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Biomass of Shrimp (*Pandalus borealis*) in NAFO Subarea 1 in 1977 - 1982 Estimated by Means of Bottom Photography[1]

by

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ABSTRACT

A shrimp survey using photographic sampling technique was carried out in July-August 1982 in NAFO SA1 in order to sample data for shrimp stock assessment.

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

A rough biomass estimate for the area between 69*30'N and 71*30'N is given separately for 1982.

The biomass estimates are obtained by means of a mathematical model introduced in an earlier document.

INTRODUCTION

Since 1977 shrimp density and biomass indices obtained by means of bottom photography have been used to describe the stock size of shrimp in the offshore areas of NAFO SA1 and a smaller adjacent area of SA0 between 66*00' N and 69*30' N.

During the years 1977 to 1979 estimates of the total biomass were derived in relation to estimates from a trawl survey in 1976 (Kanneworff, 1978). In 1980 a mathematical model for the photographic material was introduced (Jørgensen & Kanneworff, 1980) to describe the biomass independent of the formerly used trawl indices. This model has been used to assess the shrimp stock during 1980 and 1981.

The present paper uses this model, including material from the 1982 survey. A slight change in the model is introduced and new estimates for 1977-82 are obtained.

A preliminary biomass estimate for the area 69*30' N to 71*30' N is given on basis of sample stations in that area in 1982.

MATERIAL AND METHODS

Bottom photography as a tool for estimating the biomass of shrimp (Pandalus borealis) has been used at West Greenland since 1977 (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. Depth layers within the range 100 to 600 meters have been sampled throughout the years as shown on Fig. 1.

As a considerable part of the fishery has been carried out north of the sampling area during the last two or three years, the photographic sampling in 1982 has been extended into the area between 69*30'N and 71*00'N (Fig. 2). Sampling north of 69*30'N was already planned for 1981, but due to technical problems it was not carried out.

[1] Further biomass calculations for Subarea 1 are given in Appendix I.

The sampling sites are not randomly distributed, but they have been chosen so as to give the best covering of the different depth strata in the blocks of the stratum system according to Carlsson & Kanneworff (1979). The stratum areas have been remeasured by means of a planimeter and the new figures are given in Table 1. However, these figures are still to be considered as preliminary until new measurements have been carried out on more precise charts than the presently used. The biomass calculations in this paper have been based on the new figures, totalling to 56406 squarekilometers for the area 66*00'N - 69*30'N.

The chart for the area north of 69*30'N (Fig. 2) has been made on basis of sea charts with very few depth soundings. Severe deviations from observed depths are to be expected, and the areas measured from this chart (part of Table 1) should thus be treated with great care.

A total of 30 sampling sites were occupied during July and August in 1982. A total of 4363 photographs from this sampling have now been included in the present material, totalling 11729 photographs from from the whole period 1977 - 82 (Table 2). In the biomass calculations, however, only stations within the areas in question have been included, viz. 10260 photographs in the area corresponding to Fig. 1, and 1206 photographs corresponding to the area shown on Fig. 2.

In order to minimize the effect of diurnal variations in the shrimp density on the bottom the sampling has been limited to July-August being a period of the year with relatively small diurnal amplitudes in the catch rates (Carlsson et al., 1978). Furthermore, the sampling has been carried out only during the day-time, because most of the shrimp population is supposed to be situated on the bottom in the hours with daylight. However, as a smaller part of the shrimp population is still supposed to swim off bottom in the middle of the day, the density figures as read from the photographs must be regarded as minimum values when used as biomass indices in the calculations.

During the reading of the photographs the shrimps were as previously classified into three size categories in order to obtain an indication of the average individual weight on which the biomass indices could be based. The three size categories are determined by the following values:

Size category	Carapace length mm	Est. mean weight grams
small	< 18-20	3.5
medium	> 18-20 and < 28-30	7.5
large	> 28-30	13.0

The size distribution as read from the photographs have been compared to samples from catches taken by shrimp trawl in connection with the photographic sampling.

Biomass indices, i.e. grams per squaremeter, were used as input values in a shrimp distribution model (Jørgensen & Kanneworff, 1980). This model uses the year, depth and geographic degree of latitude as parameters in a squared equation under the assumption that the material is lognormal distributed. In the model average biomass indices for 30-minute sampling periods have been used as a standard in order to minimize the effect of a large variation in shrimp density from photograph to photograph, and to level out the class effect in the reading, using one shrimp as a reading unit. The 30-minute periods were chosen to permit an analysis of diurnal variation in order to correct the input values for this sort of variation. This analysis has, however, not yet been carried out, so it is proposed that average biomass indices per sampling station should be used as input values to the model.

In this paper an extension of the model to include degree of longitude and temperature is discussed. A multiple regression analysis is used to calculate the parameters of the model, on which the biomass estimates are based.

RESULTS AND DISCUSSION

Size distribution.

The distributions of shrimps in the three size groups are given in Figs. 3-8 for six sampling sites between 66 and 69*30'N, representing different depth layers and different geographical areas.

In the northern areas (Figs. 3 and 4) a large proportion of the shrimps is in the size group 'small'. This seems to have been fairly constant during the years of sampling.

The size distributions from the vast area between 68 and 69*N in the depth layer 300-400 meters (Figs. 5 and 6) seem to be of a much more variable nature. To the west (Fig. 5) the size group 'medium' dominates, whereas the samples from the central area (Fig. 6) show some years with high concentrations of small shrimps. For this sampling site it has even been noted earlier (Kanneworff, 1981) that the size group 'small' is possibly underestimated because of a high amount of very small shrimps, which may be difficult to distinguish on the photographs being close to the resolution of the photographic system.

In the central eastern area with deep water of 400-500 meters research trawl catches in the early 70'ies showed large shrimps (90-100 numbers/kg). The size distribution in the photographic material from this place (Fig. 7) shows many large shrimps in 1977, while in the later years this size group has been reduced to nearly the same level as in the other areas sampled, apart from the areas to the north.

Fig. 8 shows the size distribution from a sampling site in the central area of commercial fishing south of 68*N. An increasing amount - both relative and absolute - of small shrimps has been noted through the years 1977 - 1981, but in 1982 the abundance of small shrimps has suddenly decreased to a very low level. In an earlier document (Kanneworff, 1981) it was proposed that the increase in abundance of small shrimps could possibly be taken as an indication of a promising recruitment. The increase in biomass from 1981 to 1982 mentioned later in this paper may thus be a result of this recruitment, but noting the lower absolute abundance of small shrimps, especially in the central fishing area, a continued good recruitment is not likely.

Most of the sampling sites north of 69*30'N (Fig. 2) have shown an abundance of small shrimps of about the same size as found in the areas south of 69*30'N (Figs. 3 and 4).

The size distribution as read from the photographs may be compared to samples taken by shrimp trawl in connection with the photographic sampling. Unfortunately it is not possible to carry out trawling on all sampling sites due to rough bottom, so only half of the stations offer this possibility in the 1982 material (Table 3). The size group 'small' is expected to be more numerous in the photographic material, because not all shrimps in this size group are retained by the meshes of the trawl. Apart from three of the sampling sites this pattern is consistent in the table. Concerning the material from 1981 it was pointed out by Kanneworff (1981), that some stations north of 68*N showed a large amount of very small shrimps. In the present material from 1982 no larger amount of this size group is found neither in the photographic nor in the trawl samples.

The model.

In order to be able to estimate the total biomass from the photographic sampling an empirical distribution model has been used since 1980 (Jørgensen & Kanneworff, 1980). The input values for the model have been indices (i.e. biomass per squaremeter) representing 30-minute periods during the sampling. However, the main purpose of using these half-hour periods, namely to make an easy correction for diurnal variation possible, has not yet been achieved. In the present study mean values for each sampling station have been used as input to the model. The variance of the input values is thus reduced significantly, but at the same time some increase must be expected for the variance of the parameters in the model.

The biomass indices for the 30-minute periods were earlier weighted by the number of photographs in the period, but in the present station analysis weighting by number of squaremeters has been chosen, being a better weighing factor due to minor variations in the exposure area on some stations.

The distribution model of 1980 includes three parameters: year, depth and latitude. The corresponding analysis produces estimates of the parameter coefficients with a fairly low correlation coefficient (0.35). This level has been accepted, bearing in mind that the model is empirical nature. Naturally, a model offering a higher correlation coefficient must be supposed to describe the biomass dependency of the input parameters better, not regarding that the variances of the basic material are still unknown.

Some trials with introducing new parameters have been made, and the final model now includes two more parameters: longitude and bottom temperature. The regression analysis using the five parameters and their interactions now produces a correlation coefficient for the model of 0.65 (Table 4). The corresponding analysis using 30-minute periods and number of photographs as weighing factor offers a correlation coefficient of 0.59.

Biomass calculations.

By means of the parameter coefficients from the regression analysis (Table 4) shrimp densities and biomass indices for the different strata can be calculated. This calculation is made for each stratum by inserting local values for the different parameters in the stratum. As regards to the latitude and longitude values a rough midpoint position has been chosen. An average of six calculations of biomass for each stratum have been made by inserting a series of depths ranging from the minimum to the maximum depth observed in the stratum in question. The temperature has shown to be one of the most sensitive parameters in the model. Unfortunately the bottom temperatures are only well known at the sampling positions. The observed temperatures have fluctuated rather much through the six years of sampling with a tendency of decreasing average temperatures. As a best estimate of the bottom temperature in the different strata the yearly averages of the observed values have been used in the biomass calculations, not taking into consideration the variations in sampling pattern in the different years. The observed average temperatures are the following:

year	1977	1978	1979	1980	1981	1982
temperature	3.4	2.2	2.7	1.3	1.6	1.5

This method causes most likely an overestimate of the biomass in the later years, the northern areas being more sparsely sampled the first years, whereas the sampling in the later years has been less concentrated in the southern areas. The observed colder temperatures in the later years are, however, also confirmed by the hydrographic data from surveys i july (Erik Buch, pers.comm.).

Fig. 9 shows levels of shrimp densities for 1982 in all strata included in the analysis. High densities are observed around "Godhavn Rende" in the northeast and in the deeper areas north of Store Hellefiskebanke and in the southwestern areas.

