The influence of spatial-temporary variability of shore polynias on of herring stocks in the northern Sea of Okhotsk

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Abstract - Spatial - temporary variability of shore polynias of the northen Sea of Okhotsk was considered of the satellite data
Some regularities of terms of occurrence, meanings of the polynia area against a background of dynamics of intraseasonal anomalies of Kats indexes are determined. The process of steady expansion of open water zones is related to the seasons of positive anomalies of meridional index prevalence, i.e. under intensive northern transport.
The presence of qualitative connection of meanings of spawning and commercial herring stocks with the given parameters of ice conditions in the researched areas in the Sea of Okhotsk proves to be true.

Keywords : the Sea of Okhotsk, ice regime, shore polynias, indexes of atmospheric circulation, herring

INTRODUCTION

The character of a seasonal ice-extent variability causes a favourable or adverse condition of spawning grounds, route and terms of migrations and formation of commercial targets stocks. Herring is one of the most important species in the Okhotsk population inhabiting waters of the northern Sea of Okhotsk. The features of migrations connected with the change of generations abundance and success in spawning. (Ayushin, 1947, Tyurnin , 1975), depend on the oceanological conditions and practically all herring strong year classes of this population occurred only under the favourable ice conditions within all over the spawning area (Melnikov, 2001). Thus, ice conditions and wind regime influence greatly on the spawning quality.
The aim of this paper was to research such features of ice regime in the Sea of Okhotsk as shore polynias (definition the terms of their occurrence, terms of steady development calculation their areas by the basic areas of Okhotsk herring spawning from1978 to 2004 (inclusive), estimation their influence on formation of herring stocks.

DATA AND METHODS

The data of satellite surveys for the period of ice cover erosion were used in the analysis.The terms of occurrence and steady development of shore polynias were determined and their areas were calculated according to these data. The shore polynias parameters in the northern Sea of Okhotsk (to north from 54°N) from March till April of the current year were investigated.
As, the ice and atmospheric processes are developed in concord (Muktepavel 2001), so to analyse the reasons of polynias formation there were used indexes of atmospheric circulation by Kats, calculated for the period since November till June.
To analyse the interrelation of herring stoks and ice conditions at the basic spawning areas of the Okhotsk herring, the data of commercial and spawning herring stokcs for 1978 - 2002 were used.

RESULTS AND DISCUSSION

The ice cover influencing on foraging areas of a herring, not only thermally but also mechanically is one of the reasons detaining a beginning herring spawning.

General ice-extent the Sea of Okhotsk does not render influence on formation of hydrological conditions on herring spawning areas .
Even in extremally extended years (1980,1986, 2000, 2003), when general ice-extent in March was up to 80 % and more, in spawning areas hydrological conditions were favorable (Fig. 1). However in some of extremally decreased ice-extent seasons (1991,1992) along coast of northwest part of the sea the insignificant areas of open water till May were marked or as in mean ice-extent years (1993, 1999) ice-holes completely were absent till May (Fig. 1)
Thus, in spring in the northwest Sea of Okhotsk forms local conditions of the ice mode which has been not connected with general ice condition of the sea.

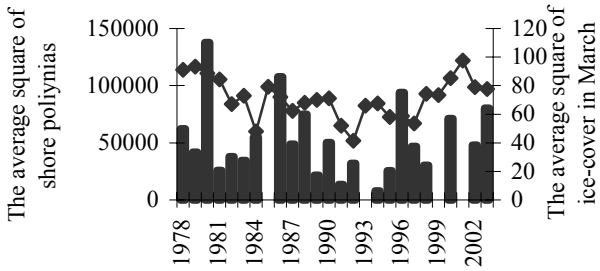


Figure. 1 Interannual distribution average total square of ice-cover in March (–♦–) and square of shore polynias in the northern Sea of Okhotsk – (▌)

Per 70 years U. Zavernin marked, that from all elements of a hydrological mode the steadiest connection with time of the approach of a herring on spawning have the terms appearance shore polynias. Such parameters, as dates of occurrence and area of ice-holes, are the main indicator in areas of a herring spawning. These parameters have significant spatial temporary variability (Tab.1, 2).

