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Stratified-random Trawl Survey for Northern Shrimp (*Pandalus borealis*) in NAFO Subareas 0+1, in 2000

by

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Abstract

Stratified-random surveys have been carried out since 1988 in NAFO Subarea 1 and Div. 0A as a part of the assessment of the stock of *Pandalus borealis* off West Greenland. This paper updates the survey series with data from the survey in July-September 2000.

The survey design has been changed in the later years: *1*. the allocation of hauls to strata was changed from pure area-proportional allocation to include a weighing factor based on historical density information; *2*. trawl sites were chosen using a minimum distance between stations (buffer zone); *3*. about half of the stations were fixed from year to year, while the rest as in earlier years was selected at random; *4*. tow duration was reduced to include hauls of 45, 30 and 15 minutes, a reduction from the earlier used 60 minutes in the offshore areas.

Total biomass was calculated, and changes in the temporal and spatial distribution were studied. Total biomass of this stock has been fairly stable over the years, however, after a low in 1997 the biomass has increased to a record high amount of about 350 thousand tons, the estimates for the last three years being the highest on record.

Introduction

Since 1988, Greenland Institute of Natural Resources has conducted annual stratified-random trawl surveys in the shrimp distribution area in Davis Strait between July and September to assess the *Pandalus borealis* stock biomass and to obtain information on size composition of the stock.

This document presents the results of the 2000 survey, and compares them with previous results in the survey series.

Material and Methods

Survey design

The offshore survey area covers the depth interval 150-600 meters in NAFO Subarea 1 and a small part of Div. 0A. Since 1991 the survey has also included the inshore area in part of Div. 1A, Disko Bay and Vaigat.

Major strata correspond to geographical areas, where possible sub-stratified by depth (Carlsson *et al*., 1995). Where reliable depth information exists four depth zones are applied: 150-200 m, 200-300 m, 300-400 m, and 400-600 m. In regions without reliable depth information the stratification is based on the distribution of the commercial fishery.

From 1988 through 1997 the trawl stations were allocated to strata proportionally to stratum area, but since 1998 the allocation has been weighted towards strata with traditionally high shrimp densities in order to get a more precise biomass estimate. In order to optimise the sampling and in accordance with results from a study group (Carlsson *et al*., 1998), a reduced coverage in depth strata with traditional low shrimp densities was applied concurrently with an increased coverage in other strata.

In 1999 a new method of choosing stations for the survey was introduced using a minimum distance between stations (a buffer zone), however still keeping the randomness in placing stations (Kingsley *et al*., 1999).

From 1988 through 1998 stations have been selected at random by re-placing sampling sites for each year. To study the stability of the stock distribution and assess the performance of a fixed-station design relative to that of resampling (Kingsley, 2000) about 50 % of the stations from the surveys in 1998 and 1999, randomly chosen, were repeated as fixed stations in the surveys in 1999 and 2000, respectively. The remainder of the stations were re-selected, using the above-mentioned buffer zone method, and using the fixed stations as already chosen stations.

Fishing practices

The survey was conducted with the 722 GRT trawler *Paamiut*, using a 3000/20-mesh *Skjervøy* bottom trawl with a twin cod-end. Mesh size in the cod-end was 20 mm (stretched). Trawl doors were *Greenland Perfect*, measuring 370*250 cm and weighing 2420 kg. Trawl geometry was measured with *Scanmar* acoustic sensors mounted on the trawl doors, and a *Furuno* trawleye on the headrope.

In order to minimise the influence of daily vertical migrations of shrimp, trawling was carried out only between 0900 and 1900 UTC. The position (GPS) of the vessel at the beginning and end of each tow was used to measure the length of the track.

Following the recommendations from a study group (Carlsson *et al*., 1998) the tow duration was reduced. The reduction was introduced stepwise as a precaution against possible loss of information. In 1998 about 25 % of the offshore hauls were reduced to 30 minutes instead of the former 60 minutes. In the 1999-survey 50 % of the stations were reduced: 25 % to 30 minutes and 25 % to 15 minutes. Further reductions were made in the 2000-survey, where half of the stations were scheduled to be of 45 minutes length while the rest were planned as 30 and 15 minutes' hauls in equal numbers.

Due to the recent changes in stratum coverage and reduction of haul duration a higher number of hauls per day have been obtained in the surveys in 1999 and 2000. The total survey time was cut down six days in 2000 compared to the year before, resulting in a reduction in the total number of hauls. However, the reduction of tow time and the concentration of stations to certain strata made it possible to reduce the total planned stations with five stations only, from 235 in 1999 to 230 in 2000.

In the 2000 survey an abnormal number of planned trawling sites (28 stations) had to be skipped. Six sites had to be skipped in the inner part of Holsteinsborg Deep (area W4, see Fig. 1) as this area was occupied by fixed fishing gear for snow crab. One site was skipped because of consistent problems with Greenland shark, which hampered successful sampling both in 1999 and in 2000. The rest of the trawling sites were skipped due to bottom conditions or problems with strong currents. As a large part of the trawling sites are chosen at random some stations may have been placed in areas in which the conditions were not sufficiently known to judge if the sites should have been removed from the list of trawlable sites. Strong currents seem to have been more predominant in 2000 than earlier.

Biological samples

From each haul a sample of about 4 kg of shrimp was taken. Shrimp were sorted by species and sexual characteristics, and oblique carapax length was measured by slide calliper to nearest 0.1 mm for *Pandalus borealis* and *P. montagui*. The samples were weighted by catch and stratum area to obtain estimates of total number of *Pandalus borealis* by sex and length group for each stratum and for the total area.

All fish by-catch was sorted to species or species group and weighed.

In overall length distributions of *Pandalus borealis* from both offshore and inshore areas modes were identified by visual inspection and by application of the deviation method (Skúladóttir, 1981). Distributions were thereafter analysed for size components by modal analysis (Macdonald and Pitcher, 1979).

Data Management and Analysis

Swept area

The distance between the doors was recorded 5 times in each haul, and the mean wingspread was calculated from that. The nominal swept area was calculated as the track length multiplied by the mean wingspread.

Unweighted estimates of biomass (tow duration and end error).

Three different target tow durations were used in 2000. Overall, 17 % (planned 25 %) of the tows lasted for about 45 minutes, 58 % (planned 50 %) for 30, and 25 % (as planned) for 15 minutes. Analyses have so far found that shorter tows are no more variable than long tows (Kingsley *et al*., in prep.), therefore, no weighting was applied to tows of different durations. Analyses of the survey data from 1999 also showed that the effective swept area is somewhat larger than the estimated (Kingsley *et al*., l.c.), corresponding to about 8% of the swept area of a 30-minute haul. No correction of this end-effect has yet been included, as further analyses of the 2000-survey data are expected to refine the results. For each tow, the catch was divided by the nominal swept area - i.e. that calculated from wingspread and track-length - to estimate the density, which was multiplied by the stratum area to estimate stratum biomass. *Unweighted* means and variances of these biomass estimates were added to those of other strata to get regional and overall estimates.

Fixed stations.

The fixing of some stations from the 1998-1999 surveys has been ignored in the analyses carried out for the present document. I.e. data from the fixed and the re-placed stations have been analysed together without distinction. Analyses are therefore the same as in previous years.

Results and Discussion

Biomass, total estimate

For all strata biomass estimates have been calculated (Tables 1a-1e) on the basis of the nominal swept area. The biomass estimates (in tons) for the five main regions in 2000 are:

REGION	BIOMASS ESTIMATE	NO. OF HAULS	CONFIDENCE LIMITS (95 %)
Disko	83,500	23	22,170
North	9,579	18	7,080
Canada	11,660	12	1,617
West	220,260	131	66,444
South	24,521	18	27,453
OVERALL	349,520	202	75,582

Since the very low observed biomass estimated for 1997 (206 thousand tons) the biomass has increased significantly to a record high estimate for 2000 of 350 thousand tons. This estimate is the third annual estimate with record highs above the observations from the period 1988-97 (Table 2). The biomass in 2000 had a fairly normal distribution (Fig. 1) with traditional high densities in the deeps south of the shallow banks along the coast, especially in Sukkertoppen and Holsteinsborg Deeps (around 64°30'N and 66°30'N, respectively) and in Disko Bay. The exceptionally high biomass in the southermost region (S: Julianehåb Bay) found in 1999 (however, with very high error variance) was not observed again in 2000. Due to the large observed variance in this area a high number of sampling sites were planned for the 2000-survey, and the observed biomass for this region was estimated to be of the same magnitude as in most of the earlier years (1994, 1997, and 1998). This region has exhibited frequent large coefficients of variation of the biomass estimate (Table 3). Also for the estimates for regions C and N large coefficients of variation are normally observed, but the biomass estimates from these regions account only for a small proportion of the total (in 2000, 13 % for regions C, N and S combined).

The biomass estimates given in this paper are calculated – as earlier – from the nominal swept area with no corrections for a possible end-error (Kingsley *et al*., in prep.). It is assumed that an end-error, i.e. error in estimating the total trawling time, is mainly connected with the time of beginning of the haul. This point is defined by means of a trawl sonde ('trawl eye'), where the distance between the various parts of the trawl (headline and ground gear) and the bottom can be read. As the trawl gear takes some time to completely 'land' on the bottom the time of beginning of a haul has to be defined by e.g. an agreed distance from the headline to the bottom. The chosen point of beginning appears from the end-error analysis to have been set a little too late. Included in the end-effect is also fishing time on that part of the shrimp stock which is swimming freely above the bottom at the time of fishing, however, this effect is very difficult to assess and is assumed to be extremely variable with time of the day, composition of the stock etc. If an end-error correction of the estimated magnitude (2.78 minutes, corresponding to 4064 m² swept area on average) is applied to the biomass calculation for 2000, the total estimate is reduced by 10 % to about 315 thousand tons.

Biomass, geographical and depth distribution

Large variations in the distribution of this stock are indicated, both from year to year and seasonally. The stratified-random trawl surveys during the time series have been carried out at the same period of the year (July-August), and seasonal variations are therefore assumed to be minimised. Fig. 4 and 5 show the variations in biomass distribution over various geographical areas and over the depth intervals used. It is indicated that areas W3 and W4 have exhibited the largest variations through the years. Most of the increase in biomass from 1999 to 2000 is seen in these areas, however somewhat counterweighted by a decline in region S. A significant increase has also taken place in the Disko area (region D). The increase in biomass appears to be well spread over all depths larger than 200 meters. A decline in biomass is observed for the shallow areas (150-200 meters). As the inner part of Holsteinsborg Deep (part of area W4) could not be reached due to commercial fishing for snow crab, and as very good catches were taken near the closed area (Fig. 1) the biomass in the area W4, and especially stratum W4-3 is considered to be underestimated

During the years since 1991 the biomass is indicated to be gradually more distributed towards shallower water (Fig. 3), however with a more stable period from 1992 to 1995. Also in 1988 and 1989 a large proportion of the biomass was observed in more shallow areas, but as the survey in these years did not cover the southern areas the periods may not be comparable. The indicated very shallow distribution in 1989 possibly reflects the entrance of the large 1985-yearclass to the catches, as it first showed up in areas W4 and W5 in shallow water (Fig. 6 and 7).

