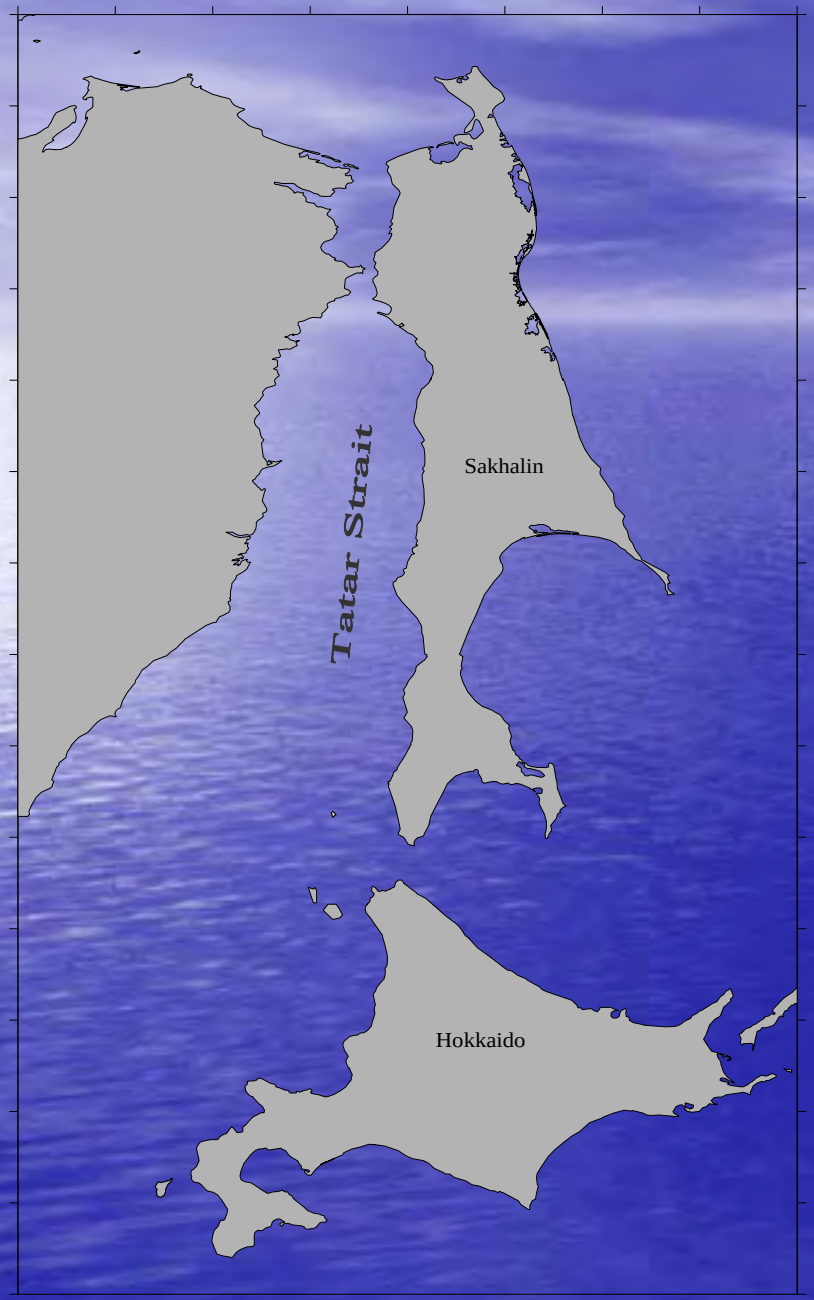

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Peculiarities of climatic and oceanological influence on long-term changes in species composition and abundance of pelagic and bottom fishes in the Tatar Strait

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Hydrologic regime of the Tatar Strait is determined by the two non-periodic currents: cold (in the western part) and warm (in the eastern part).

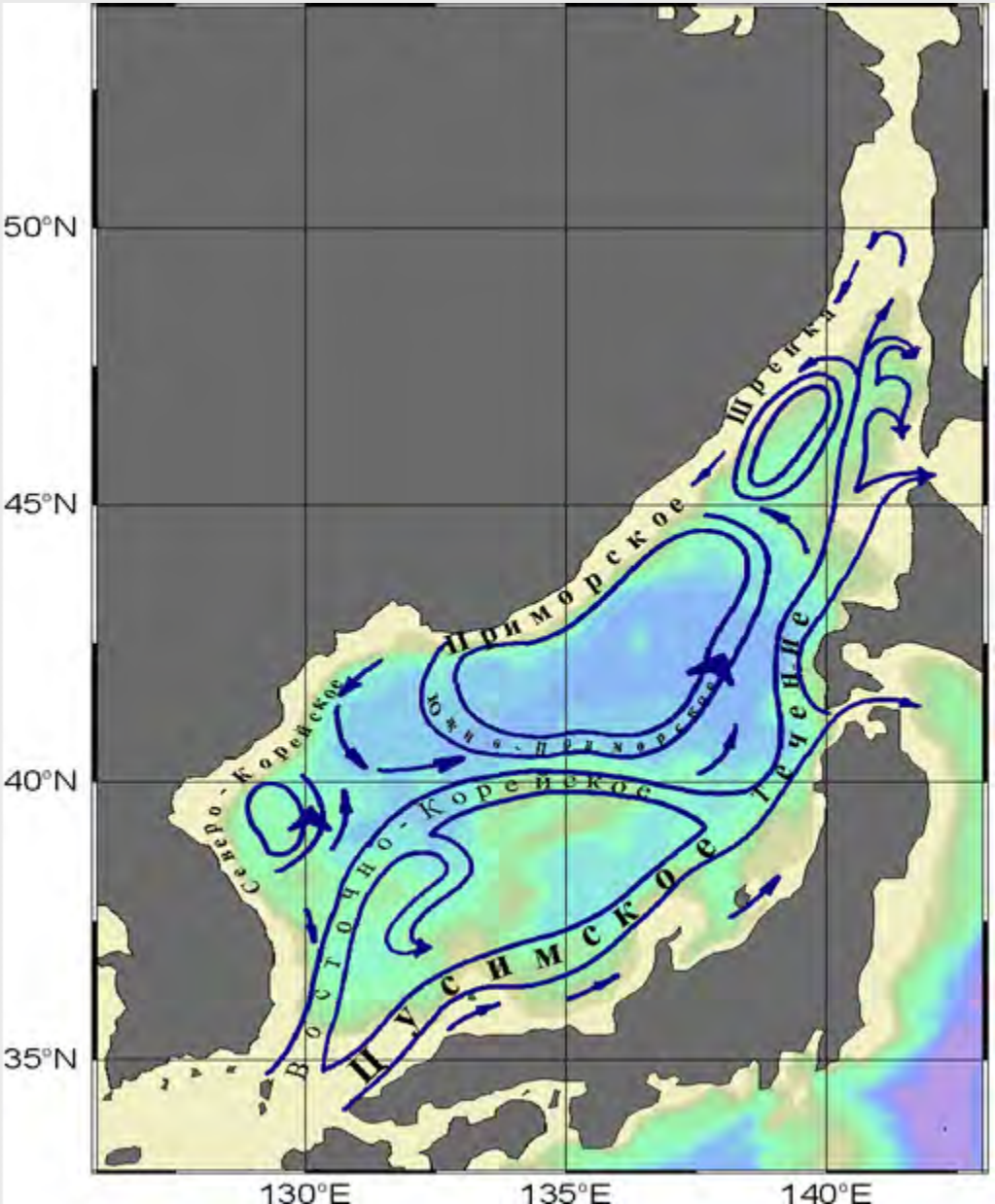
Fish communities of the Tatar Strait are represented by species from different biogeographic and ecological groups.

Species composition of ichthyofauna of the Tatar Strait varies significantly due to the periodic migrations of the south-latitude fishes.

In the 20th century, Tatar Strait was rather important for fishery in the Russian zone of the Sea of Japan and particularly along Sakhalin Island (annual catch of herring reached 350 000 tons, sardine – 160 000 tons, walleye pollock – 140 000 tons, and Pacific cod – 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.

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



Basic tasks:
- to reveal trends of long-term changes in abundance for common pelagic and bottom fishes in the Tatar Strait in 1950-2005;
- to reveal occurrence (absence) of conjugation of the long-term changes in climatic and oceanological factors and fish abundances.

Data Sources

1.Catch statistics: 1950-2005 for 10 marine fish species.

