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Norwegian investigations on the deep sea shrimp (Pandalus borealis) in the Barents Sea in 1982

by

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ABSTRACT

A bottom trawl survey of the shrimp grounds in the Barents Sea between N71°30' and N76°00', and between E16°30' and E35°30' based on stratified random sampling made in May 1982. On the basis of the data from 112 trawl stations, the biomass of the shrimp, Pandalus borealis, in the area surveyed was estimated by the swept-area method to be approximately 285 000 tonnes. The by-catches of fish in the hauls are also discussed.

En May 1982 on a fàit dans la mer de Barents une recherche sur des crevettes, Pandalus borealis, en usant la méthode d'ē chantillonage stratifiéeau hasard avec un chalutiér de recherche. La zone parcourue est comprise entre les 71°30'-76°00' latitude Nord et 16°30'-35°30' longitude Est. et partir des rēsultats de 112 stations de chalut de fond et usant la mēthode

de l'aire balayée, on a stime en 285 000 mille tones la biomasse de crevettes dans cette zone.

INTRODUCTION

A stratified random sampling scheme was carried out during a bottom trawl survey with R/V "Michael Sars" from 3 May to 1 June 1982 in the Barents Sea (sub-area I). The objectives of the cruise were to study the structure of the shrimp stock, the by-catches of fish and to estimate the abundance of shrimps.

MATERIAL AND METHODS

The cruise in 1982 covered the most important fields where commercial fishing for shrimp has been carried out in the last two years in the Barents Sea. The boundaries of the strata are indicated in Fig. 1.

The main commercial fishing grounds in the spring of 1982, as the year before, were on the "Nordkappleira" (strata 1-4) and the "Thor Iversen" field (strata 11 and 12).

In the strata (14-18) the cruise in 1981 was severely hampered by ice but there were no such problems in 1982.

Each stratum was sub-divided into rectangles of 5 x 5 nautical miles. Within each stratum, rectangles were given consecutive numbers starting from 1. Within each stratum the trawl stations were randomly allocated to rectangles. In the most important shrimp trawl fields (strata 3,4,6,7,12 and 15) 9% of the rectangles were trawled, and in the other strata, 5-6% were trawled. For further information on the methods see (TEIGSMARK & ØYNES 1981). The rectangles trawled in each stratum are marked in Fig. 2, 3 and 4 with station numbers.

The distance trawled was 3,0 nautical miles, but on some stations (station nos. 46,57,61 and 76) trawling had to be much shorter due to the rough bottom.

By-catches of fish were counted and length measurements were taken of all important species. In Table 1 the catch of shrimps (in kg) and by-catch of fish (in numbers) are listed.

Fishing gear and techniques were the same as in 1980 and 1981, and are described by (TAVARES & ØYNES 1980).

The statistical treatment of the data follows (TEIGSMARK & ØYNES 1981). During the cruise in 1981, the width covered by the trawl was calculated for most hauls, giving an average width of 11.7 m. This has lead to recalculation of the results from 1981, giving an increase of approximately 30% for the stock size estimates. The length-weight relationship $w=4.586 \cdot 10^{-3} l^{3.12}$ was used in these calculations.

The commercial stock, i.e. that part of the stock available to the commercially used 35 mm trawlnet, was calculated as in (TEIGSMARK & ØYNES 1981).

In addition to estimates of total stock in numbers, estimates are also given for the number of females, intersexes and males in the different strata.

Larvae production in the different strata was calculated from the length distribution of the females producing larvae, i.e. females carrying eyed eggs and females having just hatched the eggs. The length-fecundity relationship $F_{ec}=0.01 \cdot l^{3.691}$ (TEIGSMARK 1980) was used in these calculations.

RESULTS AND DISCUSSION

Shrimps

Stock size estimates

The estimated biomass of the total stock in each stratum in 1982 is given in Table 2 with the precision of the estimate. The total stock in all strata summarized is estimated to be 285 000 ± 26 000 tonnes, (Table 2) which corresponds to an

increase of approximately 5% for the strata investigated both years. In Fig. 5 the total stock density estimates in the different strata in 1982 are compared with the recalculated stock density estimates for 1981. Fig. 6 gives the percentage change in density from 1981 to 1982.

In the strata close to the Norwegian coast (1-4) the stock seems to be declining, while on the important fishing grounds in the Thor Iversen area (strata 11-13) it seems to be approximately in balance. In strata 5-9 west of Tiddlybanken, the stock has been increasing the last few years. The entire Hopen area (strata 15-18) was investigated this year. This was the most important fishing area from 1972 to 1976. High concentrations of shrimps were found in stratum 15, but the concentrations decreased northwards. The concentrations were also higher in the eastern part of the area compared to the western.

The total stock in 1982 is estimated to be $(66.9 \pm 6.0) \cdot 10^9$ individuals (Table 3) corresponding to an increase of 2.9% from 1981 for the strata investigated both years.

The commercial stock is estimated to be 210 000 ± 22 000 tonnes (Table 4), corresponding to $(49.6 \pm 4.5) \cdot 10^9$ individuals (Table 5). This gives a 5.1% increase from 1981.

The density of males, intersexes and females in the different strata has been calculated for 1981 and 1982 (Fig. 5). Fig. 6 gives the percentage change from 1981 to 1982 for the different stages.

The total number of males in 1982 is estimated to be $(49.2 \pm 4.8) \cdot 10^9$ individuals. This is 2% lower than in 1981. The highest concentrations were found in strata 8-12. Only in the central part of the Barents Sea (strata 5,6,8,9,10) and in the deep strata south of Bjørnøya (21,22) has an increase in the number of males been observed. On both the important fishing grounds at Nordkappleira and Thor Iversen banken a marked decline has been observed.

The total number of intersexes was calculated to be (8.9 ± 1.0) $\cdot 10^9$. which is 12% higher than in 1981. The highest concentrations of intersexes were found in strata 6,9-12,14 and 15. Here the shrimps change sex mainly 5 years old. In strata 1-4 where the shrimp change sex 4 years old, high concentrations of intersexes were found in 1981. This indicates that the 1977 yearclass must have been above average strength in most areas.

The total number of females is calculated to be (8.8 ± 1.0)$\cdot 10^9$ individuals which gives a 27% increase from 1981. This increase is mainly due to the strong 1977 yearclass, and the increase has taken place in most strata.