The distribution of the biomass over the various strata has varied much over the years (Fig. 6 and 7), and no clear trends can be seen. The major part of the biomass has, however, consistently been observed in areas W2, W3, W5, and in Disko Bay (Table 2). There was a general increase in most areas from 1999 to 2000, while an especially large increase is seen in W3 and Disko Bay.

Fig. 6 shows the biomass estimates in depth strata in the main areas W1-W7 from all years of surveys. Until 1994 the area W1 constituted a large proportion (> 10 %) of the estimated total biomass. Most of the biomass was found in the depth layer 300-400 m. Since 1999 some increase is observed, and in 2000 more than 10 % of the biomass is again found in this area. However, this area is very large and the density of shrimp has consistently been low compared with other areas (Fig. 7), and the area has therefore been of low interest for the commercial fleet through most of the years.

The area W3 was in the early days of the commercial fishery of a significant importance. In good agreement to this the observed biomass in the first years of the survey series was fairly large and relatively stable, but from 1991 the biomass in the depth stratum 200-300 meters decreased sharply. Higher biomass for this stratum is again observed through the later three years, the area W3 having 16 % of the total estimated biomass for 2000.

The Disko Bay area has the longest history of commercial fishery for shrimp in Greenland, as it developed in the early 1950'ies. When the trawl survey first included this area a biomass of around 50 thousand tons was estimated, corresponding to 29 % of the biomass for the total survey area at that time. The estimates through the following years (1991-97) were fairly stable, followed by an increase to the record high estimate of about 84 thousand tons in 2000 (24 % of the total).

Stock Composition

Total abundance

Estimated total number of shrimp in the survey area (including both inshore and offshore areas) from 1988 to 2000 are given in Table 4. Total number of shrimp in 2000 was higher than all other years, and numbers of both male and female are the highest on record (Table 4 and Fig. 8a). A conversion of overall length frequency distributions to weight by applying a weight-at-length key

$$w = 0.000669 * cl**2.96$$

(where w = weight in grams, cl = oblique carapace length in mm) derived from numerous measurements of carapace length and weight of individual specimens during surveys in earlier years is shown in Fig. 8b. Biomass estimates calculated from length frequency distributions follow the trend in survey biomasses, but are generally 2-5% lower.

Size group abundance by areas

Overall length distributions for the offshore survey area from 1988-2000 are shown in Fig. 9a and 9b, and for the inshore survey area from 1991-2000 in Fig. 10a and 10b. Fig. 11(a-b) and 12(a-b) show total length frequencies by areas in 2000 offshore and inshore, respectively. Offshore areas north of 69°30'N are combined in area NW (N1-N4) and area NS (N5-N9), areas on the Canadian side of the midline are combined into region C (C1 and C3), while the southermost areas S1 and S2 are combined in area S.

The overall length-frequency distribution for the offshore area in 2000 show a number of distinct male modes (at 9, 15, 19-20 and 22 mm CL), a mode of primiparous females at 24.5 mm CL and one of multiparous females at 26.5 mm CL. As in 1999 (Carlsson *et al*., 1999) the presence of several male groups are promising in terms of recruitment to the female group in coming years.

The overall length-frequency distribution for the inshore area in 2000 show similar male and female modes as in the offshore areas, however as in earlier years with higher proportion of smaller males. Different from all other years in the survey series primiparous females in 2000 form a distinct mode (or two modes) in the inshore distribution, indicating that at least some spawning is taking place at a later time than usual (primiparous females are in this context defined as pre-first-spawning females and have been almost absent in the inshore area, because the survey here traditionally -and also in 2000 - is undertaken at a time when most spawning usually has taken place).

Length distributions for offshore stratification areas in 2000 (Fig. 11a and 11b) show dominance of the larger male groups in most areas, as it normally has been the case in the past (Carlsson and Kanneworff, l.c.). In the southermost areas W7 and S the distribution is dominated by large males, while shrimp below 17 mm CL are almost absent.

In 2000 total number of males for all areas combined is the highest recorded. At the same time the male length group at 9 mm CL is more abundant than seen before (before 1993 a mesh size of 44 mm stretched was used in the survey and this size group would not have been retained in the trawl in any proper relation to its actual abundance). Also in 2000 the male group at 19 mm CL is as abundant as the '1985 year class' as it entered survey catches in 1989 and later dominated commercial catches for several years.

Length-at-age interpretation

A length-at-age key for the West Greenland offshore Northern shrimp stock was presented by Savard *et al*. (1994), implying that the male component consisted of six size groups, assumed to be age group one to six. Sex reversal would generally take place at age seven. This interpretation has also been used in the analysis of age structure of inshore shrimp, as basically the same size groups occurred in this area.

However, in recent years significant modal groups have moved through the length frequency distributions from both offshore and inshore areas, occurring not to be in agreement with the former offshore length-at-age interpretation. Inshore length distributions from recent surveys were therefore reanalysed, and a new length-at-age interpretation was established (Carlsson, 1997; Carlsson and Kanneworff, 1998), identifying five modal groups of males, around 9, 13-14, 17, 20-22, and 22-24 mm carapace length.

Visual inspection of length-frequency distributions from the offshore survey areas in 1997 indicated that the new inshore length-at-age interpretation might be more applicable than the old model in these areas also. By modal analysis using the MIX program (Macdonald and Pitcher, 1979) five male modes resulted in a better fit than six modes, and these modes were similar to those found in survey data from inshore Disko Bay areas in 1997 (Carlsson l.c.) and were especially prominent in the areas off the Disko Bay (areas W1, W2, and W3).

In 1999, visual inspection of length-frequency distributions from both the inshore and the offshore survey again indicated a new growth pattern in both areas, as the male modes at 13 and at 16-17 mm carapace length appeared to be replaced by one mode at 15 mm CL. To elucidate this problem, overall distributions from both areas from 1993 (after the shift from 44 mm to 20 mm mesh size in the cod-end) to 1999 were examined by the deviation method (Carlsson *et al*, 1999). For the offshore areas there seemed to be too much noise to draw obvious conclusions on the progress of cohorts from year to year. For the inshore areas data indicated that the five-male-mode model is applicable from 1993 to 1997, and that a change in growth pattern takes place between 1997 to 1998.

A preliminary analysis of both offshore and inshore overall length distributions from 1998, 1999 and 2000 indicate faster growth and a change of sex at age five, in the offshore areas between 1997 and 1998 and in the inshore area between 1998 and 1999. These changes may be the result of changes in the temperature regime in the two areas as described by Carlsson and Kanneworff (1999). Preliminary results from cohort analysis of annual overall samples from the inshore surveys 1992-2000 are given in Table 6 and show a reasonable progression of modes between years. However, abundance indices as shown in Fig. 13 do not show a logical progression from year to year of size of year classes, indicating that further analysis is necessary.

The interpretation of number of modal groups of males by Savard *et al.* (1994) may not only have been mislead by small differences in growth between depths and areas. Also the analysis may have been strongly influenced by focusing too much on details in length frequencies caused by differences between different persons measurements of shrimp.

Conclusions

During the period of stratified random surveys in the offshore areas of shrimp distribution the biomass estimates have indicated a good stability until 1998 around a level of 250 thousand tons, apart from somewhat lower values in 1991, 1995 and 1997. From 1998 a significant increase is observed with record high biomass in 2000 of 350 thousand tons. Large variations from year to year both geographically and over depth zones are observed and may suggest that the stock is highly migratory. Some areas account for a large proportion of the variances of the estimated biomasses. The survey design has been evaluated and adjusted in the later years in order to reduce the sampling variation and to study and optimise the performance of the sampling.

Total number of shrimp in 2000 is at the highest level found in the survey series, accounting for both male and female shrimp. Recruitment to the female group appears therefore to be secured for the coming years.

Inspection of overall length-frequencies by the deviation method and a preliminary modal analysis of offshore and inshore length distributions indicate a change in recent years to faster growth. At the same time age at sex reversal appears to have changed from six years to five years, in the offshore areas between 1997 and 1998, in the inshore area one year later.

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Table 1a. Estimated trawlable biomass and sampling statistics for strata in region W, 2000.

AREA	STRATUM	SQKM	HAULS	TONS	STD	CV
W1	150-200 M	2416	2	1	0	3
	200-300 M	5295	3	8285	4154	66
	300-400 M	9239	11	32887	57201	174
	400-600 M	752	2	3	5	141
W2	150-200 M	1857	2	24	24	98
	200-300 M	3026	3	1953	2663	136
	300-400 M	2158	9	17153	9418	55
	400-600 M	1723	5	9654	13110	136
W3	150-200 M	2215	2	0	0	-
	200-300 M	4810	11	33366	68540	205
	300-400 M	2714	4	12187	15496	127
	400-600 M	3361	3	11411	1734	15
W4	150-200 M	4252	2	9	6	66
	200-300 M	1791	4	5269	9208	175
	300-400 M	812	10	10415	18095	174
	400-600 M	1967	6	61	69	113
W5	150-200 M	1995	3	127	172	136
	200-300 M	3454	15	34478	37627	109
	300-400 M	1797	5	7271	1134	157
	400-600 M	2806	3	509	882	173
W6	150-200 M	1095	6	1093	1664	152
	200-300 M	1491	7	8855	6104	69
	300-400 M	1300	2	4747	571	12
	400-600 M	884	2	1598	601	38
W7	150-200 M	2419	2	0	0	141
	200-300 M	985	5	20518	20590	100
	300-400 M	239	2	385	532	138
OVERALL			Standard Error	33222	Error CV	15

Table 1b. Estimated trawlable biomass and sampling statistics for strata in region C, 2000.

AREA	STRATUM	SQKM	HAULS	TONS	STD	CV
C1	300-400 M	655	2	3992	542	14
	400-600 M	312	2	94	123	131
C3	200-300 M	660	4	1219	1384	113
	300-400 M	1192	2	6289	176	3
	400-600 M	623	2	66	94	141
OVERALL			Standard Error	809	Error CV	7

Table 1c. Estimated trawlable biomass and sampling statistics for strata in region D, 2000.

AREA	SQKM	HAULS	TONS	STD	CV
D1	819	3	7043	5631	80
D2	566	2	5401	976	18
D3	1124	3	6258	3019	48
D4	1834	4	21088	5367	25
D5	612	2	7748	4250	55
D6	1014	2	11605	1192	10
D7	1447	2	4935	285	6
D8	652	2	6222	659	11
D9	1296	3	13200	16576	126
		Standard		Error	
OVERALL		Error	11085	CV	13

Table 1d. Estimated trawlable biomass and sampling statistics for strata in region N, 2000.

AREA	SQKM	HAULS	TONS	STD	CV
N1	3664	2	3164	1212	38
N2	11740	3	46	40	87
N3	368	1	745	734*	99*
N4	2257	1	128	126*	99*
N5	2985	2	305	398	130
N6	10830	3	3284	5651	172
N7	1029	2	17	23	137
N8	3237	2	210	288	137
N9	2407	2	1681	1117	66
		Standard		Error	
OVERALL		Error	3540	CV	37

*) Estimated from STD = biomass * 0.985

Table 1e. Estimated trawlable biomass and sampling statistics for strata in region S, 2000.

