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BIOMASS OF SHRIMP *(PANDALUS BOREALIS)* IN NAFO SUBAREA 1 IN 1977-81 ESTIMATED BY MEANS OF BOTTOM PHOTOGRAPHY

by

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ABSTRACT

In continuation with previous years a photographic survey in the main area for shrimp fishery in NAFO SA1 was carried out using a standard sampling procedure.

The material obtained by this sampling was used in a mathematical model to produce estimates for the shrimp areas between 66°N and 69°30'N during the years 1977-81.

INTRODUCTION

Shrimp density in the offshore areas af NAFO SA1 and a smaller adjacent part of SA0 has been estimated by means of bottom photography since 1977. The sampling method has been described earlier and biomass estimates for part of the area were given in relation to estimates derived from trawl surveys (Kanneworff, 1979a, 1979b).

The material from 1977-80 was used in a mathematical model to produce biomass estimates which are independent of trawl sampling (Jørgensen & Kanneworff, 1980).

The present paper uses this model, including photographic material from 1981, and new estimates for the shrimp biomass in the area 66°N - 69°30'N are obtained for the years 1977-81.

MATERIAL AND METHODS

During the years 1977 to 1981 bottom photography has been used in the offshore area of Div. 1A-1C to obtain information on the density of shrimps. The same technique and equipment has been used throughout the five years. This method of sampling has earlier been described by Kanneworff (1979a).

The bottom photographs cover as a standard 3.39 squaremeters, but due to a minor adjustment failure most of the photographs from 1981 cover 3.7 squaremeters.

The sampling rate has been two exposures per minute, giving an estimated average distance between photographs of 5-15 meters dependent on the wind and current speed.

Many of the strata within the area 66°N to 69°30'N and within the depth range 100 to 600 meters have been sampled during the five years of sampling as shown on Figure 1. The choice of sampling sites in the different years has been influenced by demands for good covering af the area and for overlapping stations in order to make a direct year-to-year comparison possible. One of the sampling sites has been chosen as a reference point being situated in one of the heavily fished strata (Stratum no. 12316050, Area code KR004). This station has been occupied in all five years.

As a large part of the fishery during the last two years has been carried out further north than the area covered by this analysis (Carlsson, 1981), the area between 69°30'N and 71°N has been incorporated into the sampling scheme for 1981, but due to technical problems with the ship it has not been possible to carry out this sampling apart from an inshore station northwest of Disko (Area code LS014).

One station has this year been occupied in one of the shrimp grounds in Div. 1C, *i.e.* Sukkertoppen Dyb (Area code JL020), which formerly was of some importance in the commercial shrimp fishery.

A total of 18 sampling sites were occupied during July and August in 1981 and from these a total of 2802 photographs have been included in the present material together with material from the other years of sampling. However, only stations within the area 66°N to 69°30'N have been included in the biomass caculations.

In order to minimize the effect of diurnal variations in the shrimp density on the bottom the sampling on the photographic stations 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 during the day-time, because most of the shrimps are supposed to be situated on the bottom in the hours with daylight. However, a smaller part of the shrimp population is still supposed to swim off bottom in the middle of the day, and the density indices as read from the photographs are thus minimum figures when used as input values for the biomass calculations.

The biomass estimates have been calculated using areas of the different strata as given by Carlsson & Kanneworff (1979) with a few minor corrections. In the field work a good agreement has normally been found between the observed depths and the charts used for estimating the strata areas, however, some discrepancies have been noted in the northwestern part (Blocks no. 11216 and 11217, Figure 2).

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	Estimated mean weight grams
small	<18-20	3.5
medium	18-20<length<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.

A multiple regression analysis was used to produce estimates for the biomass dependency of the three parameters 'year', 'depth' and 'latitude' in the area sampled. The model for this analysis was established earlier (Jørgensen & Kanneworff, 1980) and it has not been changed in the present material. The analysis was carried out by means of a 'General Linear Model' procedure included in the 'Statistical Analysis System' (SAS) programme package in the computer center of the Danish Technical University (NEUCC).

A regression analysis including only the medium sized shrimps has been run in order to determine the possible effect of a relative increase of the small shrimps in the photographic material from 1981.

The input values to the analysis were biomass indices, *i.e.* grams per square-meter, from the sampling sites collected in 30-minutes periods. The values were weighted in the analysis by the number of photographs in each period.

The model used in the analysis was as described earlier *(l.c.)* the following:

$$B_{i,j,k} = e^{\left(a_0 + a_1 y_i + a_2 y^2 + a_3 d_j + a_4 d_j^2 + a_5 l_k + a_6 l_k^2 + a_7 y_i d_j + a_8 y_i l_k + a_9 d_j l_k - \frac{\sigma^2}{2n} + \varepsilon\right)}$$

The material is still assumed to be lognormal distributed.

RESULTS AND DISCUSSION

In Table 1 a list of photographic sampling stations from 1977 to 1981 is given together with shrimp density figures in the three size categories and the corresponding mean weight. The mean weight is based on average weights of 3.5, 7.5 and 13 grams in the three size categories respectively. Naturally, the condition for the repetitive use of these values is that the size distributions in the size groups are constant. It is obvious from the material sampled on the same sites in more than one year, *e.g.* the 'check station' in Stratum no. 12316050 (Area code KR004), see Table 3 and Figure 3, that a considerable change towards a larger amount of small shrimps has taken place. This shift leads not only to a lower estimate for the average shrimp weight in the total material, but also to a decreasing average weight in each of the size groups.

In order to get a check of the absolute values of the average weights as estimated from the photographic material a comparison is made with samples taken by shrimp trawl in connection with the photographic sampling (Tables 4a and 4b). A large part of the small shrimps are not caught by the trawl, and a somewhat lower average weight is thus to be expected in the photographic samples than in the trawl samples. In The 1980 material (Table 4a) the ratio between the average weights in the photographic material and the trawl material was rather constant around 0.8 on stations with a 'normal' amount of small shrimps. In the material from 1981 (Table 4b) this ratio seems to have increased somewhat. This is probably due to the fact that the used weight estimates in the three size groups this year are overestimated, the smaller shrimps becoming more numerous.

On some stations, as indicated in Table 2, the small shrimps are further underestimated being so small that they are close to the resolution of the photographic system.

The coverage by the sampling stations of the area of shrimp distribution between 66°N and 69°30'N has varied much through the five years of sampling as shown on Figure 1. A large part of the strata, however, have been sampled one or more times throughout the period from 1977 to 1981.

