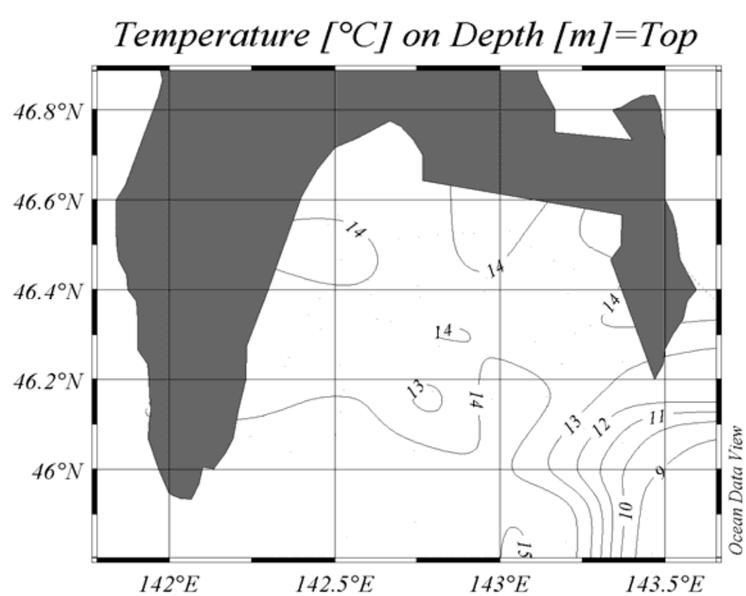

Fig. 2. Sea surface temperature distribution from 6 through 10 July, 2005.

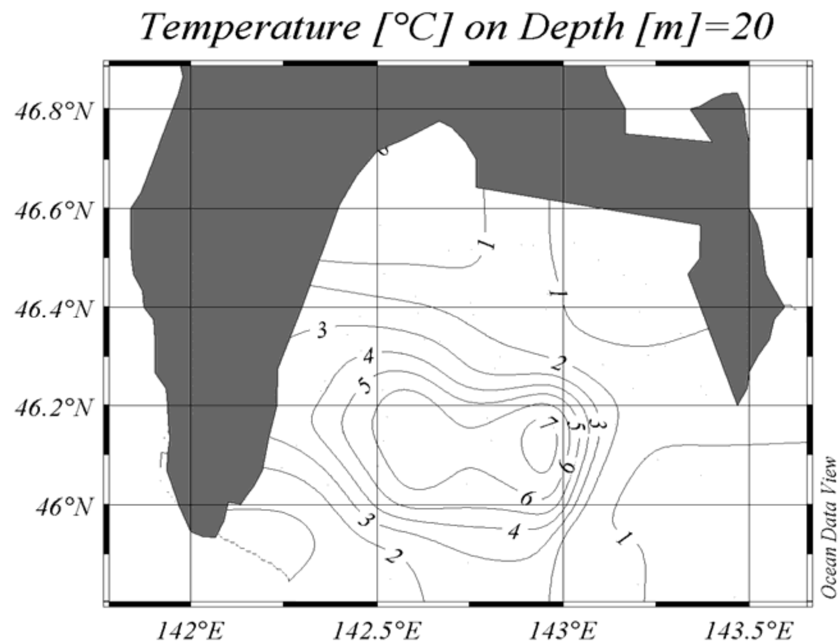

Fig. 3. Sea temperature distribution at 20 m horizon from 6 through 10 July, 2005.

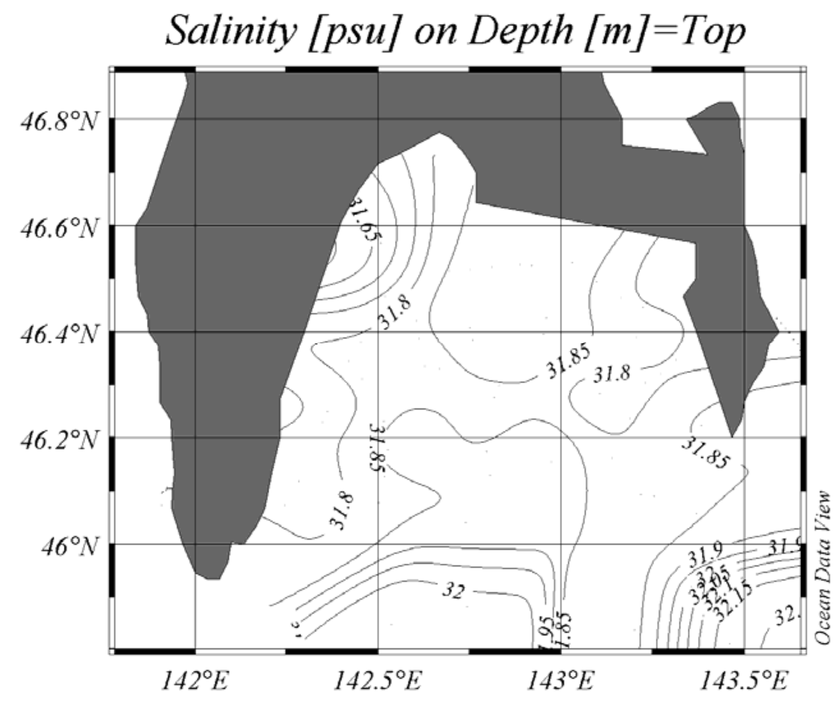

Fig. 4. Sea surface salinity distribution from 6 through 10 July, 2005.

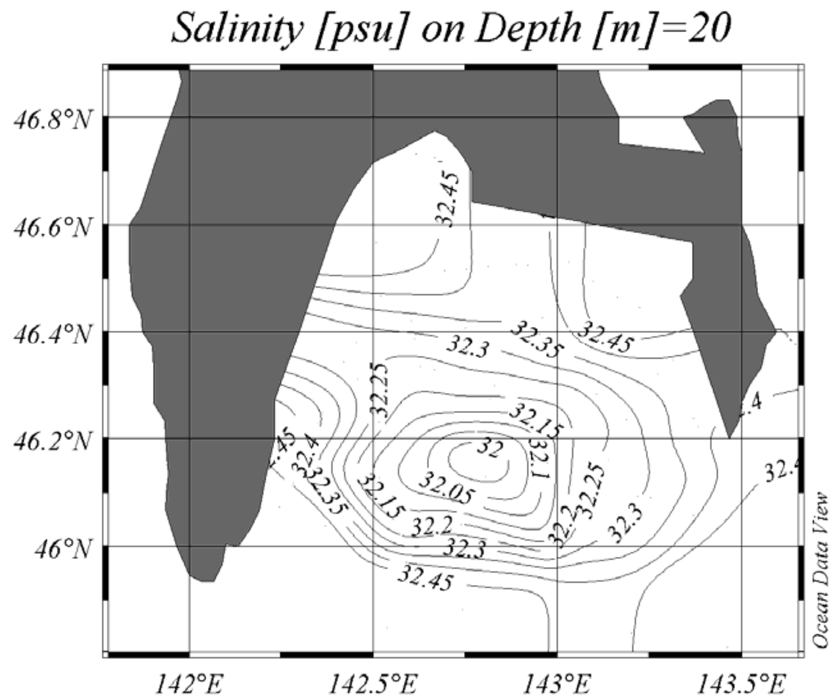

Fig. 5. Sea salinity distribution at 20 m horizon from 6 through 10 July, 2005.

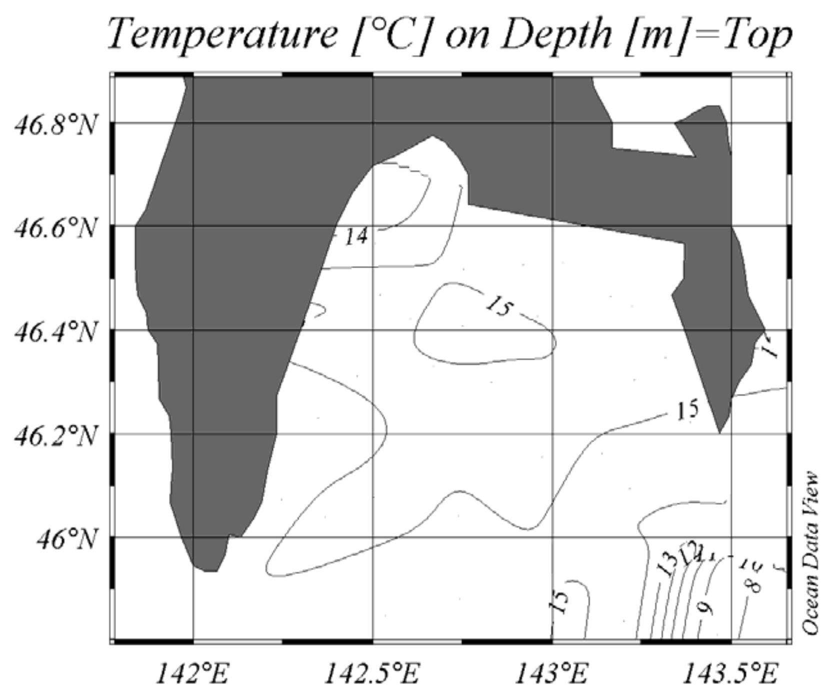

Fig. 6. Sea surface temperature distribution from 20 through 25 July, 2005.

