Northwest Atlantic Fisheries Organization

Serial No. N5989 **SCR Doc. 11/064**

NAFO/ICES *PANDALUS* ASSESSMENT GROUP MEETING – OCTOBER 2011

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 2011

by

G. Søvik[*] and T. Thangstad[#]

[*]Institute of Marine Research
Box 1870 Nordnes, N-5817 Bergen, Norway

[#]Institute of Marine Research
Box 6404, N-9294 Tromsø, Norway

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.

There was no trend in the annual survey biomass estimates 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 in 2009-2011.

Recruitment (abundance of 1-group) in Skagerrak was much lower in 2008-2011 than in the two preceding years. However, recruitment has increased in 2011 compared with 2010, which may imply improved catches in 2012. 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 33.09 kg/nm in 2011. 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 2011 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. The 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. Ideally, 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 2011 the survey was carried out from January 10 to 27. 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 fish banks the tow duration is reduced to 5-10 minutes to prevent the trawl filling up with fish. Tow speed is roughly 3 knots. In 2011 the average tow speed was 2.90 knots (SD = 0.22). No compensation for diurnal vertical migration is made. Strapping was introduced on the survey in 2008 in order 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

The swept area was estimated by applying a wingspread of 11.7 m to tow length. Tow length was 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 stratum to give estimates of stratum biomass and abundance. The biomass and abundance for the 17 strata were

summed to give the overall values for the survey area. 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, females with head roe 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.

Results

Area coverage

Three days out of the 18 days of the 2011 survey was reserved for hydrographical investigations. 92 out of the 111 fixed stations were covered (Fig. 3). Out of these three tows were invalid ("mud hauls"). These data were not used in the calculations.

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 o 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. 4). Mean bottom temperature dropped with respectively 2 °C and 0.7 °C in Skagerrak and the Norwegian Deep from 2010 to 2011. 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 2011-data show that the bottom water is still unusually cold.

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 2008-2011 (Table 3). The former relationship of increased door spread with increased depth is not seen in the 2008, 2010 and 2011 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 biomass index increased from the late 1980s to the early 1990s, remained at a stable level until the mid 1990s where after it started fluctuating at a slightly higher level (Table 4, Fig. 5). 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 2011 (Figs. 5, 6a, 6b).

As the time series is short (only 6 years), there are few years with which to compare the low values of 2010 and 2011, and it is not possible to state whether these indices are extraordinarily low. The LPUE-index has been decreasing since 2007 and was in 2010 at the same level as in 2000. However, the 2010- landings were the lowest since the beginning of the 1980's (Søvik and Thangstad 2011). Thus, the shrimp biomass is possibly at a very low level in 2010 and 2011.

In 2006-2009 the estimated shrimp biomass was higher in Skagerrak (Div. IIIa) compared with the Norwegian Deep (Div. IVa east), however, in 2010 this pattern was reversed with a slightly higher estimated biomass index in the Norwegian Deep (5 840 t) compared with Skagerrak (4 290 t). Similarly, in 2011, the biomass index for the Norwegian Deep (5 030 t) was higher than the Skagerrak index (3 590 t).

Size, age and sex distribution

The 2011-data suggest four age groups in Skagerrak and five age groups in the Norwegian Deep (Table 5, Fig. 7). The model analysis, however, gave only four age groups in the Norwegian Deep (Table 5). Length frequency distributions for earlier years showed three age groups in Skagerrak and four in the Norwegian Deep (Fig. 8).

In Skagerrak, the 1-group has declined from 2007 to 2010, but increased slightly in 2011 (Fig. 8). The small 1-group in 2010 appeared as a small 2-group in 2011. Because of the good correlation between the size of the 1-group in one year and the 2-group in the following year (Fig. 2), the increased 1-group in 2011 (compared with 2010) implies an increased 2-group and thus larger catches in 2012.

In the Norwegian Deep in 2006-2009, the 1-group was very small compared with Skagerrak (Figs. 8, 9). 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 the 1-group was of equal size in the two areas. In 2011, however, the 1-group was again larger in Skagerrak compared with the Norwegian Deep (Figs. 7, 9).

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. However, it is not known why recruitment has decreased in recent years.

SSB had decreased since 2007 (Fig 10a). So far no relationship is found between SSB and recruitment (1-year old shrimp), but this can also be explained by few data points (Fig. 10b).

Predator abundance

Mean catch per trawl haul (kg/nm) in 2011 are given for various shrimp predators (Table 6). Saithe is the most abundant species, with an average catch of 7.52 kg/nm. The total index of shrimp predator biomass was estimated to 33.09 kg/nm in 2011, which is below the mean of the series for 2006-2011 (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).

References

Bhattacharya, C. G. 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics 23: 115-135.

ICES 2004. Report of the *Pandalus* assessment working group, 26 – 29 August 2003. ICES CM 2004/ACFM: 05. 42 pp.

ICES 2005. Report of the *Pandalus* assessment working group, 27 October – 5 November 2004. ICES C.M. 2005/ACFM:05, 74 p.

ICES 2006. *Pandalus* assessment working group report (WGPAND), 26 October – 3 November 2005. ICES CM 2006/ACFM:10. 60 pp.

Søvik, G. and Thangstad, T. 2011. The Norwegian Fishery for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east), 1970-2011. NAFO SCR Doc. 11/68. 26 pp.

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 2011. 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	0.00	0.00	0	0
2	200-300	2 500	8	0.52	0.17	53	17
3	100-200	277					
4	200-300	1 560	5	0.76	0.42	144	95
5	100-200	1 401	6	0.02	0.01	3	1
6	200-300	1 159	7	1.93	0.63	349	122
7	300-500	555	2	0.60	0.07	80	2
8	100-200	136	1	0.04	-	8	-
9	200-300	590	4	0.47	0.40	86	70
10	300-500	541	4	0.69	0.30	81	33
11	100-200	367	7	0.31	0.12	72	29
12	200-300	254	2	0.32	0.15	74	44
13	300-500	739	5	0.50	0.17	96	35
14	100-200	1 411	12	0.69	0.32	149	68
15	200-300	739	14	0.88	0.25	195	47
16	300-500	1 138	8	0.72	0.23	189	90
17	> 500	1 137	2	0.16	0.03	30	13
Total		15 749	89	8.62	1.07	1 609	222

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 2006-2011.

