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Research survey information regarding northern shrimp (*Pandalus borealis*) in the Barents Sea and Svalbard area

by

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Abstract

The geographical distribution of the stock in 2008 is similar to that of the previous year. The estimate of mean biomass increased by about 40% from 2004 to 2006 and then decreased again to slightly below the 2004 value.

Overall size distributions indicate a relatively large amount of smaller shrimp in 2004 which resulted in the increase in stock biomass until 2006. The recruitment index decreased since 2004.

The new 'ecosystem survey' has not been calibrated to the 'shrimp survey' which was discontinued in 2004.

Introduction

Research surveys have been conducted to assess the stock status of northern shrimp, *Pandalus borealis*, in the Barents Sea. The main objectives were to obtain index values for stock biomass, abundance, recruitment and demographic composition. Recently (since 2004) the monitoring of a multitude of other ecosystem variables has been included in the joint Norwegian-Russian "Ecosystem survey" (www.imr.no).

Three time series exist: (1) The Norwegian shrimp survey 1982-2004 (ICES, 2002a, 2003b, 2005a), (2) The Russian shrimp survey 1984-2002 and 2005 (ICES 2006), (3) The joint Norwegian-Russian ecosystem survey. The ecosystem survey (3) combines surveys 1 and 2, as well as several earlier 0-group and groundfish surveys.

This paper presents the results of the 2004-2008 ecosystem surveys, for the first time including data from both Norway and Russia.

Methods

Survey and coverage

The joint Norwegian-Russian ecosystem survey has since 2004 been conducted annually from August to October by five research vessels covering the entire Barents Sea from the edge of the continental shelf in the west, to Novaja Semlja in the east, from the coast of Norway and Russia in the south to the ice-edge in the north (Olsen, 2006)

(Fig. 1). Due to economical considerations (mainly drastically rising fuel prices in the last few years) it was in 2008 decided to reduce the total number of ecosystem and other stations, as well as to limit days-at-sea for two of the three Norwegian vessels so that the survey area is no longer covered fully synoptically. In addition, the Russian part of the survey was conducted by one instead of two research vessels as in previous years.

In most of the covered area both in the Norwegian and Russian EEZs the survey followed a regular grid with ecosystem sampling stations approx. 30-35 nm apart (Fig. 1). In the important juvenile shrimp areas in the central Barents Sea (Hopen Deep), additional demersal trawl stations were placed at ½ the standard grid size to get a more detailed coverage of the shrimp distribution in this area. These stations were, for the same economical reasons described above, in 2008 reduced to only 7 in number. In the other high density shrimp area in the north-west around Spitsbergen a depth-stratified survey was conducted. Here ecosystem sampling stations were placed approx. every 30-35 nm as in the other areas, but in addition a number of exclusively demersal trawl stations were placed at irregular intervals within this part of the survey area.

Sampling trawl gear

Sampling of demersal species like shrimp within the ecosystem survey was conducted with a standard Norwegian research trawl, which is a modified Campelen 1800 shrimp trawl with rockhopper ground gear (Fig 2). Mesh size in the cod-end was 22 mm with a 6 mm lining. A juvenile (Hoita) bag with 0.8 mm lining was always attached under the trawl in front of the cod-end in order to collect juvenile shrimp < 10 mm in the catch.

Trawl geometry and behaviour of the trawl were monitored using *Scanmar* trawl sensors. The Norwegian vessels used standard *Steinshamn* W9 bottom V trawl doors with an area of 6.7 m^2 and a weight of 2 250 kg. "Strapping" – a rope 150-180 m in front of the doors locks the distance the trawl doors to approximately 50 m – is used. The towing time is 15 min. GPS positions were used to calculate towed distance. A speed sensor (symmetry) was used on all bottom hauls, giving information about the direction and amount of currents entering the trawl and making it possible to tow at the right speed and geometry in proportion to underwater crosscurrents by adjusting wires or warps to compensate a skewed trawl.

Other trawl settings are described in detail in a separate manual for rigging of trawl and trawl equipment (Engås, 1995).

Sampling routines

For each haul on board Norwegian vessels, samples of 250-300 adult shrimp specimens were taken from the main bag, sorted by sexual characteristics, and measured by caliper to the nearest mm below (carapace length, cpl, as defined in Allen (1959); McCrary (1971)). A sample of up to 100 juvenile individuals was taken from the Hoita bag and measured the same way as the adults. Shrimp sampling on board Russian vessels was done in a similar manner.

Russian and Norwegian scientists use different database systems (BioFox and Regfisk, respectively) to register biological data from marine animals surveys. At the end of the survey the Russian ecosystem data are converted and included in the Norwegian database system; however, it has to date not been possible to convert the Russian shrimp length data, so that normally only total weight per haul is given.

The length- and sex frequency distribution in the samples was weighted by total catch and stratum area to obtain estimates of the overall distribution.

Area stratification

Data from the sampling were stratified by depth and area as in Fig. 3. We devised this new stratification scheme, which is different to the one used previously, to better accommodate for additional data from the Russian part of the survey area. Five main areas were identified in the whole Barents Sea, which each were further sub-divided into 6 depth strata (0-600 m). The depth strata boundaries follow depth contours obtained from the GEBCO world bathymetry database (http://www.gebco.net). The individual strata were constructed using ArcGIS 9.3 software; then each stratum's area was calculated in km^2 using an equal area projection (Europe Albers Conic) (Table 2, Fig. 4).