STRATUM	SQKM	HAULS	TONS	STD	CV
S1	1993	16	11908	22116	186
S2	4526	2	12613	17768	141
		Standard		Error	
OVERALL		Error	13727	CV	56

Table 2. Biomass estimates 1988-2000 (thousand tons) in combined areas from north to south. Standard errors and error percentages are also given.

Year	N1-N9	D1-D9[1]	W1-W2	W3-W4	C1+C3	W5-W7[2]	S1-S2	Total	SE	%
1988	21.7	46.5	58.6	74.4	9.6	19.0	-	229.8	24.7	13.5
1989	11.3	46.5	48.2	79.6	3.9	38.6	-	228.0	32.3	17.8
1990	11.1	46.5	82.1	54.2	11.1	23.3	-	228.3	32.6	17.9
1991	5.8	50.6	30.9	52.4	4.8	28.1	-	172.6	22.8	13.2
1992	20.6	47.4	52.0	35.0	24.1	46.1	-	225.1	30.4	13.5
1993	8.0	33.6	103.1	41.3	3.4	67.5	-	256.8	30.1	11.7
1994	8.0	40.0	107.7	49.7	6.8	37.7	20.7	270.6	53.0	19.6
1995	8.2	47.3	43.7	58.6	4.4	53.0	1.7	217.1	29.2	13.5
1996	10.0	54.3	53.8	34.9	1.7	90.5	3.7	248.9	40.1	16.1
1997	7.2	52.3	40.1	15.1	0.2	66.5	24.9	206.2	30.6	14.8
1998	8.3	61.9	42.2	107.1	0.4	50.9	22.3	293.3	55.6	18.9
1999	14.4	61.2	54.2	26.1	11.9	55.9	63.7	287.4	40.6	14.1
2000	9.6	83.5	68.0	72.7	11.7	79.6	24.5	349.5	37.8	10.8

[1]) D1-D9 1988-90 not sampled, but set to mean of 1991-97.

[2]) Areas W6 and W7 were sampled from 1990 and 1993, respectively

Table 3. Error coefficients of variation for the biomass estimates in the five main regions 1988-2000.

	Region				
Year	**C**	**D**	**N**	**S**	**W**
1988	37	-	30	-	16
1989	44	-	23	-	16
1990	44	-	42	-	20
1991	25	23	40	-	17
1992	77	16	17	-	17
1993	54	21	51	-	14
1994	19	26	48	99	24
1995	45	17	47	84	18
1996	91	10	52	95	22
1997	59	14	37	16	24
1998	41	18	41	59	26
1999	80	14	54	51	14
2000	7	13	37	56	15

Table 4. Numbers (billions) of male and female Northern shrimp in over-all length distributions from the total survey area (mean values for inshore areas 1991-1997 used in 1988-1990).

Year	males	females	total	males, %	females, %
1988	24.3	9.9	34.2	71.0	29.0
1989	35.0	7.6	42.5	82.2	17.8
1990	28.5	10.0	38.5	74.1	25.9
1991	17.4	6.2	23.6	73.8	26.2
1992	29.7	7.3	36.9	80.3	19.7
1993	35.5	9.7	45.2	78.5	21.5
1994	33.9	10.9	44.8	75.7	24.3
1995	29.2	7.9	37.1	78.7	21.3
1996	41.4	8.1	49.5	83.7	16.3
1997	29.5	7.6	37.0	79.6	20.4
1998	42.9	11.5	54.5	78.8	21.2
1999	44.8	11.3	56.2	79.9	20.1
2000	66.7	12.7	79.4	84.0	16.0
Average (1)	32.7	9.0	41.7	78.0	22.0

Table 5. Biomass estimates of male and female shrimp (thousand tons) in total survey area, based on weight-at-length key applied to overall length-frequency distributions (mean values for Disko Bay 1991-1997 used in 1988-1990).

Year	males	females	total	males, %	females, %
1988	125.9	107.4	233.3	54.0	46.0
1989	150.2	81.3	231.5	64.9	35.1
1990	129.8	102.0	231.8	56.0	44.0
1991	102.6	70.0	172.6	59.4	40.6
1992	149.3	75.8	225.1	66.3	33.7
1993	156.5	100.3	256.8	60.9	39.1
1994	157.9	112.7	270.6	58.3	41.7
1995	133.3	83.8	217.1	61.4	38.6
1996	161.9	87.0	248.9	65.0	35.0
1997	126.6	79.6	206.2	61.4	38.6
1998	181.9	111.4	293.3	62.0	38.0
1999	175.4	112.0	287.4	61.0	39.0
2000	228.7	120.8	349.5	65.4	34.6
Average	152.3	95.7	248.0	61.2	38.8

Table 6. Mean length of year class cohorts, proportions and abundance in a preliminary analysis of overall shrimp length frequency distributions from the inshore area 1992-2000. Group 5 in 1999 and 2000 is the 5+ group.

CL, Disko

	1	2	3	4	5	C.V.	Standard error
1992	-	11.7	15.3	18.2	21.6	0.06	.03-.05
1993	-	-	15.7	20.4	22.6	0.06	.04-.09
1994	-	11.3	15.8	18.5	21.8	0.06	.04-.06
1995	-	12.8	16.4	19.8	22.6	0.06	.06-.26
1996	-	12.8	16.6	19.6	22.5	0.06	.06-.30
1997	8.5	12.8	16.9	19.9	22.8	0.06	.06-.37
1998	9.2	13.6	17.2	19.6	22.7		.04-.14
1999	9.8	14.8	18.4	21.2		0.08	.02-.09
2000	8.5	14.6	18.5	21.6			

Proportions (%)

	1	2	3	4	5	Standard error	Total males
1992	-	0.03	0.13	0.41	0.42	.002-.008	6405.9
1993	-	-	0.28	0.51	0.22	.008-.015	3199.9
1994	-	0.05	0.20	0.35	0.40	.003-.010	4839.3
1995	-	0.03	0.10	0.39	0.48	.009-.048	4211.0
1996	-	0.25	0.19	0.20	0.36	.018-.032	6003.4
1997	0.02	0.21	0.44	0.13	0.20	.004-.023	8559.9
1998	0.08	0.23	0.28	0.20	0.20	.004-.013	9169.9
1999	0.15	0.39	0.32	0.14		.003-.009	13201.1
2000	0.34	0.30	0.25	0.11			19684.2

Abundance (millions)

	1	2	3	4	5	+	Total no.
1992		192.2	832.8	2626.4	2690.5	1714.7	8056.5
1993			896.0	1631.9	704.0	1415.3	4647.2
1994		242.0	967.9	1693.8	1935.7	1609.3	6448.6
1995		126.3	421.1	1642.3	2021.3	2113.6	6324.6
1996		1500.9	1140.6	1200.7	2161.2	2272.9	8276.3
1997	171.2	1797.6	3766.4	1112.8	1712.0	1662.1	10222.0
1998	733.6	2109.1	2567.6	1834.0	1834.0	2450.6	11528.8
1999	1980.2	5148.4	4224.4	1848.2	1866.8		15067.9
2000	6692.6	5905.3	4921.1	2165.3	3109.3		22793.5

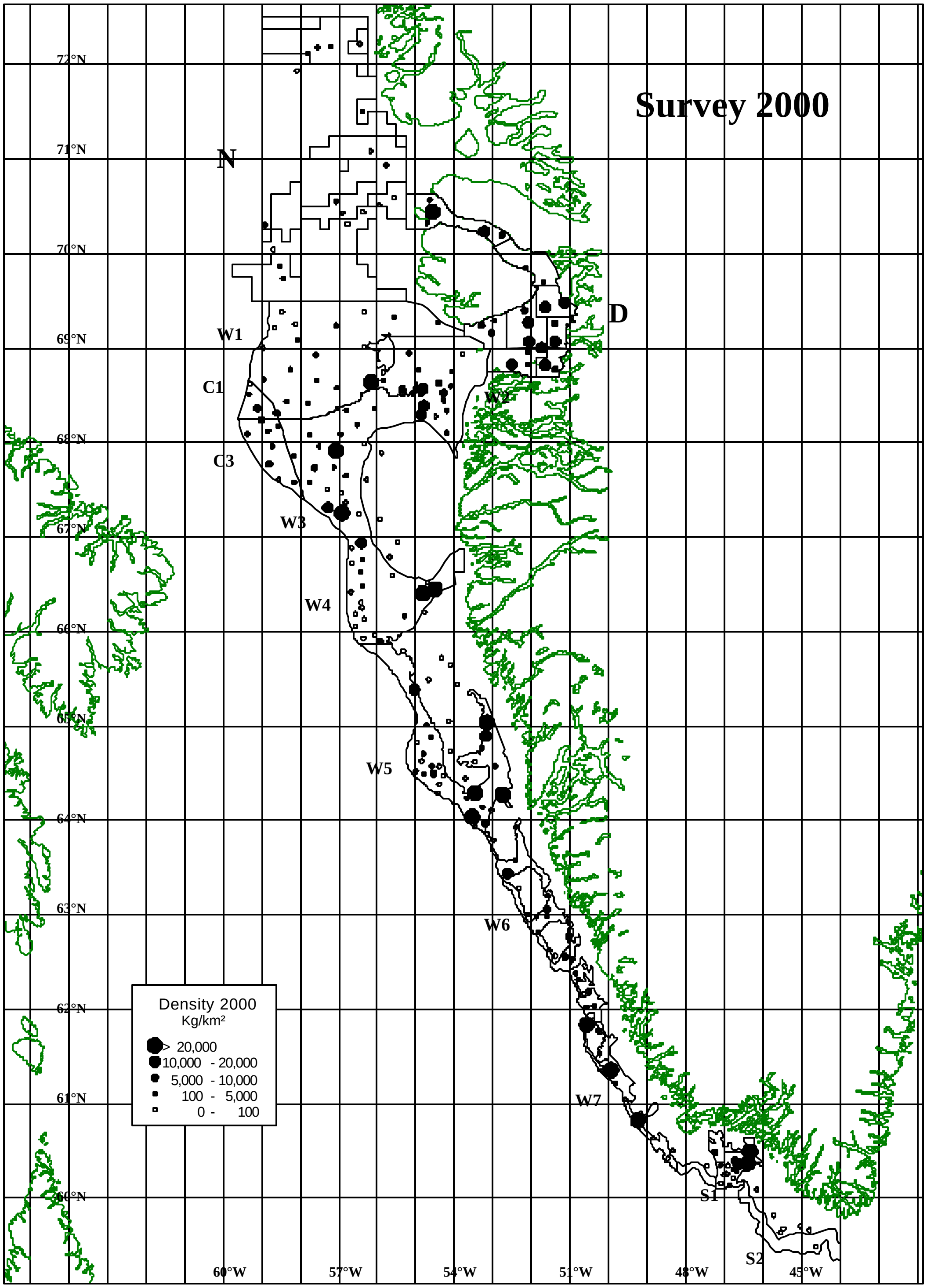


Figure 1. Sampling sites and shrimp densities in the trawl survey 2000.

