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Survey Biomass of Redfish (*Sebastes spp.*) off West Greenland (NAFO Subareas 0+1), July-August 1988-91

by

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1. Introduction

A yearly stratified-random shrimp trawl survey in the main distribution area for shrimp (Pandalus borealis) off West Greenland was initiated in July 1988 by Greenland Fisheries Research Institute (Carlsson and Kanneworff 1991). This paper presents estimates of biomass, abundances and size frequency distributions of redfish based on by-catch data collected during the shrimp trawl surveys in July-August 1988-91.

2. Materials and Methods

Survey design

The shrimp surveys were carried out in the offshore area of West Greenland between 61°52'5N to 72°30'N and from the 3-mile limit to the 600 meter depth contour line (Fig. 1).

The surveys were conducted with five commercial shrimp trawlers of about similar size. In July 1988 with M/Tr Elias Kleist (722 GRT), in July-August 1989 with M/Tr Sisimiut (722 GRT), in July-August 1990 with M/Tr Maniitsoq (722 GRT) and M/Tr Auveq (695 GRT), in July-August 1991 with M/Tr Paamiut (722 GRT), respectively.

The five trawlers used similar trawling gear (Skjervoy 3300/20 with bobbin gear and a double-bag with 44 mm mesh-size in the cod-end). The trawl-doors used were in 1988, 1990 and 1991 of the Perfect type, while in the 1989-survey BMV doors were used. The BMV doors gave a smaller wing spread. In the 1988-survey the wing spread was estimated to 26.5 m, lacking suitable equipment to measure the actual wing spread. During the trawl operations in 1989, 1990 and 1991 the wing spread were measured by means of SCANMAR equipment to an average of 17.2 m, 28.1 m and 27.7 m, respectively.

The standard trawling haul was about 60 minutes at a mean towing speed of about 2.4 knots throughout all four surveys. In order to minimize the influence of vertical shrimp migrations the trawl operations were planned to be carried out only during daytime (hours: 0900-1900 UTC). Due to time constraint it became necessary to work on a 24-hour schedule in the last part of the surveys in 1989 and 1990.

In the area between 61°52'5N and 69°30'N (named 'WEST' and 'CANADA') the stratification was based on the depth contours and divided in subareas which were further divided in four depth strata. The area between 69°30'N and 72°30'N (named 'NORTH') was divided in separate shrimp grounds defined by the effort distribution in the commercial shrimp fishery. Due to scarce information on the bottom topography this area was not subdivided in depth strata. The size of the strata by subarea and depth in squarekilometres are given in Table 1.

The number of hauls per strata were allocated proportionally to strata sizes. However a minimum of two hauls per stratum was always scheduled. Within the strata the trawling sites were chosen at random according to Doubleday (1981).

Biomass, abundance and size distribution

The mean biomass with standard deviation by subarea, depth-stratum and year was calculated by means of the swept area method and assuming a catchability coefficient of 1.0. From most of the hauls in 1988 the total length of redfish were measured to the nearest centimetre below. From some of the hauls during the two surveys in 1990 the redfish were length measured or the mean weight per fish was estimated. During the survey in 1991 the redfish from most of the hauls was length measured. The length compositions of redfish in each haul were weighted by effort and pooled by subarea and depth-strata.

Abundance estimates by area were calculated simply by dividing the estimated biomass by the estimated mean weight per redfish for each strata.

Catch distribution

The catch rates (kg/hour) of redfish were examined by the following general linear model (GLM):

$$\log(\text{catch}) = a0 + a1(\text{subarea}) + a2(\text{depth}) + a3(\text{year}) + \text{error}$$

where subarea, depth and year were included as class variables.

The computer procedure "GLM" in the statistical computer package (SAS Institute Inc., North Carolina) was used.

Log(catch) was assumed to be normally distributed and this was justified as the standard deviation is proportional to the mean. The distributions are, however, not strictly log normal because several of the trawl catches were zero. To avoid to take the log of zero 1 gram was added to all catch rates.