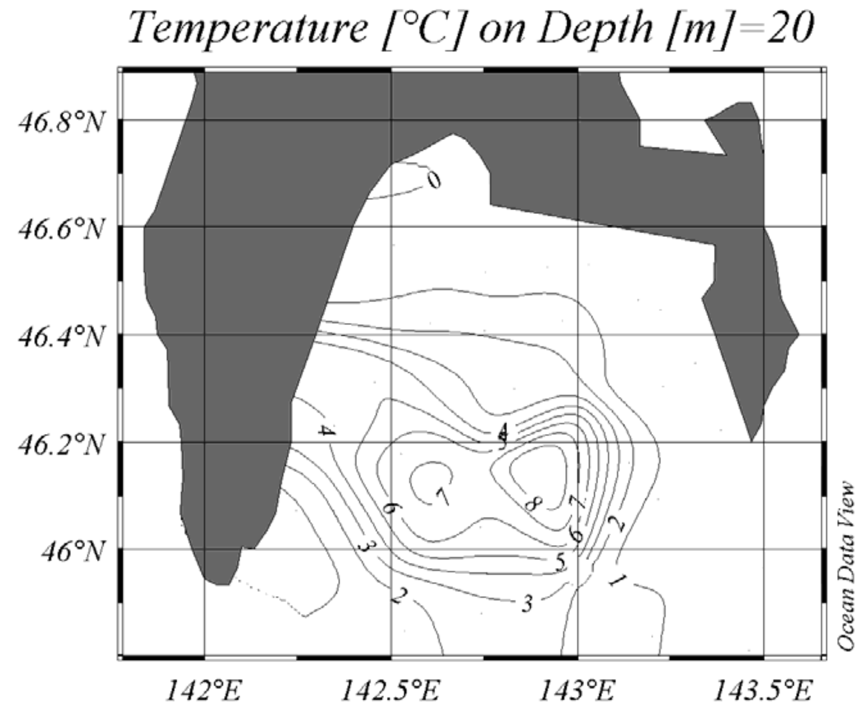

Fig. 7. Sea temperature distribution at 20 m horizon from 20 through 25 July, 2005.

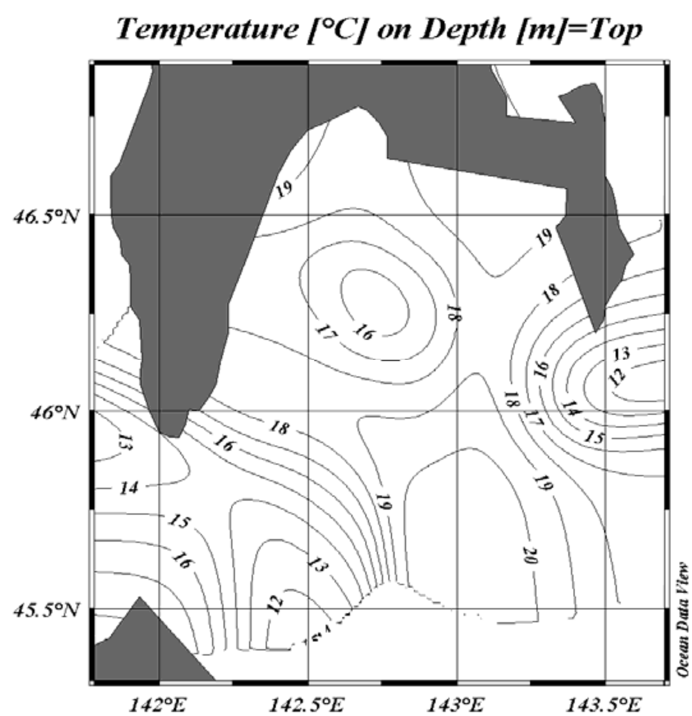

Fig. 8. Sea surface temperature distribution from 11 through 18 August, 2005.

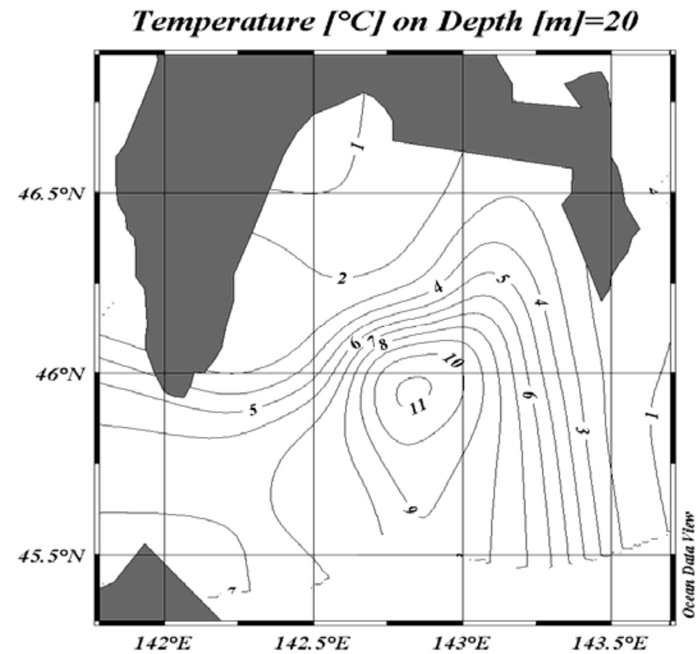

Fig. 9. Sea temperature distribution at 20 m horizon from 11 through 18 August, 2005.

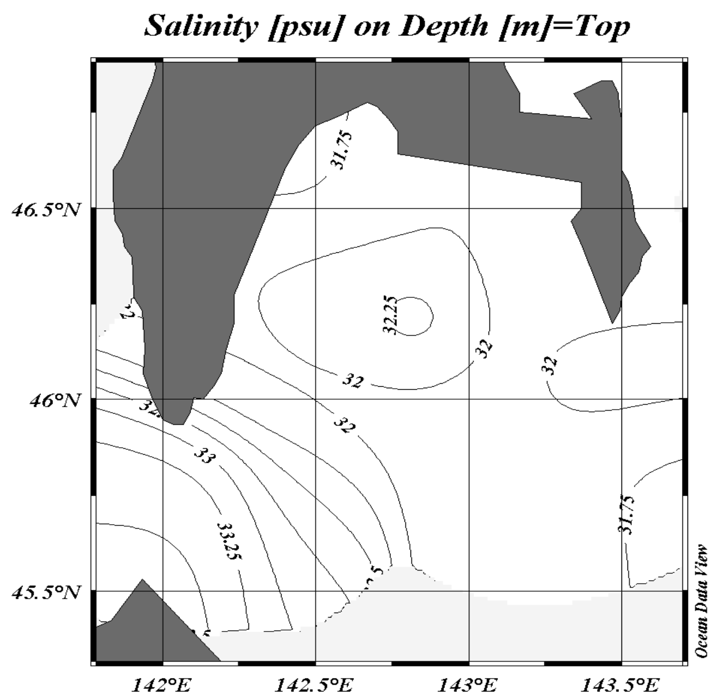

Fig. 10. Sea surface salinity distribution from 11 through 18 August, 2005.

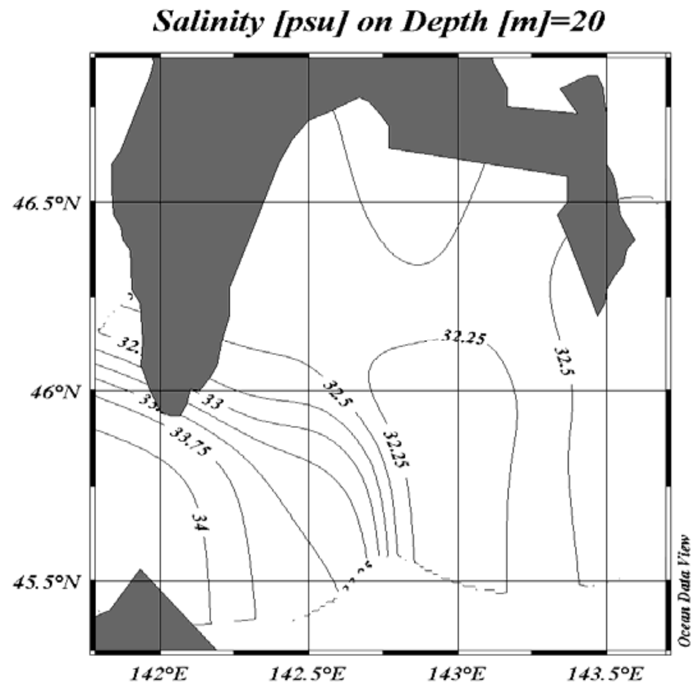

Fig. 11. Sea salinity distribution at 20 m horizon from 11 through 18 August, 2005.