Swept area analysis

The catch in each tow divided by the swept area represents a sample of shrimp density in a stratum. From these samples the mean and standard error of the density in each stratum was calculated and multiplied by the area of the stratum to give an estimate of stratum biomass and abundance. Standard error was calculated as B ∗ 0.985 Cochran (1977) for strata with only one tow. The means and their standard errors for the strata were summed to give the overall values for the survey area.

Results

The estimate of mean biomass increased by about 40% from 2004 to 2006 and then decreased again to slightly below the 2004 value (Fig. 5a-c). The trend of this new stock biomass series is similar to the one used in previous assessments (Fig 6).

The geographical distribution of the stock in 2008 is similar to that of the previous years (Fig. 7).

Overall size distributions (Fig. 8) indicate a relatively large amount of smaller shrimp in 2004 which resulted in the increase in stock biomass until 2006 (Fig. 4). The recruitment index – estimated abundance of shrimp at 13-16mm CL supposed to enter the fishery in the following one-two years decreased since 2004 (Fig. 9).

The summer temperatures decreased in 2007 and 2008, but the temperatures in late winter 2008 (March) were record-high in the western Barents Sea. However, as the Atlantic inflow in late March and April was well below average, the typical temperature increase in spring did not occur this year. In summary the climatic situation in the Barents Sea has been somewhat extraordinary in 2008. The bottom temperatures recorded in 2007 and 2008 is seen in Fig. 10. Catches of shrimp were only recorded at temperatures above 0°C. Highest shrimp densities were found between zero and 4°C, while the limit of upper temperature preference appeared to lie at about 6-8°C.

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Table 1 Estimated biomass, abundance and mean weight of the total and fishable (>16 mm cpl) stock and of recruits (13-16 mm cpl).

	Biomass (ktons)				Abundance (#10^9)			Mean weight (g)		
Year	Total	Fishable	Recruits	CV (%)	Total	Fishable	Recruits	Total	Fishable	Recruits
2004	457	325	124	9	122	58	56	3.74	5.55	2.22
2005	579	489	87	23	132	92	36	4.39	5.29	2.40
2006	645	549	91	8	143	103	37	4.52	5.36	2.48
2007	507	454	51	7	96	75	19	5.26	6.02	2.67
2008	369	330	35	9	71	54	14	5.16	6.08	2.47

Table 2 Estimated total biomass and density by stratum and year .

Stratum			2004				2005				2006				2007				2008			
Name	Depth	Area	Hauls	Biom.	Dens.	CV	Hauls	Biom.	Dens.	CV	Hauls	Biom.	Dens.	CV	Hauls	Biom.	Dens.	CV	Hauls	Biom.	Dens.	CV
(code)	(m)	(km^2)	(#)	tons	kg/km^2	%	(#)	tons	kg/km^2	%	(#)	tons	kg/km^2	%	(#)	tons	kg/km^2	%	(#)	tons	kg/km^2	%
1.1	0-100	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	79	2	85
1.2	100-200	40	17	5943	150	49	16	6182	156	58	9	7005	177	74	10	3390	86	49	16	4102	104	45
1.3	200-300	20	26	15311	776	26	24	18859	956	29	25	15539	788	21	20	11765	596	25	22	13862	703	39
1.4	300-400	10	30	12721	1316	24	23	10148	1050	22	25	5200	538	14	22	11870	1228	28	16	4571	473	35
1.5	400-500	7	17	4327	608	28	18	4164	585	22	14	4254	598	23	11	5370	755	23	7	5248	738	38
1.6	500-600	6	8	1696	293	25	10	3018	522	40	6	2035	352	42	6	1670	289	39	7	1234	213	50
2.1	0-100	41	1	0	0	0	1	0	0	0	2	0	0	0	2	0	0	0	1	0	0	0
2.2	100-200	153	25	3260	21	50	16	7383	48	36	23	1512	10	51	24	2399	16	39	16	2038	13	59
2.3	200-300	230	34	150557	654	21	69	153493	667	14	69	242092	1051	16	67	168005	730	18	62	116391	505	21
2.4	300-400	119	35	81699	685	18	56	95050	797	12	63	143045	1199	13	67	130541	1094	9	29	65561	550	16
2.5	400-500	43	7	29982	698	22	28	18289	426	11	27	24034	559	11	27	30831	717	13	15	11106	258	15
2.6	500-600	2	0	0	0	0	1	783	490	85	1	29	18	85	0	0	0	0	0	0	0	0
3.1	0-100	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.2	100-200	61	23	4054	66	86	9	222	4	59	12	584	10	37	13	489	8	72	5	870	14	72
3.3	200-300	83	50	12389	150	31	23	136155	1646	98	20	33372	404	48	33	25034	303	26	14	15580	188	44
3.4	300-400	35	50	44459	1270	35	25	29951	855	59	34	22089	631	32	35	26424	755	24	14	12890	368	37
3.5	400-500	12	8	5501	458	45	3	62	5	31	2	2749	229	46	4	8491	707	107	3	1381	115	57
3.6	500-600	2	4	372	179	74	3	306	147	120	1	686	330	85	6	276	133	52	2	6	3	141
4.1	0-100	13	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	1	787	62	85
4.2	100-200	75	2	564	8	126	10	462	6	75	6	218	3	70	11	0	0	0	11	1473	20	83
4.3	200-300	119	15	22445	188	40	25	33658	282	35	11	72137	604	26	26	28109	236	39	21	55148	462	22
4.4	300-400	34	8	13596	398	43	7	12213	357	38	5	12211	357	79	9	9586	280	43	8	21229	621	30
5.1	0-100	188	14	0	0	0	28	44	0	82	54	2	0	101	35	0	0	0	27	0	0	0
5.2	100-200	71	15	962	14	94	19	2567	36	52	23	0	0	0	20	1327	19	40	19	820	12	76
5.3	200-300	40	11	38646	963	13	11	33817	843	26	22	37384	932	20	18	25316	631	20	22	19033	474	18
5.4	300-400	25	8	8596	343	29	7	12009	480	30	7	18413	736	37	12	16229	649	18	10	15382	615	32
Total	0-600	1504	408	457078	304	9	433	578834	385	23	461	644592	429	8	480	507122	337	7	349	368792	245	9

