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A NEW EPOCH FOR SALMON STOCKS IN THE NORTH-WESTERN PACIFIC

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Joint VNIRO-KamchatNIRO studies of the Pacific salmon biology and distribution in marine areas in 1994-2000 have covered the period preceding spawning migrations and spawning migrations themselves. Russian driftnet vessels engaged for the scientific purposes have operated in Russian Exclusive Economic Zone outside territorial waters in the Bering Sea and in the Pacific waters off the eastern Kamchatka and the Kurils.

In 1990s the Pacific salmon abundance was high. Maximum catches in the northern Pacific occurred in 1995. The total catch of all the northern Pacific states exceeded 900,000 t. This value approximated the maximum one for the entire period of salmon fishery. The observed natural increase of the stock abundance coincided with Japanese large-scale artificial propagation of chum. Japanese chum stock became the largest by biomass among the Pacific salmons. Since 1980s Japan has annually released about 2,000,000,000 of smolts. By 1990, fishery yield of chum released by hatcheries in Hokkaido and Honshu exceeded 200,000 t. It is well-known that Japanese chum mixed with Russian stocks in feeding area in the Bering Sea and the Pacific waters off Kamchatka and the Kurils in summer and autumn (Fig. 1). It was presence of Japanese migrating chum that significantly contributed to a high total abundance of salmons in the 1990s.

Major peculiarities of salmon biology and distribution in the first half of the 1990s are the following:

The period from 1990 to 1996 (except 1993) could be considered warm; it was characterized by warm winters, early warming-up of seawater in spring and high SST compared to the long-term SST values in the north-western Pacific for the period from early spring till late autumn. Therefore, the majority of areas had favorable conditions for salmons' marine life starting from downstream migrations. Rich stocks of food and favorable temperature conditions considerably contributed to increase of salmon abundance in the first half of the 1990s. These conditions were particularly favorable for chum from Japanese hatcheries. Mainly because of a large size the released smolts escaped from predation, grew quickly, and started their wintering being well-fed. Moreover, vegetation period for Japanese chum was longer than for northern populations of Russian chum that migrated downstream later than Japanese smolts. The boom of Japanese chum changed ecological situation in the north-western Pacific. Japanese chum became the primal feeder in the northern Pacific. There were changes in food ratio both on the interspecies and species level, particularly crucial for chum itself. Chum is the least active feeder among pacific salmon. An extremely large stomach, most in genera Oncorhynchus (Welch, 1997), allows chum to shift with low caloric jelly-zooplankton (ctenophora, medusa, etc.) consuming them in large quantities and thus escaping food competition. This way of feeding was unavoidable and characterized the species in 1995-1997. Sometimes jelly-fish made 100% of chum ration in areas of densest concentrations of salmon.

There were some indications that density resulted from growth of Japanese chum stock affected all salmon species but primarily chum stocks themselves. Thus, starting from the 1970s increase of Japanese chum stocks from coincided with a gradual decrease abundance of Asian chum stocks. Besides, Japanese chum itself showed a decrease in average length and weight along with an increase in the average age of spawners (Ishida et al., 1993; Kaeriyama, 1996). We discibed another phenomenon caused by a high density of salmons at feeding area: frequent softening of the chum skeletal muscles in chum which was very common in 1994-1996. Trends in variations of abundance of the flabby chum corresponded with ways and terms to those in migrations of Japanese chum. We showed that some part of flabby fish died while another part of them recuperated getting mature. It was most likely that inadequate food was the cause of muscle softening (Gritsenko et al., 1995; Klovatch and Gritsenko, 1998; Klovatch, 1999).

We consider that a large number of weak individuals could indicate exceeding of carrying capacity of North Pacific epipelagial, or at least close approaching to the critical point.

Thus, at the beginning of work we have seen a high density of salmon feeding stocks proved by high CPUEs, a large number of flabby fish, strong inter-species feeding competition, and, as a result, jelle zooplankton in the chum ration, numerous elder fishes in catches, a low abundance in majority of Russian chum stocks, and stable high yields of Japanese chum.

