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DISTRIBUTION AND MIGRATION OF COD IN THE SPITSBERGEN AREA IN DEPENDENCE ON OCEANOGRAPHIC CONDITIONS

by

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Introduction

Investigations into the dependence of behaviour and distribution of marine species on the variations in hydrographic conditions in their habitats have been an important line of research at the PINRO laboratory of Fisheries Oceanography. The hydrographic data collected in the course of integrated cruises and the special-purpose surveys in the Barents, Norwegian and Greenland Seas, as well as in the Northeast and Northwest Atlantic, serve as the information basis of the research.

Since the 1950s, Russian scientists have been studying the biological resources of waters around Spitsbergen. Long-term investigations of PINRO have shown that this area is the margin of distribution areas for many marine species (Figure 1). Cod is one of the most abundant species, and its migration behaviour, seasonal distribution and concentration depend on the biological state of fish and their environment.

The present paper describes the influence of hydrographic conditions on the migration, distribution and fishery of the Barents Sea cod in the Bear Island-Spitsbergen area where valuable species are fished. Our investigations were based on the research of PINRO scientists Maslov N., Konstantinov K., Ponomarenko V., Sarynitsyna R., Mukhin A. and others who made a great contribution to the study of cod migration behaviour.

Material and methods

Fisheries, biological and oceanographic data for August-December 1967-2004 obtained by PINRO in the Spitsbergen area were used to study cod distribution and migrations, as well as temperatures of the Barents Sea.

The efficiency of cod fishery in the study area in the autumn/winter season immediately depends on the knowledge of the feeding area and the time of back migration. To analyse variations in the spatial distribution of cod, daily vessel reports were used.

Deepwater observations along the standard sections in the central and northwestern Barents Sea and at the trawl stations were used to describe interannual and seasonal variability of water temperature in the study area.

Results of research

Oceanigraphic regime in that area is determined by the interaction between warm and salty Atlantic waters and cold and brackish Arctic waters of the Barents Sea (Fig.1).

The analysis made in PINRO suggests that northward feeding migrations of cod start in April-May (Cod of the Barents Sea: biology and fishery, 2003). Fish mainly migrate with the warm currents, and migration routs stretch from the spawning grounds off the Scandinavian coast to the West Spitsbergen and Hope Islands.

In the Bear Island-Spitsbergen area, the biggest aggregations of cod are observed in the third quarter of the year, when the fish migrate to the margins of the feeding area, aggregating in the areas south-east of Spitsbergen (Figure 2).

The starting/ending time of feeding and return (to the wintering and spawning grounds) migrations, as well as migration routes, can vary depending on the hydrographic conditions. In the cold years, feeding migrations are not so long, cod later approach the feeding areas and the westward migration begins earlier. This means that in the cold years the feeding period is considerably shorter than in the warm ones (Cod of the Barents Sea…, 2003; Boitsov, Mukhin, Yaragina, 1987; Shevelev, Tereshenko, Yaragina, 1987). In the years with lower temperatures in the bottom waters cod migrations to the north are limited. Good commercial aggregations are found only on the eastern and southern slopes of the Bear Island Bank. When the temperature in the bottom layers is high, fish are distributed more widely and form concentrations with different density in the large area from the eastern slope of the Bear Island Bank to the Hope area and the Persey Elevation. The correlation between migration behaviour of cod and temperatures of the Atlantic currents is confirmed by cod fishery in summer-autumn 1998 and 1999 (Figure 3).

The research indicated that one of the factors determining the northern margins of cod feeding area was the temperature of waters of the Atlantic origin in the bottom layers during the first quarter of the year (Figure 4). The derived significant relationship ($R=0.57$ for August and $R=0.62$ for October with $n=40$) suggests that, at the beginning of the year, temperatures along Section 29 (east of the Bear Island) in the 300 m bottom layer of the northern branch of the North Cape Current largely determine the northern margin of cod feeding aggregations migrating northward between 25ºE and 35ºE in summer and autumn.

Cod fishery areas on Section 29 of the Bear Island-Spitsbergen area were identified (Fig.5) for years with different water temperatures (Figure 5).