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

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

Table 3. Norwegian shrimp surveys in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in 2006-2011: 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

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 1984-2011. 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	2441	-	2144	4048	3093	1313	-	336	346	316	[1)]556	605	1253	1305	1535		19291	
1985	1	0	4768	-	1162	3288	2607	2016	0	815	475	[1)]1900	794	840	4921	2664	4066		30316	
1986	1	0	2183	-	920	[1)]933	1940	663	-	389	177	[1)]857	540	618	1521	2073	733		13547	
1987	1	88	3765	-	2482	4103	3294	1237	0	1370	254	[1)]1470	584	419	2168	1350	964		23548	
1988	1	0	1126	-	720	373	1079	682	0	294	96	472	391	282	814	777	343		7449	
1989	1	-	932	-	2347	[1)]898	1722	1159	0	560	263	579	556	498	1375	1443	918		13248	
1990	1	0	705	187	3245	[1)]1067	2373	471	0	647	171	1044	559	564	2088	1895	907		15920	
1991	1	0	1903	1008	2612	189	2851	1053	152	725	189	740	526	716	2163	2683	1312		18821	
1992	1	0	615	717	585	136	5743	2299	0	568	527	2091	951	669	3567	2550	1211		22229	
1993	1	0	1481	401	4063	[1)]1487	1437	688	-	621	281	2596	758	728	2735	3823	1237		22336	
1994	1	0	1391	626	2321	345	2439	1992	-	461	255	1627	468	844	3004	2284	1320		19377	
1995	1	0	2794	-	1420	202	4042	953	-	818	236	1836	513	665	2950	2076	1714		20220	
1996	1	0	4901	-	1367	133	3576	1108	-	533	441	3590	616	921	4277	2456	1286		25205	
1997	1	0	7882	-	1995	416	3393	2406	-	764	349	1969	1530	1487	3199	3584	3169		32143	
1998	1	-	5069	-	3357	586	2223	1049	-	682	401	1105	451	529	3186	2439	1378		22455	
1999	1	0	5180	-	5360	3158	3254	1051	-	235	243	475	266	311	4560	2228	1596		27917	
2000	1	-	3436	-	2664	1121	2181	695	-	343	158	939	380	286	4159	2495	1497		20354	
2001	1	-	5180	0	5360	3158	3254	1051	-	307	245	512	266	311	4560	2228	1596		28028	
2002	1	-	[1)]3922	-	[1)]3104	459	3749	1847	-	1153	364	1403	496	411	5425	4470	3329		30133	
2003	2	-	-	-	1410	750	2770	840	300	1240	430	480	770	960	2210	1950	850		14960	

2004	3	-	3590	-	2830	-	3540	1530	-	690	400	120	1390	1230	11060	4650	2890		33920	11600
2005	3	0	3790	-	5460	0	3160	1900	-	1130	580	1580	570	910	3370	3150	4500		30100	11100
2006	4	-	2920	-	2010	[2)]150	2110	[2)]888	-	380	130	870	900	1910	3340	1600	2490	[2)]39	19737	[3)]2282
2007	4	-	3500	-	910	120	2980	950	-	1250	980	2130	1250	6860	1480	2230	12470	0	37120	8021
2008	4	20	2910	-	1210	290	2550	1230	-	650	160	780	1100	5270	1140	600	2420	40	20360	2758
2009	4	0	1840	-	680	190	3400	140	-	410	80	580	1270	1270	1010	1990	1600	70	14500	2168
2010	4	0	1620	-	580	30	1230	1290	-	590	500	200	370	540	700	930	1520	30	10130	1777
2011	4	0	520	-	760	20	1930	600	40	470	690	310	320	500	690	880	720	160	8620	1069

1) Estimated as an average of the stratum estimates scaled by overall biomass of the year.
2) Estimated as an average of the stratum estimates in 2007-2011, scaled by yearly overall biomass.
3) Based on all strata SEs except 1, 3, 5, 7, 8, and 17

Table 5. Mean carapace length (CL) with standard deviation (SD), abundance (millions) and proportions of age groups from the 2011 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	11.50	1.15	284	0.50
2	16.17	1.27	137	0.24
3	19.96	1.45	78	0.14
4+	23.44	1.28	72	0.13

Norwegian Deep				
age	CL (mm)	SD	abundance	proportion
1	10.39	0.99	47	0.11
2	17.04	1.05	212	0.49
3	20.22	1.17	86	0.20
4+	25.55	36	85	0.20

Total				
age	CL (mm)	SD	abundance	proportion
1	11.37	1.18	330	0.36
2	16.95	1.26	371	0.41
3+	23.80	2.03	212	0.23

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 2006-2011.

Species		biomass index						
English	Latin	2006	2007	2008	2009	2010	2011	mean
Blue whiting	*Micromesistius poutassou*	0.13	0.13	0.12	1.21	0.27	0.62	
Saithe	*Pollachius virens*	7.33	39.75	208.32	53.89	18.53	7.52	
Cod	*Gadus morhua*	0.51	1.28	0.78	2.01	1.79	1.66	
Roundnosed Grenadier	*Coryphaenoides rupestris*	3.22	6.85	19.02	19.03	10.05	4.99	
Rabbit fish	*Chimaera monstrosa*	2.24	2.15	3.41	3.26	3.51	2.73	
Haddock	*Melanogrammus aeglefinus*	0.97	4.21	1.85	3.18	3.46	5.82	
Redfish	Scorpaenidae	0.18	0.40	0.26	0.43	0.80	1.02	
Velvet Belly	*Etmopterus spinax*	1.31	2.58	1.95	2.42	2.52	1.47	
Skates, Rays	Rajidae	0.41	0.95	0.64	0.17	0.60	0.88	
Long Rough Dab	*Hippoglossoides platessoides*	0.22	0.64	0.42	0.28	0.47	0.51	
Hake	*Merluccius merluccius*	0.98	0.78	0.64	2.56	1.60	0.56	
Angler	*Lophius piscatorius*	0.15	0.91	0.87	1.25	1.70	0.92	
Witch	*Glyptocephalus cynoglossus*	0.24	0.74	0.54	0.16	0.13	0.24	
Dogfish	*Squalus acanthias*	0.31	0.19	0.28	0.14	0.11	0.21	
Black-mouthed dogfish	*Galeus melastomus*	0.00	0.05	0.05	0.15	0.09	0.09	
Whiting	*Merlangius merlangus*	0.35	1.01	1.35	3.02	2.42	3.07	
Blue Ling	*Molva dypterygia*	0	0	0	0	0	0	
Ling	*Molva molva*	0.04	0.11	0.34	0.79	0.64	0.24	
Four-bearded Rockling	*Rhinonemus cimbrius*	0.06	0.14	0.04	0.03	0.05	0.03	
Cusk	*Brosme brosme*	0.20	0	0.02	0.05	0.13	0.29	
Halibut	*Hippoglossus hippoglossus*	0.08	0.07	3.88	0.09	0.20	0.05	
Pollack	*Pollachius pollachius*	0.06	0.25	0.03	0.13	0.12	0.15	
Greater Forkbeard	*Phycis blennoides*	0	0	0	0.01	0.04	0.02	
Total		18.99	63.19	244.81	94.26	49.23	33.09	83.93
Total (except saithe and roundnosed grenadier)		8.44	16.59	17.47	21.34	20.65	20.58	17.51

