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RESULTS OF 2003 SALMON RESEARCH CRUISE OF THE SRTMK "SOVREMENNIK "

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Abstract

The cruise of the SRTM-K “Sovremennik” equipped with drift nets during the period prior to anadromous migrations of Pacific salmons was conducted in June-August, 2003, to study distribution of stocks of Pacific salmons during marine period of life and to evaluation of biotic factors in their mortality in the North-West Pacific.

Studies were performed in three areas of the Russian EEZ: Northwestern Bering Sea (western Bering Sea 6101), Southwestern Bering Sea Karaginski Sub-zone 6102.1) and Kamchatka Pacific waters (Petropavlovsk-Komandor Sub-zone 6102.2).

The research included daily temperature control of 200-meter upper layer, daily collection of all salmon species caught by drift gillnets of 55 mm mesh size, biological analyses of all trapped salmon species, evaluation of stomach content, assessment of salmon specimens injured by predator fishes and mammals and samples of tissues of sockeye and chinook salmon for molecular-genetic analysis. In total 64 stations of gillnets were set (Fig.1), 3304 biological analyses were performed, including 782 pink, 1098 chum, 1077 sockeye, 261 chinook and 86 coho salmon.

Introduction

For 10 years VNIRO has been conducting annual surveys to evaluate distribution and biological conditions of salmons during pre-spawning migrations in the northwestern part of the Bering Sea and adjacent waters of the Pacific Ocean. During these years we could establish a number of regularities concerning the peculiarities of interactions between different salmon stocks and species in the years characterized by different climatic and hydrological conditions, define the causes and mechanisms of self-regulation processes in the chum populations. In 2003, our essential tasks of the research included study of regularities in the distribution and interaction of local salmon populations in the feeding areas and migrations caused by the dynamics of their number, abiotic and biotic factors.

Materials and methods

Salmon were caught by gillnets with mesh of 65 and 55 mm. Nets were set during the night time and retrieved 9 to 12 hours later. The location of gillnets was determined by means of a satellite radio navigation device.

The reserach included daily temperature conditions control of 0-200 meter upper layer using AST-500. Soundings were conducted every 2 meters prior to the setting and retrieving of gillnets.

All caught salmon species were systematized qualitatively and quantitatively. Salmons were sampled daily from control drift nets (55 mm mesh) for biological analysis. Sockey, chum, and pink salmons were analyzed only from catches taken by control drift nets, while chinook and coho were analyzed totally (55 and 65 mm mesh).

In addition to standard biological analyses samples were taken for molecular-genetic studies (liver and gonads of sockey and chinook). During the whole period of cruise all analyzed salmonid fishes were subjected to examination of bites caused by predatory fishes and mammals. The injuries were fixed in the register of biological analyses with special reference to their nature and location on the fish body. Measuring board and electronic scales up to 20 kg were used for measurements. For gonads weighing pharmaceutical scales were used.

Results and discussions

Hydrometeorological conditions in June-August 2003 in the areas under survey

As in previous years, the hydrological conditions in the areas under study were mostly determined by synoptic situation. High temperature values of surface water layer in June in the Petropavlovsk-Komandor Sub-zone were shown to depend primarily on intensive solar warming as the development pattern of meteorological processes above the North Pacific waters greately affects the formation of the field of sea surface temperature (SST). Cyclones did not occur in the areas under study in June and early July. In the majority of cases the weather was sunny, therefore the year might be considered as a “warm” one. SST was higher than in 2001-2002 during the same period (Table 1).

As a whole, the development pattern of hydrological conditions in the beginning of the summer of 2003 was shown to be close to that in 1994, 1995 and 2000. Subsequently, in July a higher temperature was observed compared with that in 2000 and 2001 and close to the water temperature recorded in such “warm” years as 1995 and 1996. Thus, in the first ten-day period of July 2003 the temperature in the Pacific waters off Kamchatka averaged 9.0 °C, in 1995 and 1996 it was 8.88 and 9.68 °C, respectively, and in other years it varied in range 5.82 - 8.14° C.

From June 27 through July 20, in the Karaginski Sub-zone surface water temperature rose from 7.75 to 13.8 °C. By the end of July in some days it was reaching 16°C (according to an observer working on board the “Blagovest”) which is considerably higher than average long-term values for this area.

In the Western Bering Sea Zone the SST was very high ranging from 11.35 to 12.17°C during the period from July 23 through August 23. It should be stressed that high values of water temperature were observed not only in the surface layer but also in a considerable depth, especially in the north-east of the zone (60-61°N 178°E). Thus, if in the area (59°16’ –

59°48’ N and 170° – 172°E) the thermocline was found at a depth of 20 m, in the north-east of the zone (60°06’04’’N and 177°26’ – 178°33’E) the temperature at a depth of 20 m was practically the same as on the surface, while the discontinuity layer was observed at a depth of 30 m. It seems likely that in the current year there was a significant advection of Pacific waters to the Bering Sea which caused such a high temperature in the upper 30 m layer. At the same time the synoptic situation was typical for that area: low cloudiness, scarce sunny days and high cyclone activity. In the course of August there occurred three strong cyclones. Nevertheless, even after the cyclones water temperature remained high and by the end of August it decreased by less than 1°C in comparison with the third ten-day period of July (Table 2).

Marine catches of salmons

In the Petropavlovsk-Komandor Sub-zone the studies were carried out during the period from June 10 to July 8. A 24-hour biological station was performed in June 18 with setting of 10 control nets 6 times during 24 hours.

Among caught fish there were sockeye, chum, pink and chinook salmons.

In the by-catch isolated individuals of lancetfish, daggertooth, prowfish, Atka mackerel and salmon sharks were recorded.

It should be stressed that pink salmons were caught from the very beginning of survey. It seems possible that they had appeared in the Pacific waters off Kamchatka prior to our studies as even the second ten-day period of June the pink salmon catches per net varied from 2.3 to 4.2 ind./net. The biggest catches of pink salmon in the Petropavlovsk-Komandor Sub-zone were taken in late June. Thus, in June 29 the catch of pink salmon per net amounted to 11.3 ind./net. Some time later the pink aggregations in the area decreased and by the end of the first ten-day period its catch per net varied from 1.3 to 3.4 ind./net. Such a situation is typical for warm years. In the “cold” 2001, first isolated pink salmons in the Petropavlovsk-Komandor Sub-zone were registered in June 15. The biggest catches were taken in the first ten-day period of July.

Characterizing the species composition of salmon catches in the Petropavlovsk-Komandor Sub-zone in June-early July 2003, it should be emphasized that sockeye salmons dominated in the catches over the course of almost the whole period of observations. The exception is provided by the last five-day period of June when a mass pink run was observed which was reflected on the species ratio in catches of control nets (Fig.2).

The share of sockeye in the catches of control nets varied during the month within 33 – 74%, chum – 12 – 36%, pink – 20 – 50%. As the catches of pink per effort increased, the catches of chum considerably decreased. Such a situation was also observed in other years in various areas. During the mass run of pink, chum being the less active species, is shown to be pushed to the peripheral edges of salmon aggregations and its catches are noticeably reduced. At the same time the catches of sockeye per effort during the period of observations changed but very little, averaging 4.92 – 6.65 ind./net for a five- day period.

In the Karaginski Sub-zone of the Bering Sea studies were carried out from June 27 through July 20. In catches there were always sockeye, chum and pink salmons. Chinook were limited in number. Atka mackerel, charr, Arctic lamprey and salmon sharks were met in the by-catch. In the Karaginski Sub-zone pink salmon were shown to predominate in the catches during almost the whole period of observations (Fig.3).

But by the end of the third ten-day period of July when the mass run of pink salmon to the spawning areas was over the catches of pink declined while those of chum salmon increased.

Thus, the CPUE of pink salmon varied depending on the fishing terms and sites within 1.73 – 17.9 ind./net, sockeye – 0.2 – 3.3 ind./net, chum – 1.2 – 8.7 ind./net. The biggest catches of pink salmon were recorded in 58°00' N 165°00' E in July 1 –5. The percentage of pink salmon in catches varied within 38.4 – 79.9, chum - 11.6 – 44.6% and sockeye – 5.6 – 18.6%.

In the Western Bering Sea - zone studies were carried out from July 23 through August 23.

In catches there were recorded five species of Pacific salmons – sockeye, chum, pink, coho and chinook. During the whole period of observations chum salmon were shown to predominate in catches. Sockeye were considerably less numerous. Unlike other areas, in this one chinook were relatively numerous averaging 4.2% of the total catch weight (Fig.4). Pink salmon were very rare in July and in August they did not occur in catches of control nets. Coho salmon were recorded during the whole period of observations incidentally.

As it is shown in Fig.4, catches of chum and sockeye in August were higher than in July. According to our data of 1995 and 1996 (Klovach et al. 1996), in late August and September the aggregations of salmonids in the northern Bering Sea grow even more, as this area is the main feeding area for immature salmonids in late summer and autumn.

Biological characteristics of Pacific salmons

SOCKEYE SALMON

Dynamics of biological data are given in Table 3. As it is shown, the average length of sockeye salmons in the Petropavlovsk-Komandor Sub-zone in June-July varied from 53.3 to 60 cm and average weight from 2.22 to 3.45 kg.

In July, the values of these characteristics were lower due to the presence of greater numbers of immature fish in catches compared with the situation in June. Thus, in June the percentage of harvested immature females did not exceed 4%, while in the first ten-day period of July they constituted as much as 19%. In accordance with it the GSI average value also decreased. So, in June the average GSI of sockeye females varied within a limited range – 4.49 to 5.76, in the first ten-day period of July the average value of this factor was only 3.99. The percentage of immature males was high from the very beginning of survey and practically did not change by five-day periods varying within insignificant limits – 30 – 40%. That is why the average GSI value neither practically changed (0.92 – 1.14).