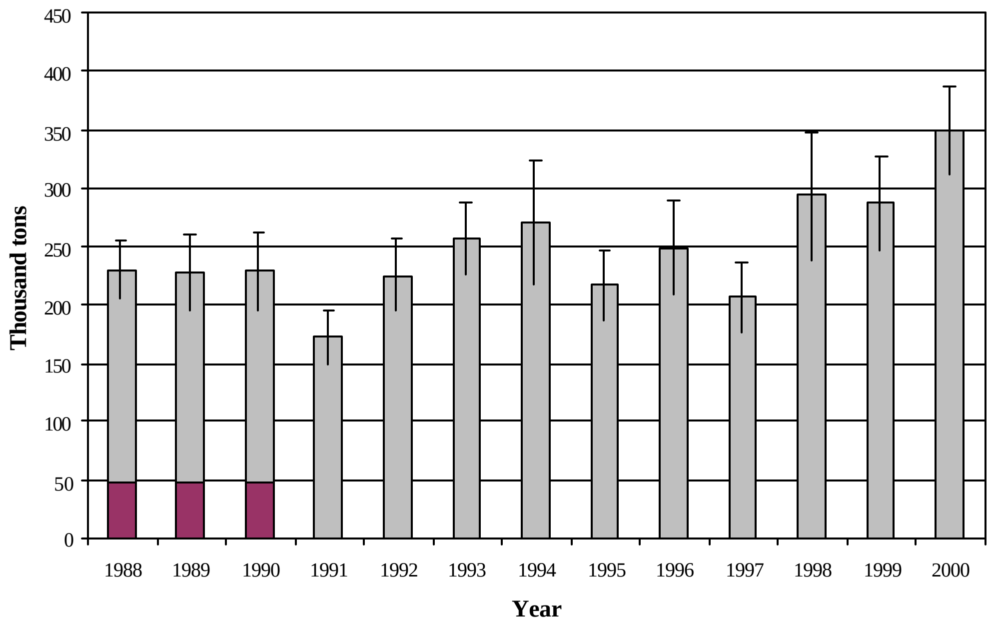


Figure 2. Estimated total yearly biomass 1988-2000 with overall standard errors. Average biomass estimate for inshore areas 1991-1997 is inserted in 1988-1990 to facilitate between-year comparisons.

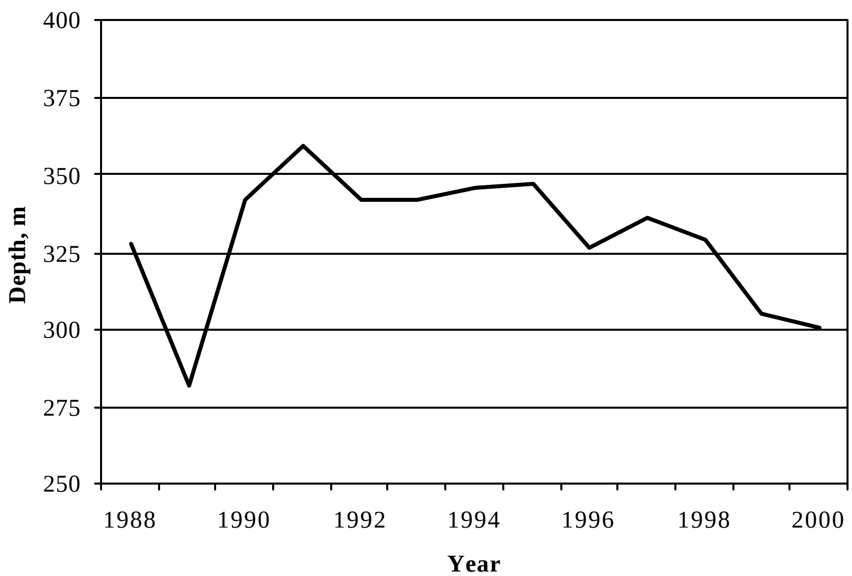


Figure 3. Mean depths with observed highest densities (in weight) in the survey catches 1988-2000 for the central strata in Davis Strait (region W).

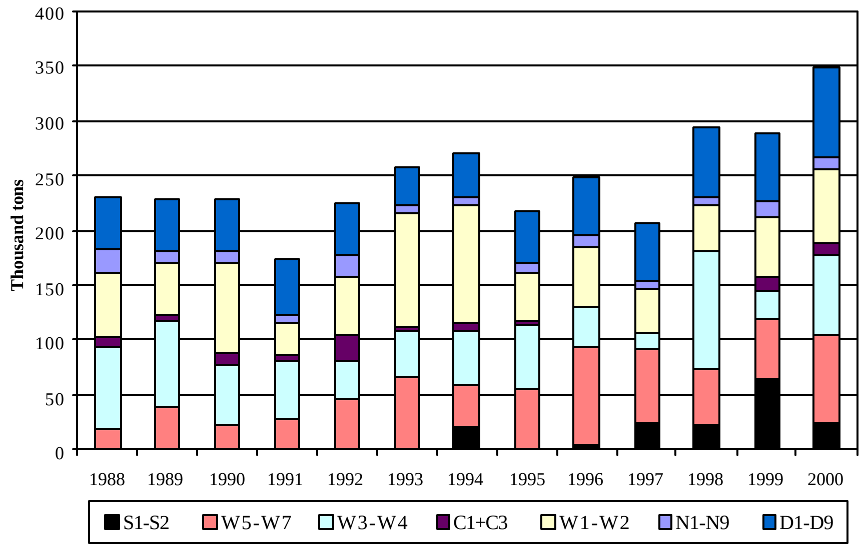


Figure 4. Estimated biomass in groups of strata for surveys in SA0+1, 1988-2000. Note that surveys in inshore areas were carried out from 1991 only, for comparison mean values for 1991-97 are inserted as values for 1988-90.

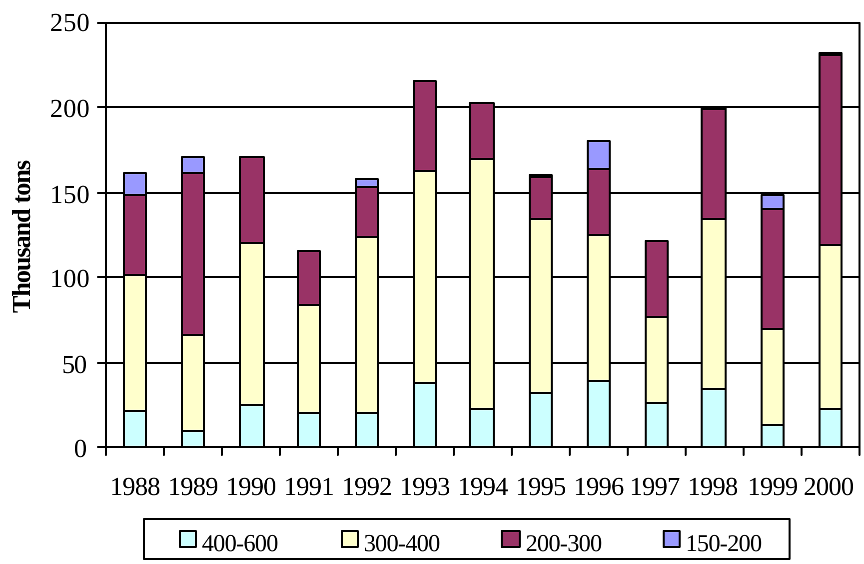


Figure 5. Estimated biomass in depth strata (regions W and C only) for surveys in SA0+1 offshore, 1988-2000.

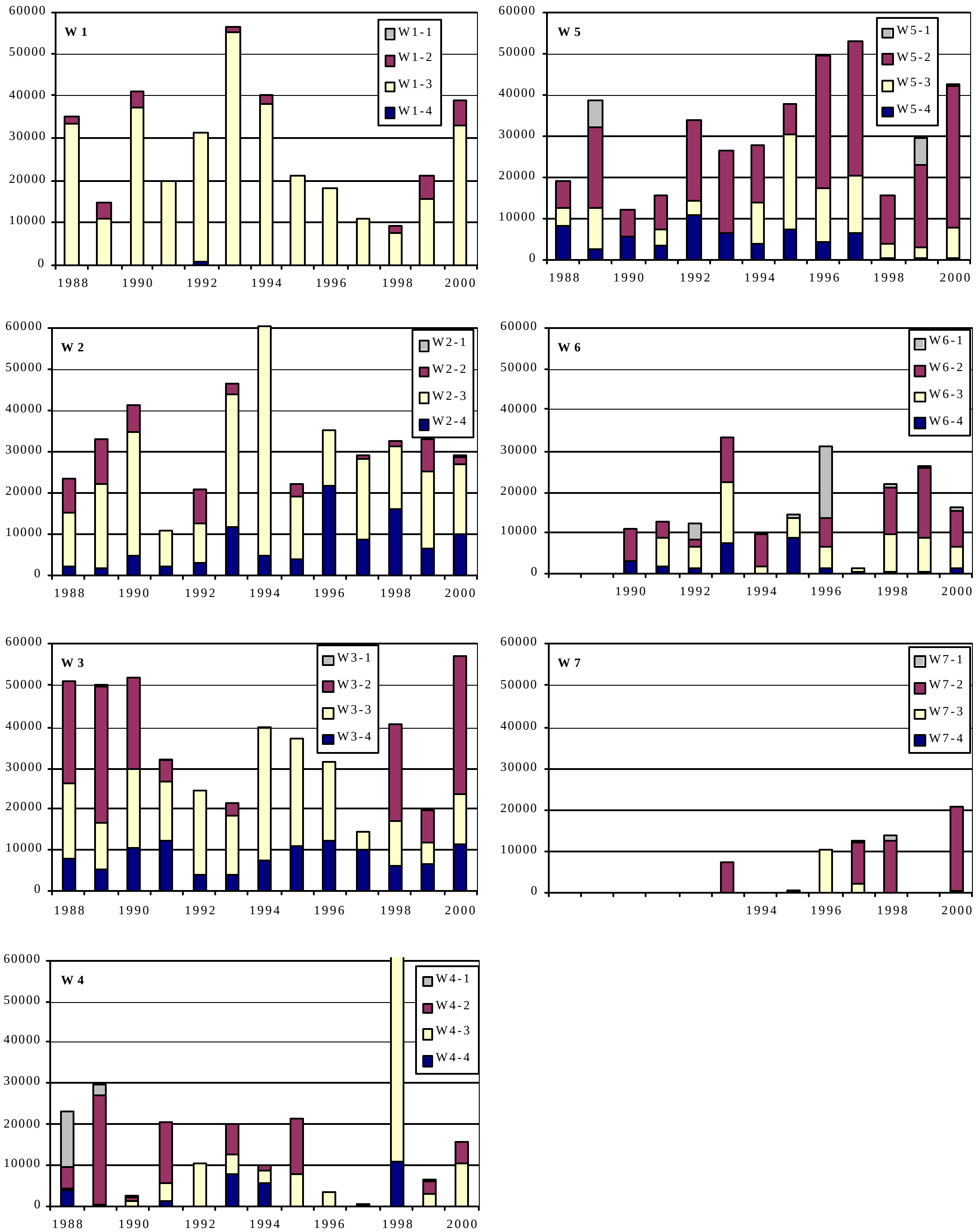


Figure 6. Biomass estimates of shrimp (tons) in region W in depth strata, 1988-2000.

