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RESULTS OF A STRATIFIED BOTTOM TRAWL SURVEY FOR SHRIMPS (PANDALUS BOREALIS) IN THE BARENTS SEA IN MAY - JUNE 1981.

by

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1 ABSTRACT

A bottom trawl survey of the shrimp grounds in the Barents Sea between N71°30' and N74°40', and between E16°30' and E35°30' based on stratified random sampling made in May-June 1981. On the basis of the data from 98 trawl stations the biomass of the shrimp, *Pandalus borealis*, in the area surveyed was estimated by the swept area method to be approximately 185 000 tonnes. In addition 7 trawl hauls were taken in Spitsbergen waters. The by-catches of fish in the hauls are also discussed.

En Mai-Juin 1981 on a fait dans la mer de Barents une recherche sur des crevettes, Pandalus borealis, en usant la méthode d'échantillonage stratifiéeau hasard avec un chalutier de recherche. La zone parcourue est comprise entre les 71°30' - 74°40' latitude Nord et 16°30' - 35°30' longitude Est. À partir des résultats de 98 stations de chalut de fond et usant la méthode de l'aire balayée, on a estimé en 185 mille tones la biomasse de crevettes dans cette zone.

2 INTRODUCTION

A stratified random sampling scheme was carried out during a bottom trawl survey with R/V "Michael Sars" from 12 May to 14 June 1981 in the Barents Sea (Sub-area I). A few hauls were also taken off Spitsbergen (Division 2b).

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.

3 MATERIALS AND METHODS

The cruise in 1980 covered the most important areas where commercial fishing for shrimps has been carried out in the Barents Sea. The boundaries of the strata covering these areas were changed this year to fit more closely the fishery statistical areas. As the cruise this year was extended by 9 days, larger areas could be investigated (Fig. 1).

The main commercial fishing areas in the spring of 1981 were on the "Nordkappleira" (strata 1-4) and the "Thor-Iversen" field (stratum 12).

In the northern fishing grounds the investigations were severely hampered by ice. The "Hopen" area and the shrimp fields along the western slope of "Sentralbanken" (strata 16-18) could not be visited due to ice conditions. Ice was also present in strata 14, 15, 19 and 20. In the Spitsbergen waters, the ice conditions were so difficult that it was impossible to make out a stratified program at all. Shrimp trawling could only be done in the western part of the "Storfjorden" (station nos. 96-100) and in the "Kveithola" area (station nos. 101 and 102).

Each stratum was sub-divided into rectangles of 5 x 5 nautical miles. Each rectangle is assumed to have been a homogeneous sampling unit. Within each stratum, rectangles were given consecutive numbers starting from 1. After fixing the total number of trawl stations, the number of stations were roughly allocated to individual strata in proportion to the size of the stratum and the expected shrimp concentrations. 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 most other strata, 5-6% were trawled. The rectangles trawled in each stratum are marked in Fig. 2 and 3, with station number.

The distance trawled in most hauls was 3.0 nautical miles, but on some stations (station nos. 3, 40, 41 and 62) trawling had to be made much shorter due to the rough bottom. On station 100, the distance trawled was 9.0 nautical miles. In some cases where the bottom was too rough to be trawled over, the first nearby rectangle was chosen.

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

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

A random sample of 350-400 shrimps was taken from each haul, and the shrimps were length measured, sexed and their reproductive stage determined.

The statistical treatment of the results in each separate stratum follows TAVARES & ØYNES (1980), and the width covered by the trawl is assumed to be 15 m (0.0081 nm.).

If A_k is the area in stratum k (square nautical miles) and $\bar{c}_k$ is the mean catch (in kg) pr. nm. in stratum k, the total stock (in tonnes) in all strata summarized is given by:

$$\sum_k \frac{A_k}{8.1} \bar{c}_k$$

The 95% confidence interval for this total stock is then

$$\sum_k \frac{A_k}{8.1} \bar{c}_k \quad \pm 1.96 \sqrt{\sum_k \left(\frac{A_k}{8.1}\right)^2 \frac{Sk^2}{n_k}}$$

where s_k^2/n_k is the variance of $\bar{c}_k$ in stratum k.

For each haul the total catch of shrimps and the length distribution of the shrimps are known. Having a length weight relationship, the total number of shrimps caught in each haul can be calculated. It is then possible to estimate the stock in numbers for each stratum and for all strata summarized. The length-weight relationship $w=0.0004313 \cdot 1^{3.15}$ (TEIGSMARK 1980) was used in these calculations. Here, w is the weight in grams and l is the carapace length.

In the Barents Sea, the Norwegian commercial shrimp trawlers use a trawl with a mesh size of 35 mm. A constructed selection curve for a 35 mm trawl is given in TEIGSMARK (1980). Using this selection curve together with information about catch and length distribution of the shrimps for each haul, estimates of biomass and numbers can also be given for the commercial stock, i.e. that part of the stock available to the 35 mm trawl.

4 RESULTS AND DISCUSSION

4.1 Shrimps

The results given concerning the treatment of the shrimp material are preliminary, and a more complete report will be given later.

4.1.1 Stock size estimates

The estimated biomass of the stock in each stratum is given in Table 2, with the precision of the estimate. As the strata were changed this year compared to 1980, changes in stock size in different areas can be most easily seen from changes in the catch pr. nautical mile. Table 3 gives the weighted mean values of catch pr. nm. for the different areas in 1980 and 1981. For the southern areas (strata 3, 4 and 6), a slight decrease in catch pr. nm. was observed. In strata 7 and 10-12 the catch pr. nm. was much higher this year, indicating a major increase in stock size in these areas. Totally, this gives an increase of 20-25% in stock size from 1980 to 1981 for the strata investigated both years.

As can be seen from Table 2, a large part of the total stock was found in areas outside the commercial shrimp fields. It is therefore clear that surveys covering only the commercial fields underestimate the total stock in the Barents Sea to a large extent.

The total stock in all strata summarized is estimated to be 185 000 ± 15 000 tonnes. This is to be regarded as a minimum estimate, and some arguments in favour of this is given in TAVARES & ØYNES (1980).

Estimates of the stock size in numbers in each stratum are given in Table 4. The total stock is estimated to be $(42.7 \pm 3.9) \cdot 10^9$ individuals.