3. Results

Biomass, abundance and size distribution

There is a general decrease in CPUE as well as in estimated biomass by subarea, depth-stratum and year from 1988 to 1991 in the northern most and deeper survey strata (Table 2 and 3). Whereas there is an increase in CPUE and in estimated biomass in the southern subareas (W3-W6) depth-strata 200-400m from 1990 to 1991. The total estimated redfish biomass and abundance decreases from about 20,000 tonnes and 631 mill. in 1988 to about 12,300 tonnes and 401 mill. in 1990, and increase again in 1991 to about 25,200 tonnes and 2,100 mill., respectively (Table 4 and 5). The large confidence intervals for the estimated redfish biomass based on the survey data from 1991 are due to large variation between hauls in CPUE. This variation in CPUE indicate a patchy distribution of the redfish probably due to shoaling. There is a very high mean CPUE (405.5 kg/hour) and calculated mean biomass (14,689 tonnes) in subarea W3, depth-stratum 200-300 m in 1991 (Table 2 and 3). These high figures are mainly caused by a catch of 1,996 kg redfish in size 7-8 cm in one of the hauls.

The length frequency distributions of the redfish by subarea and depth-strata in 1991 shows a marked peak at 7-8 cm which is seen in all the surveyed strata (Fig. 2). Larger redfish are sparse and they are with a few exceptions only seen in the deeper survey strata (400-600 m).

The biomass, abundance and size frequency distributions estimated from the shrimp trawl surveys 1988-91 indicate that there have been a large recruitment to the redfish nursery grounds off West Greenland in 1991.

Catch distribution

Analysis of variance on the logarithmic transformed trawl-survey catches (grams/hour) shows significant effects ($P<0.01$) of subarea, deptha nd year (Table 6). The model explains 55% of the total variation. The model solution indicate a general decrease in CPUE from south to north and from deeper to shallow water. There is a decrease in CPUE from 1988 to 1990 and thereafter an increase again in 1991.

4. Discussion

The West Greenland shelf area from the Diskobank region to the Fyllabank region is an important nursery ground for redfish (mainly Sebastes mentella). The highest densities of young redfish are observed in trawl fishery around Store Hellefiskbank (NAFO Division 1B) and large quantities of young redfish are by-caught in the shrimp fishery in this area. (Jensen, 1979; Atkinson, 1987; Yamada et al., 1988; Riget et al., 1988; Pedersen and Lehmann, 1989).

The survey data presented in this paper confirm that young redfish are highly abundant around Store Hellefiskbank (NAFO Division 1B), and that major nursery grounds for redfish coincide with the distribution area for shrimp.

Length frequency distributions and average weight data by subarea and depth indicate a gradual migration and growth of young redfish from the northern areas (Division 1A and 1B) westward and south and from shallow to deeper water. Average length and weight data collected during stratified-random bottom trawl surveys off West Greenland at depths between 50-1500 m in 1986, 1987 and 1990 support these findings (Atkinson, 1987; Yamada et al., 1988; Due et al., 1991; Rätz, 1991). According to Zakharov (1966) the marked peak in the length frequency distributions at about 7-8 cm in most of the survey area represents age 1+ redfish. In September-November pelagic redfish fry age 0+ (40-68 mm) have been observed drifting northward from Kap Farvel along the West Greenland coast in large quantities (Zakharov, 1966; Pedersen, 1990; Wieland, 1991). Since the 1920's no breeding of redfish have been observed off West Greenland, and it is assumed that the redfish populations in West Greenland waters are recruited from breeding areas in the Irminger Sea southwest of Iceland (Zakharov, 1966; Anon., 1984; Pavlov et al., 1989; Anon., 1990; Magnusson et al., 1990).

When comparing biomass and abundance estimates calculated from trawl survey data, it is important that the catch data is collected with similar ships and trawl gear, during the same time period and area etc. This has not completely been fulfilled during the three years shrimp trawl surveys off West Greenland, 1988-91. For instance were the trawl-doors used in 1988 and 1990 of the Perfect type, while in the 1989-survey BMV doors were used. The BMV doors gave a smaller wing spread and a horizontally higher net opening. The effects of differences in ships and gear used between years is unknown as is the catchability for redfish. The biomass estimates derived from these surveys are therefore merely indices. However, the decrease in the total biomass and abundance estimates from about 20,000 tons and 631 mill. in 1988 to about 12,800 tons and 401 mill. in 1990 is an indication for a reduction in the West Greenland redfish populations from 1988 to 1990. The increase in the total biomass and abundance estimates to about 25,200 tons and 2,100 mill. in 1991 are due to a large recruitment of 7-8 cm redfish from the breeding areas in the Irminger Sea (the 1990 yearclass) to the West Greenland redfish nusery grounds. It will be interesting to see if this large yearclass can be followed as it grow on the nusery grounds in the years to come.

