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Biomass of shrimp (*Pandalus borealis*) in NAFO Subarea 1 in 1981-84, estimated by means of bottom photography

by

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ABSTRACT

Data for shrimp stock assessment in NAFO SA1 was sampled on a photographic survey in July-August 1984 as a continuation of earlier sampling of that kind. The material from this survey is analyzed together with similar data from the years 1977-83 to produce biomass estimates for the shrimp stock. The size distribution of shrimp in the photographic material is discussed, and estimates for the total biomass in the area 66°00´N-69°30´N are given in the paper.

INTRODUCTION

Since 1977 regular sampling of data on shrimp abundance has been carried out during July-August in part of NAFO SA1. Data from the 1984 survey is presented in this paper, and biomass estimates for 1981-84 are given, based on a shrimp abundance model introduced earlier.

The principles for the model used in the present paper are the same as for the original model. The combinations of variables used for describing the biomass dependency, however, have been changed substantially from year to year in the use of this model. By including values for sea temperature up to four years before the photographic sampling the time series for the model runs is limited to cover only four sampling years (1981-84). Data from the whole period of sampling (1977-84), however, is given in terms of density and size distribution.

MATERIAL AND METHODS.

This paper updates earlier works concerning estimation of shrimp biomass based on bottom photography.

The sampling sites in the 1984 survey have been the same as occupied through the years 1977-83 (Figs. 1 and 2). A total of 36 stations were sampled in 1984, and 5359 photographs have been analyzed from this

year. As a result of earlier discussions in the working group on the availability of size grouping the shrimp on the photographs, a new reading of the whole material (in all 22128 photographs) has been commenced. Most of the work has bee done, only analysis of the material from 1982 and 1983 remains. The new analysis classifies the shrimp into five size groups, while the earlier method used three groups. Biomass calculations in the old method were based on fixed mean weights in the groups. The mean weights in the new groups are calculated for each sampling station based on the actual size distribution of the shrimp and the following relationships:

$$\text{weight} = 0.003548 \times \text{carapace-length}^{2.44}$$

(Carlsson, pers.com.) and

$$\text{carapace-length} = 10.67 + 0.8333 \times \text{screen-length}.$$

´Screen length´ is a certain measure for shrimp size as detected on the photographic reading screen and agreed among the readers.

A listing of the material from the re-analysis (1977-81) and from the recent survey is given in Table 1. The size distribution and the calculated mean weights in the groups are also shown in the tabel. The size groups are described ad follows:

Category	´Screen length´, mm	Carapace length, mm
Group 1	< 7	< 16.5
Group 2	> 7 and < 10	> 16.5 and < 19.0
Group 3	> 10 and < 14	> 19.0 and < 22.3
Group 4	> 14 and < 18	> 22.3 and < 25.7
Group 5	> 18	> 25.7

The model used for estimating the biomass dependency of various parameters is essential the same as was described by Jørgensen & Kanneworff (1980). Only the different parameters, their squares and interactions have been changed and tested for their descriptive value during the years in which the model has been in use. The present model (which was also used in Kanneworff, 1984) includes the following parameters:

> Year, depth, latitude, longitude, bottom temperature at the time of sampling, July bottom temperatures two and three years earlier at the sampling site, and finally, mean July temperatures in the depth zone 0-50 meters in the area west of the banks in the Davis Strait four years earlier.

The photographic sampling covers the years 1977-84, but due to scarcity of hydrographic observations, runs with the present model are limited to the period 1981-84. The input data for the model is unfortunately based on partly the old reading of the photographs (1982 and 1983) and partly the new (1981 and 1984); however, the difference in the average biomass indices between the old and the new reading is not significant (only about 2 % lower in the new).

New information on bottom temperatures for 1984 (Fig. 10) has been provided by Erik Buch (pers. com.), and has been used in calculations of the biomass estimates.

Model runs including all the above mentioned parameters, their squares and interactions produced a high correlation coefficient ($r^2 = 0.82$), but many of the parameter estimates were not significantly different

from zero, i.e. they could not be assumed to describe the biomass density well enough. After a filtering process, in which parameters were removed one by one, a final shape of the model was chosen with a relatively high correlation coefficient (r^2 = 0.74) and with all remaining parameter estimates significant on the 10 % level (Table 2).

Due to the short time series for the photographic sampling north of 69°30´N (Fig. 2) the model runs and the biomass calculations are limited to the area from 66°00´N to 69°30´N. However, a separate analysis of the data from the northern area (between 69°30´N and 71°00´N) has been carried out on basis of photographs from 1981-84 and of new information on bottom temperatures (Erik Buch, pers.com.). Unfortunately, good information on the topography in this area is only limited, thus making a biomass calculation somewhat doubtful.

RESULTS AND DISCUSSION

Size distribution.

The distributions of shrimp in the five size groups are given for all sampling sites in Table 1. For the years 1982 and 1983 (which have not yet been re-analyzed) the size distributions were given by Kanneworff (1984). Due to the very few size groups in the old reading it is not possible to ´translate´ the old distributions to the new, but roughly the group ´small´ in the old material correspond to the two first groups in the new. In order to describe the development in the size composition of this stock a mean size distribution should be calculated, weighted by the predicted biomass estimates for each sampling site. To do so with a mixed material from the old and new reading has no real value, and the distributions from the different sampling sites must thus be studied one by one.

In Figs. 3 and 4 the size distributions and absolute densities are shown from four sites, which all encounter typical features. The area around KR004 (see map, Fig. 1) has always been one of the most important for the commercial fishery, and the figures might thus reflect the size composition of the most exploited part of the stock. The area KZ014 has in some years been of substantial importance for the fishery, and the catches have normally consisted of larger shrimp. Samples from LE005 have consistently showed a large proportion of small shrimp. In the area around LH014-LJ011 (Godhavn Rende) a high density of small shrimp has remained stable through all the years of sampling.

In all four areas the proportion of small shrimp seems to have been increasing or stable through the years 1979-81. In 1982-84, however, small shrimp are indicated to be less abundant in the area south of 68°N, while this group seems more stable in the northern areas. The abundance of middle sized shrimp seems to have been fairly stable during the years of sampling, and the decrease in total biomass estimate from 1983 to 1984 (as explained below) might thus be due to a reduction in the amount of small shrimp in part of the area.

The time series for the sampling north of 69°30´N is still too short to describe possible changes in the size distribution, but the figures for shrimp density for that area seem to indicate a somewhat lower biomass per areal unit compared to the areas to the south.

Biomass estimates.

By means of a regression model with a reduced sets of parameters an estimate of the biomass dependency of these parameters is calculated (Table 2) for data from the area 66°00´N to 69°30´N covering water depths from 100 to 600 meters. Table 3 shows for each sampling site the observed density of shrimp in terms of number per squaremeter together with the corresponding biomass per squaremeter as calculated by means of the model´s parameter estimates. It is seen, that there is a fairly good correlation between the observed values and those predicted by the model.

Calculation of biomass indices for all relevant strata in the area covered by the sampling is done by inserting local values (year, latitude, longitude, depth, etc.) in the equation used in the model. Total biomass in the strata are obtained by multiplying the biomass indices with the areas of the strata, according to the figures given by Carlsson & Kanneworff, 1979. The overall figures for the whole area in question are given in Table 4 and Fig. 5. An increase in total biomass is noted from 1981 to 1982, followed by a slow decrease through the last three years. The biomass figures are summed up for each 30 minutes latitude strips in order to show a possible north-southward shift in the distribution. However, the figures do not indicate any drastic changes of that kind but show only a small increase in biomass in the area 67-68°N from 1981 to 1982, followed by a similar reduction from 1982 to 1984.

If, however, the biomass indices for all strata are plotted on maps for each year (Figs. 6-9), it can be seen that some concentration of the biomass might have taken place in the northeastern areas in 1983-84. At the same time a reduction of the biomass is indicated in the westernmost areas and in Holsteinsborg Dyb. During all four years the deep water (> 400 m) seem to be of low importance.

A biomass estimate for the northern area (69°30´N to 71°00´N) is still not possible to develop on basis of a regression analysis similar to that described above, because of the short time series of sampling and hydrographic observations. The observed densities of shrimp in this area seems to indicate somewhat lower biomass indices. The total biomass might thus be within the range of 40 to 60 thousand tons.

CONCLUSION

Data from photographic sampling in the period 1977-84 has been examined, and biomass of shrimp in the area 66°00´N to 69°30´N is estimated for the years 1981 to 1984. The total biomass for 1984 is estimated to about 220000 tons, which is a small decrease compared to the 1983-estimate. Small shrimp seem to be less abundant in part of the area in 1984, prospecting somewhat lower recruitment than the years before.

REFERENCES

Carlsson, D.M. & P. Kanneworff, 1979. Areas of basic strata in West Greenland, ICNAF/NAFO Subarea 1. ICNAF Res. Doc. 79/XI/11.

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Table 1. List of sampling stations in 1977-81 and 1984. The percentage size distribution and the calculated mean weights are given for the five size groups.

