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Changes in the state of highly abundant fish stocks as a response to the West Pacific pattern regime shifts.

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Summary
Based on the dynamics of the mean winter index of the West Pacific teleconnection pattern over the last 50 years, two climatic regimes with the quite different habitat conditions of the most abundant fish populations in the Northwest Pacific were identified. The climatic, oceanological and biotic factors during the first (cold) period of 1963-1986 were favorable for frequent appearance of the strong year classes of the main walleye pollock stocks and Japanese sardine (only in 1972-1985), but the Asian salmon stocks during these years had a low abundance. The second, warm, regime (1987-2011) was characterised by the reverse tendencies in fish populations. In the winter of 2011-2012, the evidence for the beginning of a new cold climatic regime has appeared. The especially severe climatic conditions were observed during this winter in the western Bering Sea. As a result, the pink salmon approaches to the East Kamchatka coast in 2013 decreased by 80%, compared to 2011.

Introduction
The issue of recruitment variability and its causes and consequences to highly abundant fish populations is the single most important problem in fisheries. In the Northwest Pacific, they include the walleye pollock populations, a share of which in the nektonic community reaches 80-90%, Asian salmon stocks (pink, chum, and sockeye salmons), and Japanese sardine, which is highly abundant during some decadal periods. All these populations are characterised by the large-scale ranges, high interannual and low-frequency variability of their year class strength (Buslov, 2008; Ovsyannikov, 2011; Smirnov, 2005; Shuntov and Temnykh, 2008, 2011; Yasuda et al., 1999). The knowledge of main causes of the low-frequency variability allows for foreseeing their state for a long period. To identify these causes, a comparative analysis of the high- and low yield periods of the above populations with the climatic, oceanological and biotic conditions of their habitat is made.

Materials and methods
The data on the year class strength of the populations were taken from the published papers (see the references above), and from the site of North Pacific Anadromous Fish Commission (www.npafc.org). The climatic regimes in the Northwest Pacific during the last 50 years were identified by the dynamics of the mean winter (January-March) indices of the West Pacific (WP) teleconnection pattern and North Pacific Gyre Oscillation (NPGO), which time series were available at www.esrl.noaa.gov/psd/data/climateindices/ and www.o3d.org/npgo/, respectively. The regime shifts were detected with the use of a sequential algorithm (Rodionov, 2004).

Results and discussion
Over the last 50 years the mean winter WP index shows the existence of two prominent regimes, with predominance of its negative values in 1963-1986 and positive ones in the 1987-2011 period. The climatic, oceanological and biotic conditions of the populations' habitat during these regimes were quite different. The regime of 1963-1986 was characterised by the increase in intensity of the Siberian High and Aleutian Low; strengthening of winter monsoon and zonal atmospheric flow; severe winters and high ice cover in the marginal seas; southward displacement of the Subarctic Front; development of negative sea surface temperature anomalies (SSTA); deepening of the winter mixed layer and lessening of water stratification; and increased bioproductivity in the subtropical and subarctic areas

during the winter-spring and spring-summer seasons, respectively. In these years, the main walleye pollock populations (Western Bering Sea, East and West Kamchatka stocks), owing to their high thermal tolerance, were characterised by frequent appearance of the strongest, strong and medium generations and rare formation of weak year classes under the good food base for feeding of both spawners and larva and young fish, favorable wind conditions during the spawning period. This ensured the high level of the stocks and high walleye pollock catches. The Asian salmon stocks, because of their high sensitivity to water temperature at all stages of the life cycle (river, coastal, marine, and oceanic) and decreased food base in the period of their seaward run into the coastal zone, were characterised by low survival rates of young fish and, as a result, low abundance, despite the rich food base in the sea and ocean during the spring and summer. The formation of favorable conditions in the Kuroshio Extension area during the spawning period resulted in frequent appearance of strong year classes of Japanese sardine in the second half of this climatic regime (1972-1985). These conditions were associated with the development of negative SSTA, deepening of the mixed layer and higher bioproductivity in the spawning area during the winter-spring season. With the establishment of a new climatic regime in 1985-1987, the habitat conditions of all populations under consideration have changed drastically, due to decrease in the intensity of the Siberian High and Aleutian Low, lessening of winter monsoon and zonal atmospheric flow, and intensification and westward displacement of Hawaiian Anticyclone. These years, except for the short 1999-2001 period, were characterised by mild winters; lighter ice conditions; formation of positive SSTA and shallowing of the winter mixed layer; higher bioproductivity in the winter, but the lower plankton production rates in the spring-summer season because of strengthening of water stratification. For the walleye pollock populations, these conditions resulted in formation of the rare strong and medium year classes and frequent appearance of the weakest and weak generations. The causes of formation of strong walleye pollock year classes since 2003 are discussed. The sharp increase in the Asian salmon stocks began from 1989, that is two years after the regime shift of 1985-1987. It was resulted from the mild winters and higher winter bioproductivity. The second jump in growth of the salmon stocks after 2003 was associated with the prominent improvement of thermal conditions at all stages of their life cycle and, first of all, during their river and coastal stages. The population of Japanese sardine after 1985 is characterised by absence of the strong year classes. The only exception is the strong 2010 generation, associated with the abnormal climatic conditions. This generation does not imply the beginning of a new 'sardine' period, but it is rather a precursor of its establishment in the 2020s. In the winter of 2011-2012, the tendency toward a shift of the warm climatic regime of 1987-2011 has appeared. The especially severe climatic conditions during this winter were observed in the western Bering Sea. They resulted in low survival rate of young pink salmon both at the river and coastal stages. As a result, the pink salmon approaches to the East Kamchatka coast in 2013 decreased by 80%, compared to 2011. With the establishment of a new cold regime, similar to that in 1963-1986, the frequent appearance of strong year classes of the main walleye pollock stocks may be expected.

References

Buslov, A.V. 2008. Walleye pollock of the East Kamchatka coast: the present state of stocks and recommendations on their rational exploitation. Izvestiya TINRO, 152: 3-17 (in Russian).

Rodionov, S.N. 2004. A sequential algorithm for testing climate regime shifts. Geophysical Research Letters, 31, doi:10.1029/2004GL019448.(L09204).

Ovsyannikov, E.E. 2011. Dynamics of spatial distribution of walleye pollock eggs and juveniles in the northern Sea of Okhotsk. Author's abstract of PhD Thesis, TINRO Publishing, Vladivostok. 20 pp. (in Russian).

Shuntov, V.P., and Temnykh, O.S. 2008. Pacific salmons in marine and oceanic ecosystems: monography. Vol. I. TINRO Publishing, Vladivostok. 480 pp. (in Russian).

Shuntov, V.P., and Temnykh, O.S. 2011. Pacific salmons in marine and oceanic ecosystems: monography. Vol. II. TINRO Publishing, Vladivostok. 471 pp. (in Russian).

Smirnov, A.V. 2005. The influence of some biotic and abiotic factors on survival rate of Okhotsk Sea walleye Pollock. Voprosy rybolovstva, 6(2): 278-297 (in Russian).

Yasuda, I., Tsugisaki, H., Watanabe, Y., et al. 1999. Interdecadal variations in Japanese sardine and ocean/climate. Fishery Oceanography, 8: 18-24.