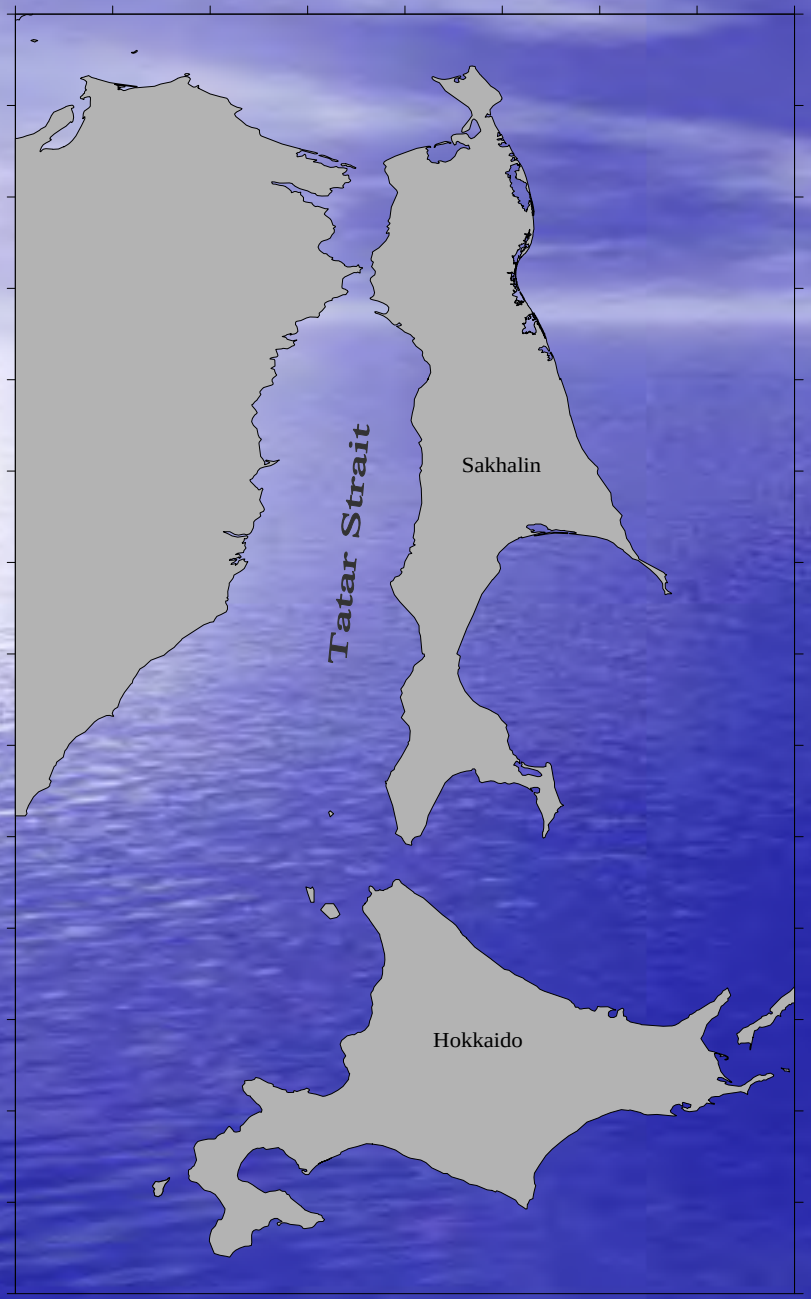

Sakhalin Research Institute of Fisheries & Oceanography (SAKHNIRO), Russia

Some features of changes in species composition and stock abundance for pelagic fishes off Sakhalin Island during the first decade of the 21 century: Recurrent influence of climatic regime shift

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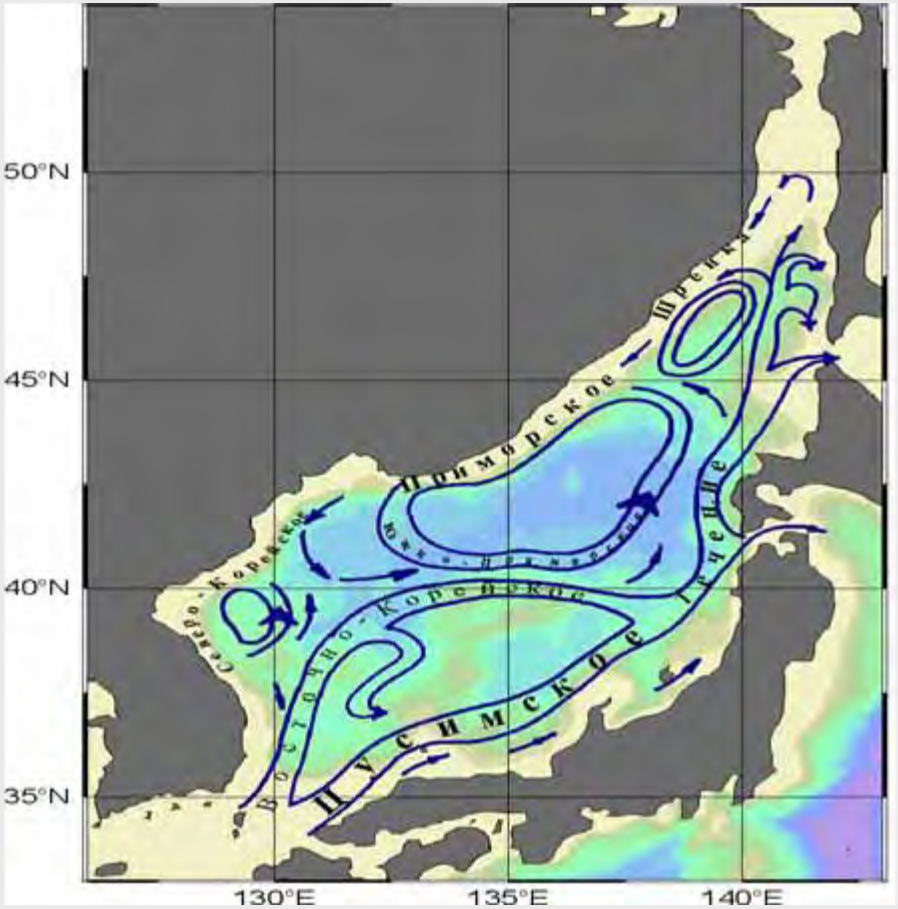
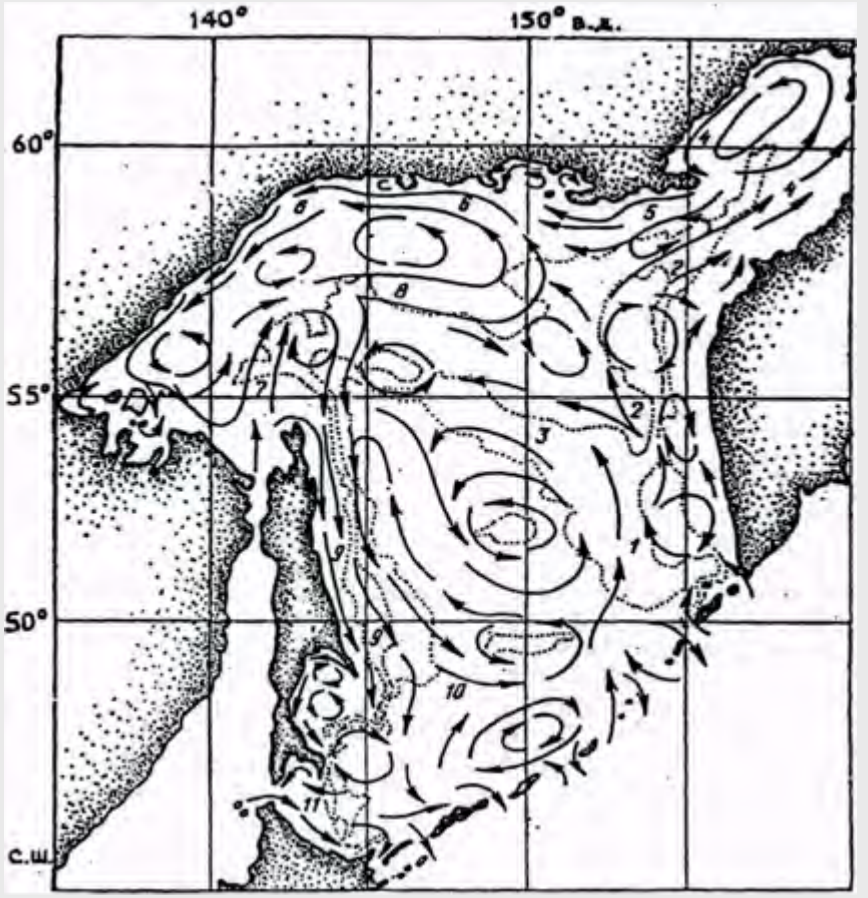
Hydrologic regime near the coast of Sakhalin Island is determined by the two non-periodic currents: warm (in the Tatar Strait) and cold (in the Sea of Okhotsk).

