NPAFC
Doc. 627
Rev.____

On Peculiarities of the Palana River Sockeye Salmon *(Oncorhynchus nerka)* Abundance (North-West Kamchatka)

by
Victor F. Bugayev
Kamchatka Research Institute
of Fisheries and Oceanography
(KamchatNIRO)
Petropavlovsk-Kamchatsky
683602, Russia

submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
By he
RUSSIAN FEDERATION
September 2002

THIS PAPER MAY BE CITED IN THE FOLOWINGS MANNER:
Bugayev, V.F. 2002. On Peculiarities of the Palana River Sockeye Salmon *(Oncorhynchus nerka)* Abundance (North-West Kamchatka). (NPAFC Doc. 627) 11 pp. Kamchatka Recearch Institute of Fisheries and Oceanography (KamchatNIRO), Petropavlovsk-Kamchatsky, 683602, Russia.

ABSTRACT

Data of the Palana River (flows into the Sea of Okhotsk at 59°06’N) sockeye salmon *(Oncorhynchus nerka)* is practically absent. Its reproduction and juveniles’ growing before migration to sea are totally concentrated in the basin of the Palana Lake. For going out to the Pacific Ocean sockeye salmon smolts make a long migration along the Western Kamchatka coast southward bypassing the southern extremity of Kamchatka peninsula (50°52’N). Mature fishes make a reverse migration.

The abundance of the stock mature part (SMP) sockeye salmon approaches to the river estuary and the abundance of the Palana River sockeye salmon spawned producers display a stable two-years cyclic recurrence. We suppose that this recurrence is connected with Western Kamchatka pink salmon (*Oncorhynchus gorbuscha*) abundance fluctuations.

INTRODUCTION

In the basin of the Palana River, which flows into the Sea of Okhotsk at 59°06’ N a big stock of sockeye salmon *(Oncorhynchus nerka)* is reproduced. This stock takes the third-fourth place of this species abundance in Asia.

Literature data about biological indicators and age structure of mature sockeye salmon of the Palana River were not numerous until recently (Pravdin 1940; Krogius 1958; Konovalov 1971; Bugayev 1995; Bugayev et al. 2001).

In the present work we summed up the main results of our researches of the Palana River sockeye abuindance dynamics as well as the biological features of smolts migrating from the Palana Lake and mature sockeye individuals from the lower Palana River stream.

RESULTS AND DISCUSSIONS

Reproduction and growing of this stock sockeye salmon juveniles prior to a roll-down migration to the sea are concentrated almost entirely in the Palana Lake basin where the above mentioned river starts.

The Palana Lake is located at the North of Kamchatka peninsula 276 m above sea level, its mirror area is 28.35 square kilometers, volume – 0.42 square kilometers, maximum depth – 28 meters, average depth – 14.8 meters, the indicator of conditional water exchange – 0.76, transparency – 5 m (Nikolayev 1993).

The solar radiation level in July and August mainly defines the warming up rate in the Palana Lake. The maximum warming up is usually observed in the last decade of July when the average temperature of the upper 10-meters layer may rise to 17 ° C.

In September a successive decrease of average monthly air and water temperatures begins. The ice cover appears in late October – first decade of November. The ice thickness reaches 1.0–1.5 meters. The ice breaks up in the end of June.

Besides sockeye the ichthyological community of the Palana Lake includes pink salmon – *Oncorhynchus gorbuscha*, coho salmon – *Oncorhynchus kisutch*, Arctic char – *Salvelinus malma* and Sakhalin char *Salvelinus leucomaenis*, Kamchatka trout – *Salmo mykiss*, living form of threespine stickleback – *Gasterosteus aculeatus (leiurus)*, ninespine stickleback – *Pungitius pungitius*.

In April of 1991 they made an artificial fertilization of the Palana Lake. They put double superphosphate on the ice. Totally (converting to P_2O_5) they put 1,298 kg along the isobath of 10–15 meters in those places where there are no spawning grounds.