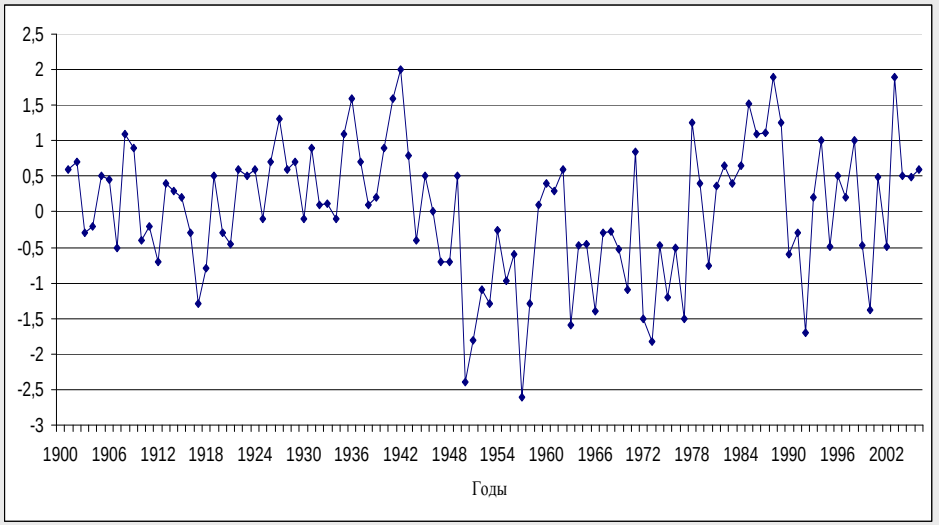
2. Data from trawl surveys (1976-2008), ichthyoplankton (1968-2005) and eggs surveys (1988-2002).

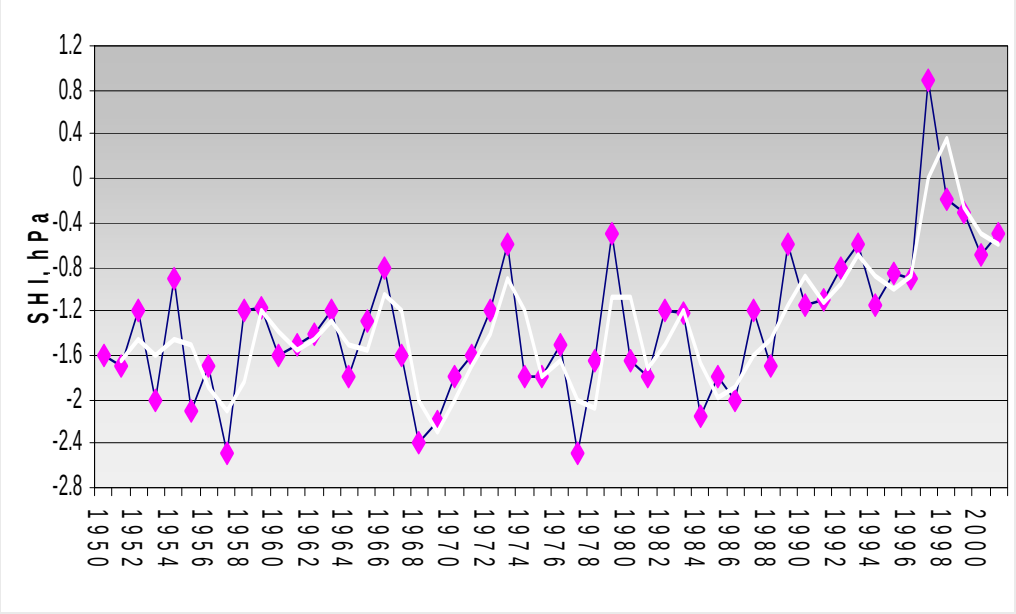
3. Long-term abundance estimates of herring, pollock, yellow-fin sole by VPA method.

4.Oceanographic data: water temperature near south-western Sakhalin (1924-1999), western Hokkaido (1964-2003), from different regions of Japan/East Sea (1931-1996).

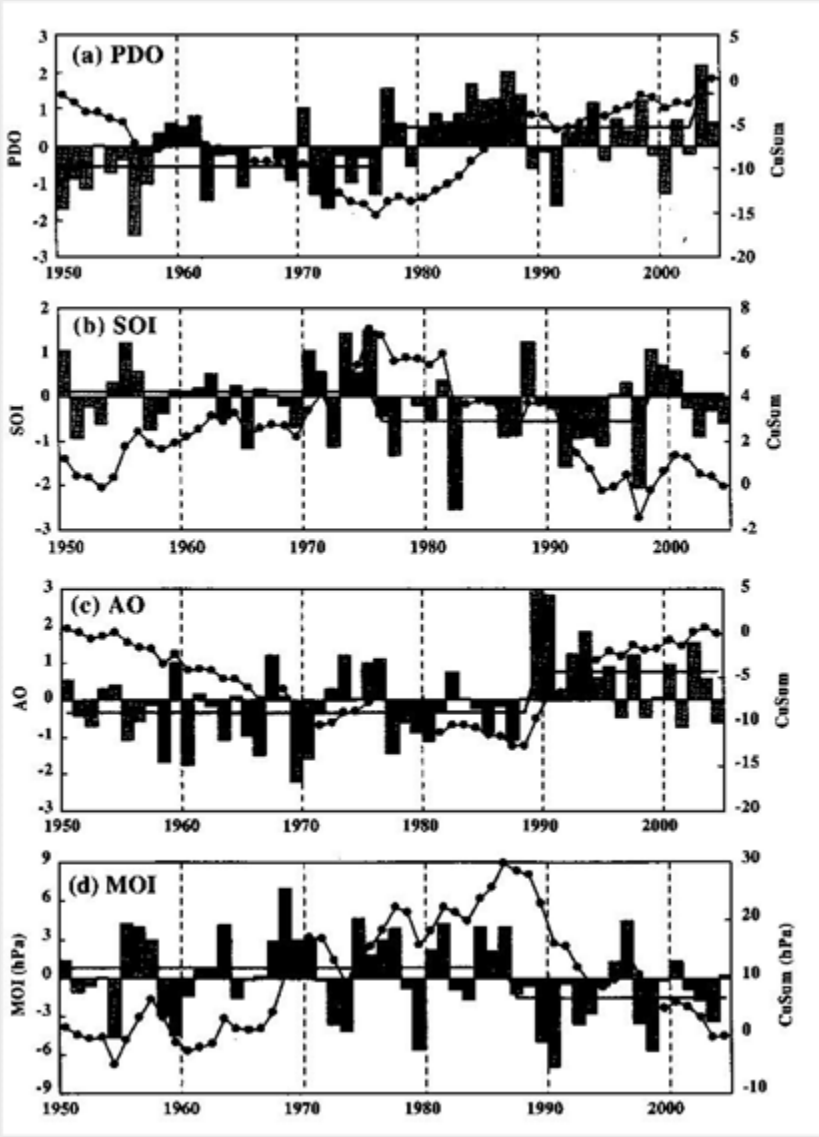
5. Climatic indices: PDO, SHI, SOI, AOI, MOI – 1950 -2003.

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)

