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The Barents Sea skates: using the fishery-independent surveys for estimation of long-term trends in relative abundance and possible considerations to reduce their bycatch.

by

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PINRO (Murmansk, Russia) has conducted the ecosystem survey together with IMR (Bergen, Norway) since 2004. Unlike all the other surveys this survey covers the whole Barents Sea. Information on many fish species including skates is collected during this survey. These data permitted to estimate long-term trends in abundance and biomass of three abundant skate species *(Amblyraja radiata, A. hyperboreus and Rajella fyllae).* Analysis of influence of skate fishery to their stock dynamics was made. Data from three research bottom surveys, which are annually conducted from August to March in the Barents Sea, were used. Areas with the densest concentrations of different skate species were discovered in this region. Measures for reduction of skate bycatch in bottom trawl fishery in the Barents Sea were developed according to new findings on skate biology and distribution.

Keywords: abundance, Barents Sea, biomass, bycatch, skates, survey.

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Introduction

The eight skate species inhabiting the coastal area of the Barents Sea eco-region are starry ray (or thorny skate) *Amblyraja radiata*, Arctic skate *Amblyraja hyperborea*, round skate *Rajella fyllae*, common skate *Dipturus batis*, spinytail skate *Bathyraja spinicauda*, sailray *Dipturus linteus*, longnose skate *Dipturus oxyrinchus* and shagreen ray *Leucoraja fullonica* (Andriyashev, 1954; Dolgov, 2000; Dolgov *et al.,* 2004b).

Of these eight species, few occur in great abundance, with *A. radiata* as the dominant species, comprising 96% by number of the total number and about 92% by weight of skates caught in surveys or as bycatch. The next most abundant species are the arctic and round skate (3% and 2% by number respectively). The rest of the species are scarce (Dolgov *et al*., 2004b; Drevetnyak *et al*., 2005).

All species may be taken as bycatch in fisheries. Skates are taken as by-catch in fishery for cod, haddock, saithe, Greenland halibut, plaice, and redfish. Since the fishery is conducted on a large scale and all the year round, the catch of skates appears to be significant. Fishers are not interested in the processing of skates due to low prices for skate products and limited market demands. Therefore, almost all skates are discarded (Drevetnyak *et al*., 2005).

The paper aims to estimate long-term trends in the abundance and biomass of three abundant skate species, starry ray *(Amblyraja radiate),* Arctic skate(*A. hyperboreus)* and round skate *(Rajella fyllae)*, to identify the areas of the densest skate concentrations in the Barents Sea and to suggest measures to reduce skate bycatches in bottom trawl fisheries in that area.

Material and Methods

Data for the estimation of abundance and biomass of skates were collected during the joint Norwegian/Russian ecosystem survey of the Barents Sea conducted by the Institute of Marine Research (Bergen, Norway) and the Polar Research Institute (Murmansk, Russia) in 2004-2009 (Anon, 2004; 2005, 2006, 2007, 2009).

The survey covers the entire Barents Sea from the edge of the continental shelf in the west to Novaja Zemlja in the east, from the coast of Norway and Russia in the south to the ice edge in the north. Due to a large variability in ice coverage the northern boundary of the survey varies from year to year, but in the years with little ice the survey extends to the northern edge of the continental shelf at ~80°N. (Fig. 2)

The trawl used in this survey was a Campelen 1800 shrimp trawl with rockhopper ground gear. Trawl settings are described in detail in a separate manual for rigging of trawl and trawl equipment (Enges, 1995). Standard tow duration was 30 minutes.

The number of individuals and biomass per length groups of skate were calculated from bottom trawl catches based on the "swept-area" method.

Length based indices for each trawl station and length, and fish density were estimated as:

$$Ps,l=\frac{fs,l}{as,l}\ ,$$

where:

Ps,l is the number of fish/n.m.^{2} observed at station s (length l)

$f_{s,l}$ is the estimated frequency of length l

as,l is swept area given as

$$as,l=\frac{ds*EWl}{1852}$$

d_s is towed distance (n.m.)

and

EW_l effective swept width set to 25 m, independent of fish length and trawl depth.

Point observations for fish density were based on length (*l) by* 1 cm length groups denoted by $p_{s,l}$. Stratified abundance indices for each length group and strata range were generated using

$$Lp,l=\frac{Ap}{Sp}*\sum Ps,l$$

where:

$L_{p,l}$ is the index for stratum *p*, length group *l*

A_p is the area (n.m.^{2}) of stratum *p*

S_p is the number of stations in stratum *p*

The strata system was constructed based on standard "low areal" WMO squares (World Meteorological Organization squares, 1°x2°). It covers the entire Barents Sea and includes all survey areas. This geographic system is also depth stratified by range: <100, 100-200, 200-300, 300-400, and >400 m (Fig. 3).

The General Bathymetric Chart of the Oceans (GEBCO®) depths data was used.

In the absence of data for a specific depth range in a square, the data for this depth range were averaged for all the eight neighboring squares. Maximum search radius for data extrapolation did not exceed one WMO square.

Fish abundance by 1 cm length groups was estimated for each square and depth range. The abundance of fish was then summarized for each square, with the total fish abundance being derived as a sum of fish in all squares.

