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Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions 3.a and 4.a East) in 2021

by

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Abstract

The timing of the Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. 3.a and 4.a East) has changed from 1984 to present, resulting in three different time series, lasting from two 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 both recruitment and spawning stock biomass (SSB). Thus, the newest time series has been established at the most optimal time of the year.

The biomass index fluctuated around a high level from the mid 1990s to 2002 when the first time series was discontinued. The biomass index decreased from 2008 to 2012, increased from 2013 to 2015, and then again decreased. Since 2017, the biomass has fluctuated without trend at a low level. The decrease of the biomass from 2015 to 2017 was due to the disappearance of the good 2013 year-class from the stock. The recent stock size is at a lower level compared with the stock size in the 80s, 90s and 2000s.

Recruitment (abundance of the 1-group) in Skagerrak has been lower in recent years compared with 2006-2007, with the exception of 2014 when the recruitment was very good and at a higher level than in 2006-2007. Since 2017, recruitment has fluctuated without trend around the median of the time series (2006-2021), with the 2021 recruitment above the median. The relatively good 2020-year class dominated the survey catches (in numbers) in 2021 (the 1-group). The mainly low recruitment since 2008 is probably the main reason behind the low stock size in recent years.

Introduction

A trawl survey for northern shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divs. 3.a and 4.a East, and the northeast corner of Div. 4.b) has since 1984 been conducted annually by the Norwegian Institute of Marine Research (IMR) with the objective of assessing the distribution, biomass, abundance, recruitment, size distribution, and demographic composition of the shrimp stock, the size of the stocks of shrimp predators, as well as measuring hydrographical conditions in the distributional area of this shrimp stock (pra.27.3a4a).

The survey data consist of: 1) one time series from 1984-2002 (October/November) using R/V *Michael Sars* and the Campelen-trawl; 2) a point estimate for 2003 (October) 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 Åkra Shrimp trawl 1420; 3) a start of a potential new time 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) one time series from 2006 until present (January/February), using R/V *Håkon Mosby* and R/V *Kristine Bonnevie* (from 2017) 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 recommended by the *Pandalus* working group in 2004 (ICES 2005).
This document presents the results of the 2021 survey. In 2021, the survey also covered the Fladen Ground.

Material and Methods

Survey design and trawl gear

The survey area covers depths of approximately 100 to 550 m in ICES Divs. 3.a and 4.a East. A couple of stations are also located in the northeast corner of Div. 4.b. 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). There are presently no trawl stations in strata 1, 3 and 8. The survey area excluding strata 1, 3 and 8 is 14 091 nm^2.

Results are in some cases presented per area, where the Norwegian Deep consists of strata 2-10, and Skagerrak consists of strata 11-17 (Fig. 1). It should be noted that the border between Skagerrak and the Norwegian Deep as defined in the strata system (following the 007° longitude, Fig. 1) does not correspond exactly with the border between ICES Divs. 3.a, and 4.a and 4.b (a straight line between Hanstholm and Lindesnes, Fig. 2).

The survey has a fixed station design with 111 stations, assuming that the temporal variation in the shrimp stock generates the necessary randomness. The deepest and shallowest stations have depths of respectively 540 and 111 m. A coverage of one haul per 131 nm^2 is obtained when all 111 stations are trawled. In some years, part of the survey area has not been covered due to time and weather constraints. As Div. 4.a East is more exposed than Div. 3.a, it is generally the former area which in some years has been poorly covered.

On former surveys (in 1987, 1988, 1989, 1991, 1993, 1994 with respectively 12, 13, 9, 10, 9, 9 trawl stations), also Fladen Ground was covered. Calm weather in January 2021 permitted trawling in this area, with the goal of investigating the present status of the shrimp stock on Fladen Ground. Positions of trawl stations were taken from old survey reports (Table 2, Fig. 1).

A Campelen 1800/35 bottom trawl with rockhopper gear is used. Strapping was introduced in 2008 to ensure fixed trawl geometry independent of depth (10 m rope 100 m in front of the doors). Mesh size in the cod end is 20 mm with an inner lining net (10 mm). The attachment of the floats on the fishing line was modified in 2021, which contributed to a more stable trawl geometry.

In 2003, a Åkra Shrimp trawl was used (ICES 2005). This trawl had a 7.5 m opening height and a wingspread of approximately 20 m. The mesh size in the cod end was 42 mm, and an inner lining net was used. As results from 2003 are not comparable with results from all the other years due to a different survey gear, data from 2003 have not been analyzed.

Tow duration was 1 hour until 1989 when it was reduced to 0.5 hour. Trawling is carried out around the clock, but no compensation for diurnal vertical migration is made. Mean annual tow speed until 2012 was roughly 3 knots (Table 3), while in 2013-2016, the mean tow speed was lower (2.2-2.5 knots) and the variation between stations increased. Since 2017, with more trawl sensors on board R/V *Kristine Bonnevie* compared to on board R/V *Håkon Mosby*, trawling has been conducted on speed-of-water-through-trawl, not speed-over-ground. Mean tow speed since 2017 is therefore not directly comparable with earlier surveys. When trawling with the current, speed-over-ground will be higher than speed-of-water-through-trawl, while when trawling against the current it is opposite.

Stock size indices

Biomass and abundance indices are calculated using SAS (version 9.4). Total abundance and numbers at length (length frequency distribution from the survey) are input data to the assessment model (Stock Synthesis, ICES 2021). Swept area is estimated by applying a wingspread of 11.7 m to tow length. Tow length is set to time towed multiplied by a towing speed of 3 knots. The swept area for all trawl hauls is thus defined to be 0.019 nm^2/hour. The catch in each tow divided by the swept area gives a sample of shrimp density (in kg and numbers) in a stratum. From these samples the mean and standard error of the density in each stratum are calculated and multiplied by the area of the respective stratum to give estimates of biomass and abundance per stratum. Strata estimates are summed to give the overall value for the survey area.

Due to weather and time constraints, some strata have not been covered in some years. For any missing stratum in year *t*, the stratum biomass is estimated as follows. 1) The proportion of biomass (*p*) (out of the total biomass) in the specific stratum is taken as the mean of all *p*'s from years where data exist for all strata. Mean *p*'s are calculated separately for the first and last time series. 2) The total biomass for year *t*, *B,* is calculated as: $B = (\Sigma$ biomass in all strata with data in year $t) / (1- p)$. The biomass in the missing stratum, $B_{stratum}$, is then given as: $B_{stratum} = B * p$. The calculations assume that the distribution of shrimp remains constant throughout the time series. The corrected biomass values increased by 8-12% compared with the uncorrected ones for the years 2006, 2012, 2014 and 2015, while the corrected value in 2002 increased by 48% compared with the uncorrected one. The abundance data have not been corrected for deficient survey coverage in 2002, 2006, 2012, 2014 and 2015, which means that the abundance indices for these years are underestimated.

Standard errors are calculated as: SE (whole survey area) = $\sqrt{[\Sigma\ (SE\ (stratum)^2)]}$.

A biomass index of potential shrimp predators is calculated as average catch (kg) per trawled nm over all hauls of 23 fish species / fish families.

Biological samples

Samples of approximately 300 shrimp are taken from each trawl haul, sorted by stage and measured with a precision of 0.1 mm (carapace length (CL)). In order to save time when sorting and staging the shrimp samples, all 1-year old shrimp are staged as males although this is not correct; a portion of the 1-group consists of primary females. When the total catch contains less than 300 shrimp the sample equals the total catch. An overall CL frequency distribution, as well as length distributions per area (Skagerrak and the Norwegian Deep), are estimated using CL truncated to the nearest mm below. The length frequency distributions are partitioned into age groups by modal analysis using the method of Bhattacharya (1967) (FISAT (version 1.2.2), http://www.fao.org/fi/oldsite/STATIST/fisoft/fisat/index.htm).

In January/February, the youngest age group is almost 1 year old (hatching of eggs takes place from February to April). The recruitment index is estimated as the abundance of these (almost) 1-year old shrimp from the modal analysis. There is a positive correlation between the abundance of 1-year old shrimp in January/February in one year and the number of 2- and 3-year old shrimp in the following two years (Fig. 3).

Hydrographical measurements

CTD is taken at each trawl station for measurements of bottom temperature and salinity (Fig. 4). To avoid damage on the equipment, the CTD is not lowered further than 10 m above the bottom.

Results and discussion

Area coverage

In 2021, the survey was carried out from January 7 to 31. The trawl gear was tested in the sea (20 tows) before the ordinary survey started (towing with open cod end on hard, sandy bottom, both with and against the current),

in order to ensure a fixed trawl geometry. All the 111 fixed trawl stations were covered (Fig. 4). In addition, nine trawl hauls were conducted on the Fladen Ground. All tows were of satisfactory quality (Table 3).

Temperature and salinity

The bottom temperature in the survey area in January/February during 2006-2021 ranged from 4.0 to 9.0 °C (Fig. 5). The year 2016 was the warmest observed in the whole time series (Table 4, Figs. 5, 6), with four and nine trawl stations in respectively Skagerrak and the Norwegian Deep with bottom temperatures >8.5 °C. This is still within the range of winter bottom temperatures from the area (December-March) in 1982-2002 (range 5-9 °C) (Schlüter and Jerosch 2009).

From 2006 to 2021, the annual average survey bottom temperatures in Skagerrak and the Norwegian Deep have varied between 7 and 8 °C, except in 2011 (an exceptionally cold year) and 2016 (Table 4, Fig. 6). In 2016, mean bottom temperature was 8.2 and 7.8 °C in the Norwegian Deep and Skagerrak respectively, the highest mean temperature measured in both areas. In the Norwegian Deep, the mean temperature decreased from 2016 to 2019, and then increased again in 2020 and 2021, while in Skagerrak, the mean temperature has more or less remained on the same level these years (Table 4, Fig. 6). In 2021, mean bottom temperature was 7.7 and 7.5 °C in respectively the Norwegian Deep and Skagerrak.

Average salinity has varied between 34.9 and 35.3 ‰ in the same time period (Table 4). This is in agreement with winter salinity data from the area, which in the period 1982-2002 was between 35 and 36 ‰ (Schlüter and Jerosch 2009).

On Fladen Ground in 2021, mean bottom temperature was 8.03 °C (with a SD of 0.10 and a range of 7.89-8.18 °C) (Fig. 7), which is warmer than the survey area in the Norwegian Deep in most years (Table 4).

Trawl geometry

The introduction of strapping in 2008 caused the average door spread to decrease from more than 50 m in 2006-2007 to 45-48 m in 2008-2012 (Table 3). The former relationship of increased door spread with increased depth disappeared with the introduction of strapping. In 2013-2016, mean door spread varied between 48 and 51 m, while in 2017-2021, it has varied between 52 and 55 m. The higher mean door spread the last five years is likely due to the change of vessel and doors. R/V *Kristine Bonnevie* has larger and heavier doors (Thyborøn) than R/V *Håkon Mosby* had (Waco). Following standards for research trawling at IMR, the door spread during the sea trial should be between 48 and 52 m (https://kvalitet.hi.no/docs/pub/dok06004.pdf). However, even if door spread during sea trials may be within acceptable limits, on the softer bottom of shrimp grounds, door spread tends to increase. In 2018, mean door spread was 55.0 m. It was concluded that the strapping rope needed to be shortened from 15 to 10 m on the following years' surveys. In 2019-2021, mean door spread (over all ordinary trawl stations) was lower (53.4, 53.7 and 53.5 m) (Table 3).

Trawl height is interconnected with door spread such that an increase in door spread generally leads to a lower trawl height. The average annual trawl height varied between 3.6 and 5.0 m in 2008-2016 (cruises on R/V *Håkon Mosby*), while in 2017-2021 (cruises on R/V *Kristine Bonnevie*) it has varied between 3.4 and 3.9 m (Table 3).

The inter-annual difference in door spread and trawl height are not corrected for in the calculations.

Stock size indices

The biomass index increased from the late 1980s to the early 1990s, remained at a stable level until the mid 1990s when it increased further to this time series' maximum in 1997 (Table 5, Fig. 8). A decrease in 1998-2000 was followed by an increase in 2001 and 2002. The low 2003 biomass estimate (Table 5) could have resulted from the use of the Åkra Shrimp trawl 1420. However, the trawl opening was taller compared with the Campelen trawl. The 2005 mean value was lower than that of 2004, but not significantly different. The 2007 value was 77% higher than the 2006 value, but was influenced by the very high mean biomass in stratum 16 (Table 5) which was due to a very large catch on one trawl station. From 2008, the biomass declined steadily to

2012. From 2013 to 2015, the biomass increased (Fig. 8). The 2015-biomass estimate includes an estimated value for stratum 2 which was not covered that year, based on the mean of all *p*'s from years back to 2007 (see above). It is likely that the estimated value of 1481 t (Table 5) in stratum 2 in 2015 is too high, as the stock has contracted into the southern part of the Norwegian Deep in recent years (see below).

The 2016 biomass estimate of 3730 t was the lowest in the time series back to 2006. Only a handful of the trawl stations had shrimp catches of >10 kg/nm trawled. Investigations into the survey showed that there had been problems with unequal lengths of the wires towing the trawl, and the survey was therefore invalidated.

The 2017 biomass estimate was at the same level as the 2014 estimate. The biomass index decreased in 2018 and further in 2019, to 5890 t, the recent time series' minimum. This decrease in biomass was due to the disappearance of the good 2013 year-class (see below) from the stock. In 2020, the biomass increased to 8390 t, possibly due to the relatively good 2018 year-class (see below). In 2021, the biomass was lower than in 2020 (7590 t).