In the cycle year of 2001 the immature males were present in catches from the very beginning of survey, i.e. from mid-May, but until the end of the second ten-day period of June their percentage did not exceed 8%. In June 21 – 25 the percentage of immature males of sockeye increased up to 15% on average. In late June – first ten-day period of July immature males constituted 5 to 10% of the total number of all revised males of sockeye.

Such a high share of immature males of sockeye in June 2003 compared with 2001 is likely to be due to climatic conditions of the current year. In relation to high water temperature the maturation of mature fish occurred faster than in 2001, they migrated earlier to spawning grounds and immature individuals migrated to their sites in the area under study.

In the Karaginski Sub-zone of the Bering Sea during July 01 – 20 the length of sockeye harvested by control nets ranged from 44 to 70 cm, averaging 53.9 cm. The weight of sockeye varied from 270 g to 4.5 kg, averaging 2.37 in females and 2.16 kg in males (Table 3). Immature sockeye individuals were harvested from the outset of observations and their percentage constituted 43 – 67% in males and 6 – 26% in females. In this case a trend towards some increment in the share of immature fish from early to late July was observed. Such a high share of immature sockeye in the Karaginski Sub-zone of the Bering Sea in July (the same as in the Pacific waters off Kamchatka) was determined by the early warming of water surface in the current year which was accelerated by a relatively early migration of maturing individuals to the spawning grounds and, correspondingly, by an early arrival of immature fishes to the feeding areas. According to our data, in the "cold" year of 2001, immature females and males had appeared in catches in the Karaginski Sub-zone only by July 20.

In the Western Bering Sea area during July 23 – August 23 the size of sockeye varied within 33 – 69 cm, constituting 48.2 cm on the average, weight ranged from 410 g to 5.15 kg, forming 1.61 kg on the average (Table 3). In the majority of cases the fishes were immature. The share of immature females in catches constituted 91% and males – 95%. It should be stressed that the proportion of immature fish increased in the course of time and from west to east. Thus, in July 21 – 31 in the West Bering zone within 58°18' – 60°09'N and 170°24' – 172°41'E the immature males and females of sockeye formed 87 and 84%, respectively. By the end of August in the northeastern part of the area (61°N 178°E) practically all the males were represented by immature individuals, while among the females the share of immature fish varied from 85 to 100%.

CHUM SALMON

Dynamics of biological characteristics of chum is given in Table 4.

The average size of females and males of chum in the Petropavlovsk-Komandor Subzone varied within 57.0 – 60.8 cm during June 10 – July 08. Males were slightly bigger than females. In this case both in males and in females a trend towards decreasing average characteristics was observed throughout the month. The same tendency was noted in the weight of chum (Table 4). In contrast to this, GSI of males and females increased during July and the first ten-day period of July from 1.2 to 3.89 in males and from 5.53 to 9.85 in females. Such a unidirectional change testifies that during one month of survey through the area under study one migrating chum stock was harvested. The portion of immature females was insignificant in the initial stage of observations. By early July they disappeared from catches. Proportion of immature males in catches during June 10 – 15 amounted to an average of 7.1%. In the following five-day period it reached 31%. Later on the share of immature males steadily decreased and in the first five-day period it formed only 9%.

In the Karaginski area of the Bering Sea during June 26 through July 20, the size of chum ranged within 45 – 76 cm, amounting to an average of 58.2 cm. Weight changed from 1.18 to 5.68 kg, being 2.73 kg on the average. GSI in males and females increased from late June to the end of the second ten-day period of July from 0.95 to 2.04 in males and from 2.47 to 4.91 in females. Such a unidirectional change in the GSI values shows that during one month of survey through the area under study one migrating chum population was fished for. The same fact is confirmed by a steady decrease in the portion of immature males in catches from 70% in late June to 16% in the second ten-day period of July.

In the Western Bering Sea zone during July 23 – August 23 the size of chum ranged within 34 - 76 cm, amounting during this period to an average of 59.4 cm. Weight varied from

430 g to 6.4 kg, being on the average at 3.08 kg. The size and weight of chum were maximum during July 21 – 25 and during August 16 – 22. In August 1 – 15 the values of these indices were lower compared with those in previous and following periods due to a higher portion of smaller immature harvested fish. It seems likely that at the beginning of our survey when the studies were conducted in the southwestern part of the Western Bering Sea zone were harvested chum salmon migrating to the Olyutorskiy area rivers in Kamchatka. In this case we might observe the final stage of pre-spawning migration of chum salmon. It is proved by ratio between females and males (55:45%), high GSI values of maturing females (2.48 – 10.61, in average 4.74), a great number of individuals with spawning changes and a considerable percent of immature males (40%) (Table 4), which were first to migrate to the feeding areas as the mature part of the aggregation was leaving the site. During July 26 – August 15 in the northeastern part of the Western Bering Sea zone (60°18' – 60°04' N 177°42' – 179°33' E), composition of the harvested chum aggregation was slightly different. The portion of immature fish became less. In this case the GSI average value was lower, while the percent of males became slightly higher compared with those in the southwestern part of the Western Bering Sea zone. At the end of the period of observations, i.e. in August 16 – 22, the situation again changed. The harvested fishes were significantly bigger compared with August 1 – 15. Mean size of males and females was in August 16 - 22 was 62.8 and 63.2 cm, and weight 3.60 and 3.71 kg, respectively. The GSI value of females also increased compared with previous period due to a sharp fall in the percentage of immature fish (Fig.5).

Thus, based on the dynamics of biological characteristics during a month we could observe three migrating aggregations of chum salmon passed through the area of survey.

The first one migrated, most probably, to the rivers of the Northeast Kamchatka, while the others to water bodies of Chukotka. Part of individuals with gonads of II, II-III and III stages was likely to be represented by various stocks of chum salmon feeding in late summer and autumn in the Bering Sea.

PINK SALMON

Dynamics of biological characteristics of pink salmon is given in Table 5.

Pink salmon are likely to appear in the Pacific waters off Kamchatka in the first ten-day period of June. At least, since the beginning of our observations, i.e. June 10, pink salmon were rather numerous in our control nets. As indicated above, the average CPUE of pink salmon during June 10 – 15 comprised 2.51. At that time males formed up to 93% of pink salmon catches. During the following five-day period, i.e. in June 16 – 20, the percentage of males decreased to 83% and by late June it constituted 53%. At the same time their maximum

CPUE was recorded. Mean values of pink size and weight during the whole period of observations in the Pacific waters off Kamchatka changed only slightly: mean size of males and females varied by five-day periods within 44.7 – 46.9 and 44.3 – 45.5 cm, respectively. By weight males were also slightly bigger than females. Mean weight of males and females by five-day periods varied within 1.28 – 1.42 and 1.18 – 1.31 kg, respectively. GSI of females and males of pink salmon increased during the period of observations (Fig.6). At the same time the portion of males in catches decreased testifying that in catches there were pink salmon of one migrating stock which spawns in the northeast of Kamchatka.

In the Karaginski Sub-zone during June 26 – July 20, size of pink salmon males and varied within 40 – 56 and 39 – 52 cm, respectively. Their weight ranged within 0.84 – 2.05 and 0.86 – 1.94 kg. Mean values of size and weight changed very little. Only during last five-day period, i.e. July 16 – 20, mean values of pink size and weight were slightly higher than during the previous period. GSI of pink males varied within 2.05 – 13.79, and 8.08 as an average. That of females varied within 4.10 – 15.62, and 11.29 as an average. The portion of males in catches ranged from 100 to 46%. It was the highest in sited off the coast and the lowest as moving from east to west.

COHO SALMON

Coho salmon were harvested scarcely in the Petropavlovsk- Komandor and Karaginski Sub-zone beginning with last five-day period of June. In the West-Karaginski Sub-zone they were taken steadily. Data on their biological characteristics and catches in the West Karaginski Sub-zone are given in Table 6.

Size of coho males during the period of studied varied within 53 –71 cm (62.3 cm as an average), that of females ranged from 53 to 70 cm (61.3 cm as an average). The mean size of coho males and females were varied by five-day periods within 60.7 – 64.5 and 60 – 62.5 cm, respectively. The weight of males and females changed from 2.24 to 5.22 kg and from 2.18 to 5.32 kg, respectively, amounting 3.61 kg in males and 3.70 kg in females. All the individuals were mature with gonads at III-IV and IV stages. GSI of males varied within 1.45 – 11.28 (7.00 as an average). That of females changed from 4.82 to 19.29 (10.58 as an average). The mean GSI value in males and females increased during the period of observations: in males from 5.82 during July 26 – 31 to 7.64 during August 21 – 22, that in females from 9.09 during July 26 – 31 to 13.3 during August 21 – 22.

As a rule, sex ratio of coho salmon in catches was in favor of females, which is testimony to the end of pre-spawning feeding. It was also proved by a high degree of gonad maturity.

CHINOOK SALMON

In the Petropavlovsk-Komandor Sub-area in June chinook salmon were represented in catches by large fishes and mainly by males (77%). The size of chinook males in May varied within a broad range: from 49 to 89 cm. The mean size was 63.9 cm. Females were bigger than males. Their size was within 66 – 100 cm, with an average of 85.9 cm (Table 7). The weight of chinook males changed from 1.93 to 8.96 kg and that of females was from 3.76 to 14.6 kg. The average weight of males and females constituted 4.09 and 9.91, respectively. All males were represented by maturing individuals migrating for spawning with gonads at III and III-IV maturity stages. Among females there was only one immature specimen with gonads at II maturity stage. Other females had gonads at III-IV maturity stage.

In the Western Bering Sea Zone chinook salmon were relatively numerous and as it was mentioned above, constituted on average about 4% by weight of the total catch. Chinook salmon were represented only by fattening immature fishes. Only two males were maturing with gonads at IV maturity stage. The size of chinook males varied from 39 to 75 cm (57.4 cm as an average), that of females varied within 34 – 80 cm (59.3 cm as an average). Size of all fishes decreased from late July to late August and from south-west to north-east. At the same time the number and proportion of chinook salmon in catches (number of individuals) in the north-east of the Western Bering Sea Zone was significantly higher than in the south-west.