The stock estimates given must be regarded as minimum estimates. In the last few years experiments have been carried out in Norway (ISAKSEN pers. comm.) to investigate the catching efficiency of the shrimp trawl.

There are at least three ways a shrimp may escape the trawl

1) It may swim in the water above the trawl

   Which part of the shrimp stock that leaves the bottom and swims freely in the water is a controversial issue. The Norwegian experiments indicate that most shrimps stay close to the bottom during the daylight period. On the shrimp investigation cruises trawling is only carried out during day. It is also known that the younger stages live more pelagically than the oldes ones (BARR 1970, TEIGSMARK 1980), and the reliability of the stock density estimates should therefore be better for the older stages, i.e. for intersexes and females compared to the males.

2) Some may escape under the trawl

   The bobbins lift the trawl above the bottom, and some shrimps may therefore escape under the trawl. Experiments (ISAKSEN pers. comm.) using a tickler-chain to get the

shrimps off the bottom resulted in approximately 20% higher catches.

3) Some escape through the meshes

The experiments (ISAKSEN pers. comm.) indicate that the loss of shrimps of commercial size is approximately 20% by weight.

These experiments indicate that the real biomass of the stock is at least 50% higher than the estimates given from the trawl survey.

In addition to the trawl survey, experiments with underwater photography were carried out this year. The main purpose of these experiments was to test the equipment and gain experience in using it. Due mainly to rough weather, the experiments were only partly successful.

From July 12 to August 1, a trawl survey was carried out in the Spitsbergen area from N74^{o} to N80^{o} in depths between 200 and 400 meters. No detailed results are yet available from this cruise, but high concentrations of shrimps were found north of N79^{o}.

Larvae production

Production of larvae is estimated to be about double that of 1981. This largely reflects the observed increase in the number of females. The intersexes observed this year will make out a large fraction of the larvae producing females next year. As the number of intersexes has increased from 1981 to 1982, the production of larvae in 1983 can be expected to be at least at the same level as in 1982. The highest production of larvae this year was observed in the strata 1,4 and 9-15 (Fig. 7).

By-catches

In Table 1 are listed by numbers the most economical important fish species for each trawl haul. Table 6 gives the by-catches (in numbers) in each stratum investigated. Here the numbers of fish are listed as mean number per hour trawled (3 nautical miles).

Except for the capelin and polar cod, the catches of commercially important fishes were lower in 1982 than the year before. Cod were only found in some numbers in the strata south of Bjørnøya (stratum 19). Altogether the catches of cod in 1982 were less than half of what was found in 1981 (TEIGSMARK & ØYNES 1981). Haddock was only sporadicly found in the catches, and they were almost all very young fish. Redfish and Greenland halibut were found in approximately the same numbers as in 1981, mostly too small to be accepted for consumption in Norway. Capelin and polar cod were present in all the strata investigated, except the western part of "Nordkappleira" (strata 1 and 3). The capelin and polar cod was most numerous in the "Tiddly" area (stratum 7). This stratum was partly overflowed by very cold bottom water (÷1.0°C) as it was in the spring 1980. The polar cod were in high numbers also on the "Thor Iversen" field (strata 11 and 12) and on the "Hopen" field (strata 16,17 and 18). Capelin and polar cod make problems for the shrimp trawlers when there are some thousand individuals of these species in an hour trawling, it is impossible to make shrimp trawling rentable. A common by-catch on all shrimp fields in the northern waters are long rough dab. On the survey in 1982 these were most numerous in the area south of Bjørnøya (stratum 19) with almost 800 individuals pr. trawl hour.

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Table 1. Trawl station data from cruise with R/V "Michael Sars" in the Barents Sea in May 1982.

