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Biomass of shrimp (PANDALUS BOREALIS) in NAFO SA1 in 1978 - 1983 estimated by means of bottom photography.

by

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ABSTRACT

A shrimp survey using photographic sampling technique was carried out in July-August 1983 in NAFO SA1 in order to sample data for shrimp stock assessment.

The material obtained by this survey is combined with similar data from the years 1977-82 to produce biomass estimates for the area between 66*00'N and 69*30'N.

The biomass estimates are obtained by means of a mathematical model introduced in an earlier document. Biomass estimates for 1981-83 are compared to estimates obtained by a new version of the model including other input parameters.

INTRODUCTION

In 1980 a model was introduced (Jørgensen & Kanneworff, 1980) to describe the possible relationship between shrimp biomass indices obtained by the photographic sampling and some physical parameters. This model has been used to assess the shrimp stock during the years 1980 to 1983.

The present paper uses this model including the data from the 1983 survey. A change in the model is introduced and new biomass estimates for 1981-83 are presented together with estimates for 1978-83 obtained by the first model.

A preliminary biomass estimate for the area 69*30'N to 71*00'N is given on basis of a low number of sampling stations occupied in 1981-83.

MATERIAL AND METHODS

Since 1977 bottom photographs have been used as a basis for estimating the biomass of shrimp (PANDALUS BOREALIS) at West Greenland (Kanneworff, 1979). Most of the photographic sampling has been carried out in the area from 66*00'N to 69*30'N, being also the main area for the commercial fishery. Depths between 100 and 600 meters have been sampled throughout the years as shown on Fig. 1. During the last three years some sampling stations have been occupied in the area 69*30'N to 71*00'N (Fig. 2), however data from these sites have not yet been included in the regression analysis, but they are only used to obtain a rough indication af a biomass relative to that of the area south of it.

During July and August 35 stations have been occupied in 1983 in the area between 66* and 71*N. On these stations a total of 5483 photographs have been taken. In all 17212 photographs have now been taken in the offshore area during the period 1977-83. A list of sampling stations with the number of counted shrimp in the three size categories is shown in Table 1.

The sampling method, the treatment of data during the reading of of the photographs and the calculation of biomass indices (grams per squaremeter) have followed the same lines as described earlier (Kanneworff, 1983).

The regression analysis model used for estimating the total biomass in the area 66*00'N - 69*30'N includes the same parameters as earlier, viz. year, depth, latitude, longitude and bottom temperature at the sampling sites. This model handles data from 1977 to 1983, however, due to scarcity of hydrographic observations, the biomass estimates can only be calculated for 1978 to 1983. The input values for temperature in these calculations are now based on new information on the hydrography for 1978-83 (Erik Buch, pers.com.) as shown in Fig. 4-8.

A new version of the model is introduced in this paper. This model is based on the former, in which the different parameters were used in a squared equation under the assumption that the material is lognormal distributed. New parameters are included: bottom temperature at the sampling sites in July-August one to three years earlier (Fig. 4-8), and mean July temperatures in the depths 0-50 meters west of the banks in the Davis Strait three and four years earlier (Erik Buch, pers.com., Fig. 9). The regression analysis gives a relatively high correlation coefficient for the model, but many of the parameters, their squares or their combined effects are of very low significance and therefore of no value in the analysis. After a filtering process the model now includes a series of parameters which are shown in Table 6. The correlation coefficient for the model remains fairly high (0.74) and the parameters can all be accepted on the 10 % probability level. This model can only be used to handle the photographic data from 1981 to 1983, because reliable hydrography observations only exist from 1979 and onwards.

RESULTS AND DISCUSSION

Size distribution.

The distribution of shrimp in the three size categories is calculated for all sampling stations shown in Table 1. Fig. 10 shows the size composition observed in the area KR004 (see Fig. 1), and Fig. 11 shows the composition as a mean for all the sampling stations in the area 66*00'N - 69*30'N, weighted by the predicted biomass indices given in Table 2. The distribution in the area KR004, situated inside the comercial area of commercial fishing, shows an increase in the proportion of small shrimp in 1977-81, whereas this size group has almost disappeared in the last two years. The mean figures for the whole area do not clearly show the same trends, however, the proportion of small shrimp is also in this material lowest in 1982 and 1983.

It has earlier been proposed that an increase in proportion of small shrimp could be taken as an indication of a stronger incoming yearclass than normal. As the mean size distribution shows a lower abundance of small shrimp in 1983 a recruitment below the level of the last five years might be expected for 1984 and 1985.

As also observed in earlier years concentrations of small shrimp were found in 1983 on some of the sampling sites in the northern part of the area (area codes LE005 and LJ011). On none of these stations, however, the small shrimp have dominated (> 50 %). This is in contrast to earlier observations in which a high density of very small shrimp have been observed (e.g. KZ002 in 1980 and LE005 in 1981).

The size distribution of shrimp in the area north of 69*30'N is almost the same as in the other area (Table 1, area codes > LJ). However, shrimp of the size group 'large' seem to be a little more abundant, while the overall indices for both density and biomass are somewhat lower (Table 4).

Model.

The model underlying the regression analyses carried out since 1980 has been described in an earlier paper (Jørgensen & Kanneworff, 1980). A squared equation with logarithmic values of biomass indices as dependent variable is still used as a basis, while only the independent parameters have been changed in the different versions of the model used in 1983 and in this paper.

A regression analysis including the same parameters as used by Kanneworff (1983) was made for the observation period 1977-83. In this analysis the correlation coefficient dropped from 0.65 to 0.53 by including the observations from 1983. Nearly all parameters were of lower significance than in last year's analysis.

In the earlier discussions about the model a fairly low correlation coefficient has been accepted, ever noting that the model is empirical, and that some combination of parameters offering a higher correlation coefficient must be supposed to describe the biomass dependency of the parameters better. Of this reason the author felt that a revised version of this analytical model was strongly needed.

Having new information on temperature observations at the bottom for the years 1978-83 (Fig. 3-8) and in the water depths 0-50 m west of the banks in the Davis Strait for 1975-83 (Fig. 9), new combinations of input parameters have been tried in the recent regression analysis. Bottom temperature one to three years earlier at the sampling sites together with 0-50 m average temperatures in the southern areas of shrimp distribution three and four years earlier have been tested for their possible effects on the shrimp biomass as read from the photographs. Only the bottom temperatures at the sampling sites two years before and the 0-50 m temperature west of Fylla bank (GHB-section on Fig. 9) four years before the photographic sampling were significant in the analysis. Many of the squared parameters or their combined effects were of low significance, and by excluding those one by one from the model, a final series of parameters were obtained, all significant at the 10 % level. The parameters in the final model are shown in Table 6. This version of the model exhibits a correlation coefficient of 0.74 and may thus be taken as a better one than the formerly used.

Biomass estimates.

By means of the parameter coefficients from the regression analysis (Table 6) biomass indices (in grams per squaremeter) for all strata is calculated by inserting local values for the different parameters. Biomass estimates are obtained by multiplying the indices with the area of the strata. Total biomass estimates for the area 66*00'N to 69*30'N in the years 1981-83 are given in Table 7, and are shown in Fig. 12 together with total biomass estimates 1978-83 obtained by the model used by Kanneworff (1983). The biomass figures obtained by the new model follow the same trends, but they are somewhat higher (roughly 20 %) than those from the old model.

A more detailed analysis of the biomass estimates in the different strata might reflect a possible stock displacement between the years. In Table 7 and in Fig. 13 sums of the stratum biomass estimates for each 30 minute latitude strips are shown. A significant increase in biomass is indicated in the southern part (A-E) in 1981-82, while the area north of 68*30'N (F, G) showed a decrease in biomass. Between 1982 and 1983 the development was

nearly opposite to the year before. The areas to the south (A-C and to a certain degree D) showed a decrease, while the areas E and F had a similar increase. The northernmost area (G) showed almost the same figures in the two years.

The sampling data north of 69*30'N is still very sparse, and an analysis like that for the other area is still not possible. The observed densities and biomass indices (Table 4) appear to be somewhat lower than those from the areas south of 69*30'N. The biomass in in this area is only supposed to make up for a low proportion of the stock in the Davis Strait, possibly being within the range 50,000 - 100,000 tons.

CONCLUSION

Data from photographic sampling in the period 1977 to 1983 has been examined, and biomass of shrimp in the area 66*00'N-69*30'N has been estimated by means of a mathematical model. A total biomass of around 250,000 tons for that area is indicated, which is at the same level as the estimate for 1982. Prospects for good recruitment to the following year seem to be poor, the smaller shrimp being less abundant in the material from 1982 and 1983.

REFERENCES

Jørgensen, A.G. & P. Kanneworff, 1979. Biomass of shrimp (PANDALUS BOREALIS) in NAFO Subarea 1 in 1977-80 estimated by means of bottom photography. NAFO SCR Doc. 80/XI/169.

Kanneworff, P., 1979. Density of shrimp (PANDALUS BOREALIS) in Greenland waters by means of photography. Rapp. P.-v. Reun., Cons. int. Explor. Mer (175):134-138.

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Table 1. List of stations 1977-83 in the offshore area with number of photographs and size distribution.

SHRIMP PHOTO 1977-83
LIST OF STATIONS WITH NUMBER OF SHRIMP AND SIZE DISTRIBUTION

YEAR=77

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
1	770804	5453	KB006	282	107	1	106	0	0.93	99.07	0.00	7.46
2	770805	5454	KF006	23	3	0	3	0	0.00	100.00	0.00	7.50
3	770726	5447	KK440	82	102	0	101	1	0.00	99.02	0.98	7.55
4	770727	5449	KK004	116	278	12	265	1	4.32	95.32	0.36	7.35
5	770726	5448	KK438	64	45	0	45	0	0.00	100.00	0.00	7.50
6	770725	5446	KT001	17	12	1	11	0	8.33	91.67	0.00	7.17
7	770805	5455	KK005	204	106	10	89	7	9.43	83.96	6.60	7.59
8	770806	5456	KK438	190	70	0	69	1	0.00	98.57	1.43	7.68
9	770724	5444	KZ012	89	56	0	29	27	0.00	51.79	48.21	10.15

YEAR=78

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
10	780727	5610	JE019	181	367	126	240	1	34.33	65.40	0.27	6.14
11	780725	5607	KA011	3	5	1	4	0	20.00	80.00	0.00	6.70
12	780726	5609	KA011	178	285	64	219	2	22.46	76.84	0.70	6.84
13	780725	5608	KF006	21	8	1	6	1	12.50	75.00	12.50	7.69
14	780724	5605	KF007	172	3	0	3	0	0.00	100.00	0.00	7.50
15	780725	5606	KF008	174	61	3	57	1	4.92	93.44	1.64	7.39
16	780722	5602	KK004	162	62	0	62	0	0.00	100.00	0.00	7.50
17	780724	5604	KK006	107	27	2	25	0	7.41	92.59	0.00	7.20
18	780724	5603	KK008	126	0	0	0	0	.	.	.	.
19	780721	5601	KK004	454	302	32	267	3	10.60	88.41	0.99	7.13
20	780802	5613	KV002	59	36	0	31	1	0.00	96.88	3.13	7.67
21	780802	5611	KZ002	169	849	477	367	4	56.18	43.23	0.59	5.89
22	780803	5614	LB003	38	33	9	23	1	27.27	69.70	3.03	6.58

YEAR=79

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
23	790801	5739	KK003	36	16	1	15	0	6.25	93.75	0.00	7.25
24	790801	5740	KK004	16	179	66	113	0	36.87	63.13	0.00	6.03
25	790723	5734	KV007	6	10	0	10	0	0.00	100.00	0.00	7.50
26	790805	5741	KX014	7	24	2	22	0	8.33	91.67	0.00	7.17
27	790810	5744	KZ438	5	5	1	4	0	20.00	80.00	0.00	6.70
28	790805	5742	KZ012	16	18	1	13	4	5.56	72.22	22.22	8.50
29	790810	5743	LB005	12	50	38	12	0	76.00	24.00	0.00	4.46
30	790731	5738	LE005	11	58	32	25	1	55.17	43.10	1.72	5.49
31	790730	5737	LJ011	49	333	192	141	0	58.35	43.65	0.00	5.35

