The Sea of Okhotsk: some conceptions applying to climate-oceanography events and fish resources

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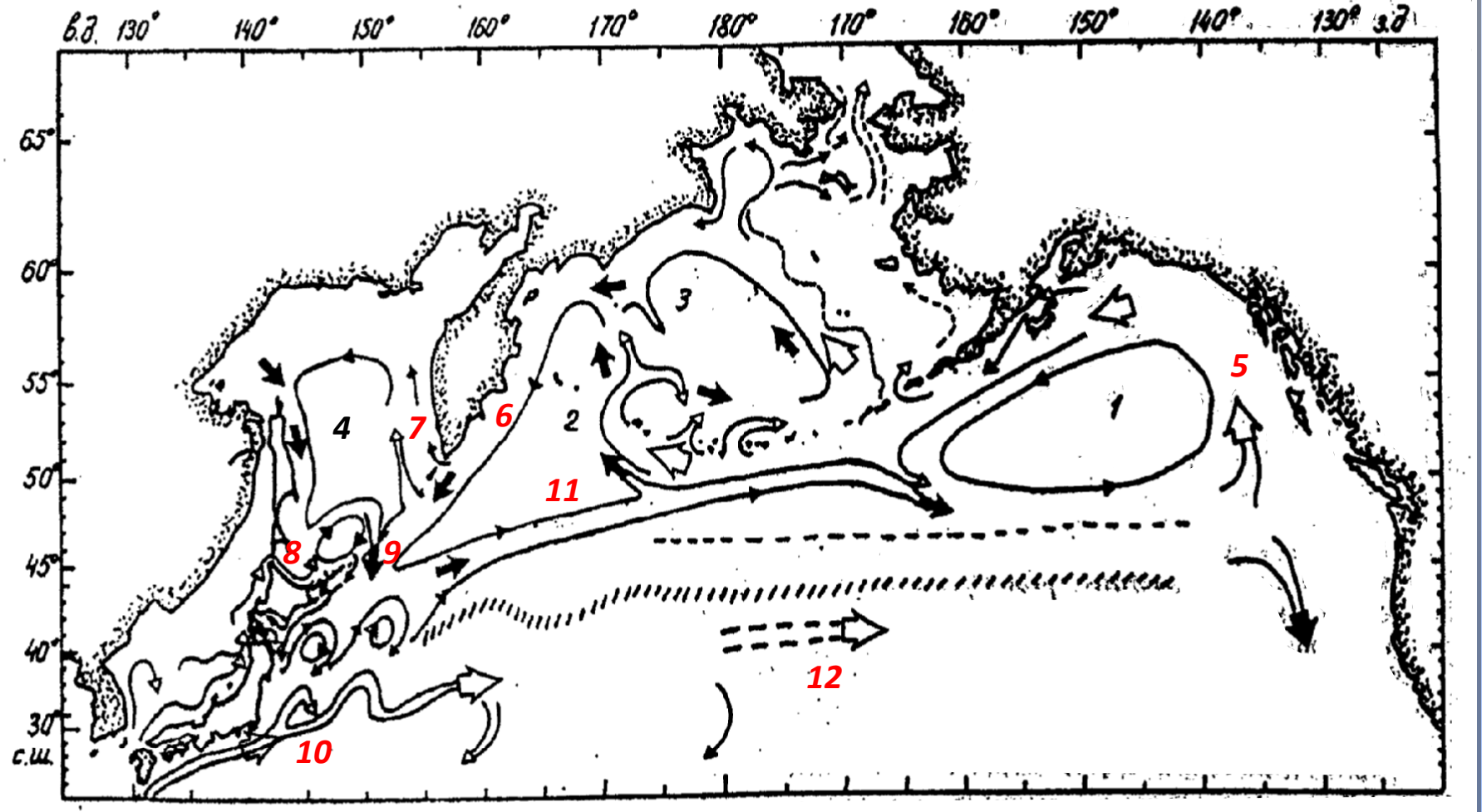
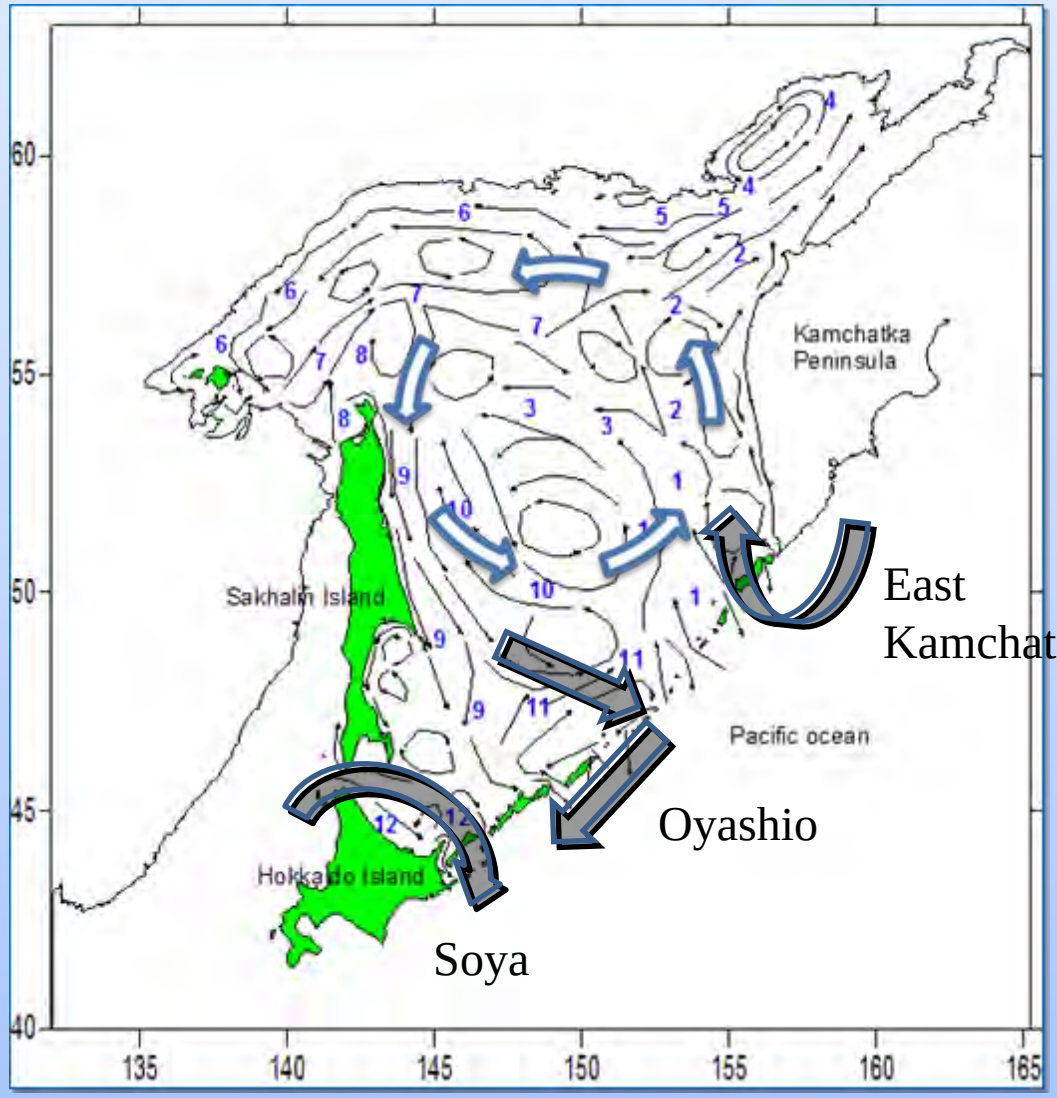
Circulation system in the North Pacific, 1 – Alaskan Gyre, 2 – Western Subarctic Gyre, 3 – Bering Subarctic Gyre, 4 – Okhotsk Subarctic Gyre. Currents: 5 – Alaskan, 6 – East Kamchatka, 7 – West Kamchatka, 8 – Soya, 9 – Oyashio, 10 – Kuroshio, 11 – Subarctic, 12 – North Pacific (Ohtani, 1991)



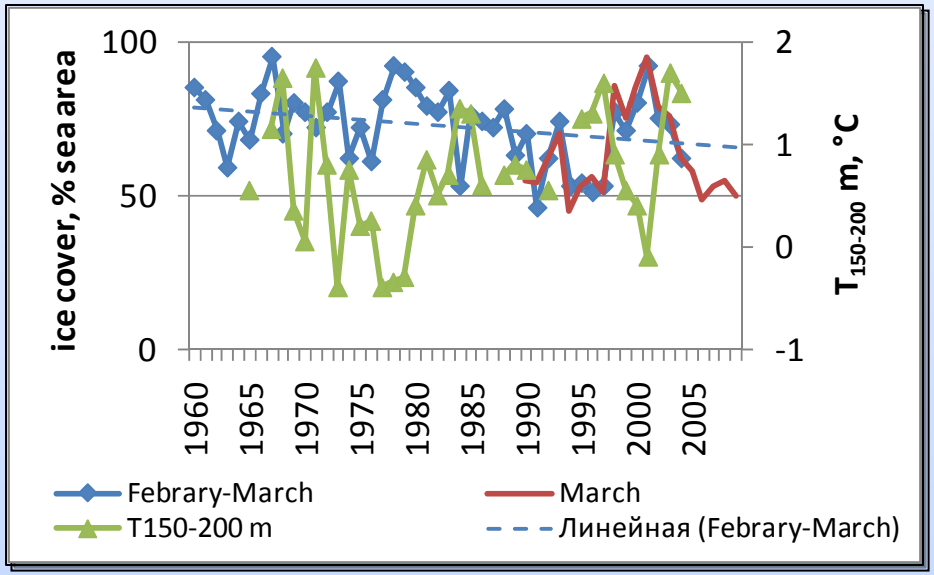
The Sea of Okhotsk cyclonic Gyre in the warm period (July-September) (Chernyavskyi et al., 1993)



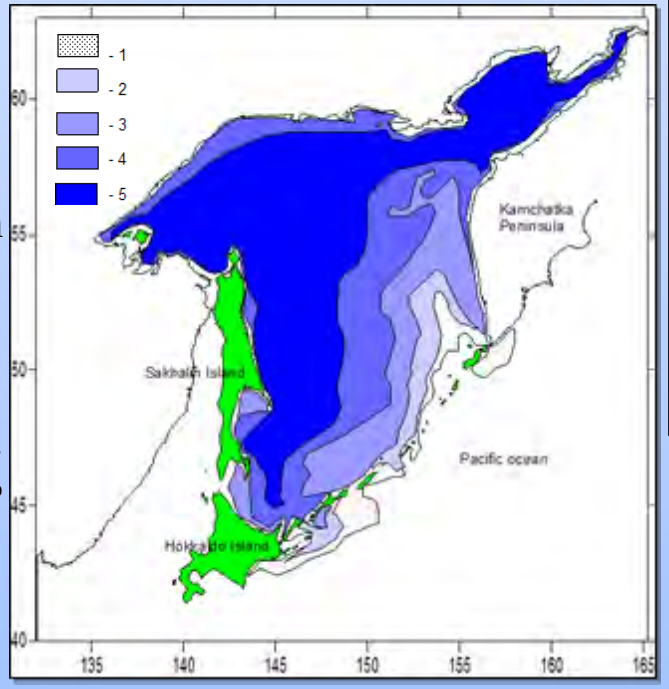
Currents

1-West Kamchatka
2-Northern
3-Median
4-Penzhinskoye
5-Yamskoye
6-North Okhotsk
7-North Okhotsk Counter
8-Amur
9-East Sakhalin
10-East Sakhalin Counter
11-North-Eastern
12-Soya

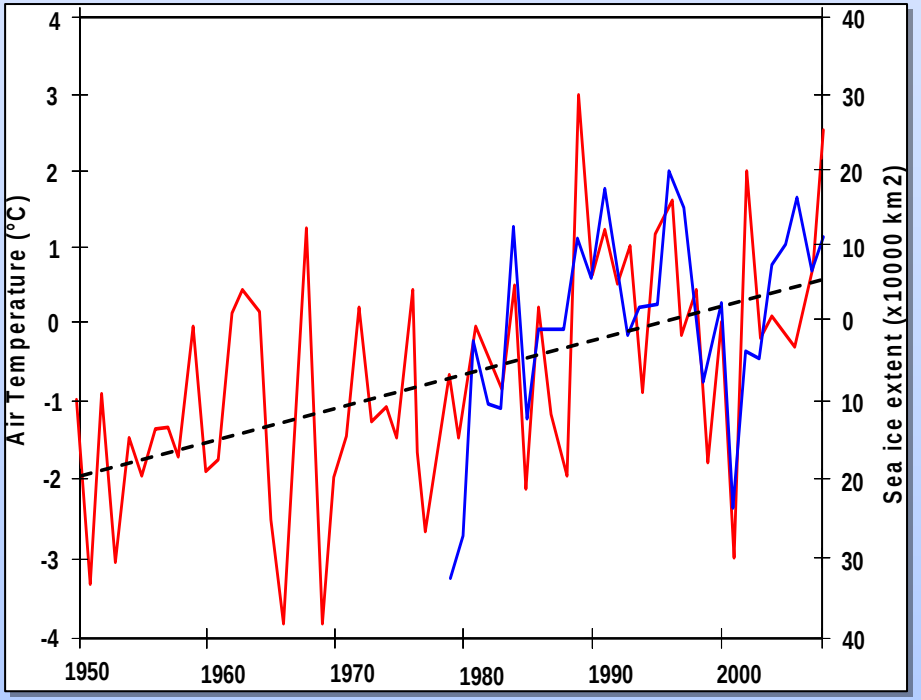
The Sea of Okhotsk: ice cover (%), surface air and bottom water temperature



Ice cover averaged in February-March 1960-2009 and bottom water temperature averaged for depth 150-200 m in July 1965-2004 (*Zhigalov, Luchin, 2010; Figurkin, 2006*)

