

# **Basis of methodology of fishers-ecological monitoring and new approaches to stock and estimation of living marine resources**

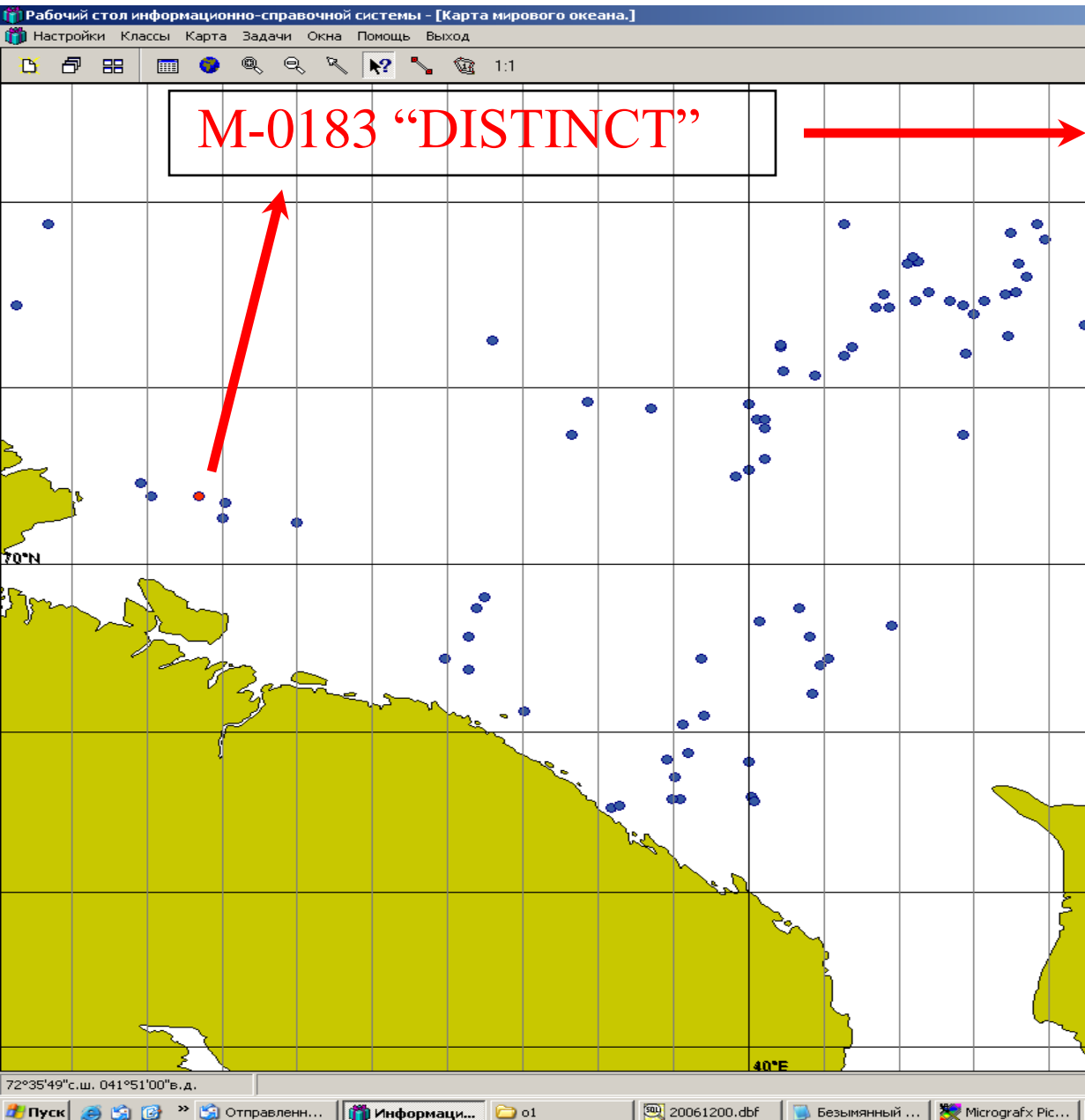
## **Purpose of work:**

***«The estimation of a minimum of the cod fishing stock based on data of the FVDR and satellite positioning»***

The purpose of our method is determine the lowest border of cod productivity stock in Barents sea by using daily reports of Russian fishery vessels.

The basic purpose of our researches is compare our quantitative estimation of the lowest border of a cod stock in Barents sea with quantitative estimation of a total cod stock in Barents sea made by ICES and NEAFK.

# Position of ships according to the data of daily reports on 26.12.2006 year.



**Date:** 26.12.2006

**Ship's number:** M-0183

**Coordinates:** 7023N 3243E

**The square of the ship working:** 1405

**Shipowner:** VARIANT

**Type of the ship:** STR

**Total catch:** 27.018т.

**First operation:**

cod: 4.787т.

haddock: 0.870т.

**Second operation:**

cod: 5.310т.

haddock: 0.650т.

coalfish: 0.020т.

**Third operation:**

cod: 3.994т.

haddock: 0.723т.

**Fourth operation:**

cod: 4.785т.

haddock: 0.319т.

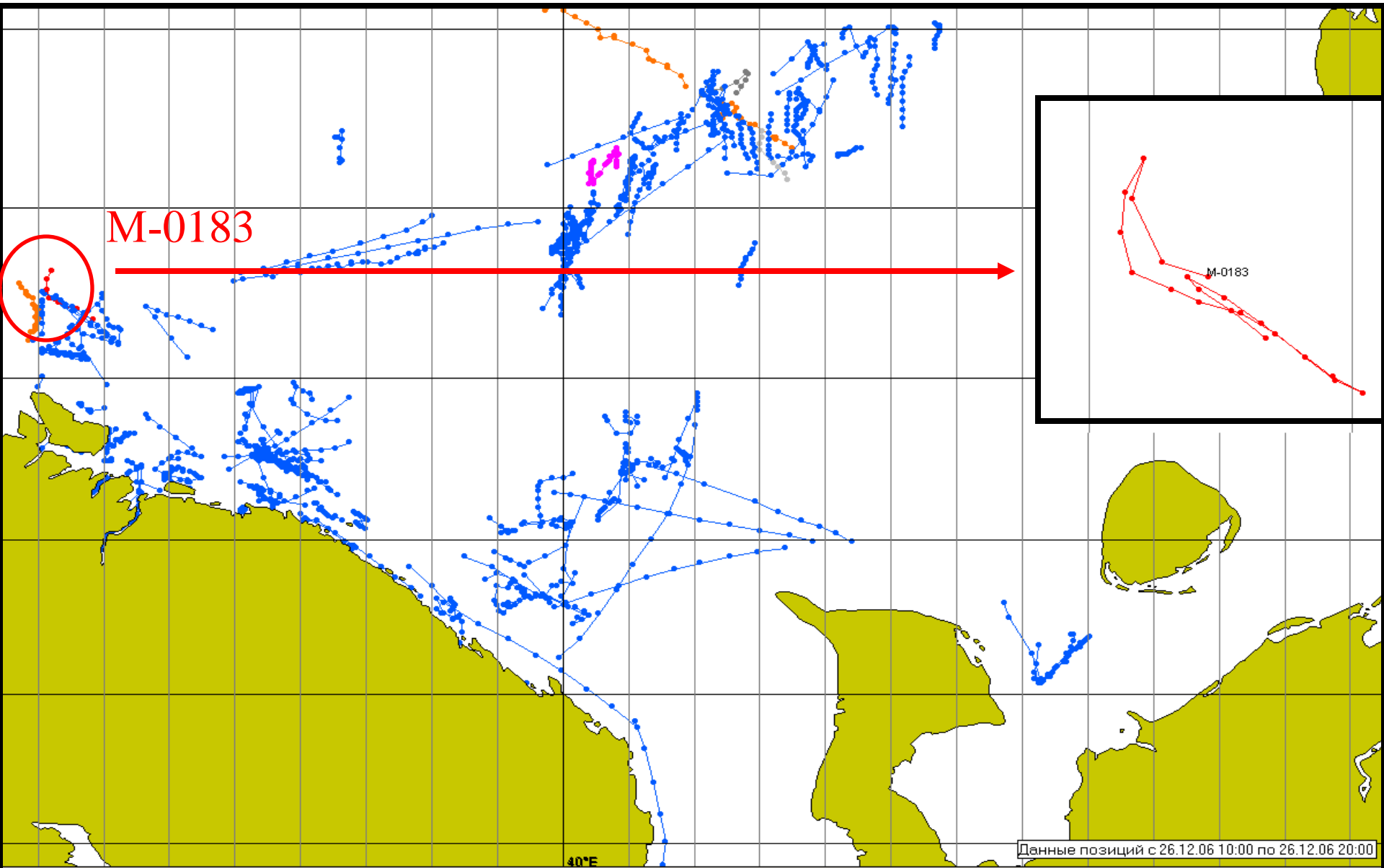
coalfish: 0.037т.