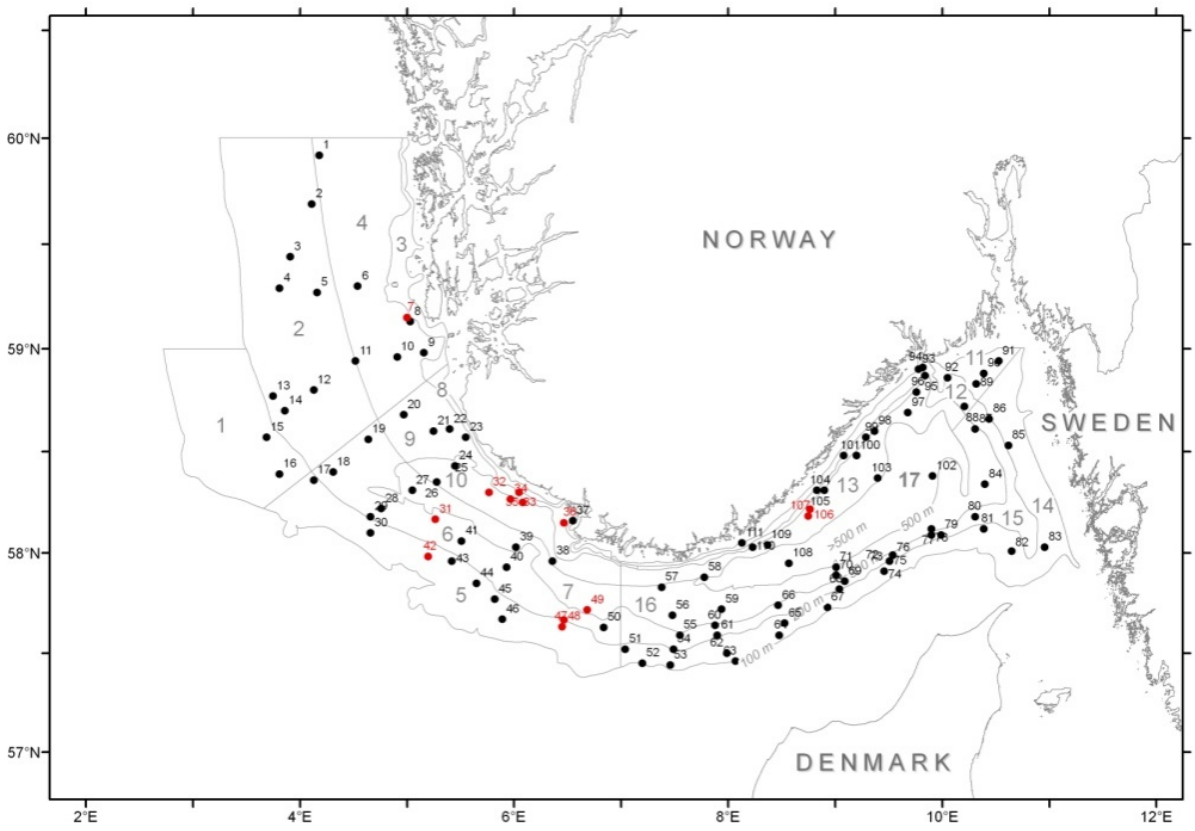

Fig. 1. Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east): the revised strata system (introduced in 2007 and adjusted in 2008) with the 111 fixed trawl stations. Trawl stations marked in red were introduced in 2008 (see text). Strata areas are given in Table 1.

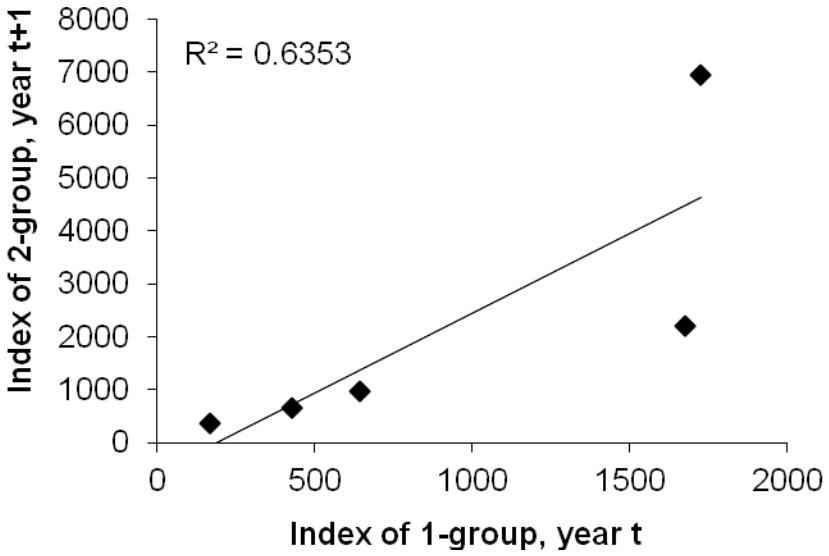

Fig. 2. Correlation between the index of 1-year old shrimps (abundance in millions) in January/February, year *t* and the index of 2-year old shrimps (abundance in millions) in January/February, year *t+1*, in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east). Data from 2006-2011.