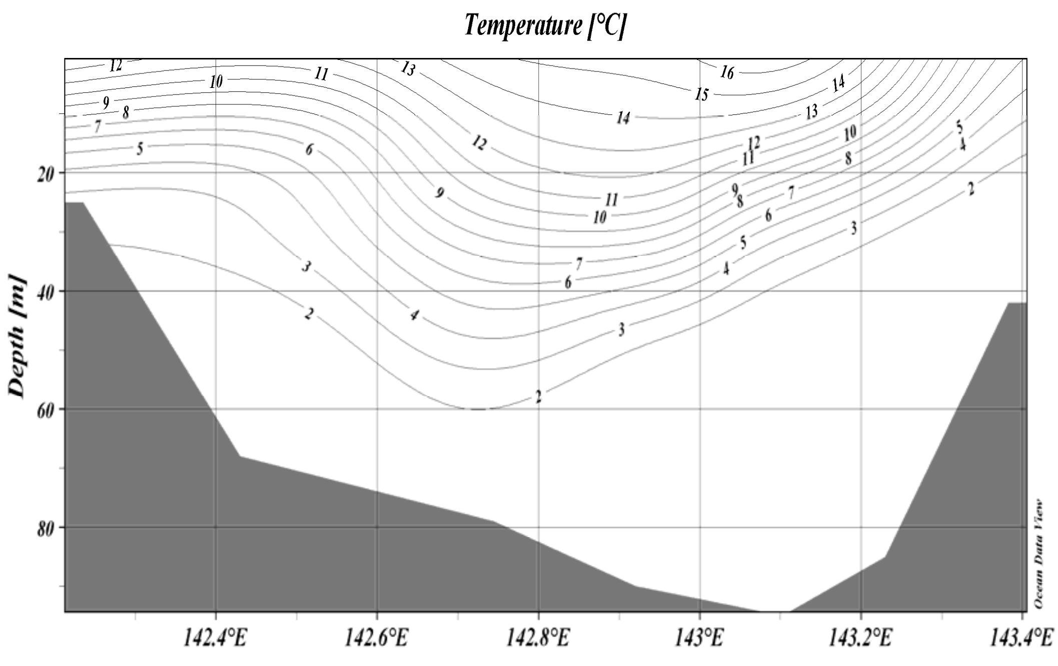

Fig. 12. Temperature profiles at the transect Cape Aniva – Cape Anastasiya from 11 through 18 August, 2005.

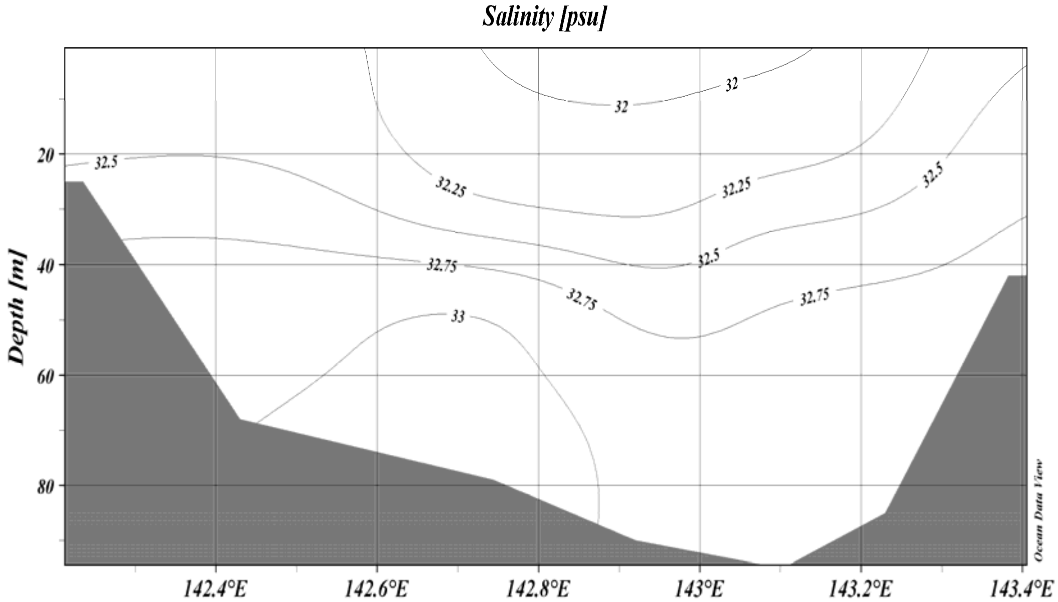

Fig. 13. Salinity profiles at the transect Cape Aniva – Cape Anastasiya from 11 through 18 August, 2005.

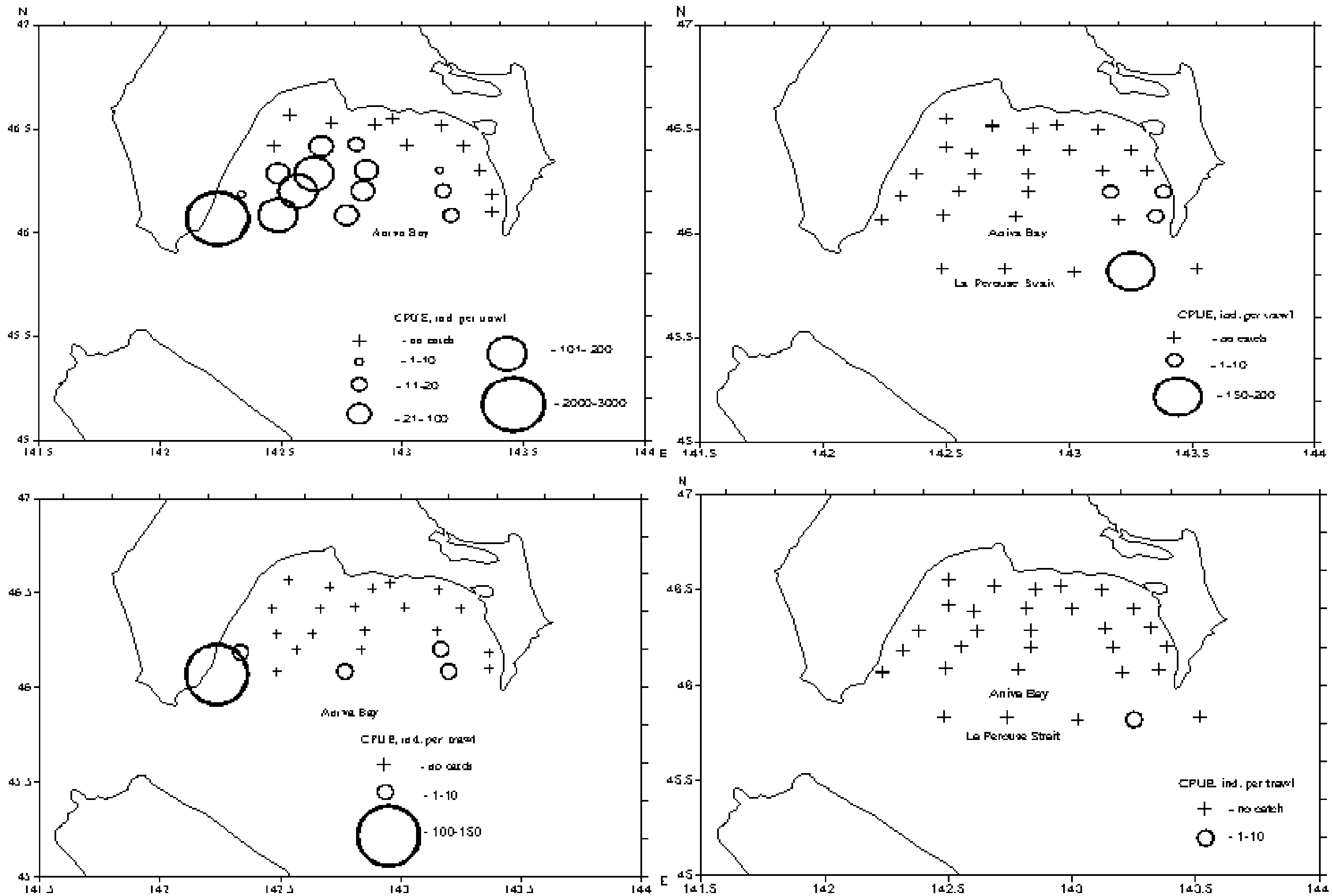

Fig. 14. Distribution CPUE of juvenile pink (top) and chum (bottom) salmon in Aniva Bay and La Perouse Strait in July 2005.

(left – the 1st phase of survey between 6 and 10 July, right – the 2nd phase of survey between 20 and 25 July, 2005).

