NPAFC
Doc. 977
Rev. ___

Reproduction indices of the Iturup Island pink salmon (Kuril Islands)

by

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Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by the

Russia

October 2006

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Kaev, A.M., V.M. Chupakhin, and M.Y. Kruchinin. 2006. Reproduction indices of the Iturup Island pink salmon (Kuril Islands). (NPAFC Doc. 977). 18 p. Sakhalin Research Institute of Fisheries @ Oceanography (SakhNIRO), Russia, Yuzhno-Sakhalinsk.

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ABSTRACT

Presented are the long-term data on pink salmon abundance on spawning grounds, wild and hatchery-reared downstream juvenile migrants, and their return. Numbers of returning pink salmon were less dependent on the numbers of downstream migrants from rivers than on further survival of these generations during marine life period. We suggest that changes in pink salmon abundance were mainly dependent on habitat conditions for juveniles in the coastal zone, whereas the biomass changes were dependent on habitat conditions in the open waters. There is shown that the long-term trends of changes in pink salmon body sizes do not conform to conception of the density-dependent regulation.

INTRODUCTION

Pink salmon are widely distributed over the rivers on the Okhotsk Sea coast; however, the base of their biomass in this area is formed by several stocks. One of them is a south-Kuril stock, which composes approximately 27% of Russian commercial catches of pink salmon in the Okhotsk Sea. Moreover, 90% of this stock supply is formed due to spawning and artificial propagation of pink salmon in the Iturup Island's rivers. The first Russian data containing the timing of pink salmon prespawning migration to rivers of this island and biological indices of fish were obtained in the second half of the 1940s (Vedensky 1949). In the 1950s, the first quantitative identifications of pink salmon stock abundance were made (Pavlov 1954). In the 1960s, based on knowledge of peculiarities in migration dynamics and biological indices, it was shown that pink salmon have an intraspecific structure coherent with the ability of this species to form local populations and seasonal forms. (Ivankov 1967a,b). This researcher (Ivankov 1968) reported about the peculiarities of pink salmon reproduction in the Iturup Island's rivers. However, the routine annual studying of abundance and biological characteristics of pink salmon has started since 1967 (Chupakhin 1973a, 1975). We have systematized and unified the materials, collected during those years, in such a way that the data used to analyze the interannual changes in the indices studied were obtained using similar methods in all years of observation. This report presents characteristics of the Iturup pink salmon reproduction, which were obtained based on these data.

MATERIALS AND METHODS

Analysis of pink salmon abundance and biological indices is based on about a 40-year period of observations.

The number of adult returns from the corresponding generations was determined as a sum of individuals caught during the commercial fishing and at the fish weir, and those passed to rivers for spawning. Every year, the SakhNIRO (researching institution) and "Sakhalinrybvod" (controlling institution) staff determined spawners abundance in 10-12 rivers in different regions of the island by the method of visual fish counting on individual sites of spawning grounds and further recalculating the data per a total spawning area in a definite river. This list (Okhotsk Sea coast from south toward north) includes the rivers with the following spawning areas:

Osenniaya	15000 m^2	Reidovaya	34200 m^2
Kuibyshevka	107000 m^2	Chistaya	11500 m^2
Saratovka	6500 m^2	Skalniy	7900 m^2
Rybatskaya	12000 m^2	Glush	15000 m^2
Kurilka	117000 m^2	Slavnaya	196000 m^2
Olya	17500 m^2	Medvezhiya	12000 m^2

Numbers of pink salmon in other rivers were calculated based on the ratio between the spawning areas and the average number of fish per 1 m^2 in baseline rivers.

During the study period, the abundance of wild pink fry migrants has been calculated by the method of sample fishing using a fyke net (Volovik 1967) in the Olya River at the fish count site of "Sakhalinrybvod". In addition, SakhNIRO had counted migrants in 1974-1979 in the Kurilka River, and since 1980 in the Rybatskaya River, using the same method of sample fishing modified with regard to small Kuril rivers (Kaev, 1989). The likely number of wild migrants in other rivers was calculated based on the pink salmon entries to spawning grounds and the average number of fry migrants from one female in the control rivers. The data on the hatchery-reared fry were taken from the "Sakhalinrybvod" statistical reports on fry release from hatcheries.

According to these data, both the downstream migration's coefficient (a ratio of number of wild fry migrants to the total fecundity of females entering the river for spawning) and the survival index of pink salmon during the marine life period (percent of returned adults to the total number of fry migrants from the corresponding generations) were calculated.

In order to describe interannual changes, biological analyses were done for fishes from the trap-net commercial catches. Biological analysis included determination of standard body length and weight, sex, stage of maturity and gonads weight, and fecundity of 25-30 females from the sample. Usually one sample consisted of 100 fish. A total of 27509 individuals (267 samples) were analyzed in 1967-2005.

We used standard statistical methods (Plokhinsky 1970). The following symbols are used in the text: *M* – mean, *SD* – standard deviation, *R* – coefficient of correlation, *P* – statistical significance, *N* – sample size.

RESULTS

Iturup Island (Fig. 1) is the largest island in the Kuril Archipelago. Its length is 196 km and area is 6725 km^2. The mountain relief, a lot of precipitation along with the relatively little losses of moisture for vaporization and infiltration facilitate a development of the thick river net. There are about 200 rivers and streams on the island, including tributaries of the first and, fewer, of the second order in the basins of the relatively large rivers and lakes' tributaries. In general, the rivers are small and most of them belong to the mountain type. As a rule, only the largest rivers are frozen in winter at the lower stream with slow current.