This change in sampling coverage is likely to introduce some bias into the assessment of the stock biomass. When using an empirical model as the present it is not possible to interpolate the calculations to years, depths and areas which are not covered by sampling, without assuming a rather stable structure within the limits of the parameters. Extrapolation is of course not allowed.

The sampling in 1980 was more concentrated in the northern part of the area than before, and some of these stations showed high densities of small shrimps. The selection of sample sites to areas with abnormal high densities could possibly lead to an overestimate for the total biomass that year. In 1981, however, the sampling has again been more evenly distributed over the area, and the possible bias from the 1980-sampling should thus be levelled out in the present analysis.

To obtain a measure of the validity of the results of the model it is necessary to calculate the variances in the material. This work has not yet been done, but a relative high variance is likely to be expected. When using the estimates based on this model it is therefore essential to include very wide confidence limits and use the figures with great caution. The variances in the present material are, however, not considered higher than those normally existing in material on which stock assessments for other species are based.

Despite the low correlation coefficient for the model Table 5a shows that many of the parameters are significant for the model, and it is thus the author's impression that this way of approaching a direct biomass estimate is better than the method formerly used, in which estimates were obtained relative to those from a trawl survey (Kanneworff, 1979b).

By means of the calculated parameters from the regression analysis (Table 5a) biomass estimates for all the strata in the area in question are calculated as shown in Table 6. The values for the total area are shown in Figure 4 together with calculated figures for the medium sized shrimps only (the corresponding parameters are shown in Table 5b).

A major increase from 1980 to 1981 in the total biomass is indicated, but as mentioned above the estimates based on fixed values for average weights in the size groups tend to be too large when the average individual weight in the population decrease. In Figure 4 the biomass estimates for shrimps of medium size are indicated (hatched part of the columns) to show the influence of this size group on the total biomass estimate. It is clearly seen that the medium sized shrimps through the five years make up for a steadily decreasing part of the total biomass although in absolute terms an increasing amount. If the possible heavy underestimate of the amount of small shrimps on certain stations (Table 2) is taken into account this descrease will be even more pronounced.

The significant increase in number of small shrimps could possibly be taken as an indication of a promising recruitment to the stock, but this should be treated with great caution. Due to the photographic system it is hardly possible to determine the shrimp species with any certainty in these very small sizes. Other species such as *Lebbeus (Spirontocaris) Passiphae* or some *Crangonidae* could be included in the countings.

Figure 5 shows the interaction between the parameters of the model, given in Table 5a. It is clearly seen that the increase in the biomass indices from 1980 to 1981 - and to a certain degree also the increase from 1979 to 1980 - is much larger in the northern part of the area than in the southern. It should also be pointed out that the highest concentrations of shrimps have been found around 300 m depth in all five years. No significant change seems to have taken place, although a weak indication of a shift to shallower water might be noted.

CONCLUSION

Photographic sampling is regarded as a valuable method for obtaining a direct estimate of the biomass of shrimp *(Pandalus borealis)*. By means of a mathematical model the fluctuations in the stock have been examined. Although the density figures obtained by this sampling should be regarded as minimum figures, the biomass estimates may be somewhat overestimated for 1980 and 1981 due to an increase in the amount of shrimp of smaller sizes. The average individual weight has decreased steadily through the five years of sampling (1977-80).

Noting the low correlation coefficients for the model and the possible high variances involved it is obvious that the model still needs some revision and that the results should be treated with great caution.

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Table 1. List of photographic stations 1977-81 with calculated shrimp densities. The average weights are based on average individual weight of 3.5, 7.5 and 13 grams respectively in the three size groups. The strata are defined by 100 m depth intervals within the blocks.

Div	Stratum No.	Stratum Area	Date	No.of Phot.	Density (no/sqm) Small	Medm.	Large	All	Mean Weight
1B	12414090	690	770724	54	0.000	0.104	0.082	0.186	9.9
1B	12414090	690	770724	35	0.000	0.084	0.101	0.185	10.5
1B	12416070	1542	770725	17	0.017	0.190	0.000	0.207	7.2
1B	12317050	631	770726	82	0.000	0.363	0.004	0.367	7.6
1B	12317070	1543	770726	64	0.000	0.207	0.000	0.207	7.5
1B	12316050	1822	770727	116	0.031	0.674	0.003	0.707	7.3
1B	12015090	122	770804	282	0.001	0.111	0.000	0.112	7.5
1B	12115110	358	770805	23	0.000	0.038	0.000	0.038	7.7
1B	12415090	727	770805	204	0.014	0.129	0.010	0.153	7.5
1B	12417070	1662	770806	190	0.000	0.107	0.002	0.109	7.6
1B	12316050	1822	780721	154	0.061	0.511	0.006	0.579	7.1
1B	12216090	209	780722	162	0.000	0.113	0.000	0.113	7.5
1B	12215030	1395	780724	126	0.000	0.000	0.000	0.000	****
1B	12215050	643	780724	107	0.006	0.069	0.000	0.074	7.2
1B	12115070	234	780724	172	0.000	0.005	0.000	0.005	7.7
1B	12115030	650	780725	174	0.005	0.097	0.002	0.103	7.4
1C	13414050	250	780725	3	0.100	0.400	0.000	0.500	6.8
1B	12015110	260	780725	21	0.014	0.085	0.014	0.113	7.8
1C	13414050	250	780726	178	0.106	0.363	0.003	0.473	6.6
1C	13012070	120	780727	181	0.205	0.391	0.002	0.598	6.1
1B	12416090	517	780802	59	0.000	0.155	0.005	0.160	7.7
1B	12416070	1542	780802	169	0.832	0.640	0.009	1.482	5.3
1B	12516070	1396	780803	38	0.070	0.178	0.008	0.256	6.6
1B	12415050	590	790723	6	0.000	0.500	0.000	0.500	7.5
1A	11214050	919	790730	49	1.096	0.849	0.000	1.946	5.2
1A	11115050	185	790731	11	0.865	0.676	0.027	1.568	5.4
1B	12316050	1822	790801	36	0.008	0.123	0.000	0.131	7.3
1B	12316050	1822	790801	16	1.222	2.093	0.000	3.315	6.0
1B	12413050	627	790805	7	0.083	0.917	0.000	1.000	7.2
1B	12414090	690	790805	16	0.019	0.241	0.074	0.333	8.5
1B	12515070	994	790810	12	0.927	0.293	0.000	1.220	4.5
1B	12417070	1662	790810	5	0.059	0.235	0.000	0.294	6.8
1B	12317050	631	800810	116	0.015	0.244	0.005	0.264	7.4
1B	12316050	1822	800811	167	0.115	0.343	0.004	0.461	6.5
1B	12415050	590	800811	49	0.018	0.096	0.000	0.114	6.9
1B	12515070	994	800811	39	0.273	0.409	0.008	0.689	6.0
1B	12413050	627	800812	110	0.056	0.861	0.003	0.920	7.3
1B	12414090	690	800812	188	0.009	0.126	0.002	0.137	7.3
1B	12514050	724	800813	71	0.041	0.734	0.000	0.776	7.3
1A	11115050	185	800813	82	0.396	1.014	0.004	1.414	6.4
1A	11213050	424	800815	134	0.081	2.293	0.007	2.381	7.4
1A	11214050	919	800817	189	2.200	1.053	0.016	3.268	4.8
1B	12517070	1525	800810	167	0.000	0.065	0.000	0.065	7.5
1B	12416070	1542	800821	40	0.184	4.081	0.000	4.265	7.3
1B	12416090	517	800821	116	0.511	0.392	0.003	0.906	5.3
1A	11217050	45	800822	68	0.000	1.338	0.017	1.355	7.6
1A	11216050	1628	800822	22	0.040	0.507	0.013	0.560	7.4
1B	12517070	1525	800823	89	0.000	0.017	0.000	0.017	7.6
1B	12416070	1542	800823	148	1.426	0.283	0.004	1.713	4.2
1B	12317050	631	810726	99	0.041	0.328	0.003	0.372	7.1
1B	12215050	643	810727	101	0.027	0.019	0.000	0.045	5.2
1B	12115070	234	810728	177	0.003	0.085	0.000	0.089	7.4
1C	13112070	130	810728	82	0.630	1.112	0.003	1.746	6.1
1C	13414050	250	810805	178	0.077	0.363	0.000	0.440	6.8
1B	12316050	1822	810806	191	0.891	0.723	0.001	1.615	5.3
1B	12413050	627	810808	169	0.822	1.272	0.000	2.094	5.9
1B	12414090	690	810808	171	0.041	0.229	0.002	0.272	6.9
1A	11115050	185	810809	181	1.499	0.633	0.000	2.131	4.7
1B	12515070	994	810809	162	0.482	0.322	0.005	0.810	5.2
1B	12417070	1662	810810	147	0.020	0.193	0.002	0.215	7.2
0A	01418050	199	810810	194	0.000	0.529	0.000	0.529	7.5
1B	12416070	1542	810611	192	0.141	0.723	0.001	0.865	6.9
1B	12416090	517	810811	173	0.383	0.239	0.000	0.622	5.0
1B	12416070	1542	810811	169	0.262	0.669	0.003	0.934	6.4
1A	11213050	424	810817	161	0.255	0.455	0.000	0.710	6.1
1A	11214050	919	810817	64	0.911	1.051	0.004	1.966	5.7
??	********	******	810818	191	0.471	0.424	0.001	0.897	5.4

