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Current Stock Assessment of Pacific Salmon in the Far East of Russia

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All six species of the genus *Oncorhynchus spp.* are reproduced in the Russia Far East. The huge length of the reproductive area of Pacific salmon in the Russian Far East, different climatic conditions of reproduction and feeding, and various terms of spawning migration determine the different dynamics of stocks in the regions, both in general, and in particular salmon species.

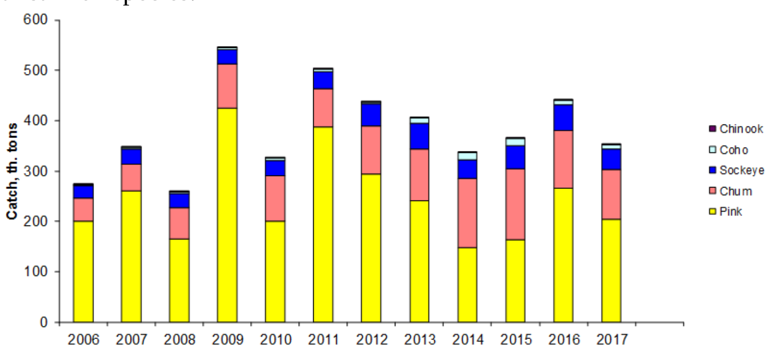

Fig. 1. Salmon catch in the Far East in 2006–2017.

As of 2017, Russian salmon stocks remain in general at a high level, but slightly below the level of recent years. The total catch of all Pacific salmon species by the coastal fishery in the Far East in 2017 was 353,000 metric tons, which is 13,000 metric tons less than the catch of 2015 and 85,000 metric tons less than the catch in 2016 (Fig. 1). Out of these 353,000 metric tons, 241,000 metric tons were caught in Kamchatka with 163,000 metric tons caught in its northeastern part. In all other regions, 112,000 metric tons of salmon were caught in total. The salmon approaches to the Northeast Kamchatka in 2017 were the third largest and the catch was the second largest in the history of the fishery in this region (Shevlyakov et al. 2017).

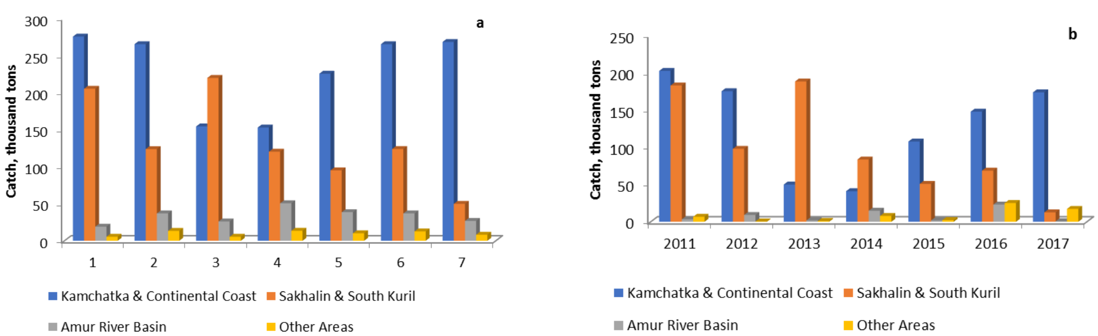

Fig. 2. All salmon species catch (a) and pink salmon catch (b) in the different regions of the Russian Far East in 2011–2017.

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In recent years due to the warming of the ocean, the main areas of salmon reproduction shifted to the north. As the result, salmon abundance and catch increased in the northern regions (Kamchatka and Continental Coast of Okhotsk); while importance of southern reproduction areas (Sakhalin and South Kuril Islands) decreased (Fig. 2a).

Pink salmon Oncorchynchus gorbuscha

Pink salmon constitute about 55–75% of the total salmon catch in the Far East. Therefore, it is the trends in the dynamics of their stocks that determine trends in the dynamics of all salmon stocks in Far East (Fig. 2b). Rise of Kamchatka pink salmon stocks in 2015–2017 was associated with a very sharp warming of water in the Northeast Pacific in 2014–2016 and the subsequent advection of heat into the Bering and Okhotsk Seas observed in all seasons of the year (Krovnin et al. 2016). The pink salmon catches in the East and West Kamchatka are strongly correlated, when East Kamchatka catch increases, it leads to increases in West Kamchatka catch the next year (Fig. 3a). However, decline of the Sakhalin Coast stocks continued in 2015–2017 under the influence of both adverse environmental conditions at early life stages and poaching in the rivers (Fig. 3b).

