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Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east) in 2012

by

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Abstract

The Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) has gone through large changes in recent years. The result is a series of four different surveys, lasting from one to nineteen years. New series were initiated in both 2004 (May) and 2006 (February). Conducting the survey in the 1st quarter gives good estimates of recruitment and SSB. Thus, a new time series at the most optimal time of year is established.

The annual survey biomass estimate was fluctuating around a high level from the mid 1990s to 2002 when this series was discontinued. The 2004 and 2005 mean values of a new biomass index series were not statistically different. The 2007 index was 77% higher than the 2006 value. In 2008 the biomass index decreased back to the 2006 level. The decline has continued since.

Recruitment (abundance of 1-group) in Skagerrak was much lower in 2008-2012 than in the two preceding years. However, recruitment increased from 2010 to 2011 and further in 2012, implying improved catches in 2013. For most of the time series recruitment has been lower in the Norwegian Deep compared with Skagerrak, implying that Skagerrak is a nursery area for the stock. The low recruitment in 2008-2011 is probably the main reason behind the decreasing stock size. The SSB-index has shown a decreasing trend since 2007.

The index of shrimp predator biomass was estimated to 30.04 kg/nm in 2012. A predator index excluding saithe and roundnose grenadier shows less interannual variation.

Introduction

A trawl survey for northern shrimp in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east, and the far north-east corner of Div. IVb) has since 1984 been conducted annually by the Norwegian Institute of Marine Research with the objective of assessing the biomass, recruitment, and demographic composition of the shrimp stock and the size of the stocks of shrimp predators, as well as measuring hydrographical conditions in the distributional area of shrimp.

The survey data consist of: 1) one time series based on a survey conducted in October/November 1984-2002 using R/V *Michael Sars* and the Campelen-trawl; 2) a point estimate for 2003 as R/V *Michael Sars* was taken out of service and substituted with R/V *Håkon Mosby*, whose winches at that time were not powerful enough for the Campelen-trawl, resulting in the survey being conducted with the Shrimp trawl 1420; 3) a start of a potential new series as the survey in both 2004 and 2005 was conducted in May/June with R/V *Håkon Mosby* using the standard Campelen trawl; and 4) a start of yet a new series in February 2006 still using R/V *Håkon Mosby* and

the Campelen trawl. Conducting the survey in the 1st quarter gives good estimates of the 1-group (recruitment) and SSB (berried females) and was strongly recommended by the *Pandalus* working group in 2004 (ICES 2005). Since 2006 the survey has been conducted in January/February. Thus, a new time series at the most optimal time of year is established.

This paper presents the results of the 2012 survey.

Material and Methods

Survey design

The survey design has not changed much throughout the whole time series.

The survey area covers depths of approximately 100 to 550 m in ICES Divs. IIIa and IVa east. A couple of stations are also located in the far north-east corner of Div. IVb. The survey is stratified by four depth zones (100-200 m, 200-300 m, 300-500 m, and >500 m), and area (Table 1, Fig. 1). In 2007 the strata division was revised. The depth contours were updated using GIS and the bathymetric database GEBCO, and the strata areas were recalculated accordingly. Strata 1-4 were extended north to 60º N in order to incorporate the two northernmost stations in the strata system, and the deep water area in the middle of Skagerrak (>500 m) was included as a 17th stratum as four trawl stations are located in this area. A second revision of the strata system in 2008 moved the northern border of stratum 1 to 59º N as the two southern trawl stations in this stratum cannot be considered representative of the whole area north to 60º N (Fig. 1). Furthermore, the strata areas were recalculated using an "equal area" projection which gives more correct area estimates than the earlier used projection. The survey area is now estimated to cover 15 749 nm² (Table 1).

The survey has a fixed station design, assuming that the temporal variation in the shrimp stock generates the necessary randomness. In 2006 it was decided that the100 stations trawled during the 2000 survey should be considered fixed stations for future surveys. In 2008 thirteen stations (positions found in old survey reports from 1984-1996) were added in order to obtain a better coverage of the area (Fig. 1), and two old stations were deleted from the list, resulting in a new total of 111 trawl stations. The deepest and shallowest stations have depths of respectively 540 and 111 m. Idealy, all stations should be trawled every year, giving a coverage of one haul per 142 nm^2. However, this rarely happens due to time and weather constraints.

In 2012 the survey was carried out from January 9 to 24. The trawl used is a Campelen 1800/35 bottom trawl with rockhopper gear. In 2006 the rigging was changed with more float added in order to reduce the number of "mud hauls". This worked out very well, and the new rigging has since been kept. Mesh size in the cod end is 20 mm with a 6 mm inner lining net. Tow duration was 1 hour until 1989 when it was reduced to 0.5 hour. When towing on shallow fish banks tow duration is reduced to 5-10 minutes to prevent the trawl filling up with fish. Tow speed is roughly 3 knots. In 2012 the average tow speed was 2.93 knots (SD = 0.23). No compensation for diurnal vertical migration is made. Strapping was introduced on the survey in 2008 to ensure a fixed trawl geometry. Due to poor door spread on the 2009 survey, various rope lengths and distances between the rope and the doors were tried out. A 10 m rope 200 m in front of the doors gave an optimal door spread of 46-47 m. This rigging has been kept since.

Stock size index

In 2012 biomass indices (with SE) from the years 1984-2002 and 2004-2005 were recalculated using the same procedure as was used for calculating the 2006-2012 indices (Table 4, Fig. 6).

The swept area was estimated by applying a wingspread of 11.7 m to tow length. Tow length was set to time towed multiplied by an average towing speed of 3 knots. The swept area is thus 0.019 nm^2/hour.

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 respective stratum to give estimates of strata biomass and abundance. The biomass and abundance for the 17 strata were summed to give the overall value for the survey area. Due to weather constraints some strata were not covered in some years. The biomass in any missing stratum was estimated by applying the portion of total biomass in the stratum, averaged over all years with data, to the total biomass of the year. Standard errors were corrected in 2009: SE (whole survey area) = $\sqrt{[\Sigma (SE\ (stratum)^2)]}$.

A biomass index of shrimp predators was calculated as average catch/nm over all hauls of 23 fish species/fish families.

Biological samples

Samples of 250-300 shrimps are taken from each trawl haul, sorted by sexual characteristics, and measured to the nearest mm below (carapace length (CL)). Overall length frequency distribution, as well as distributions per area (Skagerrak and the Norwegian Deep), were estimated. The length frequency distributions were partitioned into age groups by modal analysis using the method of Bhattacharya (1967) (software: FISAT).

A recruitment index was estimated as the number of 1-year old shrimp from the modal analysis. There is a good correlation between the number of 1-year old shrimps in January/February in one year and the number of 2-year old shrimps the following year, despite few data points (Fig. 2).

A SSB-index was estimated as the total number of berried females and recently spawned females. Berried females are dominating the catches in January-February.

Hydrographical measurements

In all present and past surveys CTD casts have been made at each station, but previously the data were not analysed. To avoid damages on the equipment, the CTD is not lowered further than 10 m above the bottom. In 2012, CTD casts were made on only 22 stations due to problems with the CTD-winch (Fig. 3).

Results

Area coverage

Due to very bad weather conditions, only 65 out of the 111 fixed stations were covered (Fig. 4). Out of these two tows were invalid ("mud hauls"). These data were not used in the calculations. Especially the Norwegian Deep was poorly covered with only 21 hauls, and strata 1 and 2 were not covered at all.

Temperature and salinity

The average temperature (10 m above the bottom) in January/February in the survey area has lied between 7 and 8 °C from 2006 to 2010. In 2006-2009 the bottom temperature was slightly higher in the Norwegian Deep compared with Skagerrak, while in 2010 the pattern was opposite (Table 2, Fig. 5). The area was cooled down during the unusually cold winter 2009-2010, which led to cold water sinking into the Norwegian Deep and Skagerrak basin in late winter 2010, replacing the warmer bottom water. The bottom water was still unusually cold in early 2011, while the sparse 2012-CTD data indicate that bottom temperature was back to average level in January 2012.

