

Northwest Atlantic



Fisheries Organization

Serial No. N2341

NAFO SCR Doc. 93/129

SCIENTIFIC COUNCIL MEETING - NOVEMBER 1993

Stratified Random Trawl Survey for Shrimp (*Pandalus borealis*)
In Disko Bay, West Greenland, 1993.

by

M. Andersen¹, D.M. Carlsson², and P. Kanneworff²

Greenland Fisheries Research Institute

¹Box 570, DK-3900 Nuuk, Greenland

²Tagensvej 135, DK-2200 Copenhagen N, Denmark

Introduction

Catches in the inshore fishery for shrimp in West Greenland has increased rapidly over the last decade, from an estimated 7,000 tons in 1987 to more than 20,000 tons in 1992. A major part of the inshore fishery takes place in Disko Bay, NAFO Div. 1A. Since 1991 Greenland Fisheries Research Institute has performed a yearly survey in this area. This paper presents results from the survey in 1993.

Materials and methods

The survey area covers the inshore West Greenland area between 68°42'N and 70°37.5'N, a total of 9364 sq.km (Figure 1). 31 hauls were taken in the period from August 7th to August 15th, 1993. One haul thus represents 302 sq.km. Depth contours are not mapped in detail, so stratification based on depth is not possible. Therefore, stratification is done by separating the area into blocks, based on information from the commercial fishery, to ensure a reasonable subdivision of the survey area.

The survey was performed with a 722 GRT trawler, the M/TR "Paamiut", OYZC, using a twin cod-end 3000/20 meshes "SKJERVØY" bottom trawl. Mesh size in the cod-end was 20 mm (stretched mesh). Trawl doors were "3.7 GREENLAND PERFECT", measuring 370*250 cm and weighing 2420 kg. Trawl geometry was measured with "SCANMAR" acoustic sensors, mounted on the trawl doors and on the headrope.

Standard towing time was 30 minutes and towing speed was around 2.5 knots. Trawling was carried out from 0900 to 1900 UTC only, to prevent impacts of nocturnal vertical migrations. Details on trawl performance on the bottom has been obtained from "Danish Institute of Fishing Technology and Aquaculture" in Denmark, based on information on size and type of trawl, trawl doors, warp length, towing speed and distance between doors. The mean wingspread was calculated to 20.7 m.

The starting position and time were recorded when the pressure on the winches increased after shooting the trawl, ending position and time were recorded when the winches began to haul. Swept area was calculated as the distance between starting and ending positions multiplied by the mean wingspread.

From each haul a sample of approx. 5 kg of shrimp was taken from the cod-end of the trawl, before it was emptied into the pounder. After 10 minutes of drip-drying the sample was weighed. The shrimp were sorted by sex and oblique carapax length was measured by slide calliper to the nearest 0.1 mm. The total catch was sorted by species and weighed.

Results and discussion

Table 1 lists the stations by stratum and shows the catch in kg of shrimp, cod, Greenland halibut, redfish, and other species combined. The weight of the category "mix" is exceptionally high in this years survey, due to the introduction of a fine meshed cod-end. There is no significant influence on the shrimp biomass estimate (Andersen *et al.* 1993).

Biomass and density

Table 2 shows the area in sq.km, the number of successful hauls, the mean density of shrimp in kg per sq.km, and the calculated biomass in tons for each stratum. The total biomass estimate from the 1993 survey is 32169 tons (+/- 11022).

Table 3 shows the calculated biomass per stratum for each year.

The total biomass has apparently decreased considerably during the last year, from 45,167 tons (Carlsson and Kanneworff, 1993) to 32,253 tons. It is important to notice, however, that the decline is well within the limits of the confidence intervals. It can thus not be stated from these results alone whether the apparent decline is significant.

In Figure 2 the estimated biomass per year is shown for groups of strata. It is evident that the decline, compared to 1992, is most pronounced in the central strata, D3-D6. In the southern part of the bay (strata D1 & D2), the Vaigat (strata D7 & D8), and the area around the island Hareo (stratum D9) a fairly stable situation in the years 1992 and 1993 is seen.

The biomass in strata D3-D6 in 1993 is at the same level as in 1991. A very large proportion of the total biomass in 1991 was located in the southern parts of the bay (strata D1 & D2). Apart from the high densities found in these southern parts, densities in 1991 were similar to those found in 1993.

In the northern parts of the survey area (strata D6-D9), there is some displacement of biomass between strata over the years, but no general trend is evident.

Over the three years the most marked changes are the decline in density in the south from 1991 to 1992, the increase and subsequent decline in stratum D4, and the decline since 1992 in stratum D3.

The results outlined above indicate a scenario with a migration of a large part of the stock from the southern to the more central parts of the bay between 1991 and 1992. Since the survey in August 1992 a proportion of the stock, similar in size to the biomass of animals immigrating to the central parts, has disappeared from these parts, which now have a density at the level they had prior to 1992. In the innermost parts of the bay there are still some remnants from the inflow.

What has happened to this disappearing part of the stock is not clear, but it seems likely that some of it has been taken by the fishery. Preliminary data indicates an increase in the fishing pressure of approx. 10 %, which would account for some of the decline. It is thus possible that the fishing pressure is too high. Another possible explanation is that there has been a migration out of the survey area, to the West, into the area covered by the offshore survey, which showed a marked increase in biomass in the neighbouring stratum in 1993 (Andersen *et al*, 1993).

In the southern parts of the bay no new input to the stock is evident. It should be noticed, however, that the high densities in the south in 1991 were based on two different size groups, one dominating in each stratum. In stratum D1 there was a peak at 22 mm CL, in stratum D2 the peak was at 17 mm, indicating two different year classes, with a gap of two years.

As the high biomass in strata D1 & D2 is due to the presence of at least two year classes, it is unlikely that the migration to the central parts should occur simultaneously (during the period between the surveys in 1991 and 1992), as a response to growth of the year-class. This indicates that the migration is not repeated regularly (on a yearly basis).