**Fifth operation:**

cod: 5.010т.

haddock: 0.513т.

# Position of ships according to the satellite data on 26.12.2006 year.

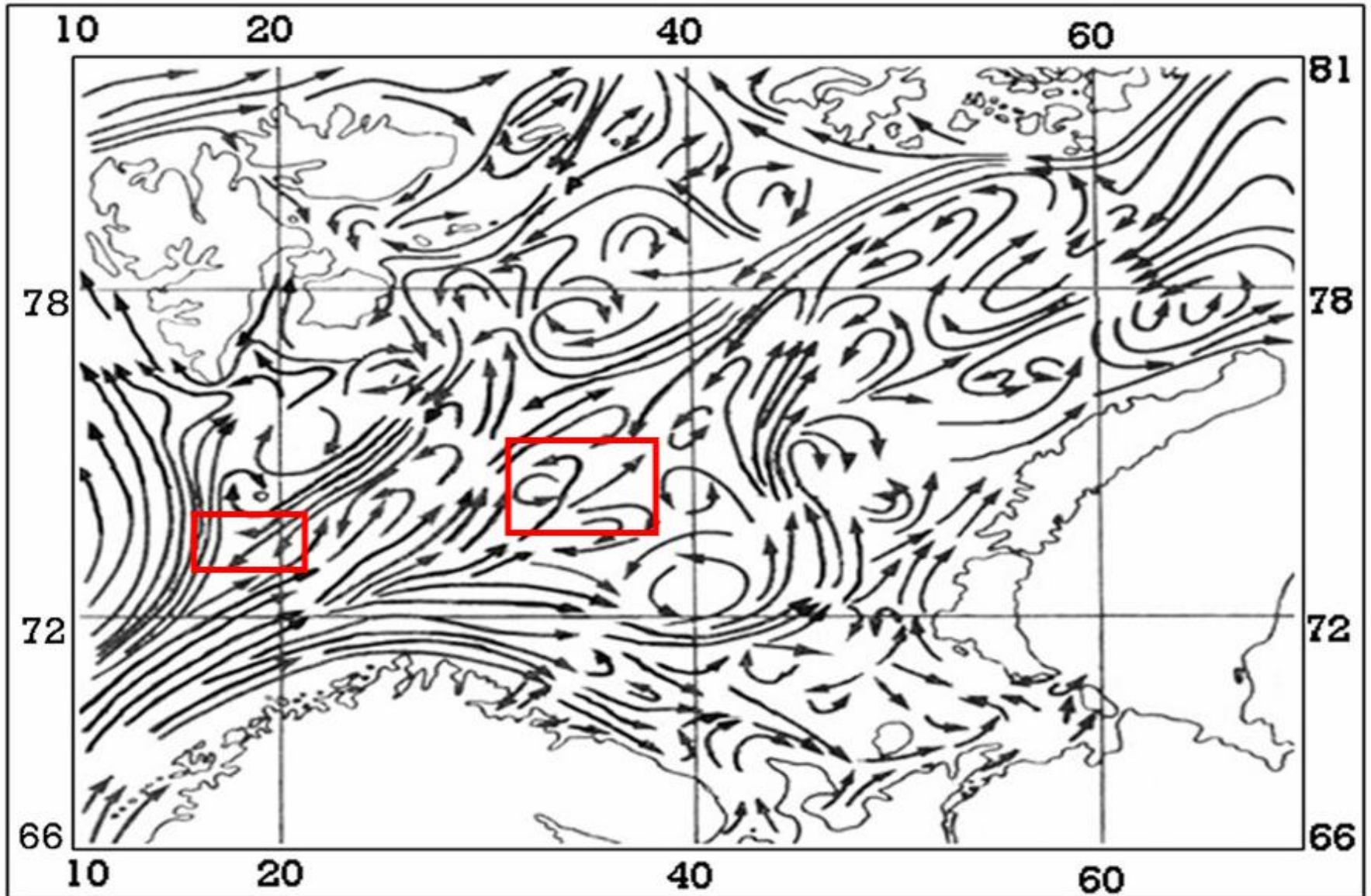


M-0183

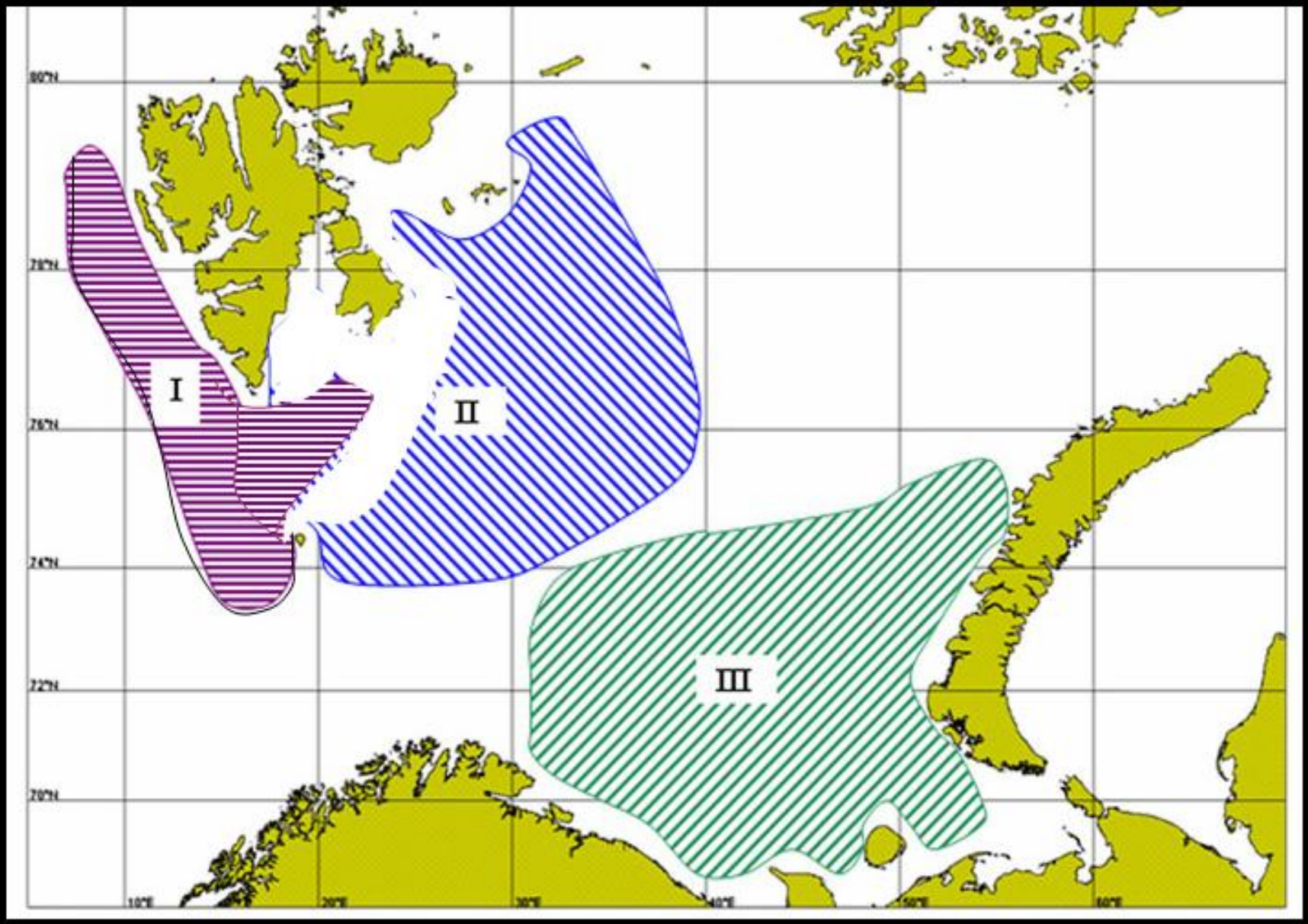
M-0183

Данные позиций с 26.12.06 10:00 по 26.12.06 20:00

# General scheme of the water circulation in the Barents Sea



# Selected areas of the cod distribution in the Barents Sea, March-November



# Filtration of the data.

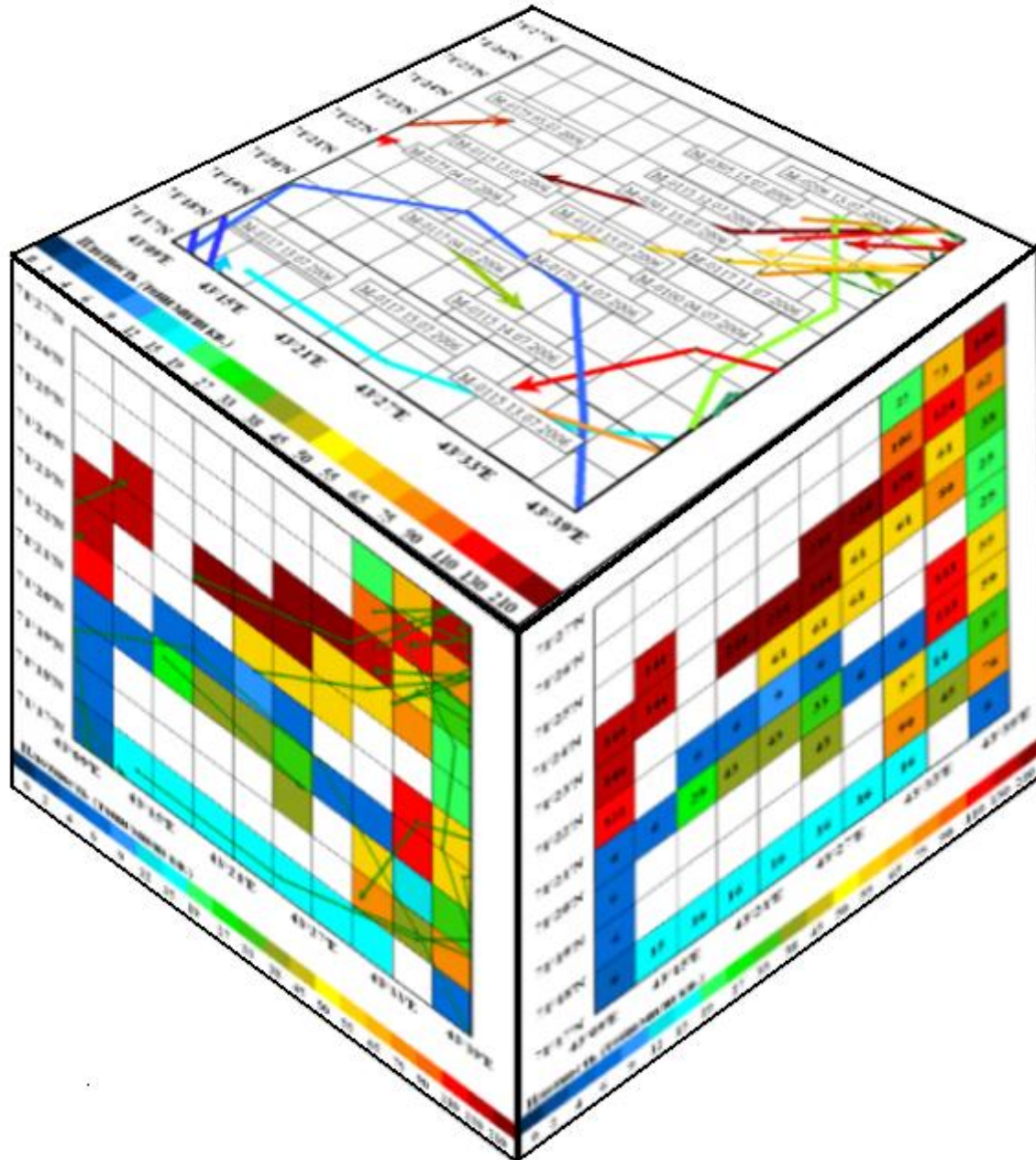
