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Results of a stratified bottom trawl survey for shrimps (Pandalus borealis) in the Barents Sea and the Spitsbergen area in May-June 1980

by

Ana Maria Tavares
Instituto Nacional de Investigação das
Pescas - Lisboa - Portugal

and

Per Øynes
Institute of Marine Research
Bergen - Norway

ABSTRACT

A stratified random bottom trawl survey of the shrimp grounds in the Barents Sea and the Spitsbergen area between 71°30'N and 78°18'N, and between 10°05'E and 35°04'E was made in May-June 1980. On the basis of the data from 60 trawling stations, the biomass of shrimps, Pandalus borealis, in the area surveyed was estimated by the swept area method to be about 65 000 tonnes.

The estimate is probably an underestimate due to various reasons discussed.

En Mai-Juin 1980 on a fait dans la mer de Barents et dans la zone de Spitsbergen une recherche sur des crevettes, Pandalus borealis, en usant la méthode d'échantillonage stratifiée au hasard avec un chalutier de recherche. La zone parcourue est comprise entre les 71°30' 78°18' latitude Nord et 10°05' 35°04' longitude Est. À partir des résultats de 60 stations de chalut du fond et usant la méthode de l'aire balayée, on a estimé en 65 mille tones la biomasse de crevettes dans cette zone, L'estimation est peut être le minimum, tenant compte les plusiers remarques que nous présentons.

INTRODUCTION

Since 1970 shrimp surveys have been conducted by the Institute of Marine Research, Bergen, in the Barents Sea and adjacent areas. Stations and sampling intensity were usually decided informally at sea while the surveys were conducted (ANON. 1978).

A stratified random sampling scheme was initiated on a bottom trawl survey with R/V "Michael Sars" from 18 May to 11 June 1980 in the Barents Sea (Sub-area I) and off Spitsbergen (Division IIb).

The main objective was to estimate the abundance and structure of the shrimp population, and estimate sampling errors.

MATERIAL AND METHODS

R/V "Michael Sars" is a stern trawler of 46.5 m length and has a main engine with 1500 horse power. The trawl used was the "Campelen Super" 1800 mesh with the following specifications: 30 m headline, 19 m groundrope, 40 mm mesh size in the body, and 20 mm mesh size in the codend. The boundaries of the strata were selected in accordance with previously known shrimp concentrations (Fig. 1).

The main commercial fishing area since 1977 has been "Thor Iversen banken" (stratum 1). The area outside the Finnmark coast is called "Nordkappleira" (stratum 7). The two grounds north of "Nordkappleira", "Bananbanken" (stratum 5) and "Tiddlybanken" (stratum 3), were the best commercial fishing grounds in 1976 and 1977. The strata 6, 4 and 2 were placed along these two grounds (Fig. 1).

The "Hopen" area (stratum 8) was an important fishing ground in 1974 and 1975. Strata 9, 10, 11, 12 and 13 are along the western slope of "Sentralbanken", and these strata have not been commercially exploited.

Only a short survey time was available for the "Spitsbergen" area. Therefore the strata were traced only for the main fishing areas (strata 15, 16, 18, 19).

The intention was to trawl in all of the 19 strata; however, due to shortage of time stratum 14 and 17 were not covered.

Each stratum was subdivided into rectangles of 5 minutes latitude by 5 minutes longitude. Each rectangle is assumed to be a homogeneous sampling unit. Within each stratum, rectangles are given consecutive numbers starting from 1 (Figs. 1 a,b,c,d).

After fixing total number of trawl stations, the number of stations was 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 allocated to rectangles randomly.

Some stations, especially within stratum 6 and 7, had a rough bottom unsuitable for trawling. In these cases the first nearby rectangle was chosen during the cruise. One tow was repeated in stratum 19 and rectangle 1 due to strong current in the area and crossed doors of the gear during the first trawl haul.

The duration of the trawl was 2 hours with a mean speed of 2.5 knots in the strata 1 to 7, and only one hour trawling with a mean speed of 3 knots in the strata 8 to 19. All the stations

were made during the day time.

The catch of shrimp (in kg) and the number of by-catch of fish in each haul were determined (Table 1).

Computational formulas are taken from Cochran (1977):

$$\bar{c}_k = \frac{\sum_{i=1}^{n_k} c_{ki}}{n_k}$$ mean catch per nautical mile in k^{th} stratum

$$s_k^2 = \frac{1}{n_k - 1} \sum_{i=1}^{n_k} (c_{ki} - \bar{c}_k)^2$$ sample variance of k^{th} stratum

$$\bar{v}(\bar{c}_k) = \frac{s_k^2}{n_k}$$ variance of $\bar{c}_k$ in k^{th} stratum

$$s.e. = \sqrt{v(\bar{c}_k)}$$ standard error of $\bar{c}_k$ in k^{th} stratum

where:

n_k = number of tows in the k stratum

c_{ki} = catch per nautical mile in k^{th} stratum and i^{th} sampling unit.