The dominating phytoplankton complex of the Palana Lake is represented by the species typical for relatively not deep lakes of arcto-boreal zone. The dominants are as a rule *Aulacoseira subarctica, Cyclotella tripartita, Asterionella Formosa* and *Tabellaria s.l.* (Lepskaya et al. 1998).

In the pelagic zooplankton of the Palanskoye Lake there are 3 species of Cladocera belonging to different genera: Holopedium *(H. giberrum),* Bosmina *(B. Longirostris)* and Daphnia *(D. longiremis),* 1 species of Copepoda – *Cyclops scutifer* and 14 species of Rotifera *(Rotatoria)* (L.V. Milovskaya and T.V. Bonk, personal communication).

Biological indicators of sockeye salmon smolts. For going out to the Pacific Ocean sockeye salmon smolts make a long migration along the Western Kamchatka coast southward bypassing the southern extremity of Kamchatka peninsula (50°52' N). Mature fishes make a reverse migration.

In Table 1 there is data of body length and weight of sockeye smolts migrating from the Palana Lake. Sockeye salmon smolts were fished in late June–July with two traps set at the Palana River head at nighttime.

As shown in Table 1, sockeye salmon down migration from the Palana Lake to the sea at the age of 1–4 years. Most of smolts roll down at age 2+, in separate years 3-year-old fishes are absent. Possibly smolts of 4+ are met as an exception. Mature fish age structure is evidence of that (Table 2).

In spite of the absence of materials for 1997, one may note that in 1995–1998 the body length and weight of Palana Lake sockeye salmon smolts of age 2+ decreased, and in 1999–2000 a tendency of increase of these indicators appeared. The latter is evidence of improvement of living conditions of juveniles in the lake. It's too early to say what exactly conditions (temperature factor, food base of some zooplankton species etc.) caused the increase of body length and weight of sockeye salmon smolts in 1999–2000 (Table 1). It's necessary to collect more data.

Biological indicators of mature sockeye salmon. The early form of sockeye salmon is practically absent in the Palana River and makes 0.6% on average, and the late one 99.4% accordingly (A.G. Ostroumov, personal communication; Bugayev 1995).

They took mature sockeye from commercial catches of the beach seine for biological analysis. The available data shows that the spawning run of this river sockeye in commercial quantities starts in mid June and ends in early August. At that maximum catches take place in mid July.

As per many years materials early sockeye spawning in the Palana Lake starts in the first half of July and ends in early August at mass spawning during the second half of July. The late form of sockeye spawning starts in the beginning of the third decade of July and may end in the middle–end of October at mass spawning since early August and till early September accordingly (A. G. Ostroumov, personal communication; Bugayev 1995).

In Table 2 one can see the age structure of mature fishes from the commercial catches in 1994–2001. This table data shows that the Palana River sockeye has 9 age groups, which differ by duration of fresh and sea water periods of life, and in most cases srawners' age is 2.3. The exception is 1996 when the producers aged 2.2 somewhat prevailed.

At this stage of the investigation we consider this fact as an atypical event and cannot find a reliable unique explanation for that. On the one hand we suppose that the fish of 1996 return on the whole matured one year sooner and spent in the ocean 2 and not 3 years. But we do not exclude a possibility that most of the fish estimated by us as aged 2.2 really were 2.3. So, in 1996 a very high abundance of sockeye salmon (of the Kamchatka and Ozernaya Rivers) and pink salmon was observed in the sea. It's not excluded that a part of the mature fish after 3 years of the marine life might not have the third marine annual ring founded on the scales.

As a result we mistakenly could underestimate the actual age in a number of cases. This is confirmed by the fact that the body sizes and weight of fish aged 2.2 were close to those aged 2.3 exactly in 1996, though in all the rest years individuals of 2.2 almost always had smaller body sizes and weight than those of 2.3 (Table 3-4). The question if all the fishes defined by us in 1996, as aged 2.2 (Table 2) were really the ones aged 2.2 (and not 2.3 partially) is still open.