YEAR=1977

OBS	STNO	ARCODE	DEPTH	TEMP	N_OBS	N_1	N_2	N_3	N_4	N_5	N_UM	N1PCT	N2PCT	N3PCT	N4PCT	N5PCT	W1	W2	W3	W4	W5
1	5453	KH006	471	4.6	239	73	6	14	56	13	67	45.06	3.70	8.64	34.57	8.02	2.6	3.6	6.3	8.4	10.3
2	5454	KF006	555	4.3	20	4	1	0	0	3	2	50.00	12.50	0.00	0.00	37.50	2.6	3.7	.	.	11.3
3	5447	KP440	277	2.6	54	2	1	11	14	28	13	3.57	1.79	19.64	25.00	50.00	2.9	4.1	6.0	8.5	11.1
4	5449	KH004	211	2.5	90	10	22	98	65	17	76	4.72	10.38	46.23	30.66	8.02	3.1	4.1	5.9	8.2	10.3
5	5448	KK438	389	3.3	30	0	0	13	6	7	1	0.00	0.00	50.00	23.08	26.92	.	.	5.9	8.3	10.8
6	5446	KT001	351	2.9	8	2	0	4	4	1	0	18.18	0.00	36.36	36.36	9.09	2.6	.	6.0	8.3	10.3
7	5455	KK005	412	3.0	179	112	14	18	35	6	78	60.54	7.57	9.73	18.92	3.24	2.6	3.7	6.1	8.4	10.3
8	5456	KK438	344	2.3	162	25	2	17	14	4	24	42.37	3.39	28.81	23.73	1.69	2.6	3.9	6.0	8.3	10.2
9	5444	KZ012	467	3.0	40	19	2	0	10	16	8	40.43	4.26	0.00	21.28	34.04	2.6	3.5	.	8.6	11.0

YEAR=1978

OBS	STNO	ARCODE	DEPTH	TEMP	N_OBS	N_1	N_2	N_3	N_4	N_5	N_UM	N1PCT	N2PCT	N3PCT	N4PCT	N5PCT	W1	W2	W3	W4	W5
10	5610	JF019	355	3.3	178	36	56	37	103	18	31	14.40	22.40	14.80	41.20	7.20	2.7	4.0	5.9	8.3	10.4
11	5609	KA011	228	1.4	173	106	18	86	67	12	26	36.68	6.23	29.76	23.18	4.15	2.6	3.9	5.9	8.3	10.3
12	5605	KF007	348	3.2	184	0	0	0	0	3	0	0.00	0.00	0.00	0.00	100.00	.	.	.	.	11.5
13	5606	KF008	172	0.9	190	2	4	24	8	2	20	5.00	10.00	60.00	20.00	5.00	3.2	4.1	5.8	8.1	10.2
14	5602	KK004	395	3.4	130	0	0	5	12	27	2	0.00	0.00	11.36	27.27	61.36	.	.	6.1	8.6	11.1
15	5604	KK006	255	1.4	115	0	1	7	13	1	7	0.00	4.55	31.82	59.09	4.55	.	4.5	6.0	8.3	10.2
16	5603	KK008	121	0.5	126	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
17	5601	KR004	244	3.0	160	6	28	92	55	17	140	3.03	14.14	46.46	27.78	8.59	3.2	4.1	5.8	8.2	10.4
18	5612	KV002	423	4.1	57	8	1	10	13	4	3	22.22	2.78	27.78	36.11	11.11	2.6	4.0	6.0	8.3	10.4
19	5613	KZ002	326	3.6	162	288	151	138	116	17	46	40.56	21.27	19.44	16.34	2.39	2.7	3.9	5.8	8.2	10.3
20	5614	LB003	331	0.5	33	1	2	7	6	2	6	5.56	11.11	38.89	33.33	11.11	3.0	4.1	5.9	8.2	10.4

YEAR=1979

OBS	STNO	ARCODE	DEPTH	TEMP	N_OBS	N_1	N_2	N_3	N_4	N_5	N_UM	N1PCT	N2PCT	N3PCT	N4PCT	N5PCT	W1	W2	W3	W4	W5
21	5739	KN003	243	2.9	33	0	1	1	3	1	8	0.00	16.67	16.67	50.00	16.67	.	4.2	6.0	8.3	10.5
22	5740	KR004	263	2.7	14	27	39	32	12	0	63	24.55	35.45	29.09	10.91	0.00	2.9	4.0	5.7	7.9	.
23	5734	KV007	234	2.4	6	0	1	6	2	0	1	0.00	11.11	66.67	22.22	0.00	.	4.1	5.8	8.1	.
24	5741	KX014	259	3.0	3	1	0	2	1	2	2	16.67	0.00	33.33	16.67	33.33	2.5	.	6.1	8.3	10.5
25	5744	KX438	335	3.2	5	1	0	1	0	0	0	50.00	0.00	50.00	0.00	0.00	2.7	.	5.8	.	.
26	5742	KZ012	464	4.1	11	1	1	1	6	2	1	9.09	9.09	9.09	54.55	18.18	2.5	4.5	6.1	8.3	10.5
27	5743	LB005	322	3.2	10	35	4	5	1	0	0	77.78	8.89	11.11	2.22	0.00	2.6	3.7	5.7	8.5	.
28	5738	LE005	217	1.8	9	10	8	8	10	0	8	27.78	22.22	22.22	27.78	0.00	2.7	4.0	5.8	8.2	.
29	5737	LJ011	260	2.1	45	36	88	48	35	2	41	17.22	42.11	22.97	16.75	0.96	3.0	4.0	5.7	7.9	10.9

YEAR=1980

OBS	STNO	ARCODE	DEPTH	TEMP	N_OBS	N_1	N_2	N_3	N_4	N_5	N_UM	N1PCT	N2PCT	N3PCT	N4PCT	N5PCT	W1	W2	W3	W4	W5
30	5855	KP440	284	1.7	31	0	2	5	0	1	11	0.00	25.00	62.50	0.00	12.50	.	4.1	5.6	.	11.4
31	5856	KR004	208	1.4	162	59	38	48	28	2	72	33.71	21.71	27.43	16.00	1.14	2.7	4.0	5.8	8.1	10.2
32	5867	KT001	350	3.5	40	30	80	254	149	25	59	5.58	14.87	47.21	27.70	4.65	3.1	4.1	5.8	8.2	10.3
33	5868	KV002	410	2.8	108	127	110	68	32	7	22	36.92	31.98	19.77	9.30	2.03	2.7	3.9	5.6	8.0	10.7
34	5857	KV007	238	1.9	47	19	4	4	1	0	31	67.86	14.29	14.29	3.57	0.00	2.6	3.8	5.6	8.3	.
35	5872	KZ002	345	3.2	151	679	208	76	46	0	81	67.29	20.61	7.53	4.56	0.00	2.6	3.8	5.5	8.4	.
36	5860	KZ012	466	3.8	178	19	7	29	25	1	11	23.46	8.64	35.80	30.86	1.23	2.6	4.0	5.9	8.2	10.2
37	5859	KZ014	270	1.7	106	32	41	113	70	10	107	12.03	15.41	42.48	26.32	3.76	2.9	4.1	5.8	8.2	10.2
38	5866	LA438	323	3.2	167	0	0	1	13	8	12	0.00	0.00	4.55	59.09	36.36	.	.	6.3	8.4	10.7
39	5858	LB005	319	2.3	37	66	22	12	23	6	17	51.16	17.05	9.30	17.83	4.65	2.6	3.8	5.9	8.3	10.3
40	5861	LD012	259	0.7	61	12	16	62	61	2	16	7.84	10.46	40.52	39.87	1.31	2.7	4.1	5.9	8.2	10.2
41	5871	LD439	329	3.1	90	1	1	6	2	0	6	10.00	10.00	60.00	20.00	0.00	3.1	4.1	5.8	8.1	.
42	5862	LE005	243	0.7	82	118	133	79	77	12	112	28.16	31.74	18.85	18.38	2.86	2.7	4.0	5.7	8.1	10.4
43	5870	LH004	203	1.9	30	0	2	15	8	3	17	0.00	7.14	53.57	28.57	10.71	.	4.1	5.8	8.2	10.4
44	5863	LH014	260	1.4	112	19	225	455	141	10	117	2.24	26.47	53.53	16.59	1.18	3.2	4.1	5.7	8.0	10.1
45	5869	LJ440	288	2.2	69	0	1	157	74	4	64	0.00	0.42	66.53	31.36	1.69	.	4.2	5.9	8.2	10.2
46	5865	LJ011	256	1.8	190	605	778	406	173	24	103	30.46	39.17	20.44	8.71	1.21	2.8	4.0	5.6	7.7	11.5