The results of the biomass calculations for the area between 66*00'N and 69*30'N are shown in Fig. 10. The increase in total biomass from 1980 to 1981, which was also observed in an earlier work (Kanneworff, 1981), was not reflected by the catch rates in the commercial fishery (Carlsson, 1981). It has been stated (Kanneworff, 1981.) that the increase was mainly due to a significant increase of very small shrimps, especially on some sampling stations in the area northwest of Store Hellefiskebanke. It was also proposed that a large amount of very small shrimps could be taken as a potential for a good recruitment to the stock the following year. The increase in biomass from 1981 to 1982 of about 40 % could be the effect of the large group of small shrimps in 1981.

In Table 5 and Fig. 11 a more detailed analysis of the biomass calculations is shown. It is very interesting to note, that the northern areas show a sharp decrease from 1977 to 1978 followed by a stabilization, while the southern areas show an increase in the biomass through the last 2-3 years. A significant increase is noted in the area west of Holsteinsborg Deep in 1981 and 1982. These variations of the biomass in the different areas indicate a southward displacement of the stock which could possibly be related to the observed decrease in bottom temperatures.

Assessment of the stock biomass for the area north of 69*30'N is still very doubtful. In 1982 eight sampling sites were occupied, as shown in Fig. 2, but as the topographical knowledge is rather sparse, it is not possible to treat the photographic data from this area in the same way as the data from the area to the south. The biomass index figures from seven of the eight sampling sites in the northern area (Table 2, station numbers 6240 - 6247) appear to be somewhat lower than the corresponding figures from the more southern sites. The average biomass index is about one gram per squaremeter, indicating a total biomass for the area between 50000 and 100000 tons.

CONCLUSION

The technique of bottom photography is regarded to be a valuable method for a direct estimate of the shrimp biomass. In this paper data from photographic sampling in the period 1977 - 1982 have been examined, and estimates of the total biomass for the shrimp distribution area between 66*00'N and 69*30'N are calculated by means of a mathematical model. An increase in total biomass is noted from 1981 to 1982, but prospects for good recruitment to the following year seem to be poor, the smaller size groups of shrimps being more scarce than before. The total biomass in the above mentioned area is calculated to about 230000 tons. A preliminary biomass estimate for the area 69*30'N to 71*30'N indicates a stock in the range of 50000 to 10000 tons.

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Table 1: Areas and depth ranges in the strata according to Carlsson & Kanneworff(1979). Only strata within 100 to 600 meteres depth are included.

blockno.	depth range	area	blockno.	depth range	area	blockno.	depth range	area	blockno.	depth range	area	blockno.	depth range	area
11113	150 - 199	386	11412	300 - 399	4	11614	400 - 499	215	12215	500 - 599	43	12416	300 - 399	1609
11113	200 - 299	154				11614	500 - 599	78	12216	230 - 299	692	12416	400 - 440	527
11114	100 - 199	414	11413	100 - 199	1052	11615	100 - 199	12	12216	300 - 399	148	12417	250 - 299	321
11114	200 - 280	142	11413	200 - 299	80	11615	200 - 299	1266	12216	400 - 499	158	12417	300 - 399	1625
11115	130 - 199	373	11414	100 - 199	1409	11615	300 - 399	611	12216	500 - 599	213	12417	400 - 449	318
11115	200 - 280	186	11414	200 - 299	623	11615	400 - 499	74	12217	260 - 299	9	12418	250 - 299	211
11116	260 - 299	310	11414	300 - 399	59	11615	500 - 599	21	12217	300 - 399	18	12418	300 - 399	837
11116	300 - 330	230	11415	100 - 199	88	11616	100 - 199	3	12217	400 - 499	18	12418	400 - 499	189
11117	300 - 399	541	11415	200 - 299	895	11616	200 - 299	863	12217	500 - 599	36	12418	500 - 599	261
11117	400 - 449	10	11415	300 - 399	947	11616	300 - 399	1117	12313	100 - 199	113	12513	100 - 199	323
11118	390 - 399	5	11415	400 - 499	158	11617	200 - 299	177	12313	200 - 220	29	12513	200 - 299	615
11118	400 - 499	63	11416	200 - 299	190	11617	300 - 399	612	12314	100 - 140	713	12513	300 - 399	484
11118	500 - 599	38	11416	300 - 399	1179	11617	400 - 499	579	12315	120 - 199	1792	12513	400 - 499	75
11213	100 - 199	1318	11416	400 - 499	685	11617	500 - 599	557	12315	200 - 249	530	12513	500 - 599	135
11213	200 - 299	424	11416	500 - 599	37	12013	100 - 199	161	12316	200 - 299	1941	12514	100 - 199	379
11214	100 - 199	1218	11513	100 - 199	360	12013	200 - 299	187	12316	300 - 349	400	12514	200 - 299	736
11214	200 - 299	954	11513	200 - 299	169	12013	300 - 399	133	12317	250 - 299	637	12514	300 - 399	434
11215	100 - 199	911	11513	300 - 399	421	12013	400 - 499	28	12317	300 - 399	1164	12514	400 - 499	118
11215	200 - 260	1245	11513	400 - 499	407	12014	150 - 199	928	12317	400 - 499	150	12515	150 - 199	223
11216	200 - 299	1664	11513	500 - 599	583	12014	200 - 280	332	12317	500 - 599	67	12515	200 - 299	344
11216	300 - 340	515	11514	100 - 199	97	12015	160 - 199	462	12318	275 - 299	59	12515	300 - 399	1022
11217	280 - 299	55	11514	200 - 299	201	12015	200 - 299	52	12318	300 - 399	118	12515	400 - 449	79
11217	300 - 399	1345	11514	300 - 399	355	12015	300 - 399	76	12318	400 - 499	77	12516	250 - 299	176
11217	400 - 499	329	11514	400 - 499	694	12015	400 - 499	128	12318	500 - 599	97	12516	300 - 380	1489
11217	500 - 599	183	11514	500 - 599	606	12015	500 - 599	270	12413	100 - 199	257	12517	280 - 299	104
11218	450 - 499	17	11515	200 - 299	30	12113	100 - 199	229	12413	200 - 299	678	12517	300 - 380	1579
11218	500 - 599	24	11515	300 - 399	901	12113	200 - 299	196	12413	300 - 399	457	12518	300 - 399	356
11313	100 - 199	1130	11515	400 - 499	954	12113	300 - 399	286	12413	400 - 499	304	12518	400 - 499	199
11313	200 - 299	304	11515	500 - 599	151	12113	400 - 499	107	12413	500 - 599	63	12518	500 - 599	148
11314	100 - 199	1195	11516	200 - 299	108	12114	100 - 160	1724	12414	100 - 199	497	13413	100 - 199	340
11314	200 - 299	937	11516	300 - 399	763	12115	140 - 199	871	12414	200 - 299	145	13414	150 - 199	769
11315	100 - 199	231	11516	400 - 499	869	12115	200 - 299	204	12414	300 - 399	176	13414	200 - 249	506
11315	200 - 299	1704	11516	500 - 599	295	12115	300 - 399	215	12414	400 - 499	687	13415	140 - 199	343
11315	300 - 399	196	11517	200 - 299	2	12115	400 - 499	255	12414	500 - 545	288	13415	200 - 299	68
11316	200 - 299	330	11517	300 - 399	173	12115	500 - 599	604	12415	120 - 199	443	13415	300 - 399	60
11316	300 - 399	890	11517	400 - 499	342	12214	100 - 149	945	12415	200 - 299	606	13415	400 - 499	126
11316	400 - 499	481	11517	500 - 599	667	12215	140 - 199	1432	12415	300 - 399	510	13415	500 - 599	310
11316	500 - 599	219	11614	100 - 199	202	12215	200 - 299	632	12415	400 - 499	686			
11412	100 - 199	356	11614	200 - 299	1127	12215	300 - 399	150	12415	500 - 520	53			
11412	200 - 299	243	11614	300 - 399	449	12215	400 - 499	104	12416	250 - 299	141			

Table 2a: List of sampling stations 1977.

Date	Station no.	Area kode	Depth	no. of photographs	density no/sqm	biomass index grams/sqm
770724	5444	KZ012	455	89	0,19	1,88
770725	5446	KT001	350	17	0,20	1,49
770726	5447	KP440	278	82	0,37	2,77
770726	5448	KR438	388	64	0,21	1,56
770727	5449	KR004	211	116	0,71	5,19
770804	5453	KB006	468	282	0,11	0,84
770805	5454	KF006	571	23	0,04	0,29
770805	5455	KX005	420	204	0,15	1,15
770806	5456	KX438	344	190	0,11	0.82

Table 2b: List of sampling stations 1978.

Date	Station no.	Area kode	Depth	no. of photographs	density no/sqm	boimass index grams/sqm
780721	5601	KR004	229	154	0,58	4,13
780722	5602	KK004	412	162	0,11	0,85
780724	5603	KK008	121	126	0	0
780724	5604	KK006	250	107	0,07	0,54
780724	5605	KF007	351	172	o,o1	0,04
780725	5606	KF008	173	174	0,10	0,76
780725	5607	KA011	228	3	0,49	3,29
780725	5608	KB006	509	21	0,11	0,86
780726	5609	KA011	229	178	0,47	3,14
780727	5610	JF019	358	181	0,60	3,67
780802	5612	KV002	426	59	0,16	1,23
780802	5613	KZ002	327	169	1,48	7,83
780803	5614	LB003	323	38	0,26	1,68

Table 2c: List of sampling stations 1979.

Date	Station no.	Area kode	Depth	no. of photographs	density no/sqm	biomass index grams/sqm
790723	5734	KV007	213	6	0,49	3,69
790730	5737	LJ011	262	49	1,94	10,20
790731	5738	LE005	219	11	1,56	8,38
790801	5739	KN003	239	36	0,13	0,95
790801	5740	KR004	265	16	3,30	19,88
790805	5741	KX014	259	7	1,01	7,25
790805	5742	KZ012	463	16	0,33	2,82
790810	5743	LB005	320	12	1,23	5,48
790810	5744	KX438	334	5	0,30	1,98

Table 2d: List of sampling stations 1980.