The situation gradually changed. Judging by the drop in CPUE (Figs.2-4), density of salmon concentrations decreased, and so did the portion of flabby chum in catches (from 40% in 1996 down to 7.4% in 2000) (Fig.5). Chum started to consume better food (there was less jelly-fish in stomach contents). In 2000 some Asian chum stocks grew more abundant, especially, the Kamchatka populations which had previously suffered from Japanese stock most of all. Fishery yields of Japanese chum considerably decreased: in 1998 they were 20% lower than in 1996, and estimations for 1999 showed a further decline.

The age composition of chum also changed. In 1996-1997 chum 4+ made the bulk of marine catches and there was a large portion of chum 5+ , however, since 1998 catches have been dominated by the age group of 3+. There is no chum 5+ in catches even in spring, in the head of migration (Fig.6).

What caused the change of the situation? We suggest that the main factor which affected salmon abundance distribution and could be the climate change. El Nino of 1997 was followed by a cold period in the north-western Pacific. The winters of 1998-1999 and 1999-2000 were especially severe. The warming-up of seawater in North-West Pacific was very slow compared to the long-term data and low SST remained till late June (Table 1).

Table 1 Spring SST in the Petropavlovsk-Kommandor Subarea, 1994-2000

		YEARS						
Month	Decade	1994	1995	1996	1997	1998	1999	2000
April	1				3,18°			
	2				2,87°		1,98°	
	3				3,2°		2,02°	
May	1			3,85°	3,57°		2,27°	
	2			3,97°	3,75°	3,40°	3,02°	
	3			5,10°	4,80°	4,28°	3,79°	3,60°
June	1			5,10°	5,30°	3,98°	2,55°	3,88°
	2	5,29°	5,72°	5,96°	6,80°	6,98°	3,50°	4,80°
	3	6,09°	6,14°	7,70°	8,75°	8,26°	5,50°	6,10°

This retarded salmon migrations to the Kamchatka coasts, made sokeye and pink salmon change their migration routes, caused redistribution of various salmon species, and led to decline of these stocks and growth of those.

Naturally, Japanese chum stock was the first to decline. Firstly, artificial breed has a poorer gene pool compared to natural populations. Hatchery selection was aimed to build a stock best suitable to certain environmental conditions. When the latter change the cultivated stock is generally less adopted to new conditions compared to wild populations with a rich gene pool. Secondly, Japanese chum stocks were southern by origin and less suitable to cold periods. Thirdly, in the 1990s chum abundance was likely to be close to its upper limit; this triggered the population regulatory mechanisms. One of these mechanisms caused a high mortality of flabby chum. Thus, the maximum number of flabby fishes was observed in 1996. These were mainly immature individuals whose spawning was to start only in 1997-1998. Since 1997 fishery yield of Japanese chum has been declining. Density of Russian and Japanese chum stocks common feeding fields has decreased. Feeding conditions for chum stocks has improved. Rations of chum, sockeye, and pink salmon became more similar. The flabby chum portion in catches has grown less.

Other salmon species were also affected by changes in oceanographic conditions. Low SST in the Kamchatka Pacific observed in spring and early summer, 1999 and 2000 caused a 2-4° southward shift of the main migration routes of sockeye; this change followed the shifting optimal temperature zone. Moreover, low temperatures in the Bering Sea did not allow sockeye from the Kamchatka river to overcome the temperature barrier, therefore, the species did not follow its usual route across the south-western Bering Sea, but migrated along the coastline to the Kamchatka Bay. There were dense concentrations of sockeye in the Petropavlovsk-Kommandor Subarea while in the Bering Sea the concentrations were very low (Figs. 2 and 3). The western-Kamchatka sockeye remained in the Pacific waters longer than usually because of low SST in April and May retarded the species maturation. Besides, low temperature in the Sea of Okhotsk made sockeye remain in the Pacific waters longer, enter the Sea of Okhotsk later than usual and approached coasts 2 weeks later. In 1999 and 2000 pink salmon also migrated to Ochotsk sea 2 weeks later compared to long-term observations. There was very small run of pink salmon to the north-eastern Kamchatka waters.

