Marine Biology in the 21st Century: Achievements and Development Prospects (on the 100th Anniversary of Birth of the Academician Alexei V. Zhirmunsky)

EFFECT OF TEMPERATURE CONDITIONS ON DYNAMICS OF CATCHES (ABUNDANCE) OF THE PINK SALMON ONCORHYNCHUS GORBUSHA BASED ON RETROSPECTIVE DATA (SEA OF JAPAN, STRAIT OF TARTARY)

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Figure 1. Location of the study areas (1–3) and the coastal stations (m): 1, southeastern coast of Khabarovsky krai, northwest of the Strait of Tartary, Sovetskaya Gavan coastal station; 2, northeastern Primorye, southwest of the Strait of Tartary, Sosunovo coastal station; 3, southeastern Primorye, north of the Sea of Japan, Rudnaya Pristan coastal station

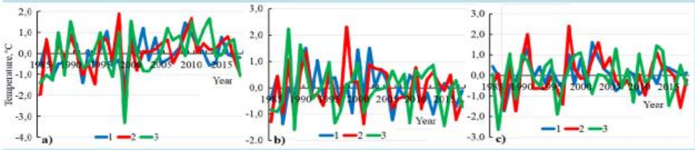

Figure 3. Anomalies of average monthly temperature of sea water in May (1), June (2) and July (3): a, northwestern part of the Strait of Tartary; b, its southwestern part; c, northern part of the Sea of Japan

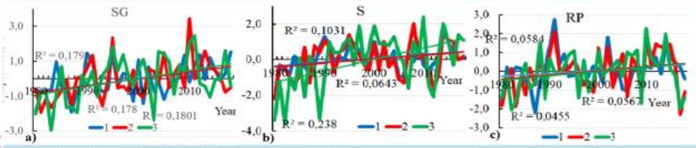

Figure 3. Anomalies of sea water temperature (Δtw) in May (1), June (2) and July (3): a, Sovetskaya Gavan; b, Sosunovo; c, Rudnaya Pristan; (—) – Δtw, (–), linear trends

The long-term (1980–2018) data on the water temperature regime and associated synoptic processes in favorable and unfavorable years of the abundance formation and the pink salmon Oncorhynchus gorbuscha return to the rivers of the Sea of Japan coast in Primorsky krai have been analyzed. The survival of pink salmon juveniles was maximal in 2009 and 2015 that is confirmed by multiplicity of the return. During the downstream migration of juveniles in May 2009, the surface water layer temperature was higher than the average one for the period of survey. The synoptic situation corresponded to favorable conditions for the survival of juveniles when the SFET center was located at 55° N and warm air masses propagated in the front zone of the surface cyclones. The maximum pink salmon return was observed in 2010 and 2016 at high positive water temperature anomalies. Thus, in June 2010, the maximum increase in the temperature was recorded at Sovetskaya Gavan coastal weather stations (Δtw = 3.4°C), at other stations towards the south Δtw was 0.3 and 1.5°C, respectively and in July, it was 2.1, 2.4 and 2.3°C. The maximum return of Primorye pink salmon in 2010 and 2016 was probably associated with redistribution of anadromous migratary flows due to the favorable temperature regime of sea waters in the surveyed region as a result of which fish from other Japanese stocks entered the rivers of Primorsky krai. During the period of low pink salmon return in 2009, negative water temperature anomalies prevailed almost in the entire surveyed area. Based on the analysis of synoptic processes the schemes of favorable and unfavorable climatic conditions for anadromous migration of Primorye pink salmon were made. An early beginning of the second stage of the summer Far Eastern monsoon during the anadromous migration leads to the formation of warm regimes and occurrence of thermal extrema on the surface of the Sea of Japan that creates favorable conditions for pink salmon return to the Primorye coast. When the effect of the Hawaiian anticyclone increases, regions with extremely high air temperature are formed over the Sea of Japan that is a prerequisite for extremely high catches of pink salmon. The delay of return is observed when a high-altitude trough is formed over the Sea of Okhotsk and a high-pressure region appears in the surface layer. The thermal regime of sea waters formed under the effect of cold and warm stages of the Far Eastern monsoon has a considerable effect on the anadromous migration of pink salmon but further detail studies of this issue are required. The results obtained in the study may be used for a short-term prediction of the dynamics of the Primorye pink salmon return.