Date	Station no.	Area kode	Depth	no. of photographs	density no/sqm	biomass index grams/sqm
800810	5855	KP440	285	116	0,22	1,65
800811	5856	KR004	208	167	0,46	3,02
800811	5857	KV007	217	49	0,11	0,79
800811	5858	LB005	321	39	0,69	4,11
800812	5859	KZ014	265	110	0,92	6,69
800812	5860	KZ012	462	188	0,14	0,99
800813	5861	LD012	260	71	0,78	5,66
800813	5862	LE005	251	82	1,41	9,04
800815	5863	LH014	261	134	2,38	17,56
800817	5865	LJ011	257	189	3,27	15,81
800820	5866	LA438	323	167	0,07	0,49
800821	5867	KT001	348	40	4,28	31,34
800821	5868	KV002	408	116	0,91	4,76
800822	5869	LH440	288	68	1,36	10,28
800822	5870	LH004	203	22	0,56	4,14
800823	5871	LD439	330	89	0,02	0,12
800823	5872	KZ002	346	148	1,71	7,17

Table 2e: List of sampling stations 1981.

Date	Station no.	Area kode	Depth	no. of photographs	density no/sqm	biomass index grams/sqm
810726	6019	KP440	281	99	0,37	2,64
810727	6020	KL006	207	101	0,05	0,23
810728	6021	KF007	338	177	0,09	0,65
810728	6022	JL020	374	82	1,74	10,58
810805	6023	KA011	221	178	0,44	2,99
810806	6024	KR004	215	191	1,62	8,56
810808	6025	KZ015	274	169	2,09	12,41
810808	6026	KZ012	469	171	0,27	1,88
810809	6027	LE005	256	181	2,13	10,00
810809	6028	LB005	321	162	0,81	4,17
810810	6029	KX438	344	147	0,22	1,54
810810	6030	KT436	278	194	0,53	3,97
810811	6031	KT001	346	192	0,86	5,93
810811	6033	KV002	405	173	0,62	3,13
810811	6034	KZ003	330	169	0,93	5,97
810817	6036	LH014	241	161	0,71	4,31
810817	6037	LJ011	252	64	1,97	11,13
810818	6038	LS014	261	191	0,90	4,85

Table 2f: List of sampling stations 1982.

Date	Station no.	Area kode	Depth	no. of photographs	density no/sqm	biomass index grams/sqm
820726	6216	KL006	185	76	0,66	3,13
820727	6217	KN003	214	106	3,10	22,35
820729	6218	KR004	213	139	0,99	7,40
820729	6219	KR006	186	179	3,34	15,07
820805	6221	KV007	202	190	0,78	4,75
820806	6222	KX438	342	170	0,29	2,18
820806	6223	KT436	284	186	0,50	3,77
820807	6224	KX007	440	197	0,74	5,15
820807	6225	LB005	327	194	0,79	4,72
820808	6226	KZ003	344	173	0,74	4,70
820808	6227	KV002	420	191	0,37	2,26
820809	6228	KT001	350	131	2,10	11,22
820809	6229	KP440	280	151	0,95	5,17
820810	6231	KF007	332	166	0,05	0,30
820810	6232	KA011	220	136	0,42	2,70
820816	6234	KZ014	260	83	0,65	4,45
820816	6235	KZ012	469	197	0,41	3,02
820817	6236	LD012	255	147	0,92	5,36
820817	6237	LE005	258	130	1,22	6,64
820818	6238	LH440	284	104	0,79	6,07
820818	6239	LH004	205	119	0,59	3,42
820820	6240	LS014	264	184	1,46	7,97
820820	6241	LR008	114	53	0,07	0,37
820821	6242	LV011	341	139	2,13	15,31
820821	6243	LX008	500	140	0,17	1,03
820822	6244	LT001	425	150	0,06	0,35
820822	6245	LT004	345	124	0,25	1,91
820822	6246	LM002	256	119	0,59	4,23
820823	6247	LM006	173	106	1,10	6,23
820823	6249	LH014	260	183	1,79	9,40

Table 3: Percentage size distribution and average weight of shrimps in the photographic material and in samples from research trawl catches in 1982.

St. no.	area kode	type	small	% medium	large	av.weight grams
6212	KL006	photo	69.6	30.4	0.0	4.7
		trawl	65.0	34.6	0.4	4.9
6218	KR004	photo	0.4	99.6	0.0	7.5
		trawl	24.9	74.6	0.5	6.5
6219	KR006	photo	74.7	25.3	0.0	4.5
		trawl	74.4	25.5	0.1	4.5
6222	KX438	photo	2.4	96.4	1.2	7.5
		trawl	15.7	84.1	0.2	6.9
6224	KX007	photo	12.2	87.8	0.0	7.0
		trawl	9.0	90.1	1.0	7.2
6225	LB005	photo	37.7	62.1	0.2	6.0
		trawl	16.0	82.9	1.1	6.9
6227	KV002	photo	36.5	63.1	0.4	6.1
		trawl	8.0	90.2	1.8	7.3
6228	KT001	photo	55.4	43.6	1.1	5.3
		trawl	5.4	93.5	1.2	7.4
6229	KP440	photo	50.8	49.2	0.0	5.5
		trawl	11.3	87.3	1.4	7.1
6232	KA011	photo	25.5	74.5	0.0	6.5
		trawl	47.8	52.0	0.2	5.6
6234	KZ014	photo	19.0	79.9	1.1	6.8
		trawl	8.3	90.8	1.0	7.2
6235	KZ012	photo	16.6	75.5	7.9	7.3
		trawl	0.0	97.5	2.5	7.6
6236	LD012	photo	43.0	56.5	0.4	5.8
		trawl	31.6	68.3	0.1	6.2
6237	LE005	photo	50.9	49.1	0.0	5.5
		trawl	26.8	72.2	1.0	6.5
6240	LS014	photo	51.5	48.4	0.1	5.4
		trawl	32.1	67.0	0.9	6.3

Table 4: Output from the regression analysis with calculated parameter coefficients.

SHRIMP PHOTO, BIOMASS 1977 - 1982
66*00N - 69*30N
PARAMETERS INCLUDED: YEAR DEPTH LAT LON TEMP

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	35409.72252781	1686.17726323	5.13	0.0001	0.646269	1745.4411
ERROR	59	19381.24045259	328.49560089		STD DEV		LNBIALL MEAN
CORRECTED TOTAL	80	54790.96298040			18.12444760		1.03838780

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
U	1	5.31120416	0.02	0.8993	1	149.76881997	0.46	0.5022
YEAR	1	13180.69814235	40.12	0.0001	1	250.71312964	0.76	0.3859
DEPTH	1	418.49896926	1.27	0.2636	1	313.66224029	0.95	0.3325
LA	1	8514.65936368	25.92	0.0001	1	0.74836083	0.00	0.9621
LO	1	136.78628539	0.42	0.5212	1	4387.04206120	13.35	0.0006
TEMP	1	445.61326299	1.36	0.2488	1	149.81202471	0.46	0.5021
YEAR*YEAR	1	51.41495946	0.16	0.6938	1	61.31803836	0.19	0.6673
DEPTH*DEPTH	1	918.90856810	2.80	0.0997	1	2500.16777928	7.61	0.0077
LA*LA	1	80.76781340	0.25	0.6218	1	1295.08670532	3.94	0.0517
LO*LO	1	472.63281588	1.44	0.2351	1	2045.32970681	6.23	0.0154
TEMP*TEMP	1	733.61988970	2.23	0.1404	1	142.98323210	0.44	0.5120
YEAR*DEPTH	1	2544.79470814	7.75	0.0072	1	269.14520844	0.82	0.3691
YEAR*LA	1	12.68927000	0.04	0.8449	1	464.65782055	1.41	0.2391
YEAR*LO	1	135.93148165	0.41	0.5225	1	148.51791597	0.45	0.5040
YEAR*TEMP	1	1901.16428889	5.79	0.0193	1	1558.10859232	4.74	0.0334
DEPTH*LA	1	187.68058713	0.57	0.4527	1	221.98550058	0.68	0.4144
DEPTH*LO	1	37.95483237	0.12	0.7351	1	568.71520111	1.73	0.1933
DEPTH*TEMP	1	868.87603149	2.65	0.1092	1	671.87688139	2.05	0.1580
LA*LO	1	3511.64690725	10.69	0.0018	1	3875.45122672	11.80	0.0011
LA*TEMP	1	668.42525587	2.03	0.1590	1	524.47140330	1.60	0.2114
LO*TEMP	1	581.64789065	1.77	0.1884	1	581.64789065	1.77	0.1884

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > !T!	STD ERROR OF ESTIMATE
INTERCEPT	-2271.86818824	-2.14	0.0362	1060.06698021
U	43.07906742	0.68	0.5022	63.79995437
YEAR	12.76941610	0.87	0.3859	14.61663085
DEPTH	0.39984574	0.98	0.3325	0.40919105
LA	1.03496736	0.05	0.9621	21.68382566
LO	58.75120575	3.65	0.0006	16.07665396
TEMP	-21.68435879	-0.68	0.5021	32.10983151
YEAR*YEAR	-0.03147181	-0.43	0.6673	0.07284377
DEPTH*DEPTH	-6.3573273E-05	-2.76	0.0077	0.00002304
LA*LA	0.34046932	1.99	0.0517	0.17147205
LO*LO	-0.18078217	-2.50	0.0154	0.07245005
TEMP*TEMP	-0.12520017	-0.66	0.5120	0.18976982
YEAR*DEPTH	0.00135110	0.91	0.3691	0.00149266
YEAR*LA	-0.14946845	-1.19	0.2391	0.12567465
YEAR*LO	0.05039528	0.67	0.5040	0.07494890
YEAR*TEMP	-0.30360820	-2.18	0.0334	0.13940534
DEPTH*LA	-0.00447429	-0.82	0.4144	0.00544286
DEPTH*LO	-0.00295993	-1.32	0.1933	0.00224956
DEPTH*TEMP	0.00372812	1.43	0.1580	0.00260681
LA*LO	-0.61259020	-3.43	0.0011	0.17835023
LA*TEMP	0.47260247	1.26	0.2114	0.37402433
LO*TEMP	0.22515815	1.33	0.1884	0.16920857

Table 5: Calculated total biomass for all strata within 66°00`N and 69°00`N in water depths 100 - 600 m.

