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STRUCTURE OF SPAWNING STOCKS OF FOUR PACIFIC SALMON SPECIES OF THE OLUTORSKY BAY (BERING SEA, NORTH-EAST KAMCHATKA)

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Abstract

The paper describes data characterizing structure of spawning stocks of pink salmon *O. gorbuscha*, chum salmon *O. keta*, sockeye salmon *O. nerka,* and chinook salmon *O. tshawytscha* from the rivers inflowing the Olutorsky Bay of the Bering Sea (North-East Kamchatka). Intraspecific forms were revealed in chum, sockeye, and chinook salmon populations that are reproduced in the rivers inflowing the Olutorsky Bay. The existence of the forms helps to maintain high abundance of the species in changing environments and indicates the fact that the North-East of Kamchatka allocated in periphery of pacific salmon areal is an area of ecological optimum for chum, sockeye and chinook salmon.

Introduction

The North-East Kamchatka coast (Karaginsky Bay and Olutorsky Bay) is one of the largest regions of reproduction of Pacific salmon. Such species as sockeye salmon, chum salmon, pink salmon, coho salmon, and chars of genus *Salvelinus* spawn in the region.

There are numerous published data on the biology of chum salmon and pink salmon from the North-East Kamchatka but it applies mainly to the rivers inflowing the Karaginsky Bay of the Bering Sea. Scarce literature data are devoted to sockeye salmon. Special studies were performed only in the Khailyulya River (Karaginsky Bay) and in the basin of the Ananavayam River in Laguna Anana Lake (Olutorsky Bay). As concerns other rivers of this region, only scrappy sockeye salmon data is available. Data on chinook salmon confines itself to catch statistics.

The subject of this study is to assess spawning stock structure of pink salmon, chum salmon, sockeye salmon, and chinook salmon in the rivers (mainly in the Apuka River) of the Olutorsky Bay of the Bering Sea.

MATERIAL AND METHODS

Material was collected on Pacific salmon run to the Olutorsky Bay coast and during the spawning run of pink salmon, chum salmon, sockeye salmon, and chinook salmon in the Apuka River in 2007-2012. Salmon were cached by pound nets in the Olyutorsky Bay and pound and throw nets in the Apuka River at 13-16.5 km from the mouth (Fig. 1). River and sea catches were analyzed separately. Samples are combined only if there aren't any differences in indices of salmon caught in the river and in the bay. A total 9841 biological analysis were performed over a period of 2007–2012.

RESULTS AND DISCUSSION

A dynamics of biological characteristics of Pacific salmon runs into the Apuka River and the Olutorsky Bay is illustrated in Figure 2.

Pink salmon. Pink salmon was caught only in the Olutorsky Bay. Pink salmon absented in the Apuka River large-mesh nets.

Biological indices of pink salmon - length, weight and gonad weight, gonadosomatic index (GSI) and condition factor vary in a wide range (Table 1). But despite the interannual variation of means a weight decreasing trend was clearly traced in the period from 2007 to 2012 (Fig. 3) especially for males. At the time individual length varied slightly from year to year. Correspondingly male condition factor decreases from 1,11 in 2007 to 0,92 in 2011, female condition factor decreases from 1,02 in 2007 to 0,83 in 2011. In our opinion the tendency noted is caused by high abundance of salmon fed in the Bering Sea, which more than two times rose in North-East Kamchatka over a period of 2007 – 2012. That can lead to intensification of inter- and intraspecies relations, decreasing of food utilization efficiency for growth, and as a consequence reduction of weight and condition of fishes.

Over a period of pink salmon run in Olutorsky Bay male and female GSI varied in a wide range. It possible can be connected with catching of individuals reproducing in different rivers of the bay. At the same time mean female GSI rose and male percentage in catches gradually decreased from the beginning to the end of the run period from 80-90% (in different years) to 43%. This fact indicates that Olutorsky Bay pink salmon have only one seasonal form – summer form that runs into the rivers of the bay in a very short time (from the end of June – the beginning of July till the end of July - the beginning of August) (Elnikov, Gritcenko, in press).

Chum salmon. Chum salmon were caught mainly in the Olutorsky Bay. They were caught in the Apuka River less often mainly in June as an incidental catch during sockeye and chinook salmon catch. Only once in 2008 we manage to get a representative sample of chum salmon (300 fishes). In this only one year over a period of observation salmon were caught in the river in June, July, and August. Chum salmon caught in the Apuka River and the Olutorsky Bay in 2008 vary slightly in length, age, and gonad maturity (Table 2). We analyzed the samples together because we didn't find any differences in indices of chum salmon caught straight in the river and in the Olutorsky Bay.

Over 6-year research period five-year individuals prevailed in even-year runs. The percentage of the individuals varied from 69 to 85%. The proportion of four-year fish in even years was 6,0-21%. The percentage of five-year fish varied from 28% to 57%. On the contrary there were much more four-year fish than in even-year runs (Table 3).

Predominance of 3+ individuals in odd-year runs and 4+ individuals in even-year runs is associated in our opinion with the fact that chum salmon gained weight at sea together with numerous pink salmon generations and experienced density-dependant factors effect. The latest affected on chum salmon maturity rate. As a result a considerable part of individuals stayed at sea for one year more and returned to breed in adjacent even year older by one year.

Mean male and female weight in runs was the greatest in 2010, the least female weight – in 2011, the least male weight – in 2012. Mean weight variations from year to year were caused both by different age structure of breeders in odd and even years and by weight of fishes of different year classes changing from year to year (Fig. 4).

In a group of 3+, 4+, and 5+ males in 2007-2012 a weight decreasing trend is traced. The trend is more pronounced among four-year individuals. 3+ and 4+ females are characterized by weight decreasing in a row of years but less marked than males of the same age. It's difficult to conclude about six-year females weight because of their small number (from 1 to 10 individuals in different years).

Phenomenon of growth and maturity retardation of chum salmon, when high number of salmon is observed in feeding area, was discovered as early as 1990-th. In 1990-th there was a sharp gain of salmon abundance in the Bering Sea because of growth of pink salmon and Japanese factory chum salmon numbers (Gritsenko et al., 2000; Ishida, Davis, 1998).

Effect of other species numbers on growth and maturity rate of chum salmon is more pronounced if age structure of breeders is compared over long periods of high and low abundance. So in 1980-th when low abundance of Bering Sea salmon took place in the Apuka River 3+ fish were dominant. In the sequel in proportion to abundance increase of pink and chum salmon simultaneously feeding in the Bering Sea an alternation in dominance of 3+ and 4+ chum salmon was observed in runs (Zavarina, 2007). In years of our researches (2007−2012) the main age classes of Apuka River and Olutorsky Bay chum salmon were 3+ and 4+ spawners as before. At that in even years a percentage of 4+ spawners was always more than in odd years.

A ratio of different age fishes in spawning runs was changing not only from year to year, but also over a season of observation. Thus among fishes cached 8-20 June 2010 56% of females and 50% of males were represented by 5+ fishes.

Later on percentage of these spawners in the runs decreased and in the beginning of August they formed 8% among females and 15% among males. A portion of 3+ individuals on the contrary rose. Mean age of chum salmon decreased. Females and males were 4,5 years old in June. Afterwards females were 3,9-4,2 in June and males were 3,8-3,9 at the end of July and in the first five days of August. However decreasing of mean age from the beginning to the end of spawning run wasn't constant. Thus in the period of 16-20 July mean age of chum salmon increased again in comparison with previous five-day period and after that sequentially decreased up to the end of the observation period (Fig. 5). Such a dynamics can indicate of heterogeneity of the stock and changing of migrating seasonal aggregations of chum salmon.

Female size during the research season varied in the range 53-76 cm, male size - 56-85 cm. At that mean length rose over the period of spawning migration despite the fact that age of fishes decreased. It means that late chum salmon was at the average bigger and at the same time younger than fishes running to spawn in the beginning of summer.

Sex ratio of the chum salmon was close to 1:1 in whole. But over the observation period it changed: decreasing and increasing in different periods in the course of the season. It can indicate of heterogeneity of the chum salmon stock of the Olutorsky Bay. The data on mean day catch of chum salmon in 2010 and 2011 point to presence of at least two seasonal aggregations (Fig. 6).

Thereby the analysis of age-size structure dynamics, sex ratio, and catch dynamics of the chum salmon in the Olutorsky Bay enable us to reveal two seasonal forms with overlapping migration time into the rivers (Klovach, El'nikov, 2013).

Sockeye salmon. Biological features of sockeye salmon varied in a wide range (Table 4). However the majority of mean values with the exception of a condition factor changed slightly and was connected with different age structure of spawners in different years. At the same time the condition factor of sockeye salmon declined from year to year. In Apuka River from 2008 to 2012 mean females' Clark's condition factor decreased from 1.20 to 1.07, whereas males' Clark's condition factor – from 1.28 to 1.13. In the Olutorsky Bay females' condition factor dropped from 1.23 in 2007 to 1.01in 2011, males' condition factor – from 1.30 in 2007 to 1.01 in 2011. It allows us to assume that feeding conditions of the sockeye salmon in a prespawning period became slightly worse over the last years.

