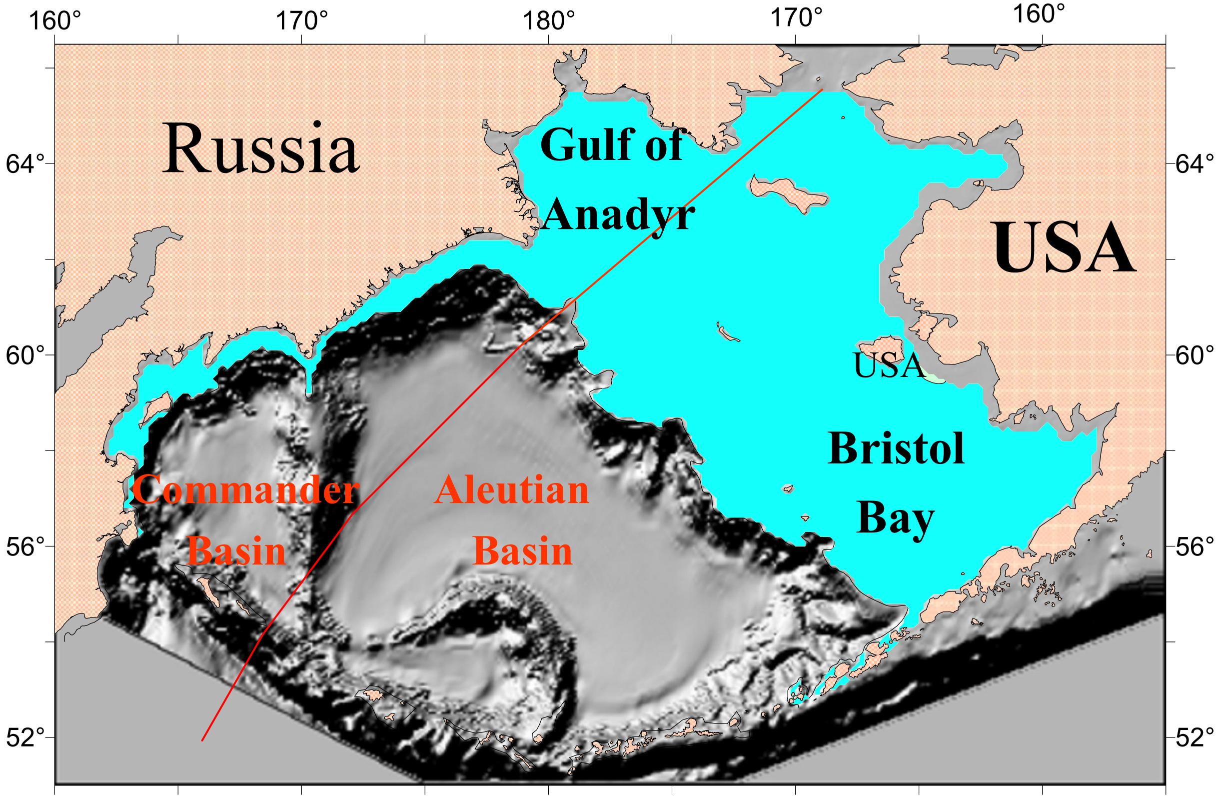
Hydrography and biological resources in the western Bering Sea

Gennady V. Khen,
Eugeny O. Basyuk

Pacific Research Fisheries Centre (TINRO-Centre)

Bering Sea: deep-sea basin, shelf, and US-Russia convention line



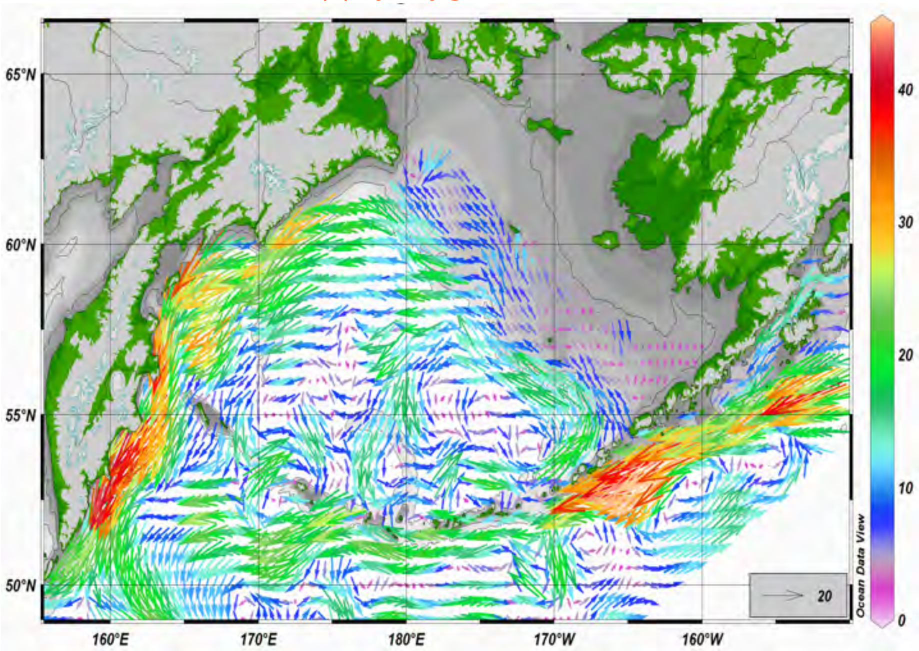
Bering Sea is divided approximately onto two equal parts: the shallow area and the deep water area The width of shallow area exceeds 500 km in the east. At the west and north-west of the sea the shelf is narrow, its width is 20-80 km

Bering Sea currents, their direction and speed in winter and summer (40 m depth)

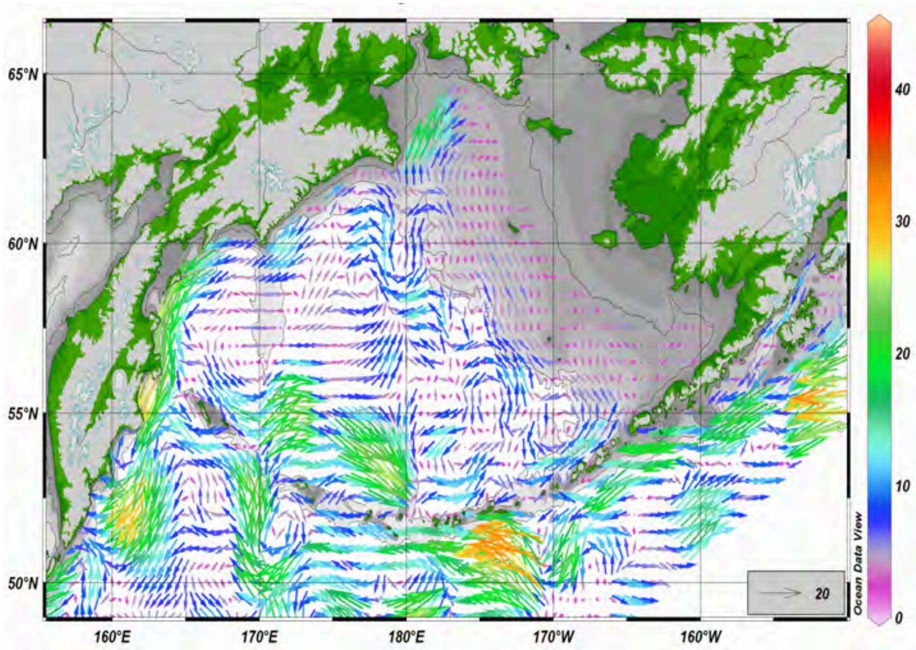
Data from 510 drifters averaged for 1986-2007