Scheme of the main non-periodic currents in the Japan/East Sea (from website)



General currents scheme in the Okhotsk Sea (Chernyavsky et al, 1993).

1-2 West Kamchatka Current, 3 –Median Current, 4 – Penzhin current, 5 – Yamskoye Current, 6 – Northern Okhotsk Current, 7 – Amursky Current, 8 – Northern Okhotsk Counterflow, 9 – East Sakhalin Current, 10 – Northeastern Current, 11 – Soya Current



Fish communities of the Tatar Strait and south-western part of the Okhotsk Sea are represented by species from different ecological groups (see diagrams on right).

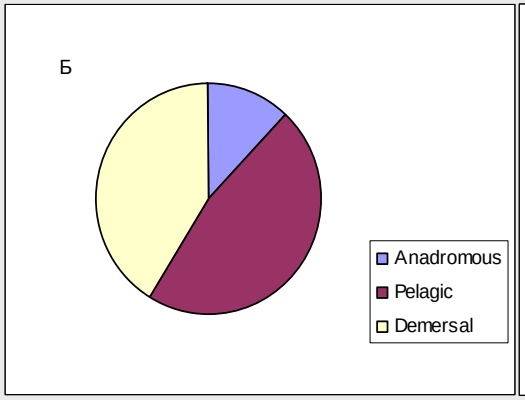
Species composition of pelagic ichthyofauna of the Tatar Strait and south-western part of the Okhotsk Sea varies significantly due to the periodic migrations of the south-latitude fishes.

In the 20th century, the shelf and coastal waters of the Sakhalin Island were rather important for fishery (annual catch of herring reached 350 000 tons, sardine – 360 000 tons, walleye pollock – 410 000 tons, pink salmon - 100 000 tons and Pacific cod – more than 50 000 tons).

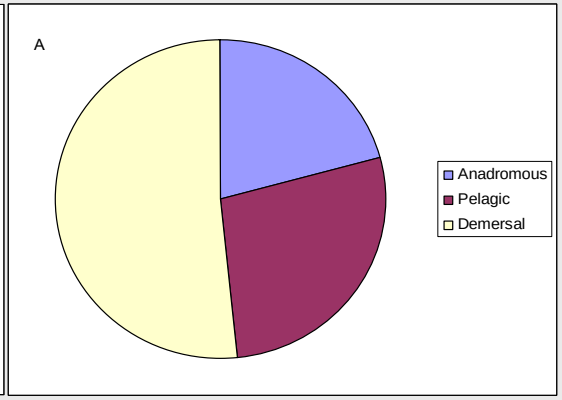
By the end of the last century, the stock abundances of many common fish species (walleye pollock, Pacific cod, sardine, and capelin) declined so that their commercial fishery was stopped.

Proportion of pelagic, anadromous and demersal species in the epipelagic fish communities in different regions of the Sakhalin sea waters (data of 1947-1997)

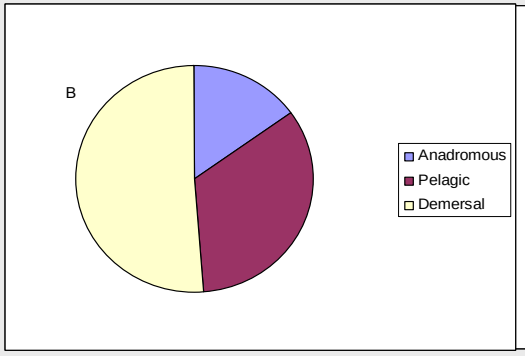
Western Sakhalin



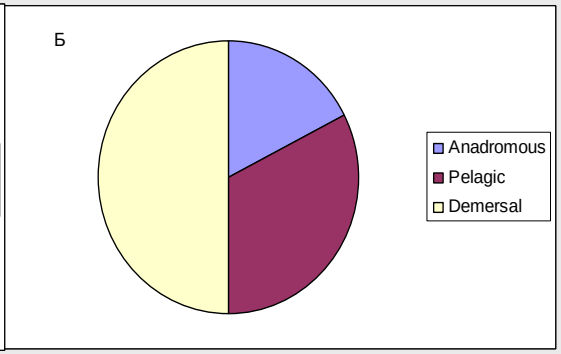
Northeastern Sakhalin



Aniva Bay



Southeastern Sakhalin



Basic tasks:

-to reveal features of changes in species composition and stock abundance for pelagic fishes off Sakhalin Island during the first decade of the 21 century;

-to reveal trends of long-term changes in abundance for common pelagic fishes in the Tatar Strait and south-western part of the Okhotsk Sea in 1950-2010;

- to reveal occurrence (absence) of conjugation of the long-term changes in climatic and oceanological factors and fish abundances;

Data Sources:

1.Catch statistics: 1950-2009 for 10 marine fish species, including pink salmon.

2. Data from trawl surveys (1976-2009), ichthyoplankton (1968-2011) and eggs surveys (1988-2010).

3. Long-term assessment of herring and walleye pollock abundance, using VPA and SCAP (stochastique cohort analyses of processes) methods correspondently.

4.Oceanographic data: water temperature at south-western Sakhalin (1924-1999), western Hokkaido (1964-2003); Ice conditions in the Okhotsk Sea (1930-2007).

5. Climatic indices: PDO, SHI, SOI, AOI, MOI – 1950 -2004.

List of warm-water fish species near the west coast of Sakhalin Island in the 20th and Early 21th centuries (based on published and own data)

Species	Years	Species	Years
Carcharodon carcharias	**1951**	*Oplegnathus fasciatus*	**1946, 1948**
Lamna ditropis	**1947-1949, 1950s, 1960s, 1980s, 2004,2007**	*Coryphaena hippurus*	**1951,1973,2007**
Pterothrissus gissu	**1980**	*Ernogrammus hexagrammus*	**1947-1949**
Sardinops sagax melanosticta	**1932-1942, 1949-1954, 1975-1991**	*Scomber japonicus*	**1931-1955, 1973, 1977-1979**
Engraulis japonicus	**1934, 1948-1967, 1989-1998, 2002,2004,2007-2009**	*Hyperoglyphe japonica*	**2002,2006**
Cololabis saira	**1933-1985, 1995-1996, 2005, 2009**	*Kareus bicoloratus*	**1947-1949, 1975**
Hyporhamphus sajori	**1948, 1975**	*Thamnaconus modestus*	**1975**
Exocoetus volitans	**1973**	*Takifugu porphyreus*	**1912,1948, 1975, 2004,2010**
Sebastes schlegeli	**1948,2001,2004**	*Lophius litulon*	**1975**
Sebastes wakiyai	**2001**		

Periodicity of migrations of some subtropical fish species to the Tatar Strait in 1910-2010

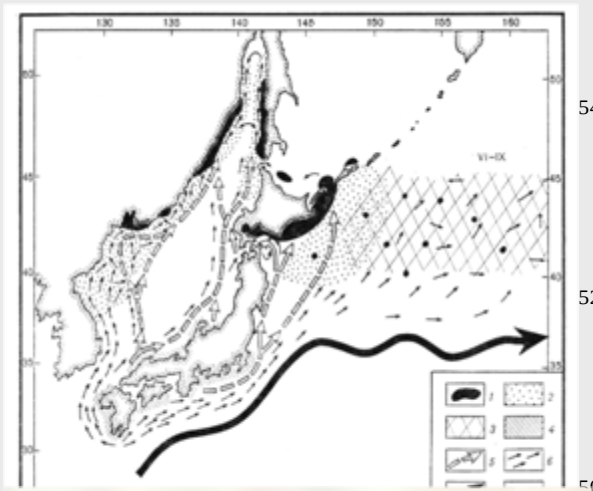
Species	1910-1919	1920-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2010
Pacific sardine	?	+	(+) – (+)	(+) –	–	+	+	(+) –	–
Japanese anchovy	?	+	(-) +	+	+	–	– (+)	+	+
Pacific saury	?	+	+	+	+	+	+	+	+
Dolphin – fish	–	–	–	+	–	+	–	–	+
Genuin puffer	+	–	+	–	–	+	–	–	+
Total	**1**	**4**	**11**	**7**	**3**	**10**	**3**	**6**	**8**

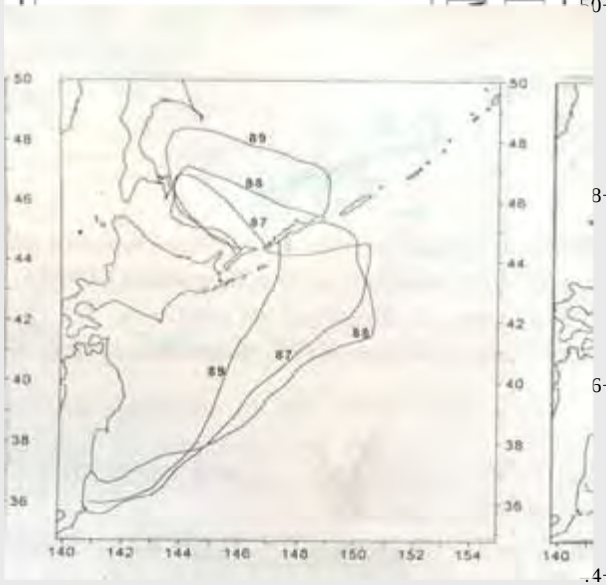
Data of south-latitude fishes occurred near the Okhotsk Sea coast of Sakhalin Island in different years