Average salinity has varied between 34.9 and 35.3 ‰ in the same time period.

Strapping

The introduction of strapping has caused the average door spread to decrease from more than 50 m in 2006-2007 to 46-47 m in 2008-2012 (Table 3). The former relationship of increased door spread with increased depth is not seen in the 2008, and 2010-2012 tows. In 2009 there was a slight decrease in door spread with depth, probably due to difficulties with the trawl gear at this year's survey. The difference in door spread between the different years is not corrected for.

Biomass indices

The recalculated biomass indices resemble the old time series quite well, except for the year 1999. The recalculation of the indices enabled the calculation of SE's. The biomass index increased from the late 1980s to the early 1990s, remained at a stable level until the mid 1990s where after it increased further to this time series' maximum in 1997 (Table 4, Fig. 6).A decrease in 1998-2000 was followed by an increase in 2001 and 2002. This series was discontinued in 2002. The very low 2003 biomass index could have resulted from the use of the Shrimp trawl 1420, which has mesh size in the cod end of 36 mm, and no lining. However, the trawl opening is taller compared with the Campelen trawl. The 2005 mean value is lower than that of 2004, but not statistically

different. The 2007 index was 77% higher than the 2006 value, but was heavily influenced by the very high mean biomass in stratum 16 (Table 4), which was due to the high biomass of one particular trawl station. In 2008 the biomass index declined to the 2006 level. The decreasing trend has continued until 2012 (Figs. 6, 7a, 7b).

As the time series is short (only 7 years), there are few years with which to compare the low values of 2010-2012, and it is not possible to state whether these indices are extraordinarily low. The LPUE-index has been decreasing since 2007 and was in 2012 at the lowest level since 2000 (Søvik and Thangstad 2012). Thus, the shrimp biomass seems to be at a very low level in 2012.

In 2006-2009 the estimated shrimp biomass was higher in Skagerrak (Div. IIIa) compared with the Norwegian Deep (Div. IVa east), however, in 2010-2011 this pattern was reversed with a slightly higher estimated biomass index in the Norwegian Deep compared with Skagerrak. In 2012, the pattern was reversed again, with a very low estimated biomass in the Norwegian Deep, even when correcting for no biomass in stratum 2 (which was not covered by the survey).

Size, age and sex distribution

The model analysis gave three age groups in Skagerrak and four age groups in the Norwegian Deep (Table 5, Fig. 8). Length frequency distributions for earlier years also showed three age groups in Skagerrak and four in the Norwegian Deep (Fig. 9).

In Skagerrak, recruitment (1-group) declined from 2007 to 2010, but increased slightly in 2011 and further in 2012 (Fig. 10). Because of the relatively good correlation between the size of the 1-group in one year and the 2-group in the following year (Fig. 2), the larger 1-group in 2012 (compared with the four former years) implies an increased 2-group and thus larger catches in late 2012 and 2013. Fishers have indeed reported better catches in autumn 2012.

In the Norwegian Deep in 2006-2009, recruitment was very low compared with Skagerrak (Fig. 10). The inter-area difference was, however, less pronounced in 2008-2009 compared with 2006-2007, due to a sharp decline in recruitment in Skagerrak. In 2010 recruitment was of equal low size in the two areas. In 2011,and especially in 2012, recruitment was again larger in Skagerrak compared with the Norwegian Deep.

The much larger abundance of 1-year old shrimp in Skagerrak indicates that these waters constitute a nursery area for the stock. The low recruitment in 2008-2011 is probably the main reason behind the decreasing stock size since 2007. However, it is not known why recruitment has been so low in recent years.

SSB had decreased since 2007 (Fig 11a). There seems to be no relationship between SSB and recruitment (1-year old shrimp (Fig. 11b).

Predator abundance

Mean catch per trawl haul (kg/nm) in 2012 are given for various shrimp predators (Table 6). Saithe is the most abundant species, with an average catch of 5.66 kg/nm. The total index of shrimp predator biomass was estimated to 30.04 kg/nm in 2012, which is below the mean of the series for 2006-2012 (Table 6). Results from the first survey series (1984-2002) range from 28.6 to 63.1 kg/nm (ICES 2004), while in 2004-2005 the indices were respectively 58.1 and 115.4 kg/nm (ICES 2006).

The index of predator biomass is heavily influenced by the indices for saithe and roundnose grenadier. Some shallow trawl stations yield large catches of saithe, while roundnose grenadier is caught mainly in the deep parts of Skagerrak. Thus the value of these two indices, and consequently the total predator index, depends largely on the number of shallow and deep stations covered each year. A predator index excluding saithe and roundnose grenadier shows less inter-annual variation (Table 6). The shallow and deep stations have very low densities of shrimp. A more informative predator index should be based on only the trawl stations with a certain minimum density of shrimp.

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Table 1. The estimated biomass available to the trawl (Ktons) and abundance (millions) from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in 2012. Depth intervals are given in meter, and stratum area in nm^2. SE is the standard error.

Stratum	Depth (m)	Area (nm^2)	Hauls	Biomass	SE	Abund.	SE
1	100-200	1 245					
2	200-300	2 500					
3	100-200	277					
4	200-300	1 560	3	0.30	0.24	72	66
5	100-200	1 401	5	0.01	0.01	3	2
6	200-300	1 159	5	1.07	0.40	182	74
7	300-500	555	1	0.14	-	25	-
8	100-200	136					
9	200-300	590	4	0.26	0.11	75	35
10	300-500	541	3	0.04	0.01	7	2
11	100-200	367	4	0.31	0.16	127	91
12	200-300	254	5	0.39	0.23	182	139
13	300-500	739	3	1.28	0.33	494	184
14	100-200	1 411	7	0.39	0.34	71	61
15	200-300	739	13	0.49	0.28	145	101
16	300-500	1 138	8	0.82	0.44	227	119
17	> 500	1 137	2	0.01	0.01	2	2
Total		15 749	63	5.51	0.90	1 613	317

Table 2. Average temperature (°C) and salinity (‰) over all trawl hauls from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in 2006-2012. The 2012 data result from only 22 CTD casts (8 in the Norwegian Deep and 14 in Skagerrak), due to difficulties with the CTD-winch.

Norwegian Deep

	Temperature (°C)		Salinity (‰)	
	mean	SD	mean	SD
2006	7.40	0.58	35.25	0.02
2007	7.90	0.50	35.20	0.07
2008	7.58	0.35	35.18	0.06
2009	7.43	0.32	35.26	0.04
2010	7.30	0.55	35.16	0.05
2011	6.61	0.47	35.15	0.04
2012	7.84	0.75	35.18	0.03

Skagerrak

	Temperature (°C)		Salinity (‰)	
	mean	SD	mean	SD
2006	7.01	0.65	35.13	0.1
2007	7.30	0.80	35.17	0.07
2008	7.03	0.36	34.88	0.31
2009	7.13	0.57	35.11	0.22
2010	7.47	0.46	35.16	0.28
2011	5.44	0.68	34.86	0.21
2012	7.28	0.64	35.01	0.22

Table 3. Norwegian shrimp surveys in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in 2006-2012: mean door spread with standard deviation, and regression coefficient and R^2 from the linear regression line.

	mean	sd	regression coefficient	R^2
2006	52.9	4.4	0.025	0.14
2007	51.6	1.8	0.014	0.31
2008	47.0	1.7	-0.004	0.05
2009	45.3	3.2	-0.012	0.10
2010	46.9	2.2	0.001	0.00
2011	47.7	2.2	-0.005	0.04
2012	47.5	3.0	-0.001	0.00

Table 4. Estimated biomass indices (t) from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) by survey and stratum 1984-2012. Indices from the different surveys series are not comparable (see text). SE is the standard error.