The warming up of a coastal zone goes slowly within with appearance of shore polynias after the 2-nd decade of April (1979, 1980, 1995, 1997). Temperature of water in June only is little bit higher 0°, therefore maturing of spawn goes with later.
Within, when the steady polynias appearance from 1-st till 3 decade of March (1978,1984,1986,1990, 2002,2003,2004), having warmed up begins early, therefore herring approaches earlier and all spawning grounds are filled evently.
Per separate years the shore polynias along northwest and northern coasts occurred in March, April and then completely were closed (1982, 1985,1987, 1989, 1994,1998,2001), or completely were absent within all spring (1993,1999) (table 1, 2). In result the part of the postponed spawn perishes or the fish approaches to spawning later.
The development of ice-holes is defined(determined) by synoptical conditions in spring, which depends of a trajectory movement of cyclones and anticyclones
The changes synoptical and seasonal scales occur of a background of long-term variability of atmospheric circulation . The development of shore polynias depends of prevalent air carries, dynamics of an atmosphere in researched region therefore was investigated. The analysis of interannual variability of the area of shore polynias (table 1,2) with features of atmospheric circulation by the given indexes Каца was executed.

Table 1. Dates of appearance and steady development of shore polynias in the northern Sea of Okhotsk in spring.

Year	From a northwest shore up to Kony peninsula region			Northern shore from Kony peninsula up to Penjinskiy gulf		Western shore of Kamchatka	
	Dates of appearance	Dates of steady development	Dates of complete purge from ice	Dates of appearance	Dates of complete purge from ice	Dates of purge West Kamchatka to 58°N	Dates of complete purge from ice
1978	3 dec. March	3 dec. March	2 dec. July	3 dec. March	-	3 dec. March	3 dec. Apr.
1979	2 dec. Apr.	ice	1 dec. July.	3 dec . Apr.	-	3 dec . Apr.	2 dec. Apr.
1980	2 dec Apr.	1 dec . May	3 dec . May.	2 dec . Apr.	3 dec . May	3 dec . Apr.	2 dec . May
1981	2 dec. March	ice	2 dec. July	-	-	-	-
1982	1 dec . Apr.	ice	2 dec June	-	-	2 dec . Apr.	-
1983	3 dec. March	2 dec. Apr..	1 dec. July	-	-	3 dec . March	3 dec . Apr.
1984	2 dec . March	1 dec. Apr.	1 dec June	2 dec . March	2 dec . пр.	3 dec . March	2 dec . Apr.
1985	1 dec . Apr.	ice	3 dec. May	-	2 dec . May	-	-
1986	2 dec. March.	1 dec . Apr..	2 dec. June	1 dec . March	1 dec. June	3 dec . March	2 dec . Apr.
1987	2 dec . Apr.	ice	3 dec May.	2 dec . March	2 dec . June	2 dec . March	2 dec . May
1988	2 dec. March	2 dec . Apr.	2 dec. June	3 dec . Apr.	2 dec . May	1 dec . Apr.	3 dec . Apr..
1989	3 dec. March	-.	3 dec May.	2 dec . March	1 dec . May	3 dec . March	3 dec . Apr.
1990	1 dec March	2 dec . March	-	-	-	2 dec . March	-
1991	3 dec. March	1 dec. Apr.	-	-	-	-	-
1992	1 dec . Apr.	1 dec . Apr..	2 dec . June	-	-	-	-
1993	закр.	ice	2 dec. June	-	-	-	-
1994	3 dec . Apr.	ice.	2 dec . June	-	-	2 dec. Apr.	3 dec . Apr.
1995	2 dec . Apr..	1 dec . Apr.	3 dec . May	2 dec . Apr.	2 dec . May	1 dec. Apr.	3 dec . Apr.
1996	1 dec. Apr.	1 dec . Apr.	3 dec . May	2 dec . Apr.	2 dec . Apr.	3 dec. March	1 dec . Apr.
1997	2 dec . Apr.	2 deck . Apr.	2 dec . June.			1 dec . Apr.	3 dec . Apr.
1998	3 dec . Apr.	ice.	3 dec . May	3 dec . May	2 dec. June	3 dec . Apr.	2 dec . May
1999	закр.	ice	3 dec. July	-	2 dec. June	1 dec. May	3 dec . May
2000	1 dec. Apr.	2 dec . Apr.	2 dec. June	2 dec . Apr.	2 dec . May	3 dec . Apr.	1 dec . May
2001	3 dec. Apr.	ice	1 dec. July	1 dec. Apr.	2 dec . Apr.	1 dec . Apr.	3 dec . Apr.
2002	3 dec. March	2 dec. May	2 dec . June	-	3 dec . May	3 dec . March	3 dec. May
2003	3 dec. March	3 dec. Apr.	1 dec. June	3 dec . March	2 dec . May	3 dec . March	3 dec . March
2004	3 dec . March	2 dec. Apr.	1 dec. May	1 dec . Apr.	2 dec . Apr.	-	2 dec. Apr.