- **Range of speed trawling: 2.5-4 mile / hour.**
- **Minimal time of trawling: 1 hour.**
- **The maximal productivity on 1 trawling operation : 8 t / hour.**

**Table of horizontal width of trawls for various types of fishery vessels.**

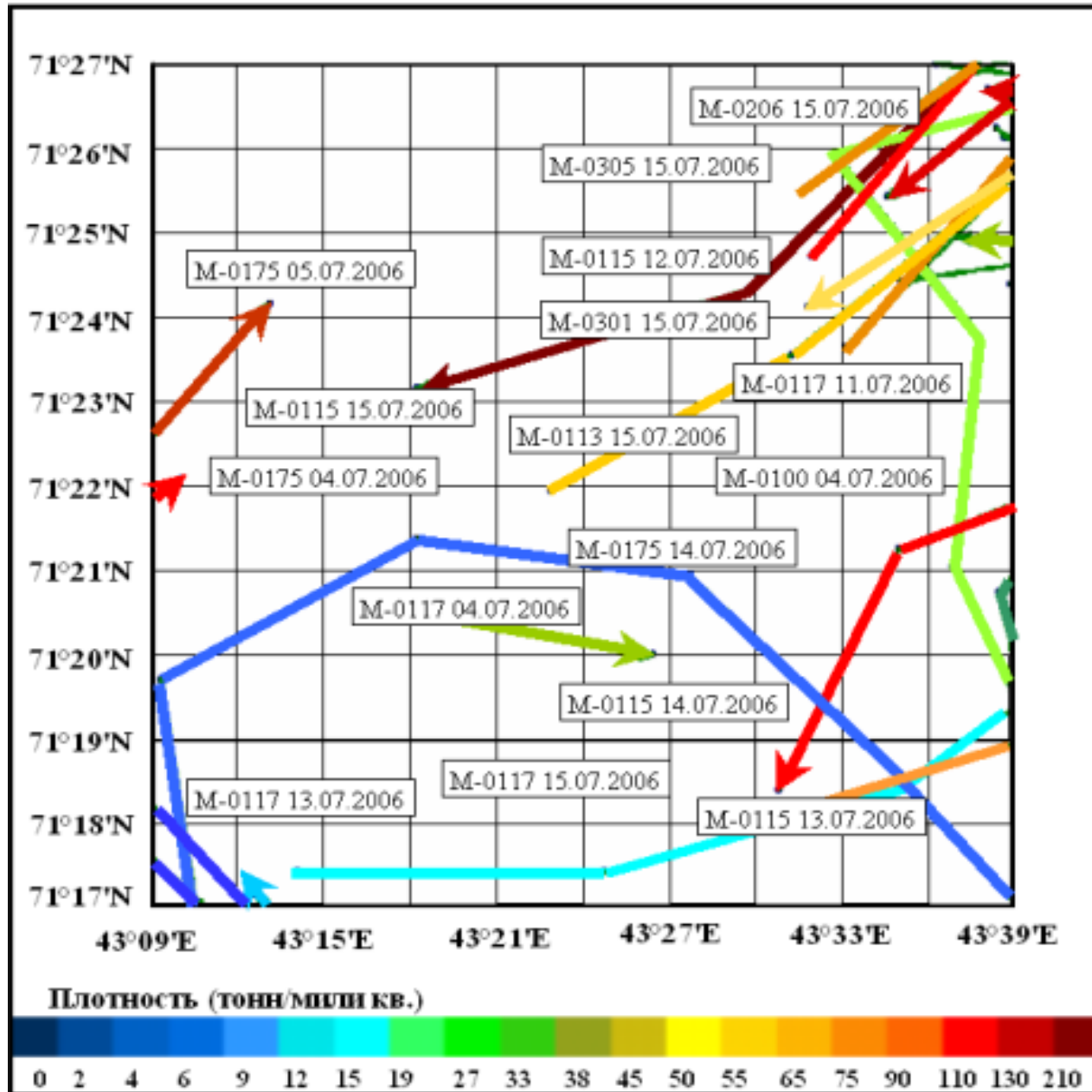
Type of vessel	Horizontal width of trawl, m
MRTK	10
SRTM-K	19
STR	20
PST	30
PSTM	30
STM	30
BMRT other	30
KRTM	60
SRTM-I	90