Total abundance of shrimp (Table 6, Fig. 9) shows the same overall trend as the biomass index, but the abundance index increased in 2014 (when the large 2013 year-class was 1 year old) rather than in 2015, as the biomass index did. In 2014, it was discovered that the SAS script did not handle lengths <7 mm; for all stations with individuals <7 mm SAS returned 0 for all length groups. This was corrected for. However, in 2020, it was discovered that the assessment model still had been run with the wrong numbers at length since 2014 (Table 7). Model runs with and without the correct numbers were run in 2020. The difference in model outputs were negligible (ICES 2020a), and the 2020-assessment was carried out using the correct numbers.

The trend in the survey time series has followed trends in LPUE-indices closely for many years. The Danish and Norwegian LPUE-time series also have their minimum in 2012. All three LPUE-series (Danish, Swedish and Norwegian) declined from 2015 until 2018-2019, and all three time series then increased in 2020 (ICES 2021).

Distribution

During the 1980s and 1990s, the estimated shrimp biomass in the Norwegian Deep was larger than the biomass in Skagerrak (Figs. 10, 11), while the biomass in Skagerrak is presently estimated to be larger than the biomass in the Norwegian Deep. It is particularly the proportion of the survey biomass in stratum 2 in the northern part of the Norwegian Deep that has decreased. In 1987 and 1998-1999, more than 30% of the total survey biomass was found in this stratum, compared with 2-6% in 2011-2021 (Fig. 10). Seasonal shifts in shrimp distribution in connection with roe hatching, documented in recent years by positions of trawl hauls of commercial fishing vessels in logbooks (Søvik and Thangstad 2016) seem to take place from deeper to shallower parts of the trench, not over larger areas. The decrease in biomass in the northern part of the Norwegian Deep has probably nothing to do with the shift in the timing of the survey from October/November to January/February. Rather, it seems that the declining shrimp stock has contracted into the southern part of the Norwegian Deep and Skagerrak (Fig. 12).

The depth distribution of shrimp differs between the Norwegian Deep and Skagerrak (Fig. 13). In the former area, the largest proportion of the biomass is found in strata with depths between 200 and 300 m and very little biomass is found in the shallowest strata 1 and 5 (100-200 m). In Skagerrak, on the other hand, the biomass is more or less equally distributed between the depth strata of 100-200 m, 200-300 m, and 300-500 m. The pattern is the same for both the October/November time series and the recent one.

Age, stage and recruitment

The modal analysis of the 2021-data gave three age groups in both Skagerrak and the Norwegian Deep (Table 8, Fig. 14). The bulk of the shrimp biomass in 2021 consisted of shrimp larger than 15 mm CL (Fig. 14a). The 1-year old shrimp dominated in numbers (Fig. 14a), indicating a relatively good 2020-year class (see below). In quarter 1, the population is dominated by males, shrimp changing sex (intersex), and females with roe (Fig. 14b). Length frequency distributions for the years 2006-2021 show that in most years in the whole Skagerrak/Norwegian Deep area there are two clearly distinguishable age groups in the first quarter (the 1-

group and 2-group) as well as a 3+-group (Fig. 15a). In the length frequency distributions from earlier years in October/November (1984-2002) often four age groups are distinguishable (0-, 1-, and 2-groups as well as a 3+-group) (Fig. 15b). Numbers per age group back to 1984 are given in Table 9ab.

In Skagerrak, recruitment (abundance of the 1-group) declined from 2007 to 2010, and then increased until 2014, to the highest level observed in this recent time series (Fig. 16). In 2015, recruitment was again low. In 2017-2021, recruitment has fluctuated without trend around the median of the time series, with the 2020-recruitment being above the median. Recruitment in the Norwegian Deep is very low compared with Skagerrak. The generally low recruitment since 2008 has probably been the main driving force behind the low stock size in recent years. It is not known why recruitment has been so low.

The high abundance of 1-year old shrimp in Skagerrak indicates that these waters constitute a nursery area for the stock. No correlation between the number of 1-year old and 2-year old shrimp in the Norwegian Deep, and a good correlation between the number of 1-year old and 2-year old shrimp in respectively Skagerrak and the Norwegian Deep suggests that there is a westward migration or drift of small shrimp from Skagerrak to the Norwegian Deep (Fig. 17).

Predator abundance

Mean catch per trawl haul (kg/nm) in 2021 is given for potential shrimp predators (Table 10). Blue whiting was by far the most abundant predator, and also the most abundant fish species in the survey catches, with an average catch of 59.0 kg/nm. Norway pout was the second most abundant fish species in the 2021 survey (19.6 kg/nm). Saithe was the second most abundant predator, while whiting and velvet belly were the third and fourth most abundant predators. The total index of predator biomass was estimated to 89.6 kg/nm in 2021, which is a large increase from 2020. Results from the first survey series (1984-2002) range from 28.6 to 63.1 kg/nm (ICES 2004), while in 2004-2005 the index was respectively 58.1 and 115.4 kg/nm (ICES 2006).

The index of total predator biomass is influenced by the indices for saithe, roundnose grenadier, and blue whiting. Some shallow trawl stations yield large catches of saithe, while roundnose grenadier is caught mainly in the deep parts of Skagerrak. Thus, the estimate of these two fish indices depends partly on the number of shallow and deep stations covered each year. A predator index excluding saithe, roundnose grenadier and blue whiting shows less inter-annual variation (Fig. 18) and fluctuated without a trend between 2007 and 2015. The index has been at a higher level since 2017, except for in 2020, mainly due to increased indices of velvet belly, rabbit fish and whiting. The increase in whiting is in accordance with the whiting assessement in Skagerrak and the North Sea (ICES 2020b).

Fladen Ground

No scientific survey has covered the shrimp stock on Fladen Ground since the beginning of the 1990s. Since 1998, landings decreased steadily and since 2004, the Fladen Ground fishery has been virtually non-existent (NAFO, ICES 2020). According to the industry, the decline in fishing was caused by low shrimp abundance, low prices on the small shrimp which are characteristic of the Fladen Ground, and high fuel prices. Recent bycatches of shrimp in the Danish and Norwegian Norway pout fisheries in the area have indicated that there still is shrimp on the Fladen Ground, and this was confirmed by this year's survey. The two highest trawl catches of shrimp in the 2021 survey were taken on Fladen Ground (Fig. 19). Three out of the four good catches on the Fladen Ground were taken at the border between areas of mud and sandy mud (Fig. 20).

The stock consists of three year-classes (Fig. 21), similar to the shrimp stock in Skagerrak and the Norwegian Deep. The stage structure is also similar (Figs. 14b, 21). However, the shrimp are smaller on the Fladen Ground. The mean sizes (± SD) of the different age groups (10.70 ± 0.94, 16.70 ± 1.06, 19.66 ± 1.14 for respectively the 1-group, 2-group and 3-group) are similar to what was found for the shrimp in the Norwegian Deep (Table 8, Fig. 22).

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.

ICES 2020a. Joint NAFO/ICES *Pandalus* Assessment Working Group (NIPAG). ICES Scientific Reports. 2:19. 22 pp. http://doi.org/10.17895/ices.pub.5554

ICES 2020b. ICES Working Group on the Assessments of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. 2:61. 1249 pp. http://doi.org/10.17895/ices.pub.6092

ICES. 2021. Joint NAFO\ICES Pandalus Assessment Working Group (NIPAG). ICES Scientific Reports. 3:22. 25 pp. https://doi.org/10.17895/ices.pub.7917

NAFO, ICES. 2020. NAFO/ICES *Pandalus* Assessment Group Meeting, 26 to 30 October 2020. By WebEx. NAFO SCS Doc. 20/21. 89 pp.

Schlüter, M., and Jerosch, K. 2009. Digital atlas of the North Sea. Alfred Wegener Institute for Polar and Marine Research et al. 91 pp. hdl: 10013/epic.34893.d001.

Søvik, G. and Thangstad, T. 2016. The Norwegian Fishery for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east), 1970-2016. NAFO SCR Doc. 16/057.

Table 1. The estimated biomass (Ktons) and abundance (millions) available to the trawl from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in 2021. 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	9	0.26	0.12	53	23
3	100-200	277					
4	200-300	1 560	6	0.60	0.36	130	79
5	100-200	1 401	7	0.01	0.01	2	2
6	200-300	1 159	8	1.23	0.49	299	120
7	300-500	555	3	0.30	0.23	51	38
8	100-200	136					
9	200-300	590	6	0.73	0.31	161	64
10	300-500	541	5	0.04	0.02	8	3
11	100-200	367	5	0.70	0.26	165	65
12	200-300	254	8	0.43	0.12	136	46
13	300-500	739	8	0.37	0.22	103	62
14	100-200	1 411	15	0.69	0.33	168	78
15	200-300	739	18	1.22	0.33	477	160
16	300-500	1 138	11	1.00	0.36	286	146
17	> 500	1 137	2	0.01	0.01	2	2
Total		15 748	111	7.59	1.01	2042	300

Table 2. Positions (with depth in meter) in ICES Div. 4.a west (the Fladen Ground) trawled during the Norwegian shrimp survey in 2021. Fig. 1 shows the positions on a map.

Latitude	Longitude	Bottom depth (m)
58.12	1.28	127
58.08	0.72	152
58.22	0.58	149
58.22	0.27	142
58.40	0.77	144
58.62	0.58	144
58.73	0.13	140
58.88	0.58	149
58.85	0.90	122

Table 3. Number of valid and discarded trawl hauls, and mean towing speed (speed-over-ground), door spread and trawl height with standard deviation (SD) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a East (Skagerrak and the Norwegian Deep), 2006-2021. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl.

	Valid stations	Discarded stations	Trawl speed		Door spread		Trawl height	
			mean	SD	mean	SD	mean	SD
2006	43	2	2.5	0.4	53.0	4.5	4.6	0.7
2007	64	2	3.0	0.2	51.4	2.6	4.7	0.3
2008	73	0	3.1	0.4	47.0	1.7	4.4	0.3
2009	91	4	2.8	0.2	45.3	3.4	4.9	0.5
2010	95	3	2.9	0.2	46.9	2.2	4.9	0.3
2011	89	3	2.9	0.2	47.6	2.3	3.6	1.0
2012	63	2	2.9	0.2	47.5	3.0	4.6	0.4
2013	101	0	2.5	0.5	51.0	1.5	4.2	0.3
2014	69	0	2.2	0.5	48.7	1.3	4.1	0.2
2015	89	3	2.4	0.5	51.1	3.4	4.4	0.5
2016	105	1	2.5	0.5	49.7	2.4	5.0	0.6
2017	108	5	3.3	0.3	52.4	1.1	3.4	0.2
2018	108	1	3.3	0.2	55.0	1.9	3.8	0.7
2019	111	0	3.5	0.3	53.4	1.5	3.5	0.2
2020	105	1	3.1	0.3	53.7	3.0	3.6	0.7
2021	111	0	3.4	0.2	53.5	1.4	3.9	0.7

Table 4. Average temperature (°C) and salinity (‰) (with standard deviation) for all trawl hauls (with available CTD data) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a East (Skagerrak and the Norwegian Deep) in 2006-2021. The 2012 data result from only 22 CTD hauls (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
2013	7.48	0.35	35.21	0.06
2014	7.05	0.54	35.17	0.04
2015	7.27	0.49	35.10	0.09
2016	8.24	0.37	35.22	0.06
2017	7.97	0.62	35.16	0.04
2018	7.76	0.38	35.11	0.06
2019	7.13	0.74	35.13	0.03
2020	7.57	0.56	35.09	0.19
2021	7.74	0.41	35.15	0.02

Skagerrak

	Temperature (°C)		Salinity (‰)	
	mean	SD	mean	SD
2006	7.01	0.65	35.13	0.10
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
2013	7.48	0.47	35.19	0.08
2014	7.29	0.71	35.07	0.14
2015	7.24	0.41	34.97	0.19
2016	7.75	0.57	35.11	0.17
2017	7.74	0.38	35.16	0.10
2018	7.69	0.59	35.00	0.18
2019	7.35	0.85	35.03	0.16
2020	7.56	0.59	35.02	0.17
2021	7.54	0.58	34.97	0.19

Table 5. Estimated biomass (t) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by year and stratum, 1984-2021. Strata 1-10 are in the Norwegian Deep, while strata 11-17 are in Skagerrak (see Fig. 1). Values from the different survey time series are not comparable (see text). SE is the standard error. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl.

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)503	370	0	400	1180	1590	1140	440	0	11513	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)118	2110	2)1188	-	380	130	870	900	1910	2730	2050	2130	2)92	19538	2303
2007	4	-	3500	-	1620	120	2980	740	-	1250	1050	2040	1320	6860	1380	2140	12470	0	37470	8055
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)]651	-	300	10	1070	140	-	260	40	310	390	1280	390	490	820	10	6161	897
2013	4	40	330	-	780	0	880	490	-	370	450	460	340	910	440	650	860	0	7000	838
2014	4	0	180	-	800	0	240	[2)]539	-	150	[2)]346	430	530	1350	540	990	2720	40	8855	1582
2015	4	-	[2)]1481	-	2460	90	590	420	-	1200	260	620	530	2180	210	260	720	2990	14010	3280
2016	4	-	170	-	390	840	180	70	-	240	50	340	90	200	490	450	210	10	3730	881
2017	4	-	230	-	640	90	1390	150	-	680	50	400	480	1260	390	1860	1170	0	8800	1460
2018	4	-	130	-	380	30	710	370	-	230	210	870	710	830	760	1360	1660	10	8250	897
2019	4	-	230	-	530	30	1170	250	-	120	60	380	190	360	490	870	1200	20	5890	890
2020	4	-	520	-	810	30	670	260	-	250	130	740	350	270	610	1930	1800	10	8390	1680
2021	4	-	260	-	600	10	1230	300	-	730	40	700	430	370	690	1220	1000	10	7590	1006

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, and 2013) applied to the total biomass of the year.
Not updated with 2017-2021 data.