GSI of immature females and males varied within 0.16 – 1.24 and 0.02 – 0.25, respectively. GSI of two maturing chinook males with gonads at IV maturity stage was 5.76 and 11.66.

Feeding of salmons

Feeding conditions for salmons were favourable in the spring and summer of 2003.

It is proved by high values of the Clark's condition factor. Thus, average values of condition factors constituted 1.24 (0.69 – 1.72) in sockeye, 1.17 (0.61 – 1.83) in chum, 1.21 (0.65 – 1.80) in pink, 1.32 (1.04 – 1.53) in coho and 1.29 (0.75 – 1.56) in chinook salmon.

At the same time it should be emphasized that stomach content index of salmons was low from the outset of our observations. Data on the stomach content of salmons given in Tables 8 –11 shown that in all areas all the salmon species the proportion of fishes with empty stomachs was high, while that of fishes with stomach content index over 2 points, by contrast, was low. Presumably high water temperature that occurred even in June and increased further on resulted in accelerated food digestion rates and weak stomach fullness.

In the cyclic year of 2001, surface water temperature was lower than in corresponding periods of 2003 (Table 1), stomach content index of salmons was considerably higher at the beginning of the season of our studies and only as water temperature increased and correspondingly food digestion rate accelerated, the average stomach content index decreased due to an increased number of fishes with empty stomachs.

Data on the stomach content of salmons obtained in the course of conducting a 24-hour station their comparison with those of similar station carried out in 2001 can serve as an indirect evidence on high food digestion rates in 2003.

The 24-hour station was carried out in 2003 in the Petropavlovsk-Komandor Sub-zone in June 18 in an area within 54°05’ – 54°06’N and 162°46’ – 162°53’E. Every array was retained in water for about 3 hours, surface water temperature was 5.3°C (Table 12).

In 2001 the 24-hour station was fulfilled in June 28-29 in the Petropavlovsk-Komandor Sub-zone in an area within 51°04’ – 51°55’ N and 161°39’ – 161°53’ E. Surface water temperature was 4.2°C (Table 13).

As shown in Tables 12 and 13, during all the daily periods the stomach content of salmons in 2003 was lower than in 2001. At the same time daily feeding dynamic as a whole in both years of observations were similar. In all salmons during 24 hours two feeding peaks were revealed: in the morning (in pink salmon in 2001 – in the afternoon) and in the evening. In other hours the average stomach content index in all salmons was lower.

Food composition was dissimilar in different salmon species being changed with space and time (Figs. 7 – 9).

Thus, in the second ten-day period of June in the Petropavlovsk-Komandor Sub-zone pink, sockeye and chum salmon fed on fish (mainly on Myctophidae and juvenile Atka mackerel), euphausiids and to a less degree on hyperiids. At the same time the relationship between these components in the food bolus of various species was somewhat different. In pink salmon the main food items consisted of fish (about 70% by volume), in sockeye – euphausiids (about 60% by volume), in chum – fish, euphausiids and hyperiids. It should be emphasized that in chum salmon the portion of fish with digested food in stomach was the highest compared with other species. It seems to be related with their feeding on coelenterates which are not present in food composition of other salmon species. The portion of fishes with completely digested food in stomachs of all species increased as water temperature increased.

In the third ten-day period of June food composition of salmon changed, increased the role of euphausiids and decreased the share of fish.

In the first ten-day period of July in the composition of food of pink and chum salmon increased the amount of hyperiids, while the amount of euphausiids decreased. Fish was of considerable importance only in the food of pink salmon (Fig. 7).

In the Karaginski Sub-zone in late June 90% of food in pink salmon belonged to fish and Euphausiids, while chum fed mainly on euphausiids. The share of fish with completely digested food in chum constituted about 60% and in pink less than 10% (Fig. 8).

In the first ten-day period of July the food qualitative composition of three salmon species was similar. All of them consumed fish consisted by almost 100% of Myctophidae, Euphausiidae and Hyperiidae. In the food of pink salmon Euphausiidae were shown to dominate, in Sockeye the proportion of Euphausiidae and fish was practically equal, while in chum salmon most important of these three food components were Hyperiidae. In the second ten-day period of July the importance of Hyperiidae in feeding of sockeye and pink salmon increased. In all species the share of fish with completely digested food became considerably higher compared with previous periods which resulted from a faster food digestion at high water temperatures (Fig. 8).

In the Western Bering Sea Zone in the last ten-day period of July main food items in sockeye salmon belonged to crustaceans – Euphausiidae and Hyperiidae. In sockeye salmon the share of Euphausiidae and Hyperidae was practically equal (about 40% by volume), in the stomachs of chum salmon the share of Euphausiidae was insignificant (less than 10%), Hyperiidae formed about 40% of the total volume of food bolus. As in other areas the share of completely digested food in the stomachs of chum salmon was considerably higher than in sockeye salmon (Fig. 9).

In August the importance of Euphausiidae in sockeye feeding increased and that of Hyperiidae decreased. The importance of fish food increased mainly due to Myctophidae both in chum and sockeye salmon (Fig. 9).

Feeding of chinook salmon in the Petropavlovsk-Komandor Sub-zone and Western Bering Sea Zone consisted almost by 100% of squids. Sometimes euphausiids, myctophids and capelin occurred in the stomachs of chinook salmon. It should be stressed that the stomachs of chinook salmon were found to be empty more often that those of other species of salmonids. It could result both from fast digestibility of squids and the fact that chinook salmon spend a major part of day at greater depths compared with other salmon species, feed in these layers and rise to the surface with already empty stomachs.

Coho salmon in the Western Bering Sea Zone practically fed on only fish, mainly on myctophids, and also on herring in the southwestern part of the Zone. The role of Crustacea and other food components was insignificant.

Impact of predator fishes and mammals upon survival rates of salmon during their marine pre-spawning feeding

Data on the number of injured fish and their percentage of the total analyzed specimens are given in Table 14.

As it is shown in Table14 in various areas salmon were injured by different predators. In the Petropavlovsk-Komandor Sub-zone in June, early July the predators were represented mainly by daggertooth and more seldom by marine mammals (fur seals). In the Karaginski Sub-zone the main predator animals were marine mammals and in the Western Bering Sea zone – lamprey. It should be emphasized that the localization and character of injuries in salmons were differentiated.

The great majority of injuries caused by daggertooth and marine mammals were located beyond the abdominal fin, a little bit over it, between the abdominal and anal fins and over the anal fin. Considerably less injuries were located between the abdominal and pectoral fins (closer to the abdominal one). Injuries in the area of pectoral fins or between the abdominal and pectoral ones (closer to the pectoral ones) occurred rather seldom.

Taking into account that the bites of attacking predator of any part of the prey body are equally probable one can assume that the fishes injured in the body cavity (injury localized between pectoral and abdominal fins, behind the pectoral one, below the pectoral one, etc) really die as at such injuries the damage of internal organs is inevitable. On the contrary, in the majority of analyzed salmons the injuries were located out of the body cavity and part of them could survive if both caught by nets. Actually in the coastal waters there occur salmons with injuries (or scars) located, as a rule, on the caudal peduncle and in the area between anal and abdominal fins. According to our data, such salmons were caught in the northern Kuril and the southeastern Sakhalin rivers but their portion was not high (1 to 5%). Nevertheless, most of salmons injured by daggertooth and marine mammals die directly because of injuries or a higher accessibility of injured fish to parasites. It counts in favor of this statement that fishes with healed injuries (or scars) were met rather seldom. In particular, only in one specimen of sockeye salmon there was a scar of marine mammal's bite over the abdominal fin.

Thus, the number of fishes injured by daggertooth in fact is to be at least doubled taking into consideration the amount of individuals died because of being injured in the body cavity. As part of individuals injured by daggertooth in the body located behind the abdominal fin also dies, the mortality rates of salmons caused by these predators may be approximately evaluated at least 1.5 times more than of fish with visible injuries. In this case in the year of spawning migration it amounts to: 5.1% for pink, 5.1% for chum and 3.5% for sockeye salmon. It was impossible to evaluate the percentage of coho and chinook salmon died because of being injured by daggertooth as these species samples were rather few and poor.

The number of died fish resulted from marine mammals in the high sea is apparently considerably more as compared with being injured by daggertooth as apart from the individuals with injuries on the body there occurred in catches approximately the same number of beheaded fishes (the head bitten by a marine mammal). The salmon death resulted from being injured by marine mammals in high sea is likely to be assessed as much as 2.5 time compared with the number of fishes with injures located in the area between abdominal and caudal fin (dead are: 100% of beheaded fishes, 100% of fishes injured in the body cavity within abdominal fin and head and 50% of specimens injured in the area between abdominal and caudal fins). Taking into account this assumption, the share of died sockeye individuals constitutes about 5%, pink – about 3.8%, chum – 7.5% of the total number of migrating fish.

To our mind, the mortality rates of salmons injured by lamprey are much lower. As shown in Table 9, the percentage of fish with lamprey bates constitutes: in sockeye – 3.7%, chum – 5.2%, coho – 1.2% and chinook – 0.9%. The majority of fish bitten by lamprey apparently will survive. It is supported by the fact that there are great numbers of fish with healed lamprey bites. At the same time in all these cases there were no more than two healed lamprey bites on the body. The fishes with numerous bites (three and more) were inert and even if they were alive after being brought to the deck they seemed to be very weak. Apparently, in case of numerous bites the salmons by all means die.

Among all salmon fishes bit by lamprey those with numerous injuries constituted 18% in sockeye and chum salmons. According to our assumption, the mortality rates of salmon species because of lamprey bites were 0.7 and 0.9%, respectively.

Thus, in accordance with an approximate assessment the total salmon mortality in an year of spawning migration resulted from daggertooth, fur seals and lamprey injuries amounts to about 10%. The highest mortality rates were caused by these animals is recorded in the Petropavlovsk-Komandor and Karaginski Sub-zones. In the Western Bering Sea Zone (especially in its northeastern part where a major part of observations was performed in 2003) salmons are mainly injured by lamprey, their mortality was less than 1%.

