Dynamics of the walleye pollock biomass in the Sea of Okhotsk

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Walleye pollock (*Theragra chalcogramma)* is the most valuable fish species in the Sea of Okhotsk. The Russian pollock fishery started in the 1960s and the first considerable landings (35,000 t) occurred in 1962 (Fadeev and Vespestad, 2001). The epoch of large-scale exploitation of pollock resources began in 1965, when the landings totaled 293,000 t. Since then landings had been increasing and in 1968 attained an impressive total of 675,000 t. The first historical maximum was marked in 1975 when 1,300,000 t of pollock were landed. In those years the fishery was exclusively concentrated in the eastern part of the sea, off western Kamchatka. Then landings started to decrease, reaching a low of 482,000 t in 1981. The second period of large catches >1,500,000 t (Fig. 1) occurred in 1985–1997. Discovery of a new fishing ground in the northern part of the Sea of Okhotsk contributed to the outgrowth of catches. These successful years in the fishery were followed by another period of low landings with a minimum (394,000 t) in 2004. The following years saw a significant increase in landings (up to 680,000 t).

The pollock fishery in the open part of the Sea of Okhotsk (*peanut hole*) is much younger than in the other fishing grounds. The first information about the pollock catches taken by foreign fishing vessels in this area appeared in the late 1980s, when there was large-scale unregulated fishing for pollock in the open part of the Bering Sea (*donut hole*). The pollock fishery continued in the peanut hole from 1991–1994 and produced a maximum yield totaling 698,000 t. Considering that this fishery was based on the pollock stocks of Russian origin, Russia suffered a severe amount of economic damage. The presented history of the pollock fishery in the Sea of Okhotsk shows that a considerable interannual variability in the yield introduces large uncertainty in planning and managing this fishery.

However, landings do not show the actual dynamics of the stocks, as they are mostly dependent on the fishing intensity, *i.e.*, on the fishing effort. There are many Russian scientific publications devoted to the pollock stock dynamics in the Sea of Okhotsk (Fadeev, 1980; Kachina, Sergeeva, 1981; Vasil'kov and Glebova, 1984; Shuntov, 1986; Shuntov *et al.*, 1993; Avdeev *et al.*, 2001; Fadeev, 2001; Varkentin and Sergeeva, 2004). Our goal is to identify cyclicity in various levels of the pollock stock and attempt to give a medium-term forecast.

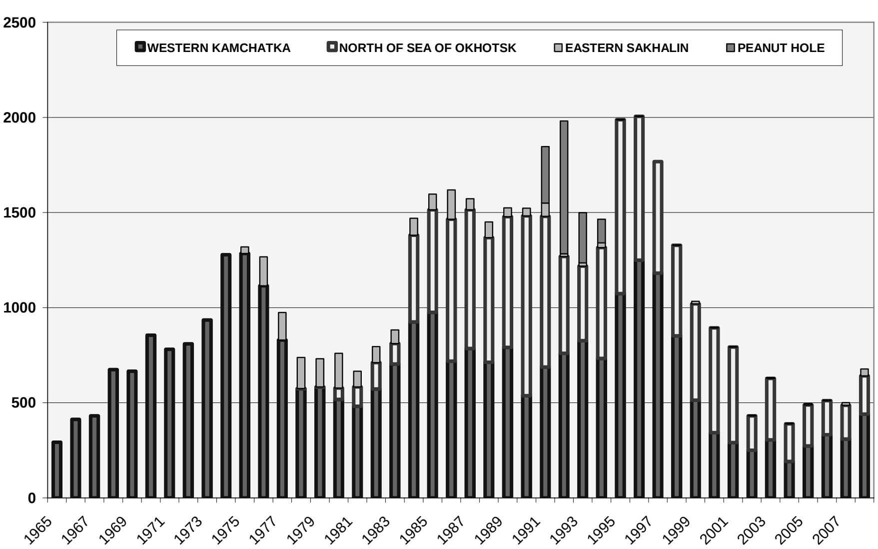

Fig. 1 Walleye pollock catch (thousands of t) by region in the Sea of Okhotsk.