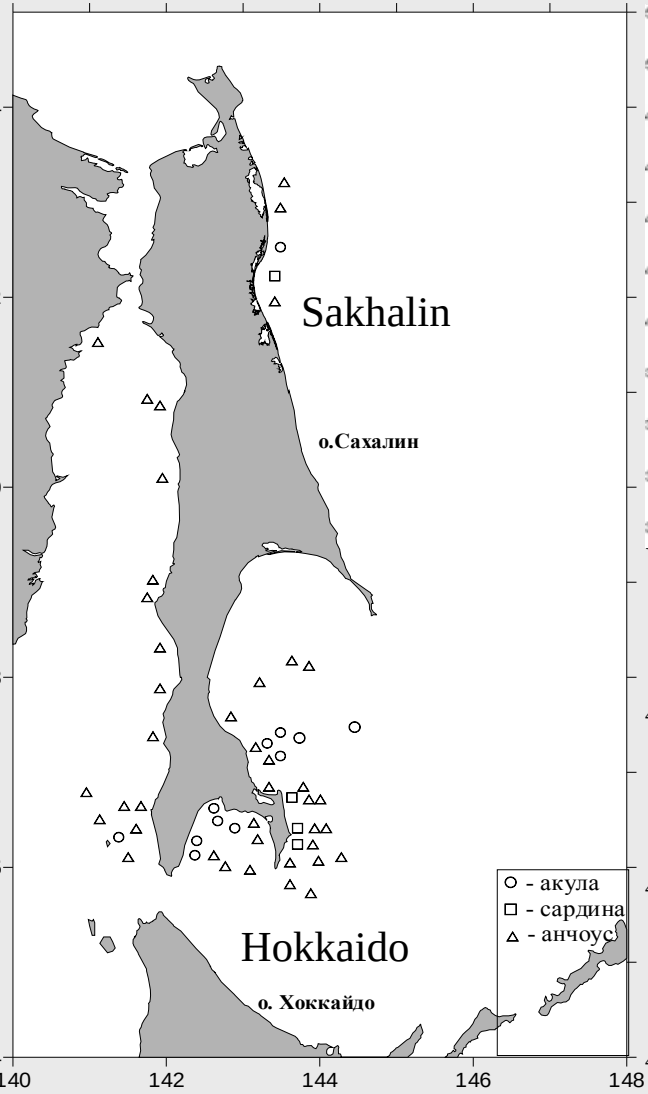
Fish species		Aniva Bay		Eastern Sakhalin	
English name	**Latin name**	**1947-1949 (Lindberg,1959)**	**2000-2010**	**1947-1949 (Lindberg,1959)**	**2000-2010**
Salmon shark	*Lamna ditropis*	+	+ (2002-2005; 2007)	+	+ (2002-2004; 2008; 2009)
White shark	*Carcharodon carcharias*	–	+ (2007)	–	–
Pacific sardine	*Sardinops melanostictus*	?	+ (2006-2007;2009)	?	+ (2001-2004)
Japanese anchovy	*Engraulis japonicus*	–	+ (2003-2009)	–	+ (2000-2004; 2008; 2009)
Pacific saury	*Cololabis saira*	+	–	+	+ (2000-2001;2008)
Green gar	*Strongilura anastomella*	–	+ (2008)	–	–
Rockfish	*Sebastes schlegeli*	+	+ (2006)	–	–
Rockfish	*Sebastes wakiyai*	–	+ (2001)	–	–
Common dolphin-fish	*Coryphaena hippurus*	–	+ (2000; 2007)	–	+ (2004;2010)
Chub mackerel	*Scomber japonicus*	+	+ (2000)	–	+ (2008)
Genuin puffer	*Takifugu porphyreus*	+	+ (2003; 2008;2010)	–	–

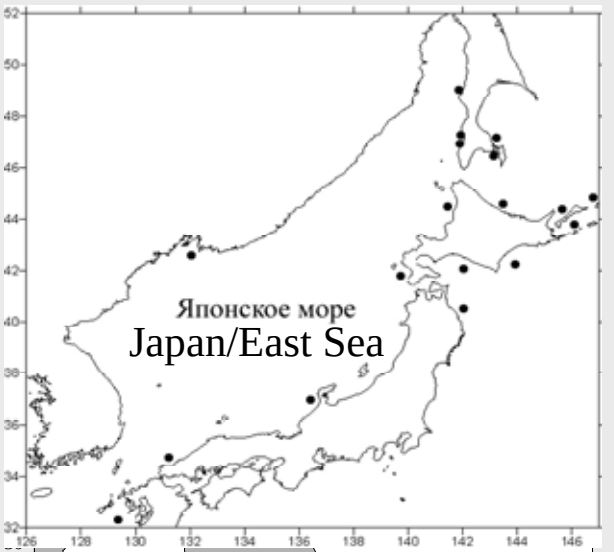
Distribution of south-latitude fishes in the sea waters of Sakhalin Island

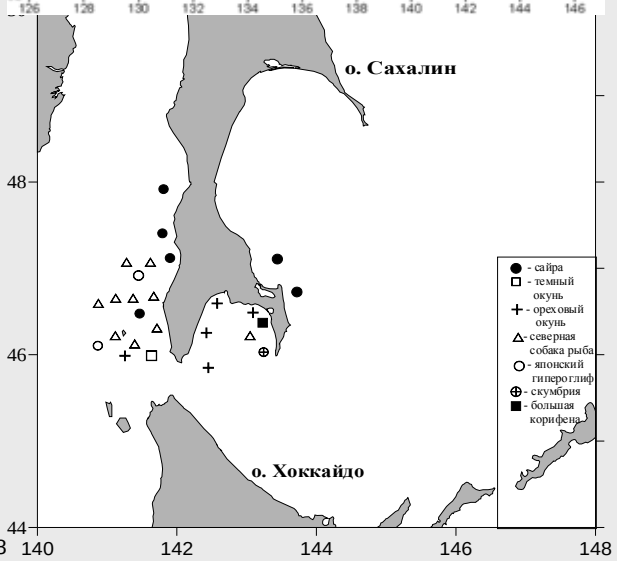
Left panel: Pacific sardine in the Japan/East Sea in the end of the 1970s - early 1980s (Dudarev, Kenya, 1986) and in the southwestern Okhotsk Sea in 1987-1989 (Zhigalin, Belyaev, 1999).
Central panel: salmon shark (○), Japanese anchovy(△) and Pacific sardine (□), 2000-2005.
Right panel:* Dolphin-fish (dorado), 1951-2007 (upper) and *some other south-latitude fish species near the Sakhalin coast in 2000-2005 (lower)