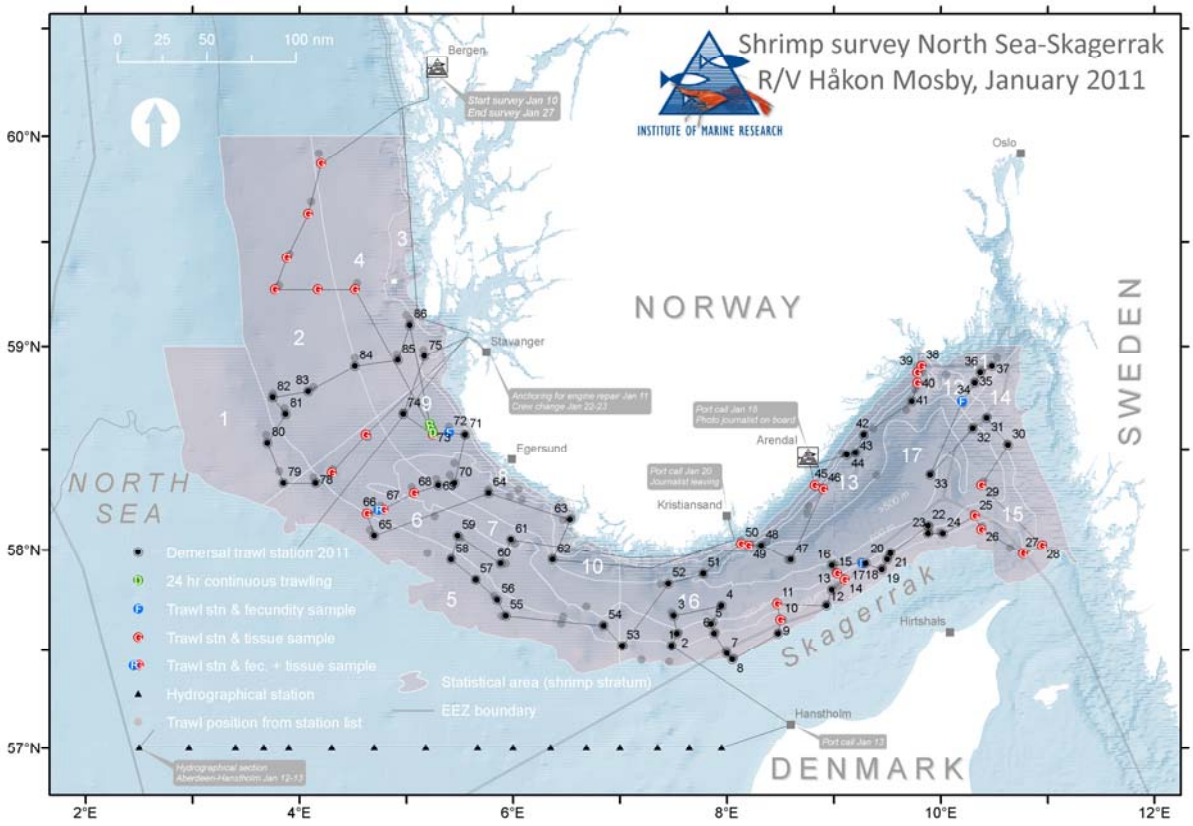

Fig. 3. The Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January 2011 with R/V *Håkon Mosby*: sailing route and trawled stations.