YEAR=1981

OBS	STNO	ARCODE	DEPTH	TEMP	N_OBS	N_1	N_2	N_3	N_4	N_5	N_UM	N1PCT	N2PCT	N3PCT	N4PCT	N5PCT	W1	W2	W3	W4	W5
47	6022	JL020	378	0.2	84	9	176	257	64	17	41	1.72	33.65	49.14	12.24	3.25	3.2	4.1	5.7	7.9	10.9
48	6023	KA011	218	0.8	180	16	62	99	23	1	161	7.96	30.85	49.25	11.44	0.50	3.1	4.0	5.7	7.9	10.0
49	6021	KF007	502	3.6	180	1	2	21	13	3	27	2.50	5.00	52.50	32.50	7.50	3.2	4.1	5.9	8.2	10.3
50	6020	KL006	206	1.4	104	17	21	6	1	0	15	37.78	46.67	13.33	2.22	0.00	2.8	3.9	5.5	7.1	.
51	6019	KP440	281	1.8	101	20	19	29	29	11	56	18.52	17.59	26.85	26.85	10.19	2.7	4.0	5.8	8.2	10.5
52	6024	KR004	218	0.2	191	311	346	134	63	14	422	35.83	39.86	15.44	4.26	1.61	2.8	3.9	5.6	7.6	11.0
53	6031	KT001	347	3.2	192	31	70	221	196	4	106	5.94	13.41	42.34	37.55	0.77	2.9	4.1	5.9	8.2	10.2
54	6030	KT436	280	2.5	195	0	0	13	268	10	94	0.00	0.00	4.47	92.10	3.44	.	.	6.3	8.3	10.2
55	6033	KV002	411	3.0	172	310	25	77	55	3	19	65.96	5.32	16.38	11.70	0.64	2.6	3.7	6.0	8.4	10.2
56	6029	KX438	347	2.8	148	1	16	49	32	7	21	0.95	15.24	46.67	30.48	6.67	3.2	4.1	5.8	8.2	10.3
57	6034	KZ003	340	2.7	169	125	118	203	155	16	29	20.26	19.12	32.90	25.12	2.59	2.7	4.0	5.8	8.2	10.2
58	6026	KZ012	470	0.2	186	6	28	37	81	21	68	3.47	16.18	21.39	46.82	12.14	2.6	4.2	5.9	8.3	10.4
59	6025	KZ015	278	0.2	171	492	323	347	158	18	260	36.77	24.14	25.93	11.81	1.35	2.7	3.9	5.7	8.1	10.2
60	6028	LB005	326	2.4	165	160	170	81	76	16	31	31.81	31.80	16.10	15.11	3.18	2.7	4.0	5.7	8.1	10.7
61	6027	LE005	256	0.2	183	591	548	191	59	8	199	42.30	39.23	13.67	4.22	0.57	2.7	3.9	5.5	7.4	12.0
62	6036	LH014	253	0.4	147	113	98	172	52	2	135	25.86	22.43	39.36	11.90	0.46	2.8	4.0	5.7	8.0	10.1
63	6037	LJ011	257	0.9	64	103	211	162	29	1	91	20.36	41.70	32.02	5.73	0.20	3.0	4.0	5.6	7.5	12.1
64	6038	LS014	262	1.1	190	123	218	194	28	3	19	21.73	38.52	34.28	4.95	0.53	2.7	3.9	5.6	8.0	10.1

YEAR=1984

OBS	STNO	ARCODE	DEPTH	TEMP	N_OBS	N_1	N_2	N_3	N_4	N_5	N_UM	N1PCT	N2PCT	N3PCT	N4PCT	N5PCT	W1	W2	W3	W4	W5
65	6713	KA010	227	1.3	87	0	23	45	22	2	34	0.00	25.00	48.91	23.91	2.17	.	4.1	5.8	8.1	10.2
66	6715	KB006	488	2.7	153	2	5	0	0	0	10	28.57	71.43	0.00	0.00	0.00	2.9	4.0	.	.	.
67	6714	KB008	184	1.2	175	0	0	3	1	0	1	0.00	0.00	75.00	25.00	0.00	.	.	5.8	8.1	.
68	6717	KF007	319	2.0	167	8	2	37	35	14	34	8.33	2.08	38.54	36.46	14.58	2.6	4.2	6.0	8.3	10.4
69	6716	KP008	172	1.1	169	0	0	3	0	0	1	0.00	0.00	100.00	0.00	0.00	.	.	5.7	.	.
70	6718	KJ006	455	2.5	167	0	0	0	0	0	6	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
71	6723	KL006	205	1.1	158	2	1	11	1	1	15	12.50	6.25	68.75	6.25	6.25	3.1	4.1	5.7	8.1	10.2
72	6721	KN003	219	1.4	121	60	57	21	3	2	129	47.96	39.86	14.69	2.10	1.40	2.8	3.9	5.5	7.2	12.0
73	6722	KP440	287	1.2	178	5	14	59	25	5	126	4.63	12.96	54.63	23.15	4.63	3.2	4.1	5.8	8.1	10.2
74	6720	KR004	217	1.3	163	31	172	161	20	4	230	7.99	44.33	41.49	5.15	1.03	3.1	4.0	5.6	7.5	12.1
75	6719	KR006	194	1.1	149	791	246	56	5	2	165	71.91	22.36	5.09	0.45	0.18	2.6	3.8	5.2	8.6	10.2
76	6724	KS002	344	2.6	163	45	195	515	96	6	273	5.25	22.75	60.09	11.20	0.70	3.2	4.1	5.7	8.0	10.0
77	6725	KT437	275	1.7	164	1	35	167	29	1	27	0.43	15.02	71.67	12.45	0.43	3.2	4.1	5.7	8.0	10.0
78	6727	KV002	415	2.8	131	24	20	75	42	3	21	14.63	12.20	45.73	25.61	1.83	2.8	4.1	5.8	8.2	10.2
79	6735	KV007	224	1.1	176	10	92	232	51	3	222	2.58	23.71	59.79	13.14	0.77	3.2	4.1	5.7	8.0	10.1
80	6734	KX007	452	2.9	116	1	8	61	38	7	60	0.87	6.96	53.04	33.04	6.09	3.2	4.1	5.9	8.2	10.3
81	6726	KX437	320	2.4	157	0	23	83	5	0	24	0.00	20.72	74.77	4.50	0.00	.	4.1	5.7	7.9	.
82	6728	KZ002	321	2.6	151	65	128	286	104	6	37	11.04	21.73	48.56	17.66	1.02	3.1	4.0	5.7	8.1	10.1
83	6737	KZ012	465	2.8	169	315	34	64	50	3	785	67.60	7.30	13.73	10.73	0.64	2.6	3.7	6.0	8.4	10.2
84	6736	KZ014	276	1.4	158	0	59	192	54	2	221	0.00	19.22	62.54	17.59	0.65	.	4.1	5.8	8.0	10.1
85	6729	LB005	321	2.5	135	61	85	58	22	1	69	26.07	37.44	25.55	9.69	0.44	2.8	4.0	5.6	7.8	11.1
86	6738	LD012	250	1.9	137	851	278	279	53	0	572	58.25	19.03	19.10	3.63	0.00	2.7	3.9	5.6	8.2	.
87	6733	LD439	325	2.4	165	14	8	28	11	2	64	22.22	12.70	44.44	17.46	3.17	2.8	4.0	5.8	8.1	10.2
88	6730	LE005	251	1.7	168	282	436	173	13	3	275	31.02	48.18	19.03	1.43	0.33	2.9	4.0	5.5	7.2	12.0
89	6731	LH004	207	1.4	116	0	20	45	13	2	72	0.00	25.00	56.25	16.25	2.50	.	4.1	5.7	8.0	10.2
90	6740	LH014	249	1.3	139	615	975	841	34	0	109	24.95	39.55	14.12	1.38	0.00	3.0	4.0	5.6	7.4	.
91	6732	LH440	274	2.2	157	0	19	111	62	8	127	0.00	9.50	55.50	31.00	4.00	.	4.1	5.8	8.2	10.2
92	6749	LJ011	254	1.4	161	214	433	57	0	0	141	30.40	61.51	8.10	0.00	0.00	2.9	4.0	5.4	.	.
93	6741	LM002	261	2.0	117	95	55	50	6	0	64	46.12	26.70	24.27	2.91	0.00	2.7	3.9	5.6	7.8	.
94	6742	LM006	175	1.2	158	7	35	38	7	0	28	8.05	40.23	43.68	8.05	0.00	3.1	4.0	5.6	7.6	.
95	6743	LR008	113	-0.7	151	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
96	6746	LS014	285	0.9	147	129	409	178	30	1	302	17.27	54.75	23.83	4.02	0.13	3.0	4.0	5.5	7.2	12.0
97	6744	LT001	397	2.6	147	1	4	24	21	1	73	1.96	7.84	47.06	41.18	1.96	3.2	4.2	5.9	8.2	10.2
98	6745	LT004	345	2.6	124	4	37	81	14	3	34	2.88	26.62	50.27	10.07	2.16	3.2	4.1	5.7	7.9	10.1
99	6747	LV012	298	1.7	106	65	225	267	39	0	244	10.91	37.75	44.00	6.54	0.00	3.1	4.0	5.6	7.6	.
100	6748	LX008	408	2.1	159	111	11	12	2	0	96	81.62	8.09	8.82	1.47	0.00	2.6	3.7	5.5	8.6	.

Table 2. Information from the model run with parameter estimates as used in the biomass calculations.