Research conducted in VNIRO (Babayan *et al.*, 2006), based on fishing statistics and the Instantaneous Separable Virtual Population Analysis (ISVPA) modeling, showed that in 1974–2003 the spawning and the fishable biomass of walleye pollock in the eastern part of the Sea of Okhotsk were changing concurrently (Fig. 2). According to our data, there was a high correlation coefficient of 0.94. Over three decades there were four maxima of the fishing and spawning stocks (1974, 1984, 1994, and 2003) and three periods of low stock abundance (1978–1979, 1990, and 2000). During the entire period of observations, the stocks restored from the minimum level to an average one fairly rapidly (3–4 years), thus demonstrating their stability. It is noteworthy that the decrease in stocks from maximum levels to minimum ones occurred with a 5- to 6-year lag after the curve bend.

The TINRO-Center studies (1983–2008) were based on assessment of eggs spawned by pollock females. Surveys took place in spring and were made with an IKS-80 ichthyoplankton net. Results of these observations (Avdeev *et al.*, 2001, TINRO-Center data) showed that values of the spawning biomass of pollock in the eastern part of the Okhotsk Sea and in the entire Sea of Okhotsk changed concurrently (Fig. 3). During the entire period of observations, there were three maxima of stocks (1984–1987, 1994–1995, and 2007–2008) and two minima (1991 and 2000–2001). According to our data, the correlation coefficient was high, having a value of 0.90. Thus, despite different techniques of the biomass assessment used in VNIRO and TINRO-Center, the results of assessment were very close: there is a 10–12 year periodicity in occurrence of the maximum and minimum stocks.

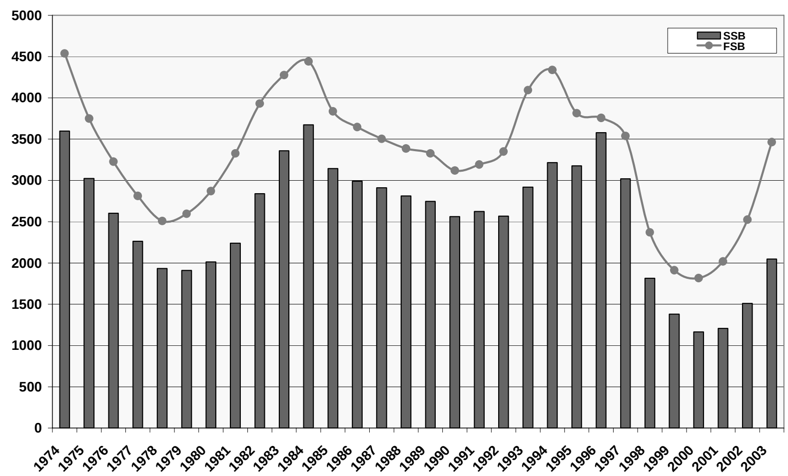

Fig. 2 Spawning stock biomass (SSB) and fishable stock biomass (FSB) of walleye pollock (thousands of t) off western Kamchatka according to the analytical approach (Babayan *et al.*, 2006).

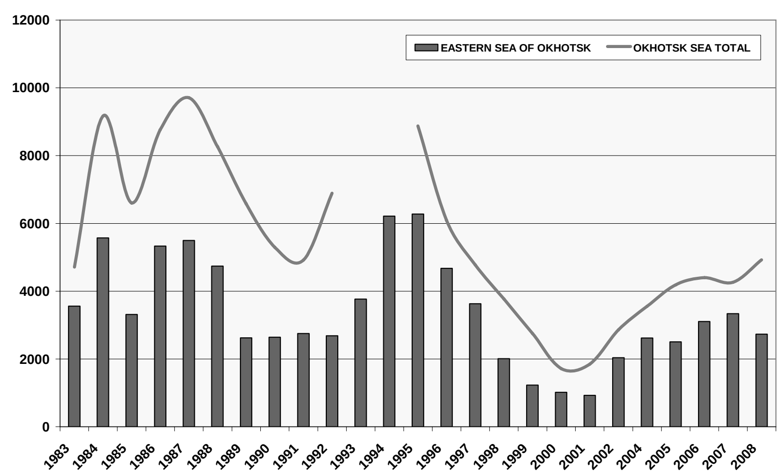

Fig. 3 The spawning stock biomass of walleye pollock in the eastern Sea of Okhotsk and in the entire Sea of Okhotsk, thousands of t (TINRO-Center data).