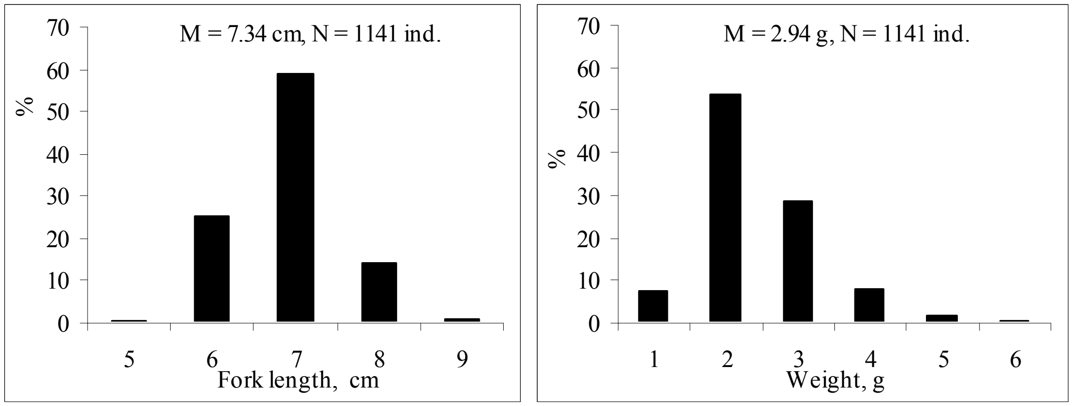

Fig. 15. Distribution of juvenile pink salmon size-weight indices in Aniva Bay (6-10 July, 2005)

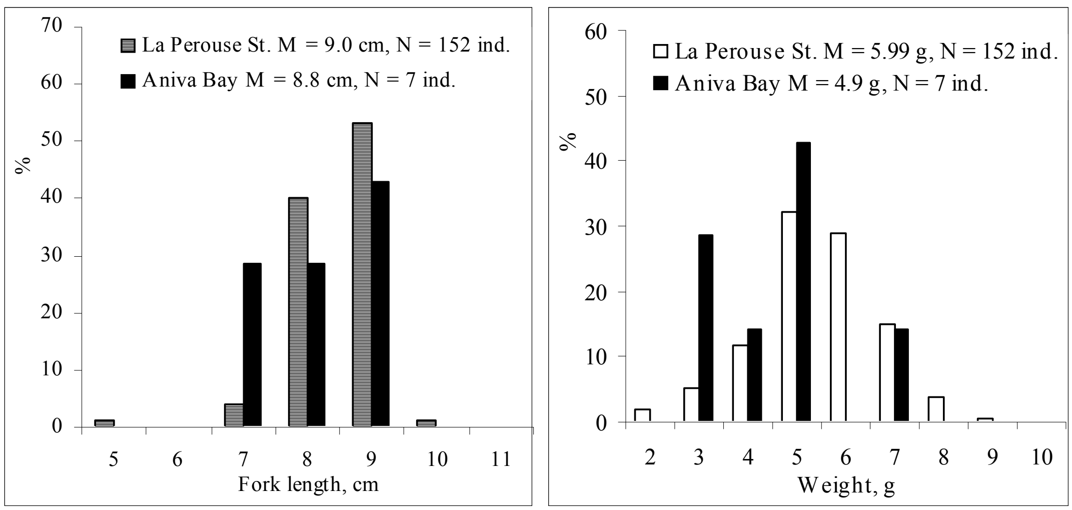

Fig. 16. Distribution of juvenile pink salmon size-weight indices in Aniva Bay and La Perouse Strait (20-25 July, 2005)

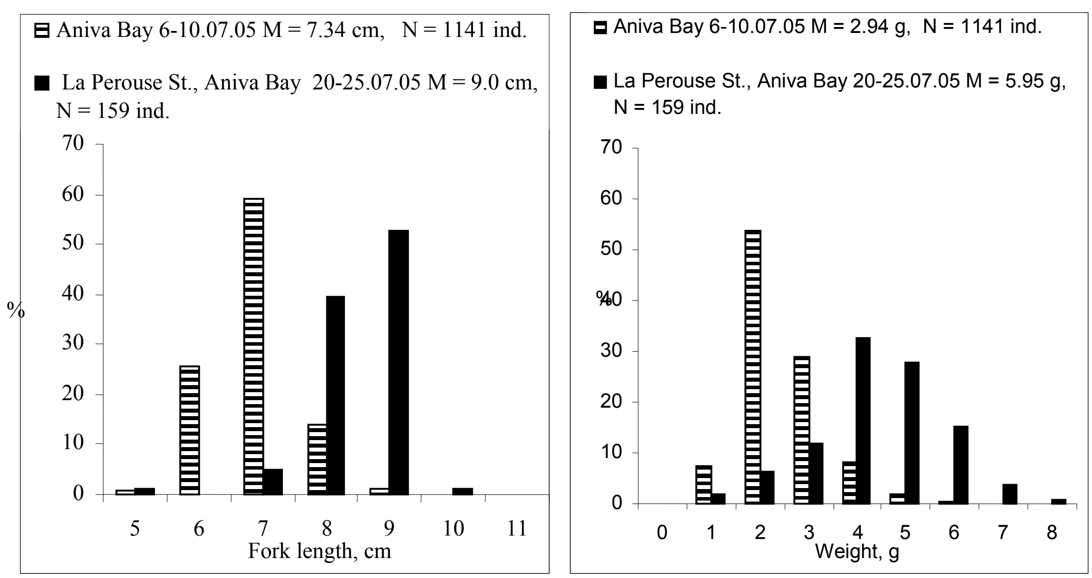

Fig. 17. Distribution of juvenile pink salmon size-weight indices in Aniva Bay (6-10 July, 2005) and in Aniva Bay - La Perouse Strait (20-25 July, 2005)

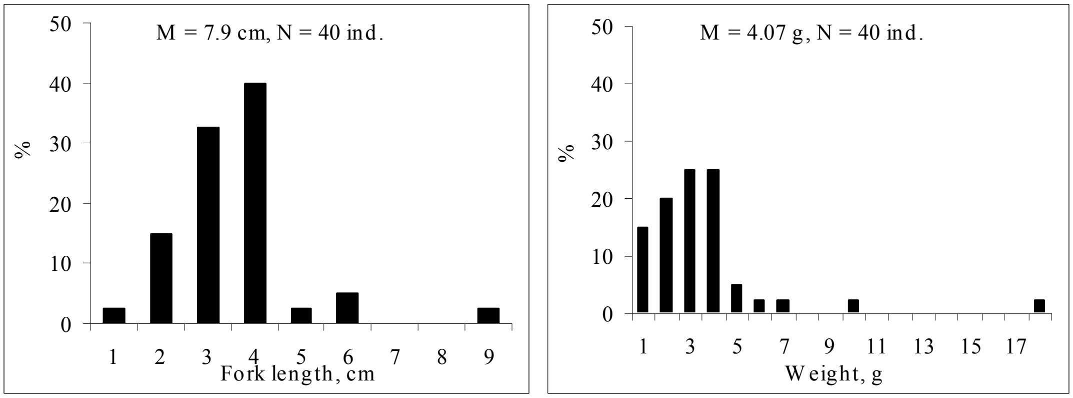

Fig. 18. Distribution of juvenile chum salmon size-weight indices in Aniva Bay (6-10 July, 2005)

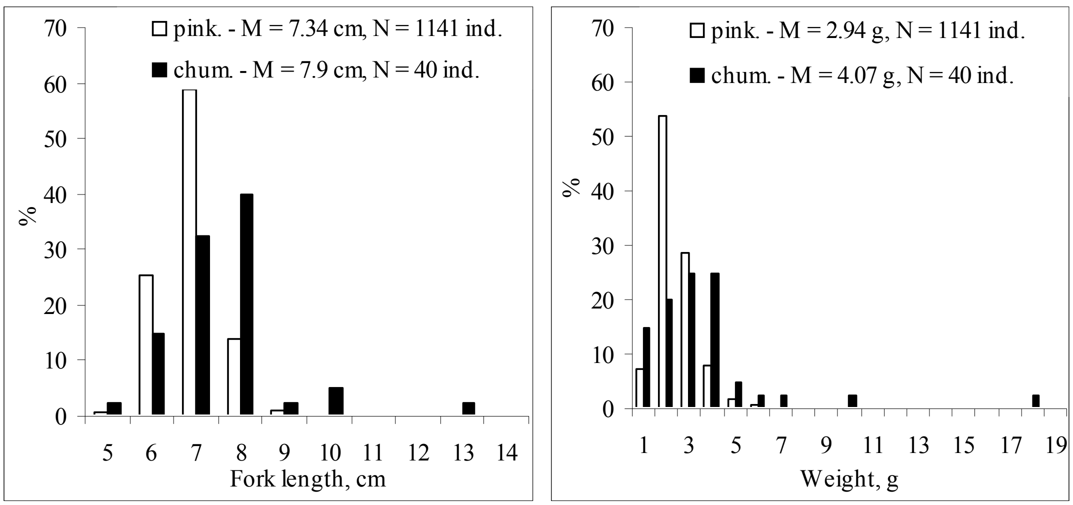

Fig. 19. Distribution of juvenile pink and chum salmon size-weight indices in Aniva Bay and La Perouse Strait (6-10 July, 2005)

