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Trends in Amur River fall chum abundance and climate change from 1907-2008, faced to fishery management

Transboundary river management problems still exists now. Amur River is one of them in Asia. U.S.-Canadian transboundary rivers are Yukon, Alsek, Taku and Stikine (Helle, 1996). After 1910-s both in China and Russia fall chum upriver populations along the mainstem Amur, and Songhua and Ussuri Rivers (tributaries) as well, falls low enough. Total catch of fall chum at Amur River mouth felt down from 50,000 mt (1910) to 0,47 mt (2000). Main part of fish biologists and fisheries managers believed in strong overcatch as a cause. After 1990-s neither Chinese nor Russians believed that Amur River is not able to recover its upriver's fall chum stocks. Russians fisheries managers believed that Chinese river drift net fishery near spawning grounds (up to 1000 km from Amur River mouth) is one of the main causes of Upper Amur River fall chum salmon populations declines. Chinese believed that Russian set net fall chum salmon fishery is main cause of Amur River fall chum salmon declines (Kurmazov, Zolotukhin, 2001; Zolotukhin, 2007). Understanding of real causes has come to early 2000-s only.

Amur River is the largest salmon basin in Asia (Fig. 1). The river is 4444 km long, and 1,855,000 km^2. Water temperature reaches 0.1^{o}C in winter, and exceeds 27^{o}C in summer. Year-to-year Amur River fall chum salmon abundance is determined mainly in the Lower Amur River, not during its 3-4 years in the North Pacific Ocean and Bering Sea. What conditions have determined it?

Tropical cyclones deliver water to the Amur River basin from southern side of Pacific Ocean (Fig. 2). During zonal type of atmospheric circulation, most of the precipitation is carried to the ocean. Warm and dry periods form in Amur River basin. During western type of atmospheric circulation, the majority of the precipitation is carried to mainland, and Amur River basin, as well. Cold and wet period forms in Amur River basin. The summer-fall floods help adult fall chum salmon to reach uppermost spawning grounds during its spawning run. The spring-summer floods help chum salmon juveniles, cooling river water during juvenile out-migration. Both sunspot and flood dynamics are similar (Fig. 3). So, we can try to predict the most poor and most abundant fall chum generation appearance by sunspot (Wolf numbers) trend. Water level in Amur River basin follows the western and zonal forms of atmospheric circulation frequency in the Pacific-

American sector of the northern hemisphere. Water levels in the Amur River increased rapidly and later dropped slowly over the course of two 11-year sunspot cycles (Fig. 4).

Fisheries statistical data on the Amur River fall chum salmon in Russia is inaccurate because commercial fishing has been closed with test fishing instead of commercial fishing in some years, and due to strong illegal fishing during 1920 - 1990-s (Fig. 5). Fall chum salmon drift net fishing was not prohibited in China. Number of fishing boats (amount of fishing effort) was similar over time (Fig. 6). Annual catches of fall chum salmon in China are correlated with Wolf's sunspot numbers (Fig. 7). Annual catch of fall chum salmon in China is like specific value because of its same CPUE - fishing effort (number of boats). We took another specific value – average fall chum salmon catch of 1 set net per 1 day in Lower Amur River. According Pearson's correlation test, their dynamics are similar, R=0.59 (Fig. 8).

Lower Amur basin has a very large floodplain area. Its water is strongly heated by sun in summer. If water temperature during chum fry downstream migration in June is greater than 23^{o}C, the return rate of adult fall chum salmon 3-4 years later declines (Fig. 9). As to causes of Amur River fall chum salmon decline in the 1960 - 1980-s, it was coincidence of several negative factors: A) Amur River water warming, B) dam construction in large Amur River tributaries, C) long-term warm dry epoch in the North Pacific Ocean.

Absence of spring-summer floods, which cools water during fall chum salmon fry downstream migration, leads to water overheating and fall chum fry mortality.