Area	TOTAL BIOMASS 1977	1978	1979	1980	1981	1982
69°00`- 69°30`	76103	39984	39786	34771	39382	40669
68°30`- 69°00`	34030	20812	24827	25692	34306	42423
68°00`- 68°30`	17342	11489	16416	19238	28576	40480
67°30`- 68°00`	6711	6666	8500	11706	22421	34052
67°00`- 67°30`	1735	2612	3043	4999	12378	20628
66°30`- 67°00`	557	1069	1446	2890	8830	17645
66°00`- 66°30`	530	1336	1897	4492	16911	38600
66°00`- 69°30`	137007	83967	95915	103788	162804	234496

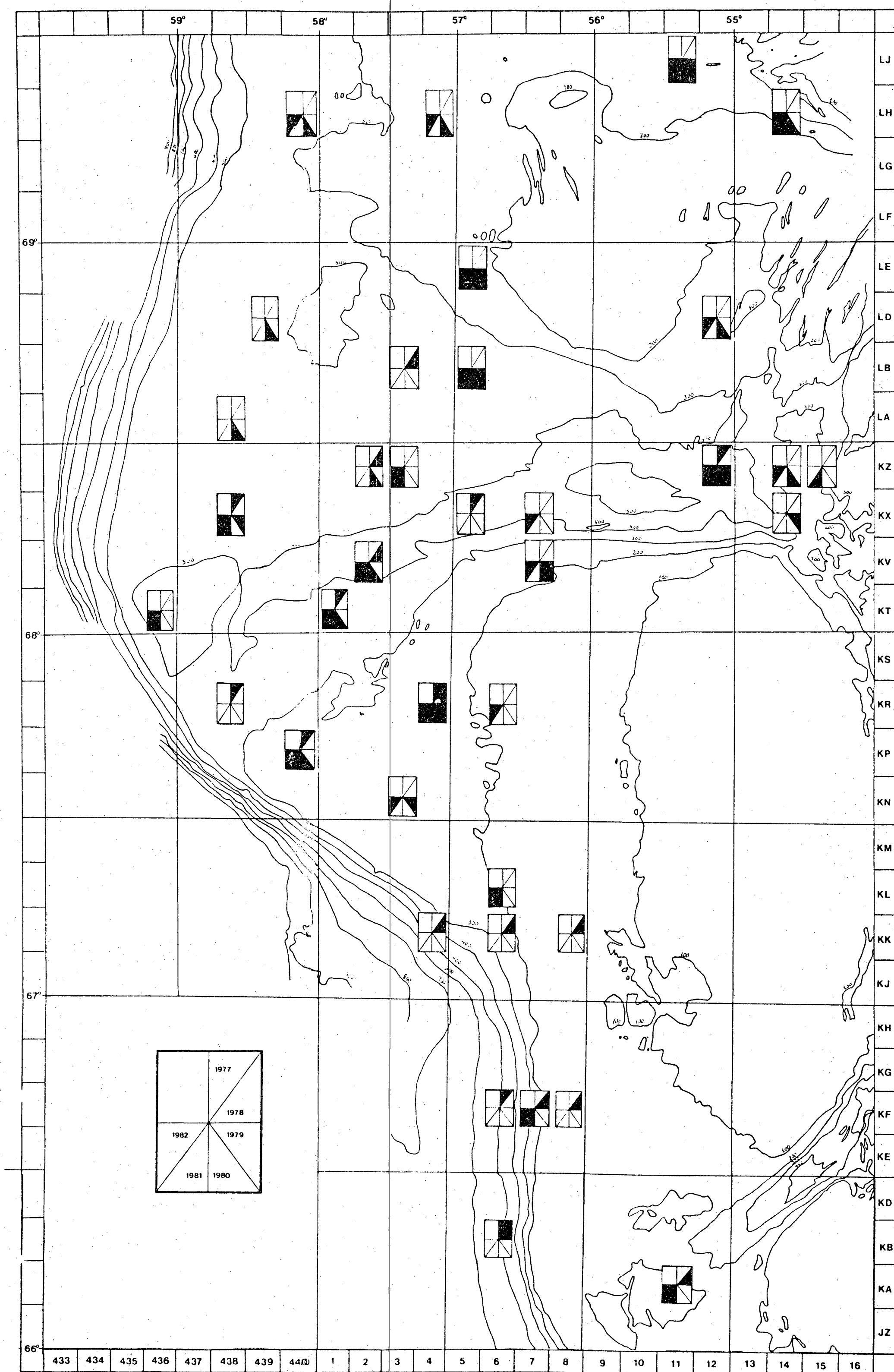

Fig. 1. Sampling stations 1977 - 1982 in the area 66°00'N to 69°30'N.

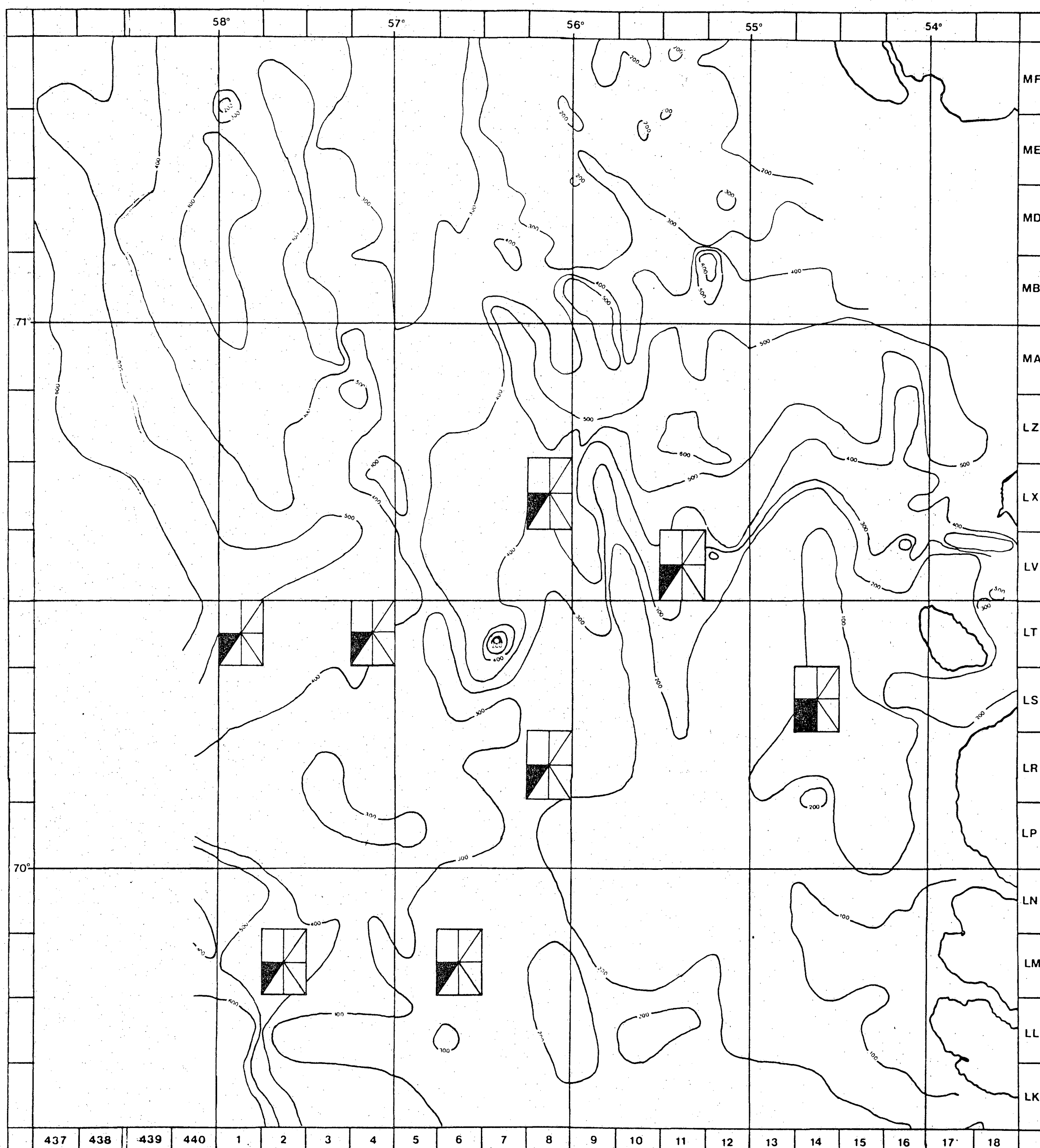

Fig. 2. Sampling stations 1981 - 1982 in the area 69°30'N to 71°30'N.