Table 2. List of photographic stations 1981 showing the number of shrimps in the three size groups together with the average density.

DIV.	Stratum no.	Area code	Date	No. of photos	Shrimp Small	Medium	large	av. shrimp/sqm
1B	12317050	KP440	810726	99	15	120	1	0.37
1B	12215050	KL006	810727	101	10	7	0	0.05
1B	12115070	KF007	810728	177	2	56	0	0.09
1C	13112080	JL020	810728	82	191	337	1	1.74
1C	13414050	KA011	810805	178	51	239	0	0.44
1B	12316050	KR004	810806	191	630	511	1	1.62
1B	12413060	KZ015	810808	169	514 a)	795	0	2.09
1B	12414100	KZ012	810808	171	26	145	1	0.27
1A	11115060	LE005	810809	181	1004 b)	424	0	2.13
1B	12515070	LB005	810809	162	289	193	3	0.81
1B	12417070	KX438	810810	147	11	105	1	0.22
0A	01418060	KT436	810810	194	0	380	0	0.53
1B	12416072	KT001	810811	192	100	513	1	0.86
1B	12416090	KV002	810811	173	245	153	0	0.62
1B	12416071	KZ003	810811	169	164 b)	418	2	0.93
1A	11213052	LH014	810817	161	152 a)	271	0	0.71
1A	11214060	LJ011	810817	64	216	249	1	1.97
1A	11413060	LS014	810818	191	333	300	1	0.90

a) The size group 'small' is possibly strongly underestimated.
b) The size group 'small'is slightly underestimated.

Table 3. Percentage size distribution and average weights of shrimps in the photographic material from the same sampling site (Area code KR004) in five succeeding years.

YEAR	percentage small	medium	large	average weight
1977	4.3	95.3	.4	7.3
1978	10.6	88.4	1.0	7.1
1979	36.9	63.1	.0	6.0
1980	24.9	74.3	.8	6.5
1981	55.2	44.7	.1	5.3

Table 4a. Percentage size distribution and average weight of shrimp in photographic material and samples from trawl catches in 1980.

Stratum no.	Area code	type	% small	% medium	% large	Average weight
12317050	KP440	photo trawl	5.8 5.5	92.3 93.4	1.9 1.2	7.4 8.9
12316050	KR004	photo trawl	24.9 21.0	74.3 78.1	.8 .9	6.5 7.4
12413050	KZ014	photo trawl	6.1 14.2	93.6 85.0	.3 .8	7.3 8.9
12414090	KZ012	photo trawl	6.9 8.0	92.0 89.1	1.1 2.9	7.3 11.1
12517070	LA438	photo trawl	.0 3.4	100.0 93.2	.0 3.4	7.5 10.3
11217050	LH440	photo trawl	.0 1.3	98.7 95.1	1.3 3.6	7.6 9.3
12416070	KZ002	photo trawl	83.3 19.6	16.5 80.3	.2 .2	4.2 11.4

Table 4b. Percentage size distribution and average weight of shrimp in photographic material and in samples from trawl catches in 1981.