The total mortality rates of salmon caused by predators in a year of spawning migration can be approximately compared with a value of their runs. About one-half this number refers to sea migration period. The main predator injuring the salmon during their pre-spawning migrations to the sea shown to be salmon sharks devouring 12.6 to 25% of migrating salmon (Nagasawa, 1998). In addition to salmon sharks there are other predators in the sea and coastal waters, such as lancetfish, daggertooth and marine mammals (fur seals, dolphins, seals, white whales) (Shuntov, 1994, Melnikov, 1998; Savinykh, Glebov, 2003; Nagasawa, 1998).

Conclusion

Hydrological conditions in 2003 were responsible for a number of peculiarities in the distribution pattern of salmon. Due to an early warming and high surface water temperatures in the second ten-day period of June in comparison with previous years the aggregations of salmon in the Petropavlovsk-Komandor Sun-zone were significant. From the outset of our survey the pink salmon were rather abundant and by the end of June a peak of pink catches per net was observed what is characteristic for "warm" years. During almost the whole period of observations in the Petropavlovsk-Komandor Sub-zone (June 10 – July 8), except the last five-day period of June, sockeye salmon represented by individuals of one migrating grouping (East Kamchatka sockeye stock) predominated in catches.

In the Karaginski Sub-zone during the whole period of observations – from late June to July 20 – pink salmon spawning in the Northeast Kamchatka rivers were shown to predominate in catches. By the end of the second ten-day period of July when the pre-spawning migration of pink had been over, chum salmon started to predominate.

The basis of catches taken in the Western Bering Sea Zone from July 23 to August 22 was formed by the chum.

Feeding conditions for Pacific salmon during the period prior to anadromous migrations in 2003 were favorable. It is proved by high values of condition factor in all salmon species in all the areas under study.

All the investigations on the assessment of natural mortality rates in salmon during their feeding and pre-spawning periods made it possible to estimate approximately their mortality resulted from daggertooth, marine mammals (mainly fur seals) and lamprey as being about 10%.

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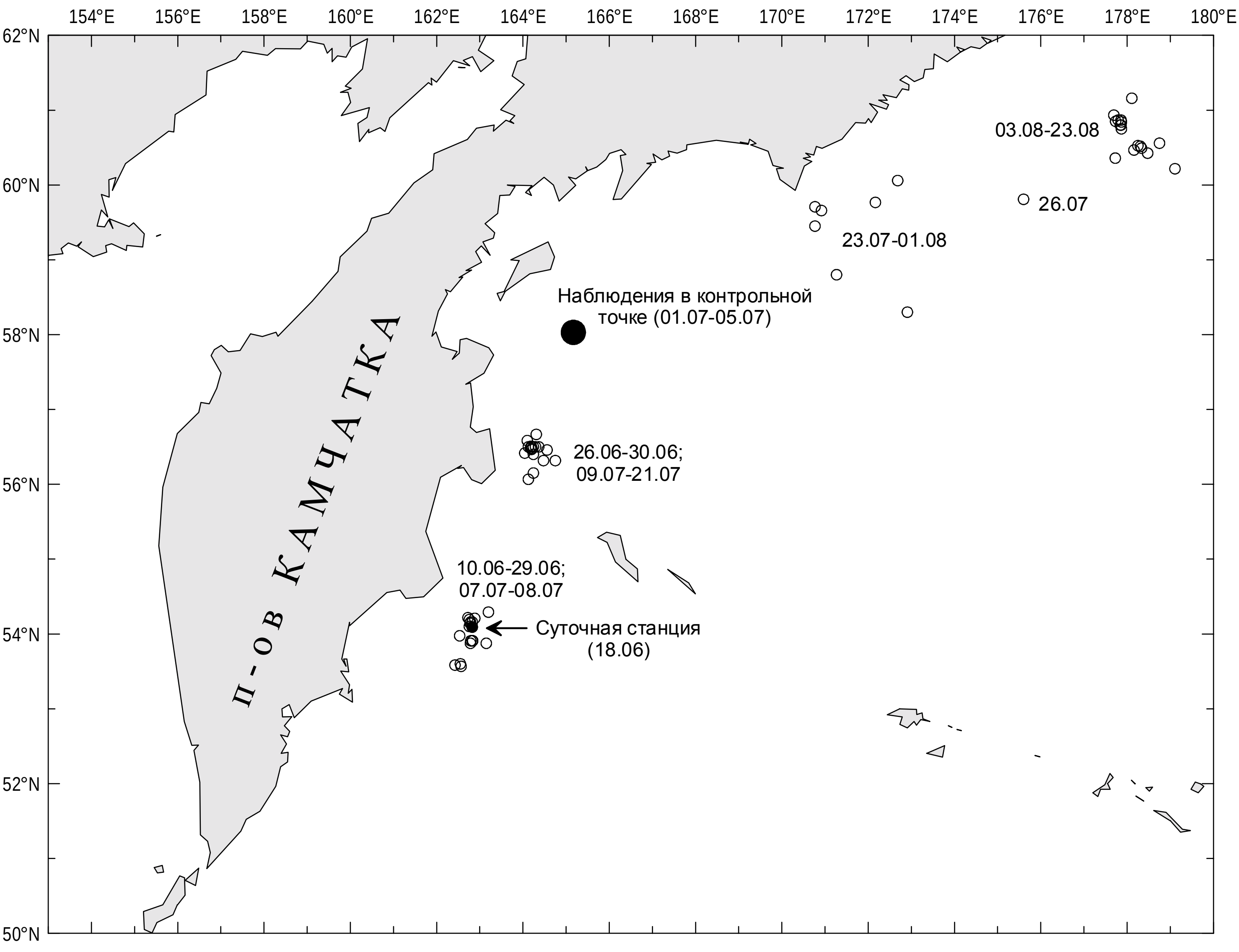


Fig. 1. Map of area surveyed in 2003.

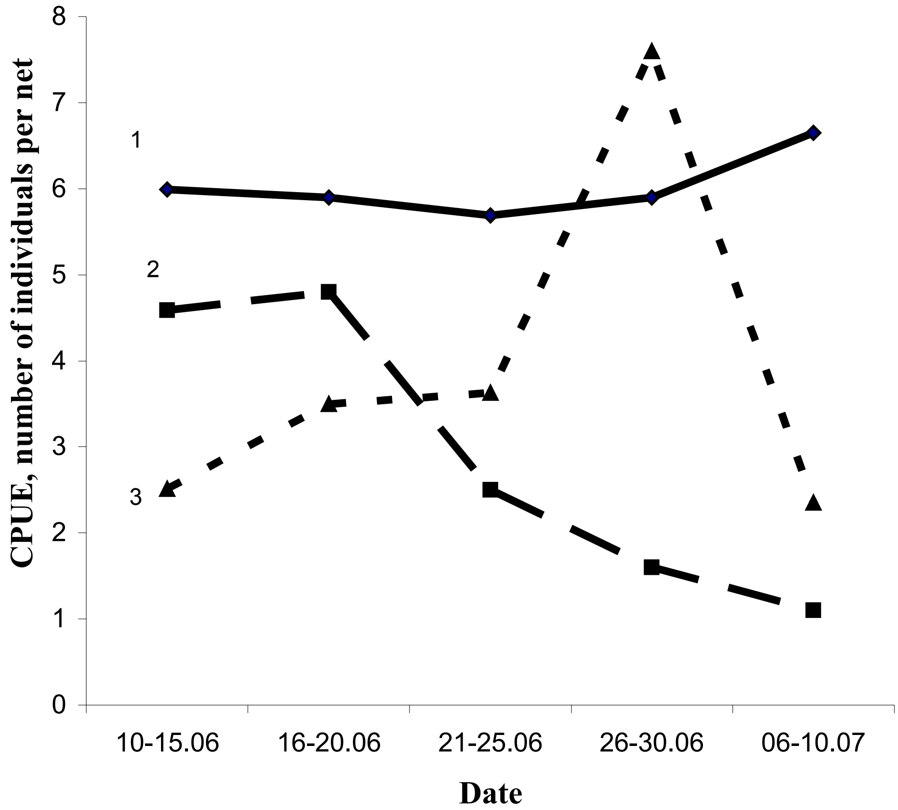


Fig. 2. CPUE (individuals per net) in the Petropavlovsk-Komandor Sub-zone, 2003):

1 - sockeye salmon; 2 - chum salmon; 3 - pink salmon

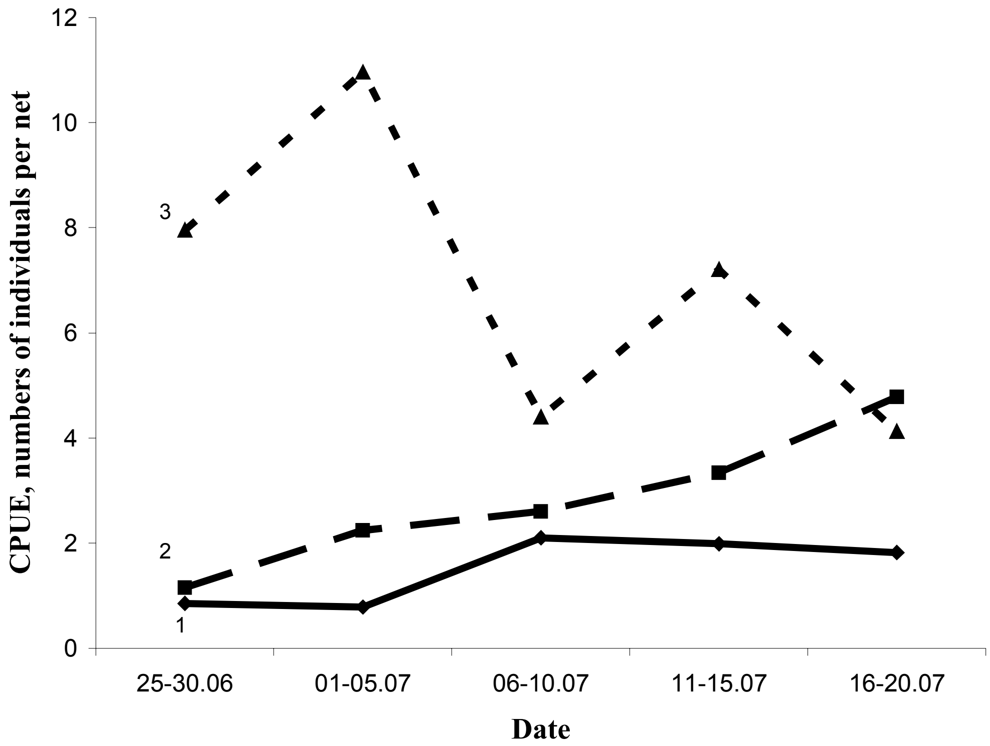


Fig. 3. CPUE (individuals per net) in the Karaginskaya Sub-zone, 2003):
1 - sockeye salmon; 2 - chum salmon; 3 - pink salmon