SHRIMP PHOTO, BIOMASS 1981 - 1984
66|00N - 69|30N
REDUCED MODEL

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNBIALL
WEIGHT: SQM

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	57113.54909451	3359.62053497	12.64	0.0001	0.741342	1355.9372
ERROR	75	19927.16101553	265.69548021		ROOT MSE		LNBIALL MEAN
CORRECTED TOTAL	92	77040.71011004			16.30016810		1.20213294

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DEP	1	3380.58765954	12.72	0.0006	1	5060.68685092	19.05	0.0001
LA	1	26418.48482082	99.43	0.0001	1	1530.10655803	5.76	0.0189
LO	1	237.23264846	0.89	0.3477	1	2265.61829188	8.53	0.0046
TE0	1	736.02889513	2.77	0.1002	1	757.05219214	2.85	0.0956
TE2	1	960.86689507	3.62	0.0611	1	2655.47998913	9.99	0.0023
TE3	1	324.32819152	1.22	0.2728	1	2363.33171299	8.89	0.0039
DEP|DEP	1	5683.24782228	21.39	0.0001	1	10911.22354025	41.07	0.0001
LA|LA	1	2885.80565971	10.86	0.0015	1	2848.42523983	10.72	0.0016
LA|YEAR	1	5941.26191684	22.36	0.0001	1	1936.22123019	7.29	0.0086
LO|YEAR	1	2891.32769121	10.88	0.0015	1	2293.19310846	8.63	0.0044
TE0|YEAR	1	743.85306708	2.80	0.0985	1	833.55105495	3.14	0.0806
DEP|LA	1	601.18271930	2.26	0.1367	1	3881.34024005	14.61	0.0003
DEP|T_4	1	92.09395172	0.35	0.5578	1	2068.94580204	7.79	0.0067
LA|TEZ	1	2522.33121085	9.49	0.0029	1	2393.58380780	9.01	0.0036
TE0|TE3	1	614.16425361	2.31	0.1326	1	1532.88920279	5.77	0.0188
TE2|TE3	1	636.57541051	2.40	0.1259	1	1614.63173805	6.08	0.0160
TE3|T_4	1	2444.17628085	9.20	0.0033	1	2444.17628085	9.20	0.0033

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	-1718.10080470	-3.43	0.0010	501.48188339
DEP	0.52970223	4.36	0.0001	0.12137218
LA	37.68080976	2.40	0.0189	15.70187343
LO	15.30088177	2.92	0.0046	5.23980556
TE0	-13.55060517	-1.69	0.0956	8.02763955
TE2	-36.45956314	-3.16	0.0023	11.53272742
TE3	-2.69241574	-2.98	0.0039	0.90275907
DEP|DEP	-8.9908474E-05	-6.41	0.0001	0.00001403
LA|LA	-0.35529468	-3.27	0.0016	0.10851215
LA|YEAR	0.14208041	2.70	0.0086	0.05263187
LO|YEAR	-0.18622937	-2.94	0.0044	0.06338988
TE0|YEAR	0.17220709	1.77	0.0806	0.09722479
DEP|LA	-0.00662826	-3.82	0.0003	0.00173421
DEP|T_4	-0.00631799	-2.79	0.0067	0.00226410
LA|TEZ	0.50922940	3.00	0.0036	0.16966069
TE0|TE3	-0.26990921	-2.40	0.0188	0.11237104
TE2|TE3	0.27119286	2.47	0.0160	0.11001036
TE3|T_4	0.88542733	3.03	0.0033	0.29193001

Table 3. Observed and predicted values of density and biomas of shrimp on all sampling sites in the area 66°00´N - 69°30´N.

OBSERVED AND PREDICTED VALUES OF TOTAL SHRIMP BIOMASS
66|00N - 69|30N
REDUCED MODEL

YEAR=1981

OBS	STNO	ARCODE	DEP	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
1	6023	KA011	218	666	0.55	2.83	1.66	-0.53
2	6021	KF007	502	666	0.11	0.69	0.30	-0.84
3	6020	KL006	206	385	0.17	0.57	0.67	0.16
4	6019	KP440	281	374	0.44	2.65	4.24	0.47
5	6024	KR004	218	707	1.82	7.61	5.00	-0.42
6	6031	KT001	347	710	0.88	5.64	3.81	-0.39
7	6030	KT436	280	722	0.55	4.44	3.59	-0.21
8	6033	KV002	411	636	0.78	3.00	2.28	-0.28
9	6029	KX438	347	548	0.25	1.51	4.40	1.07
10	6034	KZ003	340	625	1.04	5.73	5.25	-0.09
11	6026	KZ012	470	688	0.34	2.51	2.41	-0.04
12	6025	KZ015	278	633	2.53	11.39	8.72	-0.27
13	6028	LB005	326	611	0.88	4.10	6.11	0.40
14	6027	LE005	256	677	2.35	8.97	14.44	0.48
15	6036	LH014	253	544	1.06	5.07	6.24	0.21
16	6037	LJ011	257	237	2.52	11.36	7.00	-0.48

YEAR=1982

OBS	STNO	ARCODE	DEP	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
17	6232	KA011	220	461	0.45	2.73	10.82	1.38
18	6231	KF007	320	563	0.08	0.34	0.78	0.83
19	6216	KL006	183	258	0.69	3.16	6.31	0.69
20	6217	KN003	215	359	3.12	22.37	5.31	-1.44
21	6229	KP440	280	512	0.97	5.20	8.15	0.45
22	6218	KR004	213	471	1.02	7.43	5.57	-0.29
23	6219	KR006	185	607	3.37	15.10	9.67	-0.45
24	6228	KT001	350	444	2.11	11.24	4.47	-0.92
25	6223	KT436	281	631	0.54	3.81	3.52	-0.08
26	6227	KV002	424	647	0.40	2.27	2.65	0.16
27	6221	KV007	191	644	0.80	4.77	11.07	0.84
28	6224	KX007	410	668	0.77	5.18	4.45	-0.15
29	6222	KX438	337	576	0.32	2.16	5.16	0.87
30	6226	KZ003	344	586	0.77	4.73	4.92	0.04
31	6235	KZ012	468	668	0.43	3.04	2.31	-0.27
32	6234	KZ014	260	281	0.67	4.47	6.34	0.35
33	6225	LB005	329	658	0.82	4.73	5.05	0.06
34	6236	LD012	245	498	0.95	5.33	6.90	0.26
35	6237	LE005	266	441	1.25	6.68	9.72	0.38
36	6239	LH004	209	403	0.61	3.42	3.40	-0.01
37	6249	LH014	259	620	1.82	9.43	8.65	-0.09
38	6238	LH440	282	353	0.82	6.10	4.84	-0.23

YEAR=1983

OBS	STNO	ARCODE	DEP	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
39	6435	KA011	225	435	0.99	6.86	2.79	-0.90
40	6437	KB007	353	467	0.08	0.33	0.29	-0.11
41	6436	KB008	176	489	0.38	2.60	0.49	-1.66
42	6439	KF007	241	464	0.12	0.67	1.43	0.76
43	6438	KF008	165	508	0.07	0.30	0.56	0.63
44	6441	KJ005	478	647	0.06	0.24	0.41	0.53
45	6440	KL006	206	585	0.12	0.60	1.30	0.77
46	6442	KN004	213	607	3.19	21.52	6.69	-1.17
47	6428	KP440	281	529	0.31	2.04	3.96	0.66
48	6444	KR004	223	488	1.12	8.32	8.00	-0.04
49	6443	KR006	185	516	2.50	14.38	8.14	-0.57
50	6445	KT001	349	539	0.86	5.19	2.93	-0.57
51	6456	KT436	293	573	1.04	7.68	5.12	-0.41
52	6459	KV002	416	580	0.48	2.67	1.59	-0.52
53	6461	KV007	256	580	0.70	4.65	4.98	0.07
54	6460	KX007	434	570	0.35	2.01	1.94	-0.03
55	6457	KX438	339	573	0.44	2.95	3.85	0.27
56	6458	KZ002	334	576	0.97	6.01	3.78	-0.46
57	6462	KZ012	463	434	0.46	2.95	7.43	0.92
58	6454	LB005	330	429	1.38	8.01	8.51	0.06
59	6429	LD012	229	456	1.55	10.62	7.03	-0.41
60	6455	LD439	334	573	0.43	2.91	3.88	0.29
61	6453	LE005	273	570	1.39	7.42	12.66	0.53
62	6452	LH004	213	546	0.54	3.71	4.84	0.27
63	6430	LH014	237	486	2.22	12.31	9.29	-0.28
64	6434	LH440	281	273	0.55	3.99	6.29	0.46
65	6446	LJ011	256	58	3.38	24.11	7.94	-1.11

YEAR=1984

OBS	STNO	ARCODE	DEP	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
66	6713	KA010	227	295	0.44	2.58	0.73	-1.26
67	6715	KB006	488	519	0.06	0.15	0.09	-0.49
68	6714	KB008	184	593	0.05	0.08	0.07	-0.11
69	6717	KF007	319	566	0.23	1.63	1.16	-0.34
70	6716	KF008	172	573	0.05	0.08	0.39	1.59
71	6718	KJ006	455	566	0.05	0.05	0.45	2.20
72	6723	KL006	205	536	0.08	0.28	0.96	1.23
73	6721	KN003	219	410	0.66	2.56	4.23	0.50
74	6722	KP440	287	603	0.39	2.41	2.76	0.14
75	6720	KR004	217	553	1.12	5.43	4.38	-0.21
76	6719	KR006	194	152	8.33	25.31	8.71	-1.07
77	6724	KS002	344	553	2.05	11.22	4.35	-0.95
78	6725	KT437	275	556	0.49	2.69	1.08	-0.91
79	6727	KV002	415	444	0.42	2.43	1.78	-0.31
80	6735	KV007	224	597	1.02	5.71	3.13	-0.60
81	6734	KX007	452	393	0.46	3.02	1.93	-0.45
82	6726	KX437	320	532	0.27	1.41	1.70	0.19
83	6728	KZ002	321	512	1.22	6.74	2.92	-0.84
84	6737	KZ012	465	573	2.18	8.34	6.78	-0.21
85	6736	KZ014	276	536	1.00	5.82	7.02	0.19
86	6729	LB005	321	305	0.97	4.31	7.85	0.60
87	6738	LD012	250	464	4.39	16.12	9.05	-0.58
88	6733	LD439	325	559	0.23	1.24	1.95	0.45
89	6730	LE005	251	570	2.08	8.35	9.96	0.18
90	6731	LH004	207	393	0.40	2.25	2.09	-0.07
91	6740	LH014	249	471	5.47	23.74	18.09	-0.27
92	6732	LH440	274	532	0.62	4.04	2.13	-0.64
93	6749	LJ011	254	546	1.57	5.87	10.94	0.62

Table 4. Calculated total biomass for all strata within 66°00´N to 69°30´N in water depths 100-600 meters with sums for 30 minutes latitude strips (see also Fig. 5).