The commercial stock in all strata summarized is estimated to be 155 000 ± 12 500 tonnes (Table 5), corresponding to $(31.2 \pm 2.7) \cdot 10^9$ individuals (Table 6).

ULLTANG (1978) has developed a method that has been used to calculate the TAC. The basic criterion here is the reduction in the reproductive potential caused by fishing. This reduction can be calculated for different values of the fishing mortality F given estimates of M_1 (natural mortality of females after first hatching of the eggs) and t (the time between age at recruitment to the fishery and the age at first hatching of the eggs). If a maximum of 50% reduction in the reproductive potential is allowed due to fishing, the F value giving this reduction can be found for combinations of M_1 and t. The TAC is then calculated as $F \cdot \bar{\bar{P}}_w$, where $\bar{P}_w$ is the equilibrium mean annual commercial stock. This model has been further developed (TEIGSMARK 1980), taking into consideration the length-fecundity relationship and the growth of the shrimps and the spawning pattern, i.e. if the females spawn each year or each second year.

The most probable values of M_1 (0.60, 0.40 and 0.30) and t (2.80 years, 3.20 years and 3.65 years), were used in these calculations for the three populations found in the Barents Sea (see 4.1.2.). The fishing mortality values giving a 50% reduction in the reproductive potential varied between 0.125 and 0.156 for the three populations, with a mean of approximately 0.14. If the biomass of the commercial stock is assumed to correspond to the mean annual commercial stock, the TAC for the stratified areas investigated should be approximately 22 000 tonnes. The t-values used in these calculations are accurate, but the values of M_1 are much more uncertain. If the real values of M_1 are higher than the values used, the TAC will be higher too. An increase in the M_1 values of 0.10 will roughly correspond to an increase in the maximum allowed F value of 0.01.

4.1.2 Biological characteristics

Three populations of P. borealis are to be found in the central part of the Barents Sea (strata 1-15), (TEIGSMARK 1980). In the southern part of this area, the shrimps change sex 4 years old, and the females spawn each year. In the two other populations the females spawn each second year, and in these populations the shrimps change sex 5 and 6 years old respectively. Besides having these differences in reproductive characteristics, the populations have different growth, different levels of mortality and are linked to water masses of different temperature.

From the cruise in 1981, the population spawning each year seems at present, to be found in strata 1-5 and in the southern part of stratum 6. This corresponds with results found during winter 1980-81. Station 106 outside the strata was also taken from this population. The borderline between the two other populations has not yet been established.

Hatching of eggs was nearly completed in all areas, and this indicates that hatching had started earlier this year compared to 1978 and 1979 (TEIGSMARK 1980).

As was expected, some females in the northern areas had started spawning. The shrimps in these areas therefore have an overlapping reproductive cycle, and females with eyed eggs and females with newly-spawned eggs were found at the same time.

4.1.3 Future treatment of the shrimp material

One factor of importance concerning the absolute magnitude of the stock estimates, is the width covered by the trawl. In the previous calculations this has, as in TAVARES & ØYNES (1980), been assumed to be 15 m. On this cruise the distance between the trawl doors was calculated for most hauls. The results showed that this distance was variable, probably due to different bottom conditions, differences in current speed and direction in relation to towing direction etc. Knowing the distance between the trawl doors and the size of the trawl and the length of the sweeps, it is possible to calculate more accurately the area swept by the trawl. This will be done for every haul. Instead of using a constant width for all hauls; adjustments can then be made for each haul for variation in the area swept.

The length distribution of the shrimps in each haul is known. This will be split into normally distributed components corresponding to year-classes, making it possible to estimate the biomass/numbers of each separate year-class. This will then be the basis for mortality estimates.

As the reproductive stage of each shrimp was determined, an estimate of the reproductive active stock of females will also be given, and using a length-fecundity relationship, the production of larvae can be calculated.

It is also intended to analyse more closely the relationship between the amount of shrimps, temperature and depth.

4.2 By-catches

Table 1 lists by numbers the most important by-catches of the most economically important fish species for each trawl haul. Table 7 gives the by-catches (in numbers) in each stratum investigated. The numbers of fish are listed as mean number per trawl haul i.e. per hour trawled.

As in 1980, there were few individuals of the commercially important fish species such as cod, haddock and Greenland halibut. This result is in contrast to the quantities of these species taken as by-catches in shrimp trawling in the same areas in the spring of 1970 (RASMUSSEN & ØYNES 1970). The abundance of these three fish species had declined in the last five years. Cod were found in some reasonable numbers only in the strata nearest the Norwegian coast and in the Svalbard region. Greenland halibut were present in the deepest strata investigated, but in few numbers and most were less than the minimum length (55 cm) generally accepted for consumption in Norway. The increase in the abundance of shrimps mentioned earlier is possibly caused by the decrease in the stock of the predators such as cod, haddock and Greenland halibut. As a rule, redfish were the most numerous in the by-catches, up to 877 as a mean number in the hauls near Spitsbergen. All of the redfish were very small, 10-20 cm. The stock of redfish must also have declined, as RASMUSSEN & ØYNES (1974) describe trawl hauls of 3 hours duratation containing up to 69 000 redfish in these areas.

Capelin and polar cod can make problems for the shrimp trawlers, especially in the eastern and northern parts of the Barents Sea. Capelin were present in all the strata investigated, most numerous in strata 10 and 11 (near the Thor Iversen bank). There were very high numbers of polar cod in strata 7, 11, 12 and 15 (Fig. 1 and Table 7). In stratum 7 (Tiddly) there were nearly 5 000 individuals pr hour's trawling. This makes shrimp trawling impossible for the commercial shrimp trawlers. A common by-catch on all shrimp fields in northern waters are long rough dab. On the survey in 1981 these were most numerous in the areas around Bjørnøya, with numbers from 500 to 750 pr trawl hour. This species is not yet used commercially in Norwegian fisheries.

5 REFERENCES

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Table 1. Catches of shrimp and by-catch per haul by R/V Michael Sars in May and June 1981 by stratum, time of hauling, distance trawled, position, direction and depth.

