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NAFO/ICES *PANDALUS* ASSESSMENT GROUP MEETING

The Norwegian Fishery for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east), 1970-2007

by

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Abstract

The resource of Northern shrimp (*Pandalus borealis*) in the North Sea and Skagerrak is assessed as three separate stocks: 1) the Skagerrak-Norwegian Deep stock which is largely confined to ICES Divs. IIIa and IVa east, 2) the Fladen Ground stock in ICES Div. IVa west, and 3) the Farn Deep stock in ICES Div. IVb west. Vessels from Norway, Denmark, Sweden, and UK exploit this resource. The Norwegian fishery is catch regulated by individual vessel quotas.

Information on the Norwegian shrimp fishery (fleet, gear, and prizes) was updated. The recording of twin trawl use is incomplete in the logbooks. In order to correct the logbooks regarding the use of single and twin trawls, interviews were made with ship owners identified from logbooks. Eleven vessels reported the use of twin trawls.

Norwegian landings have increased recently from 6 000 t in 2000 to 9 000 t in 2004, but have decreased again in the last two years. 8 214 t were landed in 2006. However, last year there was a large difference between Skagerrak and the Norwegian Deep, with landings respectively increasing and decreasing in the two areas. Correcting for boiling implies that 300-550 t should be added to the nominal landings for the years 2000-2005.

Landings per unit effort (LPUE) increased from 33 to 55 kg/hour in 2000-2004, dropped in 2005, and increased again in 2006 to 54 kg/hour. Standardised LPUE values calculated for 2000-2006 follow the same trend. Again, there was a large difference between Skagerrak and the Norwegian Deep in 2006, with LPUE respectively increasing and decreasing in the two areas.

The 2006 catch composition was evaluated using samples from shrimp fishers and the Coast Guard.

Introduction

The resource of Northern shrimp (*Pandalus borealis*) (hereafter synonymous with shrimp) in Skagerrak and the North Sea is assessed as three separate stocks (Munch-Petersen et al. 2006): 1) the Skagerrak-Norwegian Deep stock which is largely confined to ICES Divs. IIIa and IVa east, 2) the Fladen Ground stock in ICES Div. IVa west, and 3) the Farn Deep stock in ICES Div. IVb west (Fig. 1). Vessels from Norway, Denmark, Sweden, and UK exploit this resource. The Norwegian vessels fish the Skagerrak-Norwegian Deep stock, with minor catches from Fladen Ground in some years (Munch-Petersen et al. 2006).

Since 1992 Norway and EU have negotiated quotas on shrimp in the North Sea and Skagerrak. Norway has the largest quota (55%) of the three Scandinavian countries. In 1998 a general quota regulation system was initiated in the Norwegian shrimp fishery in this area, resulting in admittance regulation for vessels ≥11 m. Vessels <11 m have

free admission to the shrimp fishery, but are subject to the same quota regulations as larger ones. In order to supply the market throughout the year the total Norwegian quota is evenly allocated to three four-month periods with respectively 40%, 30% and 30% of the quota. The vessels have a maximum period-quota and a trip-quota of 4 t (tons) for each trip to sea.

The Norwegian fishery is conducted by multi-purpose fishing vessels mainly trawling south of 60º N. In 2006 a total of 296 vessels participated in the shrimp fishery south of 62º N (Table 1, Fig. 2). The length group 10-10.99 m dominated in numbers, with the length group 11-14.99 m as the second largest. During the last eleven years the fleet has changed considerably (Fig. 2). The number of trawlers <10 m has decreased, as has the number of vessels 11-20.99 m, while there has been an increase in vessels 10-10.99 m, and a minor increase in vessels ≥21 m. Small vessels dominate in the eastern Skagerrak, while the fleet in the west is more varied with a predominance of larger vessels. These changes can partly be explained by different condemnation arrangements in 1998-2005 to reduce the capacity of the fleet, resulting in 69 less shrimp permits. However, in several instances fishers have condemned vessels ≥11 m followed by a reinvestment in new vessels just <11 m, often with larger capacity. Few new large vessels can be explained by the required fishery permits for vessels ≥11 m. However, vessels with permits can be substituted by larger ones, increasing the capacity of the fleet.

In 2006 about 90% of the shrimp landings were landed by vessels 10-27.99 m (Table 1). The yearly mean landings per vessel increased with length, but there are large variations. Most catches are landed in ports along the Norwegian coast, while some are landed in Sweden. Subsequent processing takes place at two factories on the Skagerrak coast and one on the North Sea coast.

Norwegian logbooks from the shrimp fishery in Skagerrak and the Norwegian Deep are incomplete. In 2006 catches recorded in logbooks only made up 19.0% and 28.5% of the respective landings in Divs. IIIa and IVa east. This is partly due to vessels <11 m not being required to fill out logbooks. However, logbooks for vessels ≥11 m are not complete either. For 2006 we have logbook data from 24 vessels, while the landings statistics contain information from at least 144 vessels ≥11 m.

Two-, three- and four-bridle shrimp trawls are in use by Norwegian shrimp fishers in the Skagerrak and North Sea, the two-bridle one being used most frequently, also in twin trawls. Twin shrimp trawls are common on larger vessels, and, according to fisheries organizations, have been used by 20-30 trawlers the last five years. This change in gear is, however, not visible in the logbooks, where only a single vessel in 2002-2003, and three vessels in 2004-2007 have recorded the use of twin trawl on a regular basis. Other vessels have sporadic records of twin trawls, from 1-6 per year. This incorrect recording is probably due to the wording of the logbooks, where fishers are asked to note the gear type used as [... shrimp trawl, twin trawl, triple trawl ...]. It seems likely that many fishers will note "shrimp trawl" for any type of shrimp trawl used, be it single, twin or triple. Further errors may be produced by the fact that the logbook data provided by the Norwegian Directorate of Fisheries are given per day, not per haul. Thus, catches from all hauls within one day are summed, and gear will be the gear most frequently used that day.

In the Norwegian fishery for shrimp in this area the minimum mesh is 35 mm. The following restrictions apply: no fishing in waters shallower than 60 m, no fishing on Sundays and holy days, and, in the inner part of Skagerrak, no trawling within the 4 nm border between 20:00 and 05:00. In the North Sea bycatch of market fish is allowed, but the catch may nevertheless not contain more than 10% (by weight) cod and haddock combined. Furthermore, bycatch of >10% monkfish or >2.5% cod are not allowed. In Skagerrak there is a limitation that up to 50% of the catch by weight may consist of other market species. It is allowed to have up to 10% undersized shrimp (<6 cm total length = 15 mm carapace length (CL)) in the catch. Per 10 kg of shrimp it is not allowed to have more than eight undersized specimens of cod, twenty of haddock and three of redfish. Discarding is prohibited in Norwegian waters. Inclined grids for sorting out smaller fish and shrimp are not compulsory south of 62º N, but are often used voluntarily. All vessels with a shrimp permit may also trawl for *Nephrops*. Some larger vessels fish mackerel and herring in addition to shrimp, and half of these also conduct industrial fishery (sandeel, blue whiting, Norway pout).

Two categories of shrimp dominate the market: In 2006 about 45% of the total landings were delivered as boiled, fresh large shrimp (140-150 individuals per kg) for the Norwegian and Swedish market, and 55% of the total as raw (smaller) shrimp for factory processing ashore (mostly 180-250 individuals per kg). The corresponding numbers for 2005 were 41% boiled and 59% raw (Søvik and Hvingel 2006). The export of boiled shrimp to the Swedish market was substantially reduced in 2005 (to app. 1 000 t) after Swedish assertions about dumping, resulting in smaller

export quotas, but also higher prize. In 2006 the fisher got app. 60 NOK/kg for boiled shrimp, and app. 10 NOK/kg for raw shrimp. The price for boiled shrimp has increased compared with 2005 (52 NOK/kg) (Søvik and Hvingel 2006).

Some high grading and discarding is assumed to take place. Especially shrimp <15 mm CL are probably all discarded and may account for 5-10% of the catches.

The present paper updates available information derived from landings statistics, logbooks and catch sampling from the Norwegian trawl fishery for shrimp in Skagerrak and the Norwegian Deep (Divs. IIIa and IVa east).

Materials and Methods

Landings statistics and logbook data were provided by the Norwegian Directorate of Fisheries. For 2007 landings were given for August inclusive, while log books were given for May inclusive.