In October-December, with the beginning of the seasonal water cooling, cod begins to migrate to the south where immature cod winter and mature fish spawn. Mass migration of fish starts when the convection reaches the bottom layer and temperatures near the bottom go past the maximum and begin to decrease. Thus, the migration of fish to the wintering grounds is a protective response to low temperatures which is often triggered by autumn storms with a following drastic cooling of shallow waters.

The influence of water temperature variations on cod behaviour can be illustrated by fisheries on the South Cape Deep in the autumn of 1988 (Figure 6). In October 1988, the most promising fishing area was the South Cape Deep, but intensive water cooling on Section 19 (the South Cape – the Bear Island) from October to November caused temperature decrease in the 0-200 m layer of the South Cape current by 1.1ºC, the long term mean being 0.6ºC. As a result, already in the early November fisheries shifted to the south, first to the western and then to the southern slope of the Bear Island Bank.

As known (Sarynina, 1980), cod behaviour (including migrations) depends not only on the rate of water temperature fluctuations, but also on the absolute thermohaline indices. It has been indicated that water temperature is an important factor to be taken into account when searching for commercial fish aggregations (Elizarov, 1959; Konstantinov, 1961; Khanaichenko, Kozlova, 1961).

Observed frequency of cod occurrence in different temperature ranges was analysed and a seasonal temperature preference was revealed. Studies of fisheries and temperatures in the near-bottom layer have shown that in October cod was observed in the near-bottom layers of the Barents Sea with temperatures ranging from -1.8^0 to 7.19^0C. The analysis of long-term data on fishing conditions indicated that ca. 48% of all cod was caught in the areas with near-bottom temperatures varying from 0.5 to 1.5^0C. The largest catches were taken in the areas with temperatures from 1.0 to1.5^0C. This temperature range appears to be the optimal one for the commercial aggregations of feeding cod.

Hela, I. and Leavastu, T (1962) who systematised the existing knowledge about the influence of environmental conditions on fish stocks did not rule out the impact of chemical properties of waters on behaviour and distribution patterns. Russian researchers (Elizarov, Kochikov, Rzhonsnitsky, 1983) assumed that salinity may also have an impact on cod aggregations observed in the areas where relatively warm Atlantic waters flow into the Arctic waters.

The analysis of temperature variations on the fishing grounds in the near-bottom layer has shown that cod inhabits waters with the salinity varying within a wide range - from 32.0 to 35.5. However, the largest catches were taken at 34.85 – 35.00 salinity.

A strong correlation between the thermohaline conditions optimal for commercial cod aggregations in October-November 2004 and the largest cod catches taken during the trawl acoustic surveys of the Barents Sea demersal fish lends support to the validity of the suggested methodological approach to searching the most promising fishing areas.

Conclusions

The present investigations show the effects of oceanographic factors on the distribution and fisheries of cod in the Spitsbergen area.

Commercial aggregations of cod are observed in the areas with near-bottom water temperatures ranging from 0.5 to 1.5^0C and salinities from 34.85 to 35.00. The obtained correlations were confirmed by the data from annual TACs of demersal fish in the Barents Sea. They can be used as reference data to forecast the location of fish aggregations throughout the year.

The revealed effects of environmental variations in the fishing areas on the distribution and migration behaviour of cod permit to use projected oceanographic conditions for simulating possible scenarios of fishing conditions to be taken into account when providing scientific advice for fisheries.