Absence of summer-fall floods helps to overheat river water in August, in early fall chum salmon spawning run. Because of water overheating some adult salmon die during river migration before spawning. The last such case was in 2008. Long term dry period leads to the disappearance of spring-fed habitats. Fall chum salmon spawning grounds in the Middle and Upper Amur River disappears. Total salmon productivity in Amur basin declines. Historically, total migration pathway for fall chum salmon in Amur River was about 3,000 km long. Now main portion of fall chum salmon migrate up from the Amur River mouth only 1,200 km. All of these factors together (long-term hot dry period, dam construction altering the natural flood regime, and overfishing) have led to a long-term decline in Amur River fall chum salmon, with periodic upswings in productivity during cool, wet climate cycles. During 1977-2005 global worming has increased the negative influence of long-term hot dry period in Amur basin. As has occurred for the upriver populations along the mainstem Amur and Ussuri River tributary, during last long-term hot dry periods 1977-2005 fall chum abundance can falls low enough (1970-s – 2005), but able to recover fast with beginning of a new favorable climate cycle (from 2006).

Now, with understanding of real fall chum decline causes, we can say that probably, Russian set net fall chum salmon fishery is one of the last causes of Amur River fall chum salmon declines. Probably, Chinese river drift net fishery is also one of the last causes of Upper Amur River fall chum salmon population declines.

Citations:

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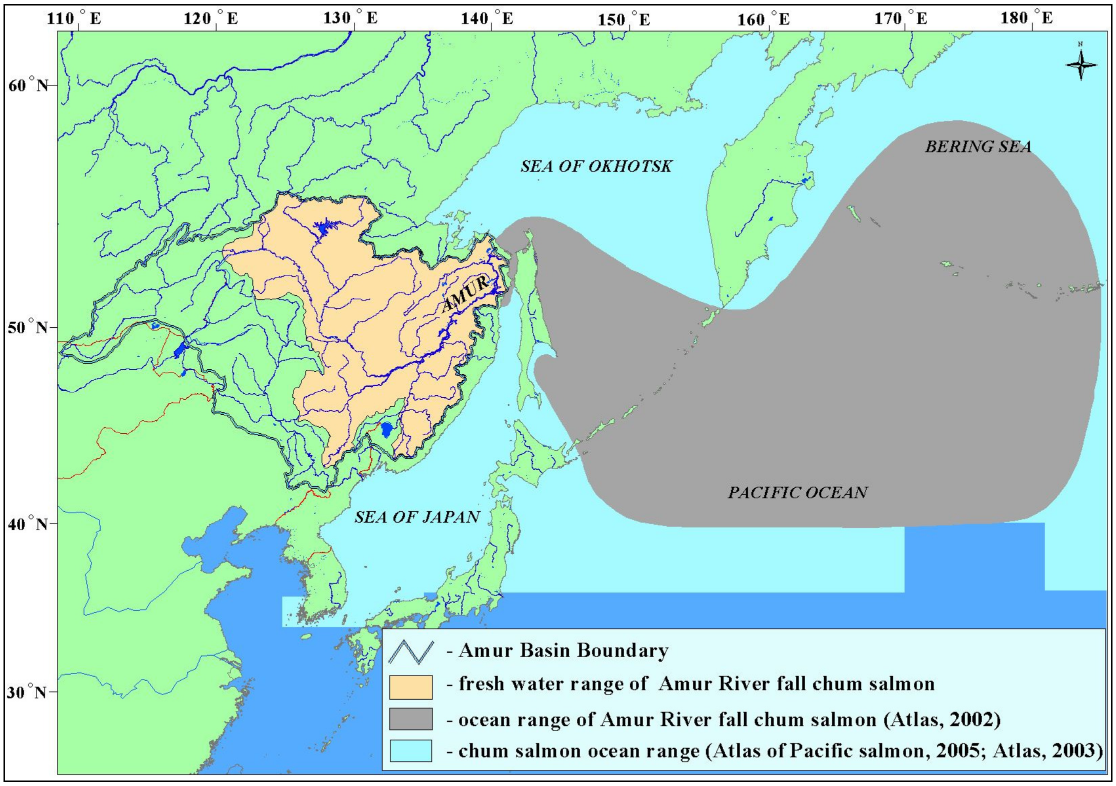