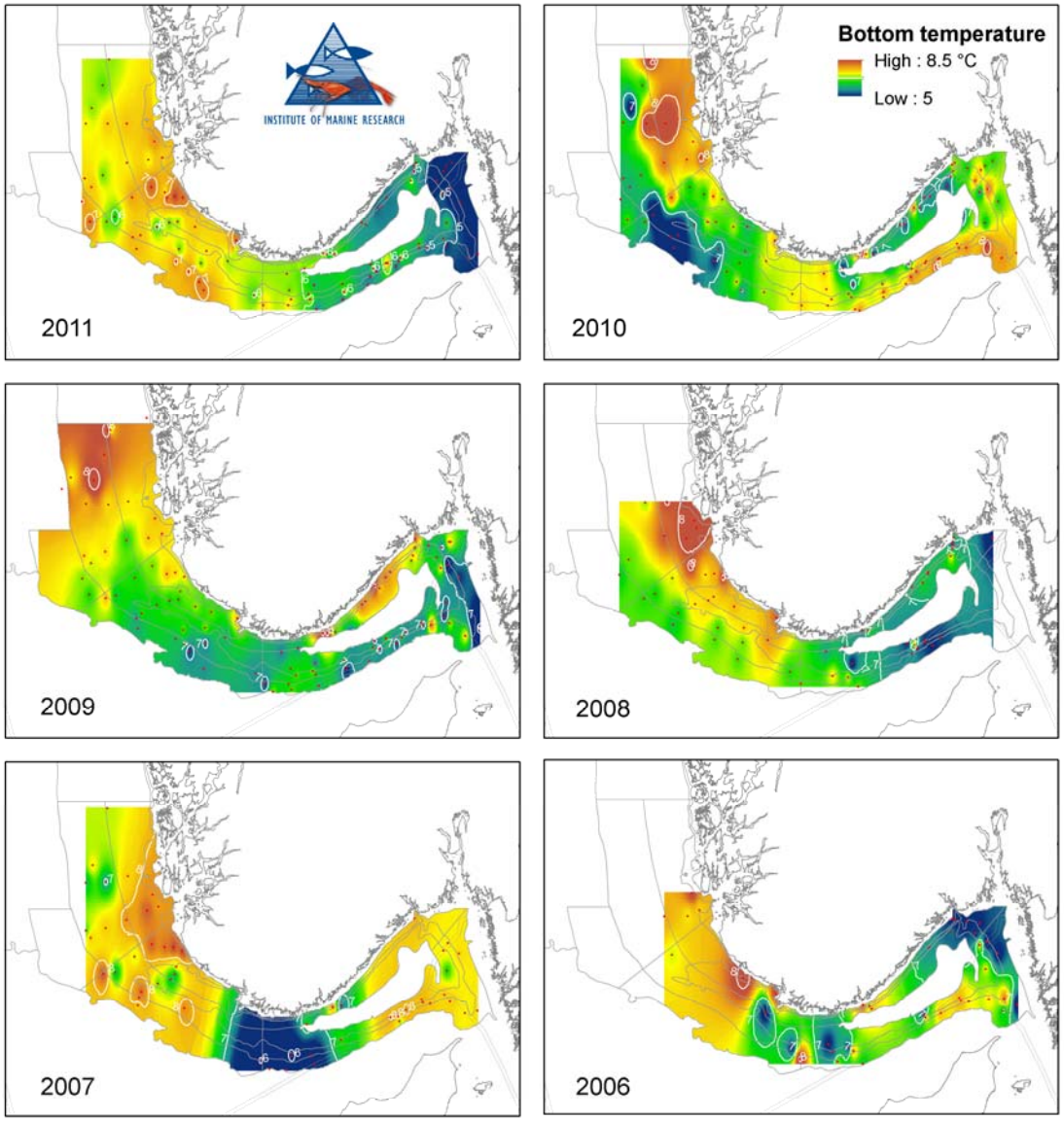

Fig. 4. Temperatures (ºC) measured with CTD on trawl stations during the 2006-2011 shrimp surveys in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east).

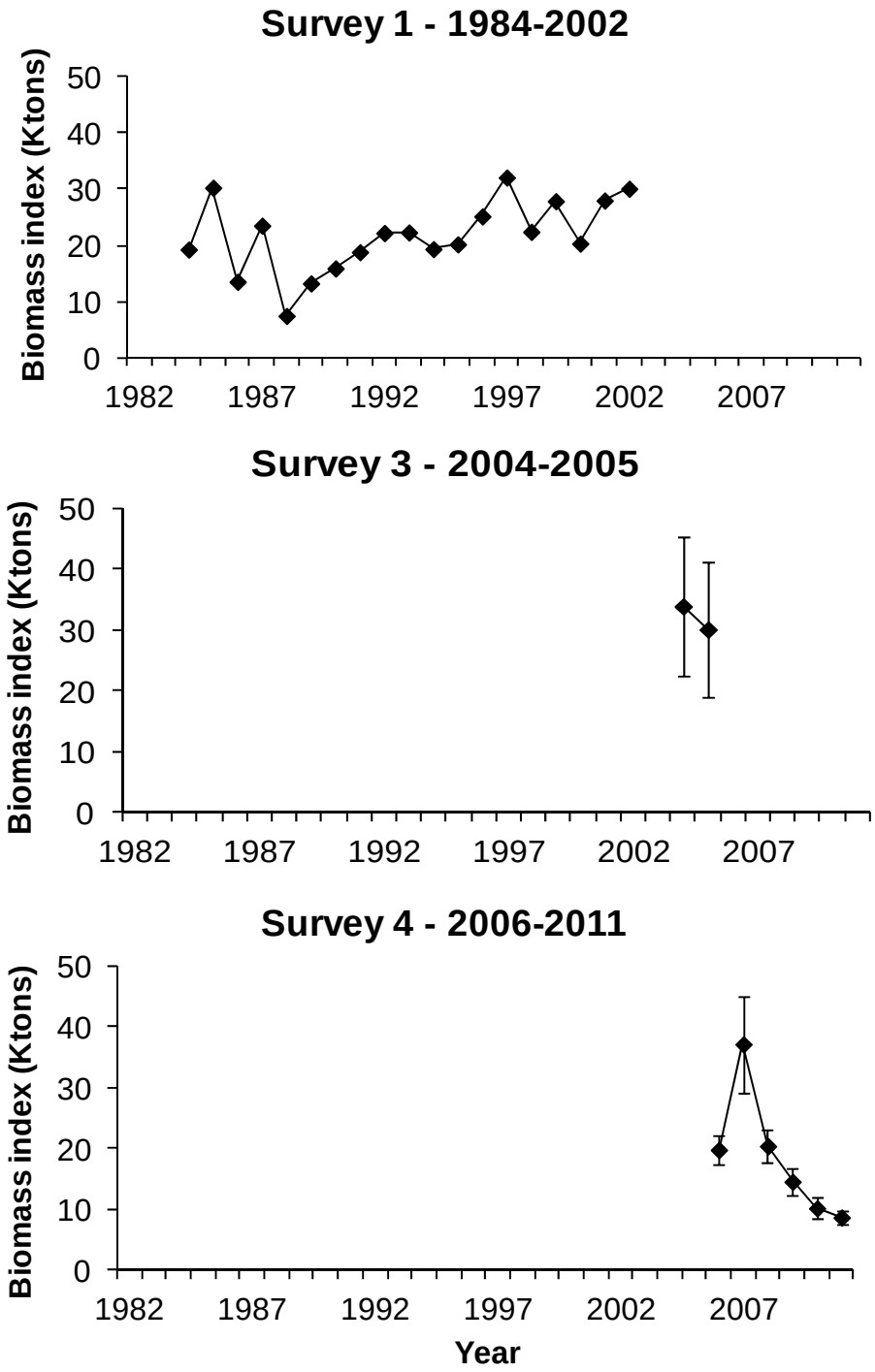

Fig. 5. Estimated survey biomass indices of shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east), 1984-2011 (see Table 4). The 2003-estimate is not shown. Standard errors have been calculated for the 2004-2011 surveys.