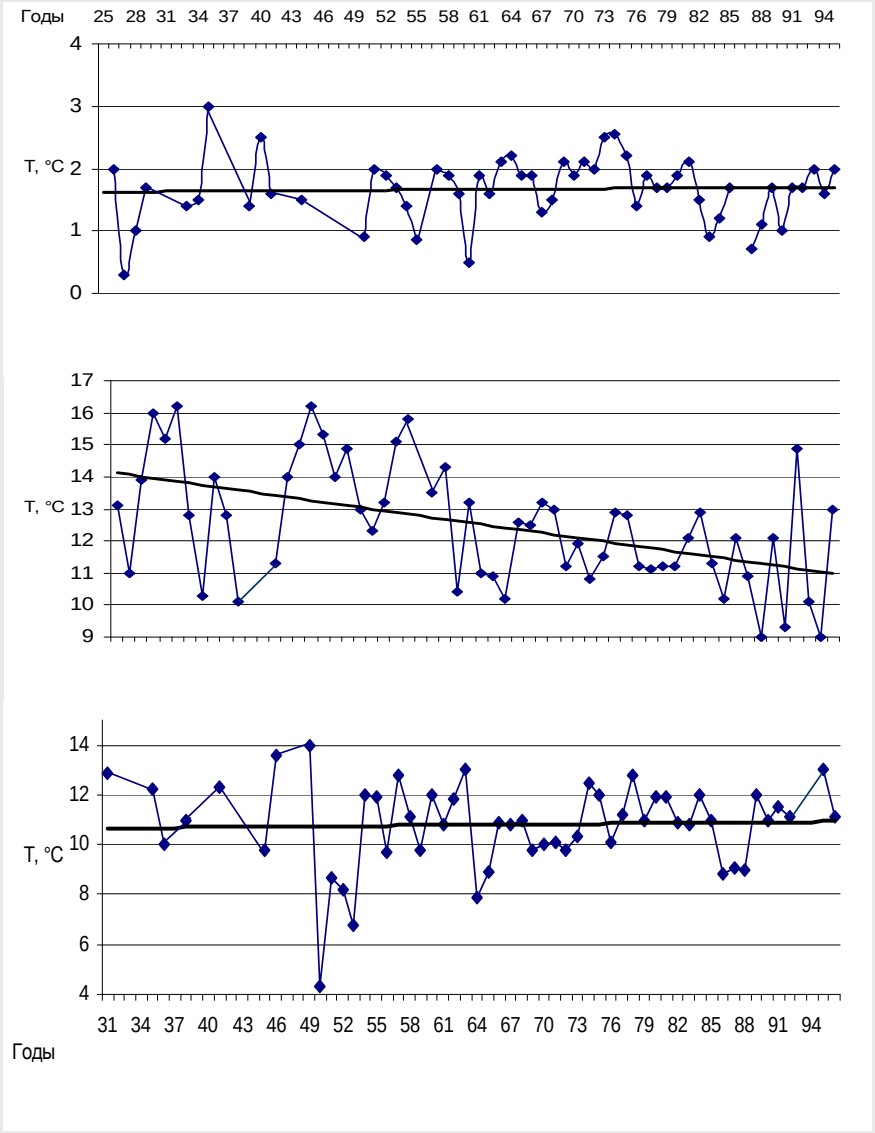




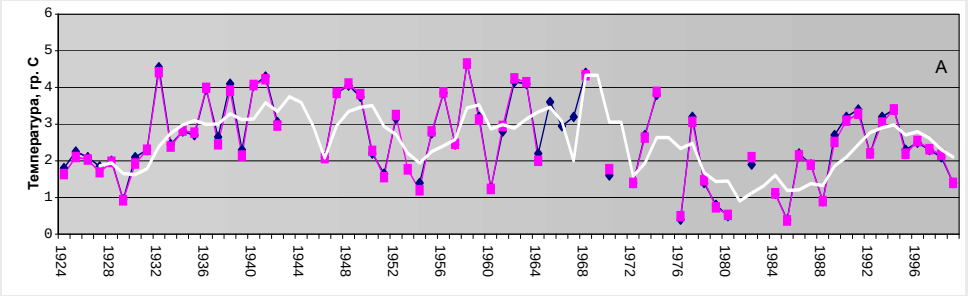
Anomalies (vertical bars) and their cumulative sums (circles) for the four climatic indices from 1950 to 2004 (Tian et al, 2008)

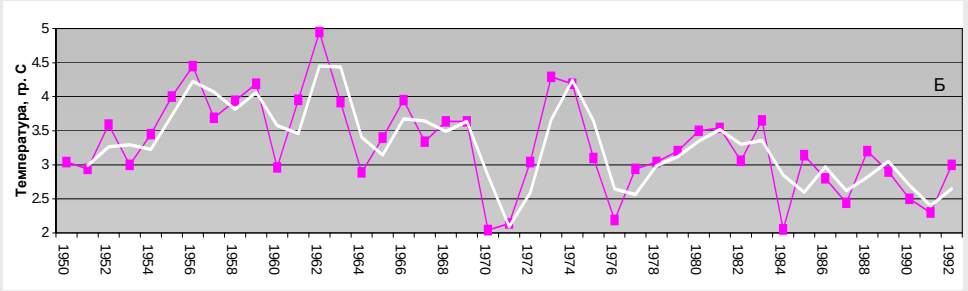


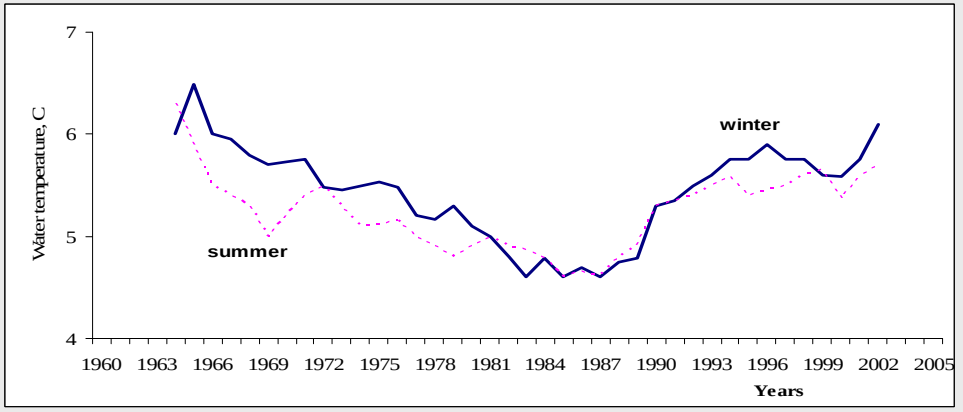
Long-term changes of water temperature in the 50-150 m layer in north-western (top), south-eastern (middle) and south-western (bottom) parts of Japan/East Sea during 20th century (Ponomarev et al, 2000)



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







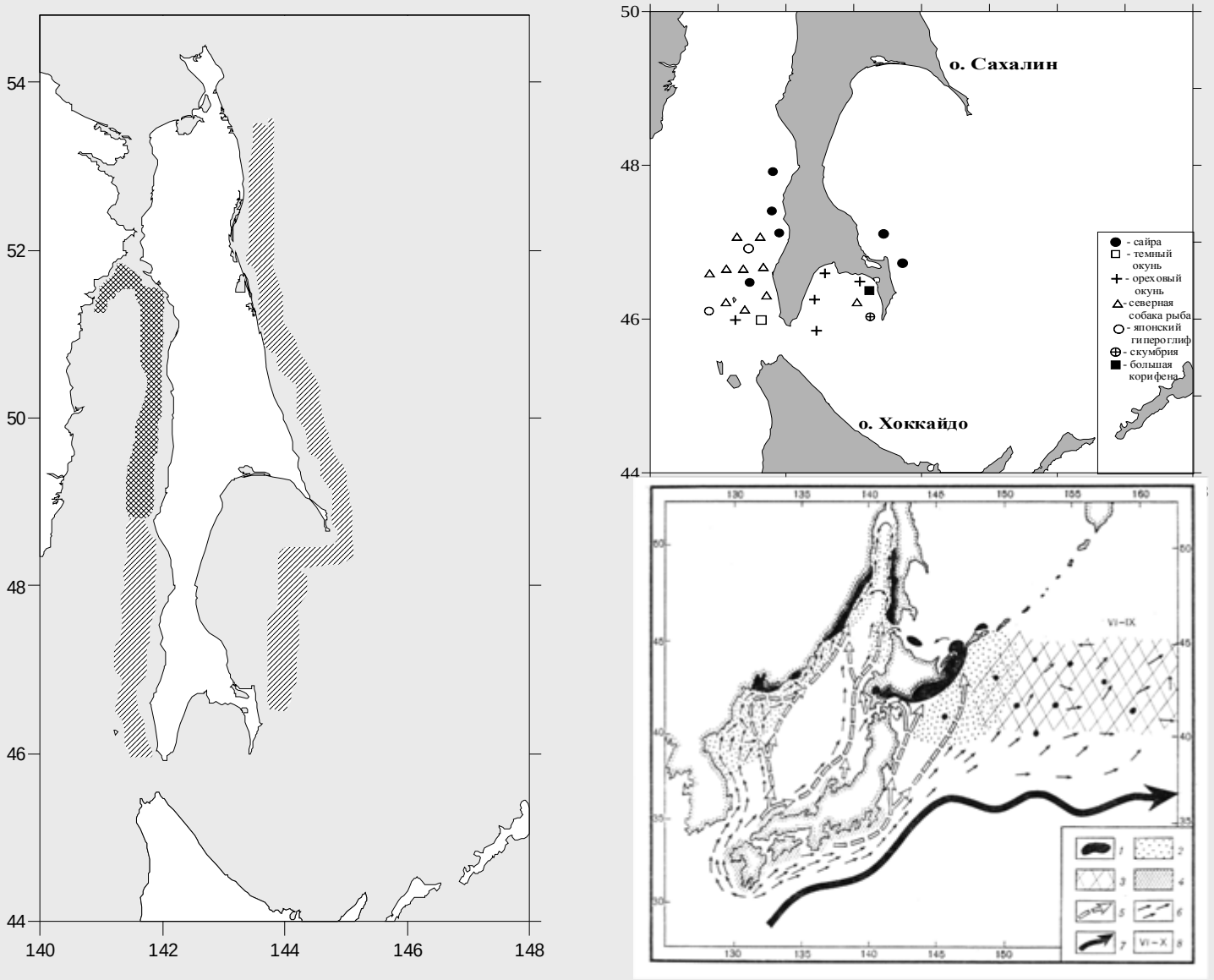
List of warm-water fish species near the west coast of Sakhalin Island in the 20th and Early 21th centuries (based on published and own data)