Survey		Stratum																	Total area	
Year	Series	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Index	SE
1984	1	0	3480	-	1430	4210	2090	570	-	510	250	290	[1)]530	1010	1050	1060	1060	[1)]57	17597	3217
1985	1	0	5630	-	1280	2100	2440	1270	180	990	1340	410	600	1370	2690	3110	1750	0	25180	3137
1986	1	0	3120	-	280	90	1870	530	-	[1)]538	370	0	400	1180	1590	1140	440	0	11548	1799
1987	1	0	6050	-	1690	1680	2590	670	0	1160	550	290	430	550	1670	750	750	0	18830	3193
1988	1	0	1420	-	620	440	890	400	0	280	410	410	260	410	500	500	300	0	6830	956
1989	1	-	1280	-	2010	0	1520	540	-	510	500	410	360	780	920	1220	570	0	10640	1324
1990	1	0	1620	-	1840	0	1980	300	0	1060	380	510	650	700	1290	1240	1120	0	12700	1750
1991	1	0	3160	-	3390	60	1890	450	-	1200	350	660	530	980	2180	1650	1820	90	18400	2409
1992	1	0	2910	-	620	940	4790	1440	290	490	1190	1920	550	1220	2010	1980	970	0	21340	2928
1993	1	0	1320	-	3010	180	1570	550	-	1050	270	2080	560	1310	1710	2650	1300	240	17770	2054
1994	1	0	2710	-	2060	380	2610	840	-	770	360	1450	740	1300	2130	1550	1590	10	18500	1586
1995	1	0	3530	-	1070	180	2840	740	360	1010	230	1460	400	800	2240	1780	930	0	17590	1732
1996	1	0	4950	-	1280	140	3060	1640	-	730	330	3630	1300	1350	2470	1880	1180	200	24150	2498
1997	1	0	8820	-	2080	520	2900	1720	280	1020	630	2420	840	1470	3220	2090	3230	800	32020	2771
1998	1	0	6860	-	2010	530	1830	610	-	910	730	680	500	720	1660	2090	1060	0	20190	2057
1999	1	0	5830	-	2430	230	1580	410	-	760	230	1130	580	620	2160	1540	290	0	17790	1915
2000	1	0	4250	-	3000	510	1720	420	290	270	290	800	330	180	2220	2160	980	0	17400	1957
2001	1	1230	5460	-	4810	1790	2330	700	-	350	470	350	170	520	3440	1770	1180	0	24560	2837
2002	1	0	[1)]5187	-	[1)]2857	160	1590	1160	-	1560	660	1110	580	490	3600	3670	2190	0	24815	1937
2003	2	-	-	-	1410	750	2770	840	300	1240	430	480	770	960	2210	1950	850	-	14960	
2004	3	-	4000	-	3230	0	2940	990	-	940	650	570	1300	1250	8840	3780	3570	350	32400	3570
2005	3	0	5480	-	3150	0	2570	1730	-	1540	870	900	640	1140	3200	2180	3760	0	27150	3028
2006	4	-	2920	-	2010	[2)]141	2110	[2)]1154	-	380	130	870	900	1910	2730	2050	2130	[2)]111	19546	2303
2007	4	-	3500	-	1620	120	2980	740	-	1250	1050	1970	1390	6860	1380	2140	12470	0	37480	8031
2008	4	20	2910	-	1210	290	2550	1230	-	650	160	780	1480	3980	1200	570	2420	40	19500	2539

2009	4	0	1840	-	680	190	3400	220	-	410	70	520	1660	1270	800	2060	1680	70	14860	2208
2010	4	0	1620	-	580	30	1230	1290	-	590	500	200	400	640	660	890	1450	30	10100	1733
2011	4	0	520	-	760	20	1930	600	40	470	690	310	320	500	690	880	720	160	8620	1069
2012	4	-	[2)]735	-	300	10	1070	140	-	260	40	310	390	1280	390	490	820	10	6245	897

1) estimated as the stratum's mean portion of total biomass (averaged over 1985, 1987-2001) applied to the total biomass of the year.

2) estimated as the stratum's mean portion of total biomass (averaged over 2007-2011) applied to the total biomass of the year.

Table 5. Mean carapace length (CL) with standard deviation (SD), abundance (millions) and proportions of age groups from the 2012 survey estimate of stock length frequency distribution in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east).

Skagerrak				
age	CL (mm)	SD	abundance	proportion
1	11.96	1.4	768	0.75
2	17.87	1.55	193	0.19
3+	22.96	1.75	65	0.06

Norwegian Deep				
age	CL (mm)	SD	abundance	proportion
1	10.00	1.18	83	0.38
2	16.59	0.99	58	0.26
3	21.22	1.88	52	0.24
4+	25.25	1.34	27	0.12

Total				
age	CL (mm)	SD	abundance	proportion
1	11.72	1.42	830	0.68
2	17.71	1.49	248	0.20
3	21.36	0.95	75	0.06
4+	24.62	1.41	60	0.05

Table 6. Estimated indices of predator biomass (catch in kg per towed nm) recorded from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in 2006-2012.

Species		biomass index							
English	Latin	2006	2007	2008	2009	2010	2011	2012	mean
Blue whiting	*Micromesistius poutassou*	0.13	0.13	0.12	1.21	0.27	0.62	3.30	
Saithe	*Pollachius virens*	7.33	39.75	208.32	53.89	18.53	7.52	5.66	
Cod	*Gadus morhua*	0.51	1.28	0.78	2.01	1.79	1.66	1.26	
Roundnosed Grenadier	*Coryphaenoides rupestris*	3.22	6.85	19.02	19.03	10.05	4.99	4.43	
Rabbit fish	*Chimaera monstrosa*	2.24	2.15	3.41	3.26	3.51	2.73	2.22	
Haddock	*Melanogrammus aeglefinus*	0.97	4.21	1.85	3.18	3.46	5.82	5.75	
Redfish	Scorpaenidae	0.18	0.40	0.26	0.43	0.80	1.02	0.37	
Velvet Belly	*Etmopterus spinax*	1.31	2.58	1.95	2.42	2.52	1.47	1.59	
Skates, Rays	Rajidae	0.41	0.95	0.64	0.17	0.60	0.88	0.98	
Long Rough Dab	*Hippoglossoides platessoides*	0.22	0.64	0.42	0.28	0.47	0.51	0.56	
Hake	*Merluccius merluccius*	0.98	0.78	0.64	2.56	1.60	0.56	0.52	
Angler	*Lophius piscatorius*	0.15	0.91	0.87	1.25	1.70	0.92	0.17	
Witch	*Glyptocephalus cynoglossus*	0.24	0.74	0.54	0.16	0.13	0.24	0.29	
Dogfish	*Squalus acanthias*	0.31	0.19	0.28	0.14	0.11	0.21	0.60	
Black-mouthed dogfish	*Galeus melastomus*	0.00	0.05	0.05	0.15	0.09	0.09	0.09	
Whiting	*Merlangius merlangus*	0.35	1.01	1.35	3.02	2.42	3.07	1.64	
Blue Ling	*Molva dypterygia*	0	0	0	0	0	0	0	
Ling	*Molva molva*	0.04	0.11	0.34	0.79	0.64	0.24	0.17	
Four-bearded Rockling	*Rhinonemus cimbrius*	0.06	0.14	0.04	0.03	0.05	0.03	0.09	
Cusk	*Brosme brosme*	0.20	0	0.02	0.05	0.13	0.29	0.04	
Halibut	*Hippoglossus hippoglossus*	0.08	0.07	3.88	0.09	0.20	0.05	0.19	
Pollack	*Pollachius pollachius*	0.06	0.25	0.03	0.13	0.12	0.15	0.07	
Greater Forkbeard	*Phycis blennoides*	0	0	0	0.01	0.04	0.02	0.05	
Total		18.99	63.19	244.81	94.26	49.23	33.09	30.04	76.23
Total (except saithe and roundnosed grenadier)		8.44	16.59	17.47	21.34	20.65	20.58	19.95	17.86

