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Results of the Russian Stratified-random Trawl Survey for Northern Shrimp (*Pandalus borealis*) in the Barents sea and Spitzbergen, 1984-2005

by

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Abstract

Russian shrimp stratified-random surveys have been carried out since 1984 as a part of the Russian-Norwegian investigation of the stock of *Pandalus borealis* in the Barents Sea and Spitsbergen area. Data from this survey series are updated with data from the survey in May and August 2005.

By results from surveys conducted in 1984-2005 shrimp biomass varied within a wide range. Maximum biomass was registered in 1990-1993. Minimum biomass was recorded in 1987-1988, 1995. By results from the survey in 2005 abundance indices were at the long-term mean level, total biomass by all areas was estimated at 656 thousand tons.

Introduction

Nowadays the stratification method runs current in the trawl Russian-Norwegian surveys for the Northern shrimp in the Barents Sea and Spitsbergen areas (Berenboim *et al*., 1992), as well as it is used to estimate the stock status of many of biological resources in the Northwest Atlantic (Doubleday, 1981) and off the Southern Norway (Report on the *Pandalus* Assessment Working Group, 2000). This method has been adopted as a standard one in NAFO (Doubleday, 1981).

The main tasks of the surveys for the Northern shrimp:

1) data collection to estimate abundance and biomass indices;
2) study of biology and distribution;
3) data collection to estimate juvenile by-catch of commercial fish species in the surveyed areas;
4) data collection to calculate the main parameters of population using the cohort methods and production models.

The surveys for shrimp have been conducted applying the standard random-stratified methods (Doubleday, 1981) by Russian and Norwegian specialists annually since 1984 in the same period and in the areas agreed previously. From 1992 to 2000 survey covered not all areas and in 2003-2004 survey has not been carried out due two some technical reasons. Russian survey renewed in 2005 and covered all the main areas. Results from this survey in comparison with the results of the previous one conducted in 2002 are presented in this paper.

Material and Methods

Survey periods

The Russian survey for the Northern shrimp is carried out in two stages:

1) 20 April - 25 May – in the Barents Sea areas;
2) 1-25 August – in the Bear Island – Spitsbergen area.

The research trawl survey is conducted from the late April to the late May. This season has been chosen due to the necessity to decrease the errors in estimates because of the daily vertical migrations of shrimp at most. In the other seasons, in the dark time, a considerable part of the Northern shrimp biomass is distributed outside the area assessed using bottom trawl.

Since 2002, the survey for shrimp in the Bear Iseland-Spitsbergen area has been carried out in August that allows to survey a great part of the high latitude areas of the Spitsbergen Archipelago which is covered with ice in the other seasons. The duration of the light day in the high latitude areas in this period permits us to obtain the correct data comparable with those ones on the Barents Sea.

Stratification

The surveyed Barents Sea area is divided into four parts (Fig. 1, Table 1). The area of the Spitsbergen Archipelago includes three areas (Fig. 2, Table 2). The areas of the Northern shrimp distribution were divided into strata allowing for accumulated knowledge on its distribution, the data on fishery statistics and the position of isobaths (Berenboim *et al*., 1992).

The Russian trawl survey covers the area of Stratum 21 in the Barents Sea and Stratum 24 in the Bear Island-Spitsbergen area. The distinctive bottom topography in the Bear Island-Spitsbergen area conditioned closer link of the stratum borders with the isobaths. Some stratum borders in this area correspond to 200, 300, 400 m isobaths. The Barents Sea areas were divided into strata allowing for the long-term data on shrimp distribution. During the further research the borders and the number of strata may be changed in order to have the optimal assessment of the shrimp stock.

The requirements to the vessel and the research fishing gear

The valid tows are made by bottom research trawl (Drawing 2548 (32.4/37.6) with the codend 2383-01 (the internal mesh size – 40 mm) with inserted cover (the cylindrical part with 10 m length and 10 mm mesh knot of knot) and without the selectivity grid. The trawl boards must have the area of 4.5 m^2. In the survey a standard tow distance equal to three miles is used (Berenboim *et al*., 1992). Recommended tow speed is 2.6-2.7 knots. During a valid tow the trawl parameters may be controlled using SCANMAR equipment.

The catchability of the research trawl concerning the northern shrimp (0.182) was derived by the experimental way (Berenboim, Lysy, Serebrov, 1980). The fishing area is calculated allowing for the average horizontal trawl opening equal to 14.5 m (the distance between wings), as well as the tow speed and duration.

Vessel route is planned in such a way to investigate all the survey strata in the most short-term period. The work is done twenty four hours a day. The passages from station to station are the shortest in distance.

Data collection and processing

Survey biological data are collected and processed in accordance with methods used in PINRO (Anon., 2001).