St. no.	Date	Stra-tum	Square	Time of hauling (hour)	Dis-tance n.m.	Position N.lat.	Position E.long.	Dir. tow.	Depth (m)	Shrimp catch (kg)	By-catches (numbers) Cod	Had-dock	Red-fish	Gr.Hal.	Capelin	Polar Cod	Othe
10	16/5	1	14	0555-0653	3.0	71°24.0'	28°30.0'	135°	400-402	165	5	1	117	6			32
11	16/5	1	25	1035-1134	3.0	71°26.8'	29°18.0'	30°	343-336	125	6	13	309	1			38
16	17/5	1	43	0706-0803	3.0	71°02.5'	30°17.8'	25°	319-323	110	8	7	117		10		111
15	16/5	2	2	2028-2125	3.0	71°23.8'	30°37.0'	130°	272-273	20	56	32	196				81
17	17/5	2	16	1836-1933	3.0	71°10.8'	31°05.0'	40°	278-270	165	141	46	117		50		251
18	18/5	2	43	0700-0756	3.0	71°00.5'	32°28.9'	360°	242-235	35	47	1	330		100		246
19	18/5	2	49	1020-1117	3.0	71°26.0'	32°46.o'	25°	284-288	90	2		176	1	500	20	309
1	14/5	3	6	1533-1631	3.0	71°32.5'	25°57.o'	325°	286-288	24	17	14	130				109
2	14/5	3	15	1845-1941	3.0	71°46.8'	26°18.8'	37°	330-322	130	13	1	252				143
3	15/5	3	25	0723-0753	1.5	71°58.5'	26°54.0'	27°	275-267	10	3	1	112		400		77
7	15/5	3	51	1557-1652	3.0	71°48.8'	28°04.0'	225°	305-320	264	9	27	426		122		76
8	15/5	3	52	1745-1843	3.0	71°43.9'	27°59.0'	225°	345-354	230	5		452	2			140
6	15/5	3	62	1348-1445	3.0	71°54.2'	28°25.0'	135°	268-276	18	36	13	117		110		99
9	15/5	3	65	2006-2103	3.0	71°38.0'	28°28.8'	135°	357-350	132	21	1	436				50
12	16/5	4	6	1224-1322	3.0	71°30.6'	29°21.0'	330°	336-333	118	10		145	2			49
13	16/5	4	10	1500-1558	3.0	71°45.7'	29°29.0'	30°	325-321	225	7		73				104
14	16/5	4	31	1806-1905	3.0	71°34.9'	30°32.0'	116°	306-300	160	4	5	145	2			88
23	19/5	4	36	0706-0803	3.0	71°55.6'	30°33.8'	40°	345-340	110			65	11			215
20	18/5	4	57	1343-1443	3.0	71°40.6'	31°49.0'	310°	310-313	125			205	1	250	1	219
21	18/5	4	62	1602-1702	3.0	71°51.0'	31°53.0'	24°	320-308	185	2		94	5	400		386
4	15/5	5	31	0905-1003	3.0	72°03.6'	27°05.8'	80°	260-269	20	21	9	102				229
5	15/5	5	43	1115-1213	3.0	72°02.0'	27°37.0'	110°	278-277	45	17		261				142
66	28/5	5	70	1647-1745	3.0	72°19.5'	28°38.0'	125°	284-280	15	29	1	87		200		101
39	22/5	6	2	0706-0804	3.0	72°51.6'	30°05.5'	40°	288-278	70	2	1			25 kg	114	173
25	19/5	6	10	1140-1236	3.0	72°10.9'	30°04.8'	75°	305-313	80	1		13		40	15	328
40	22/5	6	24	0853-0926	1.8	72°55.9'	30°21.6'	45°	261-260	16	15		55			112	157
27	19/5	6	29	1647-1747	3.0	72°36.0'	30°39.0'	20°	282-280	160	1		112			114	302
26	19/5	6	31	1430-1528	3.0	72°26.0'	30°35.0'	22°	286-287	120	4	1	95	1	75		486
24	19/5	6	36	0857-0955	3.0	72°01.7'	30°45.0'	310°	332-333	150	1	1	45	7	50		315
22	18/5	6	61	1836-1933	3.0	72°01.0'	31°32.5'	315°	318-318	150	1		63				352
38	21/5	6	74	1949-2044	3.0	72°51.0'	31°56.3'	315°	262-254	170			25		52 kg	753	359
35	21/5	6	88	1035-1133	3.0	72°15.7'	32°06.8'	320°	285-300	140		1	74		18 kg	110	285
36	21/5	6	102	1326-1427	3.0	72°30.6'	32°20.0'	360°	275-272	135			315		6 kg	337	319
37	21/5	7	10	1617-1717	3.0	72°35.6'	32°53.0'	360°	286-292	160	-				26 kg	300	405
34	21/5	7	14	0740-0838	3.0	72°17.6'	32°54.2'	312°	290-293	110			50			684	288
33	20/5	7	29	1845-1943	3.0	72°23.8'	33°30.8'	220°	282-283	180					36 kg	5544	748
32	20/5	7	36	1625-1724	3.0	72°31.0'	33°50.0'	300°	270-283	320					360	12096	1200
31	20/5	7	54	1358-1458	3.0	72°25.7'	34°34.0'	340°	270-285	70					63	9694	801
30	20/5	7	57	1150-1246	3.0	72°17.5'	34°42.8'	90°	270-276	7					120	157	452
29	20/5	7	73	0704-0801	3.0	72°38.6'	35°21.8'	100°	247-233	4						5632	81
81	4/6	8	1	0925-1022	3.0	72°56.0'	25°38.0'	340°	402-423	135	1		431	12	3	47	153
80	4/6	8	3	0700-0800	3.0	72°49.0'	25°32.0'	100°	350-330	100	3		601			65	190
65	28/5	8	43	1333-1431	3.0	72°34.0'	27°44.0'	225°	305-311	60	7		99	3	4 kg		163
64	28/5	8	82	0920-1017	3.0	72°47.0'	29°17.6'	126°	296-295	130	1		30	4	10 kg	233	354
63	28/5	8	86	0704-0802	3.0	72°54.0'	29°41.7'	270°	400-403	70	5		138			270	290
28	19/5	8	92	1940-2037	3.0	72°39.0'	29°54.5'	230°	301-316	50	4	1	30	3	1 kg		282
62	27/5	9	21	1754-1815	1.0	73°12.0'	28°15.5'	270°	357-363	62	2		75	10	50		91
54	26/5	9	25	0656-0754	3.0	73°28.9'	28°28.5'	190°	383-373	155			171	50	20		259
61	27/5	9	40	1515-1630	3.0	73°12.8'	29°07.0'	270°	327-360	145	3		70	7	87		213
60	27/5	9	46	1236-1335	3.0	73°17.2'	29°17.0'	320°	345-361	140	5		264	24	105		298
52	25/5	10	3	1650-1747	3.0	73°48.5'	30°07.0'	165°	366-384	185			140	10	25	15	260
41	22/5	10	14	1137-1200	1.3	73°07.4'	30°24.0'	85°	307-320	55			90		1 kg		68
51	22/5	10	20	1359-1459	3.0	73°39.9'	30°32.6'	230°	387-390	275			60	35	30	11	397
42	22/5	10	41	1411-1511	3.0	73°20.2'	30°53.0'	40°	350-354	150	2		186	66	48 kg		271
45	24/5	11	7	0854-0950	3.0	73°33.8'	32°07.3'	100°	295-297	135	36	12	780	6	240	30	908
43	22/5	11	27	1836-1933	3.0	73°14.0'	32°39.7'	95°	270-263	205	1		297	11	12 kg	44	522
48	24/5	11	44	1754-1852	3.0	73°47.6'	34°26.0'	90°	298-288	220			54		7 kg	1962	784
44	24/5	12	13	0700-0758	3.0	73°33.4'	31°52.4'	100°	297-294	110	3		264	6			785
50	25/5	12	17	1028-1123	3.0	73°53.0'	31°53.5'	135°	341-347	260			384		90	840	420
49	25/5	12	29	0654-0752	3.0	73°51.9'	32°53.0'	300°	302-302	385			220		66	1152	504
46	24/5	12	40	1348-1447	3.0	73°44.0'	33°22.0'	130°	322-322	300			248		6 kg	2067	393
47	24/5	12	53	1619-1717	3.0	73°48.0'	34°11.0'	110°	316-296	145			35		16 kg	1281	1000