A R E A	1981	1982	1983	1984
69°00´N - 69°30´N	47235	40839	50385	43146
68°30´N - 69°00´N	48235	50547	74319	61725
68°00´N - 68°30´N	42741	80328	60345	54745
67°30´N - 68°00´N	31111	61760	53817	40106
67°00´N - 67°30´N	6055	19971	10292	11803
66°30´N - 67°00´N	4567	8903	5552	5426
66°00´N - 66°30´N	5134	13523	5198	2962
T O T A L	185078	275871	259908	219913

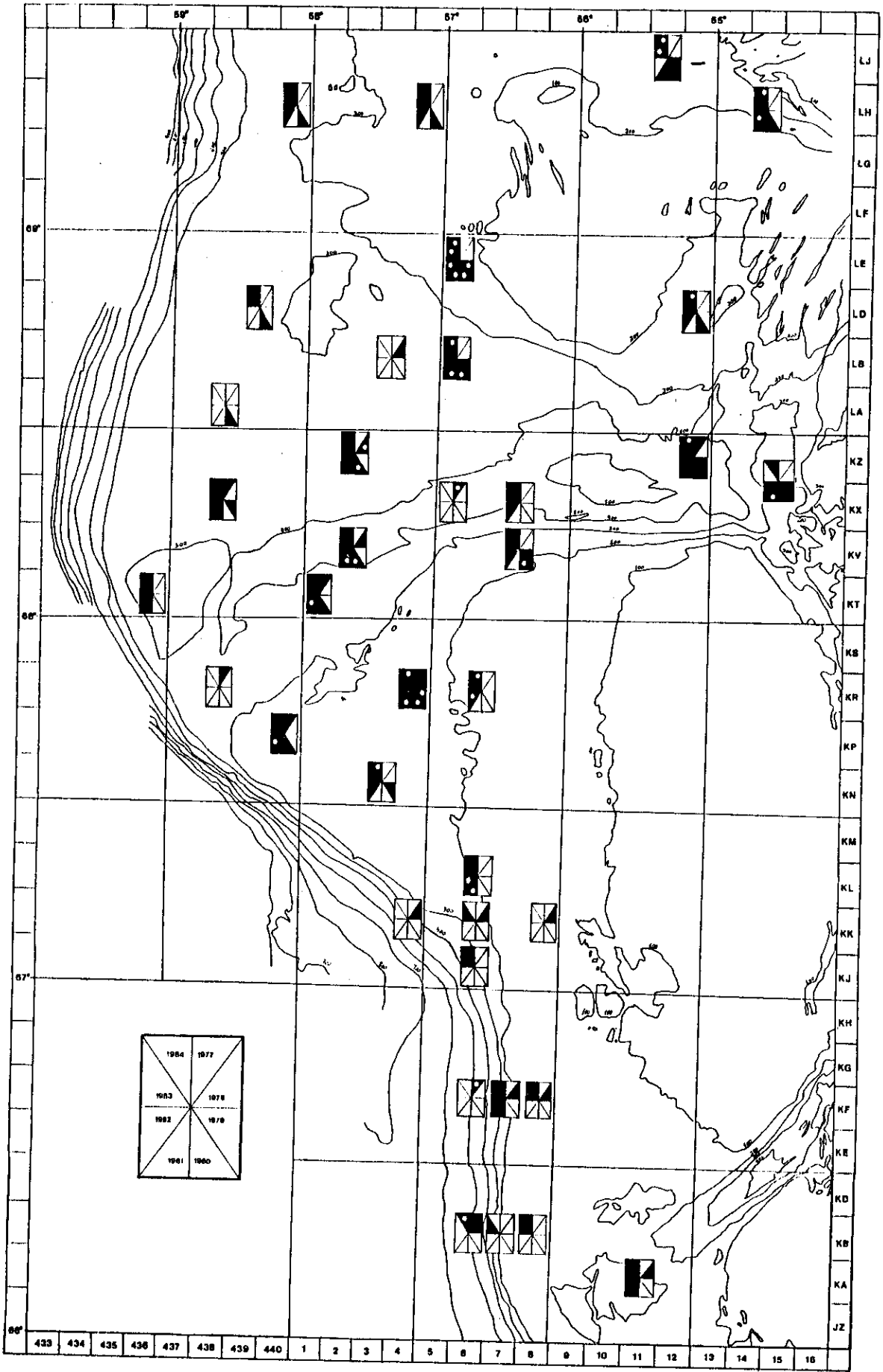

Fig. 1. Map with sampling stations 1977-84 in the area 66°00´N to 69°30´N. The white dots in certain of the filled fields denote sites on which small shrimp were dominating in the actual year.

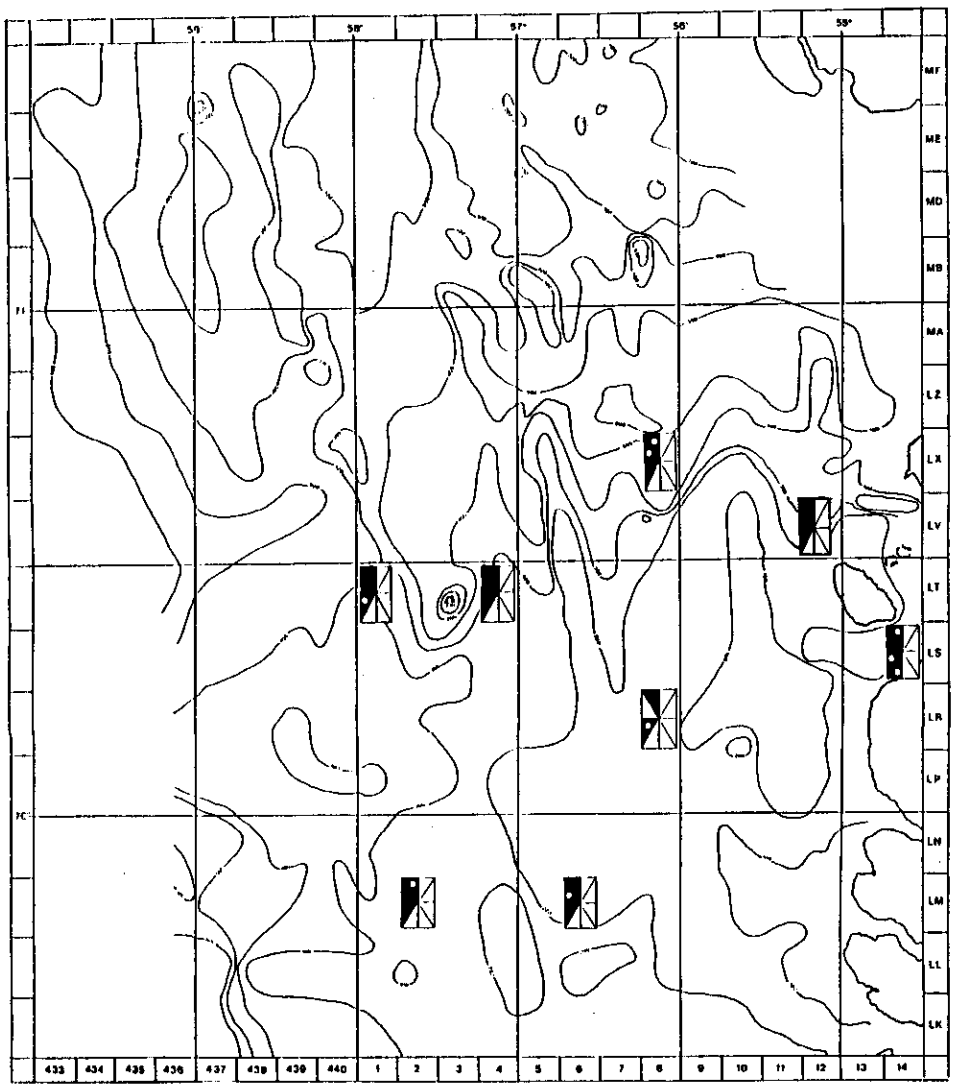

Fig. 2. Map with sampling stations 1981-84 in the area 69° 30´N to 71°30´N. The white dots in certain of the filled fields denote sites on which small shrimp were dominating in the actual year.