Pink salmon spawn almost in all water bodies of the island, except for those with acidic water and streams ending in waterfalls. Directly from the sea, they enter 54 rivers. Of them, only three rivers are over 20 km long; six rivers are from 11 to 20 km long; and the rest are referred to small rivers and streams. A spawning fund of pink salmon is distributed unevenly: 82.2% of spawning grounds (600,000 m^2) are concentrated in the island's rivers on the Okhotsk Sea coast. The rest spawning grounds are spread out in 23 rivers on the Pacific Ocean coast, where the fishery is not conducted because of the low pink salmon stock abundance. So, all the data on pink salmon abundance and biological characteristics are given for the Okhotsk Sea coast from Cape Kabara to Cape Prishvin.

On the Okhotsk Sea coast there is also a large-scale artificial propagation of this species, mainly in rivers flowing into the bays Kuril and Prostor. That is why it is not surprising that 95% of the total pink salmon catches occur in central and northern parts of the Okhotsk Sea coast of the island (Table 1).

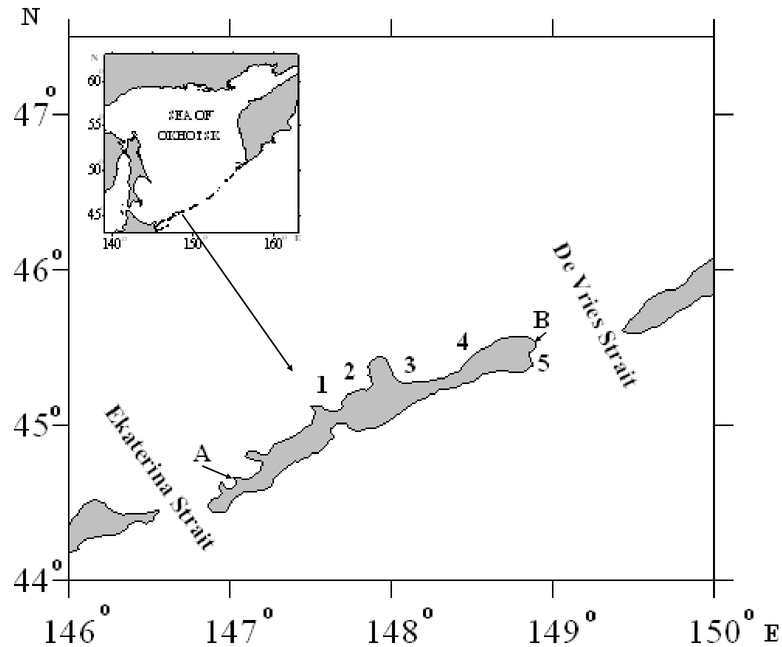


Fig. 1. Iturup Island – study regions of pink salmon.
A– Cape Kabara,
B– Cape Prishvin;
1– Kuibyshev Bay,
2– Kuril Bay,
3– Prostor Bay,
4– Tornaya Bight,
5– Medvezhiya Bight.

Table 1. Pink salmon catches at the individual sites of the Iturup Island coast in 2001-2005

Area	Catch, t				
	2001	2002	2003	2004	2005
Northern coast*	5089	7118	1936	7634	3532
Prostor Bay	5242	11367	2527	7866	5918
Kuril Bay	8825	10525	7348	11578	14123
Kuibyshev Bay	1307	1244	2046	2600	3368
The rest coast	617	1746	2423	1866	2549

*from Tornaya Bight to Medvezhiya Bight

Such distribution of catches occurs also due to the productive peculiarities of the sea coastal waters. Mainly, they are formed under the influence of anticyclonic circulation of waters, which temperature and salinity have resulted from the interaction of the warm Soya Current (branch of Tsushima Current) and cold Oyashio Current. Warm and saline waters of the Soya Current are transported round the northern coast of Hokkaido to the Okhotsk Sea. Then they are carried out to the ocean through Ekaterina Strait along the Kunashir Island. A cold-water stream close by temperature and salinity to the Oyashio Current comes to the Okhotsk Sea along the Iturup Island coast through the same strait but in opposite direction. At the same time part of the Soya Current moves to the Okhotsk Sea in the northeastern direction round the Iturup Island. It is carried out to the ocean through the western part of De Vries Strait. The warming effect of this current is manifested mainly on the areas of the bays Kuibyshev, Kuril, Prostor and further along the coast to De Vries Strait. Just in this area the relatively dense and almost unchangeable by years zooplankton aggregations (food for juvenile salmon) have been observed (Kaev, 2003).

Coincidence of the most “harvest” fishing sites with the basic pink salmon reproductive areas allows us to suggest that a stock of pink salmon in the island’s waters is formed due to the local populations. This is completely supported by the results of tagging adults in coastal waters along the northern extremity of the island. Tagged fish were recaptured only in bays and rivers of the Iturup Island (Ivankov 1967a, 1968; Chupakhin 1973b). High straying between the Sakhalin and Iturup pink salmon groups revealed during tagging of the hatchery-reared fry by means of amputating some fins and subsequent recoveries of returning adults (Rukhlov and Lyubaeva 1980) were not proved when studying in detail primary materials (Kaev and Chupakhin 2003; Kaev and Antonov 2005).