The abundance indices by strata and areas are calculated separately by sex and the areas with 0.5 mm interval, as well as by the groups: <17 mm, 17-20 mm, 21-23 mm and >23 mm. The calculations are made in accordance with standard methods adopted in NAFO and developed by Cochran (1997).

The number of small areas (N_k) in stratum k which are equal to the area of a standard tow is calculated by the formula:

$$N_k = S_k / S_t ,$$

where S_k – the area of stratum (sq. miles)
S_t – the area of a standard tow.

Mean arithmetic index of shrimp abundance ($\overline{y_k}$) in a catch of one tow in stratum k in the area surveyed is calculated by the formula:

$$\overline{y_k} = \frac{1}{n_k} \sum_{i=1}^{n_k} y_{i,k} ,$$

Where n_k – the number of tows in stratum k
$y_{i,k}$ – the catch of shrimp (ind.) per i-tow in stratum k.

The variance ($s_{\overline{y_k}}^2$) of mean arithmetic index of abundance in stratum k is calculated using a standard method:

$$s_{\overline{y_k}}^2 = \frac{1}{n_k - 1} \sum_{i=1}^{n_k} (y_{i,k} - \overline{y_k})^2 .$$

Mean weighted index of abundance **($\overline{y_m}$)** is calculated for area m and the entire survey area, on the whole:

$$\overline{y_m} = \frac{1}{N_m} \sum_{k=1}^{L} N_K \overline{y_k} ,$$

where N_m – a number of small areas in area m which are equal to the area of one standard tow,
L – a number of strata in the area.

The variance ($s_{\overline{y_m}}^2$) of mean weighted index of abundance in area m is calculated by the following formula:

$$s_{\overline{y_m}}^2 = \frac{1}{N_m^2} \sum_{k=1}^{L} \frac{N_k^2 s_{\overline{y_k}}^2}{n_k} .$$

The error of average is calculated by the formula:

$$\sigma_{\overline{y_m}} = \sqrt{s_{\overline{y_m}}^2}$$

The variation coefficient is derived using the formula:

$$CV = \frac{\sigma_{\overline{y_m}}}{\overline{y_m}} .$$

The shrimp abundance index Y_m for area m:

$$Y_m = N_m \overline{y_m} \pm N_m * (\sigma_{\overline{y_m}} * t(P_c)),$$

where $t(P_c)$ - Student's coefficient depending on choosing the confidence probability P_c.

Choosing P_c-value is rather the result of agreement, than of the strict analysis. ICES advices to take P_c = 95% when estimating the reference points, while the other sources which are not less authoritative consider that it is possible to diminish the confidence probability to $P_c \geq 50\%$ (Anon., 1992; Anon., 2000).

In our case we have chosen $P_c = 95\%$, then :

$$Y m = N_m * \overline{y_m} \pm N_m * 2\,\sigma_{\overline{y_m}}.$$

Results and Discussion

Biomass, total estimate

For all strata biomass estimates have been calculated (Tables 1) on the basis of the nominal swept area. The biomass estimates (in thousand tons) for the nine main regions in 2005 are:

REGION	BIOMASS ESTIMATE (THOU. TONS)	NO. OF HAULS	COEFFICIENT OF VARIATION (%)
Iversen Bank	126	14	15
Hopen	203	21	19
Tiddly Bank	103	16	21
East Finmark	23	7	29
Kola coast	29	20	26
Bear Island	31	20	24
Storfiord Trench	54	18	28
Spitsbergen	30	37	33
Goose Bank	58	13	23
OVERALL	656	166	8

By results from surveys conducted in 1984-2005 shrimp biomass varied within a wide range (Table 2). Maximum biomass was registered in 1990-1993. Minimum biomass was registered in 1987-1988, 1995. By results from the survey in 2005 abundance indices were at the long-term mean level, total biomass by all areas was estimated at 656 thousand tons.

Biomass distribution in 2005 was rather traditional (Fig. 1) with high densities in the Hopen, Iversen Bank, and Goose Bank areas.

Goose Bank. Biomass of the Northern shrimp on the Goose Bank reduced to the long-term mean level and amounted to 61.9 thousand tons. As compared to estimates made in 2002, stock reduced almost in two times. Marked changes took place in the northern areas of the Bank (Stratum «8s»), where the mean catch constituted 77 kg per a haul and maximum catch made up 180 kg. The highest catches of shrimp were taken in the Stratum 7s in the Goose Bank area and amounted to 240 kg.

Kola coast. The stock of the Northern shrimp along the Kola coast decreased more than in two times compared with 2002 and the long-term mean level (Fig. 4). The total stock of the Northern shrimp constituted 28.9 thousand tons. Especially low catches were registered in the Stratum «3s» in the immediate proximity to the Kola Bay, where their values were estimated at less than 1 kg per a haul.