Table 3-4 characterizes average body sizes and weight of sockeye salmon males and females of the Palana River by age groups. On these tables one can see that for the period of our researches the average body weight of bigger individuals in the most abundant age group of 2.3 in some years was less than that of the smaller ones.

During the period of 1994–2001 the Palana River sockeye's (without subdivision in age groups) values of coefficients of Spirman rank correlation between the indicators of a males' (females') body length and weight were low and doubtful and made: r_s – 0.455, P>0.05, n = 8) (r_s = 0.405, P>0.05, n = 8). The values of coefficients of rank correlation of 2.3 aged males (females) were also doubtful though higher: r_s = 0.619, P>0.05, n = 8 (r_s = 0.515, P>0.05, n = 8). 2.2 aged males' (females) values of coefficients of rank correlation were authentic and accordingly higher that in the previous case: r_s = 0.847,(P<0.05, n = 7 (r_s = 0.857, P<0.05, n = 7).

We connect the observed differences in the correlation of the body length and weight of the Palana River mature sockeye salmon with interannual distinctions in the conditions of the fish life in the marine period.

The nature of discordance between the body length and weight for the Palana River sockeye salmon is not clarified yet, it's necessary to collect more data. Nevertheless it's not excluded that this fact is directly connected with the fluctuations of the Western and North-Eastern Kamchatka pink salmon abundance. Earlier it was shown that the Ozernaya River sockeye salmon had minimum sizes when a very high abundance of the Western and North-Eastern Kamchatka pink salmon was observed (Bugayev 1995). Some observations of the Palana River sockeye salmon do not allow making a correlation analysis between the size-weight indicators and environmental factors and sockeye and pink salmon abundance yet.

The observed differences in the correlation of the body length and weight of the Palana River mature sockeye salmon we connect with interannual distinctions in the conditions of the fish life in the marine period.

In this paper we have for the first time tried to estimate the abundance of the stock mature part (SMP) of the Palana River sockeye salmon in the sea. In our estimation we issued from the assumption that the intensity of the sea driftnet catch of the Palana River sockeye salmon (because the latter migrates by the same way that the one of the Ozernaya River) should be not less than the one of the driftnet catch of the Ozernaya River sockeye salmon.

Considering that now we have estimated the abundance of (SMP) of the Ozernaya River sockeye salmon (Bugayev and Dubynin 2000), we have used our data of the Ozernaya River sockeye salmon catch rate in the sea (out of the total SMP abundance) and calculated the SMP abundance of the Palana River sockeye salmon (Fig. 1).

At present when studying the dynamics of the Palana River abundance we are using the SMP abundance and the abundance of the sockeye salmon approach to the Palana River estuary (Fig. 1). At calculations we supposed that in all the years the Palana River sockeye salmon 100% matured at the age of 2.3 (for example fishes of 1993 spawn in our calculations reached the full maturity in 1999). That is why the values of the generations' abundance and SMP abundance in our researches coincide. The observations accumulation will further allow discovering a systematical error got as a result of our omissions.

As shown at Fig. 1, the SMP abundance, sockeye approaches to the river estuary and the abundance of the Palana River spawned sockeye salmon producers reveal a stable two years cyclic dates (violated in 1983–1984 only): in 1979, 1981, 1985, 1987, 1989, 1993, 1995, 1997, 1999 and 2001 peaks of abundance are observed, and in 1978, 1980, 1982, 1986, 1988, 1990, 1992, 1994, 1996, 1998 and 2000 – decreases of abundance. We suppose that this cyclic recurrence is connected with the pink salmon fluctuations, which, as is well known, has a two-years life cycle.