In the end of May- beginning of June 2010 the average GSI of females was in a range 9.6 –11.1% and increased over a period from 26 May till 10 June. A proportion of females with high GSI (more than 11) grew from the end of May till the middle of June from 20 to 45-50% (Fig. 7). In the second decade of June silvery individuals without signs of spawning changes began to appear in catches. The appearance of fish with a silvery coloration was accompanied by an increase in the proportion of individuals with a low GSI value. Mean female GSI by the beginning of third decade of June decreased till 8.24. The curve of distribution of female sockeyed salmon according to GSI from samples on June 10-15 became two peak, which indicates the presence in catches of individuals of different dates of run and low GSI. Correspondingly a ratio of less mature females became more prominent. Thereby, the spawning run of early sockeye salmon terminated by the end of the second decade of June in 2010, and only late run individuals (late sockeye salmon) were present in catches from the third decade of June.

As our observations showed the beginning of spawning run of the late sockeye salmon falls on different dated in different years. Thus, in 2008 the beginning of the migration of the late sockeye salmon was on June 22-25, whereas in 2010 it was on June 10-15.

Sockeye salmon spawners from the Apuka River and the Olutorsky Bay in different years were presented by 8 – 10 year groups. At that over the period of study individuals that migrated downstream to the sea at the age of one year dominated in spawning population of the Apuka River. Their proportion varied from 80 to 100% of the total number of fish in the sample. The ratio of fish that migrated downstream to the sea at the age of two years was 0-20%, and that of sockeye salmon that migrated downstream to the sea as a fingerling was only 0 - 7%. Age structure analysis of catches showed that individuals migrating to the river to breed from the end of June were older than spawners migrating in May – first half of June. Late Apuka River sockeye salmon was older than early one mainly because of a gain of ratio of 1.3+ and 1.4+ individuals and a decrease of 1.2+ fish ratio from the end of May till the end of June. Sockeye salmon cached in the river by the end June was bigger than sockeye salmon cached in May-beginning of June (Fig. 8).

Sockeye salmon from July catches of sea pound nets slightly differed by length and weight from individuals from river catches at the end of June. It can be caused by mixed composition of the sea catches. At the same time males from sea catches were much bigger than females. Apparently it is typical of late run sockeye salmon breeding in Olutorsky Bay rivers. On the contrary females of early sockeye salmon are bigger than males.

Sockeye salmon from July sea catches differed from sockeye salmon from the Apuka River in gonad maturity stage (Fig. 9). The vast majority of females caught in the bay had high gonad maturity stage (GSI>11). It indicates of proximity of their spawning sites to outfalls of the rivers flowing into the Olutorsky Bay. At the same time more than 80% of females caught in the river at the end of June had a low GSI indicating of coming long way to a spawning site. Thereby we can conclude that in July catches in the Olutorsky Bay there were sockeye salmon from other rivers' lower reaches in high numbers. The sockeye salmon spawns mainly in Ananapylgen River drainage where near the lower reach of the river samples were taken in July 2010. Late run sockeye salmon from the Apuka River probably spawns much more upstream than sockeye spawning in the Laguna Anana Lake (Ananapylgen River drainage).

Parallel consideration of such indices as spawning metamorphosis intensity (breeding dress), gonad maturity stage of females (GSI), weight of fishes, and age structure of catches allowed us to get characteristics of sockeye salmon of two periods of run –early and late. The early run sockeye salmon begin to approach into the Apuka River at the end of May – the beginning of June. Its spawning run ends in the third decade of June.

Spawning run of the late sockeye salmon begins in II or in the beginning III decade of June in different years. Abundance of the Apuka River late sockeye is considerably lower than those of early sockeye salmon. Its spawning run is expanded and continues till the end of the second decade of August. Late sockeye salmon is bigger and on the average older than the early form. The discovered differences of sockeye salmon of different run terms allow us to suggest that the early run sockeye salmon spawn in the Vatyt-Gythyn Lake allocated 40 km from the outfall on the left tributary of the Apuka River, whereas the late sockeye salmon spawns in distant spawning grounds. In favour of this suggestion bigger size of the late sockeye spawners and their lower gonad maturity indicate (Klovach, Roi, 2010; El'nikov, 2012; Klovach, El'nikov, 2013).

Chinook salmon. Biological indices of chinook salmon catched in the Apuka River and the Olutorsky Bay didn't differ substantially. It is caused by the fact that the river drainage is the main reproducing site of sockeye salmon in the Olutorsky Region. Therefore mainly Apuka River chinook salmon is present in the river and sea catches. That is why we analyzed the chinook salmon without dividing it by those caught in the river and those caught in the Olutorsky Bay.

Mean indices of length and weight, GSI of spawners, and their limits of fluctuation differ considerably from year to year (Table 5). It is caused by unequal age composition of spawners in different year approaches. The cumulative age (freshwater + marine) of the spawners of chinook salmon ranged from 2+ (1.1+) to 7+ (1.6+) (Table 6). The main age groups of chinook salmon in the catches in all years of observations were represented by the females at the age of 1.4+ and 1.3+ and the males at the age of 1.2+, 1.3+, and 1.4+. The number of exemplars at the age 2 (1.1+) and 7 (1.6+) years was very low. They were represented only by females. The fishes migrating into the sea at the age of 1+ prevailed in all years. Among the fishes that migrated to the sea as the young of the current year (0+), only three males (0.9%) and six females (3.7%) were registered. The proportion of fish that migrated to the sea at the age 2+ in 2008 was also low: eight males (2.4%) and four females (2.5%). The age composition of chinook salmon in the catches in other years was similar to that in 2008. However, the exemplars migrating to the sea as the young of the current year were absent. Therefore, the number of age groups of chinook salmon in 2007, 2010, and 2011 was lower than that in 2008.

Size-weight structure of the catches varied considerably in concordance with the ratio of different age fiches in approaches changing from year to year.

It should be noted that the ranges of the body length and weight of the spawners of different age groups are wide, and the ranges of the size of the fishes from adjacent age classes are substantially overlapped. The body length and weight of the spawners of chinook salmon depend mainly on the number of years spent in the ocean: the more prolonged marine period of life, the larger size of the fish. The individuals with different duration of freshwater period of life, but with similar duration of life in the sea are characterized by similar body length.

The frequency distribution of chinook salmon by body length shows a large fraction of small males in the spawning runs of 2008 and 2010 (Fig. 10). The left parts of the lines are associated with the individuals ≤ 70 cm FL. The majority of these fishes spent 2 years in the sea, some of them spent 1 year in the sea. Among the males > 70 cm FL, the fishes, which spent 1 or 2 years in the sea either were absent in 2008, or they were found as singe specimens (2010). A large proportion of small fishes and almost total absence of the males from 71 to 90 cm FL in the spawning runs of 2008 and 2010 represented a reason for a bimodal distribution of the body length in chinook salmon males. Owing to this pattern of distribution, heterogeneity of the stock of the chinook salmon from the Apuka River can be suggested (Klovach et al., 2011).

In 2011 the proportion of small males in Apuka River chinook salmon stock was less than in previous two years. At the same time in spawning approaches in 2011 a group of very small males > 50 cm FL and less than 1 kilo weight was relatively more abundant than in the previous years. Though bigger than in previous years size of the males is caused by minor percentage of small males (> 70 cm FL) in total in 2011 in comparison with 2008 and 2010.

Such a large proportion of the males at the age of 3 years registered in the spawning runs of chinook salmon of the Kamchatka Peninsula in this study was not observed before. According to Vilenskaya et al. (2000), the frequency distribution of body length in chinook salmon from the Kamchatka River was similar to normal, and the spawners spent 2 years in the sea, as a rule, were not numerous. The main part of the spawning runs consisted of the individuals that spent 3 years and 4 years in the sea.

It is important to note that the GSI in all small (FL < 70 cm) and early matured (in the majority of cases, at the age of 1.2+), males was (on average) larger than in the large males (Fig. 11). The differences between the GSI values in the small and large males were significant.

Sufficient percentage of small early maturing males of Apuka River chinook salmon from our point of view is an example of ecological morphogeny inherent in salmonids. Large intraspecies diversity allows salmon to realize one or another life strategy depending on environment conditions (Glubokovsky, 1995; Ivankov, 2001, Pavlov et al., 2001).

CONCLUSIONS

1. Decreasing of weight of chum and pink salmon spawners of the Olutorsky Bay being observed over 6 years of observations from 2007 to 2012 is caused by high abundance of salmon on feeding sites these years. The abundance favours intensification of inter- and intraspecies relations, decreasing of food utilization efficiency for growth, and as a consequence reduction of weight and condition of fishes.