Table 2. The average square of shore polynias in the northern Sea of Okhotsk (April-May)

Year	Northwest shore Kony peninsula (km²)	Northern shore from Kony peninsula up to Penjinskiy gulf (km²)	Total square of polynias (km²)
1978	0	62126	62126
1979	18676	23069	41745
1980	101735	35928	137663
1981	23635	2025	25660
1982	24232	13563	37795
1983	27782	6584	34366
1984	31768	23118	54886
1985	0	0	0
1986	0	107533	107533
1987	0	48890	48890
1988	48402	26579	74981
1989	0	21583	21583
1990	50234	0	50234
1991	13422	0	13422
1992	31938	0	31938
1993	0	0	0
1994	0	7976	7976
1995	4129	21362	25491
1996	18632	75180	93812
1997	46718	0	46718
1998	2364	27839	30203
1999	18632	0	0
2000	46718	10005	71257
2001	2364	0	0
2002	18632	3244	47971
2003	46718	0	80071
2004	68161	11519	77680

As we see in Fig. 2 the fluctuations of shore polynias square from March to May has the expressed return course with anomalies of meridional indexes from December to March.. The process of steady expansion of open water zones is dated for seasons of prevalence of negative anomalies, of positive meridional indexes anomalies, i.e. at intensification northern air carries.

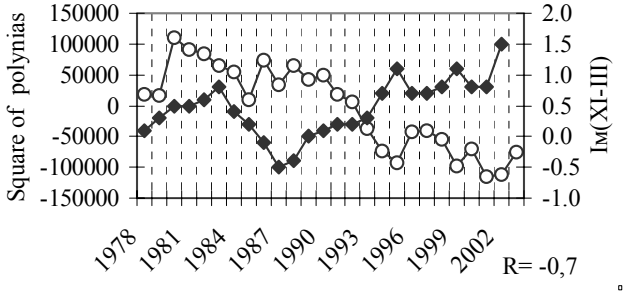


Figure 2 Interannual distribution of shore polynias square anomalies- (–o–) and meridional indexes anomalies – (–♦–) – Iм

The of shore polynias dates of occurrence and of steady development vary considerably and earlier appearance (in March) occurs at prevalence of positive meridional indexes anomalies from December to March, i.e. at decrease of northern carry intensity . Such regularities are not revealed for anomalies of a zonal index.

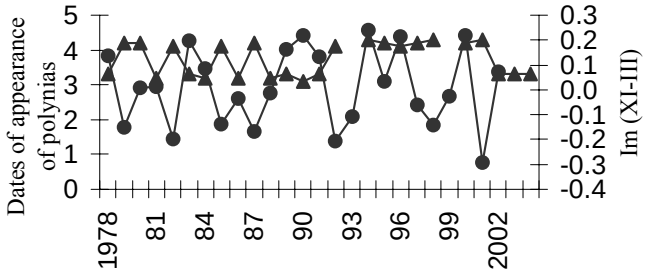


Figure 3. Interannual distribution the dates of shore polynias appearance in the northern Sea of Okhotsk in spring anomalies- (—●—) and meridional indexes (Iм)- (—▲ —)

Abundance of generations and the features of oceanological conditions in spawning and foraging areas have the essential interannual differences.

The search of connection of herring quantity and biomass of different age with the spawning grounds square at shift for year of birth of fishes, has shown the steadiest connection with by number of generation 4 + (Fig. 4)

The analysis of the data (1978-2003) confirms the U. Zavernin assumption , that all of a herring generation abundant of this population had been occurred at favorable ice conditions in shore polynias areas.