Iversen and Tiddly Banks, East Finmark. In the area covered the Central Plateau (strata 6, 7 1s), the Demidov Bank (strata 10-12, 25) and the Finnmarken Bank (strata 2, 4) stock of the Northern shrimp constituted 251.4 thousand tons. In spite of decrease in shrimp biomass by 20-37% compared to 2002, values of 2005 were close to the long-term mean level. The highest catches were registered in the northern Demidov Bank and estimated at 140-280 kg / per a haul.

Hopen. Total stock of the Northern shrimp in the Western Deep area constituted 203.2 thousand tons. This value was 42% lower than values of 2002 and 34% lower than long-term mean level. The lowest catches were registered in the southern (14, 15) and western (16) strata, where their values reached 1 kg per a haul. Catches taken in the northern strata (17, 18) were noticeably higher and estimated at 325 kg/per a haul. Four Norwegian vessels fishing shrimp were registered in the northern part of this area.

Bear Island. Abundance indices increased in two times compared to 2002 and were 1.5 higher than the long –term mean level in the Bear Island area. Catches varied from 0 to 70 kg.

Storfiord Trench. The Northern shrimp biomass increased to the long-term mean level in the South Cape Deep area. As compared with estimates made in 2002, the stock increased by 40%. The highest catches of shrimp in this area were registered in the Stratum 44 and reached 260 kg.

Spitsbergen. The Northern shrimp stock along the West Spitsbergen decreased by 20% both compared to 2002 and the long-term mean level. Total stock of the Northern shrimp amounted to 30 thousand tons. High catches were registered in the Stratum 58 in the immediate proximity to Isfjord and in the northern areas, where catches reached 400 kg.

Biological status of the Northern shrimp in the surveyed period

The basis of shrimp population in the Barents Sea as in the previous years of observations was represented by individuals of younger age groups (males with carapace 10-20 mm and females with carapace 19-24 mm). Sex ratio in the Northern shrimp aggregations varied depending on place of trawling, but, on the whole, over the surveyed area males predominated in catches and constituted about 66% of the total shrimp abundance. Spawning females constituted about 20%, post-spawning females made up about 13% of the catch. The ratio of large old individuals and small young ones is described well in number of individuals in 1 kg of the catch. Thus, over the greater part of the surveyed area 170-220 individuals occurred in 1 kg of the catch. A higher percentage of large individuals occurred in the south-eastern part of the Coastal area, where less than 120 individuals were found in 1 kg of the catch. The greatest number of small individuals was registered in the Eastern area of the Goose Bank, where more than 420 individuals of the northern shrimp occurred in 1 kg of the catch.

Individuals with carapace length of 10-28 mm (Fig. 4) were found in *Hopen area* of the survey. Major part of catches was represented by males with carapace length of 17-21 mm. Nonspawning females were represented by a modal group within a range from 21 to 23.5 mm. Females without sternal spines were found in small numbers, their carapace length varied from 20.5 to 26.5 mm.

Size – sex structure of shrimp aggregations in *the Grey area (Iversen and Tiddly Banks, East Finmark)* was similar to that one in the Northern area (Fig. 4). A modal group of males was represented by individuals with carapace length of 17-21 mm as well, and a modal group of females without sternal spines by individuals with carapace length of 21-23 mm.

Size-sex structure of the Northern shrimp aggregations in *the Goose Bank* was similar to that one of aggregations in the Central and Northern areas. The most remarkable feature of shrimps inhabiting this area is decrease in modal carapace length of the both sex groups (Fig. 4). Thus a modal group of males was represented by individuals with carapace length of 12-20 mm. Non-spawning females were represented mainly by individuals with carapace length of 19-22.5 mm. Females without sternal spines were represented within the same range.

A considerable difference in size-sex structure of the Northern shrimp was observed in *the Kola Coast* of the survey (Fig. 4). Size structure of males was represented by two modal groups of 12-15 mm and 15-19 mm. Percentage of the females compared to other investigated areas was noticeably higher in this area and made up 50% of the total abundance. A modal group of females with sternal spines was represented by individuals with carapace length of 19-23.5 mm, females without sternal spines were represented by individuals with carapace length of 21-24.5 mm.

Size – sex structure analysis of the Northern shrimp, inhabiting the Spitsbergen area, showed that the basis of the population (about 50%) consisted of males with carapace length of 14-20 mm. A quarter of all individuals were represented by non-spawning females with carapace length of 1-26 mm. The rest part of analyzed shrimp consisted of females with carapace length less than 30 mm, which have spawned once or more.