YEAR=80

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
32	800810	5855	KP440	116	52	3	48	1	5.77	92.31	1.92	7.38
33	800811	5856	KK004	167	261	45	194	2	24.90	74.33	0.77	6.55
34	800821	5867	KT001	40	380	55	325	0	4.31	95.69	0.00	7.33
35	800821	5868	KV003	116	356	201	154	1	56.46	43.26	0.28	5.26
36	800811	5857	KV007	49	19	3	16	0	15.79	84.21	0.00	6.87
37	800825	5872	KZ002	148	860	716	142	2	83.26	16.51	0.23	4.18
38	800812	5860	KZ012	198	87	4	80	3	6.90	91.95	1.15	7.29
39	800812	5859	KZ014	118	343	21	321	1	6.12	93.59	0.29	7.27
40	800810	5866	LA43H	167	37	0	37	0	0.00	100.00	0.00	7.50
41	800811	5858	LB005	39	91	56	34	1	39.56	59.34	1.10	5.98
42	800813	5861	LD013	71	187	10	177	0	5.35	94.65	0.00	7.19
43	800823	5871	LD439	89	5	0	5	0	0.00	100.00	0.00	7.50
44	800813	5862	LE005	82	393	110	282	1	27.99	71.76	0.25	6.39
45	800822	5870	LH004	22	42	3	38	1	7.14	90.48	2.38	7.35
46	800815	5863	LH014	134	1081	37	1041	3	3.42	96.30	0.28	7.36
47	800822	5869	LH440	68	313	0	309	4	0.00	98.72	1.28	7.57
48	800817	5865	LJ011	189	2095	1410	675	10	67.30	32.22	0.48	4.83

YEAR=81

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
49	810728	6022	JL020	82	529	191	337	1	36.11	63.71	0.19	6.07
50	810805	6023	KA011	178	290	51	239	0	17.59	82.41	0.00	6.80
51	810728	6021	KF007	177	58	2	56	0	3.45	96.55	0.00	7.36
52	810727	6020	KL006	101	17	10	7	0	58.82	41.18	0.00	5.15
53	810726	6019	KP440	99	136	15	120	1	11.03	88.24	0.74	7.10
54	810806	6024	KK004	191	1142	638	503	1	55.87	44.05	0.09	6.30
55	810811	6031	KT001	192	614	100	513	1	16.29	83.55	0.16	6.86
56	810810	6030	KT436	194	380	0	380	0	0.00	100.00	0.00	7.50
57	810811	6033	KV002	173	398	245	153	0	61.56	38.44	0.00	5.04
58	810810	6029	KX438	147	117	11	105	1	9.40	89.74	0.85	7.17
59	810811	6032	KZ003	169	584	164	418	2	28.08	71.58	0.34	6.40
60	810808	6026	KZ012	171	172	26	145	1	15.12	84.30	0.58	6.93
61	810808	6025	KZ015	169	1309	514	795	0	39.27	60.73	0.00	5.83
62	810809	6028	LB005	162	485	289	193	3	59.59	39.79	0.62	5.15
63	810809	6027	LE005	181	1428	1004	424	0	70.31	29.69	0.00	4.69
64	810817	6036	LH014	161	423	152	271	0	35.93	64.07	0.00	6.06
65	810817	6037	LJ011	64	466	216	249	1	46.35	53.43	0.21	5.44
66	810818	6038	LJ014	191	634	333	300	1	52.52	47.32	0.16	5.41

YEAR=82

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
67	820810	6232	KA011	136	192	49	143	0	25.52	74.48	0.00	6.48
68	820810	6231	KF007	166	26	6	20	0	23.08	76.92	0.00	6.58
69	820726	6216	KL006	76	171	119	52	0	69.59	30.41	0.00	4.72
70	820727	6217	KN003	184	1114	84	1028	2	7.54	92.28	0.18	7.21
71	820809	6229	KP440	151	484	246	238	0	50.83	49.17	0.00	6.47
72	820729	6218	KK004	139	466	2	464	0	0.43	99.57	0.00	7.48
73	820729	6219	KK006	179	2037	1515	517	0	74.34	25.36	0.00	4.51
74	820909	6258	KT001	131	932	516	406	10	55.36	43.56	1.07	5.34
75	820806	6223	KT436	166	317	0	317	0	0.00	100.00	0.00	7.50
76	820808	6227	KV002	191	241	88	152	1	36.51	63.07	0.41	6.06
77	820805	6221	KV007	190	501	180	317	4	35.93	63.27	0.80	6.11
78	820807	6225	KX007	197	491	60	431	0	12.42	87.78	0.00	7.03
79	820806	6222	KX438	170	168	4	162	2	2.38	96.43	1.19	7.42
80	820808	6226	KZ003	173	436	129	307	0	29.59	70.41	0.00	6.32
81	820816	6235	KZ012	197	277	68	209	22	24.61	75.45	0.94	7.27
82	820814	6234	KZ014	83	104	15	147	2	19.02	79.89	1.09	6.80
83	820807	6225	LB005	194	517	195	321	1	37.72	62.09	0.19	6.00
84	820817	6236	LD012	147	460	198	260	2	43.04	56.52	0.43	5.80
85	820817	6237	LE005	130	506	273	233	0	54.15	46.07	0.00	5.44
86	820818	6239	LH004	119	237	101	135	1	42.62	56.96	0.42	5.82
87	820823	6249	LH014	183	1108	619	489	0	55.87	44.13	0.00	5.27
88	820818	6238	LH440	104	270	0	268	10	0.00	96.40	3.60	7.70
89	820822	6246	LJ002	119	239	24	213	2	10.04	89.12	0.84	7.14
90	820823	6247	LJ004	106	396	183	213	0	46.21	53.79	0.00	5.65
91	820820	6241	LK008	53	12	6	6	0	50.00	50.00	0.00	5.50
92	820820	6240	LS014	184	911	470	442	1	51.48	48.41	0.11	5.45
93	820822	6244	LT001	124	32	16	16	0	50.00	50.00	0.00	5.50
94	820822	6245	LT004	124	107	1	105	1	0.93	98.13	0.93	7.51
95	820821	6242	LV011	139	1006	86	918	2	8.55	91.25	0.20	7.17
96	820821	6243	LX008	140	80	33	43	4	41.25	53.75	5.00	6.13

YEAR=83

OBS	DATE	STNO	AREACODE	N_PHOTO	N_SHRIMP	N_SMALL	N_MEDIUM	N_LARGE	SMPCT	MEPCT	LAPCT	AV_WGT
97	830807	6435	KA011	161	416	38	378	0	9.13	90.87	0.00	7.13
98	830807	6436	KF008	161	171	7	164	0	4.09	95.91	0.00	7.34
99	830807	6437	KD007	173	21	4	17	0	19.05	80.95	0.00	6.74
100	830811	6439	KF007	172	42	5	37	0	11.90	88.10	0.00	7.02
101	830808	6438	KF008	188	22	7	15	0	31.82	68.18	0.00	6.23
102	830812	6441	KJ005	191	20	4	16	0	20.00	80.00	0.00	6.70
103	830811	6440	KL006	187	46	2	44	0	4.34	95.65	0.00	7.33
104	830812	6442	KN004	179	1915	331	1584	0	17.28	82.72	0.00	6.81
105	830730	6428	KP440	196	152	21	128	3	13.82	84.21	1.97	7.06
106	830813	6444	KR004	144	539	5	529	5	0.93	98.14	0.93	7.21
107	830813	6443	KK006	156	1276	539	737	0	42.24	57.76	0.00	5.81
108	830813	6445	KT001	159	445	138	306	1	31.01	68.76	0.22	6.27
109	830830	6456	KT436	169	598	3	585	11	0.50	97.75	1.90	7.39
110	830821	6439	KV002	171	262	105	155	2	40.08	59.16	0.76	5.94
111	830822	6461	KV007	171	387	56	331	0	14.47	85.53	0.00	6.92
112	830822	6460	KX007	168	185	64	121	0	34.59	65.41	0.00	6.12
113	830821	6457	KX438	169	235	23	212	0	9.79	90.21	0.00	7.11
114	830821	6458	KZ002	170	539	149	390	0	27.64	72.36	0.00	6.39
115	830823	6462	KZ014	128	189	35	153	1	18.52	80.95	0.53	6.79
116	830819	6454	LB005	159	579	230	349	0	39.72	60.28	0.00	5.91
117	830731	6429	LD012	169	694	4	690	2	12.25	86.89	0.29	7.00
118	830820	6455	LD439	169	227	11	215	1	4.85	94.71	0.44	7.33
119	830819	6453	LE005	168	773	398	375	0	51.49	48.51	0.00	5.44
120	830819	6452	LH004	161	283	33	246	4	11.66	86.93	1.41	7.11
121	830731	6430	LH014	180	1045	500	540	5	47.47	51.58	0.00	5.60
122	830804	6434	LH440	101	143	1	139	3	0.70	97.20	2.10	7.59
123	830817	6446	LJ011	17	193	120	73	0	62.18	37.82	0.00	7.19
124	830817	6448	LM002	107	162	8	154	0	4.94	95.06	0.00	7.38
125	830817	6447	LM004	157	303	159	144	0	52.48	47.52	0.00	5.40
126	830802	6431	LS014	181	441	137	302	2	31.07	68.48	0.45	6.28
127	830818	6451	LT001	158	41	19	19	3	46.34	46.34	7.32	6.05
128	830818	6450	LT004	183	154	5	144	5	3.25	93.51	3.25	7.55
129	830802	6432	LT012	186	377	18	350	9	4.77	92.84	2.39	7.44
130	830802	6433	LX008	7	2	1	1	0	50.00	50.00	0.00	5.50
131	830818	6449	LX008	167	73	14	56	3	19.18	76.71	4.11	6.96

Table 2. List of stations 1977-83 in the area 66°00'N - 69°30'N with observed density and biomass indices and biomass indices predicted by the model according to SCR Doc. 83/I/1.

YEAR=1977

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
1	KB006	471	956	0.13	0.85	0.41	-0.72
2	KF006	573	78	0.06	0.31	0.14	-0.82
3	KP440	278	278	0.38	2.75	2.17	-0.24
4	KK004	211	393	0.71	5.47	0.88	-1.77
5	KK438	390	217	0.33	1.58	1.61	0.02
6	KT001	350	58	0.22	1.50	3.06	0.71
7	KX005	412	692	0.15	1.15	1.98	0.54
8	KX438	344	644	0.13	0.82	1.49	0.60
9	KZ012	467	302	0.20	1.89	1.35	-0.34

YEAR=1978

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
10	KA011	228	603	0.48	3.10	0.88	-1.26
11	KB006	508	71	0.10	0.86	0.62	-0.33
12	KF007	348	583	0.03	0.06	0.59	2.29
13	KF008	172	590	0.12	0.75	0.76	0.01
14	KK004	395	549	0.13	0.87	1.97	0.82
15	KK006	755	363	0.09	0.55	3.14	1.74
16	KK008	171	427	0.03	0.03	0.51	1.95
17	KK009	244	522	0.58	4.12	1.21	-1.23
18	KV002	423	200	0.17	1.18	1.61	0.31
19	KZ002	326	573	1.48	7.92	2.63	-1.09
20	LB003	331	129	0.26	1.68	2.20	0.27

YEAR=1979

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
21	KN003	243	122	0.14	0.96	1.46	0.42
22	KK004	263	54	3.31	19.90	2.59	-2.04
23	KV007	234	20	0.51	3.71	3.76	0.01
24	KX014	259	24	1.02	7.35	2.02	-1.25
25	KX438	335	17	0.31	1.99	5.25	0.97
26	KZ012	464	54	0.31	2.02	1.83	-0.43
27	LB005	322	41	1.23	5.49	6.75	0.21
28	LE005	217	37	1.56	8.38	4.19	-0.69
29	LJ011	260	166	1.96	10.21	12.23	0.18