It is assumed that all shrimps of fishable size present in the area swept by the trawl are caught. It is also assumed that catch per nautical mile trawled ($\bar{c}_k$) is proportional to the density of shrimps within the stratum. The density of shrimps in stratum k as given by the swept area method is,

$$\rho_k = \frac{\bar{c}_k}{a}$$

where a is width covered by the trawl (15 m = 0.0081 n.m.). The biomass of the stock in stratum k is given by

$$B_k = \rho_k \times A_k$$

where A_k is the area of stratum k.

RESULTS AND DISCUSSION

Table 2 gives results in each stratum with the precision of the estimate. The biomass of the shrimp in each stratum is given in Table 3. The biomass in the area surveyed (12 350 square nautical miles) is estimated to be 65 000 tonnes (Table 3). These estimates are of the biomass of shrimps available to a 20 mm mesh size, and they are less than the total biomass of the shrimp population.

For several reasons the trawling speed was not constant from station to station. Therefore catch per nautical mile is assumed to be a more consistent index of biomass than catch per hour trawling in the present survey.

Stratified random sampling permits the control and estimation of sampling errors and avoids the errors which can arise from the selection of stations (Manual on ICNAF Groundfish Surveys, 1978).

The results of this survey are subject to two possible errors:

(i) A persistent error or bias in the method used is possible since it is assumed to be a 100% availability of shrimp to the gear. However, this may not be valid due to possible extensive vertical distribution of shrimps during certain time of the day.

(ii) The random variation of catches at different trawl stations.

The precision of an estimate, expressed by the coefficient of variation (Table 2), indicates the likely size of (ii) while the accuracy refers to the closeness of the estimates to the "true value" and includes both of these possible errors.

The coefficient of variation ranges from 6% to 77% (Table 2). Because of the possible error (i) the stock estimates given in Table 3 are probably underestimates.

REFERENCES

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Table 1. Catches of shrimp and by-catch per haul by R/V "Michael Sars" in May and June 1980 by stratum, time of hauling, distance trawled, position, direction and depth.