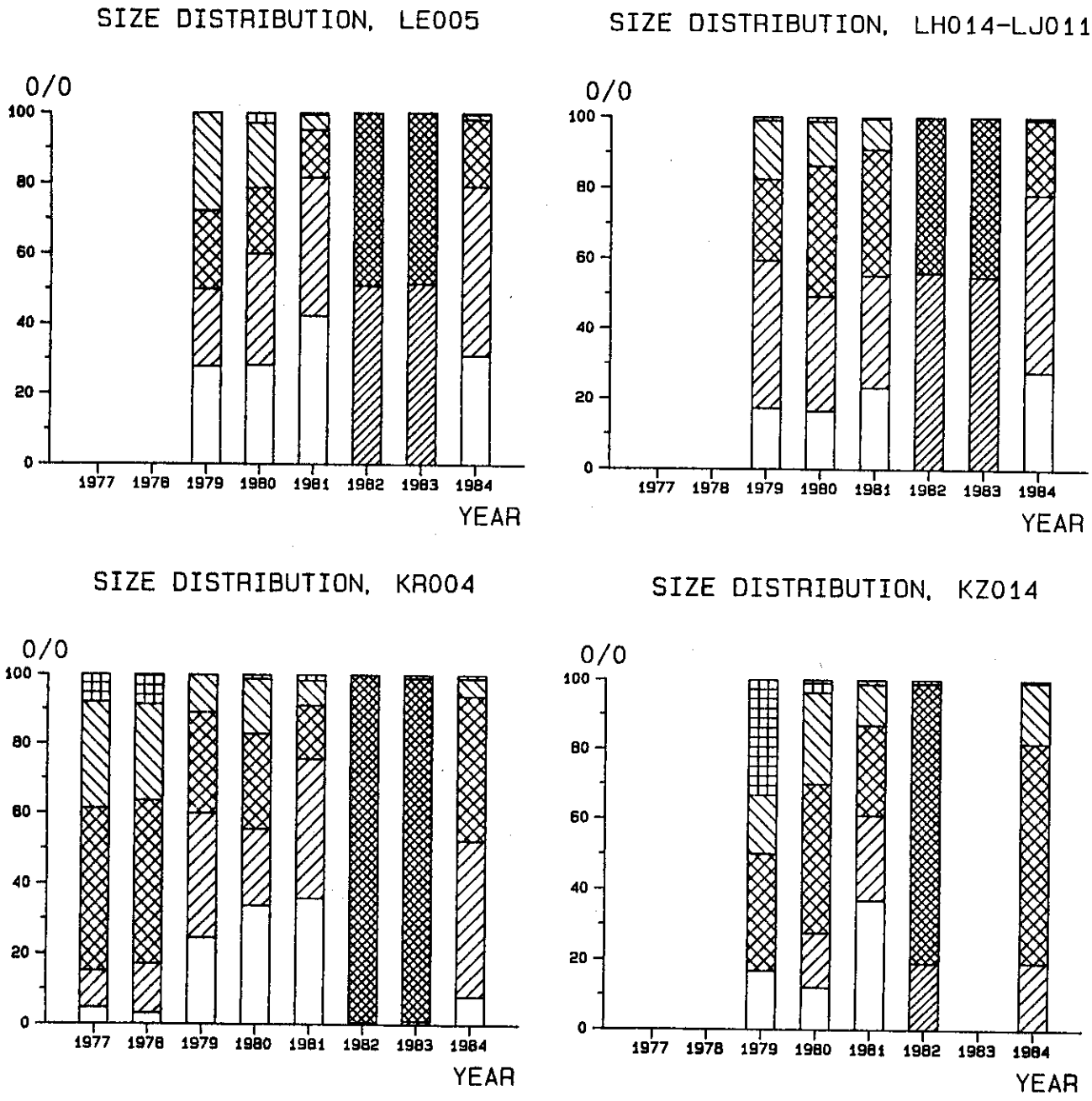

Fig. 3. Size distribution in four different areas (for area codes see Fig. 1). In 1982 and 1983 (old reading) the lowermost column (small shrimp) correspond roughly to the two lower columns the other years.

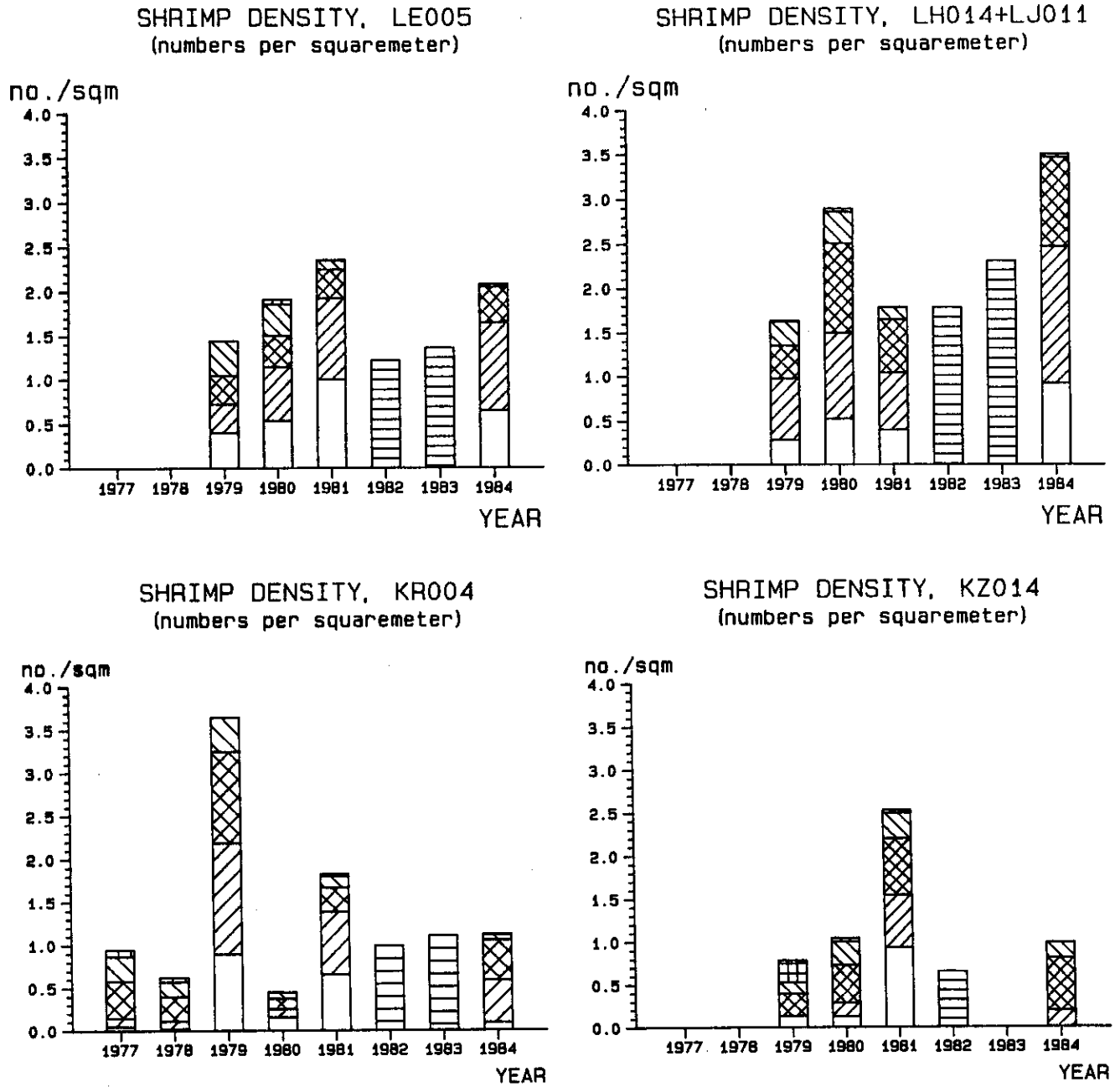

Fig. 4. Shrimp density in numbers per squaremeter in four different areas (for area codes see Fig. 1). In 1982 and 1983 (old reading) the density figures are not broken down into size groups.