Table 1. Catches of shrimp and by-catch per haul by R/V Michael Sars in May and June 1981 by stratum, time of hauling, distance trawled, position, direction and depth.

cont.

St. no.	Date	Stratum	Square	Time of hauling (hour)	Distance n.m.	Position N.lat.	Position E.long.	Dir. tow.	Depth (m)	Shrimp catch (kg)	By-catches (numbers) Cod	Haddock	Redfish	Gr.Hal.	Capelin	Polar Cod	Other
58	26/5	13	2	2000-2056	3.0	73°51.5'	25°25.6'	105°	444-447	120			36	18	90		374
57	26/5	13	35	1615-1720	3.0	73°47.0'	26°36.0'	130°	438-430	120			49	21	45	10	146
59	27/5	13	41	0654-0751	3.0	73°20.7'	26°51.8'	11°	427-421	180			54	10	46		121
56	26/5	13	58	1226-1326	3.0	73°46.0'	27°35.0'	300°	400-412	175			75	20	25	20	234
55	26/5	13	76	0953-1050	3.0	73°42.0'	28°27.3'	340°	395-393	110			104	44	1 kg	20	183
53	25/5	13	92	1943-2040	3.0	73°38.3'	29°20.0'	243°	375-381	135			288	22	32	4	189
76	3/6	14	9	0830-0928	3.0	74°03.0'	26°01.0'	220°	440-452	140			43	11	47	495	242
71	1/6	14	28	1744-1845	3.0	74°16.0'	27°39.0'	315°	415-412	120			116	12		40	324
70	1/6	14	50	1445-1545	3.0	74°06.0'	28°34.0'	315°	389-392	150			186	24	40		203
69	1/6	15	10	1252-1450	3.0	74°04.9'	28°51.0'	230°	375-390	180			172	30	70	77	233
75	2/6	15	18	1529-1629	3.0	74°37.6'	29°01.0'	130°	383-381	160			119	20	176	663	209
74	2/6	15	25	1220-1318	3.0	74°29.0'	29°31.0'	220°	382-380	115			115	13	65	103	259
73	2/6	15	44	0945-1045	3.0	74°34.0'	30°10.0'	220°	355-362	210			158	18	158	235	239
68	1/6	15	47	0930-1028	3.0	74°19.0'	30°10.0'	220°	341-350	265			498	15	110	2000	292
67	1/6	15	74	0700-0800	3.0	74°19.5'	30°57.0'	220°	300-314	280			157		194	4777	290
72	2/6	15	78	0700-0800	3.0	74°38.7'	31°02.0'	210°	300-305	170			78			880	216
103	9/6	19	14	1455-1555	3.0	74°09.0'	17°20.0'	135°	206-211	5	97						704
93	6/6	19	34	1441-1540	3.0	73°41.0'	18°32.0'	110°	310-316	105	84		66			624	717
95	6/6	19	53	2000-2100	3.0	73°45.5'	20°21.0'	60°	450-450	50				7	15	195	428
104	10/6	20	3	0700-0800	3.0	73°46.0'	21°33.0'	80°	503-504	170			53	45	23	303	1024
78	3/6	20	18	1535-1635	3.0	74°04.0'	23°14.0'	230°	437-445	175	1		45	6		318	570
105	10/6	20	35	1215-1315	3.0	73°53.0'	23°59.0'	195°	463-460	170			96	12	57	560	527
77	3/6	20	56	1125-1223	3.0	74°10.5'	25°08.0'	315°	445-437	215		1	26	23	10	68	468
90	6/6	21	11	0555-0655	3.0	73°06.0'	16°37.0'	45°	465-475	25	3		66	3	2	51	169
91	6/6	21	32	0845-0945	3.0	73°20.0'	17°12.0'	30°	482-475	95	4		46	2		14	473
92	6/6	21	34	1105-1203	3.0	73°31.0'	17°21.0'	340°	432-422	30	13		66	7	14	41	81
89	5/6	21	55	1905-2005	3.0	73°02.0'	18°32.0'	240°	418-419	20	Stone and mud.						
94	6/6	21	88	1720-1820	3.0	73°38.0'	19°27.0'	110°	394-425	45	10		37	2	40	700	242
88	5/6	21	96	1531-1631	3.0	73°03.0'	19°58.0'	270°	432-429	60	3		193	11		7	470
87	5/6	21	115	1250-1350	3.0	73°04.0'	20°50.0'	225°	460-455	60	2		37	12	4	21	302
86	5/6	22	6	1000-1058	3.0	73°19.0'	21°24.0'	220°	473-480	110			198	2	20	314	261
85	5/6	22	34	0655-0755	3.0	73°31.0'	22°17.0'	290°	457-460	90			58	18		472	327
84	4/6	22	59	1820-1918	3.0	73°21.0'	23°08.0'	315°	430-430	165	1	1	234	11		28	184
83	4/6	22	66	1553-1650	3.0	73°11.4'	23°25.0'	300°	306-386	80	134		136		8	20	232
82	4/6	22	99	1300-1400	3.0	73°01.7'	24°15.0'	300°	405-386	130	2		312	9	3	3	340
79	3/6	22	108	1925-2028	3.0	73°44.5'	24°25.0'	116°	450-449	116	1		30	37	14	44	164
96	7/6			1115-1215	3.0	75°21.0'	14°43.0'	350°	370-387	120	25		1000	7	10		439
97	7/6	Spitsbergen		1322-1422	3.0	75°31.0'	14°34.0'	350°	394-393	200	32		856	4	4		415
98	7/6	(Storfjorden)		1722-1820	3.0	76°01.0'	14°29.0'	360°	327-357	40	11		774	7	2		395
99	7/6			1940-2038	3.0	76°12.0'	14°48.0'	340°	350-362	50	Stone and mud.						
100	8/6			1755-2055	9.0	75°34.0'	14°47.0'	130°	396-401	450	20	Other fish not counted.					
101	9/6			0655-0755	3.0	74°46.5'	16°07.0'	45°	345-330	125	10		450	24	21	77	926
102	9/6			1020-1115	3.0	74°48.0'	17°40.0'	90°	300-265	225	2		268	8	20	396	1416
106	10/6			2110-2210	3.0	72°31.0'	22°18.0'	194°	377-350	6	Stone and mud.						