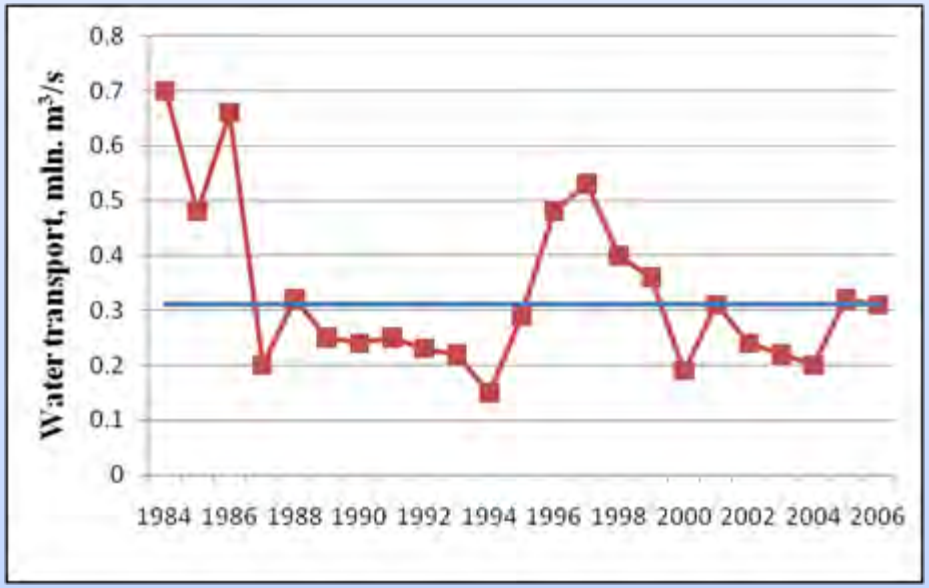


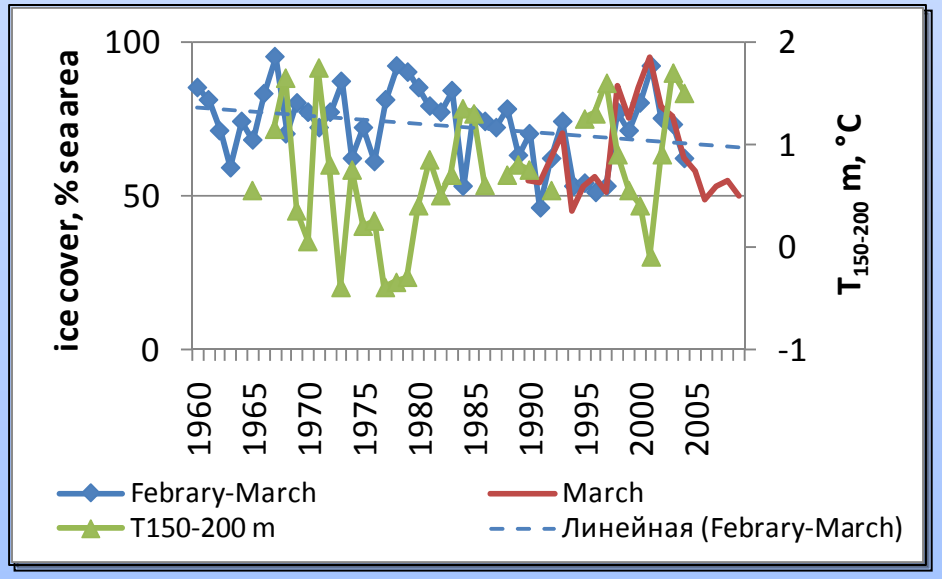
Average ice cover in March 1971-1990 (*JMA, 1991*): 1 - >90% of probability, 2 - 70-90%, 3 – 30-70%, 4 – 10-30%, 5 - <10%

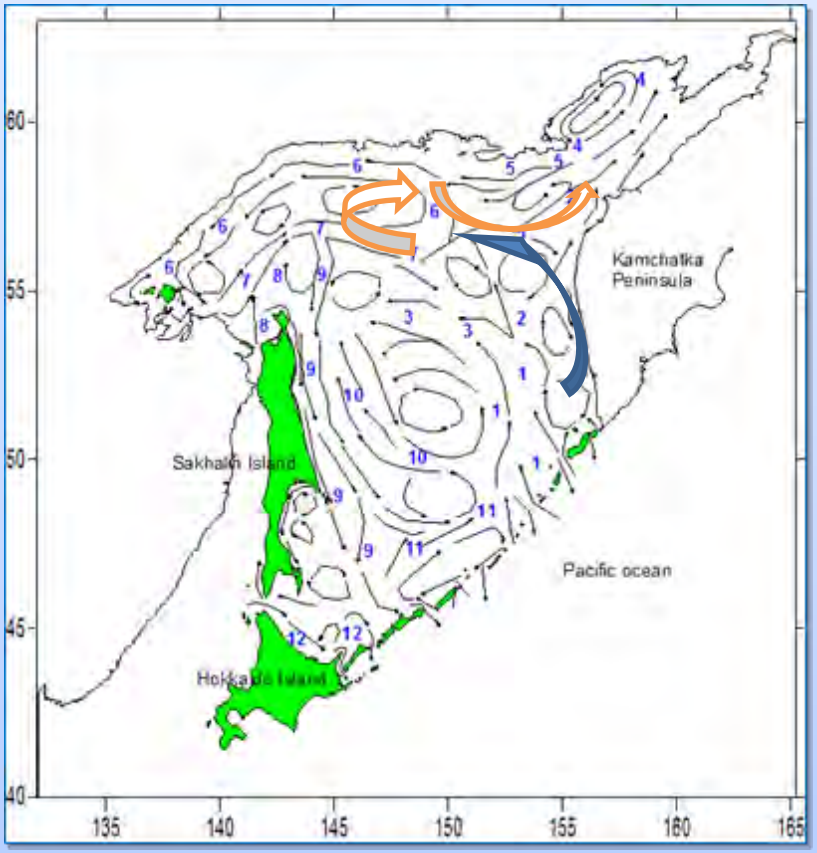


Air temperature anomaly in October-March over northeastern Eurasia (red) and annual sea ice extent anomaly in the Sea of Okhotsk (February) (blue) (*Ohshima et al., 2006*).

Water transport of the Western Kamchatka Current (Northern Branch) within the 0-200 m layer in April 1983-2006 (Figurkin et al., 2008)





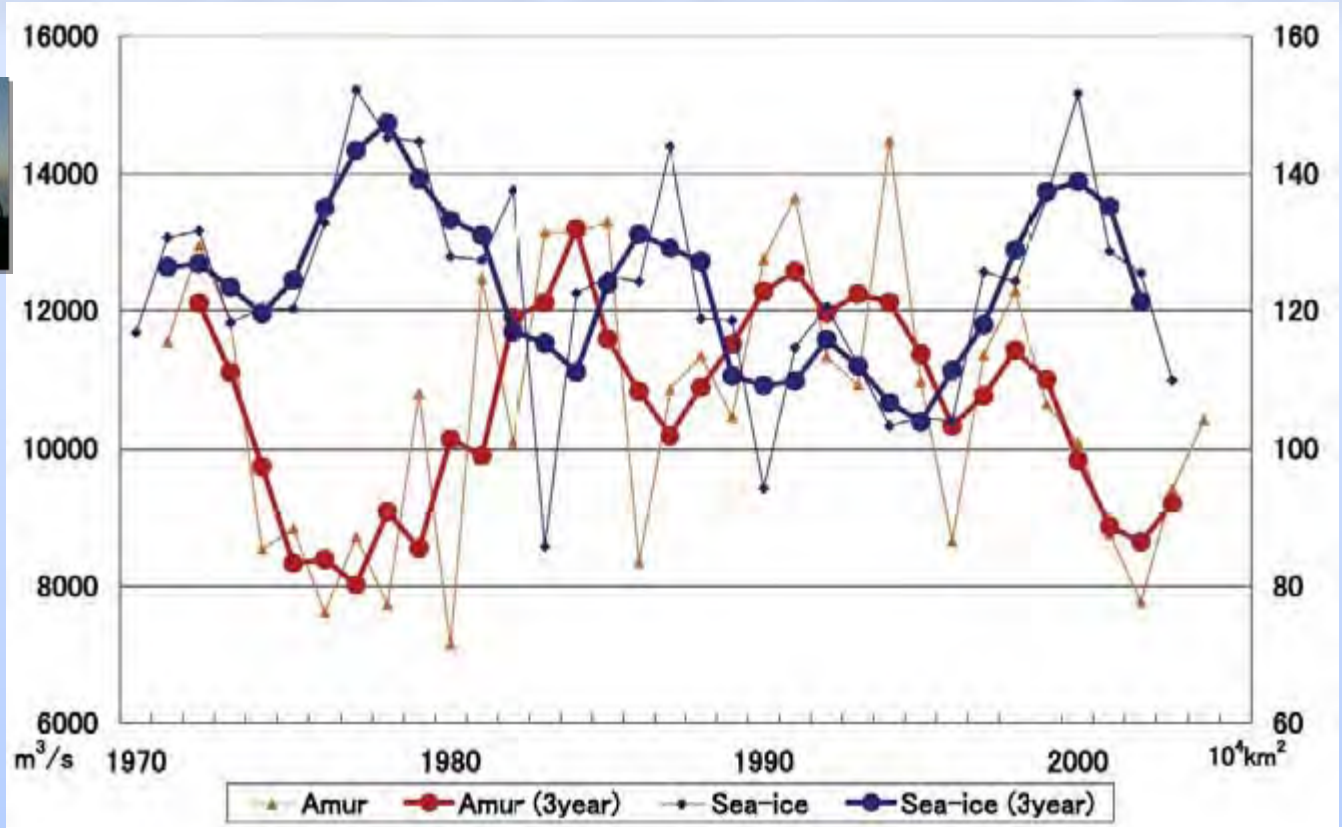


Warm year transport

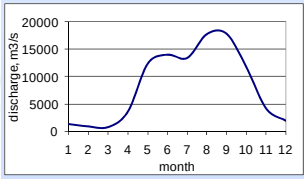
Cold year transport

Annual mean discharge of Amur River (red lines) and sea ice area over the Okhotsk Sea (blue lines). The lines are smoothed (3-year average) (Tachibana, Ogi, 2009 (1))

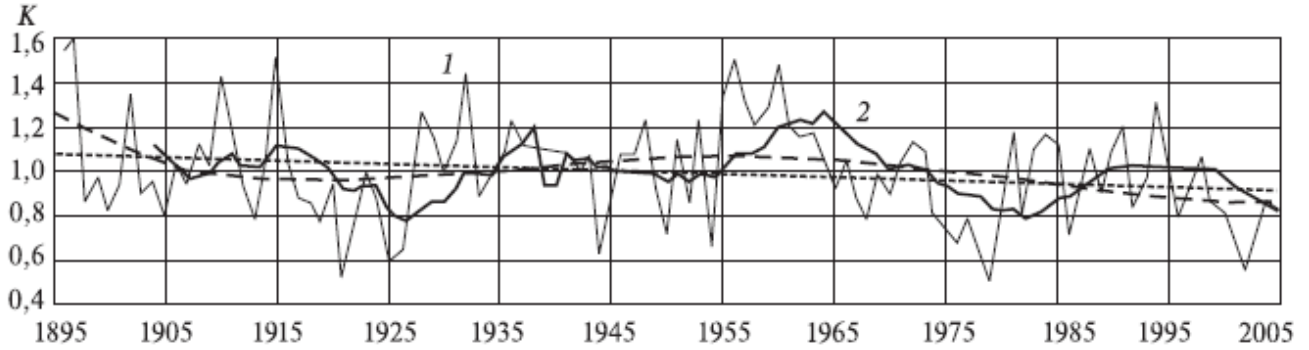
Long-term discharge from Amur River (Novorotskii, 2007 (2)), below



Seasonal variation of Amur River discharge

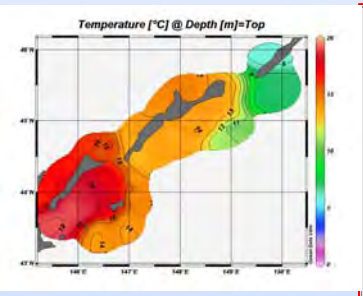


1

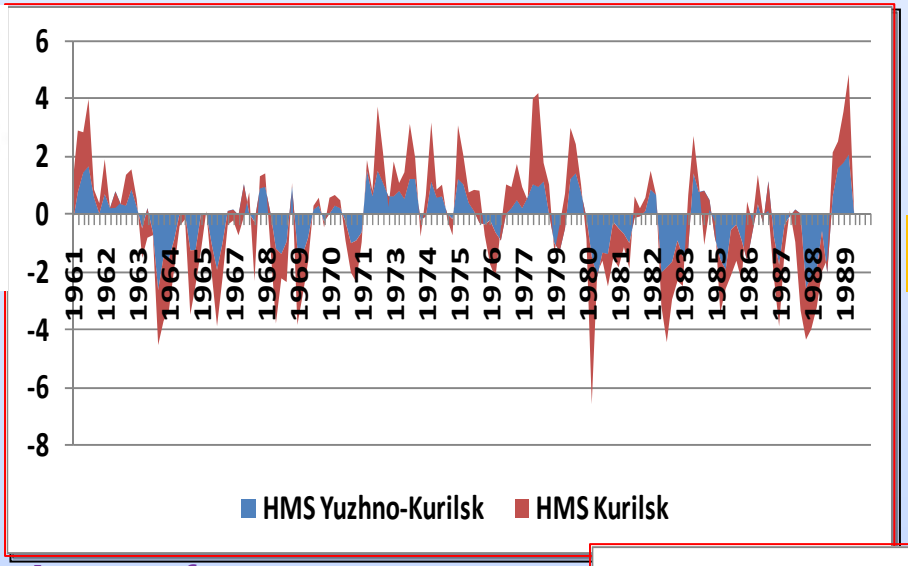


2

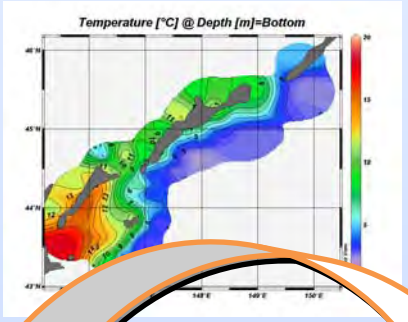
Waters temperature anomalies at South Kuril Islands area in 1961-1990, June-October (Shatilina, 1996) (1), in 1982-2007, March (Zhigalov, 2010)(2)



Surface T

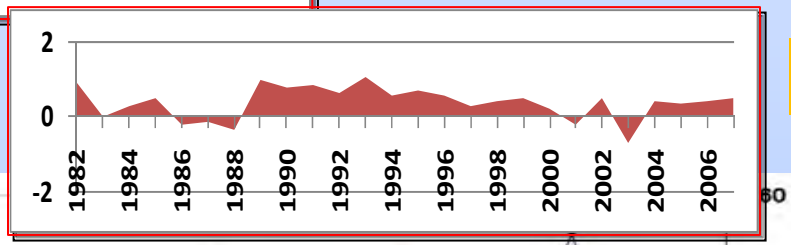


1



Bottom T

Annual mean discharge of Amur River (red lines) and sea ice area over the Okhotsk Sea (blue lines). The lines are smoothed (3-year average) (Tachibana, Ogi, 2009).