Conclusions

1. The survey for the Northern shrimp in the Barents Sea showed the total reduction in stock by 11% in comparison with the long-term mean level and by 30% in comparison with 2002, the stock constituted 545.3 thousand tons.
2. The basis of the Barents Sea shrimp population consists of males of a modal group with carapace length of 10-20 mm. No drastic changes in length frequency distribution took place.
3. Density distribution of the shrimp in the surveyed areas was as in the previous years, with high densities in the investigated areas of Hopen, Iversen Bank, and Goose Bank. On the whole, the status of the Northern shrimp in 2005 is characterized as satisfactory.

References

Berenboim, B., S. Mukhin, and K. Sunnanå. 1992. Results from Norwegian and Soviet investigations of shrimp *Pandalus borealis* in the Barents Sea. *ICES C.M. Doc*., No. 1992/K:14.

Cochran, W. G. 1997. Sampling Techniques. Third Edition. John Wiley & Sons, Toronto, 428 p.

Table 1. Estimated biomass (thou. tons) and sampling statistics for strata in Barents Sea and Spitzbergen, 2005

Strata/ Region	Area (sq. miles)	Biomass	CV% in region	Average catch in strata/region	Hauls
25	1200	59		210	3
12	1423	26		77	3
11	1364	19		61	4
10	2373	22		39	4
Iversen Bank	**6360**	**126**	**15**	**97**	**14**
18	2457	95		166	7
17	1535	59		166	3
16	1553	19		51	3
15	2039	14		30	4
14	2535	15		26	4
Hopen	**10119**	**203**	**19**	**88**	**21**
7	1953	44		96	5
6	2776	37		57	6
1c	2017	22		47	5
Tiddly Bank	**6746**	**103**	**21**	**67**	**16**
4	1841	18		41	3
2	1697	5		13	4
East Finmark	**3538**	**23**	**29**	**27**	**7**
6c	798	7		38	4
5c	1168	2		6	3
4c	1539	5		14	4
3c	1120	1		5	3
2c	1824	14		32	6
Kola coast	**6449**	**29**	**26**	**19**	**20**
45	357	3		31	3
44	1217	18		63	6
43	786	1		6	3
40	3861	4		4	3
39	871	5		27	2
38	1399	0		1	3
Bear Island	**8491**	**31**	**24**	**22**	**20**
50	246	2		28	3
49	611	2		14	8
48	1883	50		113	7
Storfiord Trench	**2740**	**54**	**28**	**52**	**18**
70	734	18		102	4
69	56	1		52	4
68	95	0		4	3
65	846	8		39	4
64	155	0		0	2
63	89	0		0	3
60	269	0		8	3
59	208	2		35	3
58	829	1		3	3
55	249	1		16	3
54	102	0		10	2
53	525	0		3	3
Spitsbergen	**4157**	**30**	**33**	**22**	**37**
8c	2108	38		77	7
7c	672	20		127	6
Goose Bank	**2780**	**58**	**23**	**102**	**13**
Total	***51380***	***656***	***8***	***55***	***166***

Table 2. Indices of shrimp biomass (1000 t) from Russian surveys in 1984-2005 by main areas of the Barents Sea

Main Area	**A East Finmark**	**B Tiddly Bank**	**C-Thor Iversen Bank**	**E Hopen**	**F Bear Island**	**G Storfiord Trench**	**H Spits-bergen**	**I Kola coast**	**K Goose Bank**	**Total**	**Sum. A,B,C,E**
Strata	1-4	6,7,1s	10-12,25	14-18	38-40, 43-45	48-50	53-55,58-60, 63-65,58-70	2s-6s	7s-8s		
1984	38	137	99	254				133		661	528
1985	14	45	74	255		6	46	19	9	468	388
1986	9	19	44	140		42	127	9	9	399	212
1987	16	17	59	107	45	36	27	25	14	346	199
1988	14	31	39	49		22	29	36	13	233	133
1989	70	128	57	132	6	60	25	105	20	603	387
1990	90	195	119	259	14	110	30	196	15	1028	663
1991	90	153	104	541	9	70	27	155	43	1192	888
1992	80	153	92	409				65	77	876	734
1993	45	91	159	382	9		58	37	111	892	677
1994	4	35	48	255	21			14	27	404	342
1995	5	28	15	80	33	53		16	18	248	128
1996	20	98	127		21			67	108	441	245
1997	26	108	130	341				108	52	765	605
1998	14	106	136	172				108	41	576	427
1999	43	139	107	523				93	61	966	812
2000	29	73	109	328	9	39		72	141	800	539
2001	11	52	105	185	19	14	13	14	55	468	353
2002	30	129	198	353	15	39	51	70	105	980	710
2005	23	103	126	203	31	54	30	29	58	656	455
% 02/01	173	148	89	91	-21	179	292	400	91	109	101
% 05/02	-23	-20	-36	-42	107	38	-41	-59	-45	-33	-36

