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Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (*Pandalus borealis*)
in Skagerrak and the Norwegian Deeps (ICES Divisions IIIa and IVa) in 2004-2005

by

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Abstract

There was no trend in the annual survey biomass estimates from the mid 1990s to 2002 where this series was discontinued. The 2005 mean value of a new biomass index series was lower than that of 2004, but not statistically different.

In both the 2004 and 2005 survey the 2003 year-class seems strong indicating that abundance of large female shrimp in 2006 will be high, as these shrimp grow into age-group 3. However the 2005 abundance estimate of age 1 shrimp was considerably smaller than that of 2004 indicating reduced recruitment of mid-sized shrimp to the fishery in 2006. Overall the average shrimp size in the 2006 fishery is therefore expected to be relatively high.

An index of shrimp predator biomass increased from 58 in 2004 to 115 in 2005 (Table 5) which might suggest a corresponding increase in shrimp mortality.

Introduction

Trawl surveys for northern shrimp in Skagerrak and the Norwegian Deeps (ICES Div. IIIa and IVa) have been conducted annually since 1984 with the objective of assessing the size and demographic composition of the stock and hydrographical conditions in its distributional area.

The survey data consist of: 1.) One series based on a survey conducted in October-November 1984 to 2002 using R/V *Michael Sars*; 2.) A point estimate for 2003, as the survey vessel and trawl previously used was changed; 3.) A start of a potential new series as the survey for both 2004 and 2005 was conducted in May-June with R/V *Håkon Mosby* using the same shrimp trawl.

The survey is a fixed station design with 100 stations evenly distributed over the survey area (Fig. 1)

This paper presents the results of the 2004 and 2005 surveys.

Material and Methods

Survey design

The survey area covers depths of 100 to 500 m in ICES Div. IIIa and IVa east. It is stratified by depth in 3 zones of 100-200 m, 200-300 m and 300-500 m, and area (Fig. 2). The total survey area is hereby divided in 16 strata covering 13128 NM².

Trawling is repeated annually on 100 evenly distributed fixed stations, giving an areal coverage of 1 haul per 1312 NMm². Tow duration was 1 hour until 1989 when it was reduce to ½ hour tows. No compensation for diurnal vertical migrations is made.

In 2004 and 2005 the survey was carried out in May-June with the R/V *Håkon Mosby* (701 GRT) using a Campelen 1800/35 bottom trawl. Mesh size in the cod-end was 22 mm with a 6 mm lining. A fixed trawl geometry is assumed.

CTD casts were made at each station. The data are not analysed.

Stock size indices

The swept area was estimated by applying a wingspread of 11.7 m (Teigsmark and Øynes, 1983) to tow-length. Tow length was time towed multiplied by an average towing speed of 3 knots. The swept area is thus 0.019 NM^2/hour.

The catch in each tow divided by the swept area represents a sample of shrimp density in a stratum. From these samples the mean and standard error of the density in each stratum was calculated and multiplied by the area of the stratum to give an estimate of stratum biomass and abundance. Standard error was calculated as B ∗ 0.985 Cochran (1977) for strata with only one tow. The means and their standard errors for the 16 strata were summed to give the overall values for the survey area.

A biomass index of shrimp predators were constructed as average catch/NM over all hauls of 22 fish species or species' groupings (Table 5).

Biological samples

Samples of 250-300 specimens are taken from each trawl haul, sorted by sexual characteristics, and measured to the nearest mm below (carapace length, cpl, as defined in Allen, 1959; McCrary, 1971). The length- and sex frequency distribution in the samples was weighted by total catch and stratum area to obtain estimates of the overall distribution. The length distribution was then split into age groups by modal analysis using the application MIX (Macdonald and Pitcher, 1979) to produce indices of abundance at age.

The mean length at sex change was estimated by fitting a logistic function to the percentage of females in 1mm length intervals.

Results

Area coverage

Due to weather and time constraints and a number of invalid tows only 58 tows from the 2004 survey and 83 tows from the 2005 survey were available for analyses (Table 1).

Biomass indices

The biomass indices increased in the late 1980s to early 1990s, was stable until the mid-1990s where after it started fluctuating at a slightly higher level (Fig. 3). This series was discontinued in 2002. The 2005 mean value is lower than that of 2004, but not statistically different (Table 2).