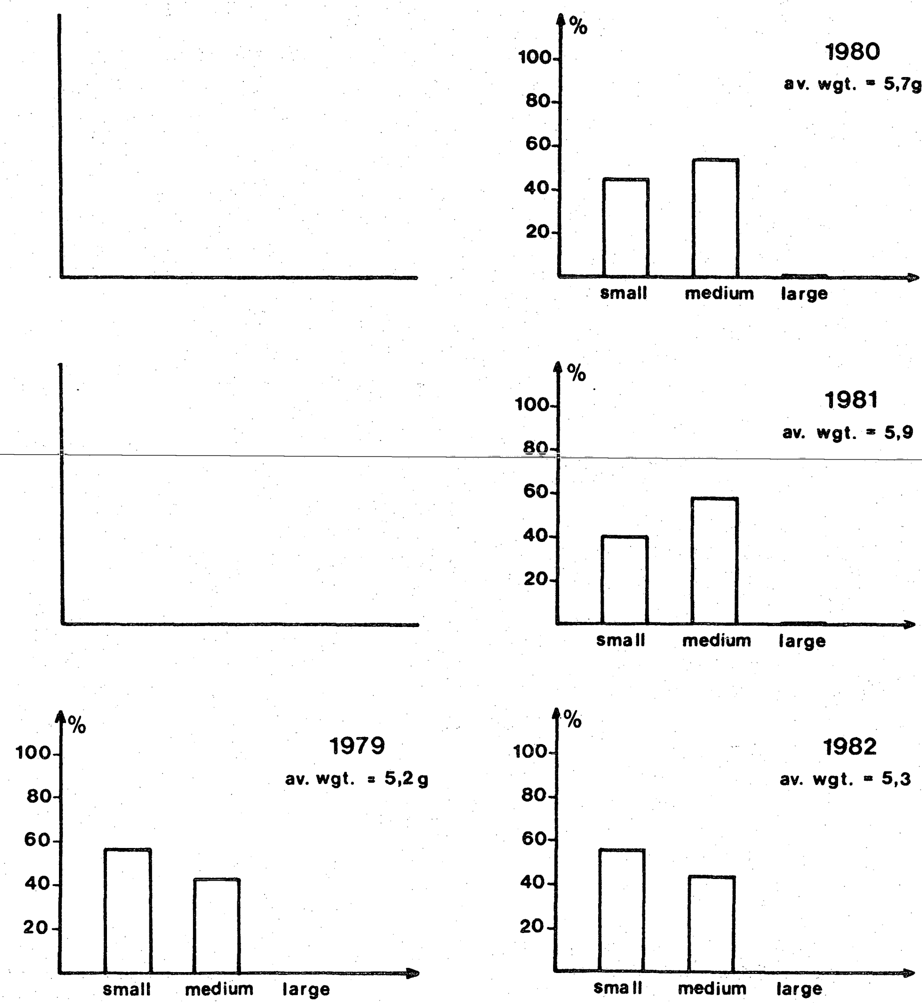

Fig. 3. Size composition of shrimps as read from the photographs sampled at area codes LJ011 and LH014 in 1979-82.

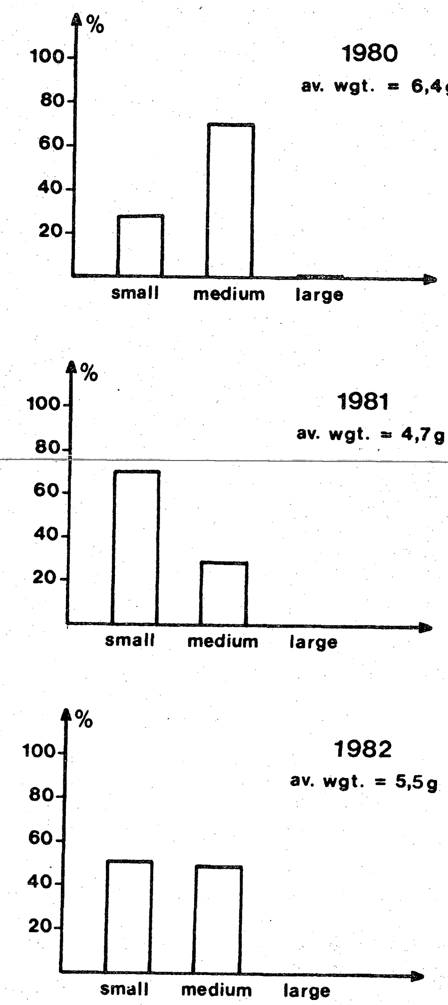

Fig. 4. Size composition of shrimps as read from the photographs sampled at area code LE005 in 1980-82.

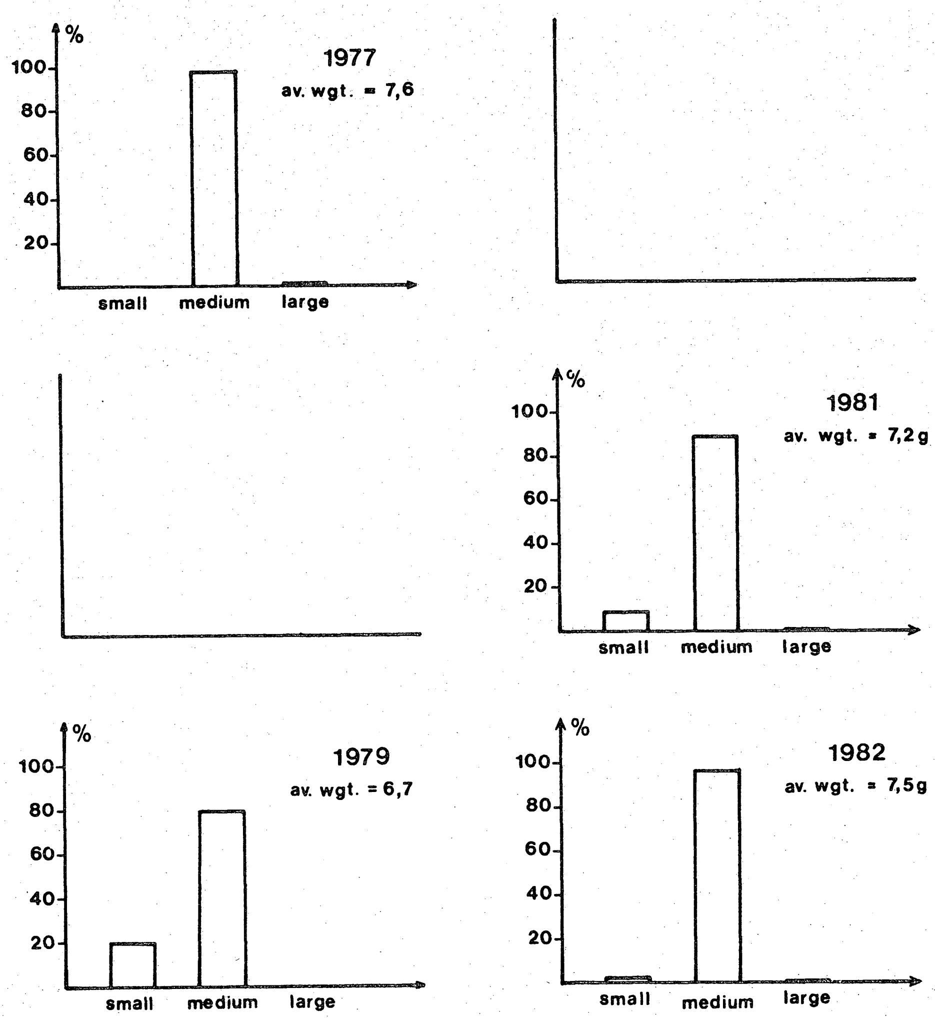

Fig. 5. Size composition of shrimps as read from the photographs sampled at area code KX438 in 1977, 1979 and 1981-82.

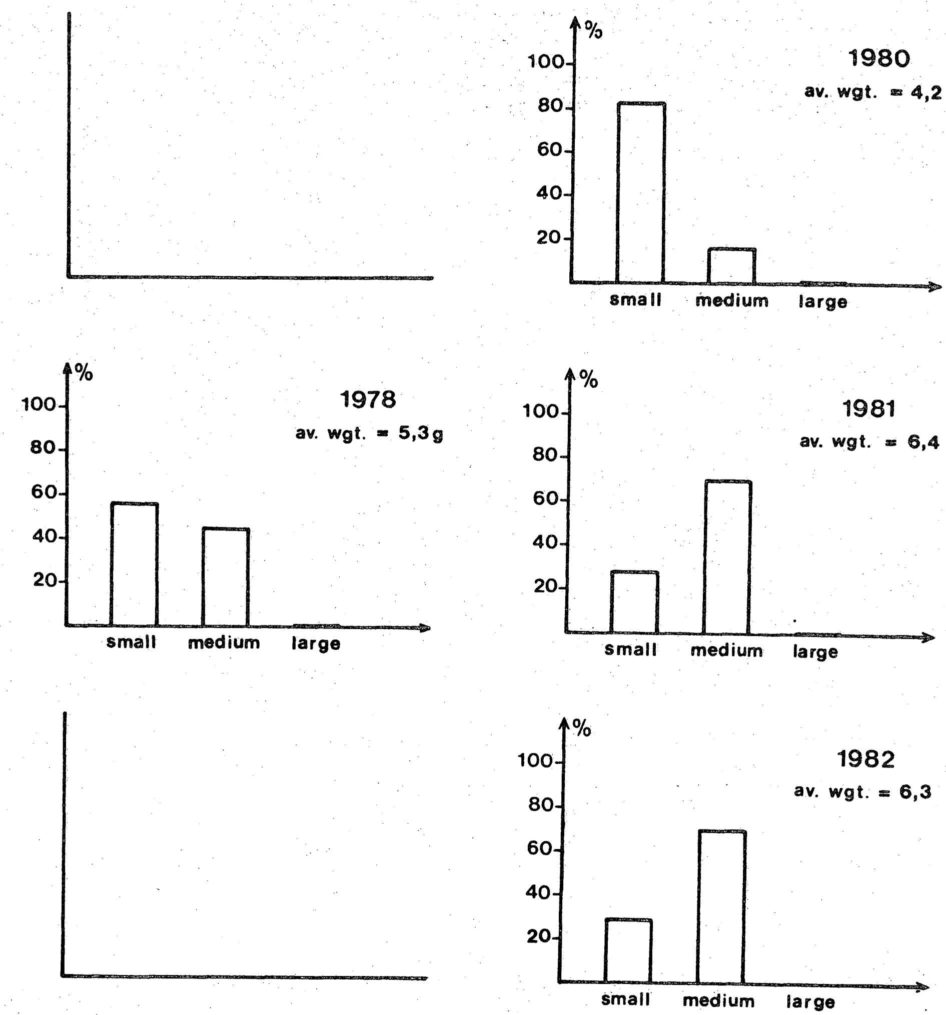

Fig. 6. Size composition of shrimps as read from the photographs sampled at area codes KZ002 and KZ003 in 1978 and 1980-82.