St. nr.	Date	Stra-tum	Square	Time hour	Dist. n.m.	Position N	Position E	Depth (m)	Shrimp catch (kg)	By-catches (number) Cod	Had-dock	Red-fish	Gr.Hal.	Capelin	Polar Cod	Other
69	20/5	1	12	8.50	3.0	71°27'	28°10'	397	98	5	1	182	20	13		29
70	20/5	1	25	11.49	3.0	71°27'	29°10'	344	167	7	1	456	4	38		65
71	20/5	1	32	15.20	3.0	71°10'	29°48'	348	130	23	1	556	12	49		84
72	21/5	2	12	6.45	3.0	71°26'	30°50'	271	60	6	3	460		128		186
73	21/5	2	16	9.40	3.0	71°13'	31°05'	271	56	21	6	604	1	214	16	249
74	21/5	2	41	12.45	3.0	71°08'	32°07'	231	50	12	4	34		310	2	158
76	22/5	2	46	6:30	1.5	71°19'	32°39'	264	36	4	1	121	1	79	13	112
3	4/5	3	3	10.35	3.0	71°46'	25°48'	305	15	107		1248				
2	4/5	3	7	7.45	3.0	71°31'	26°15'	290	50	15	1	149		1		129
4	4/5	3	11	12.35	3.0	71°50'	25°58'	308	63	1		230		240		102
1	3/5	3	41	20.20	3.0	71°36'	27°30'	375	150	2		78	1			82
6	4/5	3	50	19.53	3.0	71°52'	27°56'	298	85	11	8	774		165		162
8	5/5	3	69	9.35	3.0	71°43'	28°44'	324	33	1		225		58	1	36
7	5/5	3	70	7.30	3.0	71°46'	28°54'	306	110	11	4	289		169		129
9	5/5	4	20	13.05	3.0	71°38'	30°04'	345	155	2	1	1344	31	111	6	185
14	6/5	4	23	12.52	3.0	71°52'	30°07'	362	141	5	1	234	66	144	4	174
13	6/5	4	26	10.40	3.0	71°52'	30°31'	355	123	1		158	6	415	375	279
10	5/5	4	42	15.50	3.0	71°34'	30°50'	304	180	5		458	25	7		143
12	6/5	4	50	7.40	3.0	71°52'	31°34'	327	165			50	10	100	140	319
11	5/5	4	53	18.00	3.0	71°36'	31°22	323	115	1		414	11	330	58	241
96	26/5	5	12	16.34	3.0	72°27'	26°04'	257	55	4		522		12		332
5	4/5	5	54	17.03	3.0	72°01'	27°50'	256	2	1				49		19
16	6/5	5	81	18.00	3.0	72°10'	29.23'	279	65	6	1	157	2	50	12	156
15	6/5	6	12	15.00	3.0	72°01'	30°07'	327	205	4		288	36	39	495	352
80	23/5	6	18	8.45	3.0	72.26'	30.25'	285	151			205	1	50	15	351
18	8/5	6	44	7.45	3.0	72°37'	31°00'	287	214			17		681	114	647
20	8/5	6	51	12.50	3.0	72°47'	31°11'	277	270			216	2	480	384	940
19	8/5	6	68	9.50	3.0	72°37'	31°27'	282	90			6		164	68	525
81	23/5	6	90	12.10	3.0	72°28'	31°54'	269	309			162		2210	247	1001
82	23/5	6	91	14.05	3.0	72°31'	32°05'	269	261	1	1	47		257	398	779
21	8/5	6	98	15.50	3.0	72°53'	32°18'	248	50			25		380	1820	265
83	23/5	6	101	16.15	3.0	72°37'	32°19'	275	33			2		78	6kg	136
77	22/5	6	106	12.25	3.0	72°12'	32°13'	276	245			35		910	628	195
79	22/5	7	4	16.45	3.0	72°26'	32°34'	277	147			14		12kg	12kg	664
78	22/5	7	6	14.25	3.0	72°16'	32°30'	279	223			7		2262	2106	430
84	23/5	7	17	19.00	3.0	72°40'	33°06	305	44					35kg	134kg	126
87	24/5	7	36	13.50	3.0	72°29'	33°49'	275	82					96kg	518kg	312
88	24/5	7	43	16.40	3.0	72°37'	33°57'	279	82					108kg	64kg	572
85	24/5	7	60	7.55	3.0	72°30'	34°52'	282	10					155kg	216kg	38
86	24/5	7	64	9.45	1.5	72°27'	34°58'	286	7					115kg	100kg	
102	27/5	8	16	10.10	3.0	72°44'	26°16'	301	69	11	2	116		2		69
95	26/5	8	30	13.50	3.0	72°34'	26°53'	148	144	2		144				181
101	28/5	8	36	6.50	3.0	72°59	27°04'	330	129	1		275		170		206
94	26/5	8	51	10.40	3.0	72°46'	28°17'	300	157	2		419		54		172
93	26/5	8	56	7.50	3.0	72°40'	28°17'	322	208	1	1	1050	8	49	21	203
92	25/5	8	96	15.55	3.0	72°58'	29°58'	271	203	2		134	2	112	188	136
100	27/5	9	9	18.00	3.0	73°15'	27°35'	351	230			411	13	19	5	201
98	27/5	9	26	10.20	3.0	73°21'	28°26'	354	190			275	17	61	6	294
97	27/5	9	40	7.45	3.0	73°14'	29°03'	343	169	2		707	8	17	40	146
68	18/5	9	58	18.25	3.0	73°20'	29°58'	332	204			204	23	24	138	301
67	18/5	10	6	15.45	3.0	73°32'	30°02'	389	152			76	21	67	261	367
91	25/5	10	13	13.24	3.0	73°04'	30°33'	263	189	3		648		804	90	382
29	10/5	10	24	11.15	3.0	73°56'	30°29'	337	157			12	13	480	92	352
90	25/5	10	57	10.20	3.0	73°17'	31°25'	299	257	1		20kg	7	765	3	19kg
22	8/5	11	13	18.40	3.0	73°03'	32°04'	217	111			51	2	1029	342	609
27	9/5	11	22	17.40	3.0	73°40'	32°46'	298	215			563	19	152	116	750
24	9/5	11	43	10.15	3.0	73°51'	34°34'	310	179			15		180	1740	624

Table 1 cont.