Fig. 1. Amur River fall chum freshwater and marine range

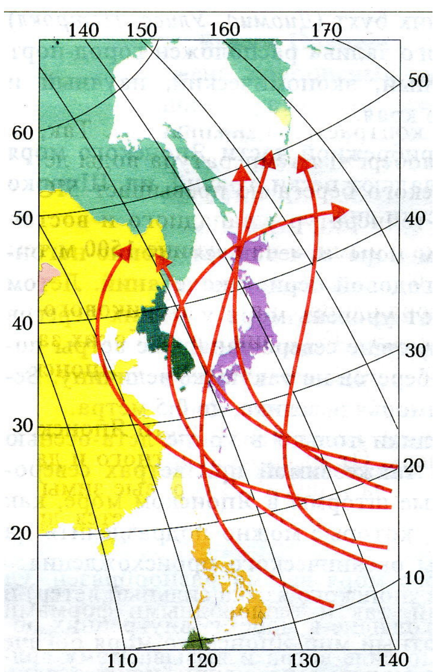


Fig. 2. Tropical cyclone (typhoon) tracks along East Asia

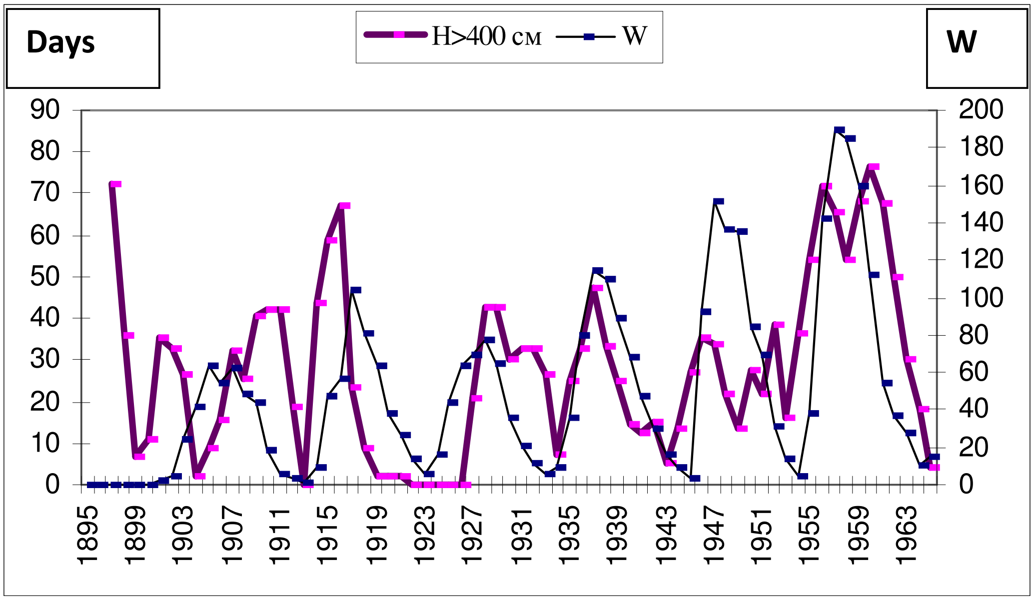


Fig. 3. Sunspot numbers (W) and strong floods 4 m in height and more (H>400 cm) duration (Days) in Amur River basin before dam construction in China and Russia