Biomass was estimated as a sum of abundance of fish in each 1 cm length interval and mean weight of fish for this length group. To estimate biomass, length-weight keys for 2004-2009 were used (Figs. 4-6).

Distribution of the most abundant species, the starry ray, in the Barents Sea was studied using not only the data from the mentioned survey, but also those from two other surveys, the joint Barents Sea winter survey (2004-2009, February – March) (Aglen *et al.*, 2001) and the Russian autumn survey (2004-2009, October-December) (Lepesevich & Shevelev, 1997; Shevelev *et al.*, 1998). This permitted to monitor the distribution of starry ray in the Barents Sea all the year round.

Results

Estimated abundance of starry ray over the period of research varied from 26 x 10^6 fish in 2005 to 50.7 x 10^6 fish in 2008, and averaged 42.2 x 10^6 fish. Estimated biomass varied between 19,000 and 41,400 tons (average 31,400 tons).

Of the other skate species, the most abundant were Arctic and round skate, with an average abundance of 4.9 x 10^6 and 3.1 x 10^6 fish, and an average biomass of 5,300 tons and 700 tons respectively.

Overall, thorny skate was the most abundant of all skate species and constituted 86 % of catch in number and 84 % by weight.

The three surveys have shown starry ray to be distributed throughout the entire Barents Sea, except its northeastern part, all the year round (Figs. 7-9). The distribution of starry ray does not vary throughout the year. All the year round, the densest concentrations of starry ray were found in the three areas, the first one being the Skolpen Bank, the second one, the central Barents Sea between the Bear Island Channel and the Central Bank, and the third one, the Svalbard Bank.

Discussion

Abundance and biomass indices of skates for 2004-2009 were found to be lower than in 1997-2003. In particular, long term mean abundance and biomass of starry ray in 1993-2003 were estimated as 142 x 10^6 fish and 98 000 tonnes respectively (Drevetnyak *et al*., 2005), while the estimates for 2004-2009 were 42 x 10^6 specimens and 31,000 tonnes. However, we do not relate lower abundance and biomass indices in 2004-2009 to the reduction in skate stocks. The difference is caused by different methods of abundance calculation. We assume the calculations presented in this study to be more precise. In particular, when calculating the indices for 1997-2003, one or several large catches of skate taken in a small part of the study area may have resulted in the overestimation of skate abundance in that area.

Knowing the abundance estimates and catch of skates, we can estimate the harvesting pressure. With thorny skate being taken as an example, its fishing mortality F was calculated as 0.05, given that the abundance of that species in 2004-2009 was estimated as 31,000 tonnes (Table 1) and catch in 1996-2003, as 1,400 tonnes (Drevetnyak *et al*., 2005). The current fishing pressure, being below the natural mortality of thorny skate (M=0.22) (Frisk *et al.,* 2005) will not cause a reduction of this stock in the Barents Sea.

It should be borne in mind that skates in the Barents Sea and adjacent waters are taken only as bycatch in the fishery for gadoid species. The fishery for skates in the area that may begin in future will involve the development of management measures to conserve those stocks. Those measures can be as follows:

a) Using of pelagic trawls in the fishery for gadoid species (cod, haddock, saithe) in the Barents Sea

There is an international concern as to how bottom trawling activities affect benthic communities and non-commercial fish species. The use of pelagic trawls will considerably reduce bycatch of skates. Norwegian and Russian scientists are now considering the possibilities of switching fishing effort in the Barents Sea from bottom to pelagic trawling.

b) Closure of areas with the densest concentrations of skates

This paper contains the preliminary results of investigations in the areas of the densest concentration of skates. Fishing fleet activity in those areas should be analysed. This will help identify the areas of skate distribution, the closure of which will be the least detrimental to the fishery for gadoids. There are several areas of the REZ that are already fully or seasonally closed for bottom fishery due to high bycatches of juvenile cod and haddock or red king crab (Fig.). A part of the area with dense skate concentrations on the Skolpen Bank falls within the mentioned closed areas (Fig.). This means that, even now, a part of skate population is not affected by bottom trawling.

c) closure of nursery sites for bottom trawling

Oviparous species such as skates (Rajidae) use nursery areas for egg deposition, embryo development, and hatching (Hitz, 1964; Hoff, 2007). The embryonic developmental period is unknown for most species of skates, but evidence indicates that it may exceed one year for temperate and deepwater species (Berestovskii, 1994). Therefore, there is a need to carry out studies on the delineation of nursery areas for skates in the Barents Sea and to close those areas for bottom trawl fishery, which will considerably reduce mortality of egg capsules of skates caused by bottom trawling.