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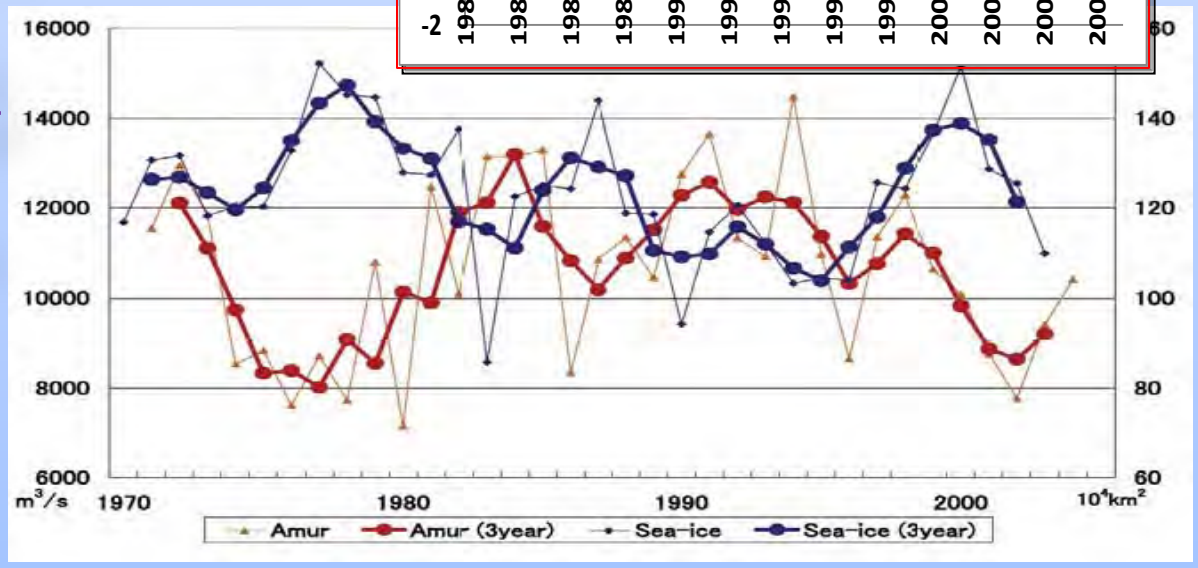
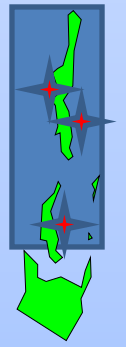
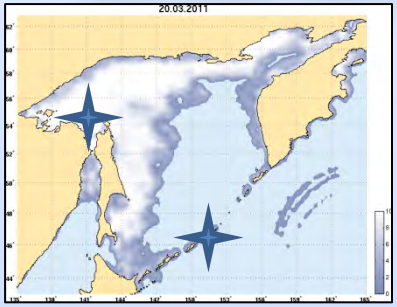
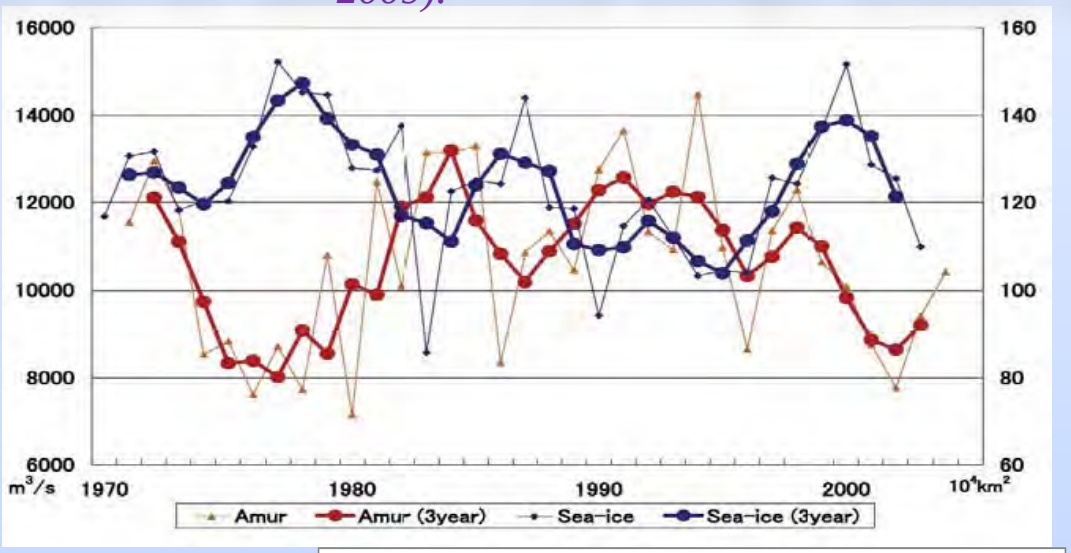


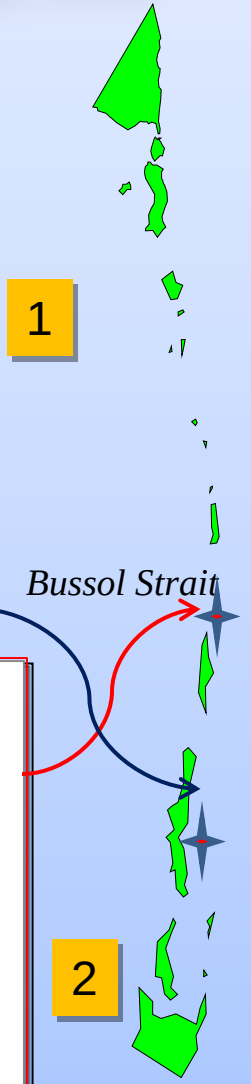


7

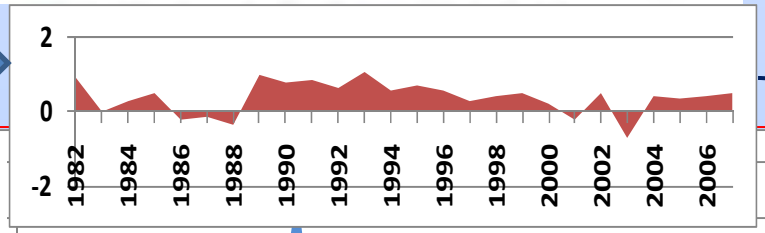
Annual mean discharge of Amur River (red lines) and sea ice area over the Okhotsk Sea (blue lines). The lines are smoothed (3-year average) (Tachibana, Ogi, 2009).