http://www.pmel.noaa.gov/foci/FOCI data.html

Winter

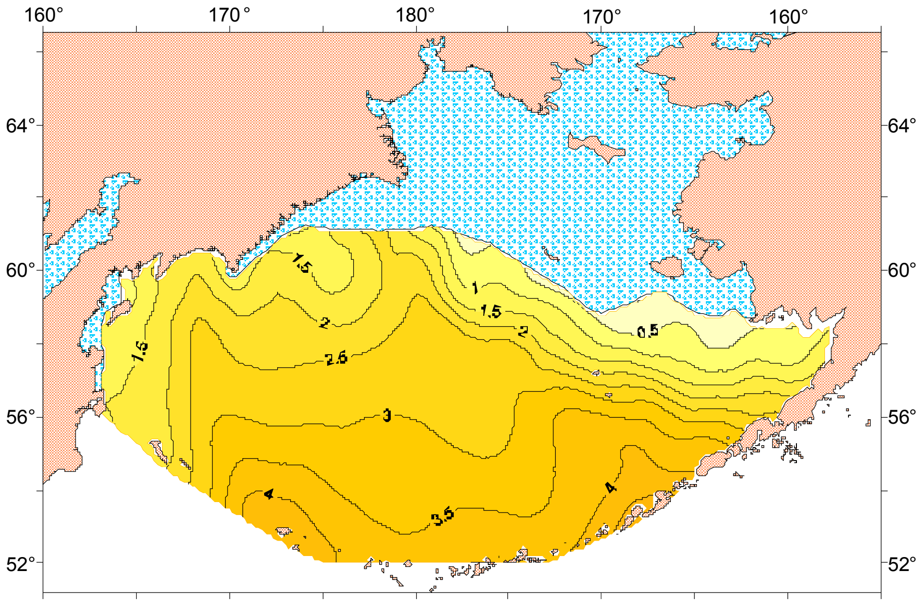


Summer

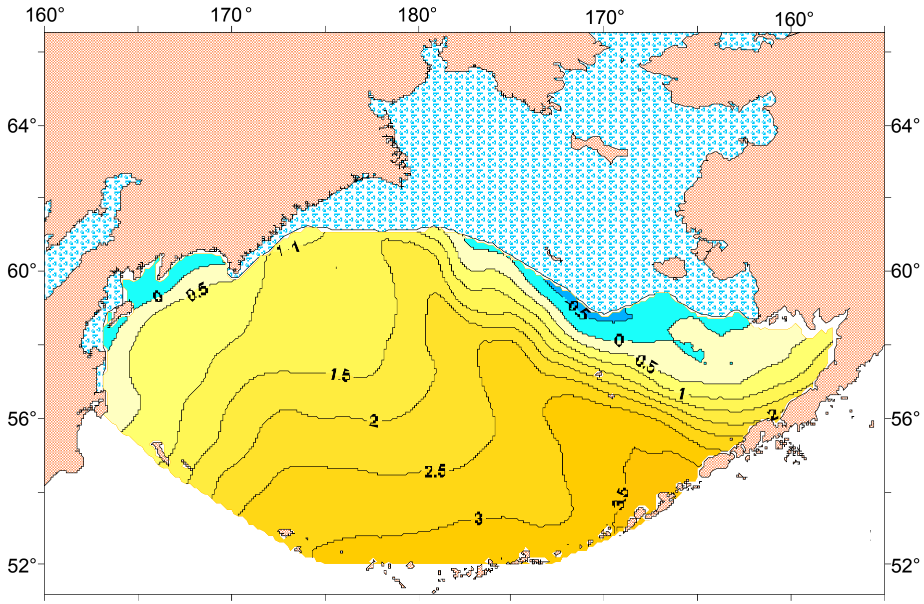


In winter a wide stream is noticeable in the north and west of the deepwater basin. In summer width of currents is much narrower. Mean current speeds in winter are 60% higher than in summer.

Sea surface temperature in spring (May)

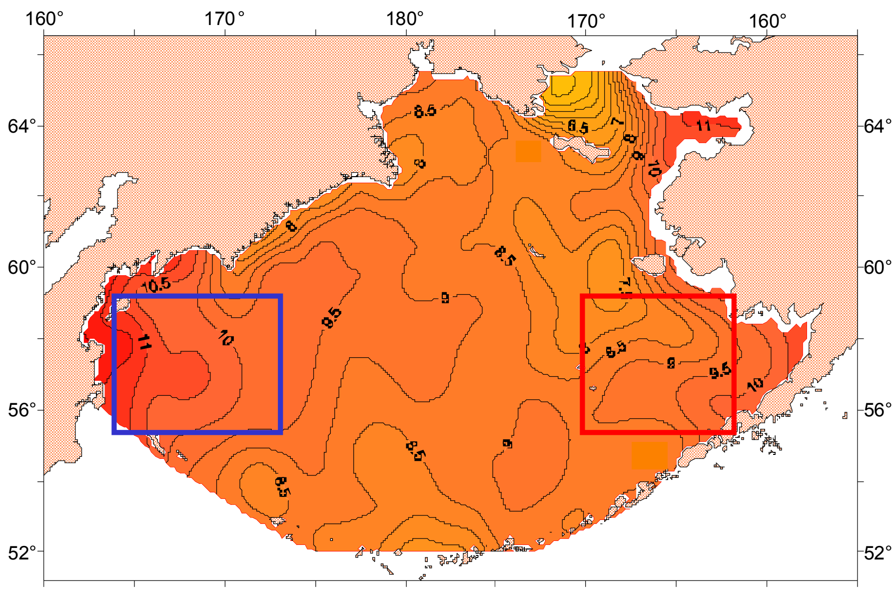


Temperature at the temperature-minimum surface in spring (May)

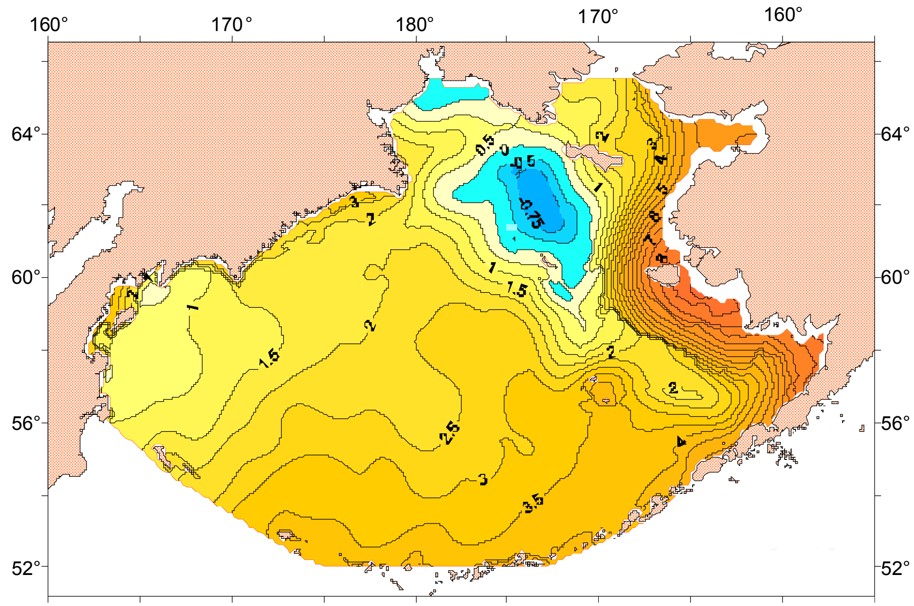


Spring temperature at sea surface and in the core of cold intermediate layer (CIL) is shown on this slide. At the surface, isotherms are oriented zonally. In the core of CIL the zonality is disturbed. A "tongue" of warm Pacific water is formed along the Bering Slope Current.

Sea surface temperature in summer (August)

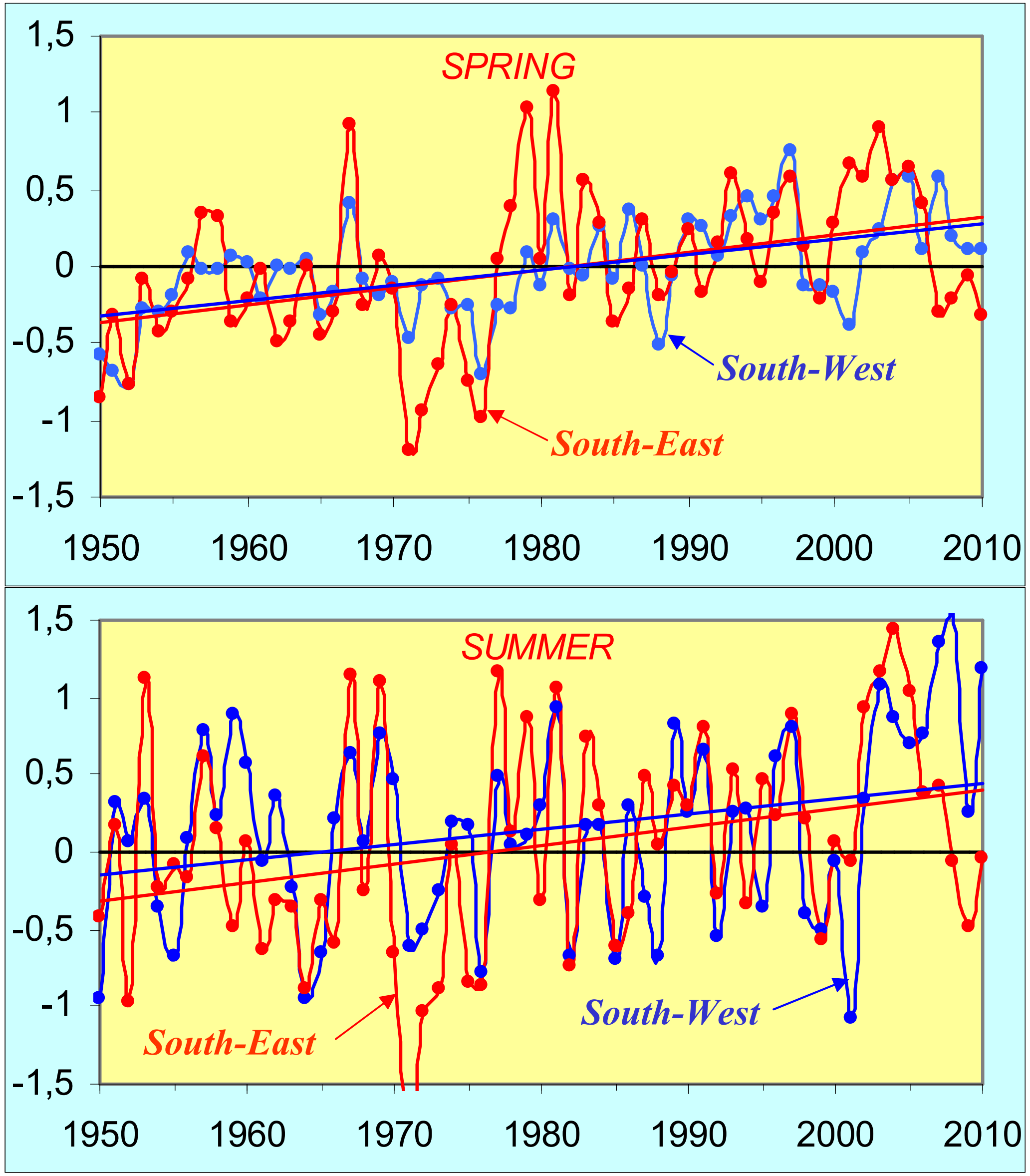


Temperature on the temperature-minimum surface in summer (August)



Two warm areas are formed in the Bering Sea in summer: first – in the southwest over the Commander Basin, second – in the southeast around the Bristol Bay. In the core of CIL in summer, two cold areas are formed. First area is located in eastern Bering Sea shelf, another one – in the southwest over the Commander Basin. Like in May, a tongue of warm water along the Slope Current separates eastern and western cold areas.