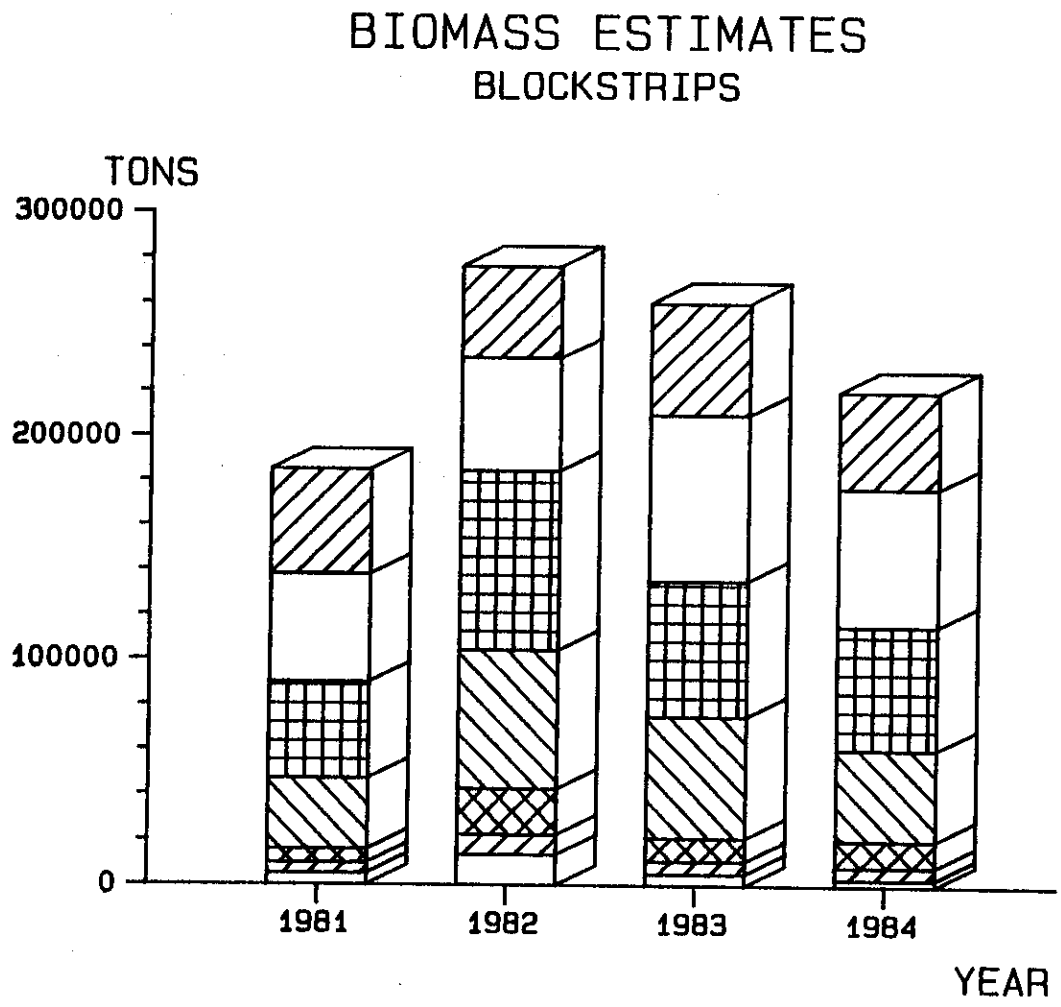

Fig. 5. Total biomass estimates in 30 minute latitude strips as given in Table 4.

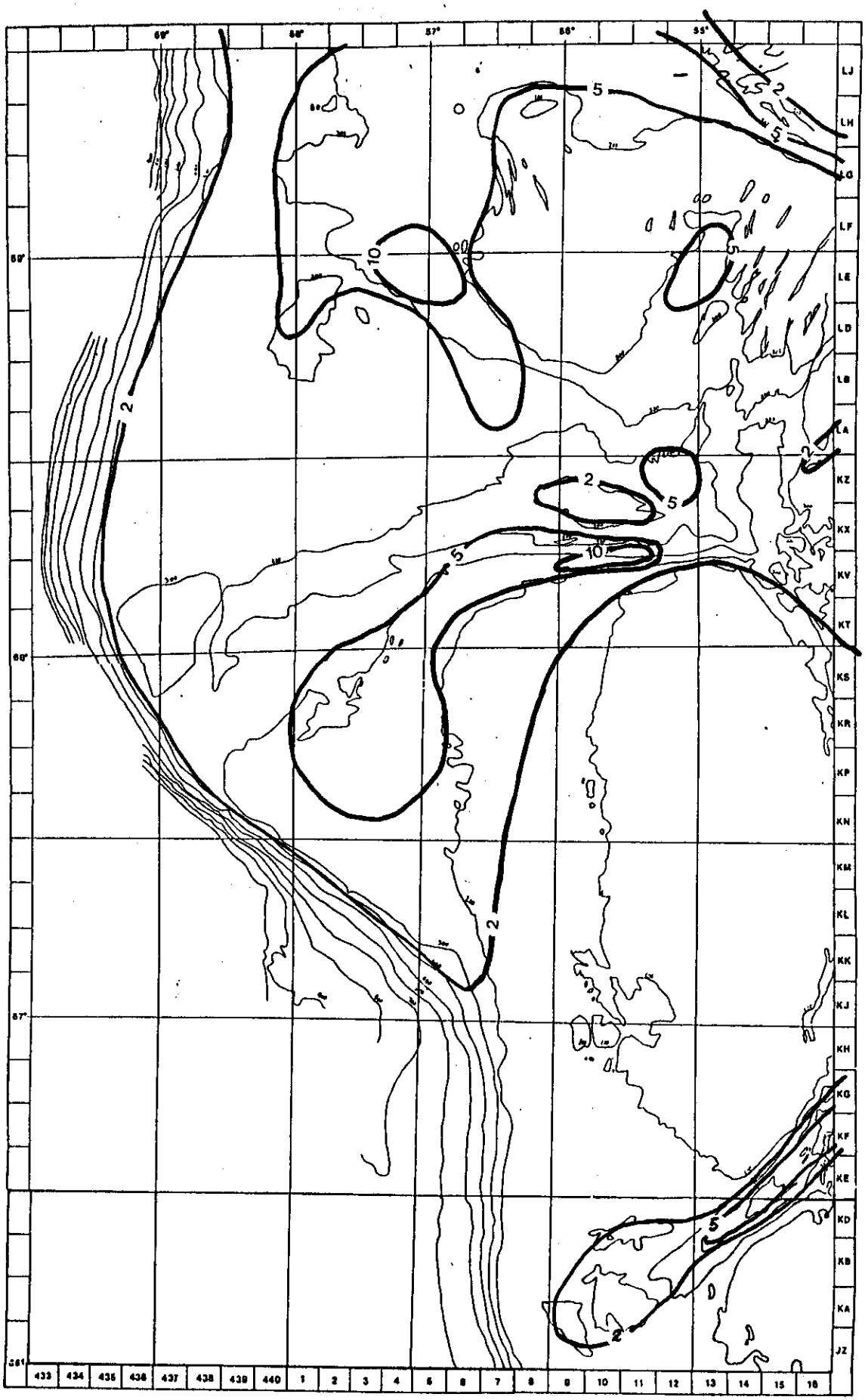

Fig. 6. Map with isolines for 2, 5 and 10 grams shrimp per squaremeter as calculated for 1981 by means of the parameters as explained in the text.

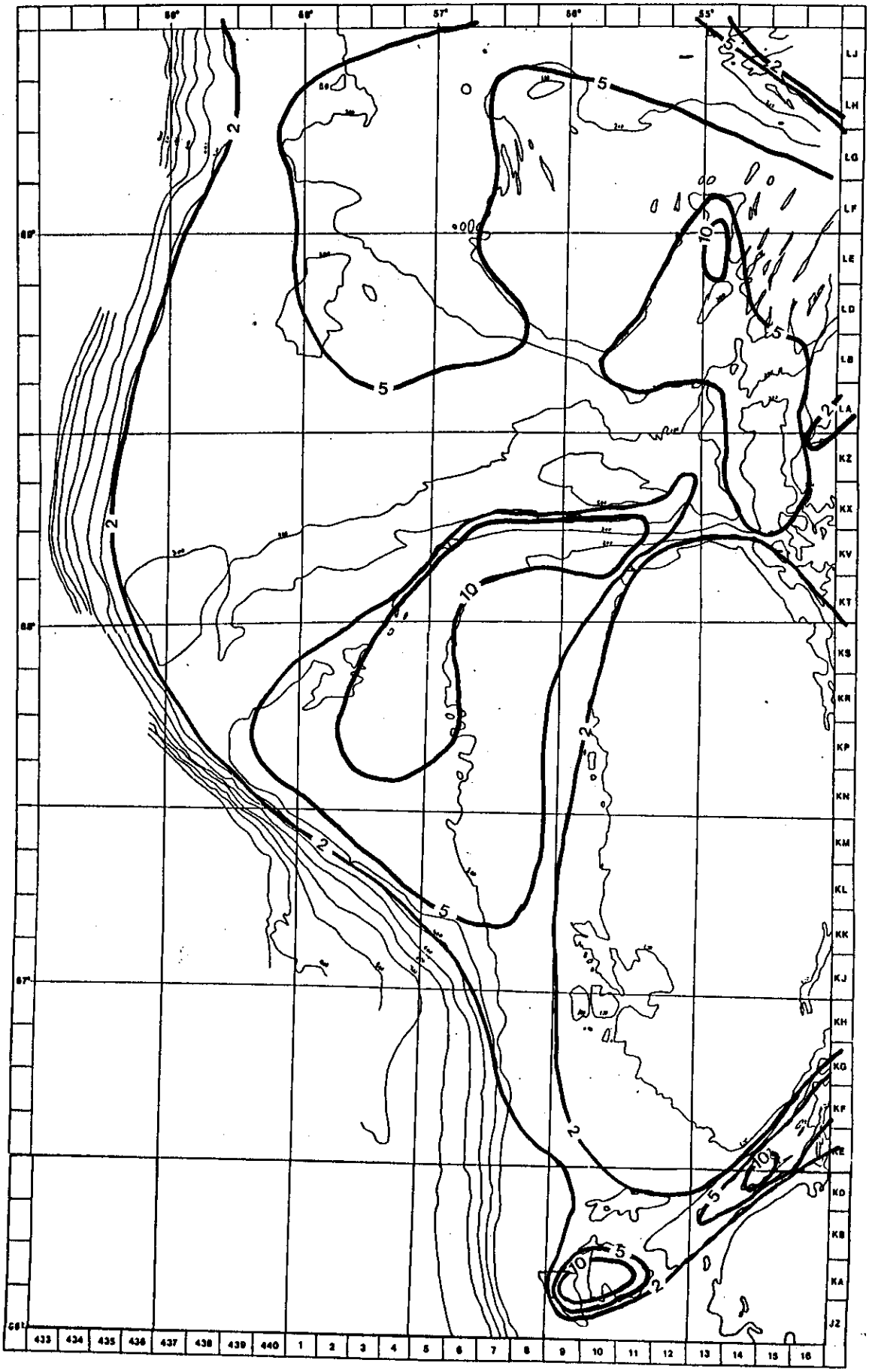

Fig. 7. Map with isolines for 2, 5 and 10 grams shrimp per squaremeter as calculated for 1982 by means of the parameters as explained in the text.