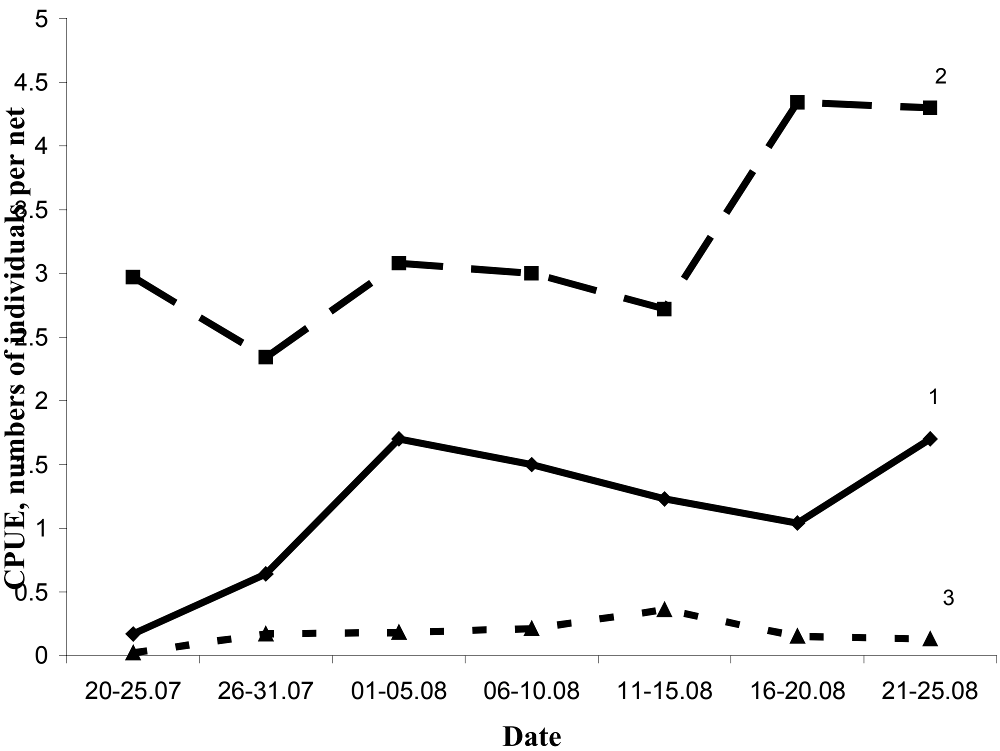


Fig. 4. CPUE (individuals per net) in the Bering Sea (6101 zone), 2003:
1 - sockeye salmon; 2 - chum salmon; 3 - chinook salmon

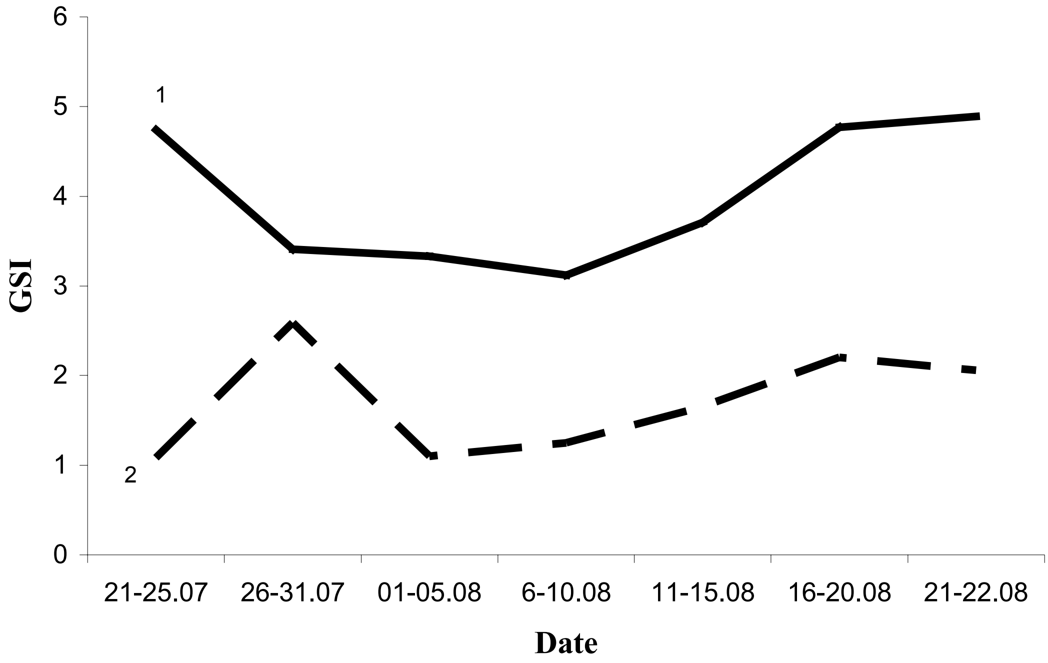


Fig. 5. Dynamics of chum salmon females (1) and males (2) GSI in the West Bering Sea (6101), 2003

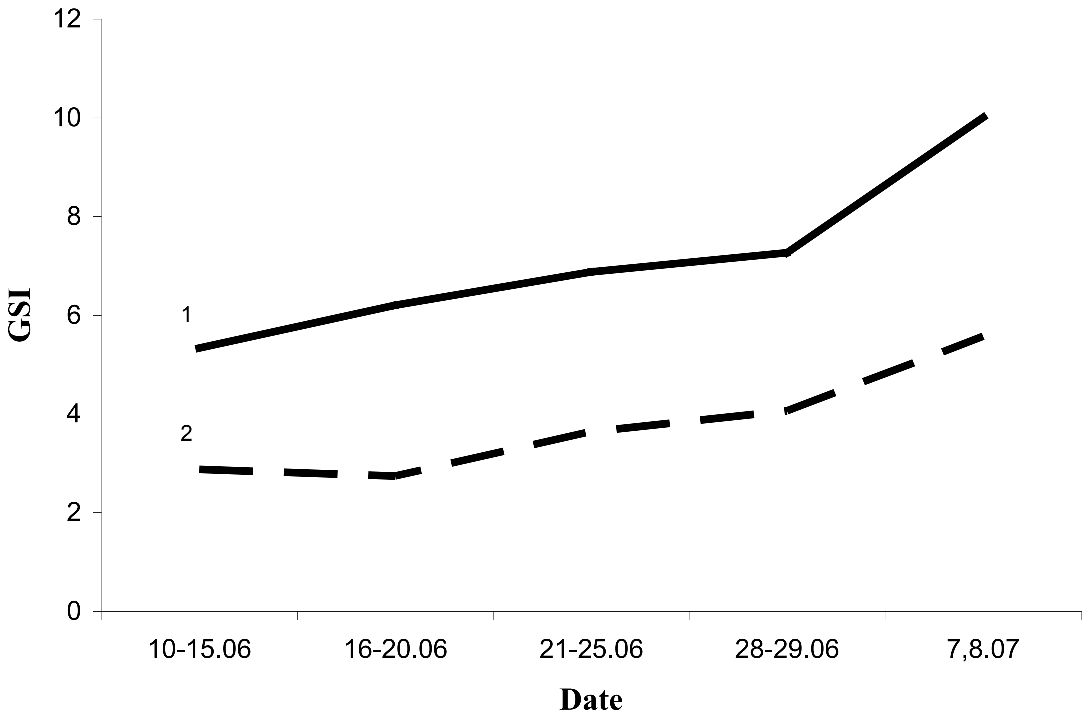


Fig. 6. Dynamic of pink salmon females (1) and males (2) GSI in the Petropavlovsk-Komandor Sub-zone, 2003