We anticipate the onset of a new epoch for salmon stocks in the north-western Pacific under cold conditions. Dr. Krovnin, (Laboratory of Climatology, VNIRO) forecasts that the cold period will remain in the northern Pacific till 2015. These conditions could be favorable for northern chum and sockeye. However, the pink salmon abundance is likely to keep declining. Possibly, Japanese chum stock will also grow less and the feeding area will decrease.

Fig. 1. Assumed schematic migration route of maturing chum salmon originating from Japan. Figures attached to arrows mean the month

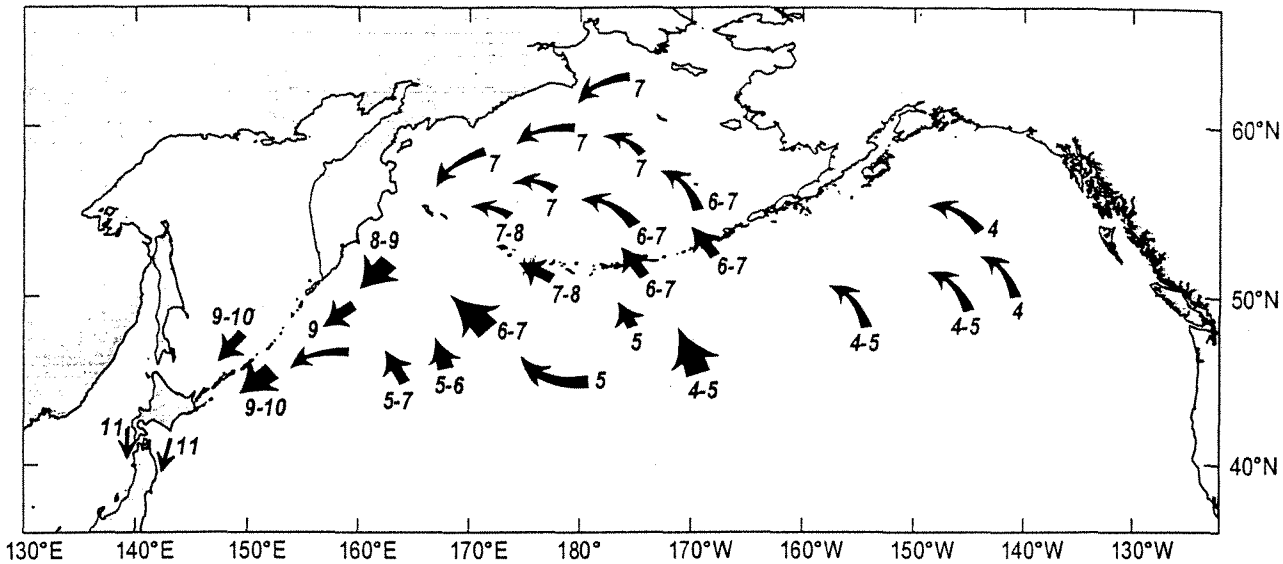


Fig. 2. Catch per unit effort (number per net). Olutorskii region
Second part of august 1995-1998

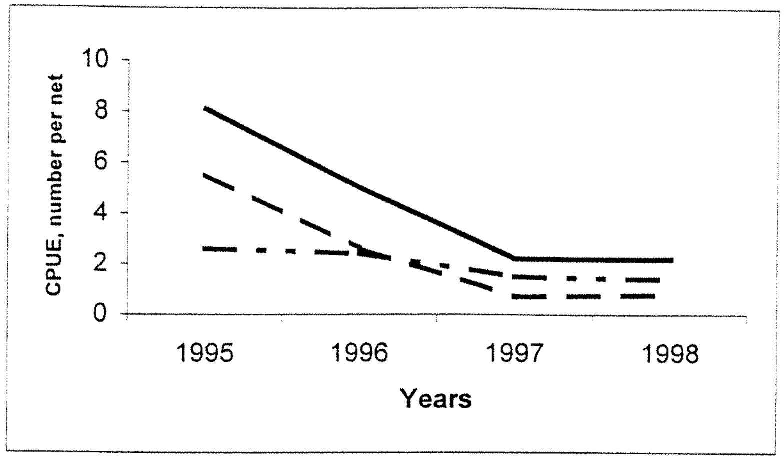


Fig. 3. Catch per unit effort (number per net). Bering Sea.
Navarinskii region. Second part of august 1995-1998