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Table 1. Estimated abundance (x 10^6 fish) and biomass (x 10^3 t) of various skate species in the Barents Sea in 2004-2009

Species		Year						Average
		2004	2005	2006	2007	2008	2009	
Starry ray	Abundance	49.6	26.0	34.9	43.6	50.7	48.1	42.2
	Biomass	31.0	19.4	26.5	32.6	41.1	37.7	31.4
Round skate	Abundance	0.5	2.3	7.2	2.6	4.0	1.9	3.1
	Biomass	0.14	0.15	2.1	0.40	0.99	0.31	0.70
Arctic skate	Abundance	3.1	1.8	4.4	5.1	8.3	6.7	4.9
	Biomass	2.1	1.5	4.5	5.2	8.6	9.5	5.3

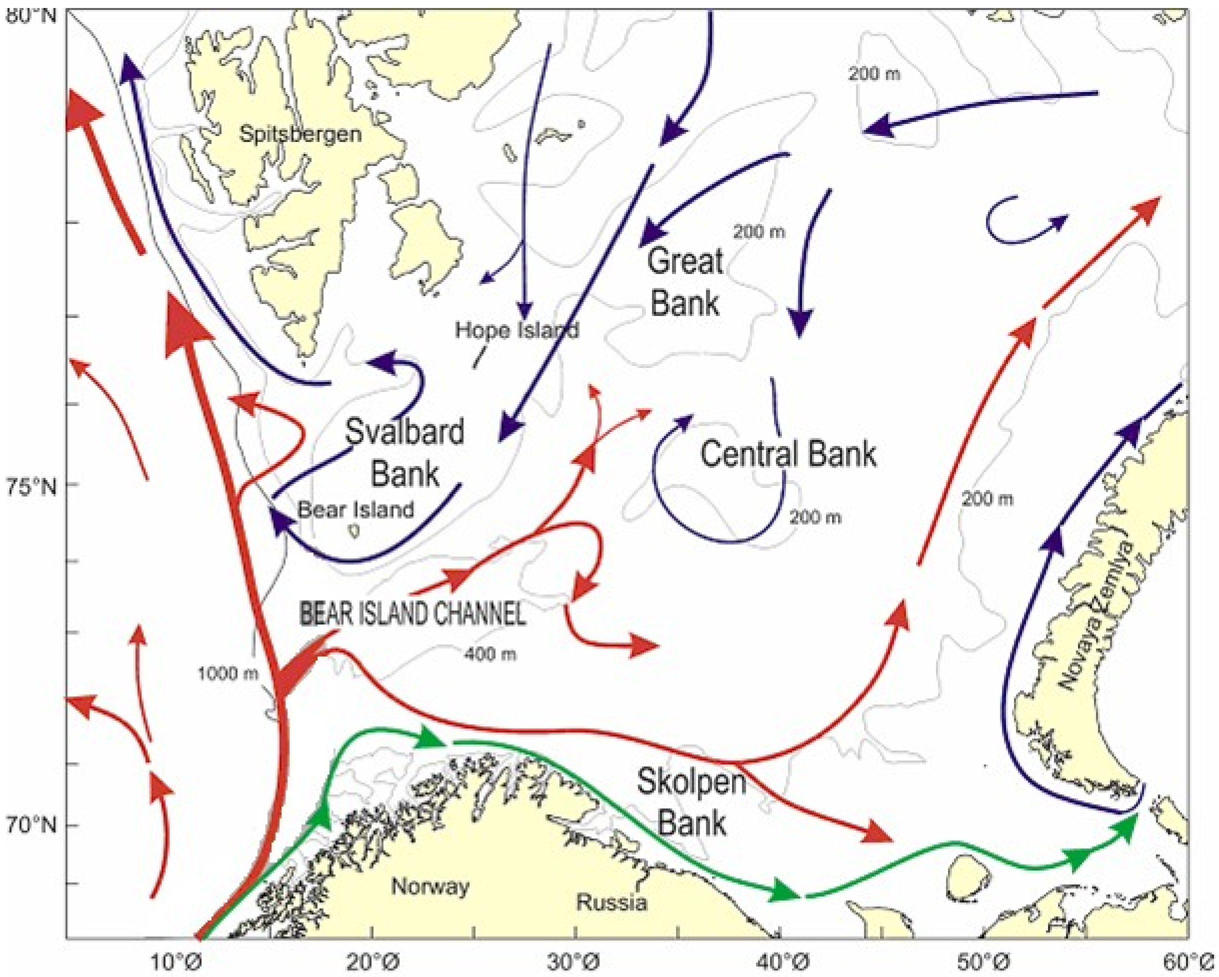

Fig. 1. The Barents Sea and dominating prevalent current systems. Red (Atlantic water) and green arrows (coastal water) – warm, dark blue – cold currents.

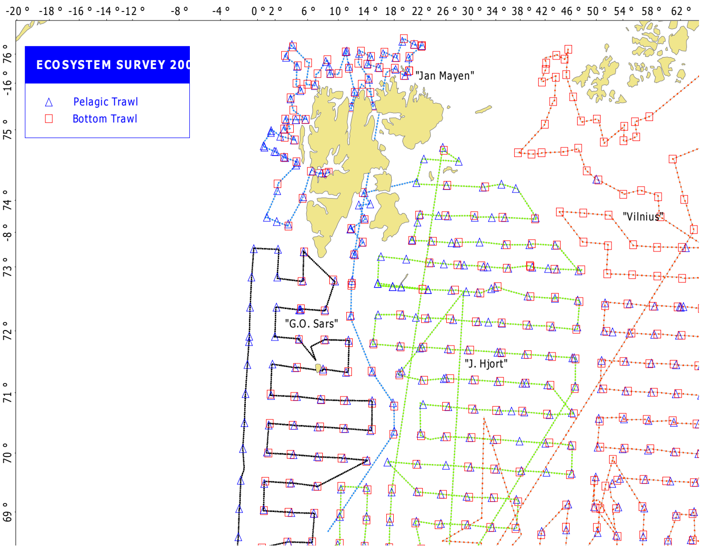

Fig. 2. Positions of trawl stations during the annual joint Norwegian/Russian ecosystem survey in the Barents Sea, August-October 2009.