Size, age and sex distribution

The mean size of males increased from 15 mm cpl in 2004 to 16 mm cpl in 2006 while the mean size of females remained close to 21 mm cpl (Table 3). Estimated cpl at which 50% of the individuals had changed sex (L_{50}) increased from 18 mm in 2004 to 19 mm in 2005 (Table 3).

The estimated size distribution of 2004 showed a large mode of mainly males at 15 mm cpl (Fig. 4, Table 3) in 2005 which was assigned to age-group 1 in the modal analyses (Table 4). These shrimp may be recognised as large mixed male and female mode at around 18-19 mm cpl in 2005 (age-group 2 in Table 4). This might indicate a high abundance of large female shrimp in 2006 as these shrimp grow into age-group 3.

However the 2005 mode at 15 mm (age 1) is considerably smaller than that of 2004 (Fig. 4). The estimated mean abundance of age 1 shrimp in 2005 is only half of the 2004 estimate indicating reduced recruitment of mid-sized shrimp to the fishery in 2006.

Overall the average shrimp size in the 2006 fishery is therefore expected to be relatively high.

Predator abundance

An index of shrimp predator biomass increased from 58 in 2004 to 115 in 2005 (Table 5)

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Table 1. The Estimated trawlable biomass (Ktons) and abundance (E10) of the Norwegian shrimp survey in the North Sea and Skagerrak 2004 and 2005 (depth interval in meters; stratum area in MN^2; SE is the standard error).

2004

Stratum	Depth	Area	Hauls	Biomass	SE	Abun.	SE
1	100-200	2794	-	-	-	-	-
2	200-300	1819	4	3.59	0.92	568	144
3	100-200	342	-	-	-	-	-
4	200-300	1824	4	2.83	1.09	761	310
5	100-200	1559	1	0	0.00	0	0
6	200-300	1392	7	3.54	0.99	707	197
7	300-500	860	4	1.53	0.25	296	43
8	100-200	206	-	-	-	-	-
9	200-300	431	4	0.69	0.25	179	88
10	300-500	299	1	0.4	0.39	54	53
11	100-200	400	1	0.12	0.12	1	1
12	200-300	295	6	1.39	0.27	316	77
13	300-500	561	6	1.23	0.54	272	153
14	100-200	1685	3	11.06	4.65	3294	1623
15	200-300	957	13	4.65	0.61	1444	236
16	300-500	1136	4	2.89	1.51	674	449
Total		16560	58	33.92	11.592	8566	3374

2005

Stratum	Depth	Area	Hauls	Biomass	SE	Abun.	SE
1	100-200	2794	1	0	0	0	0
2	200-300	1819	4	3.79	0.65	593	99
3	100-200	342	-	-	-	-	-
4	200-300	1824	3	5.46	3.03	1312	796
5	100-200	1559	5	0	0.00	0	0
6	200-300	1392	6	3.16	1.13	664	230
7	300-500	860	4	1.9	0.60	363	104
8	100-200	206	-	-	-	-	-
9	200-300	431	3	1.13	0.12	335	78
10	300-500	299	2	0.58	0.10	123	33
11	100-200	400	1	1.58	1.56	436	429
12	200-300	295	8	0.57	0.10	160	33
13	300-500	561	8	0.91	0.26	212	73
14	100-200	1685	16	3.37	0.90	1018	276
15	200-300	957	13	3.15	0.39	920	102
16	300-500	1136	7	4.5	2.27	1238	639
Total		16560	81	30.1	11.106	7374	2892

Table 2. Estimated biomass indices (tons) by survey and stratum 1984-2005 (CV is the coefficient of variation; estimates of the different survey series are not comparable, see text).