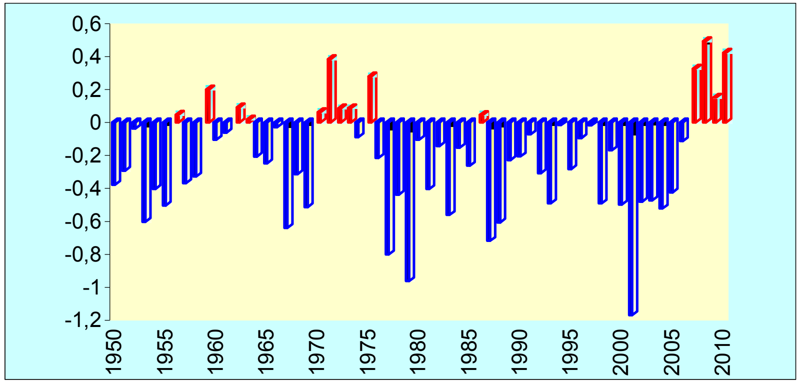
Interannual variability of sea surface temperature anomalies in the southwestern and southeastern Bering Sea



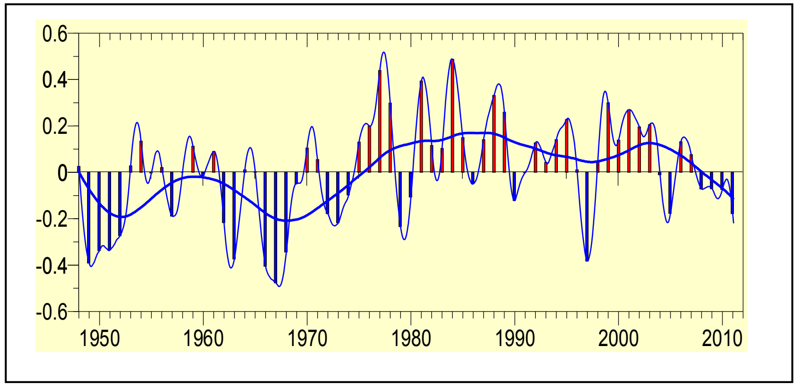
On the background of total warming, several cooling periods can be recognized: in the 1970s, late 1990s, and mid of current decade. The last cooling has been observed only the Bristol Bay where temperature fell below normal. In the southwest, it practically has not changed, remaining above the normal values.

Differences of the annual sea surface temperature (A) and sea level pressure (B) between southwestern (Commander Basin) and southeastern (Bristol Bay) parts of the Bering Sea (left panels) Annual sea level pressure for 1950-1974 and 1975-2003 (right panels)

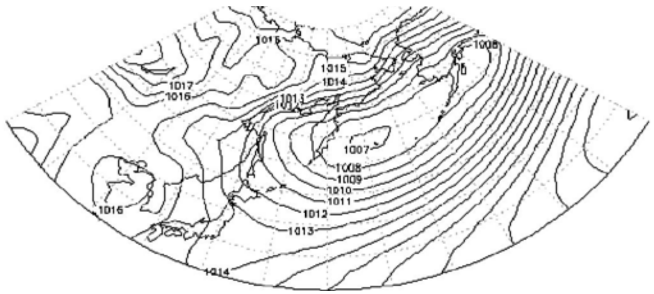
A



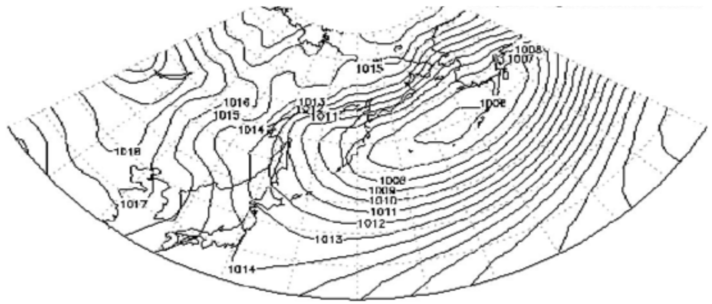
B



Annual SLP 1950-1974



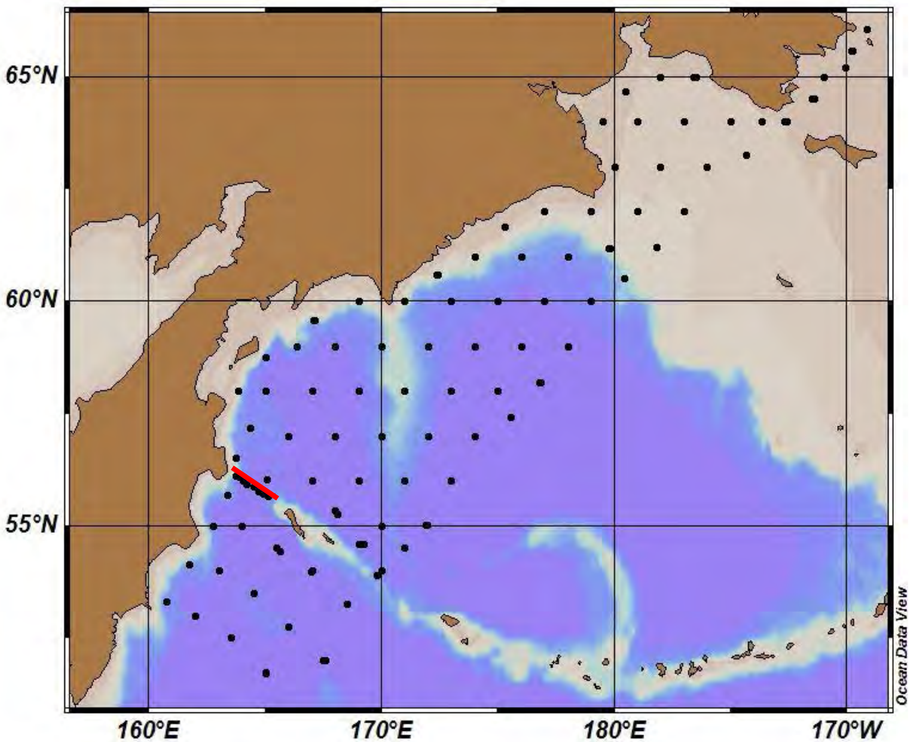
Annual SLP 1975-2003



Oceanographic stations in the TINRO-Centre study area:
A – survey for epipelagic fish resources
B – survey for bottom fish resources

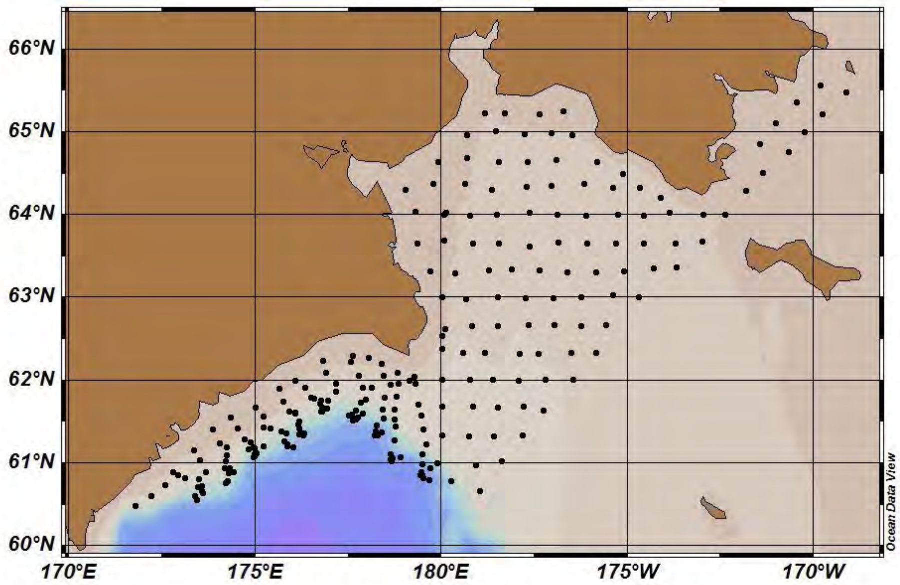
red line shows Kamchatka Strait oceanographic section; research years are shown in red