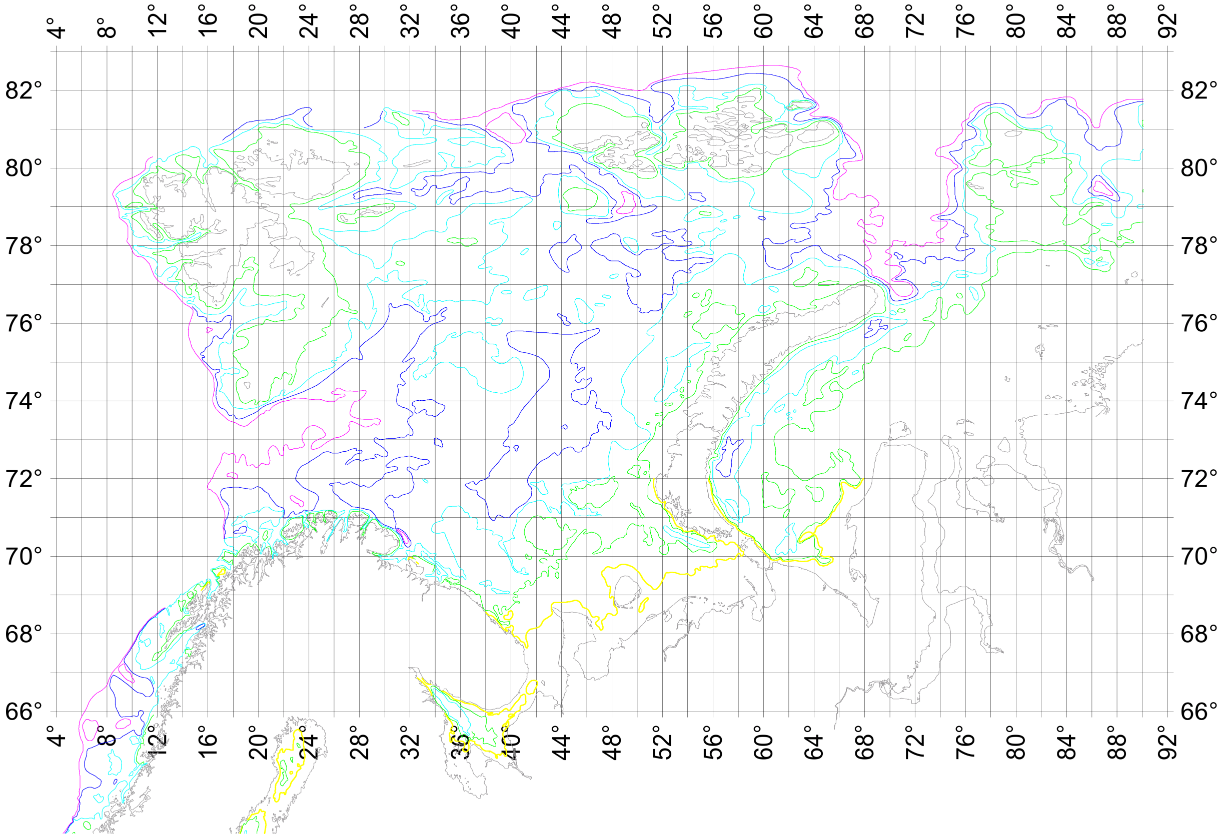

Fig. 3. The system of WMO depth-stratified squares

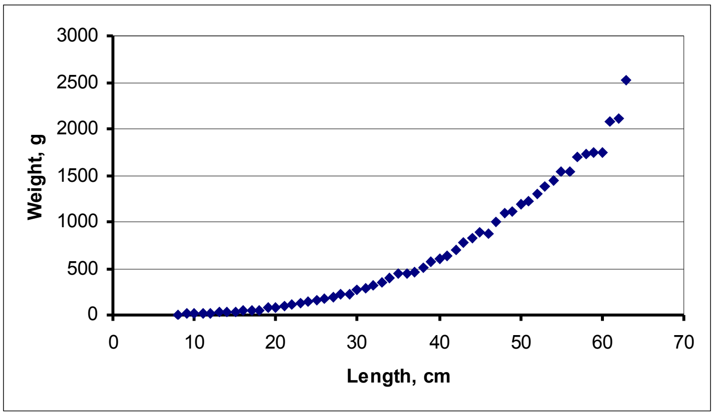

Fig. 4. Mean weight at length of **starry ray** (observed data from ecosystem surveys 2004-2009)