Table 6a. Estimated mean numbers at length from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by year, 1984-2002 (October/November). Values from the different survey time series are not comparable (see text).

CL (mm)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
7	1	22	0	3	22	0	0	2	0	4	5	6	1	1	8	15	32	15	1
8	41	61	19	17	49	29	3	19	40	83	34	51	76	9	45	55	36	100	67
9	112	63	47	34	92	255	82	45	363	106	63	59	253	43	100	111	160	246	155
10	108	32	29	14	23	374	188	65	786	120	92	37	284	101	75	59	225	118	93
11	8	10	2	5	33	138	36	15	671	35	15	9	26	21	16	10	124	2	19
12	4	8	1	24	107	13	9	9	154	6	2	1	1	8	3	1	10	0	5
13	15	55	7	142	125	6	14	47	15	17	5	8	7	69	11	9	20	24	8
14	100	266	45	329	74	46	70	163	73	74	36	44	23	228	46	55	84	106	53
15	368	688	173	534	43	217	232	392	146	291	165	188	165	582	139	224	317	376	248
16	668	922	269	474	38	510	435	646	341	717	423	370	704	959	254	532	683	726	666
17	591	551	195	324	45	537	428	560	473	761	470	369	780	795	268	524	599	615	756
18	310	287	106	290	81	215	263	269	426	464	281	229	445	390	339	286	292	398	401
19	193	292	115	262	102	107	174	175	381	241	196	223	280	354	365	146	179	341	235
20	159	347	103	242	103	78	201	178	345	221	239	269	278	392	283	142	164	291	185
21	175	295	102	219	77	60	215	231	259	153	257	182	256	416	272	130	176	235	162
22	148	247	103	191	45	82	184	250	280	166	317	210	250	405	237	201	232	298	171
23	130	148	97	213	21	93	79	164	199	135	215	221	214	309	251	186	175	246	112
24	117	102	67	195	9	74	50	126	146	110	128	195	201	225	231	180	96	217	91
25	128	90	51	147	7	54	39	95	82	80	101	124	172	228	151	151	80	103	58
26	94	96	26	81	6	41	29	58	58	53	67	69	109	145	102	96	68	74	26
27	88	93	15	38	2	21	18	43	36	29	38	34	53	91	58	46	32	39	17
28	39	63	9	13		10	7	17	16	10	16	19	21	32	19	26	20	24	5
29	10	29	5	5		3	1	6	7	6	5	3	5	10	5	2	3	5	2
30	4	9	2	3				1	5	4		1	2	1		1	1		
31	2								1	1									
Total	3613	4776	1588	3799	1104	2963	2757	3576	5303	3887	3170	2921	4606	5814	3278	3188	3808	4599	3536

Table 6b. Estimated mean numbers at length from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by year, 2004-2005 (May/June).

CL (mm)	2004	2005
7	3	0
8	8	0
9	27	10
10	101	18
11	259	71
12	562	206
13	890	377
14	1211	551
15	1177	576
16	789	631
17	518	805
18	479	730
19	462	575
20	433	426
21	393	336
22	365	273
23	275	261
24	182	226
25	110	137
26	52	95
27	42	33
28	12	14
29	4	3
30	2	1
31	2	
Total	8358	6355

Table 6c. Estimated mean numbers at length from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by year, 2006-2021 (January/February). The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl.

CL(mm)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
7	0	0	3	0	0	0	1	2	9	0	1	4	1	6	0	1
8	10	13	18	4	1	2	10	10	30	8	4	16	4	29	3	7
9	48	119	74	24	19	18	52	41	273	44	26	64	23	144	19	39
10	157	296	166	65	43	65	135	96	700	82	61	136	78	235	47	129
11	301	502	212	112	58	98	196	168	752	98	69	212	137	276	104	251
12	432	496	144	125	31	91	212	177	348	63	42	219	199	211	144	278
13	438	292	98	67	16	45	138	95	94	38	20	127	142	84	109	159
14	264	541	168	96	26	29	70	50	30	139	23	67	97	26	74	71
15	206	1250	288	230	75	61	47	124	61	379	52	111	130	40	116	78
16	314	1906	443	358	148	163	75	239	140	619	90	212	220	99	252	155
17	440	1800	453	396	170	223	140	304	227	625	106	314	303	166	378	199
18	489	1105	378	267	161	163	157	229	184	257	73	227	269	165	323	182
19	429	464	370	185	166	98	105	89	117	185	69	161	149	103	180	133
20	324	284	361	142	185	92	81	55	90	148	55	107	103	78	88	114
21	216	282	261	158	164	82	58	51	73	98	57	104	73	65	58	112
22	165	240	232	197	116	80	35	43	74	81	36	94	70	64	58	74
23	119	212	174	182	106	75	25	44	49	137	29	72	62	38	53	36
24	103	140	117	136	101	68	25	30	43	45	15	33	35	24	25	15
25	60	111	83	83	76	62	21	17	11	19	8	10	16	12	11	6
26	55	54	46	39	42	47	17	13	3	6	4	3	5	3	2	2
27	17	32	18	18	15	31	8	7	1	2	1	2	1	1	1	
28	9	9	9	6	4	12	4	4	0	1						
29	0	2	1	3	1	3	1	2	5							
30	1			1												
31																
Total	4597	10150	4117	2894	1724	1608	1613	1890	3314	3074	841	2295	2117	1869	2045	2041

Table 7. Estimated total abundance (sum of numbers at length) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by year used as input data to the assessment model (Stock Synthesis) until 2019, and the correct numbers used in the 2020 assessment, as well as the percentage increase in total abundance for the years where incorrect values were previously used.

Year	Numbers used until 2019	Correct numbers	Percentage change
1988	842	1104	31.1
1989	2963	2963	
1990	2757	2757	
1991	3576	3576	
1992	5303	5303	
1993	3887	3887	
1994	3170	3170	
1995	2853	2921	2.4
1996	4606	4606	
1997	5814	5814	
1998	3082	3278	6.4
1999	3163	3188	0.8
2000	3791	3808	0.4
2001	4497	4599	2.3
2002	3536	3536	
2004	8358	8358	
2005	6355	6355	
2006	4568	4597	0.6
2007	10149	10150	0.0
2008	4023	4117	2.3
2009	2849	2894	1.6
2010	1724	1724	
2011	1608	1608	
2012	1613	1613	
2013	1890	1890	
2014	3314	3314	
2015	3074	3074	
2017	2295	2295	
2018	2117	2117	
2019	1869	1869	
2020		2045	

Table 8. Mean carapace length (CL) with standard deviation (SD), abundance (millions), and proportion of numbers in age groups out of total numbers from the 2021 survey length frequency distribution in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep).

Total				
age	CL (mm)	SD	abundance	proportion
1	11.73	1.42	966	0.45
2	17.50	1.54	822	0.39
3+	21.10	1.85	347	0.16

Norwegian Deep				
age				
1	10.32	1.25	115	0.16
2	16.32	1.38	307	0.43
3+	20.32	1.73	300	0.42

Skagerrak				
age				
1	11.83	1.13	801	0.58
2	17.42	1.25	401	0.29
3+	20.97	1.89	181	0.13

Table 9a. Estimated numbers per age group in the shrimp stock (*Pandalus borealis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep), 1984-2002 (October/November).

	0-group	1-group	2-group	3-group
1984	273	2324	576	599
1985	197	2869	1536	402
1986	100	849	767	9
1987	75	1955	1435	571
1988	196	401	530	12
1989	816	1613	616	
1990	320	1882	602	139
1991	150	2210	1049	250
1992	2038	2133	1127	122
1993	356	2681	945	7
1994	212	1518	1347	209
1995	164	1322	673	985
1996	642	2270	973	918
1997	187	3228	2337	366
1998	249	1912	1205	
1999	254	1769	370	992
2000	561	2152	1007	181
2001	483	2463	1879	
2002	338	2349	839	172

Table 9b. Estimated numbers per age group in the shrimp stock (*Pandalus borealis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep), 2006-2021 (January/February). The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl.

	1-group	2-group	3-group	4-group
2006	1806	2297	592	
2007	1795	7293	1361	
2008	705	1750	1160	629
2009	425	1485	1087	
2010	155	1345	256	
2011	330	779	559	
2012	830	696	103	
2013	663	1029	309	
2014	2261	774	360	
2015	346	2125	491	268
2016	233	384	275	
2017	880	1117	361	
2018	757	1099	338	
2019	1020	629	270	
2020	497	1326	244	
2021	966	822	347	

Table 10. Index of predator biomass (mean catch in kg per trawled nm) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in 2006-2021. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl.

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Blue whiting	*Micromesistius poutassou*	0.13	0.13	0.12	1.21	0.27	0.62	3.30	29.03	1.88	5.25	*6.26*	31.18	6.38	19.68	13.04	59.02
Saithe	*Pollachius virens*	7.33	39.75	208.32	53.89	18.53	7.52	5.66	112.80	14.13	8.56	*6.93*	9.71	12.87	5.77	1.88	5.13
Cod	*Gadus morhua*	0.51	1.28	0.78	2.01	1.79	1.66	1.26	1.69	2.92	2.37	*2.74*	2.00	2.05	2.58	0.58	1.00
Roundnose grenadier	*Coryphaenoides rupestris*	3.22	6.85	19.02	19.03	10.05	4.99	4.43	1.97	2.90	1.46	*0.3*	1.41	2.17	2.10	3.53	1.85
Rabbit fish	*Chimaera monstrosa*	2.24	2.15	3.41	3.26	3.51	2.73	2.22	3.05	3.90	2.19	*1.7*	5.99	5.03	5.40	4.35	4.01
Haddock	*Melanogrammus aeglefinus*	0.97	4.21	1.85	3.18	3.46	5.82	5.75	5.18	2.15	2.60	*1.66*	1.86	1.51	0.97	1.15	3.94
Redfish	Scorpaenidae	0.18	0.40	0.26	0.43	0.80	1.02	0.37	0.47	0.48	0.20	*0.25*	0.53	0.97	0.82	0.31	0.50
Velvet belly	*Etmopterus spinax*	1.31	2.58	1.95	2.42	2.52	1.47	1.59	2.67	1.91	2.51	*1.2*	4.19	3.85	4.34	2.92	4.19
Skates, rays	Rajidae	0.41	0.95	0.64	0.17	0.60	0.88	0.98	1.00	2.25	1.69	*0.35*	1.64	1.20	1.76	0.65	1.39
Long rough dab	*Hippoglossoides platessoides*	0.22	0.64	0.42	0.28	0.47	0.51	0.56	0.56	1.17	1.45	*0.52*	0.94	0.81	1.02	0.34	0.41
Hake	*Merluccius merluccius*	0.98	0.78	0.64	2.56	1.60	0.56	0.52	1.06	0.69	0.59	*1.07*	1.24	1.66	0.91	1.00	1.16
Angler	*Lophius piscatorius*	0.15	0.91	0.87	1.25	1.70	0.92	0.17	0.65	0.75	0.58	*0.9*	1.13	0.57	1.12	0.71	0.76
Witch	*Glyptocephalus cynoglossus*	0.24	0.74	0.54	0.16	0.13	0.24	0.29	0.27	0.35	1.38	*0.28*	0.47	0.17	0.16	0.19	0.40
Dogfish	*Squalus acanthias*	0.31	0.19	0.28	0.14	0.11	0.21	0.60	1.02	1.00	0.36	*0.24*	0.42	0.45	0.43	0.26	0.32
Black-mouthed dogfish	*Galeus melastomus*	0.00	0.05	0.05	0.15	0.09	0.09	0.09	0.12	0.11	0.35	*0.34*	0.26	0.24	0.24	0.35	0.16
Whiting	*Merlangius merlangus*	0.35	1.01	1.35	3.02	2.42	3.07	1.64	2.02	3.38	1.59	*1.87*	2.60	4.56	5.20	2.62	4.62
Blue Ling	*Molva dypterygia*	0	0	0	0	0	0	0	0.01	0.01	0.03	*0*	0.01	0.03	0.02	0.25	0.08
Ling	*Molva molva*	0.04	0.11	0.34	0.79	0.64	0.24	0.17	0.22	0.32	0.63	*0.18*	0.90	0.99	1.09	0.41	0.27
Four-bearded rockling	*Rhinonemus cimbrius*	0.06	0.14	0.04	0.03	0.05	0.03	0.09	0.04	0.06	0.12	*0.05*	0.04	0.05	0.09	0.05	0.04
Cusk	*Brosme brosme*	0.20	0	0.02	0.05	0.13	0.29	0.04	0.10	0.05	0.19	*0.01*	0	0.14	0.38	0.02	0.02
Halibut	*Hippoglossus hippoglossus*	0.08	0.07	3.88	0.09	0.20	0.05	0.19	0	0	0.10	*0*	0.16	0.09	0.24	0.29	0.17
Pollack	*Pollachius pollachius*	0.06	0.25	0.03	0.13	0.12	0.15	0.07	0.24	0.65	0.23	*0.08*	0.10	0.15	0.22	0.19	0.09
Greater forkbeard	*Phycis blennoides*	0	0	0	0.01	0.04	0.02	0.05	0.06	0.12	0.05	*0.07*	0.18	0.22	0.2	0.07	0.11
Total		18.99	63.19	244.81	94.26	49.23	33.09	30.04	164.23	41.18	34.48	27.00	66.96	46.16	54.74	35.16	89.64