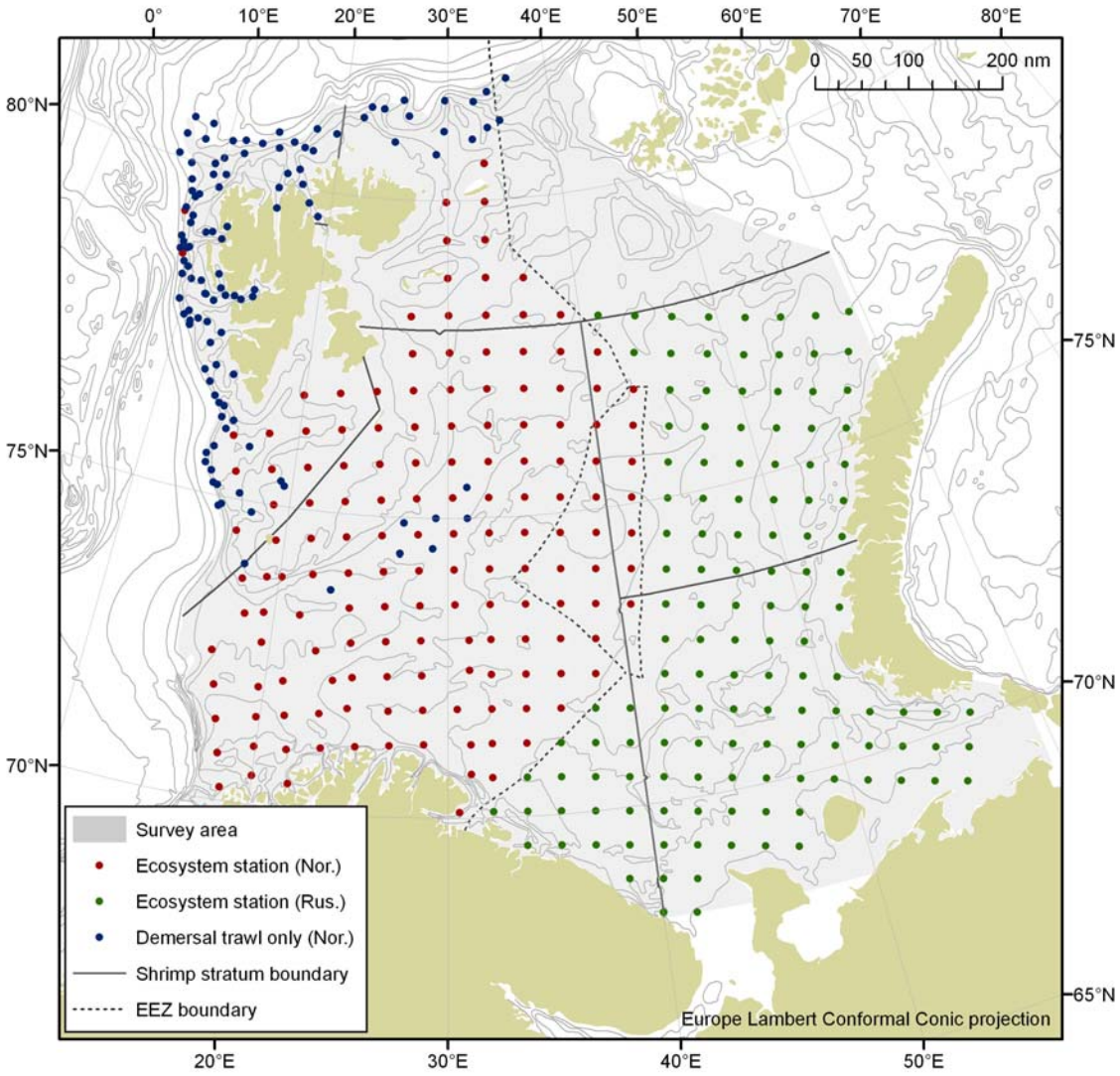

Fig. 1 Sampling grid used for the 2008 Norwegian-Russian ecosystem survey in the Barents Sea.