2. Age structure of Olutorsky Bay chum salmon includes 2+– 6+individuals. Individuals spending 3-4 years at sea accounted for more than 80% of spawner numbers in runs. Predominance of 3+ individuals in odd-year (2007, 2009, 2011) runs and 4+ individuals in even-year (2008, 2010, 2012) runs is associated with maturity retardation of generations in the odd years, when chum salmon gained weight at sea together with numerous pink salmon generations and experienced density-dependant factors effect. As a result considerable part of individuals stayed at sea for one year more and returned to breed in adjacent even year older by one year.

3. Age structure and spawners size dynamics, sex ratio, females' GSI, and day catch dynamics indicate of heterogeneity of the chum salmon stock in the Olutorsky Bay represented by two seasonal forms – early and late.

4. Sockeye salmon reproducing in the Apuka River have two seasonal forms – early and late. Early sockeye salmon run to the river to spawn at the end of May – the beginning of June. Spawning migration of late sockeye salmon begins in the second decade or in the beginning of third decade of June depending of a year. Late sockeye salmon is less abundant as compared with early form. It's also bigger and older that the last one because of more prolonged sea feeding period.

5. The base of Apuka River chinook salmon stock is the spawners spent 1 year in the river and from 1 to 4 years at sea. The age composition of the males and females of chinook salmon is different. The females of the spawning runs are represented by 8 age groups, and the males include 11 age groups. The main age classes of the females and males of the spawning runs include 3 or 4 years in the sea and 2, 3, or 4 years in the sea, respectively.

6. Presence in Apuka River chinook salmon stock a considerable proportion of small early maturing males is an example of ecological morphogeny peculiar to salmonids and can be compared with dwarf males of sockeye salmon, "jack" of masou and coho salmon, diversified phenotypes of Kamchatka steelhead.

7. The existence of the various ecological forms of chum, sockeye and chinook salmon is caused by diversity of environment conditions.

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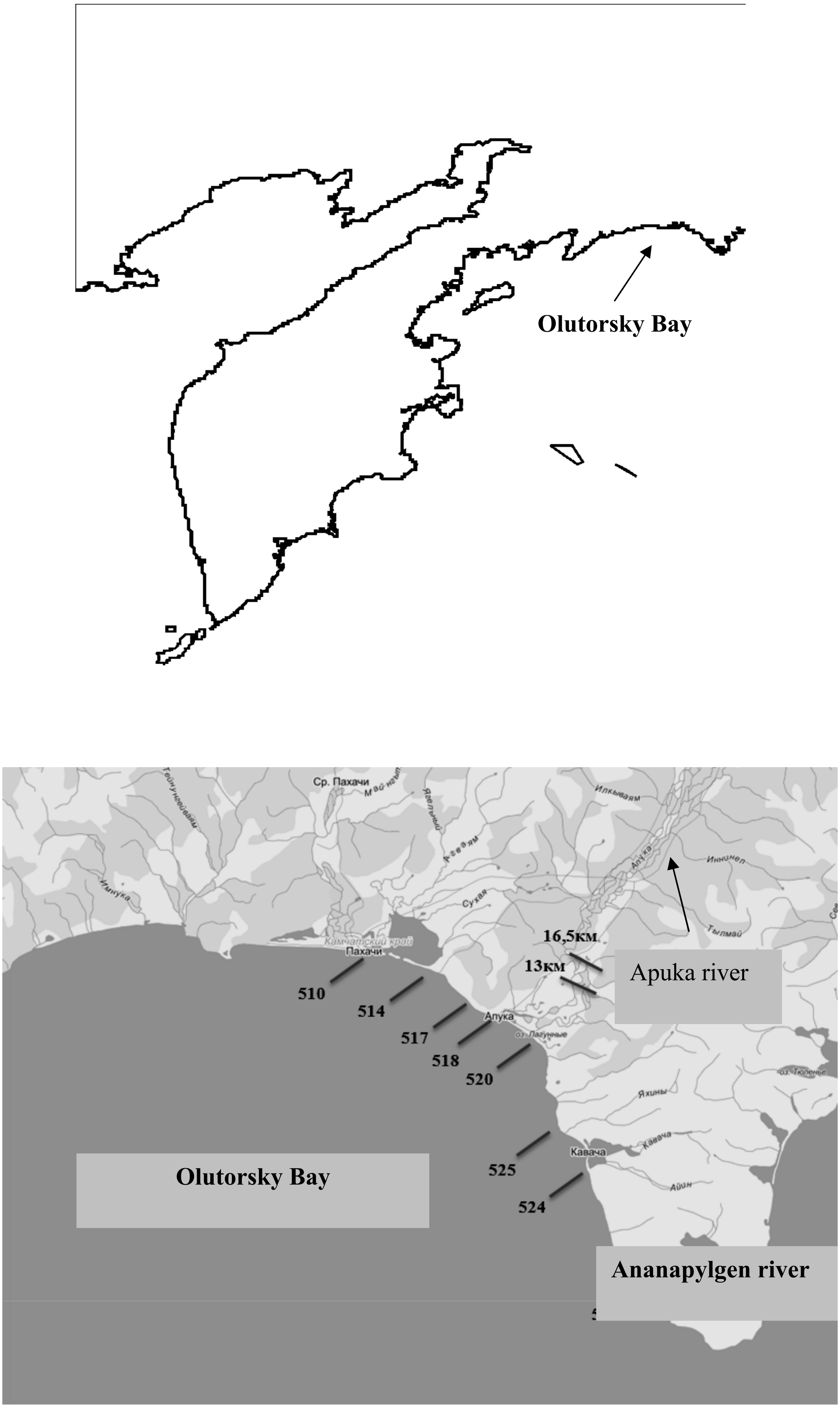


Fig. 1. Scheme of stationary pound nets location (514-527) in the Olyutorsky Bay; 13 and 16,5 – river fishery sites.

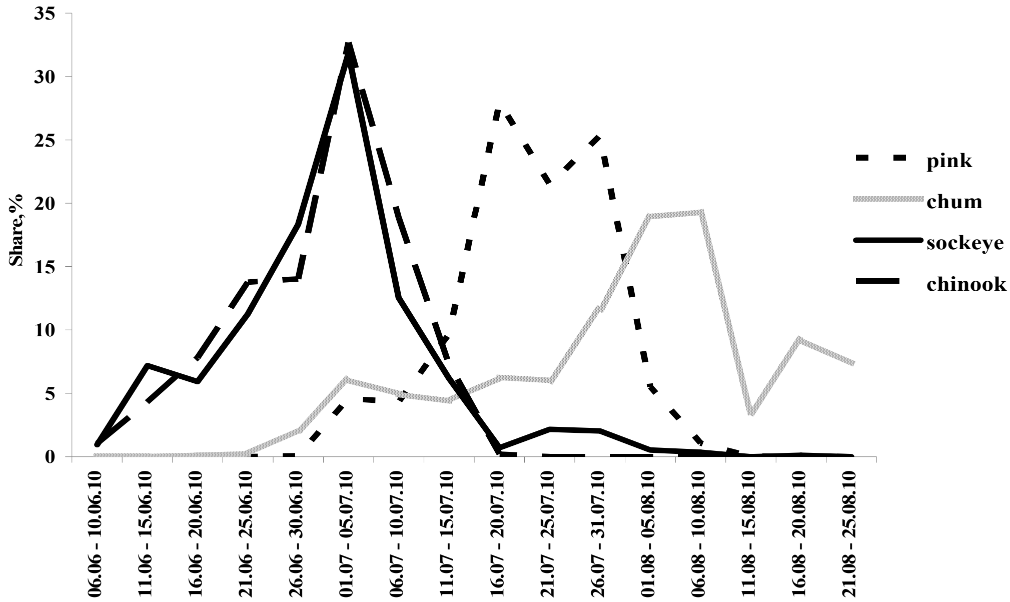


Fig. 2. Seasonal catch dynamics of Pacific salmons in the Apuka River and the Olutorsky Bay in 2010 (in percentage of catch a kind for a season).

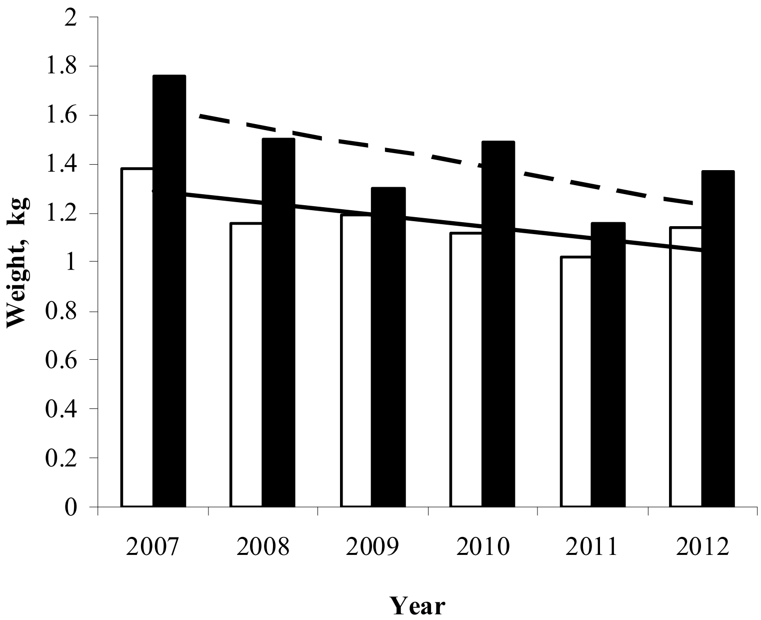


Fig. 3. Average weight of Pink salmon males (black columns) and females (white columns) in the Olutorsky Bay in 2007-2012 and linear trends of its changes.