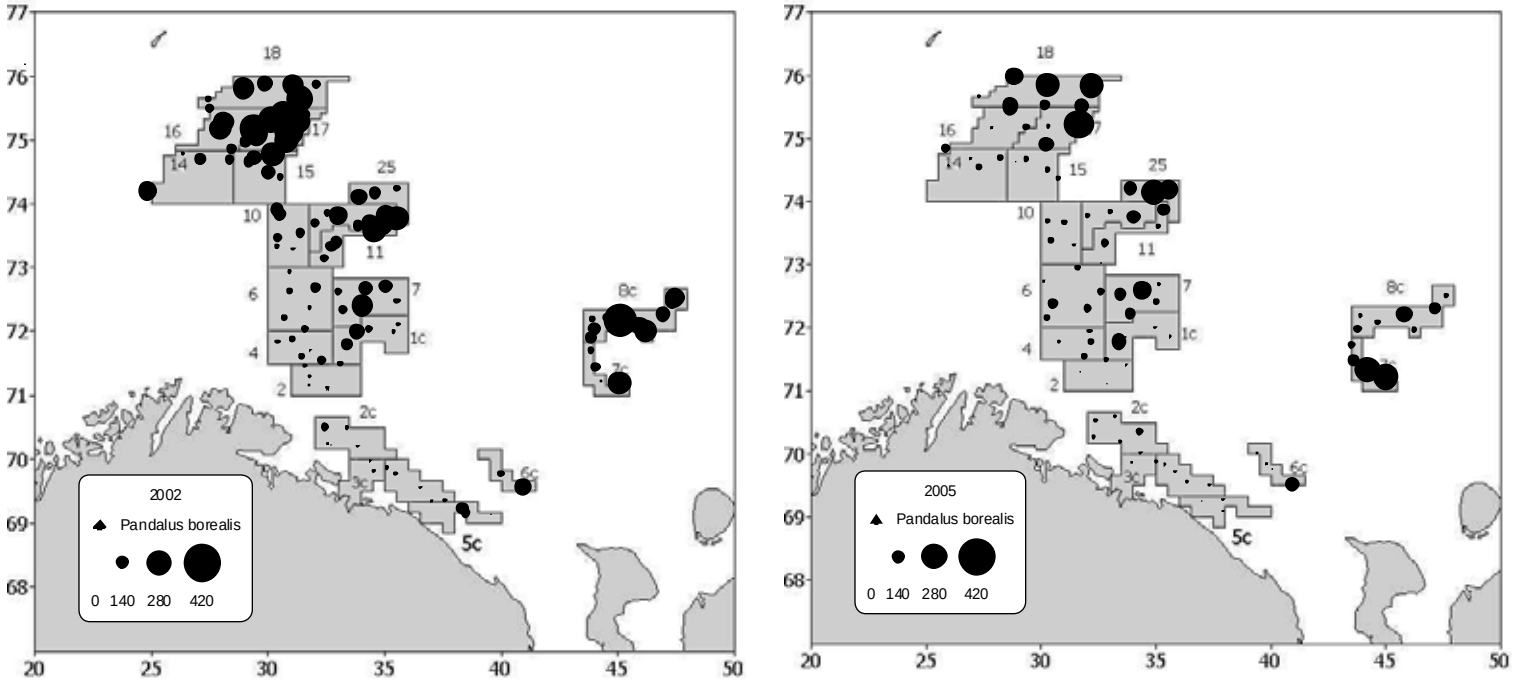

Fig. 1. Survey stratification, sampling locations and density of northern shrimp in the Barents Sea in 2002 and 2005.