The landings are given per Norwegian statistical areas, where area 9 corresponds to ICES Div. IIIa, area 8 and 28 correspond to Div. IVa east, area 42 to Div. IVa west, and area 41 to Div. IVb. Thus, landings from the Fladen Ground can be identified in the data, while landings from area 41 (Div. IVb) are more ambiguous. Landings from the northern part belong to the Norwegian Deep/Skagerrak stock, while landings from the southern part do not and are most likely bycatch. In this document, landings from Div. IVb are therefore not included in numbers for Divs. IIIa or IVa east, only in figures for Subarea IV. LPUE and effort are calculated only for Divs. IIIa and IVa east.

Landings consist of a fraction of larger shrimp that are boiled on board and a remaining portion of smaller shrimp landed fresh (see above). Official landings give landed weight as a mixture of raw and boiled shrimp, but upon request the Norwegian Directorate of Fisheries provided us with landing statistics for the years 2000-2005, where these can be separated. To obtain fresh weight, the fraction of the landings consisting of boiled shrimp, must be corrected using a conversion factor of 1.13. As we have not obtained the 2006 data yet, uncorrected landings have been used in all calculations.

Fleet composition was derived from the landings statistics. Logbook data wre analysed to show the spatial and temporal distribution of the fishery. Due to the incomplete nature of the Norwegian logbooks, total fishing effort was estimated by dividing nominal landings (not corrected for boiling) by LPUE (landings per unit effort) calculated from the logbooks. We decided to use the combined LPUE from both single and twin trawl to estimate total effort as the nominal landings, which are divided by LPUE to estimate effort, derive from the use of both types of trawl. Calculations of LPUE and total effort in last year's report were based on only single trawl data. Thus, figures for the years 2000-2006 have been updated in tables and figures in this SCR.

In order to include gear use in the calculation of standardised LPUE-indices, logbook data were corrected regarding the incorrect recording of single and twin trawl. In 2007 interviews were made with ship owners identified from the logbooks for the years 2004-2007, and the international ship base www.ship-info.com. The following questions were asked:

1) Do you use twin trawl?
2) If yes, when did you start using twin trawl?
3) If yes, how often do you use twin trawl when fishing for shrimp?

Using the results from these interviews, the logbook data for 2000-2007 were corrected in the following way:

1) All recordings of shrimp catches from gear other than single and twin shrimp trawls were deleted (possible bycatch).
2) For all vessels, for which owners informed twin trawl was not in use, any twin trawl recordings were corrected to single trawl (rare recordings of twin trawl were assumed to be incorrect).
3) All recordings from 8 vessels, for which we could not get secure information on gear use, were deleted (10% of all recordings).

4) All recordings from 4 vessels, for which owners informed of use of both single and twin trawls, were deleted (since it was impossible to know when which gear was used) (8.5% of all recordings). One vessel owner informed that they did record twin trawl when using this gear, thus these data were kept.
5) For all vessels, for which owners informed of 100% use of twin trawl, any single trawl recordings were corrected to twin trawl from the starting year inclusive. The starting year of twin trawl use was not always precisely given by ship owners, and then owners' information was compared with the logbook data (vessel specific annual mean LPUE).

Data from the corrected logbooks were used in multiplicative models in order to calculate standardised LPUE indices (2000-2007), thereby removing effects of monthly variations in fishing pattern, geographical variation (Divs. IIIa or IVa east), gear use (single or twin trawl), and changes in the composition of the fleet (e.g., Hvingel et al. 2000, Hvingel and Aschan 2006). The SAS statistical software was used in the calculations. The multiplicative model was represented in logarithmic form:

$$\ln(LPUE_{hijkl}) = \ln(LPUE) + \ln(V_h) + \ln(A_i) + \ln(M_j) + \ln(Y_k) + \ln(G_l) + e_{hijkl}$$

where $LPUE_{hijkl}$ is the mean LPUE for vessel h, fishing in area i in month j and year k, using gear l; ln($LPUE$) is the overall mean; V_h is the effect of the hth vessel; A_i is the effect of the ith area; M_j is the effect of the jth month; Y_k is the effect of the kth year; G_l is the effect of the lth gear; and e_{hijkl} is the error term assumed to be normally distributed $N(0,\sigma^2/n)$, where n is the number of observations in the cell. The standardised LPUE indices are the antilog of the year coefficients. A standardised effort series for 2000-2007 was derived by dividing the nominal landings by the standardised LPUE indices.

Until 2001 discards were estimated by assuming that all shrimp <15 mm CL were discarded. Length distributions of unprocessed catches from research surveys in March, June and October/November were used, whilst assuming that the amount of the 1-group was the same in the research trawl and the commercial trawl. For 2002-2006 discards have been estimated by applying the mean discard percentage (discard as percentage of total landings) for the years 1985-2001 to the nominal landings. From 2007 and onwards discards will be estimated by comparing length distributions from unprocessed commercial catches (sampling initiated in 2005) and sorted landings (sampling initiated in 2007).

Samples (app. 1.5 kg, 250-400 specimens) for resolving the size, age and stage distribution of the 2006 catches were obtained from five Norwegian shrimp fishers (28 samples) and from Coast Guard inspection of Norwegian, Danish, and Swedish shrimp trawlers (24 samples) (Fig. 3). A single sample from Div. IVb was analyzed together with the IIIa samples. Samples were taken from the trawl before sorting. The ones collected by fishermen and the Coast Guard "Lafjord" were sorted to stage by sexual characteristics and measured to the nearest mm below by staff at the Norwegian Institute of Marine Research. Samples collected by the Coast Guard "Eigun" were measured by Coast Guard staff, however, they do not stage determine the shrimp. The length distributions were split into age groups by modal analysis by the method of Bhattacharya (1967) (software: FISAT).

Results

Landings

Total Norwegian landings from Skagerrak and the North Sea (Div. IIIa and Subarea IV) increased from 2 000 t in 1970 to around 8 300 t in 1987 (Fig. 4a, Table 2). In the following years landings fluctuated around 7 500 t with a maximum in 1998 of 9 611 t. From 2000 to 2004 overall landings increased continuously from about 6 000 t to 9 000 t, but have decreased again in the last two years. Correcting for boiling implies that 300-550 t should be added to the nominal landings for the years 2000-2005 (Table 2).

Since 2002 landings have been equally divided between Skagerrak (Div. IIIa) and the Norwegian Deep (Div. IVa east), but this pattern changed in 2006 with landings from Skagerrak being 70% higher than the ones from the Norwegian Deep. In Skagerrak, the Norwegian landings peaked in 1998 at about 6 500 t, decreased to 3 000 t in 2001, and have since increased. A total of 5 177 t were landed from Skagerrak in 2006. In the Norwegian Deep landings fluctuated around 3 000 t in the 1990s, increased to around 4 300 t in 2004, followed by a small drop in 2005, and a further drop in 2006 to 3 037 t (Fig. 4a, Table 2). Comparisons between 2005, 2006, and 2007 show that

the trend of respectively increasing and decreasing landings in Skagerrak and the Norwegian Deep continues in 2007 (accumulated landings January-August for 2005, 2006, 2007: Skagerrak: 2 914, 3 393, 4 030 t; Norwegian Deep: 3 416, 2 443, 1 804 t) (Fig. 5).

In Skagerrak most shrimp are landed in spring and late summer/autumn, while landings are highest in late winter to late summer in the Norwegian Deep. Lower landings during winter are probably due to weather conditions (Fig. 5).

During the ten last years the Norwegian quota has only been overfished twice (1997 and 2004). Because of the arrangement of evenly allocating the quota to three periods in order to supply the market throughout the year, and because of often bad weather in late autumn and winter rendering fishing difficult, the whole Norwegian quota is rarely fished. In 2006 92% of the quota was landed: 8 214 t from a quota of 8 961 t. In 2007 the Norwegian quota has increased to 9 331 t (3 916 and 5 415 t in respectively the North Sea and Skagerrak).

Use of single and twin trawl

The logbooks for 2004-2007 contain data on 41 vessels. We managed to get in touch with 37 ship owners, and out of these 11 said they use twin trawl. One vessel started fishing with twin trawl in 2001, one in 2002, three in 2003, one in 2004, two in 2005, and two in 2006. One ship owner did not inform about starting year. The use of twin trawl is not correlated with size of the vessel (Fig. 6). Five vessels use twin trawl seasonally or occasionally, while six vessels use twin trawl all the time. For these six vessels the mean annual LPUE from twin trawl use is 28-77% higher than the corresponding mean LPUE from single trawl use (yearly comparisons) (Fig. 7).

Effort

In 2006, as in 2005, most of the recorded effort was allocated to waters off Egersund and Lindesnes (Fig. 8). The number of trawling hours off Kragerø decreased from 2005 to 2006. However, as effort recorded in the logbooks, only make up a minor portion of the actual effort, the true fishing pattern is different, with more effort allocated to Div. IIIa. The estimated number of fishing hours in 2006 was in fact higher in Div. IIIa compared with Div. IVa east (77 vs. 71 Khours) (Table 2). The estimated effort in the Norwegian Deep decreased from 2005 to 2006 (88 vs. 71 Khours), but remained at the same level in Skagerrak (78 vs. 77 Khours).