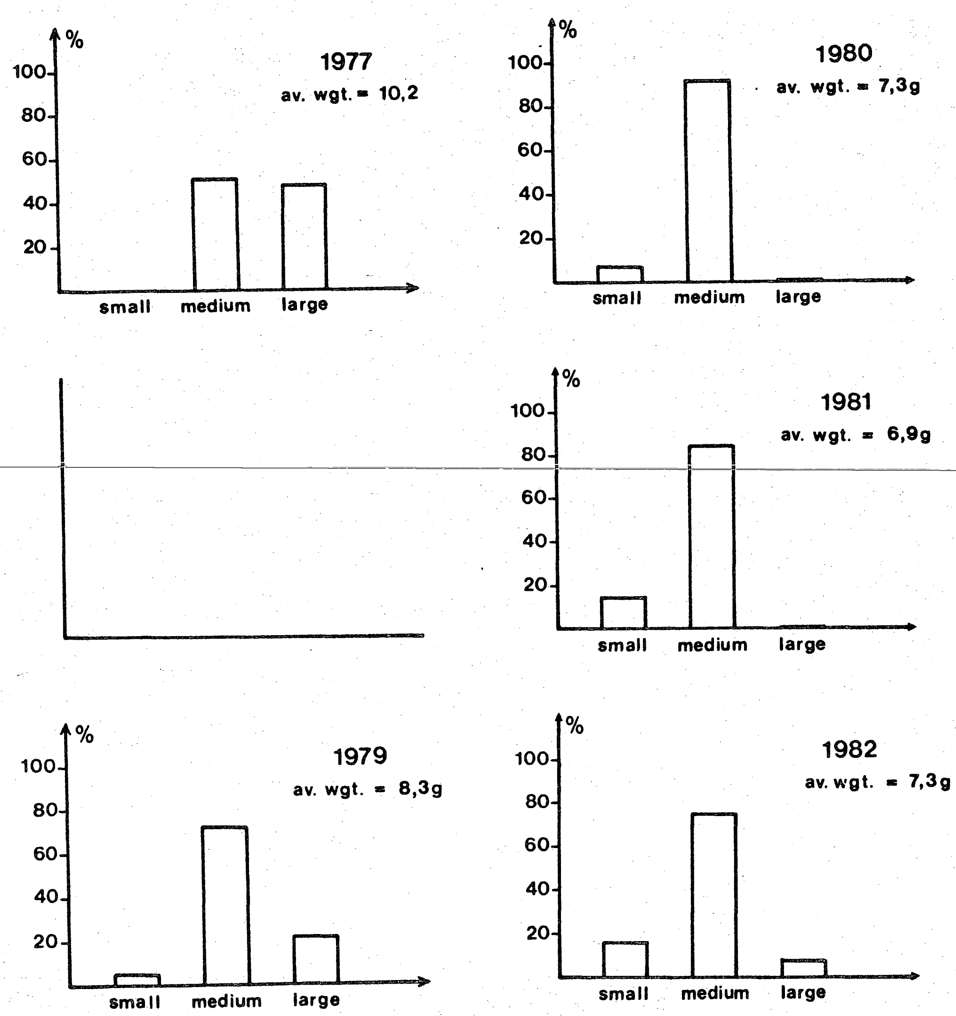

Fig. 7. Size composition of shrimps as read from the photographs sampled at area code KZ012 in 1977, 1979 and 1980-82.

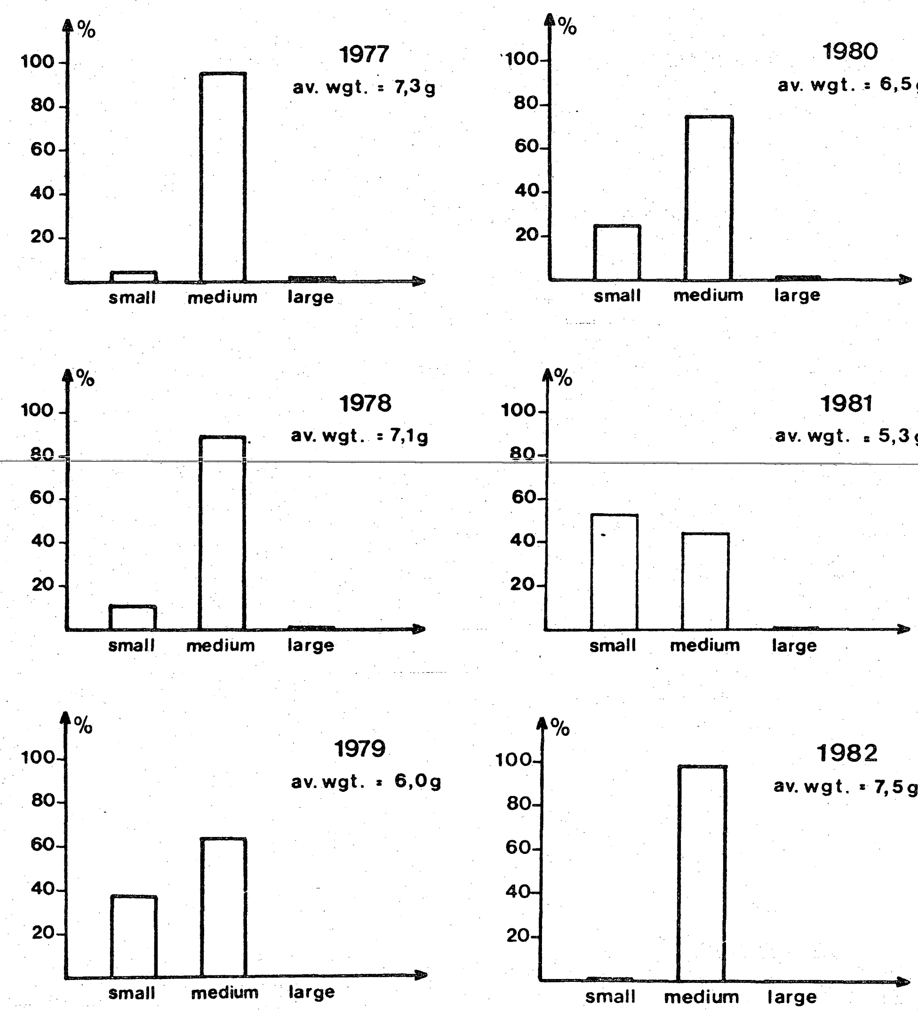

Fig. 8. Size composition of shrimps as read from the photographs sampled at area code KR004 in 1977-82.

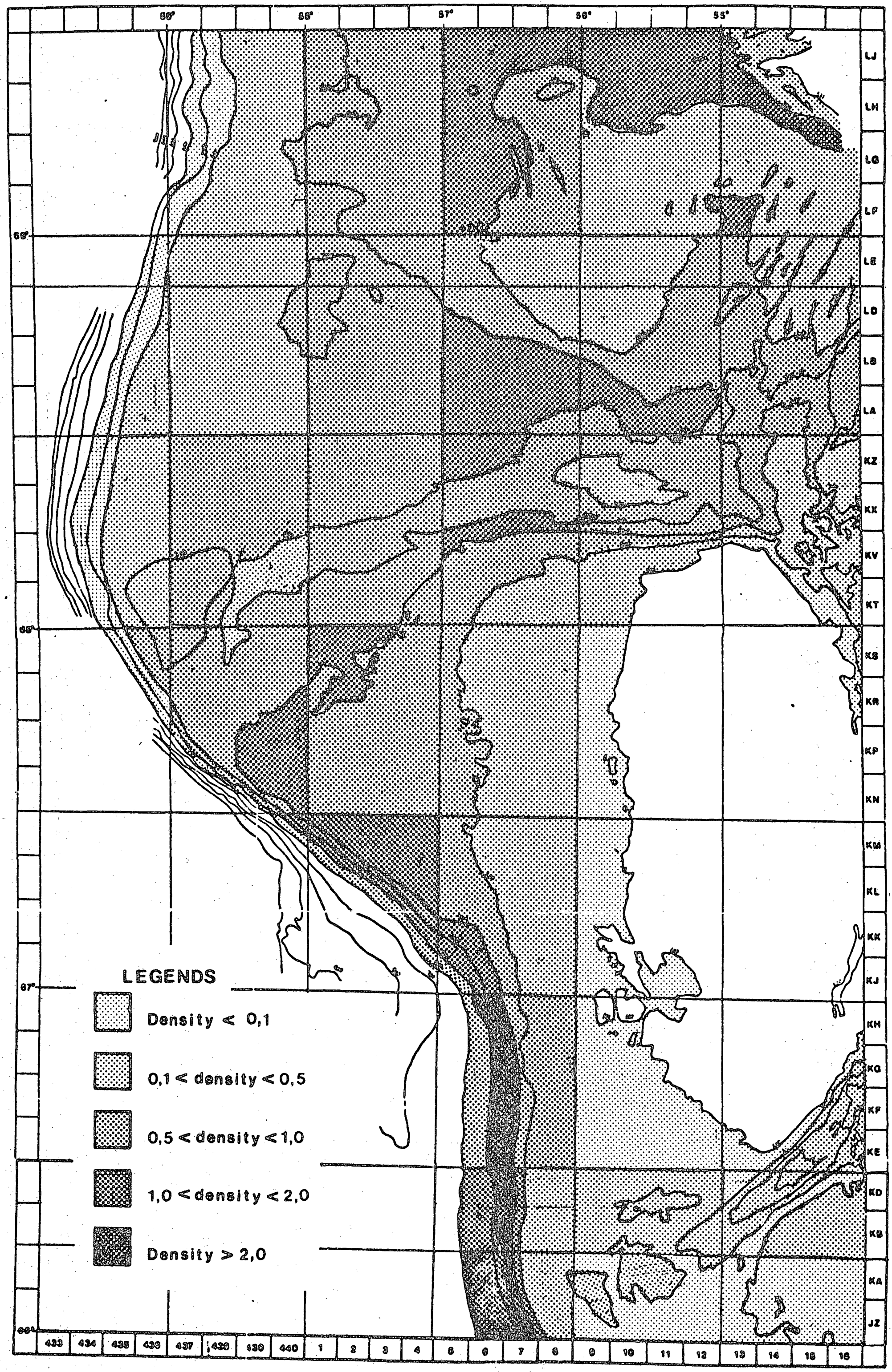

Fig. 9. Levels of shrimp densities, grams per squaremeter, as calculated from the five-parameter model.