YEAR=1980

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
30	KP440	285	51	0.32	2.29	6.75	1.08
31	KF440	284	172	0.21	1.56	5.23	1.21
32	KK004	208	566	0.46	2.98	2.15	-0.32
33	KT001	350	146	4.28	31.36	2.56	-2.51
34	KV002	410	393	0.91	4.74	2.05	-0.84
35	KV007	218	166	0.13	0.79	2.97	1.32
36	KZ012	345	503	1.72	7.12	3.15	-0.82
37	KZ012	466	637	0.15	0.98	1.37	0.34
38	KZ014	270	373	0.93	6.67	2.67	-0.91
39	LA438	323	566	0.09	0.51	2.03	1.38
40	LB005	319	132	0.69	4.11	5.51	0.29
41	LD012	259	241	0.79	5.68	6.26	0.10
42	LD439	329	302	0.14	0.94	2.56	0.91
43	LE005	243	278	1.47	9.00	4.42	-0.73
44	LH004	203	75	0.56	4.15	4.16	0.05
45	LH014	260	454	2.38	17.57	10.66	-0.50
46	LH440	288	231	1.37	10.29	3.14	-1.17
47	LJ011	256	441	3.27	15.80	12.41	-0.24

YEAR=1981

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
48	KA011	218	659	0.45	3.00	2.68	-0.11
49	KF007	352	655	0.11	0.66	0.80	0.19
50	KL006	204	374	0.06	0.24	2.15	2.19
51	KP440	281	366	0.38	2.43	5.37	0.71
52	KK004	218	707	1.62	8.55	2.58	-0.42
53	KT001	347	710	0.87	5.95	2.62	-0.80
54	K143A	280	718	0.55	3.99	2.04	-0.67
55	KV002	411	640	0.63	3.14	2.01	-0.45
56	KX438	347	544	0.22	1.51	2.11	0.34
57	KZ003	340	625	0.94	5.94	3.22	-0.47
58	KZ012	470	633	0.28	1.87	3.24	0.55
59	KZ012	278	655	2.10	12.43	7.41	-0.52
60	LB005	326	599	0.81	4.17	5.34	0.28
61	LE005	256	670	2.14	10.01	6.45	-0.44
62	LH014	253	596	0.72	4.31	5.01	0.15
63	LJ011	252	737	1.97	11.09	14.37	0.26

YEAR=1982

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
64	KA011	220	461	0.43	2.71	1.07	-0.93
65	KF007	320	563	0.06	0.32	0.75	0.86
66	KL006	183	258	0.67	3.14	4.56	0.37
67	KN003	215	359	3.10	22.35	7.36	-1.11
68	KP440	280	342	0.95	5.18	7.07	0.31
69	KK004	213	471	1.00	7.41	6.31	-0.16
70	KK006	185	607	3.35	15.08	3.17	-1.56
71	KT001	350	444	2.09	11.22	4.81	-0.85
72	KT438	281	631	0.52	3.29	4.03	0.06
73	KV002	424	647	0.38	2.25	2.44	0.08
74	KV007	191	644	0.78	4.75	4.93	0.04
75	KX007	410	658	0.75	5.14	4.03	-0.25
76	KX438	337	576	0.30	2.14	3.11	0.37
77	KZ003	344	586	0.75	4.71	5.24	0.11
78	KZ012	448	668	0.41	3.02	2.13	-0.35
79	KZ014	260	281	0.65	4.45	3.74	-0.17
80	LB005	329	458	0.80	[illegible]	7.24	0.43
81	LD012	245	498	0.93	5.31	8.04	0.42
82	LE005	266	441	1.23	6.66	8.08	0.19
83	LH004	209	403	0.59	3.40	5.69	0.52
84	LH014	259	670	1.80	9.41	17.44	0.62
85	LH440	282	353	0.80	6.08	3.99	-0.42

YEAR=1983

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM	P_BIOM	RES
86	KA011	225	435	0.97	6.84	1.90	-1.24
87	KB008	176	489	0.36	2.58	1.41	-0.61
88	KB007	353	467	0.06	0.31	0.51	0.49
89	KL007	241	644	0.10	0.65	0.38	-0.54
90	KF008	145	508	0.05	0.28	2.16	2.04
91	KJ005	478	642	0.04	0.22	0.37	0.53
92	KL006	206	585	0.10	0.58	3.69	1.85
93	KN004	213	607	3.17	21.50	5.14	-1.43
94	KP440	281	529	0.29	2.02	10.02	1.60
95	KK004	223	408	1.10	8.30	7.66	-0.08
96	KK006	185	516	2.48	14.36	4.06	-1.26
97	KT001	349	539	0.84	5.17	3.13	-0.50
98	KT438	293	573	1.02	7.66	3.27	-0.85
99	KV002	416	580	0.46	2.65	1.92	0.32
100	KV007	256	580	0.68	4.63	9.05	0.67
101	KX007	434	570	0.33	1.99	1.99	0.00
102	KX438	339	573	0.42	2.93	2.88	-0.02
103	KZ002	314	526	0.95	5.99	4.61	-0.26
104	KZ012	463	434	0.44	2.93	1.75	-0.52
105	LB005	330	429	1.36	7.99	6.06	-0.24
106	LD012	229	456	1.53	10.60	6.12	-0.55
107	LD439	334	523	0.41	2.89	3.45	0.18
108	LE005	273	570	1.17	7.40	9.53	0.25
109	LH004	213	546	0.52	3.69	2.56	0.22
110	LH014	247	486	2.20	12.29	17.26	0.37
111	LH440	281	273	0.53	3.97	5.21	0.27
112	LJ011	256	58	3.36	24.09	32.45	0.30

Table 3. List of stations 1981-83 in the area 66*00'N - 69*30'N with observed density and biomass indices and biomass indices predicted by the model introduced in this paper.

OBSERVED AND PREDICTED VALUES OF SHRIMP BIOMASS
66*00N - 69*30N
REDUCED MODEL WITH BASIC PARAMETERS YEAR DEPTH LO TEMP TE2 T_4

YEAR=1981

OBS	AREACODE	DEPTH	O_SUM	O_DENS	O_BIOM	P_BIOM	RES
1	KA011	218	659	0.45	3.00	3.52	0.16
2	KF007	352	655	0.11	0.66	0.57	-0.14
3	KL006	206	374	0.06	0.24	0.66	1.02
4	KP440	281	366	0.38	2.61	3.82	0.38
5	KR004	218	707	1.62	8.55	4.10	-0.74
6	KT001	347	710	0.87	5.92	4.12	-0.36
7	KT436	280	718	0.55	3.99	2.73	-0.38
8	KV002	411	640	0.63	3.14	1.92	-0.49
9	KX438	347	544	0.22	1.53	2.70	0.57
10	KZ003	340	625	0.94	5.94	5.15	-0.14
11	KZ012	470	633	0.28	1.87	2.31	0.21
12	KZ015	278	625	2.10	12.43	8.41	-0.39
13	LB005	326	599	0.81	4.17	7.03	0.52
14	LE005	256	670	2.14	10.01	9.02	-0.10
15	LH014	253	596	0.72	4.31	9.07	0.74
16	LJ011	252	237	1.97	11.09	13.00	0.16

YEAR=1982

OBS	AREACODE	DEPTH	O_SUM	O_DENS	O_BIOM	P_BIOM	RES
17	KA011	220	461	0.43	2.71	3.55	0.27
18	KF007	320	563	0.06	0.32	0.36	0.11
19	KL006	183	258	0.67	3.14	7.98	0.93
20	KN003	215	359	3.10	22.35	7.66	-1.07
21	KP440	280	512	0.95	5.18	12.93	0.92
22	KR004	213	471	1.00	7.41	6.44	-0.14
23	KR006	185	607	3.35	15.08	5.95	-0.93
24	KT001	350	444	2.09	11.22	8.87	-0.23
25	KT436	281	631	0.52	3.79	2.84	-0.29
26	KV002	424	647	0.38	2.25	3.09	0.32
27	KV007	191	644	0.78	4.75	5.81	0.20
28	KX007	410	668	0.75	5.16	4.48	-0.14
29	KX438	337	576	0.30	2.14	2.99	0.33
30	KZ003	344	586	0.75	4.71	6.54	0.33
31	KZ012	468	668	0.41	3.02	2.13	-0.35
32	KZ014	260	281	0.65	4.45	4.45	0.00
33	LB005	329	658	0.80	4.71	4.62	-0.02
34	LD012	245	498	0.93	5.31	6.24	0.16
35	LE005	266	441	1.23	6.66	6.26	-0.06
36	LH004	209	403	0.59	3.40	4.17	0.20
37	LH014	259	620	1.80	9.41	9.82	0.04
38	LH440	282	353	0.80	6.08	4.12	-0.39

YEAR=1983

OBS	AREACODE	DEPTH	O_SUM	O_DENS	O_BIOM	P_BIOM	RES
39	KA011	225	435	0.97	6.84	2.57	-0.98
40	KB008	176	489	0.36	2.58	0.98	-0.97
41	KD007	353	467	0.06	0.31	0.16	-0.69
42	KF007	241	464	0.10	0.65	1.62	0.91
43	KF008	165	508	0.05	0.28	1.04	1.31
44	KJ005	478	647	0.04	0.22	0.35	0.47
45	KL006	206	585	0.10	0.58	1.18	0.71
46	KN004	213	607	3.17	21.50	11.00	-0.67
47	KP440	281	529	0.29	2.02	7.58	1.32
48	KR004	223	488	1.10	8.30	9.45	0.13
49	KR006	185	516	2.48	14.36	5.67	-0.93
50	KT001	349	539	0.84	5.17	3.67	-0.34
51	KT436	293	573	1.02	7.66	5.03	-0.42
52	KV002	416	580	0.46	2.65	1.42	-0.63
53	KV007	256	580	0.68	4.63	6.38	0.32
54	KX007	434	570	0.33	1.99	2.24	0.12
55	KX438	339	573	0.42	2.93	2.45	-0.18
56	KZ002	334	576	0.95	5.99	4.25	-0.34
57	KZ012	463	434	0.44	2.93	3.53	0.19
58	LB005	330	429	1.36	7.99	11.12	0.33
59	LD012	229	456	1.53	10.60	8.10	-0.27
60	LD439	334	573	0.41	2.89	3.42	0.17
61	LE005	273	570	1.37	7.40	7.22	-0.02
62	LH004	213	546	0.52	3.69	7.30	0.68
63	LH014	237	486	2.20	12.29	7.65	-0.47
64	LH440	281	273	0.53	3.97	6.26	0.46
65	LJ011	256	58	3.36	24.09	5.83	-1.42

Table 4. List of stations 1981-83 in the area north of 69°30'N with observed density and biomass indices.

OBSERVED VALUES OF SHRIMP BIOMASS
NORTH OF 69°30N
MODEL AS USED IN NAFO RES.DOC 83/I/1

YEAR=1981

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM
1	LS014	262	707	0.9	4.84

YEAR=1982

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM
2	LM002	255	403	0.60	4.18
3	LM006	177	359	1.11	6.24
4	LR008	110	180	0.07	0.38
5	LS014	256	624	1.47	7.96
6	LT001	421	509	0.07	0.36
7	LT004	333	420	0.27	1.89
8	LV011	337	471	2.14	15.26
9	LX008	508	475	0.17	1.03

YEAR=1983

OBS	AREACODE	DEPTH	O_SQM	O_DENS	O_BIOM
10	LM002	260	363	0.45	3.27
11	LM006	178	526	0.58	3.12
12	LS014	262	489	0.91	5.62
13	LT001	444	536	0.09	0.46
14	LT004	321	553	0.28	2.10
15	LV012	353	502	0.76	5.59
16	LX008	518	19	0.11	0.60
17	LX008	488	586	0.13	0.90

Table 5. Output from the regression analysis 1977-83, using the model from SCR Doc. 83/I/1.