Water temperature has a significant impact on the generation success in the first year of the pollock life history. As a rule, weak generations appear in cold years, while abundant generations occur in warm years. This phenomenon could be associated with several facts: there is better food availability in warm years; young fish have a higher initial growth rate; metabolism accelerates and increases the fish viability. Abundance of recruitment influences the growth or decrease of the fishing and spawning stocks. Among the most important global climatic events which influence the sea temperature is the Pacific Decadal Oscillation (PDO). We analyzed the variability in the pollock fishable and spawning stocks in connection with the PDO anomalies and found that periods of high pollock biomass occurred during years of PDO positive anomalies. Minimum values of biomass were generally observed in periods of PDO negative anomalies. (Figs. 4 and 5). A sharp drop in the PDO in 2008 suggests that the years of positive anomalies ended and another period of negative anomalies will begin which will likely to lead to a decrease in pollock biomass.

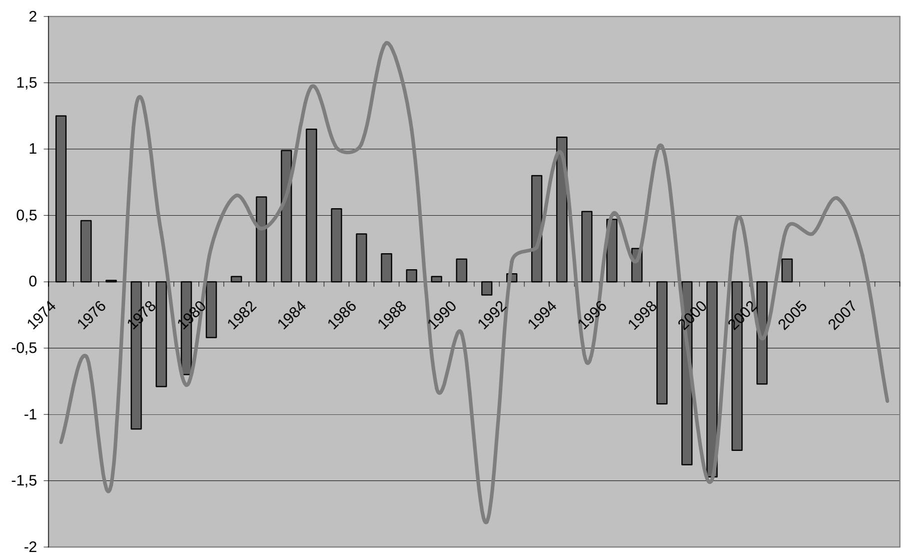

Fig. 4 Fishable biomass of pollock (millions of t, bars) in the eastern Sea of Okhotsk and PDO anomalies (line).