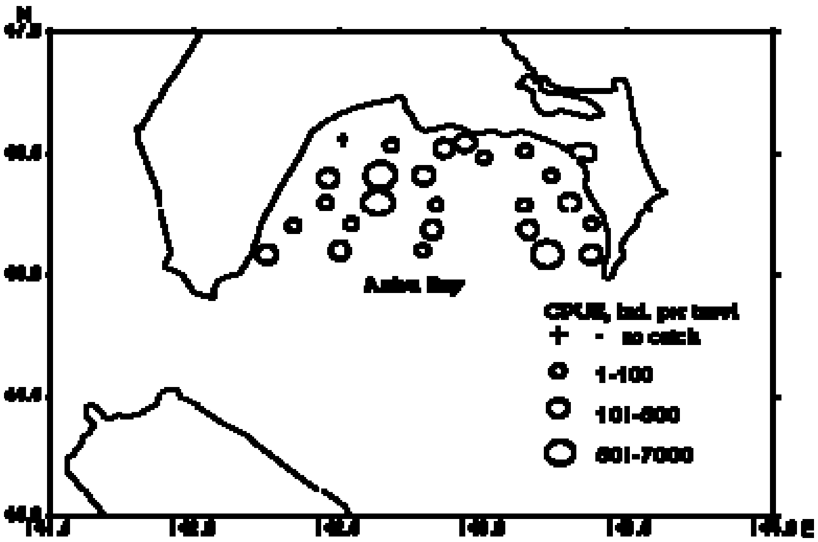

Fig. 20. Distribution CPUE of juvenile *Pleurogrammus azonus* in Aniva Bay (6-10 July, 2005)

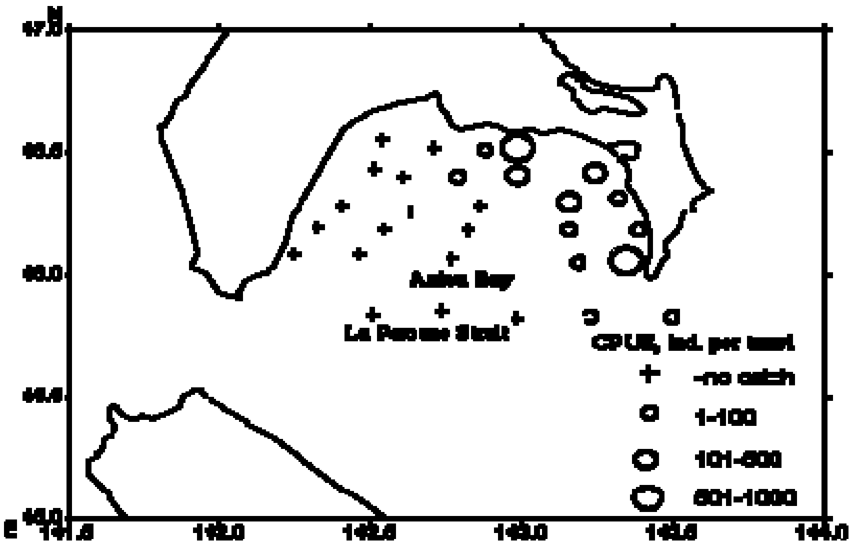

Fig. 22. Distribution CPUE of juvenile *Pleurogrammus azonus* in Aniva Bay and La Perouse Strait (21-25 July, 2005)

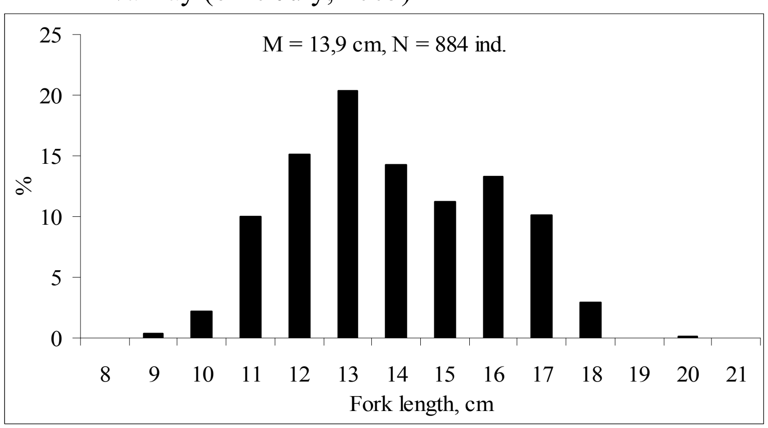

Fig. 21. Size composition of juvenile *Pleurogrammus azonus* In Aniva Bay (6-10 July, 2005)

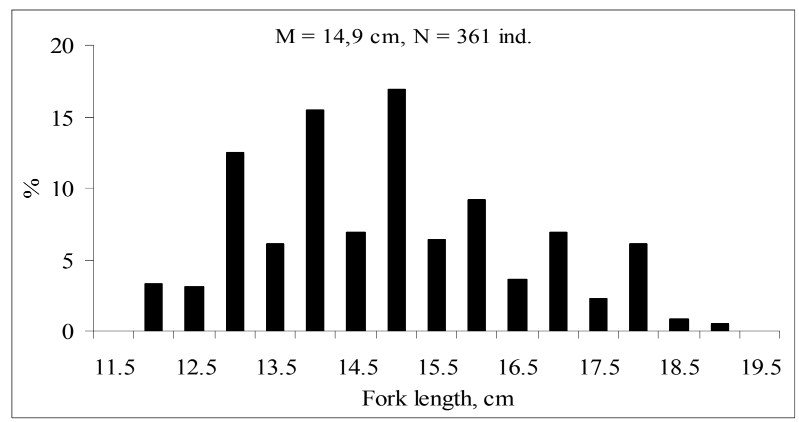

Fig. 23. Size composition of juvenile *Pleurogrammus azonus* in Aniva Bay (21-25 July, 2005)

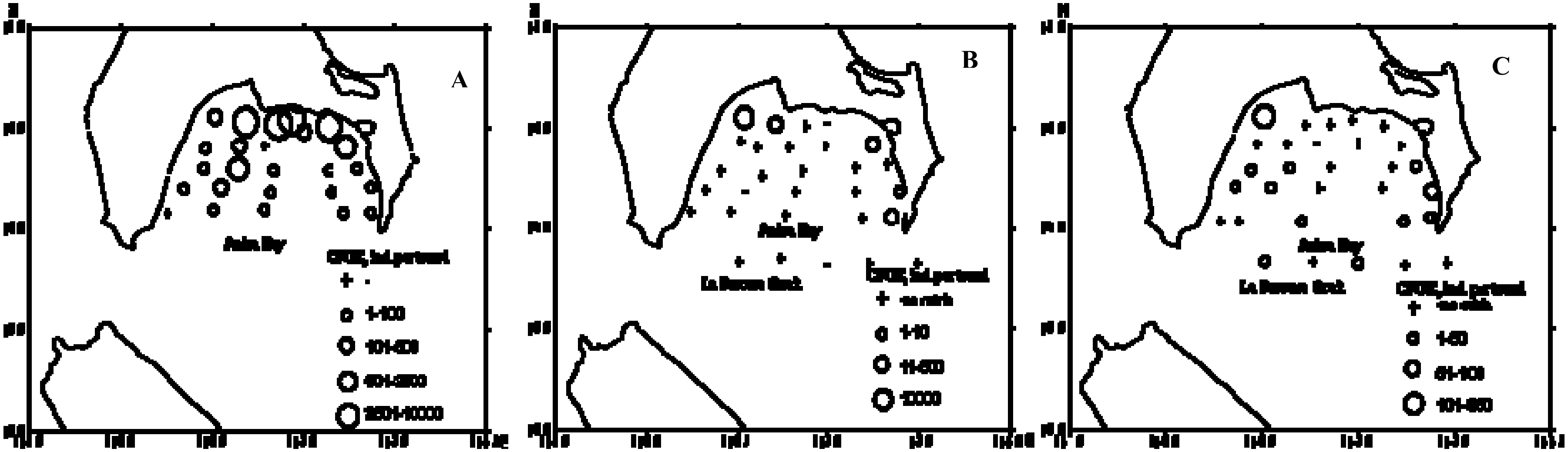

Fig. 24. Distribution CPUE of *Mallotus villosus catervarius* in Aniva Bay and La Perouse Strait on 6-10 July (A), 21-25 July (B) and 14-18 August (C) 2005.