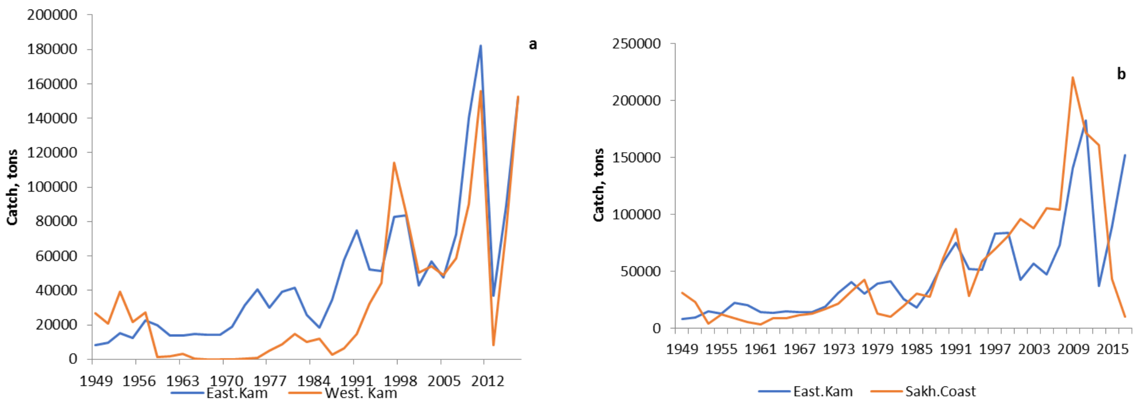

Fig. 3. Dynamics of pink salmon catch in Western and Eastern Kamchatka (a) and Eastern Kamchatka and Sakhalin Coast (b) in 1949–2017.

The intensive growth of Sakhalin pink salmon stocks was noted in the early 2000s, that resulted in the historical maximum of catches of both generative lines. This was associated mainly with an increase in survival during the marine life period. In 2015–2017 there was a sharp reduction in the number of pink salmon. After 2012 the tendency towards a decrease in sea surface temperature (SST) in the southern Okhotsk Sea has appeared. Apparently, it resulted in a decline in Sakhalin salmon stocks. In addition, in the southern Okhotsk Sea in winter-spring seasons of 2014–2017 there was an increased intensity of cyclonic activity and frequent occurrence of typhoons with heavy rainfall. These factors also contribute to decreases in pink salmon stocks in the eastern Sakhalin and South Kurils. At the same time, in the South Kurils, in contrast to the Sakhalin Coast, declines in pink salmon catches in 2011–2015 were replaced by their rise in 2016 and 2017. It should be noted that both in Sakhalin and in the southern Kuril Islands, the basis of returns was the late temporal form of pink salmon in recent years (Kaev 2012; Kaev and Sidorenko 2015; Klovach et al. 2017; Romasenko et al. 2017).

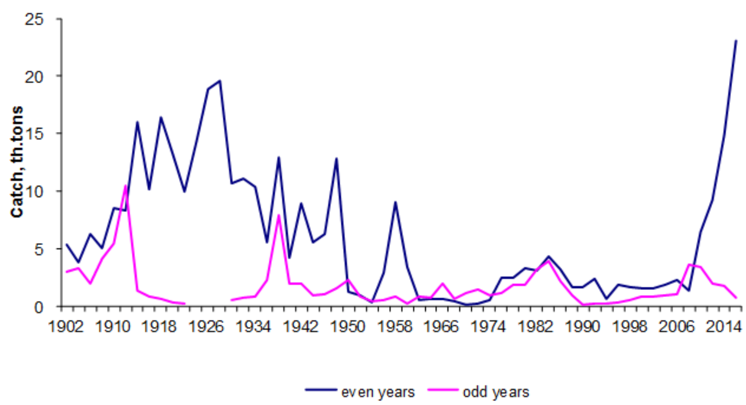

Fig. 4. Catch Dynamic of Amur basin Pink Salmon in 1900–2017.

At present, even-year generations of Amur and Primor'e pink salmon stocks and their catches exceed the level of the early 20th century (Ostrovsky 2014). One of possible reasons may be associated with effects of continental hydrometeorological processes in winter on survival during embryonic development in nests (Fig. 4).

Chum salmon Oncorchynchus keta

Chum salmon stocks are currently at high levels. From 2001 to 2015, their catches in the Far East have increased more than five times, from 28,000 to 142,000 metric tons (Volobuev et al. 2017). Since 2016, decline in catch of chum salmon has been noted. In 2017, catch of chum was 98,000 metric tons in all regions of the Far East (Fig. 5a). The contribution of chum salmon catches from different regions to the total salmon catch in the Far East varied with time. In recent years, the largest contribution of chum salmon to total catches was from the Amur basin stock (Fig. 5b). Its catches from 2001 to 2015 increased 17 times, from 2,140 to 36,700 metric tons. In 2017, Amur chum salmon catch was 26,100 metric tons. Decrease in the catch of the Amur chum in 2017 is generally due to the decrease in the catch of the summer race (Fig. 6).