Stock composition

The estimated total numbers of shrimp (billions) in 1991, 1992, and 1993 are as follows (almost all females are multiparous in the autumn, when the surveys have been performed):

Year	males	females	total
1991	5.46	1.97	7.43
1992	5.55	1.55	7.10
1993	3.20	1.45	4.65

The decrease in biomass observed between 1992 and 1993 is mainly based on a decrease in abundance of males (in spite of the use of a smaller mesh size in the cod-end in 1993), while the number of females is relatively stable.

Estimated numbers of shrimp per year and stratum are shown in Figure 3a-c. Total number of shrimp decreased in most strata from 1992 to 1993 (strata D1, D3, D4, D5, D7, and D9). Only in the central part of the Vaigat (stratum D8) an increase was found in numbers of both male and female shrimp. The number of male shrimp decreased in all other strata. The number of females was stable or increased in southern and eastern strata (stable in D1, increasing in D2, D5, and D7), and decreased in D3, D4, D6, and D9.

The overall length frequency distributions of shrimp in 1991, 1992, and 1993 are shown in Figure 4.

In 1991 the distribution was dominated by two components of males at 17 and 21 mm CL respectively - assumed to be the 1987 and 1985 year classes. Several modes of females at 24.5, 26, and 27.5 mm CL were evident.

In 1992 dominant male peaks were found at 18.5 and 22 mm CL (1987 and 1985 year classes), and a new recruiting year class (1988) at 16 mm CL was indicated. The females were dominated by a mode around 25 mm CL, probably at least partly made up by a transitioning part of the 1985 year class, indicating that the transition from males to females of a year class may take place over more than one year.

In 1993 males are dominated by a peak at 20.5 mm CL (the 1987 year class), but peaks at 16, 18, and 22.5 mm CL are also evident (1989, 1988, and 1986 year classes). Female modes are indicated at 25.5,

27.5, and 29.5 mm CL. Although the total number of shrimp is reduced in 1993 compared to 1991 and 1992, the overall size distribution still shows the presence of a wide range of year classes in the population.

The observation that the number of females is almost stable between 1992 and 1993 can be explained by the contribution to the female group in 1993 of transitioning males from the 22 mm CL in 1992 (that part of the 1985 year class, that did not change sex in 1992).

Figure 5a-b shows the overall length frequency distributions by stratum in 1993. Modes at 16, 18, 20.5, 22.5, 24.5, and 25 mm CL are identified in most strata. The abundance of males is highest in strata D4 and D6, while females are most abundant in stratum D4.

Closing remarks

The actual change in biomass may not be very big, only two strata (D3 & D4) show a marked decrease, and others (D2 & D8) even show an increase. In 1991 an offshore survey showed a very low biomass, which triggered reductions in the advised TAC given in 1992 (NAFO, 1992). The results from the 1992 survey showed that the biomass was again at a high level (Carlsson *et al*, 1993b) and it was concluded that the low biomass seen in 1991, could have been caused by a reduced catchability of shrimp (Carlsson *et al*, 1993a).

Data from the analysis of the stock composition does not contradict a reduction in biomass. It therefore seems fairly well supported that the biomass of shrimp in Disko Bay has declined from 1992 to 1993. The cause of the decline is likely to be the ever increasing fishing pressure, but a substantial emigration from the area cannot be ruled out.

The decline in the bay is not of a magnitude that causes concern for the whole stock, but may be a first warning that fishing pressure locally is too high.

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TABLE 1. List of trawl stations in the inshore shrimp survey 1993. Catches are given in kg.

STATION- IDENTIFICATION	AREA- CODE	DEPTH	TR- TIME	SHR	COD	GHL	RED	MIX	TOTAL
STRATUM 1									
93PA0050525	531 LD022	342.0	30	396	0	5	8	45	453
93PA0050523	530 LD023	274.5	30	96	0	1	0	26	123
93PA0050524	529 LE024	192.0	30	6	0	0	0	2	8
STRATUM 2									
93PA0050526	528 LD026	386.5	30	65	0	17	6	41	129
93PA0050527	527 LE026	349.0	30	207	0	27	1	26	260
STRATUM 3									
93PA0050517	525 LG020	492.0	25	128	0	8	0	4	141
93PA0050519	526 LG020	482.0	30	42	0	10	3	9	64
93PA0050518	523 LG021	561.0	30	8	0	4	0	5	17
93PA0050520	524 LH019	359.0	30	78	0	19	4	75	176
STRATUM 4									
93PA0050521	521 LF023	410.5	30	106	0	7	6	12	130
93PA0050528	522 LF025	455.0	30	229	0	49	5	22	305
93PA0050535	520 LG023	487.5	30	124	0	24	3	18	169
93PA0050516	519 LH023	474.5	30	3	0	4	1	4	12
93PA0050536	518 LH024	387.5	30	371	0	15	2	11	399
93PA0050515	517 LJ024	265.0	30	357	0	3	0	25	384
STRATUM 5									
93PA0050529	516 LG026	395.5	30	268	0	55	3	29	354
STRATUM 6									
93PA0050530	515 LH027	338.0	30	193	0	15	0	8	216
93PA0050514	512 LJ025	257.5	30	136	0	2	0	24	161
93PA0050513	514 LJ027	257.5	30	284	0	2	0	33	318
93PA0050512	513 LJ028	304.0	30	318	0	6	0	33	357
STRATUM 7									
93PA0050511	511 LL026	244.5	30	623	0	5	0	66	694
93PA0050509	509 LM025	496.5	31	68	0	14	1	6	88
93PA0050510	510 LM027	597.0	30	27	0	25	0	5	57
93PA0050507	507 LN023	397.0	30	2	0	5	0	2	9
93PA0050508	508 LN026	374.5	30	19	0	13	0	3	35
STRATUM 8									
93PA0050505	506 LR019	285.0	30	381	0	11	0	74	466
93PA0050506	505 LR021	509.5	30	0	0	11	1	3	15
STRATUM 9									
93PA0050501	503 LS012	264.0	30	28	0	0	0	11	39
93PA0050502	504 LS014	244.0	30	79	0	0	0	37	116
93PA0050504	501 LS016	353.5	30	547	0	40	2	64	653
93PA0050503	502 LT015	376.5	30	242	0	17	0	22	281

Table 2: The area in sq.km, number of hauls, mean density in kg per sq.km, and calculated biomass per stratum.