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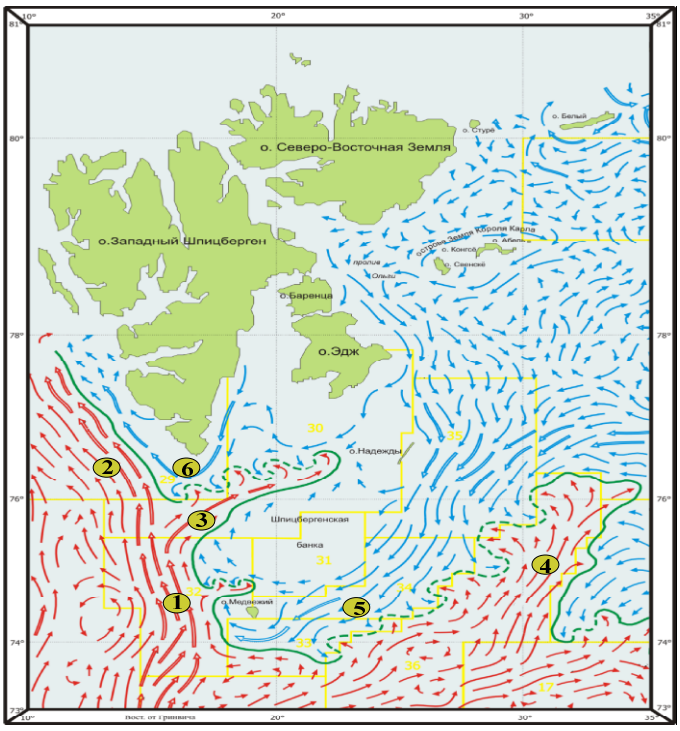

Fig.1 Stationary surface currents in the Bear Island-Spitsbergen area of the Barents Sea (Tantsura, 1959, 1973)
Warm atlantic currents: 1 – Spitsbergen, 2 – West Spitsbergen, 3 – South Spitsbergen, 4 – the northern branch of the North Cape Current
Cold currents: 5 – Bear Island, 6 – South Cape

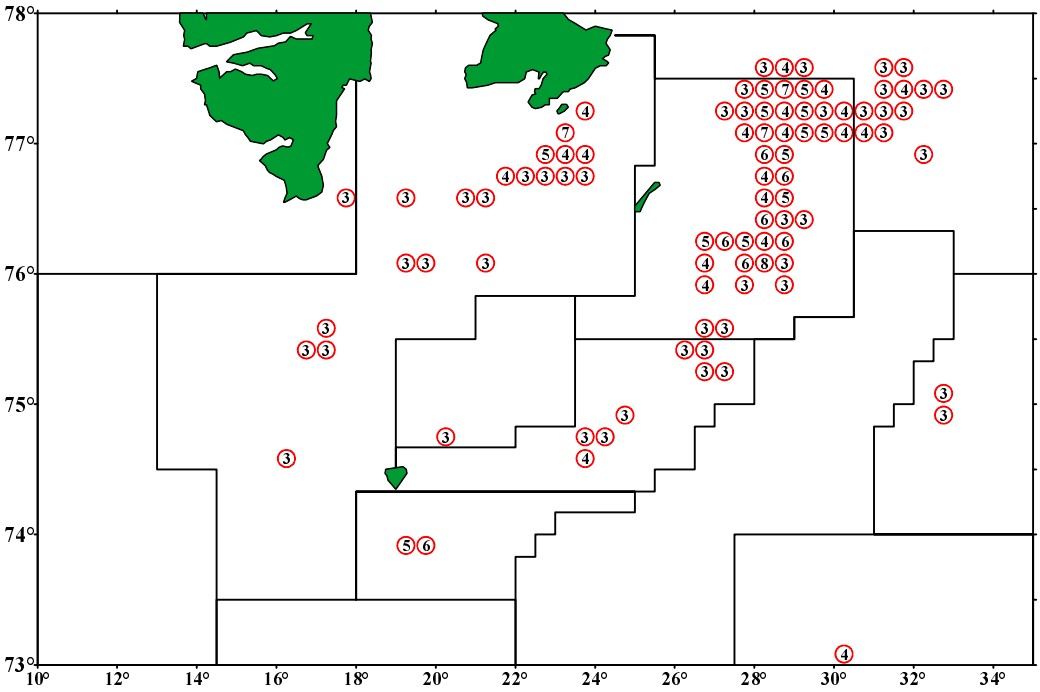

Fig.2 Areas of cod fishing and the number of years with the catch of more than 50 t by fishing squares in September 1967-2004