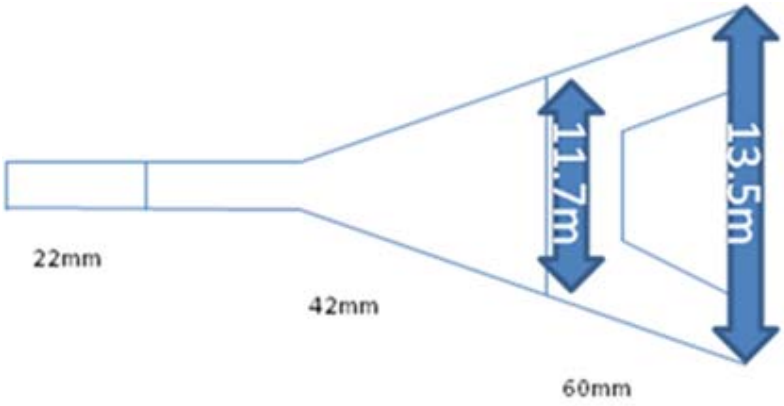

Fig. 2 Schematic drawing of a Campelen 1800 survey bottom trawl with 22 mm mesh size in the cod-end, 42 mm in the mid-section, and 60 mm in the trawl opening. The width of the trawl opening (11.7 m) and wing spread (13.5 m) is also indicated.

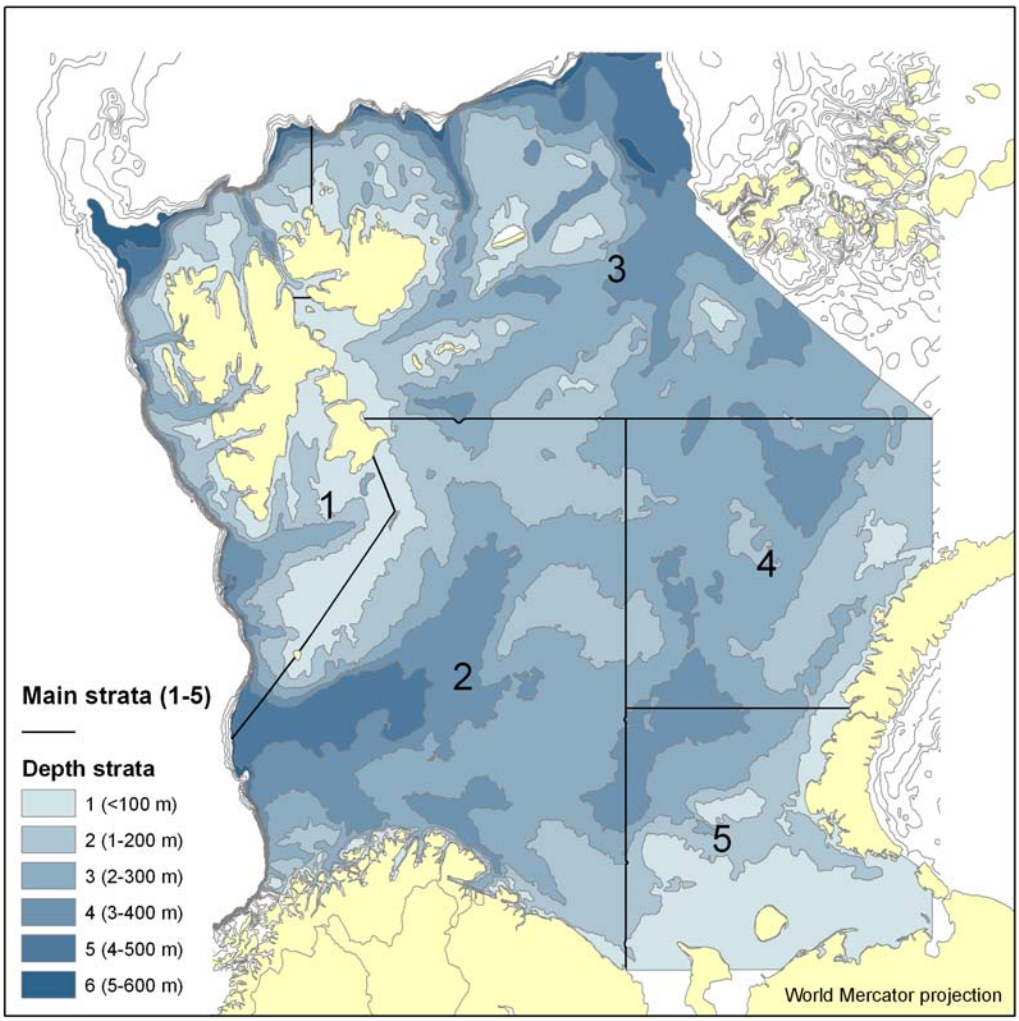

Fig. 3 The new (2008) survey stratification used in calculations in this paper. Elsewhere in the text each stratum is given a code for [main area]+[depth stratum within]; e.g. [1.3] indicates main stratum = 1 and depth stratum = 3, i.e. covering depths from 201 to 300 m.