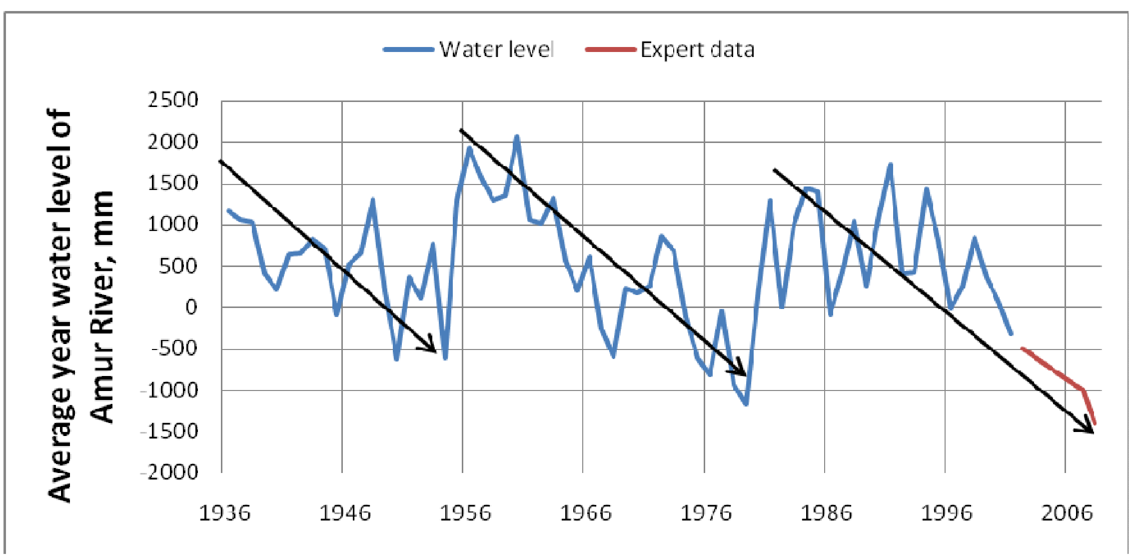


Fig. 4. Average year water level (mm) in Amur River near Khabarovsk city during 1936-2006

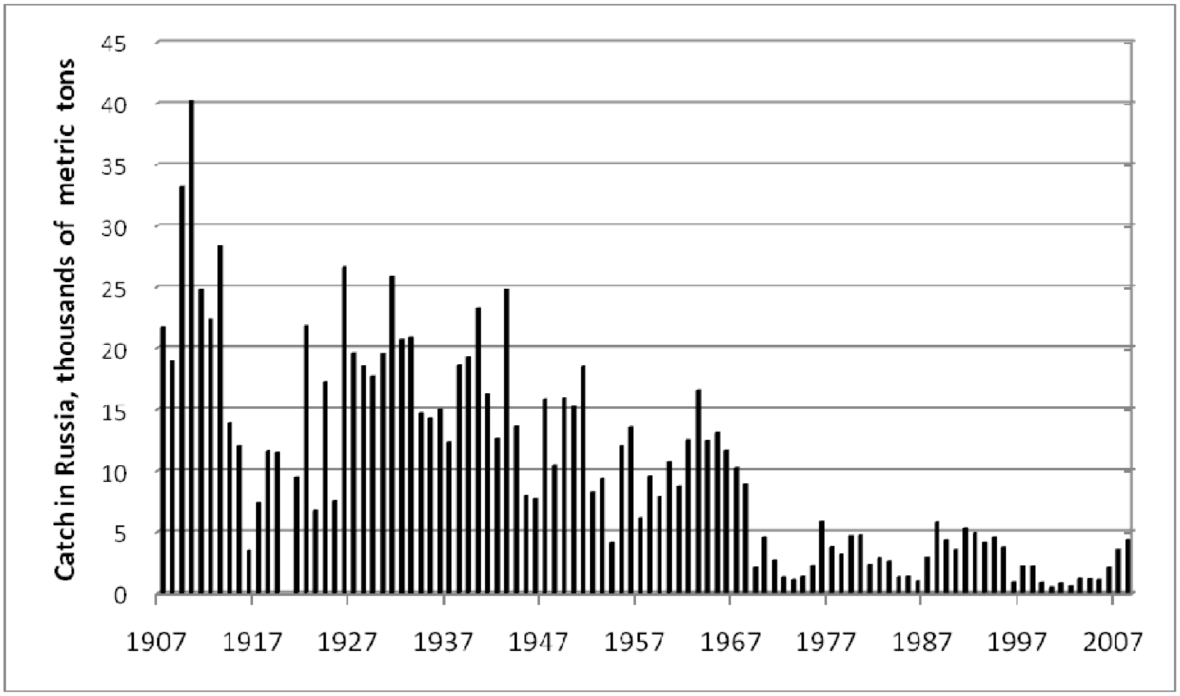


Fig. 5. Annual catch of Amur River fall chum salmon in Russia, in thousands of metric tons, 1907-2008