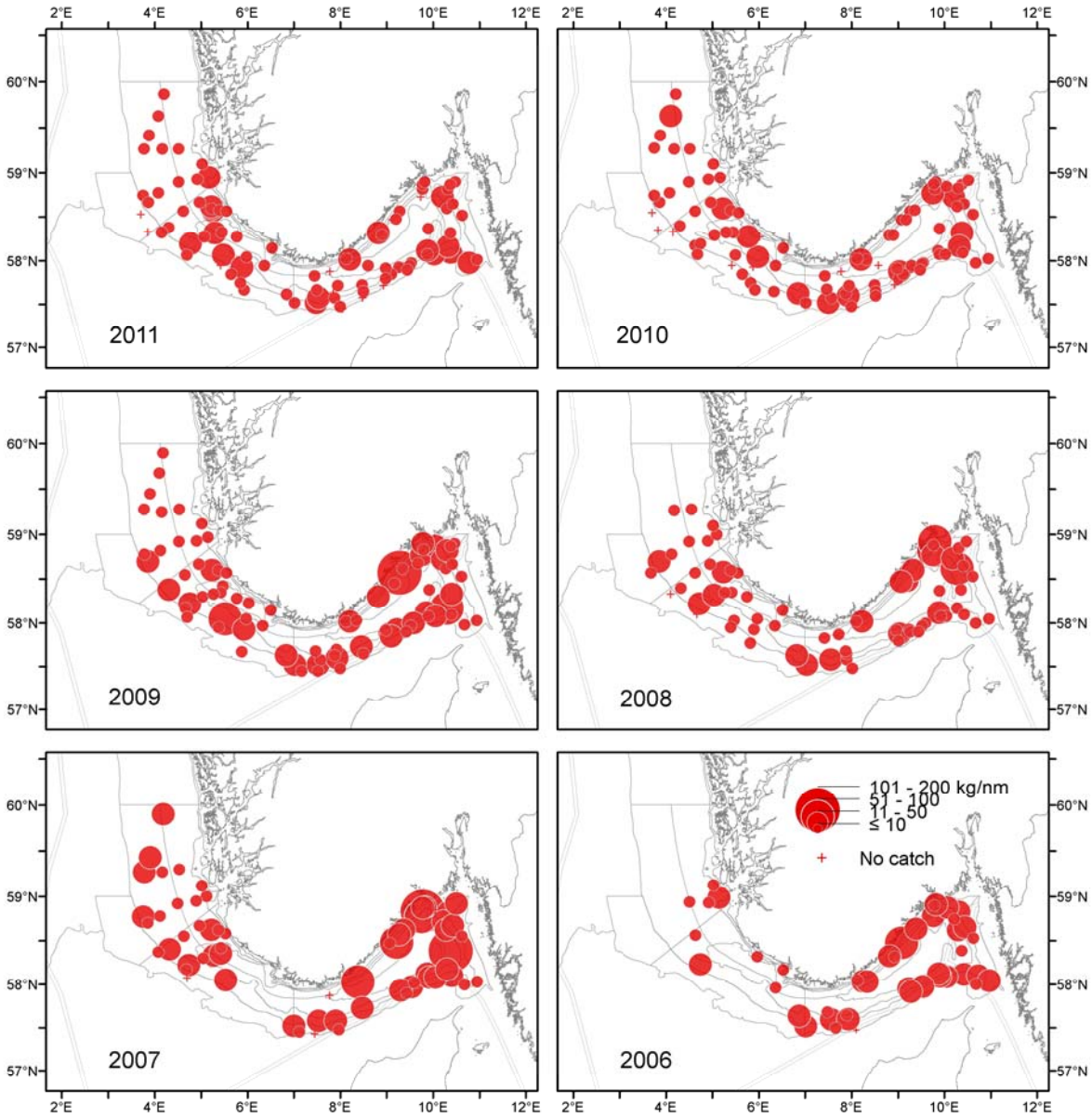

Fig. 6a. Shrimp catches per trawl station (kg/nm) from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January/February 2006-2011.