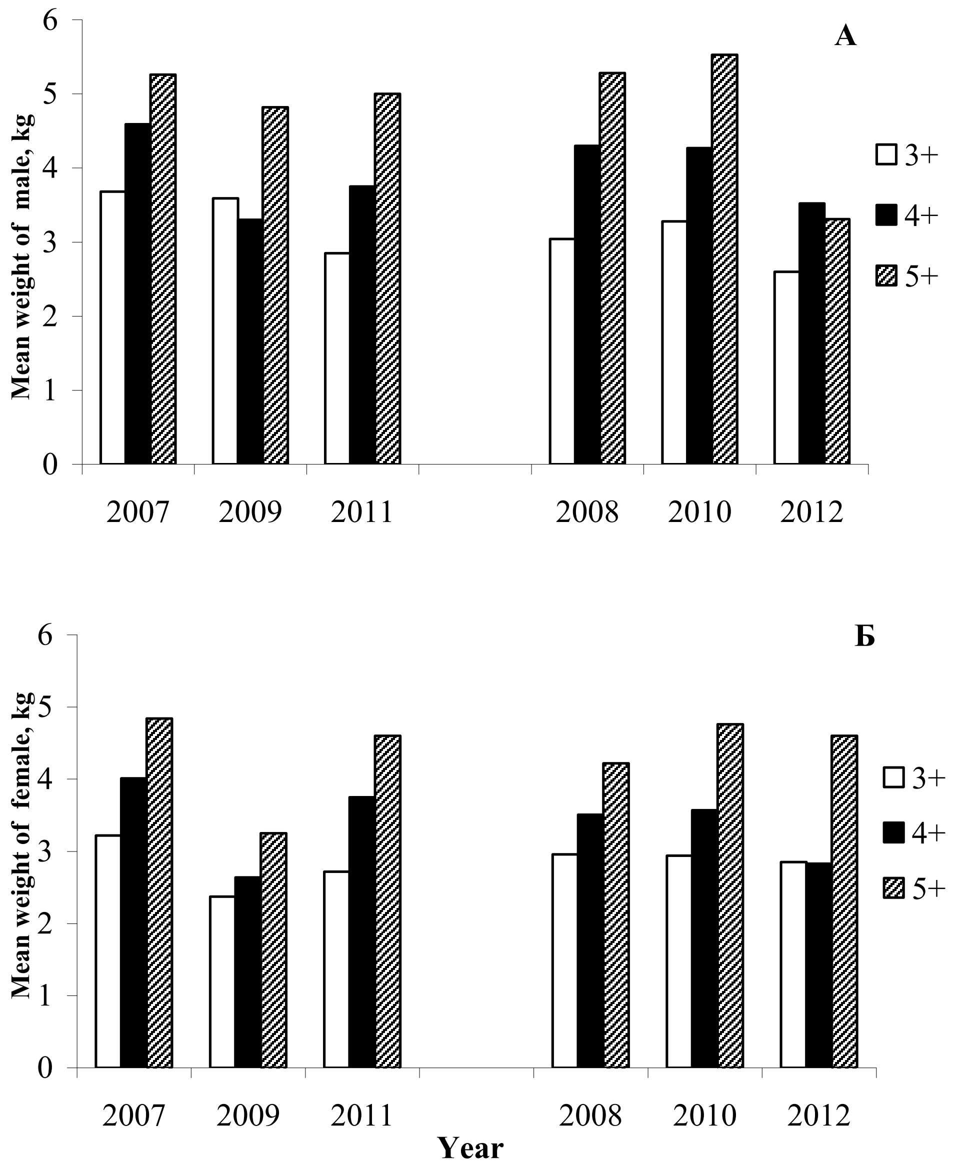


Fig. 4. Average weight of Chum salmon males (A) and females (B) of the age 3 +, 4 + and 5 + in Apuka River and the Olutorsky Bay in 2007-2012

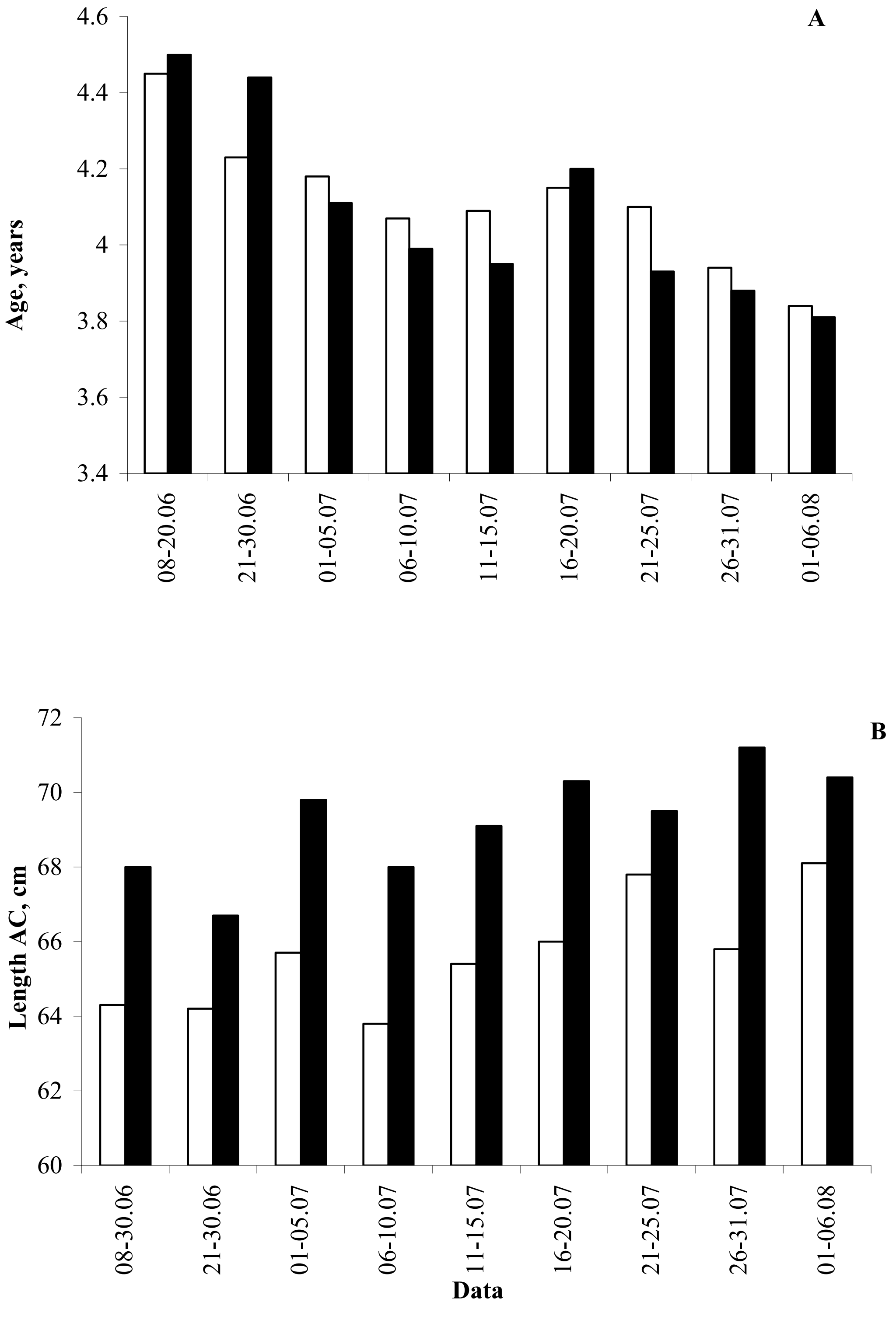


Fig. 5. Seasonal dynamics of Chum salmon mean age (A) and length (B) in Apuka River and Olutorsky Bay in 2010 (white columns - females; black - males)