A



1986, 1987, 1991, 1993, 1995, 2002-2010

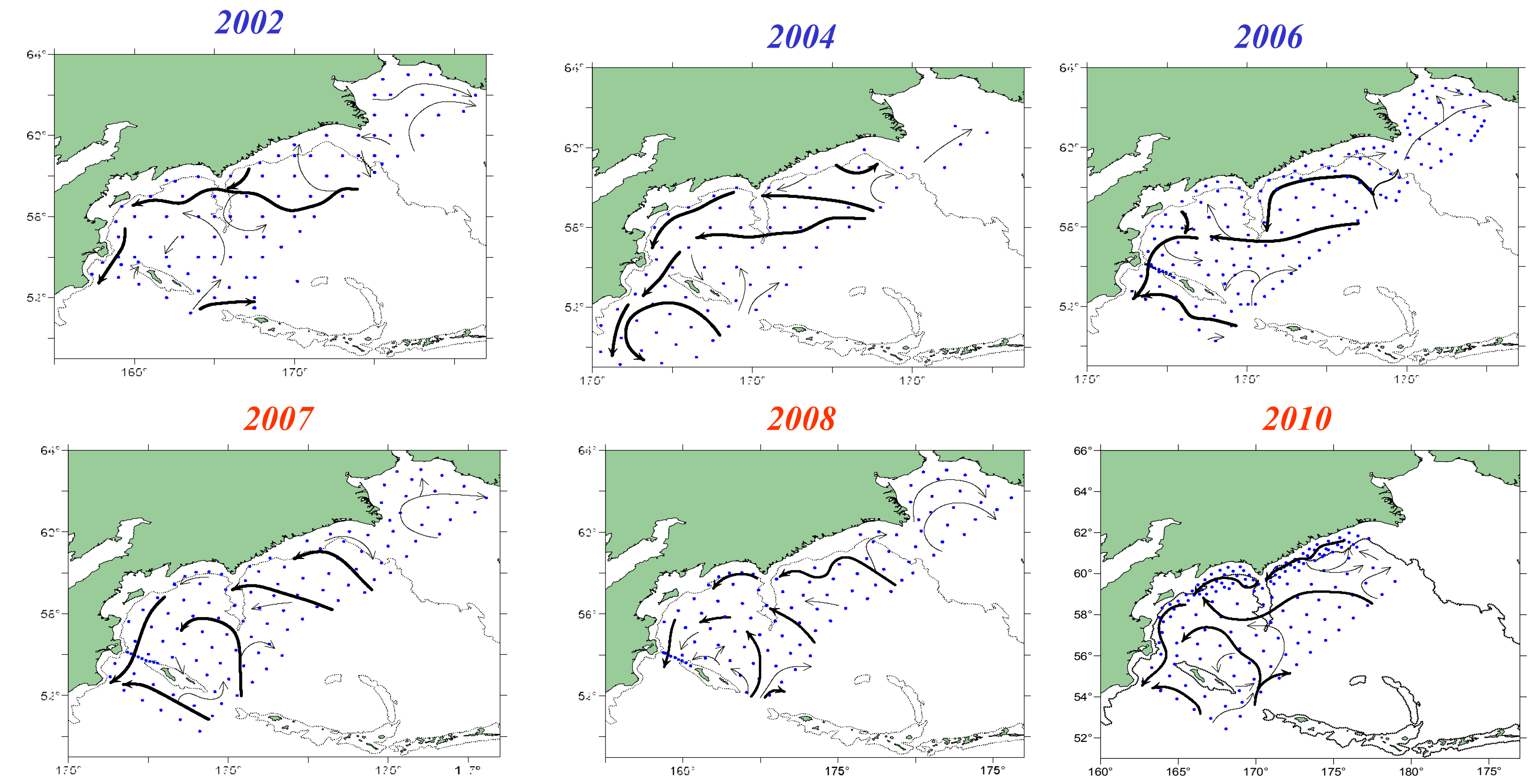
B



1985, 1996, 1998, 2001, 2002, 2005, 2008, 2010

Major geostrophic currents in the western Bering Sea in warm half-year

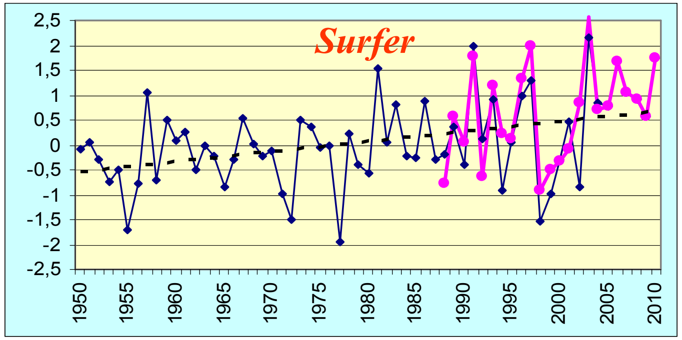
thick lines show current with speed >5 cm/s relative to 1000 dbar

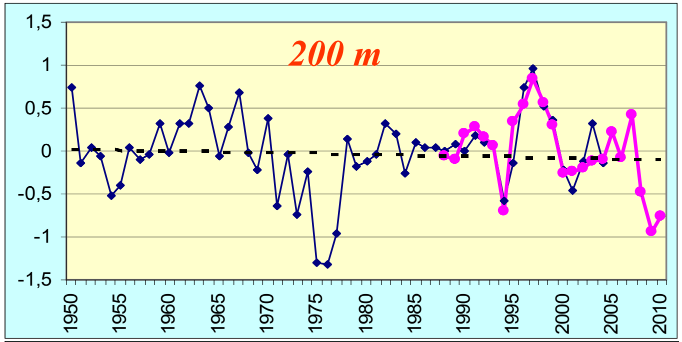


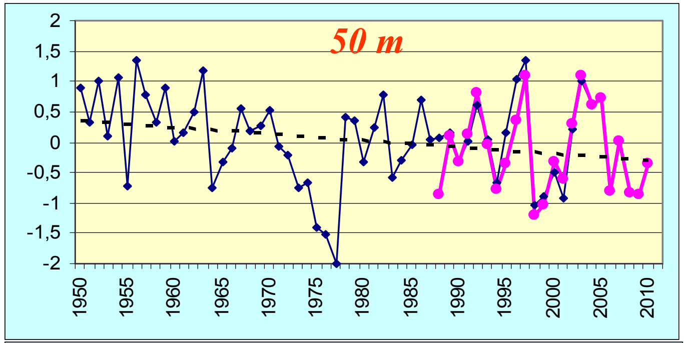
Schemes of geostrophic currents suggest that, until 2006, latitudinal water transport from the Aleutian to Commander Basin prevailed. Beginning from 2007, northward inflow of Pacific waters through the Near Strait has increased,

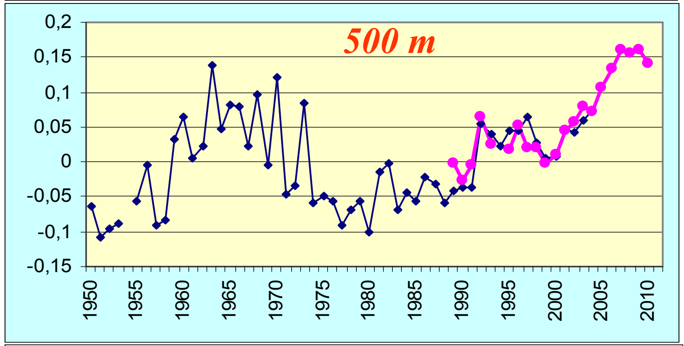
Interannual variability of the temperature anomalies from surface to 800 m in the deep area within Russian EEZ

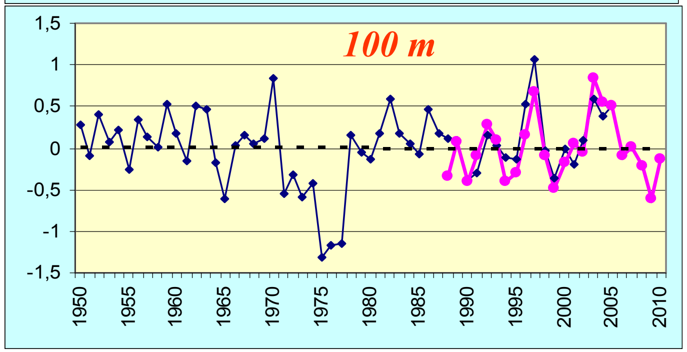
blue lines show data from Climatic Atlas … (2009), 1950-2004
pink lines show data obtained by TINRO-Centre, 1986-2010