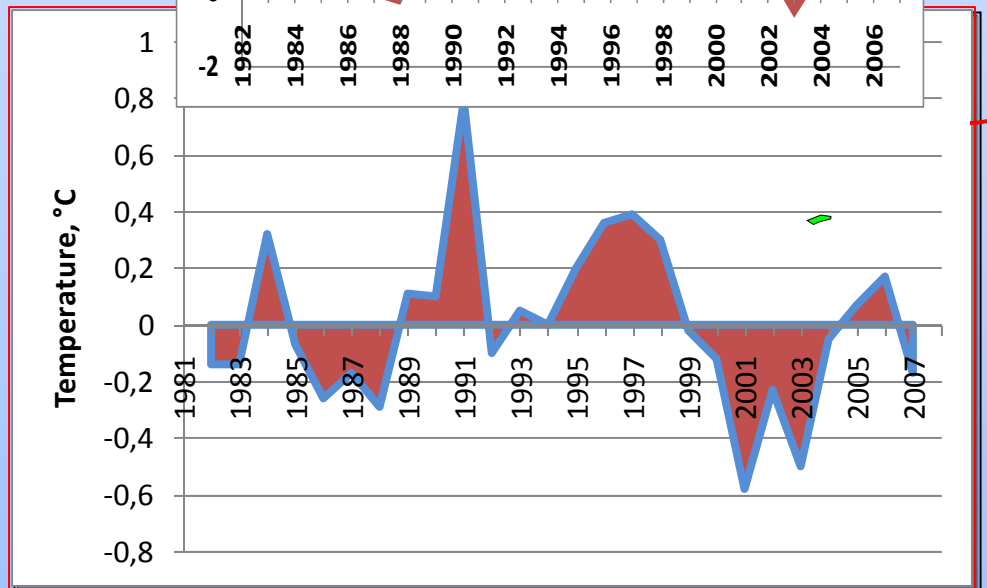




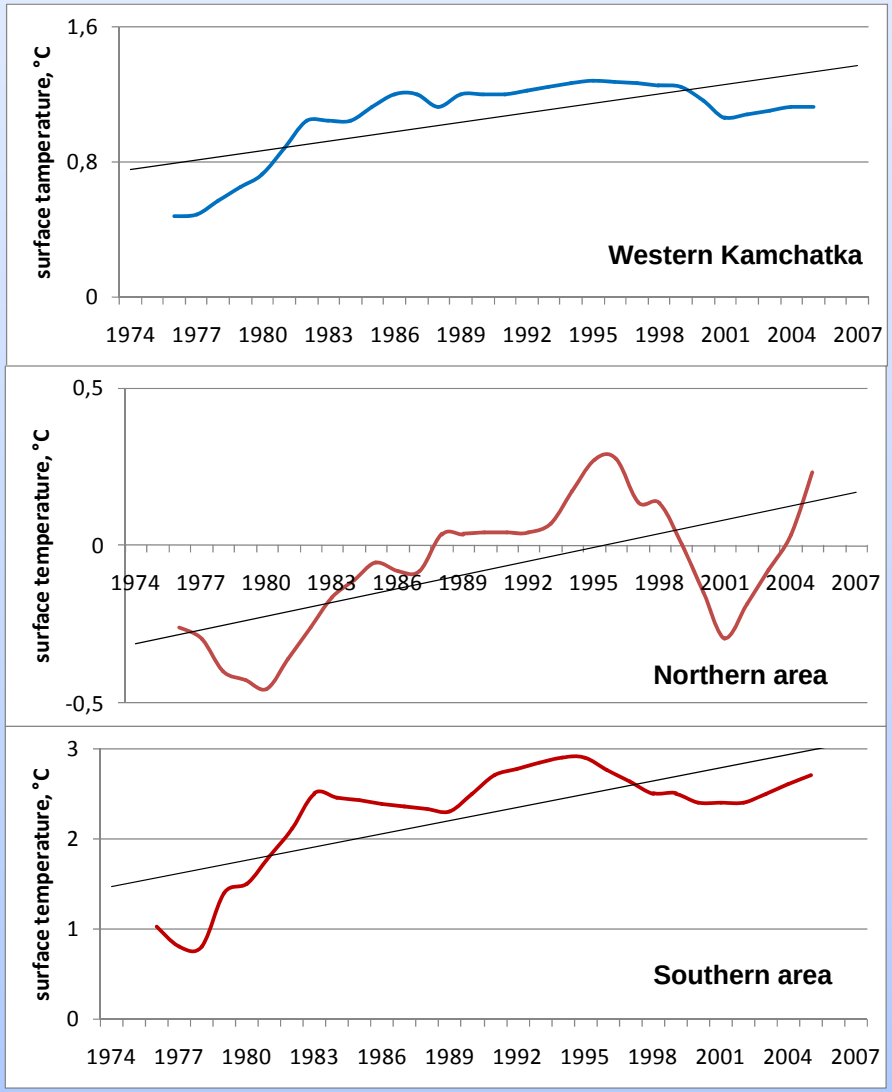
Oceanic coast of Ithurup Island

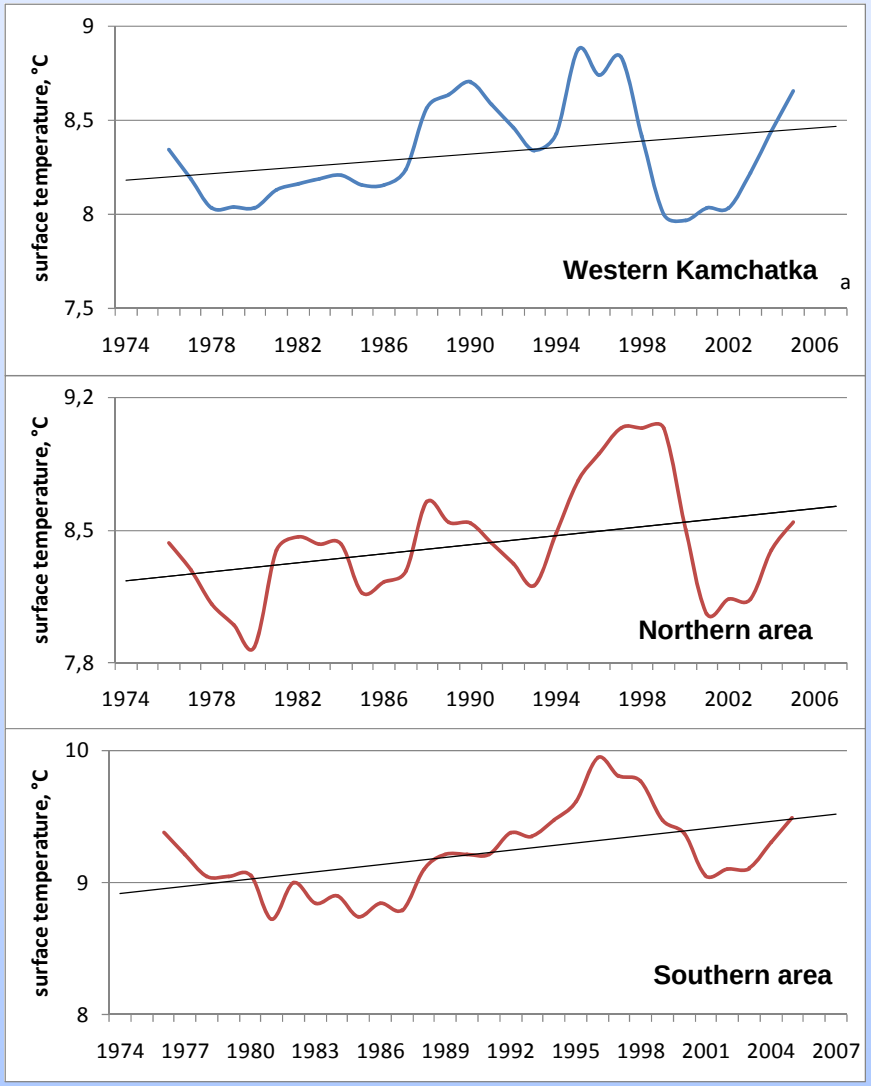


Temperature anomaly in Bussol Strait area in 1982-2007 (Muktepavel, Shatilina, 2007) .



Sea surface temperature in the Okhotsk Sea in spring (left) and summer (right)(Glebova et al., 2009).

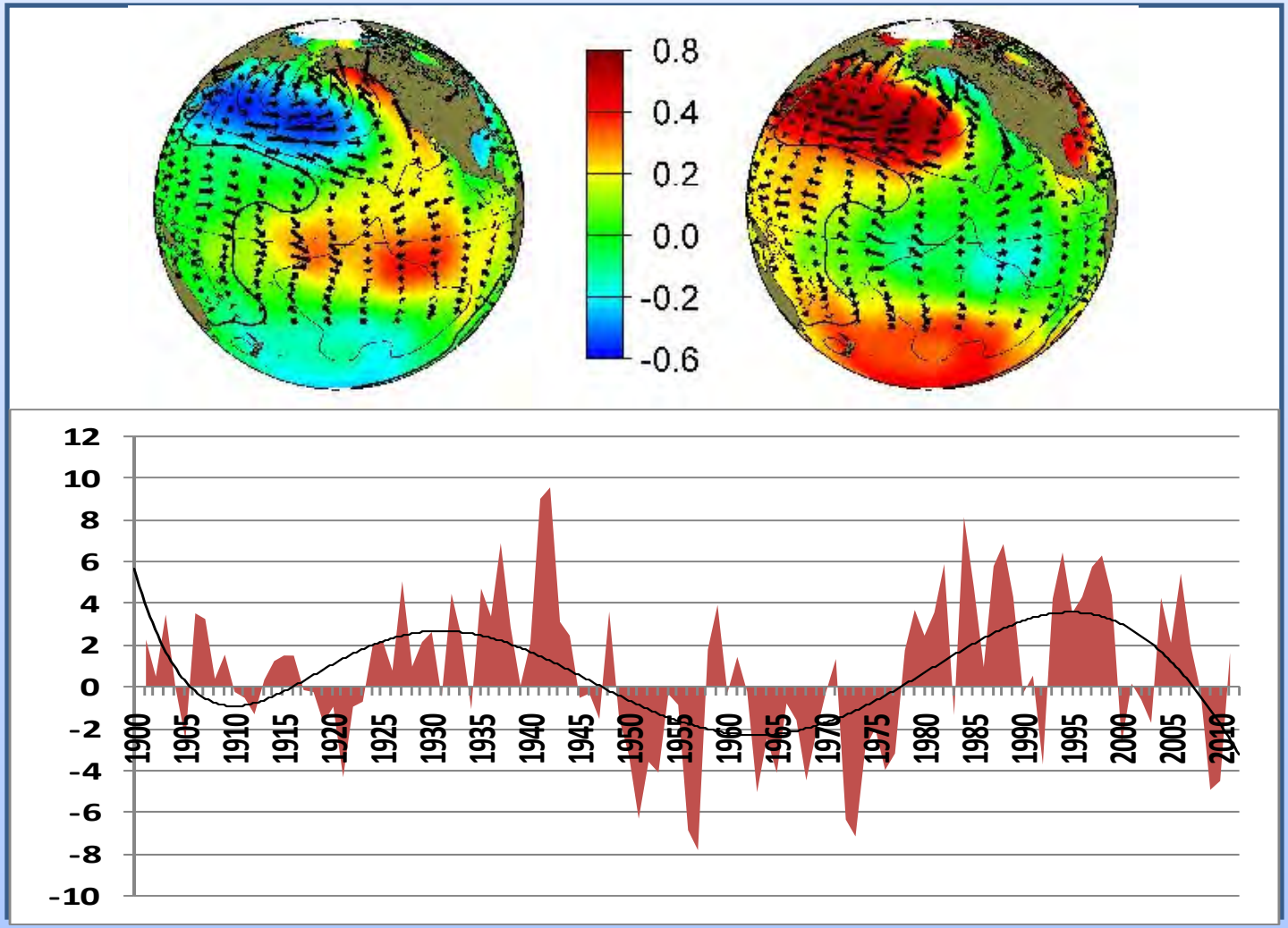




Warming in 1980-early1990, cooling in 2000-2002, warming after 2003

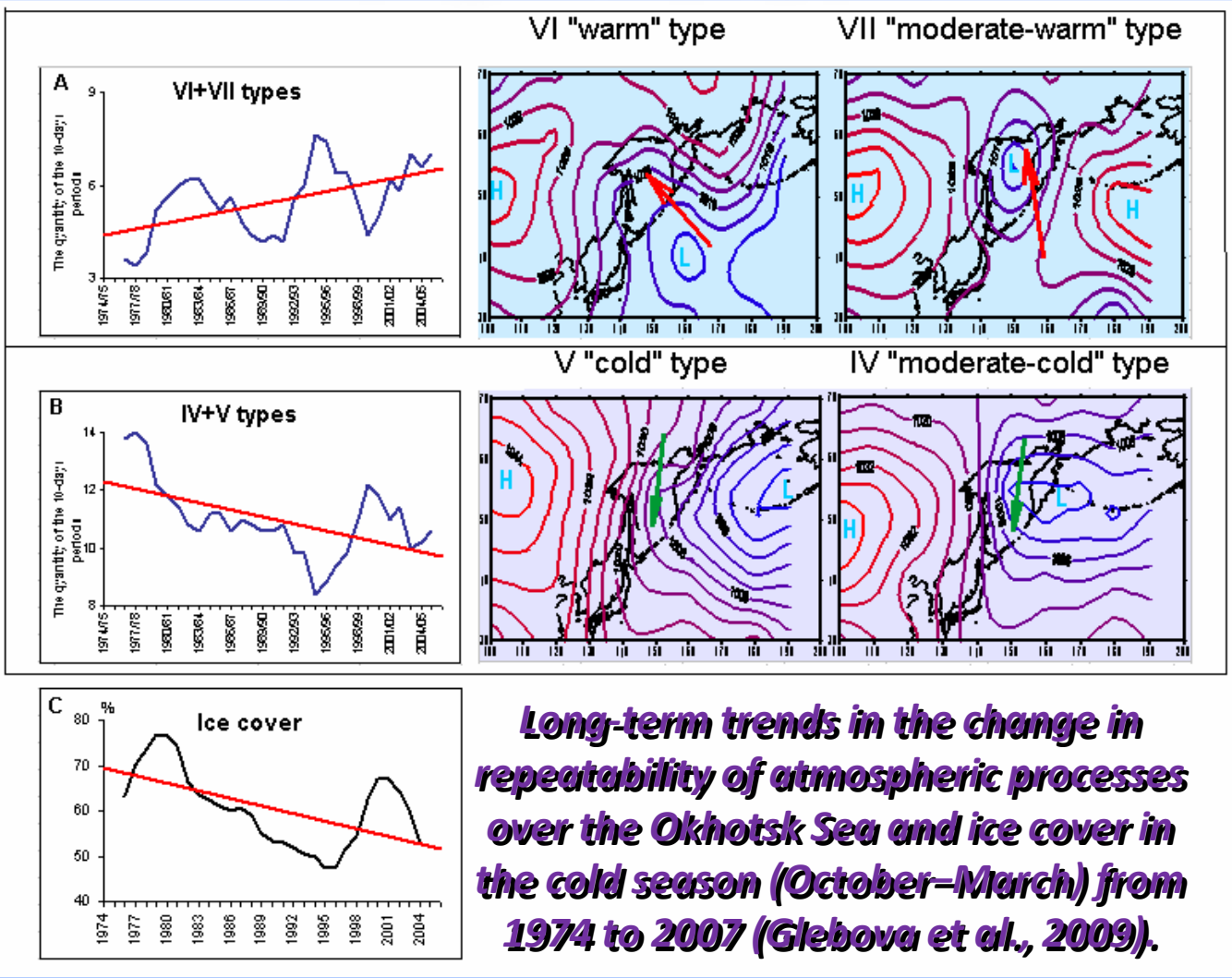
The Pacific Decadal Oscillation (PDO)

warm phase *cool phase*



Forecast to the future decade – cooling, may be by soft type

The atmospheric centers of action



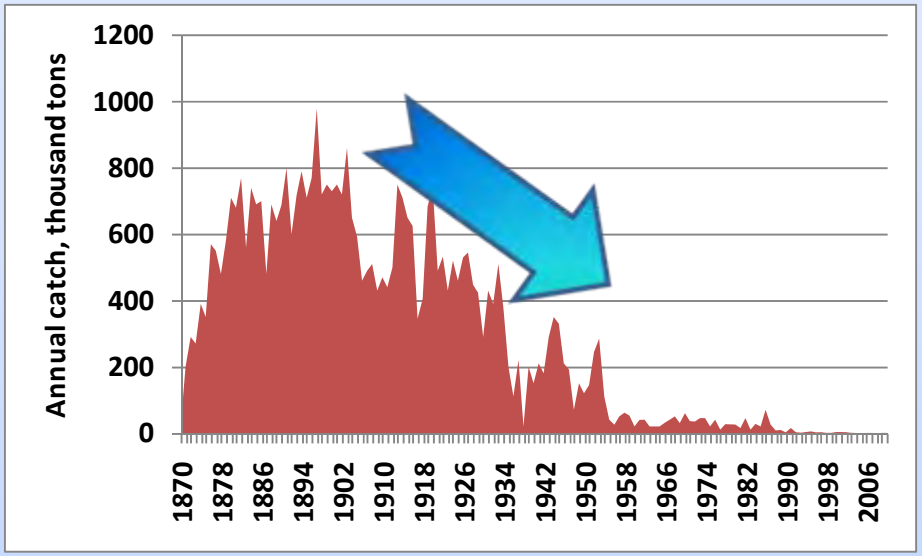
Long-term trends in the change in repeatability of atmospheric processes over the Okhotsk Sea and ice cover in the cold season (October–March) from 1974 to 2007 (Glebova et al., 2009).

Forecast to the future decade – cooling, but by soft type

Present status and forecasting

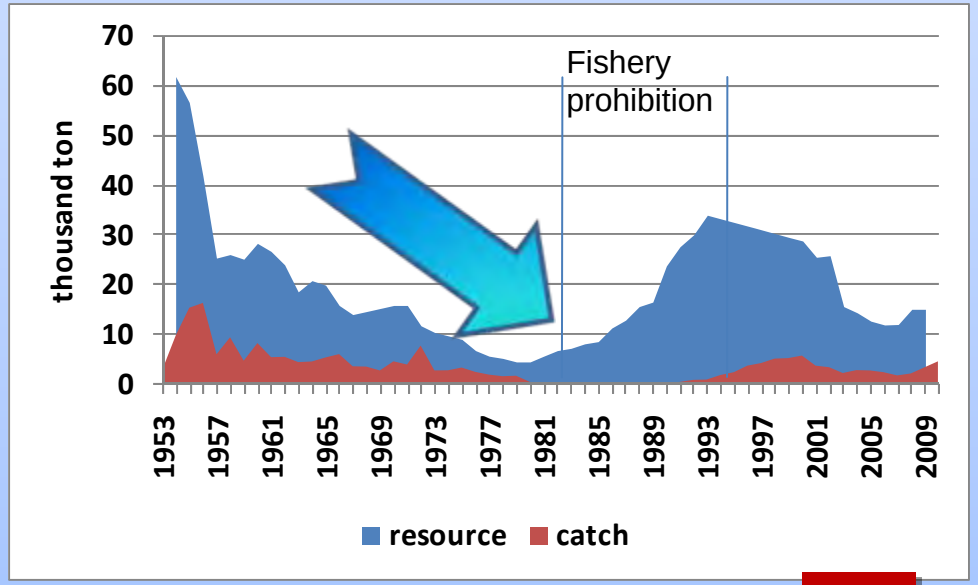
- In the 2010s, the overall warming of the Okhotsk Sea waters, at least the northern area, is suggested by many processes such as reduced ice cover, increase in average values of SST over the sea, increase in Amur River runoff, and some other less noticeable processes.
- In the 2020s, apparently, some cooling should be expected (Khen et al., 2008, Ustinova et al., 2004, Glebova, 2007).