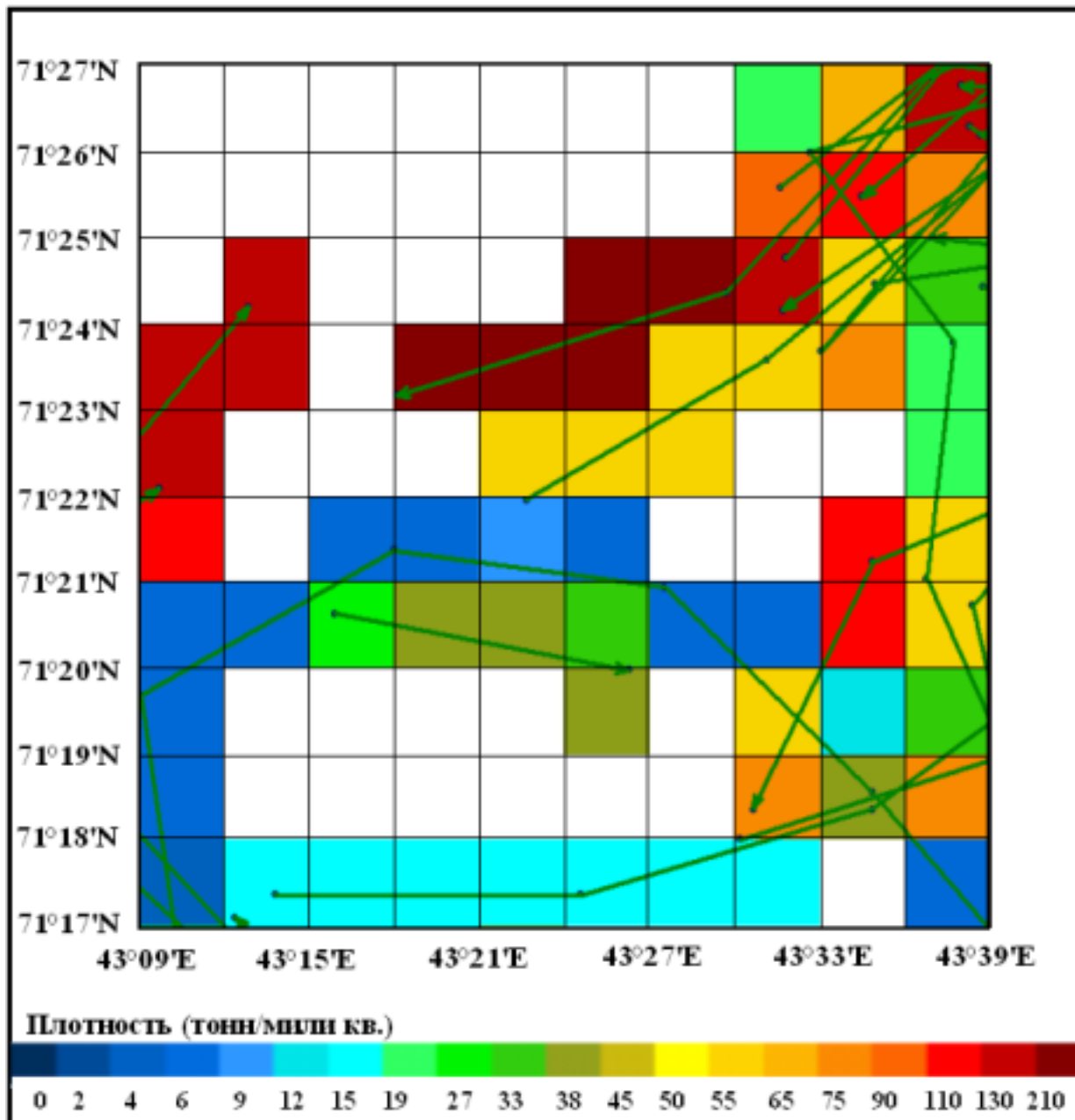
Graphic display of a method of an estimation of a biomass of a cod in Barents sea according to ship daily reports (FVDR) and satellite positioning of fleet



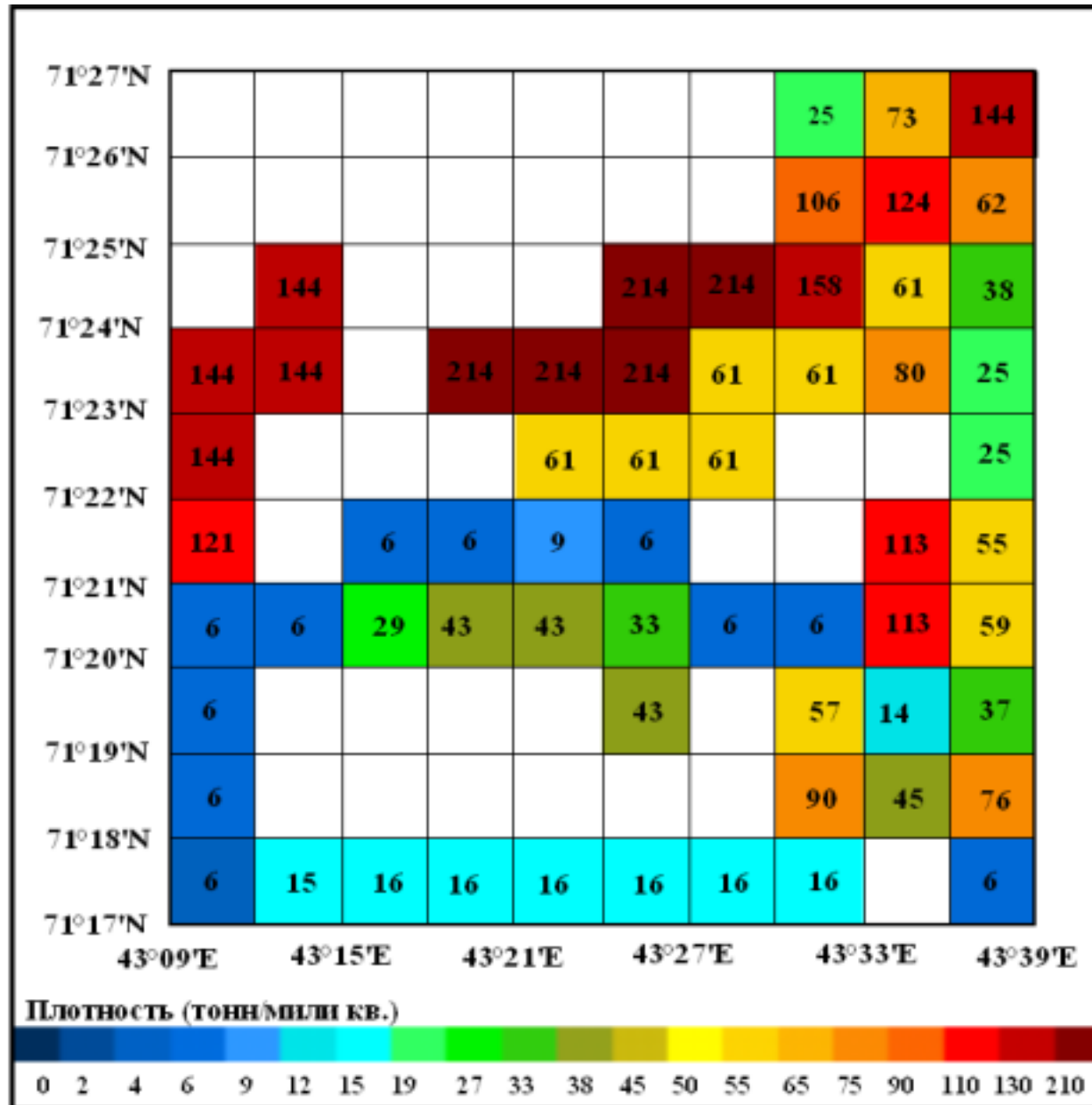
# Trajectories and results of trawlings in a separate fishing square (frag. 1)



# Density of congestions of a cod average-out on one-mile fishing squares (frag. 2)



Distribution of a biomass of a cod in one-mile fishing squares according to daily ship reports (FVDR) and satellite positioning (frag. 3)



## Formula for biomass calculating

1) Trawlings are fragmentary displayed on 1-mile squares, in other words: we determine length of a fragment trawling and its biomass density for each 1-mile square through which passed trawling.

$$\rho_i = \frac{\text{Catch}_{\text{trawling}}}{l_{\text{trawling}} * \text{Width}_{\text{trawling}}}$$

2) We calculate average biomass density for each 1-mile square:

$$\rho_{sq.} = \sum_{i=1}^n \rho_i * \frac{l_i}{\sum_{i=1}^n l_i}, \text{ where } \frac{l_i}{\sum_{i=1}^n l_i} - \text{weight coefficient of each length trawling, in a square.}$$

3) Formula for calculating a biomass in each 1-mile square:

$$f_{sq.} = \frac{\rho_{sq.} * S_{sq.}}{0,27}, \text{ где } S_{sq.} - \text{the area of a 1-mile square (calculated as the area of a trapeze), } 0,27 - \text{coefficient of catchability.}$$

# Algorithm of restoration fields of a biomass density (the method sliding average)

Here, we present the algorithm used to reconstruct the biomass distribution field from the values averaged by a 1-mile square. The mean value for the density field equals:

$$\xi_0 = \sum_{i=1}^n p_i \xi_i, \text{ where } \xi_i \text{ is the element value in each of } n \text{ points,}$$

$$p_i \text{ is the weight of the element, } \sum_{i=1}^n p_i = 1.$$

The weight of each of  $n$  points surrounding the knot is considered to be inversely proportional to the distance between the point and the knot. Consequently, the target value could be derived using the following formula:

$$\xi_0 = \sum_{i=1}^n \frac{\xi_i}{l_i \sum_{i=1}^n 1/l_i^k} = \frac{1}{\sum_{i=1}^n 1/l_i^k} \sum_{i=1}^n \frac{\xi_i}{l_i}, \text{ where } l_i \text{ is the distance between the knot and the measurement points;}$$

$k$  is the exponent of a power from 1 to 3.

The distance between points on the Earth surface is found with the following formula:

$$l_i = R_3 \arccos(\sin \lambda_i \sin \lambda_j + \cos \lambda_i \cos \lambda_j \cos(\varphi_j - \varphi_i)),$$

where  $R_3 = 6371$  km is Earth's radius;

$(\varphi_i, \lambda_i)$  и  $(\varphi_j, \lambda_j)$  are the geographical coordinates of the points (in radians); west longitude and south latitude should be given with the minus (-) sign.