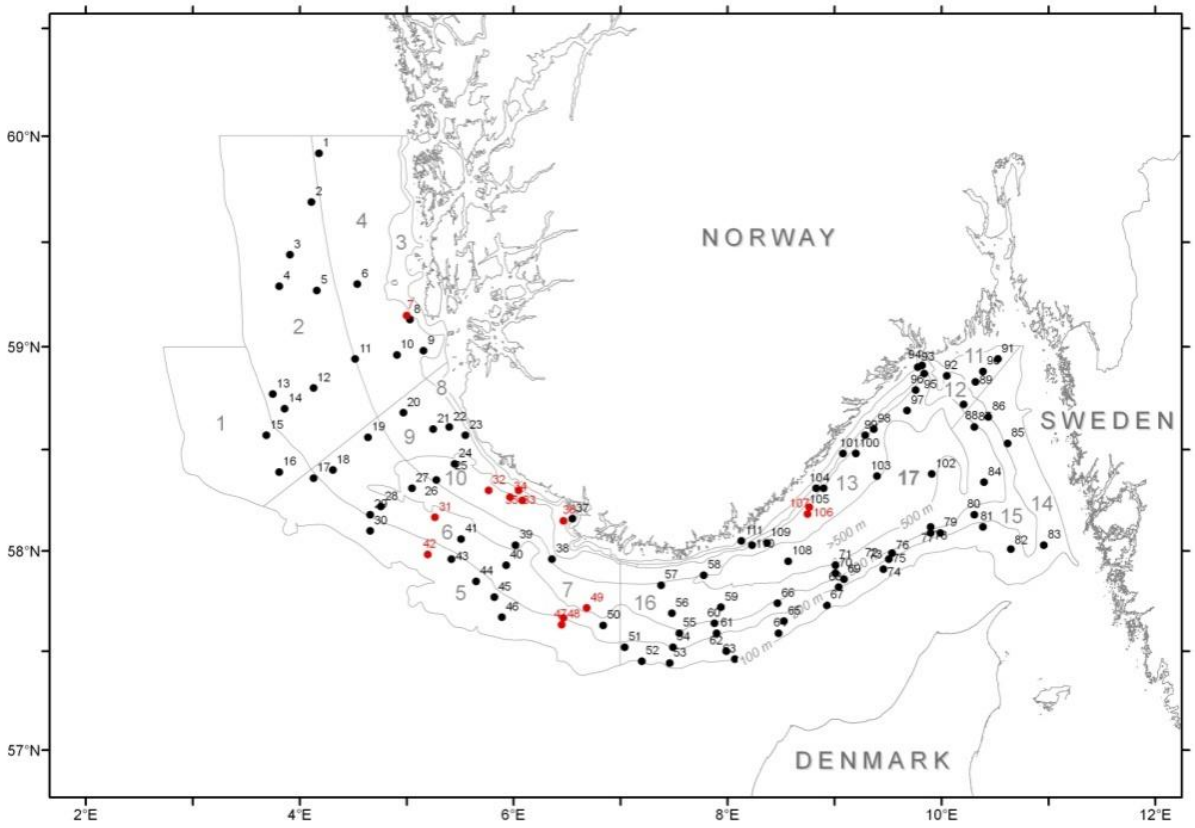

Fig. 1. Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east): the revised strata system (introduced in 2007 and adjusted in 2008) with the 111 fixed trawl stations. Trawl stations marked in red were introduced in 2008 (see text). Strata areas are given in Table 1.

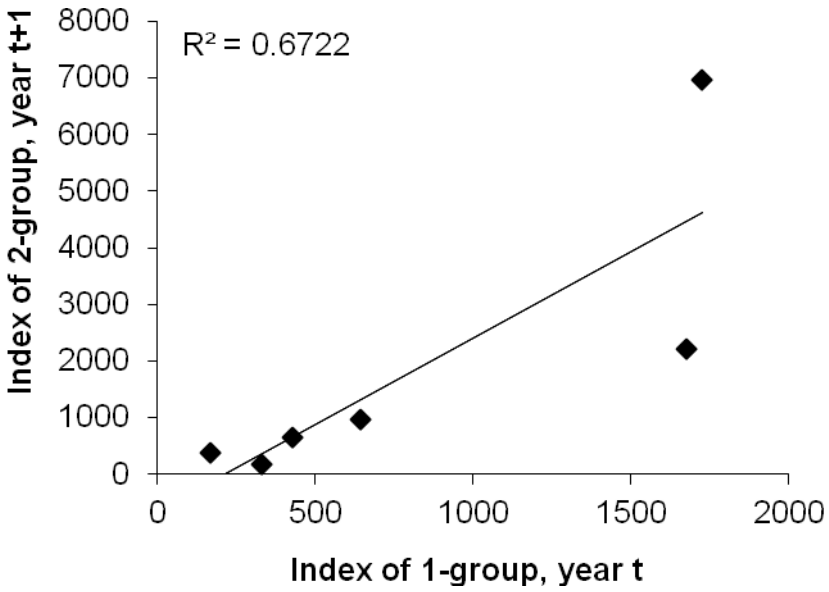

Fig. 2. Correlation between the index of 1-year old shrimps (abundance in millions) in January/February, year *t* and the index of 2-year old shrimps (abundance in millions) in January/February, year *t+1*, in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east). Data from 2006-2012.

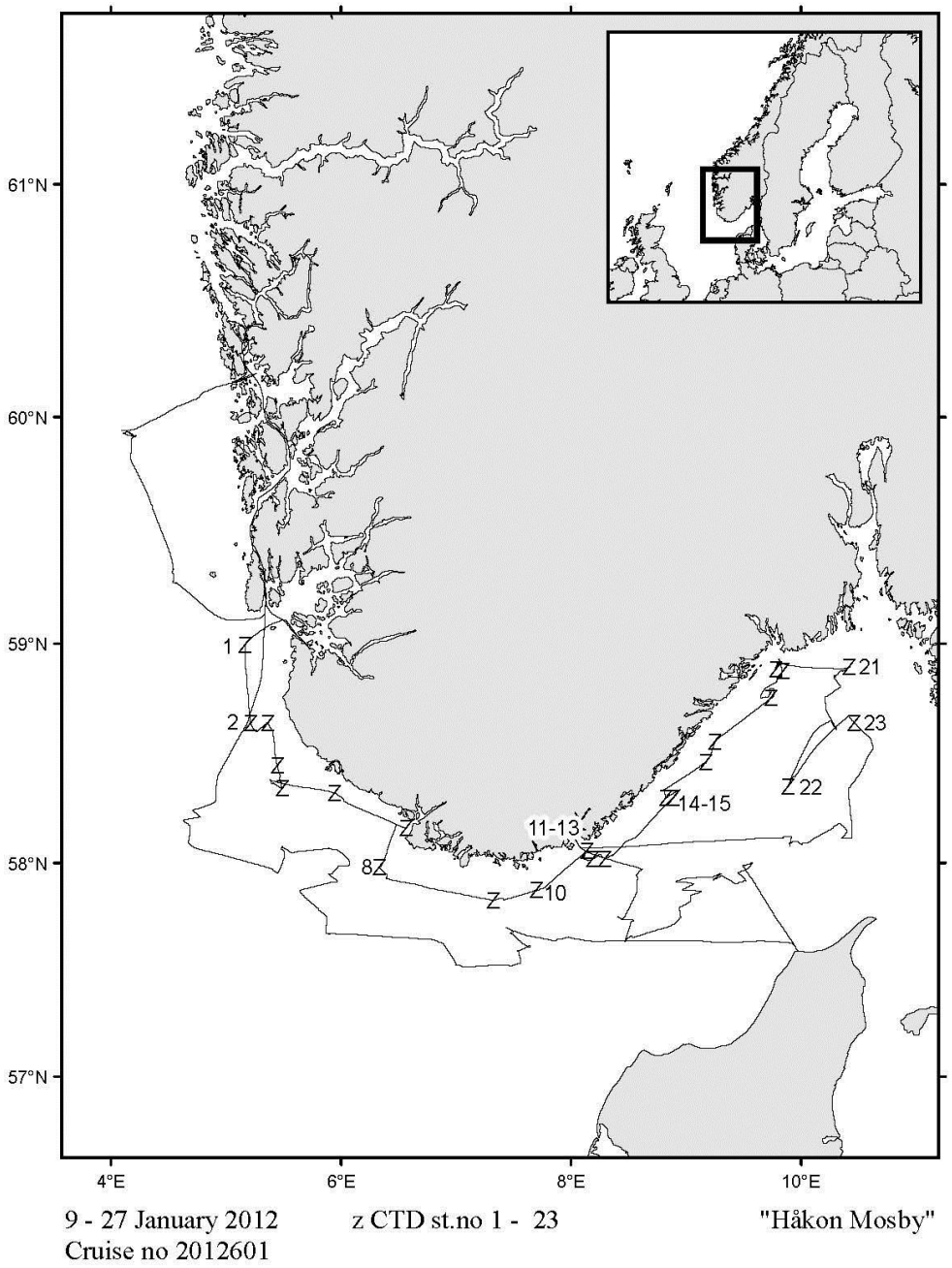

Fig. 3. CTD-stations (z) in the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January 2012.