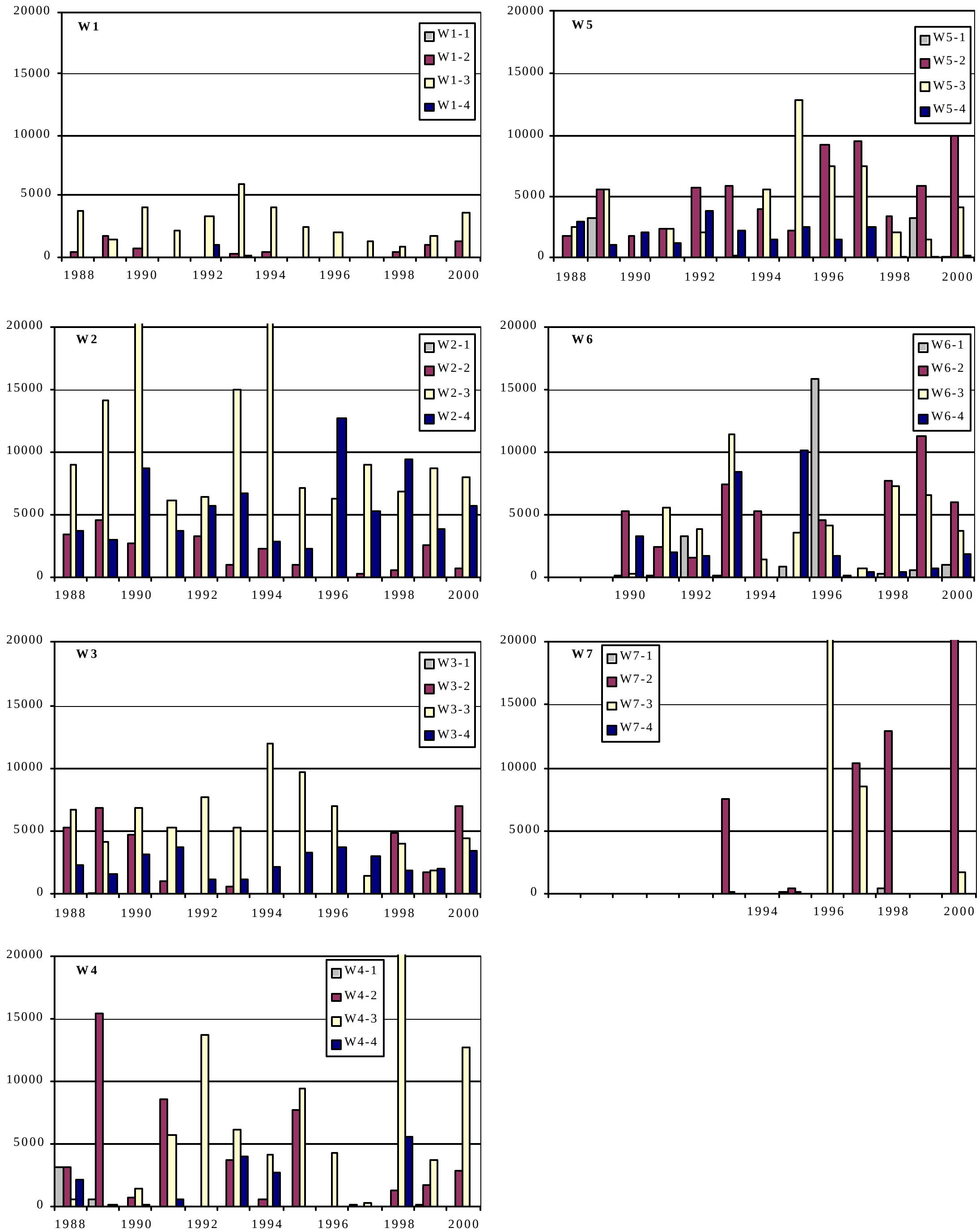


Figure 7. Estimated densities of shrimp (kg/km²) in region W in depth strata, 1988-2000.

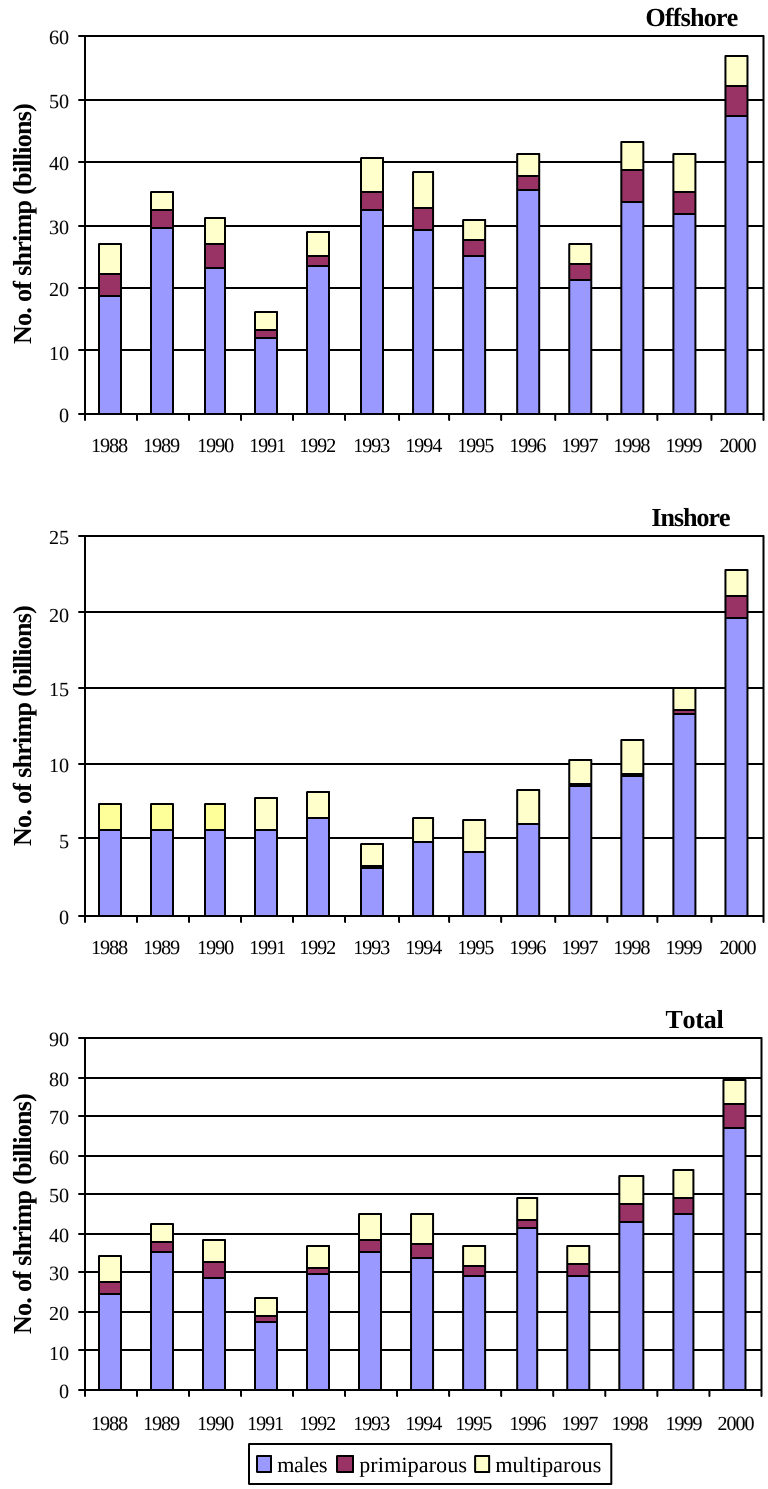


Figure 8a. Estimated total number of northern shrimp in offshore, inshore and total survey area by sexual stage (mean values for Disko Bay 1991-1997 used in 1988-1990).

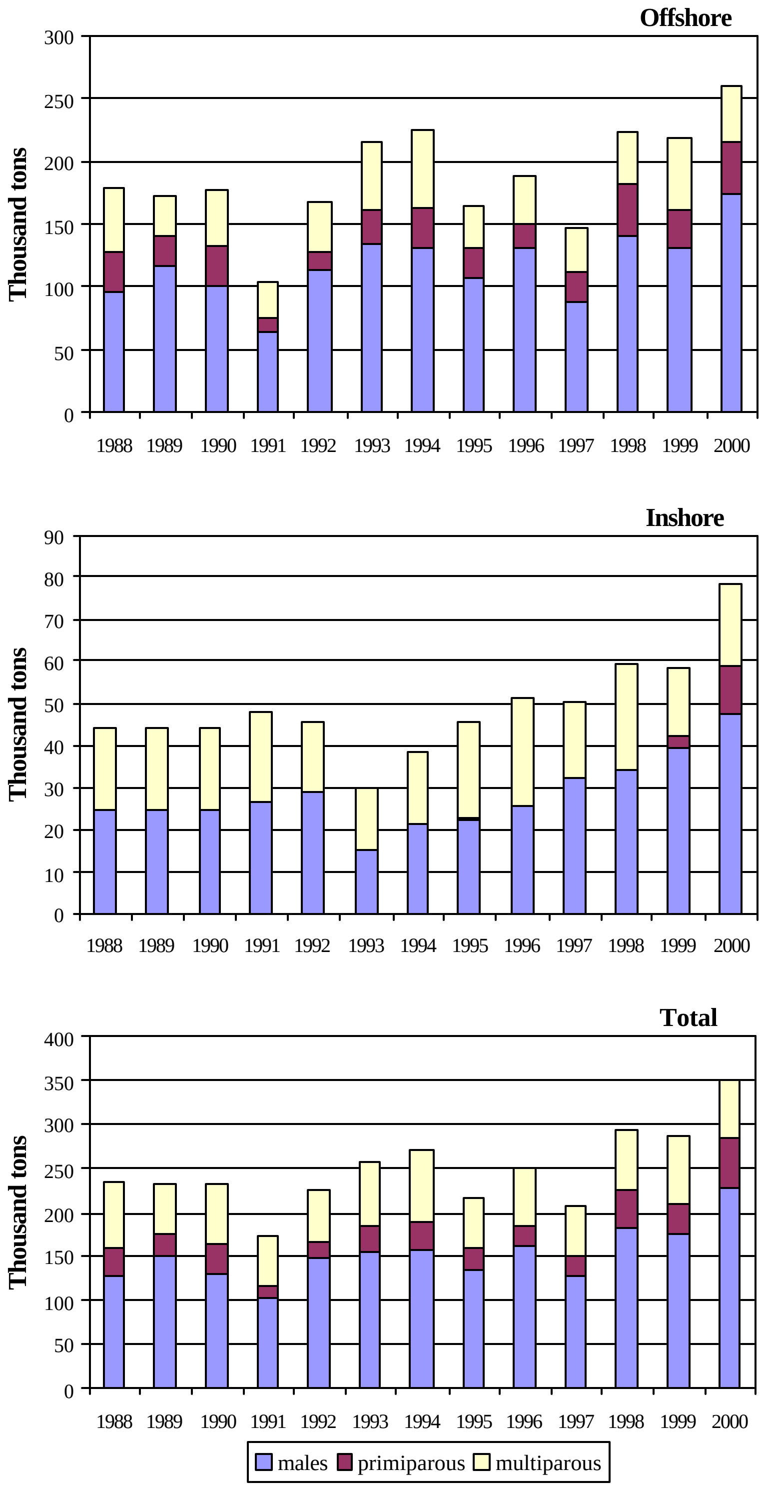


Figure 8b. Biomass estimates of male and female shrimp (thousand tons) in total survey area, based on a weight-at-length key applied to overall length-frequency distributions (mean values for Disko Bay 1991-1997 used in 1988-1990).