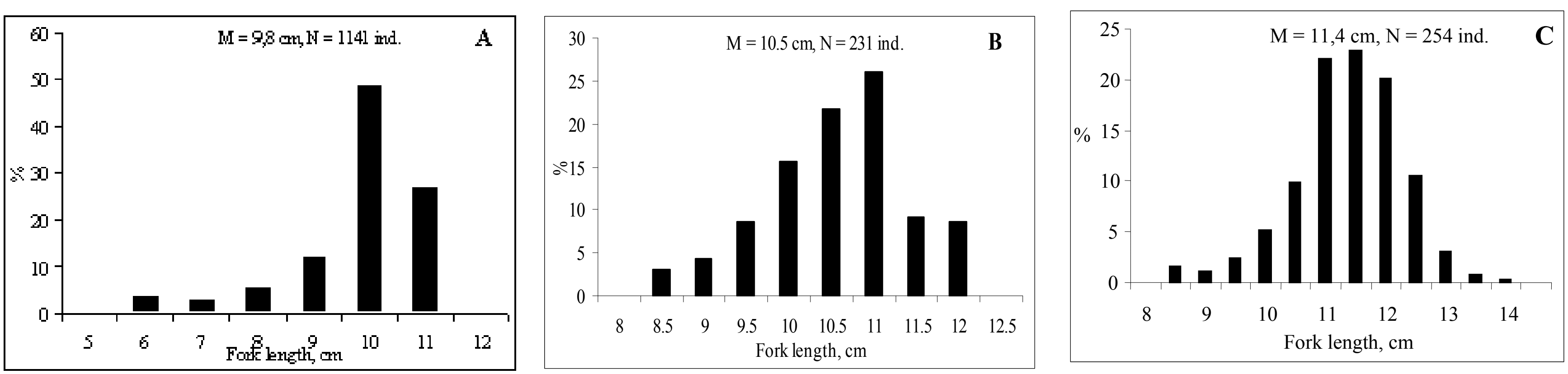

Fig. 25. Size composition of *Mallotus villosus catervarius* in Aniva Bay and La Perouse Strait on 6-10 July (A), 21-25 July (B) and 14-18 August (C) 2005.

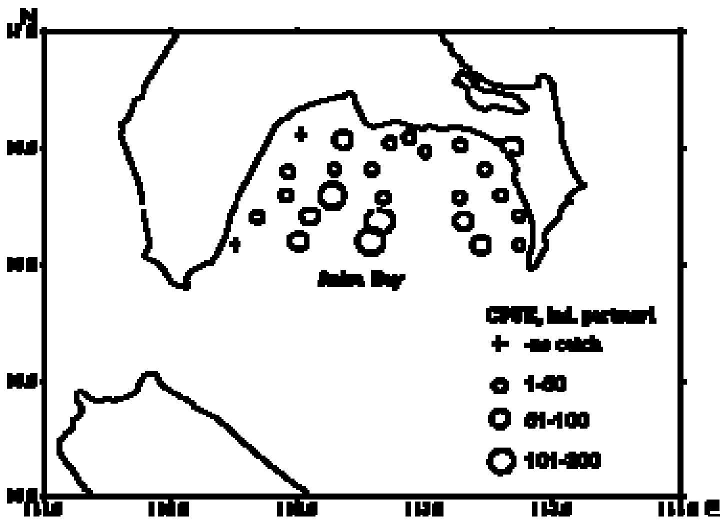

Fig. 26. Distribution CPUE of juvenile *Anarhichas orientalis* In Aniva Bay (6-10 July, 2005).

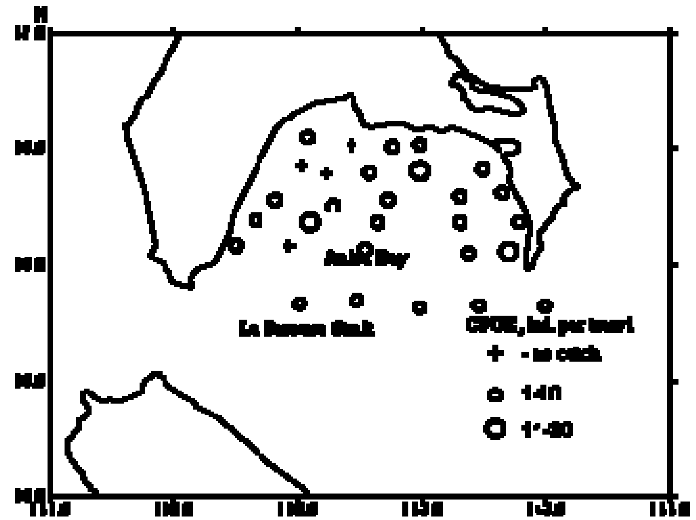

Fig. 28. Distribution CPUE of juvenile *Anarhichas orientalis* *i*n Aniva Bay (21-25 July, 2005).

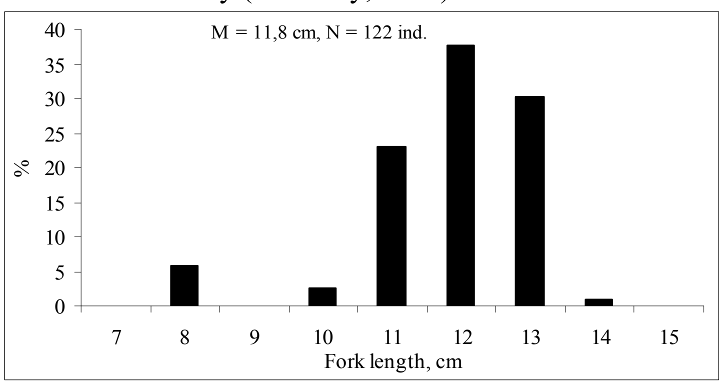

Fig. 27. Size composition of juvenile *Anarhichas orientalis* in Aniva Bay (6-10 July, 2005).

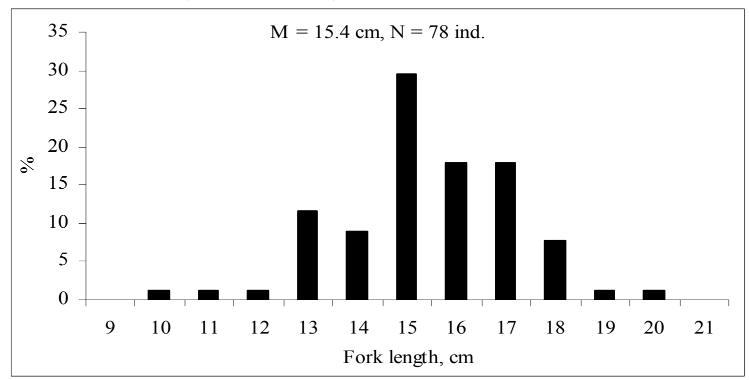

Fig. 29. Size composition of juvenile *Anarhichas orientalis* In Aniva Bay (21-25 July, 2005).

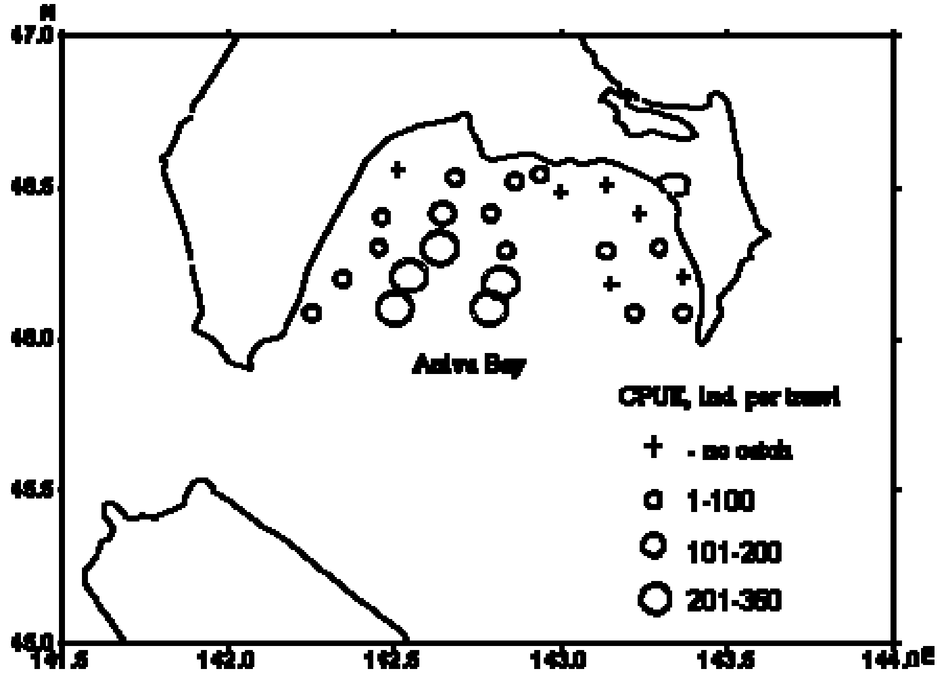

Fig. 30. Distribution CPUE of juvenile *Hemitripterus villosus*
in Aniva Bay (6-10 July, 2005).