Species	Years	Species	Years
Isurus oxyrhynchus or Carcharodon carcharias (?)	**1951**	*Oplegnathus fasciatus*	**1946, 1948**
Lamna ditropis	**1947-1949, 1950s, 1960s, 1980s, 2004**	*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, 2002,2004,2007-2008**	*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**
Sebastes schlegeli	**1948,2001,2004**	*Lophius litulon*	**1975**
Sebastes wakiyai	**2001**		

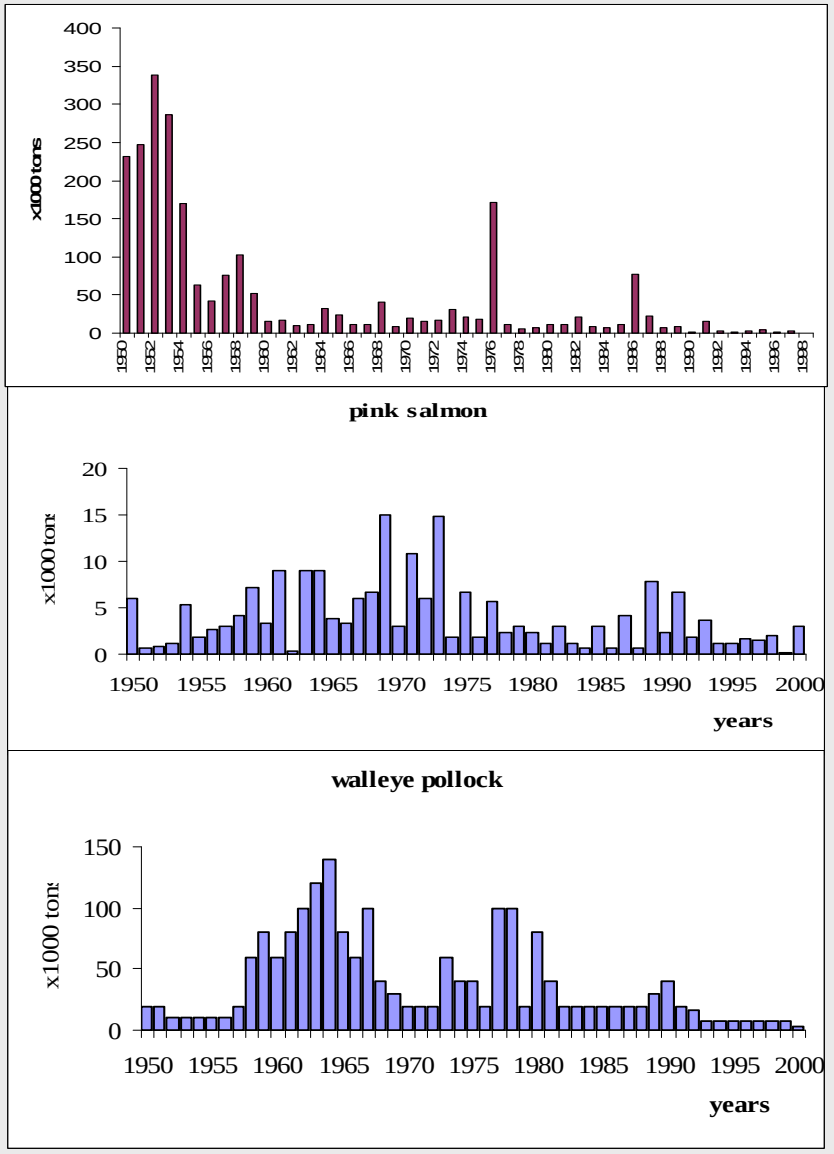
Periodicity of migrations of some subtropical fish species to the Tatar Strait in 1910-2008

Species	1910-1919	1920-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009
Pacific sardine	?	+	(+) – (+)	+	-	+	+	(+) -	-
Japanese anchovy	?	+	(-) +	+	+	-	- (+)	+	+
Pacific saury	?	+	+	+	+	+	+	+	+
Dolphin – fish	-	-	-	+	-	+	-	-	+
Swell fishes puffers	+	-	+	-	-	+	-	-	+
Total	**1**	**4**	**11**	**7**	**3**	**10**	**3**	**6**	**8**

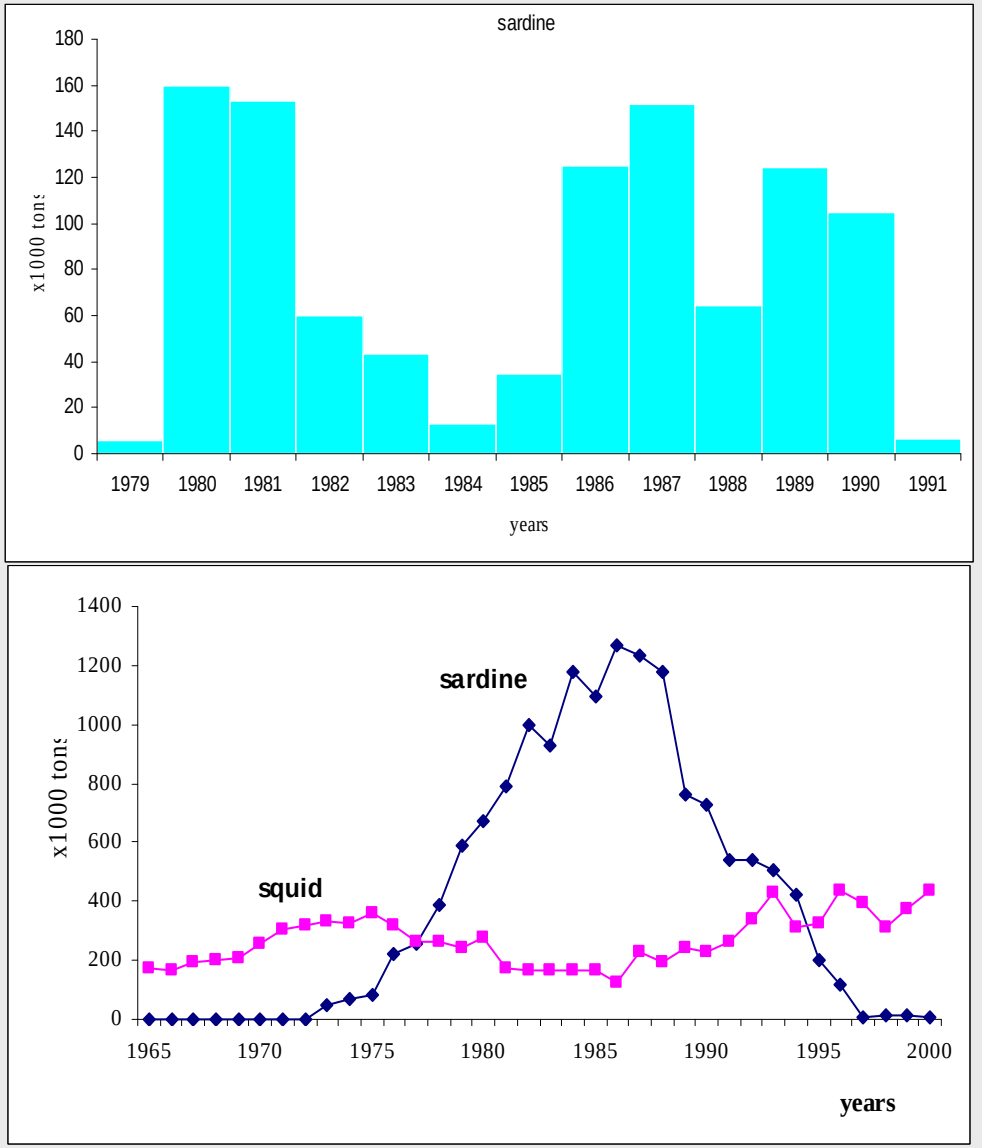
Distribution of Japanese anchovy in 2002 (left panel), some other south-latitude fish species near the Sakhalin coast in 2000-2005 (right upper panel) and Pacific sardine in the Japan/ East Sea in the end of the 1970s-early 1980s (right low panel; from Dudarev, Kenya, 1986),