STRATUM	AREA	HAULS	DENSITY	BIOMASS
AREA 1	819	3	3168	2595
AREA 2	566	2	3119	1765
AREA 3	1124	4	1529	1719
AREA 4	1834	6	4191	7686
AREA 5	612	1	4722	2890
AREA 6	1014	4	4651	4717
AREA 7	1447	5	2517	3643
AREA 8	652	2	3196	2084
AREA 9	1296	4	3979	5156

Table 3: Estimated trawlable biomass per stratum and year in the Disko Bay - Vaigat area 1991-93.

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Stratum	Sqkm	Biomass		
		1991	1992	1993
1	819	9390	3238	2595
2	566	5869	1510	1765
3	1124	5667	5700	1719
4	1834	7928	13676	7686
5	612	892	3416	2890
6	1014	4006	5552	4717
7	1447	5298	6077	3643
8	652	3264	1046	2084
9	1296	5264	4953	5072
Total	9364	47578	45167	32169

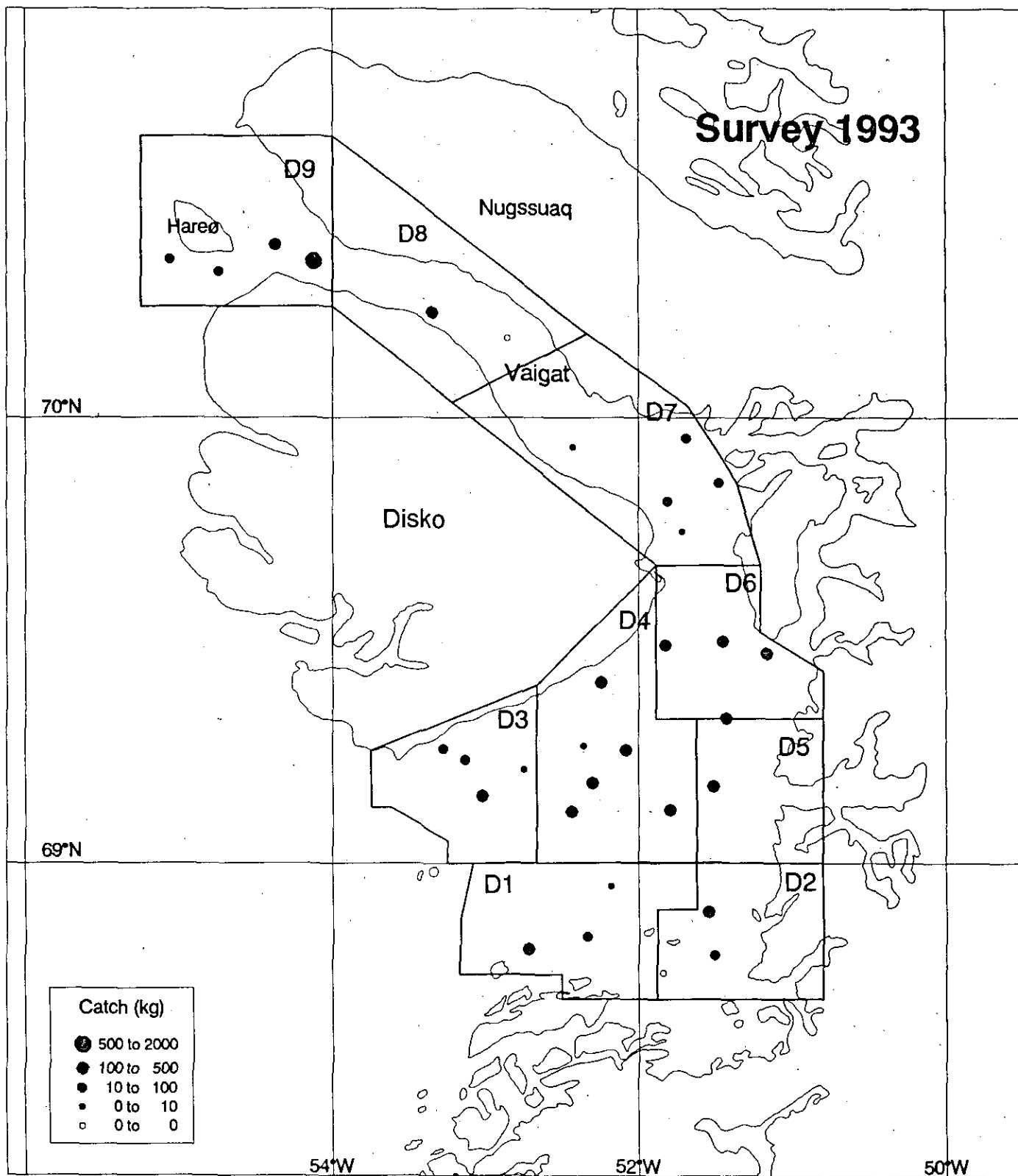


Figure 1. Stratification scheme and sampling sites in the Disko Bay - Vaigat survey area 1993. Trawl catch levels (kg per hour) are also indicated.