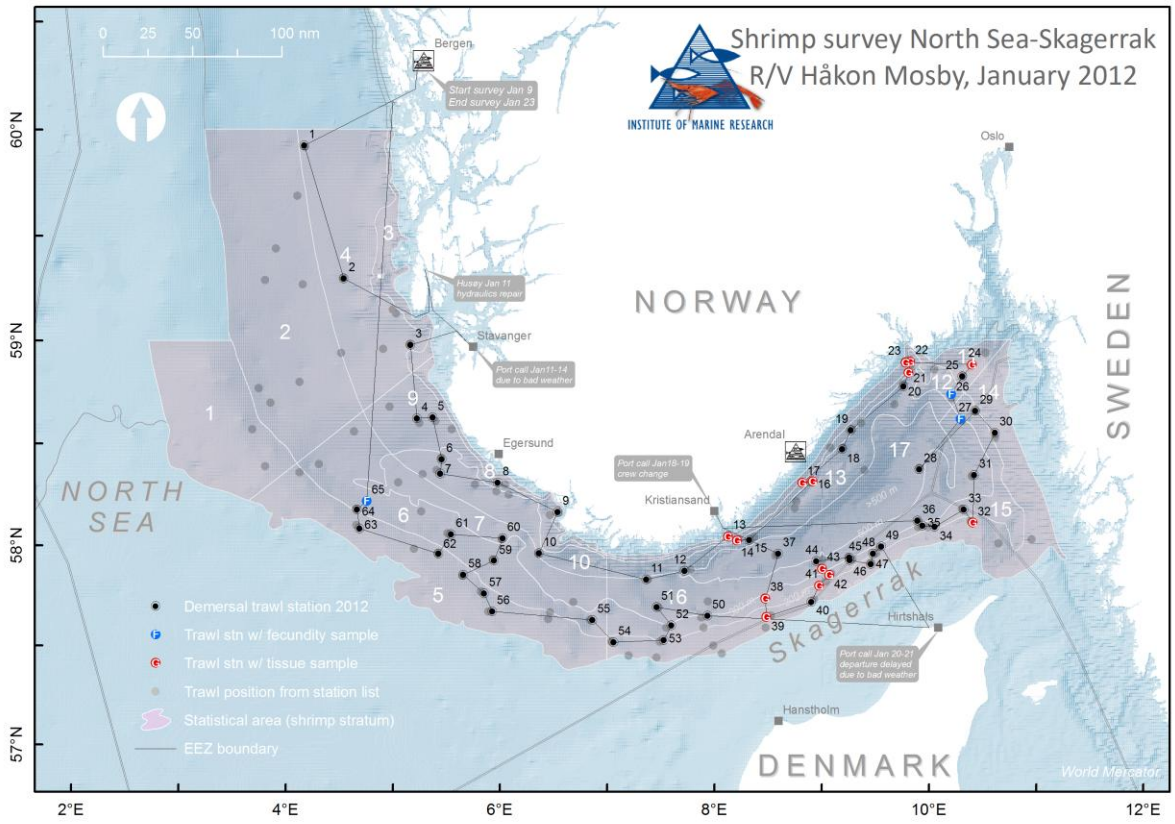

Fig. 4. The Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January 2012 with R/V *Håkon Mosby*: sailing route and trawled stations.

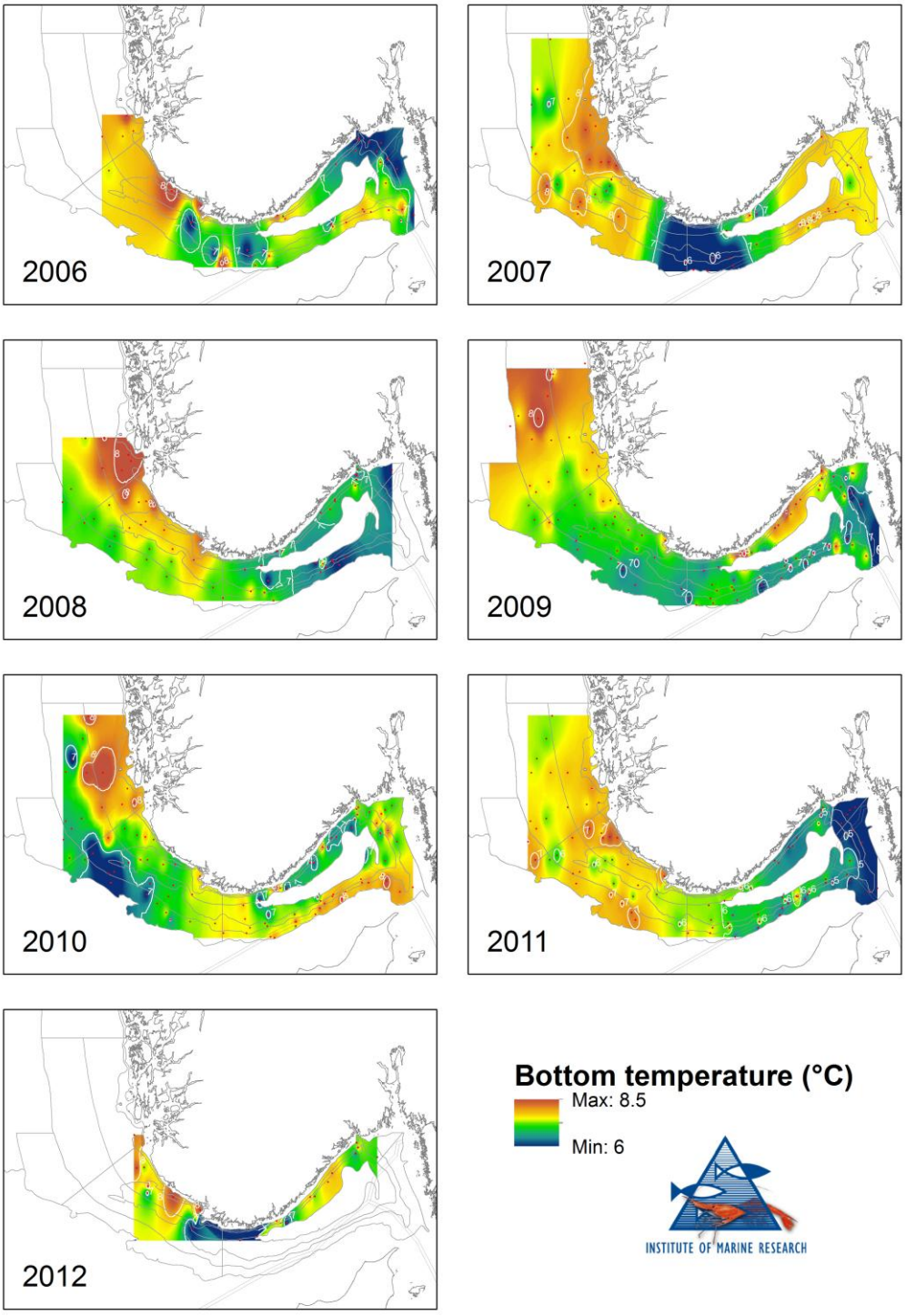

Fig. 5. Temperatures (ºC) measured with CTD on trawl stations during the 2006-2012 shrimp surveys in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east).