Table 2. Estimated mean catch pr n.m. ($\bar{c}_k$) 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	$\bar{c}_k$ (kg/nm)	s_k^2	$v(\bar{c}_k)$	Coeff. of var. (s.e./$\bar{c}_k$)	Biomass (t)	s.e. of biomass
1	1200	3	44.44	89.81	29.94	0.123	6584	810.61
2	1650	4	25.83	478.70	119.68	0.424	5262	2228.45
3	1950	7	38.95	1159.83	165.69	0.330	9377	3098.83
4	1800	6	51.28	224.69	37.45	0.119	11395	1359.88
5	2400	3	8.89	28.70	9.57	0.348	2634	916.50
6	2700	10	40.06	238.71	23.87	0.122	13352	1628.61
7	1850	7	40.52	1370.51	195.79	0.345	9255	3195.80
8	2400	6	30.00	145.56	24.26	0.164	8889	1459.37
9	1500	4	52.17	47.30	11.82	0.066	9660	636.78
10	1500	4	61.41	470.21	117.55	0.177	11372	2007.80
11	1325	3	62.22	228.70	76.23	0.140	10178	1428.26
12	1375	5	80.00	1415.28	283.06	0.210	13580	2855.97
13	2700	6	46.67	101.11	16.85	0.088	15556	1368.37
14	1275	3	45.56	25.93	8.64	0.065	7171	462.73
15	2025	7	65.71	385.05	55.01	0.113	16421	1854.18
19	1325	3	17.78	278.70	92.90	0.542	2908	1576.67
20	1525	4	60.83	52.78	13.19	0.060	11453	683.88
21	3300	7	15.95	76.72	10.96	0.208	6499	1348.75
22	3125	6	36.67	118.89	19.81	0.121	14146	1717.35
					All strata		185700	7796.76

Table 3. Mean catch pr n.m. in different corresponding areas in 1980 and 1981.

1981		1980	
Strata	Mean catch (kg/nm)	Strata	Mean catch (kg/nm)
3+4	44.87	5+6+7	47.26
6	40.06	4	48.60
7	40.52	3	13.84
10+11+12	67.75	1+2	45.10

Table 4. Estimated mean number of shrimps pr n.m. ($\bar{c}_k$) and the total number of shrimps in each stratum and in 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 $\cdot 10^{-6}$
1	1200	3	9.251	3.945	1.315	0.124	1370.535	169.893
2	1650	4	7.152	49.504	12.376	0.492	1456.787	716.619
3	1950	7	9.473	80.119	11.446	0.357	2280.480	814.459
4	1800	6	12.465	15.332	2.555	0.128	2769.926	355.231
5	2400	3	2.165	2.732	0.911	0.441	641.613	282.738
6	2700	10	8.659	12.324	1.232	0.128	2886.411	370.038
7	1850	7	10.688	110.744	15.821	0.372	2441.141	908.443
8	2400	6	6.202	7.480	1.247	0.180	1837.597	330.829
9	1500	4	11.970	2.401	0.600	0.065	2216.651	143.460
10	1500	4	14.637	32.248	8.062	0.194	2710.539	525.812
11	1325	3	17.690	11.251	3.750	0.109	2893.753	316.791
12	1375	5	20.402	71.009	14.202	0.185	3463.257	639.718
13	2700	6	10.346	3.868	0.645	0.078	3448.741	267.632
14	1275	3	10.409	1.547	0.516	0.069	1638.384	113.032
15	2025	7	13.594	18.553	2.650	0.120	3398.381	407.007
19	1325	3	3.807	18.210	6.070	0.647	622.695	403.014
20	1525	4	12.950	4.129	1.032	0.078	2438.180	191.273
21	3300	7	2.995	3.048	0.435	0.220	1220.088	268.853
22	3125	6	7.591	6.841	1.140	0.141	2928.519	411.965
					All strata		42663.678	1995.291

Table 5. Estimated commercial mean catch pr n.m. ($\bar{c}_k$) and commercial biomass in each stratum and in all strata summarized with the precision of the estimates.