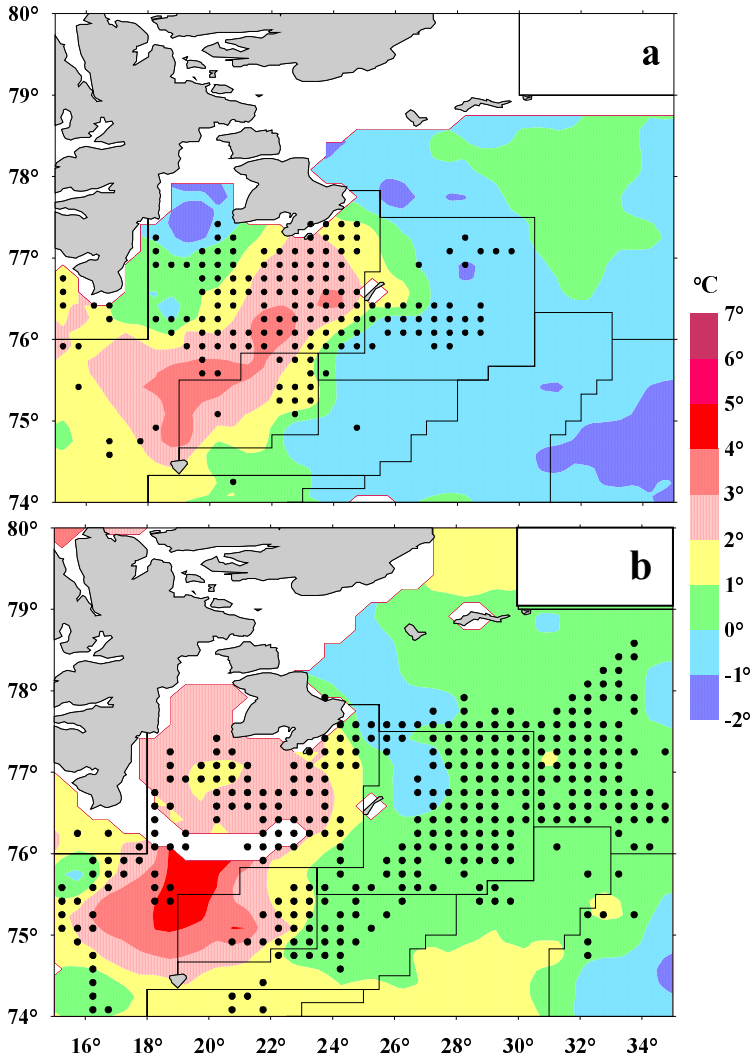

Fig.3 Distribution of bottom temperature and cod fishery in September 1998 (a) and 1999 (b)

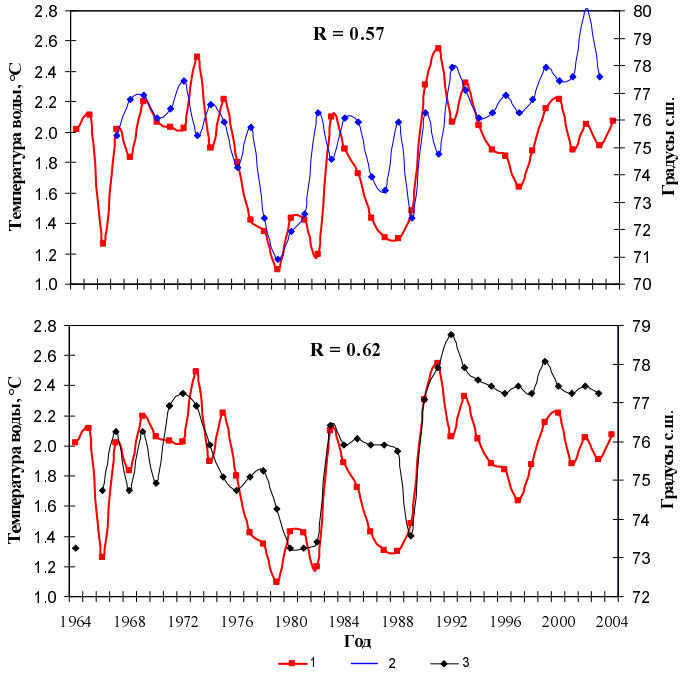

Fig.4 Average water temperature in the northern branch of the North Cape Current (Section No.29, St. 7-11) in the 300 m – bottom layer (1) in the first quarter and the northern border of the cod fishery between 25ºE and 35ºE in August (2) and October (3) in 1964-2004