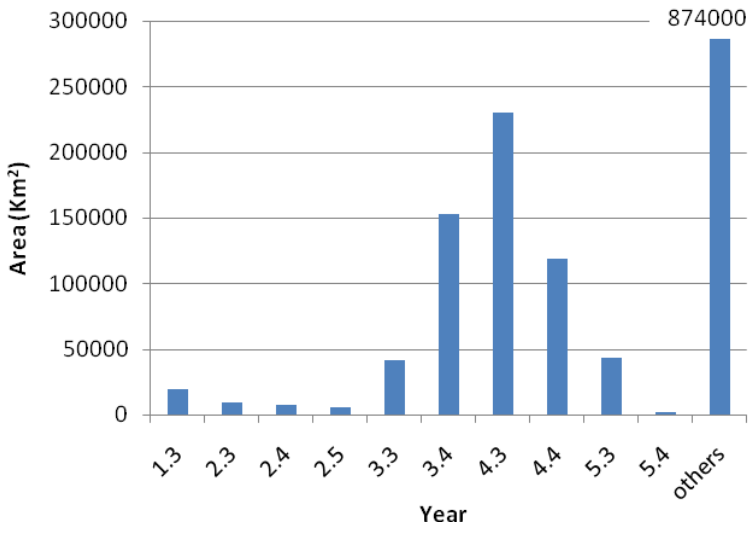

Fig. 4 Areas of the 10 most important stratas (code: see Table 2 and Fig. 3 for definition)

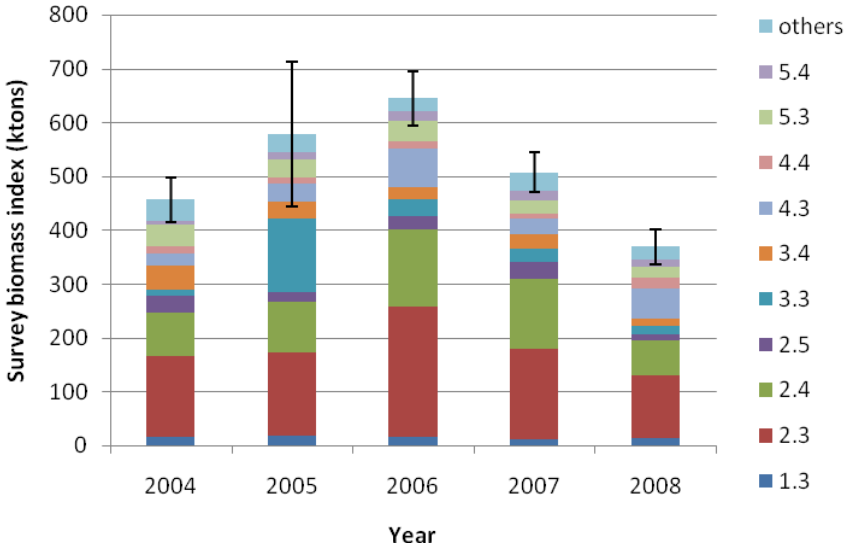

Fig. 5a Estimated mean biomass by year and strata (code: see Table 2 and Fig. 3 for definition). Error bars indicate +/- one Standard Error of the overall estimate.

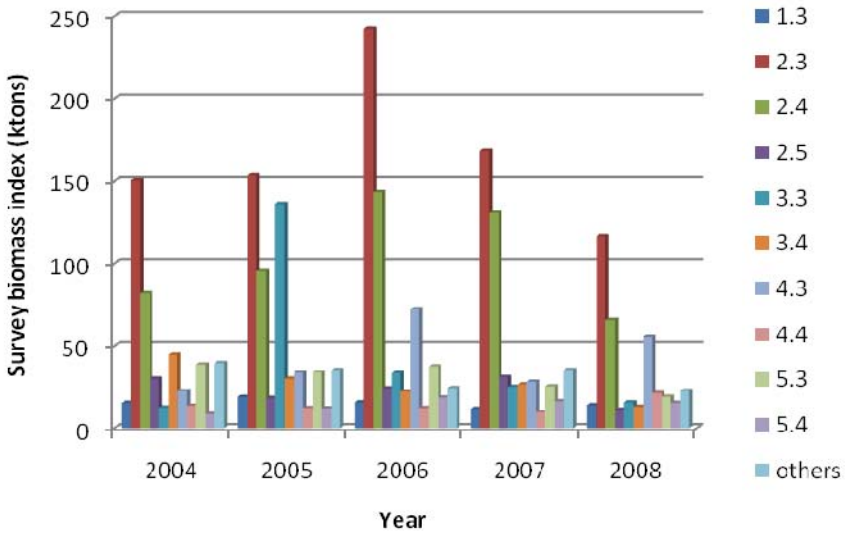

Fig. 5b Estimated mean biomass by strata (code: see Table 2 and Fig. 3 for definition) for the years 2004-2008.