Survey		Stratum																Total area	
Year	Series	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Index	CV
1984	1	0	2441	-	2144	4048	3093	1313	-	336	346	316	[1)]556	605	1253	1305	1535	19291	
1985	1	0	4768	-	1162	3288	2607	2016	0	815	475	[1)]1900	794	840	4921	2664	4066	30316	
1986	1	0	2183	-	920	[1)]933	1940	663	-	389	177	[1)]857	540	618	1521	2073	733	13547	
1987	1	88	3765	-	2482	4103	3294	1237	0	1370	254	[1)]1470	584	419	2168	1350	964	23548	
1988	1	0	1126	-	720	373	1079	682	0	294	96	472	391	282	814	777	343	7449	
1989	1	-	932	-	2347	[1)]898	1722	1159	0	560	263	579	556	498	1375	1443	918	13248	
1990	1	0	705	187	3245	[1)]1067	2373	471	0	647	171	1044	559	564	2088	1895	907	15920	
1991	1	0	1903	1008	2612	189	2851	1053	152	725	189	740	526	716	2163	2683	1312	18821	
1992	1	0	615	717	585	136	5743	2299	0	568	527	2091	951	669	3567	2550	1211	22229	
1993	1	0	1481	401	4063	[1)]1487	1437	688	-	621	281	2596	758	728	2735	3823	1237	22336	
1994	1	0	1391	626	2321	345	2439	1992	-	461	255	1627	468	844	3004	2284	1320	19377	
1995	1	0	2794	-	1420	202	4042	953	-	818	236	1836	513	665	2950	2076	1714	20220	
1996	1	0	4901	-	1367	133	3576	1108	-	533	441	3590	616	921	4277	2456	1286	25205	
1997	1	0	7882	-	1995	416	3393	2406	-	764	349	1969	1530	1487	3199	3584	3169	32143	
1998	1	-	5069	-	3357	586	2223	1049	-	682	401	1105	451	529	3186	2439	1378	22455	
1999	1	0	5180	-	5360	3158	3254	1051	-	235	243	475	266	311	4560	2228	1596	27917	
2000	1	-	3436	-	2664	1121	2181	695	-	343	158	939	380	286	4159	2495	1497	20354	
2001	1	-	5180	0	5360	3158	3254	1051	-	307	245	512	266	311	4560	2228	1596	28028	
2002	1	-	[1)]3922	-	[1)]3104	459	3749	1847	-	1153	364	1403	496	411	5425	4470	3329	30133	
2003	2	-	-	-	1410	750	2770	840	300	1240	430	480	770	960	2210	1950	850	14960	
2004	3	-	3590	-	2830	-	3540	1530	-	690	400	120	1390	1230	11060	4650	2890	33920	34%
2005	3	0	3790	-	5460	0	3160	1900	-	1130	580	1580	570	910	3370	3150	4500	30100	37%

[1)]Estimated as an average of the stratum estimates scaled by overall biomass of the year.

Table 3. Indices of abundance and biomass, and mean carapace length (cpl) by sex, and estimated cpl at which 50% of the individuals had changed sex (L_{50}).

	Abund. (index)				Biomass (index)				Mean cpl (mm)			L_{50} mm
Year	♂	♀	All	%♀	♂	♀	All	%♀	♂	♀	All	♂→♀
2004	61	27	87	31%	15	19	34	55%	15.0	21.3	16.9	18.03
2005	45	29	74	39%	13	17	30	58%	16.1	21.1	18.0	19.04

Table 4. Mean carapace length (cpl), and relative within and between year abundance of age classes as calculated by applying modal analysis (MIX (MCdonnald and Pitcher, 1979)) to the overall survey estimates of stock length frequency distribution

	mean cpl (mm)			SE			Proportions			SE		
	1	2	3+	1	2	3+	1	2	3+	1	2	3+
2004	14.8	18.2	21.25	0.06	-	1.1	0.57	0.22	0.21	0.05	0.16	0.12
2005	14.6	18.2	22.6	0.21	0.14	0.3	0.32	0.45	0.23	0.04	0.06	0.03

	Abund.(index)			SE		
	1	2	3+	1	2	3+
2004	49.4	19.1	18.2	19.8	16.5	13.2
2005	23.6	33.2	17.0	9.7	13.7	7.0

Table 5. Estimated indices of predator biomass based on catch per NM recorded in the Norwegian shrimp survey.

Species	2004	2005
Blue Whiting =30cm	5.4	12.7
Saithe	20.4	68.4
Cod	1.9	3.3
Roundnosed Grenadier	11.0	6.7
Rabbit fish	9.5	4.5
Haddock	0.8	3.3
Redfishes	0.2	0.4
Velvet Belly	1.5	7.5
Skates,Rays	1.9	0.2
Long Rough Dab	0.3	0.6
Hake	1.5	4.1
Angler	2.0	0.6
Witch	1.1	0.2
Dogfish	0.2	0.1
Whiting	0.0	1.0
Blue Ling	0.0	0.0
Ling	0.1	0.6
Fourbearded Rockling	0.0	0.1
Cusk	0.3	0.4
Halibut	0.0	0.6
Pollack	0.0	0.2
Greater Fork-beard	0.0	0.0
Total	58.1	115.4