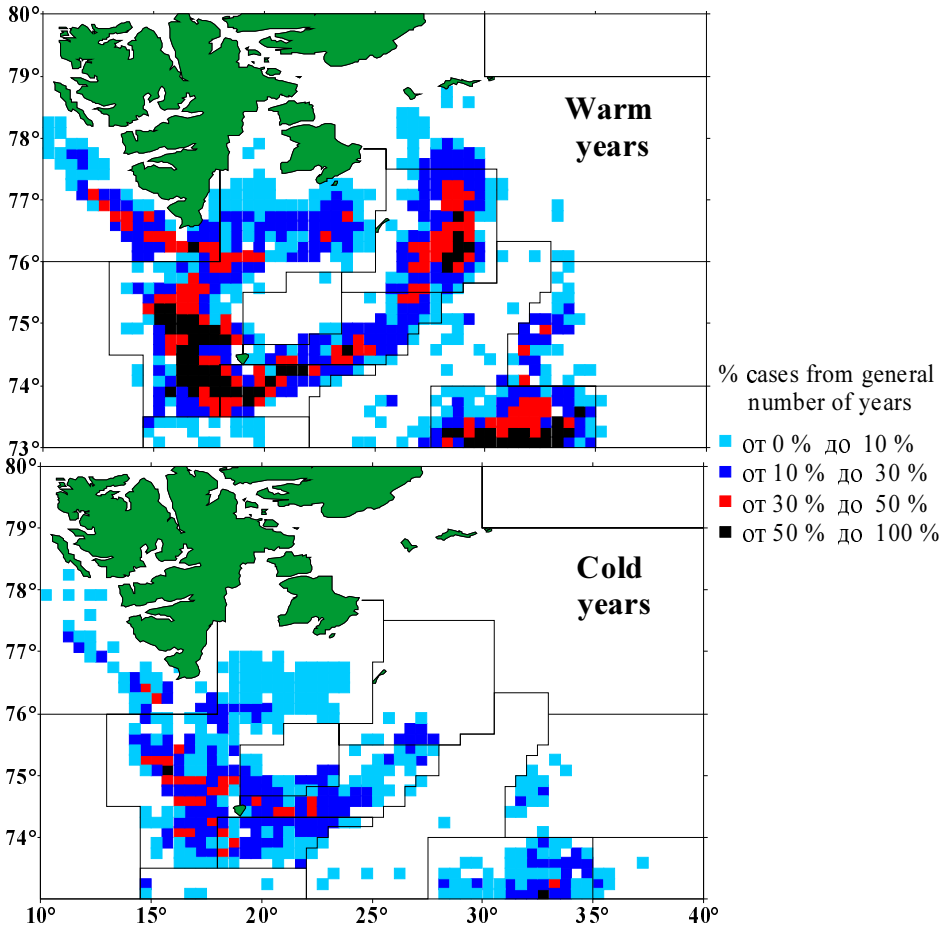

Fig.5 Cod fishery by fishing squares (% of cases from the total number of years) in the Bear Island-Spitsbergen area, in October 1967-2003: in the warm and cold years. (classification of years by temperature was made by Section No.29)