The researches recommend (Bugayev 1995; Bugayev, Dubynin 2000; Bugayev 2001) to consider the abundance dynamics of the Asian stocks of sockeye salmon by periods of growing in the ocean: 1 – before 1984 inclusive, when the abundance of the dominant generations of the Western and North-Eastern Kamchatka pink salmon fluctuated in one phase, and 2 – starting 1985, when there happened a shift of the dominant generations of the Western Kamchatka pink salmon abundance from odd years to even ones. As a result a high pink salmon abundance (dominant generations) was observed at Western and North-Eastern Kamchatka in different and not in the same years like before. Considering that we have divided all the available data about the Palana River sockeye salmon abundance in generations of 1972–1981 and 1982–1999.

At present the abundance forecasting of the Palana River (generations) SMP is realized on the bases of the connections "parents–offspring" and even (1982–1994) and odd years (1983–1995) subdivided into the generations. For the even years generations the connection formula looks like this:
$Y = -0.02*X^2 + 3.3305*X$ ($R^2 = 0.4313$, $n = 7$); for the odd ones: $Y = -0.0114*X^2 + 3.5084*X$ ($R^2 = 0.4618$, $n = 7$). Where, Y – the SMP (generations) abundance, in thousands of fish; X – the sockeye salmon parents-producers' abundance, in thousands of fish.

As the analysis shows, the observed connections between the abundance of the parents-producers and that of SMP (generations) are stated rather poor with the Palana River sockeye salmon. The latter is connected with the fact that this river sockeye abundance as well as that of the Ozernaya River sockeye salmon abundance (Bugayev and Dubynin 2000) is influenced by the system of factors whose combination may cause different results in the formation of generations' abundance.

In "STATICTICA" program we have calculated the coefficients of the multiple regression – R (Borovikov, Borovikov 1998) between the Palana River sockeye SMP and environmental factors and fish abundance by the forward stepwise method of inclusion at the generations of 1982–1995. Considering that for the Palana River sockeye the age of pubescence for calculations was taken as 2.3, the abundance of SMP in this case is at the same time the abundance of generations (ZRPAL). This equation of the multiple regression looks like this:

LnZRPAL = 19.5504 + 0.0407*LnPINE-2 + 0.7758*LnSPKU – 0.4383*LnPINE-3 – 3.3311*LnLSMKU + 0.2658*LnPINW-0 + 0.1737*LnPINW-2 – 0.6267*LnOZZR + 0.2468*LnSPPAL + 0.0613*LnPINE-1; R = 0.997, P < 0.001, n = 14.

In this work we have made a transform of all the initial indicators into natural logarithms as recommended by the authors (Borovikov and Borovikov 1998).

As it is seen from the equation of the multiple regression in our case the Palana River sockeye SMP is influenced by the following factors:

PINE-2 - the inshore run of mature North-East Kamchatka pink salmon (after driftnet harvesting) during the second year of marine life of sockeye salmon of the Palana River, which returned at the studied year (SY), millions of fish;

SPKU - the abundance of the parent escapement of sockeye salmon of all the age groups spawned in the Kuril Lake at the year of spawning of the studied generation of the Palana River sockeye salmon, which returned at the SY, in thousands of fish;

PINE-3 - the inshore run of mature North-Eastern Kamchatka pink salmon (after driftnet harvesting) during the third year of marine life of the Palana River sockeye salmon, which returned at the SY, millions of fish;

LSMKU - the body length of the Kuril Lake sockeye salmon smolts at the age 2+, from which the return of mature sockeye salmon happens at the SY, mm;

PINW-0 - the inshore run of mature Western Kamchatka pink salmon (after driftnet harvesting) one year prior to ocean migration of sockeye salmon smolts of the Palana River (from Palana Lake) at the age 2+, which returned at the SY, millions of fish;

PINW-2 - the inshore run of mature Western Kamchatka pink salmon (after driftnet harvesting) during the second year of the Palana River sockeye salmon, which returned at the SY, millions of fish;

OZZR - the SMP of the Ozernaya River sockeye salmon at ocean prior to the beginning of the driftnet harvesting at the SY, in thousands of fish;

SPPAL - the abundance of the parent escapement of sockeye of all the age groups spawned in the Palana Lake at the year of spawning of the studied generation of sockeye salmon, which returned at SY, in thousands of fish;

PINE-1 - the inshore run of mature of the North-East Kamchatka mature pink salmon (after driftnet harvesting) during the first year of marine life of the Palana River sockeye salmon, which returned at SY, millions of fish.