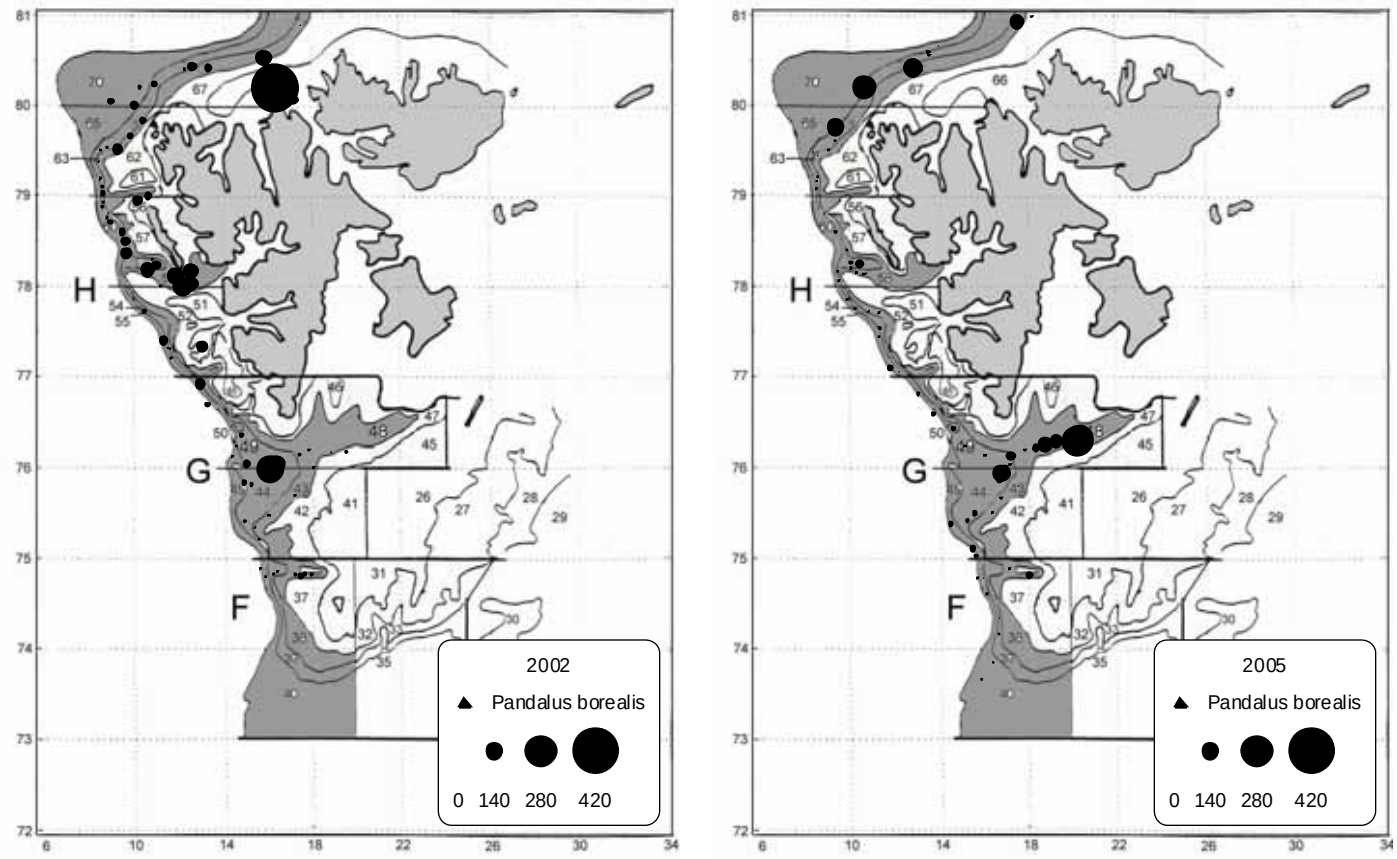

Fig. 2. Survey stratification, sampling locations and density of northern shrimp in Spitsbergen area in 2002 and 2005.