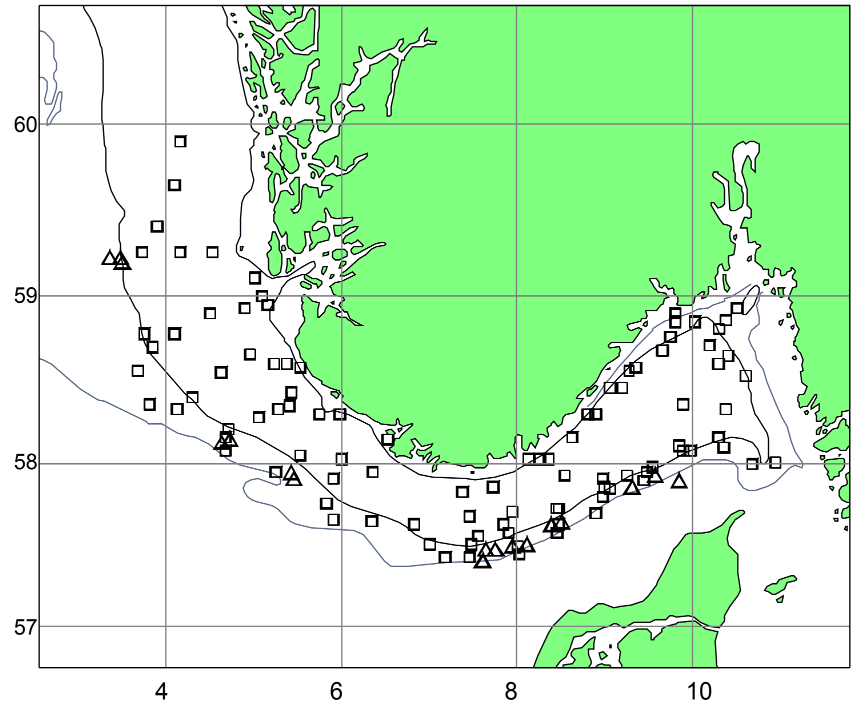

Fig. 1. Trawl stations of the Norwegian survey (squares are shrimp stations; triangles are Norway lobster stations).

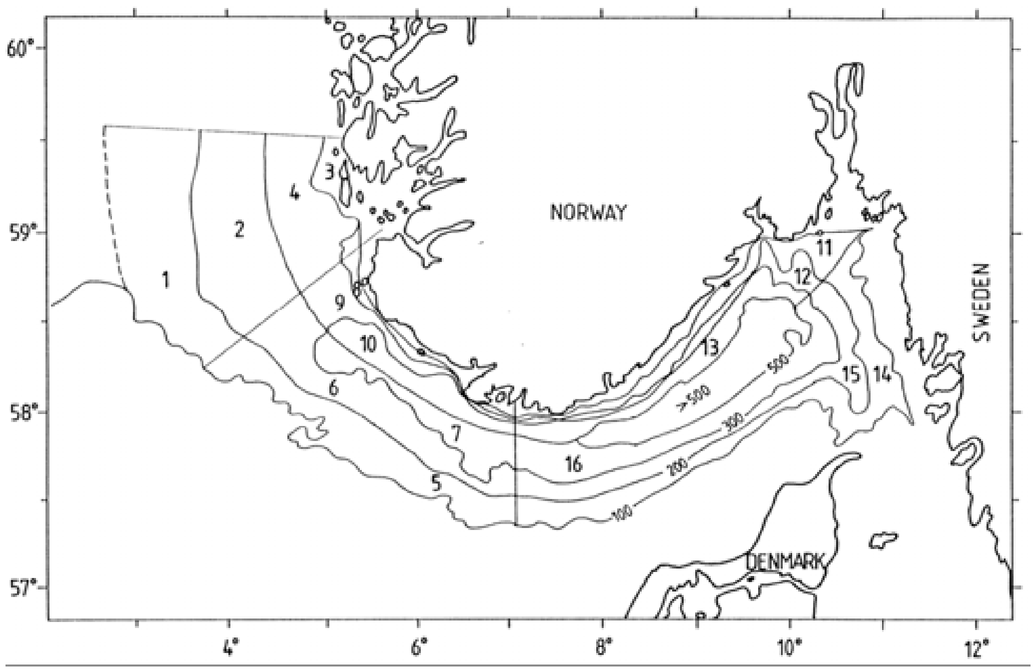

Fig. 2. Stratification used in the Norwegian shrimp survey.