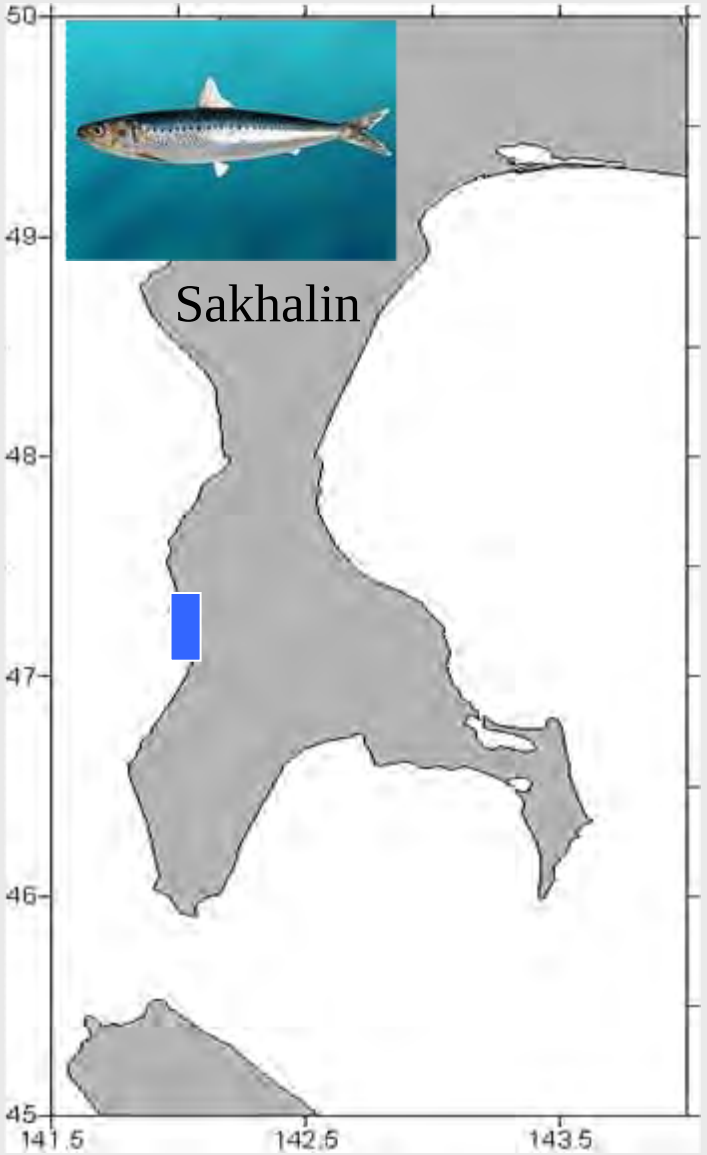


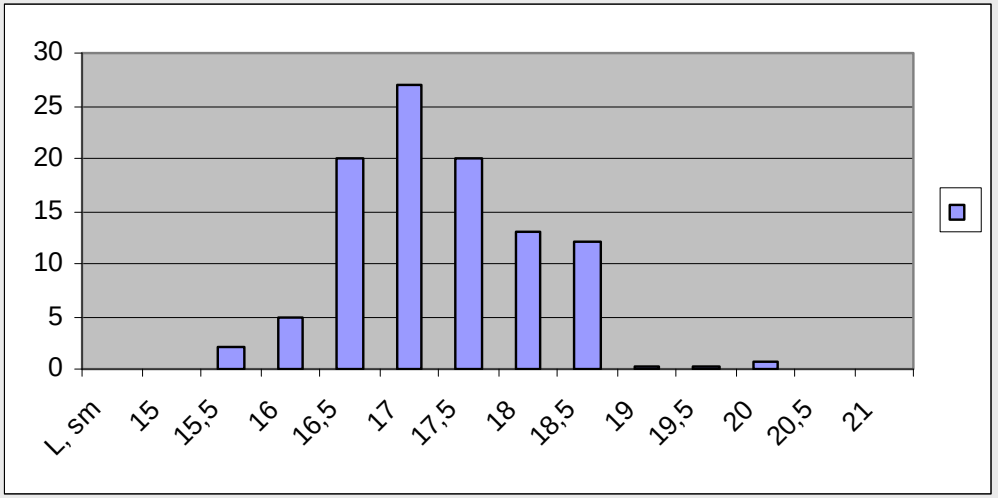






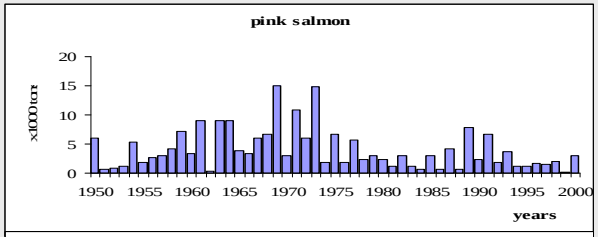
A new appearance of Pacific sardine near the western coast of Sakhalin Island, Early October, 2011. **Left panel**: area of found sardine schools. **Right panel**: dead sardine in the tidal coastal zone near the settlement Sadovniky, website foto (upper); length composition of Pacific sardine, sampled in the tidal zone (lower)



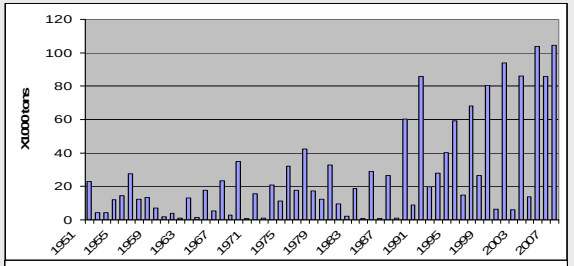


Dynamics of different pelagic fish catches in the Tatar Strait (left panel) and in the southwestern part of the Sea of Okhotsk (right panel) in the second half of the 20th century

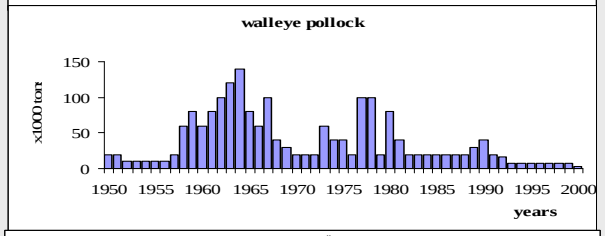
Pink salmon



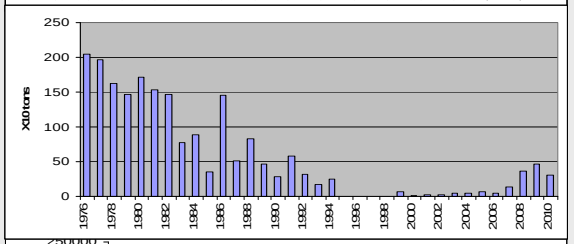
Pink salmon



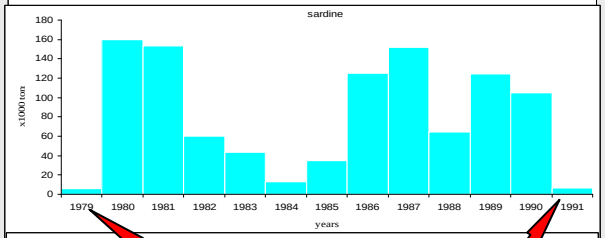
Walleye pollock



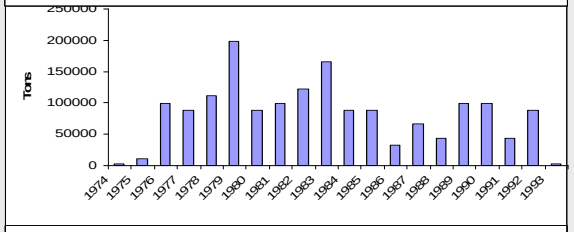
Walleye pollock (north-eastern Sakhalin)



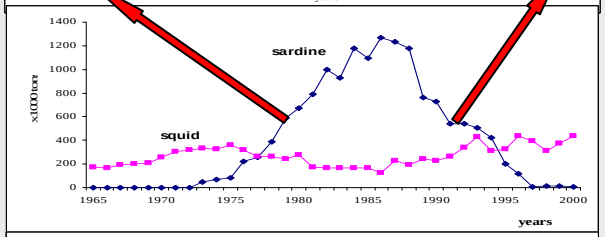
Pacific sardine



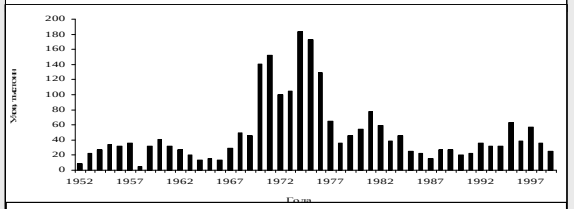
Pacific sardine



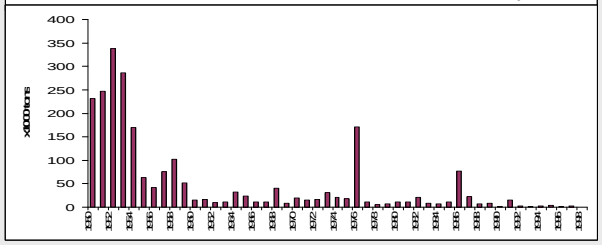
Pacific sardine (western Japan coast)



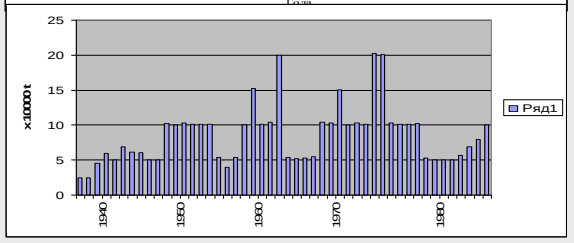
Sand-lance (La Perouse Strait, northern Hokkaido)