The annual catch of pink salmon varied in 1967-2005 from 2398 to 37250 tons (83-94%), averaged 17278 tons (89.7% of the total biomass of returns) a year. That is, in different years a size of catches reflected changes in the total Iturup pink salmon stock ($R=0.999$; $P<0.001$; $N=37$). On the average, pink salmon capture during the whole observation period was almost the same in the odd years (from 3200 to 31430, average - 16980 t) as in the even years (from 2398 to 37250, average - 17592 t). However, a ratio between catches in the even and odd years varied significantly in some periods (Fig. 2). Thus, prior the 1980s, the interannual changes were not great. However, in 1982-1991, catches were almost two times as high in the odd years (average - 22316 t) than in the even years (average - 10398 t). After its decline in the beginning of the 1980s, a stock of the pink salmon even-year-classes had not only been gradually restored by 1992, but continued to increase during the following years. In contrast, the odd-year-classes stock after its maximum in 1985 had tended to decrease. As a result, a change in the dominating lines took place in the first half of the 1990s, being particularly produced by the abrupt decline in pink salmon stock abundance in 1993. In

1992–2004, catches in the even years (average - 28345 t) exceeded those in the odd years (average - 18217 t) more than 1.5 times. A significant increase in pink salmon stock abundance in 2005 may lead to recurrent change in the dominant lines.

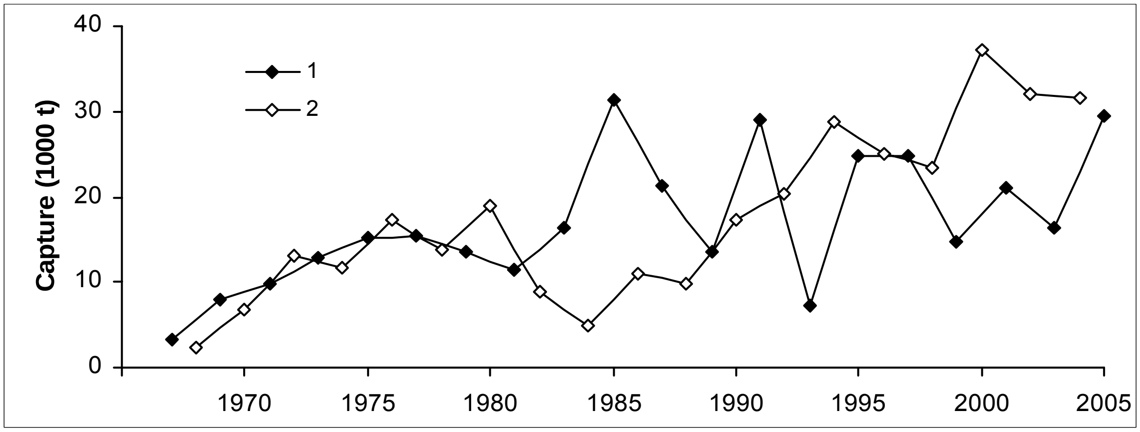


Fig. 2. Dynamics of pink salmon catches in Iturup Island waters in 1967–2005
1 – odd years, 2 – even years.

Mainly, trap nets are used in pink salmon fishery; additionally, fish weirs and beach seines are used at the estuarine sites of some rivers (Kurilka, Reidovaya, Slavnaya and others). Usually a fishing season continues for about two months and a half. The escapement timing of pink salmon was not similar in different years; however, definite tendencies have been found in its changes. The middle time of fishing period has changed in dates proving that until the mid 1970s the escapement timing of the main bulk of pink salmon was gradually shifted for the later dates; during the following 10 years there has been an insignificant variation. In the second half of the 1980s, a small shift for the earlier dates was observed in escapement timing of the fish bulk. However, in 1990-1991 there was recorded an abrupt shift of the pink salmon main run for the later dates; but after that there appeared a relatively stable trend of shifting the main run of pink salmon for the earlier dates (Fig. 3). Perhaps, a recurrent cycle of these changes has started since 2005. Variation of dates in which pink salmon began to approach was higher (SD=7.40 for the date of reaching 1% of the catch and SD=7.14 for the date of reaching 5% of the catch of the summarized annual catch) than the dates of the end of approaches (respectively, 5.22 and 5.26 for the dates of reaching 95% and 99% of catch). This peculiarity is related to the proportion of pink salmon group with early spawning timing (decline or increase in total capture). Occurrence of two groups of pink salmon (early and late) in escapements of Iturup Island was reported in the first years of observation (Ivankov, 1967a) and proved later by the results of the annual analysis of this stock (Kaev, Chupakhin, 2003).