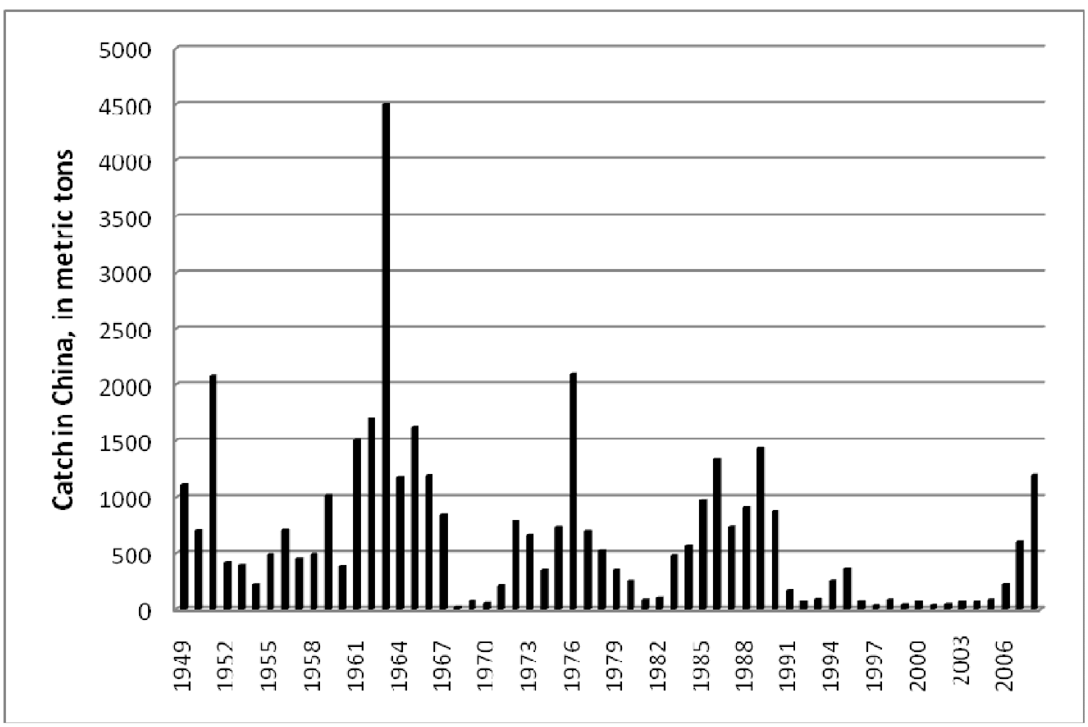


Fig. 6. Annual catch of Amur River fall chum salmon in China, in metric tons, 1949-2008