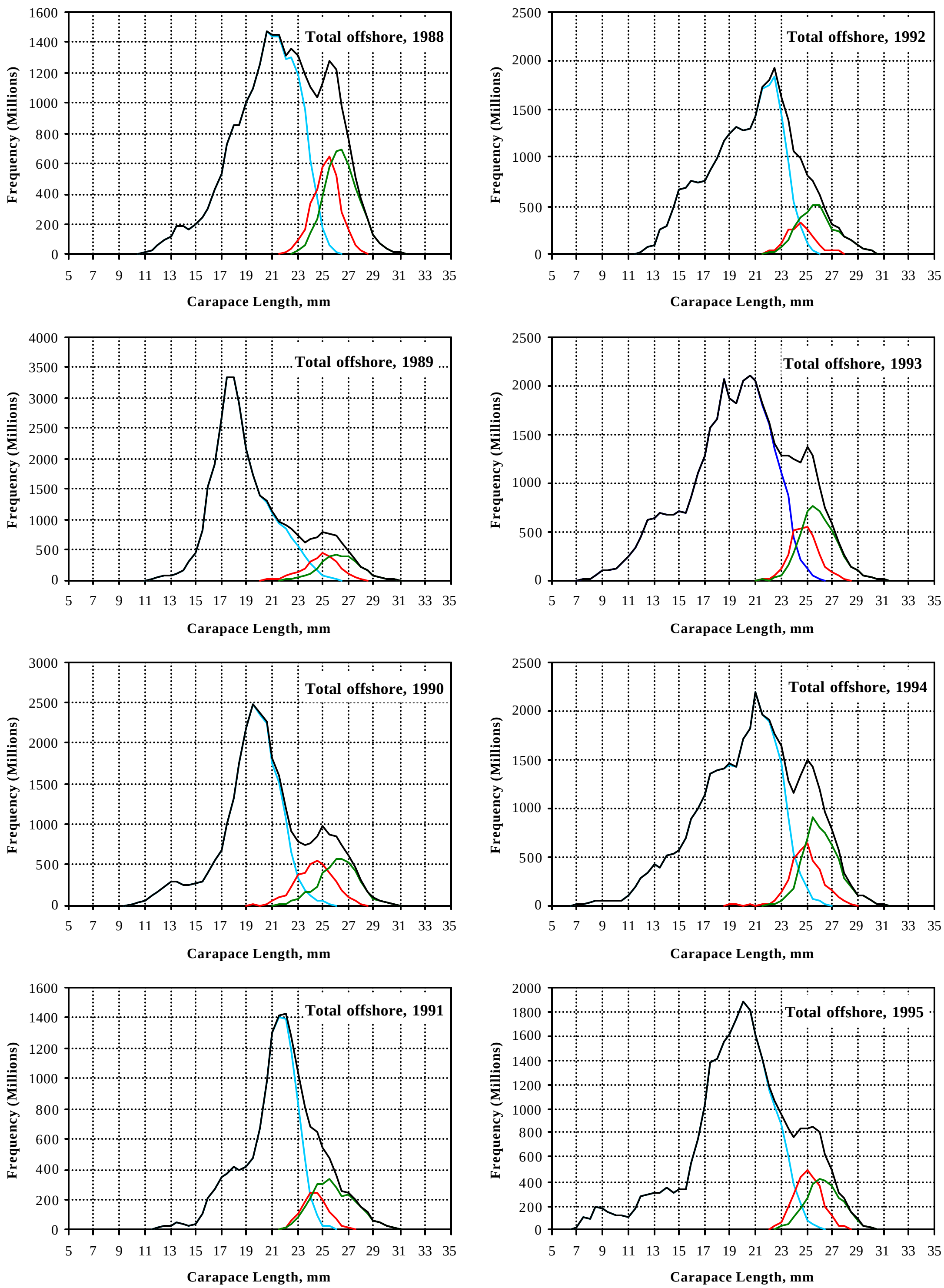


Figure 9a. Numbers of shrimp by length group (CL) in total offshore survey area in 1988-95.

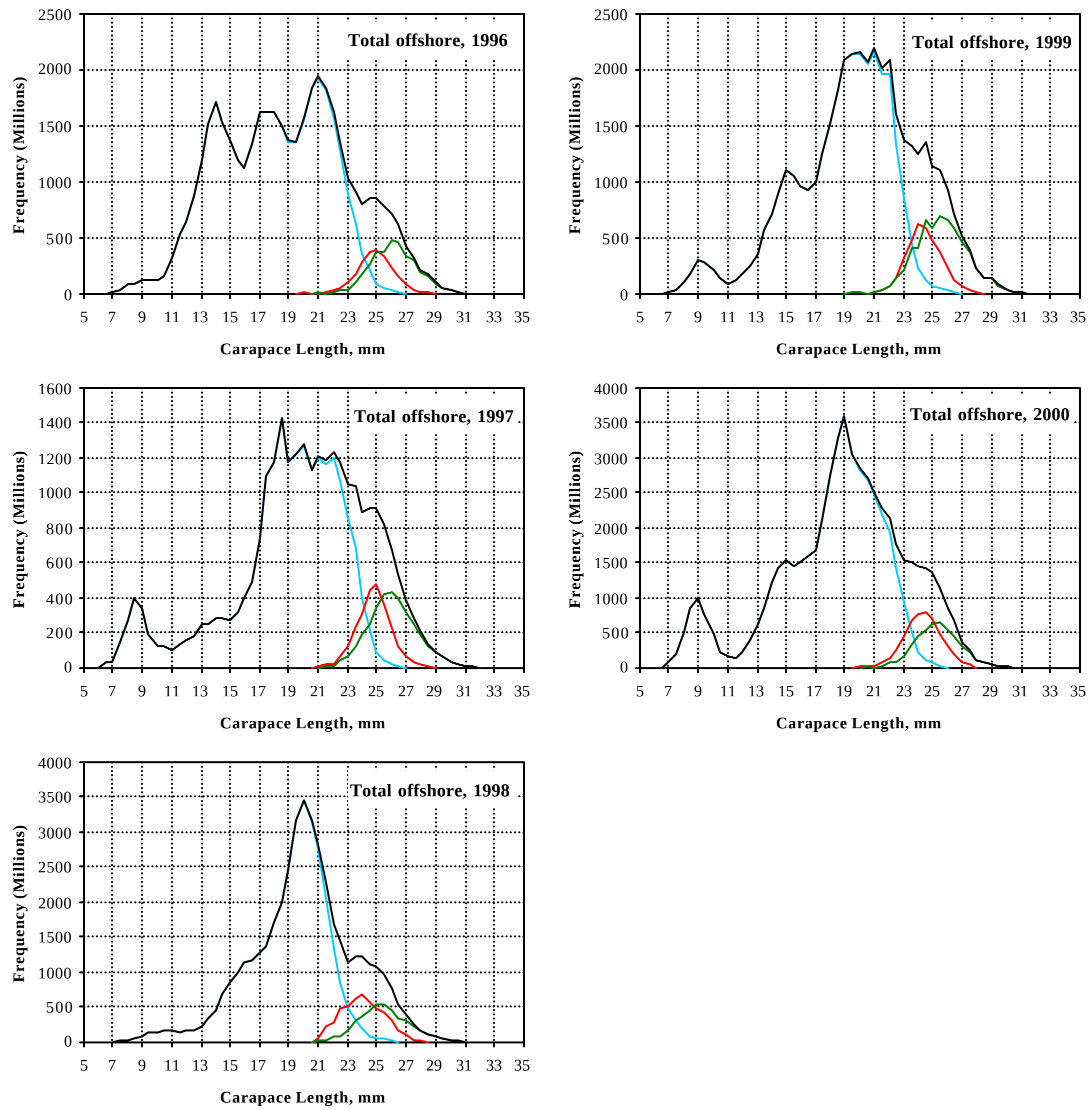


Figure 9b. Numbers of shrimp by length group (CL) in total offshore survey area in 1996-2000

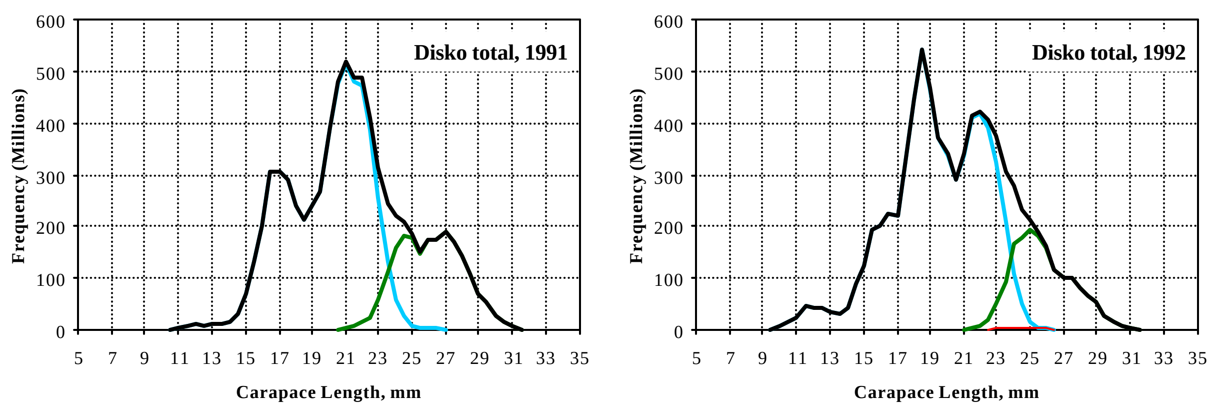


Figure 10a. Numbers of shrimp by length group (CL) in total inshore survey area in 1991-92.