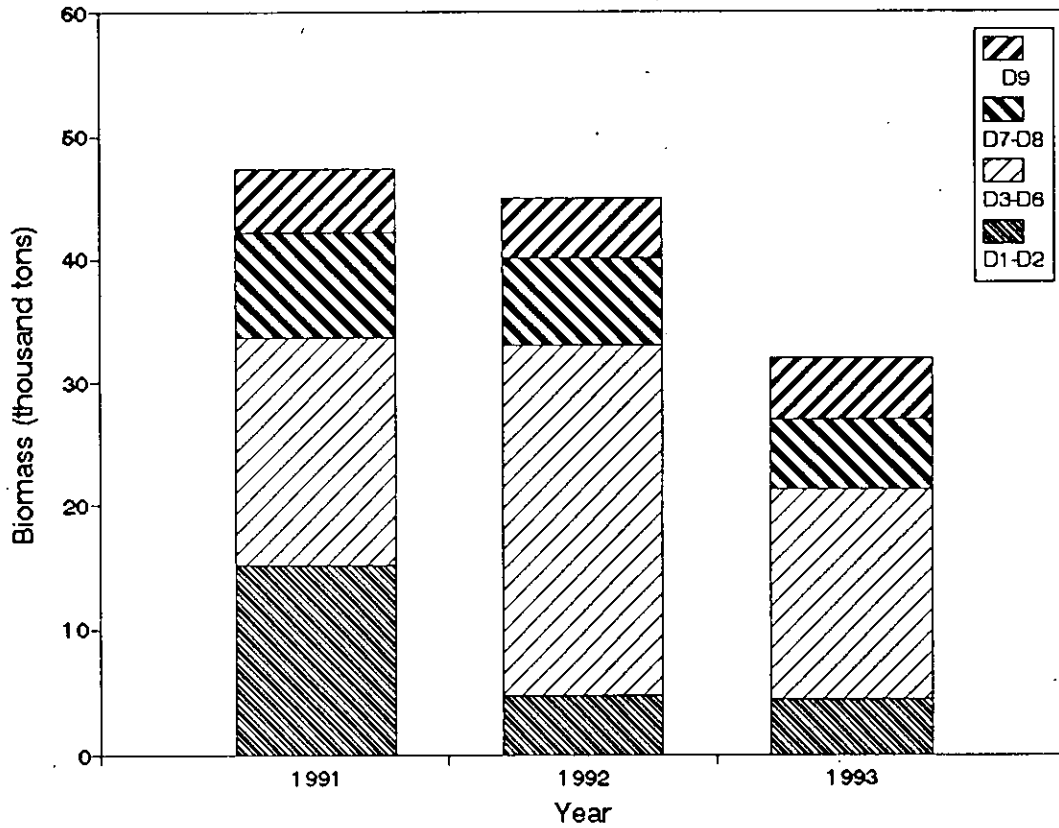


Figure 2. Estimated total biomass 1991-93 for groups of strata in the Disko Bay - Vaigat area.

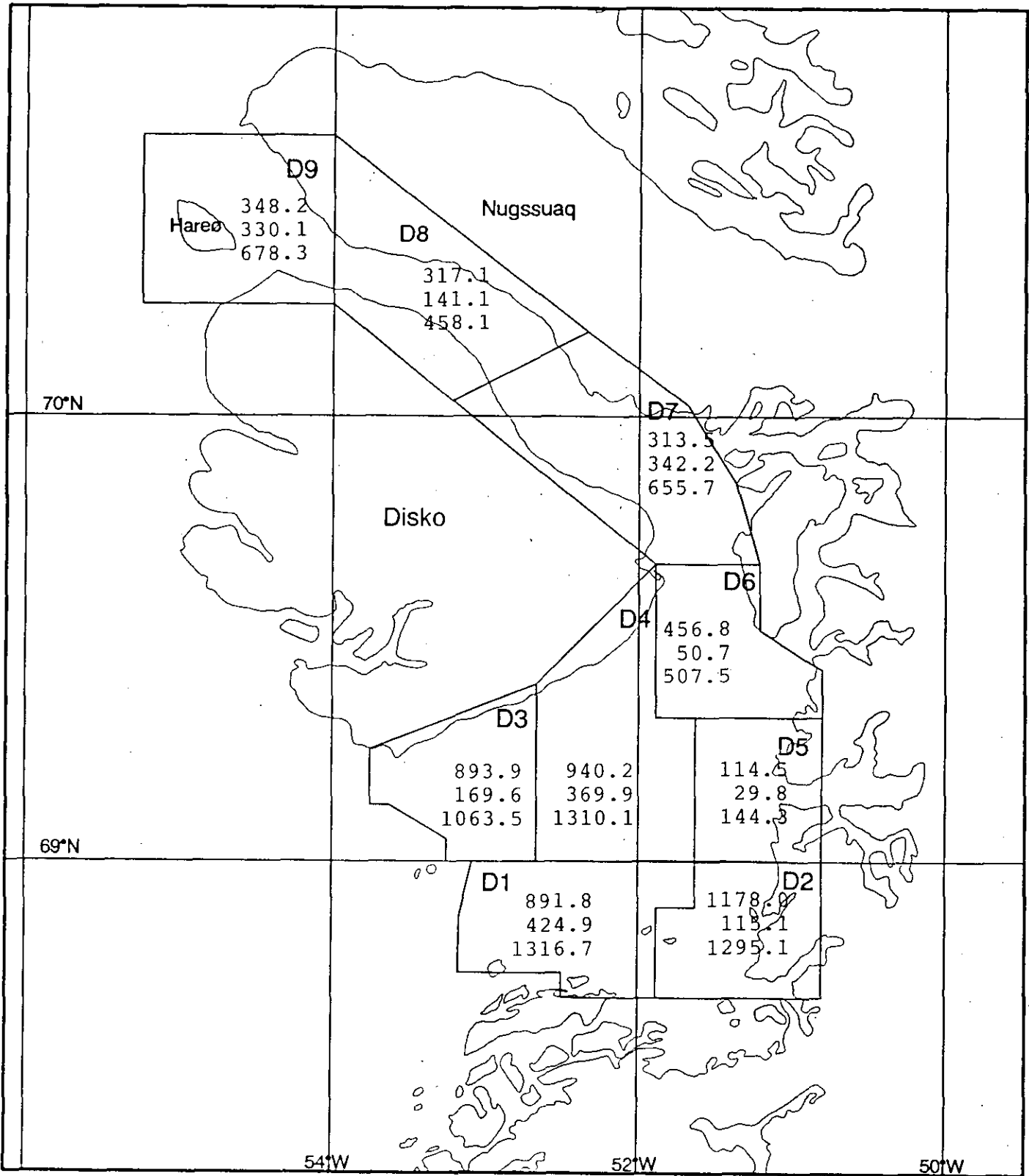


Figure 3a. Calculated numbers of shrimp (males, females and total, in millions) per stratum in 1991.