Stratum	Area (nm^2)	Number of hauls	$\bar{c}_k$ (kg/nm)	s_k^2	$v(\bar{c}_k)$	Coeff. of var. (s.e./$\bar{c}_k$)	Biomass (t)	s.e. of biomass
1	1200	3	38.48	73.17	24.39	0.128	5701	731.66
2	1650	4	19.91	250.63	62.66	0.398	4055	1612.46
3	1950	7	31.78	723.97	103.43	0.320	7652	2448.28
4	1800	6	41.95	137.32	22.89	0.114	9322	1063.11
5	2400	3	7.28	15.81	5.27	0.315	2157	680.21
6	2700	10	34.03	169.57	16.96	0.121	11342	1372.65
7	1850	7	32.11	813.23	116.18	0.336	7333	2461.75
8	2400	6	25.84	101.89	16.98	0.159	7656	1221.03
9	1500	4	43.22	40.67	10.17	0.074	8022	590.47
10	1500	4	50.52	296.07	74.02	0.170	9355	1593.21
11	1325	3	48.54	198.88	66.29	0.168	7940	1331.87
12	1375	5	64.58	979.76	195.95	0.217	10962	2376.25
13	2700	6	39.29	84.40	14.07	0.095	13097	1250.21
14	1275	3	38.12	16.07	5.36	0.061	6001	364.34
15	2025	7	56.55	285.74	40.82	0.113	14139	1597.25
19	1325	3	15.17	182.03	60.68	0.513	2482	1274.23
20	1525	4	52.10	37.56	9.39	0.059	9808	576.90
21	3300	7	14.17	58.56	8.37	0.204	5774	1178.38
22	3125	6	31.58	80.86	13.48	0.116	12183	1416.28
					All strata		154981	6329.73

Table 6. Estimated commercial mean number of shrimps pr n.m. ($\bar{c}_k$) and the commercial number of shrimps in each stratum 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 $\cdot 10^{-6}$
1	1200	3	7.166	2.499	0.833	0.127	1061.630	135.214
2	1650	4	4.712	18.543	4.636	0.457	959.852	438.589
3	1950	7	6.920	40.085	5.726	0.346	1665.892	576.091
4	1800	6	8.679	8.163	1.360	0.134	1928.741	259.196
5	2400	3	1.554	1.081	0.360	0.386	460.477	177.856
6	2700	10	6.626	6.657	0.666	0.123	2208.789	271.978
7	1850	7	7.063	42.726	6.104	0.350	1613.187	564.266
8	2400	6	4.991	4.683	0.781	0.177	1478.848	261.766
9	1500	4	9.007	1.293	0.323	0.063	1668.009	105.299
10	1500	4	10.299	13.733	3.433	0.180	1907.241	343.128
11	1325	3	10.865	8.082	2.694	0.151	1777.372	268.492
12	1375	5	13.711	40.804	8.161	0.208	2327.462	484.935
13	2700	6	7.928	2.659	0.443	0.084	2642.519	221.891
14	1275	3	7.415	1.115	0.372	0.082	1167.211	95.949
15	2025	7	10.434	11.172	1.596	0.121	2608.476	315.835
19	1325	3	2.873	8.739	2.913	0.594	469.966	279.195
20	1525	4	9.962	1.570	0.392	0.063	1875.577	117.950
21	3300	7	2.537	2.117	0.302	0.217	1033.457	224.041
22	3125	6	6.136	4.192	0.699	0.136	2367.177	322.460
					All strata		31221.883	1393.741

Table 7. Shrimps and by-catch composition taken in different strata in the Barents Sea from 14 May to 10 June 1981

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	133	6	7	147	2	3		52	8
2	4	78	62	20	205		163	5	262	96
3	7	117	15	8	295		90		99	9
4	6	154	4		121	4	108		142	9
5	3	27	22	3	116	0	67		134	23
6	10	120	3		89	1	300	160	286	28
7	7	122			7	0	136	4872	363	224
8	6	90	5		222	5	125	103	216	23
9	4	157	4		183		91		177	39
10	4	184			127	28	640	7	184	68
11	3	187	12	4	377	6	410	678	545	193
12	5	240			230	1	250	1068	349	272
13	6	140			101	23	48	7	168	39
14	3	137			115	16	29	178	188	69
15	7	197			185	14	110	1248	124	125
19	3	53	60		22	2	5	273	516	39
20	4	183			55	22	23	312	513	137
21	7	48	58		74	6	10	139	246	25
22	6	110	23		161	13	8	147	210	45
	5	123	13		877	6	5	416	288	100
	2	175	6		356	16	21	237	745	146