Fisheries impact: long-term trends of annual catches of Sakhalin-Hokkaido herring (1) and Terpeniye Bay's yellowfin sole (2)

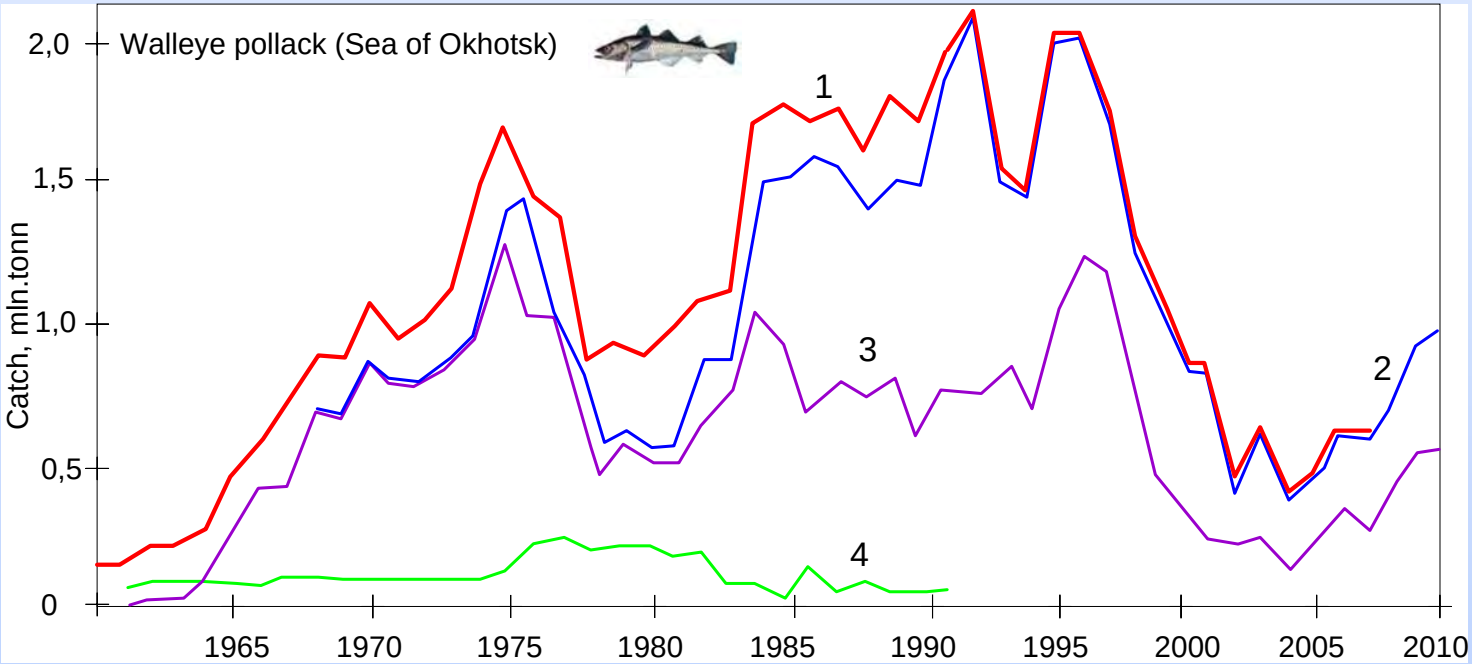


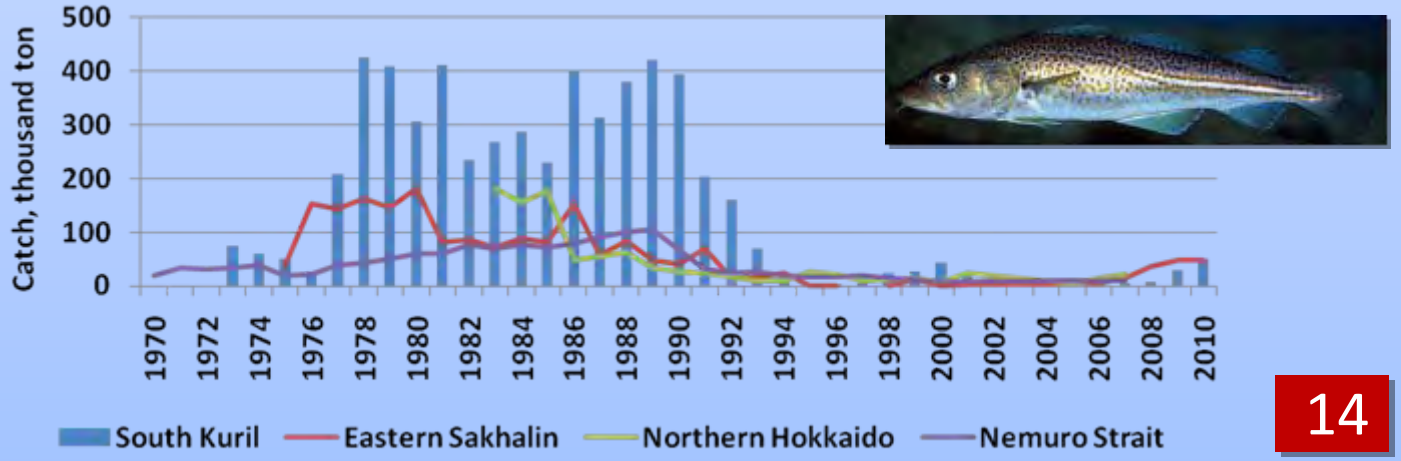
1

2

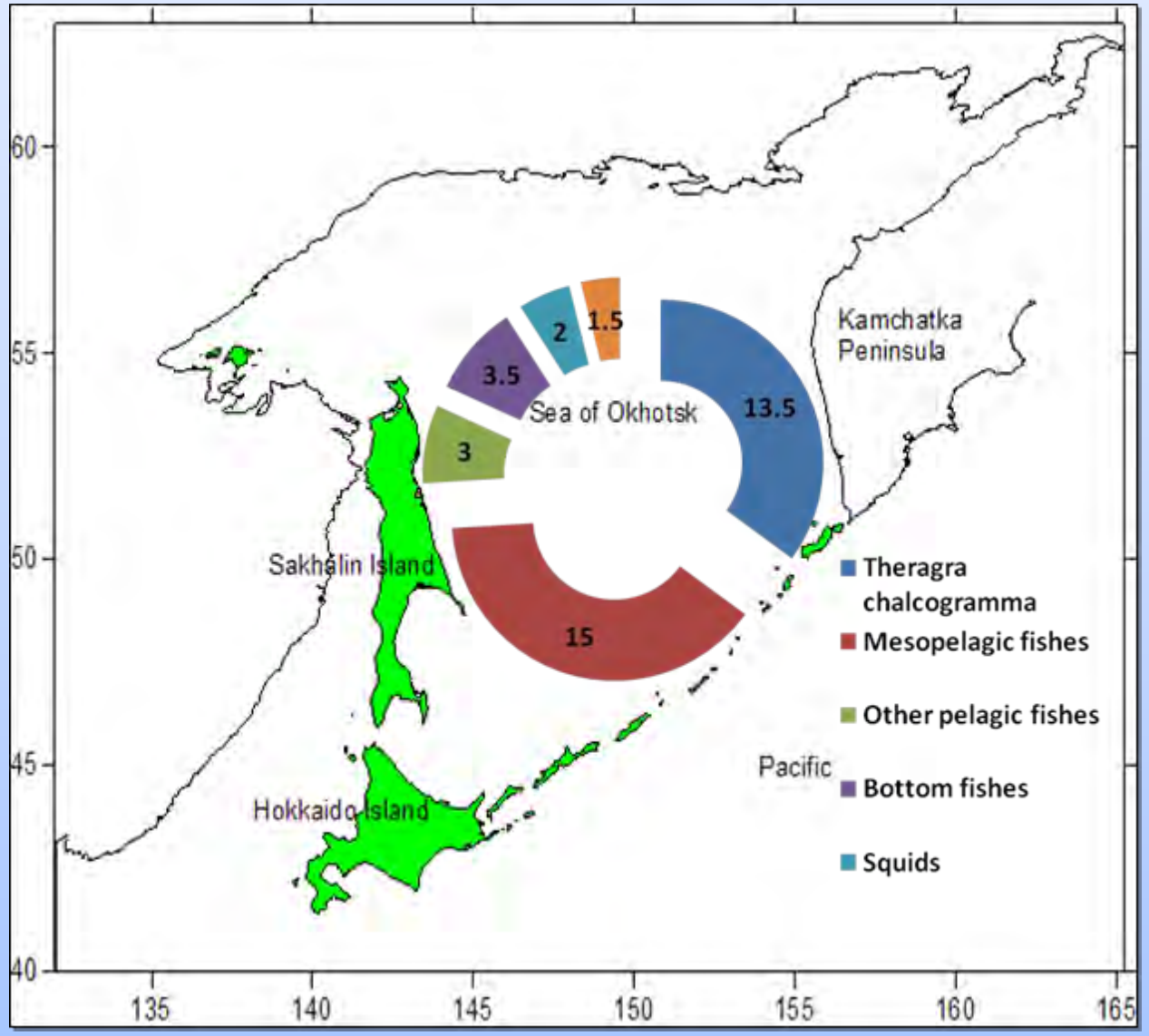


Annual catches of walleye pollock in the Sea of Okhotsk: 1-Total Sea (with Hokkaido area), 2-Northern Okhotsk Sea, 3-Western Kamchatka, 4-Eastern Sakhalin (below – South Kuril and adjacent waters)

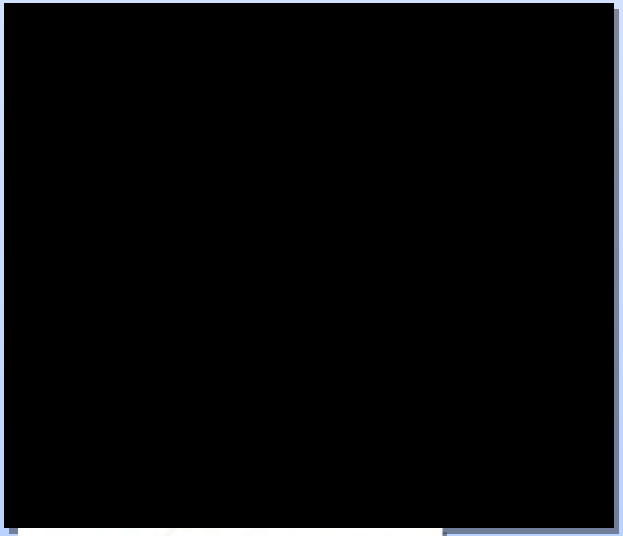




Some quantitative aspects of the Sea of Okhotsk for 1980-th by total fishes biomass=35 mln. ton, year's production=17.5 mln. ton (Shuntov et al., 1997)

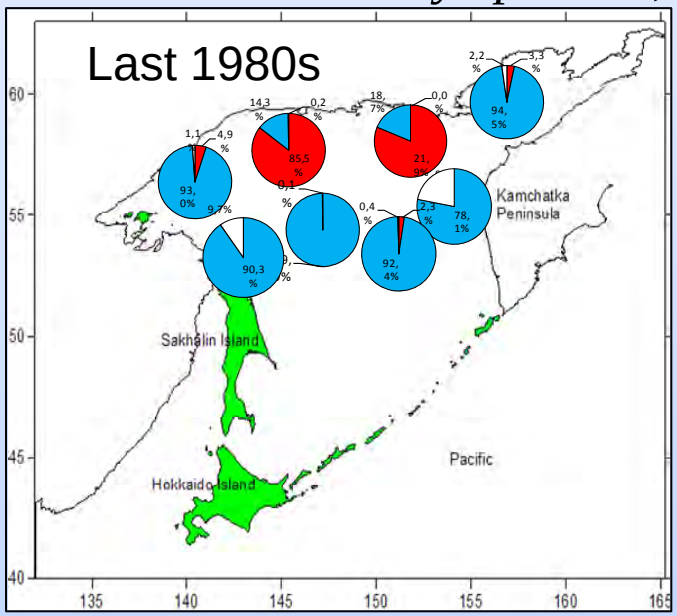


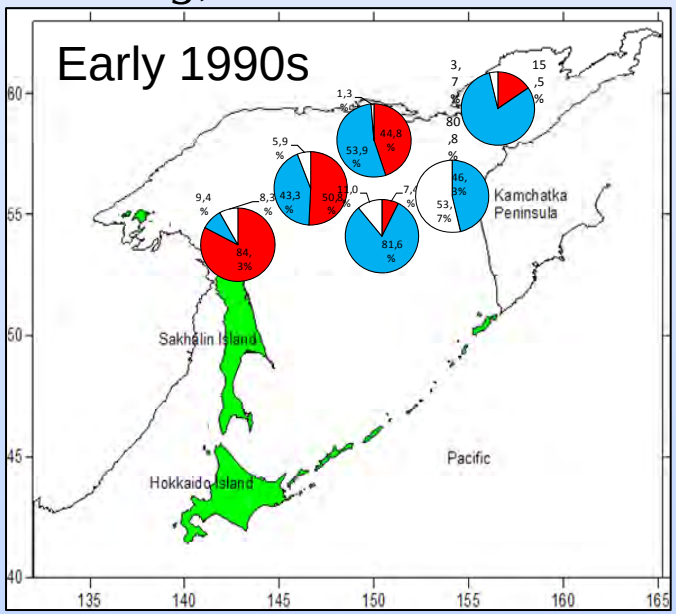
Biomass and production of the main groups organisms in the Sea of Okhotsk in 1980th