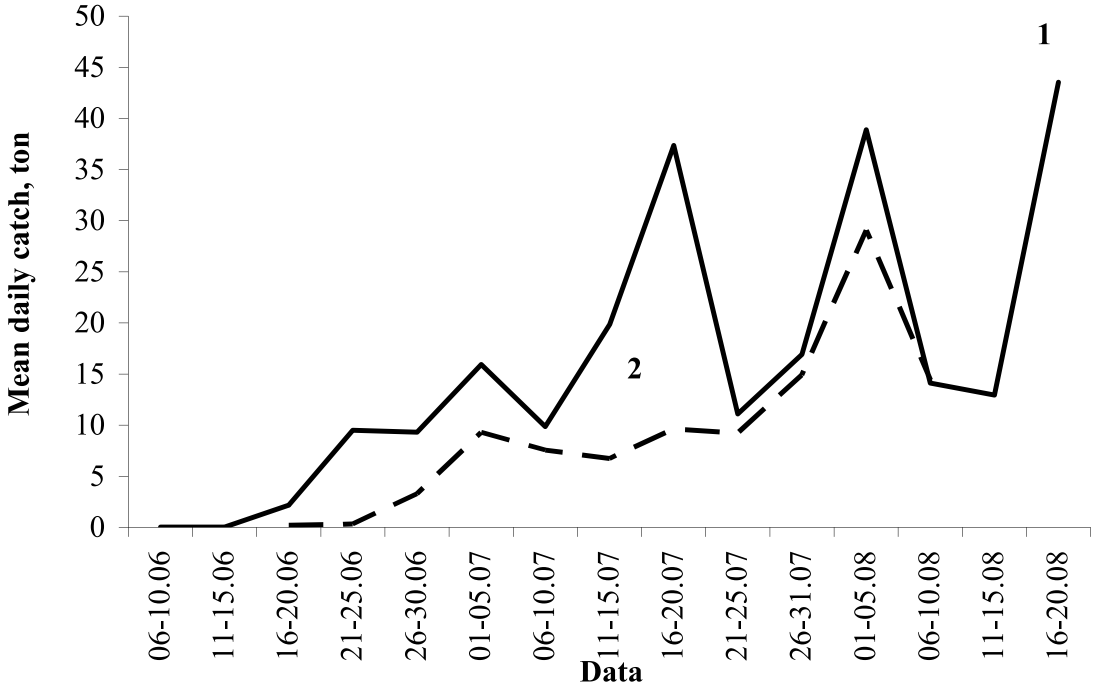


Fig. 6. Dynamics of chum salmon daily catch in the Olutorsky Bay and Apuka River in 2010 (1) and 2011 (2).

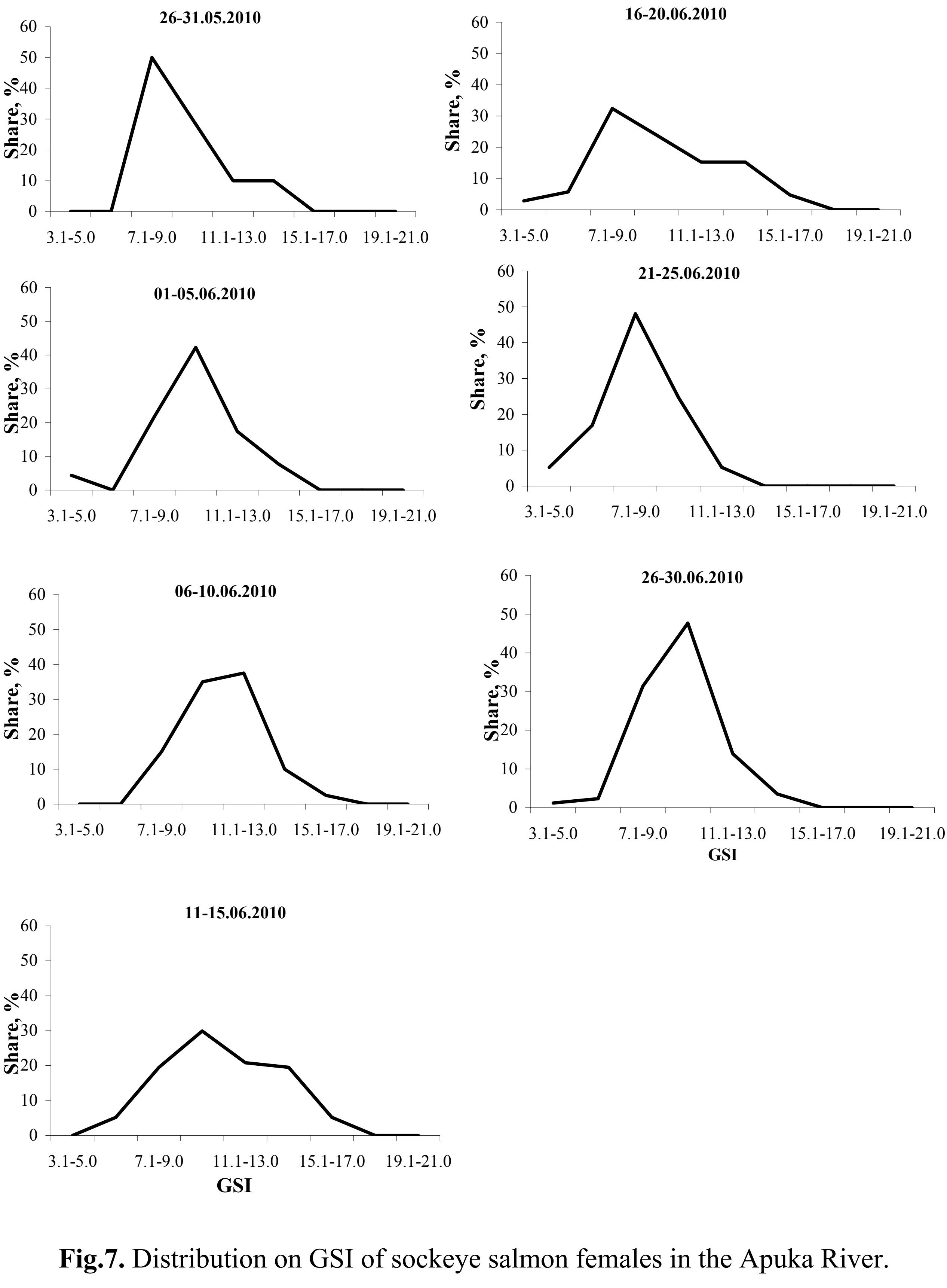
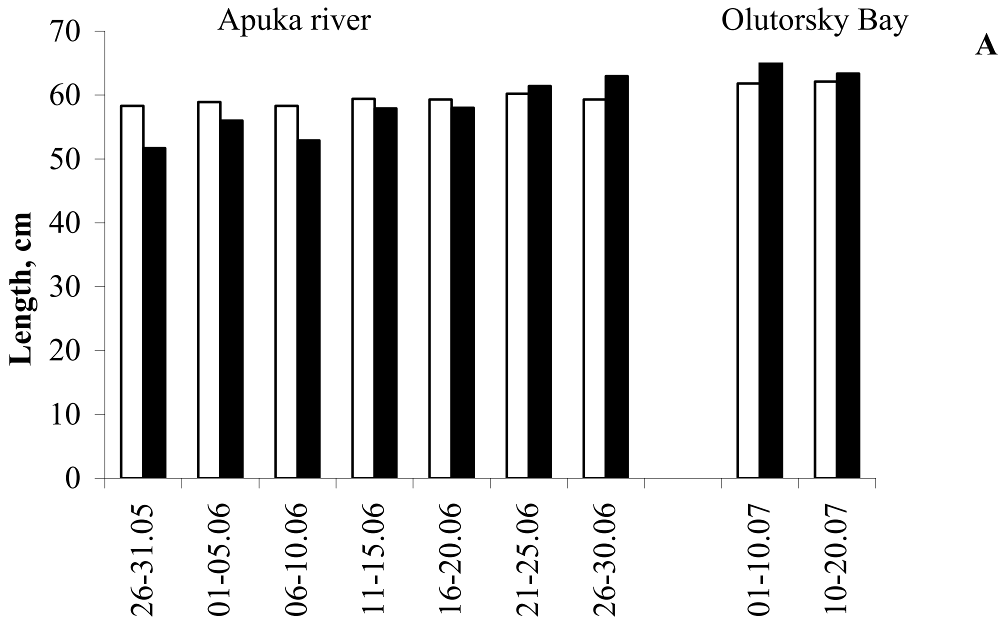


Fig.7. Distribution on GSI of sockeye salmon females in the Apuka River.