The fishery in 2006 took place in all months (Fig. 9), but was most intense in March, and from May to August. Fishing effort thereafter declined throughout autumn and winter. Maximum and minimum effort was recorded in respectively March and December. The seasonal variations in the shrimp fishery in 2006 is similar to the pattern in 2005 (Fig. 9), however, the number of estimated trawling hours in November and December was halved from 2005 (12 and 9 Khours) to 2006 (6 and 4 Khours).

After a relatively stable 1996-2001 period with total fishing efforts of around 200 Khours/year, effort declined to 163 Khours in 2003, stabilized, and then declined further to 154 Khours in 2006, mainly due to a reduction of effort spent in Div. IIIa by 46% over that whole period (Table 2, Fig. 4c). Since 2002 about 75-85 Khours have been spent in each of the two areas. Standardised effort indices (Table 3) show the same trend as the unstandardised figures.

Standardised landings per unit effort (LPUE)

Overall LPUE increased from 33 kg/hour in 2000 to 55 kg/hour in 2004 (Fig. 4b, Table 2), dropped in 2005, and then increased again in 2006 to 54 kg/hour. The LPUE-values in Skagerrak and the Norwegian Deep followed each other closely for the years 1999-2004. However, in the last two years the development of LPUE in the two areas has differed strongly. In 2005 the LPUE dropped in the Norwegian Deep, while it remained at the same level in Skagerrak. In 2006 the decrease continued in the Norwegian Deep, while the LPUE in Skagerrak increased to a historic maximum.

Standardised LPUE values have been calculated for 2000-2007 (Fig. 10), and are seen to follow the same trend as the raw data. The fleet structure and fishery pattern have probably been stable during this relatively short time period, which explains the little difference between standardised and unstandardised values. The LPUE-index

increases in both areas in 2007, especially in Skagerrak. However, it should be kept in mind that these data are preliminary.

Due to the incomplete logbooks, it can be questioned whether the LPUE data are representative of the fishery, and whether they can be used as indices of stock biomass. However, the respectively increasing and decreasing LPUE's in Skagerrak and the Norwegian Deep are accompanied by increasing and decreasing landings in the two areas, indicating that the LPUE's do reflect stock abundance. The different development in the shrimp stock in the two areas is also supported by the Norwegian survey in February 2007 (Søvik and Thangstad 2007).

Discards

Discard of shrimp may take place in two ways: 1) At sea, as a result of "high-grading" (discard of medium, less valuable shrimp to improve the economic return of quotas), and 2) at shore, as a "quality discard", since the processing plants do not accept shrimp smaller than app. 15 mm CL.

Estimates of discards due to high-grading was estimated for 1996 and 1997 based on separate quarterly length distributions for the categories large and medium sized and the selection ogive for the sieved ones (ICES 1999). However, already next year the working group considered these estimates too inaccurate to be included in assessments (ICES 2000). Later Norwegian estimates of high grading are not available. Estimates of discards at shore varied from 2 to 16% of the catches, i.e., from 200 to 1000 t annually (Table 2).

Catch composition

The length frequency distributions from respectively Divs. IIIa and IVa east from quarters 1-2 indicate large differences in recruitment (1-group) between the two areas (Figs. 11 and 12, Table 4). In quarter 3-4 the 1-group dominated the catches in Skagerrak, while the 3-group dominates the catches in the Norwegian Deep. There is, however, a deficiency of stage determined data from the Norwegian Deep. The difference in recruitment between the two areas is supported by data from the Norwegian shrimp survey in February 2007 (Søvik and Thangstad 2007).

The almost complete lack of 1-year old shrimp in the 2006 catches in the Norwegian Deep are obvious when comparing the length distributions from quarter 1-2 with the corresponding length distributions from 2005 (Fig. 13). In Skagerrak the 2004 year class seems to be stronger than the 2005 year class (Fig. 14). However, as the y-axis shows only percentages, the relative sizes of the two 1-groups cannot be judged. Survey data from February 2007 show that the 2005 year class is a very strong one as well.

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Table 1. The Norwegian fleet participating in the fishery for shrimp (*Pandalus borealis*) in ICES Div. IIIa and Subarea IV (Skagerrak and the North Sea) in 2006: Number of vessels and total landings (t) per length group; and total landings per vessel in each length group (mean, median, and standard deviation).

Length group	# of vessels	Landings (t)	Landings per vessel (t)		
			Mean	Median	Stdev
< 10 m	32	77	2.4	0.7	4.8
10-10.99 m	101	1,383	13.7	5.7	17.3
11-14.99 m	68	2,229	32.8	18.9	35.4
15-20.99 m	40	2,086	52.1	45.9	47.3
21-27.99 m	26	1,729	66.5	57.8	58.5
≥28 m	10	639	63.9	64.4	67.9
unknown	19	71	3.8	1.7	4.5
Total	296	8214			

Table 2. Norwegian nominal shrimp (*Pandalus borealis*) landings from ICES Div. IIIa and Subarea IV; separate landings from Divs. IIIa and IVa east; increase in landings due to correction for boiling; Total Allowable Catch (TAC); estimated discard for IIIa and IV (discard at sea are not included); landings per unit effort (LPUE) and estimated number of trawling hours (effort) of the Norwegian shrimp fishery in Divs. IIIa and IVa east 1970-2007. Landings, TAC and discards are in tons (t), LPUE is kg per hour trawled, and effort is in thousand hours.

	Landings (t)				TAC (t)	Disc. (t)	LPUE (kg/hour)			Effort (Khours)		
Year	IIIa	IVaE	Total	Corr.	Total	Total	IIIa	IVaE	Total	IIIa	IVaE	Total
1970	982	747	2089									
1971	1392	1094	2657									
1972	1123	1354	2339									
1973	1415	918	2346									
1974	1186	623	1953									
1975	1463	876	2067									
1976	2541	807	3592									
1977	2167	837	3127									
1978	1841	599	2533									
1979	2489	551	3083									
1980	3498	1064	4638									
1981	3753	1430	5188									
1982	3877	1165	5422									
1983	3722	1639	5379									
1984	3509	1274	4783									
1985	4772	1874	6557			460						
1986	4811	1679	6492			338			36			179
1987	5198	3145	8343			634			36			230
1988	3047	4614	7661			645			31			251
1989	3156	3255	6574			920			24			266
1990	3006	3102	6152			990			27			230
1991	3441	2678	6156			376			30			205
1992	4257	2879	7202			414			35			202
1993	4089	3282	7538			695			31			238
1994	4388	2425	6814			157			31			218
1995	5181	2914	8060		8775	212			32			256
1996	5143	2735	7915		8160	253	43	31	37	119	89	213
1997	5460	3105	8572		8160	821	45	39	40	122	80	212
1998	6519	3087	9611		10505	279	45	40	44	144	78	219
1999	3987	2752	6748		10505	486	32	29	31	125	93	219
2000	3556	2562	6116	326	7110	521	33	33	33	108	78	185
2001	2959	3933	6914	374	8140	565	33	34	33	90	117	206
2002	3709	3612	7331	382	8040	*534	43	44	44	86	83	168
2003	3736	3986	7731	455	8040	*563	48	47	47	78	84	163
2004	4638	4360	9002	546	8530	*656	58	53	55	80	82	164
2005	4419	4087	8507	452	8530	*620	57	46	50	78	88	171
2006	5177	3037	8214		8961	*599	67	43	54	77	71	154
2007	4174	1852	6026		9331							

Data from the Norwegian Directorate of Fisheries.

Data from 2007 are preliminary.

*Based on mean discard percentage 1985-2001.

"Total" refers to the sum of Divs. IIIa and IVa east, except for "total landings" and discards, which refer to Div. IIIa and all of Subarea IV.

Table 3. Standardised LPUE (landings per unit effort) and effort indices from the Norwegian shrimp (*Pandalus borealis*) fishery in Divs. IIIa and IVa east, 2000-2007. The 2007 effort indices are calculated using estimated landings (based on data until August).

	Stand. LPUE (index)			Stand. effort (index)		
Year	IIIa	IVaE	Total	IIIa	IVaE	Total
2000	0.28	0.82	0.48	2.42	1.34	1.68
2001	0.28	0.87	0.50	1.99	1.96	1.82
2002	0.39	1.02	0.62	1.84	1.52	1.57
2003	0.40	1.04	0.64	1.79	1.66	1.61
2004	0.48	1.14	0.72	1.83	1.65	1.66
2005	0.47	1.02	0.67	1.80	1.73	1.69
2006	0.53	0.93	0.68	1.86	1.41	1.61
2007	1.00	1.00	1.00	1.00	1.00	1.00

2007 data are preliminary

Table 4. Mean carapace length (CL) with standard deviation (SD), and proportions of age classes 1, 2, and 3+ from the length frequency distributions of the 2006 catch samples.