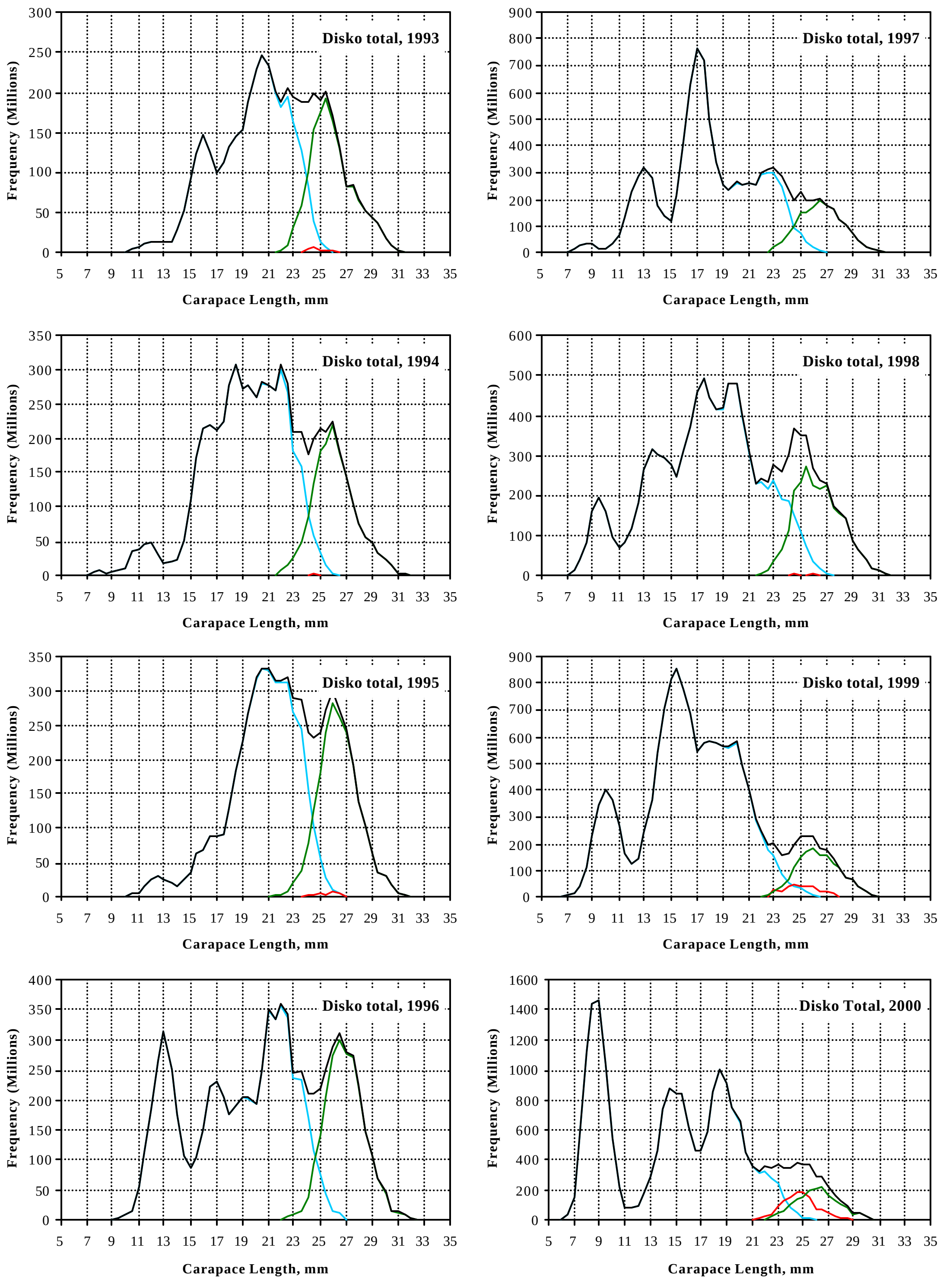


Figure 10b. Numbers of shrimp by length group (CL) in total inshore survey area in 1993-2000.

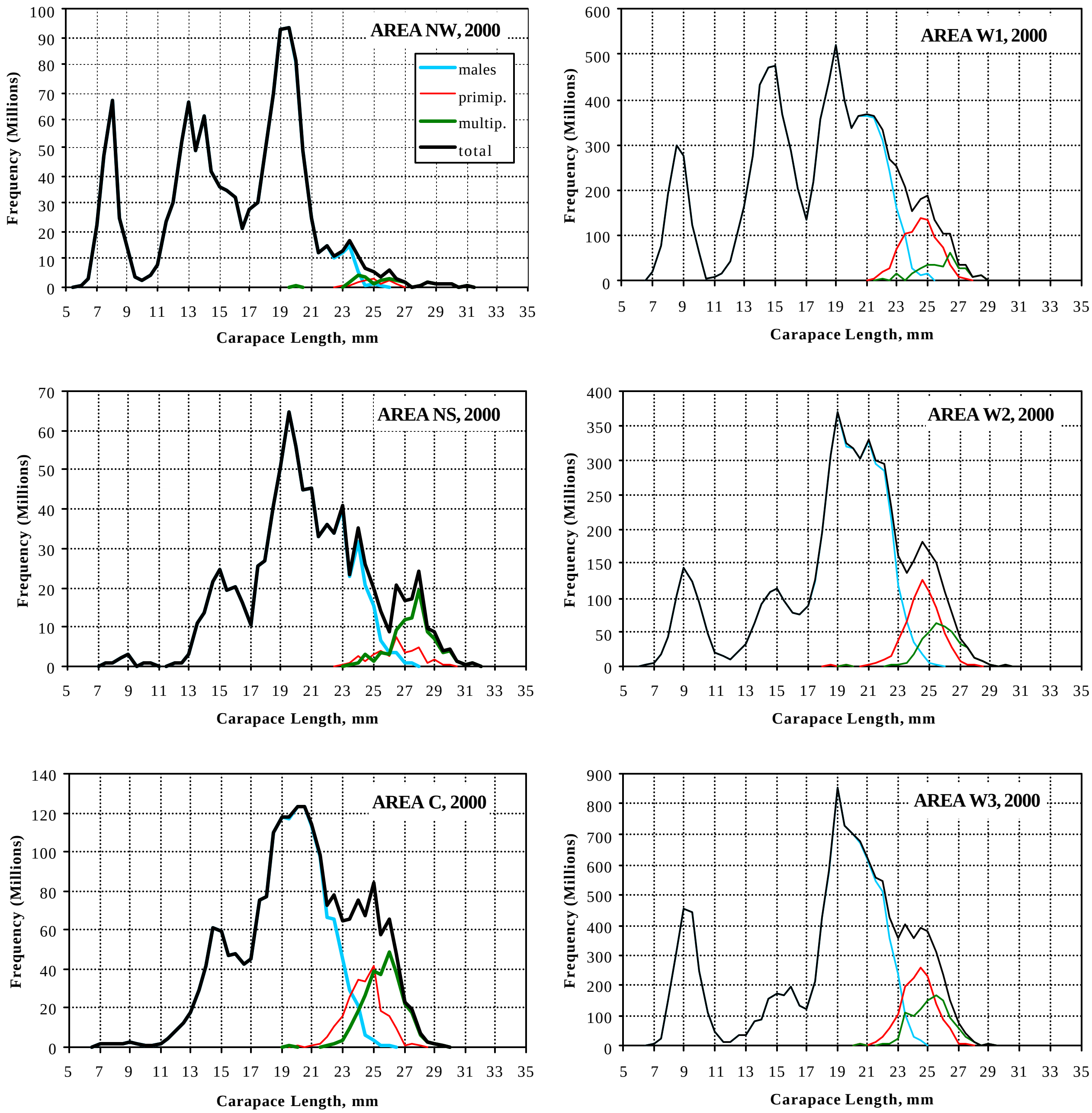


Figure 11a. Numbers of shrimp by length group (CL) in areas NW, NS, C, W1, W2 and W3 in 2000.

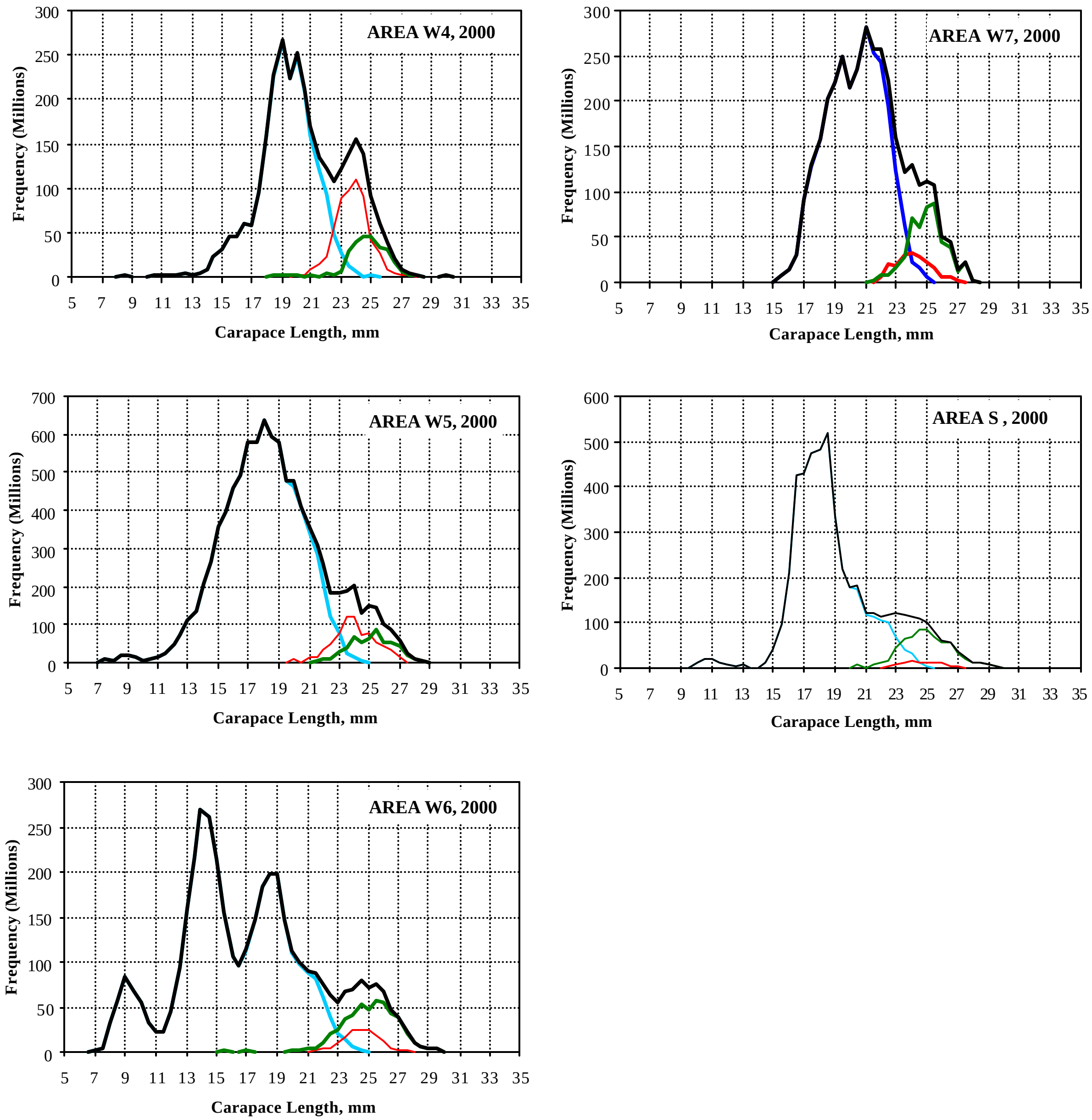


Figure 11b. Numbers of shrimp by length group (CL) in areas W4, W5, W6, W7 and S in 2000.