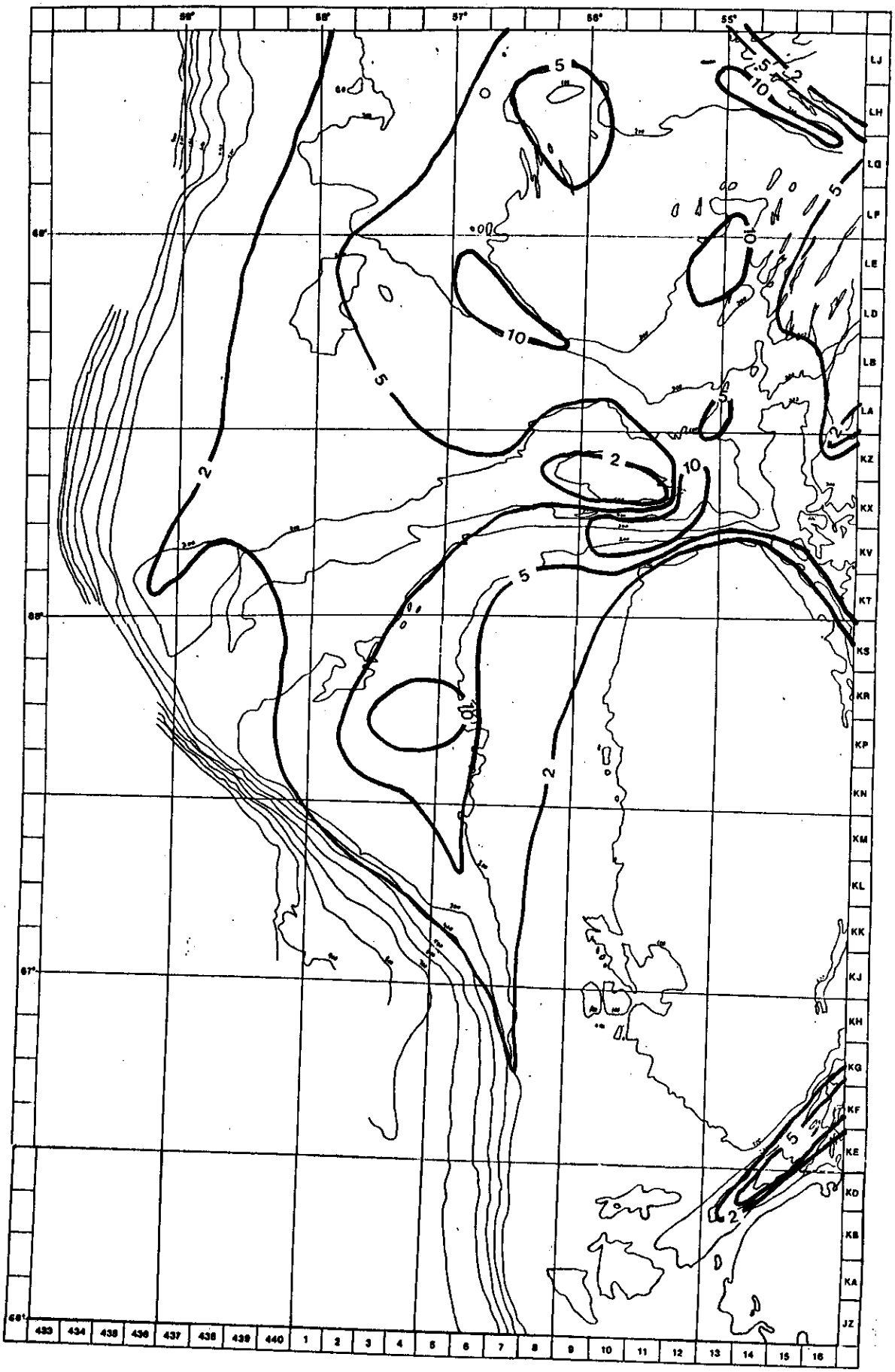

Fig. 9. Map with isolines for 2, 5 and 10 grams shrimp per squaremeter as calculated for 1984 by means of the parameters as explained in the text.

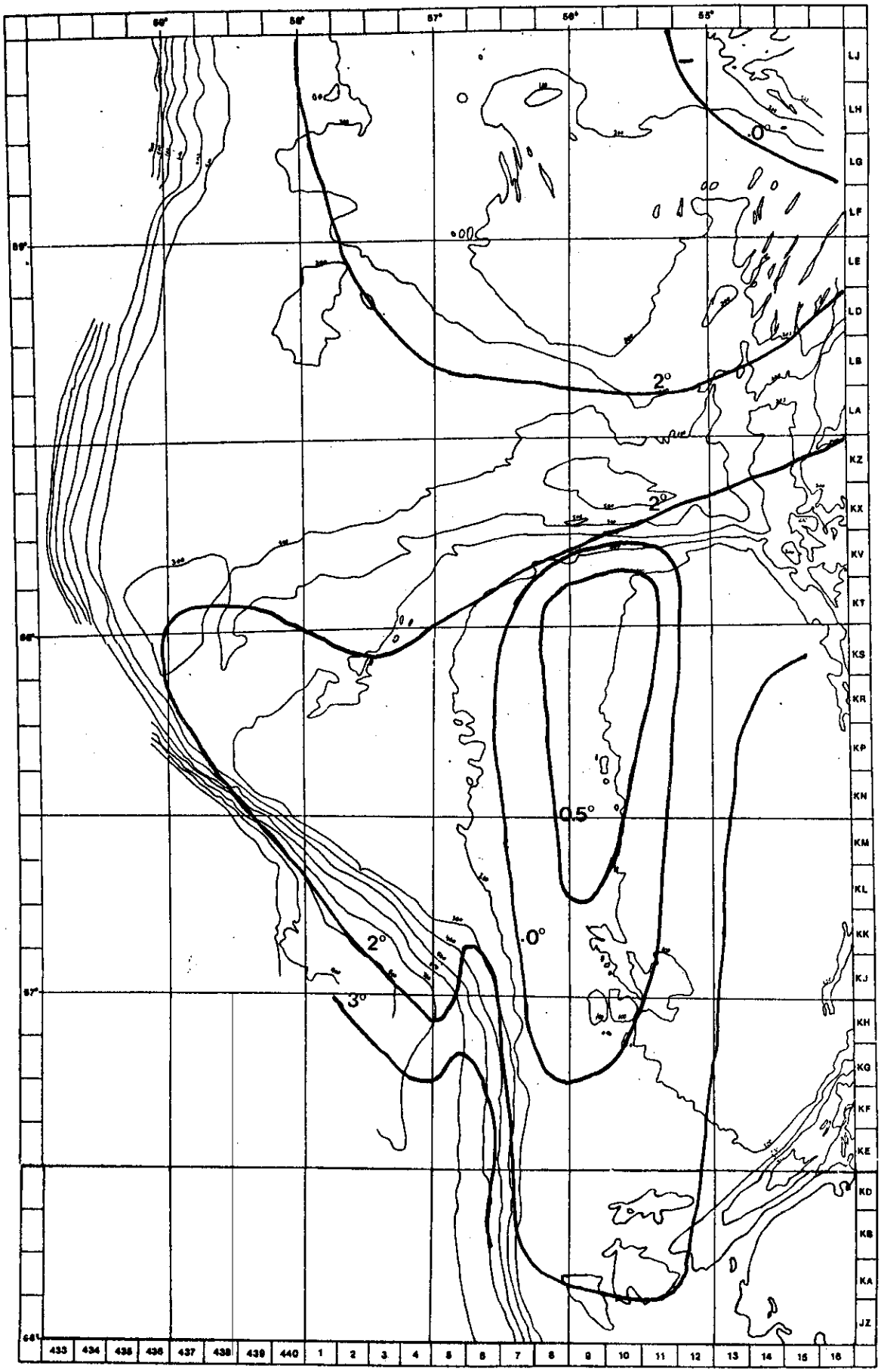

Fig. 10. Bottom temperatures (isotherms) for July 1984 in the area included in the analysis.