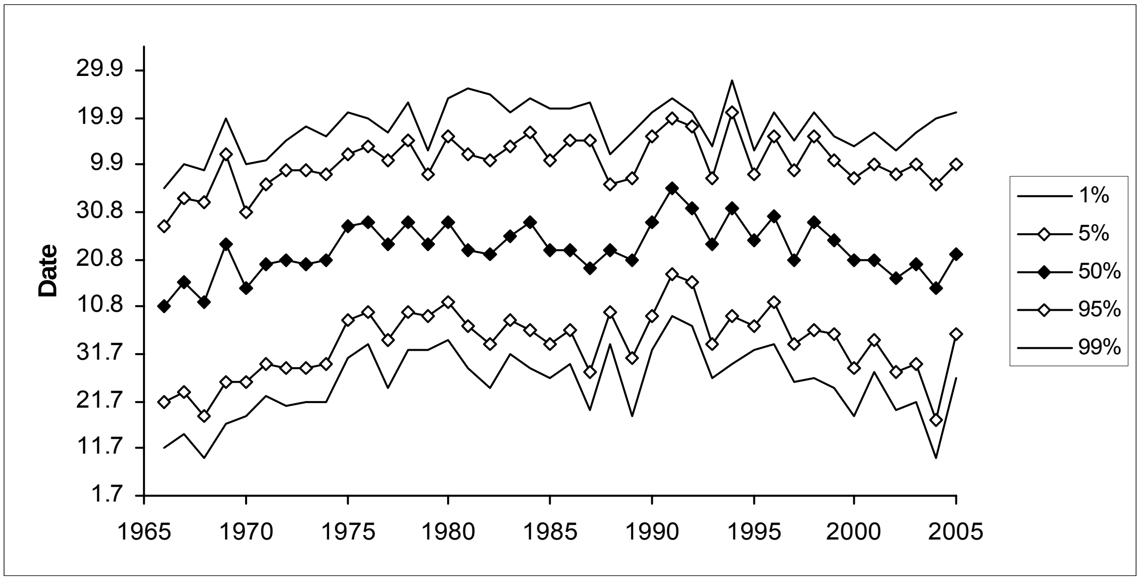


Fig. 3. Changes in escapement timing of the Iturup Island's pink salmon in 1966 – 2005 (dates of the 1, 5, 50, 95, and 99% increasing capture).

Pink salmon sampling regime was not unchangeable during the years of observation: in some years samples were more numerous in the first half of fish run and in other years in the second half. Since biological indices of pink salmon vary during the spawning run, only samples taken during their main run (between the dates when capture was growing from 20 to 80%) were used to describe a long-term dynamics of body length and weight and fecundity (Kaev, Chupakhin, 2003). As a result, 14990 fish from 145 samples (54% of samples taken) were analyzed. Fork length in different years was from 45,6 to 51,6 cm (Table 2), averaged 48,4 cm; weight from 1022 to 1724 g, averaged 1320 g; and female fecundity from 1202 to 1726 eggs, averaged 1445 eggs. On average, males (47.9 cm and 1287 g) were smaller than females (48.9 cm and 1356 g) during the years of observation.

During the observation period, from 0.845 to 2.467 million fish entered the rivers (Table 3). In years of low abundance, pink salmon entries declined, but not so significantly as catches. This positive effect was achieved due to fishery regulation. Coefficient of commercial capture (percent of caught fish of the total return) decreased in years when pink salmon were low-abundant (return < 10 million adults) to 82.6–

85.8%. On the contrary, in years with a high abundance of pink salmon (return > 20 million adults) this index increased to 90.3–94.0%.

The calculated number of wild pink salmon migrants in the Iturup Island's rivers constituted from 66 to 460 million individuals in different years (Table 3) or from 7.6 to 61.3% of the total female fecundity in the rivers. Additionally, there was a release of 62 to 215 million hatchery fry in different years. Thus, a total of 206 to 566 million fry have left the rivers during the observation period. The catch of returning adults totaled from 4.962 to 30.003 million individuals in different years. Taking into account the numbers of spawners entering the rivers, a total return of fish from the individual year-classes varied between 5.862 and 32.103 million individuals. Consequently, survival of fish from different year-classes (wild and hatchery-reared) constituted from 1.78 to 9.72% during the marine life period.

Table 2. Fork length, weight and fecundity of the Iturup Island's pink salmon in 1967–2005

Year	FL (cm)			Weight (g)			Fecundity (eggs)	N
	Male	Female	Total	Male	Female	Total		
1967	47.1	49.0	48.0	1221	1341	1277	1582	400
1968	51.2	51.9	51.6	1706	1744	1724	1726	200
1969	48.4	49.4	48.8	1351	1416	1375	1463	700
1970	51.3	51.6	51.5	1689	1731	1710	1662	300
1971	47.0	48.5	47.7	1191	1322	1250	1475	300
1972	49.6	50.2	49.9	1438	1532	1483	1520	399
1973	47.4	48.9	48.0	1230	1343	1282	1479	300
1974	48.9	51.0	49.8	1358	1501	1418	1391	400
1975	48.1	49.1	48.6	1238	1318	1278	1286	400
1976	47.1	48.6	47.9	1185	1314	1256	1357	400
1977	45.5	46.6	46.1	1124	1217	1173	1202	390
1978	46.6	48.3	47.4	1127	1263	1190	1296	400
1979	46.9	47.6	47.3	1140	1156	1149	1219	400
1980	47.1	47.8	47.5	1228	1273	1252	1282	600
1981	49.1	50.5	49.8	1220	1293	1256	1389	600
1982	47.8	49.1	48.4	1118	1225	1168	1389	400
1983	46.9	48.0	47.5	1130	1208	1170	1553	400
1984	44.3	46.8	45.6	934	1100	1022	1355	300
1985	45.8	46.8	46.4	1002	1081	1043	1359	300
1986	46.2	48.1	47.1	1127	1224	1171	1463	300
1987	47.4	47.7	47.6	1140	1129	1134	1393	300
1988	46.0	47.6	46.7	1103	1170	1133	1411	300
1989	47.0	47.4	47.2	1197	1207	1202	1347	300
1990	47.8	48.2	48.0	1300	1362	1330	1372	400
1991	46.3	47.6	46.9	1213	1286	1248	1390	200
1992	50.4	51.3	50.9	1527	1634	1580	1626	200
1993	50.9	51.7	51.2	1630	1663	1643	1451	300
1994	47.4	48.4	47.8	1198	1261	1227	1485	395
1995	51.1	51.4	51.3	1527	1566	1547	1663	300
1996	48.1	48.6	48.3	1242	1278	1258	1320	400
1997	50.7	50.8	50.8	1610	1580	1594	1559	500
1998	45.5	46.3	45.8	1114	1184	1147	1364	300
1999	48.6	48.6	48.6	1465	1471	1469	1519	300
2000	49.6	49.6	49.6	1485	1530	1509	1470	400
2001	48.6	49.1	48.8	1449	1498	1473	1536	398
2002	48.0	48.8	48.4	1287	1363	1330	1357	200
2003	48.0	48.2	48.1	1295	1314	1305	1507	400
2004	49.0	49.7	49.3	1445	1526	1482	1667	930
2005	46.5	47.2	46.9	1199	1242	1218	1456	578