Date	Stratum	Square	Time of hauling (hr.)	LOG distance (n.mil)	Position N. lat.	Position E. long.	Direction towed	Depth (m)	Shrimp catch (kg)	By catches (numbers) COD	HADDOCK	REDFISH	Green Halibut	Capelin	Polar cod	Other fish
27/5	1	8	1750-1840	2.5	71°10'.4	31°58'.5	315	315-318	145	-	-	220	9	120	140	233
27/5	1	14	1433-1617	5.0	71°14'.6	32°36'.7	225	297-291	350	-	1	995	32	645	352	882
27/5	1	18	1150-1335	5.0	71°14'.3	32°38'.0	135	298-299	515	1	-	1190	5	1060	545	920
27/5	1	28	0600-0800	5.0	71°54'.4	32°34'.0	225	318-328	200	1	-	348	-	14	840	426
26/5	1	45	0525-0725	5.0	71°35'.4	31°52'.5	345	294-309	190	-	-	627	4	4161	6935	1846
26/5	1	52	1755-1955	2.5	71°55'.0	34°30'.0	315	300-309	25	-	-	-	-	355	2235	230
26/5	1	56	0915-1015	2.5	71°40'.5	34°45'.2	315	268-288	100	-	-	14	-	217	8184	365
26/5	1	62	1125-1325	5.0	71°45'.6	34°50'.0	045	296-281	150							
28/5	2	1	1350-1535	5.0	71°55'.1	30°21'.0	315	338-346	185	-	-	85	4	30	-	743
28/5	2	29	0950-1130	5.0	71°19'.0	30°57'.0	225	380-391	307	-	-	75	14	30	230	843
28/5	2	61	0555-0738	5.0	71°54'.8	31°50'.5	225	342-342	91	-	-	74	2	30	590	262
7/6	2	75	0552-0712	5.0	73°14'.6	32°19'.4	130	270-270	285	1	1	420	1	420	2765	1435
27/5	2	79	0708-1040	5.0	71°54'.4	32°34'.0	225	318-328	210	-	-	213	10	20	500	311
25/5	3	12	0522-0717	5.0	72°29'.1	33°17'.5	135	295-288	110	-	-	-	1	230	2330	1203
24/5	3	23	1812-1912	2.5	72°39'.4	33°35'.4	135	289-300	70	-	-	-	1	201	1155	594
25/5	3	31	0905-1105	5.0	72°13'.0	34°13'.0	135	281-277	55	-	-	-	-	506	7095	836
25/5	3	48	1300-1500	5.0	72°30'.7	34°39'.8	045	280-285	14	-	-	-	-	1062	5706	684
25/5	3	60	1600-1800	5.0	72°34'.5	35°21'.0	135	274-262	27	-	-	-	-	1404	4113	407
23/5	4	20	1245-1445	5.0	72°05'.5	31°02'.0	045	317-317	370	15	-	5	8	11	-	1379
23/5	4	39	1540-1740	5.0	72°15'.5	31°22'.5	045	300-290	255	11	-	4	1	67	-	1278
24/5	4	47	0915-1115	5.0	72°35'.0	31°38'.0	135	282-264	280	5	-	-	1	120	100	807
24/5	4	51	1300-1500	5.0	72°50'.2	31°39'.6	045	255-250	130	-	-	-	1	100	120	1206
25/5	4	60	0525-0725	5.0	72°19'.9	32°08'.1	315	308-301	280	2	-	4	1	65	-	757
21/5	5	1	1610-1805	5.0	71°54'.2	30°31'.5	135	350-358	215	9	4	10	5	-	-	214
21/5	5	9	1955-2155	5.0	72°00'.8	30°57'.0	315	326-312	170	15	-	17	27	34	-	1110
21/5	5	11	1925-2125	5.0	71°30'.0	30°41'.0	045	344-340	225	39	2	75	12	-	-	558
22/5	5	13	0520-0720	5.0	71°49'.0	31°01'.5	135	315-323	195	15	-	42	6	-	-	262
21/5	6	3	0915-1115	5.0	71°41'.0	29°25'.0	045	346-318	350	16	66	1078	2	-	-	408
21/5	6	20	1240-1440	5.0	71°50'.7	29°12'.6	045	300-302	230	75	22	220	-	-	-	135
22/5	6	39	1000-1200	5.0	71°30'.7	30°23'.0	045	294-316	220							
22/5	6	47	1415-1530	2.5	71°40'.4	31°23'.0	045	325-320	95	7	2	17	4	11	-	151
22/5	6	51	1650-1845	5.0	71°35'.8	31°12'.5	045	320-311	165	15	12	20	1	17	-	138
23/5	6	60	0520-0715	5.0	71°45'.8	32°02'.7	045	325-306	105	7	-	33	1	28	-	662
20/5	7	1	0850-1050	5.0	71°16'.1	26°46'.0	045	346-332	310	7	20	185	2	-	-	205
20/5	7	3	0525-0721	5.0	71°16'.1	26°45'.8	045	352-372	280	12	12	739	8	-	-	59
20/5	7	7	1150-1350	5.0	71°14'.1	27°02'.0	135	358-375	150	11	6	260	7	-	-	105
20/5	7	9	1500-1655	5.0	71°15'.8	27°17'.5	045	349-331	210	3	13	410	3	-	-	243
20/5	7	16	1745-1945	5.0	71°49'.4	27°31'.8	135	330-331	160	9	9	1170	9	-	-	240
21/5	7	20	0530-0730	5.0	71°33'.8	27°49'.6	135	375-389	400	16	9	1216	4	-	-	91
5/6	8	1	0451-0551	1.0	75°55'.4	30°03'.0	040	310-317	2	-	-	24	-	456	16200	61
5/6	8	10	0912-0912	1.0	75°53'.5	31°21'.0	135	325-323	15	-	-	32	1	210	17550	110
5/6	8	4	1145-1245	1.0	75°29'.3	31°36'.0	225	355-351	85	-	-	25	-	270	1145	475
5/6	8	7	1415-1515	1.0	75°23'.0	32°01'.0	140	325-316	60	-	-	56	-	20	22935	140
5/6	12	2	1840-1940	1.0	75°12'.8	30°58'.0	270	365-372	105	1	-	229	3	294	1520	320
5/6	12	6	1618-1718	1.0	75°14'.0	31°33'.8	235	347-354	100	-	-	50	-	140	3800	435
6/6	11	1	0553-0642	2.5	75°08'.0	30°28'.0	135	372-384	60	-	-	14	4	49	650	140
6/6	11	6	0800-0900	1.0	74°04'.6	31°33'.0	115	365-357	108	-	-	48	-	120	1640	408
6/6	12	4	1050-1150	1.0	74°49'.3	30°35'.0	225	376-377	150	-	-	53	-	64	864	145
6/6	12	6	1243-1343	1.0	74°44'.0	30°45'.7	135	362-329	175	-	-	-	-	90	850	327
6/6	13	1	1819-1910	1.0	74°34'.7	29°09'.0	305	380-378	60	-	-	139	13	126	1080	254
6/6	13	7	1536-1636	1.0	74°33'.6	30°00'.0	220	362-374	120	-	-	91	9	182	610	463
2/6	15	4	1552-1652	1.0	78°04'.0	12°17'.5	135	253-248	105	-	-	16	150	-	720	4485
2/6	15	3	1735-1835	1.0	78°30'.0	12°31'.6	239	245-245	400	-	-	147	231	126	6783	8141
2/6	16	1	1140-1240	1.0	78°16'.1	10°24'.0	300	324-308	75	5	-	52	19	-	27	818
2/6	16	2	0950-1050	1.0	78°11'.0	13°48'.0	285	294-308	90	45	-	83	39	20	30	3276
1/6	18	2	2025-2125	1.0	75°57'.0	15°51'.0	315	370-369	33	4	-	68	9	5	325	707
4/6	18	13	0625-0725	1.0	75°59'.2	16°45'.0	135	333-329	450	14	-	98	147	5	440	1492
1/6	19	20	1710-1810	1.0	75°46'.0	17°19'.0	315	253-289	325	9	-	135	116	40	53	287
1/6	19	1	1100-1200	2.5	74°49'.0	16°08'.0	090	340-328	30	3	-	4895	1	-	-	223
1/6	19	3	0555-0645	2.5	74°49'.0	17°29'.5	270	300-302	153	-	-	27	11	-	-	1344