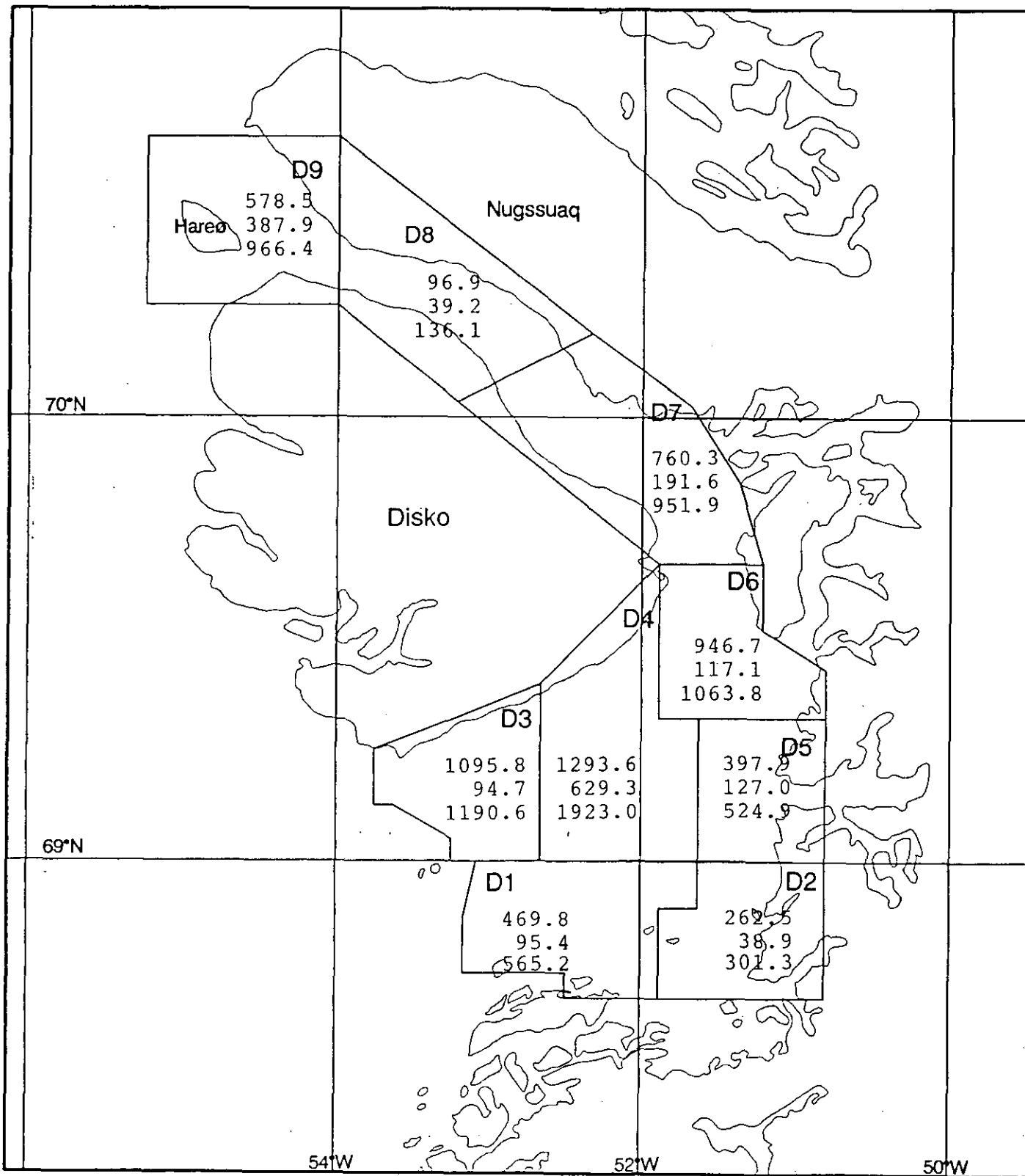


Figure 3b. Calculated numbers of shrimp (males, females and total, in millions) per stratum in 1992.