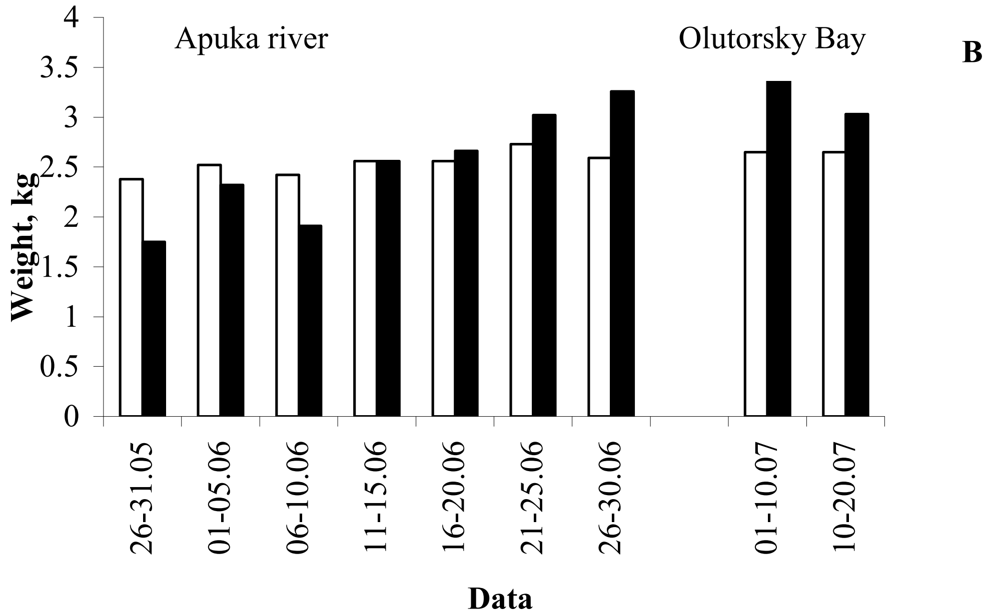


Fig. 8. Length (A) and weight (B) for Apuka river and Olutorsky Bay Sockeye salmon in 2010.

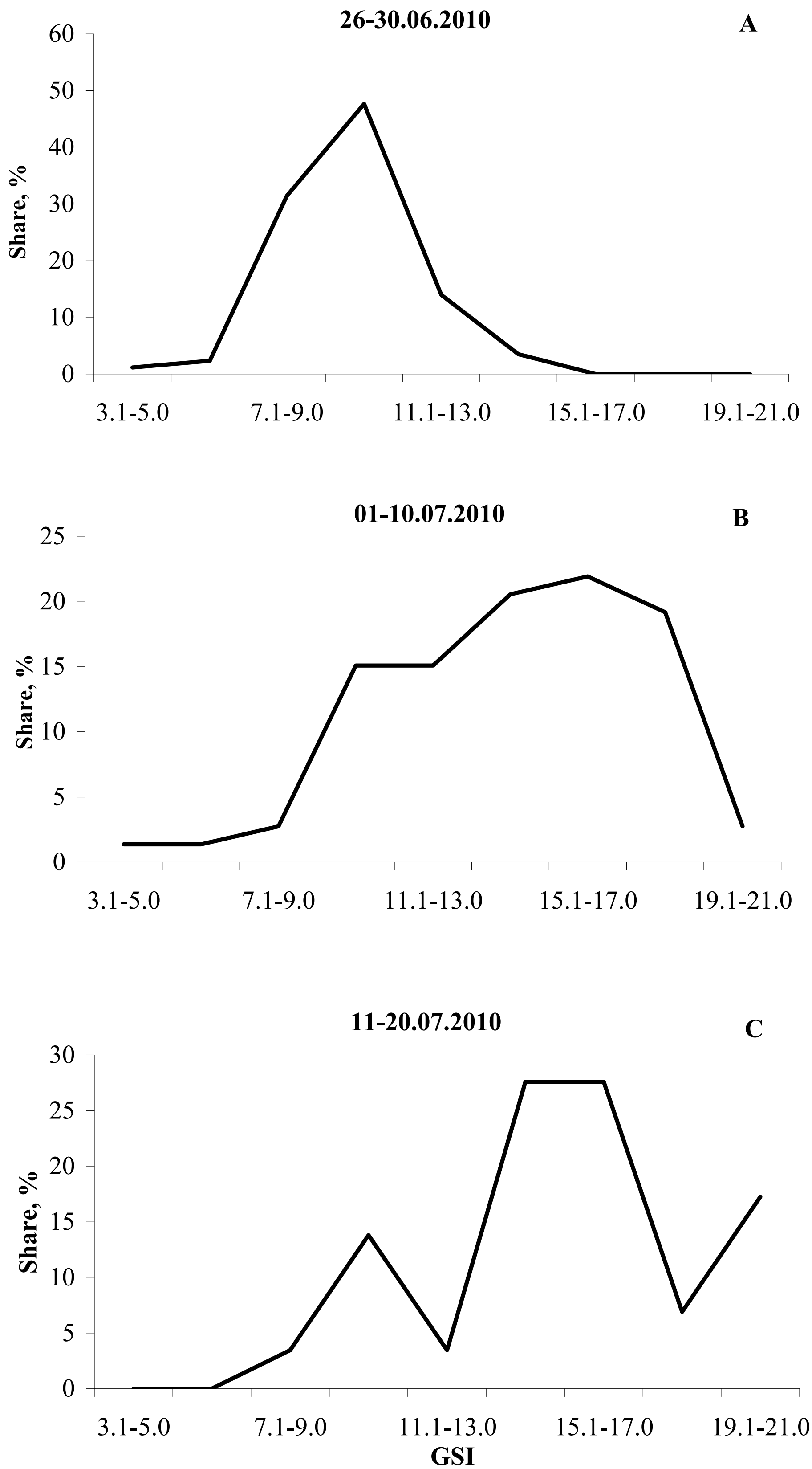


Fig. 9. Distribution of GSI of sockeye salmon females in the Apuka River (A) and in the Olutorsky Bay (B, C).

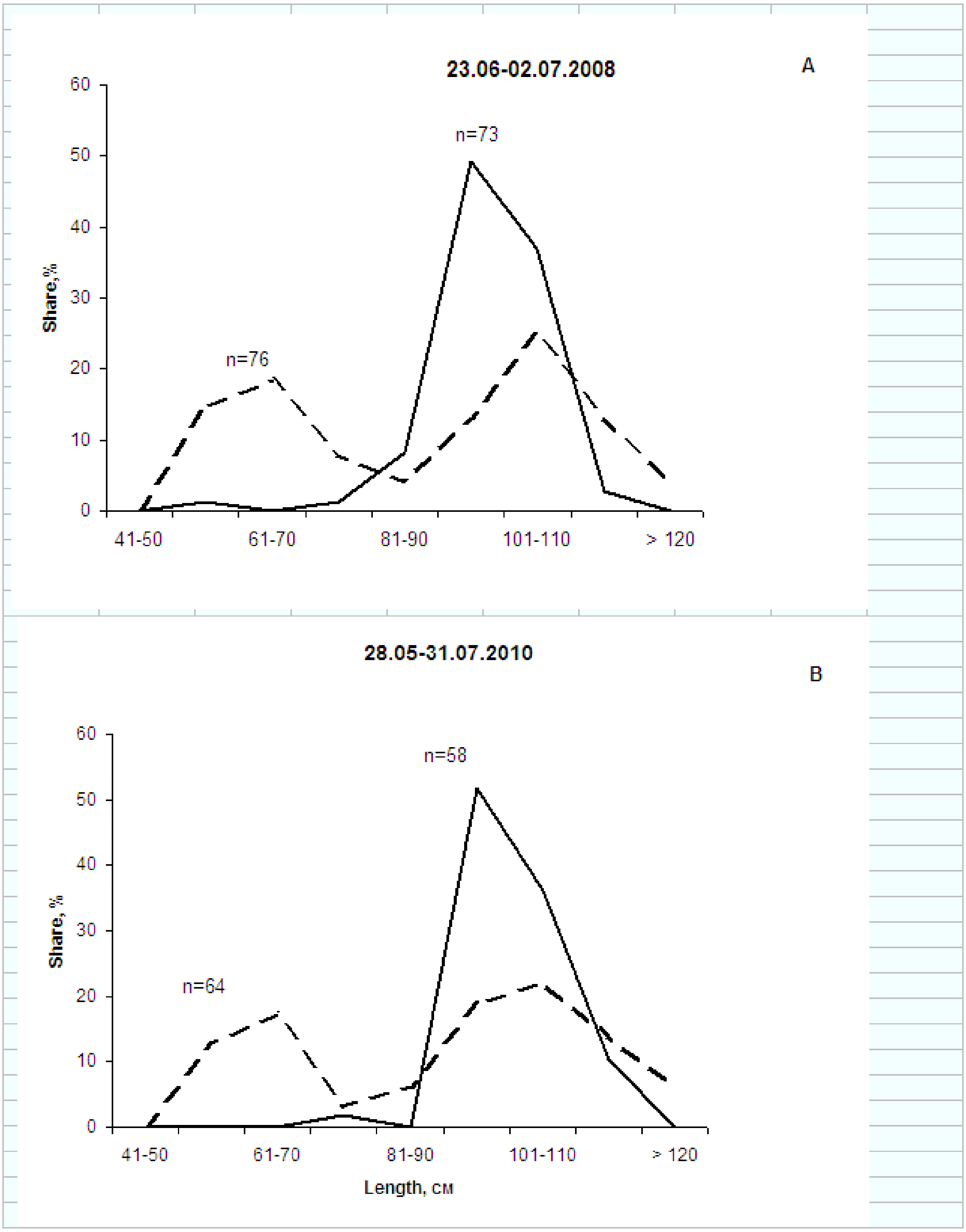


Fig.10. Distribution of length of males (continuous line) and females (dashed line) of chinook salmon in 2008 (A) and 2010 (B)