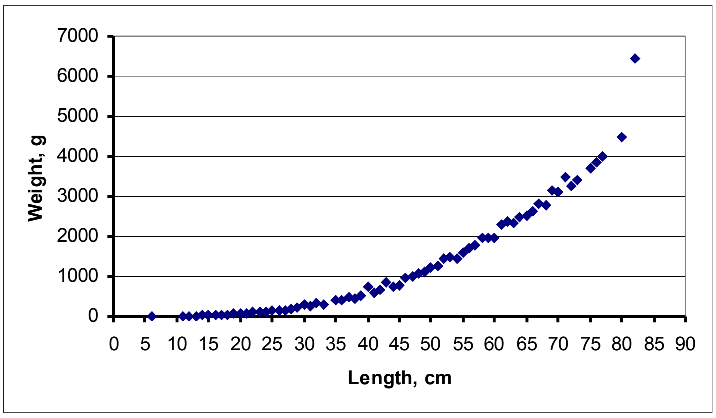

Fig. 5. Mean weight at length of **arctic skate** (observed data from ecosystem surveys 2004-2009)

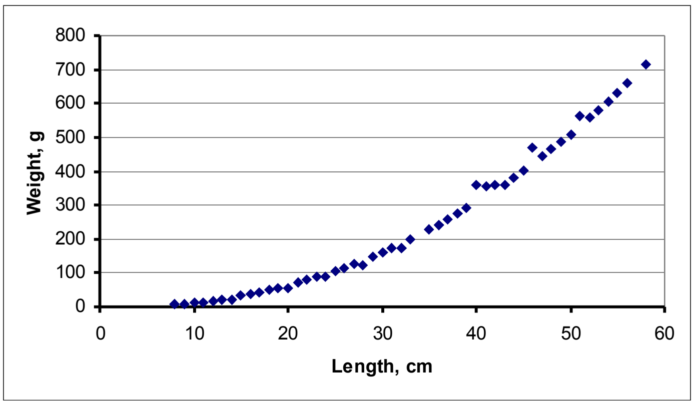

Fig. 6. Mean weight at length of **round skate** (observed data from ecosystem surveys 2004-2009)

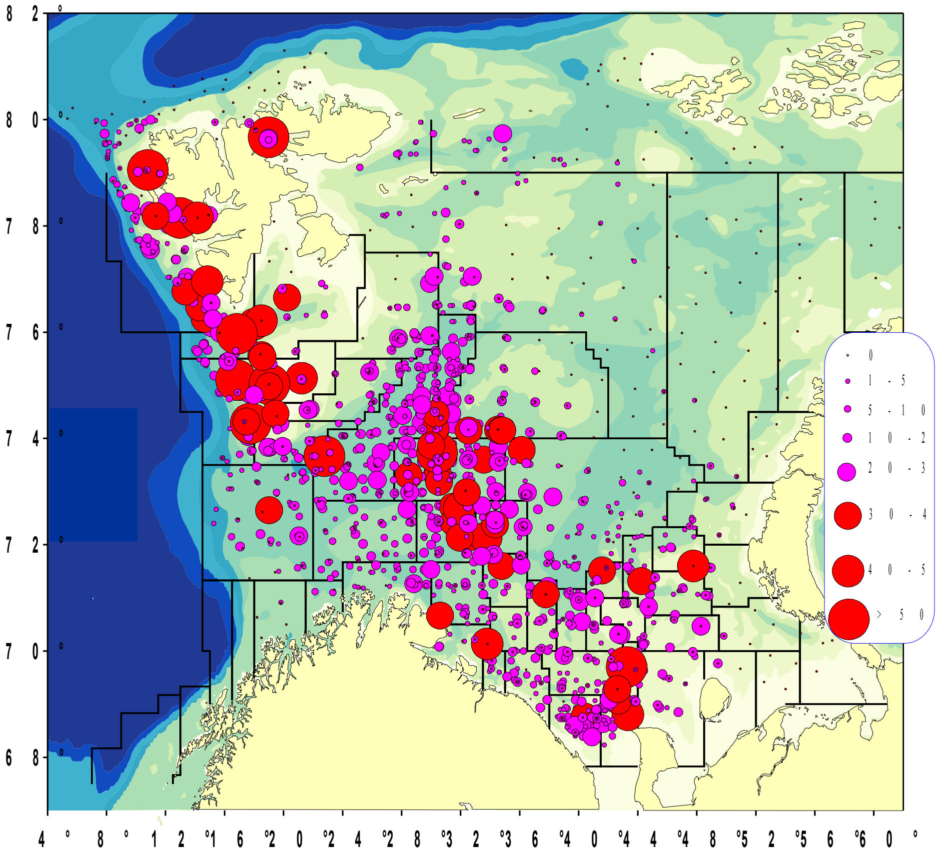

Fig. 7. Starry ray. Distribution in trawl catches (number per hour trawling)
(Joint ecosystem survey August-October 2004-2009)