Stratum no.	Area code	type	% small	% medium	% large	Average weight
12317050	KP440	photo trawl	11.0 12.5	82.2 86.1	0.7 1.4	7.1 8.7
12215050	KL006	photo trawl	58.8 32.7	41.2 66.2	0.0 0.8	5.1 6.8
12115070	KF007	photo trawl	3.4 3.4	96.6 94.7	0.0 1.9	7.4 9.3
13414050	KA011	photo trawl	17.6 52.9	82.4 47.1	0.0 0.0	6.8 5.1
12316050	KR004	photo trawl	55.2 44.2	44.7 54.5	0.1 1.3	5.3 6.7
12414100	KZ012	photo trawl	15.1 4.9	84.3 93.1	0.6 2.0	6.9 10.0
11115050	LE005	photo trawl	70.3 41.4	29.7 58.1	0.0 0.5	4.7 4.9
12515070	LB005	photo trawl	59.6 23.0	39.8 76.6	0.6 0.4	5.2 6.6
12417070	KX438	photo trawl	9.4 27.6	89.7 71.5	0.9 0.9	7.2 6.4
01418050	KT436	photo trawl	0.0 0.2	100.0 91.1	0.0 8.6	7.5 10.5
12416090	KV002	photo trawl	61.6 10.1	38.4 88.9	0.0 1.0	5.0 8.5
12416070	KZ003	photo trawl	28.1 32.5	71.6 67.0	0.3 0.5	6.4 6.4
11214050	LJ011	photo trawl	46.4 57.4	53.4 42.6	0.2 0.0	5.7 4.1
11413050	LS014	photo trawl	52.5 55.6	47.3 44.4	0.2 0.0	5.4 5.7

Table 5a. Output from the regression analysis including shrimps of all sizes according to the model as described in the text.

SHRIMP PHOTOGRAPHY, LOGMODEL OF 801106, BIOMASS 23:46 TUESDAY, NOVEMBER 17, 1981

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNBIMS
WEIGHT: BILLNO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	10	6193.53048444	619.35304844	13.52	0.0001	0.343871	1389.7108
ERROR	258	11817.68297183	45.80497276		STD DEV		LNBIMS MEAN
CORRECTED TOTAL	268	18011.21345627			6.76793711		0.48700329

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
U	1	132.44666270	2.89	0.0903	1	74.85565140	1.63	0.2023
YEAR	1	2379.33327243	51.94	0.0001	1	117.75075213	2.57	0.1101
DEPTH	1	49.88197952	1.09	0.2977	1	41.90392034	0.91	0.3397
BR	1	2448.60063191	53.46	0.0001	1	201.49482151	4.40	0.0369
YEAR*YEAR	1	210.08988137	4.59	0.0332	1	159.78640684	3.49	0.0629
DEPTH*DEPTH	1	558.81119297	12.20	0.0006	1	557.88189628	12.18	0.0006
BR*BR	1	368.62535331	8.05	0.0049	1	200.64840359	4.38	0.0373
YEAR*DEPTH	1	44.20094199	0.96	0.3269	1	26.55699878	0.58	0.4471
YEAR*BR	1	1.23320407	0.03	0.8698	1	0.35693466	0.01	0.9297
DEPTH*BR	1	0.30736417	0.01	0.9348	1	0.30736417	0.01	0.9348

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > ITI	STD ERROR OF ESTIMATE
INTERCEPT	1704.62179333	2.28	0.0233	746.83503514
U	-3.24408291	-1.28	0.2023	2.53767478
YEAR	-18.23227945	-1.60	0.1101	11.37143932
DEPTH	0.08044598	0.96	0.3397	0.08410723
BR	-30.22965498	-2.10	0.0369	14.41310533
YEAR*YEAR	0.11420310	1.87	0.0629	0.06114547
DEPTH*DEPTH	-3.7042246E-05	-3.49	0.0006	0.00001061
BR*BR	0.22347297	2.09	0.0373	0.10677350
YEAR*DEPTH	-0.00062814	-0.76	0.4471	0.00082495
YEAR*BR	0.00790637	0.09	0.9297	0.08956512
DEPTH*BR	-0.00012673	-0.08	0.9348	0.00154708

Table 5b. Output from the regression analysis including medium sized shrimps only.

SHRIMP PHOTOGRAPHY, LOGMODEL OF 801106, BIOMASS 23:47 TUESDAY, NOVEMBER 17, 1981

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNBIMS
WEIGHT: BILLNO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	10	5115.84607729	511.58460773	11.37	0.0001	0.305837	2586.2610
ERROR	258	11611.51004863	45.00585290		STD DEV		LNBIMS MEAN
CORRECTED TOTAL	268	16727.35612593			6.70864017		0.25939533

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
U	1	138.94589565	3.09	0.0801	1	82.15584843	1.83	0.1778
YEAR	1	1845.43963883	41.00	0.0001	1	115.84014594	2.57	0.1099
DEPTH	1	53.52059534	1.19	0.2765	1	54.29052209	1.21	0.2731
BR	1	1872.84447514	41.61	0.0001	1	182.23959034	4.05	0.0452
YEAR*YEAR	1	176.93358960	3.93	0.0485	1	172.05904650	3.82	0.0516
DEPTH*DEPTH	1	643.90818573	14.31	0.0002	1	616.08371611	13.69	0.0003
BR*BR	1	347.14605770	7.71	0.0059	1	200.79923254	4.46	0.0356
YEAR*DEPTH	1	4.38093264	0.10	0.7553	1	1.02558258	0.02	0.8801
YEAR*BR	1	7.39579876	0.16	0.6855	1	0.39565173	0.01	0.9254
DEPTH*BR	1	25.33090791	0.56	0.4538	1	25.33090791	0.56	0.4538

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > ITI	STD ERROR OF ESTIMATE
INTERCEPT	1651.87402881	2.23	0.0265	740.29167710
U	-3.39859091	-1.35	0.1778	2.51544107
YEAR	-18.08375738	-1.60	0.1099	11.27180902
DEPTH	0.09156701	1.10	0.2731	0.08337033
BR	-28.74899129	-2.01	0.0452	14.28682563
YEAR*YEAR	0.11850775	1.96	0.0516	0.06060975
DEPTH*DEPTH	-3.8926561E-05	-3.70	0.0003	0.00001052
BR*BR	0.22355695	2.11	0.0356	0.10583801
YEAR*DEPTH	0.00012344	0.15	0.8801	0.00081772
YEAR*BR	-0.00832414	-0.09	0.9254	0.08878040
DEPTH*BR	-0.00115049	-0.75	0.4538	0.00153352

Table 6. Calculated total biomass for all strata at different latitude areas within the 100–600 m depth range. All three size groups of shrimps are included.