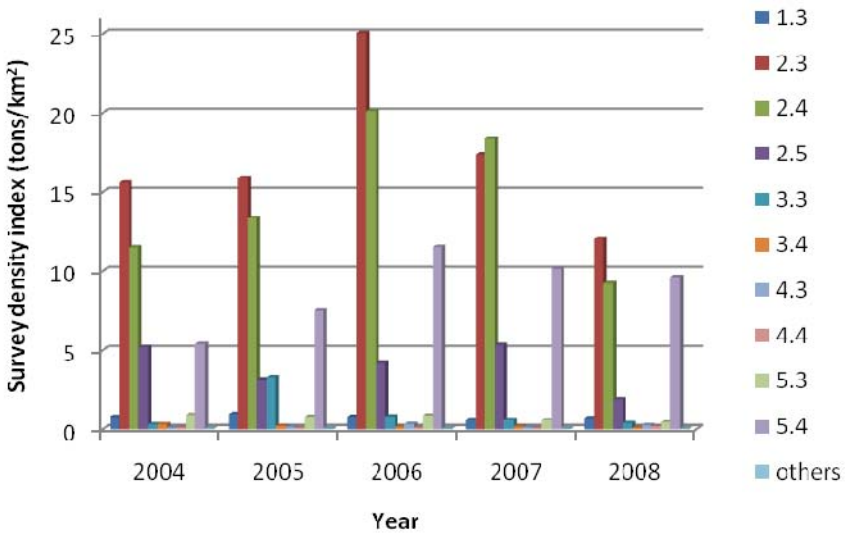

Fig. 5c Estimated mean biomass density by strata (code: see Table 2 and Fig. 3 for definition) for the year 2004-2008.

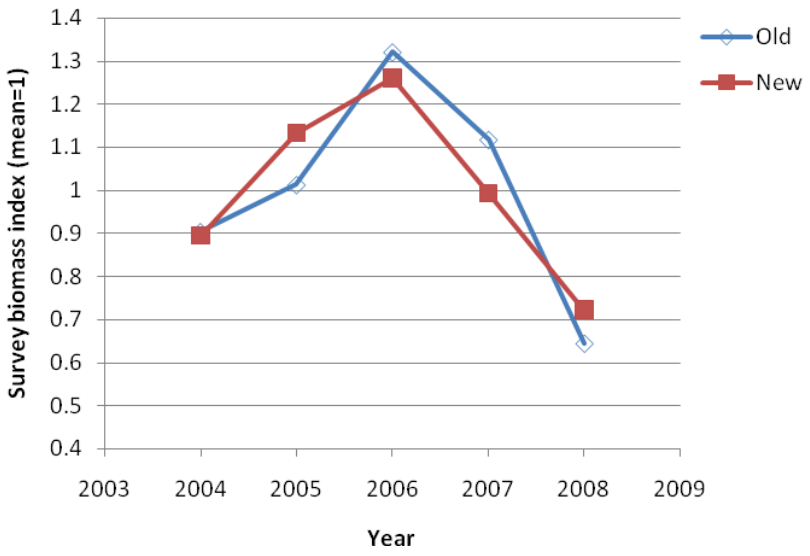

Fig. 6 Estimated mean biomass as calculated by using the old stratification (Hvingel and Thangstad 2007) and Norwegian data only ('Old') and by using both Norwegian and Russian data in a new stratification scheme ('New').