SHRIMP PHOTO, BIOMASS 1977 - 1983
66*00N - 69*30N
MODEL AS USED IN NAFO RES.DOC 83/I/1

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNBIALL
WEIGHT: SQMETER

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	21	40357.01965845	1921.76284088	4.78	0.0001	0.527510	1809.4041
ERROR	90	36147.66757053	401.64075078		STD DEV		LNBIALL MEAN
CORRECTED TOTAL	111	76504.68722898			20.04097679		1.10760094

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
U	1	40.91838698	0.10	0.7503	1	93.75645728	0.23	0.6302
YEAR	1	7121.13277758	17.73	0.0001	1	87.04097421	0.22	0.6427
DEPTH	1	2510.15755530	6.25	0.0142	1	871.96674356	2.17	0.1441
LA	1	16989.55052100	42.30	0.0001	1	174.10535306	0.43	0.5120
LO	1	155.53022816	0.39	0.5353	1	3787.97604522	9.43	0.0028
TEMP	1	2299.38128183	5.72	0.0188	1	1145.72708191	2.85	0.0947
YEAR*YEAR	1	30.61219332	0.08	0.7831	1	1.53005320	0.00	0.9509
DEPTH*DEPTH	1	2691.39505081	6.70	0.0112	1	4198.83920698	10.45	0.0017
LA*LA	1	1.05134538	0.00	0.9593	1	1097.58953875	2.73	0.1018
LO*LO	1	310.13195201	0.77	0.3819	1	1452.33856393	3.62	0.0604
TEMP*TEMP	1	30.45618798	0.08	0.7837	1	0.00541771	0.00	0.9971
YEAR*DEPTH	1	1731.11670557	4.31	0.0407	1	0.06201857	0.00	0.9901
YEAR*LA	1	364.98519694	0.91	0.3430	1	163.13781100	0.41	0.5255
YEAR*LO	1	31.41781777	0.08	0.7804	1	16.78496192	0.04	0.8385
YEAR*TEMP	1	970.09304956	2.42	0.1237	1	457.25090898	1.14	0.2888
DEPTH*LA	1	14.89066484	0.04	0.8477	1	495.85305861	1.23	0.2695
DEPTH*LO	1	3.33610965	0.01	0.9276	1	391.53270743	0.97	0.3261
DEPTH*TEMP	1	687.15037867	1.71	0.1942	1	103.70036633	0.26	0.6126
LA*LO	1	2258.24543509	5.62	0.0199	1	3269.38590672	8.14	0.0054
LA*TEMP	1	1998.03730454	4.97	0.0282	1	1707.43062116	4.25	0.0421
LO*TEMP	1	117.42951547	0.29	0.5900	1	117.42951547	0.29	0.5900

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	-855.34842654	-1.17	0.2467	733.57895406
U	36.24474396	0.48	0.6302	75.01762783
YEAR	-3.21626015	-0.47	0.6427	6.90888850
DEPTH	0.43694341	1.47	0.1441	0.29654740
LA	-12.36367615	-0.66	0.5120	18.77848034
LO	48.05411271	3.07	0.0028	15.64753155
TEMP	-36.90001930	-1.69	0.0947	21.84765801
YEAR*YEAR	-0.00204025	-0.06	0.9509	0.03305588
DEPTH*DEPTH	-6.7618574E-05	-3.23	0.0017	0.00002091
LA*LA	0.27005538	1.65	0.1018	0.16336226
LO*LO	-0.13158011	-1.90	0.0604	0.06919508
TEMP*TEMP	-0.00059919	-0.00	0.9971	0.16314572
YEAR*DEPTH	-1.2685284E-05	-0.01	0.9901	0.00102084
YEAR*LA	0.04774276	0.64	0.5255	0.07491161
YEAR*LO	0.01108934	0.20	0.8385	0.05424558
YEAR*TEMP	-0.09630382	-1.07	0.2888	0.09025787
DEPTH*LA	-0.00409525	-1.11	0.2695	0.00368573
DEPTH*LO	-0.00200701	-0.99	0.3261	0.00203276
DEPTH*TEMP	0.00116173	0.51	0.6126	0.00228631
LA*LO	-0.49244472	-2.85	0.0054	0.17260099
LA*TEMP	0.57543940	2.06	0.0421	0.27909172
LO*TEMP	0.08198541	0.54	0.5900	0.15162360

Table 6. Output from the regression analysis 1981-83, using the model introduced in this paper.

SHRIMP PHOTO, BIOMASS 1981 - 1983
66*00N - 69*30N
REDUCED MODEL WITH BASIC PARAMETERS YEAR DEPTH LO TEMP TE2 T_4

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNBIALL
WEIGHT: SQMETER

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	16	27702.15109668	1731.38444354	8.50	0.0001	0.739043	1074.9111
ERROR	48	9781.66312582	203.78464845		STD DEV		LNBIALL MEAN
CORRECTED TOTAL	64	37483.81422251			14.27531605		1.32804624

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
U	1	235.51168752	1.16	0.2877	1	0.14250207	0.00	0.9790
YEAR	1	220.80420775	1.08	0.3031	1	2428.52659133	11.92	0.0012
DEPTH	1	2883.90550808	14.15	0.0005	1	2567.38465131	12.60	0.0009
LO	1	12.66274927	0.06	0.8042	1	2205.02099716	10.82	0.0019
TEMP	1	5900.45523122	28.95	0.0001	1	702.23377122	3.45	0.0696
TE2	1	2658.03428577	13.04	0.0007	1	2816.92539202	13.82	0.0005
T_4	1	68.64316952	0.34	0.5644	1	863.35045359	4.24	0.0450
DEPTH*DEPTH	1	7243.27324059	35.54	0.0001	1	5872.91702217	28.82	0.0001
YEAR*LA	1	2836.02009748	13.92	0.0005	1	2310.55595172	11.34	0.0015
DEPTH*LA	1	130.49093832	0.64	0.4275	1	1959.46169747	9.62	0.0032
DEPTH*LO	1	37.25954105	0.18	0.6709	1	1092.35227175	5.36	0.0249
DEPTH*T_4	1	59.24563247	0.29	0.5922	1	1062.74412851	5.22	0.0269
LO*LA	1	211.88324658	1.04	0.3130	1	2107.40634862	10.34	0.0023
TEMP*LA	1	1382.58181134	6.78	0.0122	1	576.28352490	2.83	0.0991
TE2*LA	1	2415.51833319	11.85	0.0012	1	2751.02312208	13.50	0.0006
TEMP*T_4	1	1405.86141653	6.90	0.0115	1	1405.86141653	6.90	0.0115

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	-9.23398690	-0.34	0.7324	26.84912294
U	-5.45024381	-0.03	0.9790	206.10620726
YEAR	-23.99119476	-3.45	0.0012	6.94970191
DEPTH	0.98330185	3.55	0.0009	0.27703020
LO	34.22421244	3.29	0.0019	10.40429915
TEMP	-30.37288192	-1.86	0.0696	16.36179241
TE2	-65.31414371	-3.72	0.0005	17.56731131
T_4	2.15309632	2.06	0.0450	1.04605767
DEPTH*DEPTH	-9.1537626E-05	-5.37	0.0001	0.00001705
YEAR*LA	0.34180447	3.37	0.0015	0.10150916
DEPTH*LA	-0.01054707	-3.10	0.0032	0.00340133
DEPTH*LO	-0.00295908	-2.32	0.0249	0.00127809
DEPTH*T_4	-0.01282756	-2.28	0.0269	0.00561714
LO*LA	-0.48806662	-3.22	0.0023	0.15177166
TEMP*LA	0.39155143	1.68	0.0991	0.23283938
TE2*LA	0.94581368	3.67	0.0006	0.25742114
TEMP*T_4	1.24561672	2.63	0.0115	0.47424079

Table 7. 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, labelled A to G (see Fig. 13).

AREA		TOTAL BIOMASS		
		1981	1982	1983
G	69*00'N - 69*30'N	54470	34121	37049
F	68*30'N - 69*00'N	55540	41719	63177
E	68*00'N - 68*30'N	37955	55430	65992
D	67*30'N - 68*00'N	29931	64299	55730
C	67*00'N - 67*30'N	6206	28665	12695
B	66*30'N - 67*00'N	6755	8178	4446
A	66*00'N - 66*30'N	9717	14327	7615
	66*00'N - 69*30'N	200574	246739	246254

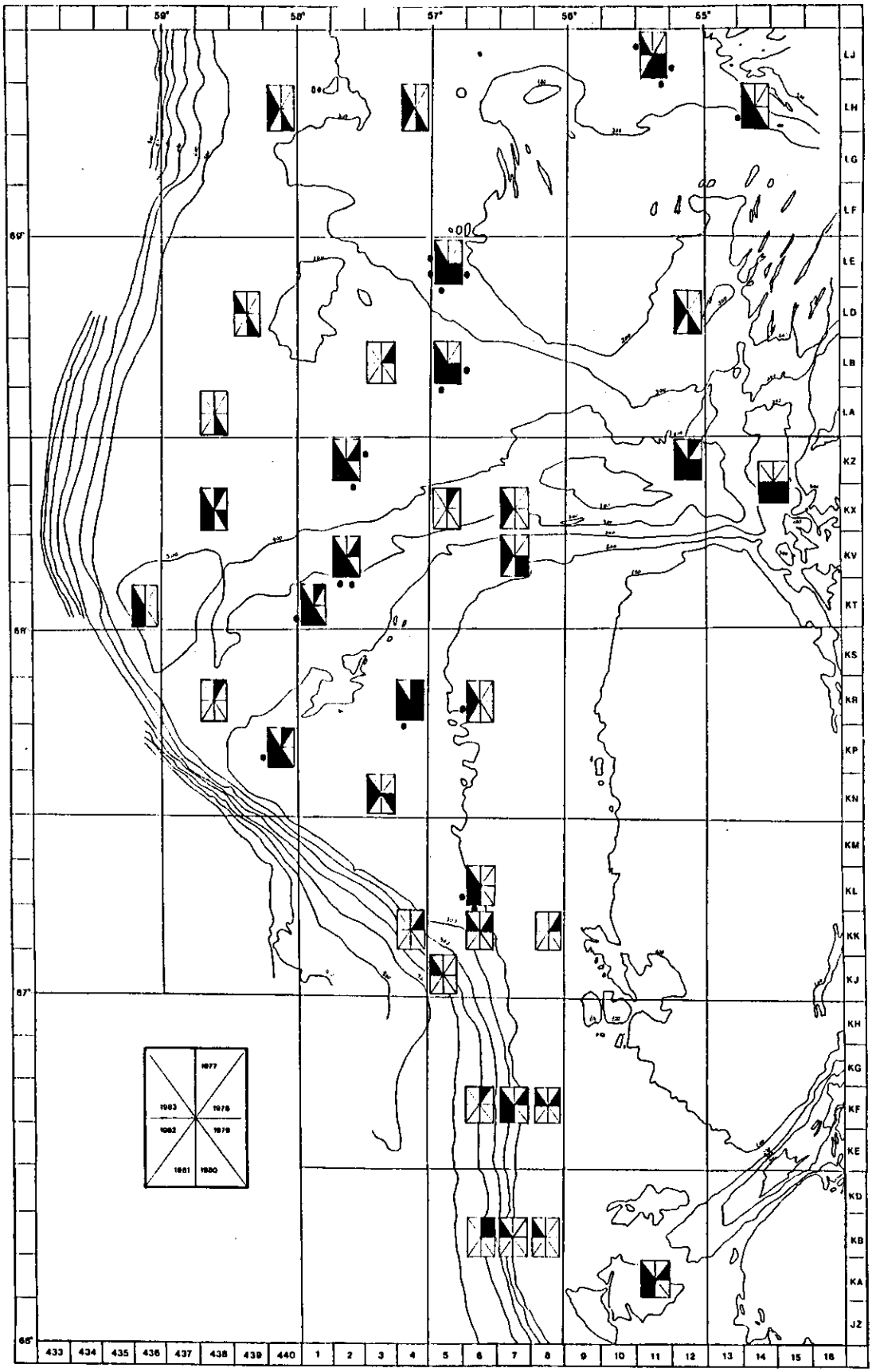

Fig. 1. Map with sampling stations 1977-83 in the area 66*00'N - 69*30'N. The dots around certain stations denote sampling years with small shrimp dominating.