AREA	Total biomass				
	1977	1978	1979	1980	1981
66°00 - 66°30	2197	1876	2020	2742	4692
66°30 - 67°00	1861	1586	1708	2323	3988
67°00 - 67°30	3591	3067	3301	4479	7658
67°30 - 68°00	8989	7590	8071	10808	18229
68°00 - 68°30	21150	17265	17751	22984	37484
68°30 - 69°00	34250	28688	30251	40157	67108
69°00 - 69°30	49974	43319	47290	65015	112563
Total area 66°00 - 69°30	122013	103391	110392	148508	251722

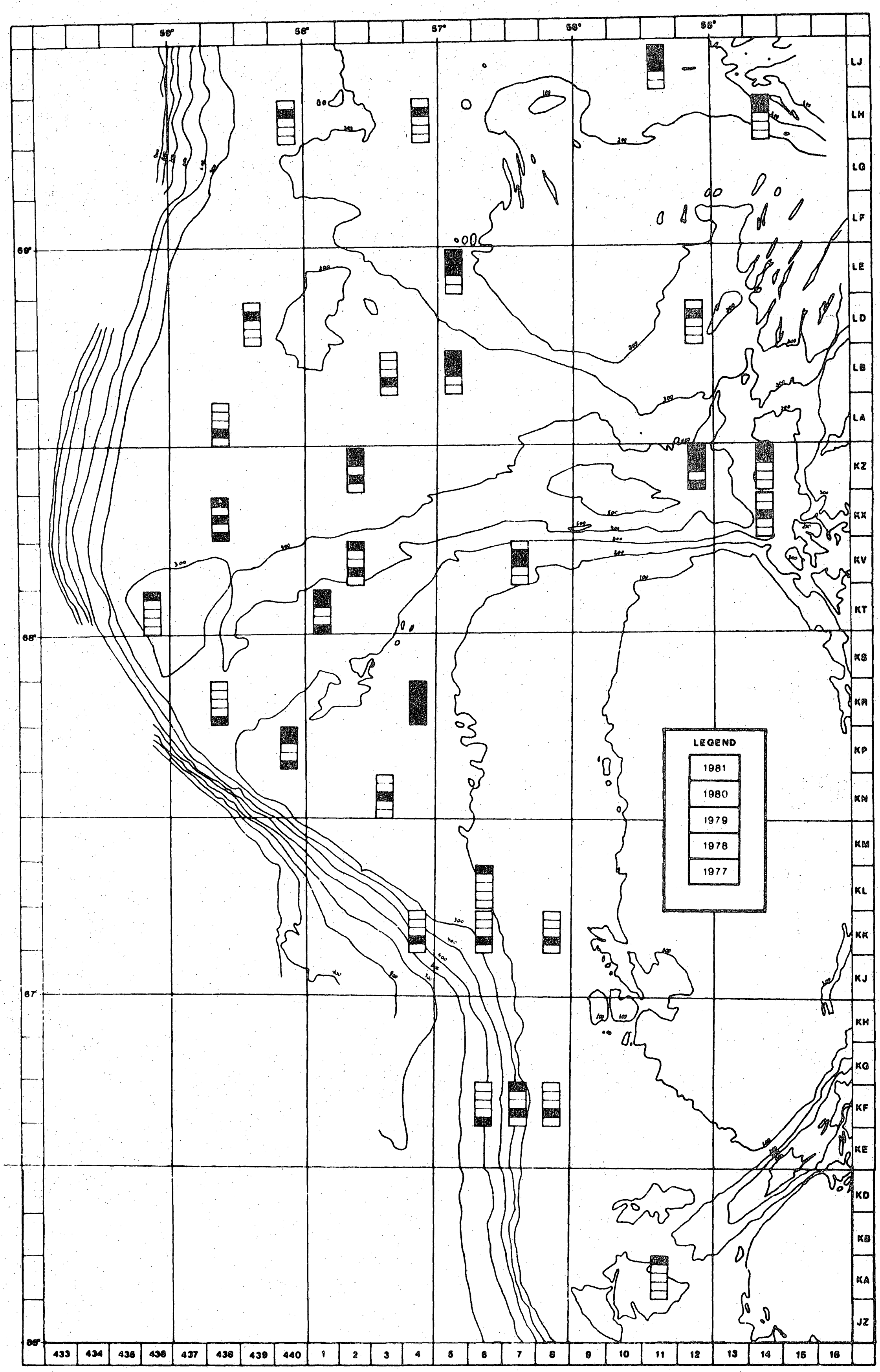


Fig. 1. Map showing the sampling stations 1977-81. Three more stations are outside the map; they are not included in the biomass analysis.