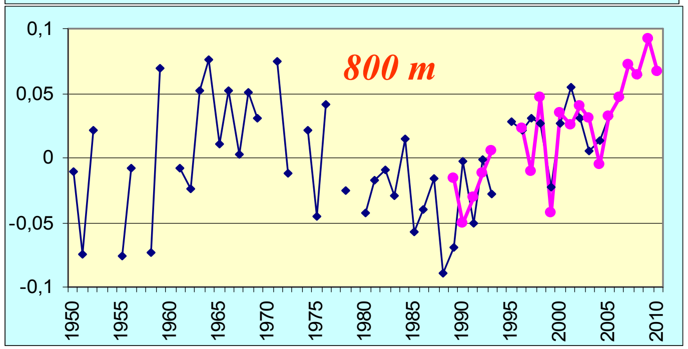


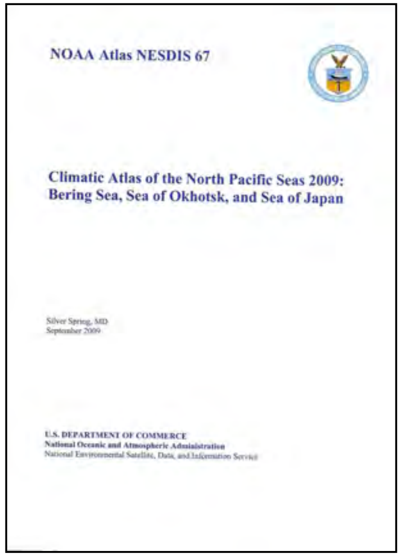










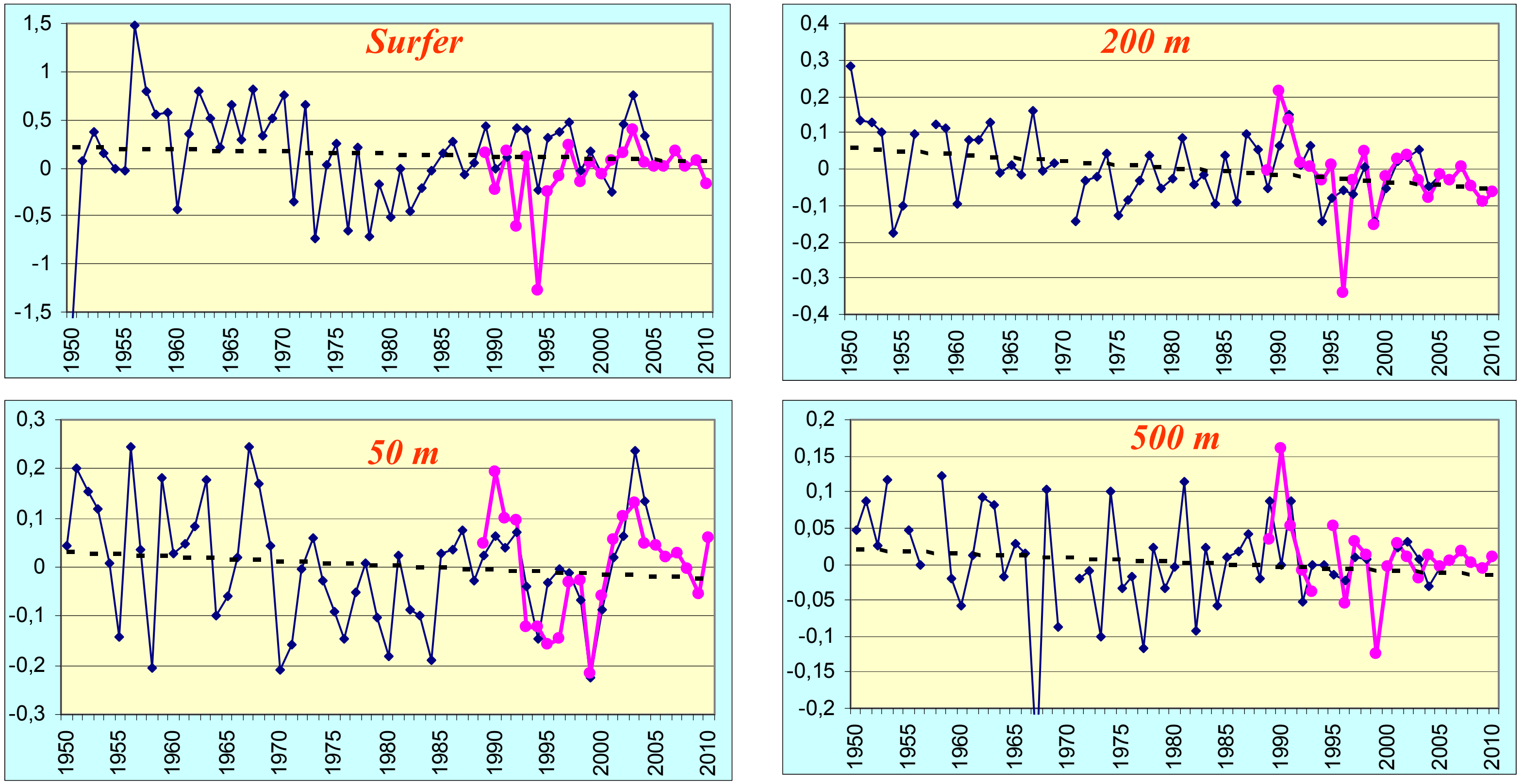


Cooling trend was present, beginning from the mid-2000s in seasonally active layer. In deep waters cooling appeared later in the decade. It is unknown, for how long will that cooling trend continue. We can suppose that, if the AL will continue to shift westward, cooling will go on.

Interannual variability of salinity anomalies from the surface down to 500 m in the deep area within Russian EEZ

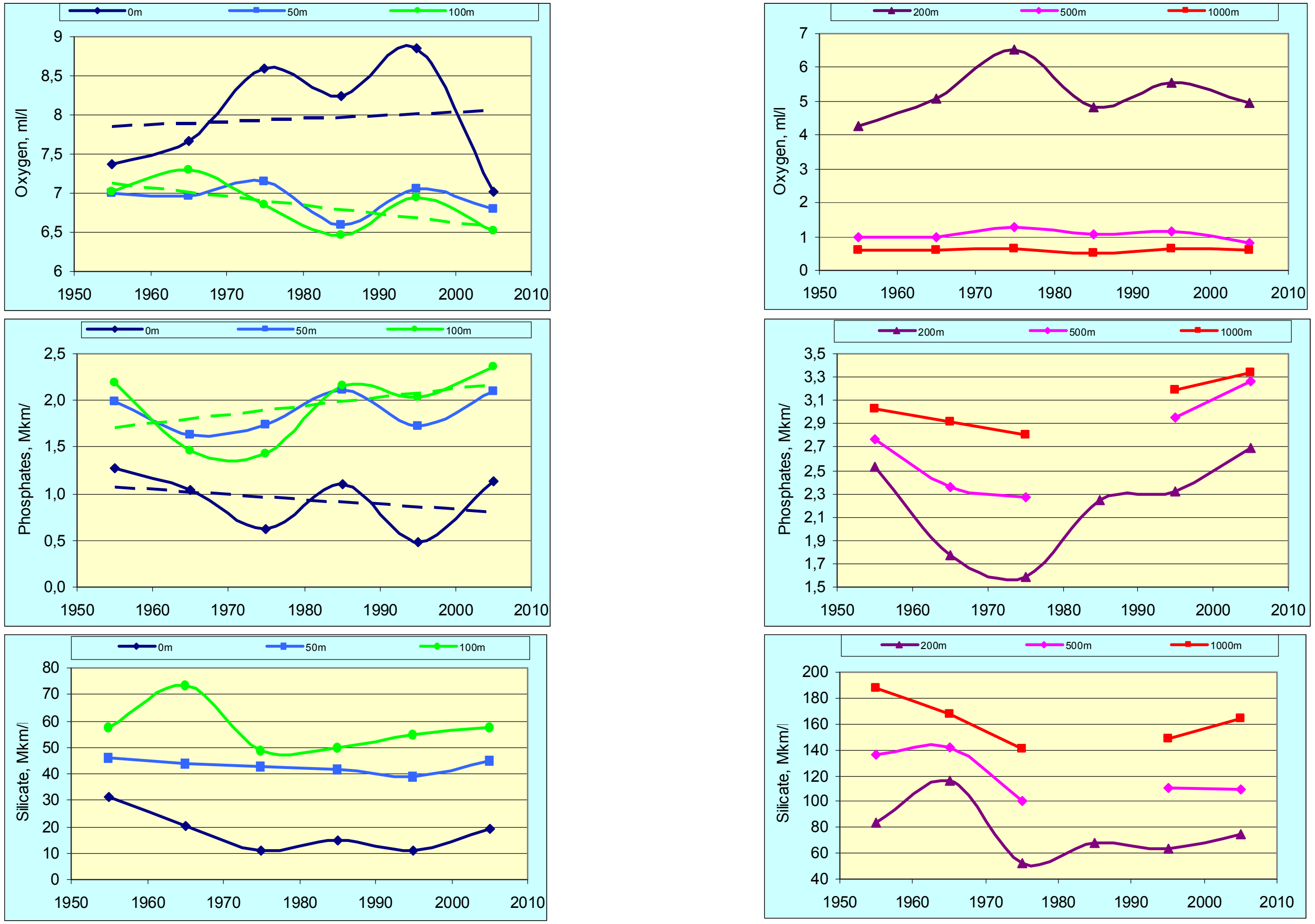
***blue lines** show data from Climatic Atlas … (2009), 1950-2004*

***pink lines** show data obtained by TINRO-Centre, 1986-2010*



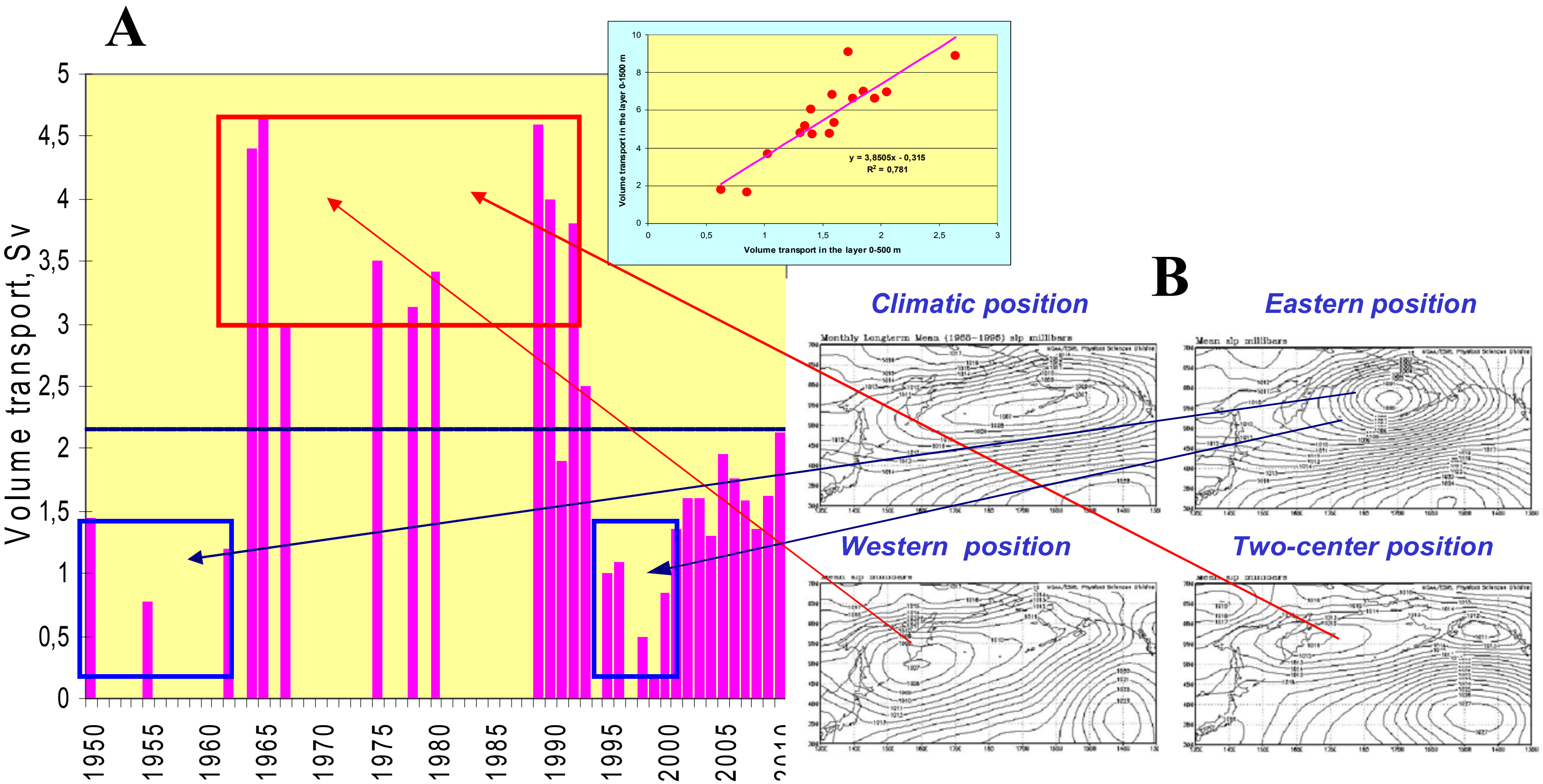
Common feature for all depths is downward trend in salinity during the last 60 years. On the sea surface, there was a 0.2 psu decrease, in the layer 100-200 m – 0.06-0.10, and at depth of 500 m - 0.04. Therefore, we may suggest that the main halocline has sharpened, or vertical stability has increased, which might have resulted in weakening of vertical water exchange in the sea.