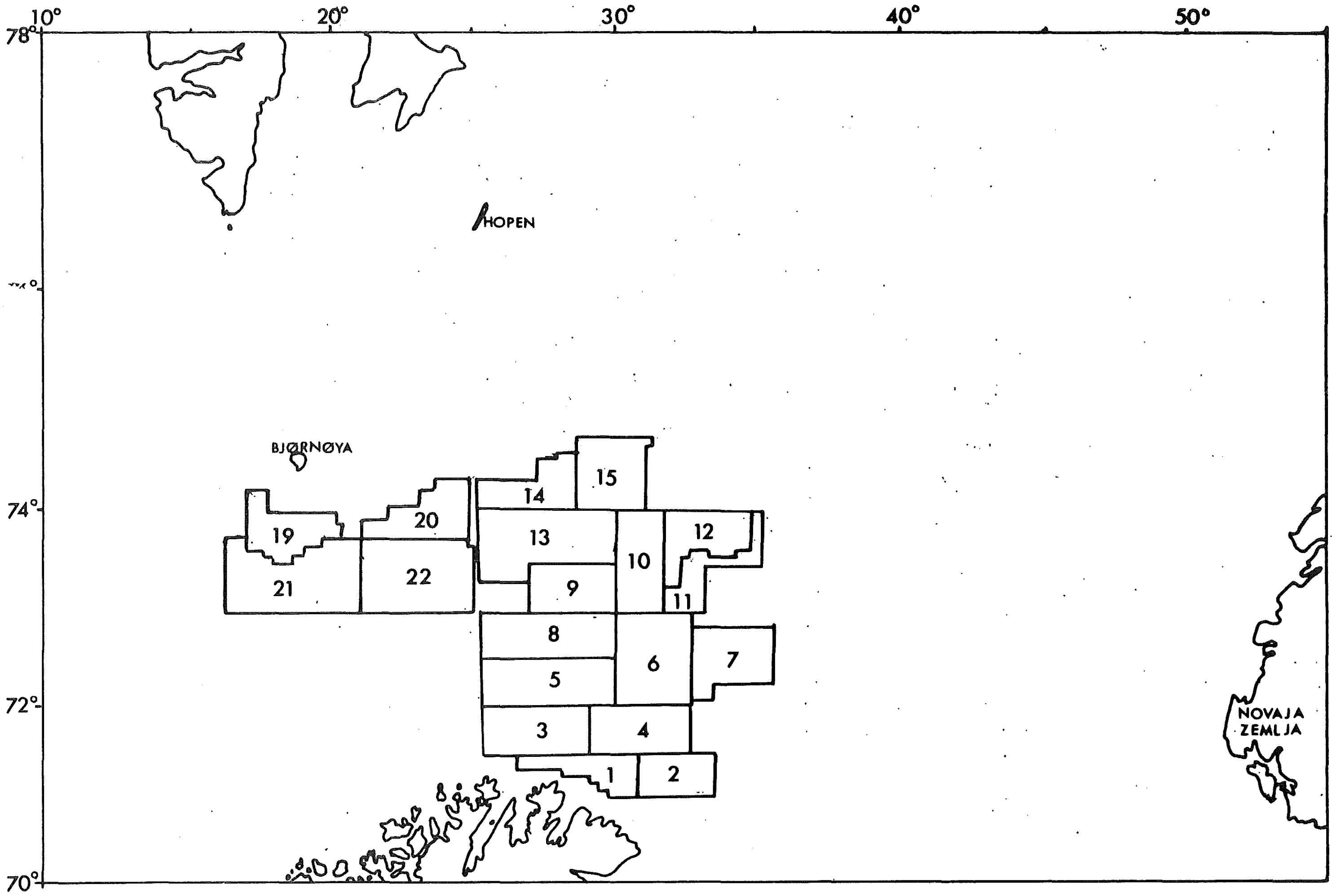

Fig. 1. Sampling strata used in May and June 1981 in the Barents Sea for the shrimp survey with R/V "Michael Sars".

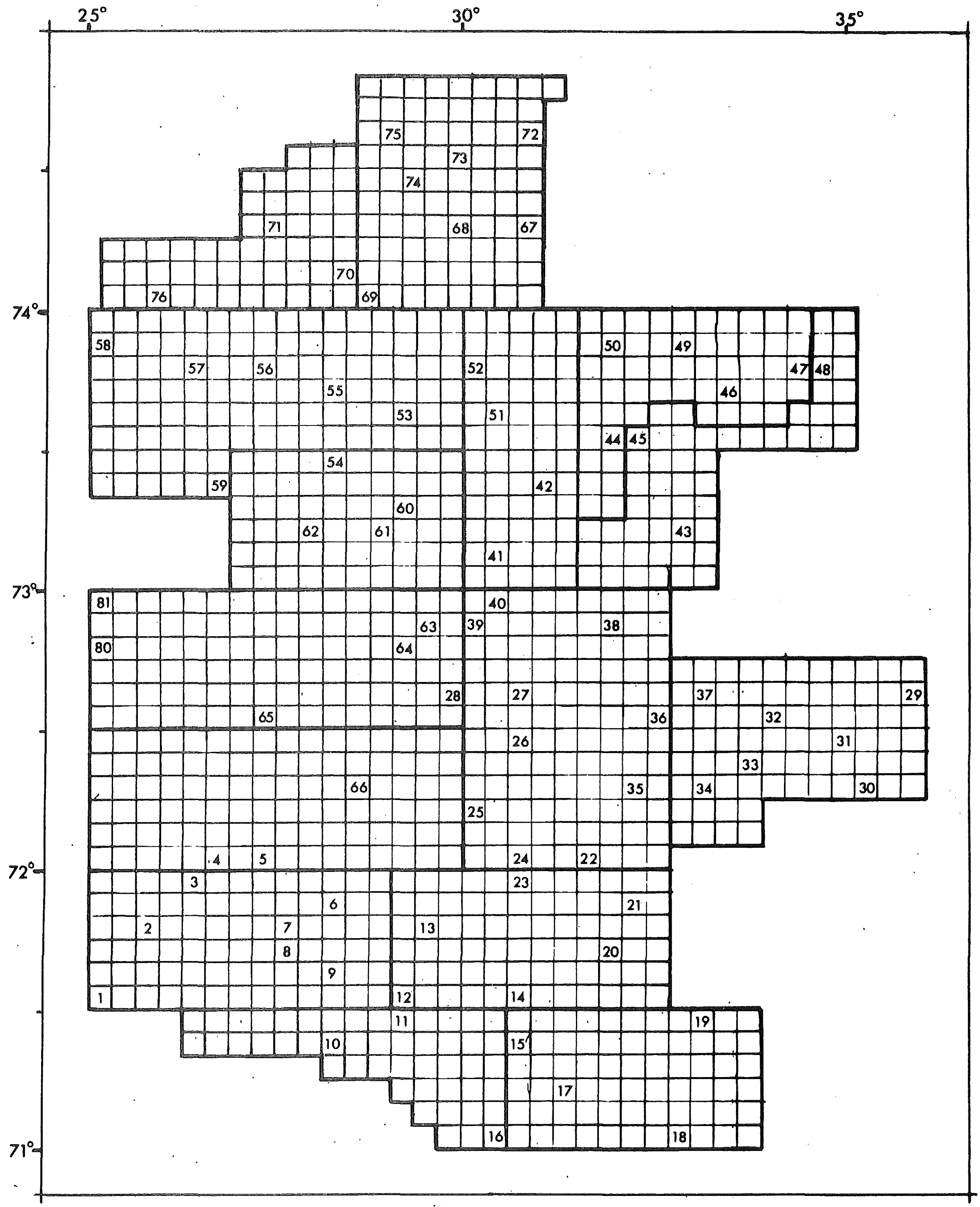

Fig. 2. Strata 1-15 subdivided into rectangles of 5x5 n.m. The rectangles trawled are indicated by station number.