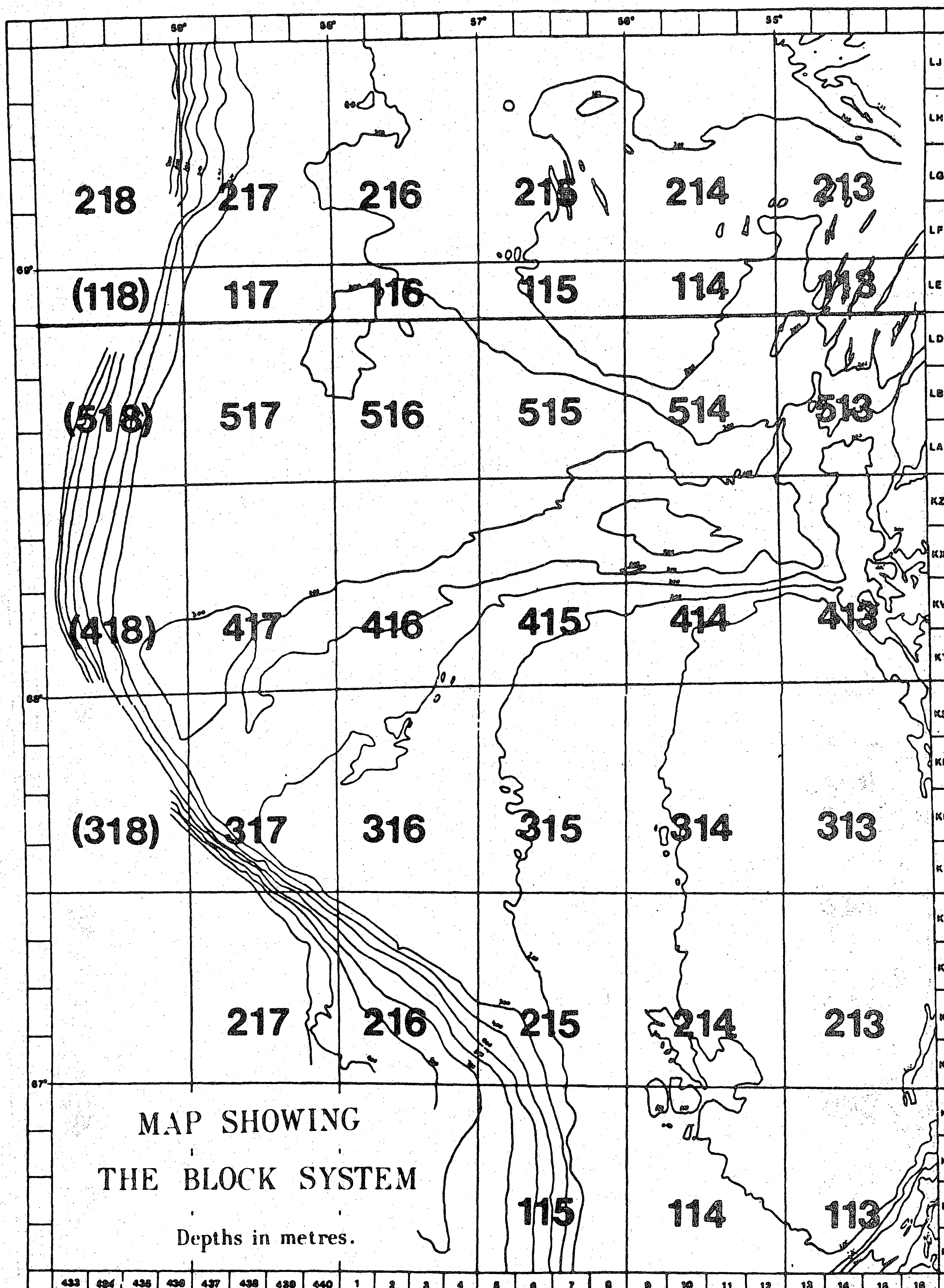


Fig. 2. Block numbers in the stratification system for Div. 1B and the southern part of Div. 1A. Block numbers in brackets west of 59°W are numbers extended to SA0 from SA1 for practical use in the ADP system.

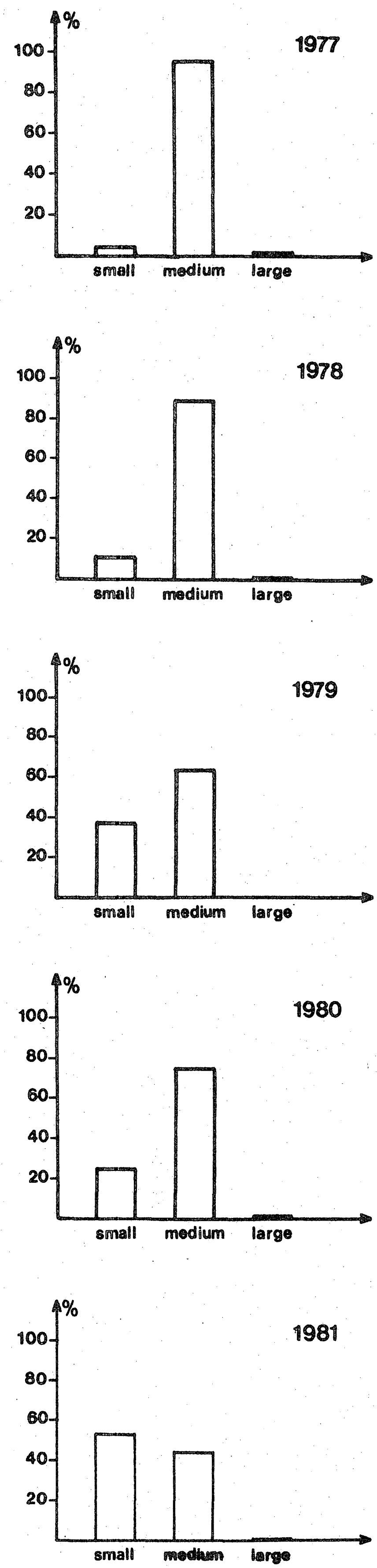


Fig. 3. Development in the size composition of shrimps in the photographic material from a check station in the central area, area code KR004.