Interannual variability of Oxygen, Phosphate and Silicate from the surface down to 1000 m



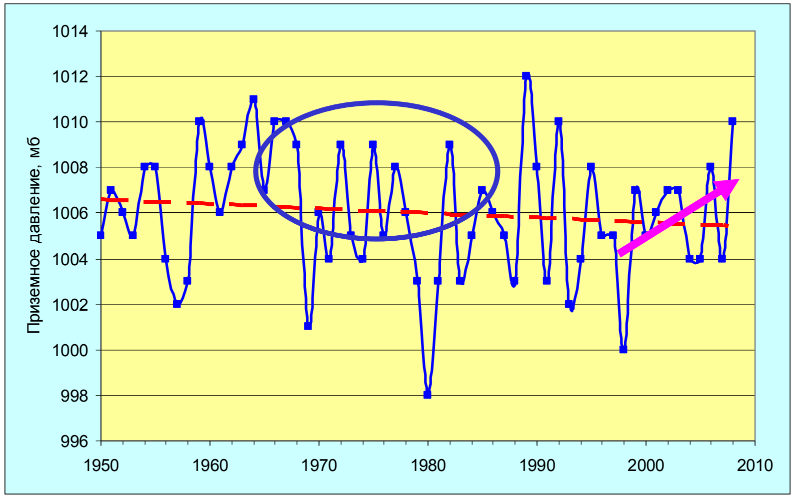
Below the surface layer, phosphate concentrations have been markedly increasing in the last 20 years. Silicate increase was weak and much less than in the 1950-1960s. Oxygen decrease below the surface layer possibly occurred due to rise of vertical stability and temperature increase in deep layers.

Variability of the Kamchatka Current transport in the 0-500 m layer in summer (A), and typical position of the Aleutian Low in March-May (B)

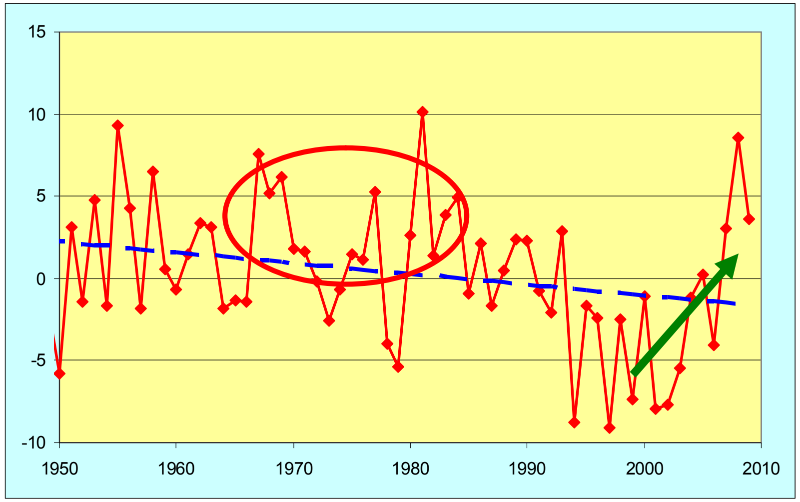


Interannual variability of surface pressure in the centre of the Aleutian Low, Asian High and Far-Eastern Low

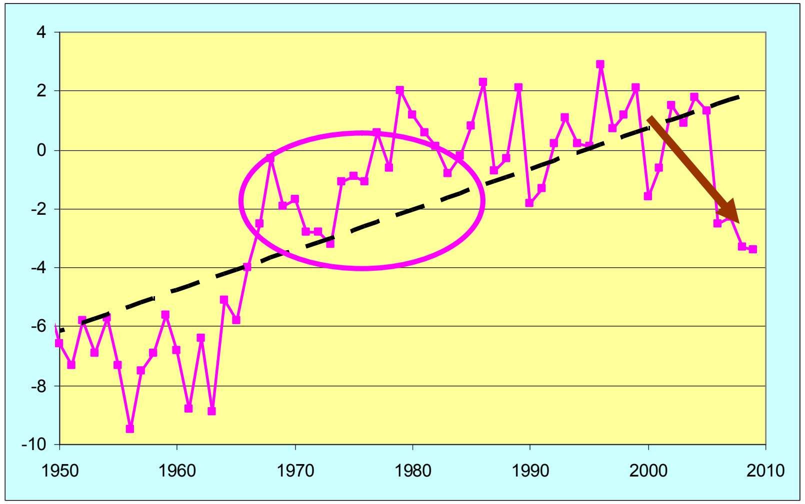
Aleutian Low, Winter



Asian High, Winter

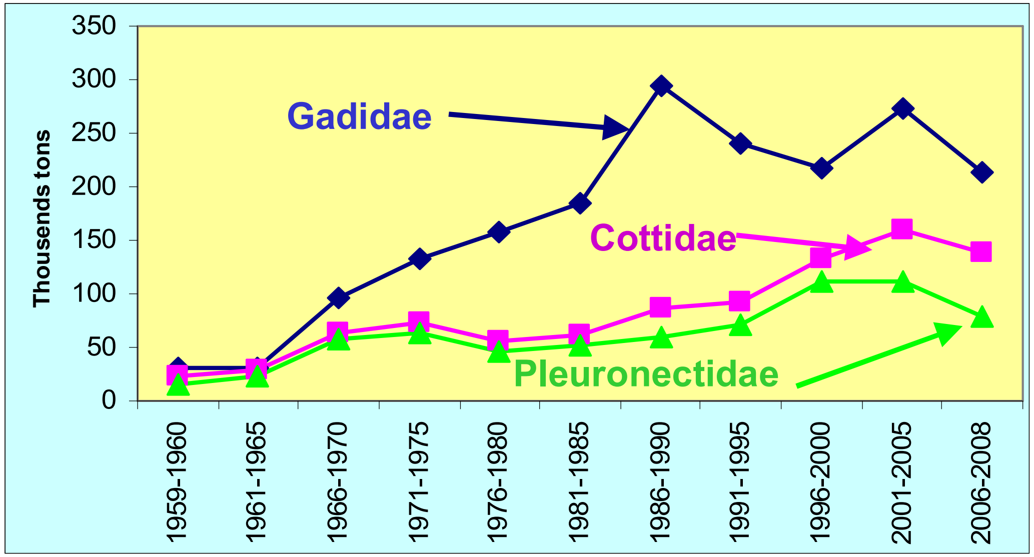


Far-Eastern Depression summer



- 1. During the second half of 20th century, sea surface temperature was rising in the western and eastern Bering Sea. However, following 2005, cooling trend has been observed, being more evident in the eastern Bering Sea.

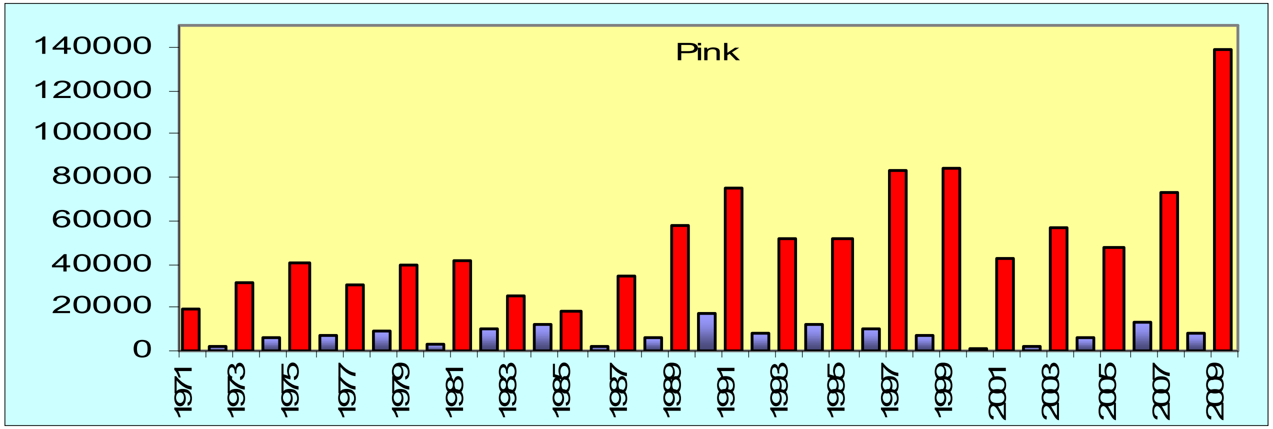
Biomass of bottom fish groups in the western Bering Sea in 1959-2008 (Zolotov, Balykin, 2010)

