What Formed the Pacific Salmon Biomass in Amur River Basin in 2000–2010s?

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The Amur River is the biggest salmon basin in Asia, and the tenth longest river in the world. It is 5,052 km in length, from the source of the Kerulen River (Mongolia) and further along Lake Dalainor and the Argun River. The area of Amur basin (1,855 km^2) is larger than the area of the Sea of Okhotsk (1,600 km^2), which the Amur River enters.

Commercial catch data for all species of Amur River Pacific salmon shows the same trend: a sharp peak of catches in the 1910s and the subsequent decline to minimum catches in the early 2000s, and a sharp peak again, 100 years later, in the 2010s (Fig. 1–3). What processes could support such strong rise in the number of three ecologically different groups of Pacific salmon in Amur basin?

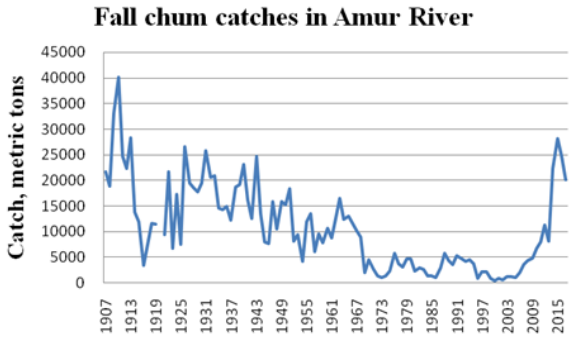

Fig. 1. Fall chum commercial catches in Amur River, 1907–2017.

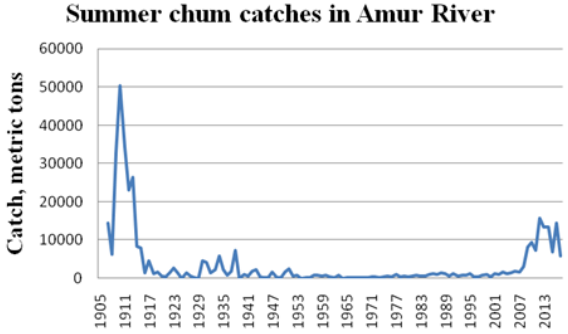

Fig. 2. Summer chum commercial catches in Amur River, 1907–2017.

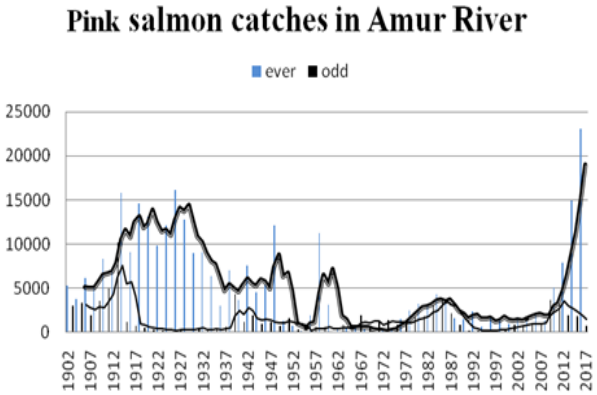

Fig. 3. Pink salmon commercial catches in Amur River, 1907–2017.

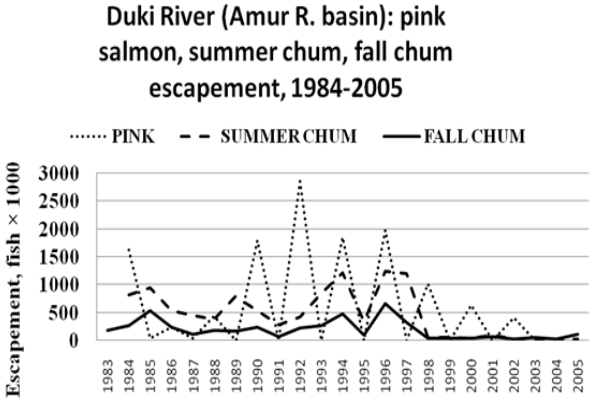

Fig. 4. Pink and chum salmon escapement in the Duki test river (Amur basin) during 1984–2005 (Amurrybvod's data).

In 1990s the numbers of pink salmon, summer, and fall chum salmon in the Amur River were low and they could not form very large generations. The small parent generation for pink and chum salmon led to low abundance of progeny. Commercial catches of pink salmon, summer, and fall chum salmon in the Amur River during 1990–2005 were as small as 2,000–5,000 metric tons each.