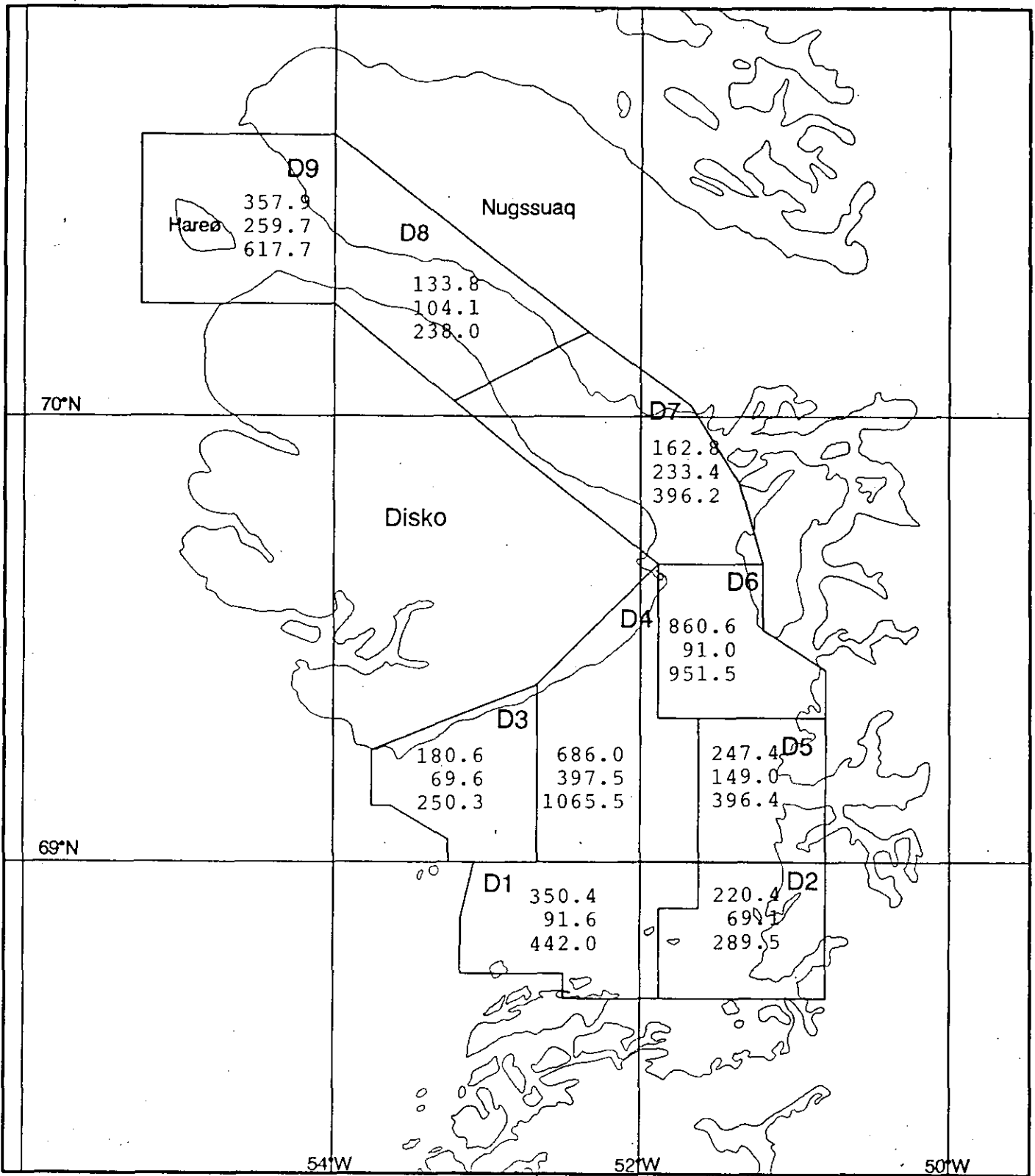


Figure 3c. Calculated numbers of shrimp (males, females and total, in millions) per stratum in 1993.

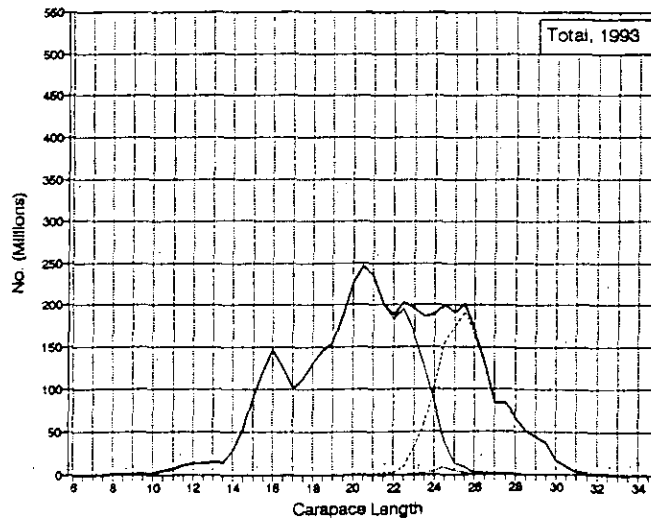
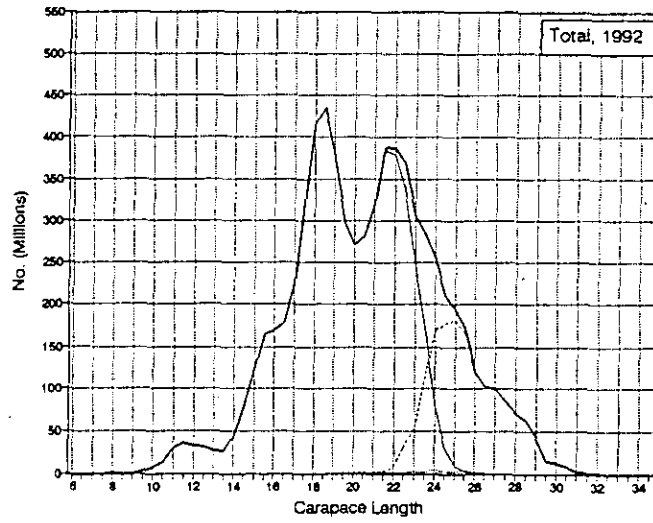
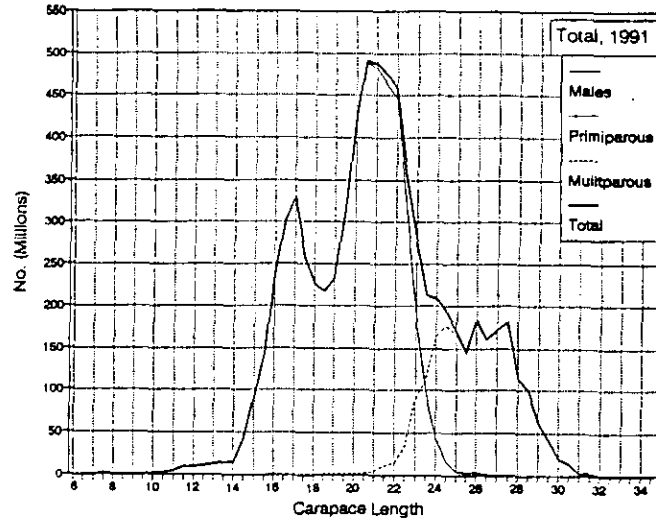


Figure 4. Numbers of shrimp per length group (CL) in the total survey area in 1991-93, based on pooling of samples weighted by catch and stratum areas.