Table 3. Ratio between the numbers of pink salmon entering the rivers of Iturup Island, numbers of fry downstream migrants and numbers of adult returns

Spawning		Downstream migration			Adult returns		
Year	Entry to the rivers	Wild fry (DMC, %)	Release from hatcheries	Total	Fishery	Entry to the rivers	Total (SI, %)
1967	0.970	167 (23.5)	98	265	8.134	1.470	9.604 (3.62)
1968	0.845	123 (17.8)	83	206	4.992	0.870	5.862 (2.85)
1969	1.470	223 (27.4)	107	330	8.994	1.318	10.312 (3.12)
1970	0.870	151 (20.3)	81	232	9.562	0.920	10.482 (4.52)
1971	1.318	219 (25.2)	115	334	10.872	1.157	12.029 (3.60)
1972	0.920	205 (30.7)	101	306	9.283	1.011	10.294 (3.36)
1973	1.157	323 (41.0)	117	440	11.891	1.990	13.881 (3.15)
1974	1.011	360 (61.3)	134	494	14.189	1.877	16.066 (3.25)
1975	1.990	161 (12.5)	160	321	13.203	1.363	14.566 (4.54)
1976	1.877	217 (15.6)	198	415	12.288	1.223	13.511 (3.26)
1977	1.363	112 (13.0)	149	261	12.508	1.072	13.580 (5.20)
1978	1.223	204 (27.7)	198	402	15.543	1.898	17.441 (4.34)
1979	1.072	142 (20.0)	166	308	9.976	1.800	11.776 (3.82)
1980	1.898	122 (9.4)	215	337	8.010	1.322	9.332 (2.77)
1981	1.800	176 (14.2)	184	360	14.411	1.542	15.953 (4.43)
1982	1.322	66 (7.6)	207	273	5.278	1.102	6.380 (2.34)
1983	1.542	226 (18.4)	205	431	30.003	2.100	32.103 (7.45)
1984	1.102	176 (22.2)	155	331	10.481	1.131	11.612 (3.51)
1985	2.100	178 (11.9)	194	372	18.605	1.837	20.442 (5.50)
1986	1.131	116 (15.6)	169	285	9.038	1.332	10.370 (3.64)
1987	1.837	205 (15.8)	183	388	11.756	1.448	13.204 (3.40)
1988	1.332	162 (19.4)	170	332	13.632	1.718	15.350 (4.62)
1989	1.448	243 (24.9)	172	415	23.367	2.010	25.377 (6.11)
1990	1.718	194 (17.1)	165	359	13.560	1.880	15.440 (4.30)
1991	2.010	187 (13.8)	150	337	4.962	1.048	6.010 (1.78)
1992	1.880	223 (14.7)	107	330	22.863	2.467	25.330 (7.68)
1993	1.048	156 (25.0)	65	221	16.009	1.531	17.540 (7.94)
1994	2.467	230 (14.0)	112	342	19.444	1.266	20.710 (6.06)
1995	1.531	281 (21.4)	62	343	15.932	1.288	17.220 (5.02)
1996	1.266	319 (41.7)	76	395	20.207	1.298	21.505 (5.44)
1997	1.288	195 (17.9)	75	270	10.065	1.175	11.240 (4.16)
1998	1.298	302 (36.6)	66	368	24.806	1.610	26.416 (7.18)
1999	1.175	337 (33.3)	89	426	14.538	1.320	15.858 (3.72)
2000	1.610	230 (18.3)	99	329	22.537	1.523	24.060 (7.31)
2001	1.320	245 (24.8)	111	356	12.523	1.068	13.591 (3.82)
2002	1.523	460 (46.4)	106	566	20.890	1.768	22.658 (4.00)
2003	1.068	147 (17.6)	112	259	23.645	1.498	25.143 (9.72)
2004	1.768	204 (14.9)	126	330	–	–	–

Note: fish numbers are given in million individuals; DMC – the downstream migration's coefficient; SI – the survival index of pink salmon.