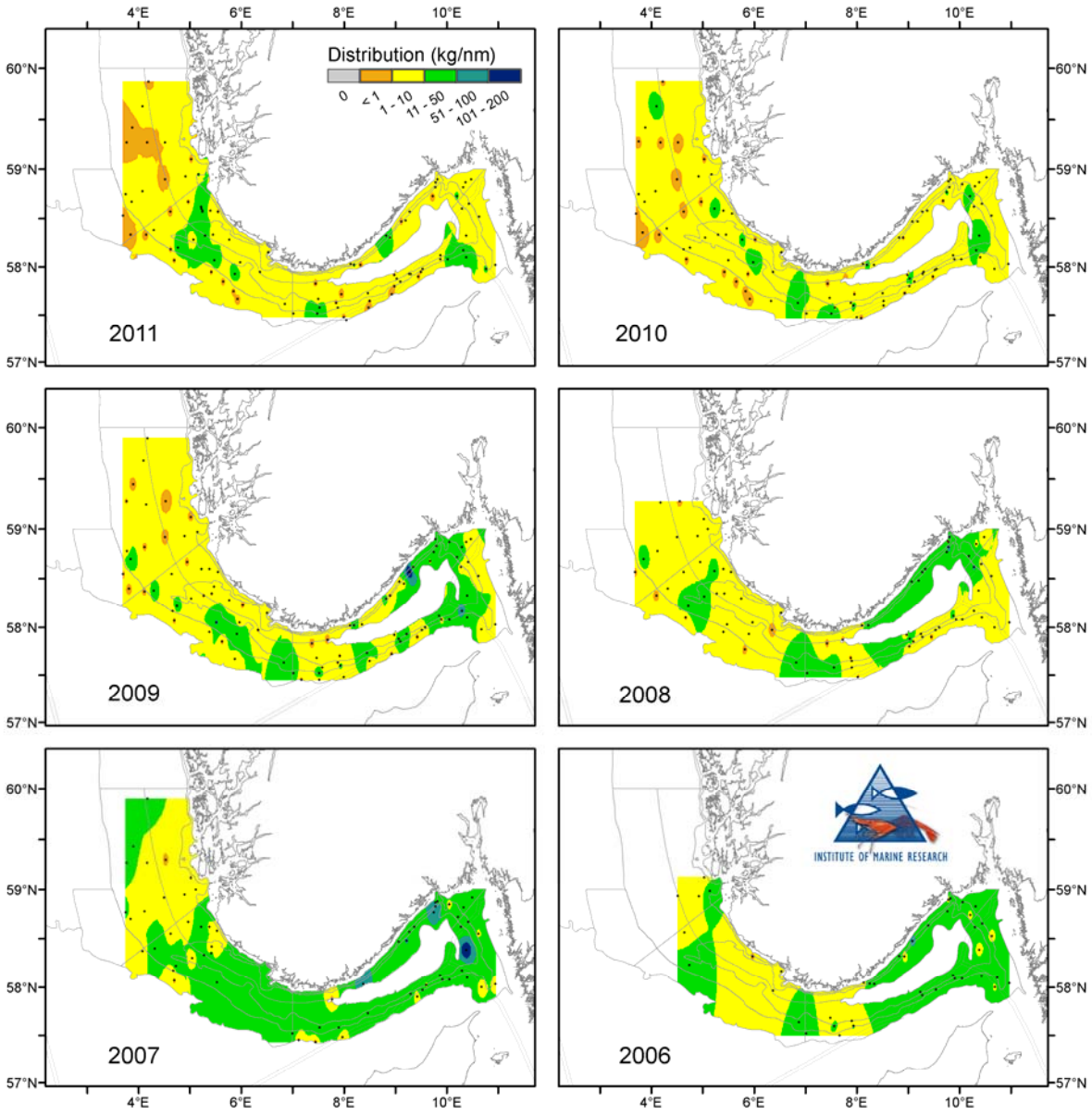

Fig. 6b. The distribution of shrimp (kg/nm) from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January/February 2006-2011.

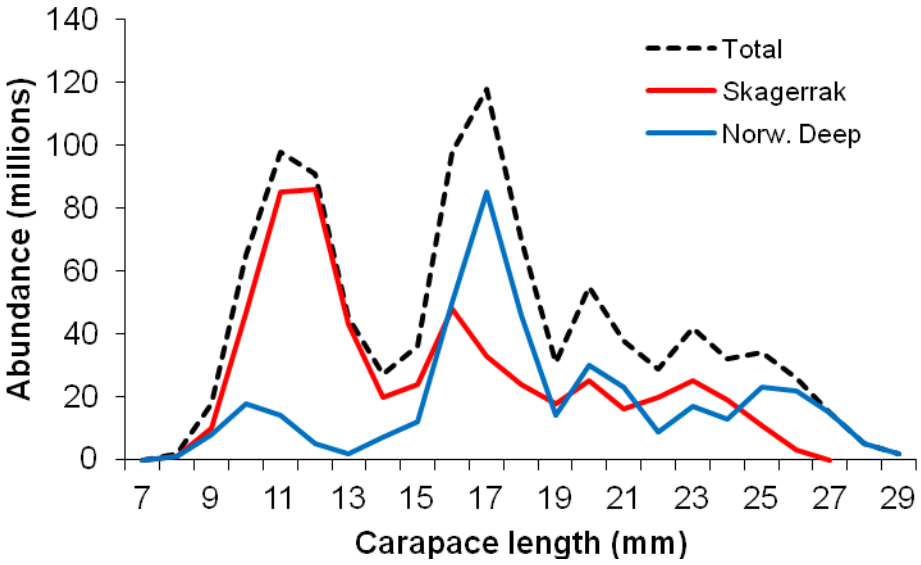

Fig. 7. Length frequency distributions for the overall area, Skagerrak , and the Norwegian Deep from the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) in January/February 2011.

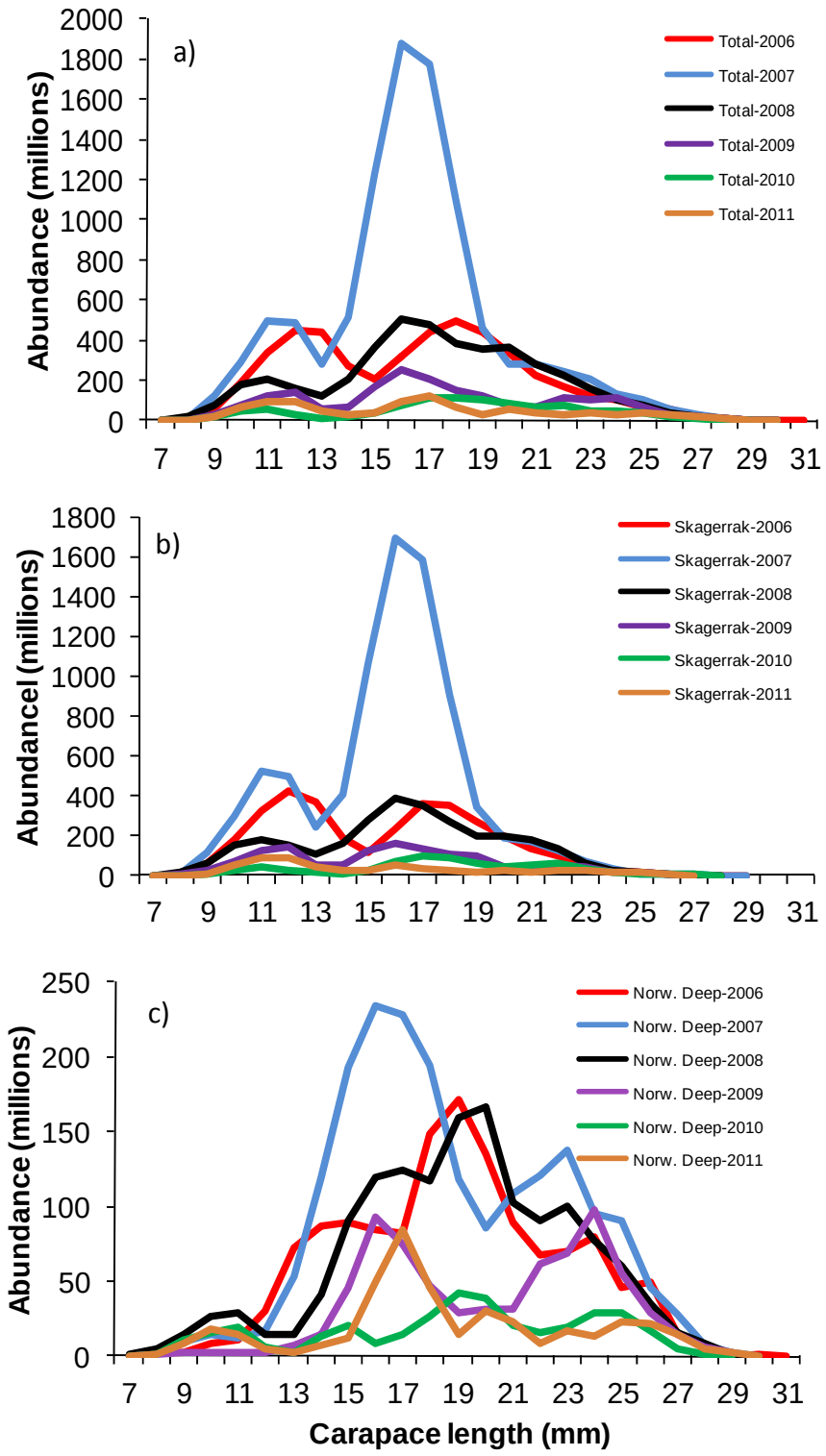

Fig. 8. Length frequency distributions for a) the overall area, b) Skagerrak (ICES Div. IIIa), and c) the Norwegian Deep (ICES Div. IVa east). Data from the Norwegian shrimp survey 2006- 2011. Note different scales on y-axes.