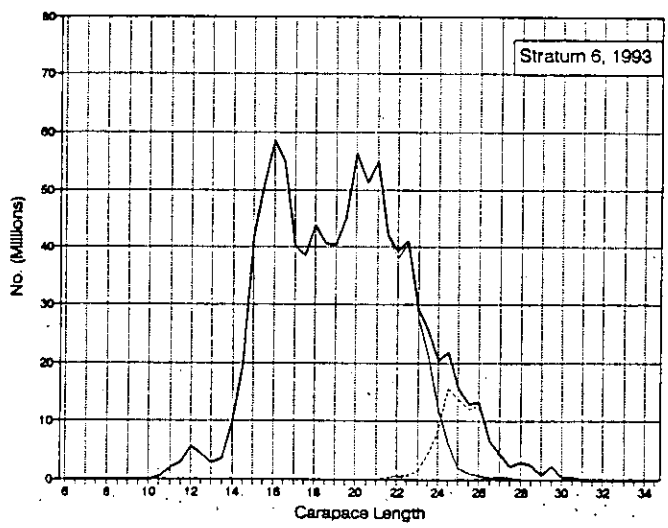
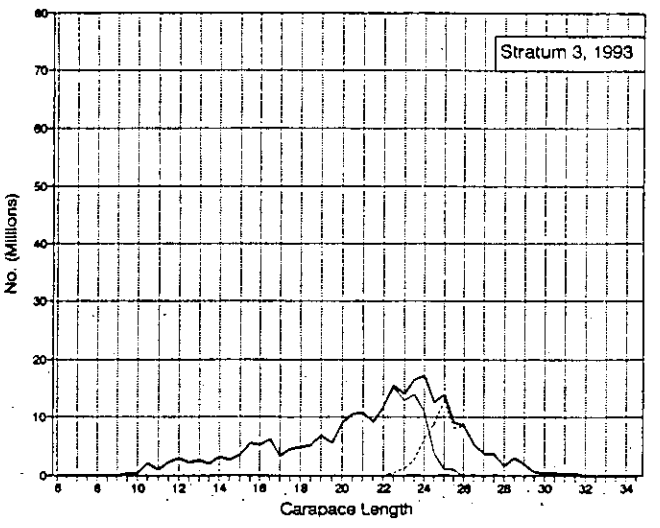
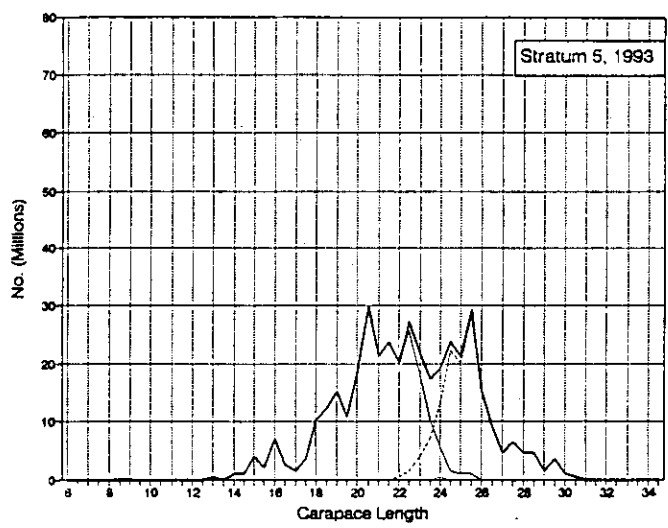
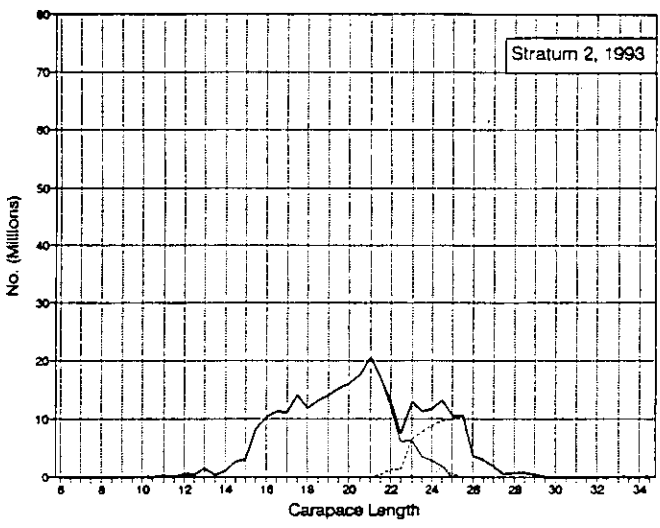
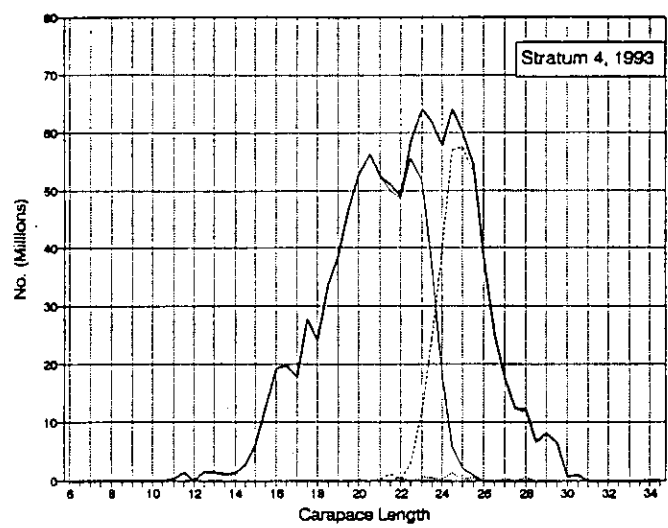
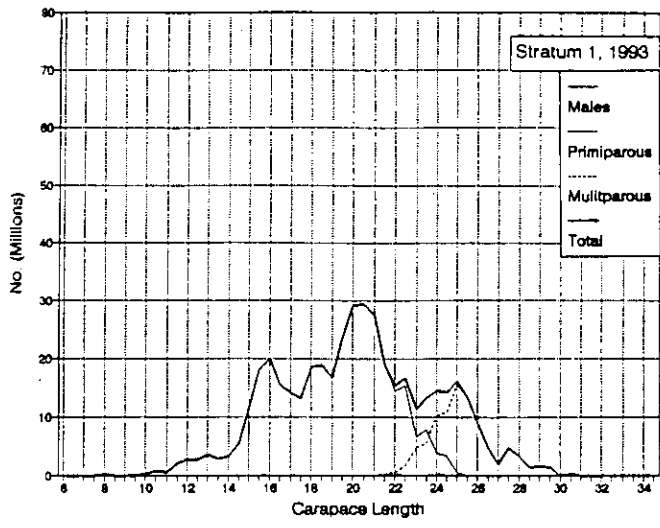