TABLE 2. Mean catch per nautical mile of shrimp on Barents Sea and Spitsbergen area in May-June 1980, and estimates of precision.

Locality	Samplings units	Numbers of Hauls	Mean catch per n.mile $\bar{c}_k$ (kg/n.m)	Sample variance s_k^2	Sampling variance $v(\bar{c}_k)$	Coefficient of variation s.e./$\bar{c}_k$
Thor Iversen (1)	64	8	48.13	852.13	106.62	.21
Out Thor Iversen (2)	98	5	43.12	296.63	59.33	.18
Tiddly (3)	62	5	13.84	117.07	23.41	.35
Out Tiddly (4)	85	5	48.60	163.80	32.76	.12
Banan (5)	16	4	39.75	26.25	6.56	.06
Nav Vardø (6)	63	6	48.00	209.20	34.87	.12
Nordkappleira (7)	24	6	50.33	373.47	62.24	.16
Hopen (8)	10	2	2.83	9.39	4.69	.77
W. Sentralbanken (9)	8	2	24.17	34.72	17.36	.17
W. Sentralbanken (10)	8	2	34.17	1.39	.69	.02
W. Sentralbanken (11)	8	2	30.00	72.00	36.00	.20
W. Sentralbanken (12)	6	2	54.17	34.72	17.36	.08
W. Sentralbanken (13)	8	2	30.00	200.00	100.00	.33
Isfjordrenna (15)	5	2	99.17	2334.72	1167.36	.34
W. Forlandet (16)	3	2	27.50	12.50	6.25	.09
Storfjordrenna (18)	21	3	89.78	5088.48	1696.16	.46
Kveithola (19)	5	2	36.60	1210.32	605.16	.67

TABLE 3. Mean catch per nautical mile, biomass and standard error of the biomass of shrimp on Barents Sea and Spitsbergen area in May-June 1980. "Michael Sars" survey.

Locality	Area (sq. n.m.)	Mean catch per. n.m.	Biomass (t)	Standard error of the biomass
Thor Iversen (1)	1600	48.13	9508	2038.70
Out Thor Iversen (2)	2450	43.12	13044	2329.29
Tiddly (3)	1550	13.84	2464	926.38
Out Tiddly (4)	2125	48.60	12751	1500.73
Banan (5)	400	39.75	1963	126.42
Nav Vardø (6)	1575	48.00	9334	1147.30
Nordkappleira (7)	600	50.33	3728	584.42
Hopen (8)	250	2.83	87	66.71
W. of Sentralbanken (9)	200	24.17	597	103.00
W. of Sentralbanken (10)	200	34.17	843	20.48
W. of Sentralbanken (11)	200	30.00	741	148.20
W. of Sentralbanken (12)	150	54.17	1003	77.21
W. of Sentralbanken (13)	200	30.00	741	247.00
Isfjordrenna (15)	125	99.17	1531	527.52
W. of Forlandet (16)	75	27.50	255	23.18
Storfjordrenna (18)	525	89.78	5820	2669.50
Kveithola (19)	125	36.60	565	379.75
TOTAL	12350		65160	