The analysis of the dynamics of the Palana River sockeye salmon generations' abundance of 1972–1981 is now of interest of science and history only, and will not be of practical use until the abundance of the Western and North-Eastern Kamchatka pink salmon dominating generations does not fluctuate in one phase.

REFERENCES

Borovikov, V. P. and I. P. Borovikov. 1998. STATISTICA. Statistical analysis and processing the data in Windows. M. "Filin" publishing house: 608 pp. (In Russian)

Bugayev, V.F. 1995. Asian Sockeye Salmon (freshwater period, local stocks structure, abundance dinamics). M. Kolos: 364 pp. (In Russian)

Bugayev, V.F. 2001. On pink salmon (Oncorhynchus gorbuscha) number influence on Asian sockeye salmon (Oncornynchus nerka). *In:* North Pacific Marine Science Organization (PICES) Tenth Annual Meeting October 5-13, 2001. Victoria, B.C., Canada: p. 139.

Bugayev, V.F., and V.A. Dubynin. 2000. Factors influencing abundance of sockeye salmon (Oncorhynchus nerka) from the Ozernaya River, Southwest Kamchatka. *In:* Recent Changes in Ocean Production of Pacific Salmon. *Edited by* J.H. Helle, Y. Ishida, D. Noakes and V. Radchenko. North Pac. Anadromous Fish Com. Bull. No. 2. Vancouver, Canada: 181-189.

Bugayev, V.F., A.G. Ostroumov, L.V. Milovskaya and I.N. Sirotenko. 2001. Sockeye salmon (Oncorhynchus nerka) of Palana River (North-Western Kamchatka). *In:* Conservation of biodiversity of Kamchatka and coastal waters. Materials of II scientific conference Petropavlovsk-Kamchatsky, April 9-10 2001: "Kamchat" publishing house. Petropavlovsk-Kamchatsky: 33-35. (In Russian)

Konovalov, S.M. 1971. Differentiation of local populations of Sockeye Salmon. Nauka Pablishing House, L., USSR: 220 pp. (In Russian)

Krogius, F.V. 1958. On the scale pattern of Kamchatka sockeye salmon of different local populations. *In* Materiali po biologii morskogo perioda zhisni Dalnevostochnykh lososei. VNIRO Press, M.: 52-63. (In Russian) (Fish. Res. Board Can. Transl. Ser. 181).

Lepskaya, E.V., E.G. Lupikina, L.V. Milovskaya, I.N. Sirotenko and V.D. Sviridenko. 1998. Phytoplankton in the Palana Lake (Kamchatka) as an indicator of stability in the ecosystem. *In:* Investigation of Biology and Abundance Dynamics of Fishery Species of the Kamchatka Shelf: Petropavlovsk-Kamchatsky. - No. 4: 176-181. (In Russian)

Nikolayev, A.S. 1993. Palana Lake (limnological review). *In:* Investigation of Biology and Abundance Dynamics of Fishery Species of the Kamchatka Shelf: Petropavlovsk-Kamchatsky. - No. 2: 3-20. (In Russian)

Pravdin, I.F. 1940. Review of investigations of Far East salmons. Izv. TINRO, 18: 107 pp. (In Russian)

Table 1. Body Fork Length and Weight of Smolts of Sockeye Salmon Migrating From the Palana Lake in 1995–2000.