Figure 5a. Numbers of shrimp per length group (CL) in strata 1-6 (see Fig. 1), based on pooling of samples weighted by catch and stratum area.

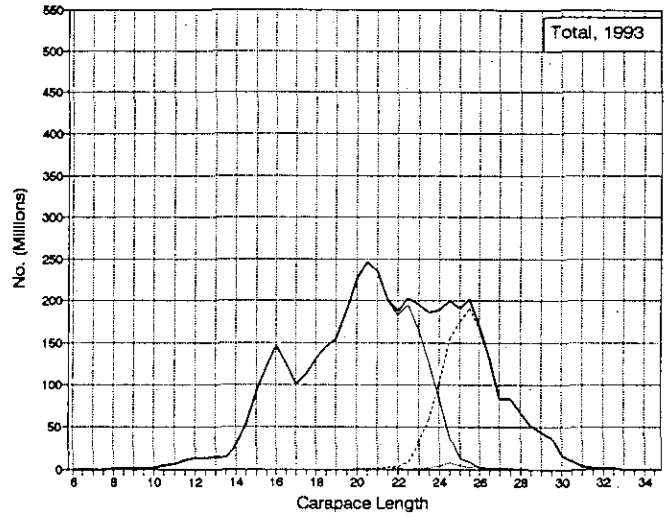
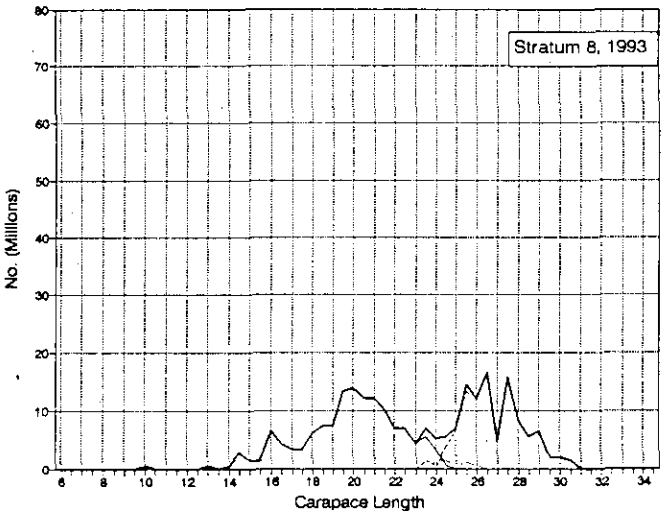
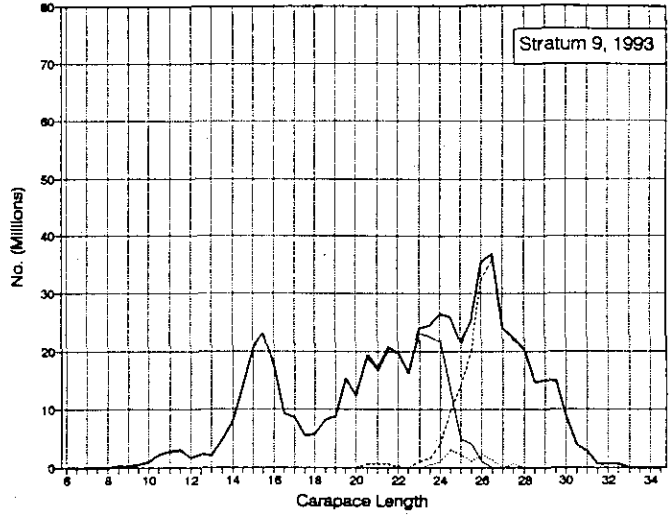
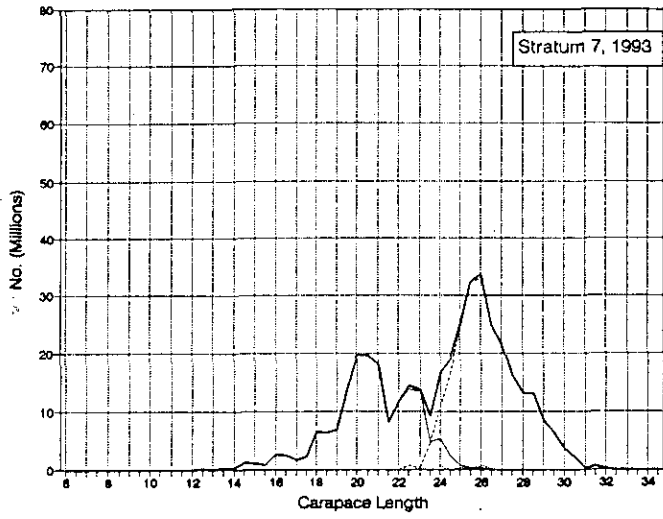


Figure 5b. Numbers of shrimp per length group (CL) in strata 7-9 (see Fig. 1) and total for the whole area, based on pooling of samples weighted by catch and stratum area.