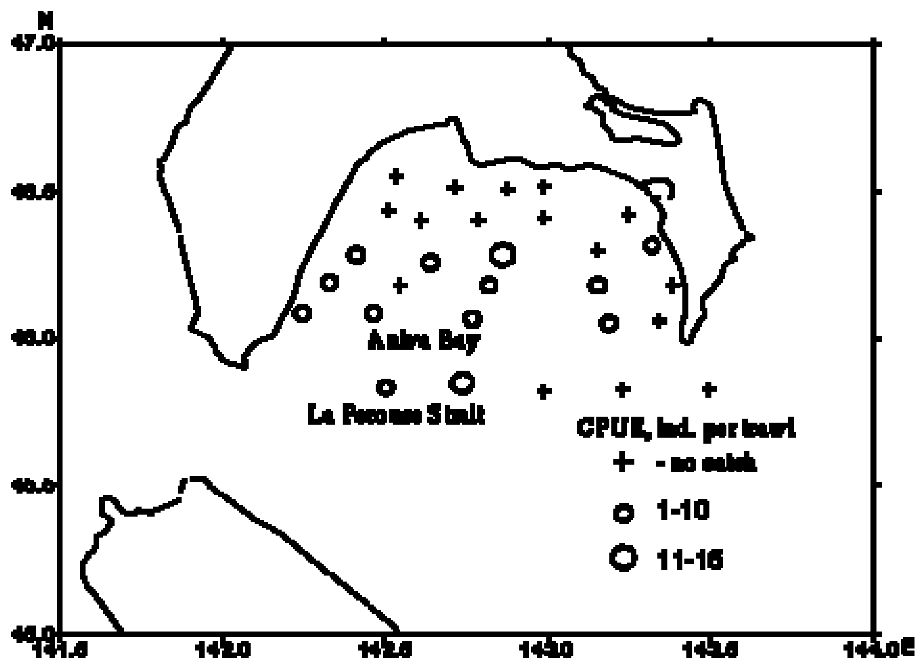

Fig. 31. Distribution CPUE of juvenile *Hemitripterus villosus*
in Aniva Bay (21-25 July, 2005).

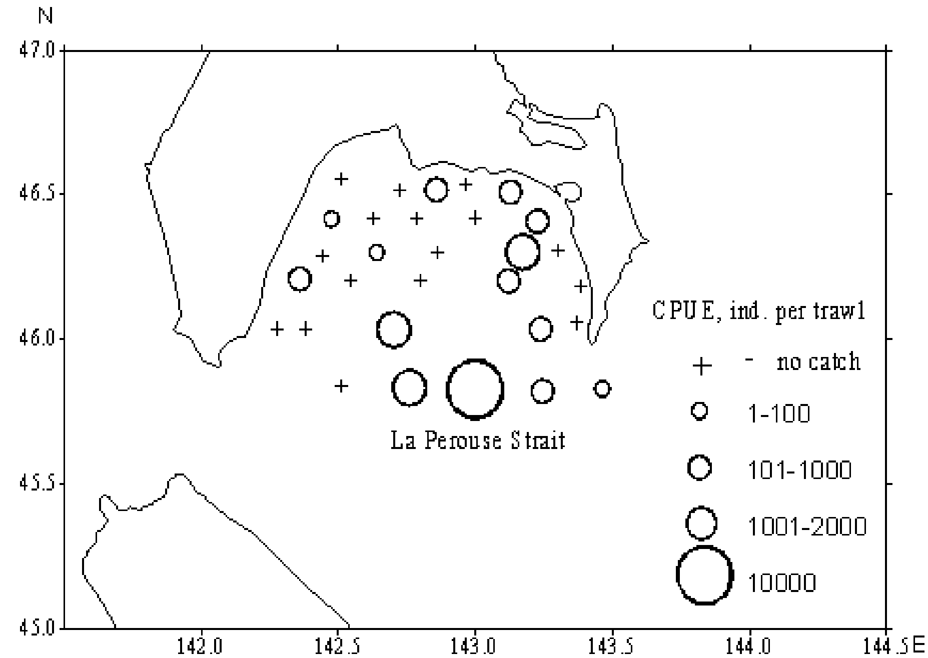

Fig. 32. Distribution CPUE of juvenile *Sebastes sp.* In Aniva Bay and La Perouse Strait (14-18 August, 2005).

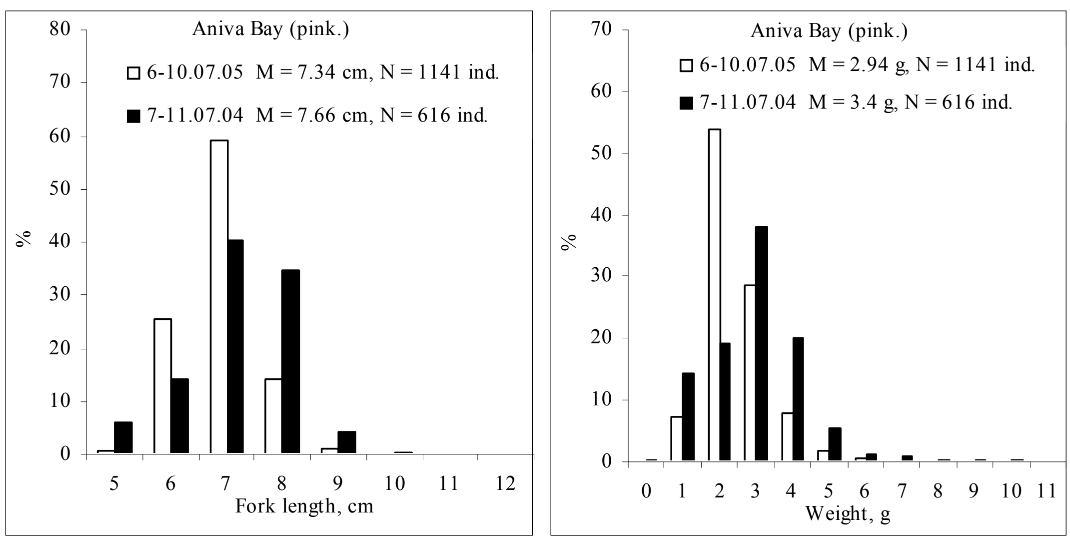

Fig. 33. Distribution CPUE of juvenile pink salmon size-weight indices in Aniva Bay from 6 through 10 July in 2004 and 2005.

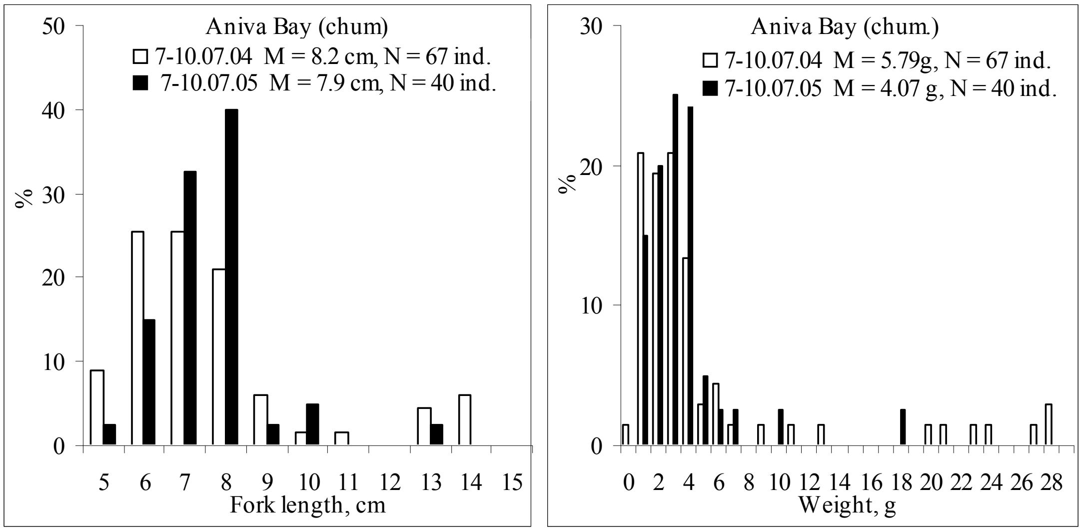

Fig. 34. Distribution CPUE of juvenile chum salmon size-weight indices in Aniva Bay from 6 through 10 July in 2004 and 2005.

Table 1 – A list of trawl stations performed in July – August 2005

Sampling date	Sampling area	Number of stations
1st phase of survey		
6-11.07	Aniva Bay	25
2nd phase of survey		
21,23-25.07	Aniva Bay	25
22.07	La Perouse Strait	5
3rd phase of survey		
11-13.08	Transect "Cape Svobodniy – Cape Terpeniya"	3
14.08	La Perouse Strait	5
15-18.08	Aniva Bay	25

Table 2 – Sea temperature anomalies by layers (in numerator) and σ (in denominator) at the transect Cape Aniva – Cape Anastasiya on 15 August, 2005.