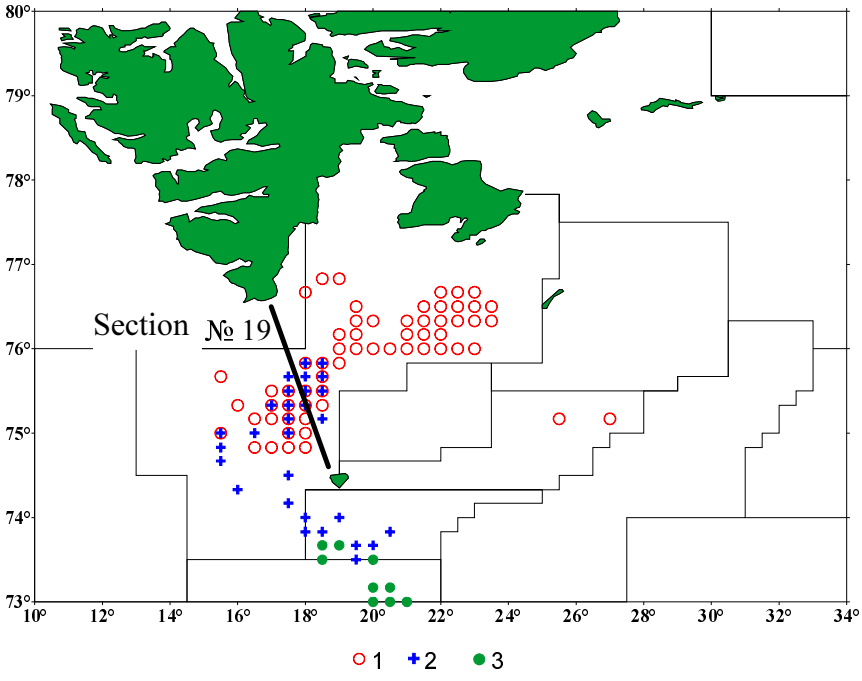

Fig.6 Distribution of cod fishery in the third ten day period of October (1) and the first (2) and second (3) ten day periods of November 1988 and position of Section No.19

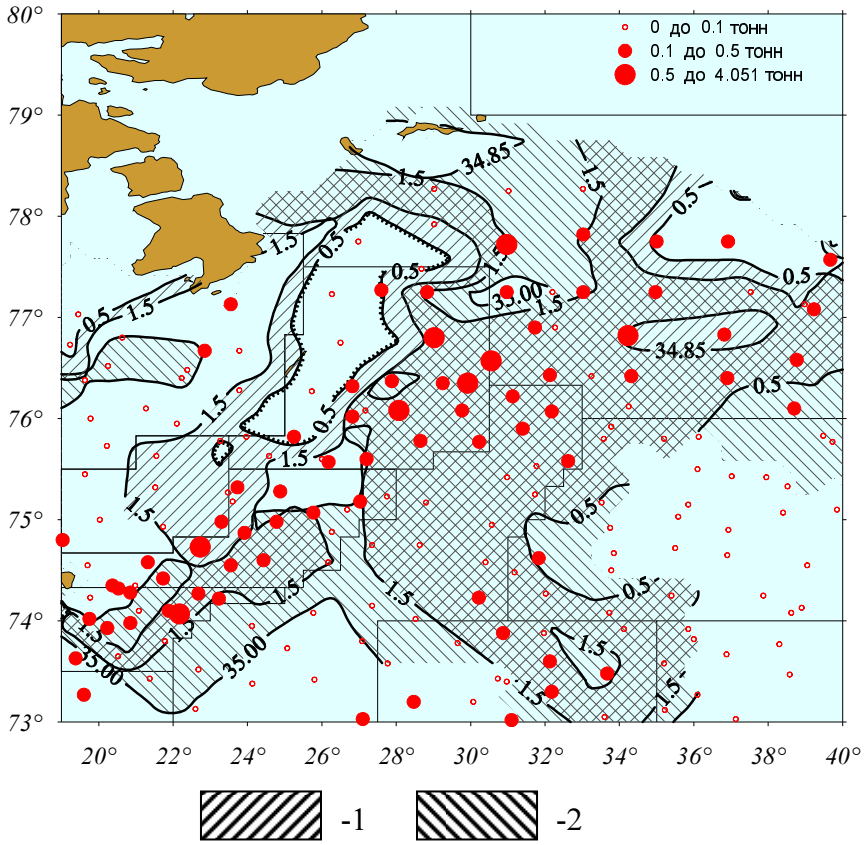

Fig. 7 – Distribution optimal temperature (1), salinity (2) and catch of Cod (dots) on the area of TAS of the Barents Sea demersal fish in October-November 2004.