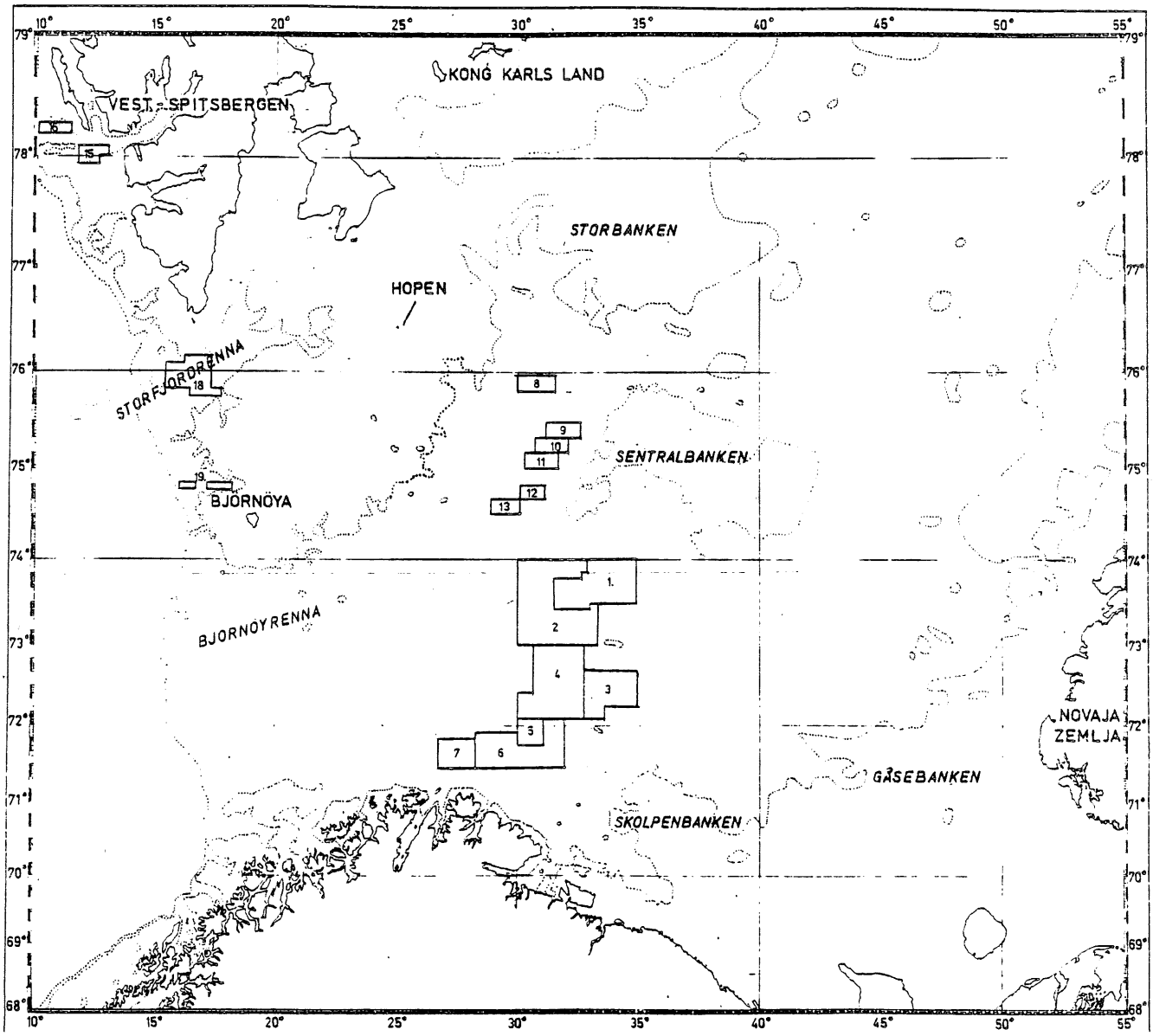

Fig. 1. Sampling strata used in May and June 1980 in the Barents Sea and Spitsbergen areas for the shrimp survey with R/V "Michael Sars".