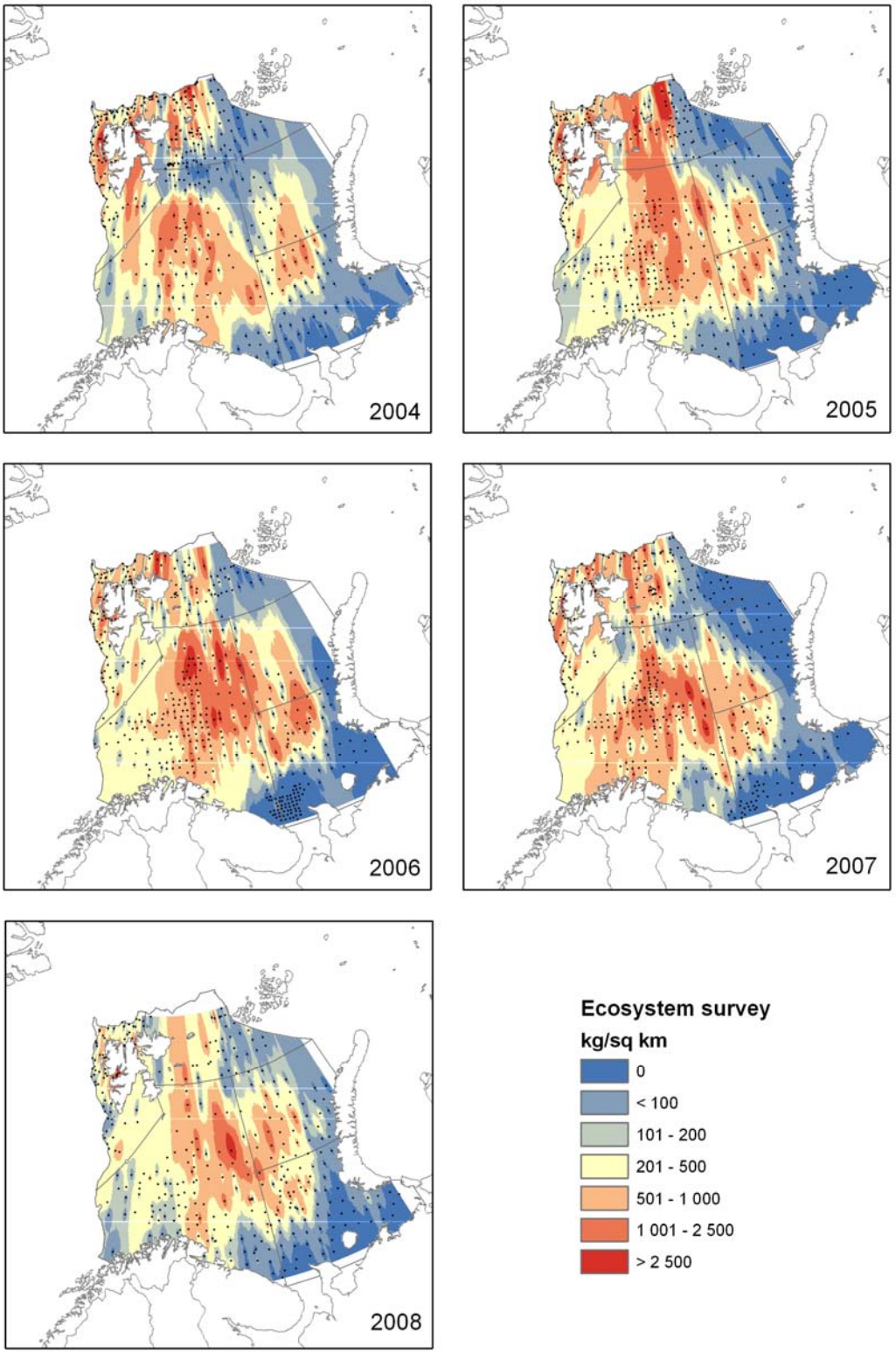

Fig. 7 Shrimp density within the new survey stratification (2004-2008) from *inverse distance weighted* interpolation (e.g. Fisher *et al*., 1987) between trawl stations (black dots) (Europe Albers Equal Area Conic projection).

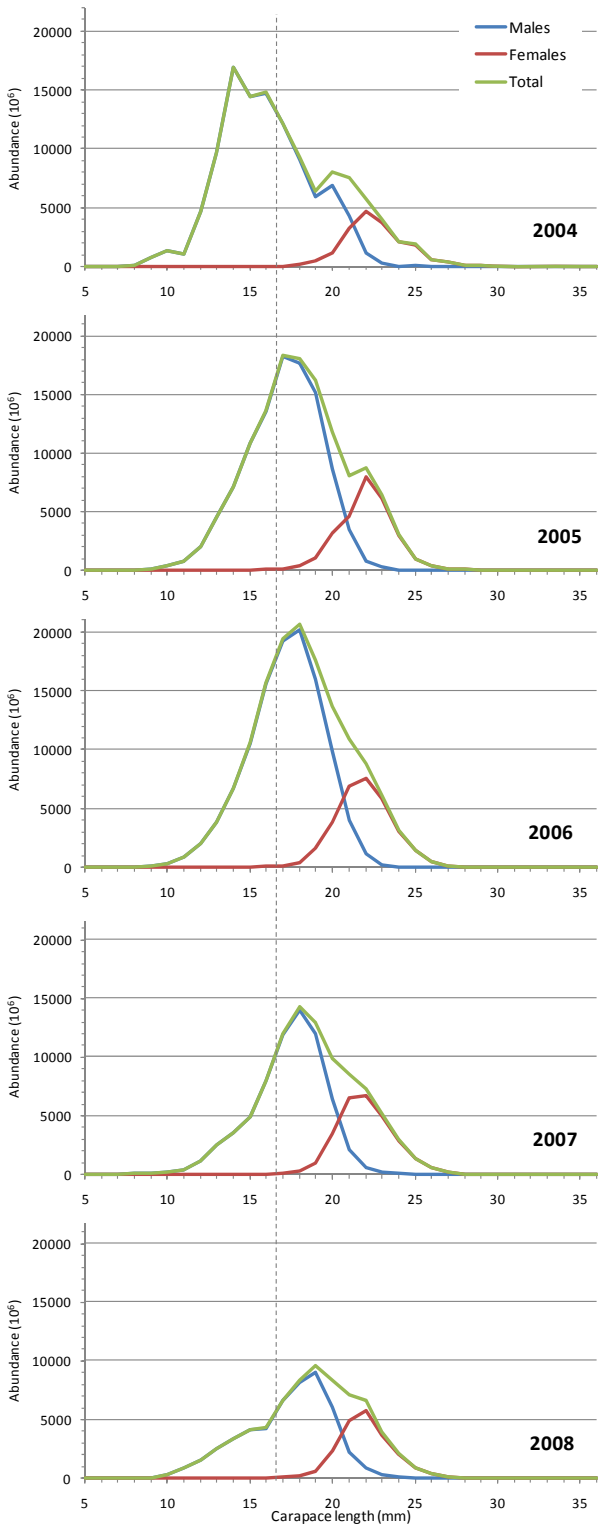

Fig. 8 Shrimp in the Barents Sea: overall size distribution of males, females and total 2004-2008.