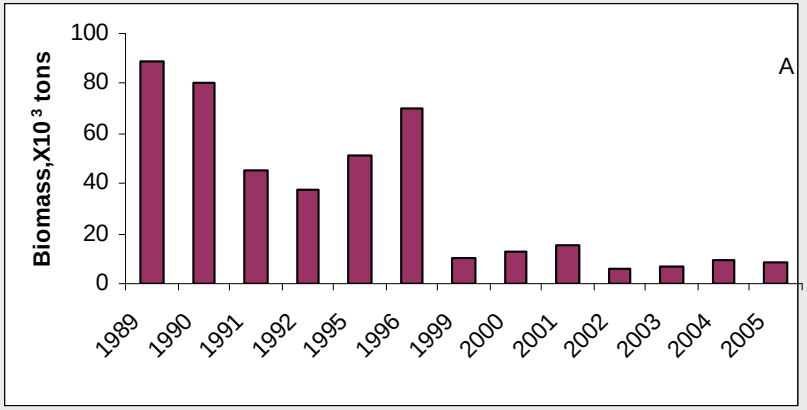
Dynamics of herring, pink salmon and walleye pollock catches in the Tatar Strait during 1950-2000

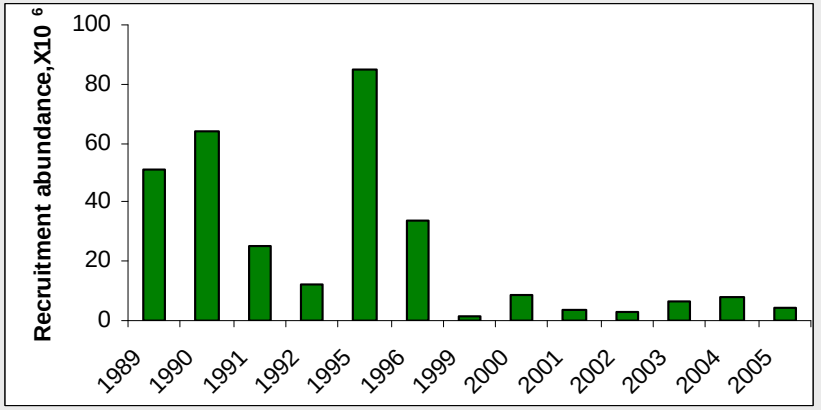


Annual catches of Pacific sardine in the Tatar Strait (top) and near the western coast of Japan (bottom) during 1965-2000



Dynamics of biomass stock (left) and recruitment abundance (right) of walleye pollock near the western coast of Sakhalin during 1989-2005



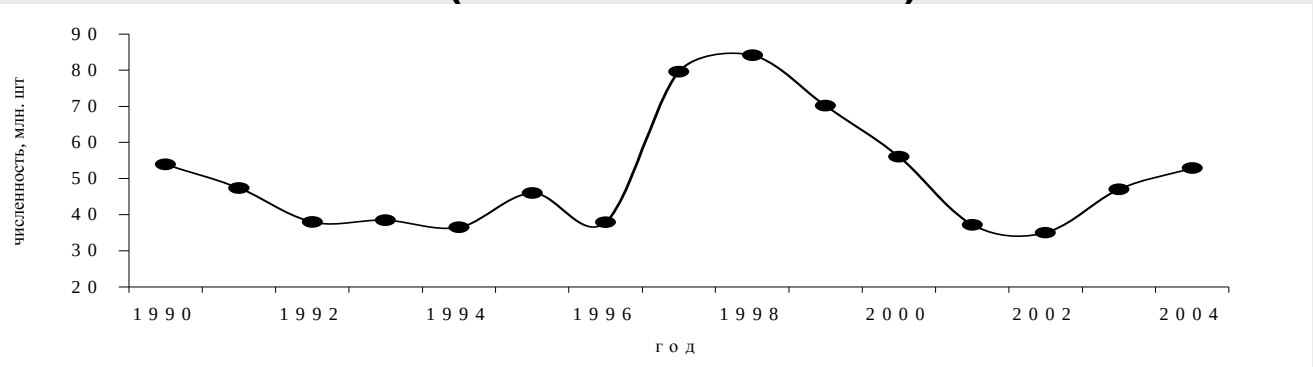


Data on walleye pollock egg concentrations sampled in the Tatar Strait in different years (eggs/m^2).

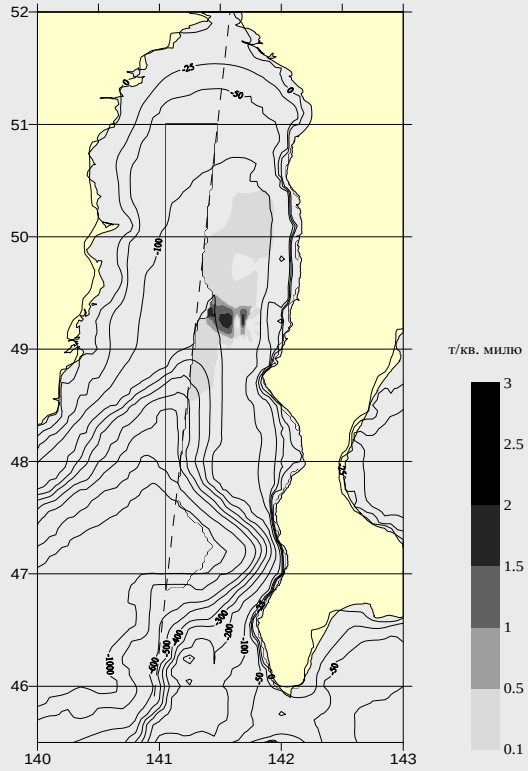
Years	1968*	1974*	1981**	1989**	1999	2001	2002	2004	2005
Area: 49-51°N	no data	1.-2000	2.0-550	2.-550	2.0-10.	2.0-4.0	2.0-10.	no data	0.00
46-49°N	100-2000	1.-2000	2.0-550	2.0-550	2.0-32.	2.0-76.	2.0-14.	2.0-8.0	2.0-8.0
46-51°N	no data	1.-2000	2.0-550	2.0-550	2.0-32.	2.0-76.	2.0-14.	no data	2.0-8.0

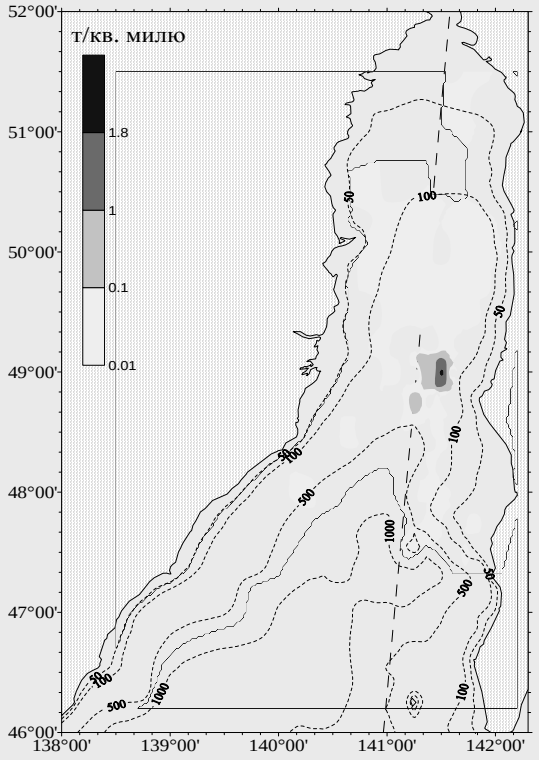
(* - Zverkova, 1977;2003; ** - Shuntov et al,1993)

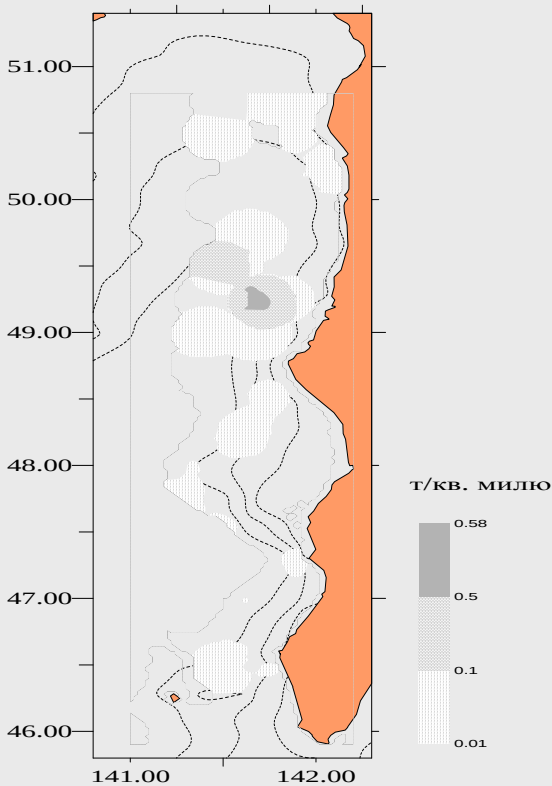
Stock abundance dynamics of Sakhalin-Hokkaido herring during 1990-2004 (data of Ivshina A. R.)