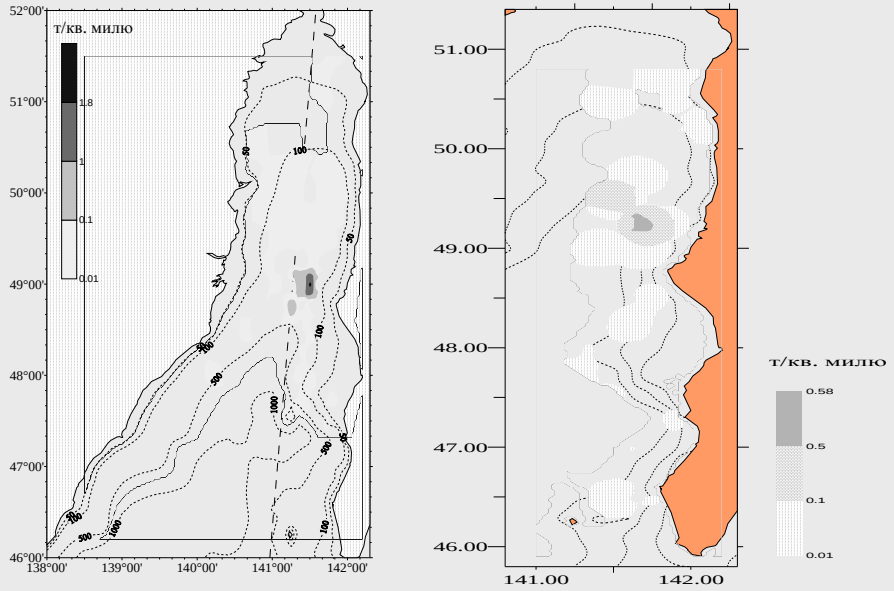
Herring (Southern Sakhalin)



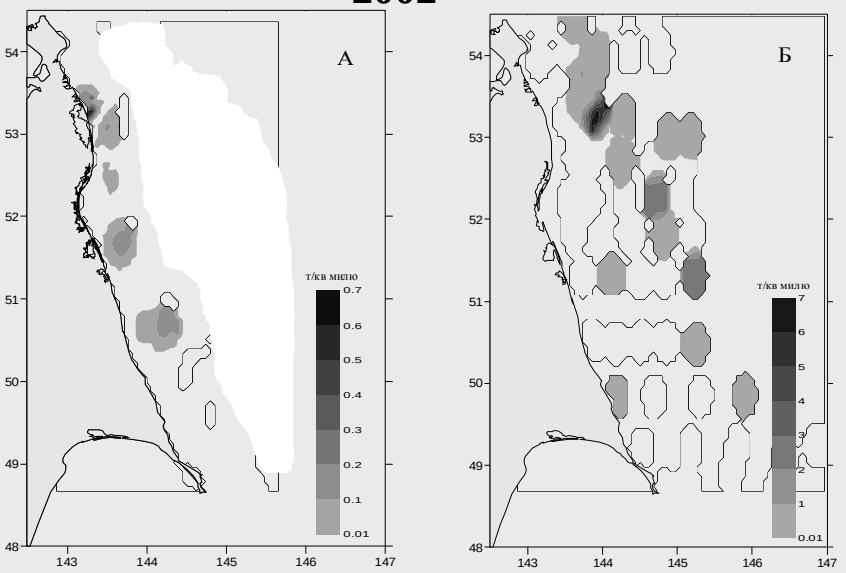
Arabesque greenling (northern Hokkaido)

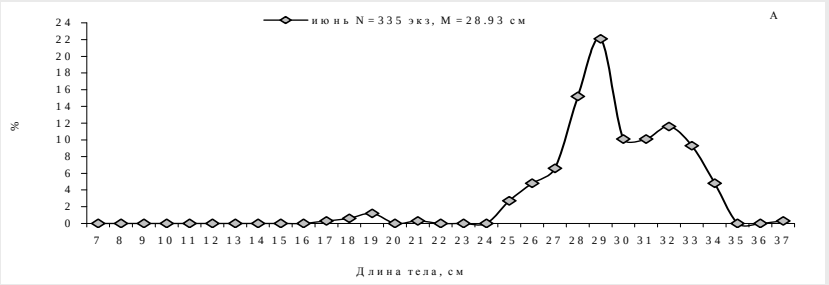


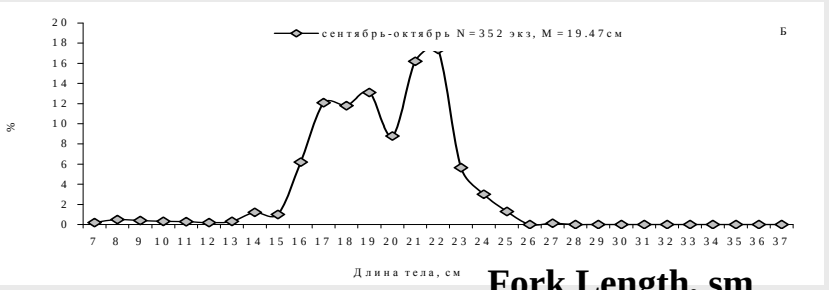
Distribution of herring in the Tatar Strait in April-May 2006 (left panel) and 2008 (right panel) by the results of trawl surveys



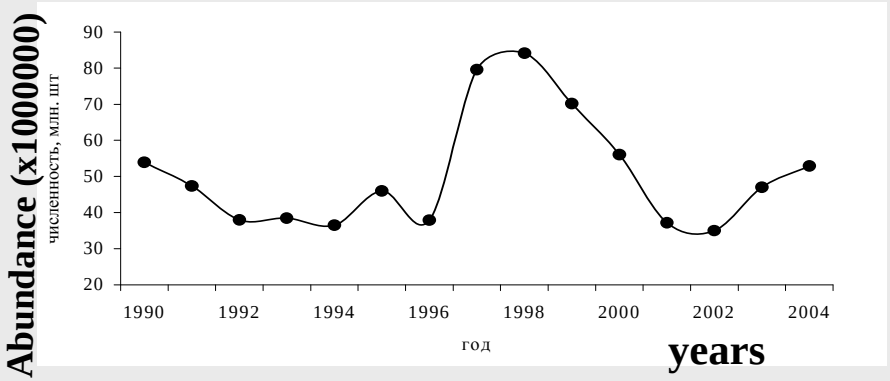
Distribution of herring along the northeastern Sakhalin coast (from left to right: October 2002; July 2002) and length-size composition of herring trawl catches in July (upper) and October (lower) 2002







Stock abundance dynamics of Sakhalin-Hokkaido herring during 1990-2004 (data of A. Ivshina)



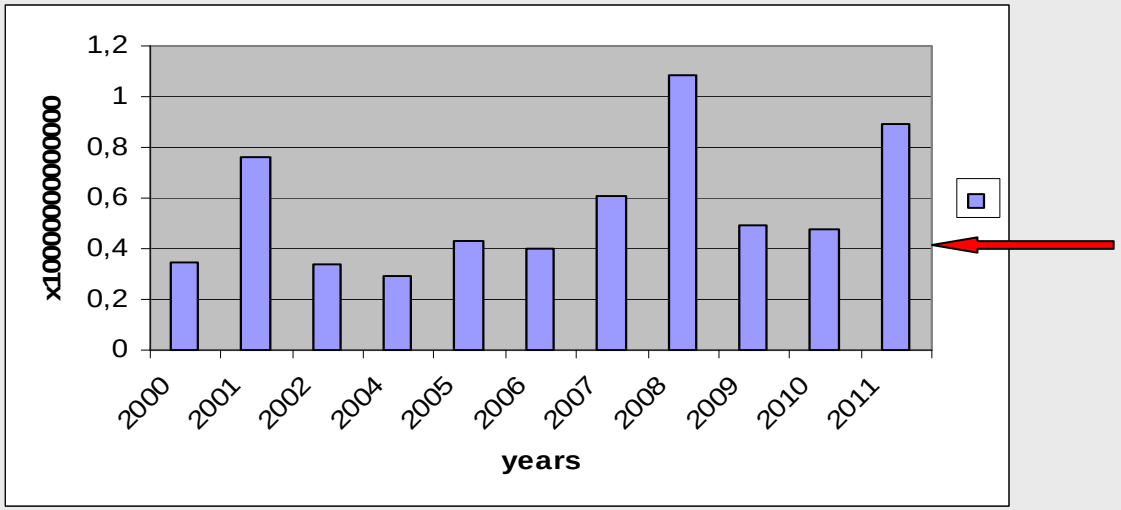
Fork Length, sm

Data on walleye pollock egg concentrations sampled in the Tatar Strait in different years (eggs/m^2)