		Skagerrak			Norwegian Deep		
quarter	age	CL (mm)	SD	proportions	CL (mm)	SD	proportions
1	1	10.67	1.35	0.11	15.62	1.04	0.03
	2	16.65	0.98	0.43	20.33	1.62	0.59
	3+	20.3	1.67	0.46	24.29	1.32	0.38
2	1	13.26	1.48	0.39	16.72	1.53	0.21
	2	17.87	1.23	0.41	19.52	1.12	0.34
	3+	21.17	1.37	0.20	22.4	1.09	0.45
3	1	15.06	1.47	0.61	15.01	1.76	0.16
	2	20.14	1.72	0.31	18.37	1.24	0.30
	3+	23.05	0.71	0.08	21.93	1.98	0.54
4	1	10.51	1.01	0.01	9.5	1.2	0.01
	2	15.88	1.5	0.60	17.64	1.87	0.41
	3+	20.99	1.58	0.38	21.8	1.33	0.58

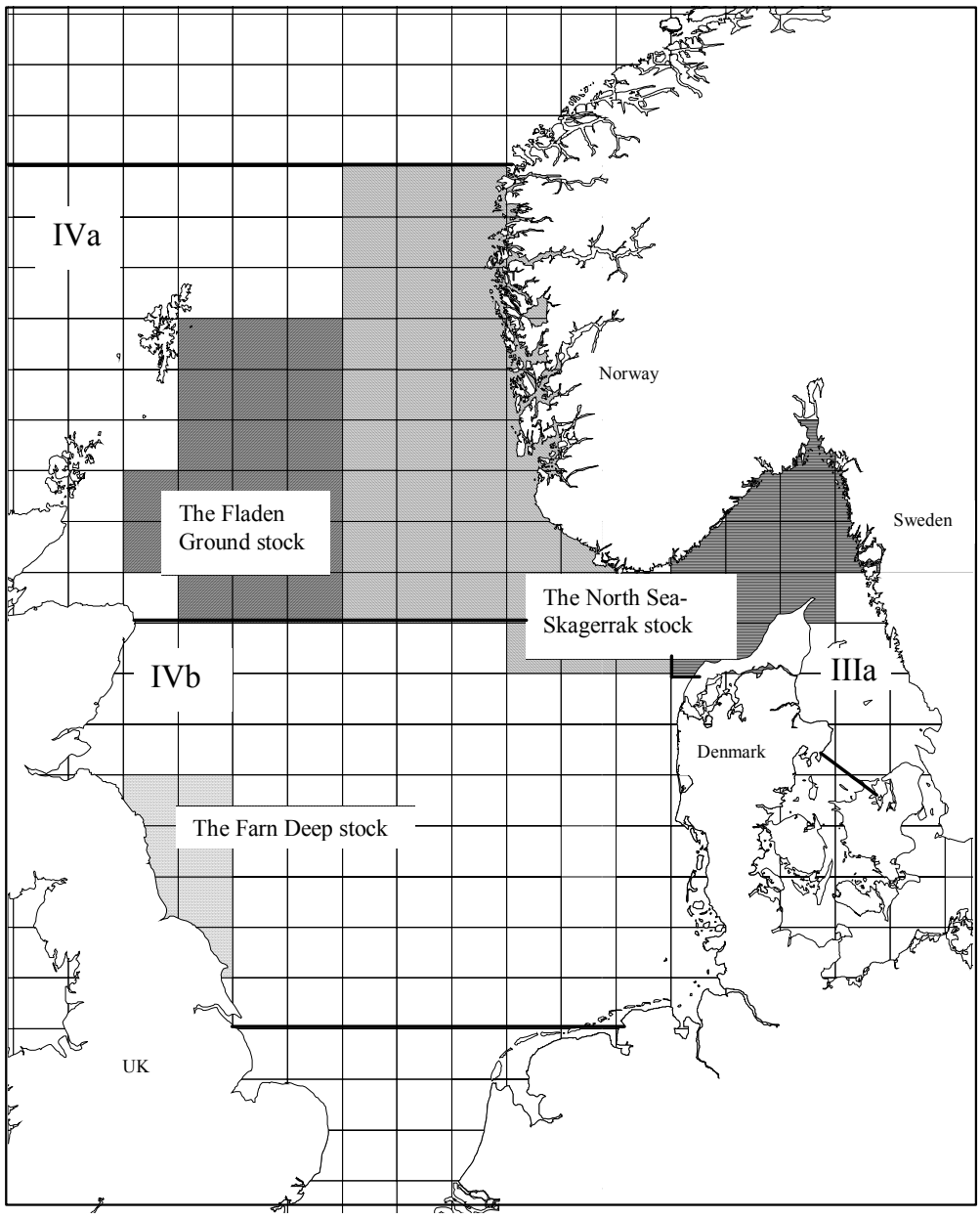

Fig. 1. Distribution of shrimp (*Pandalus borealis*) in ICES Div. IIIa and Subarea IV (Skagerrak and the North Sea), and the defined assessment units. Grid is standard "ICES squares": 0.5º lat. by 1º long. (based on Munch-Petersen et al. 2006).

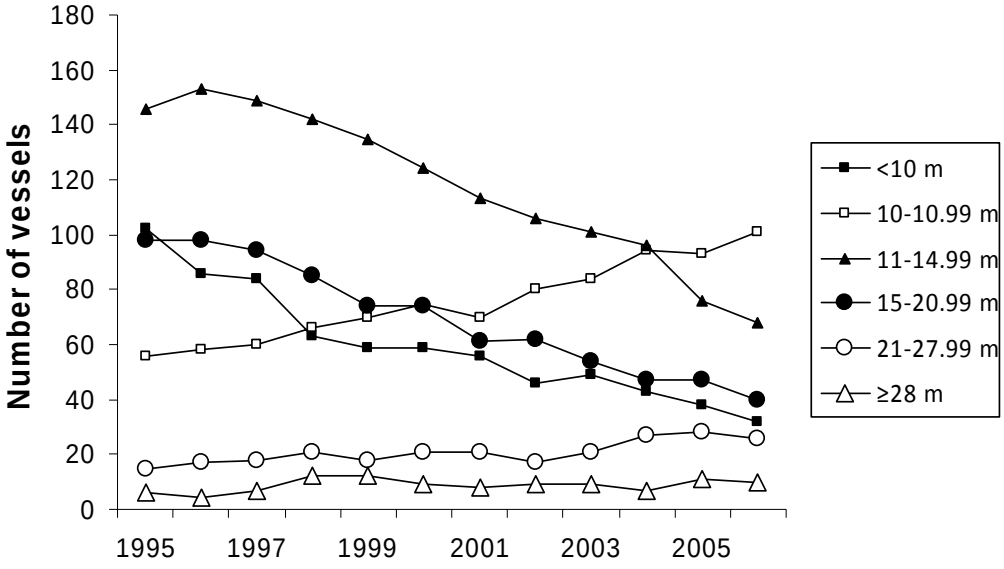

Fig. 2. The Norwegian fleet involved in the fishery for shrimp (*Pandalus borealis*) in ICES Div. IIIa and Subarea IV (Skagerrak and the North Sea) 1995-2006: number of vessels per length group (m). Data from the Norwegian Directorate of Fisheries.