Distribution of herring in the Tatar Strait in April-May 2005 (left panel), 2006 (central panel) and 2008 (right panel) by the results of trawl surveys







Data of capelin frequency and catches during the bottom trawl survey in the Tatar Strait in different years

Year	1976	1977	1978	1981	1982	1983	1984	1986	2000	2001	2002
Month	1V-V	1V-V	V	1V-V	1V-V	V	V	V	1V-V	V-V1	V-V1
Type of vessel	SRTM-500	SRTM-500	SRTM-500	SRTM-500	SRTM-500	SRTM-500	RS-300	SRTM-500	STR-420	STR-420	STR-420
Number of trawling stations	87	50	66	73	34	65	76	27	75	120	147
FREQUENCY, %	48.0	38.0	36.4	38.4	58.8	26.2	15.8	63.0	17.3	7.6	29.2
Mean Catch per Unit Effort (amount of fish)	402	240	256	192	544	111	2735	5000	14	6	2598
Mean Catch per Unit Effort (kg)	12.7	7.0	5.6	6.5	15.8	2.8	87.5	125.0	0.44	0.15	78.2

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

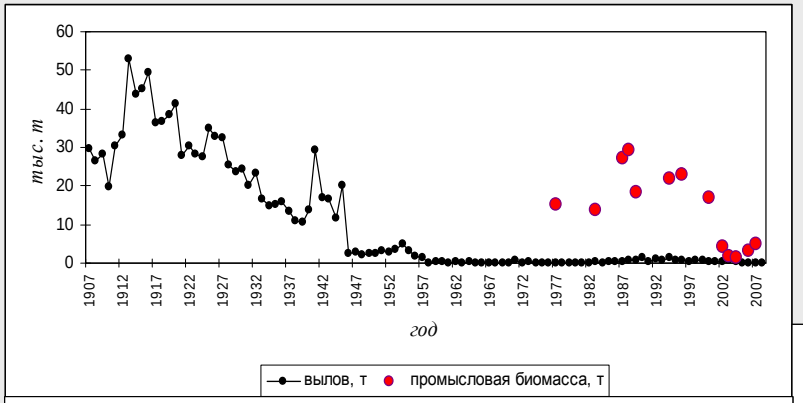
Year	1988	1989	1992	1995	1996	1997	1998	1999	2002
Spawning area (mln. sq. м)	2.34	1.90	1.61	0.94	0.50	0.08	0.15	0.76	2.88
Concentration of eggs (x1000000)	3.60	0.88	1.56	0.64	0.18	0.15	0.052	0.028	3.80

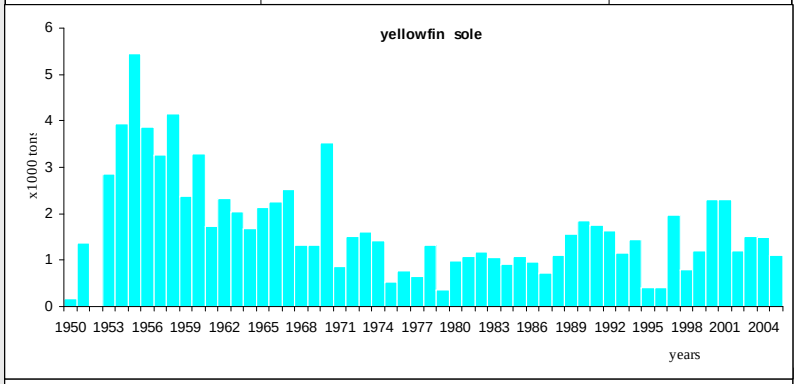
Long-term catch dynamics of Pacific cod and yellowfin sole in the Tatar Strait and sand-lance in the La Perouse Strait