Calculation of a biomass of trade congestions of a cod on three allocated areas, on 10-mile fishing squares (June-August, 2005), th. toons

Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	696 644,2	598 125,5	584 689,0	155 406,2	36 201,2	21 139,8
2	3 003,0	0,0	31 940,2	609 309,0	597 522,4	678 587,3
3	864 128,0	1 038 909,2	1 260 197,4	848 565,8	479 884,5	655 303,6
<b>Total</b>	<b>2 635 428,9</b>					

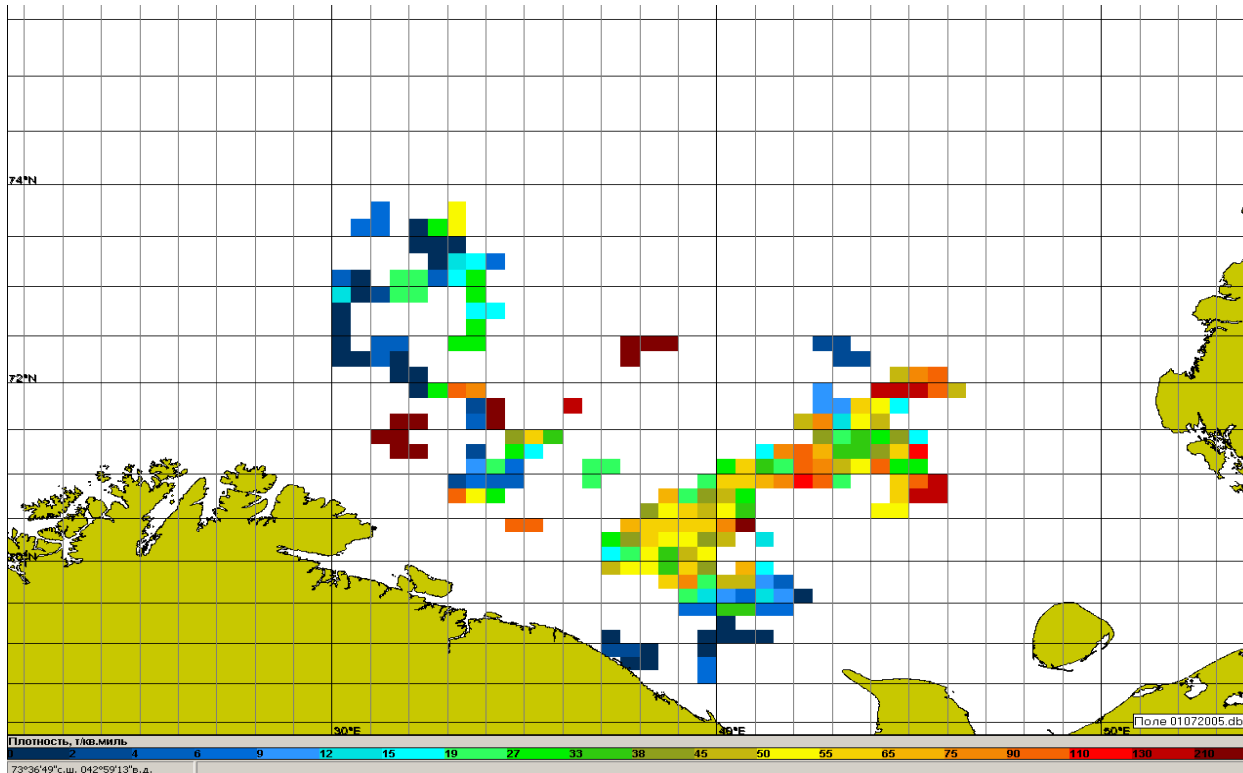


Fig.11. Density of a biomass of the cod, calculated on 10-mile fishing squares in area 3, on July, 1-15st, 2005

Calculation of a biomass of trade congestions of a cod on the restored fields of one-mile fishing squares, with radius of 5 miles (June-August, 2005), th.tonns

Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	585 436,6	531 357,0	544 408,3	126 062,3	16 752,0	16 979,7
2	300,7	0,0	16 322,3	576 874,4	558 189,4	652 170,8
3	813 144,9	869 999,3	1 030 056,9	604 292,0	457 504,9	595 818,9
<b>Total</b>	<b>2 267 664,3</b>					