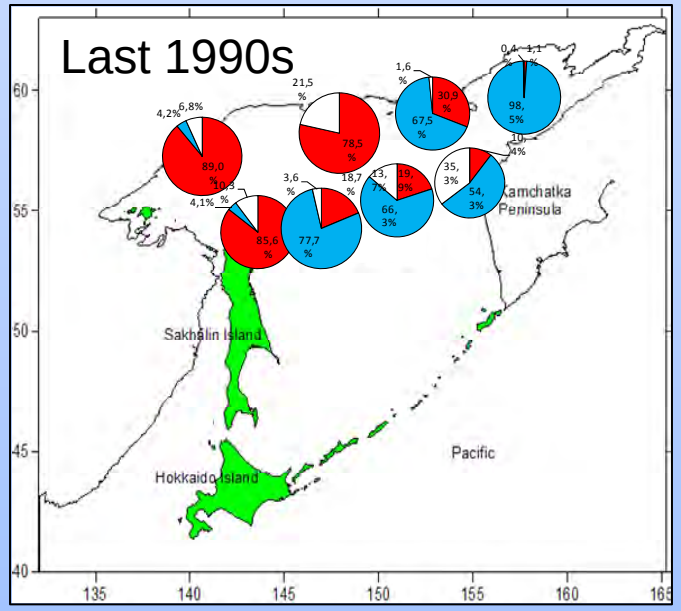


Fish species biomass ratio in pelagic communities of the northern Sea of Okhotsk in the last 1980s, early 1990s, last 1990s (Shuntov et al., 1997), 1 – walleye pollock, 2 – herring, 3 - others

- 1
- 2
- 3



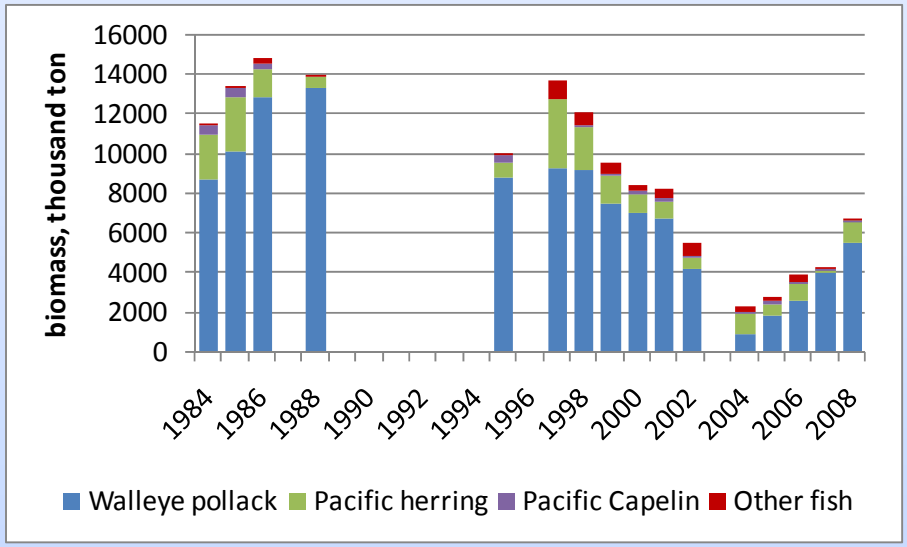




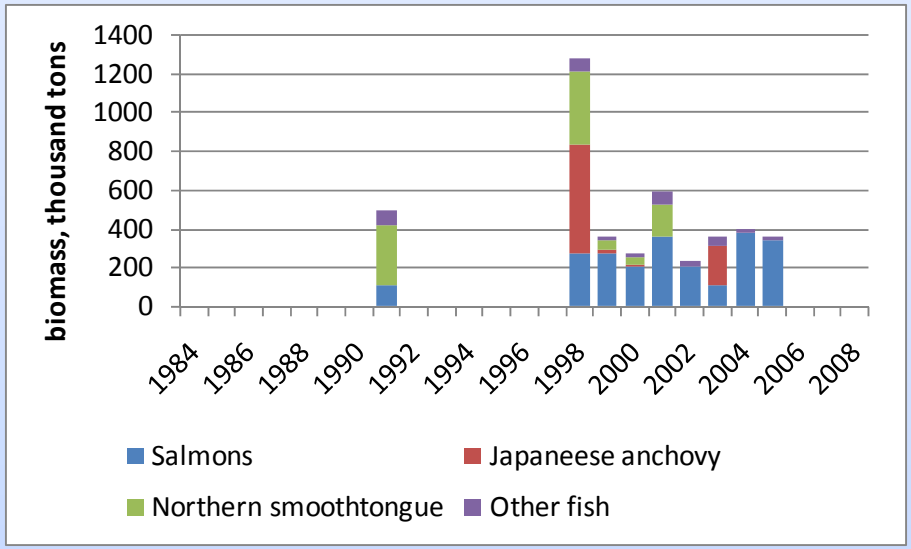
Species	1980th	1990th
Theragra chalcogramma	10000	6000
Clupea pallasii	500	2500
Leuroglossus schmidti	2500	1200
Stenobrachius leucopsarus	10	30
salmons	150	480
Mallotus villosus	150	250
Sardinops melanostictus	500	+
other fish	135	85
Total	13945	10545

Biomass x1000 tons

Composition and biomass of epipelagic fish communities in the Sea of Okhotsk (Dulepova, Merzlyakov, 2007)

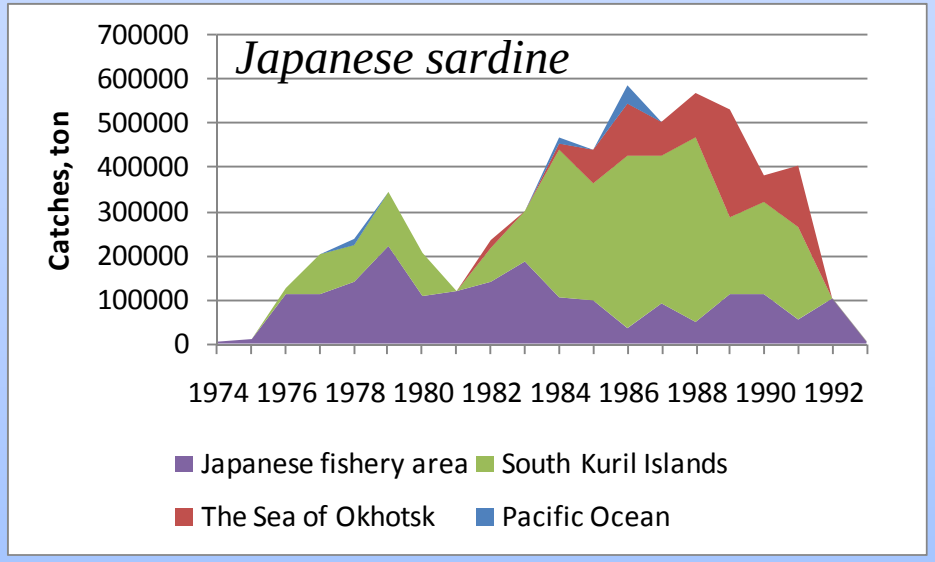


Northern Okhotsk Sea

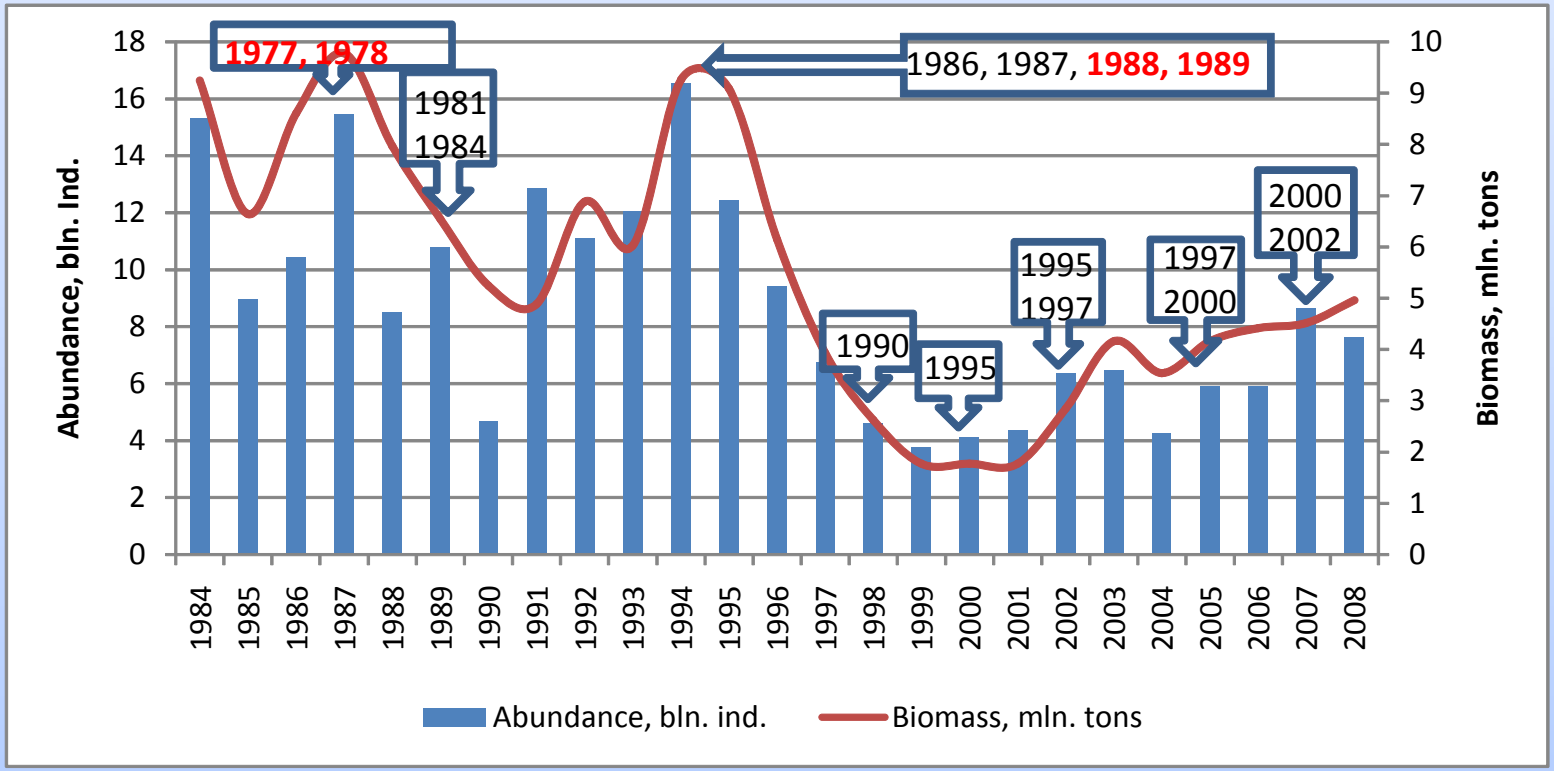


Southern Okhotsk Sea

Annual catches of Japanese sardine in 1974-1992 (Belayev, 2003)



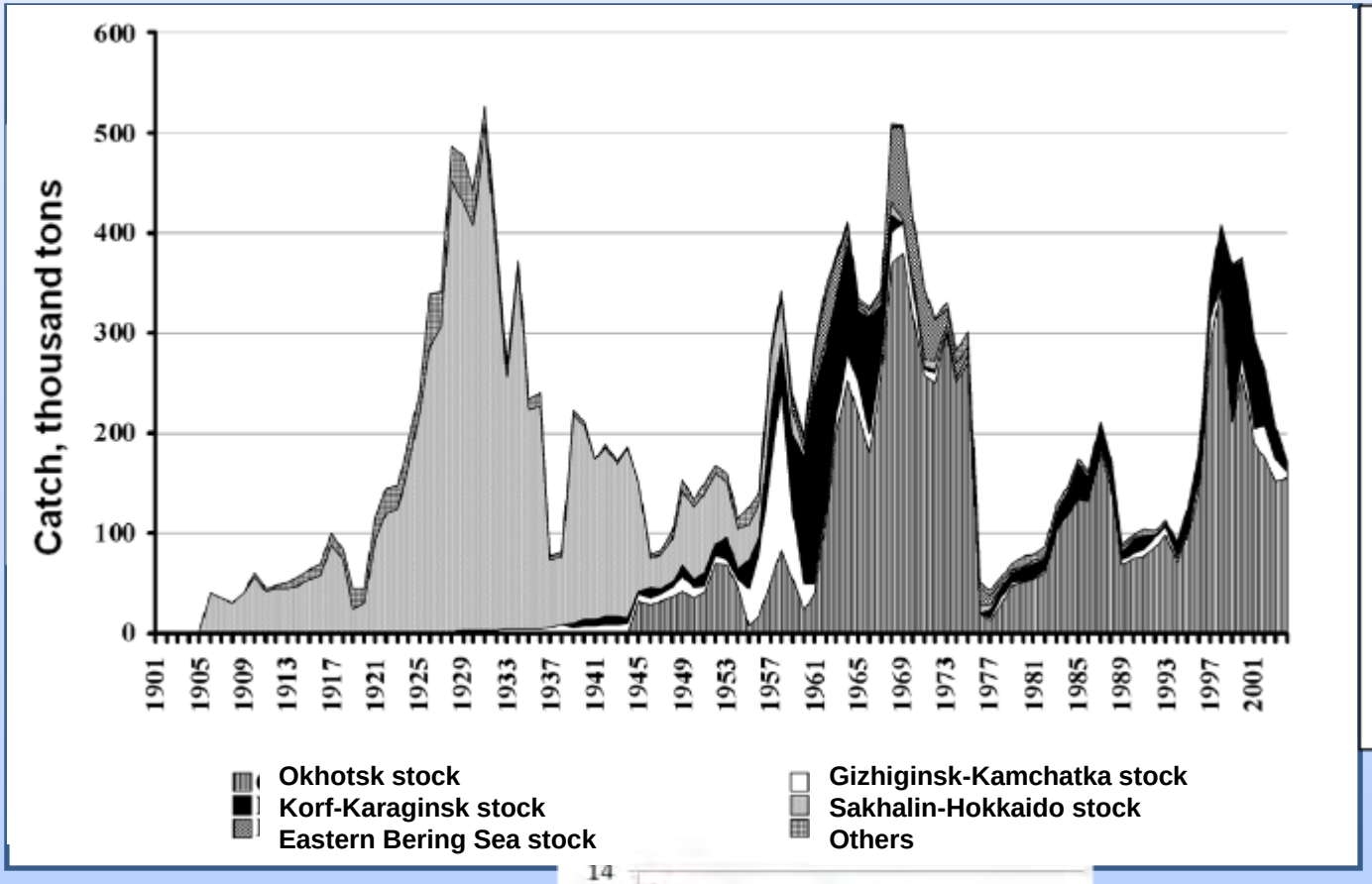
Annual abundance and biomass of walleye pollack spawning stock in the northern Okhotsk Sea (Ovsyannikov, 2009)