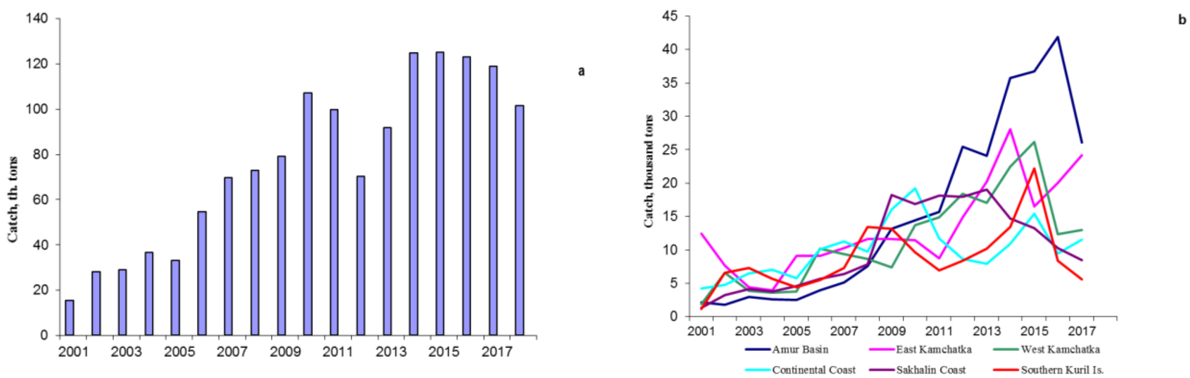

Fig. 5. Chum salmon catches in the Russian Far East in total (a), and in various regions (b) in 2001–2017.

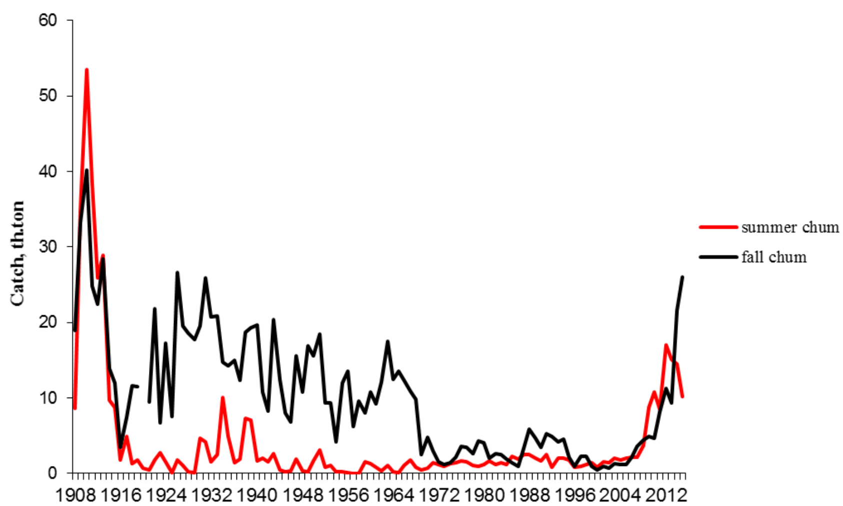

Fig. 6. Dynamic of Amur summer and fall chum salmon catch in 1950–2017.

Sockeye salmon Oncorchynchus nerka

Sockeye salmon stocks—the third numerous species of Pacific salmon in the Russian Far East—are at high levels. Their catch of 42,100 metric tons in 2017 was slightly lower compared to previous two years. This catch consists mainly of fish from two stocks—stock of Kurilskoe Lake in the West Kamchatka and stock of the Kamchatka river in the East Kamchatka. The abundance of both stocks are now at high levels in Kamchatka. In

2017, 40,000 metric tons of sockeye salmon were caught in Kamchatka waters. In other areas, such as Chukotka, Continental Coast of Okhotsk and Kuril Islands, 2,100 tons in total were caught.

Coho salmon Oncorchynchus kisutch

Coho salmon catch in 2017 was about 7,000 metric tons. This is less than half of the catch in 2015 and 2014 (14,500 metric tons). About the same amount was caught in 2016. Nevertheless, now Kamchatka coho salmon stocks are above mean long-term level. There is also an increase in Continental Coast coho salmon stocks (645 metric tons).