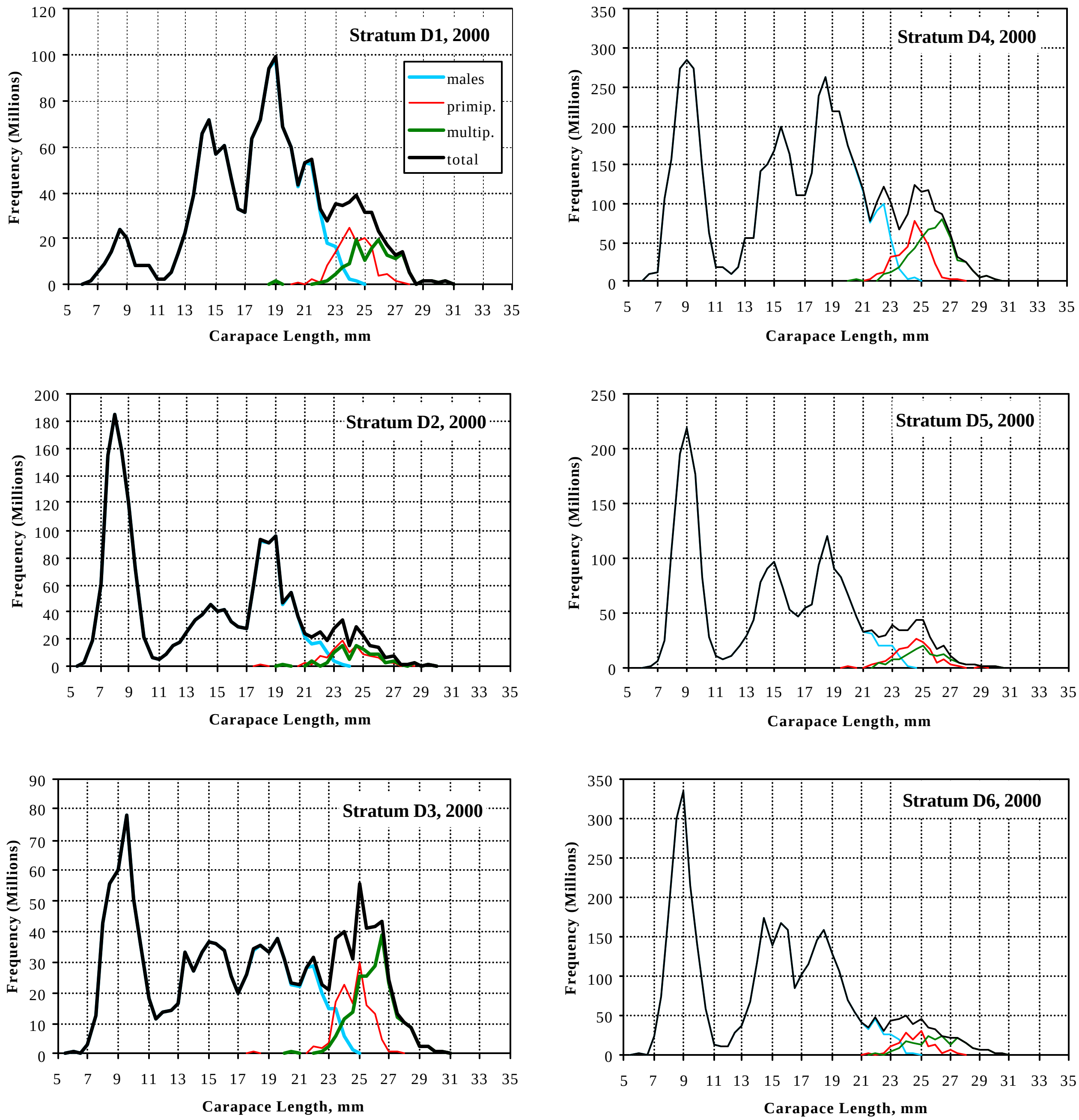
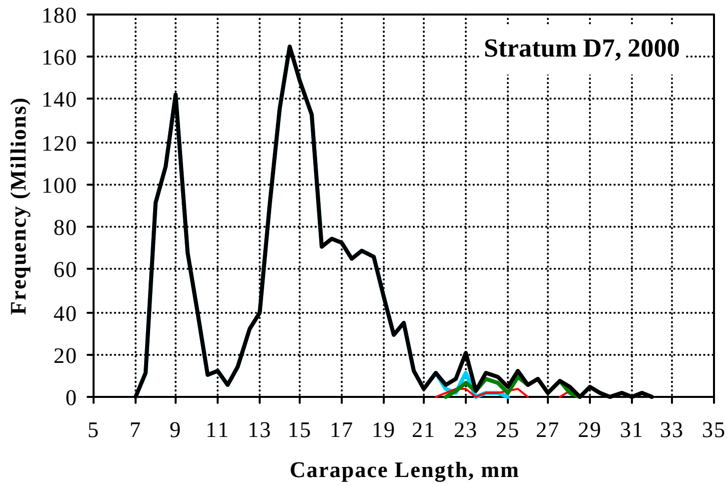
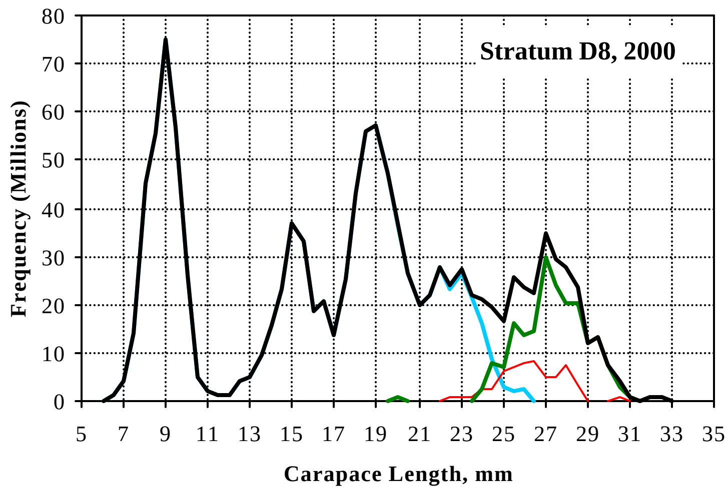


Figure 12a. Numbers of shrimp by length group (CL) in strata D1-D6 in 2000.





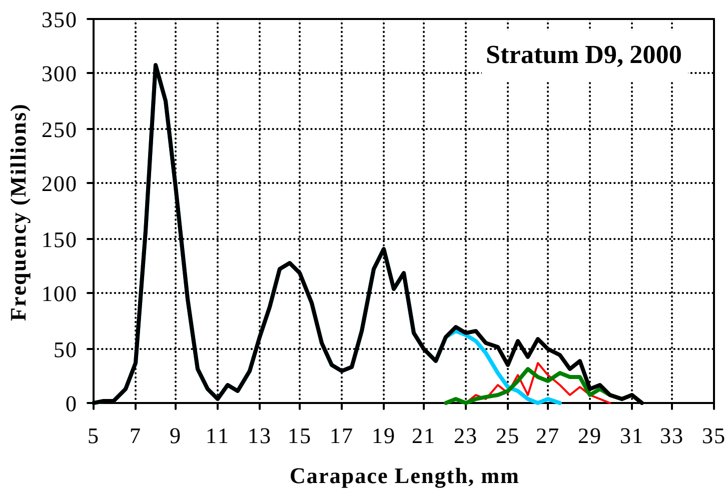


Figure 12b. Numbers of shrimp by length group (CL) in strata D7-D9 in 2000.

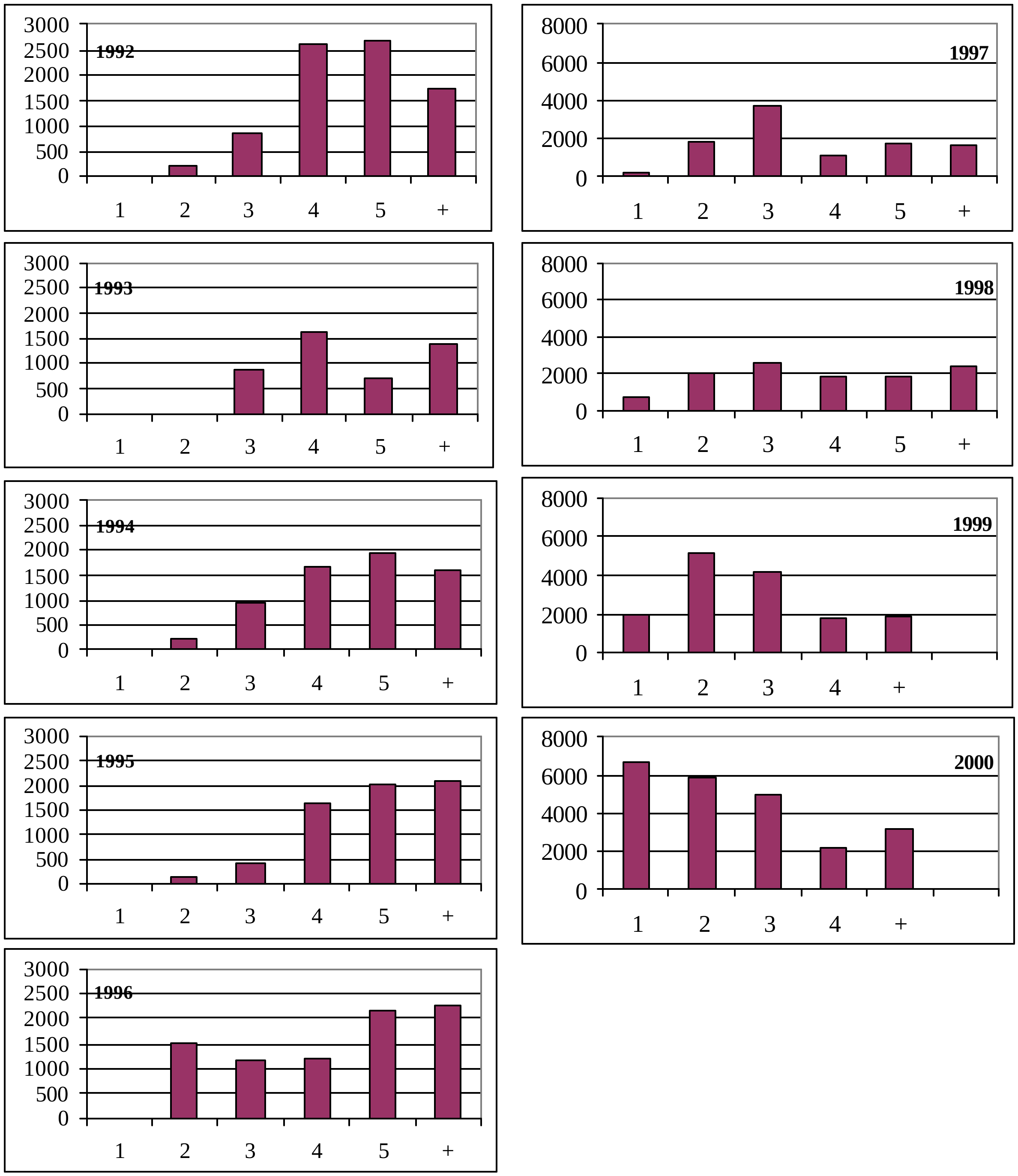


Figure 13. Abundance by age and year of shrimp in the inshore area, based on a preliminary interpretation of overall length distributions from the area (Table 6).