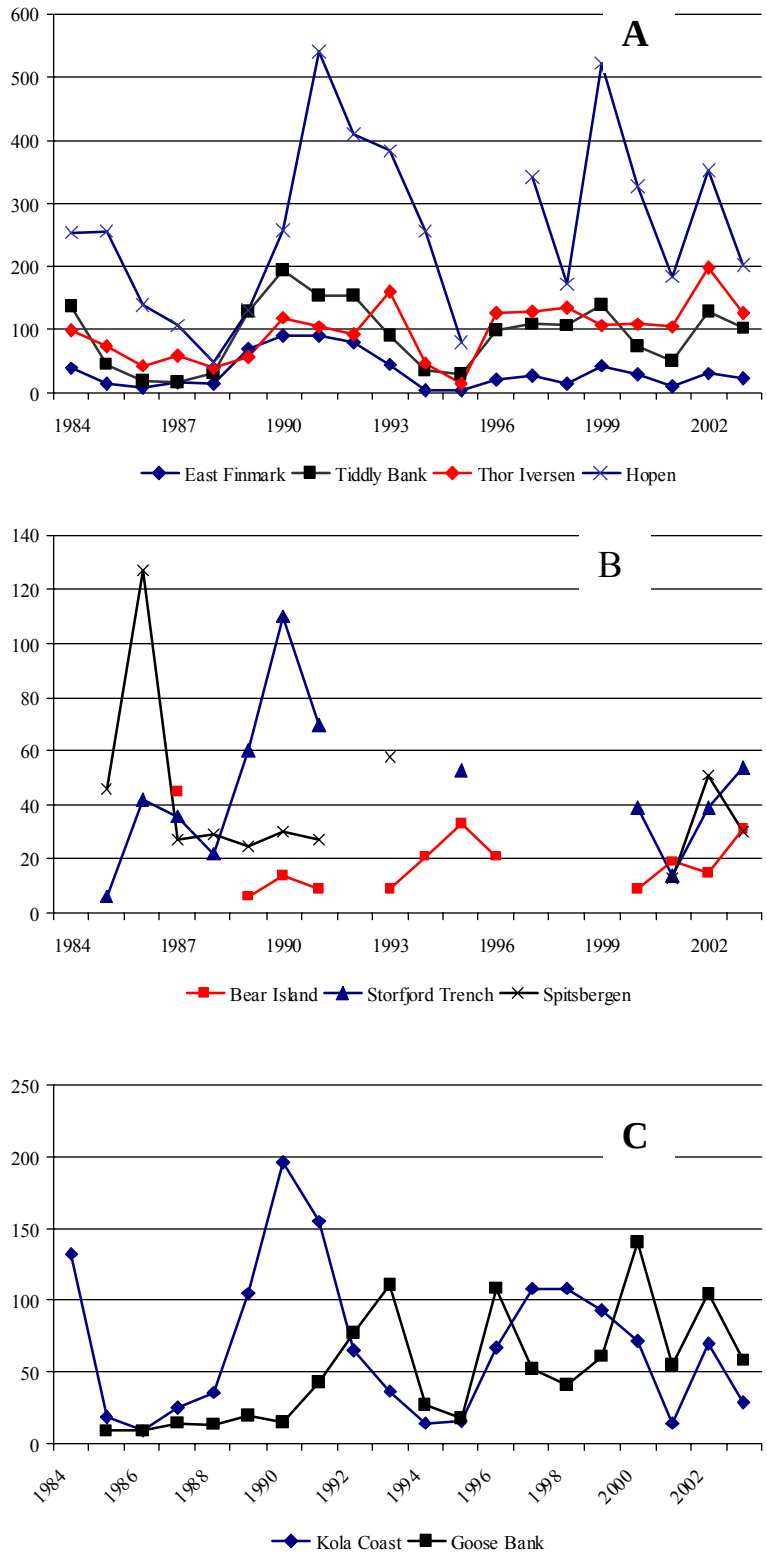

Fig. 3. Distribution of estimated biomass in main areas for surveys in central part of Barents sea (A), Spitsbergen (B) and REZ (C) 1984-2005.