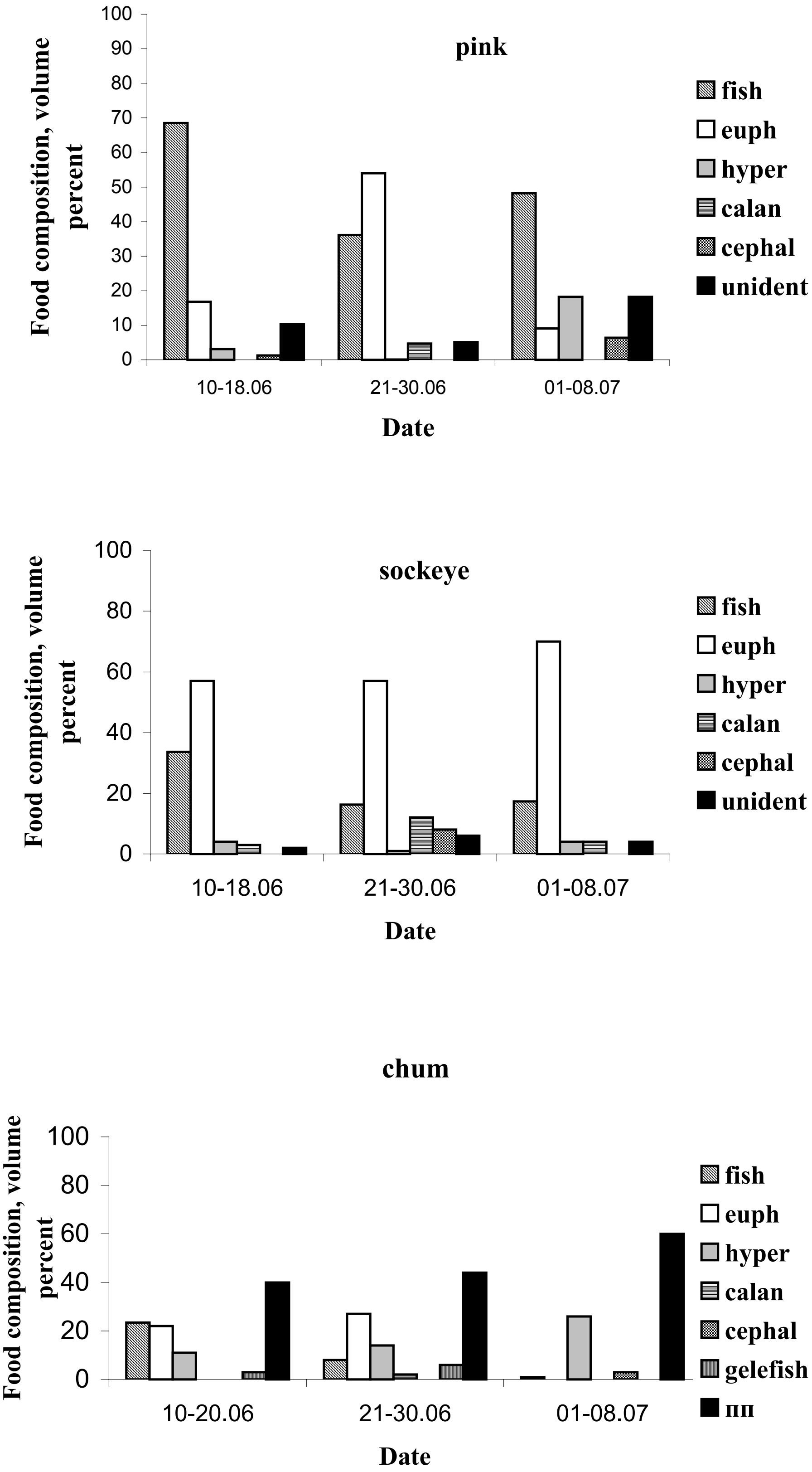
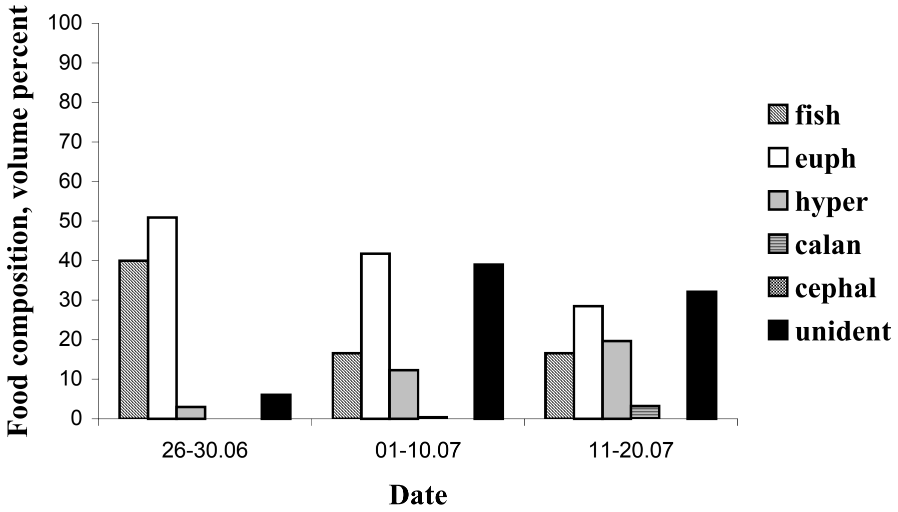
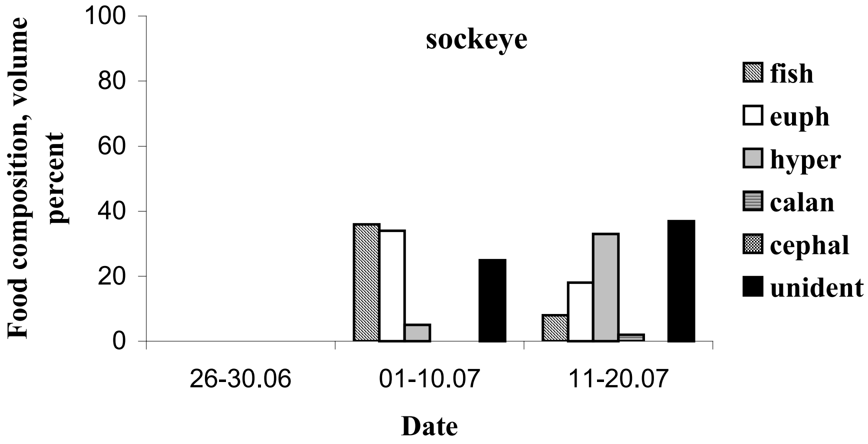


Fig 7. Food composition in salmon stomachs, Petropavlovsk-Komandor Sub-zone, 2003





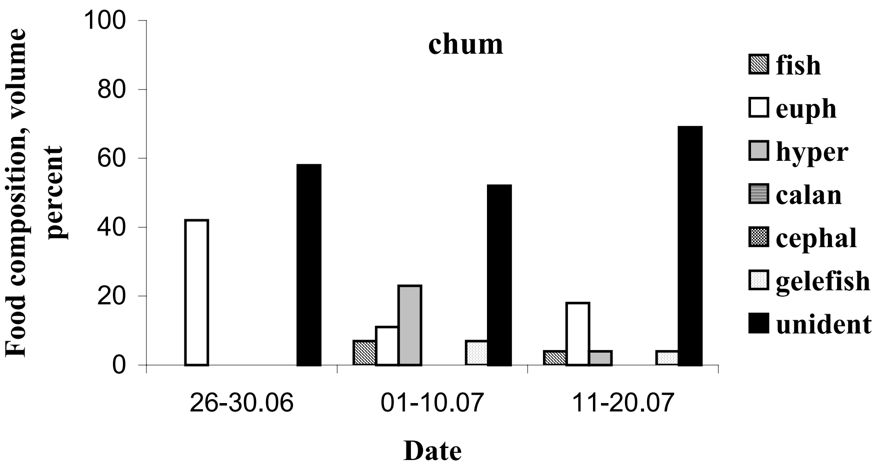
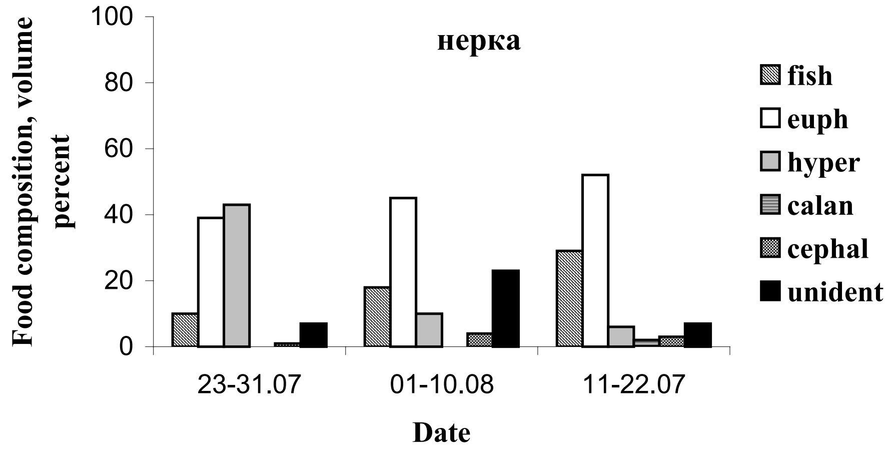


Fig 8. Food composition in salmon stomachs, Karaginskaya Sub-zone, 2003



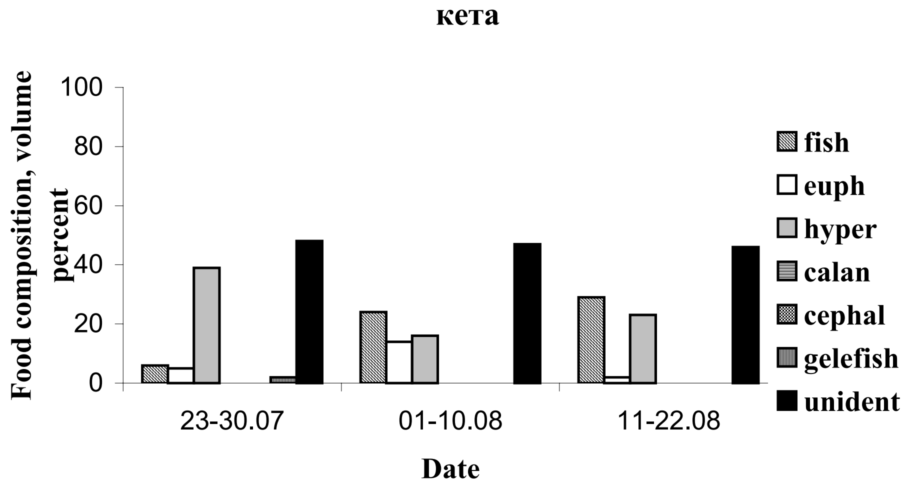


Fig. 9. Food composition in salmon stomachs, the West Bering Sea (6101), 2003

Table 1. Average SST (°C) in the Petropavlovsk-Komandor sub-zone (May-July, 1994-2003)