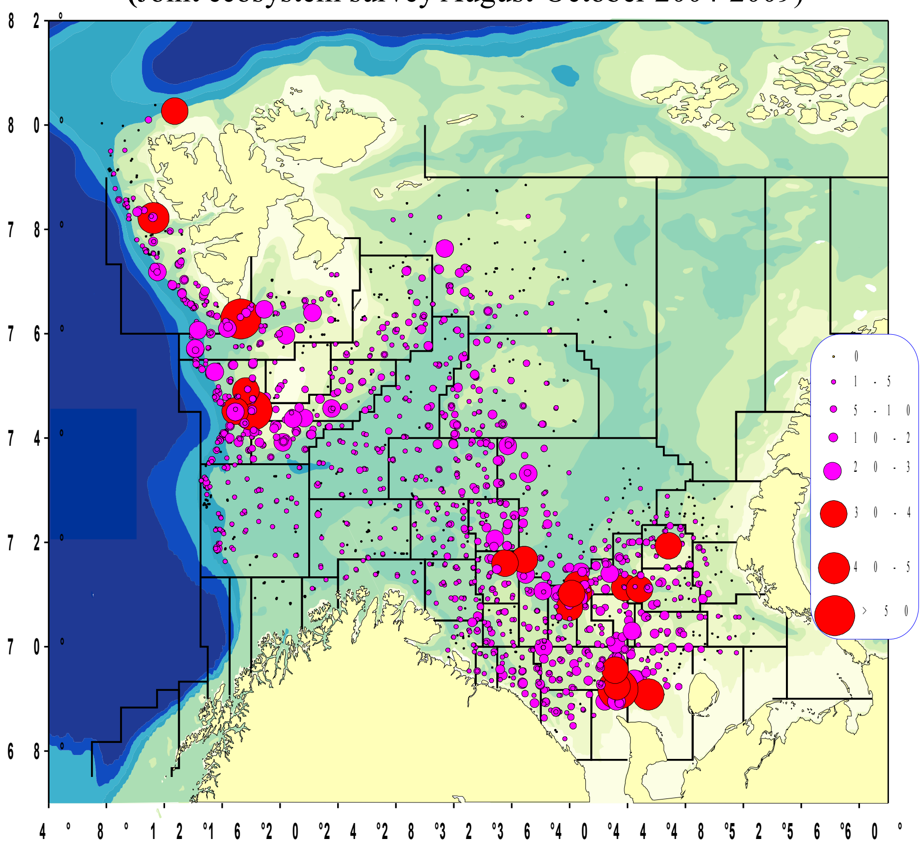

Fig. 8. Starry ray. Distribution in trawl catches (number per hour trawling)
(Russian autumn survey October-December 2004-2009)

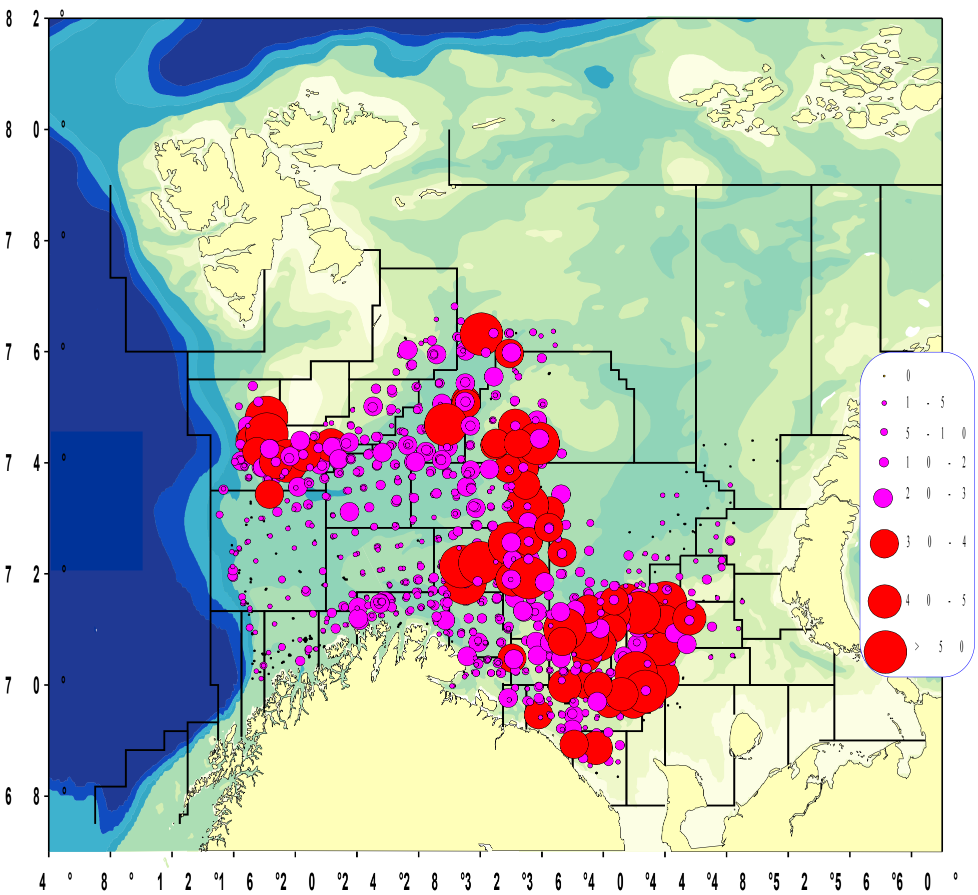

Fig. 9. Starry ray. Distribution in trawl catches (number per hour trawling)
Joint Barents Sea winter survey (February – March 2004-2009)