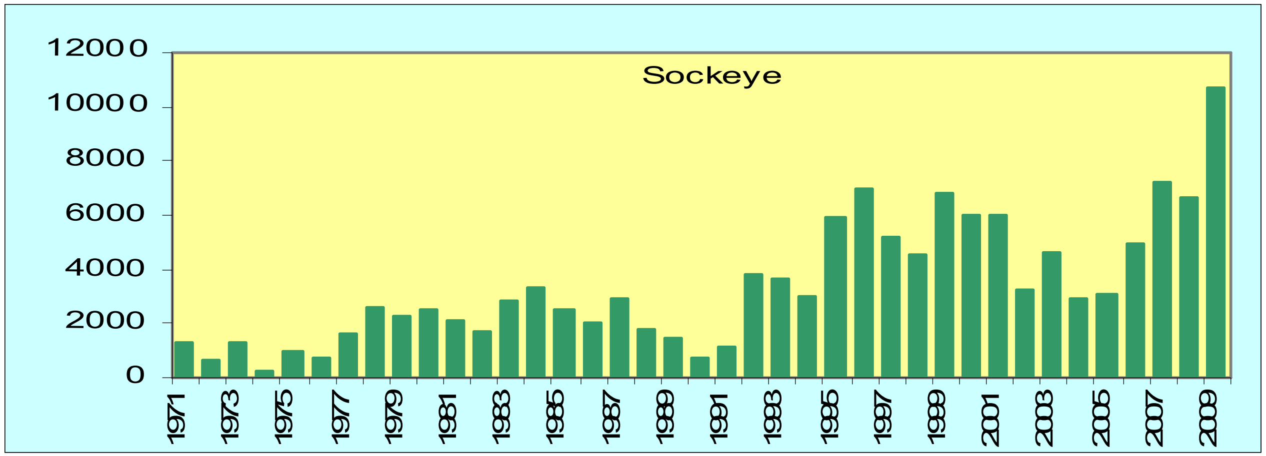


Biomass (thousand tons) of mezopelagic fish and squid in the upper pelagic layer (0-50 m) (data provided by I.I. Glebov)

	1991	*1992*	*1993*	*1995*	*2003*	*2005*	*2007*	*2009*
Mezopelagic fish	**4,6**	**1,5**	**13,2**	**9,0**	**15,8**	**14,8**	**150,9**	**40,9**
Squid	**70,1**	**5,1**	**95,0**	**48,1**	**99,3**	**203,7**	**243,3**	**231,2**

Catch (thousand tons) of Pink and Sockeye salmon off eastern Kamchatka



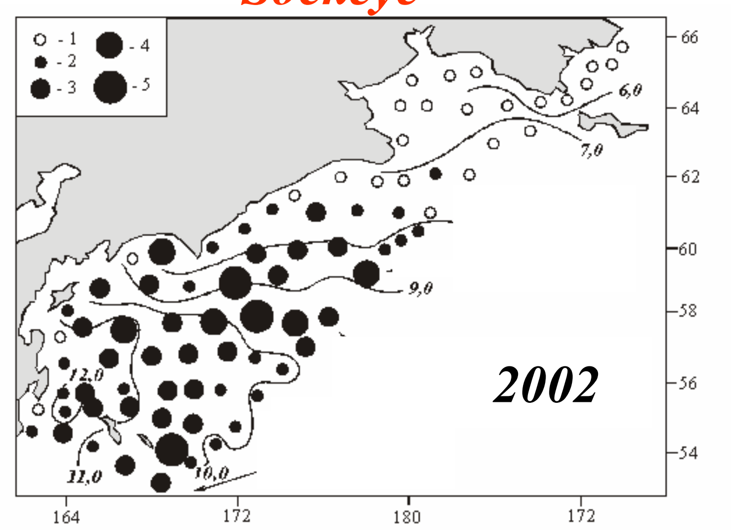


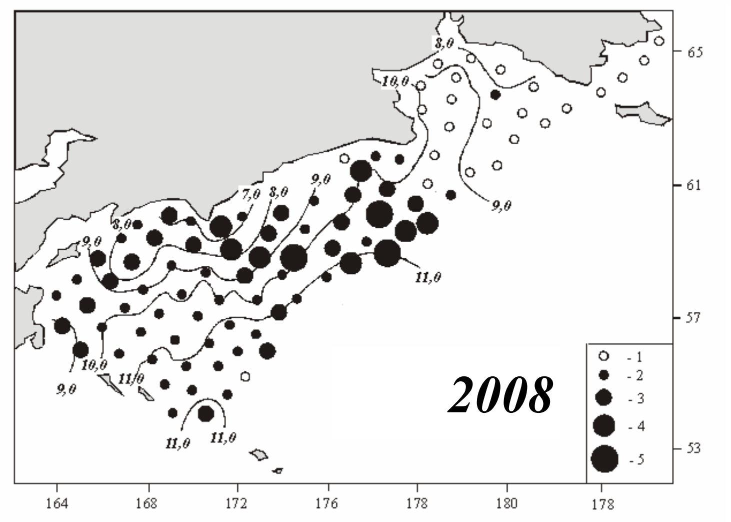
Catches of pink and sockeye salmon along the east coast of Kamchatka have also increased, especially in the late 1980s and early 1990s.

- 2. During 2002-2006, geostrophic currents were mainly latitudinal with water flowing westward from the Aleutian Basin towards the Commander Basin; during 2007-2010, northward stream from the Near Strait was present

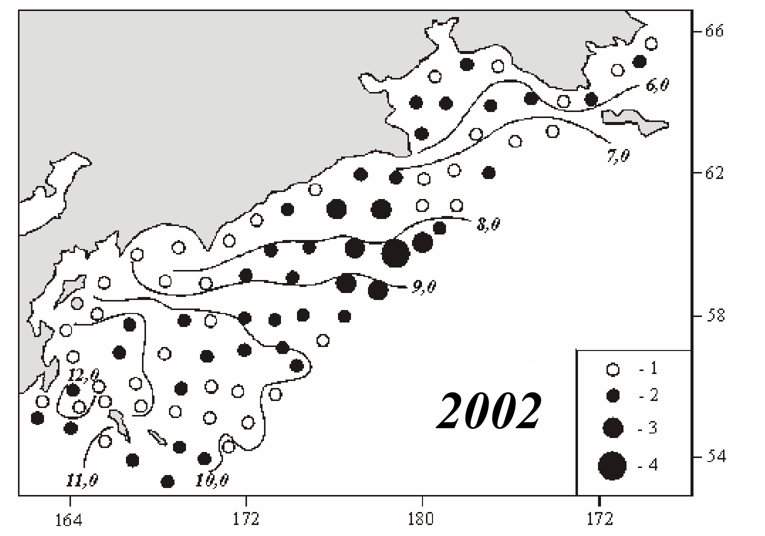
Distribution of Sockeye and Chinook in different types of current systems

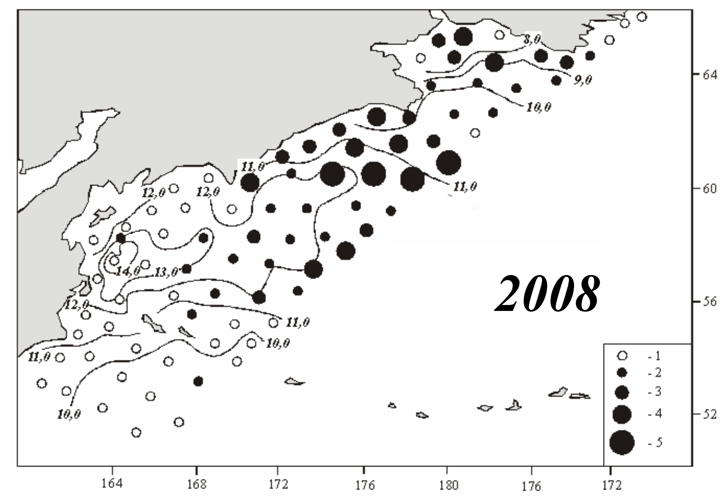
Sockeye





Chinook





Annual biomass (thousands tons) of immature Chum, Sockeye and Chinook salmon in the upper epipelagic (0-50 m) western Bering Sea during September-October

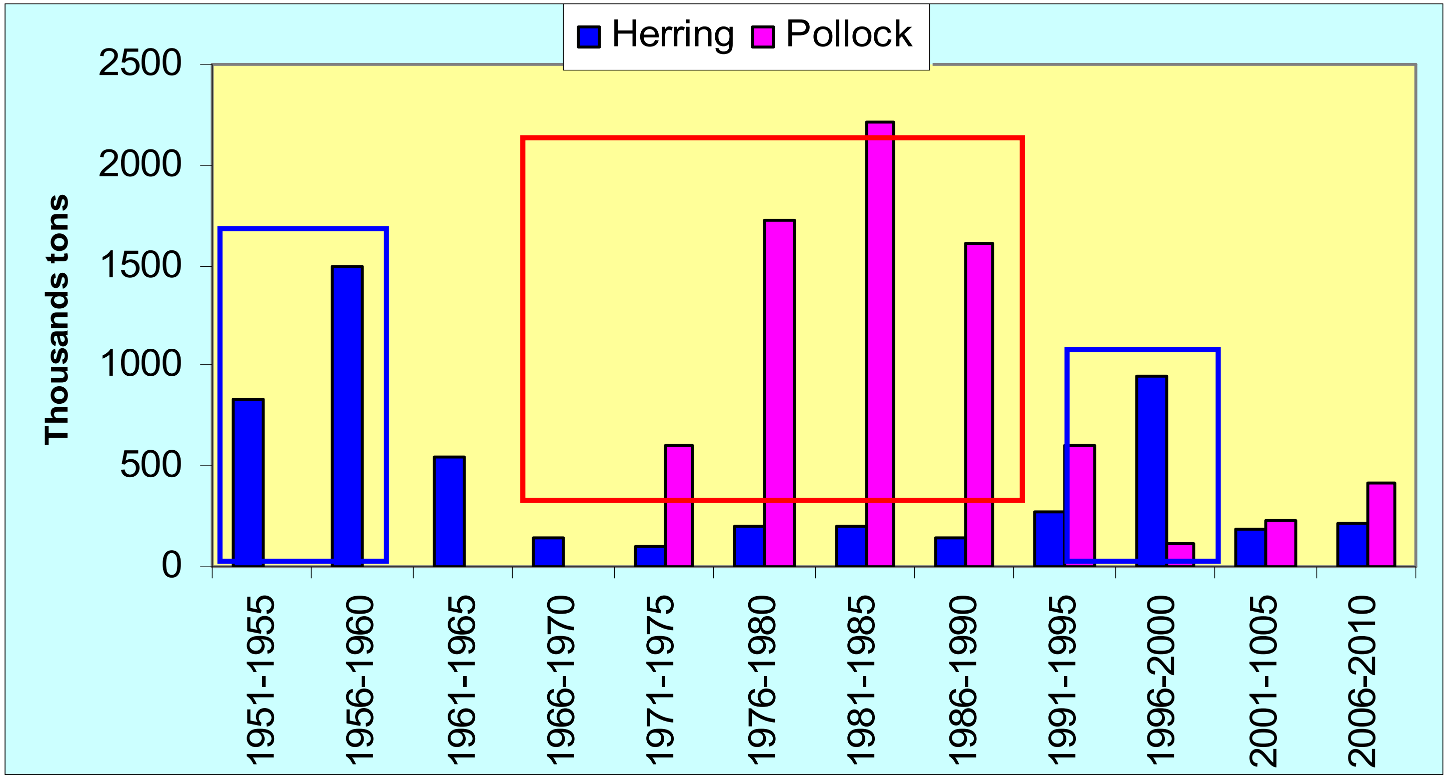
	Chum	Sockeye	Chinook
2002-2006	283.0	132.7	17.9
2007-2009	178.8	62.8	5.5