Temperature anomalies(℃) for layers (m)								
0 – 20	0 – 30	0 – 50	0-100	0-200	20 – 100	30 – 100	50 – 100	100-200
-2,6 2,19	-2,64 2,47	-1,91 2,51	-1,06 2,05	–	-0,5 2,01	-0,05 1,78	-0,35 1,28	–

Table 3 - Sea salinity anomalies by layers (in numerator) and σ (in denominator) at the transect Cape Aniva – Cape Anastasiya on 15 August, 2005.

Salinity anomalies (‰)for layers (m)								
0 – 20	0 – 30	0 – 50	0-100	0-200	20 – 100	30 – 100	50 – 100	100-200
+0,35 0,37	+0,32 0,36	+0,28 0,33	+0,2 0,3	–	+0,21 0,28	+0,21 0,27	+0,19 0,25	–

Table 4 – A list of fish species and their frequency (%) by sampling areas in July – August 2005.

Fish species	Aniva Bay			Southeastern Sakhalin
	1st phase	2nd phase	3rd phase	
Petromyzontidae				
Lethenteron camtchaticus	4,0	3,3	-	-
Lamnidae				
Lamna ditropis	8,0	-	10,0	-
Clupeidae				
Clupea pallasii	20,0	6,7	-	-
Engraulidae				
Engraulis japonicus	8,0	3,3	-	-
Osmeridae				
Mallotus villosus catervarius	92,0	16,7	40,0	-
Salmonidae				
Oncorhynchus gorbuscha (juvenile)	56,0	13.3	-	-
O. gorbuscha (spawner)	+	+	+	+
O. keta (juvenile)	20,0	+	-	-
O. keta (spawner)	+	+	+	+
Stichaeidae				
Lumpenus sagitta	8,0	-	3,3	-
Gadidae				
Theragra chalcogramma	16,0	6,7	-	-
Eleginus gracilis	-	6,7	6,7	+
Gasterosteidae				
Gasterosteus aculeatus	-	-	6,7	-
Scorpaenidae				
Sebastes minor	8,0	23,3	3,3	+
Sebastes sp.(juvenile)	-	-	46,7	-
Ammodytidae				
Ammodytes hexapterus	-	10,0	20,0	+
Anarchichadidae				
Anarchichas orientalis	92,0	86,7	13,3	+
Ptilichthydae				
Ptilichthus goodei	-	-	6,7	-
Hexagrammidae				
Hexagrammos sp.	-	-	20,0	-
Pleurogrammus azonus	96,0	46,7	-	+
Cottidae				
Hemilepidotus gilberti	20,0	-	-	-
Gymnocanthus detrisus	4,0	-	-	-
G. intermedius	-	-	3,3	-
Triglops jordani	4,0		-	-
Hemitripteridae				
Hemitripterus villosus	76,0	46,7	10,0	-
Blepsias bilobus	-	-	6,7	+
Agonidae				
Podothecus gilberti	48,0	6,7	3,3	+
Cyclopteridae				
Eumicrotremus orbis	-	20,0	6,7	-

E.s pacificus	16,0	-	-	-
E. taranetzi	28,0	10,0	-	-
Pleuronectidae				
Limanda aspera	4,0	3,3	-	-
Limanda sakhalinensis	-	-	3,3	-
Reinhardtius hippoglossoides matsuurae	-	-	6,7	-
Numbers of trawl operations	25	30	30	3

+ - species was found from catches

– - species was not found from catches

Table 5 – Mean/maximum catches of some fish species (ind./trawling) in July – August 2005.

Fish species	Aniva Bay		
	1st phase	2nd phase	3rd phase
Clupea pallasii	0,3/3	0,1/1	-
Mallotus villosus catervarius	950/6976	359/10000	31/825
Theragra chalcogramma	0,2/1	0,1/1	-
Sebastes sp.	-	-	584/10000
Ammodytes hexapterus	-	0,2/3	2/30
Anarhichas orientalis	46/200	4,5/20	0,3/4
Pleurogrammus azonus	484/6572	97/1000	
Hemitripterus villosus	79/344	1,6/15	0,2/3

Table 6 - Mean/maximum catches of some fish species (kg/trawling) in July – August 2005.

Fish species	Aniva Bay		
	1st phase	2nd phase	3rd phase
Clupea pallasii	0,01/0,05	0,01/0,14	-
Mallotus villosus catervarius	4,1/28	3,2/90	0,2/5,6
Theragra chalcogramma	0,0004/0,003	0,002/0,05	-
Sebastes sp.	-	-	0,1/1,0
Ammodytes hexapterus	-	0,0003/0,01	0,001/0,01
Anarhichas orientalis	0,5/2,0	0,1/0,6	0,01/0,2
Pleurogrammus azonus	9,1/118	2,8/30	-
Hemitripterus villosus	0,2/0,9	0,004/0,04	0,001/0,01

Table 7 – Changes in fish abundance/ichthyomass (%) from catches in July – August 2005.

Fish species	Aniva Bay		
	1st phase	2nd phase	3rd phase
Mallotus villosus catervarius	54,9/37,1	74,3/45,3	5,0/7,4
Sebastes sp.	-	-	92,9/2,6
Anarhichas orientalis	2,7/2,8	0,9/1,5	0,1/0,4
Pleurogrammus azonus	28,0/56,2	20,1/39,3	-
Hemitripterus villosus	4,6/0,7	0,4/0,06	0,02/0,003
Oncorhynchus gorbuscha (spawner)	0,002/0,3	0,1/5,9	0,3/84,4
Oncorhynchus gorbuscha (juvenile)	8,4/1,9	1,1/ 0,4	-
Oncorhynchus keta (spawner)	0,002/0,7	0,01/0,1	-
Oncorhynchus keta (juvenile)	0,3/0,1	-	-
Other fish	1,1/0,2	3,1/7,5	1,7/5,2

Note: ichthyomass was calculated without taking into account salmon sharks

Table 8 – Size-weight indices of juvenile pink salmon in Aniva Bay (6.07-10.07.2005).

№	Date	Trawl (№)	Coordinates		Depth, m	FL, cm	W, g	Catch, ind.	Examined, ind.
1	07.07.05	8	46.24	142.37	52	6,43 5,0-9,0	2,12 1,06-6,02	19	19
2	07.07.05	9	46.23	142.27	48	6,95 6,2-7,8	2,45 1,71-3,61	30	30
3	08.07.05	11	46.07	142.31	36	7,05 5,8-9,1	2,58 1,2-5,27	2867	753
4	08.07.05	12	46.07	142.48	71	7,38 5,9-8,6	2,95 1,62-4,48	140	50
5	08.07.05	13	46.05	143.14	85	7,62 5,8-9,4	3,58 2,0-5,88	90	50
6	08.07.05	14	46.04	143.22	91	7,14 5,9-9,8	2,7 1,37-4,12	19	19
7	09.07.05	17	46.10	143.48	88	7.31 6,5-8,4	2,79 1,6-4,41	13	13
8	09.07.05	18	46.13	142.31	76	7,48 6,3-9,2	2,92 1,63-5,37	53	53
9	09.07.05	19	46.13	142.21	63	7,38 5,9-8,5	3,24 1,8-5,38	122	50
10	09.07.05	20	46.19	142.25	33	7,31 6,2-8,3	2,67 1,73-3,69	8	8
11	09.07.05	21	46.19	142.38	33	7,19 6,1-8,5	2,84 1,63-4,66	33	20
12	09.07.05	22	46.17	142.63	53	7,24 6,1-8,6	2,88 1,79-5,02	189	50
13	10.07.05	23	46.30	143.07	79	6,99 6,2-7,8	2,46 1,64-3,28	29	22
14	10.07.05	24	46.18	143.16	79	6,82 5,6-7,6	2,24 1,07-3,05	5	4
	Total:					7,34 5,1-9,7	2,94 1,15-6,56	3617	1141

Table 9 - Frequency (%) and abundance (ind.) of some fish species from catches in Aniva Bay in late June 2002 – 2003 and in the first half of July 2004 – 2005.

Species	2002	2003	2004	2005
Pleurogrammus azonus	83,3/1262	100/647	79,1/21666	96,0/12105
Mallotus villosus catervarius	100,0/9469	94,1/168110	70,8/104588	92,0/23752
Anarhichas orientalis	83,3/146	100/526	75,0/1519	86,7/1177
Hemitripterus villosus	83,7/94	100/3124	70,8/10082	76,0/1970
Clupea pallasii	33,3/2	76,5/11724	33,3/22151	20,0/7
Eumicrotremus orbis	-	47,0/140	12,5/418	16,0/13
Podothecus gilberti	-	-	0,000/3	48,0/310
Ammodytes hexapterus	-	-	21,7/390	-