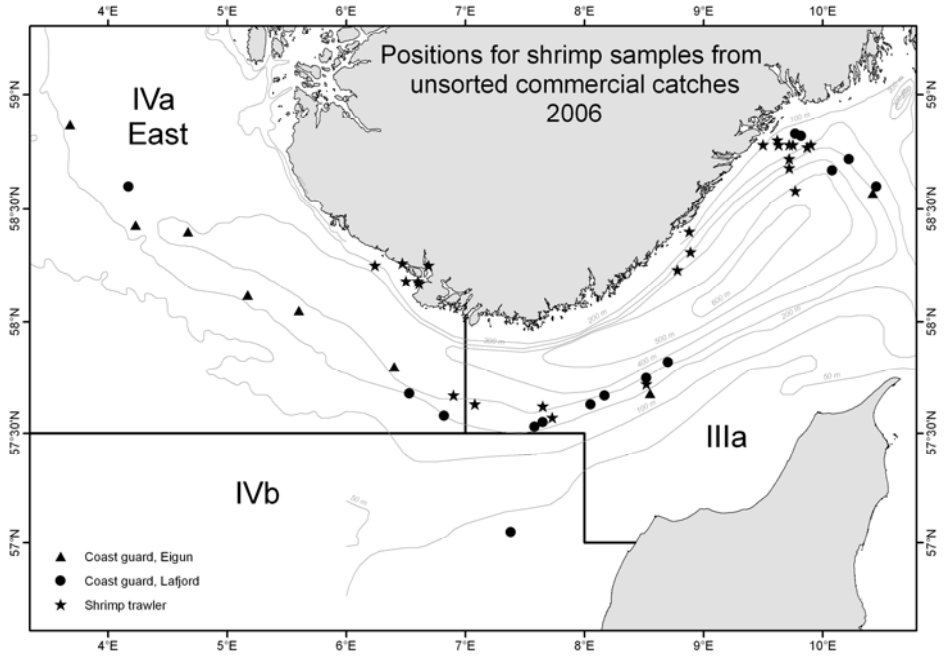

Fig. 3. Positions of shrimp (*Pandalus borealis*) samples from unsorted commercial catches in 2006 in Skagerrak and the North Sea (ICES Div. IIIa and Subarea IV). Samples were taken by Norwegian fishers, and the Norwegian Coast Guard inspecting Norwegian, Danish and Swedish shrimp trawlers.

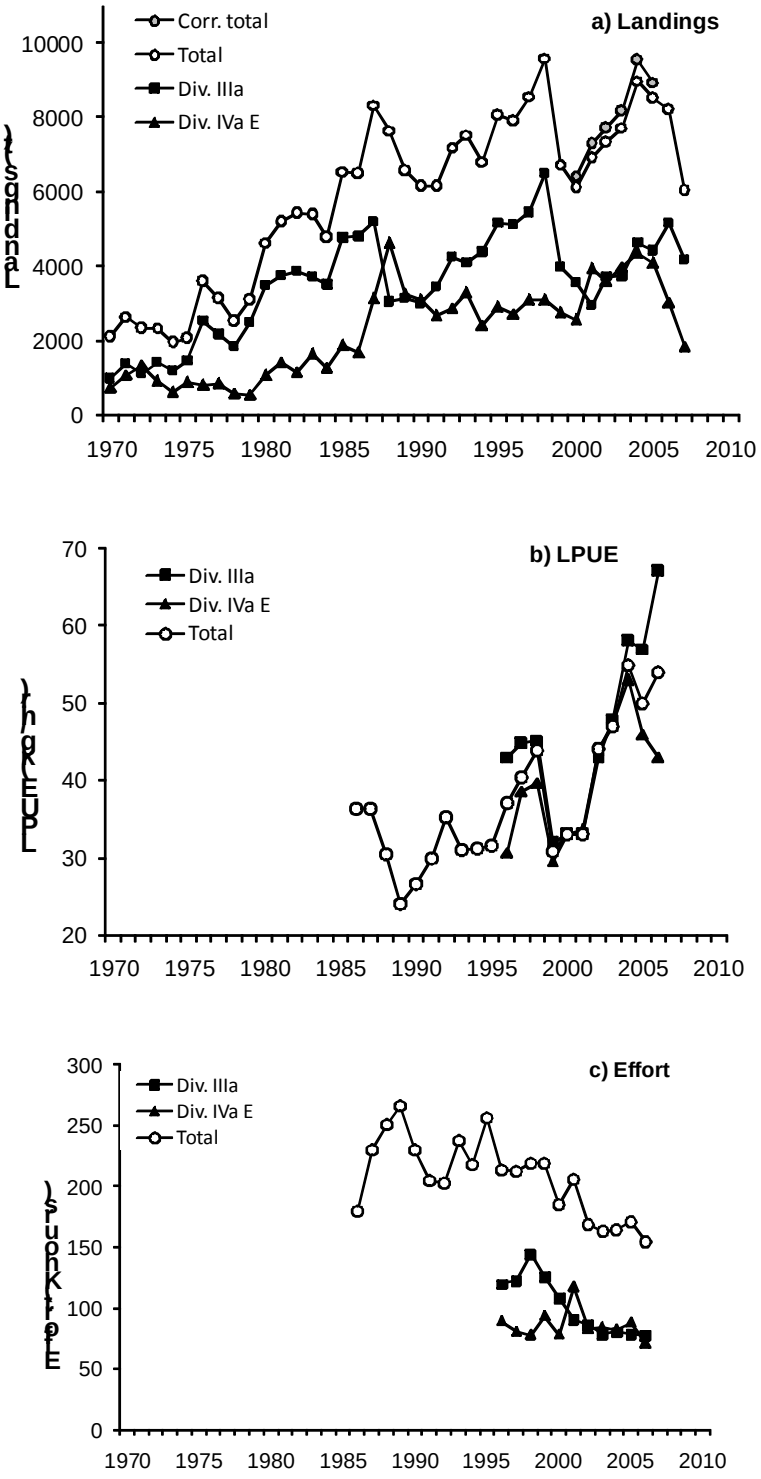

Fig. 4. Landings **a**), estimated total effort **b**), and landings per unit effort (LPUE) **c**) from the Norwegian shrimp (*Pandalus borealis*) fishery in ICES Divs. IIIa and IVa east for all years for which data are available. In a) "total" includes Div. IIIa and all of Subarea IV, and "Corr. total" are corrected landings due to boiling. Data from 2007 are preliminary.

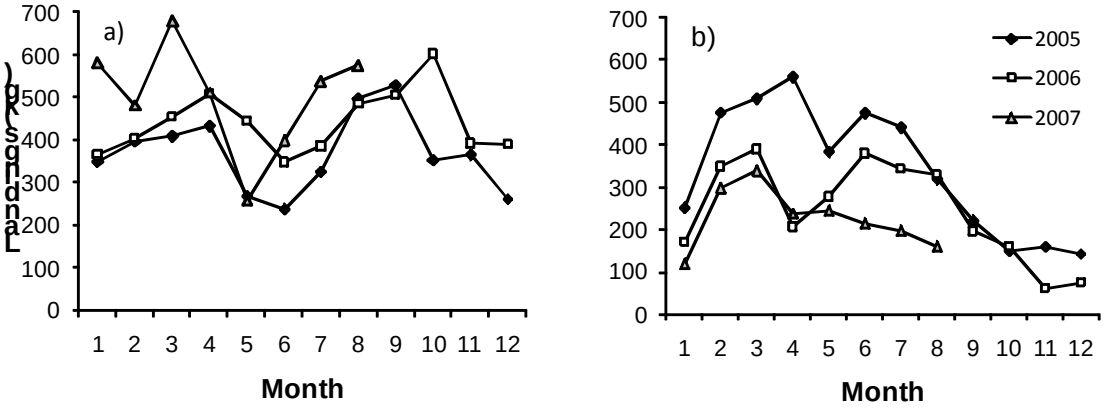

Fig. 5. Monthly landings of shrimp (*Pandalus borealis*) for 2005, 2006, and 2007 (January-August) for a) ICES Div. IIIa (Skagerrak), and b) ICES Div. IVa east (Norwegian Deep). Data from the Norwegian Directorate of Fisheries. 2007 data are preliminary.

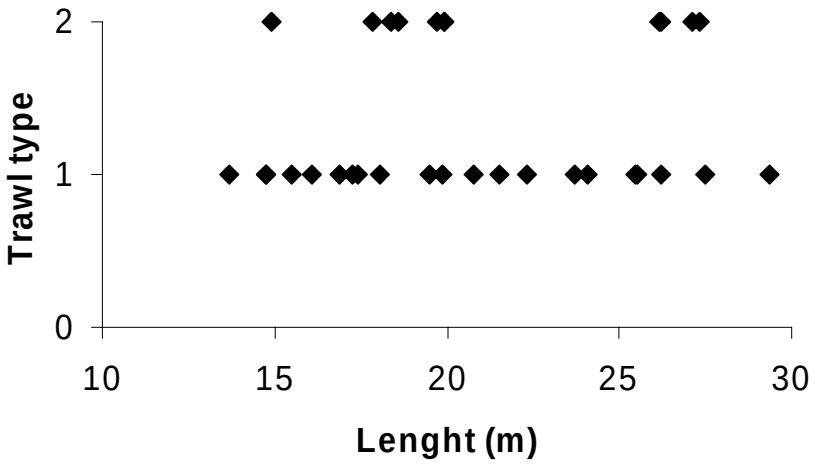

Fig. 6. Gear use by vessel length (m). Data from interviews with vessel owners involved in the fishery for shrimp (*Pandalus borealis*) in ICES Divs. IIIa and IVa east (Skagerrak and the Norwegian Deep), 2000-2007. Single trawl=1, twin trawl=2.