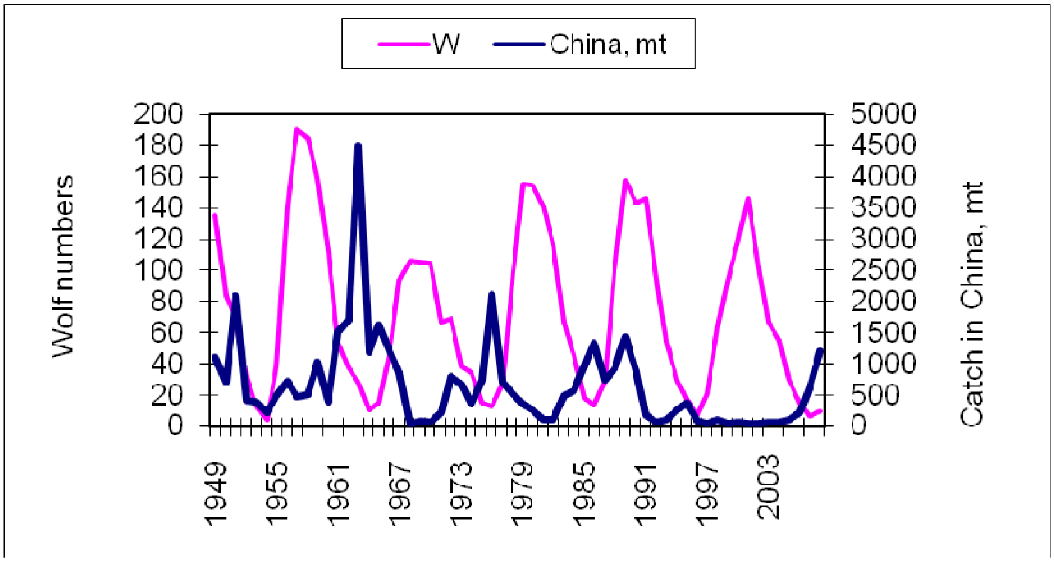


Fig. 7. Annual catch of Amur River fall chum in China, and Wolf numbers, 1949-2008

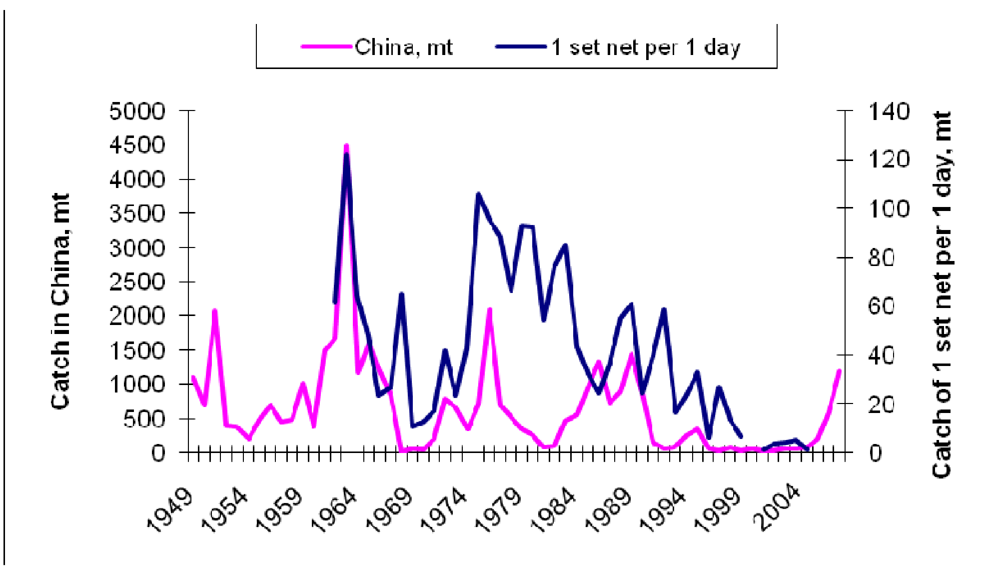


Fig. 8. Annual catch of Amur River fall chum in China (left), and fixed effort catch trend (one set net catch per one fishing day) in Russia (right), 1949-2008, in metric tons.