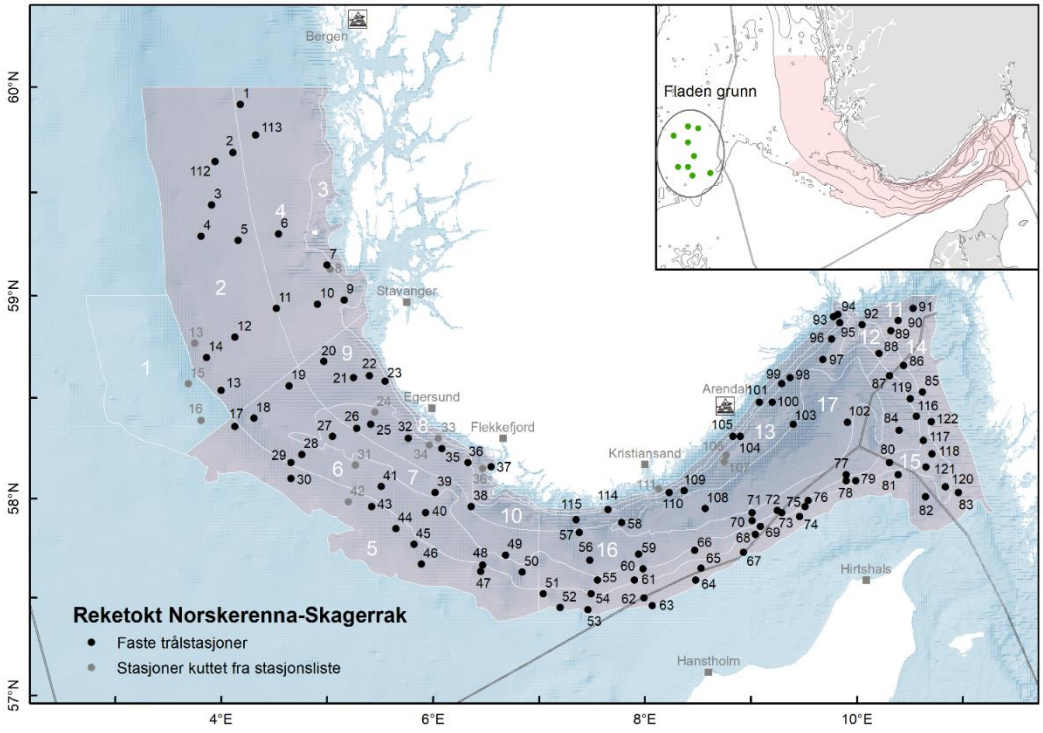

Figure 1. Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. 3.a and 4.a East): Strata system with the 111 fixed trawl stations. Trawl stations marked in grey have been deleted from the station list (see text). Trawl stations on Fladen Ground (from previous surveys in 1987-1994) were also trawled in 2021. Strata areas are given in Table 1.

Figure 2. The partition of the North Sea and Skagerrak into ICES Divisions 3.a (Skagerrak), 4.a (North Sea north) and 4.b (North Sea south).

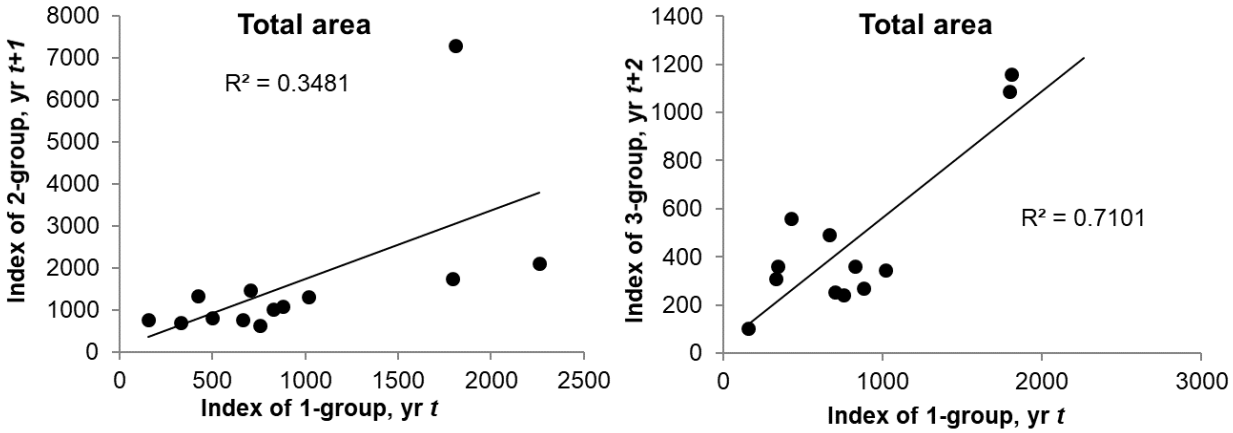

Figure 3. Correlation between the index of 1-year old shrimp (*Pandalus borealis*) (indices are abundance in millions) in year *t* and the index of 2-year old shrimp in year *t*+1 (left); and correlation between the index of 1-year old shrimp in year *t* and the index of 3-year old shrimp in year *t*+2 (right), in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep). Data from January/February 2006-2021. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

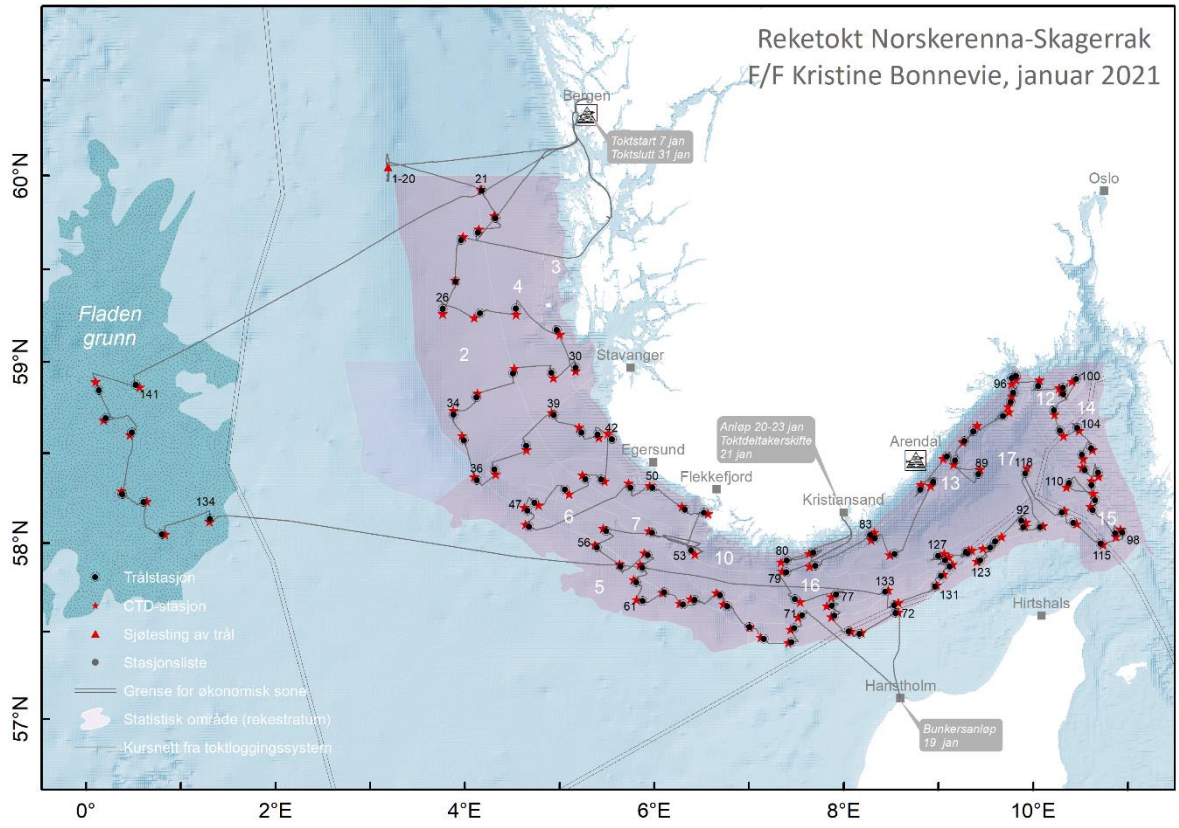

Figure 4. The Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep, and Fladen Ground) in January 2021 with R/V *Kristine Bonnevie*: sailing route with fixed stations (grey dots), testing area for trawl gear (red triangles), trawled stations (black dots), and CTD-stations (red stars).

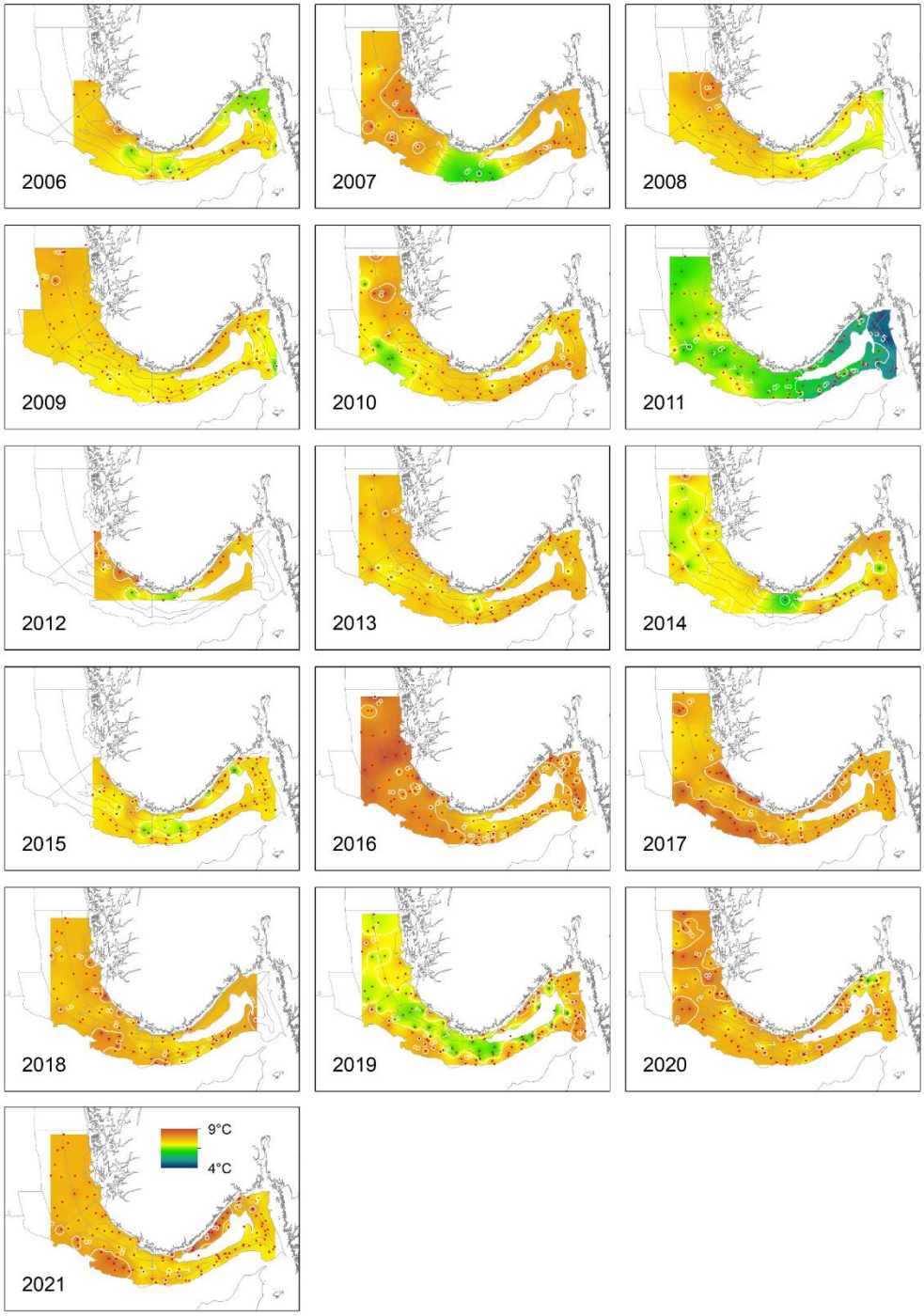

Figure 5. Bottom temperatures (ºC) from CTD from the Norwegian shrimp survey in 2006-2021 in ICES Divs. 3.a and 4.a East (Skagerrak and the Norwegian Deep). The 2012 data result from only 22 CTD hauls (8 in the Norwegian Deep and 14 in Skagerrak) due to difficulties with the CTD-winch. Red points show CTD stations.