Age	Fork Length, mm			Weight, g			Number of fishes (%)
	Limits	Average	Error	Limits	Average	Error	
				1995			
1+	50-62	57.15	1.07	0.80-2.40	1.74	0.12	13(10.2)
2+	71-107	89.35	0.64	3.60-11.80	6.67	0.15	113(88.3)
3+	87-100	93.5	6.50	6.20-9.40	7.8	1.6	2(1.5)
				1996			
1+	47-57	52.67	2.96	1.20-2	1.73	0.27	3(11.1)
2+	66-100	82.5	1.32	2.20-10.70	5.84	0.31	24(88.9)
3+	-	-	-	-	-	-	-
				1998			
1+	54-65	60.80	2.13	1.15-2.41	1.85	0.23	5(8.5)
2+	70-85	77.22	0.54	2.02-6.26	4.09	0.11	51(86.4)
3+	85-88	86.33	0.88	5.42-5.82	5.68	0.13	3(5.1)
				1999			
1+	56-79	67.63	3.16	1.51-4.64	3.14	0.42	8(9.9)
2+	78-101	87.89	0.71	4.63-11.34	6.62	0.16	64(79.0)
3+	83-100	92.89	1.91	5.32-9.25	7.64	0.45	9(11.1)
				2000			
1+	61-62	61.50	0.50	1.46-2.98	2.22	0.76	2(3.8)
2+	76-105	92.55	0.99	4.48-12.58	7.87	0.25	42(79.2)
3+	95-111	103.25	2.01	8.70-13.19	11.19	0.49	8(15.1)
4+	134	134.00	-	26.37	26.37	-	1(1.9)

Note. In 1997 the studies of dynamics sockeye smolt migration were not realized

Table 2. Age Structure of the Palana River Mature Sockeye Salmon from the Commercial Catches in 1994–2001, %.

???	1.2	1.3	1.4	2.2	2.3	2.4	3.2	3.3	3.4	Number of fishes
1990*	-	14.6	-	-	79.2	2.1	-	4.1	-	48
1994	0.7	18.4	-	10.9	54.8	2.0	1.0	12.2	-	294
1995	1.0	5.1	-	11.2	82.7	-	-	-	-	98
1996	-	9.7	-	50.0	40.3	-	-	-	-	72
1997	-	3.1	0.4	2.4	85.5	1.0	-	7.2	0.4	290
1998	8.4	9.4	0.7	26.2	50.7	1.0	1.8	1.8	-	286
1999	-	20.1	-	7.7	69.4	-	-	2.8	-	284
2000	-	9.4	-	-	86.4	1.1	-	3.1	-	287
2001	-	1.8	-	9.7	82.1	3.6	2.1	0.7	-	279

Note. The fist figure – duration of the fresh water life period, the second one – duration of the marine life period. * - fish caught at the Palana Lake spawning grounds.

Table 3. Average Body Fork Lenght of the Palana River Mature Sockeye Salmon by the Age Groups from the Commercial Catches in 1994–2001, cm.

???	1.2	1.3	1.4	2.2	2.3	2.4	3.2	3.3	3.4	All ages
					Females					
1994	53.00	59.03	-	54.71	59.23	60.40	51.00	59.71	-	58.81
1995	53.00	59.20	-	55.14	59.22	-	-	-	-	58.77
1996	-	64.00	-	63.08	63.46	-	-	-	-	63.29
1997	-	61.33	66.00	53.90	62.01	60.83	-	60.62	63.00	61.66
1998	58.94	58.44	57.50	58.98	58.80	-	58.80	57.25	-	57.78
1999	-	59.11	-	61.15	59.58	-	-	59.00	-	59.61
2000	-	60.89	-	-	60.18	63.0	-	61.8	-	60.32
2001	-	57.0	-	52.17	57.77	58.60	55.17	58.00	-	57.32
Average 1994-2001	54.98	59.87	61.75	57.02	60.03	60.71	54.99	59.40	63.00	59.69
					Males					
1994	55.00	62.52	-	58.22	63.05	66.00	57.5	64.33	-	62.33
1995	-	-	-	54.50	61.80	-	-	-	-	60.35
1996	-	71.8	-	67.41	68.83	-	-	-	-	68.58
1997	-	-	-	58.00	66.85	-	-	66.19	-	66.63
1998	60.75	65.59	-	62.60	62.66	64.83	-	63.00	-	62.93
1999	-	66.40	-	65.00	67.13	-	-	67.58	-	66.90
2000	-	64.50	-	-	64.77	62.50	-	66.25	-	64.77
2001	-	58.75	-	54.73	61.46	63.1	55.33	-	-	60.45
Average 1994-2001	57.87	64.93	-	60.07	64.57	64.11	56.41	65.47	-	64.12

Table 4. Average Body Weight of the Palana River Mature Sockeye Salmon by the Age Groups from the Commercial Catches in 1994 – 2001, kg.