Chinook salmon Oncorhynchus tshawytscha

The catch of Far East Chinook in 2017 was 388 metric tons, which was more than two times lower than in 2016 (818 metric tons). The abundance of the East Kamchatka stocks has stabilized at an average level. However, the catch-by- weight is lower than in the 1990s due to a decrease in the proportion of females, their rejuvenation, and reduction in body weight (Shevlyakov et al. 2017). The population of the Bolshaya River Chinook salmon (West Kamchatka) is in a depressed state now (Fig. 7). Commercial fishing of cherry salmon has been closed for many years, however, catching cherry salmon for fish farming, scientific research purposes, and sport fishing still occurs.

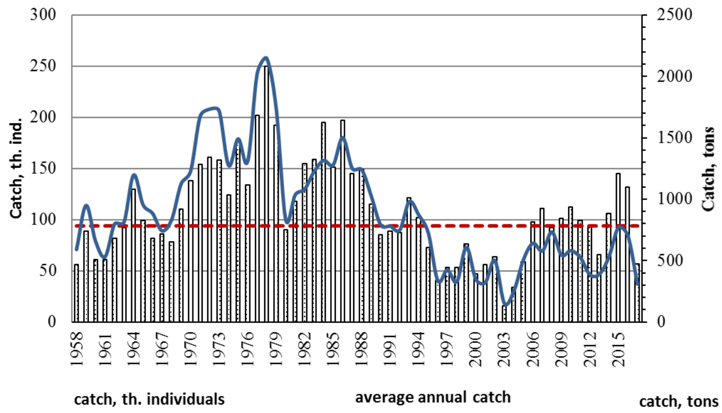

Fig. 7. Chinook salmon in Kamchatka river (East Kamchatka) in 1958–2017.

The contribution of artificial reproduction of Pacific salmon to stocks and catches

There are 68 salmon hatcheries in the Far East. In 2017, they released 1,043,500 juveniles in total; 82.6% of juveniles were released from the Sakhalin and Iturup hatcheries. Chum and pink salmon constituted 99.2% of the hatchery fish released (Fig. 8). The growth of catches of chum salmon in Sakhalin and the southern Kuril Islands from 3,598 metric tons (on average for 1991–2000) to 33,573 metric tons (on average for 2011–2015) was mainly due to the development of artificial reproduction. Changes in chum salmon hatchery culture since the 1990s—reconstruction of the operating hatcheries, progress in biotechnology, appearance of new hatcheries with a private property form—have led to a substantial growth of their catches. In the recent years a method of the out-of-hatchery culturing of chum juveniles began to be approbated. Currently, up to 90% of Sakhalin and Iturup chum salmon are represented by hatchery fish. The problem of the effectiveness of pink salmon culture relative to the increase in their commercial catches is shown to remain controversial (Morita et al. 2006; Kaev and Ignatyev 2015; Klovach et al. 2017).

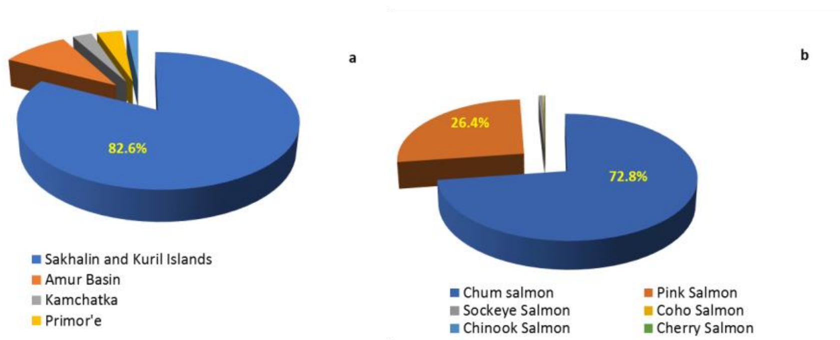

Fig. 8. Share of salmon fry and smolts hatchery releases by area (a) and species (b) from the total production in the Far East in 2017, %.

Summary

The anomalous surface warming started in autumn 2013 which had spread into the western Bering Sea by spring 2014, and in 2015/2016 it reached the North Kuril area and northern Okhotsk Sea. This was accompanied by northward shift of reproduction areas of pink salmon. As a result of increased marine survival of the northern pink salmon stocks (West and East Kamchatka and Continental Coast of Okhotsk), their approaches to the coast and catches increased. At the same time, the Sakhalin and South Kuril pink salmon stocks decreased. In 2017, all chum salmon stocks were at a high level but somewhat lower than during two previous years. All chum salmon stocks except for the South Kuril and Sakhalin stocks, were maintained by means of natural reproduction. The South Kuril and Sakhalin stocks were maintained by artificial reproduction, approximately 90% of the stocks are hatchery fish. Coho and sockeye stocks, originated mainly from Kamchatka, are in a good state now. Further research is needed to explain the reasons of sharp increase in Amur and Primor'e pink salmon stocks in even years, as well as the reasons of degradation and changes in biological features of Kamchatka Chinook salmon.

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