DISCUSSION

Almost all the pink salmon specimens become mature at the second year of life. This leads to occurrence of two generative lines in pink salmon stocks (odd- and even-year) with the level of divergence between them higher (by genetic markers) than between their local stocks (Glubokovsky 1995; Altukhov et al. 1997). In this connection, major researchers consider dynamics of pink salmon abundance regarding to different generative lines. With such a traditional approach, Fig. 4 illustrates changes of some indices characterizing reproduction of the Iturup pink salmon separately for even- and odd-year-classes.

The downstream migration's coefficient shows (Fig. 4a) that no distinctive trends of changing in survival have been observed for pink salmon from different generative lines during the freshwater period. For both lines there was the increase in survival for individual year-classes in the first half of the 1970s and at the boundary of XX – XXI centuries. These changes could be caused by the interannual fluctuations of water level in the autumn period, since, based on the results of analysis of pink salmon reproduction in the Olya River, this factor significantly affects spawning effectiveness (Kaev and Chupakhin 2003).

In contrast to freshwaters, significant differences in survival of the even- and odd-year-class pink salmon were noted for seawaters in some periods (Fig. 4b). Thus, up to the end of the 1970s the survival indices of individual generations varied insignificantly and were close for pink salmon with different generative lines. However, in the 1980s the odd-year-classes survival was significantly higher than that of the even-year-classes, and in the following years, on the contrary, mainly the even-year-classes survival was higher. Based on the 1974 – 1988 results of studying juvenile chum and pink salmon in the coastal waters of Iturup Island (Kaev and Chupakhin 2002), differences in the even- and odd-year class survival in the 1980s could be caused by habitat and feeding conditions of juveniles. In 1981 – 1988 they were more favorable in the even years (feeding of juveniles from the odd year-class), especially in 1984.

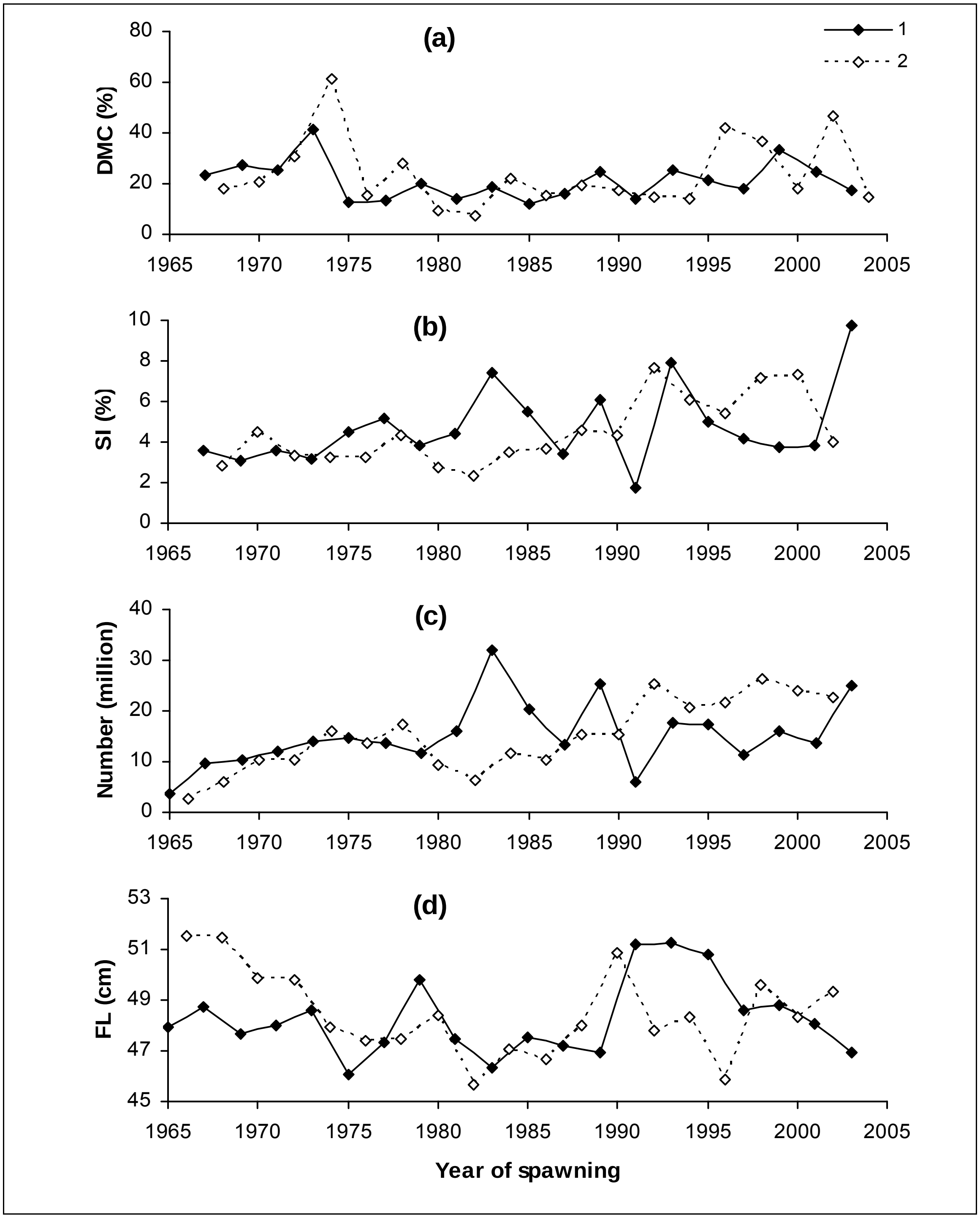
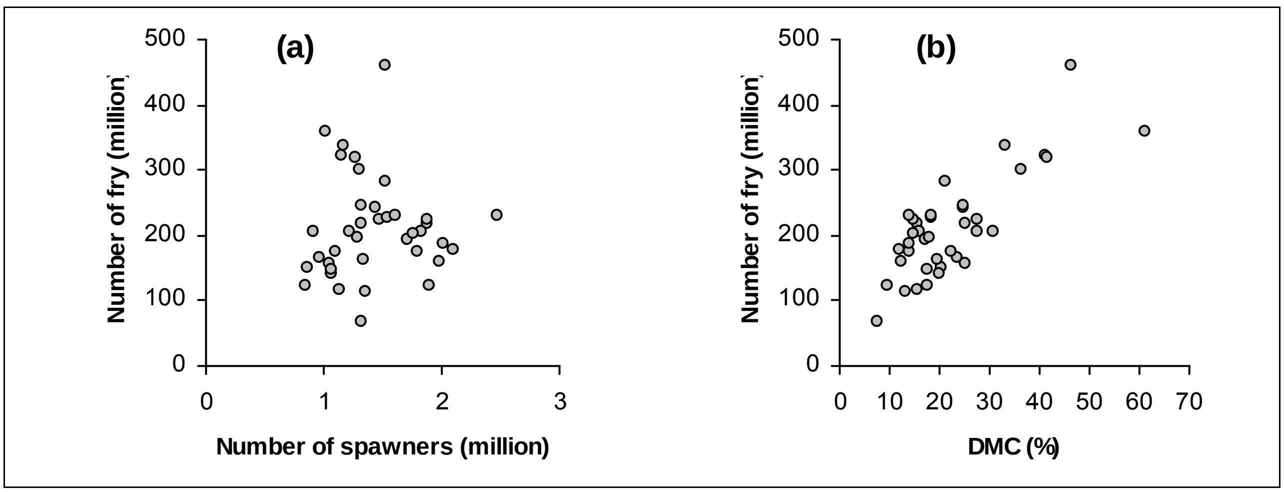