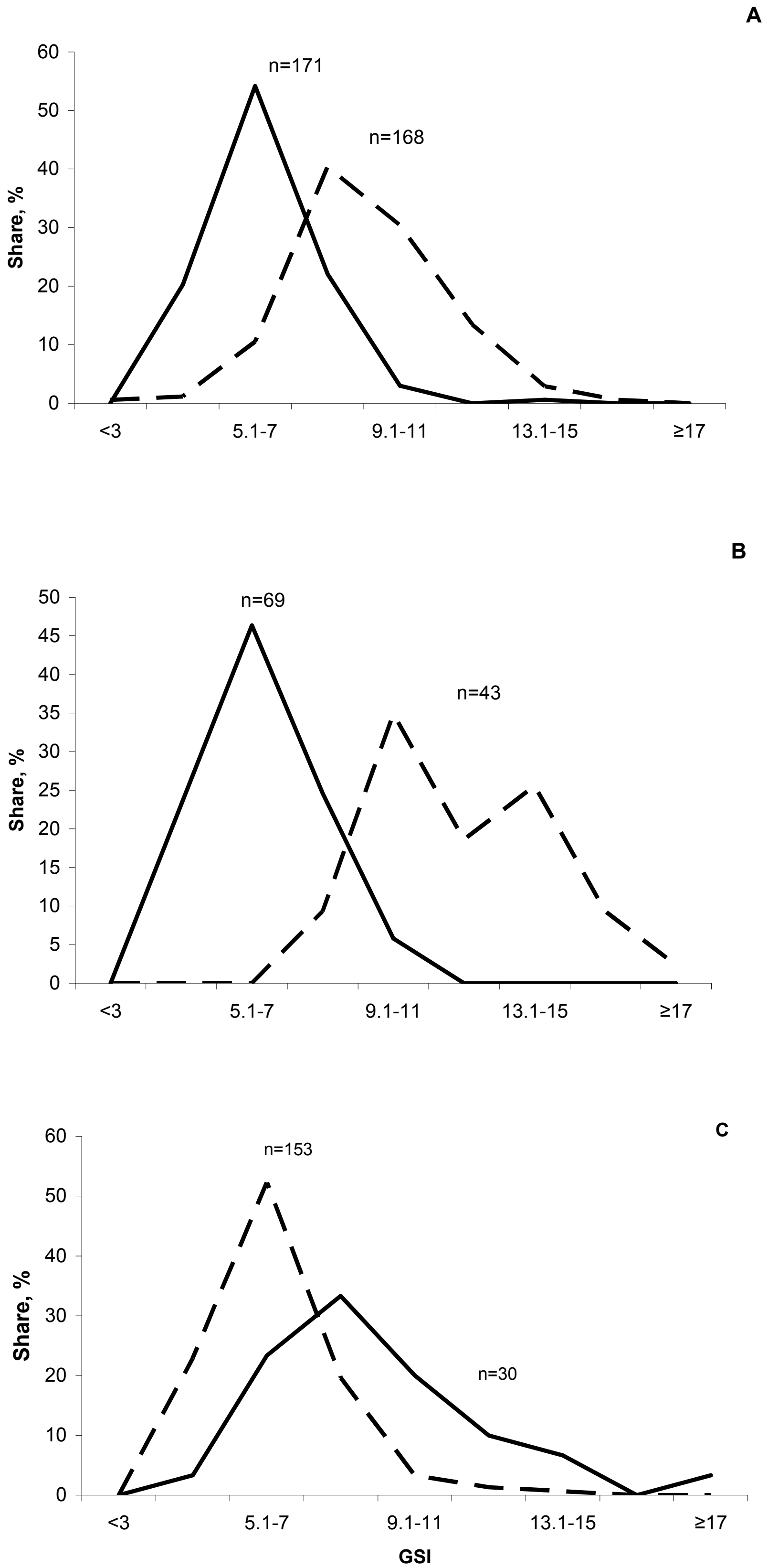


Fig.11. Distribution of GSI of chinook salmon males in the length ≤70 cm (continuous line) and > 70 cm (dashed line) in 2008 (A), 2010 (B), 2011 (C).

Table 1. Biological indices of Olutorsky Bay adult pink salmon in 2007-2012

Year	Sex	Biological indicators				N, ind.
		L (AC), cm	Weight, kg	GSI	Condition factor	
2007	female	47,92 ± 0,18 39,00 – 61,00	1,38 ± 0,01 0,70 – 2,24	14,74 ± 0,16 6,34 – 21,74	1,02 ± 0,007 0,51 – 1,55	250
	male	51,10 ± 0,29 42,00 – 62,00	1,76 ± 0,03 0,78 – 3,06	9,59 ± 0,16 4,35 – 17,71	1,11 ± 0,009 0,69 – 2,10	200
2008	female	45,26 ± 0,12 39,10 – 57,00	1,16 ± 0,009 0,63 – 2,27	15,10 ± 0,18 7,69 – 23,60	1,00 ± 0,004 0,78 – 1,16	291
	male	48,47 ± 0,12 41,20 – 56,30	1,50 ± 0,01 0,82 – 2,25	9,81 ± 0,10 5,19 – 15,57	1,11 ± 0,004 0,85 – 1,43	309
2009	female	45,91 ± 0,36 40,10 – 51,50	1,19 ± 0,03 0,71 – 1,68	15,03 ± ,0,43 9,57 – 20,85	1,00 ± 0,009 0,70 – 1,10	51
	male	46,70 ± 0,53 38,20 – 54,10	1,30 ± 0,04 0,72 – 1,97	9,05 ± 0,31 2,73 – 13,00	1,03 ± 0,012 0,89 – 1,28	48
2010	female	46,20 ± 0,14 39,50 – 51,50	1,12 ± 0,012 0,60 – 1,90	15,35 ± 0,23 4,89 – 24,50	0,92 ± 0,005 0,75 – 1,75	219
	male	49,60 ± 0,20 39,60 – 59,50	1,49 ± 0,02 0,67 – 2,59	9,88 ± 0,13 4,63 – 15,14	1,03 ± 0,005 0,75 – 1,32	259
2011	female	45,40 ± 0,14 39,00 -53,50	1,02 ± 0,01 0,55 – 1,64	16,75 ± 0,18 5,46 – 25,07	0,83 ± 0,004 0,63 – 1,00	294
	male	47,40 ± 0,20 38,00 – 57,30	1,16 ± 0,02 0,49 – 1,97	10,39 ± 0,14 1,03 – 22,62	0,92 ± 0,005 0,51 – 1,71	306
2012	female	45,87 ± 0,19 41,00 – 53,00	1,14 ± 0,02 0,82 – 1,66	-	-	104
	male	47,82 ± 0,45 41,00 – 56,00	1,37 ± 0,04 0,77 – 2,09	-	-	58

Table 2. Biological indices of Olutorsky Bay and Apuka river adult chum salmon in 2007-2012

Year	Sex	Biological indicators				N, ind.
		L (AC), cm	Weight, kg	Average age	GSI	
Apuka river						
2008	female	66,33 ± 0,26 71,0 – 55,0	3,42 ± 0,05 4,90 – 1,93	4,11	15,85± 0,27 7,85–28,00	166
	male	65,91± 0,38 77,0 – 57,0	3,98 ± 0,08 7,14 – 2,28	4,02	7,07 ± 0,14 3,02–13,94	134
2010	female	64,40±0,74 60,0–68,3	3,37±0,15 2,30–4,21	4,35	11,44±0,70 5,15–15,25	17
	male	68,00±1,30 59,0–73,0	4,28±0,29 2,52–5,29	4,50	7,14±0,56 3,66–9,79	12
2011	female	66,70±0,74 60,0–70,7	3,46±1,22 2,80–4,23	3,71	13,70±0,63 10,15–18,55	14
	male	69,52±1,91 59,0–80,0	4,33±2,91 3,11–5,82	4,30	6,66±0,49 4,27–9,11	10
Olutorsky Bay						
2007	female	61,85 ± 0,24 53,0 – 71,0	3,22 ± 0,04 1,86 – 4,84	3,12	12,44 ± 0,16 6,73 – 29,29	218
	male	65,65 ± 0,21 55,0 – 74,0	4,00 ± 0,04 2,27 – 5,97	3,49	7,27 ± 0,08 2,92 – 13,38	332
2008	female	63,00±0,18 73,0 – 52,0	3,31± 0,03 1,65–5,72	4,06	14,99 ± 0,15 6,32–26,23	432
	male	66,30 ± 0,22 77,0 – 49,0	4,16 ± 0,05 1,33–7,13	4,06	6,93 ± 0,08 2,31–17,74	468
2009	female	61,20± 0,40 55,0 – 68,0	3,10 ± 0,06 2,23 – 4,64	3,58	13,06 ± 0,35 8,18 - 19,86	62
	male	65,82 ± 0,62 58,0 – 77,0	4,20 ± 0,13 2,67 – 6,94	3,92	7,24 ± 0,26 3,16 – 11,62	38
2010	female	66,00 ± 0,21 52,5 – 76,0	3,61 ± 0,03 1,63 - 5,86	3,79	13,88 ± 0,14 5,15 – 22,62	305
	male	70,00 ± 0,23 56,00 – 84,50	4,49 ± 0,04 1,98 – 7,73	4,16	7,07 ± 0,09 2,07 – 15,93	319
2011	female	65,20 ± 0,23 53,50 – 75,40	3,14 ± 0,03 1,66 – 4,98	3,48	15,40 ± 0,17 6,32 – 30,63	369
	male	68,90 ± 0,30 52,30 – 83,00	3,88 ± 0,01 1,52 – 7,39	4,07	7,22 ± 0,08 2,09 – 12,03	339
2012	female	60,72 ± 0,32 55,00 – 66,50	2,91 ± 0,06 2,05 – 4,01	4,07	-	68
	male	63,77 ± 0,46 50,50 – 73,00	3,48 ± 0,07 1,62 – 5,14	3,98	-	66