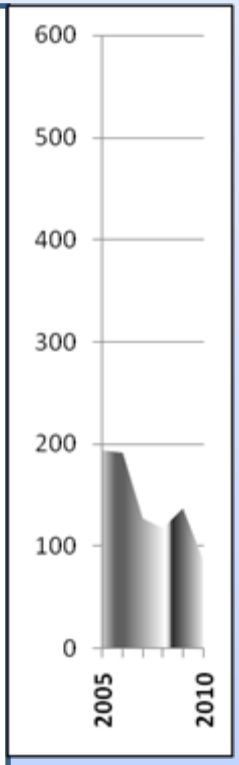


2000 Prevailed generation

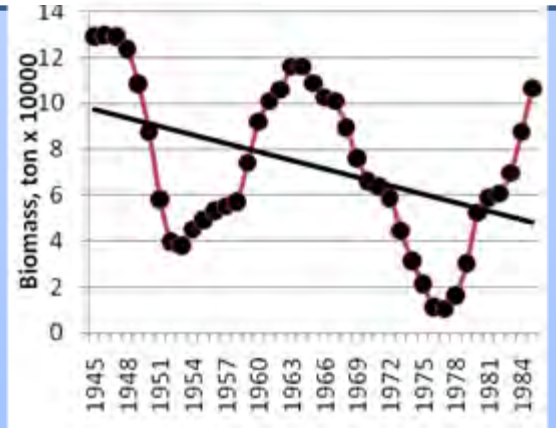
1988 Abundant generation

Annual catches of Pacific herring in the far-eastern seas (Naumenko, 2007)



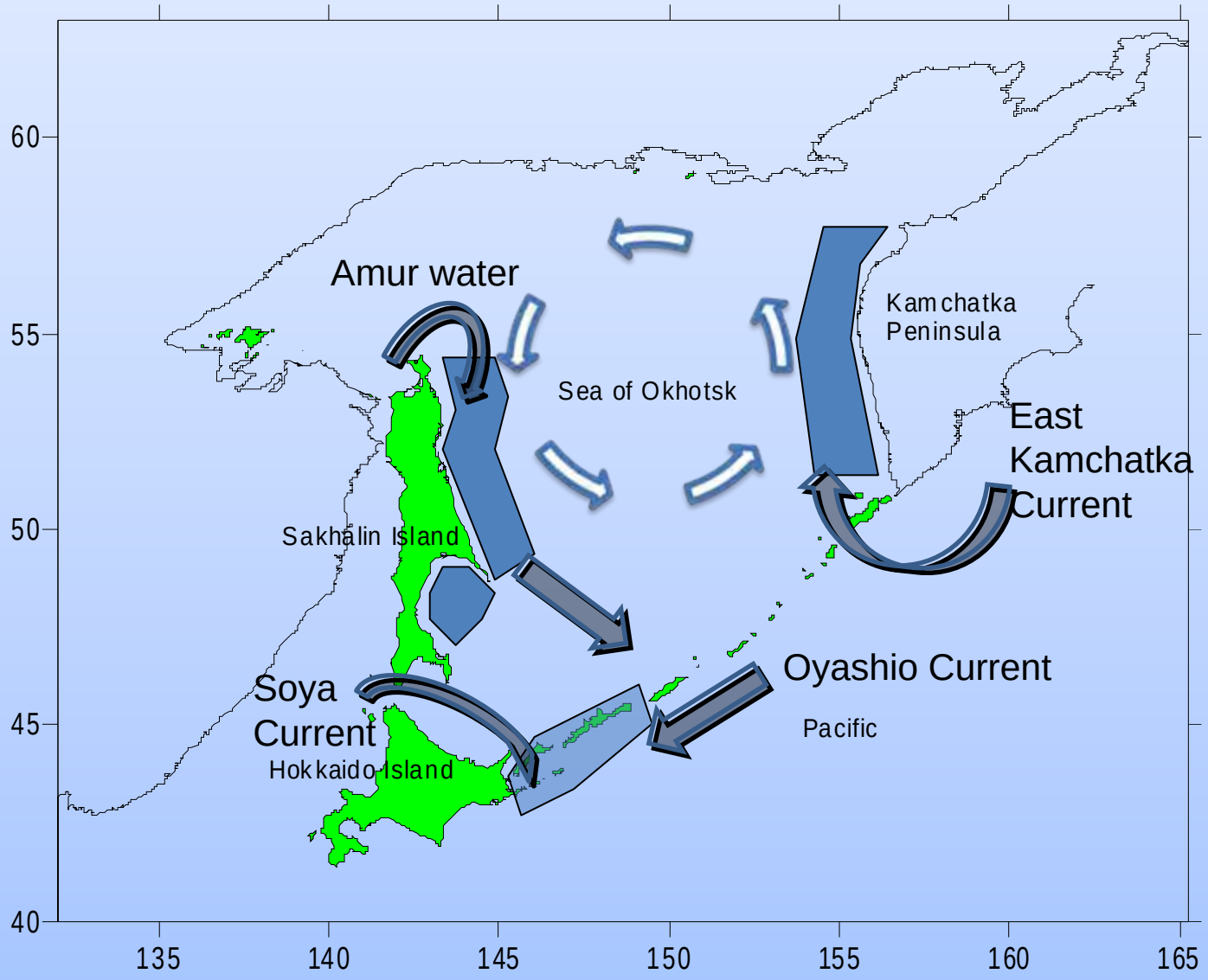


Okhotsk stock

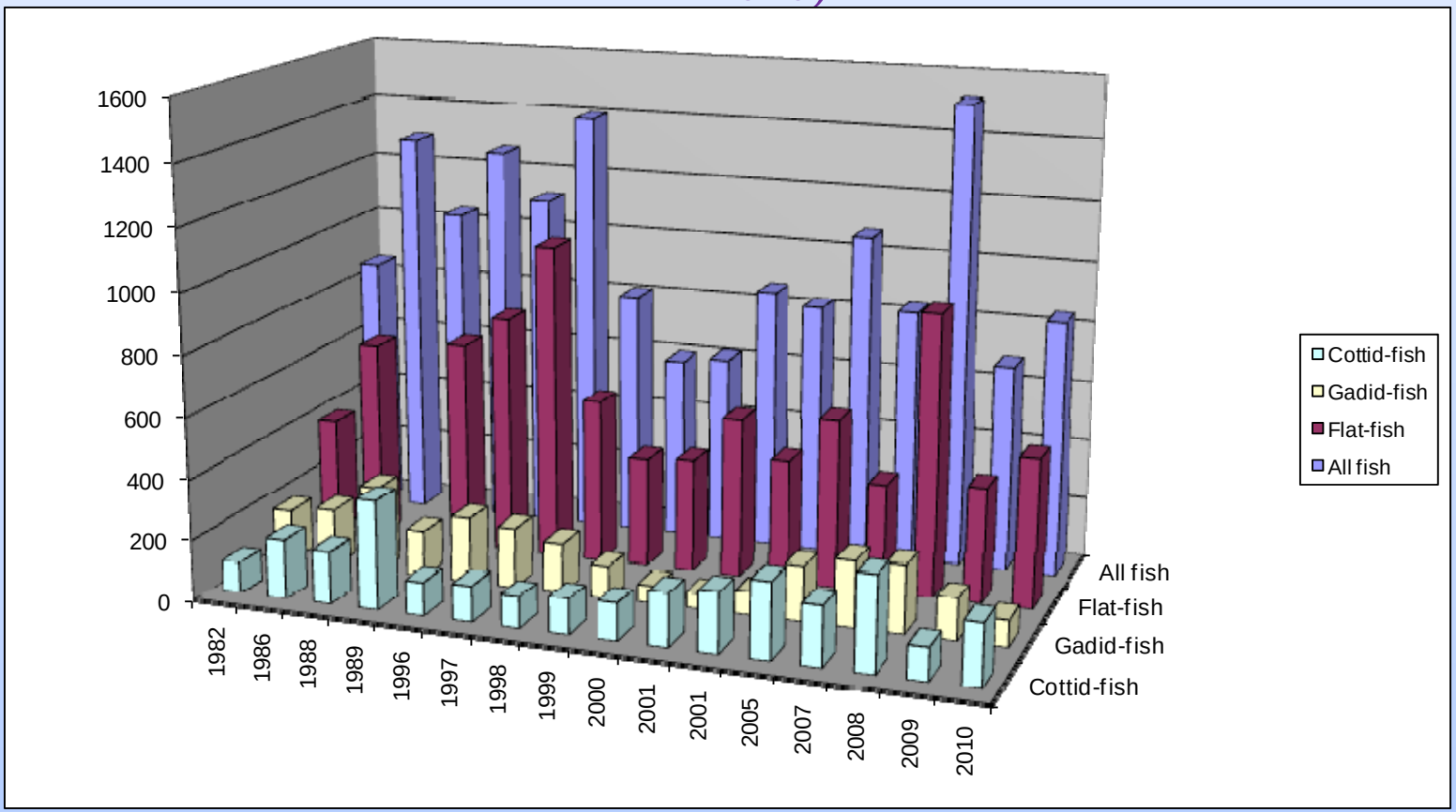


Annual dynamics of resources of Okhotsk herring in 1945-1985 (5-years smoothing)

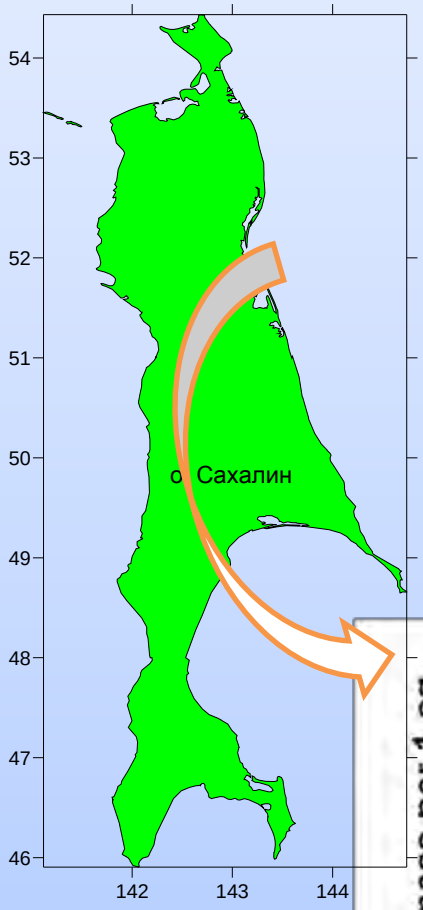
Regular bottom trawl surveys areas in the Sea of Okhotsk