Table 1. Values of pink salmon Oncorhynchus gorbuscha escapement, return and its multiplicity relative to parents in rivers of the Primorsky krai in 2000–2019

Year of spawning	Number of spawners, thous. ind.	Year: downstream migration	Year: return	Abundance of return specimens, thous. ind.	Multiplicity of return (K_{ω})	Conditional survival of generation *
2000	1433.0	2001	2002	2461.00	1.72	Medium
2001	N.d.	2002	2003	N.d.		
2002	1550.0	2003	2004	1599.60	1.03	Low
2003	N.d.	2004	2005	94.90		
2004	900.0	2005	2006	1513.20	1.68	Medium
2005	90.5	2006	2007	139.40	1.54	The same
2006	1150.0	2007	2008	1934.10	1.68	"-"
2007	135.0	2008	2009	89.85	0.67	Minimum
2008	1400.0	2009	2010	5402.00	3.86	Maximum
2009	87.4	2010	2011	170.10	1.95	Medium
2010	3300.0	2011	2012	4126.00	1.25	Low
2011	165.0	2012	2013	141.33	0.86	Minimum
2012	1550.0	2013	2014	2411.00	1.56	Medium
2013	140.0	2014	2015	154.21	1.10	Low
2014	1545.0	2015	2016	4820.00	3.12	Maximum
2015	150.0	2016	2017	128.00	0.85	Minimum
2016	1330.0	2017	2018	1500.00	1.13	Low
2017	127.9	2018	2019	195.00	1.52	Medium
2018	550.0	2019		N.d.		
2019	90.0					

*Ranges of multiplicity values in distinguished groups: minimum, <1.00, low, 1.00–1.49, medium, 1.50–2.00, maximum, >2.00. Here and in Table 2: N.d., no data, since commercial f[...] out in years of low abundance.

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Table 2. The timing of the pink salmon Oncorhynchus gorbuscha return to spawn in the rivers of the Primorsky krai and average decadal water temperature during that period, according to the data of Sosunovo, 2000–2018

Years	Dates of run		Water temperature, °C						Water temperature anomaly, °C					
	beginning	mass	June			July			June			July		
			I	II	III	I	II	III	I	II	III	I	II	III
2000	20–23.06	27.06–10.07	7.9	9.0	10.8	13.8	14.3	15.9	1.4	0.8	0.9	2.6	1.5	2.2
2001	29.06–03.07	04–15.07	6.0	7.8	9.3	12.7	13.3	15.0	-0.5	-0.4	-0.6	1.5	0.5	1.3
2002	18–20.06	10–18.07	7.5	9.4	10.9	12.8	14.0	14.2	1.0	1.2	1.0	1.6	1.2	0.5
2003	12–13.06	30.06–18.07	5.7	7.2	10.7	12.4	14.9	13.4	-0.8	-1.0	0.8	1.2	2.1	-0.3
2004	13–14.06	19–25.06	6.6	7.8	10.6	12.6	13.9	15.7	0.1	-0.4	0.7	1.4	1.1	2.0
2005	23–25.06	03–12.07	5.9	6.9	7.2	11.2	12.4	15.7	-0.6	-1.3	-2.7	0	-0.4	2.0
2006	20–23.06	10–20.07	5.7	6.8	8.5	10.0	12.2	15.4	-0.8	-1.4	-1.4	-1.2	-0.6	1.7
2007	15–17.06	03–09.07	6.4	9.7	10.5	12.9	11.3	9.7	-0.1	1.5	0.6	1.7	-1.5	-4.0
2008	27–29.06	30.06–05.07	7.0	8.3	10.3	9.9	15.2	15.9	0.5	0.1	0.4	-1.3	2.4	2.2
2009	N.d.	N.d.	7.9	7.7	8.4	10.6	12.5	15.7	1.4	-0.5	-1.5	-0.6	-0.3	2.0
2010	24–26.06	03–25.07	6.5	7.2	12.2	14.5	14.8	16.3	0.0	-1.0	2.3	3.3	2.0	2.6
2011	19–25.06	01–20.07	6.1	7.4	9.3	11.6	14.4	11.3	-0.4	-0.8	-0.6	0.4	1.6	-2.4
2012	15–20.06	23.06–15.07	4.6	7.0	8.6	6.8	11.6	13.3	-1.9	-1.2	-1.3	-4.4	-1.2	-0.4
2013	19–22.06	02.07–12.07	6.1	5.5	9.2	8.0	9.1	11.4	-0.4	-2.7	-0.7	-3.2	-3.7	-2.3
2014	13–20.06	29.06–10.07	8.5	9.3	11.4	13.9	15.9	10.9	2.0	1.1	1.5	2.7	3.1	-2.8
2015	15–17.06	03–15.07	7.4	9.8	11.1	11.7	13.5	15.7	0.9	1.6	1.2	0.5	0.7	2.0
2016	15–23.06	28.06–15.07	7.9	9.2	10.9	10.4	13.5	13.5	1.4	1.0	1.0	-0.8	0.7	-0.2
2017	20–23.06	30.06–15.07	6.3	8.0	10.5	13.0	14.5	15.0	-0.2	-0.2	0.6	1.8	1.7	1.3
2018	05–10.06	20.06–10.07	6.3	8.6	10.6	12.5	13.8	15.4	-0.2	0.4	0.7	1.3	1.0	1.7