Month	ten-day period	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
SST,°C											
May	1			3.85	3.57		2.27				
	2			3.97	3.75	3.40	3.02			3.37	
	3			5.10	4.80	4.28	3.79	3.60	3.15	3.83	
June	1			5.10	5.30	3.98	2.55	3.88	3.74	4.13	
	2	5.29	5.72	5.96	6.80	6.98	3.50	4.80	4.00	4.56	5.7
	3	6.09	6.14	7.70	8.75	8.26	5.50	6.10	4.41	4.22	6.7
July	1		8.88	9.68	-	8.14		7.30	5.82		9.0

1,2,3 – ten-day period of month

Table 2. Sea water temperature (°C) in the depth 0-50 m in the West Bering Sea (July-August, 2003)

West Bering Sea (6101)

Date	**Coordinates**		**Depth, m**						
	N	**E**	**0**	**5**	**10**	**20**	**30**	**40**	**50**
24.07	59 58	172 41	11.56	11.37	11.14	6.2	3.8	2.98	2.55
26.07	59 48	175 35	12.15	12.11	11.23	8.58	4.77	3.67	3.34
28.07	59 38	171 04	12.52	12.52	12.52	6.77	4.47	3.57	2.59
29.07	59 16	170 24	9.4	9.34	9.17	5.24	3.77	3.11	2.98
30.07	59 40	171 28	12.56	12.56	12.17	5.98	3.5	3.06	2.54
31.07	59 46	171 13	12.82	7.54	5.19	1.12	2.81	2.52	2.5
1.08	59 46	171 60	12.5	12.51	12.51	5.46	3.31	2.62	2.4
3.08	60 35	178 38	12.22	12.04	11.82	9.29	4.8	3.62	2.71
4.08	60 18	179 33	11.24	10.8	10.77	7.62	5.03	4.54	4.1
5.08	60 16	178 50	12.88	11.69	11.32	7.18	4.59	3.56	2.99
10.08	60 36	178 33	11.39	11.39	11.37	11.11	6.96	4.52	3.38
11.08	60 36	178 05	11.71	11.7	11.62	10.99	4.96	3.67	2.87
14.08	61 04	177 56	10.58	10.58	10.57	10.57	5.21	4.04	3.22
15.08	60 36	178 06	10.32	10.32	10.33	10.33	4.18	3.69	3.56
16.08	60 39	178 00	10.8	10.8	10.8	10.65	4.57	3.7	2.22
17.08	60 38	178 01	10.57	10.56	10.58	10.56	5	3.64	2.99
18.08	61 04	177 34	10.34	10.34	10.35	10.34	4.39	4.09	3.66
19.08	61 07	177 26	10.42	10.42	10.43	10.41	4.4	3.1	2.85
20.08	60 59	177 35	10.37	10.39	10.37	10.29	5.56	3.73	2.92
21.08	60 35	178 03	10.67	10.67	10.67	10.65	4.84	3.47	3.09
22.08	60 38	178 03	10.41	10.15	10.03	5.04	3.69	3.23	3.09

Table 3. Dynamics of biological characteristics of sockeye salmon in 2003

Date, region	CPUE indiv/ net	Sex	Number of indiv.	%	Fork length,cm	Body weight,g	GSI	Immature indiv.,%	Fullness of stomach,points average	empty,%
10-15.06	5.59	males	33	33	58.4	2890	1.09	32.8	1.4	33
6102.2		females	67	67	55.8	2520	4.51	0	1.4	24
16-20.06	4.92	males	50	48	58.2	2980	1.32	40	1.72	8
6102.2		females	54	52	55	2470	5.76	1.9	1.33	26
21-25.06	5.69	males	59	58	58.4	3116	1.13	25	1.5	18.6
6102.2		females	42	42	56.6	2690	4.49	0	1.7	16.7
28-29.06	5.9	males	21	47	57.7	3026	1.14	29	1.2	28.6
6102.2		females	24	53	55.7	2526	5.39	4	1.3	20.8
26,27,30.06	0.85	males	4	36	54.3	2271	1.98	50	0.25	75
6102.1		females	7	64	57.7	2704	5.59	14	1.14	28.6
01-05.07	0.78	males	10	38	57.2	2620	1.51	50	1.2	30
6102.1		females	16	62	56.3	2766	7.63	6	1.4	25
7,8.07	6.65	males	18	36	54.4	2394	0.92	39	0.83	50
6102.2		females	32	64	54.6	2416	3.99	19	0.78	56.3
10.07	2.1	males	15	71	53	2022	1.39	67	0.07	93.3
6102.1		females	6	29	50.3	1728	2.31	83	0.33	83.3
11-15.07	1.99	males	42	60	51.5	1937	1.3	60	0.36	69
6102.1		females	28	40	55.3	2388	6.33	21	0.32	71.4
16-20.07	1.82	males	44	45	54	2309	1.64	43	0.4	68
6102.1		females	47	55	53.1	2259	5.94	26	0.4	64
21-25.07	0.17	males	5	50	59	3101	1.39	40	0.8	40
6101		females	5	50	58	2989	8.95	20	1	40
26-31.07	0.64	males	50	60	47.3	1590	0.34	92	1	52
6101		females	33	40	44	1240	0.65	91	1	36
1-5.08	1.7	males	58	70	48.8	1667	0.06	100	0.98	33
6101		females	25	30	46	1379	0.73	96	1	40
6-10.08	1.5	males	24	59	48.5	1634	0.06	100	0.38	67
6101		females	17	41	43.7	1178	0.7	100	0.71	59
11-15.08	1.23	males	60	71	50.5	1804	0.17	93	0.85	40
6101		females	25	29	47.4	1519	1.04	96	0.8	44
16-20.08	1.04	males	82	77	49.5	1683	0.07	100	0.68	50
6101		females	24	23	47.9	1536	0.82	96	1	38
21-22.08	1.7	males	29	59	47.3	1478	0.39	90	0.28	76
6101		females	20	41	47.9	1574	1.68	85	0.1	95

Table 4. Dynamics of biological characteristics of chum salmon in 2003										
Date, region	CPUE indiv/ net	Sex	Number of indiv.	%	Fork length,cm	Body weight,g	GSI	Immature indiv.,%	Fullness of stomach,points average	empty,%
10-15.06	4.59	males	39	39	60.8	3445	1.2	7.7	0.97	46
6102.2		females	61	61	57.7	2677	5.53	1.6	0.93	41
16-20.06	4.03	males	45	45	60.1	3039	2.14	31	1.67	24
6102.2		females	54	55	58.4	2787	5.38	5.6	1.28	31.5
21-25.06	2.5	males	32	36	60.5	3217	2.55	25	1.59	15.6
6102.2		females	58	64	58.9	2813	7.05	0	1.45	31
28-29.06	1.6	males	8	53	58.1	2743	2.27	13	1.38	25
6102.2		females	7	47	57.9	2660	8.32	0	1.57	14.3
26,27,30.06	1.15	males	10	59	58.2	2710	0.95	70	1.3	10
6102.1		females	7	41	58.7	2830	2.47	14	0.43	57.1
01-05.07	2.24	males	47	49	57	2568	1.6	51	1.15	29.8
6102.1		females	48	51	57.8	2734	3.73	19	1.33	22.9
7,8.07	1.1	males	11	50	57.5	2678	3.89	9	0.73	45.5
6102.2		females	11	50	57	2587	9.85	0	1.45	54.5
10.07	2.6	males	12	46	57.3	2669	1.34	42	0.67	50
6102.1		females	14	54	58.1	2667	2.85	7	1.21	7.1
11-15.07	3.34	males	45	49	59	2871	2	16	0.80	42.2
6102.1		females	46	51	57.4	2607	4.7	11	0.91	28.3
16-20.07	4.78	males	43	44	58.9	2732	2.04	16	0.49	58
6102.1		females	55	56	59.3	2855	4.91	9	0.64	53
21-25.07	2.97	males	20	45	59.5	2914	1.08	40	0.80	38
6101		females	24	55	61.3	3221	4.74	13	0.54	54
26-31.07	2.65	males	44	52	58	2777	2.59	52	0.50	25
6101		females	40	48	56.2	2582	3.41	50	0.50	58
01-05.08	3.08	males	40	50	56.2	2661	1.1	50	0.53	60
6101		females	40	50	59.1	2920	3.33	30	0.38	65
6-10.08	3	males	18	46	56.7	2672	1.25	55	0.22	83
6101		females	21	54	56.3	2861	3.12	33	0.24	81
11-15.08	2.73	males	39	53	59	3140	1.65	33	0.44	69
6101		females	35	47	59.4	3127	3.71	23	0.37	69
16-20.08	4.34	males	45	52	62.8	3604	2.2	22	0.07	96
6101		females	41	48	63.2	3714	4.77	2	0.02	98
21-22.08	4.3	males	17	47	61.2	3496	2.06	24	0.24	82
6101		females	19	53	62.1	3422	4.89	11	0.11	95

Table 6. Dynamics of biological characteristics of pink salmon in 2003									
Date, region	CPUE indiv/ net	Sex	Number of indiv.	%	Fork length,cm	Body weight,g	GSI	Fullness of stomach,points average	empty,%
10-15.06	2.51	males	93	93	45.6	1417	2.88	1.56	22.6
6102.2.		females	7	7	44.6	1297	5.34	2.43	0
16-20.06	2.94	males	83	83	46.3	1462	2.74	1.42	26.5
6102.2.		females	17	17	45	1308	6.21	1.06	29.4
21-25.06	3.63	males	78	78	45.9	1415	3.64	1.68	17.9
6102.2.		females	22	22	44.5	1228	6.88	1.27	27.3
28-29.06	7.6	males	36	53	44.7	1277	4.06	0.64	58.3
6102.2.		females	32	47	43.5	1184	7.27	0.19	87.5
26,27,30.06	7.95	males	44	64	44.8	1312	4.78	1.05	50
6102.1		females	25	36	44.3	1235	7.91	0.96	56
01-05.07	10.96	males	75	68	46.2	1391	6.05	1.05	37.3
6102.1		females	35	32	44.9	1272	9.5	1.54	28.6
7,8.07	2.35	males	22	58	45.9	1332	5.58	0.41	63.6
6102.2.		females	16	42	44.9	1234	10.01	0.25	81.3
10.07	4.4	males	13	54	44.8	1241	7.19	0.23	76.9
6102.1		females	11	46	45.1	1231	10.85	0.09	90.9
11-15.07	7.21	males	42	44	46.8	1397	7.84	0.52	64.3
6102.1		females	53	56	44.8	1211	11.53	0.3	75.5
16-20.07	4.12	males	34	35	46.9	1384	8.71	0.35	76
6102.1		females	62	65	45.5	1265	12.24	0.52	60