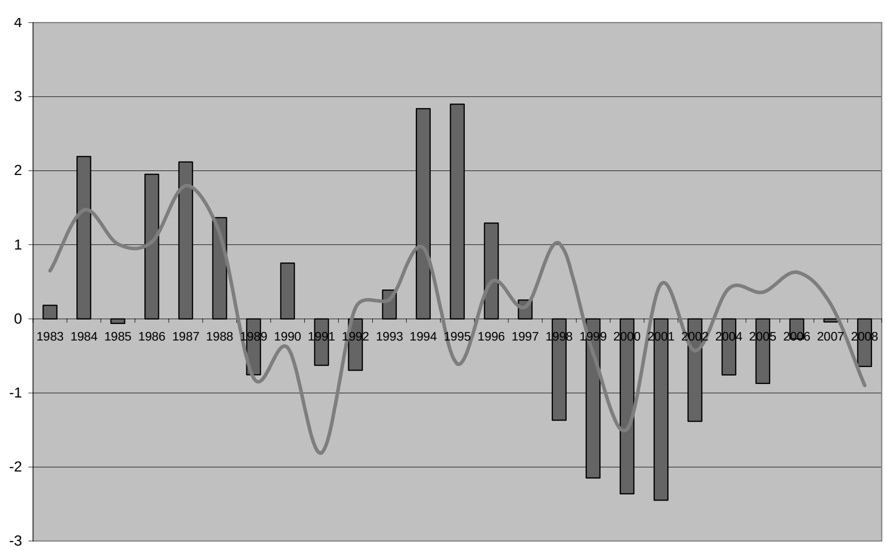

Fig. 5 Spawning biomass of pollock (millions of t, bars) in the eastern Sea of Okhotsk and PDO anomalies (line).

Studies show that the stock dynamics is characterized by a 10-year interval. Tables 1 and 2 summarize data on the pollock stock assessment grouped by decades. Thus, in the first column of Table 1 the value of 4,538,000 t corresponds to 1974, while in the first column of Table 2 the value of 3,560,000 t corresponds to 1983, *etc*. The last column gives averages for the entire period of observations. These data are also presented graphically (Fig. 6). These figures show that the minimum averaged values of spawning and fishing stocks correspond to points 9 and 0 (see Tables 1 and 2), *i.e.*, occur at the end of the decade.

The obtained results allow us to already forecast a considerable decrease in pollock stocks in 2009–2010. The 10-year minimum is likely to be attained in 2011–2012, and the stock will probably restore in 2014–2015 with further growth reaching a maximum in 2016–2017.

Table 1 Assessment of the walleye pollock spawning stock in the eastern Sea of Okhotsk (Avdeev *et al.*, 2001, TINRO-Center data, ichthyoplankton surveys), 1000 t.

	1983–1989	**1990–1999**	**2000–2008**	**Average**
0	no data	2642	1015	1828
1	no data	2750	927	1838
2	no data	2683	2039	2361
3	3560	3766	no data	3663
4	5570	6215	2620	4802
5	3313	6275	2506	4031
6	5330	4671	3105	4368
7	5495	3631	3335	4152
8	4743	2009	2734	3162
9	2623	1230	no data	1926

Table 2 Assessment of the walleye pollock fishable biomass in the eastern Sea of Okhotsk (Babayan *et al.*, 2006, ISVPA), 1000 t.

	1974–1979	**1980–1989**	**1990–1999**	**2000–2003**	**Average**
0	no data	2870	3120	1817	2602
1	no data	3327	3192	2019	2846
2	no data	3930	3349	2525	3268
3	no data	4276	4094	3464	3945
4	4538	4442	4338	no data	4439
5	3750	3837	3815	no data	3801
6	3228	3647	3757	no data	3544
7	2812	3504	3539	no data	3285
8	2508	3386	2371	no data	2755
9	2596	3327	1912	no data	2611