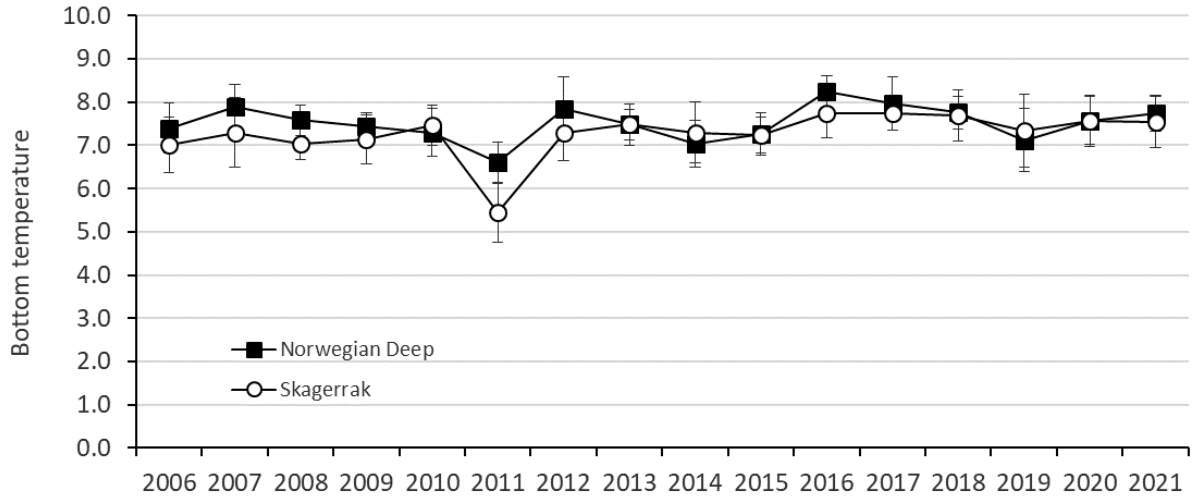

Figure 6. Mean bottom temperatures (ºC) (±SD) from CTD from the Norwegian shrimp survey in 2006-2021 in ICES Divs. 3.a and 4.a East (Skagerrak and the Norwegian Deep). The 2012 data result from only 22 CTD hauls (8 in the Norwegian Deep and 14 in Skagerrak) due to difficulties with the CTD-winch.

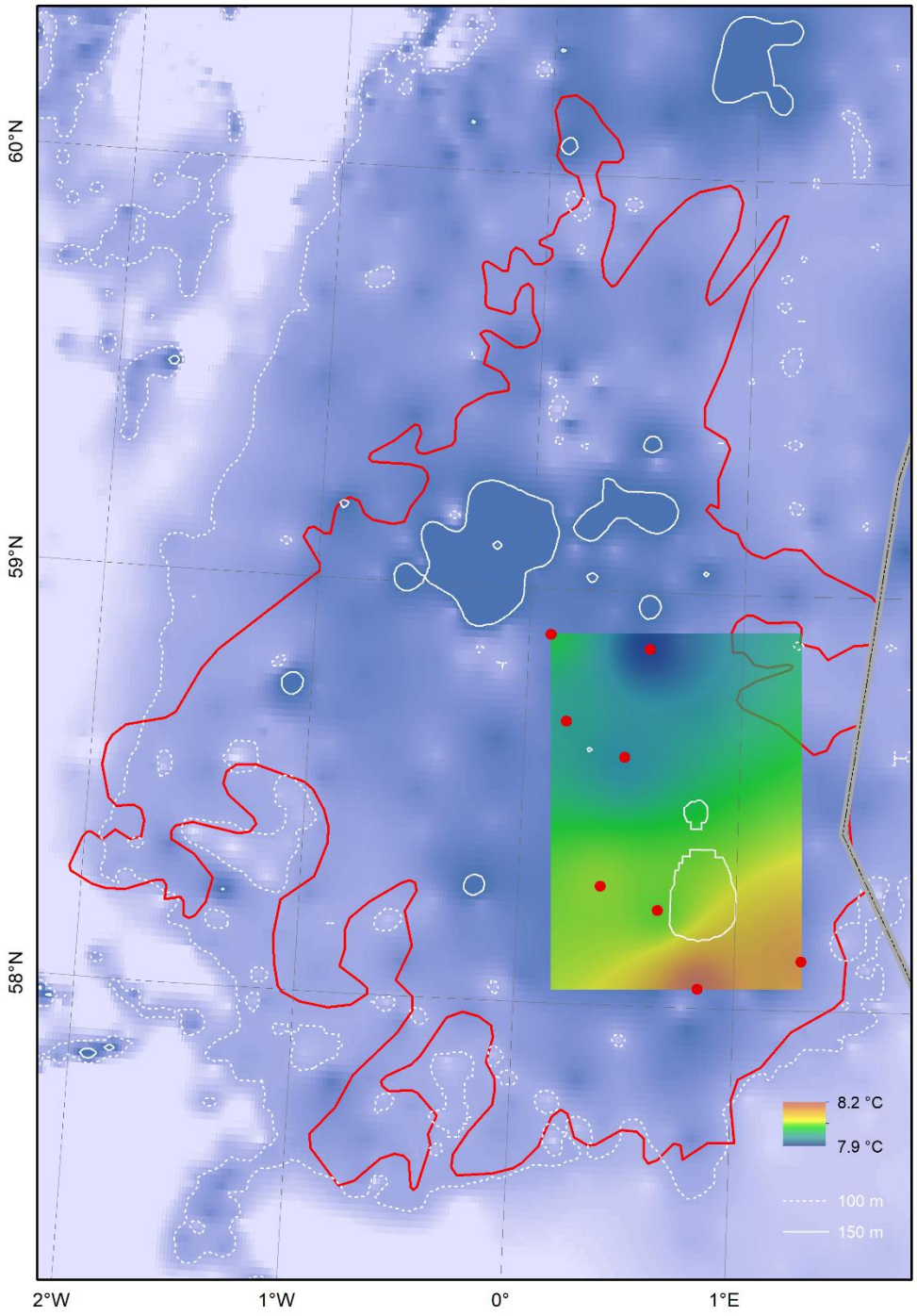

Figure 7. Bottom temperatures (ºC) from CTD in the 2021 survey in ICES Div. 4.a west (the Fladen Ground). Red points show CTD stations.

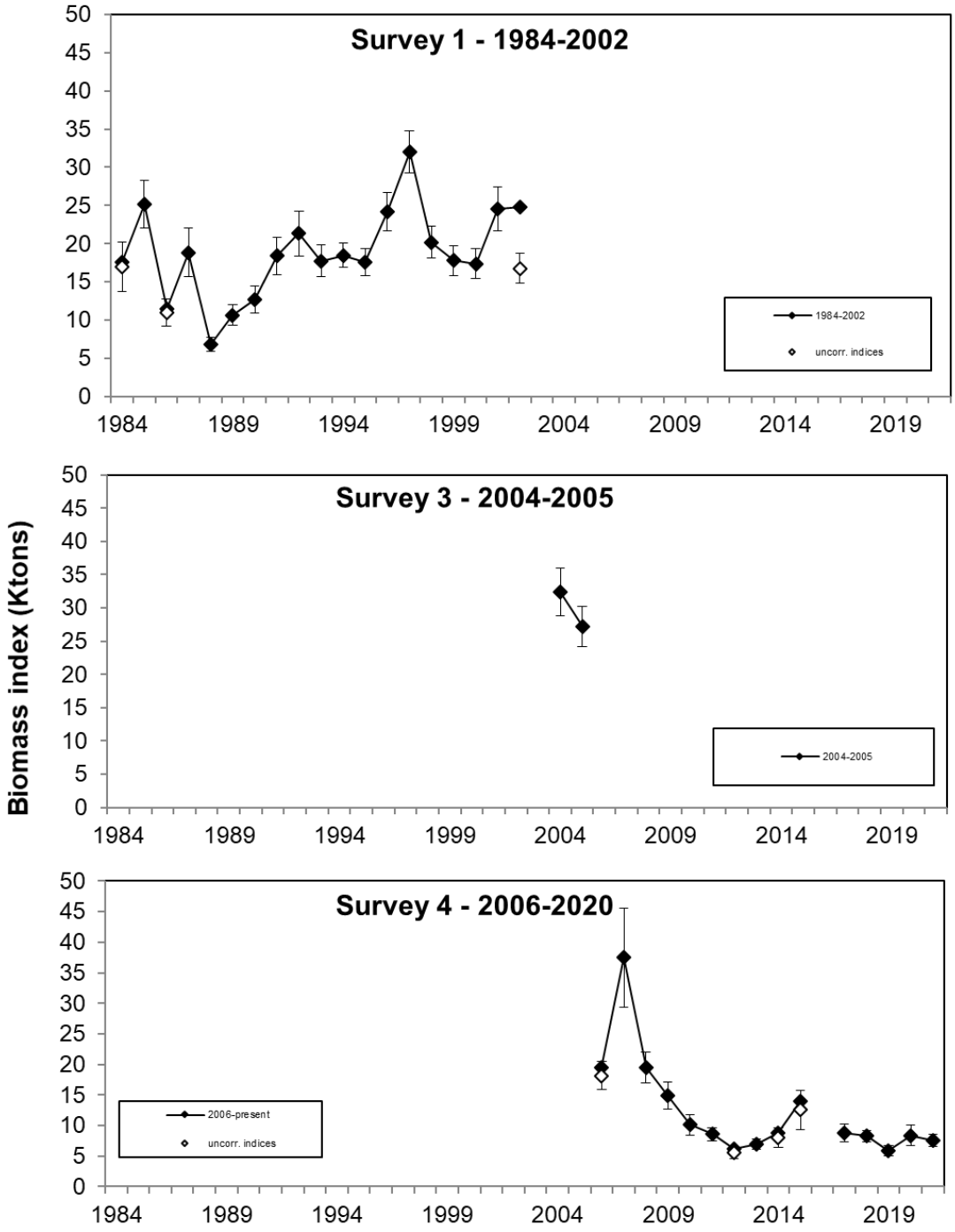

Figure 8. Biomass index (with standard error) of shrimp (*Pandalus borealis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep), 1984-2021. The 2003-value is not shown. The 2016-survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure. Uncorrected values (◊) due to deficient survey coverage in some years (see Table 5) are plotted together with the corrected ones (♦). Standard errors of the corrected values have not been calculated.

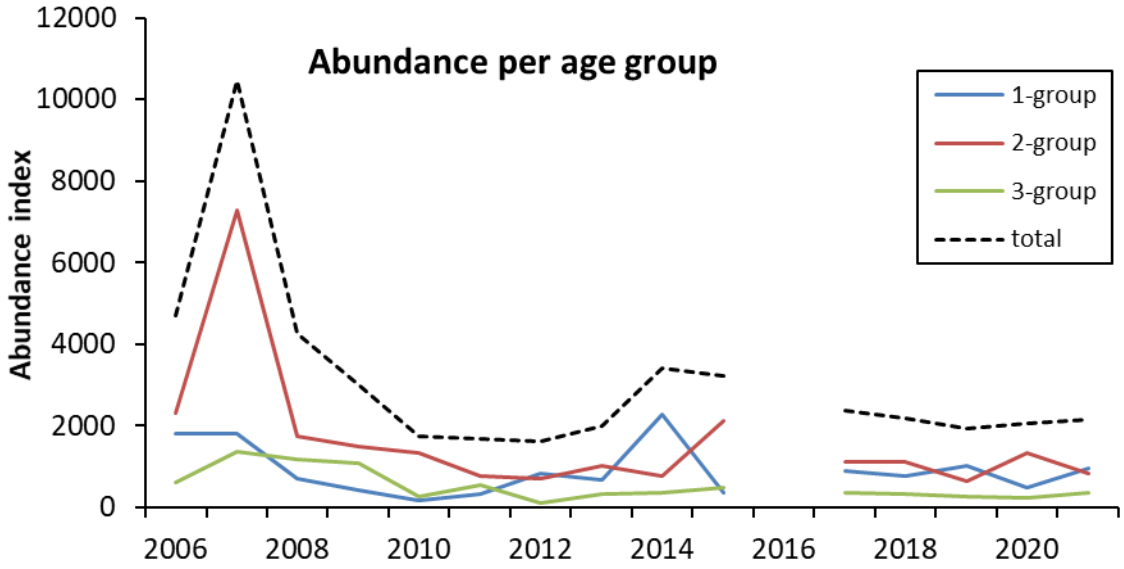

Figure 9. Abundance index per year class of shrimp (*Pandalus borealis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep), 1984-2021. The 2016-survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure. Indices (Table 6) have not been corrected for deficient survey coverage in some years.

Figure 10. The proportion of shrimp biomass (*Pandalus borealis*) per stratum from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in years when all survey strata were covered, in the time period 1984-2021. Strata 1-10 are in the Norwegian Deep, and strata 11-17 are in Skagerrak (Fig. 1). The vertical lines mark the different survey time series (1984-2002, 2004-2005, 2006-2021). The 2003-value is not shown. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

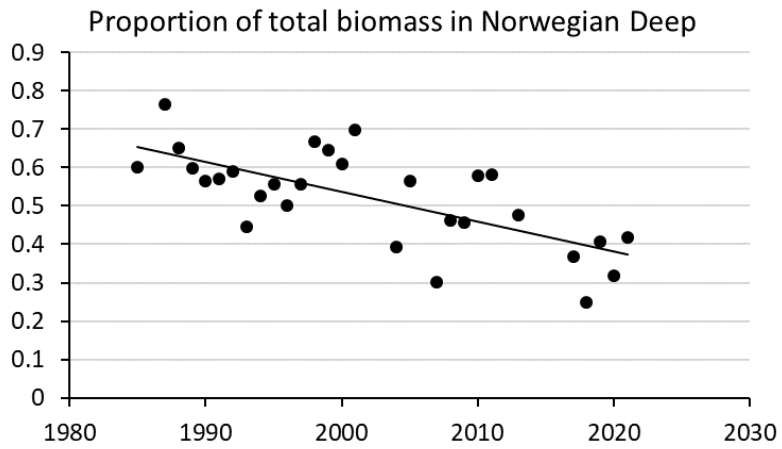

Figure 11. The proportion of estimated shrimp biomass (*Pandalus borealis*) in the Norwegian Deep from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in years when all survey strata were covered, in the time period 1984-2021.