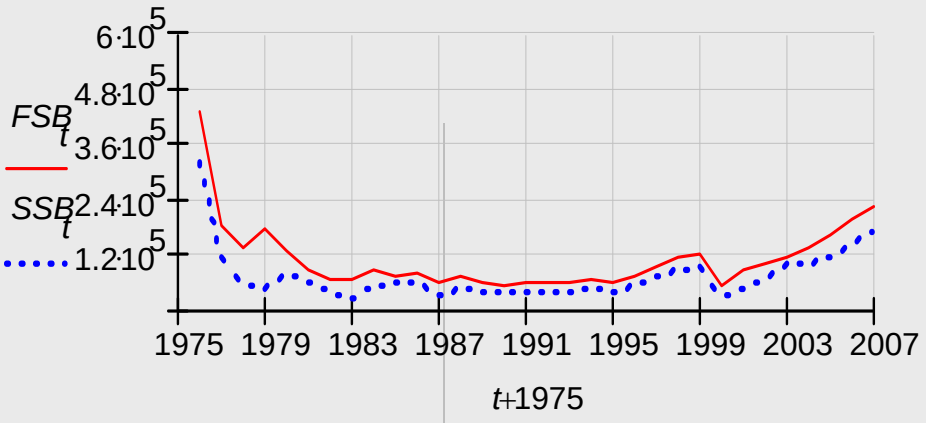
Years	1968*	1974*	1981**	1989**	1999	2001	2002	2004	2005; 2010
Area: 49-51°N	no data	1.-2000	2.0-550	2.-550	2.0-10.	2.0-4.0	2.0-10.	no data	0.00
46-49°N	100-2000	1.-2000	2.0-550	2.0-550	2.0-32.	2.0-76.	2.0-14.	2.0-8.0	2.0-8.0
46-51°N	no data	1.-2000	2.0-550	2.0-550	2.0-32.	2.0-76.	2.0-14.	no data	2.0-8.0

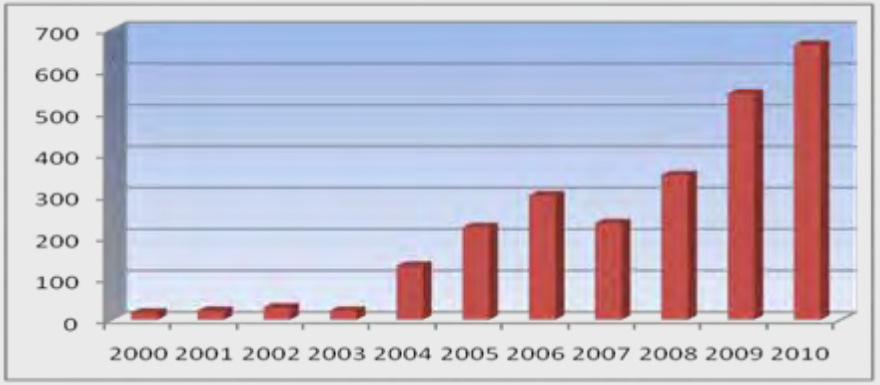
(* - Zverkova, 1977;2003; ** - Shuntov et al,1993)

Dynamics of abundance index of walleye pollock floating eggs near the northeastern Sakhalin coast in 2000-2011

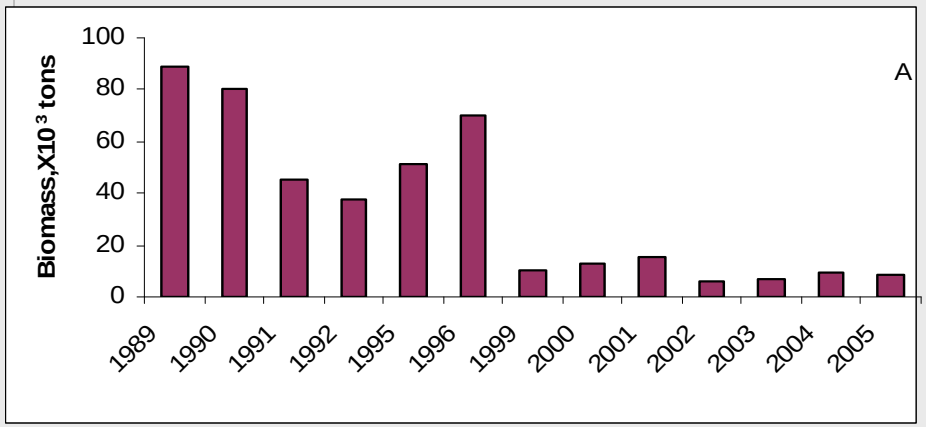


Dynamics of walleye pollock biomass near the northeastern Sakhalin: spawning biomass in 1975-2007 (left) and stock biomass in 2000-2010 (right)





Dynamics of walleye pollock spawning biomass near the western coast of Sakhalin during 1989-2005



Data of capelin spawning intensity near the western coast of Sakhalin Island in different years

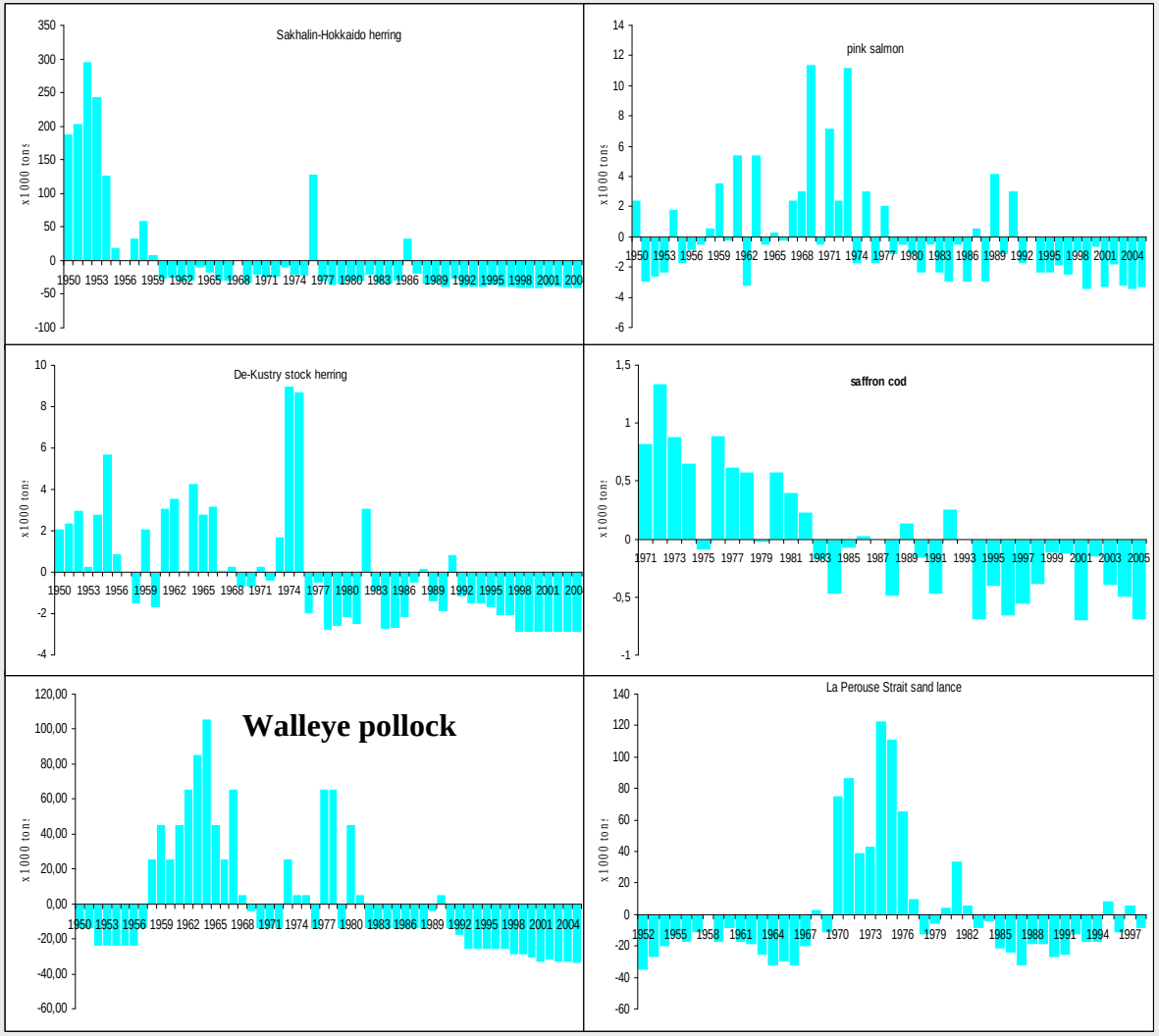
Year	1988	1989	1992	1995	1996	1998	1999	2002	2003-2010
Spawning area (mln. sq. м)	**2.34**	1.90	1.61	0.94	0.50	0.15	0.76	**2.88**	< 0.9
Average number of eggs (x10^6 egg/m^2)	3.60	0.88	1.56	0.64	0.18	0.052	0.028	**3.80**	< 0.6

Data of capelin spawning area and eggs concentration in Aniva Bay and near southeastern Sakhalin in different years