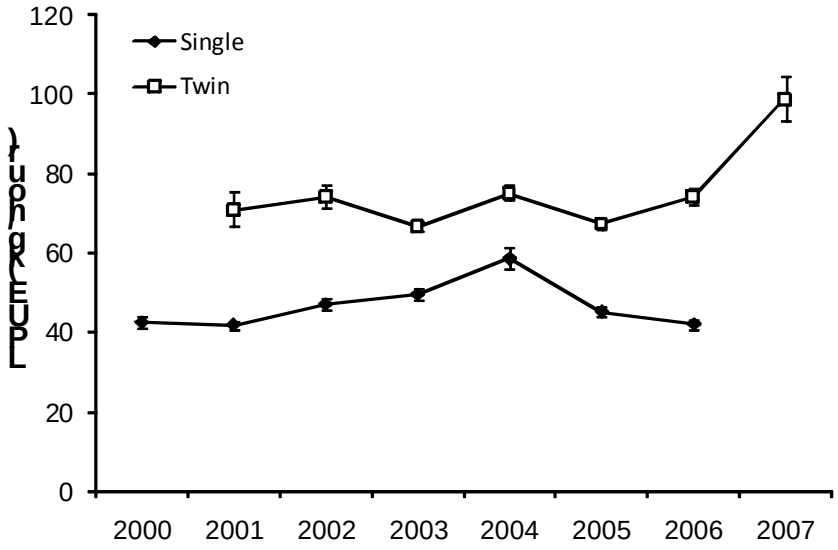

Fig. 7. Unstandardised mean LPUE (with standard error) per gear type and year from six Norwegian shrimp trawlers. All vessels started using twin trawl between 2001 and 2006, and thereafter used it 100 % of the time. Data from interviews with vessel owners, and Norwegian logbooks.

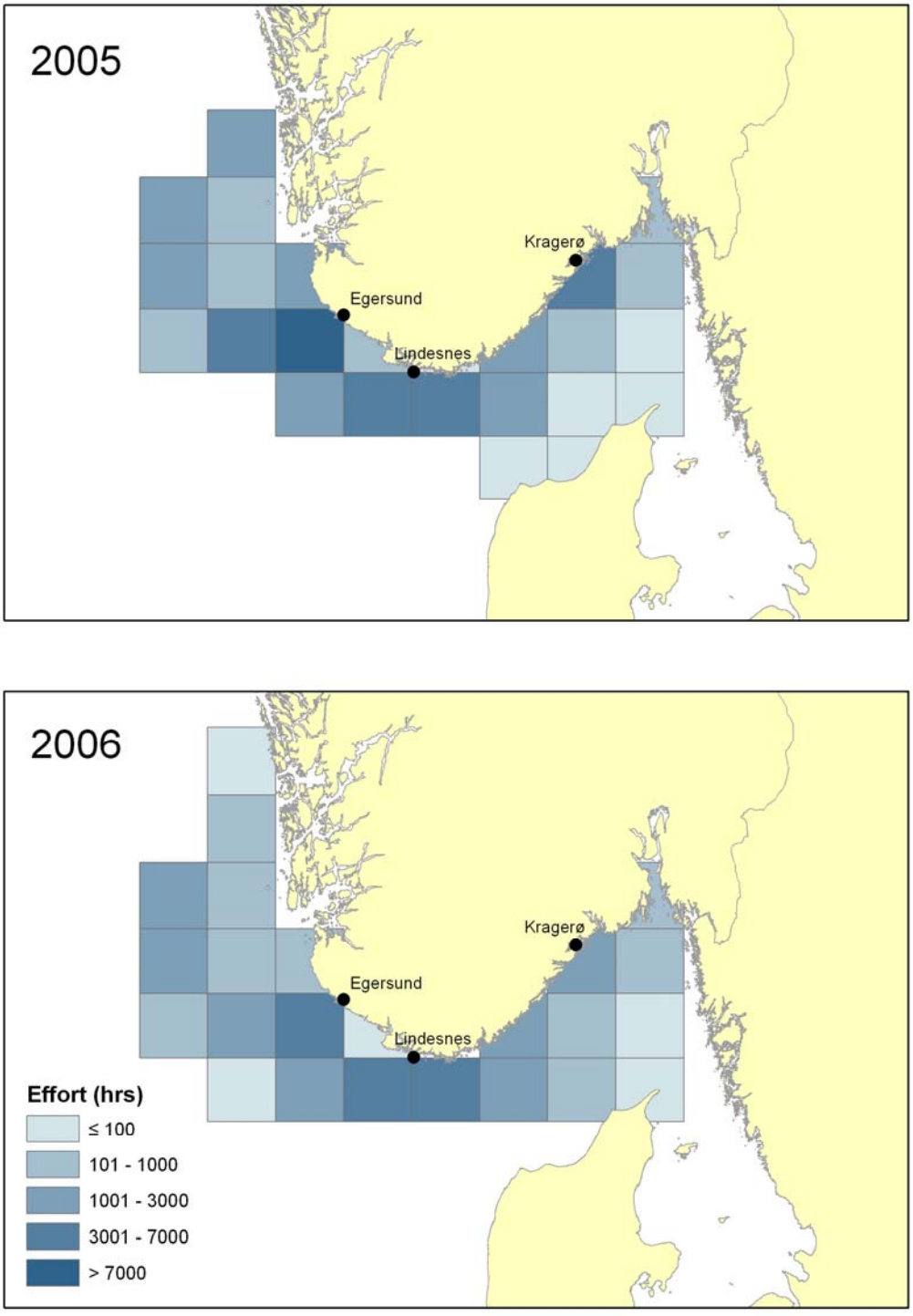

Fig. 8. Geographical distribution of recorded effort (trawling hours) by Norwegian shrimp trawls in 2005 and 2006 in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east) by statistical squares (standard "ICES squares": 0.5º lat. by 1º long.). Fishing by both single and twin trawl is included.

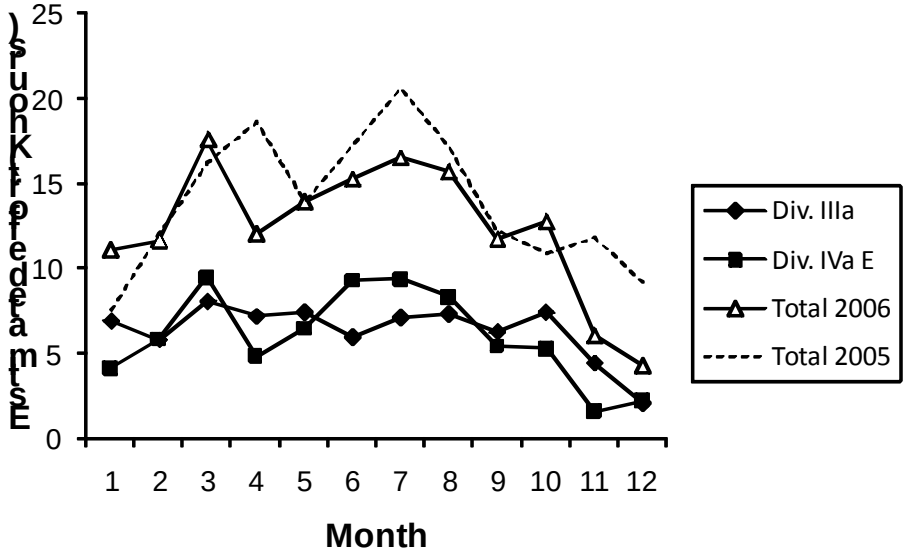

Fig. 9. Monthly distribution of estimated total effort (trawling hours) by Norwegian shrimp trawlers in 2006 in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east).