Year	1.2	1.3	1.4	2.2	2.3	2.4	3.2	3.3	3.4	All ages
					Female					
1994	2.00	2.85	-	2.35	2.91	3.10	2.00	2.95	-	2.85
1995	1.90	2.71	-	1.99	2.69	-	-	-	-	2.62
1996	-	2.35	-	2.47	2.79	-	-	-	-	2.59
1997	-	2.41	3.00	1.74	2.55	2.27	-	2.44	2.60	2.51
1998	2.14	2.21	1.95	2.19	2.25	-	2.16	2.17	-	2.22
1999	-	2.26	-	2.67	2.46	-	-	2.35	-	2.43
2000	-	2.59	-	-	2.46	2.80	-	2.76	-	2.48
2001	-	2.31	-	1.73	2.39	2.51	1.83	2.27	-	2.34
Average 1994-2001	2.01	2.46	2.47	2.16	2.56	2.67	2.00	2.49	2.60	2.51
					Male					
1994	2.50	3.47		2.86	3.46	4.25	2.50	3.73	-	3.39
1995	-	-		2.13	3.11	-	-	-	-	2.91
1996	-	3.86		3.10	3.13	-	-	-	-	3.21
1997	-	-	-	2.00	3.34	-	-	3.26	-	3.31
1998	2.44	3.10	-	2.66	2.85	2.93	-	2.70	-	2.79
1999	-	3.30	-	3.00	3.35	-	-	3.53	-	3.33
2000	-	3.06	-	-	3.12	2.70	-	3.15	-	3.11
2001	-	2.55	-	2.13	2.90	3.20	2.24	-	-	2.79
Average 1994-2001	2.47	3.22	-	2.55	3.16	3.27	2.37	3.27	-	3.11

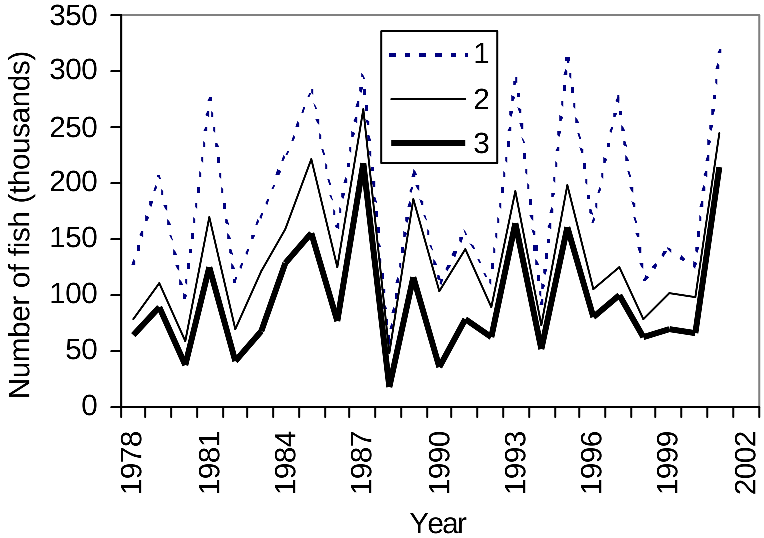

Fig. 1. The Palana River sockeye salmon abundance in 1978–2001: at the stock mature part (SMP) the ocean prior to the driftnet catch (1), at the approach to the river estuary (2) and the escapement into Palana Lake (3), in thousands of fish.