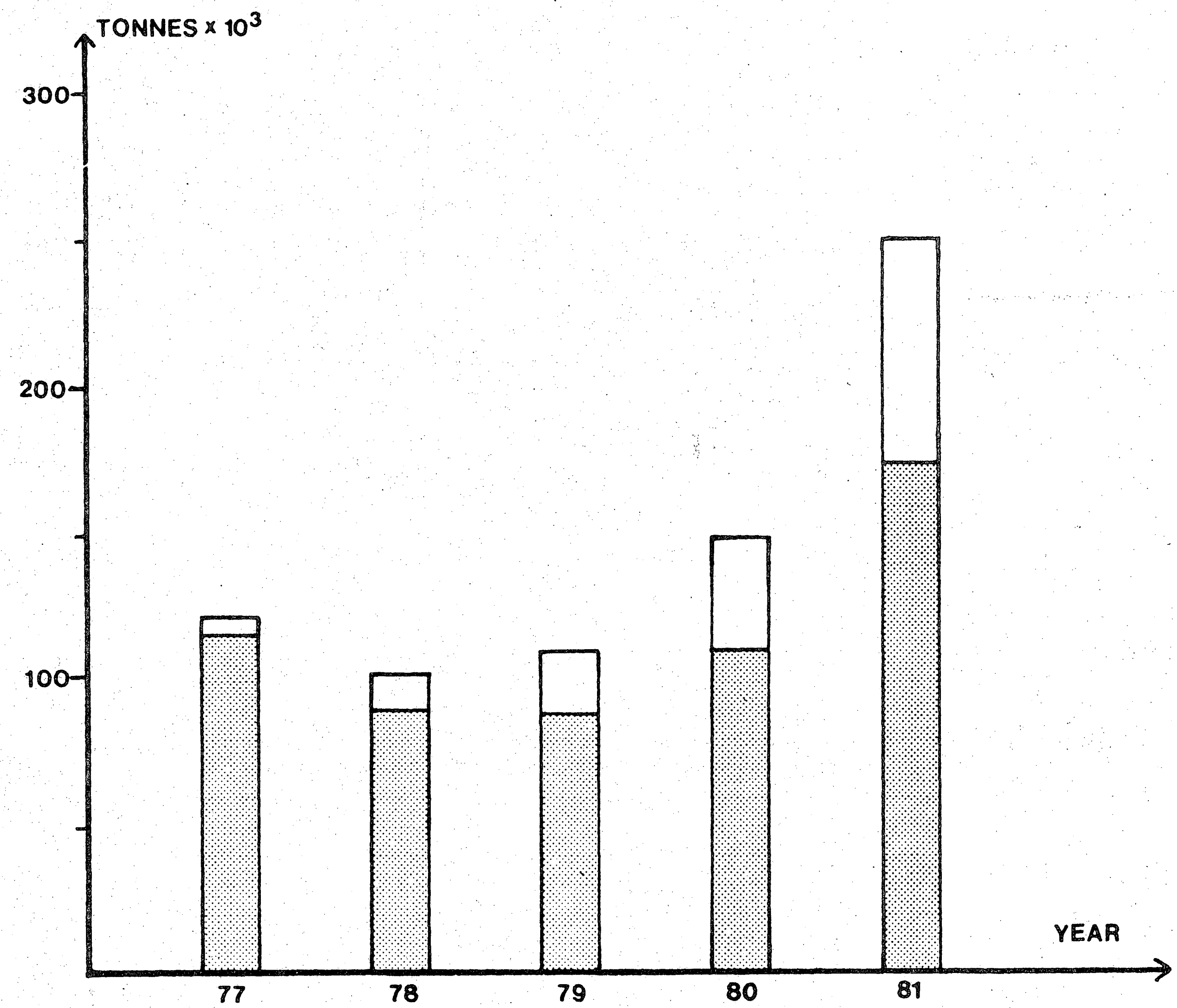


Fig. 4. Total biomass estimates for the area between 66°N and 69°30'N in the depth range 100-600 meters. The hatched part of the columns shows the estimates for the shrimps of medium size only.

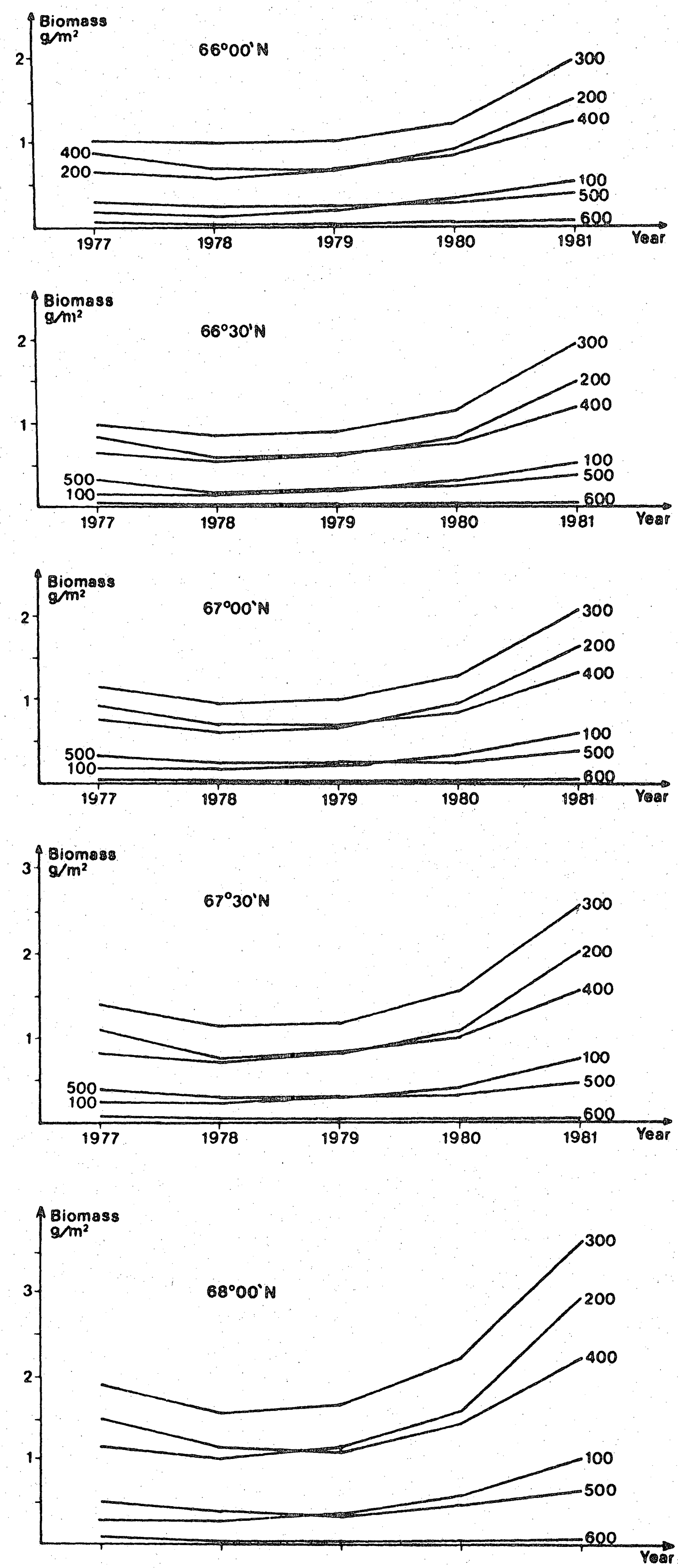
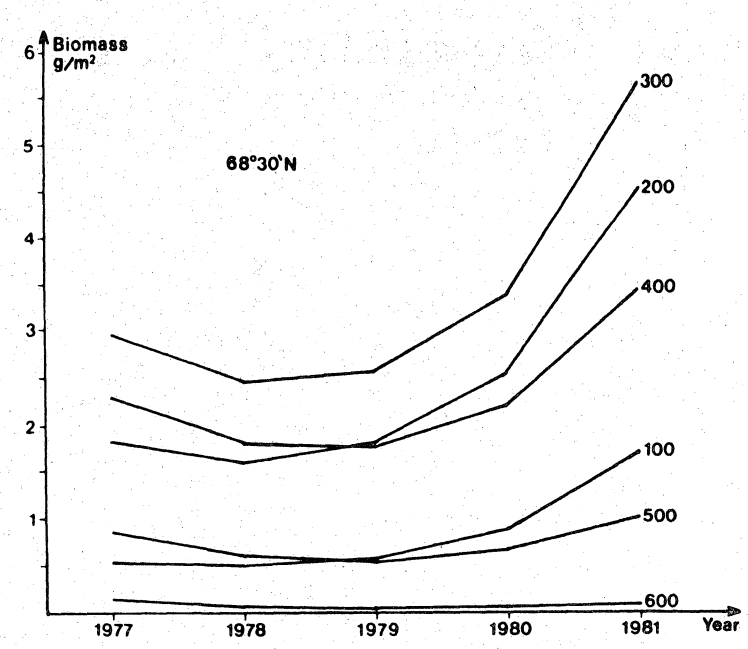


Fig. 5. The figures show the estimated shrimp biomass indices (grams per squaremeter) at different latitudes and in different depths according to the calculated parameters of the model.