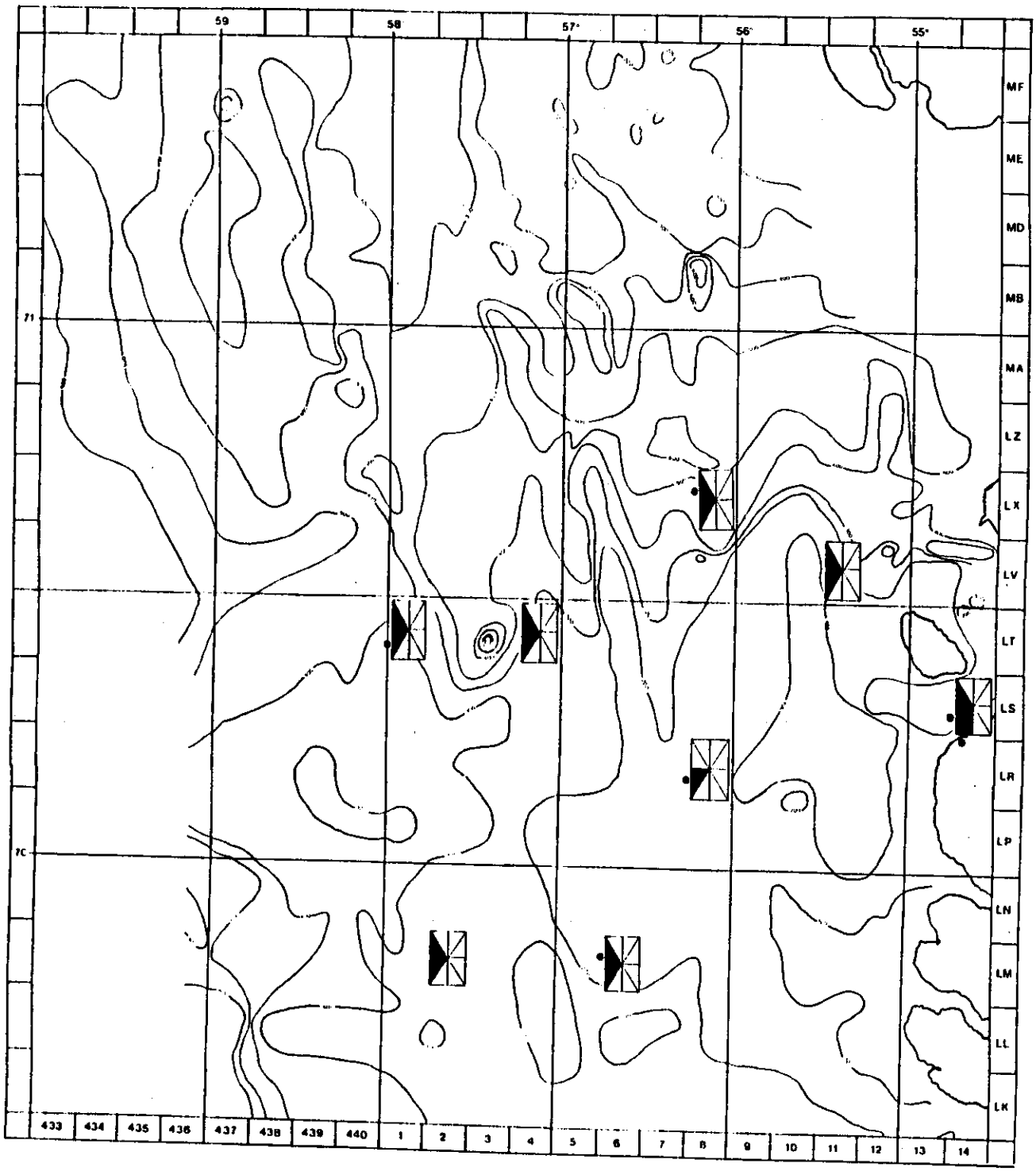

Fig. 2. Map with sampling stations 1981-83 in the area north of 69*30'N. Legends as in Fig. 1.

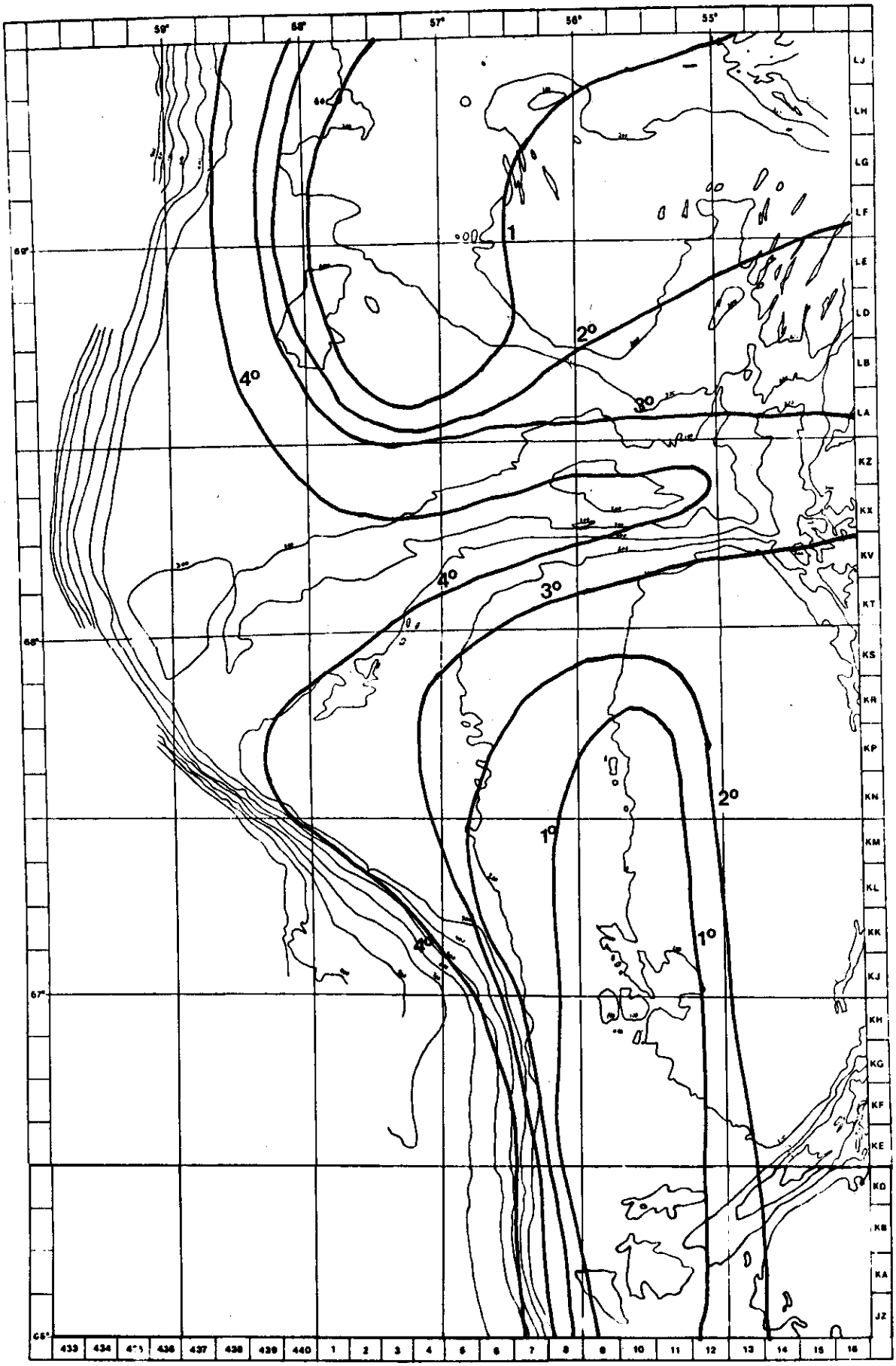

Fig. 3. Bottom temperatures (isotherms) in July-August 1978.

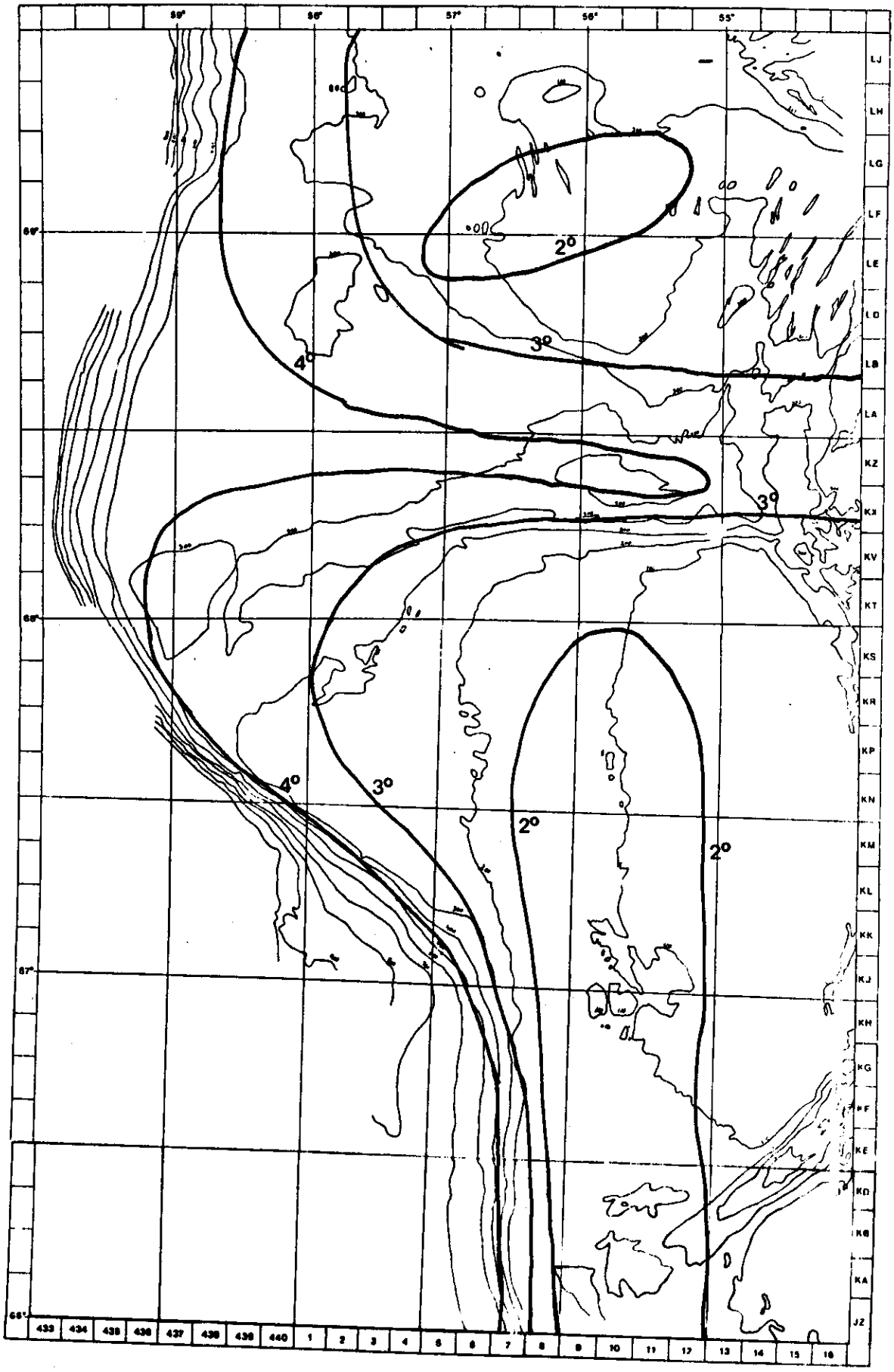

Fig. 4. Bottom temperatures (isotherms) in July-August 1979.