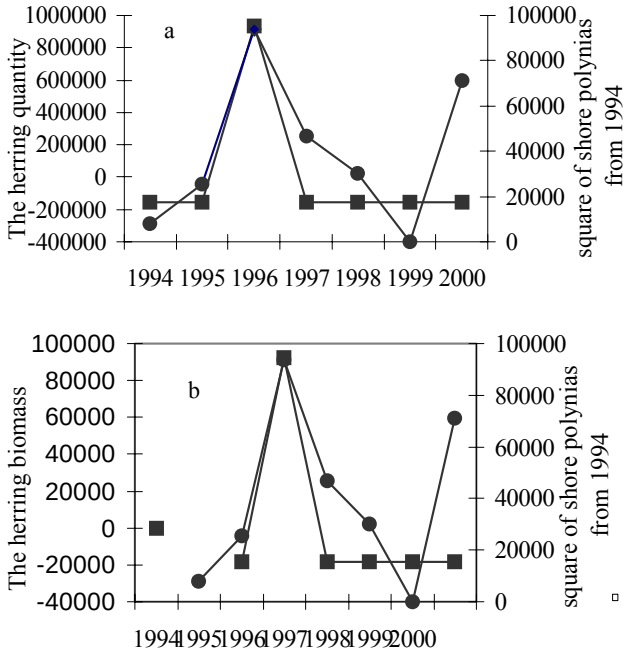
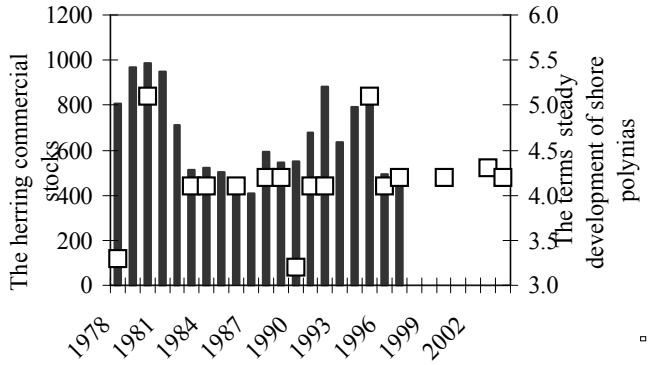


Figure 4. Connection of a) herring quantity (of age 4+) (–■–) , б) herring biomass (of age 4+) (–■–) with the square of shore polynias in the northen Sea of Okhotsk

The qualitative connection of herring stocks of a with appearance dates of steady shore polynias and their area, is found at 5-year's shift of stocks data since the herring spawning stoks is defined by productivity of generations of the age of 5 years (figure 5,6).

Fig. 5 The dynamics of interannual variability herring spawning stocks (from 1983)- (▌) on a background of occurrence terms in shore polynias areas (from 1978)- (□)



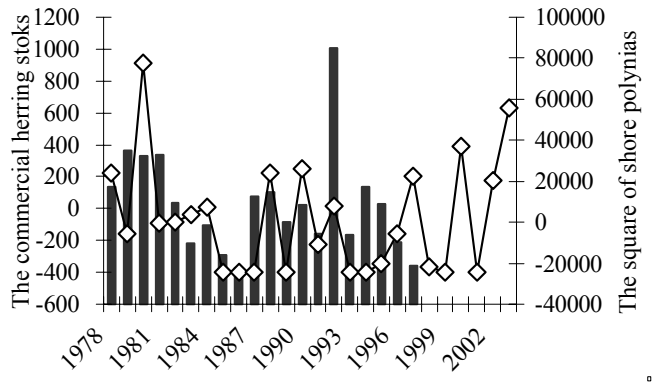


Fig. 6 Dynamics the interannual variability of herring stocks in the northern Sea of Okhotsk (from1983) (shift for 5 years)- (▌) of a background the anomalies square of shore polynias (March - May)- (–◊–).

Dynamics of the herring spawn stock in the northern the Sea of Okhotsk was determined by alternation of generations various of productivity.

As we see at fig. 6 there were most herring generation abundant in1980, 82, 83, 84, 85, 86, 88, 89, 92, 98, 99, 2000 years(fig.6)

The high level of 1983-87 period was caused by occurrence of herring strong year classes in 1979 and 1980 years. In 1979 has taken place early purge shore from ice of ice in northwest of the sea (1 dec. April) and in 1980 it were marked extensive and steady shores along northwest, central and nothern- east of shore.