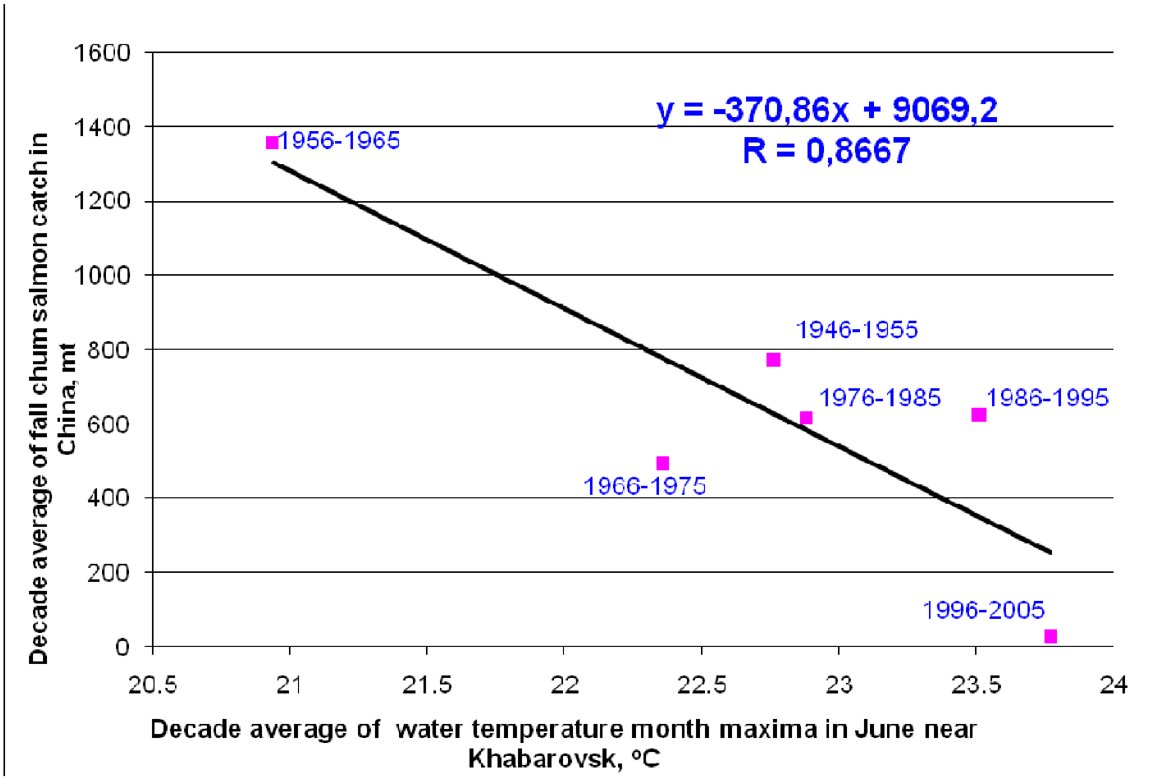


Fig. 9. Decadal mean water temperature maxima in June (peak of chum salmon fry seaward migration) and decadal mean annual catch of Amur River fall chum in China three years later, 1946-2005

Cause A.

Strong water heating of Amur River basin from 1980-s (Table 1)

Table 1

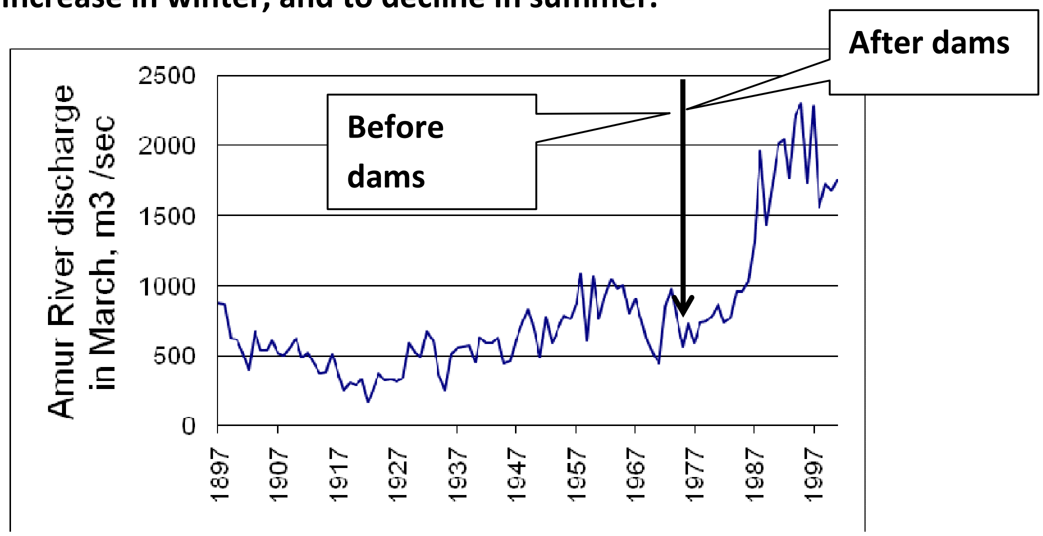
Water temperature monthly maxima in Amur River near Khabarovsk during fall chum salmon downstream migration in June. Lethal water temperature for chum salmon is near 24.0°C (Brett, 1952)