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Table 1 Stratum areas in squarekilometers.

AREA=NORTH

Area in km2	SUBAREA						
	N1	N2	N3	N4	N5	N6	N7
	AREA	AREA	AREA	AREA	AREA	AREA	AREA
DEPTH							
200-600	3649	11789	367	2249	5990	15926	1159

AREA=CANADA

Area in km2	SUBAREA	
	C1	C3
	AREA	AREA
DEPTH		
200-300	.	660
300-400	655	1192
400-600	312	623

AREA=WEST

Area in km2	SUBAREA					
	W1	W2	W3	W4	W5	W6
	AREA	AREA	AREA	AREA	AREA	AREA
DEPTH						
150-200	2363	1499	2215	4204	1995	1095
200-300	5213	2477	4810	1736	3454	1491
300-400	9239	1453	2714	745	1797	1300
400-600	752	559	3361	1915	2806	884

Table 2 Mean catch of redfish (kg/hour) and number of hauls by subarea, depth-stratum and year.

AREA=NORTH

KG PR HOUR		SUBAREA													
		N1		N2		N3		N4		N5		N6		N7	
		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR														
200-600	88	0.2	5	0.5	7	0.6	3	2.9	5	20.8	4	6.9	10	0.2	2
	89	0.5	6	0.0	6	0.0	3	0.2	4	2.8	16	.	.	0.0	2
	90	0.0	6	0.0	4	0.0	2	0.0	2	13.0	7	0.0	4	0.4	2
	91	0.4	5	0.0	3	0.0	2	1.3	5	0.7	8	0.2	5	0.0	2

AREA=CANADA

KG PR HOUR		SUBAREA			
		C1		C3	
		REDFISH		REDFISH	
		MEAN	N	MEAN	N
DEPTH	YEAR				
200-300	90	.	.	2.5	2
	91	.	.	14.5	1
300-400	88	8.3	3	43.5	3
	89	96.7	3	105.6	3
	90	11.4	2	246.0	2
	91	23.5	2	85.5	3
400-600	88	146.3	1	.	.
	89	38.0	1	51.4	3
	90	.	.	28.5	2
	91	26.9	1	43.3	1

AREA=WEST

KG PR HOUR		SUBAREA											
		W1		W2		W3		W4		W5		W6	
		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR												
150-200	88	0.0	3	0.0	4	2.4	4	2.5	7	2.8	4	.	.
	89	0.6	2	1.2	3	0.6	4	2.3	8	0.8	4	.	.
	90	0.0	2	0.0	2	0.4	3	0.3	6	0.1	3	1.2	2
	91	0.0	4	0.1	2	0.2	3	3.3	5	4.1	2	0.9	2
200-300	88	0.8	9	0.9	4	23.3	9	11.5	3	155.6	7	.	.
	89	0.7	4	1.9	5	3.1	10	8.7	3	24.6	7	.	.
	90	0.2	8	12.2	3	1.4	5	0.0	2	2.6	5	9.3	1
	91	0.0	6	4.2	3	405.5	6	32.5	2	49.4	4	39.5	1
300-400	88	42.3	14	44.8	2	83.2	2	94.1	2	91.5	3	.	.
	89	22.6	11	2.3	3	22.0	3	223.3	2	38.8	4	.	.
	90	7.8	11	70.7	2	16.6	5	481.6	2	1.1	2	6.5	2
	91	23.3	10	30.4	3	26.8	3	105.8	2	26.4	2	24.7	1
400-600	88	105.7	1	29.8	2	22.6	8	37.6	3	51.7	4	.	.
	89	39.5	1	26.2	2	5.2	4	35.8	3	42.6	5	.	.
	90	2.9	2	49.8	2	60.6	4	27.9	3	21.6	4	8.9	1
	91	4.9	2	31.9	1	52.9	5	27.5	2	9.7	3	44.4	3

Table 3 Mean biomass of redfish (tonnes) and number of hauls by subarea, depth-stratum and year.