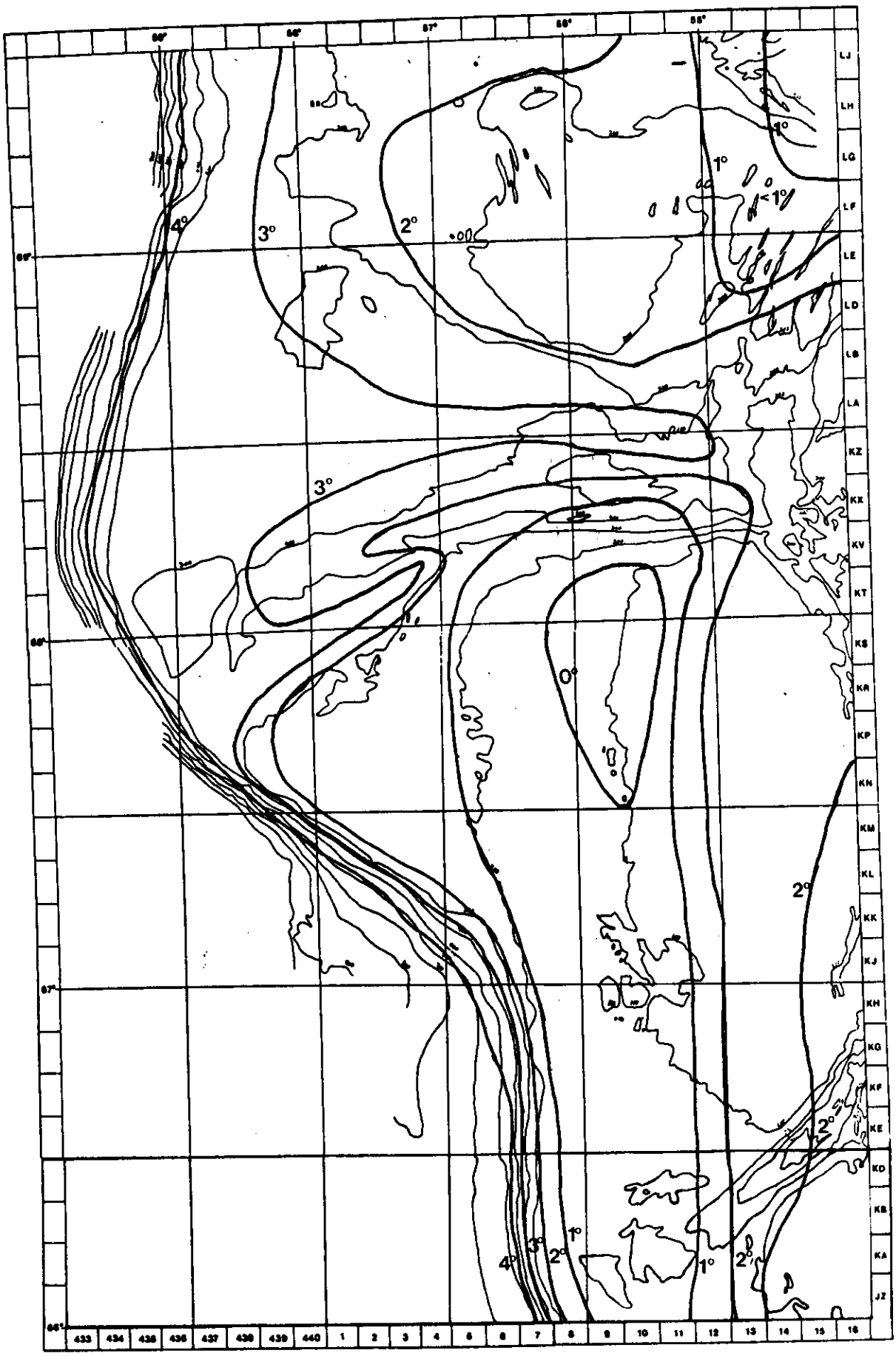

Fig. 5. Bottom temperatures (isotherms) in July-August 1980.

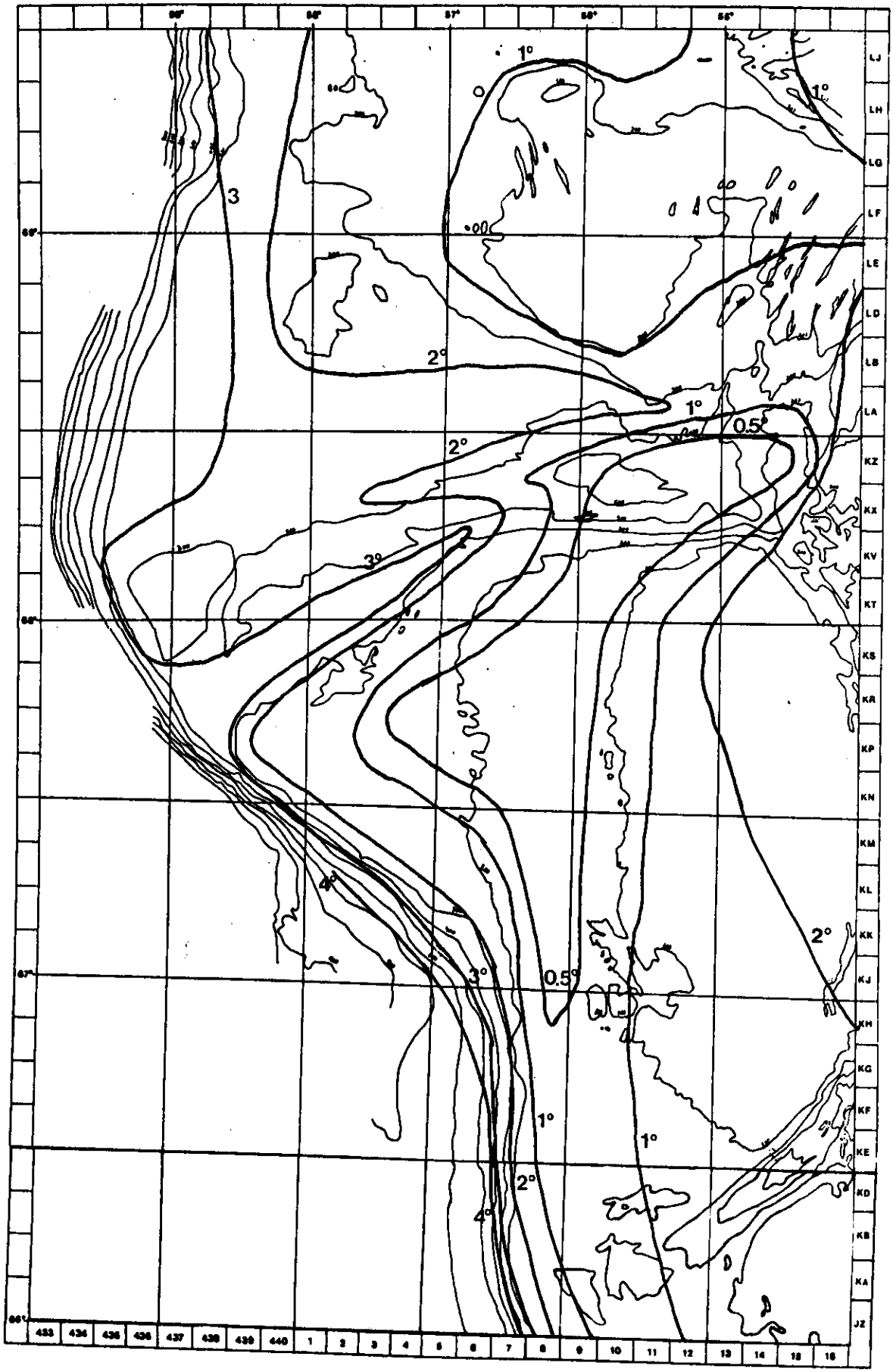

Fig. 6. Bottom temperatures (isotherms) in July-August 1981.

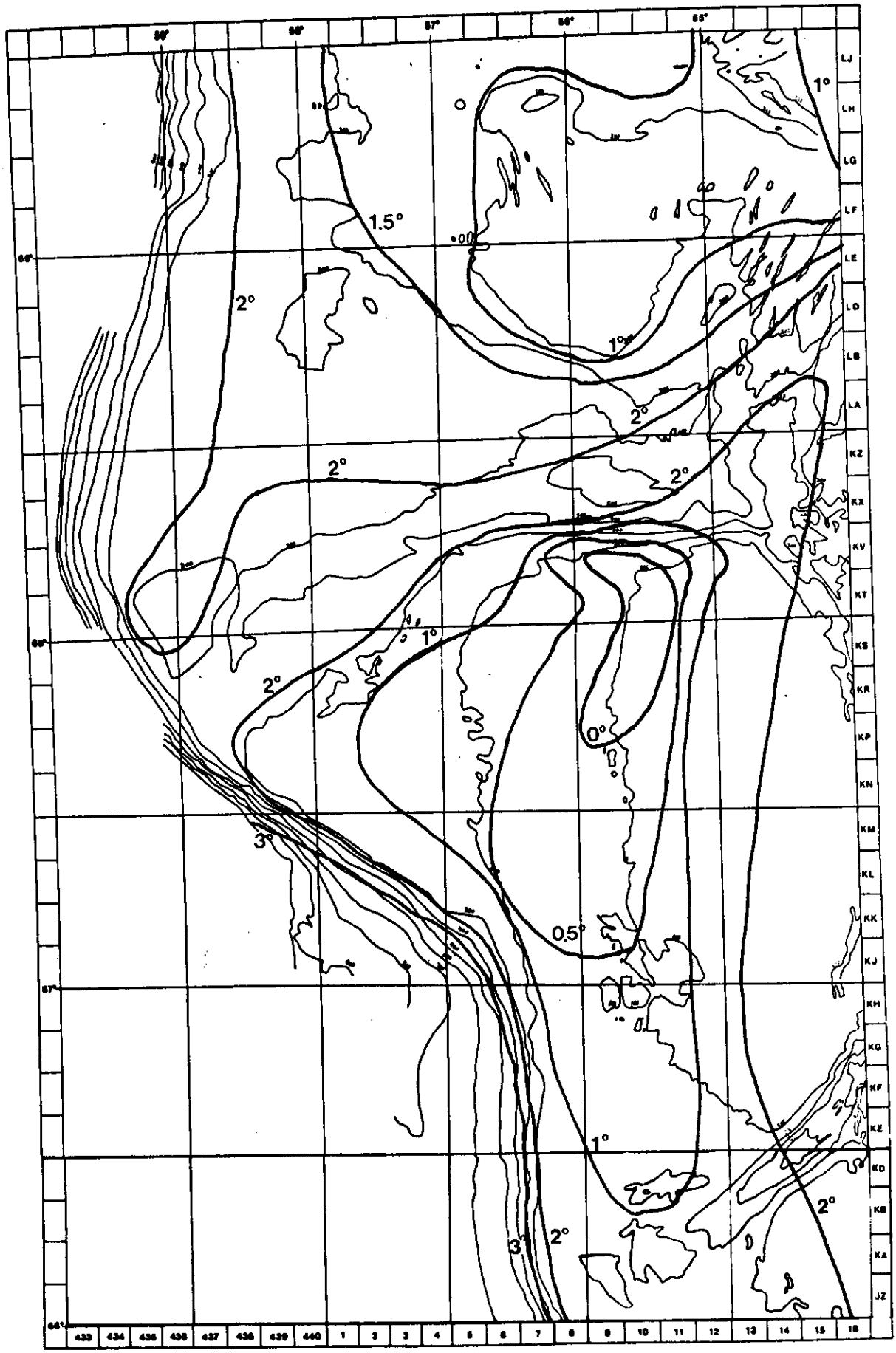

Fig. 7. Bottom temperatures (isotherms) in July-August 1982.