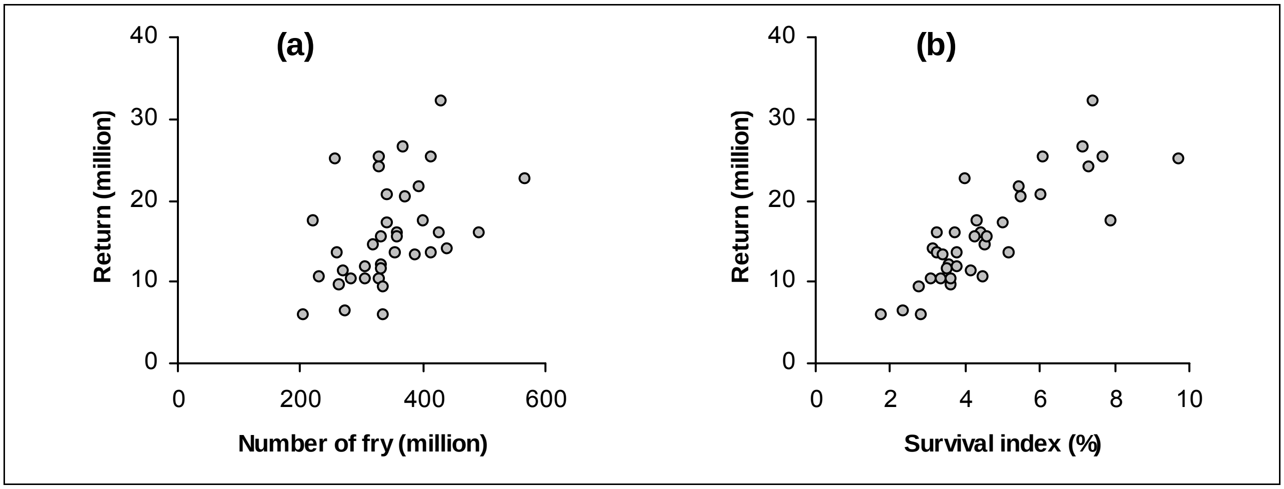
Fig. 4. Changes in survival during the river (a) and sea (b) life periods, numbers of returning adults (c), and fork length (d) for the odd-year-classes (1) and even-year-classes (2) of the Iturup Island's pink salmon in 1965–2003

Changes in absolute abundance of pink salmon returns (Fig. 4c) have corresponded to fluctuations of their survival during the marine life period regarding both a line of the odd year-classes ($R=0.80$; $P<0.001$; $N=37$) and a line of the even year-classes (R=0.89; P<0.001; N=35). It means that the interannual changes in pink salmon abundance were mainly dependent on natural conditions, but not on any specific peculiarities in forming abundance for the even- and odd-year-classes. A harvest of the downstream migrating fry was not dependent on the number of spawners on spawning grounds (Fig. 5a), because even in the years of the relatively low pink salmon returns there were enough spawners on spawning grounds to maintain a high level of reproduction. In these conditions changes in numbers for fry migrants were related to the total survival of pink salmon during the periods of spawning and embryonic and larval development (Fig. 5b). As regards the year-classes return numbers, they were also poorly dependent on the total abundance of wild and hatchery-reared fry migrants (Fig. 6a), being mostly determined by their further survival during the marine life period (Fig. 6b).