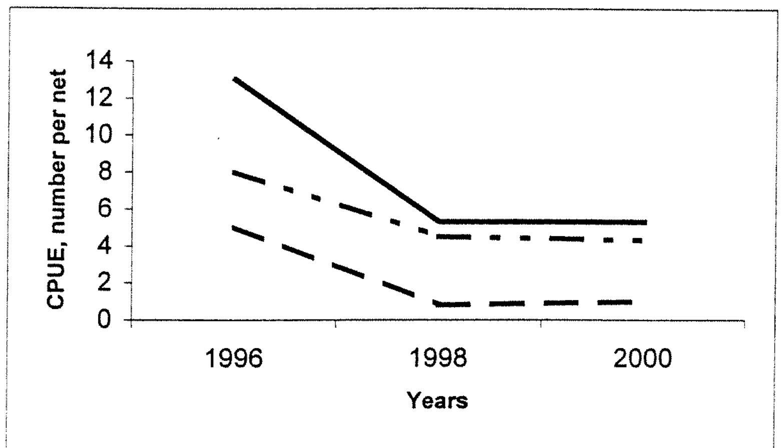
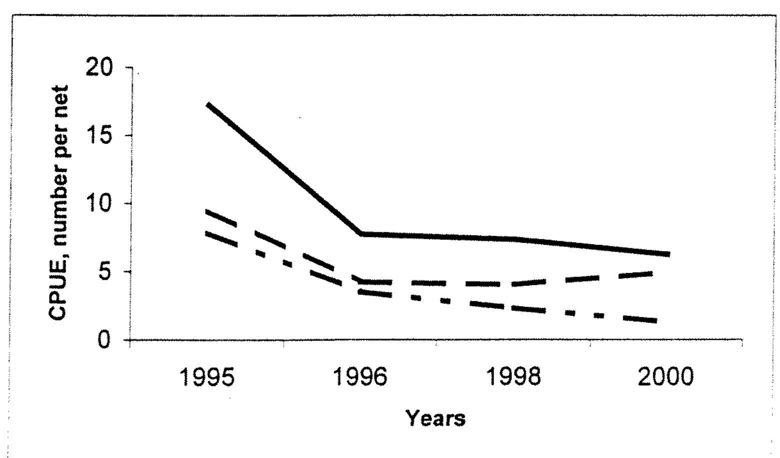


Fig. 4. Catch per unit effort (number per net). Pacific ocean
East Kamchatka. June 1995-1998



——— all salmon
– – – – red salmon
— · · — · chum salmon

Fig. 5. Part of flabby chum, (%) in West-North Pacific ocean in the different yea