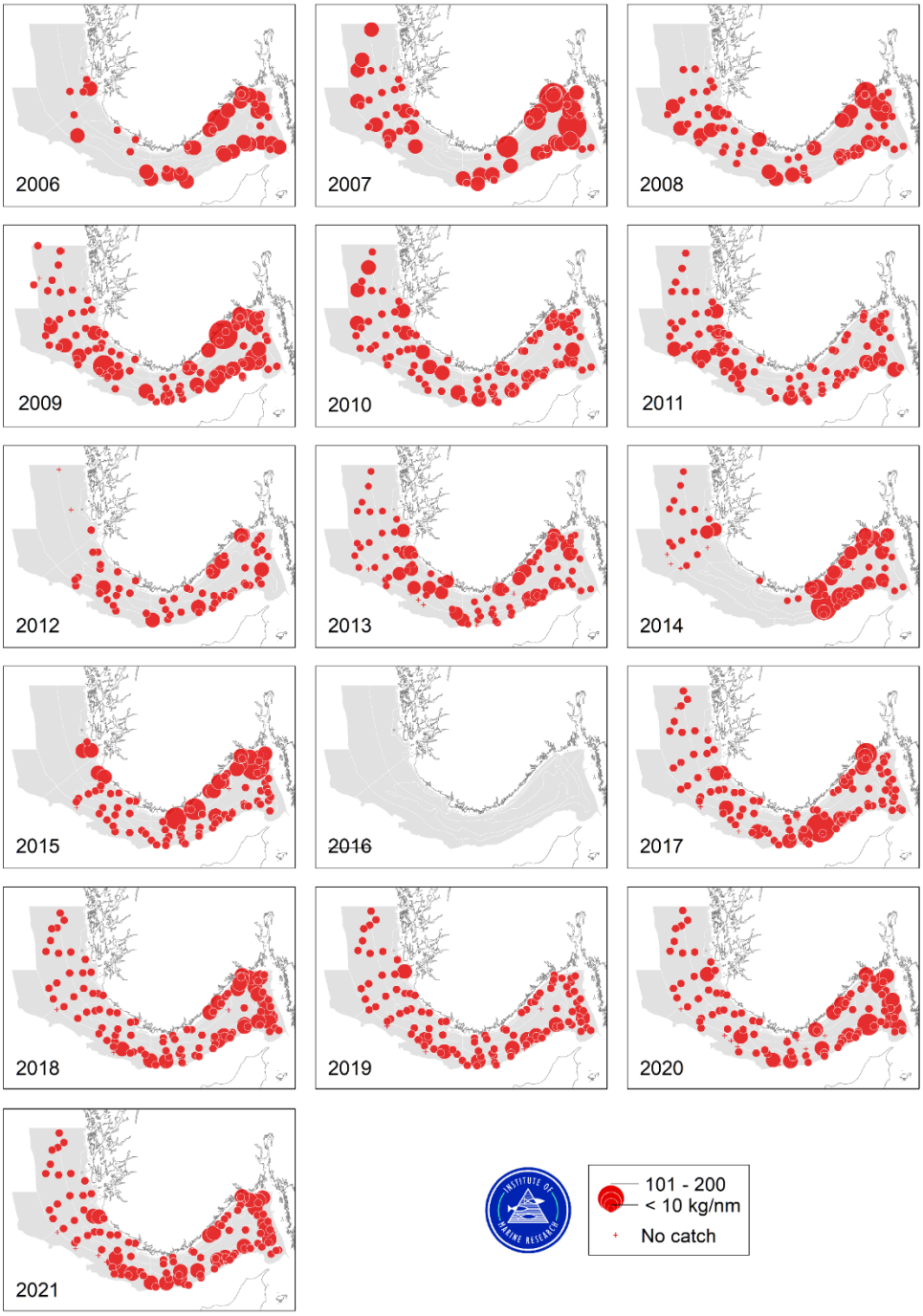

Figure 12. Shrimp (*Pandalus borealis*) catches per trawl station (kg/nm) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in January/February 2006-2021. The 2016-survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

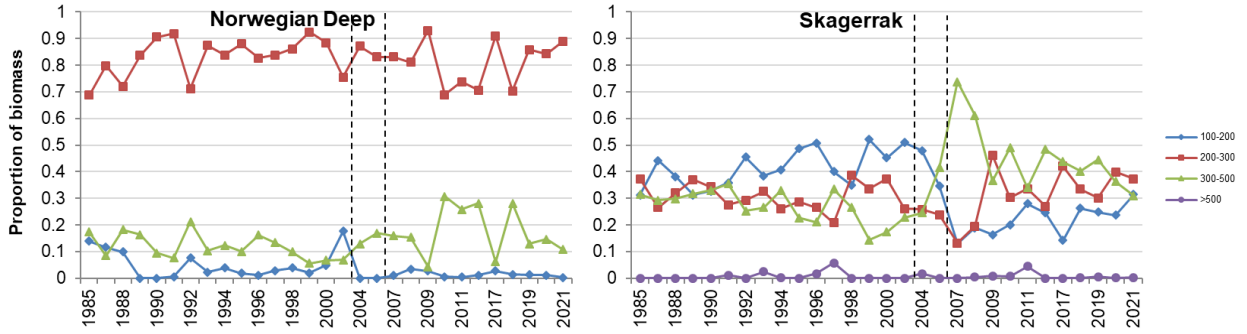

Figure 13. The proportion of shrimp biomass (*Pandalus borealis*) per depth interval from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in years when all survey strata were covered, in the time period 1984-2021. The vertical lines mark the different survey time series (1984-2002, 2004-2005, 2006-2021). The 2003-value is not shown. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

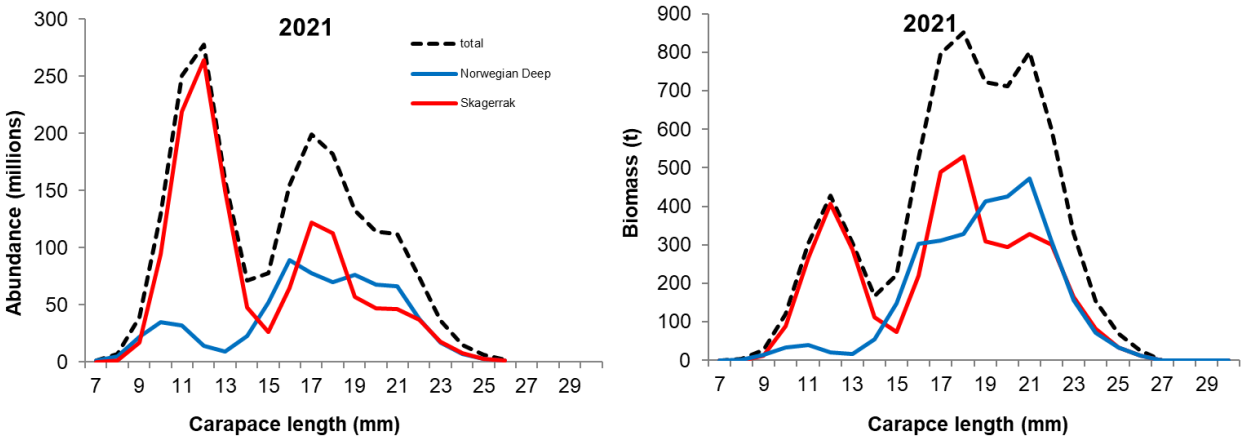

Figure 14a. Length frequency distributions of numbers per length (left) and biomass per length (right) of the shrimp stock (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by area and total, in 2021. Mean weight per length are Danish average values for 1998-2011.

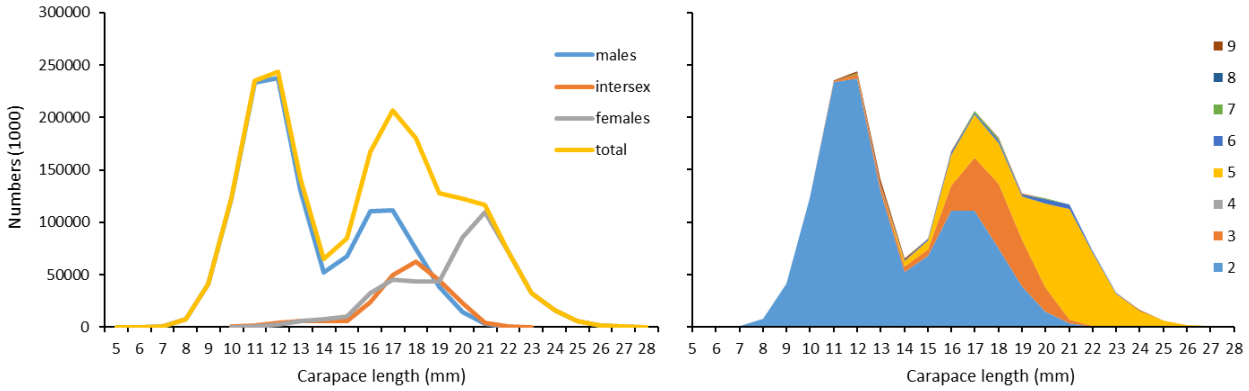

Figure 14b. Length frequency distributions of numbers per length of the shrimp stock (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) for males, intersex, females and total (left) and by stage (right), in 2021. Stages: 2 = males; 3 = transitional; 4 = ripe gonads, first time spawner; 5 = berried; 6 = breeding dress; 7 = second time spawner with no roe; 8 = ripe gonads, second time spawner; 9 = first time spawner with no roe.

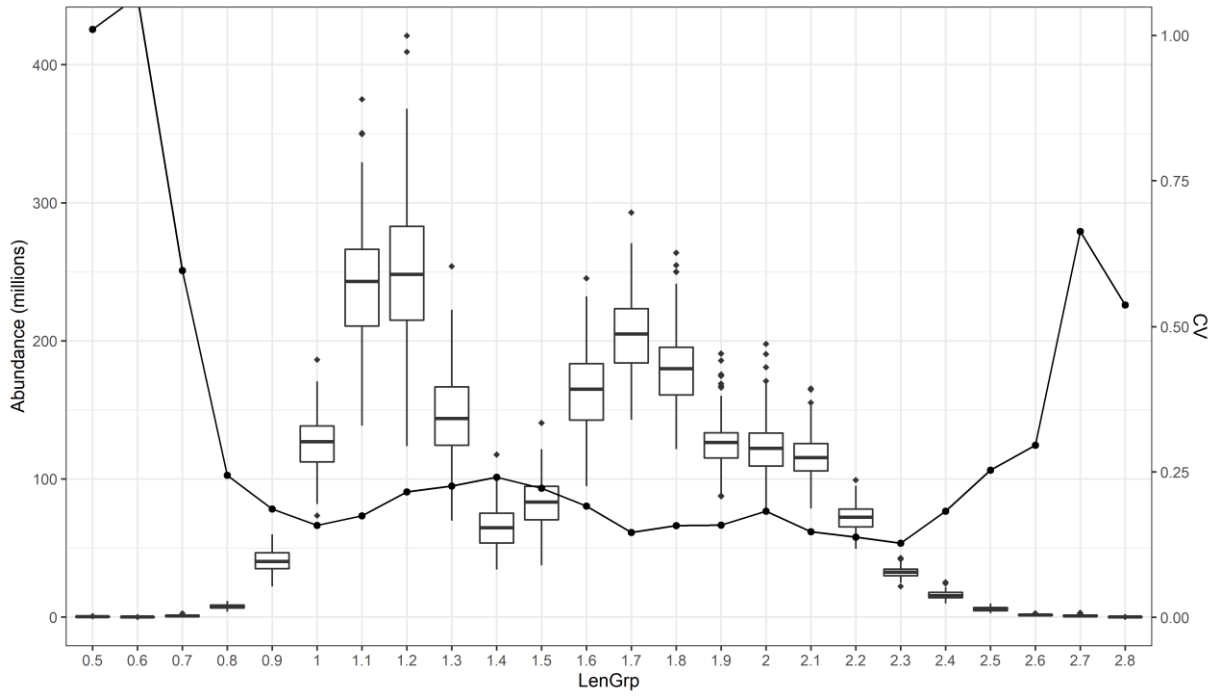

Figure 14c. Length frequency distribution of numbers per length of the shrimp stock (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in 2021, boxplot and CV.