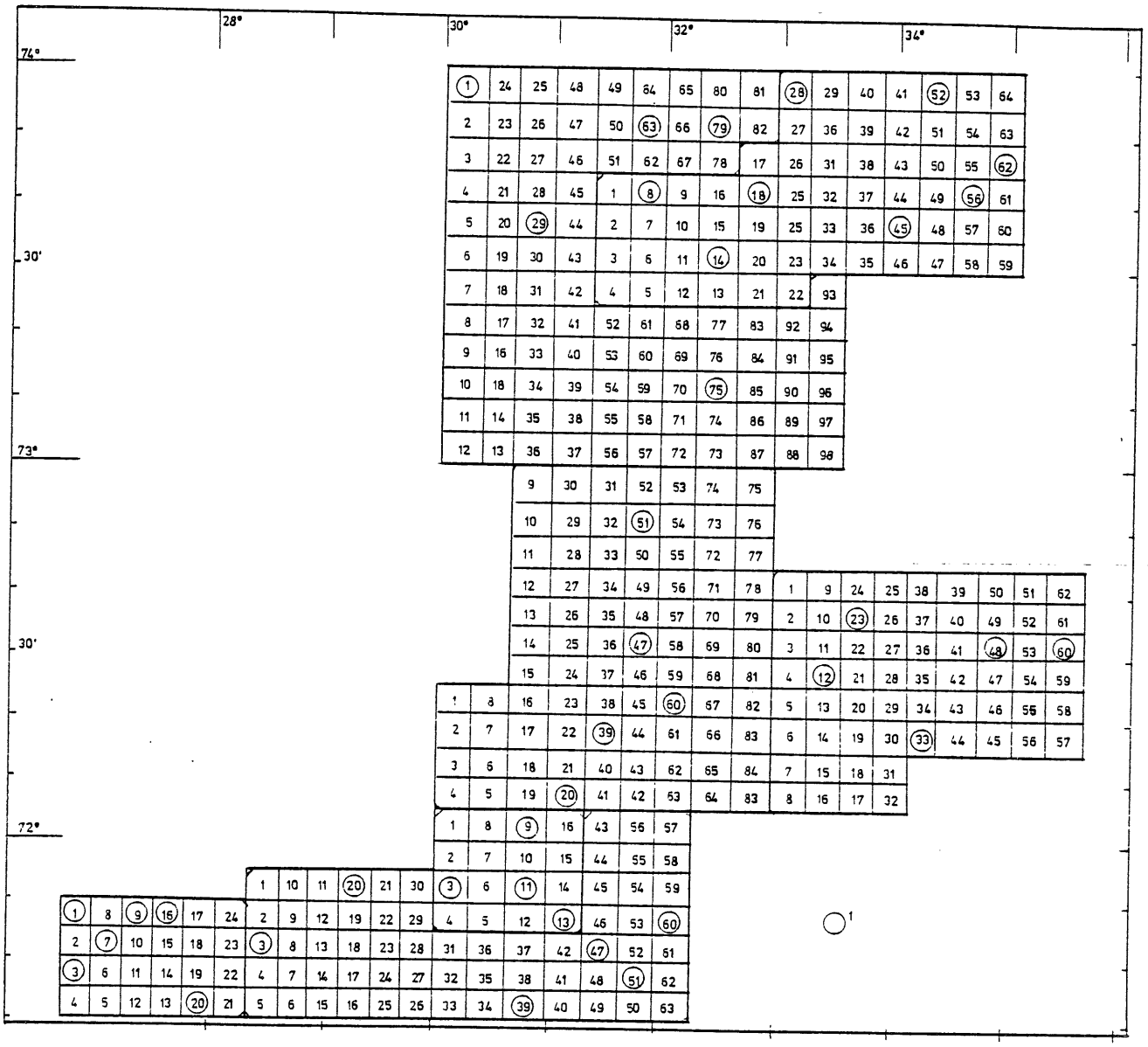

Fig. 1a. Strata 1 to 7 subdivided into 5'x5' rectangles.
Legend: 1= trawl station.