St. nr.	Date	Stra-tum	Square	Time hour	Dist. n.m.	Position N	Position E	Depth (m)	Shrimp catch (kg)	By-catches (number) Cod	Had-dock	Red-fish	Gr.Hal.	Capelin	Polar Cod	Other
28	10/5	12	4	7.45	3.0	73°41'	31°43'	355	183			115	20	120	50	504
89	25/5	12	11	7.55	3.0	73°22'	31°56'	286	302	2		531	8	2268	135	891
26	9/5	12	30	15.35	3.0	73°49'	32°54'	299	220	1		140	2	370	660	892
25	9/5	12	45	12.58	3.0	73°53'	33°47'	320	167			5		1050	3145	781
23	9/5	12	52	7.40	3.0	73°41'	34°08'	315	285			32		203	333	809
60	17/5	13	13	9.45	3.0	73°45'	25°43'	451	65			11	19	23	63	100
61	17/5	13	31	12.15	1.6	73°50'	26°10'	461	48			11	18	21	48	134
99	27/5	13	43	14.00	3.0	73°31'	27°02'	423	108			250	39	50	15	254
64	18/5	13	72	6.45	3.0	73°59'	28°02'	401	80			180	32	33	75	180
65	18/5	13	75	9.15	3.0	73°48'	28°16'	392	93			319	32	10	75	196
66	18/5	13	79	12.15	3.0	73°33'	28°35'	383	122			276	55	32	32	260
59	17/5	14	4	6.45	3.0	74°02'	25°15'	458	72			126	21	18	102	210
52	15/5	14	18	15.30	3.0	74°24'	26°06'	392	379	2		260	2	80	60	558
51	15/5	14	52	12.14	3.0	74°44'	26°48'	341	195			13	1	78	390	1210
63	17/5	14	59	18.15	3.0	74°16'	27°21'	413	103	2		30	8	79	109	492
62	17/5	14	64	15.57	3.0	74°06'	27°25'	417	86			147	25	35	81	349
48	14/5	14	93	19.20	3.0	74°49'	28°33'	462	108			46	6	88	168	374
36	11/5	15	3	16.32	3.0	74°38'	28°55'	384	270			141	9	182	336	375
32	10/5	15	24	19.45	3.0	74°31'	29°30'	383	142			192	9	170	116	453
31	10/5	15	27	16.46	3.0	74°15'	29°30'	377	185			87	15	213	80	390
30	10/5	15	32	14.20	3.0	74°07'	29°44'	364	269			72	11	108	156	434
35	11/5	15	42	13.10	3.0	74°42'	30°11'	377	285			63		301	378	492
33	11/5	15	67	7.45	3.0	74°18'	30°48'	315	207			10	9	373	257	153
34	11/5	15	76	10.00	3.0	74°25'	30°57'	298	108			3	1	266	298	444
50	15/5	16	12	9.20	3.0	74°59'	27°36'	326	130			95	8	126	945	603
49	15/5	16	18	6.55	3.0	75°13'	27°48'	292	25			14		385	2268	293
42	13/5	15	55	14.05	3.0	75°18'	29°39'	361	105			50		2100	6300	700
47	14/5	17	1	17.00	3.0	74°53'	29°16'	384	150			50	8	95	510	455
41	13/5	17	17	11.10	3.0	75°19'	30°40'	376	114			41		416	1012	496
46	14/5	17	35	12.40	3.0	75°09'	31°17'	358	125			4		210	378	631
45	14/5	17	57	9.30	3.0	75°22'	32°07'	317	73					96	330	510
43	13/5	18	22	18.15	3.0	75°41'	29°00'	289	9		Stone and mud					
39	12/5	18	38	16.08	3.0	75°57'	30°05'	316	10		Stone and mud					
40	13/5	18	54	7.45	3.0	75°37'	30°45'	359	90			6	2	495	1494	663
38	12/5	18	73	11.42	3.0	75°56'	31°42'	322	70			8		83	216	474
110	30/5	19	15	13.00	3.0	74°05'	17°45'	206	0	164	1	54		270	18	2266
111	30/5	19	21	17.00	3.0	73°38'	17°54'	365	57	9	1	173	5	185	20	135
109	30/5	19	51	6.50	3.0	73°52'	20°19'	313	10		Stone and mud					
108	29/5	20	13	19.10	3.0	73°46'	22°25'	482	76			63	24	14	14	391
55	16/5	20	33	9.30	3.0	73°50'	23°45'	462	132	1		195	31	5	43	448
54	16/5	20	45	6.50	3.0	73°59'	24°23'	453	172	1		368	19	21	100	411
53	15/5	20	55	18.25	3.0	74°17'	25°06'	420	265	1		418	3	44	209	588
113	31/5	21	12	9.40	3.0	73°14'	16°45'	485	33	2			5	Stone and mud		
112	31/5	21	23	6.55	3.0	73°23'	17°06'	472	41			110	8	5	5	303
114	31/5	21	44	14.15	3.0	73°12'	17°57'	453	75	6		912	13	Stone and mud		
115	31/5	21	62	18.15	3.0	73°23'	18°41'	473	30	4			18	Stone and mud		
117	1/6	21	94	8.00	3.0	73°12'	19°57'	450	85		1	458	13			297
116	1/6	21	101	5.15	3.0	73°24'	20°09'	480	99	1		128	13	36	8	188
106	29/5	21	121	12.50	3.0	73°32'	20°51'	499	220			117	7	13	13	323
103	28/5	22	44	17.55	3.0	73°06'	22°34'	425	76			490	11	21	4	215
105	29/5	22	15	9.35	3.0	73°28'	21°30'	474	249			62	10	72	24	483
107	29/5	22	35	16.26	3.0	73°37'	22°04'	478	158	2		130	11	105	20	375
56	16/5	22	70	12.34	3.0	73°34'	23°26'	445	174	1		819	26	7	10	291
57	16/5	22	77	14.52	2.2	73°24'	23°30'	420	106			49	7	9	12	134
58	16/5	22	104	17.50	3.0	73°14'	24°21'	412	86			228	8	14	11	257

Table 2. Estimated density ($\bar{c}_k$) and biomass in each stratum and estimated biomass in all strata summarized with the precision of the estimates.

Stratum	Area (nm^2)	Number of Hauls	$\bar{c}_k$ Tons/$(nm)^2$	s_k^2	$V(\bar{c}_k)$	Coeff. of var. (S.E./$\bar{c}_k$)	Biomass (tons)	S.E. of biomass
1	1200	3	6.947	3.319	1.106	0.151	8337	1262.273
2	1650	4	3.139	0.240	0.060	0.078	5180	404.461
3	1950	7	3.814	6.047	0.864	0.244	7437	1812.341
4	1800	6	7.730	1.732	0.289	0.070	13914	967.232
5	2400	3	2.146	3.191	1.064	0.481	5150	2475.369
6	2700	10	9.645	26.194	2.619	0.168	26042	4369.842
7	1850	7	4.093	17.958	2.565	0.391	7572	2963.098
8	2400	6	8.002	7.374	1.229	0.139	19206	2660.622
9	1500	4	10.460	1.823	0.456	0.065	15691	1012.717
10	1500	4	9.959	6.512	1.628	0.128	14939	1913.826
11	1325	3	8.882	7.765	2.588	0.181	11768	2131.765
12	1375	5	12.209	10.076	2.015	0.116	16788	1951.928
13	2700	6	4.916	1.098	0.183	0.087	13273	1155.267
14	2550	6	8.293	38.035	6.339	0.304	21146	6420.343
15	2025	7	11.050	13.162	1.880	0.124	22377	2776.714
16	1575	3	4.573	8.375	2.792	0.365	7202	2631.581
17	1525	4	6.094	2.867	0.717	0.139	9294	2631.581
18	2500	4	2.361	4.798	1.200	0.464	5903	2738.493
19	1325	3	1.178	2.579	0.860	0.787	1561	1228.493
20	1525	4	8.508	17.634	4.409	0.247	12975	3202.000
21	3300	7	4.394	12.141	1.734	0.300	14502	4345.974
22	3125	6	7.805	11.145	1.858	0.175	24391	4259.138
						All strata	284646	13238.066

Table 3. Estimated number of shrimps pr. square nautical mile in the different strata and for all strata summarized with the precision of the estimates.