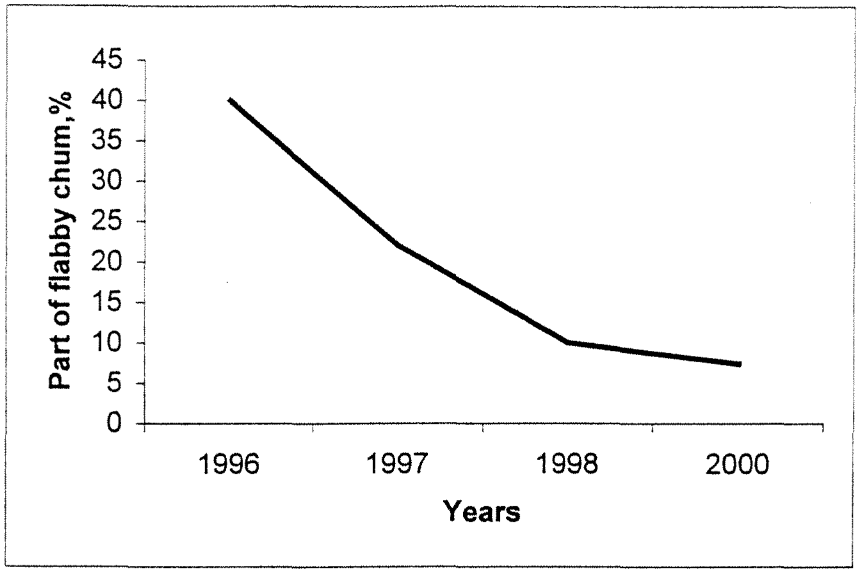
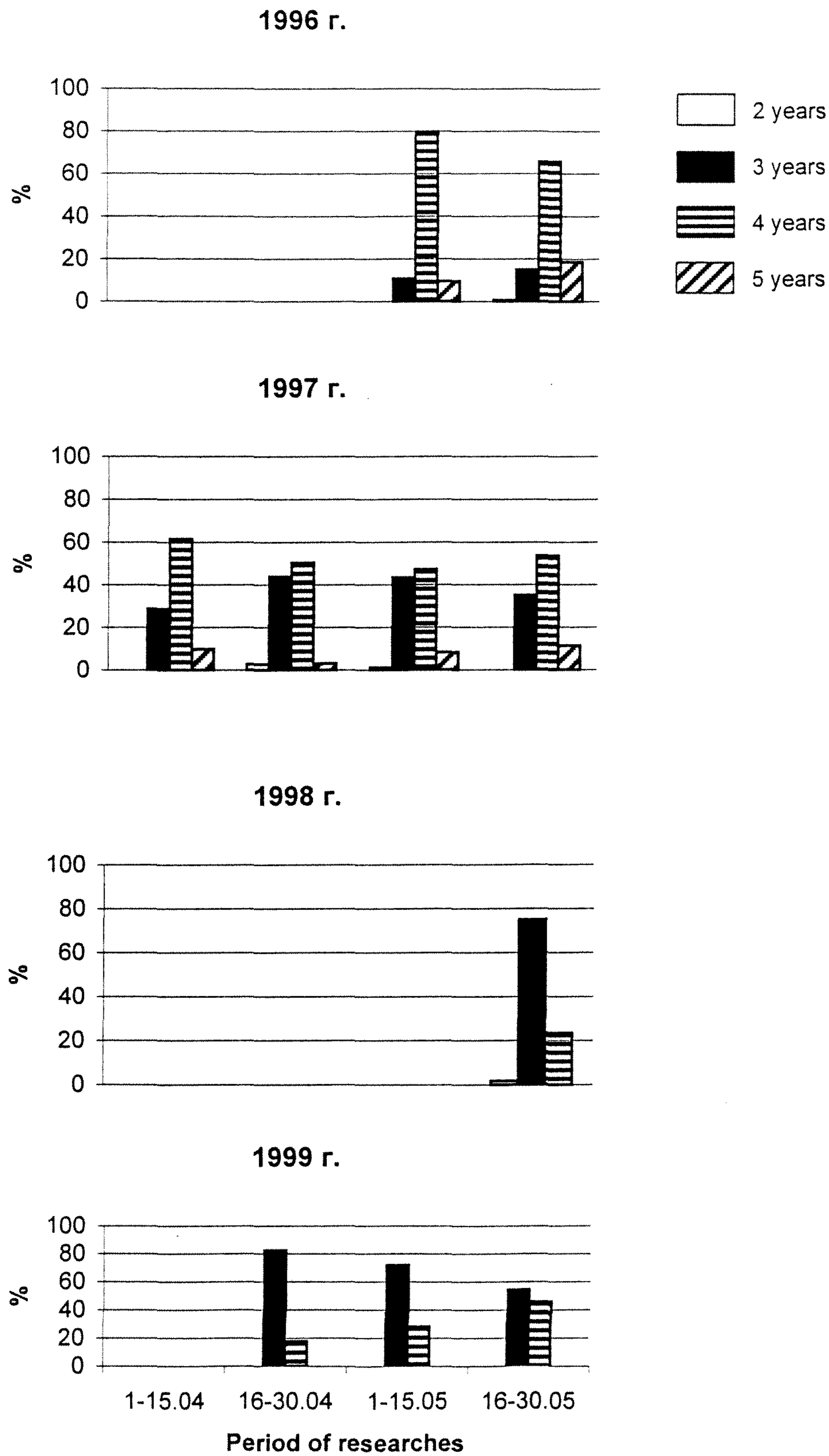


Fig. 6. Age composition of chum salmon. Pacific ocean near East Kamchatka. 1994-1999. April-May.



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