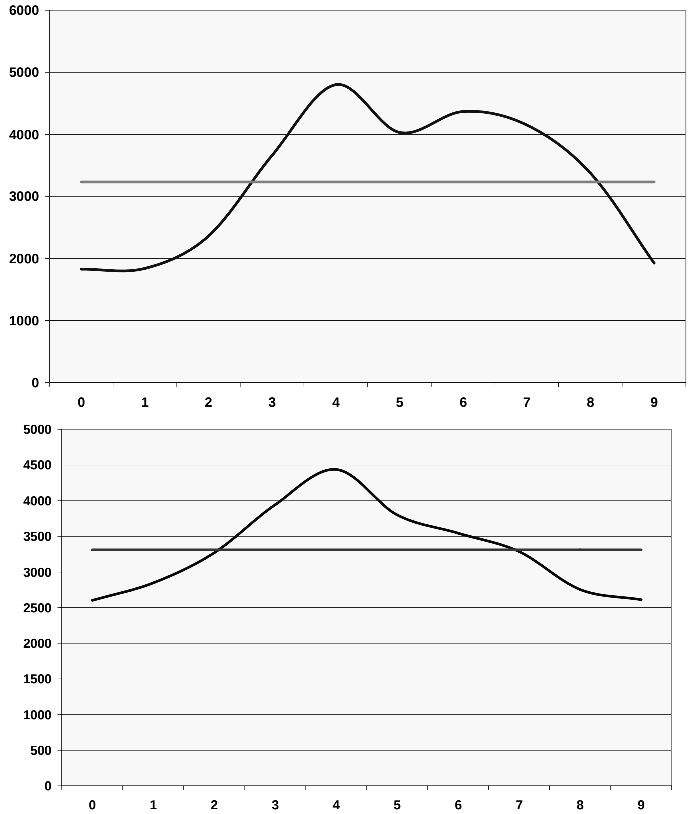

Fig. 6 Average spawning (top) and fishable biomass (bottom) in the eastern Sea of Okhotsk according to ichthyoplankton data from TINRO-Center and the analytical approach by VNIRO (thousands of t). Grey horizontal line represents the average for all the decades.

References

Avdeev G.V., Smirnov, A.V. and Fronek, S.L. 2001. Osnovnie cherty dinamiki chislennosti mintaya severnoi chasti Ohotskogo morya v 90-e gody (General trends in the pollock stock dynamics in the northern part of the Sea of Okhotsk). *Izv. TINRO* **128**: 207–221 (in Russian).

Babayan, V.K., Vasil'ev, D.A., Varkentin, A.I. and Sergeeva, N.P. 2006. Metodicheskie osobennosti obosnovaniya ODU mintaya v usloviyah neopredelennosti (Methodological peculiarities of the pollock TAC estimation under uncertainty). Trudy VNIRO, Vol.146, pp. 13–37 (in Russian).

Kachina, T.F. and Sergeeva, N.P. 1981. Dinamika chislennosti vostochnoohotomorskogo mintaya: Ekologiya, zapasy i promysel mintaya (Dynamics of the pollock stock abundance in the eastern Okhotsk Sea). TINRO, Vladivostok, pp. 19–27 (in Russian).

Fadeev, N.S. 1980. Byla li "vspyshka" chislennosti mintaya v severnoi chasti Tihogo okeana? (Was there an outburst in the pollock abundance in the Northern Pacific?) *Biol. Morya* **5**: 66–71 (in Russian).

Fadeev, N.S. 2001. Urozhainost' pokolenij severoohotomorskogo mintaya (Pollock generation success in the northern part of the Sea of Okhotsk). *Voprosy Rybolovstva* **2**: 299–318 (in Russian).

Fadeev, N.S. and Vespestad, V. 2001. Obzor promysla mintaya (Review of the pollock fishery). *Izv. TINRO* **128**: 75–91 (in Russian).

Shuntov, V.P. 1986. Sostoyanie izuchennosti mnogoletnih tsiklicheskih izmenenij chislennosti ryb dal'nevostochnyh morei (State-of-art in studies of long-term cyclic variations in abundance of fish species in the Far East seas). *Biol. Morya* **3**: 3–14 (in Russian).

Shuntov, V.P., Volkov, A.F., Temnyh, O.S. and Dulepova, E.P. 1993. Mintai v ekosystemah dal'nevostochnyh morei (Pollock in ecosystems of the Far East seas). TINRO, Vladivostok:, 426 p. (in Russian).

Varkentin, A.I. and Sergeeva, N.P. 2004. The fisheries and current state of walleye pollock (*Theragra chalcogramma*) stock abundance in the eastern Sea of Okhotsk. PICES Sci. Rep. No. 26, pp. 251–253.

Vasil'kov, V.P. and Glebova, S.Yu. 1984. Faktory, opredelyayuschie urozhainost' pokolenij mintaya zapadnoi Kamchatki (Factors influencing the pollock generation success off the western Kamchatka). *Voprosy ihtiologii*. **24**: 561–570 (in Russian).