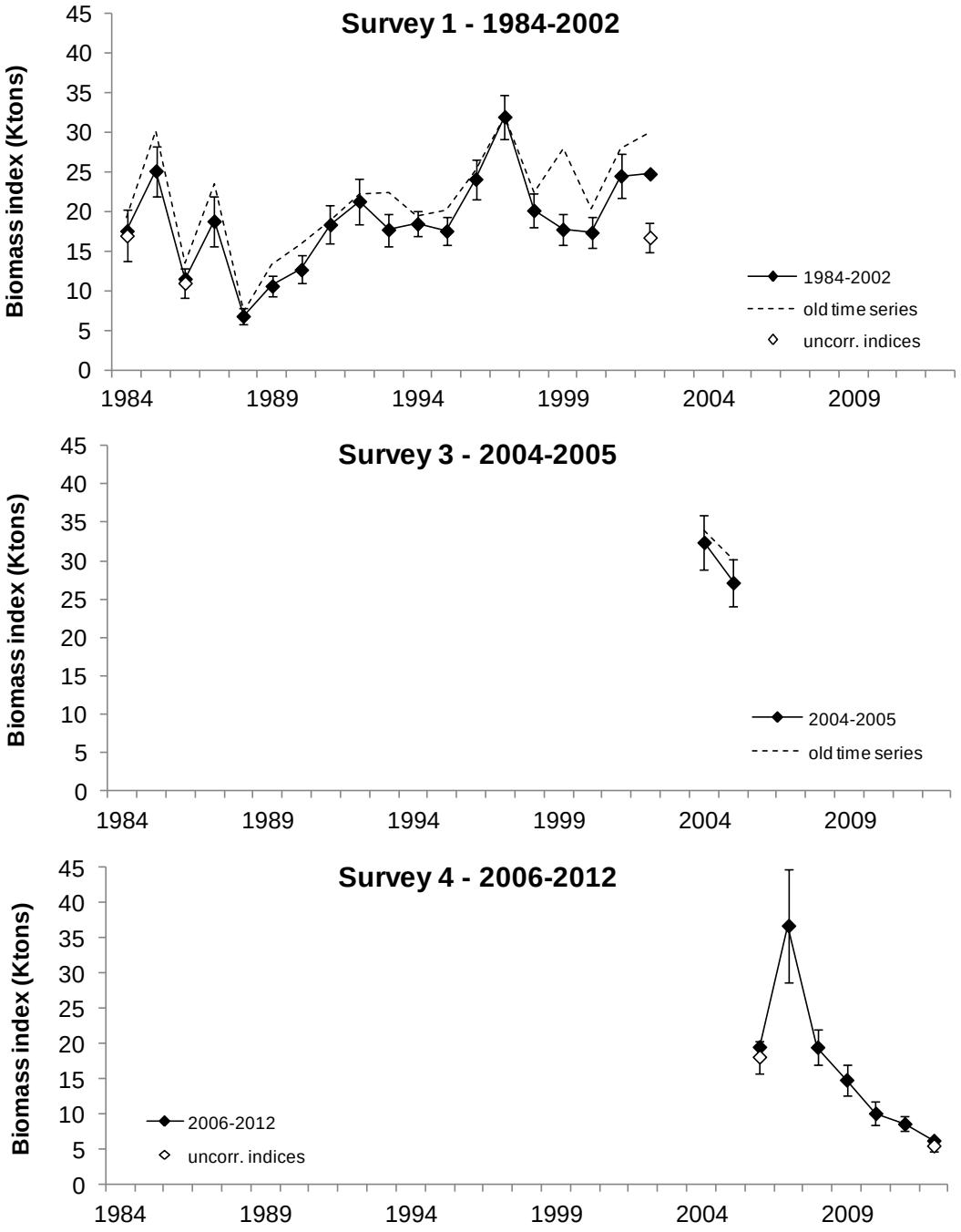

Fig. 6. Estimated survey biomass indices (with standard errors) of shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east), 1984-2012. The 2003-estimate is not shown. Recalculated indices for 1984-2002 and 2004-2005 (♦) are shown together with the uncorrected indices for some years (◊) (Table 4), and the old indices (---).

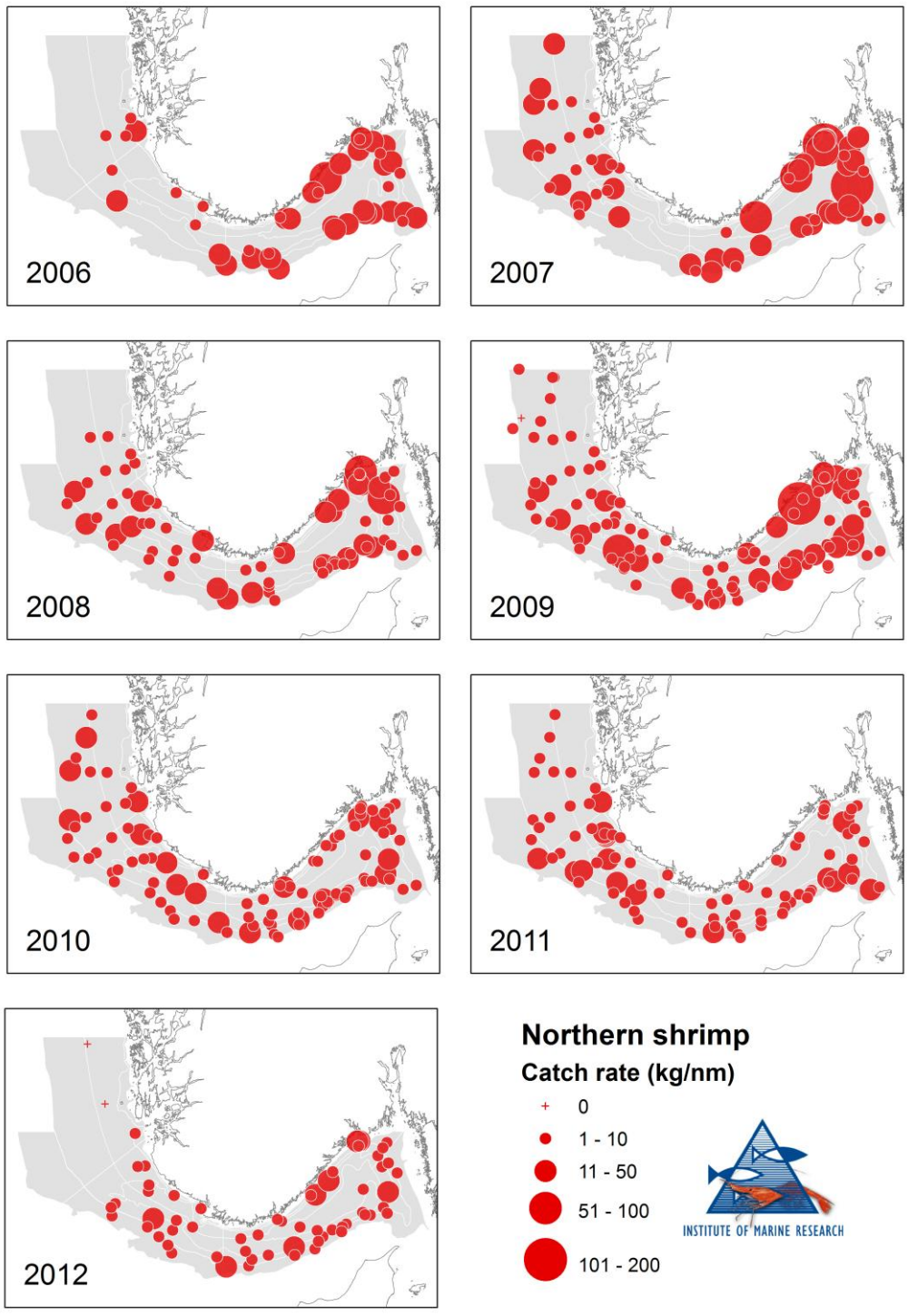

Fig. 7a. Shrimp catches per trawl station (kg/nm) from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January/February 2006-2012.