There was also a decrease in biomass of immature chum, sockeye and chinook since 2007. Of course, that could be mainly due to decrease in population abundance of these species. However, such a decrease in biomass could also be attributable to weak migrations of fish from the US EEZ due to certain changes in patterns of circulation.

- 3. Salinity within the 0-1000 m layer gradually decreased since 1950. In the upper layer the rate of decrease was about 10 times higher than in deep waters. Therefore the main halocline has sharpened, vertical stability has increased, which ultimately led to weakening of vertical water exchange and to a decrease in oxygen supply

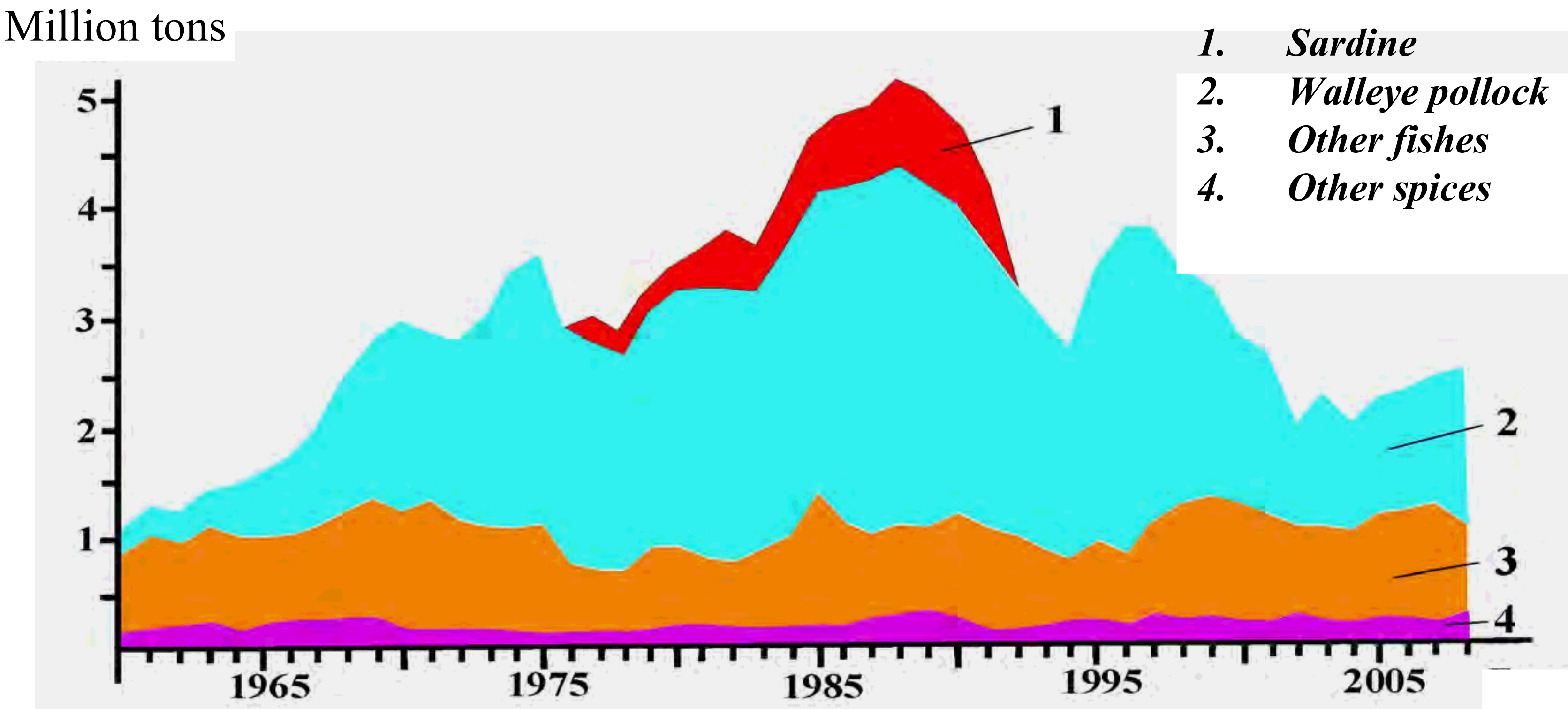
- 4. Up to the mid-1960s, water exchange between the Bering Sea and the Pacific Ocean was relatively weak. During the following 25 years, it has increased to a fairly high level. In the early 1990s, it has dropped and remains at low level till now

Changes in biomass of walleye pollock (Balykin, 2010, with supplements) u Pacific herring (Naumenko, 2001, with new data from Zolotov and Balykin, 2010) in the western Bering Sea



High biomass of pollock was observed during the 1970-1980s. In the early 1990s, pollock populations sharply declined and remain at low level till now. Herring stocks during intense water exchange period were at low level, whereas during weakening of the Kamchatka Current herring abundance increased.

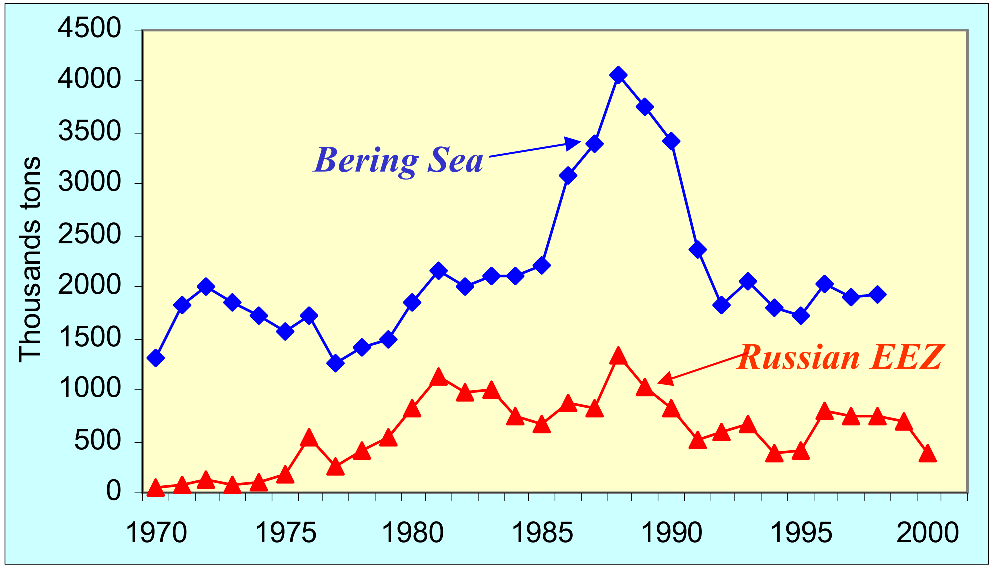
Dynamic of fish and non-fish catches within Russian exclusive economic zone in the North Pacific (Shuntov, 2009)



It should be noted in the early 1990s, evident events have occurred in fishery. For instance Russian catch in the Pacific Ocean has declined from 5 million tons in 1990 to 3 million tons in the mid-decade.

Walleye pollock catches by all countries in the Bering Sea:

blue line – total catch
red line – catch in the Russian exclusive economic zone (EEZ)



In the Bering Sea, strong reduction in catches for pollock and some other fishes occurred in the early 1990s.

Biomass of fish and squid within 0-50 m in different years

	1980-1990	*1991-1995*	*1996-2005*	*2006-2010*
All fish, 0-50 m, million tons	**5.0**	**1.34**	**2.19**	**2.14**
Squid, 0-50 m, million tons	**0.14**	**0.09**	**0.21**	**0.28**

Fish biomass on the northwestern Bering Sea shelf and in the Gulf of Anadyr in different years (Shuntov, 2009)

	1980	*1990*	*2000-2002*	*2005-2008*
Northwestern shelf and Gulf of Anadyr	**700**	**524**	**275**	**1163**

Biomass of fish and squid in the upper epipelagic layer decreased, populations of bottom fishes declined on the shelf. It is worth noting that strong decrease in biomass of fish and squid occurred in Okhotsk and Japan seas as well.

Climate indices:

SHI (Asian continent), and AO (relation between moderate and polar latitudes), PDO (North Pacific), NAO (North Atlantic),