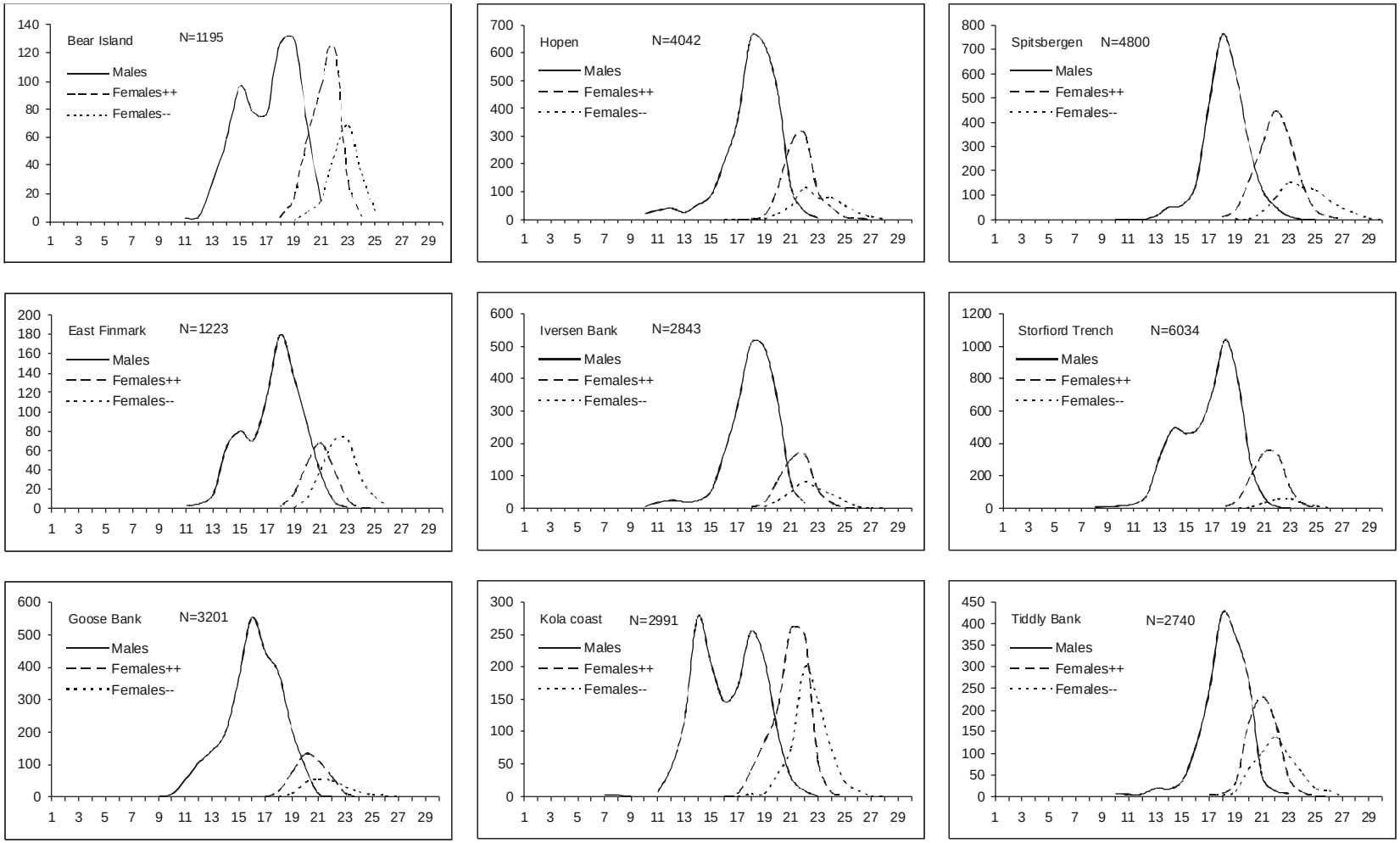

Fig. 4. Length frequencies of northern shrimp in main areas in the Barents Sea and Spitzbergen area.

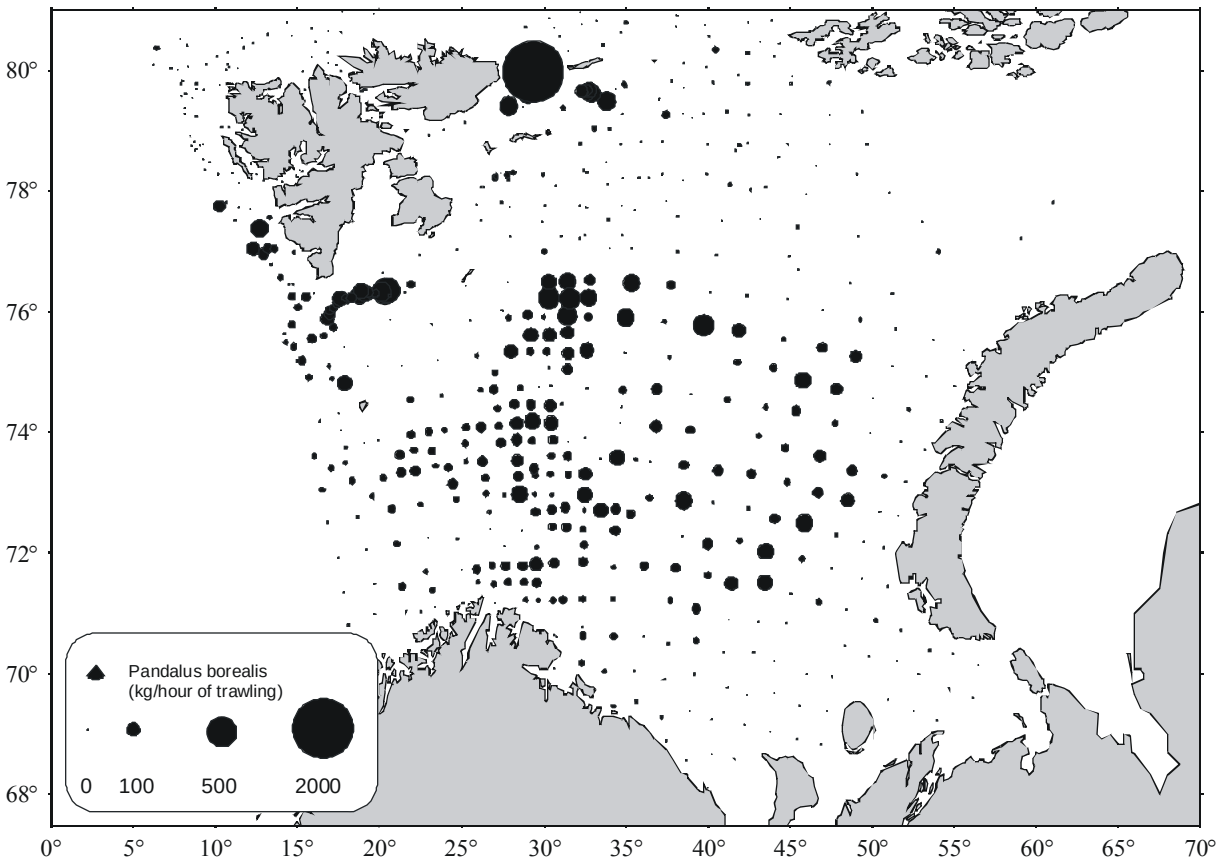

Fig. 5. Shrimp distribution in the Barents Sea according to 2nd joint ecosystem survey conducted in the period August-October 2005.