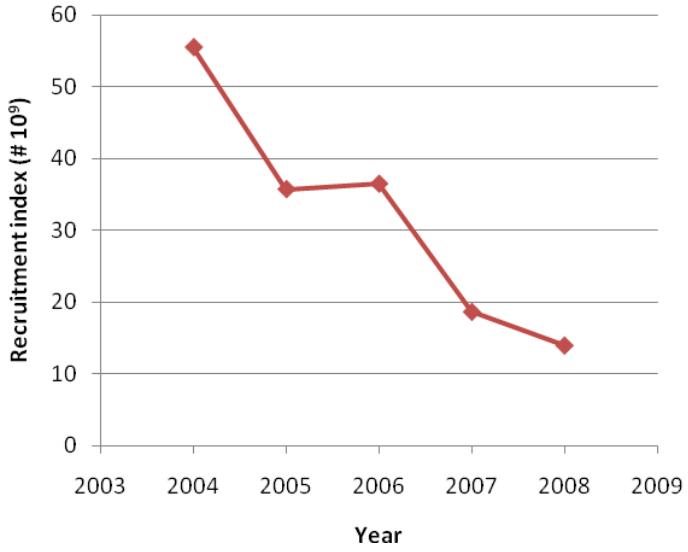

Fig. 9 Index of recruitment: estimated mean abundance of shrimp at size 13-16 mm cpl.

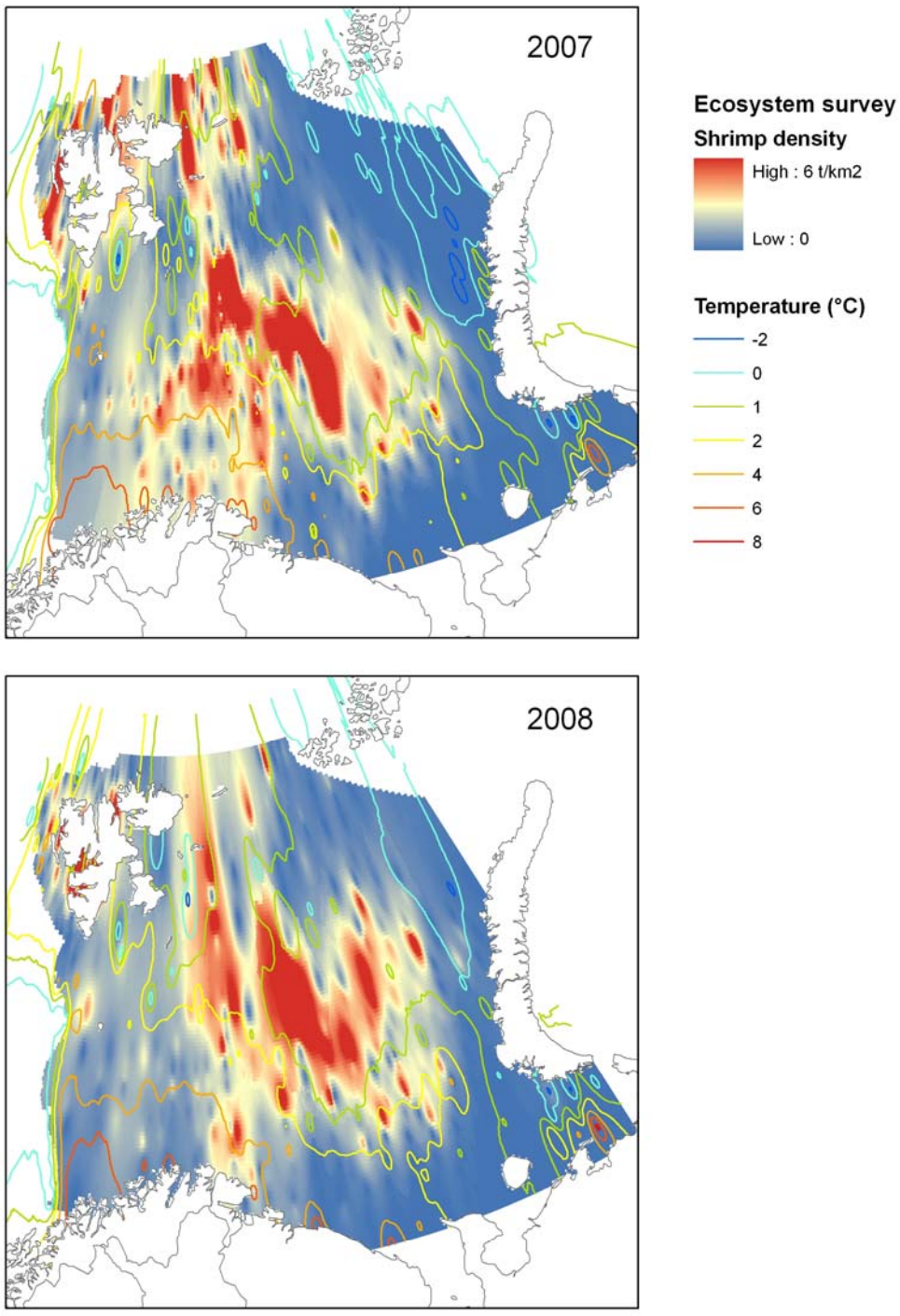

Fig. 10 Bottom temperature contour overlays from the 2007 and 2008 ecosystem surveys on shrimp density distributions as in Fig. 7.