Year	Tmax°C	Year	Tmax°C	Year	Tmax°C
1946	21.2	1966	24.2	1986	23.2
1947	23.0	1967	20.7	1987	24.8

1948	23.6	1968	25.6	1988	27.2
1949	22.6	1969	20.2	1989	22.7
1950	23.4	1970	22.2	1990	22.3
1951	22.6	1971	19.8	1991	20.8
1952	24.8	1972	21.8	1992	25.0
1953	23.9	1973	22.6	1993	21.9
1954	23.2	1974	21.4	1994	22.0
1955	19.3	1975	25.1	1995	25.2
1956	21.9	1976	22.0	1996	22.8
1957	20.8	1977	21.9	1997	23.0
1958	19.8	1978	25.2	1998	25.4
1959	22.0	1979	22.4	1999	23.2
1960	18.4	1980	23.6	2000	25.0
1961	23.6	1981	22.4	2001	22.8
1962	19.6	1982	24.8	2002	22.1
1963	22.0	1983	18.2	2003	25.2
1964	20.0	1984	21.1	2004	23.8
1965	21.3	1985	21.2	2005	24.4

Cause B.

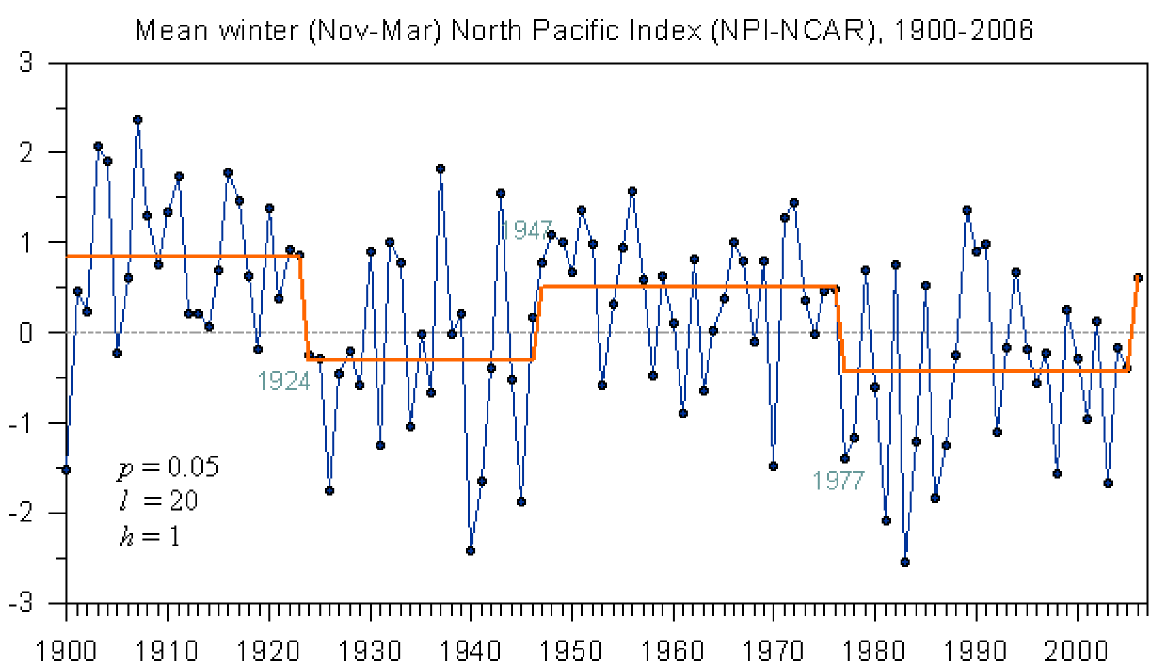
Amur River fall chum salmon abundance declines during low water periods (Rosly, 2002). Some large Amur River tributaries were dammed in 1980-s. After that Amur River water level (m) have started to work in wrong regime: to increase in winter, and to decline in summer.



Cause B. Dam construction has altered the natural flood regime after 1980-s

Cause C.

Long-term hot dry period



Cause C. The PNI index trend shows long-term hot dry period during 1977-2005