Table 6. Dynamics of biological characteristics of coho salmon in 2003									
Date, region	CPUE indiv/ net	Sex	Number of indiv.	%	Fork length,cm	Body weight,g	GSI	Fullness of stomach,points average	empty,%
26-31.07	0.13	males	6	38	64.5	4079	5.82	1.00	50
6101		females	10	62	60	3356	9.09	0.30	80
01-05.08	0.34	males	15	54	61	3495	7.45	0.93	60
6101		females	13	46	60.2	3476	11.77	1.08	38
16-20.08	0.12	males	10	29	63.3	3866	6.84	1.00	50
6101		females	24	71	62.5	3782	9.99	0.80	63
21-22.08	0.05	males	3	38	60.7	3383	7.64	1.33	33
6101		females	5	62	62.4	3692	13.3	0.80	40

Table 7. Dynamics of biological characteristics of chinook salmon in 2003										
	CPUE		Number		Fork	Body		Immature	Fullness of stomach,points	
Date, region	indiv/ net	Sex	of indiv.	%	length,cm	weight,g	GSI	indiv.,%	average	empty,%
10-15.06	0.02	males	10	63	63.4	3959	3.73	0	0.40	70
6102.2		females	6	37	83.5	9128	7.44	17	1.17	67
16-20.06	0.02	males	2	100	62	3968	2.66	0	1.50	50
6102.2		females	0							
21-25.06	0.01	males	12	92	64.6	4213	3.89	0	0.42	66.7
6102.2		females	1	8	100	14600	12.18	0	0.00	100
26,27,30.06	0.001	males	0							
6102.1		females	2	100	86.5	9295	7.09	50	0.00	100
01-05.07	0.001	males								
6102.1		females	1	100	77	5840	0.48	100	0	100
21-25.07	0.02	males	6	67	60	3078	1.03	83	0.50	67
6101		females	3	33	63.7	3968	0.28	100	0.33	67
26-31.07	0.17	males	22	52	57.9	2853	0.57	96	0.55	64
6101		females	20	48	58.7	2912	0.53	100	0.45	65
01-05.08	0.18	males	18	62	59.1	3110	0.04	100	1.06	39
6101		females	11	38	56.7	2764	0.55	100	0.18	82
6-10.08	0.21	males	11	50	57.3	2917	0.04	100	1.45	45
6101		females	11	50	61.5	3339	0.54	100	0.00	100
11-15.08	0.36	males	24	47	54.8	2577	0.06	100	0.96	42
6101		females	27	53	59.1	3034	0.44	100	0.89	85
16-20.08	0.15	males	20	34	58.4	2853	0.05	100	0.75	55
6101		females	38	66	61	3202	0.46	100	0.53	66
21-22.08	0.13	males	5	33	57	3089	0.04	100	2.4	0
6101		females	10	67	53.5	2300	0.38	100	1.2	40

Table 8. Intensity of of sockeye salmon feeding, %. June-August 2003							
	Fullness of stomach,points					Average	N, indivd.
Date, area	0	1	2	3	4		
10-15.06 (6102.2)	26	25	35	13	1	1.38	100
16-20.06 (6102.2)	17	22	53	7	1	1.52	104
21-25.06 (6102.2)	18	24	41	16	1	1.6	101
26-30.06 (6102.2)	24	33	37	2	4	1.29	45
26-30.06 (6102.1)	45	28	27	0	0	0.82	11
01-05.07 (6102.1)	27	27	35	11	0	1.31	26
06-10.07(6102.2)	54	16	13	7	0	0.8	50
06-10.07 (6102.1)	90	5	5	0	0	0.14	21
11-15.07 (6102.1)	70	26	4	0	0	0.34	70
16-20.07 (6102.1)	66	24	10	0	0	0.44	91
21-25.07 (6101)	40	30	10	20	0	1.1	10
26-31.07 (6101)	48	24	27	1	0	0.85	83
01-05.08 (6101)	35	40	24	1	0	0.92	83
06-10.08 (6101)	63	24	10	3	0	0.51	41
11-15.08 (6101)	41	35	22	2	0	0.84	85
16-20.08 (6101)	47	34	19	0	0	1	106

Table 9. Intensity of of chum salmon feeding, %. June-August 2003							
	Fullness of stomach,points					Average	N, indivd.
Date, area	0	1	2	3	4		
10-15.06 (6102.2)	43	50	0	7	0	0.95	100
16-20.06 (6102.2)	28	22	27	22	1	1.45	99
21-25.06 (6102.2)	26	19	39	13	3	1.5	90
26-30.06 (6102.2)	20	20	53	7	0	1.47	15
26-30.06 (6102.1)	29	53	12	6	0	0.94	17
01-05.07 (6102.1)	26	30	38	6	0	1.24	95
06-10.07(6102.2)	55	23	22	0	0	0.68	22
06-10.07 (6102.1)	27	50	23	0	0	0.96	26
11-15.07 (6102.1)	35	44	21	0	0	0.86	91
16-20.07 (6102.1)	55	35	8	2	0	0.57	98
21-25.07 (6101)	50	34	16	0	0	0.66	44
26-31.07 (6101)	55	40	5	0	0	0.5	84
01-05.08 (6101)	63	30	7	0	0	0.45	80
06-10.08 (6101)	82	13	5	0	0	0.23	39
11-15.08 (6101)	69	22	8	0	0	0.41	74
16-20.08 (6101)	97	2	1	0	0	0.05	86

Table 10. Intensity of of pink salmon feeding, %. June-July 2003

	Fullness of stomach,points					Average	N, indivd.
Date,area	0	1	2	3	4		
0-15.06 (6102.2	21	11	53	15	0	1.62	100
6-20.06 (6102.2	27	27	29	17	0	1.36	100
1-25.06 (6102.2	20	27	30	20	3	1.59	100
6-30.06 (6102.2	62	20	16	2	0	0.58	50
6-30.06 (6102.1	52	14	18	12	4	1.01	69
1-05.07 (6102.1	35	26	23	14	2	1.21	110
)6-10.07(6102.2	71	24	5	0	0	0.34	38
6-10.07 (6102.1	83	17	0	0	0	0.17	24
1-15.07 (6102.1	70	21	6	2	0	0.4	95
6-20.07 (6102.1	66	23	11	0	0	0.46	96

Table 11. Intensity of of chinook salmon feeding, %. July-August 2003

	Fullness of stomach,points					Average	N, indivd.
Date, area	0	1	2	3	4		
26-31.07 (6101)	64	24	10	2	0	0.5	42
01-05.08 (6101)	56	28	10	3	3	0.72	29
06-10.08 (6101)	74	4	4	14	4	0.73	22
11-15.08 (6101)	45	25	24	4	2	0.92	51
16-20.08 (6101)	62	21	14	1.5	1.5	0.6	58

Table 12. Changes salmon stomach fullness (average values) during 24 hours in 2003.

Date	Time of nets setting and retrieving	Average stomach fullness, points		
		sockeye salmon	chum salmon	pink salmon
18.06	0.45-3.40	1.45	-	1.00
18.06	04.00-07.00	1.73	1.80	1.40
18.06	07.20-10.30	2.00	2.56	1.90
18.06	10.45-14.00	1.67	2.10	1.73
18.06	14.20-17.55	1.50	1.82	1.30
18.06	18.15-22.00	1.75	2.27	2.14

Table 13. Changes salmon stomach fullness (average values) during 24 hours in 2001.

Date	Time of nets setting and retrieving	Average stomach fullness, points		
		sockeye salmon	chum salmon	pink salmon
28.06	16.05-19.30	1.67	2.25	2.79
28.06	19.50-22.30	3.42	2.80	3.00
29.06	01.30-04.30	2.25	1.86	2.25
29.06	05.05-08.30	1.64	1.87	2.27
29.06	08.20-11.30	2.09	2.73	2.17
29.06	13.25-16.30	2.09	2.60	3.00

Table 14. Predation of sea lampreys, daggertooth and fur-seals on Pacific salmon in the North West Pacific, 2003.

Species of Predator	Daggertooth	Fur-seals	Sea lampreys	Total number of examined fish
Zone, sub-zone	Number/percent of injured pink salmon			
Petropavlovsk-Komandor Sub-zone	13/3.4	-	-	388
Karaginskaya Sub-zone	5/1.3	6/1.5	-	394
	Number /percent of injured chum salmon			
Petropavlovsk-Komandor Sub-zone	11/3.4	-	-	327
Karaginskaya Sub-zone	5/1.5	10/3.1	-	327
West Bering Sea Zone	8/2.1	2/0.5	17/5.2	443
	Number /percent of injured sockeye salmon			
Petropavlovsk-Komandor Sub-zone	8/2.1	13/5.9	-	400
Karaginskaya Sub-zone	1/0.5	13/5.9	-	219
West Bering Sea Zone	-	3/0.7	17/3.7	457
	Number /percent of injured coho salmon			
West Bering Sea Zone	-	-	1/1.2	86
	Number /percent of injured chinook salmon			
Petropavlovsk-Komandor Sub-zone	4/12.9	-	-	31
West Bering Sea Zone			2/0.9	225