R=0.02; P>0.05; N=38   R=0.80; P<0.001; N=38

Fig. 5. Numerical dependence of pink salmon fry migrants on (a) the number of spawners in rivers and (b) survival during a freshwater period (the downstream migration's coefficient - DMC).



R=0.43; P<0.01; N=37 R=0.83; P<0.001; N=37

Fig. 6. Dependence of pink salmon returns on (a) the harvest of fry migrants and (b) fish survival during a sea life period (survival index).

Undoubtedly, changes in pink salmon size composition when returning to natal rivers directly depend on habitat and feeding conditions of fish during the marine life period. The largest pink salmon were recorded in escapements in the late 1960s and mid 1990s (Fig. 4d). Changes in fish weight and female fecundity tended to be similar to changes in body length. This relationship between length and weight of pink salmon is defined by a highly-reliable correlation coefficient (R=0.92; P<0.001; N=39). The relationship between female fecundity and both length (R=0.65; P<0.001; N=39) and weight (R=0.71; P<0.001; N=39) is weaker, since pink salmon fecundity begins to form as early as at the first stages of development, whereas its length and weight are developing mainly under the habitat conditions in the open seawaters.

Table 4 shows averaged biological indices of pink salmon for the three time periods. The first period includes 1967–1975 (returns of relatively large fish); the second period includes 1976–1991 (returns of smallest fish); the third period includes 1992–2005 (again returns of relatively large fish). These data illustrate that in the earlier period the even-year-class pink salmon were largest and in the later period, on the contrary, the odd-year-class fish. In the intermediate period, sizes of the even- and odd-year-class fish were approximately equal. The interannual changes in pink salmon size are shown to be poorly related to fluctuations in its abundance when analyzing both the odd-year-classes (R=-0.38; P<0.05; N=39) and the even-year-classes (R=-0.21; P>0.05; N=37). As was shown above, such analysis assumes using the abundance of individual local pink salmon stocks within the southern Sakhalin and southern Kuril islands, since changes in abundance for each of these stocks correspond to trends of changes in abundance for the regional pink salmon group (Kaev and Chupakhin 2003; Kaev and Antonov, 2005). Based on this, one can assert that the long-term changes in sizes revealed for the Iturup pink salmon do not correspond to the earlier view point that density-dependent factors have a significant importance in forming a size structure of this local fish stock (Yefanov and Chupakhin 1982).

Table 4. Fork length (FL), body weight and absolute fecundity (AF) of the Irurup even- and odd-year pink salmon in different periods

Period	FL (cm)		Weight (g)		AF (eggs)	
	odd	even	odd	even	odd	even
1967–1975	48.2	50.7	1292	1584	1457	1574
1976–1991	47.3	47.3	1172	1190	1356	1366
1992–2005	49.4	48.6	1464	1362	1527	1470

If we acknowledge a priori that a rate of fish growth reflects their habitat and feeding conditions, we would see that a relatively well expressed long-term cyclic character of changes in pink salmon body size (Fig. 4d) proves a strong influence of environmental conditions on dynamics of its stock abundance. At the same time, the absence of relationship between the growth rate of pink salmon and its survival during the marine life period for odd-year-classes ($R=-0.17$; $P>0.05$; $N=37$) and even-year-classes ($R=0.11$; $P>0.05$; $N=35$) seems to be strange at first. In our opinion, this discrepancy is caused by the fact that the cycles of changes in the coastal habitat conditions and open seawaters do not coincide. Thus, in 1982, 1984 (especially), and 1986 the growth and feeding indices for juveniles in the bays of Iturup Island were significantly better than in 1981, 1983, and 1985 (Kaev and Chupakhin 2002). Abundance of fry migrants in the above mentioned even years was as high as 1.1–1.6 times, compared to the odd years, whereas the abundance of corresponding returns of the pink salmon odd-year-classes (fry migration in the even years) exceeded the even-year-classes abundance as much as 1.7–5.0 times (Table 3). At the same time, the returning fish from these even- and odd-year-classes had small-sized bodies (Fig. 4d).

Obviously, the same situation occurred in the 1990s (juveniles were not surveyed in the bays), when a significant difference in survival had been noted for the even- and odd-year-classes of pink salmon, and returning fish were comparatively large.

CONCLUSION

On the average, during the years of observation, a total of 1.438 million spawners entered the rivers for spawning, and 210 million fry (22.5% of the total female fecundity in rivers) migrated downstream. Abundance of wild juveniles depended on the numbers of spawners in rivers, being determined mainly by the losses during the periods of spawning and embryonic and larval development. The total harvest of fry migrants increased annually by 134 million on average, due to the hatchery release of juveniles. A subsequent return of adult fish comprised 15.736 million individuals (4.61% of fry migrants' abundance). The abundance of returning pink salmon was established to be less dependent on the fry migrants' abundance than on generation survival during the marine life period. Occurrence of the three sequent periods that are characterized by returning, respectively, of large, small and again large fish and the absence of distinctive interannual synchronism in changes of pink salmon sizes and abundance do not conform to conception of density-dependant regulation in stock dynamics. Changes in pink salmon abundance and survival at different stages of its life cycle showed that abundance of returning adults was mostly dependent on habitat conditions in the early marine life period, whereas changes in biomass were facilitated by habitat conditions in the open seawaters.

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