Stratum	Area (nm^2)	Number of hauls	$\bar{c}_k \cdot 10^{-3}$	$s_k^2 \cdot 10^{-6}$	$v(\bar{c}_k) \cdot 10^{-6}$	Coeff. of var.	Stock$\cdot 10^{-6}$	S.E. of stock 10^{-6}
1	1200	3	1470.250	156.121	52.040	0.155	1764.300	273.748
2	1650	4	807.327	25.021	6.255	0.098	1334.089	130.499
3	1950	7	929.206	403.964	57.709	0.259	1811.951	468.443
4	1800	6	1841.638	87.344	14.557	0.066	3314.948	217.177
5	2400	3	531.671	193.089	64.363	0.477	1276.011	608.876
6	2700	10	2215.208	1360.002	136.000	0.166	5981.062	955.711
7	1850	7	1099.408	1174.541	167.792	0.373	1033.904	757.804
8	2400	6	2012.701	594.792	99.132	0.156	4830.483	755.646
9	1500	4	2440.428	30.578	7.645	0.036	3660.642	131.150
10	1500	4	2282.717	436.802	109.200	0.145	3424.076	495.682
11	1325	3	2460.788	675.783	225.261	0.193	3260.544	628.867
12	1375	5	3046.469	638.869	127.774	0.117	4188.895	491.500
13	2700	6	1126.257	62.656	10.443	0.091	3040.894	275.912
14	2550	6	1596.301	1230.571	205.095	0.284	4070.567	1154.829
15	2025	7	2118.492	509.912	72.845	0.127	4289.946	546.542
16	1575	3	1188.704	603.812	201.271	0.377	1872.209	706.595
17	1525	4	1790.470	70.664	17.666	0.074	2730.467	202.693
18	2500	4	712.258	480.458	120.114	0.487	1780.645	866.438
19	1325	3	236.613	114.088	38.029	0.824	313.513	258.389
20	1525	4	1962.385	788.252	197.063	0.226	2992.638	676.974
21	3300	7	935.334	694.792	99.256	0.337	3086.601	1039.662
22	3125	6	1866.630	707.168	117.861	0.184	5833.218	1072.842
						All strata	66889.604	3085.847

Table 4. Estimated commercial density ($\bar{c}_k$) and biomass in each stratum and estimated biomass in all strata summarized with the precision of the estimates.

Stratum	Area (nm^2)	Number of Hauls	$\bar{c}_k$ Tons/$(nm)^2$	s_k^2	$V(\bar{c}_k)$	Coeff. of var. (S.E./$\bar{c}_k$)	Biomass (tons)	S.E. of biomass
1	1200	3	6.002	2.352	0.784	0.148	7202	1062.627
2	1650	4	2.522	0.148	0.037	0.076	4161	316.993
3	1950	7	3.134	3.976	0.568	0.240	6112	1469.596
4	1800	6	6.392	1.233	0.206	0.071	11505	816.143
5	2400	3	1.736	2.112	0.704	0.483	4167	2013.803
6	2700	10	8.136	18.697	1.897	0.169	21968	3719.121
7	1850	7	3.260	12.041	1.720	0.402	6031	2426.314
8	2400	6	6.454	4.378	0.730	0.132	15490	2050.187
9	1500	4	8.704	1.800	0.450	0.077	13056	1006.192
10	1500	4	8.386	4.259	1.065	0.123	12579	1547.832
11	1325	3	7.009	4.436	1.479	0.173	9287	1611.132
12	1375	5	9.979	7.111	1.422	0.120	13721	1639.818
13	2700	6	4.136	0.789	0.132	0.088	11166	979.143
14	2550	6	7.368	31.287	5.214	0.310	18788	5822.993
15	2025	7	9.838	10.379	1.483	0.124	19922	2465.740
16	1575	3	3.649	5.204	1.735	0.361	5767	2074.447
17	1525	4	4.630	3.268	0.817	0.195	7061	1378.485
18	2500	4	1.764	2.570	0.643	0.455	4409	2003.984
19	1325	3	1.032	1.925	0.642	0.776	1367	1061.420
20	1525	4	7.155	13.626	3.406	0.258	10911	2814.625
21	3300	7	3.786	8.280	1.183	0.287	12494	3589.034
22	3125	6	6.466	7.453	1.242	0.172	20208	3482.824
					All strata		237351	11222.800

Table 5. Estimated commercial number of shrimps pr. square nautical mile in the different strata and for all strata summarized with the precision of the estimates.

Stratum	Area (nm^2)	Number of hauls	$\bar{c}_k \cdot 10^{-3}$	$s_k^2 \cdot 10^{-6}$	$v(\bar{c}_k) \cdot 10^{-6}$	Coeff. of var.	Stock$\cdot 10^{-6}$	S.E. of stock 10^{-6}
1	1200	3	1160.404	100.112	33.371	0.157	1392.484	219.211
2	1650	4	556.412	10.773	2.693	0.093	918.079	85.628
3	1950	7	696.293	206.715	29.531	0.247	1357.771	335.098
4	1800	6	1366.848	47.461	7.910	0.065	2460.326	160.090
5	2400	3	401.583	110.557	36.852	0.478	963.799	360.726
6	2700	10	1661.117	770.859	77.086	0.167	4485.015	749.638
7	1850	7	746.092	547.443	78.206	0.375	1380.271	517.359
8	2400	6	1496.533	265.270	44.212	0.141	3591.679	504.638
9	1500	4	1889.438	38.513	9.628	0.052	2834.157	147.185
10	1500	4	1698.405	221.899	55.475	0.139	2547.608	353.296
11	1325	3	1553.298	273.615	91.205	0.194	2058.120	400.152
12	1375	5	2149.855	302.572	60.514	0.114	2956.051	338.246
13	2700	6	847.817	32.242	5.374	0.086	2289.106	197.923
14	2550	6	1291.752	892.113	148.686	0.299	3293.967	983.274
15	2025	7	1703.770	322.264	46.038	0.126	3450.135	434.492
16	1575	3	841.321	287.053	95.684	0.368	1325.080	487.193
17	1525	4	1125.503	55.589	13.897	0.105	1716.392	179.777
18	2500	4	456.082	180.408	45.102	0.466	1140.204	530.931
19	1325	3	197.940	78.360	26.120	0.816	262.270	214.142
20	1525	4	1463.349	424.630	106.158	0.223	2231.607	496.873
21	3300	7	764.173	416.724	59.532	0.319	2521.772	805.173
22	3125	6	1410.750	389.022	64.837	0.180	4408.592	795.722
					All strata		49584.486	2287.231

Table 6. Catch of shrimps and by-catch composition in the different strata.