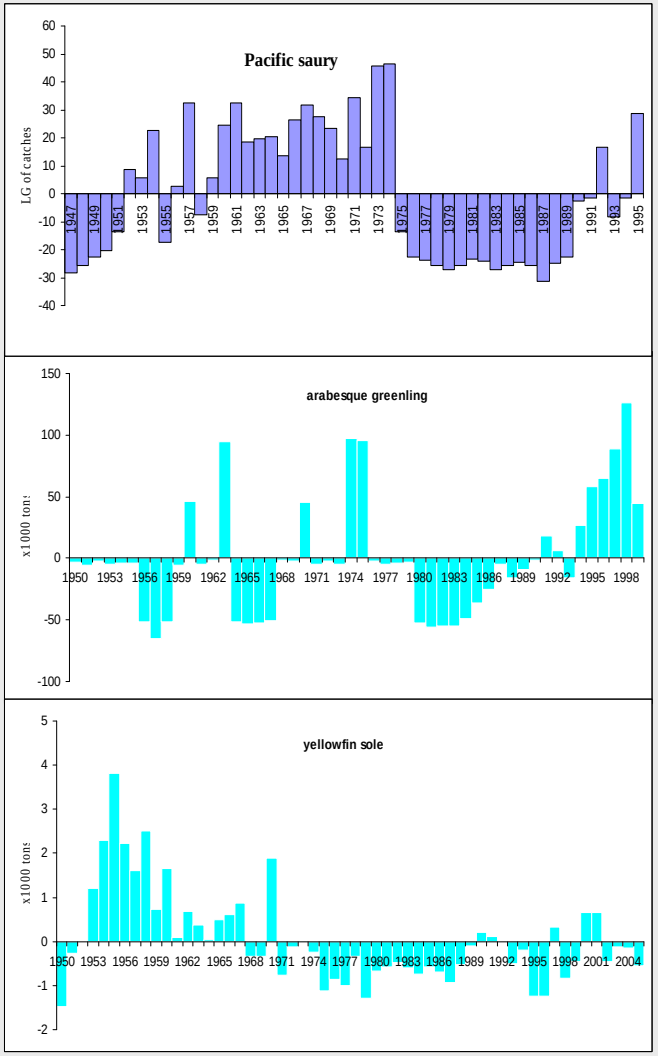
Year	Aniva Bay		South-Eastern Sakhalin	
	Egg concentration (x10^6 egg/m^2)	Spawning area (x10^6 m^2)	Egg concentration (x10^6 egg/m^2)	Spawning area (x10^6 m^2)
1979	**3,14 – 15,90**	**0.60**	no data	no data
1985-1989	**0.01 – 3.66**	**0.5-0.71**	**0.01 - 8,77**	**0.51-0.89**
2000-2004	**0.002 – 2.025**	**0.09-0.20**	**0,01 – 1,01**	**0.40-0.60**
2005-2010	**< 2,0**	**< 0.20**	**< 1.0**	**<0.60**

Annual changes in catch anomalies for herring, walleye pollock, pink salmon, saffron cod, yellowfin sole near western Sakhalin, sand-lance and arabesque greenling near northern Hokkaido, and Pacific saury in Japan/East Sea in 1950-2005

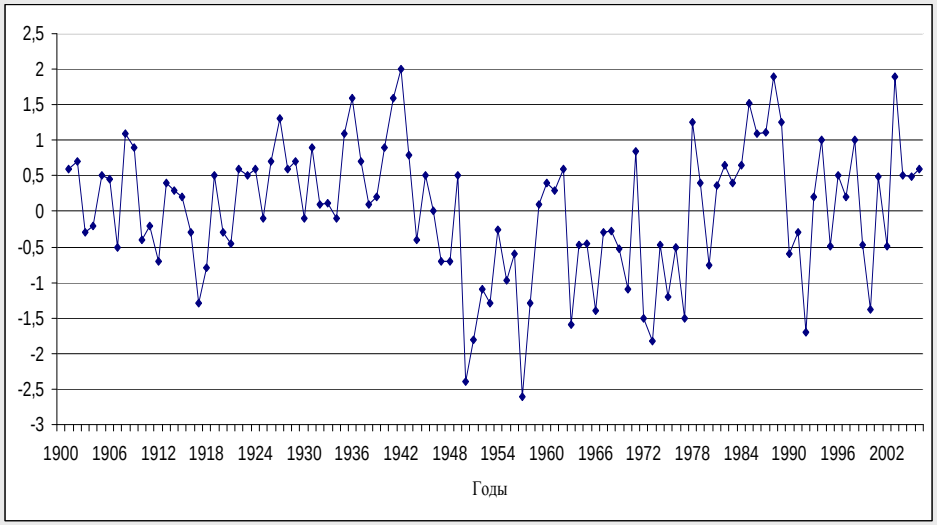
Fish species with winter-spring spawning

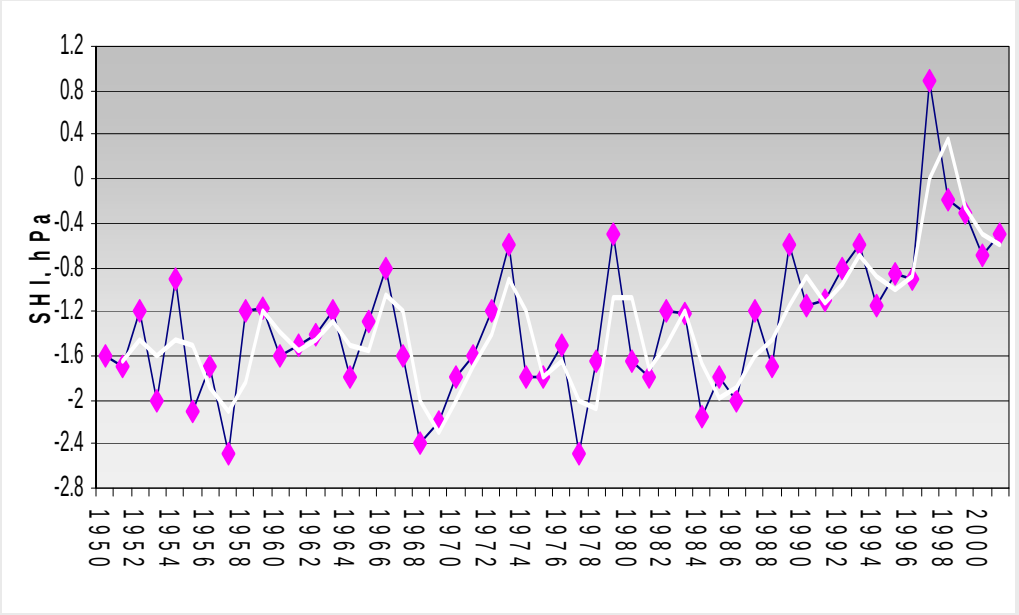


Fish species with summer-autumn spawning

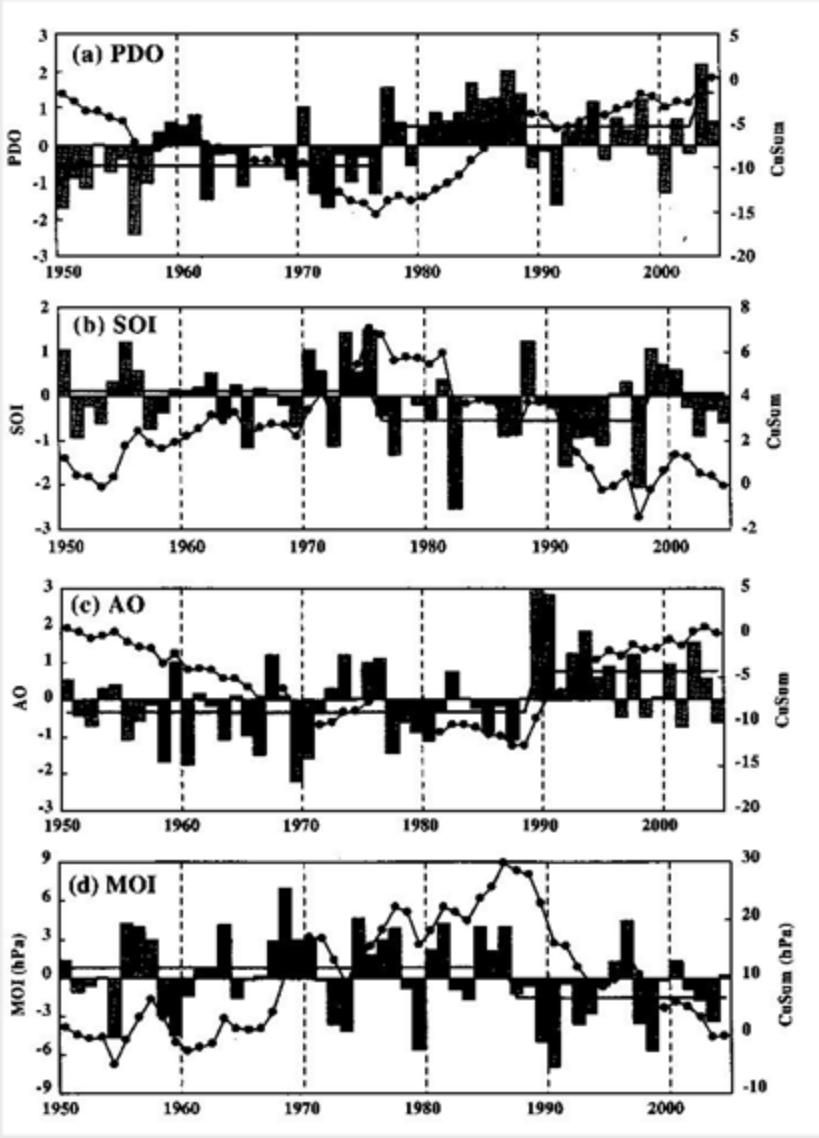


Dynamics of PDO Winter Index in 1901-2006 (upper; Batchelder, Kim,2006) and Siberian High Index in 1950-2001 гг. (lower; Panagiotopoulos et al,2005)