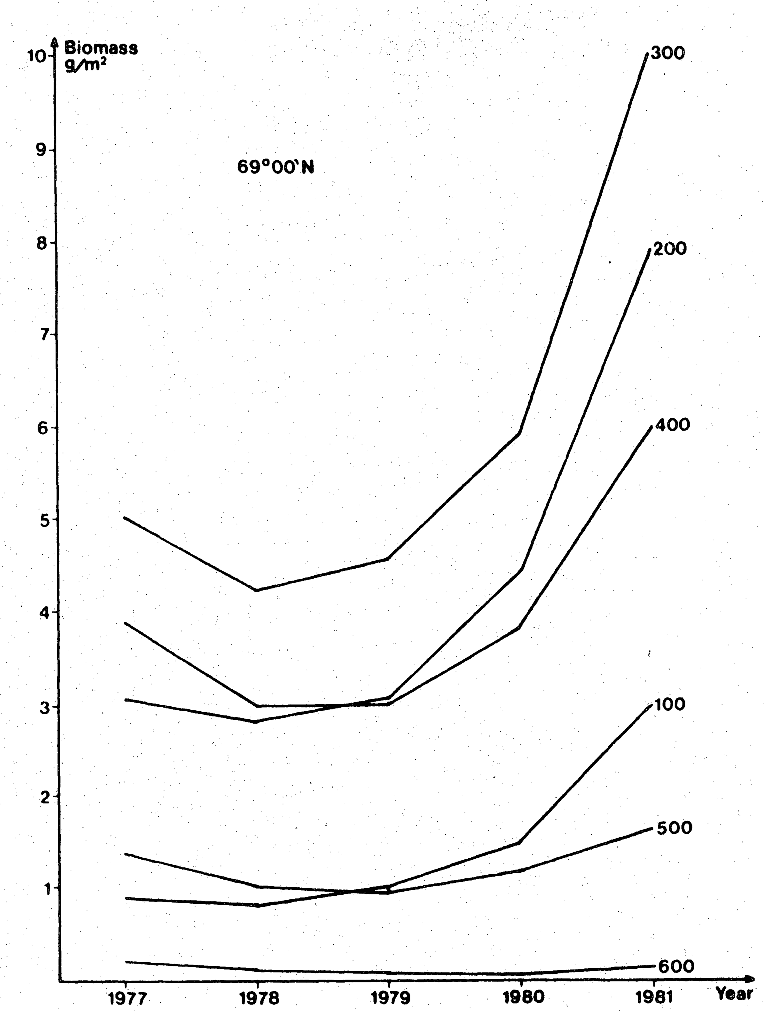
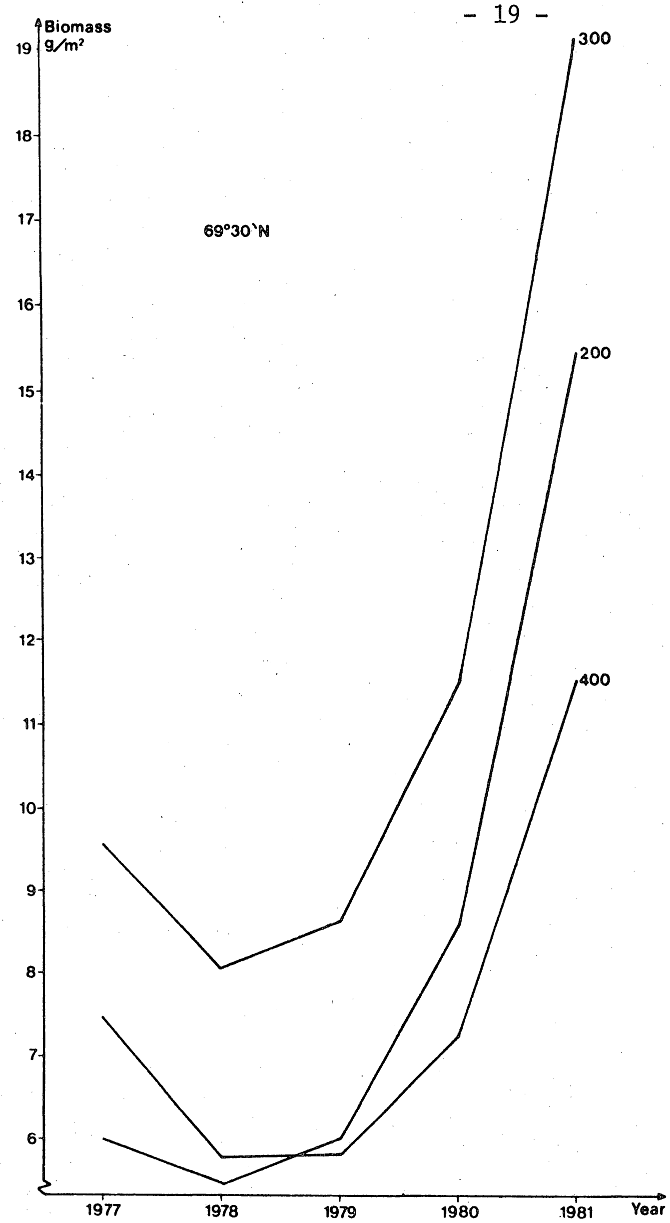


Fig. 5 continued.



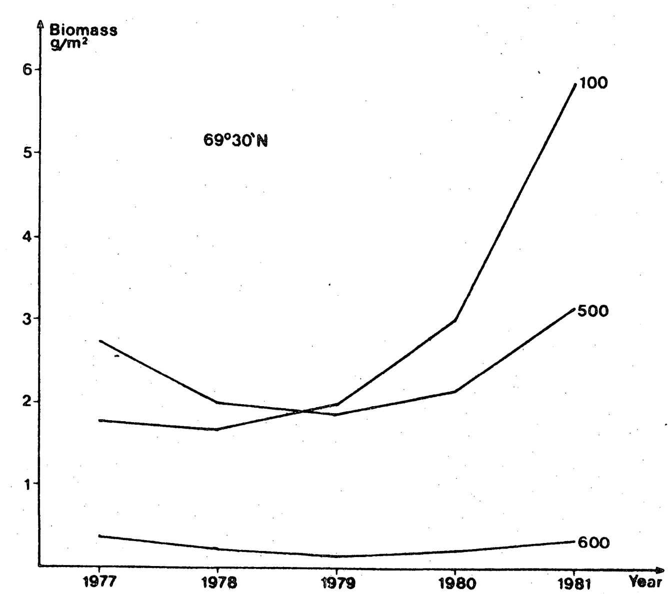


Fig. 5 continued.