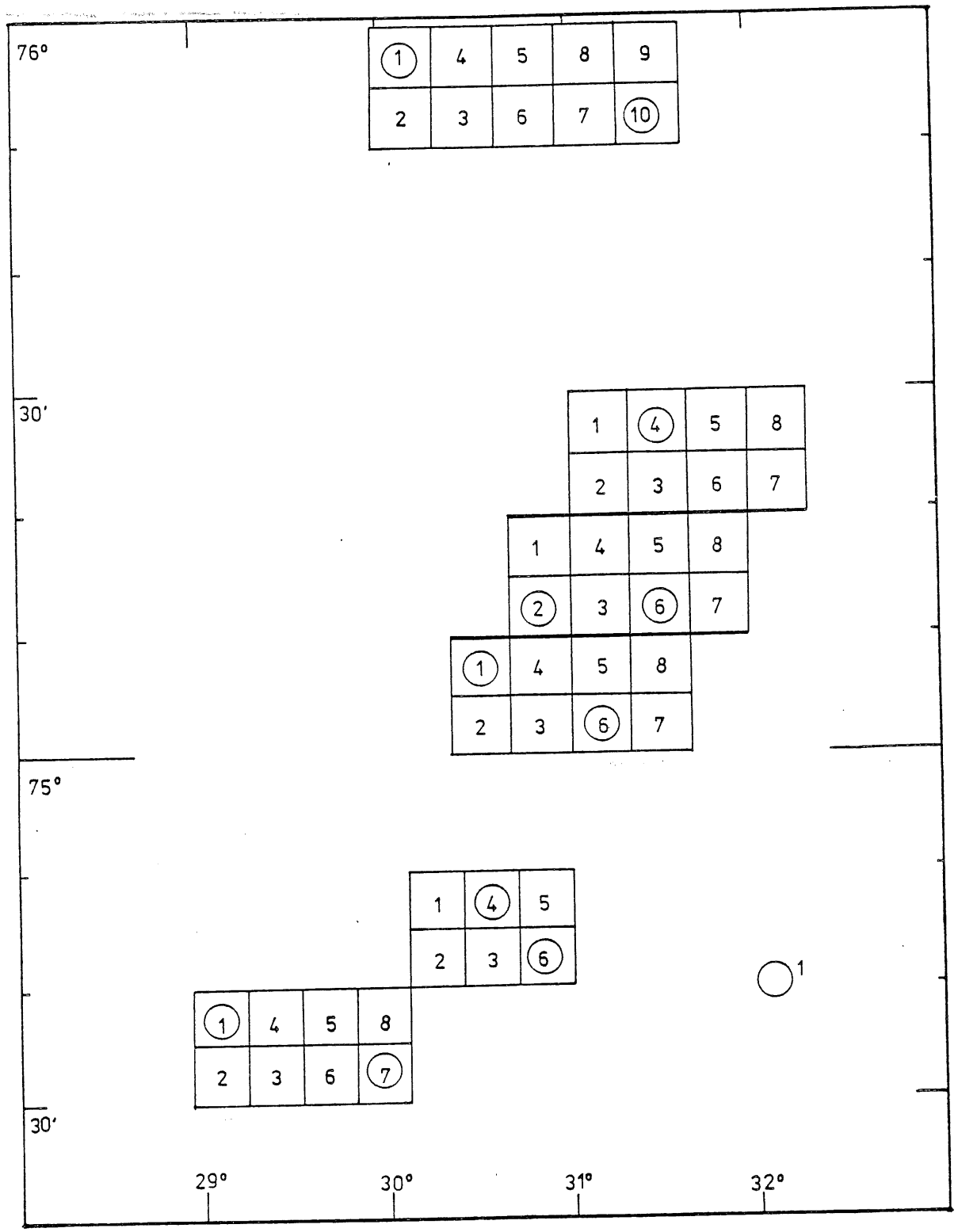

Fig. 1b. Strata 8 to 13 subdivided into 5'x5' rectangles.
Legend: 1= trawl station.