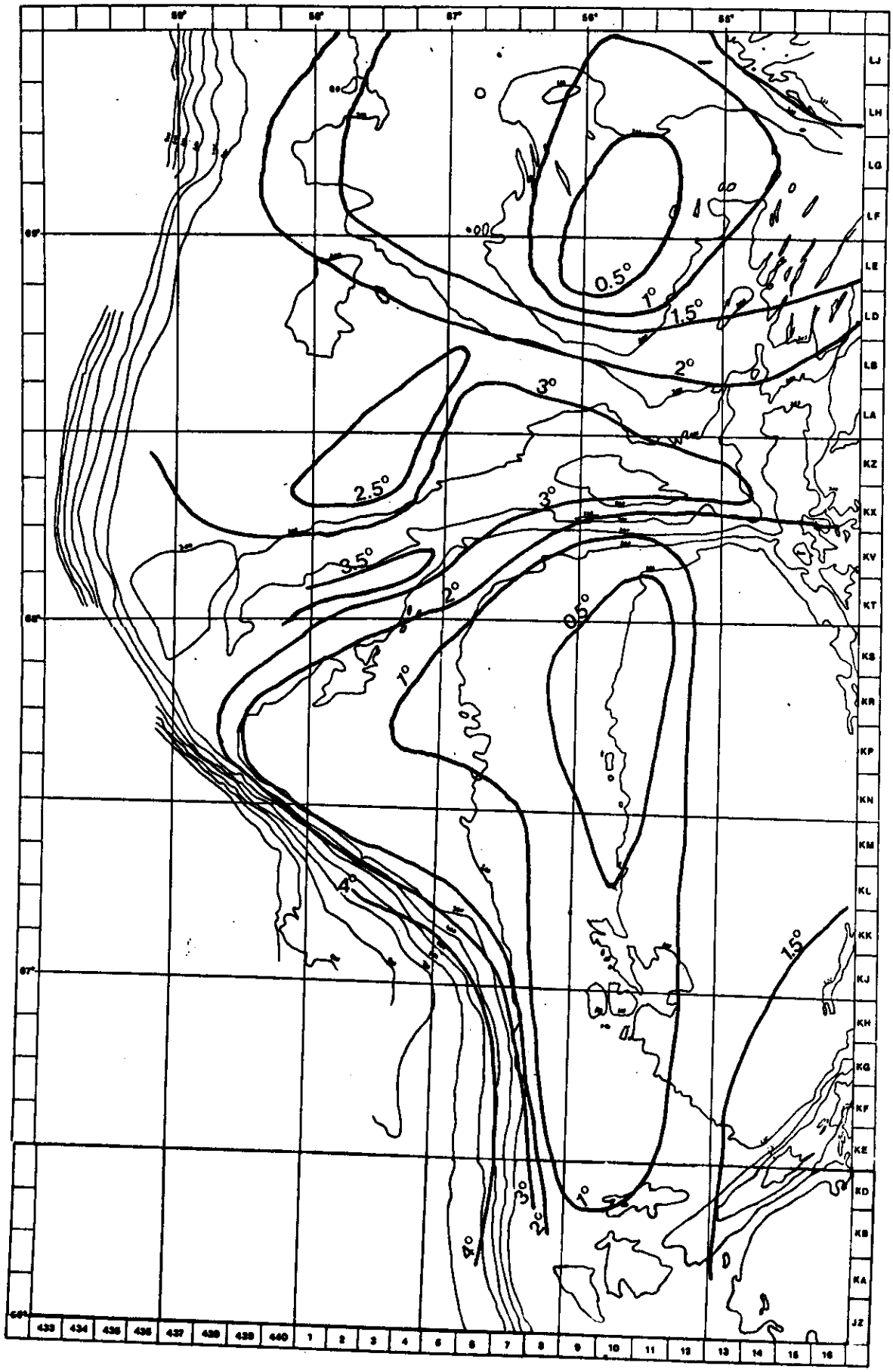

Fig. 8. Bottom temperatures (isotherms) in July-August 1983.

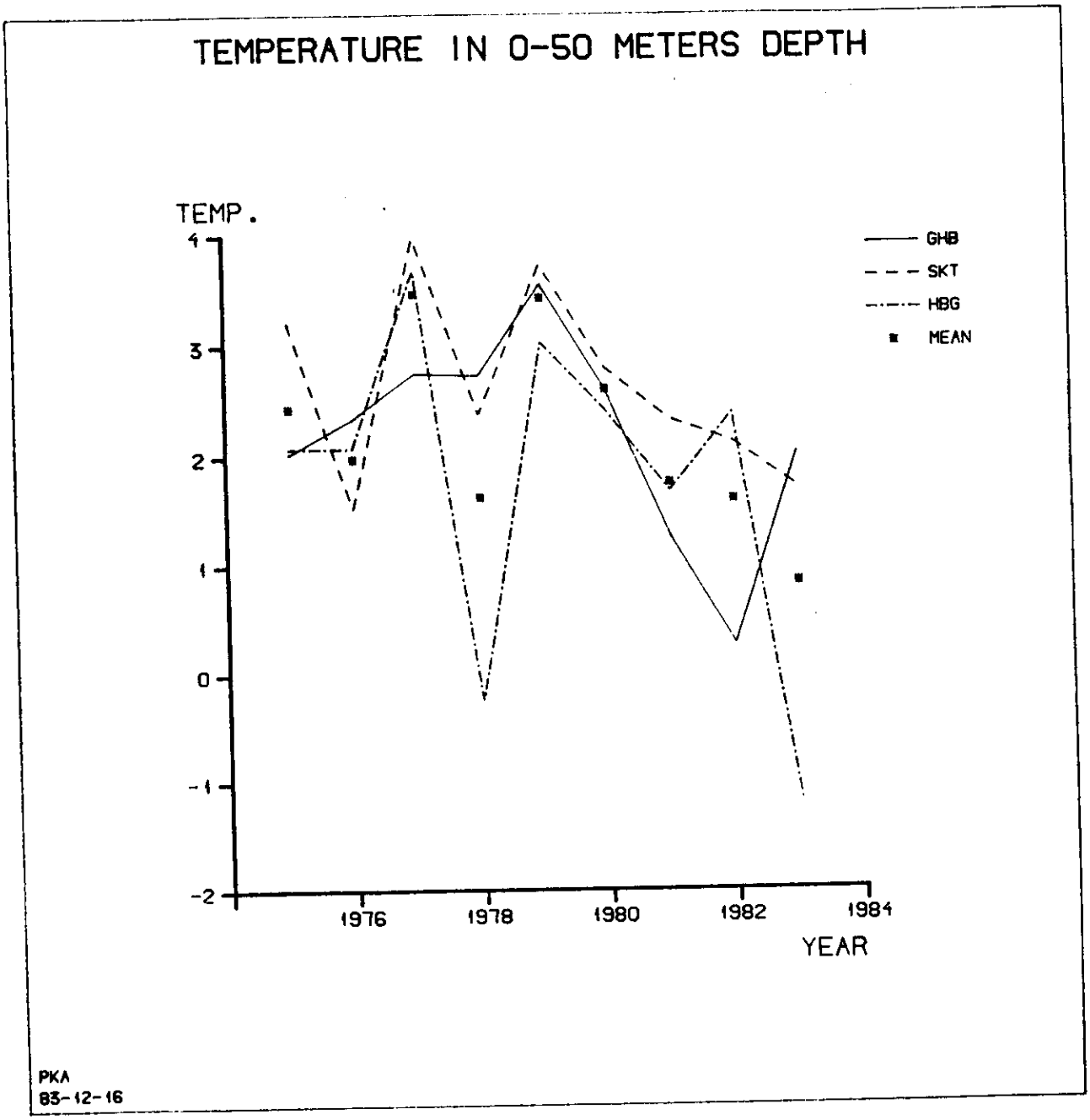

Fig. 9. Temperatures in 0-50 meters depth (average) in July 1975-83 west of the banks, observed on the hydrography sections off Godthåb, Sukkertoppen and Holsteinsborg.

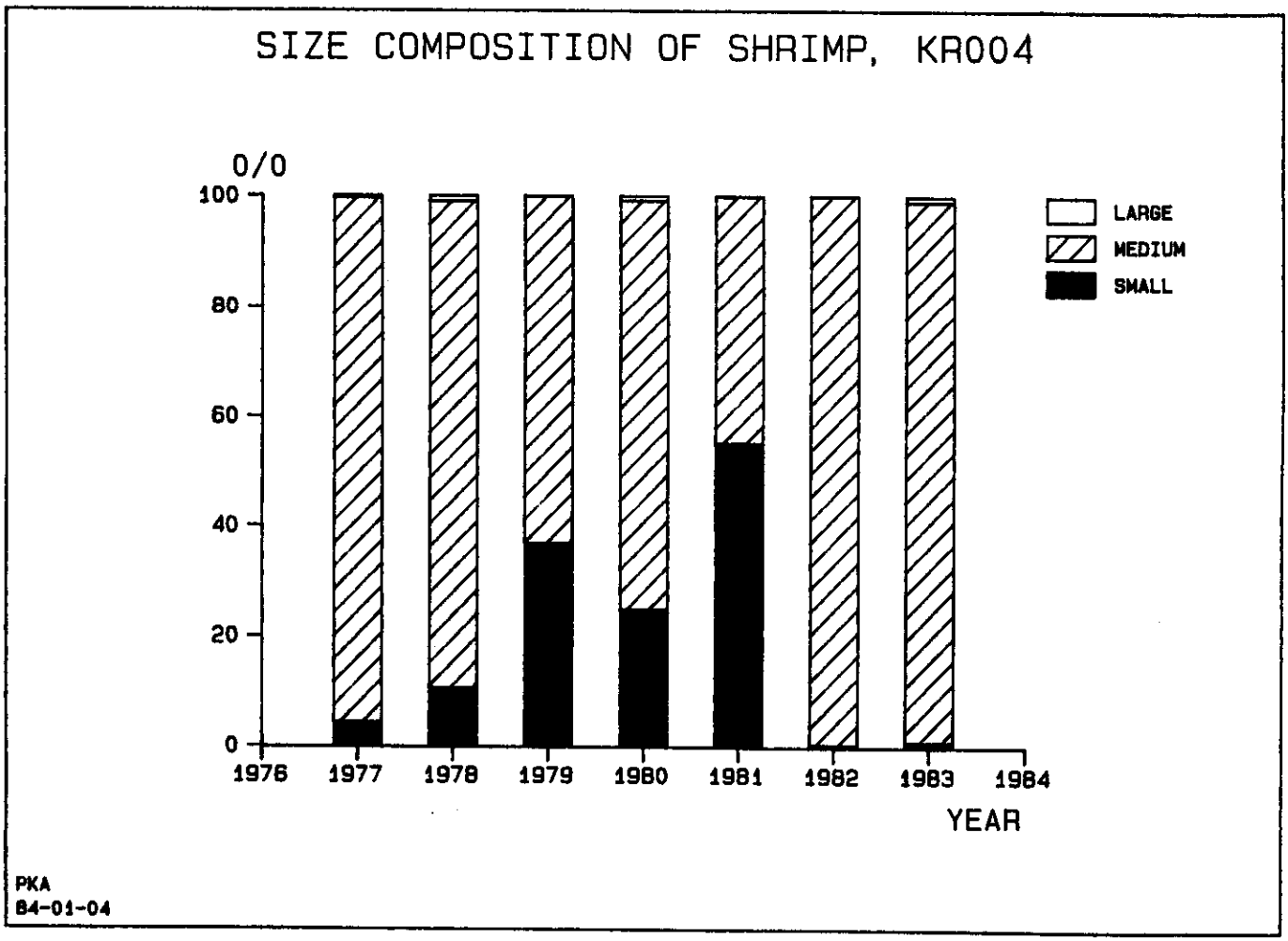

Fig. 10. Size composition of shrimp as observed in the photographic material 1977-83 from the area KR004.