Stratum number	Number of hauls	Shrimps pr 3 n.m. (kg)	By-catch of fish in numbers pr 3 n.m. trawled							
			Cod	Haddock	Redfish	Gr.Hal.	Capelin	Polar cod	Long rough dab	Others
1	3	132	12	1	398	12	33		34	25
2	4	51	11	4	305	1	185	10	169	27
3	7	72	21	2	428		90		54	37
4	6	147	2		443	25	185	97	206	17
5	3	41	4		226		37	4	144	25
6	10	183	1		100	4	525	480	387	132
7	7	78			3		7766	16644	131	175
8	6	152	3	1	334	2	81	35	121	40
9	4	198	1		399	15	30	47	163	73
10	4	189	1		234	10	529	112	247	120
11	3	168			210	7	454	733	342	319
12	5	231	1		165	6	802	865	408	367
13	6	94			176	36	32	59	140	70
14	6	157	1		104	11	63	152	187	345
15	7	209			81	8	230	232	169	223
16	3	87			53	3	870	3171	187	345
17	4	116			24	2	204	558	207	316
18	4	45			7	1	289	855	222	337
19	3	22	87	1	114	3	228	19	784	417
20	4	161	1		261	19	21	92	278	181
21	7	83	2		345	11	18	9	247	51
22	6	142	1		296	12	38	24	205	154

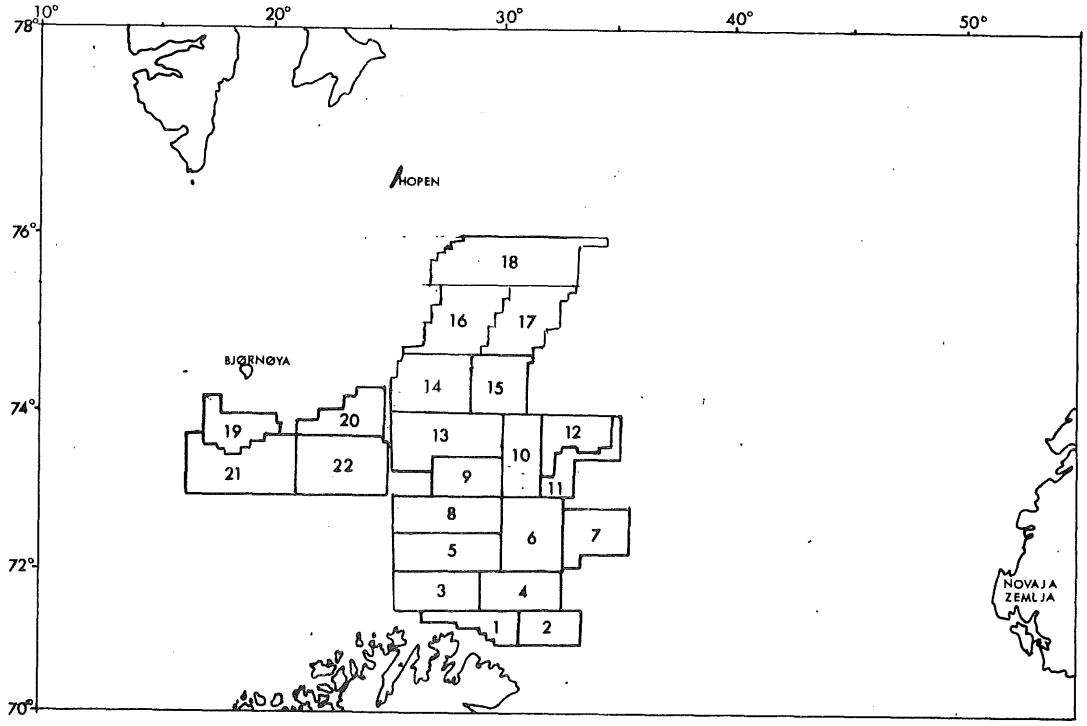

Fig. 1. Sampling strata used in May 1982 in the Barents Sea for the shrimp survey with R/V "Michael Sars".

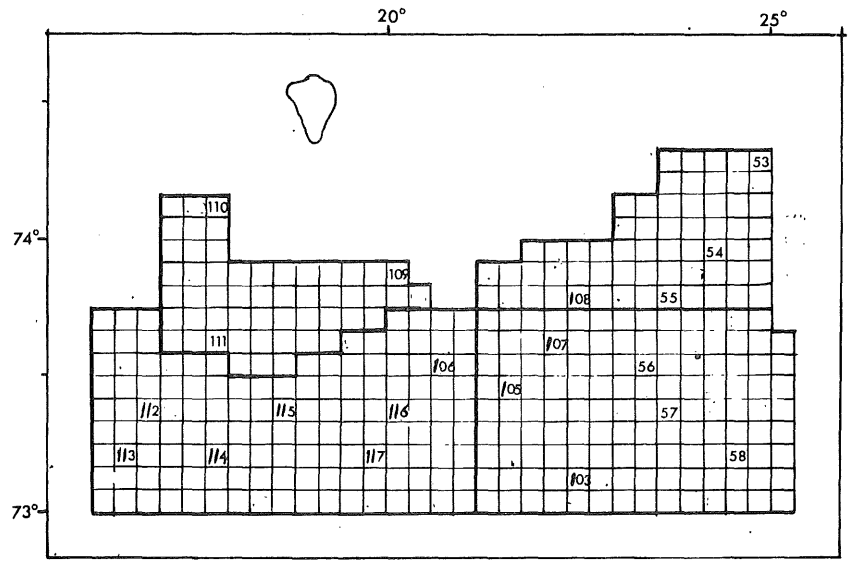

Fig. 2. Strata 19-22 subdivided into rectangles of 5x5 n.m. The rectangles trawled are indicated by station number.

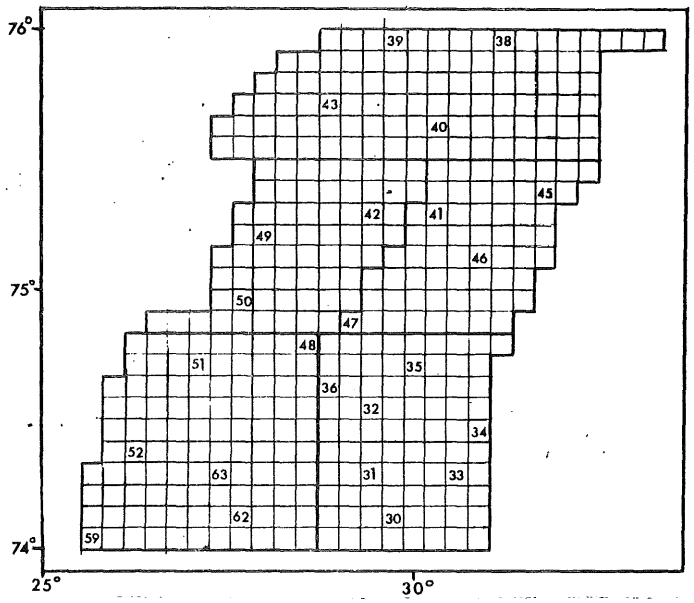

Fig. 3. Strata 14-18 subdivided into rectangles of 5x5 n.m. The rectangles trawled are indicated by station number.