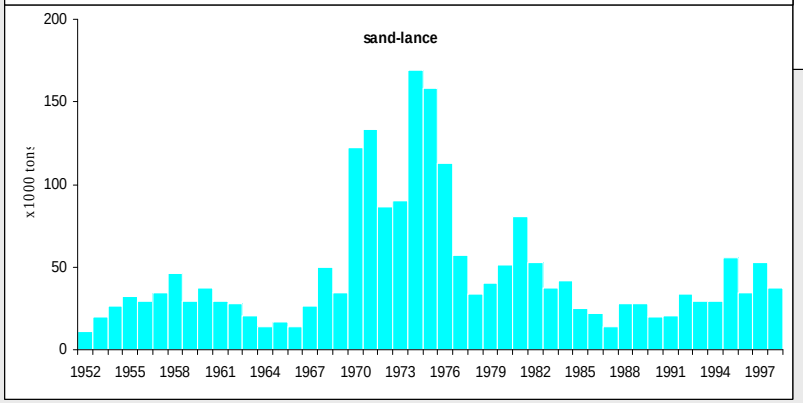
Pacific cod

Yellowfin sole

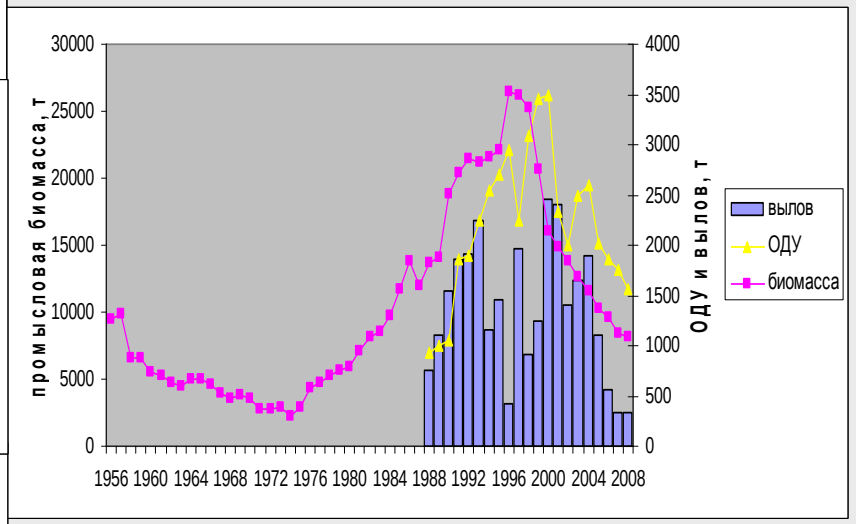
Sand-lance



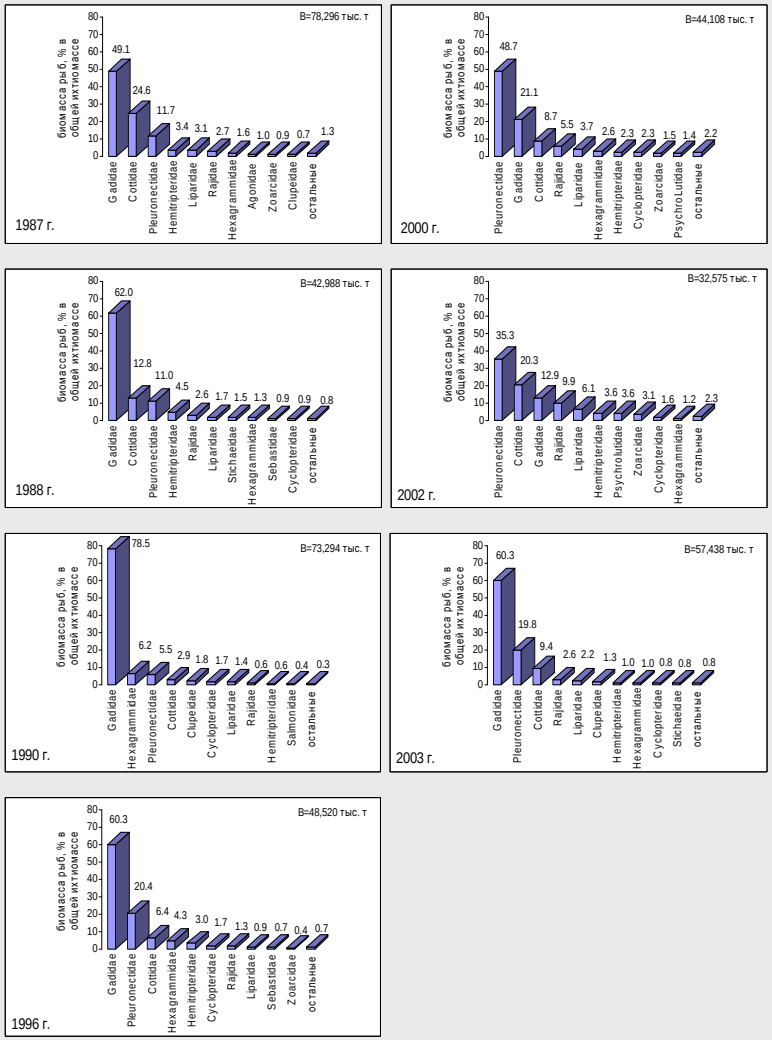


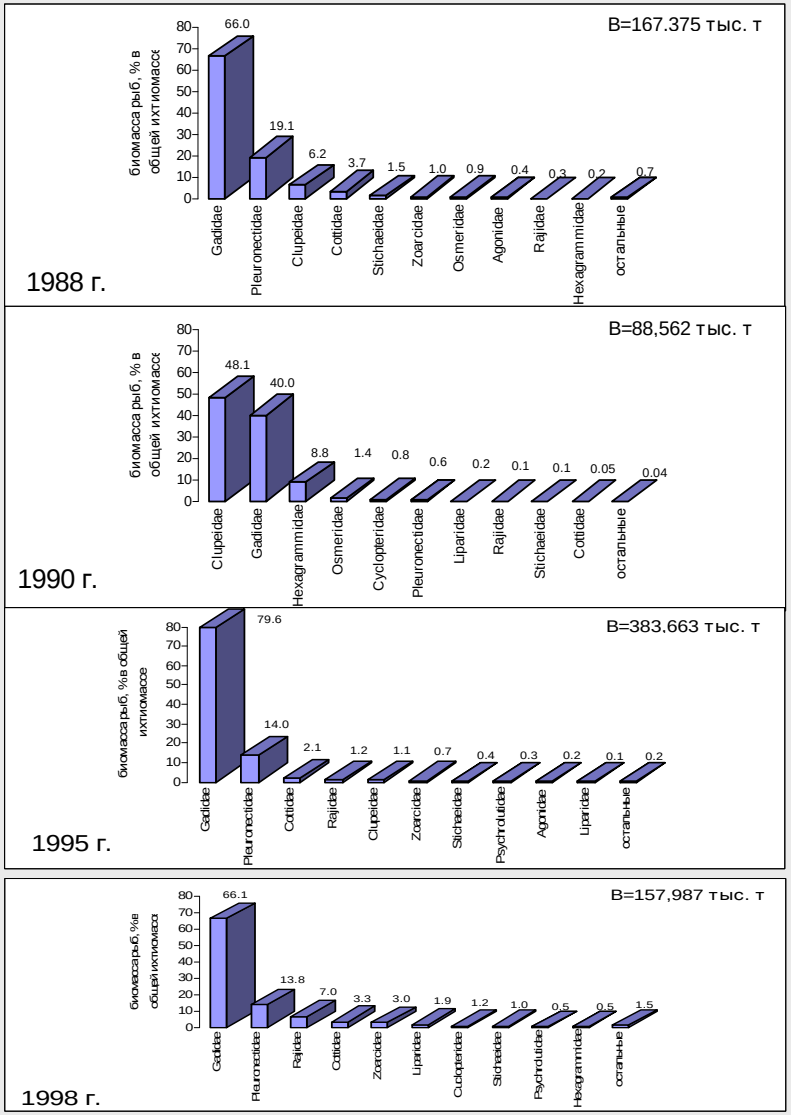


Long-term stock biomass dynamics of yellowfin sole in the northern Tatar Strait

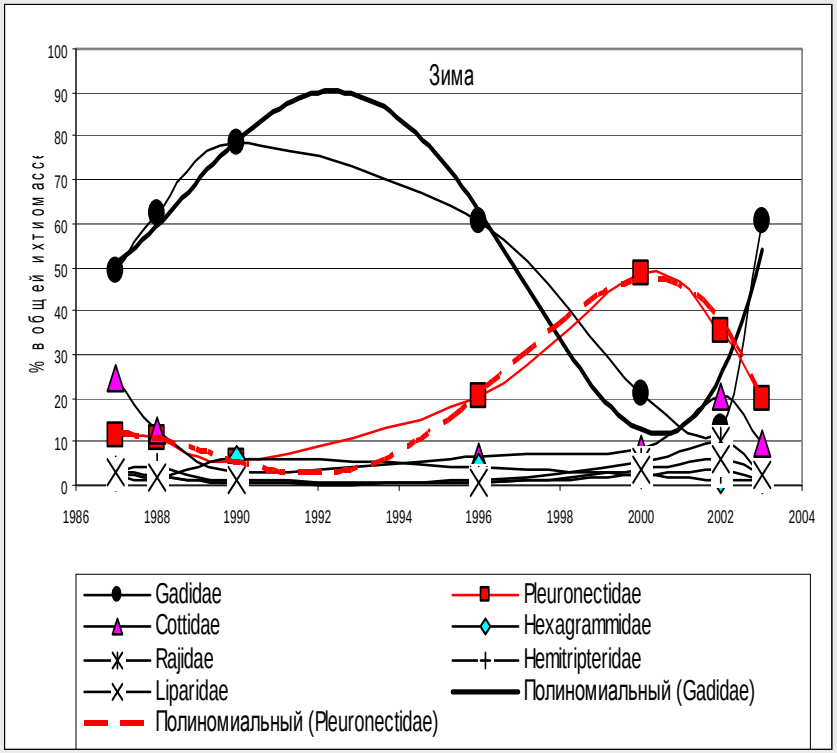


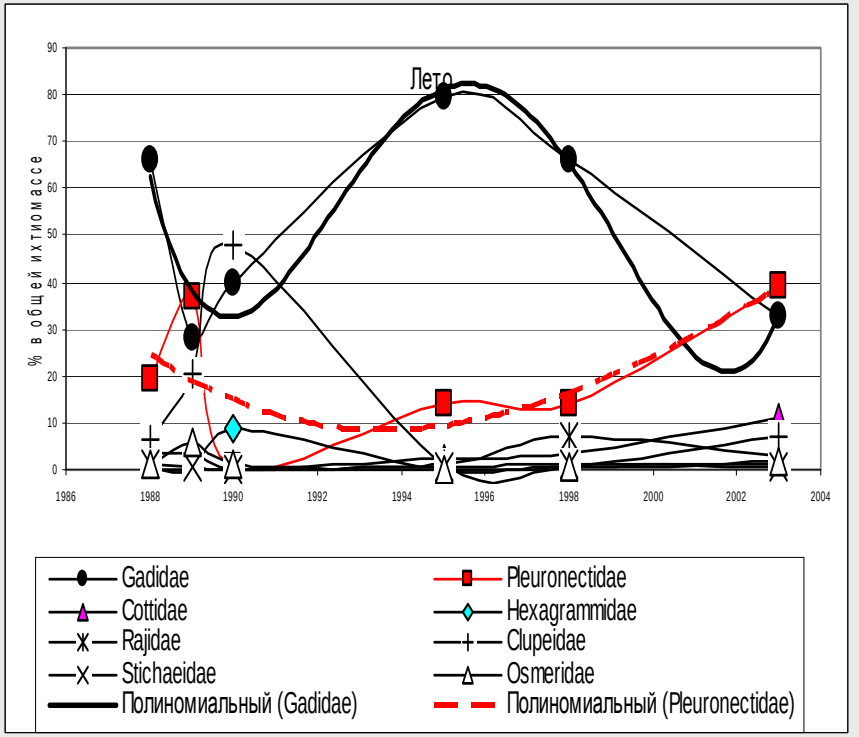
Ranking of fish biomasses by families along western Sakhalin from the data of winter, 1987-2003 (left panel) and summer, 1988-1998 (right panel) bottom trawl surveys





Smoothed long-term dynamics of fish biomasses from the dominant families and trends of stock changes for Gadidae and Pleuronectidae from the data of winter (left) and summer (right) bottom trawl surveys performed by SakhNIRO in 1987-2003





Correlation coefficients between annual catches of different commercial fish species from the Tatar Strait and adjacent waters in 1950-1998

Fish species	Pink salmon	Herring (Sakhalin-Hokkaido)	Herring (De – Kustry)	Walleye pollock	Pacific cod	Arabesque greenling	Sand-lance	Yell. Fin sole
Pink salmon	1	-0.178	0.115	0.232	-0.133	0.133	**0.503**	-0.039
Herring (Sakhalin-Hokkaido Stock)	-0.178	1	0.189	-0.268	**0.745**	-0.056	-0.213	0.185
Herring (De –Kustry Stock)	0.115	0.189	1	0.163	0.258	0.255	0.061	0.225
Walleye pollock	0.232	-0.268	0.163	1	-0.364	-0.063	-0.113	0.056
Pacific cod	-0.133	**0.745**	0.258	-0.364	1	-0.061	-0.215	0.461
Arabesque greenling	0.133	-0.056	0.256	-0.063	-0.061	1	0.198	-0.146
Sand-lance	**0.503**	-0.213	0.061	-0.113	-0.215	0.198	1	-0.096
Yellow-fin sole	-0.039	0.184	0.225	0.056	0.461	-0.146	-0.096	1