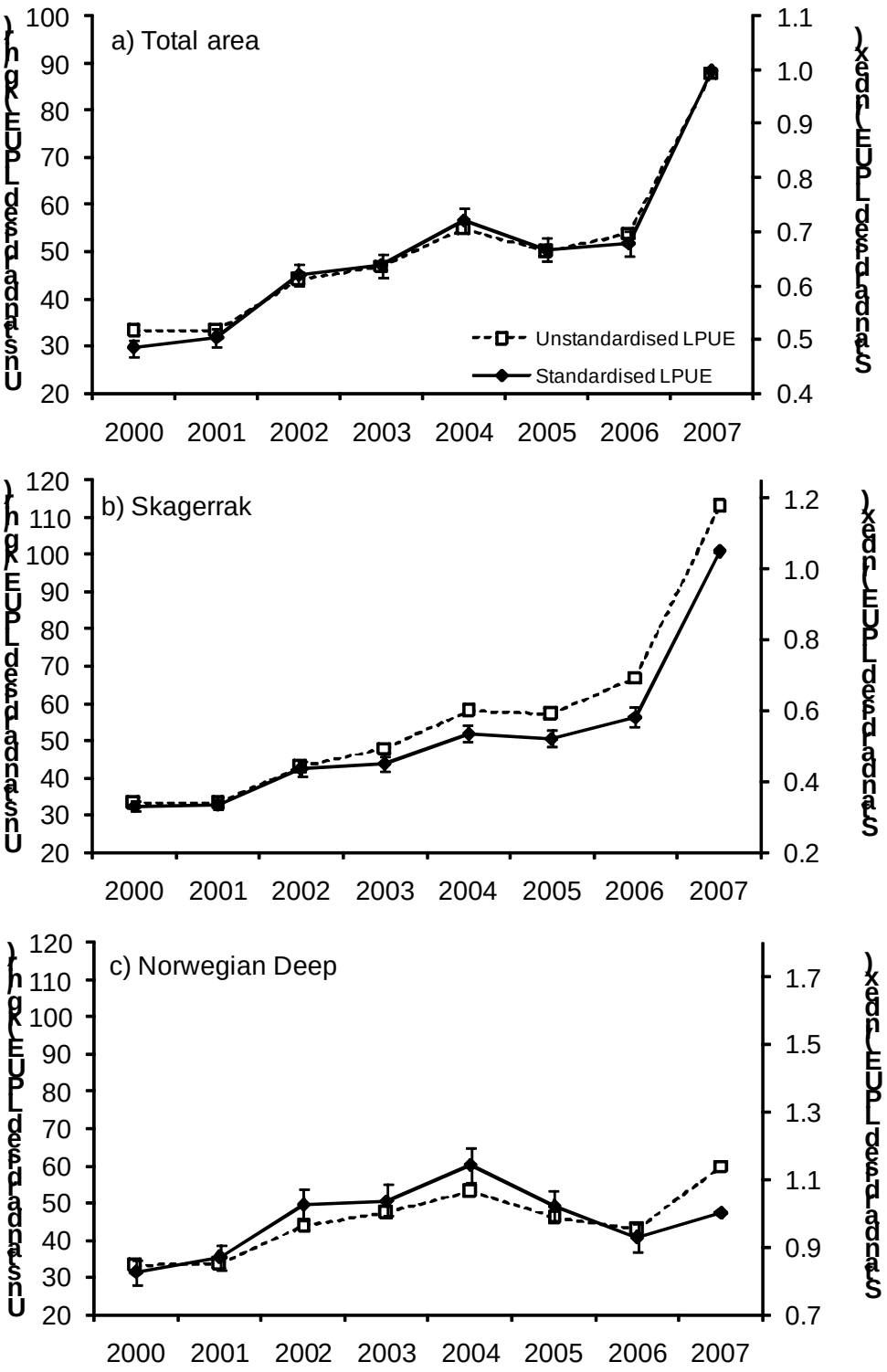

Fig. 10. Standardised LPUE-indices (with standard error), and unstandardised LPUE-values (kg/hour) for 2000-2007 from the Norwegian shrimp (*Pandalus borealis*) fishery in a) both Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east), b) only Skagerrak, and c) only the Norwegian Deep. Data from 2007 are preliminary.

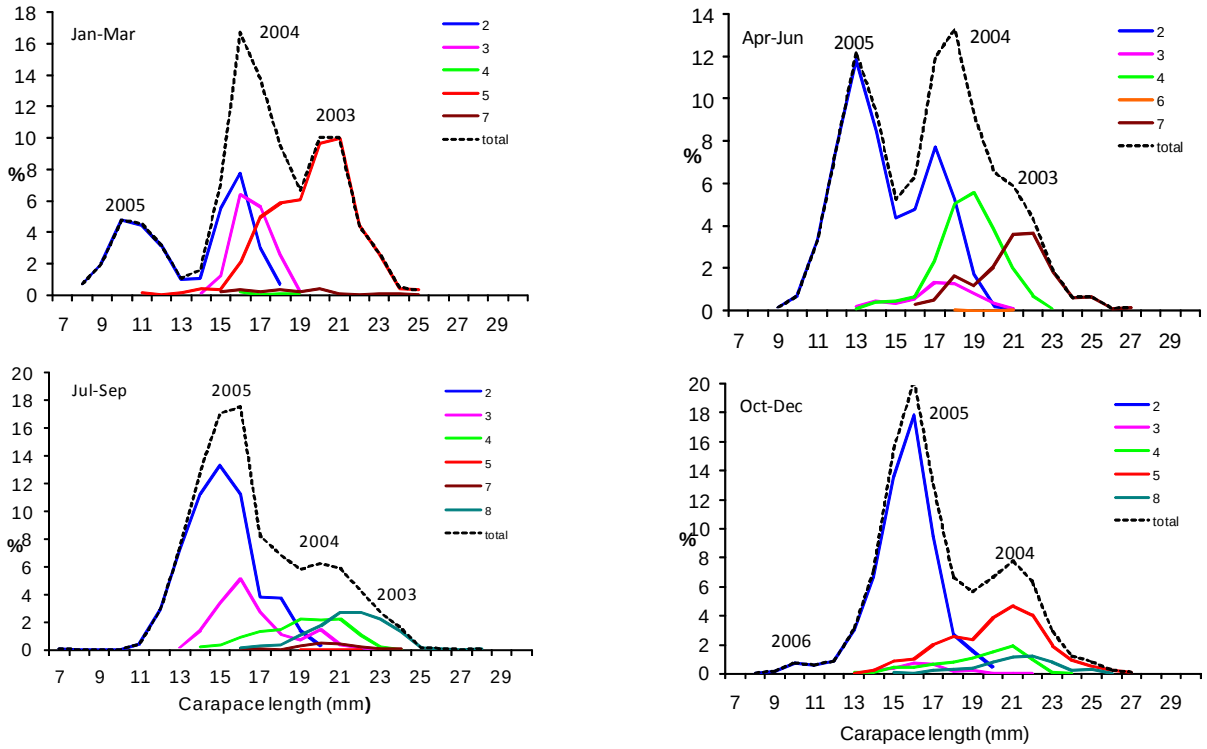

Fig. 11. Stage based length frequency distributions (%) of shrimp (*Pandalus borealis*) from unsorted commercial catches from Div. IIIa (Skagerrak) from quarter 1 (4 samples, n = 1002), quarter 2 (7 samples, n = 1833), quarter 3 (9 samples, n = 1866), and quarter 4 (11 samples, n = 3359). Samples were collected by local fishermen and the Norwegian Coast Guard. Stages: 2 = males; 3 = transitional; 4 = ripe gonads, first time spawner; 5 = berried; 6 = breeding dress; 7 = resting stage; 8 = ripe gonads, second time spawner. Note different scales on the y-axes.