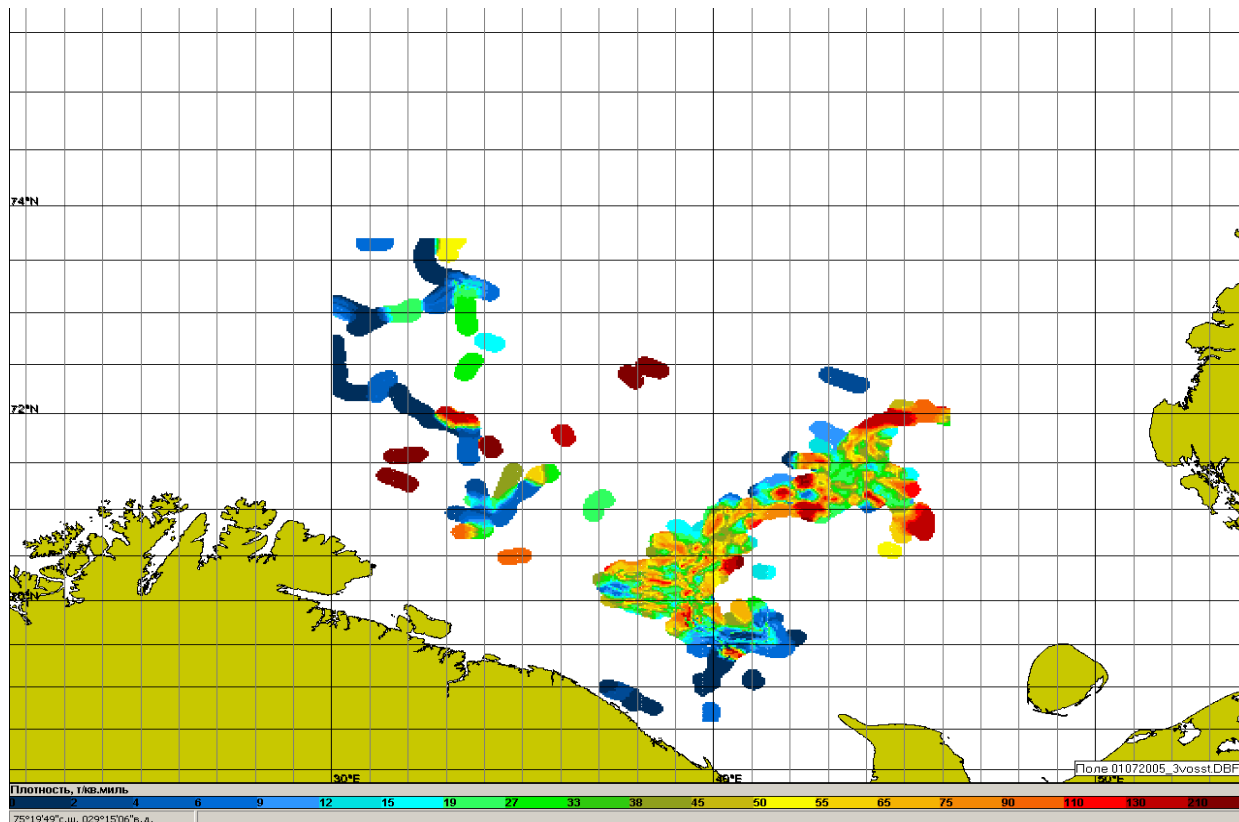
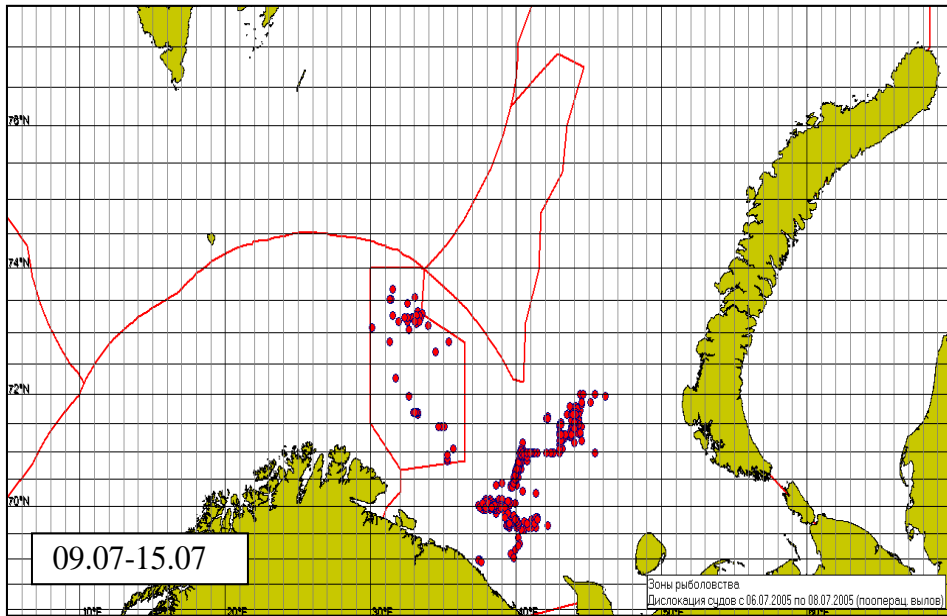
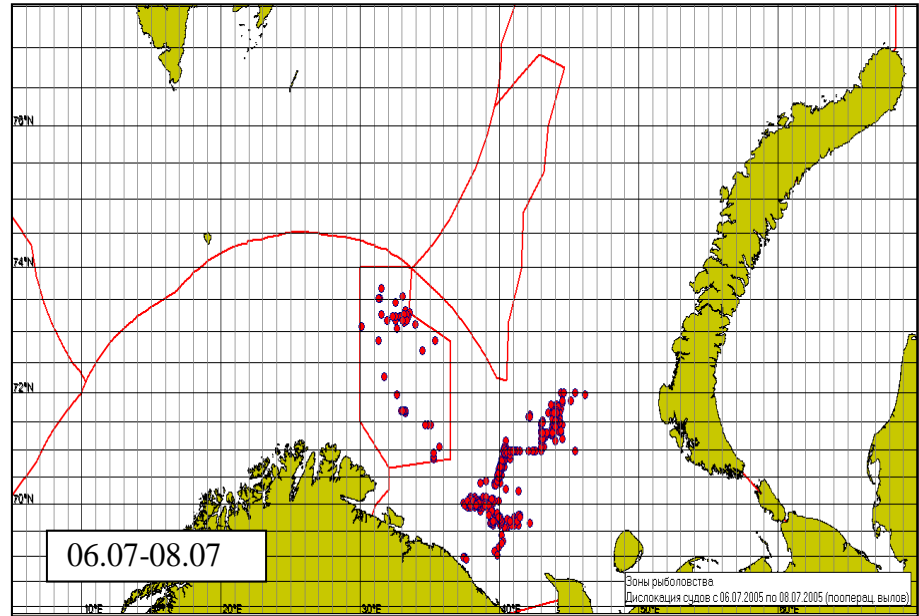
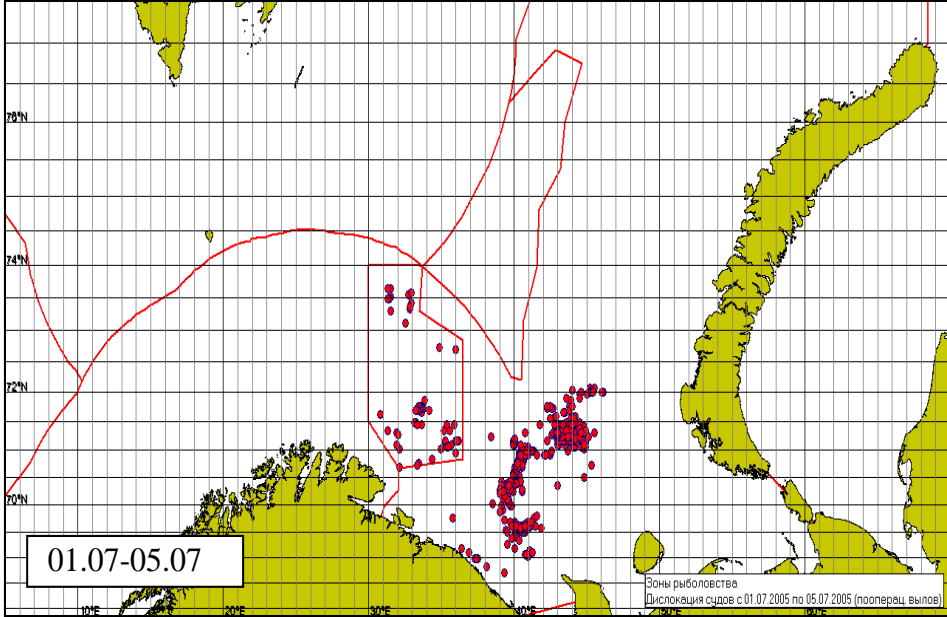
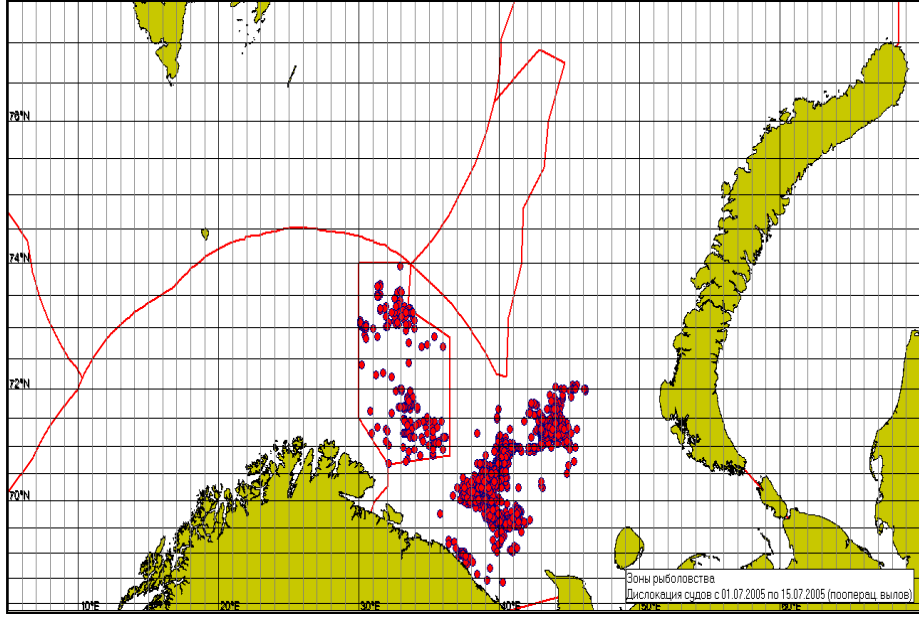


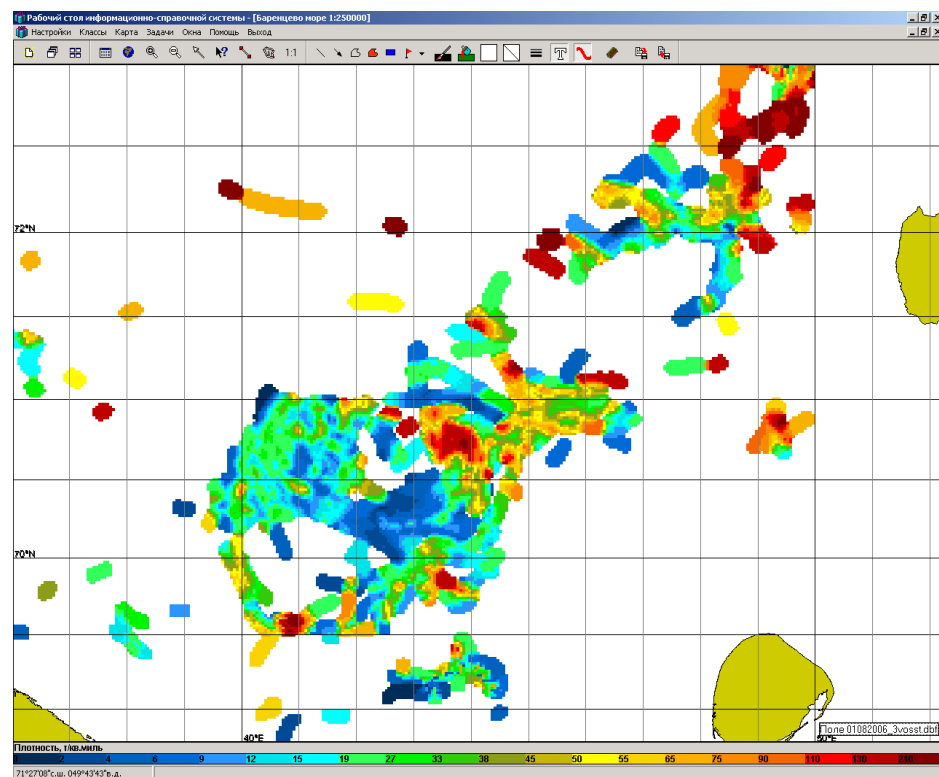
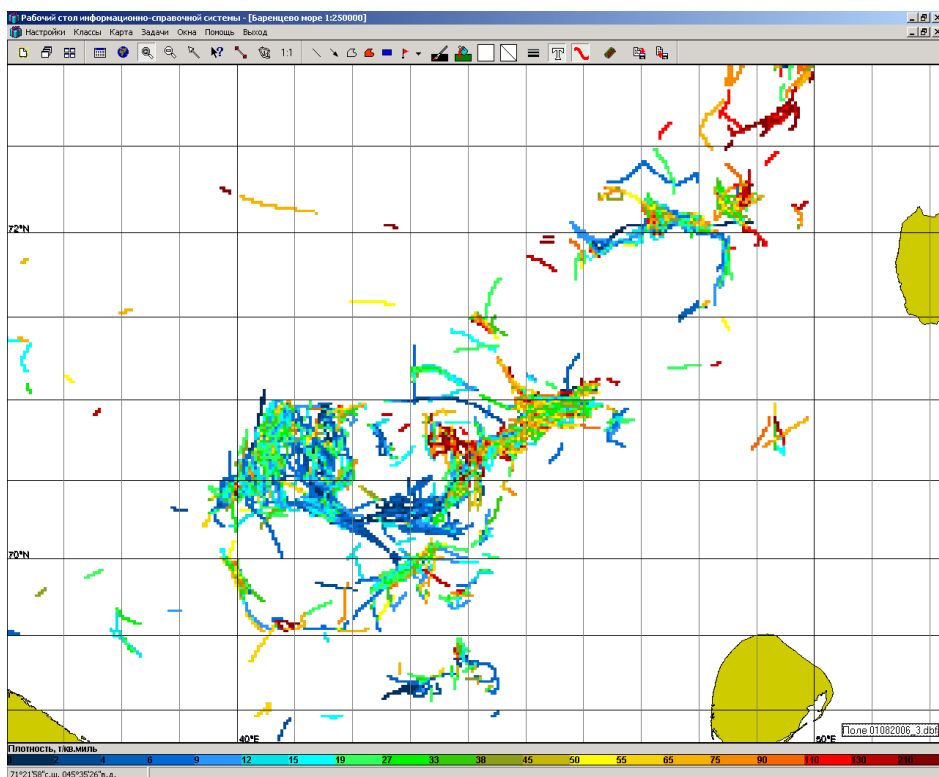
Fig.12. The restored field of density of a biomass of a cod on one-mile fishing squares in area 3, with radius of 5 miles, on July, 1-15st, 2005