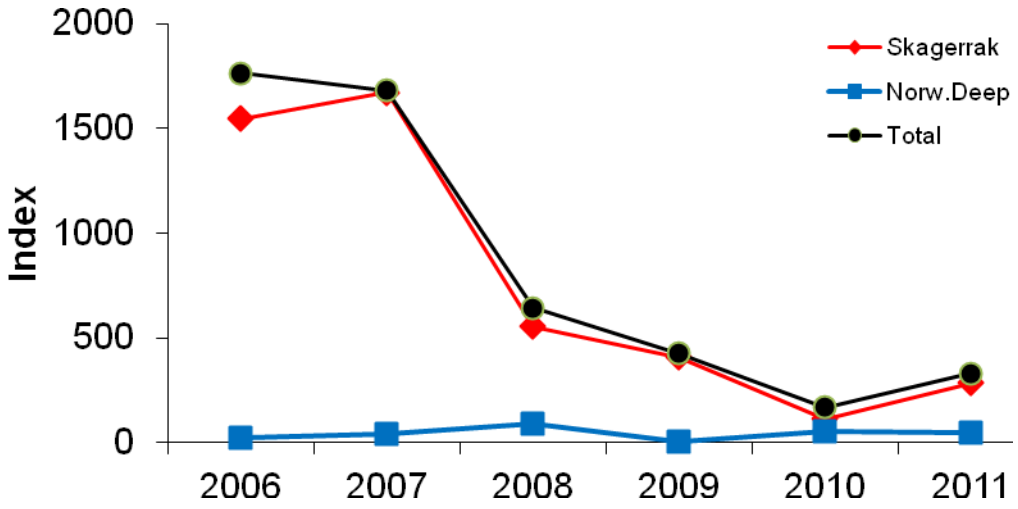

Fig. 9. Recruitment index (abundance in millions) of 1-year old shrimp in Skagerrak (ICES Div. IIIa), the Norwegian Deep (ICES Div. IVa east), and in the overall area for 2006-2011.

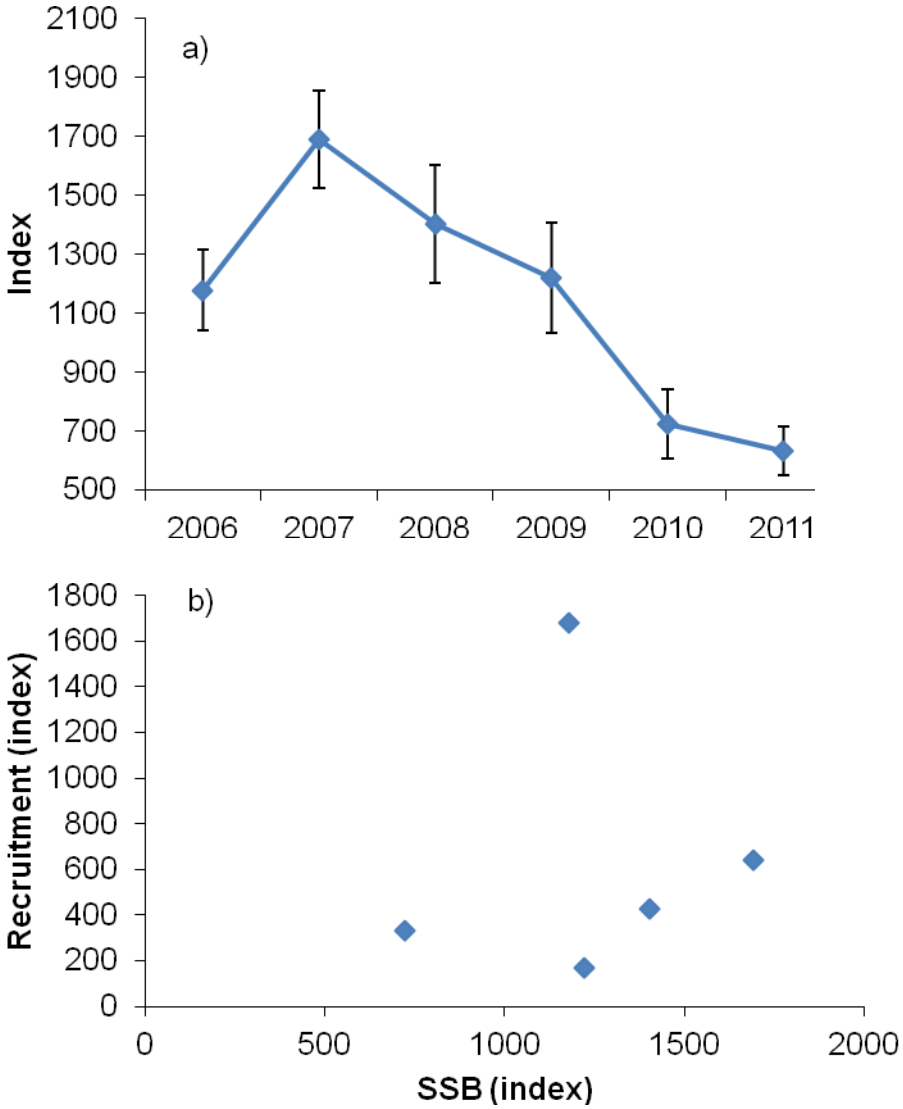

Fig. 10. a) SSB index (abundance in millions) in 2006-2011, and b) SSB-recruitment relationship 2006-2010 in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east).