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After 2005, the number of Pacific salmon in the Amur River began to grow. Commercial catches of each species reached 5,000 metric tons in 2009, and quickly exceeded 10,000 metric tons. In 2016, the catches of pink salmon reached a new historical maximum 23,100 metric tons. At the same time, the escapement graph from the test Duki River declined for all species of Amur River Pacific salmon, and in 1998 reached a minimum, which continued past 2005 (Fig. 4).

Which factor prevailed for the formation of the of Amur River salmon biomass? It is unlikely that hatchery reproduction could affect the Amur River Pacific salmon population when there was such a small contribution of hatchery fry compared to natural processes (Belyaev and Zolotukhin 2000) (Fig. 5). It is also unlikely that the Amur River Pacific salmon populations could be affected by changes in the average surface air temperature, as the first peak of their abundance occurred when the negative anomalies were at a maximum in 1900–1910s. The second peak in abundance of Amur River salmon occurred when the positive surface air temperature anomalies were at a maximum in 2000–2010s (Fig. 6).

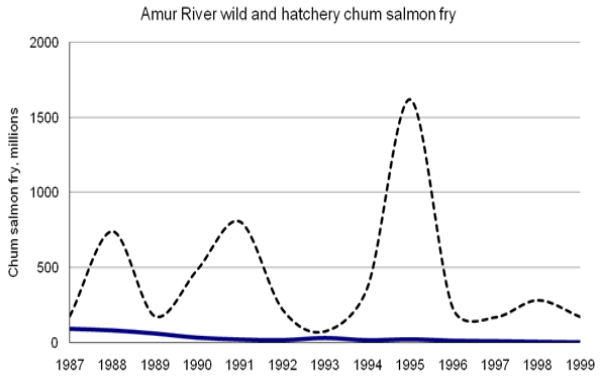

Fig. 5. Number of wild and hatchery chum salmon fry in Amur River during 1987–1999, million. Dotted line—wild chum salmon fry; solid line—hatchery chum salmon fry.

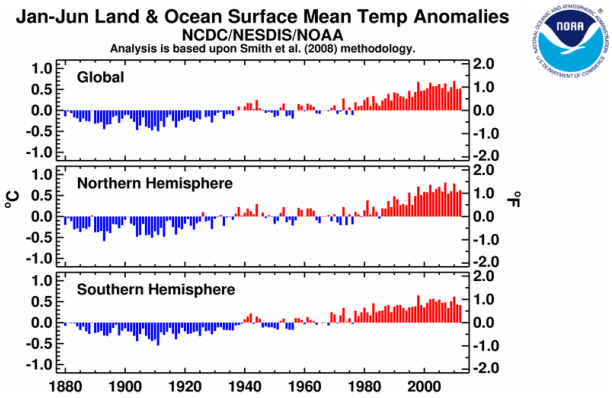

Fig. 6. Land and Ocean surface mean temperature anomalies, 1880–2012. NOAA data.

The mortality rate for the Amur River Pacific salmon continued to be small in 2015: gill net traumas were 0.1%, traumas from Alepisaurus ferox and other predator fish were about 1.8%, and traumas from long line hooks were 0.1% in the Amur River. These values are lower than the mortalities from 1994–2000 (Zolotukhin and Kaplanova 2002). It is most likely that abundance of the Amur River Pacific salmon generations is regulated within estuaries and in the early marine periods, when the juvenile mortality rate is increased by the ice presence and ice movement into the coastal zone. Dynamics of the Sea of Okhotsk ice cover is similar to the dynamics of solar cycles (Wolf`s numbers) (Shuntov 2001), but their impact on the Amur salmon juveniles number is mediated by complex of environmental and climatic factors. The resulting impact of Sea of Okhotsk ice cover is heavily influenced by the survival rate of the Amur River Pacific salmon during ocean migration, which has the highest weight among other environmental and climatic factors. Most good Pearson`s correlation for some climate indexes and total commercial chum salmon catch in the Amur River during 1990–2017 were: North Pacific Circulation PCI 0.6471, and Global Air Temperature GLB.Ts+dSST -0.4952. Other indexes had small power: AFI (-0.0478), ALPI (-0.1709), NP (0.1382), N. HEMI (-0.2759), PDO (0.0358), LOD (0.2074), Wolf`s numbers (-0.2402).

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