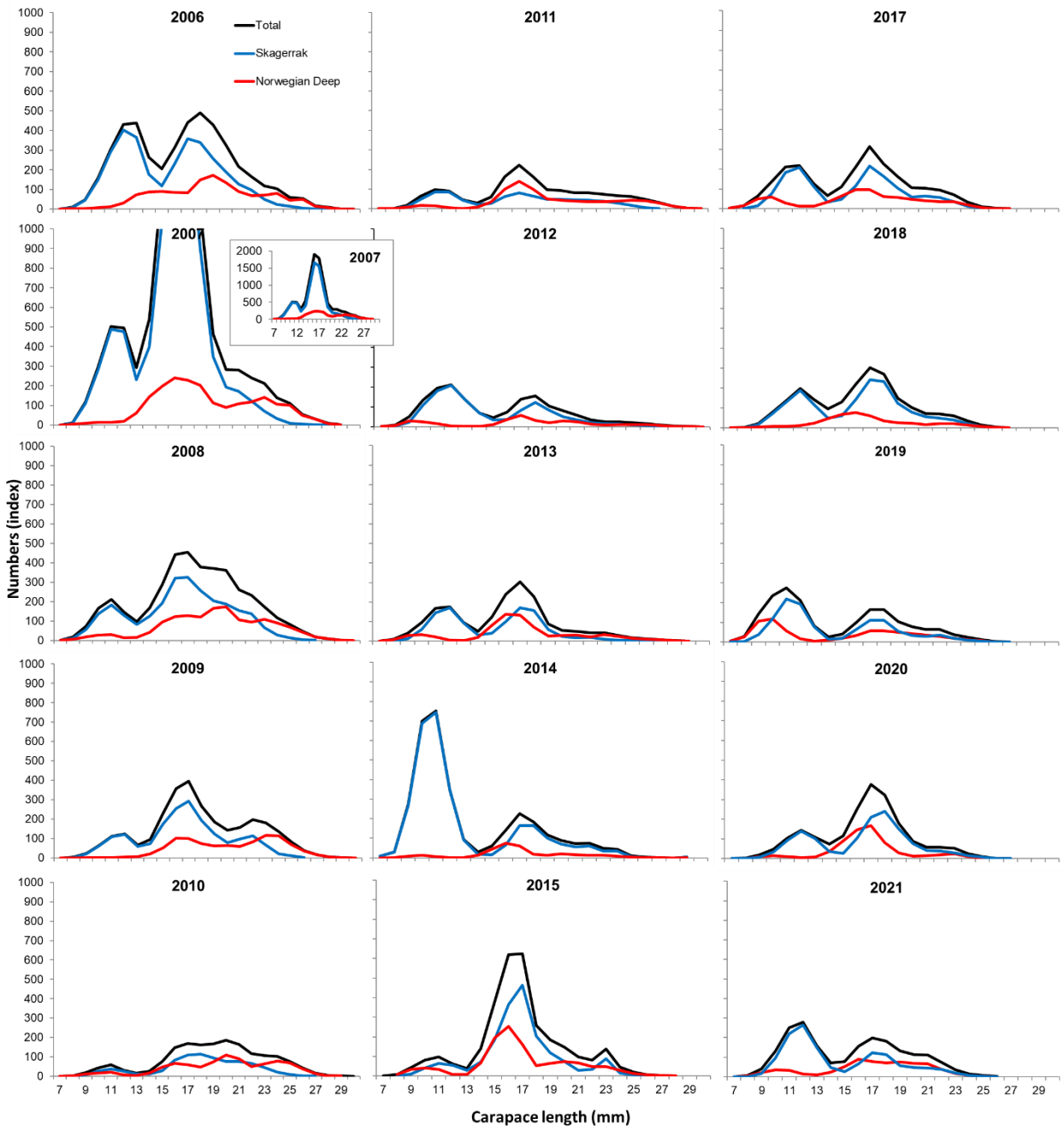

Figure 15a. Length frequency distributions for the shrimp stock (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) by area and total, in 2006-2021. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

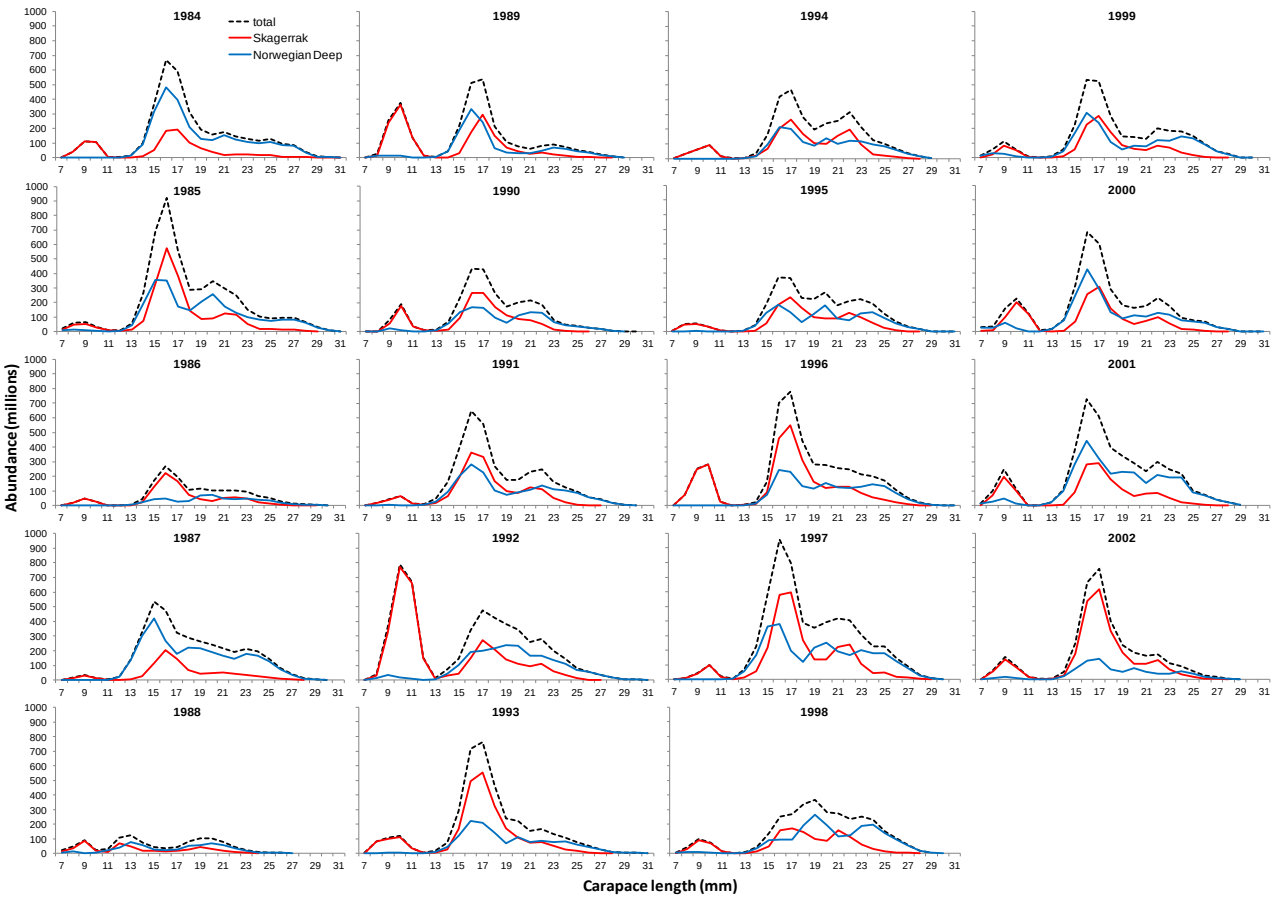

Figure 15b. Length frequency distributions for the shrimp stock (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in 1984-2002.

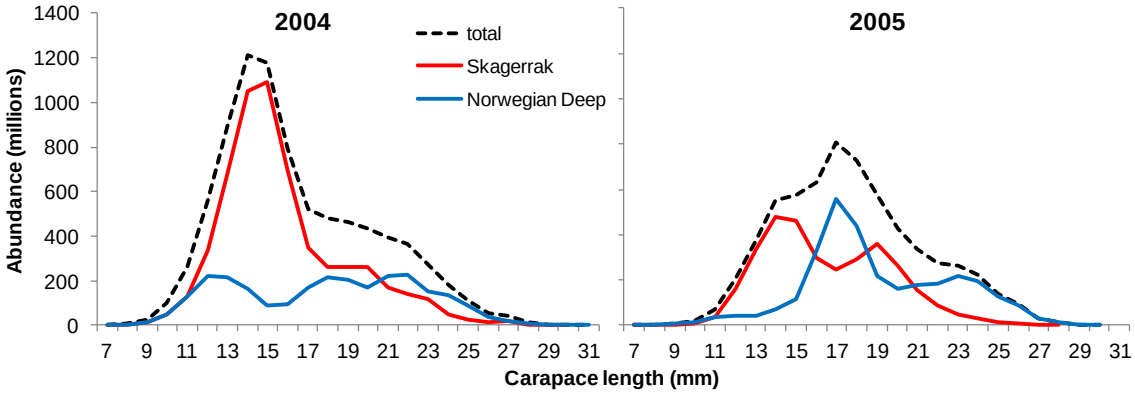

Figure 15c. Length frequency distributions for the shrimp stock (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) in 2004-2005.

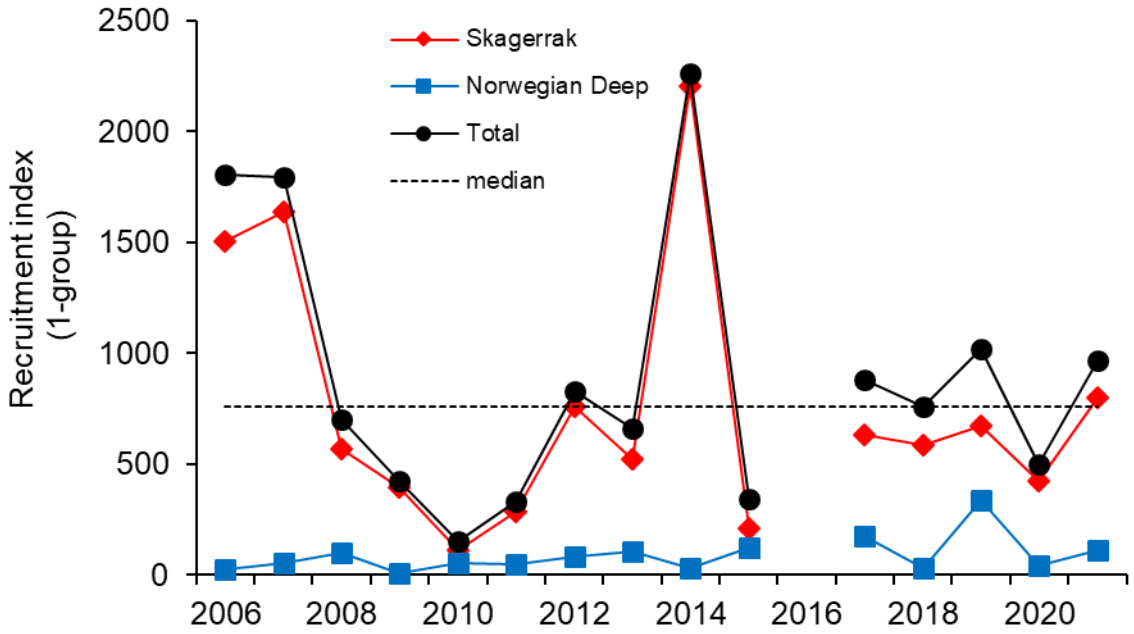

Figure 16. Recruitment index (abundance in millions) of 1-year old shrimp (*Pandalus borealis*) in ICES Div. 3.a (Skagerrak), Div. 4.a east (the Norwegian Deep), and in the overall area, 2006-2021. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure. 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, is caused by the 1-groups in the two areas having different mean lengths. In the total area, shrimp < 15.5 mm are defined as 1-year old by the modal analysis, while the analysis puts shrimp > 12 mm in the 2-group in the Norwegian Deep (see Fig. 15a).

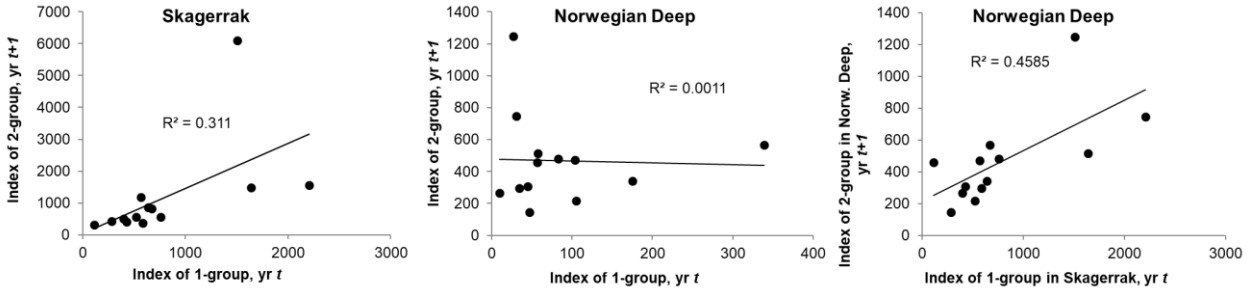

Figure 17. Correlation between the index (in millions) of 1-year old shrimp (*Pandalus borealis*) in year *t* and the index of 2-year old shrimp in year *t*+1, in Skagerrak (left) and in the Norwegian Deep (middle); and correlation between the index of 1-year old shrimp in year *t* in Skagerrak and the index of 2-year old shrimp in year *t*+1 in the Norwegian Deep (right), in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep). Data from January/February 2006-2021. The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