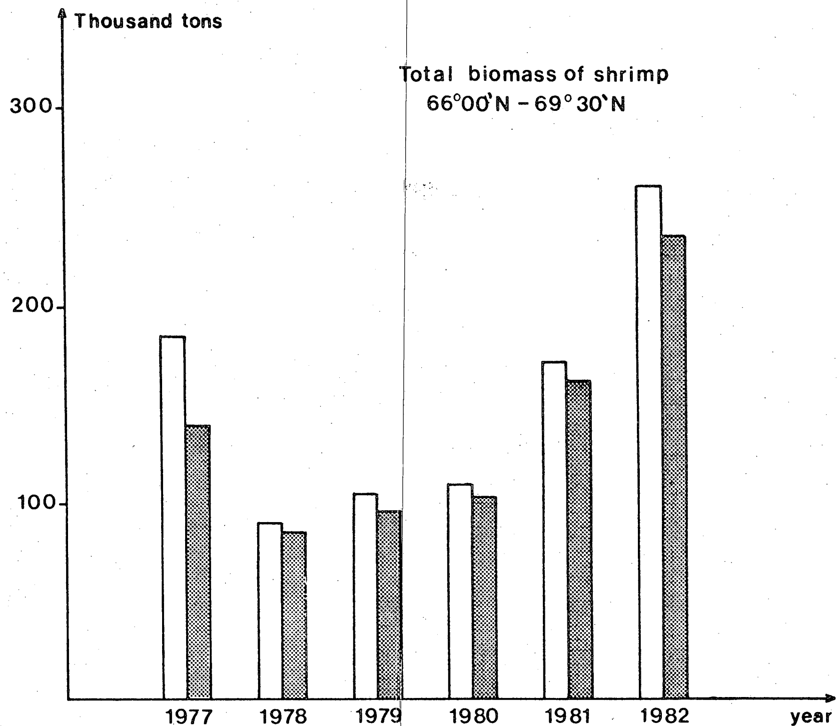

Fig 10. Total biomass of shrimps in the area 66°00'N to 69°30'N estimated by two metodes as explained in the text. Open columns: 30-minute analysis, hatched columns: station analysis.

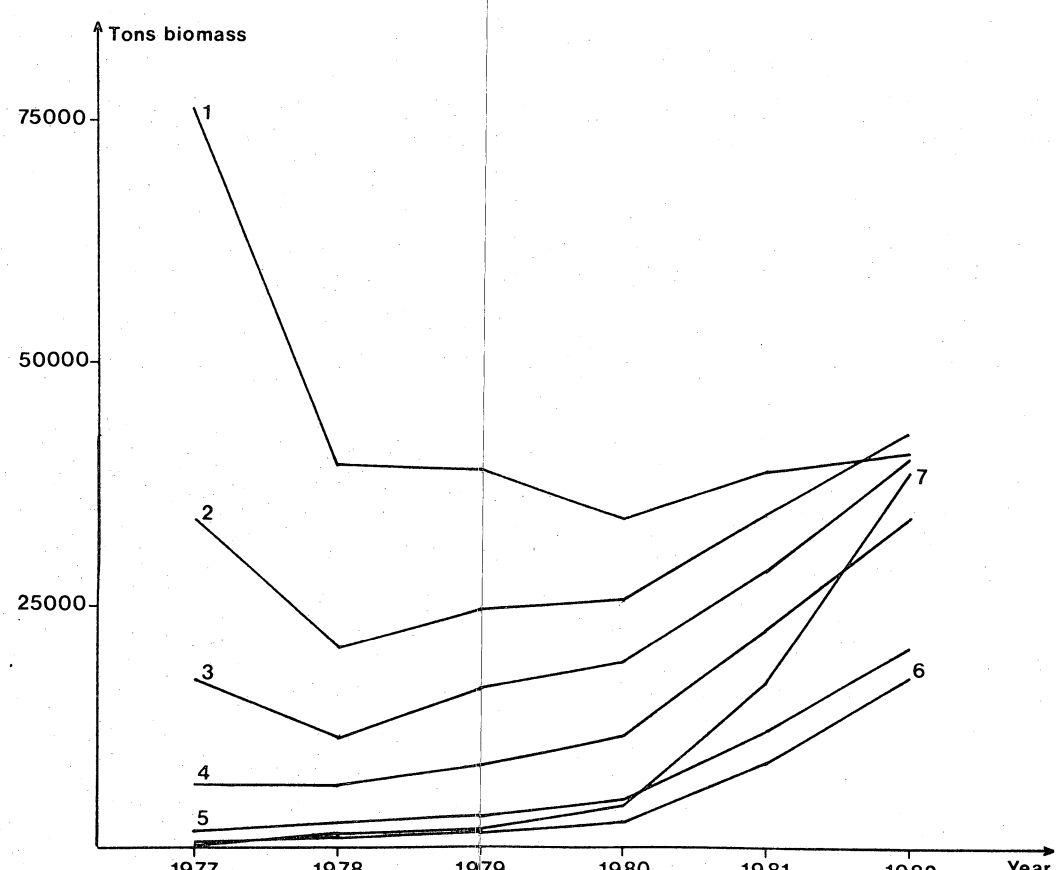

Fig 11. Biomass of shrimps in 30 minute latitude strips as given in table 5. The seven curves are numbered from north to south.

APPENDIX I. FURTHER BIOMASS CALCULATIONS BASED ON BOTTOM PHOTOGRAPHY

by

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Realizing that the temperature is a highly sensitive parameter in the calculation of total biomass, a recalculation with a more graduated hydrography pattern has been made.

Bottom temperatures measured at the hydrography sections III-IV (Fig. 1) were used to establish average temperatures through 1977-82. Only section III has been occupied in all six years, whereas sections IV and V have only been occupied in 1980-82. These sections have no observations deeper than 300 and 250 meters respectively, so for the deeper water layers the observed temperatures from section III have been used for the whole area in 1980-82. For the period 1977-79 the temperatures from section III have been used.

The estimated mean temperatures used in the new biomass calculations are given in Table 1 and Fig. 2. The recalculated biomass estimates are shown in Fig. 3 together with the former ones as given in the main part of this document. Fig. 4 shows the calculated biomass in 30-minute strips, numbered from north to south.

Table 1. Bottom temperatures in different water layers 1977-82 as used in the biomass calculations.

Depth	1977	1978	1979	1980	1981	1982
100	2.0	1.1	1.8	0.2	0.2	0.6
200	2.2	1.8	2.0	1.3	1.4	1.1
300	3.2	4.2	3.9	3.1	3.0	2.1
400	4.1	4.5	4.1	3.7	3.9	3.3
500	4.5	4.7	4.1	4.2	4.2	3.3
600	4.6	4.8	4.0	4.5	4.5	3.5

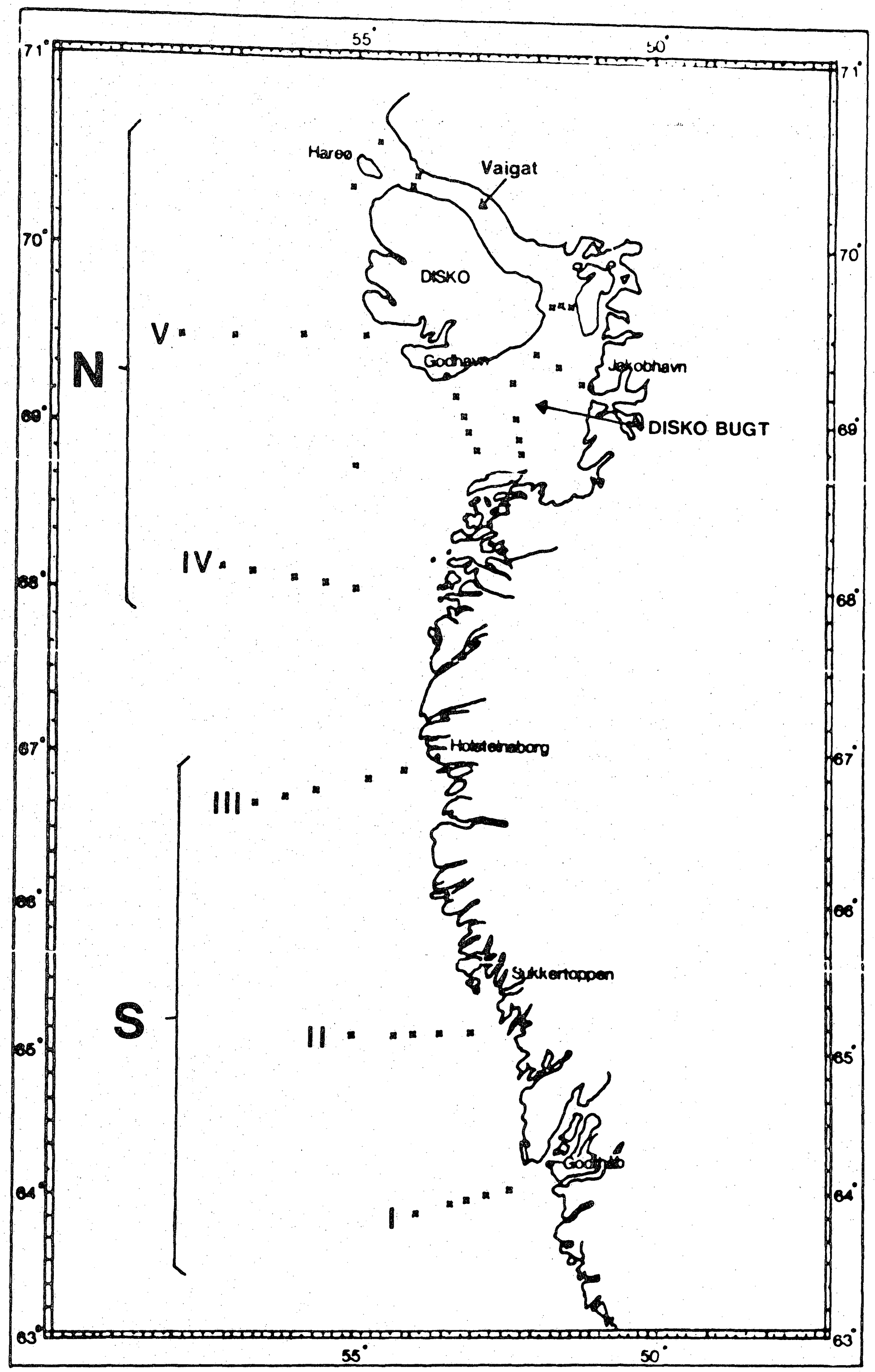

Fig. 1. Oceanographic stations in NAFO SA1. Sections I - IV are international standard sections.