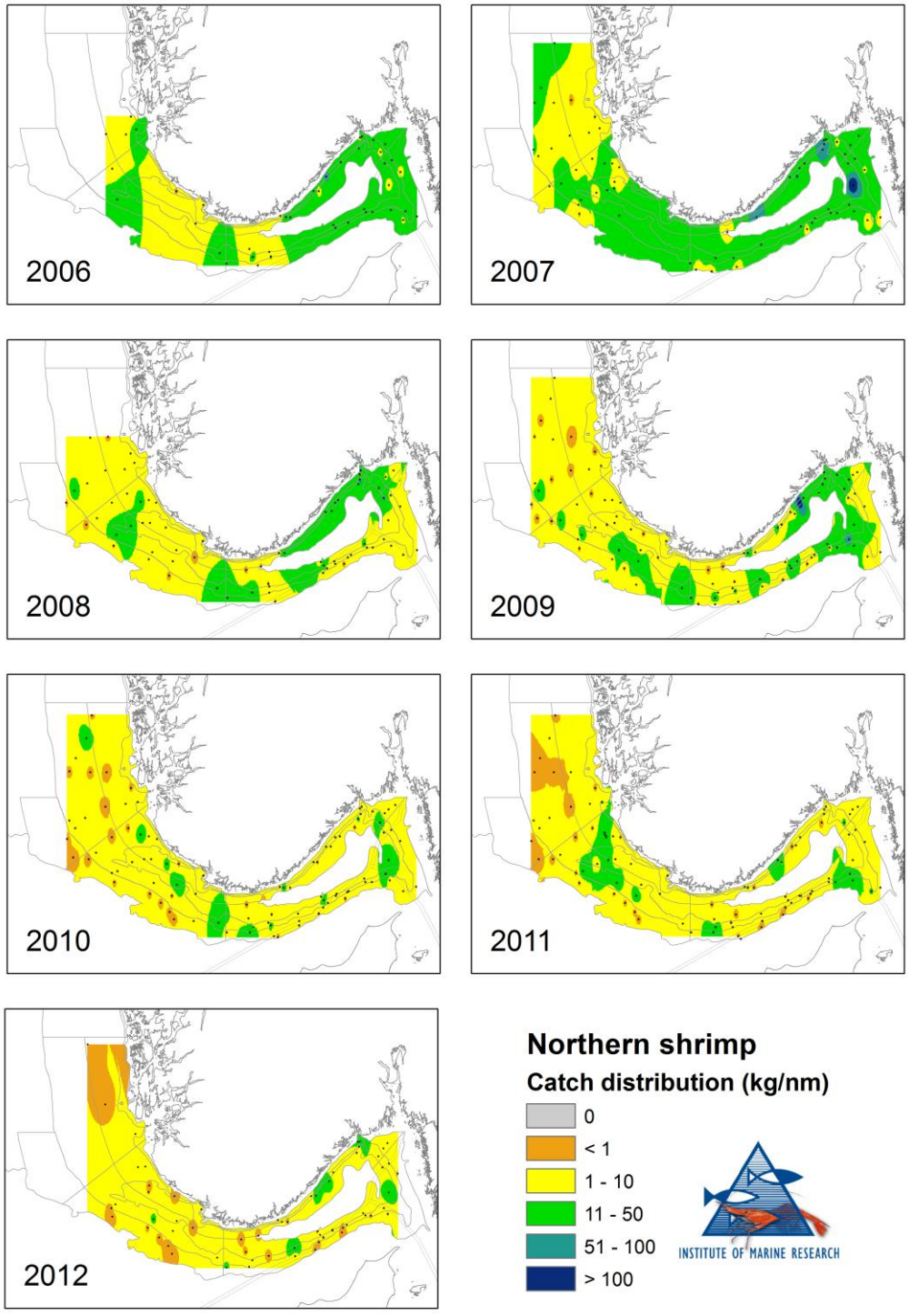

Fig. 7b. The distribution of shrimp (kg/nm) from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January/February 2006-2012.

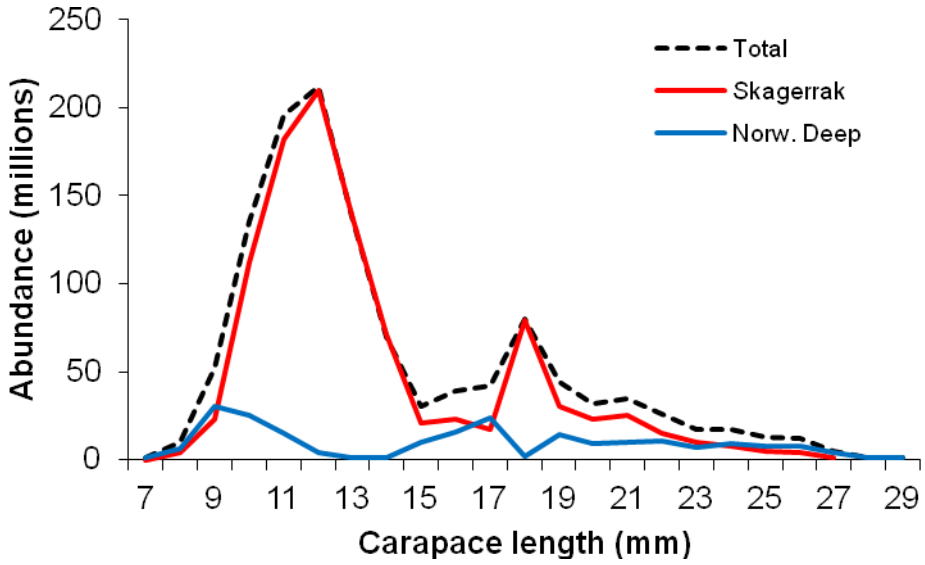

Fig. 8. Length frequency distributions for the overall area, Skagerrak , and the Norwegian Deep from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January 2012.