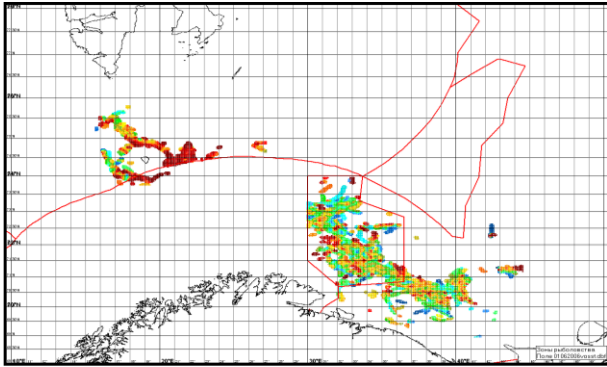


- Fig.6. Dislocation of fleet on fishing of a cod in area 3 on corresponding synoptic periods (a maximum of a biomass, on July, 1-15st, 2005)
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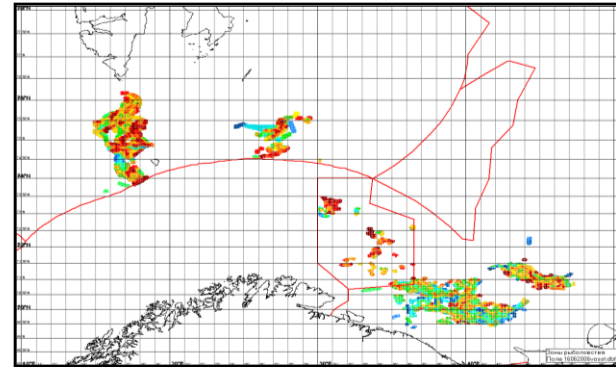
# Fragment of biomass field: initial field and restored field with 3 miles radius for August 2006, 1-15.



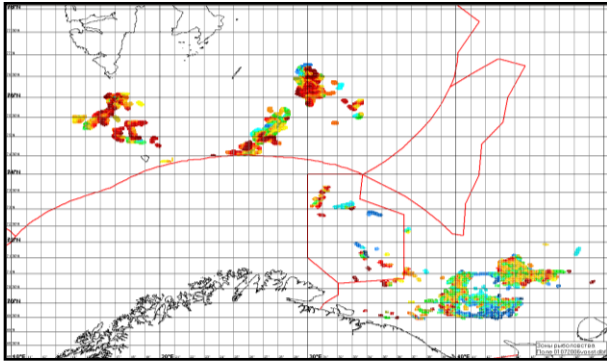
# The restored field of density of a biomass of a cod on one-mile fishing squares with radius of 3 miles, June-August 2006



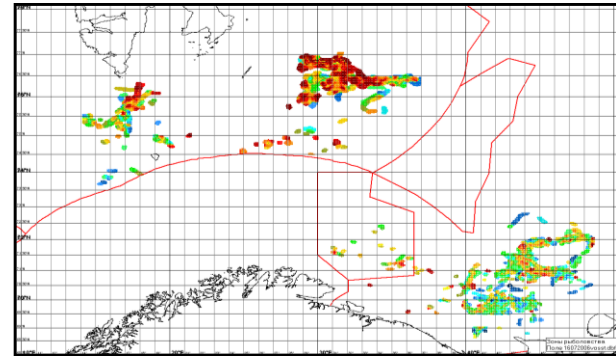
June,1-15



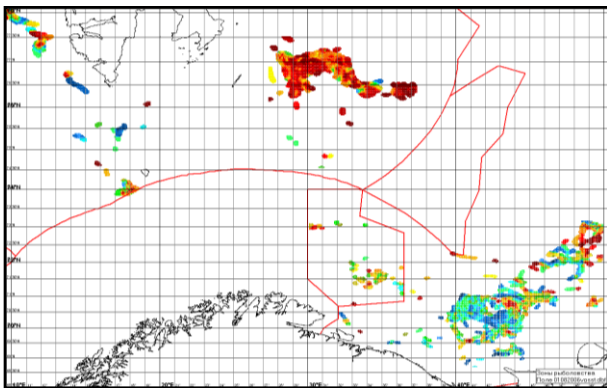
June,16-30



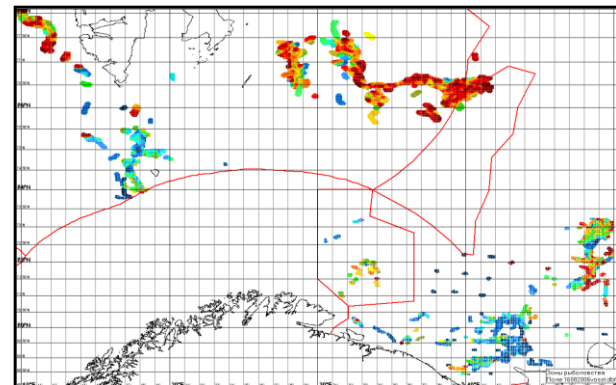
July,1-15



July,16-31



August,1-15



August,16-31



Calculation of a biomass of trade congestions of a cod on the restored fields of one-mile fishing squares, with radius of 3 miles, th.tonns, coefficient of catchability 0,27

Summer, 2003						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	342 398,8	187 318,0	81 369,3	48 562,3	17 254,1	30 973,8
2	10 201,1	5 849,3	0,0	0,0	16 114,1	107 316,8
3	1 123 833,3	1 669 357,6	917 635,8	761 967,2	802 091,6	685 404,6
<b>Total</b>	<b>2 119 073,2</b>					
Summer, 2004						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	160 772,9	108 154,6	126 420,3	391 745,6	220 308,7	217 941,5
2	1 311,6	14 470,5	63 978,5	125 141,6	301 679,2	526 492,3
3	1 047 259,6	1 294 386,9	1 271 085,4	850 096,1	572 385,2	510 812,4
<b>Total</b>	<b>2 212 624,8</b>					
Summer, 2005						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	521 764,8	476 021,3	526 098,6	148 900,8	34 517,0	73 177,1
2	2 710,5	4 972,7	64 815,9	573 629,6	542 575,9	803 191,1
3	1 028 810,3	934 774,6	812 607,8	492 709,8	498 199,1	581 041,3
<b>Total</b>	<b>2 353 766,2</b>					
Summer, 2006						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	568 857,4	438 917,4	315 633,7	177 336,9	132 872,1	211 011,8
2	45 227,0	131 322,3	417 052,1	639 366,4	670 302,8	772 863,3
3	1 286 334,3	1 010 730,6	758 145,9	658 814,9	830 673,3	593 414,4
<b>Total</b>	<b>2 628 055,0</b>					