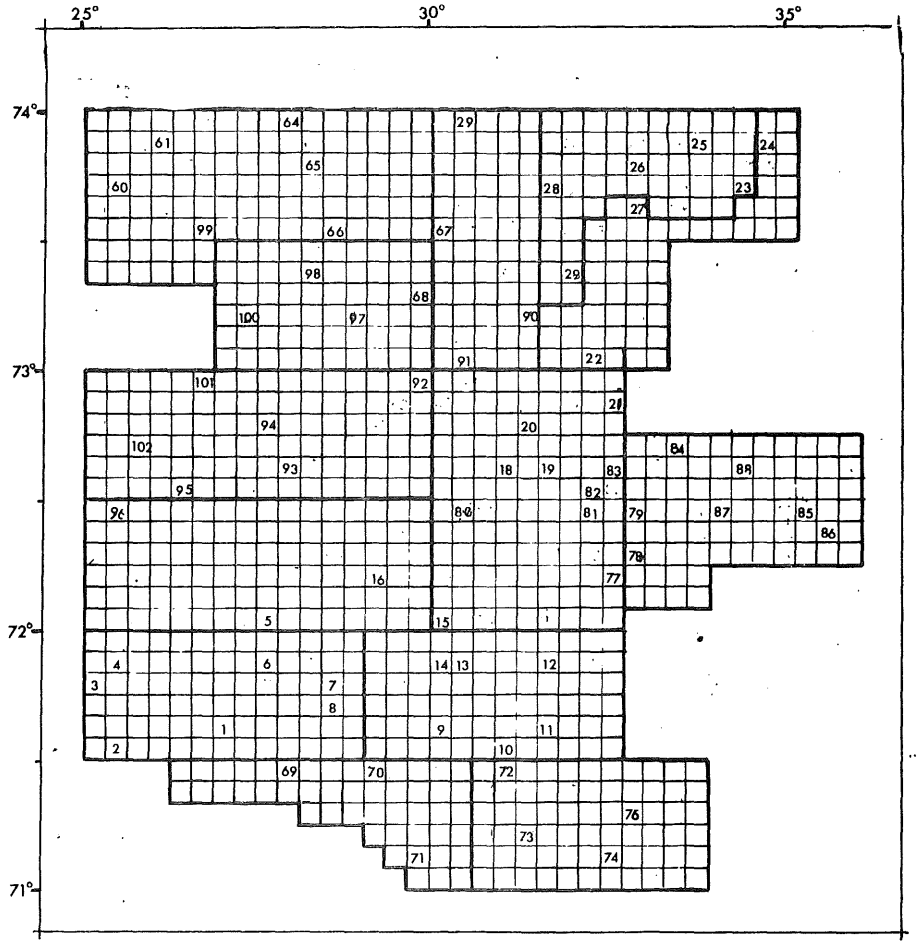

Fig. 4. Strata 1-13 subdivided into rectangles of 5x5 n.m. The rectangles trawled are indicated by station number.