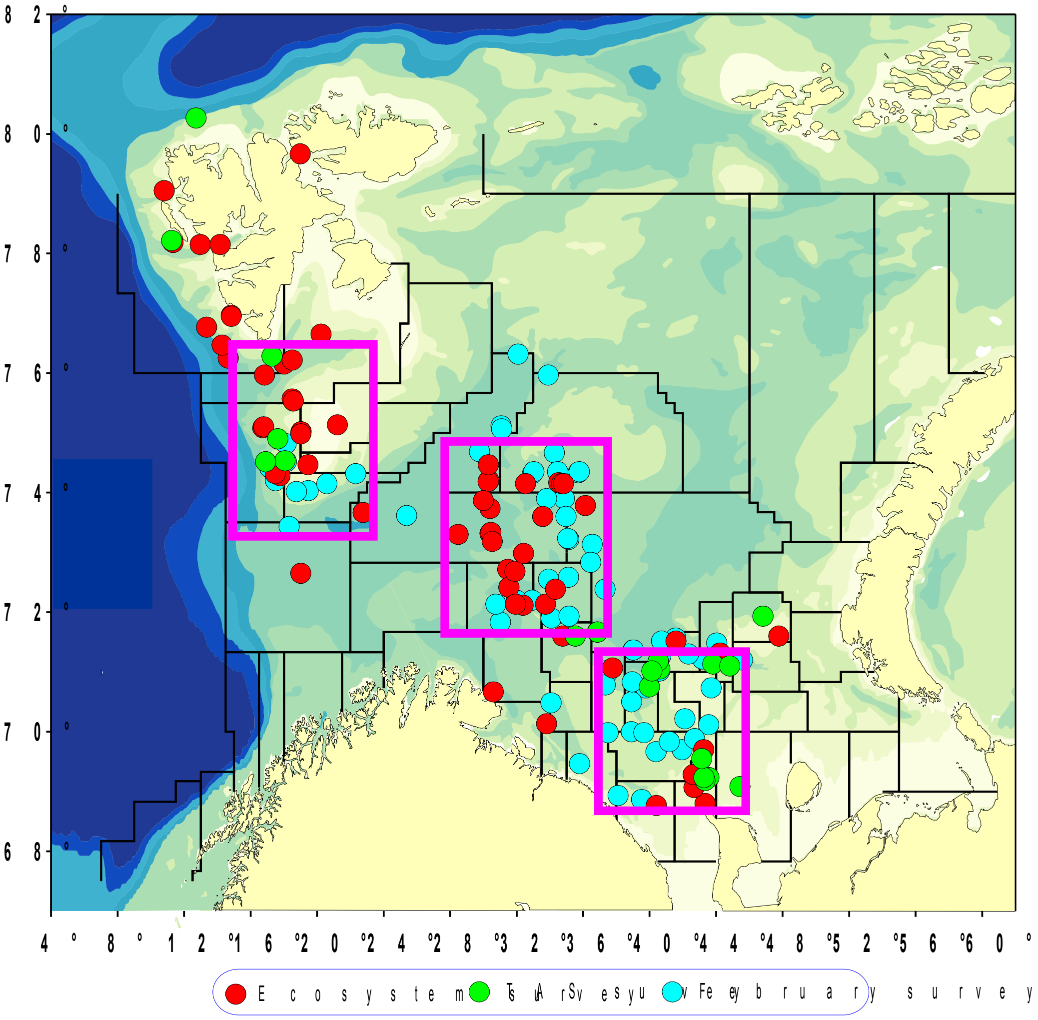

Fig. 10. Starry ray. **Maximal catch areas** (≥30 fish per hour trawling) by the data from 3 surveys, 2004-2009