But, since 1987 there was a sharp reduction of generations the herring productivity on 1991 on a background of reduction of the general shore polynias in traditional spawning areas.

Dynamics of growth of herring number since 1992 was defined by the introduction into of generations 1986-1987 generated within favorable ice conditions in the spawning areas.

However, the years are marked, when conform to of parameters was broken.

So, in 1979, 1980 and the 1992 at negative shore polynias anomalies, were marked positive anomalies of herring stocks (fig. 6) In 1997, on the contrary, on a background of extensive shore polynias the decrease the stock Okhotsk herring was marked. Probably, it was caused by features of hydrological conditions in the shore areas, which have influenced redistribution of a spawning herring.

In 1975 by B. Tyurnin has revealed 4 types of ice concentration areas of herring reproductive zone (Tyurnin, 1975). According to these types in spring 1979,1981 and 1997 when at the small areas of shore-polynias , the stocks of a herring were marked at a level above the average. But the ice conditions in spawning areas are developed for 1 type (fig. 7)

1-st type

3-d type

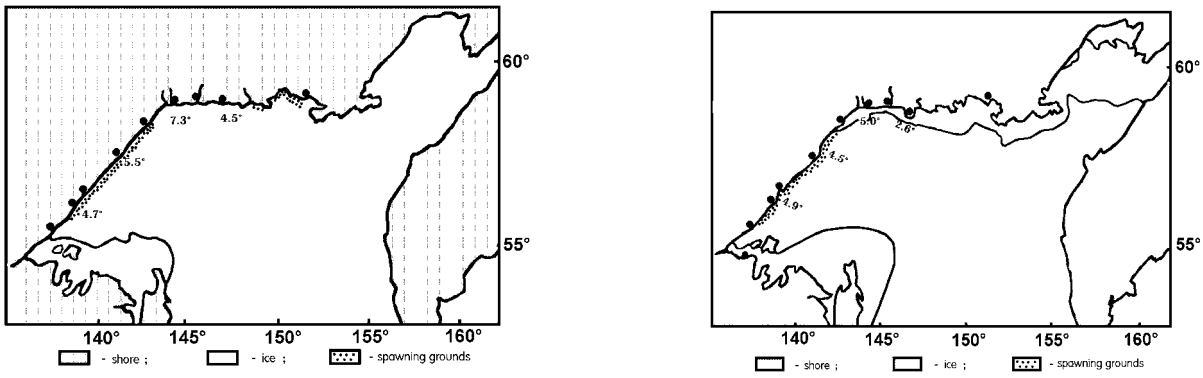


Figure 7 Types of herring spawning grounds by B. Turnin (1975)
1- shore; 2- ice-cover; 3- spawning grounds

The duplication of a herring at favorable ice conditions is characteristic for this type. These years the early opening of all northwest coasts up to Kony peninsula (3 dec. March 2 dec. April) (Tab. 1,2) was marked. The warming up of water in shore zone began earlier. In such cases mass spawning occurs in regular intervals on all spawning zone.

In 1997 the duplication passed by 3-d type i.e. at unfavorable ice conditions of East group spawning ground and at a small herring stock of previous year1996. According B. Tyurnin the duplication low on number of herd spawning at any features of use spawning ground is accompanied by occurrence of decreasing population.

Results

A long-term data set about ice conditions of a herring spawning grounds of North Okhotsk population in the spring period is received

Time of appearance, steady development of shore polynias

The shore polynias squares (March - May) in northern Sea of Okhotsk (1978 – 2003)

Conclusions

The received data about shore polynias allows to analyze long-term variability of ice conditions in the spawning grounds of the northen Okhotsk herring population

The degree of development shore polynias in northern Sea of Okhotsk depends from the prevailling of atmospheric circulation form.

The process of steady expansion shore polynias on spawning ground in spring is determined mainly by influence meridional component of atmospheric circulation above the Sea of Okhotsk.

The analysis of the received long-term number of the data confirms presence of qualitative connection of meanings herring spawning and commercial stocks formed by number generation 4+ with the received parameters of a hydrological mode in researched area.

The presence of such connections, taking into account the intraannual peculiarities of ice processes in the main spawning grounds makes it possible to use these data in the forecasts formation of spawning and commercial stocks of the Okhotsk herring.

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