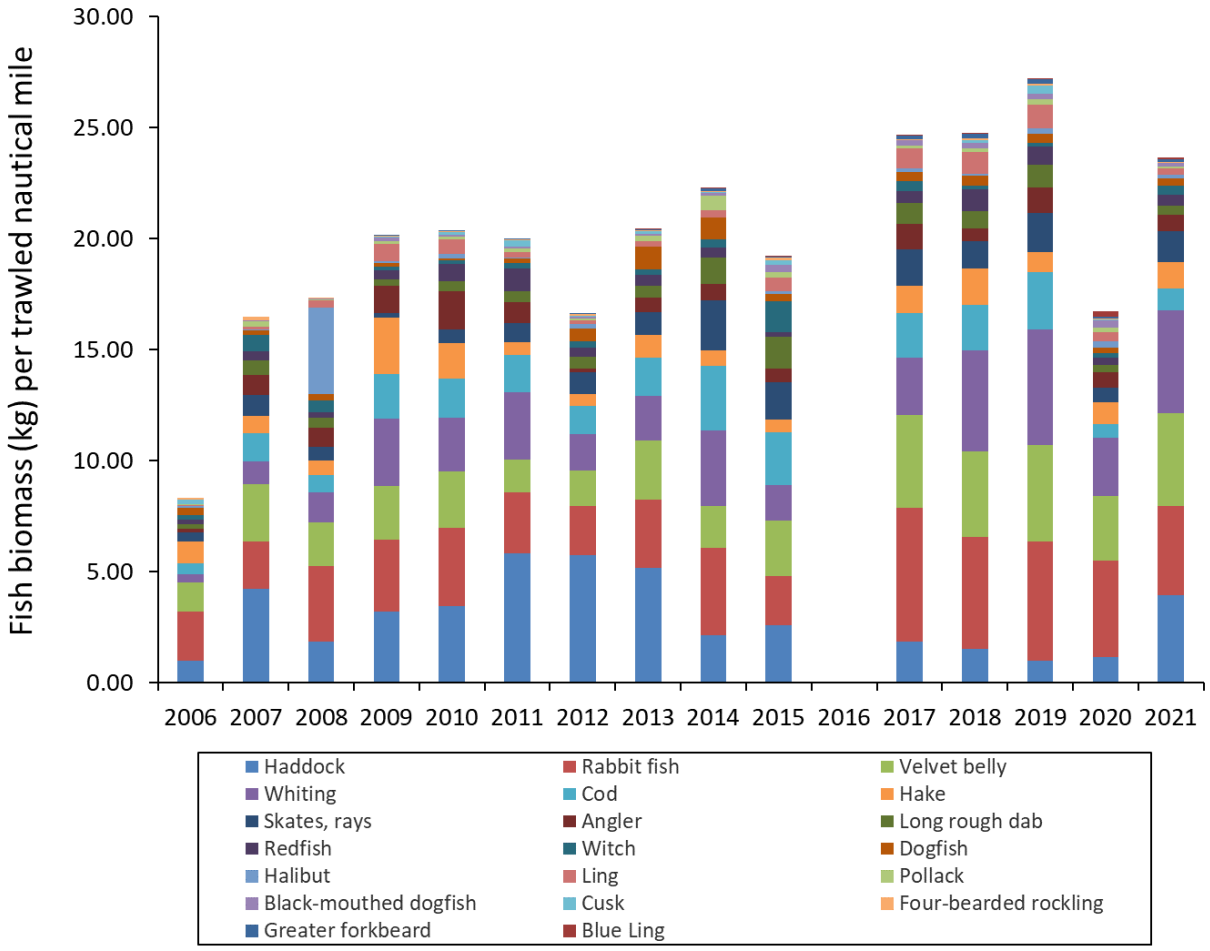

Figure 18. Indices of demersal fish species (potential shrimp predators) (kg per trawled nm) in 2006-2021 in ICES Divs. 3.a and 4. east (Skagerrak and the Norwegian Deep), not including indices of saithe, roundnose grenadier and blue whiting (see text). The 2016 survey was invalidated because of problems with unequal wire lengths of the trawl and these data are not included in the figure.

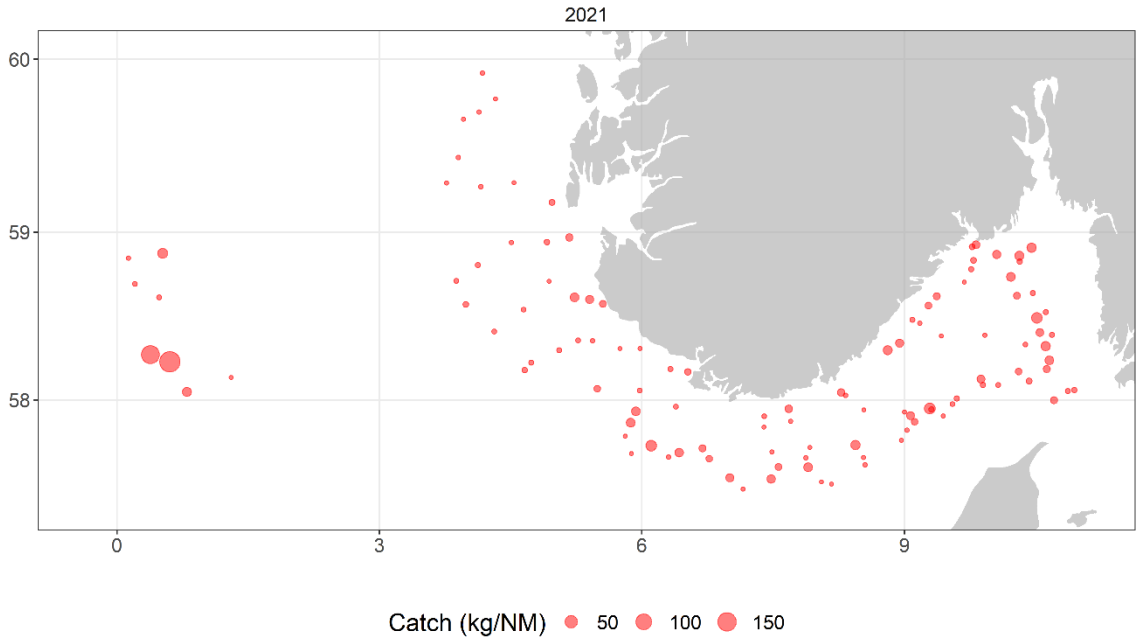

Figure 19. Shrimp (*Pandalus borealis*) catches per trawl station (kg/nm) from the Norwegian shrimp survey in ICES Divs. 3.a and 4.a (Skagerrak, the Norwegian Deep and the Fladen Ground) in January 2021.

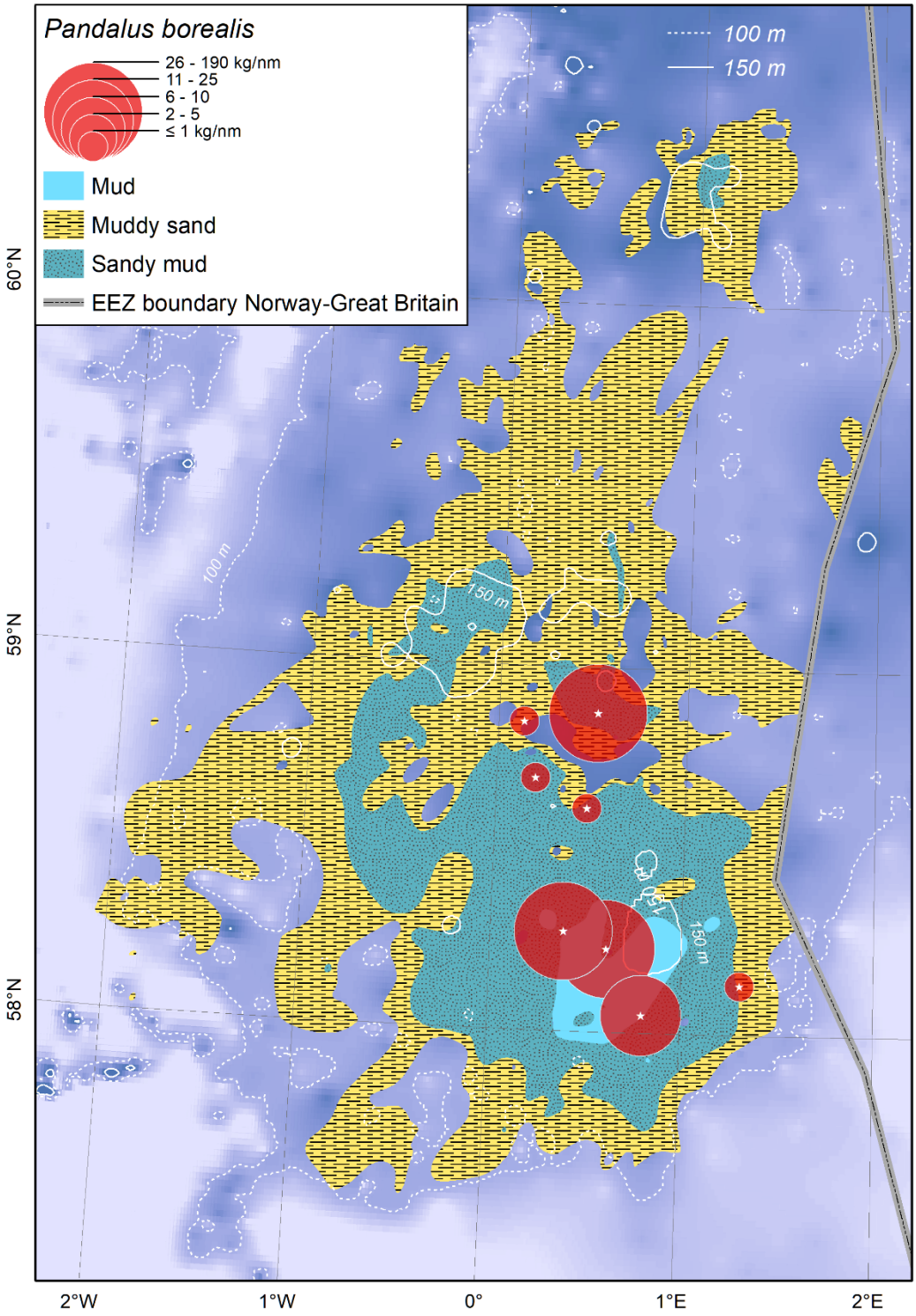

Figure 20. Shrimp (*Pandalus borealis*) catches per trawl station (kg/nm) from the Norwegian shrimp survey in ICES Div. 4.a west (the Fladen Ground) in January 2021 per substrate type. The underlying shape file was generously shared by C. Mesquita.

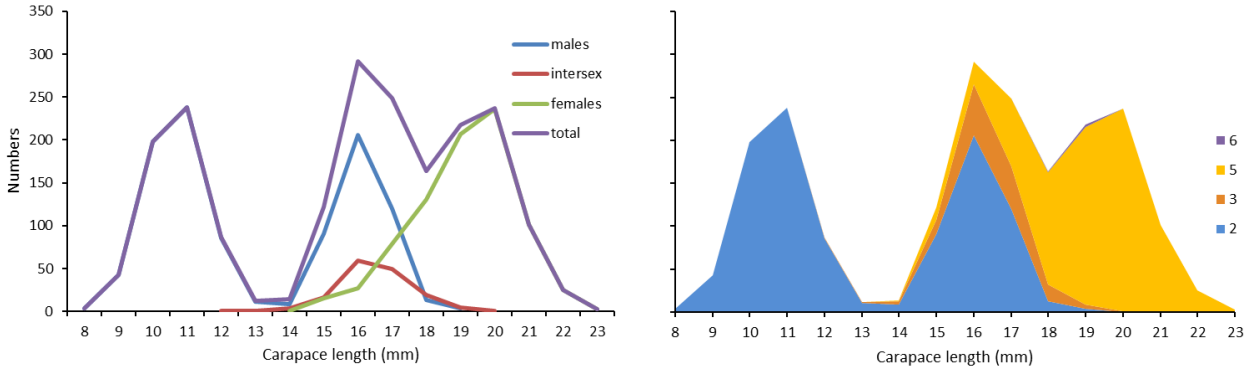

Figure 21. Length frequency distributions of numbers per length (all survey samples pooled) of the shrimp stock (*Pandalus borelis*) in ICES Div. 4.a west (the Fladen Ground) for males, intersex, females and total (left) and by stage (right), in 2021. Stages: 2 = males; 3 = transitional; 5 = berried; 6 = breeding dress.

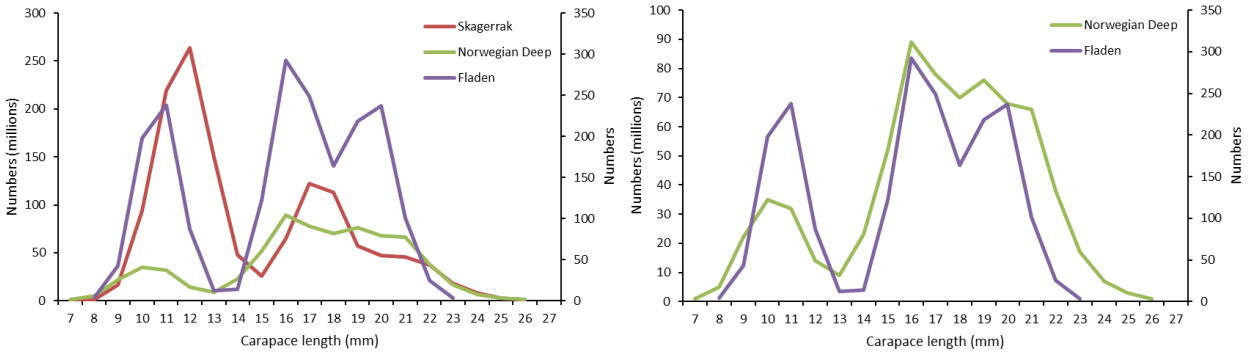

Figure 22. Length frequency distributions of numbers per length of the shrimp stocks (*Pandalus borelis*) in ICES Divs. 3.a and 4.a east (Skagerrak and the Norwegian Deep) and in ICES Div. 4.a. west (the Fladen Ground) (numbers in all survey samples pooled) in 2021. The right figure shows only the Fladen Ground and the Norwegian Deep length distributions for comparison.