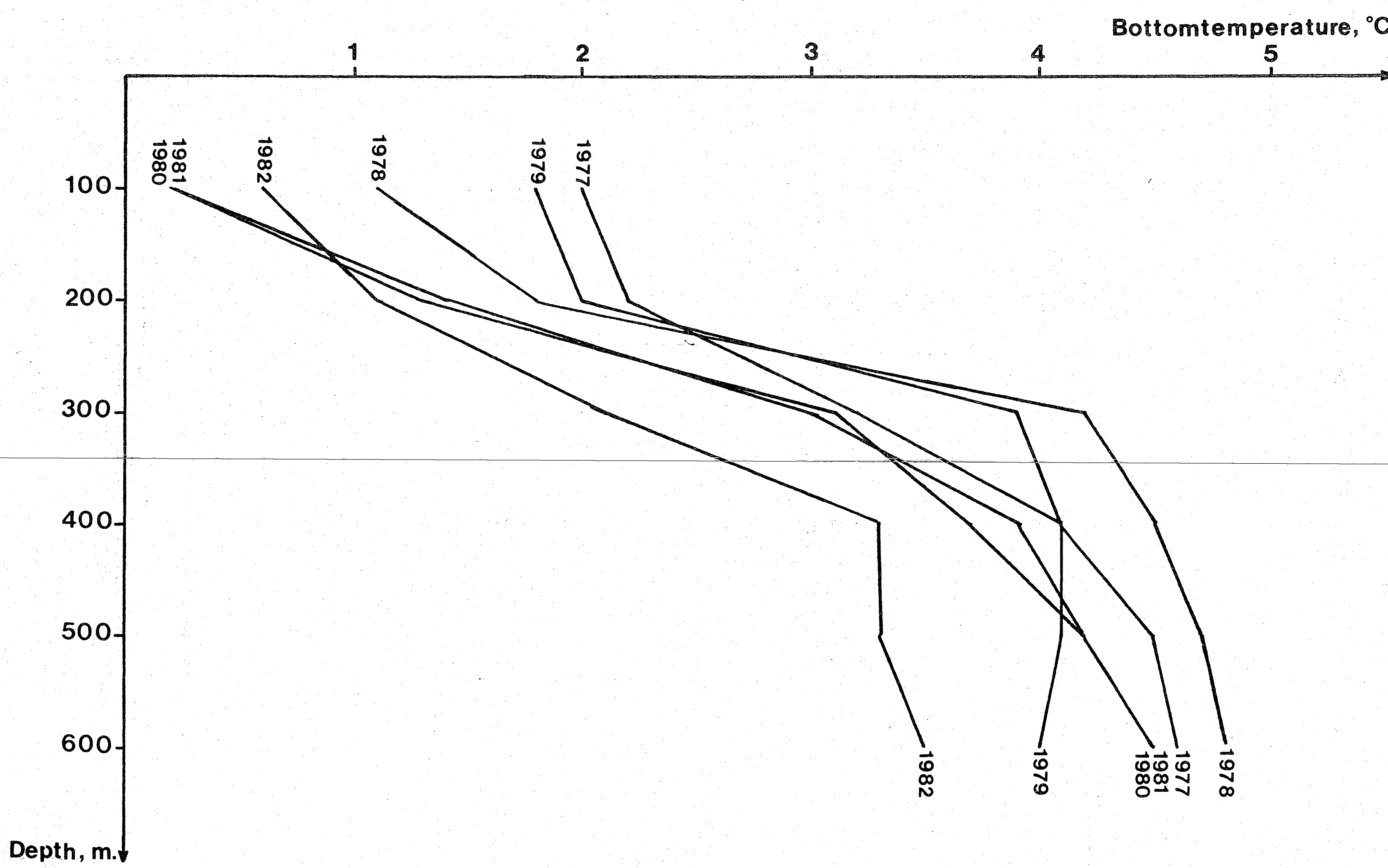

Fig. 2. Mean bottom temperatures used in the biomass calculations.

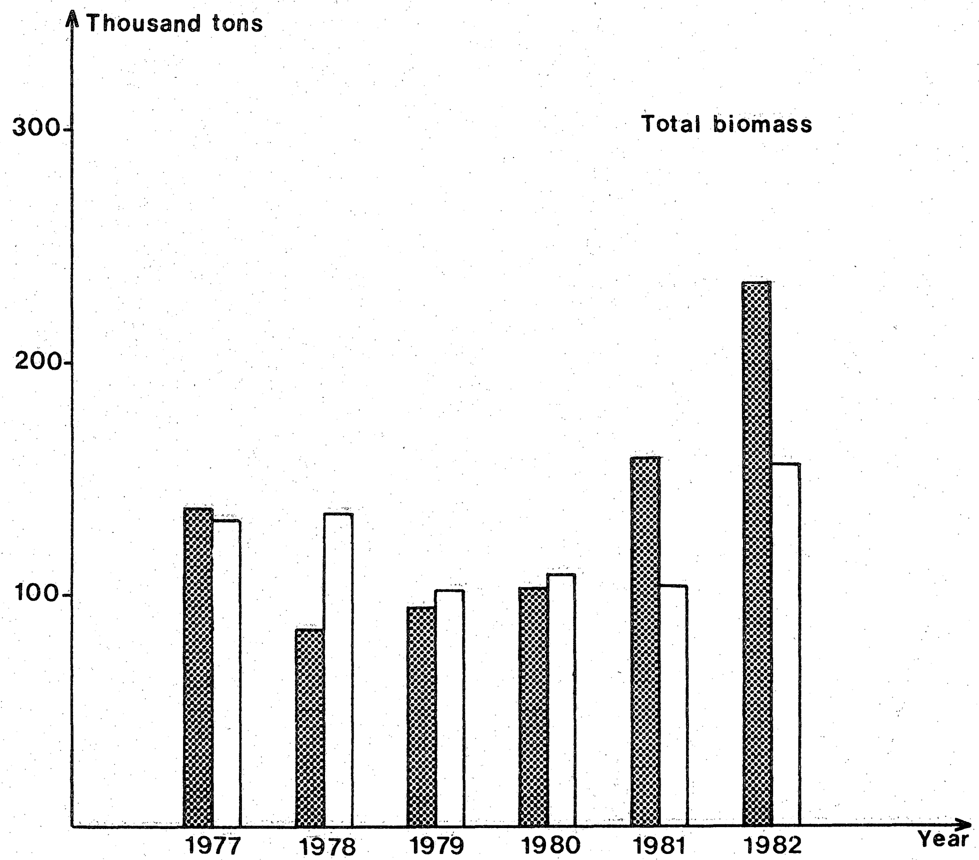

Fig. 3. Total biomass of shrimps in the area 66°00'N to 69°30'N calculated with two different hydrography patterns as explained in the text.

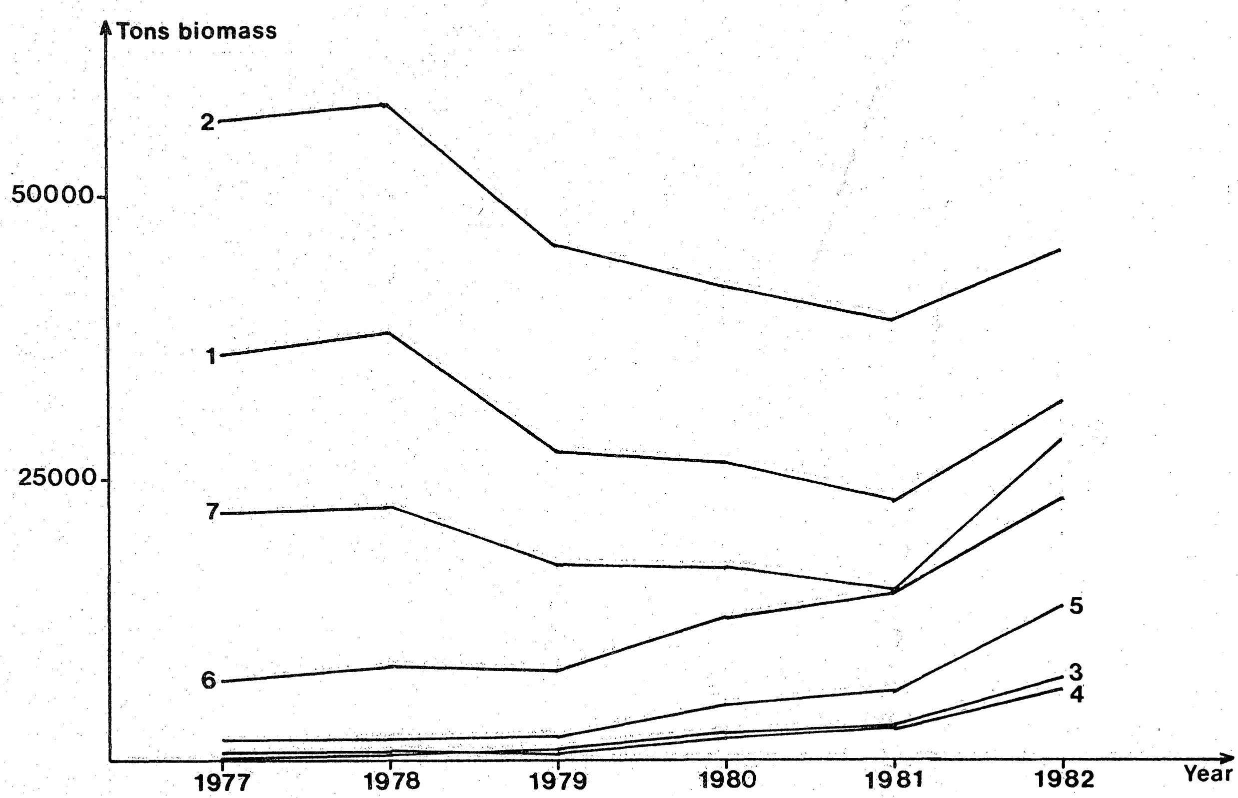

Fig. 4. Biomass of shrimps in 30-minute latitude strips.