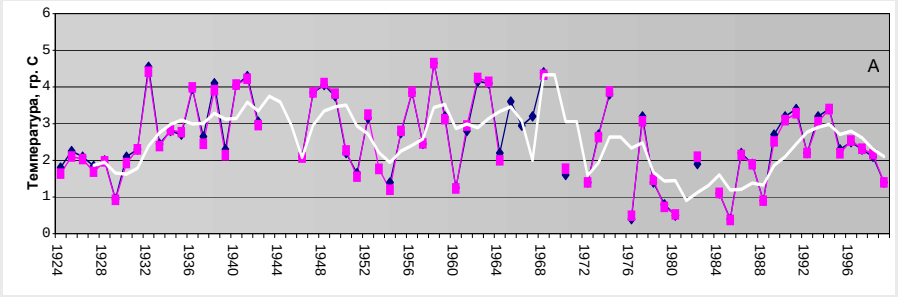


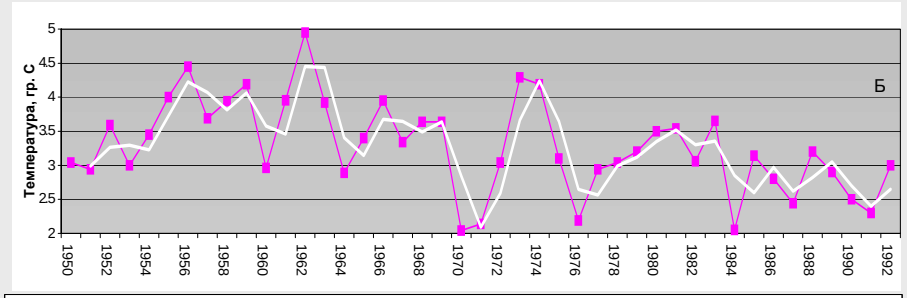


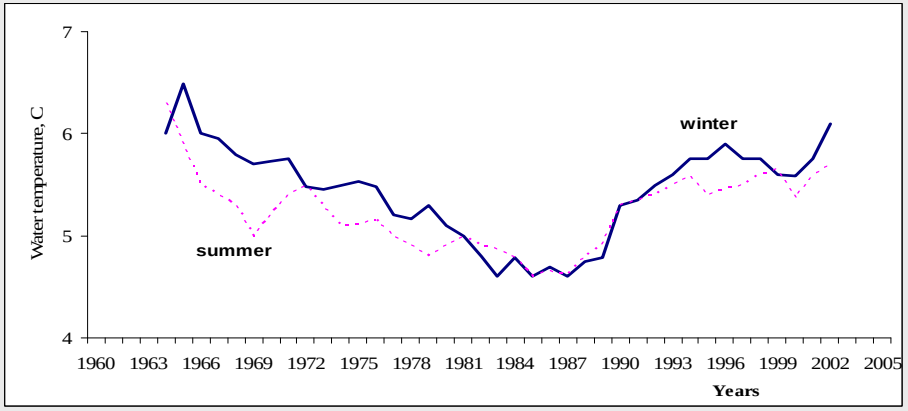
Anomalies (vertical bars) and their cumulative sums (circles) for the four climatic indices from 1950 to 2004 (Tian et al, 2008)



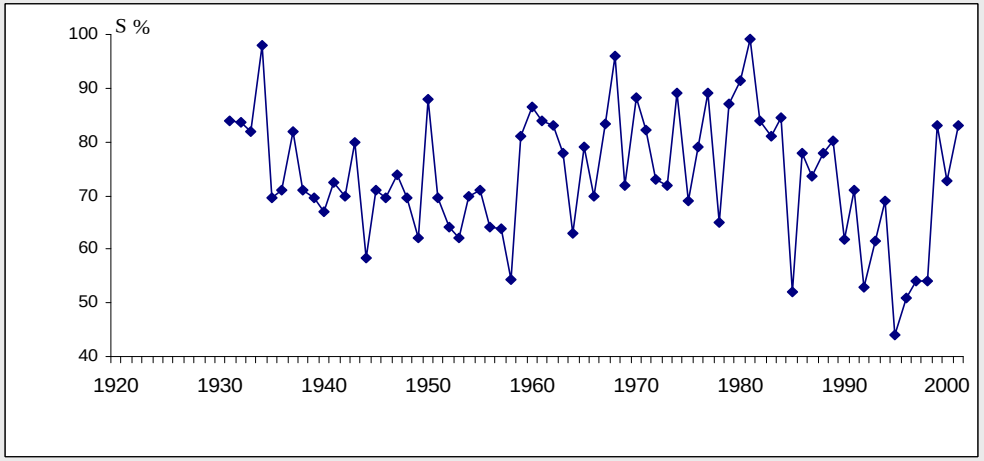
Long-term changes of water temperature:
(top) along south-western Sakhalin (Antonovskiy transect, layer 50-100 m, May 1924-1999 (Kantakov, 2000);
(middle) mean year temperature (layer 0-200 m, 1950-1992) (Karpova, Shatilina, 2000);
(bottom) along western Hokkaido (200 m depth, 1964-2003 (Tian et al,2008)



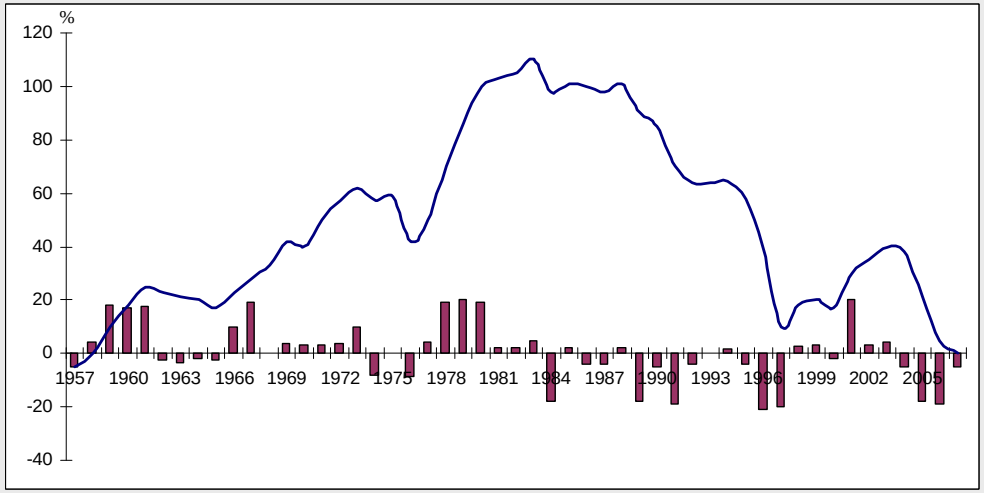




Ice conditions in the Okhotsk Sea in March (Ustinova et al., 2002)



Long-term distribution of average annual deviation of ice cover in the Okhotsk Sea and background of ice cover anomaly distributions (Muktepavel, Shatilina, 2009)



Conclusions

- In 2000-2010 a number of south-latitude fish species in the Tatar Strait and southwestern part of the Okhotsk Sea has increased in comparison with the 1980-1990s. Stock abundance of walleye pollock, herring, Far East capelin was low in most areas, but Japanese anchovy, saury, arabesque greenling were comparatively high-abundant.
- Significant changes in stock abundance have been observed for many fish species in the Tatar Strait and southwestern part of the Okhotsk Sea during 1950-2010.
- Changes in abundance, revealed for different fish species, had different-directed trends and were independent from any belonging to biogeographic or ecological groups of fishes.
- Changes in fish abundance in the Tatar Strait and southwestern part of the Okhotsk Sea occurred against the background of increase in Siberian High Index and PDO Index, decrease in MOI Index, increase in water temperature in the eastern part of the Japan/East Sea in the 1980s and especially in the 1990s, and decrease of ice cover of the Okhotsk Sea during the last 30 years.
- Major south-latitude fish species of the Tatar Strait were more frequent in the years of higher intensity of the Tsushima Current and lower monsoon intensity as well; near the eastern Sakhalin these species were more frequent in the years when ice cover was minimal in the Okhotsk Sea.
- There was revealed a general trend: a comparatively high abundance of fishes that spawn in winter-spring was observed in the periods when intensity of the warm Tsushima Current lowered. In the years of high intensity of Tsushima Current, the abundance of summer-autumn spawning fishes increased.