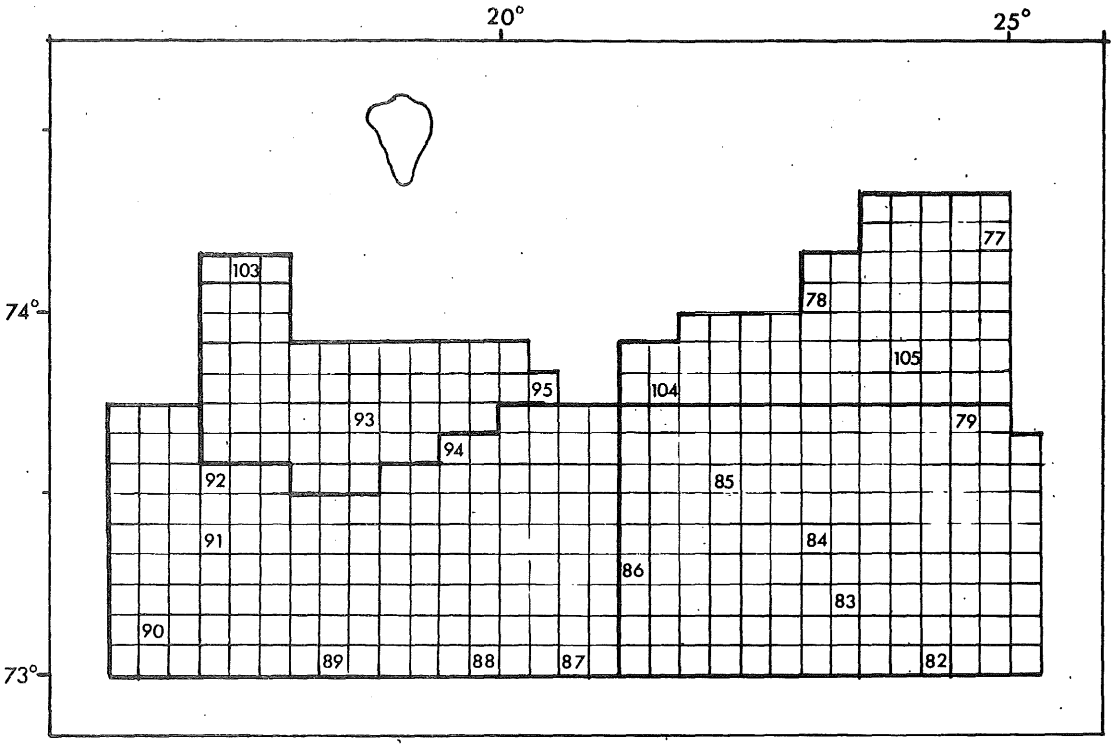

Fig. 3. Strata 19-22 subdivided into rectangles of 5x5 n.m. The rectangles trawled are indicated by station number.

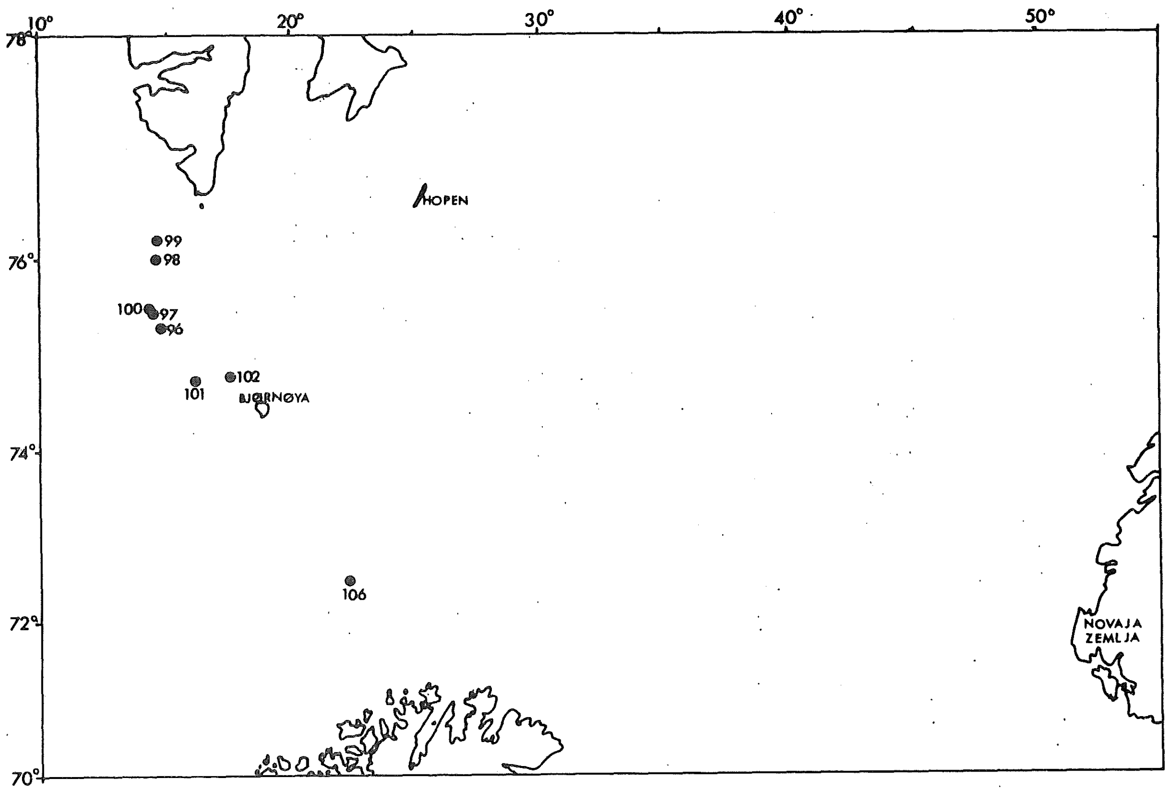

Fig. 4. Trawl stations taken outside the stratified areas. Number refers to station number.