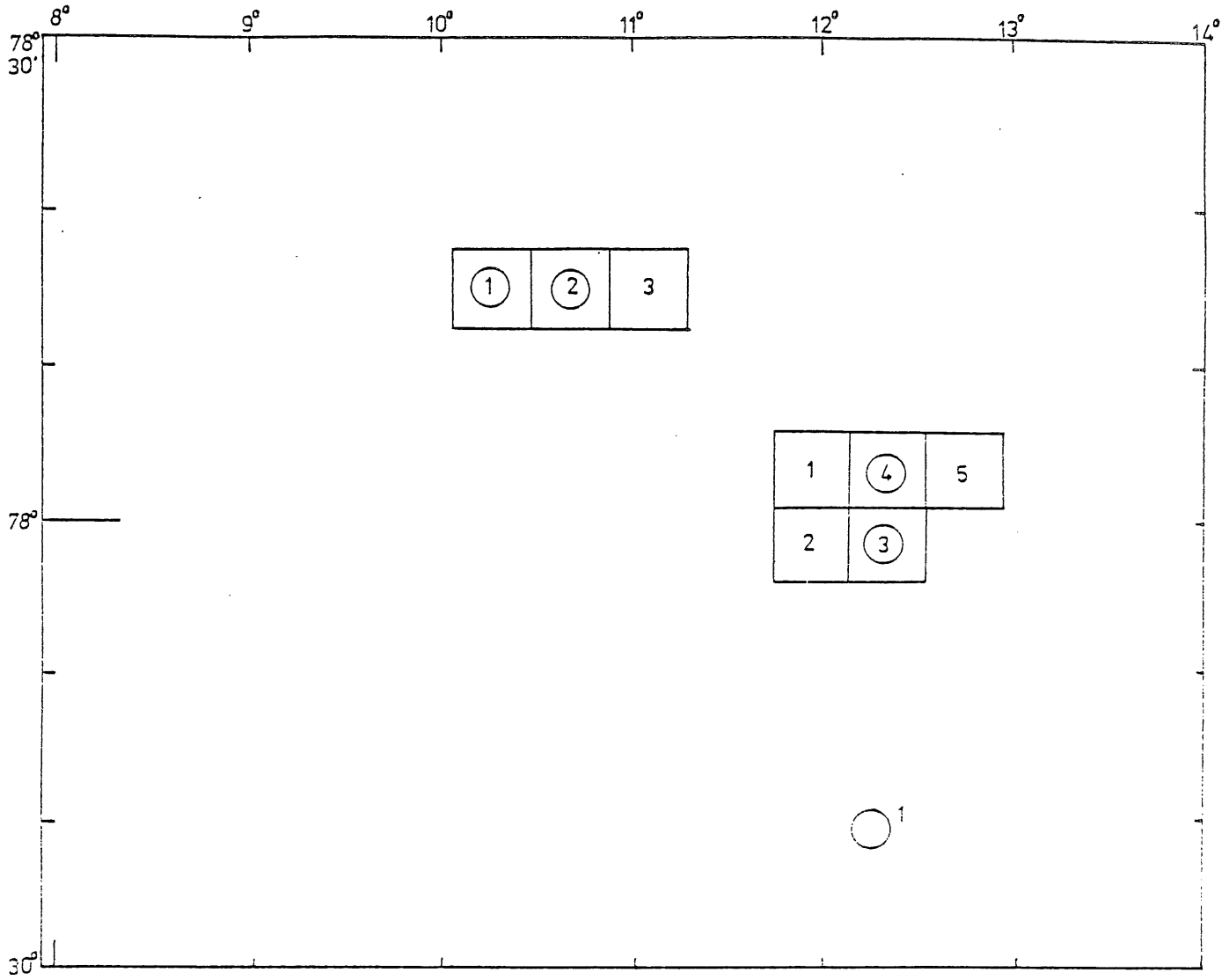

Fig. 1c. Strata 15 and 16 subdivided into 5'x5' rectangles.
Legend: 1= trawl station.

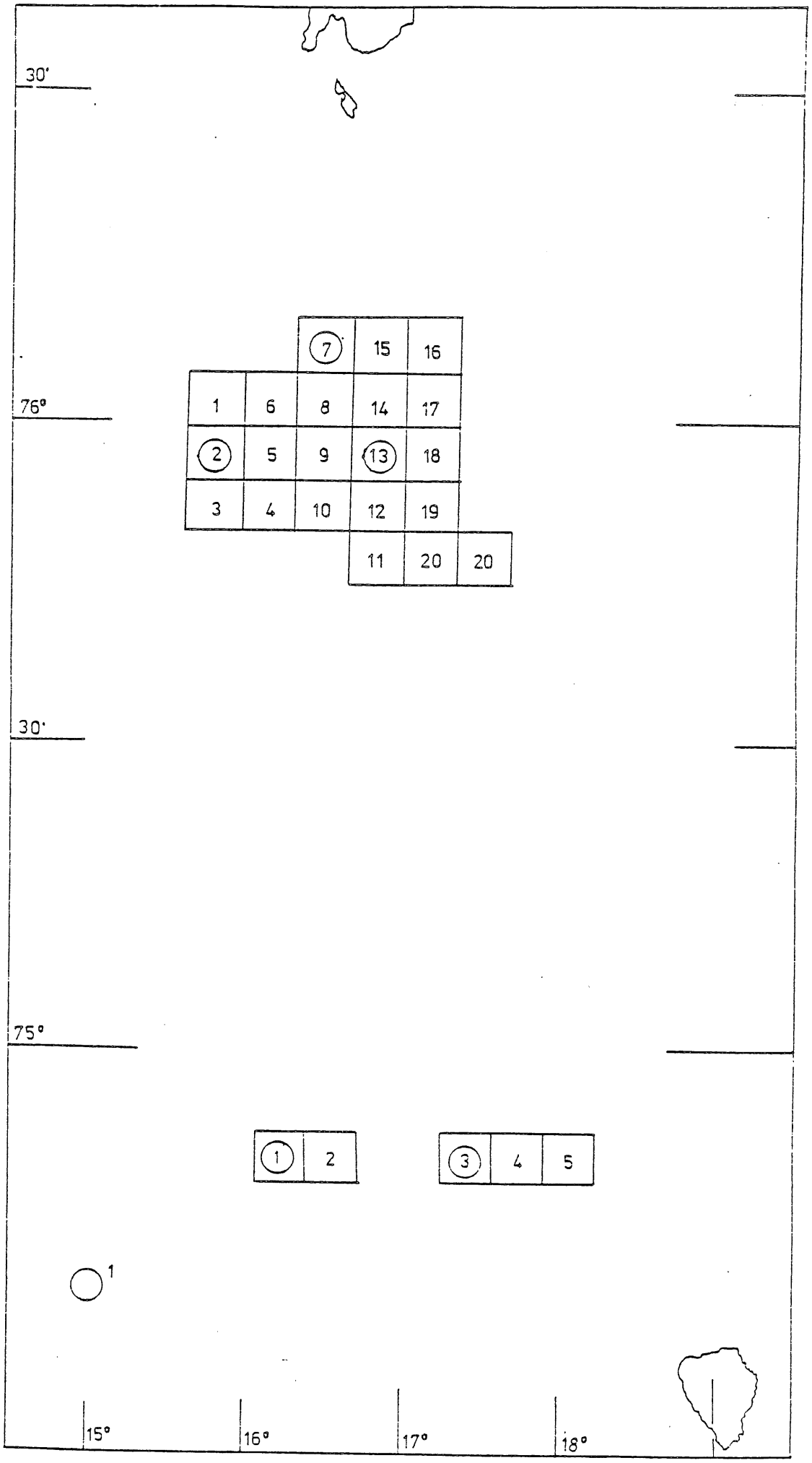

Fig. 1d. Strata 18 and 19 subdivided into 5'x5' rectangles. Legend: 1= trawl station.