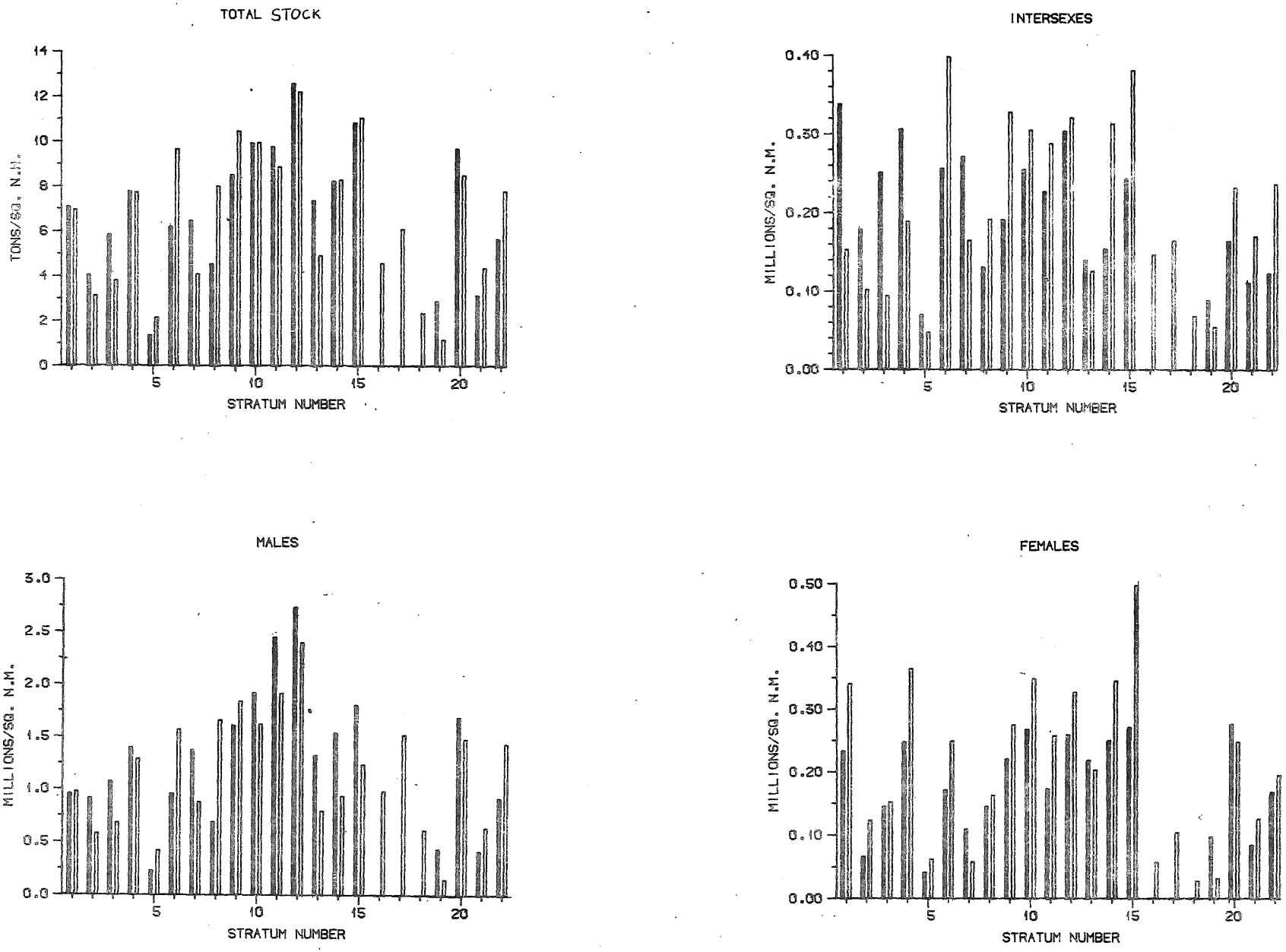

Fig. 5. Density estimates for total stock, males, intersexes and females in the different strata in 1981 (closed bars) and 1982 (open bars).

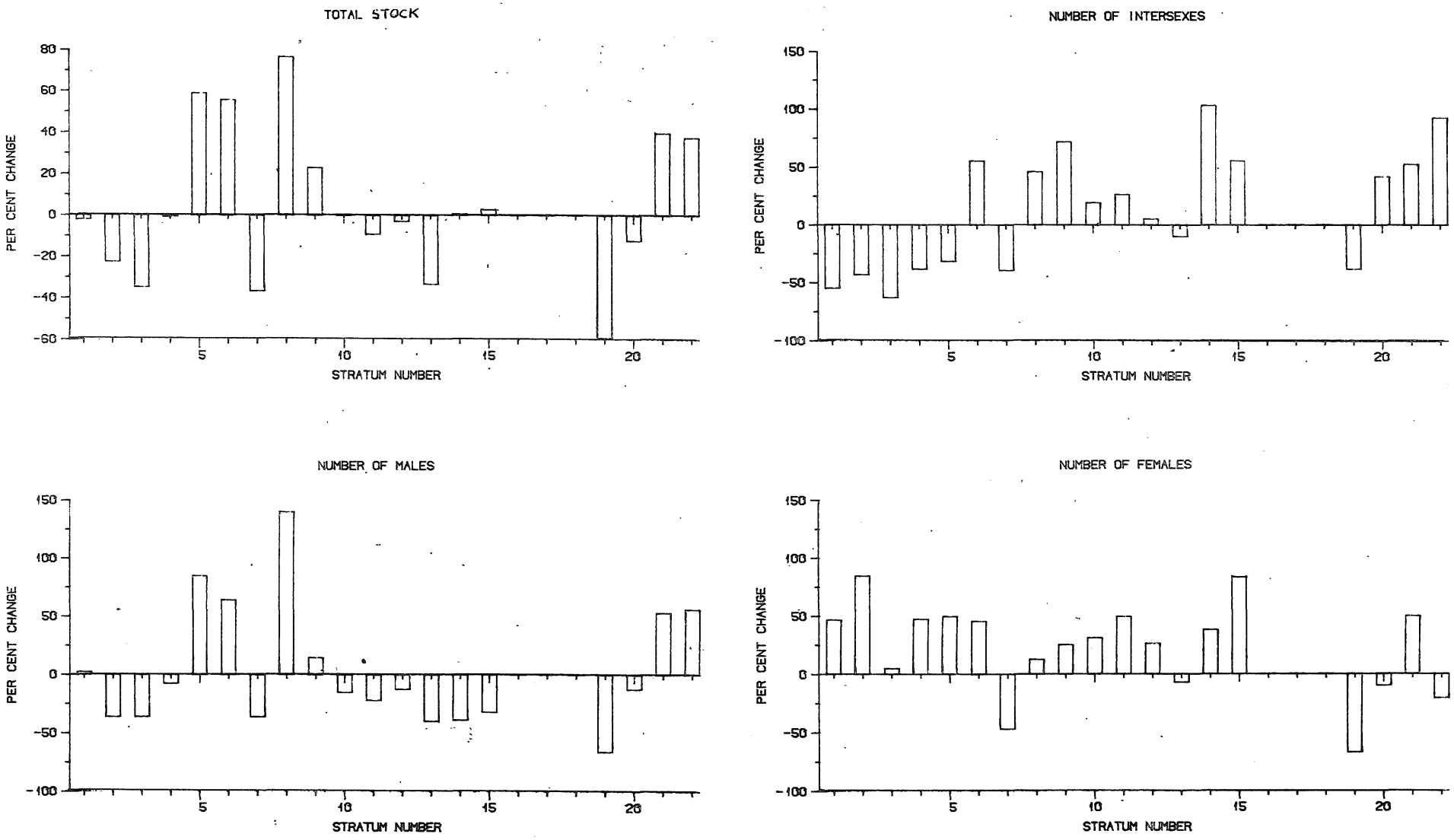

Fig. 6. Per cent change in the density estimates in the different strata for total stock, males, intersexes and females from 1981 to 1982.

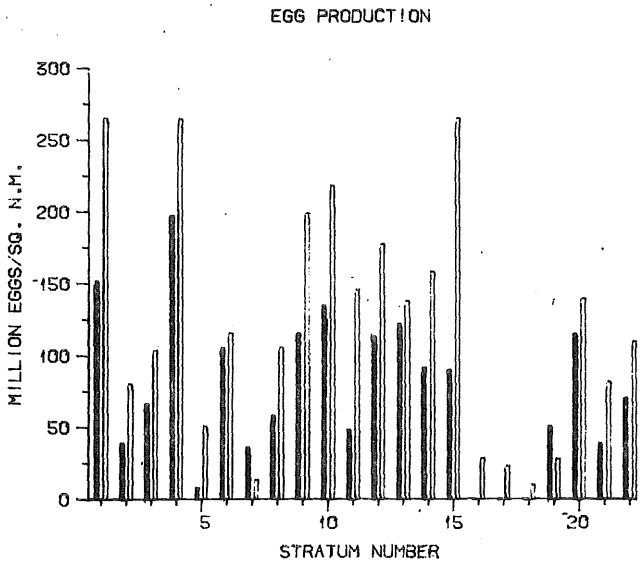

Fig. 7. Larvae production estimates for the different strata in 1981 (closed bar) and 1982 (open bar).