Table 3. Age composition of chum salmon catches in the Olutorsky Bay in 2007-2012

Year	Percent of different age fishes					N, ind.
	2+	3+	4+	5+	6+	
2007	5,0	61,0	27,6	6,4	-	250
2008	-	14,5	73,0	12,5	-	600
2009	-	36,0	57,0	7,0	-	100
2010	0,1	20,9	68,8	10,2	-	723
2011	2,5	37,2	41,7	18,3	0,3	399
2012	-	6,0	85,0	9,0	-	100

Table 4. Biological indices of Olutorsky Bay and Apuka river adult sockeye salmon in 2007-2011

Year	Sex	Biological indicators					N, ind.
		L (AC), cm	Weight, kg	Average age	GSI	L (AC), cm	
Apuka river							
2008	female	58,08 ± 0,21 51,00 – 56,00	2,74 ± 0,03 1,62 – 3,65	3.88	10,22 ± 0,29 5,45 – 19,14	1,20 ± 0,009 0,94 – 1,41	141
	male	59,57 ± 0,59 47,00 – 71,00	3,03 ± 0,09 1,16 – 4,95	3.70	3,67 ± 0,11 1,53 – 8,25	1,28 ± 0,009 0,98 – 1,50	108
2010	female	59,20 ± 0,13 51,00 – 67,50	2,56 ± 0,02 1,66 – 3,44	3.77	10,10 ± 0,14 3,64 – 18,06	1,06 ± 0,005 0,52 – 1,94	312
	male	56,6 ± 0,42 44,00 – 75,5	2,42 ± 0,05 1,04 – 5,64	3.51	4,16 ± 0,07 1,12 – 10,13	1,15 ± 0,007 0,87 – 1,95	363
2011	female	58,50 ± 0,16 30,50 – 67,00	2,41 ± 0,01 1,23 – 3,89	3.91	11,42 ± 0,12 2,79 – 20,71	1,07 ± 0,022 0,78 – 6,64	565
	male	60,10 ± 0,31 36,60 – 75,00	2,70 ± 0,04 1,05 – 4,90	3.66	3,91 ± 0,08 1,01 – 15,85	1,13 ± 0,017 0,58 – 5,51	534
Olutorsky Bay							
2007	female	59,52 ± 2,26 53,00 – 65,00	3,01 ± 0,04 2,17 – 4,08	4.12	10,61 ± 0,24 5,80 – 18,17	1,23 ± 0,010 0,94 – 1,48	72
	male	62,45 ± 1,05 36,00 – 70,00	3,55 ± 0,14 0,65 – 5,12	4.05	3,94 ± 0,32 2,14 – 10,90	1,30±0,024 0,99 – 2,08	40
2008	female	56,95 ± 0,21 50,00 – 63,00	2,46 ± 0,03 1,61 – 3,62	3.75	12,39 ± 0,28 6,04 – 20,39	1,12 ± 0,008 0,90 – 1,38	152
	male	59,97 ± 0,58 45,00 – 70,00	2,99 ± 0,09 1,21 – 4,64	3.64	3,65 ± 0,14 1,45 – 8,33	1,24 ± 0,013 0,65 – 1,58	98
2009	female	57,55 ± 0,42 50,00 – 63,50	2,56 ± 0,06 1,52 – 3,33	3.79	10,82 ± 0,31 5,74 – 16,60	1,12 ± 0,012 0,97 – 1,28	54
	male	62,51 ± 0,87 51,5 – 69,00	3,33 ± 0,13 1,66 – 4,31	3.76	4,08 ± 0,34 1,15 – 8,50	1,20 ± 0,020 0,97 – 1,44	26
2010	female	60,70 ± 0,19 51,00 – 69,80	2,64 ± 0,03 1,60 – 3,96	3.96	11,64 ± 0,26 1,26 – 22,07	1,01 ± 0,007 0,66 – 1,33	215
	male	64,10 ± 0,62 49,00 – 74,30	3,29 ± 0,09 1,35 – 5,49	4.0	3,66 ± 0,14 1,12 – 7,82	1,11 ± 0,010 0,88 – 1,37	110
2011	female	61,50 ± 0,33 51,00 – 69,50	2,51 ± 0,04 1,59 – 3,62	-	12,70 ± 0,30 5,18 – 23,53	0,90 ± 0,010 0,70 – 1,42	104
	male	65,5 ± 0,72 48,20 – 72,20	3,12 ± 0,10 1,14 – 4,07	-	3,87 ± 0,41 1,75 – 18,95	1,00 ± 0,012 0,80 – 1,15	48

Table 5. Biological indices of Apuka river and Olutorsky Bay chinook salmon in 2007, 2008 and 2010 – 2011.

Year	Sex	Indicators					N, ind.
		Length (AC), cm	Weight, kg	Mean age	GSI	Condition factor	
2007	female	95,32 ± 0,13 84,00 – 111,00	12,24 ± 0,38 8,63 – 16,50	4.11	17,36 ± 0,63 6,40 – 24,87	1,13 ± 0,015 0,99 – 1,35	34
	male	92,41 ± 2,48 47,00 – 115,00	11,24 ± 0,66 1,48 – 17,30	3.94	6,18 ± 0,27 3,02 – 10,14	1,20 ± 0,016 0,99 – 1,41	37
2008	female	98,01 ± 0,55 60,00 – 113,00	13,59 ± 0,22 3,32 – 19,98	4.86	17,24 ± 0,25 8,70 – 28,31	1,16 ± 0,009 0,92 – 2,17	161
	male	79,00 ± 1,23 40,00 – 124,00	8,86 ± 0,36 1,01 – 25,31	3.18	7,64 ± 0,12 2,54 – 15,96	1,28 ± 0,005 1,04 – 1,74	339
2010	female	100,20 ± 0,76 74,50 – 113,50	12,83 ± 0,28 5,74 – 18,72	4.66	18,41 ± 0,40 7,91 – 29,15	1,01 ± 0,008 0,83 – 1,27	90
	male	86,80 ± 2,09 51,00 – 126,00	9,75 ± 0,58 1,68 – 24,00	3.80	7,60 ± 0,24 2,88 – 18,82	1,13 ± 0,009 0,91 – 1,95	120
2011	female	98,90 ± 0,57 90,50 – 118,20	12,52 ± 0,23 8,16 – 19,16	4.64	16,74 ± 0,32 10,26 – 26,10	1,04 ± 0,008 0,82 – 1,26	89
	male	93,40 ± 1,43 41,50 – 123,80	11,30 ± 0,42 0,93 – 21,50	4.08	6,69 ± 0,16 3,09 – 18,05	1,11 ± 0,006 0,90 – 1,56	183

Table 6. Age structure of Apuka river and Olutorsky Bay Chinook salmon in 2007-2008 and 2010-2011.

Year	Sex	Indicators													N, ind.
		Percent of different age fishes													
		0.3+	0.4+	0.5+	1.1+	1.2+	1.3+	1.4+	1.5+	1.6+	2.1+	2.2+	2.3+	2.4+	
2007	female	-	-	-	-	-	88,2	11,8	-	-	-	-	-	-	34
	male	-	-	-	2,7	13,5	70,3	13,5	-	-	-	-	-	-	37
2008	female	-	1,2	2,5	-	0,6	29,2	47,8	16,2	-	-	-	0,6	1,9	161
	male	0,3	-	0,6	2,7	42,6	20,5	14,5	15,4	0,9	-	0,3	0,6	1,5	331
2010	female	-	-	-	-	1,1	55,1	34,8	5,6	-	-	1,1	-	2,2	89
	male	-	-	-	5,8	31,4	48,8	9,9	4,1	-	-	-	-	-	121
2011	female	-	-	-	-	-	40,0	53,8	4,6	-	-	-	1,5	-	65
	male	-	-	-	0,7	18,5	52,6	22,2	3,0	-	1,5	-	0,7	0,7	135