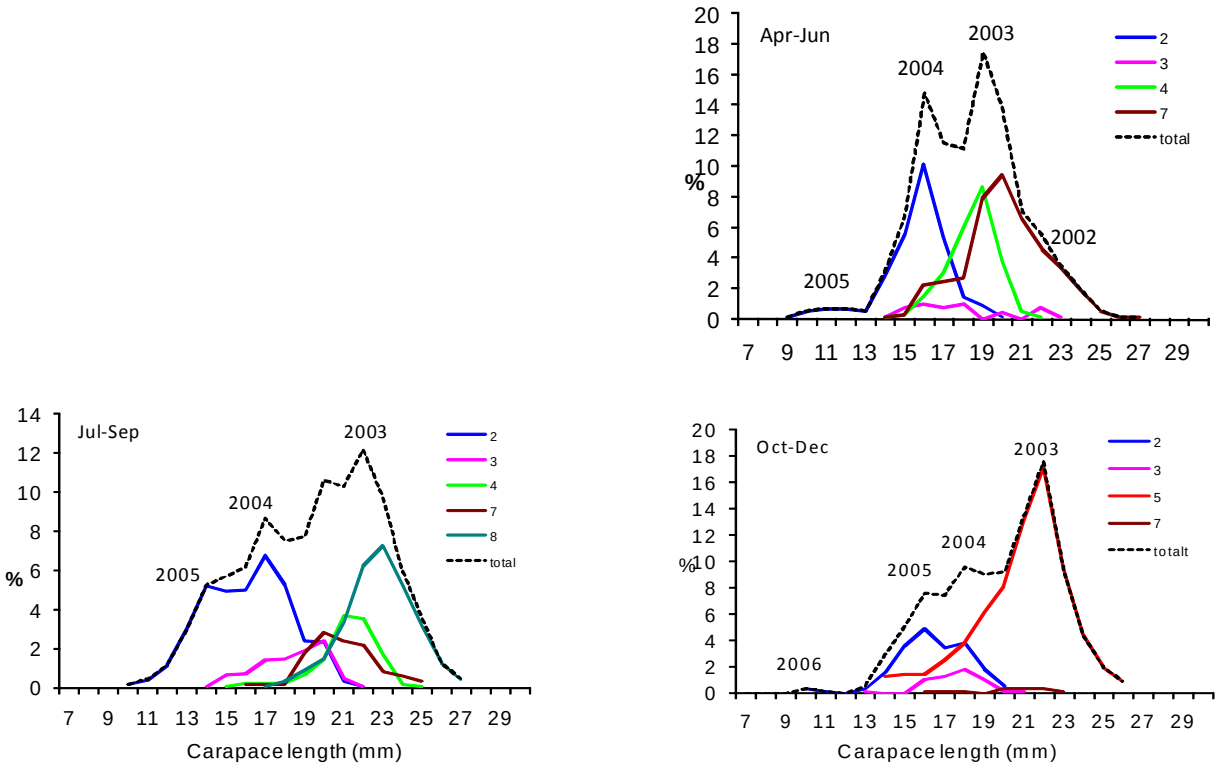

Fig. 12. Stage-based length frequency distributions (%) of shrimp (*Pandalus borealis*) from unsorted commercial catches from Div. IVa east (Norwegian Deep) from quarter 2 (4 samples, n = 770), quarter 3, (4 samples, n = 1196), and quarter 4 (2 samples, n = 552). Samples were collected by one local fisherman and the Norwegian Coast Guard. Stages: 2 = males; 3 = transitional; 4 = ripe gonads, first time spawner; 5 = berried; 6 = breeding dress; 7 = resting stage; 8 = ripe gonads, second time spawner. Note different scales on the y-axes.

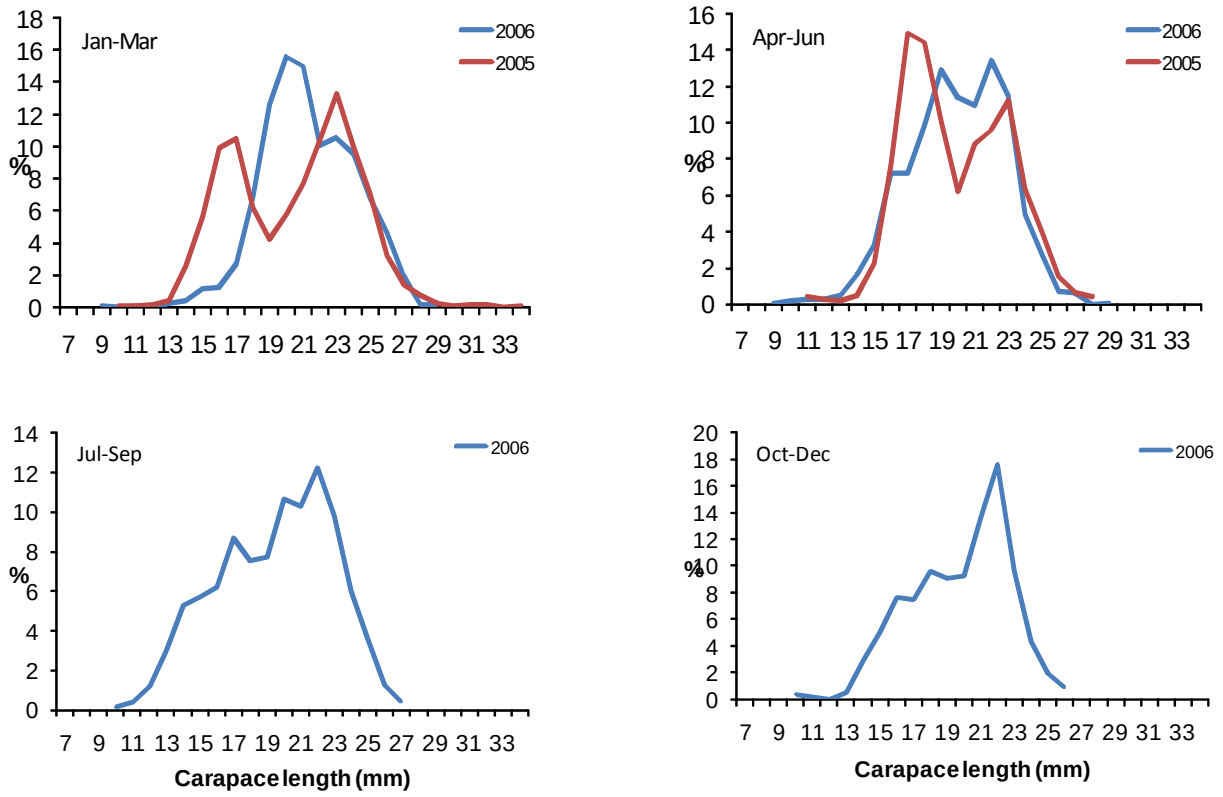

Fig. 13. Length frequency distributions (%) from unsorted commercial catches from Div. IVa east (Norwegian Deep) from 2005 (quarter 1-2 (n = 1541, 914)) and 2006 (quarter 1-4 (n = 1503, 1750, 1196, 552)). Samples were collected by local fishermen and the Norwegian Coast Guard. Note different scales on the y-axes.

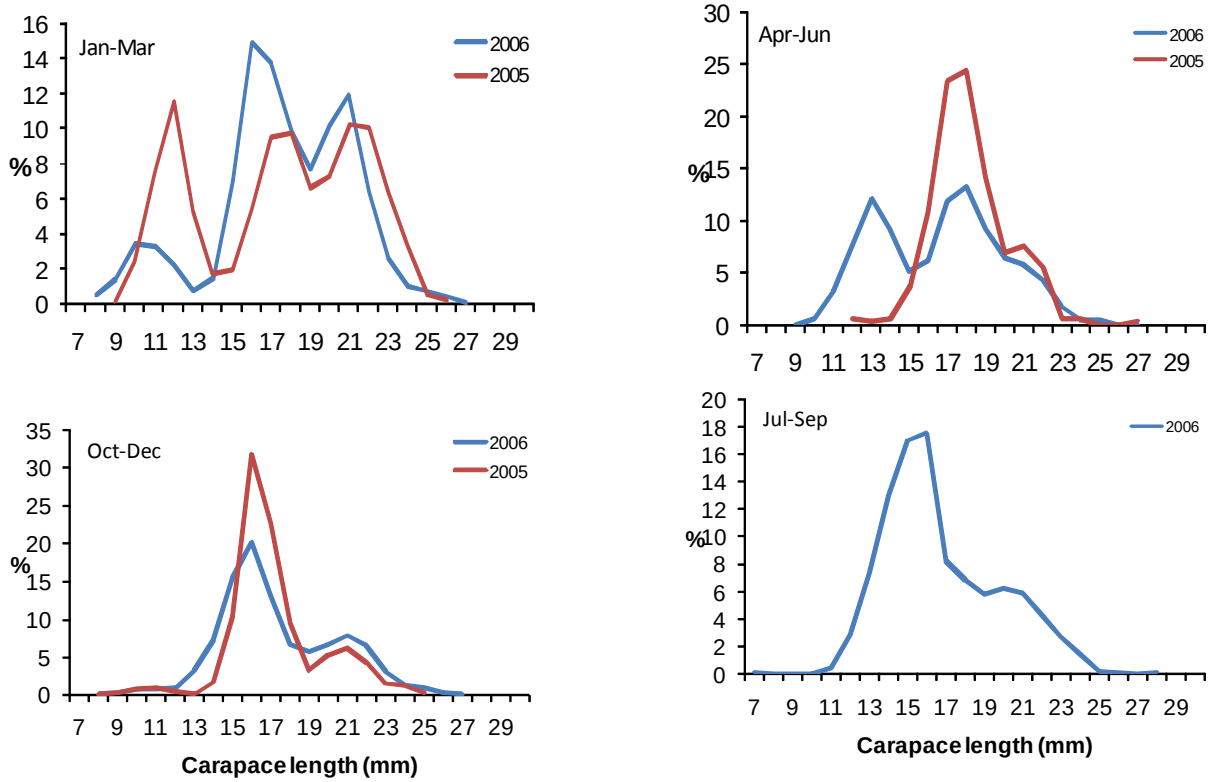

Fig. 14. Length frequency distributions (%) from unsorted commercial catches from Div. IIIa (Skagerrak) from 2005 (quarter 1-2, 4 (n = 1249, 303, 1087)) and 2006 (quarter 1-4 (n = 1398, 1833, 1866, 3359)). Samples were collected by local fishermen and the Norwegian Coast Guard. Note different scales on the y-axes.