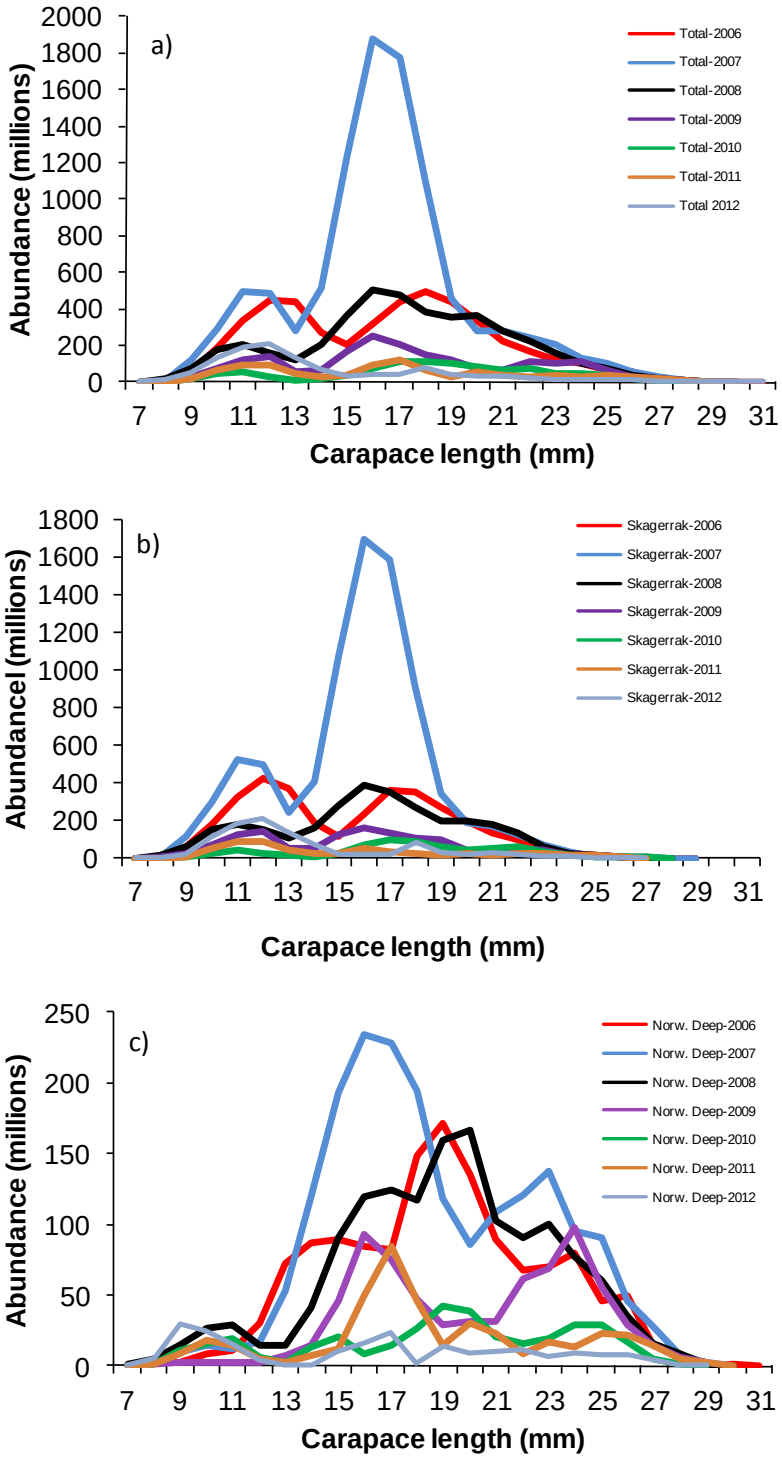

Fig. 9. Length frequency distributions for a) the overall area, b) Skagerrak (ICES Div. IIIa), and c) the Norwegian Deep (ICES Div. IVa east). Data from the Norwegian shrimp survey 2006- 2012. Note different scales on y-axes.

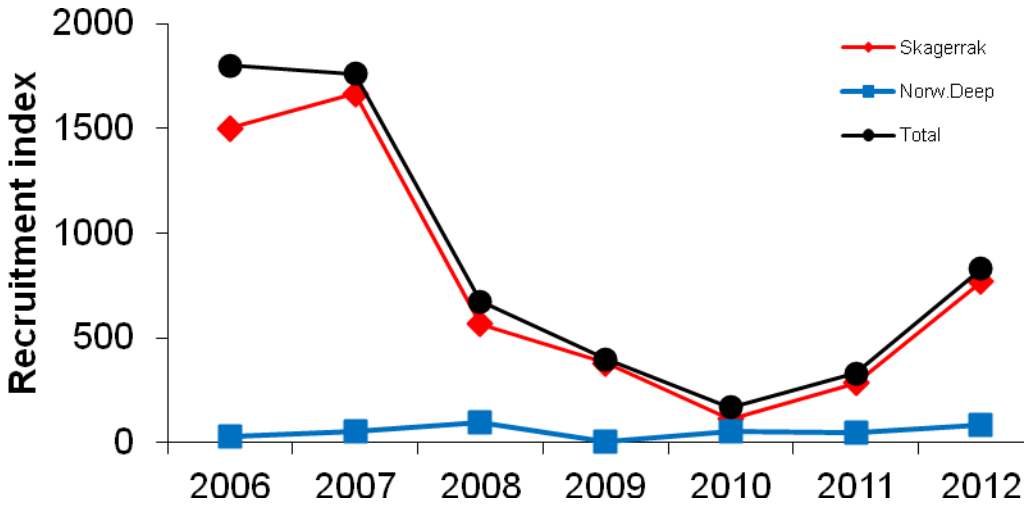

Fig. 10. Recruitment index (abundance in millions) of 1-year old shrimp in Skagerrak (ICES Div. IIIa), the Norwegian Deep (ICES Div. IVa east), and in the overall area for 2006-2012. The higher number of 1-year old shrimp in the whole area in 2006 compared with Skagerrak, despite hardly any 1-year old shrimp in the Norwegian Deep, can be explained by modal groups being slightly skewed. In the total area, shrimps < 15.5 mm are defined as 1-year old by the modal analysis, while the analysis put shrimps > 12 mm in the 2-group in the Norwegian Deep.

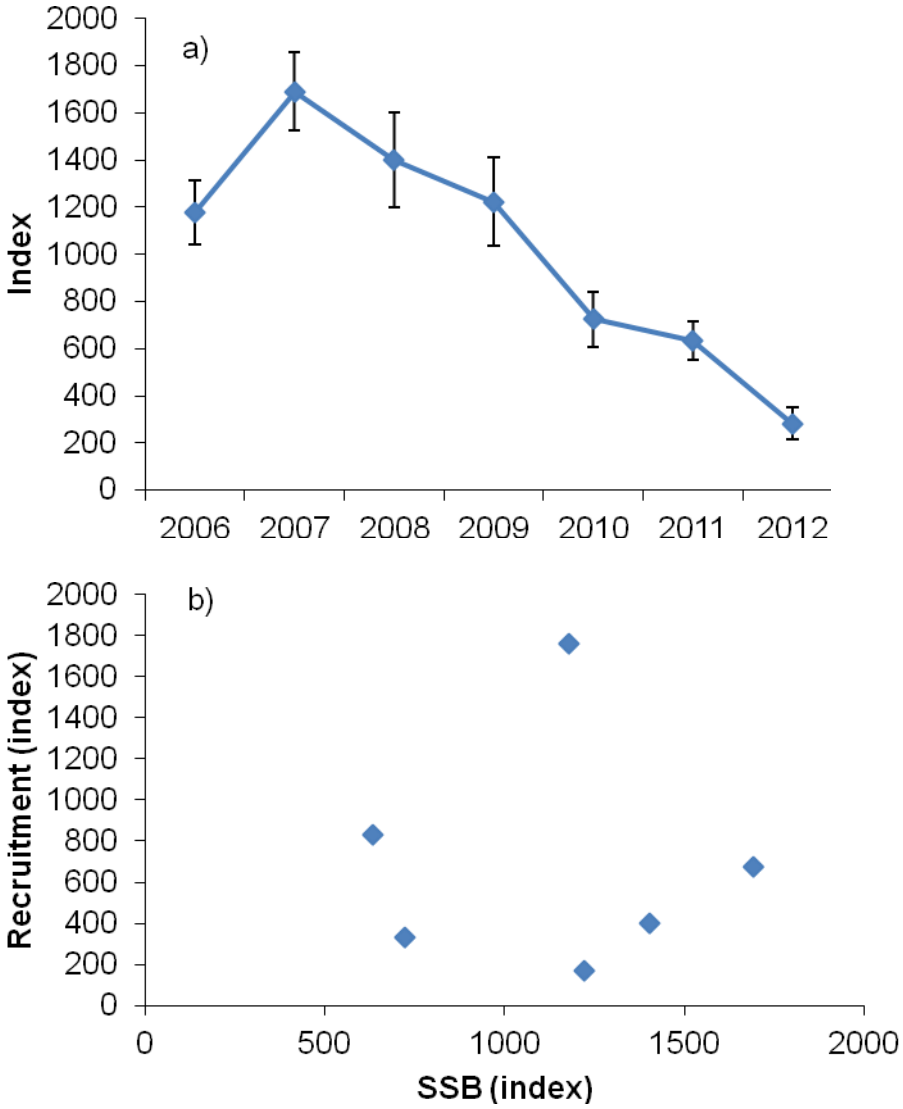

Fig. 11. a) SSB index (abundance in millions) in 2006-2012, and b) SSB-recruitment relationship 2006-2011 in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east).