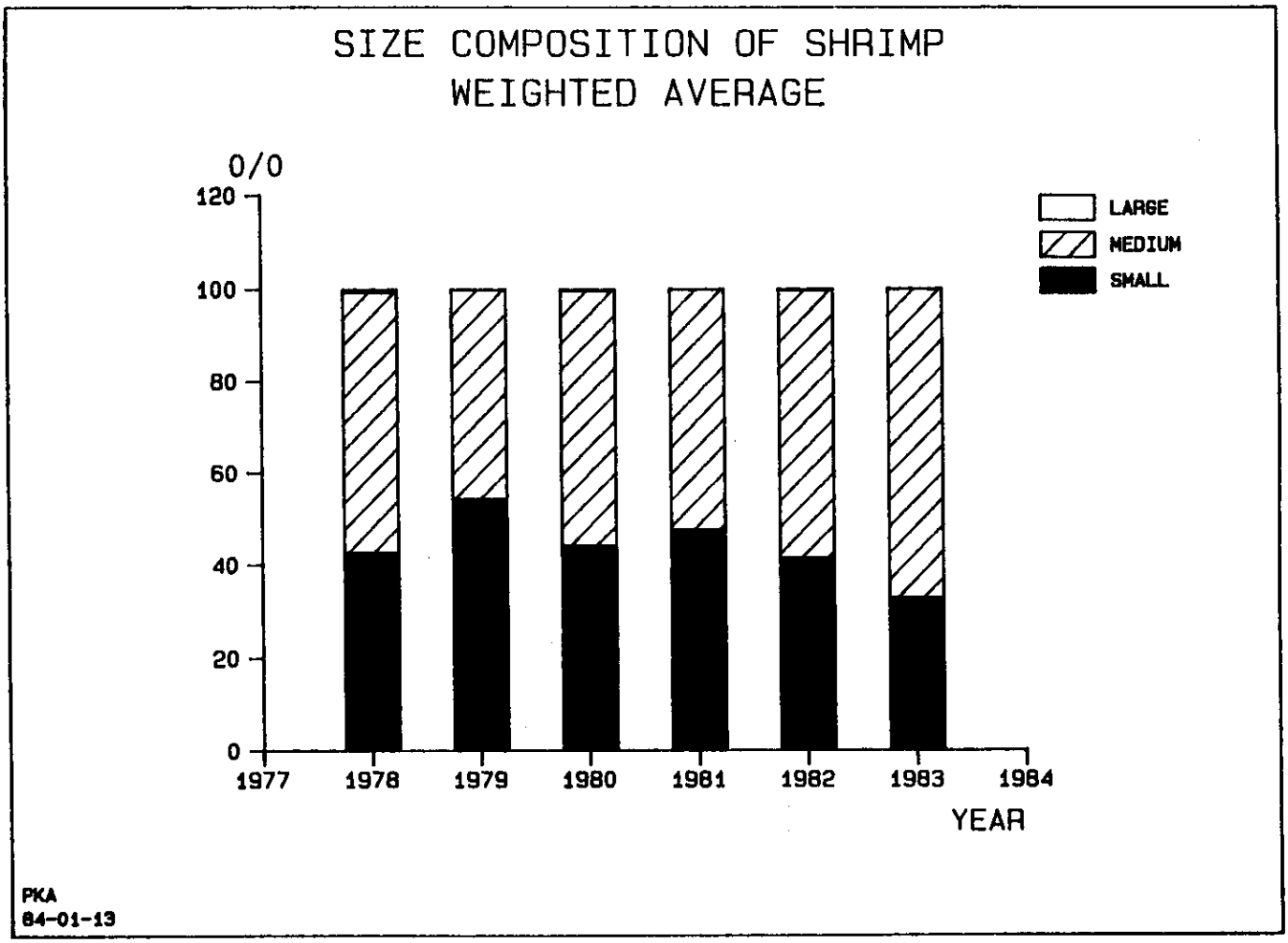

Fig. 11. Size composition of shrimp as observed in the photographic material 1978-83. Weighted average of all sampling stations in the area 66*00'N - 69*30'N.

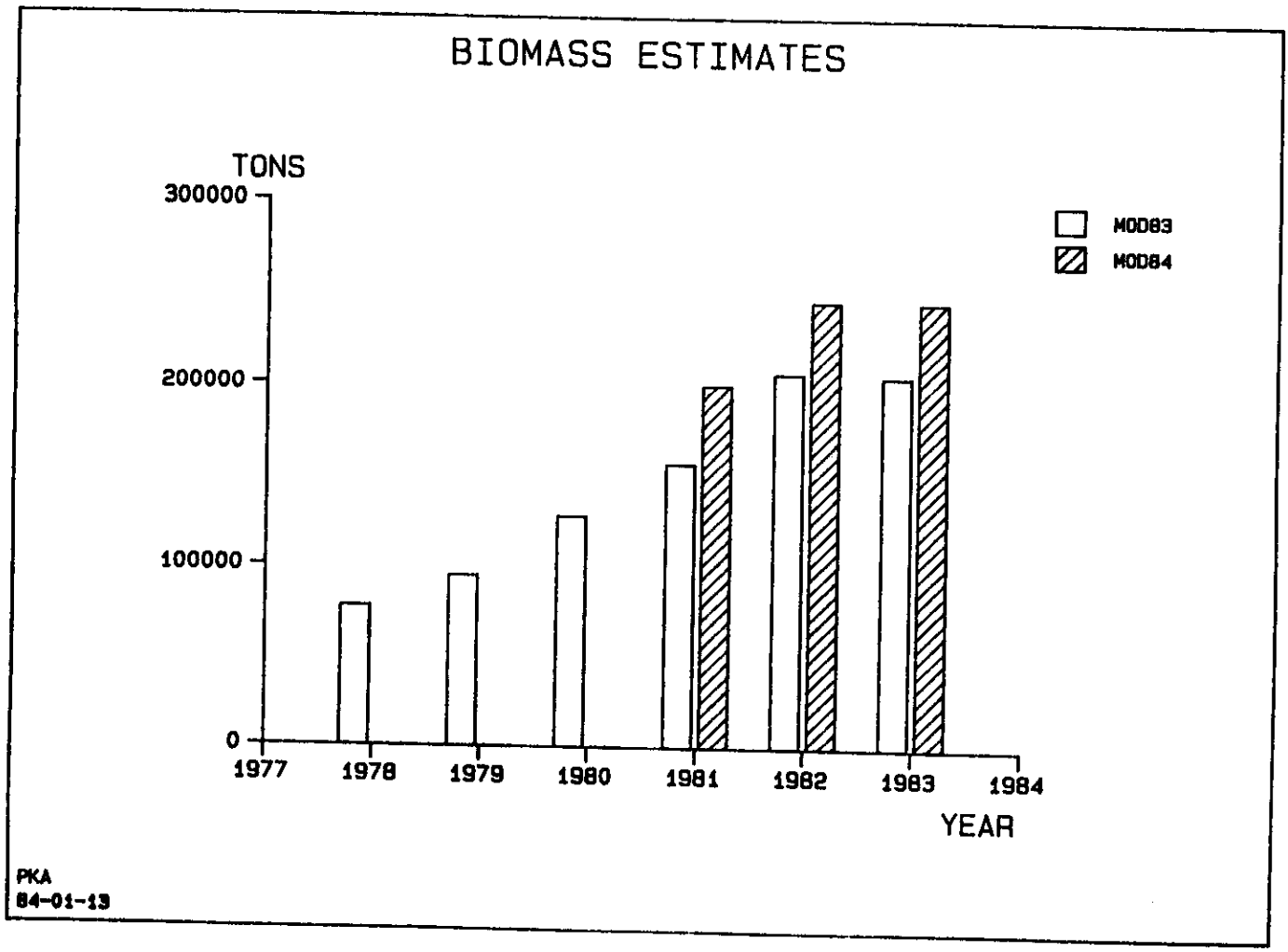

Fig. 12. Total biomass estimates in the area 66*00'N to 69*30'N for 1977-83 obtained by the two models as explained in the text.

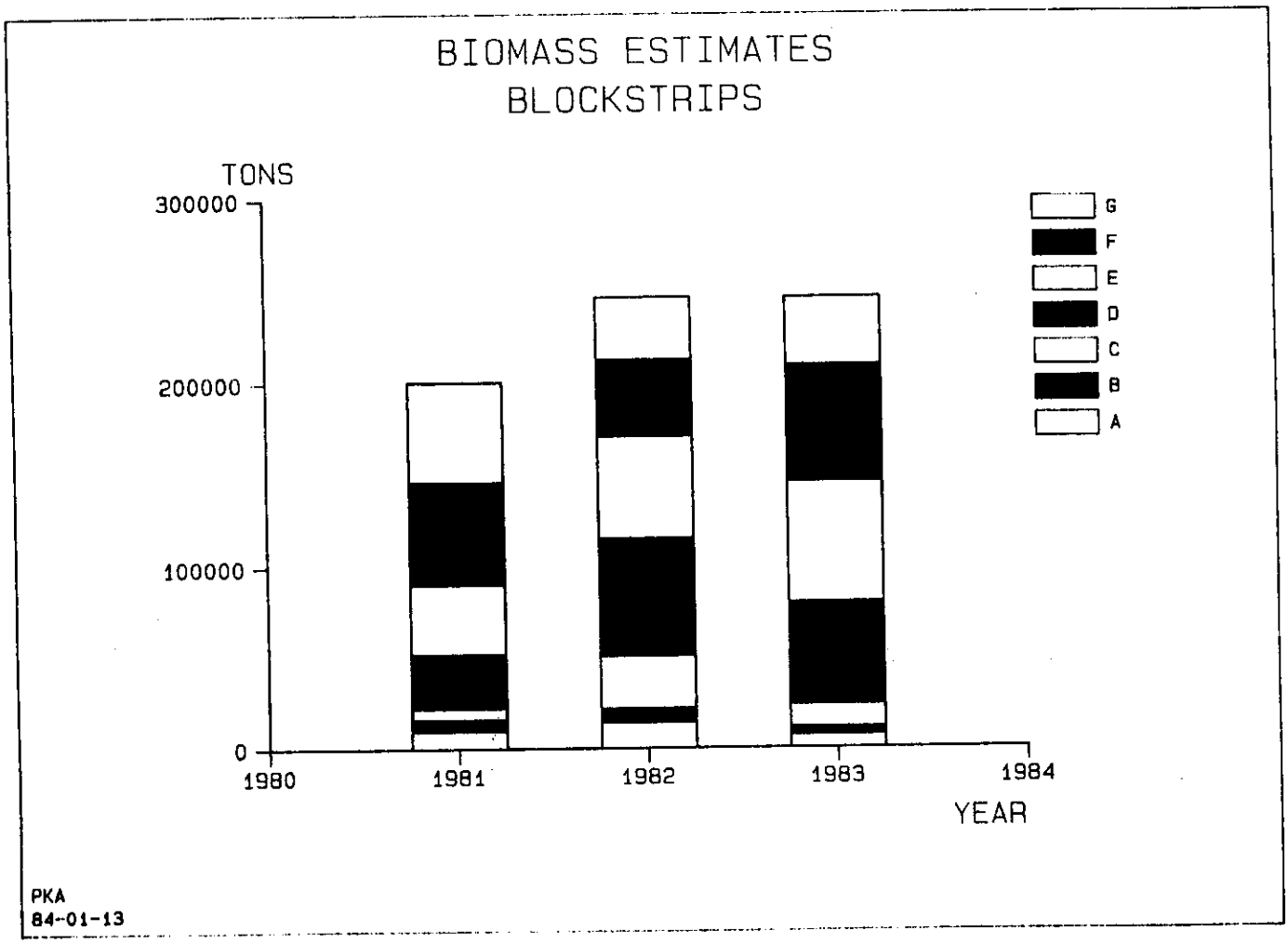

Fig. 13. Total biomass in 30 minutes latitude strips as given in Table 7. The strips are labelled A to G from south to north.