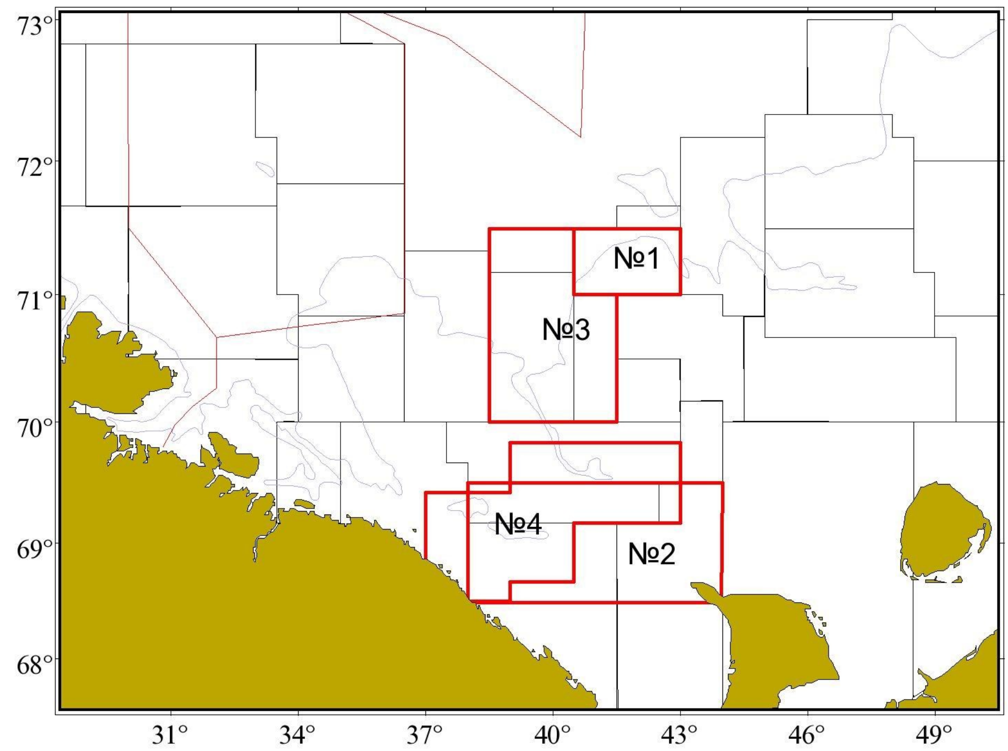

Fig. 11. Areas of the Russian EEZ closed for bottom trawling

1-4 – all year round
2- from 1 January to 30 June
3 – from 1 January to 15 April

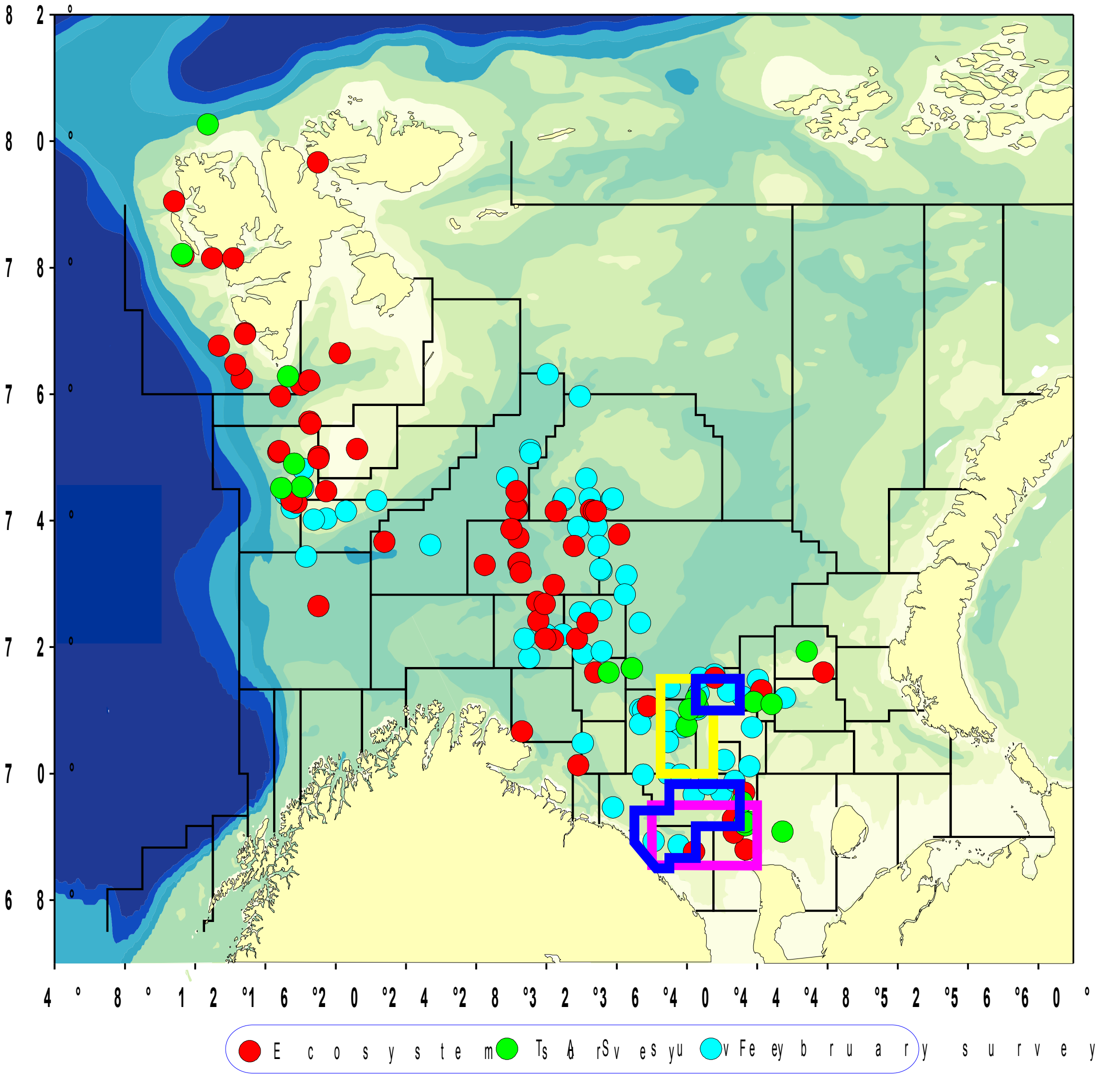

Fig. 12. Starry ray. **Maximal catch areas** (≥30 fish per hour trawling) shown with respect to areas closed for bottom trawling