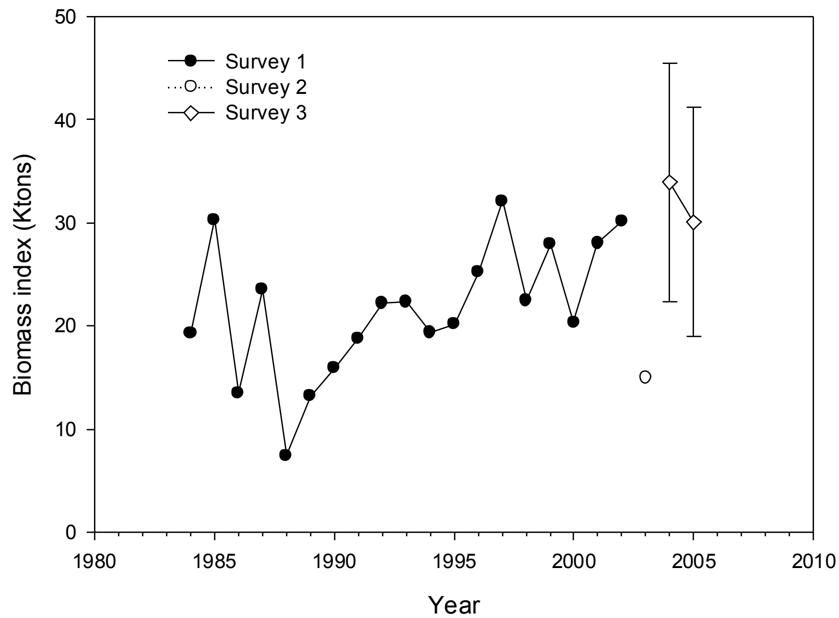

Fig. 3. Estimated survey biomass index of northern shrimp in Skagerrak and Norwegian deeps. The three surveys are not calibrated to a common scale. Standard errors (error bars) were calculated for the 2004 and 2005 surveys.

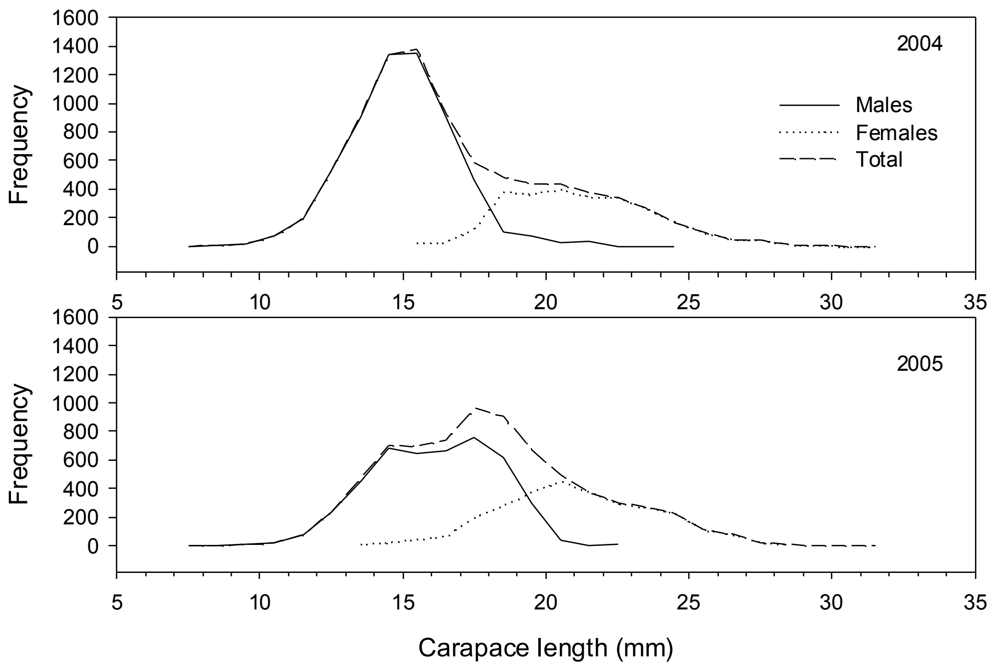

Fig. 4. Estimated length frequency distribution of shrimp in Skagerrak and the Norwegian deeps 2004 and 2005.