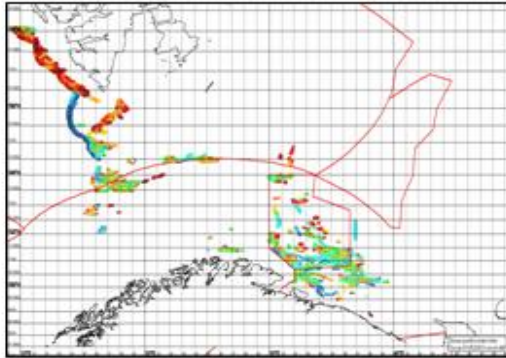
Calculation of a biomass of trade congestions of a cod on the restored fields of one-mile fishing squares, with radius of 3 miles, th.tonns, coefficient of catchability **0,21**

Summer, 2003						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	440 227,0	240 837,4	104 617,7	62 437,2	22 183,8	39 823,4
2	13 115,7	7 520,5	0,0	0,0	20 718,1	137 978,7
3	1 444 928,5	2 146 317,0	1 179 817,5	979 672,1	1 031 260,7	881 234,4
<b>Total</b>	<b>2 724 522,7</b>					
Summer, 2004						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	206 708,0	139 055,9	162 540,4	503 672,9	283 254,1	280 210,5
2	1 686,4	18 605,0	82 258,0	160 896,3	387 873,2	676 918,7
3	1 346 476,7	1 664 211,7	1 634 252,6	1 092 980,6	735 923,8	656 758,9
<b>Total</b>	<b>2 844 803,3</b>					
Summer, 2005						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	670 840,5	612 027,4	676 412,5	191 443,9	44 379,0	94 084,8
2	3 484,9	6 393,5	83 334,7	737 523,8	697 597,6	1 032 674,3
3	1 322 756,1	1 201 853,1	1 044 781,5	633 484,0	640 541,7	747 053,1
<b>Total</b>	<b>3 026 270,8</b>					
Summer, 2006						
Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	731 387,1	564 321,8	405 814,8	228 004,7	170 835,7	271 300,4
2	58 149,0	168 843,0	536 210,3	822 040,5	861 818,4	993 682,9
3	1 653 859,5	1 299 506,6	974 758,2	847 041,5	1 068 009,4	762 962,8
<b>Total</b>	<b>3 378 929,5</b>					

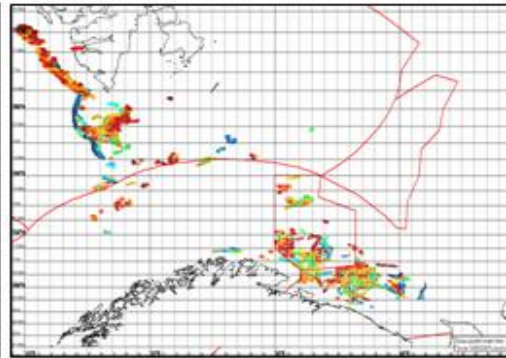
Calculation of a biomass of trade congestions of a cod on the restored fields of one-mile fishing squares, with radius of 3 miles (Summer, 2006), th.tonns

Area	June		July		August	
	01-15	16-30	01-15	16-31	01-15	16-31
1	568 857,4	438 917,4	315 633,7	177 336,9	132 872,1	211 011,8
2	45 227,0	131 322,3	417 052,1	639 366,4	670 302,8	772 863,3
3	1 286 334,3	1 010 730,6	758 145,9	658 814,9	830 673,3	593 414,4
∑	1 900 418,7	1 580 970,3	1 490 831,7	1 475 518,2	1 633 848,2	1 577 289,5
<b>Total</b>	<b>2 628 055,0</b>					

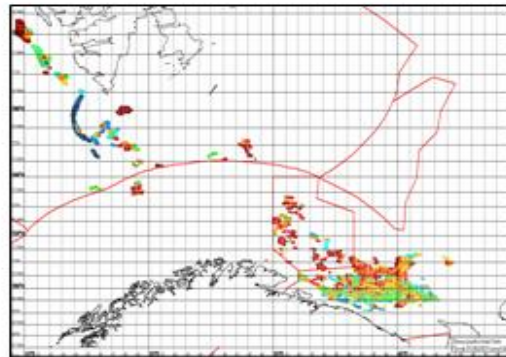
Биомасса трески 2007г.



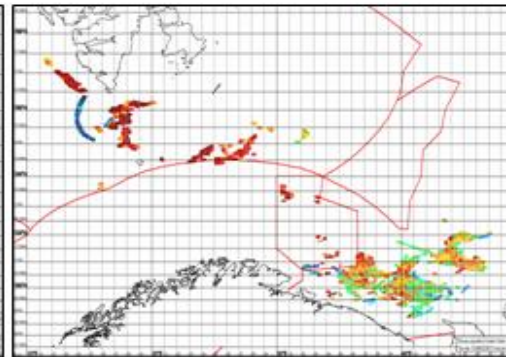
01-15 мая



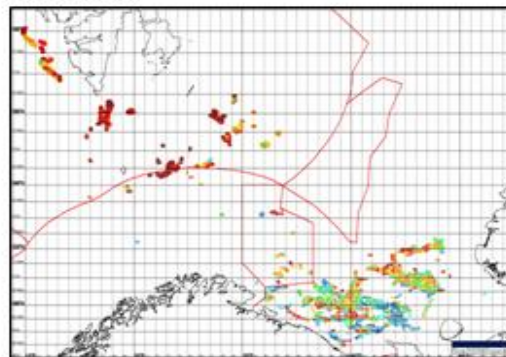
16-31 мая



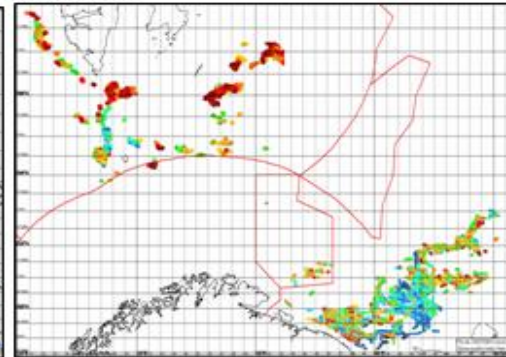
01-15 июня



16-30 июня



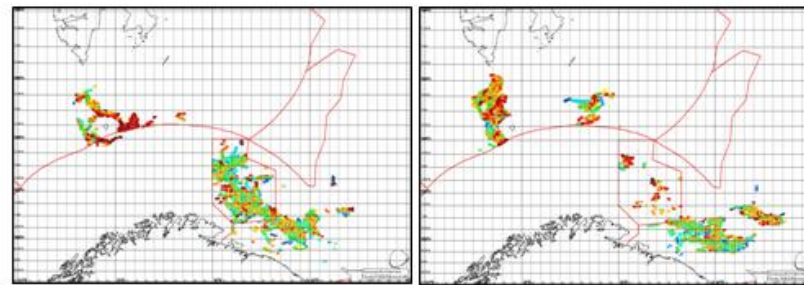
01-15 июля



16-31 июля

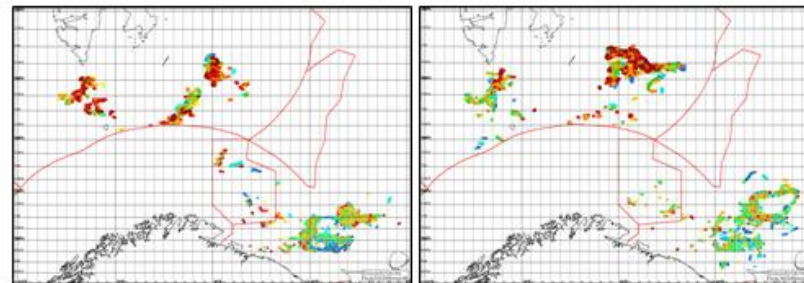


2006



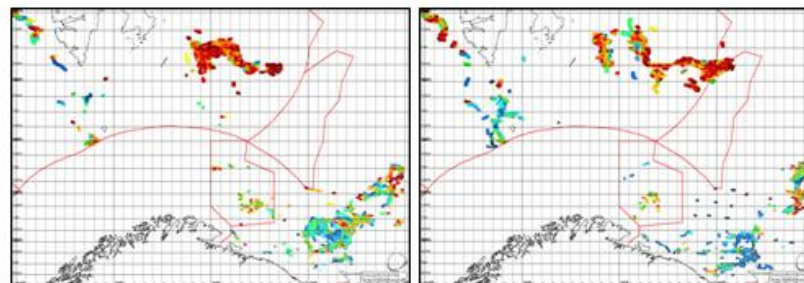
01-15 июня

16 – 30 июня



01-15 июля

16-31 июля



01-15 августа

16-31 августа



Т/КВ.МІЛЬ

Рис. 1. Распределение биомассы скоплений трески по данным операционного лова (отдельным тралениям) и спутникового позиционирования, июнь-август 2006 г.