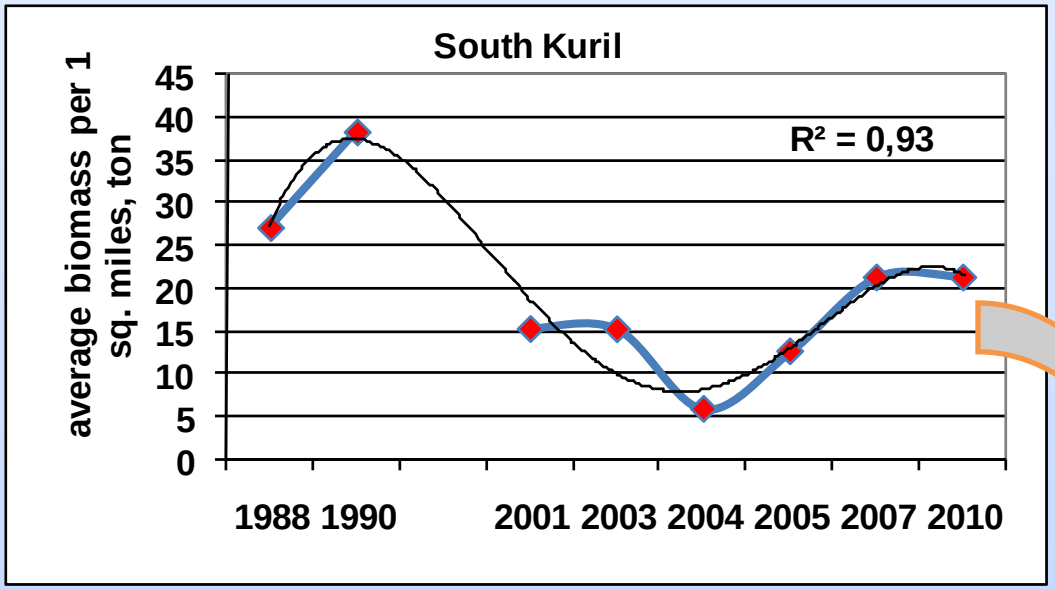


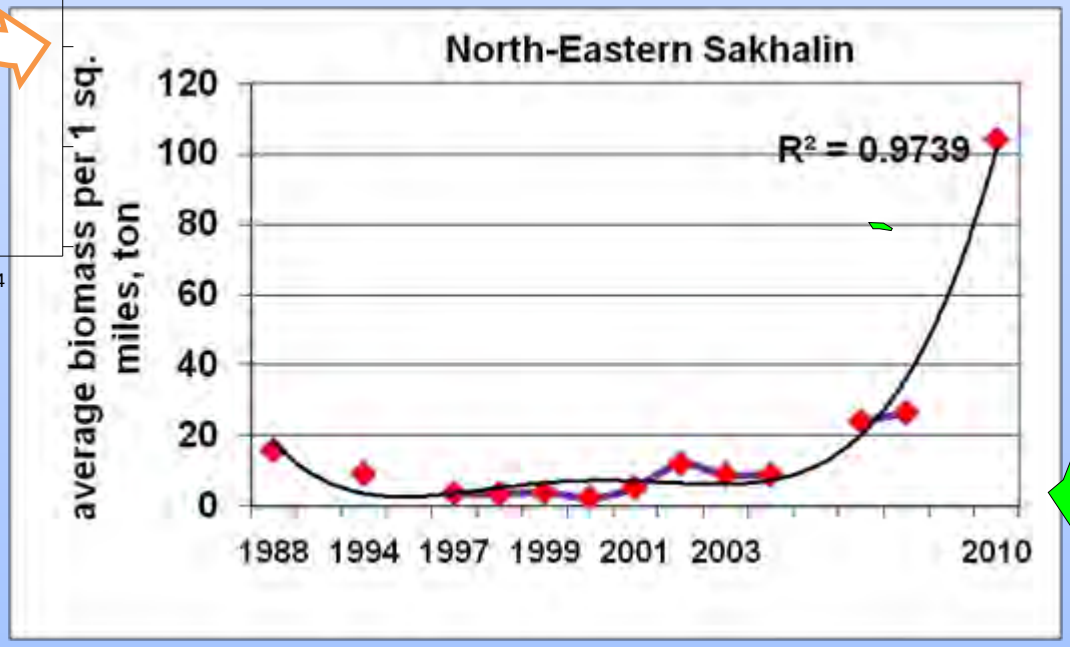
Annual biomass of cottid-fishes (1), gadid-fishes (2), flat-fishes (3), and all demersal fish (4) on west Kamchatka shelf, thousand ton (Ilyinskiy et al., 2010)



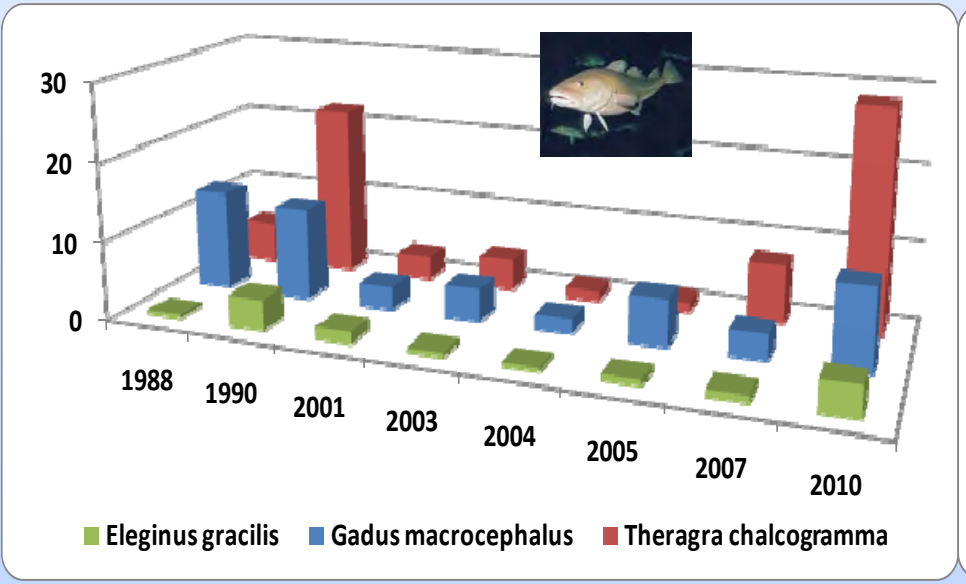
Some long-term trends of demersal fish biomass at Sakhalin and Kuril Islands

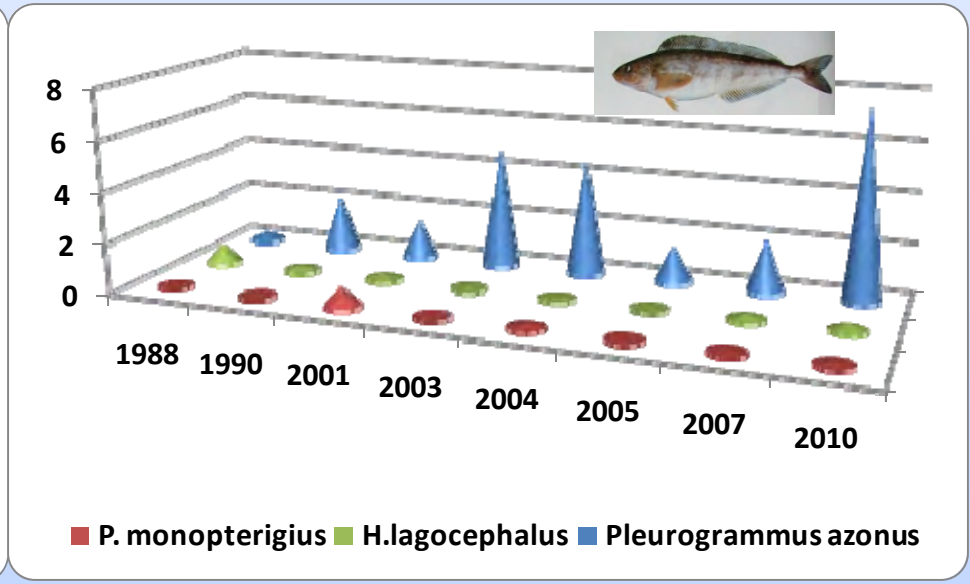


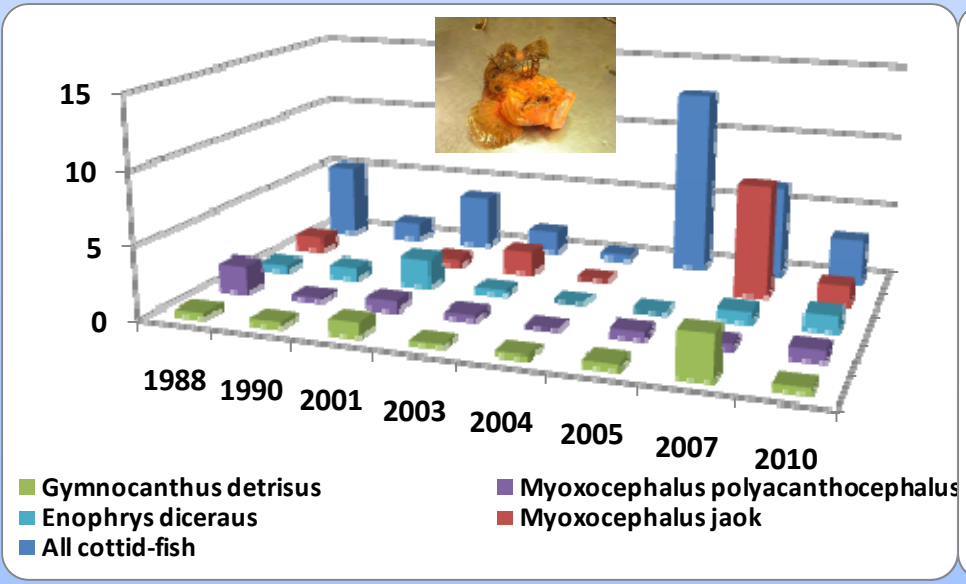


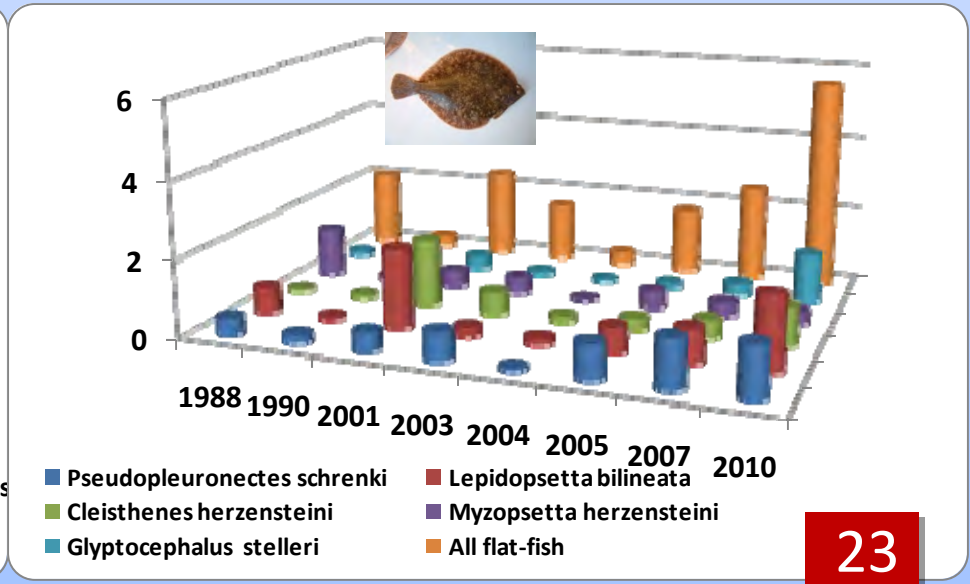


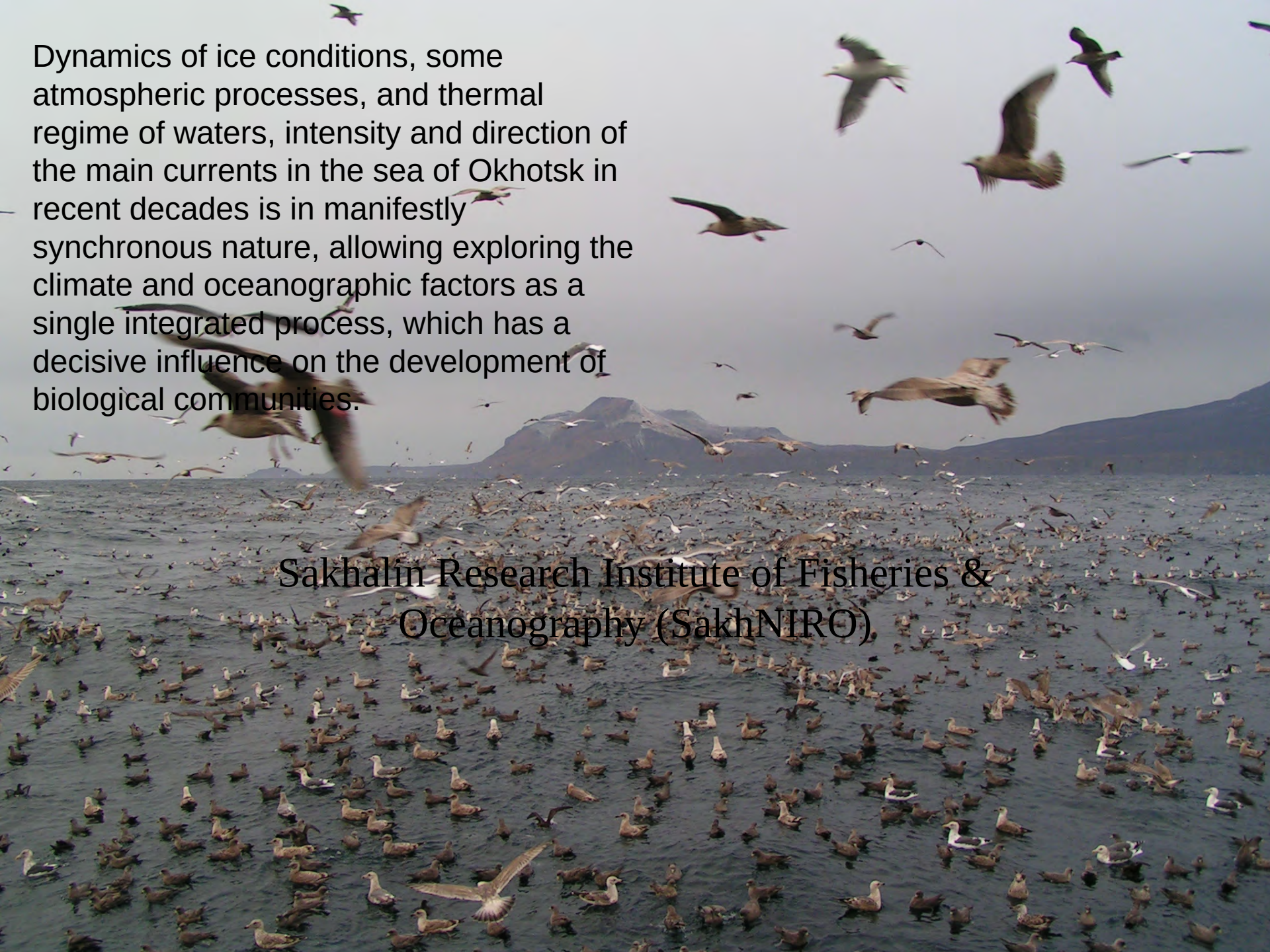
Average relative biomass of dominant species of fishes at South Kuril, ton/sq. mile











Dynamics of ice conditions, some atmospheric processes, and thermal regime of waters, intensity and direction of the main currents in the sea of Okhotsk in recent decades is in manifestly synchronous nature, allowing exploring the climate and oceanographic factors as a single integrated process, which has a decisive influence on the development of biological communities.

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