Note. Δtw - deviation of the average decadal temperature of each year from the average temperature for the period 2000-2018; temperature the values at the beginning of the run are in bold and the temperatures during the mass run are in pink.

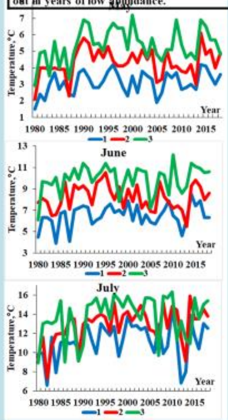

Figure 2. Anomalies of sea water temperature in the Sosunovo area in May, June and July from the average for the period 1980-2018 in the decades of the month: 1, 2 and 3

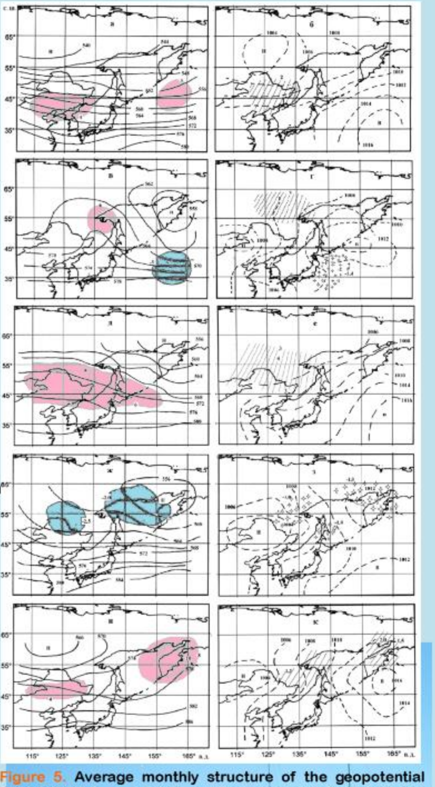

Figure 5. Average monthly structure of the geopotential field (H500) (a, c, e, g, i), surface pressure field (P0) and surface air temperature (ta) (b, d, f, h, j): a, b, May 2009; e, f, June 2018; g, h, June 2010; i, j, July 2016; (—) – H500 isolines, hPa; (– –) – P0 isolines, hPa; (■), (■) – regions of extremely low and high H500 values; ( ), ( ) – regions of extremely low and high ta values; L, center of low pressure, H, center of high pressure