Fish species	SHI	PDO
Pink salmon	-0.290	-0,096
Herring (Sakhalin – Hokkaido)	-0.142	-0,353
Herring (De - Kustry Stock))	-0.351	-0,125
Walleye pollock	-0.309	-0,181
Pacific cod	-0.078	-0,259
Arabesque greenling	0.227	0.049
Sand-lance	-0.090	-0.168
Yellow fin sole	-0.024	-0.295
Saffron cod	**-0.536**	-0.212

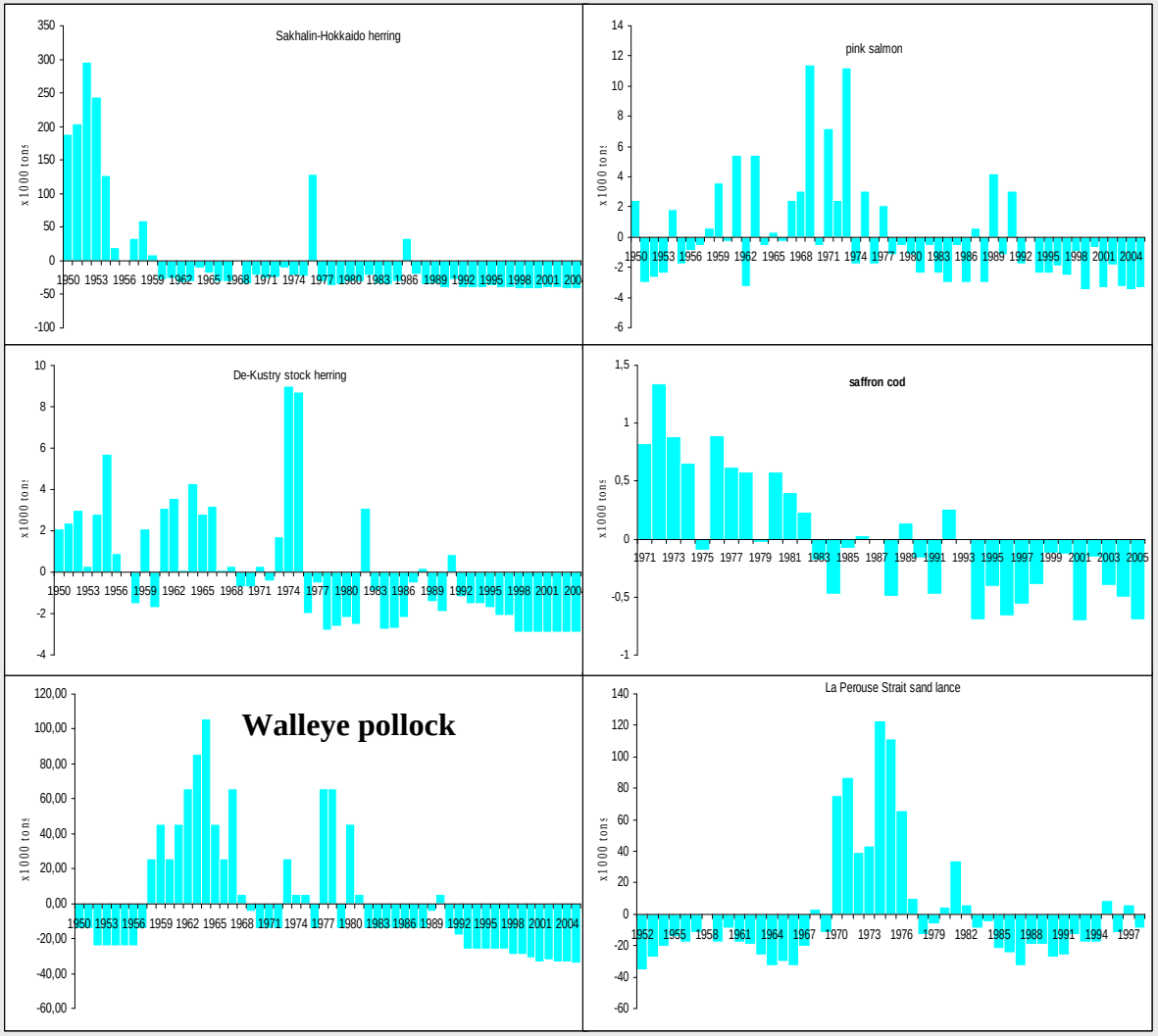
Correlation coefficients between annual fish catches and PDO Winter Index, annual catches and Siberian High Index in 1950-2001**(with a 4-year shift forth)**

Correlation coefficients between annual fish catches and water temperature near western Hokkaido and southwestern Sakhalin in 1964-1993 (with a 4-year shift forth)

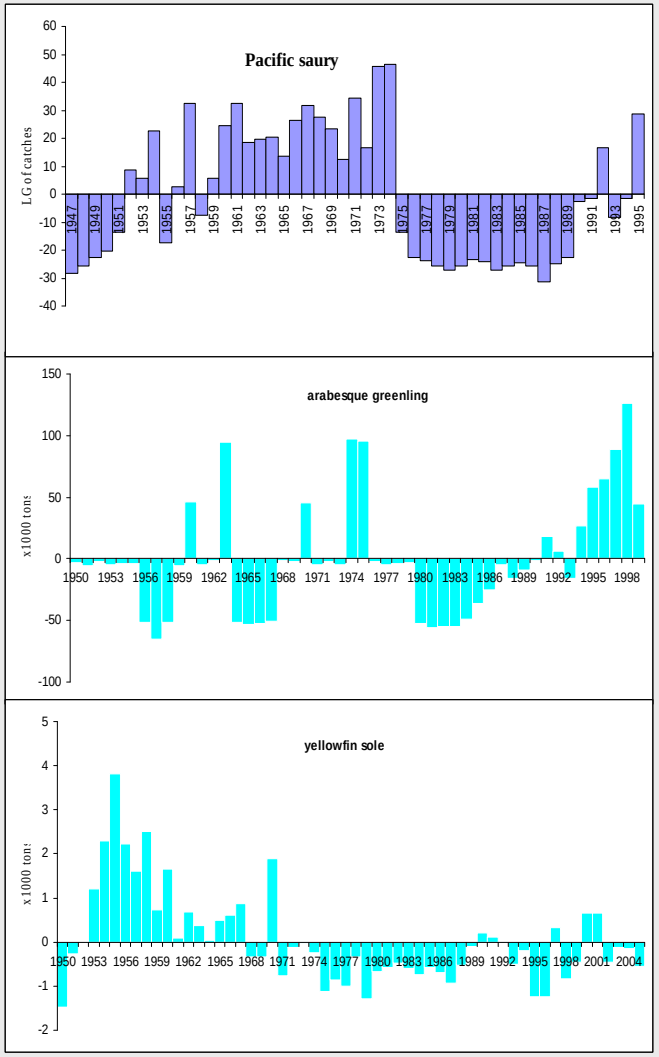
Fish species	Hokkaido (winter)	Hokkaido (summer)	Sakhalin
Pink salmon	0.293	0.211	0.015
Herring (Sakhalin-Hokkaido)	0.073	0.211	0.114
Herring (De - Kustry stock)	0.249	0.104	-0.302
Walleye pollock	0.196	0.048	0.315
Pacific cod	-0.281	-0.321	-0.138
Arabesque greenling	0.311	0.365	-0.291
Sand-lance	0.580	0.367	-0.032
Yellow fin sole	0.089	-0.004	0.160
Saffron cod	**-0.814**	0.201	0.409

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



Conclusions

- In the second half of the 20th century, significant changes in stock abundance have been observed for many fish species in the Tatar Strait.
- North-boreal, subtropical, bottom and pelagic fish species experienced abundance fluctuations. Changes in abundance, revealed for different fish species, had different-directed trends and were independent from any belonging to biogeographic or ecological group of fishes.
- Changes in fish abundance in the Tatar Strait 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 Sea of Japan in the 1980s and especially in the 1990s, and limitation of the warming water trend in the early 2000s.
- No close correlation was observed between the annual catches of different fish species and climatic indices, and between the catches and water temperature, except for saffron cod catches.
- There was revealed a general trend: a comparatively high abundance of fishes that spawn in winter-spring (herring, capelin, sardine, walleye pollock, Pacific cod, saffron cod and others) 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 (anchovy, saury, arabesque greenling, and yellowfin sole) increased.
- Major south-latitude fish species of the Tatar Strait are more frequent in the years of higher intensity of the Tsushima Current and lower monsoon intensity as well.


•Thank you for attention