AREA=NORTH

BIOMASS TONS		SUBAREA													
		N1		N2		N3		N4		N5		N6		N7	
		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR														
200-600	88	6	5	50	7	2	3	58	5	1656	4	713	10	2	2
	89	25	6	0	6	0	3	4	4	331	16	.	.	0	2
	90	0	6	0	4	0	2	0	2	982	7	0	4	4	2
	91	10	5	0	3	0	2	23	5	36	8	25	5	0	2

AREA=CANADA

BIOMASS TONS		SUBAREA			
		C1		C3	
		REDFISH		REDFISH	
		MEAN	N	MEAN	N
DEPTH	YEAR				
200-300	90	.	.	12	2
	91	.	.	71	1
300-400	88	48	3	425	3
	89	738	3	1473	3
	90	66	2	2243	2
	91	125	2	920	3
400-600	88	332	1	.	.
	89	153	1	371	3
	90	.	.	153	2
	91	62	1	192	1

AREA=WEST

BIOMASS TONS		SUBAREA											
		W1		W2		W3		W4		W5		W6	
		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH		REDFISH	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR												
150-200	88	0	3	0	4	47	4	86	7	54	4	.	.
	89	14	2	18	3	17	4	121	8	20	4	.	.
	90	0	2	0	2	8	3	10	6	2	3	12	2
	91	0	4	1	2	4	3	136	5	69	2	8	2
200-300	88	31	9	18	4	866	9	162	3	4763	7	.	.
	89	41	4	58	5	204	10	219	3	944	7	.	.
	90	8	8	294	3	66	5	0	2	91	5	144	1
	91	0	6	82	3	14689	6	525	2	1422	4	495	1
300-400	88	3294	14	507	2	1896	2	438	2	1529	3	.	.
	89	2525	11	34	3	737	3	1749	2	917	4	.	.
	90	625	11	983	2	448	5	2954	2	14	2	81	2
	91	1630	10	332	3	564	3	642	2	373	2	283	1
400-600	88	713	1	117	2	582	8	507	3	1051	4	.	.
	89	345	1	162	2	206	4	769	3	1302	5	.	.
	90	20	2	238	2	1792	4	403	3	548	4	68	1
	91	33	2	155	1	1364	5	428	2	221	3	353	3

Table 4 Total estimated biomass of redfish (tonnes) and 95% confidence intervals (%) by area and year.

Area\year	1988 Biomass	C.V.	1989 Biomass	C.V.	1990 Biomass	C.V.	1991 Biomass	C.V.
NORTH (N1-N7)	2428	74%	354	47%	986	48%	60	105%
CANADA(C1+C3)	799	105%	2735	30%	2474	54%	1369	113%
WEST (W1-W6)	16800	58%	10326	42%	8809	38%	23806	96%
Total	20027		13414		12269		25235	

Table 5 Total estimated abundance of redfish (mill.) by area and year.

Area\year	1988 Abundance	1990 Abundance	1991 Abundance
NORTH (N1-N7)	37	5	4
CANADA(C1+C3)	31	82	120
WEST (W1-W6)	563	314	2000
Total	631	401	2124

Table 6. Analysis of variance (ANOVA) on log (catch of redfish in grams/hour) with a three factor model (subarea, depth and year). The ANOVA table and the estimated parameters for the least squares model are given.

General Linear Models Procedure

Dependent Variable: LOGRED

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	5197.386038	259.869302	29.46	0.0001
Error	484	4268.707532	8.819644		
Corrected Total	504	9466.093570			

R-Square	C.V.	Root MSE	LOGRED Mean
0.549053	47.68561	2.969788	6.22785061

Source	DF	Type I SS	Mean Square	F Value	Pr > F
SUBAREA	14	2955.129198	211.080657	23.93	0.0001
DEPTH	3	1955.479880	651.826627	73.91	0.0001
YEAR	3	286.776959	95.592320	10.84	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SUBAREA	14	3064.624457	218.901747	24.82	0.0001
DEPTH	3	1974.539175	658.179725	74.63	0.0001
YEAR	3	286.776959	95.592320	10.84	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		10.53113843 B	12.00	0.0001	0.87775125
SUBAREA	C1	-1.38786474 B	-1.17	0.2446	1.19122536
	C3	-0.24367716 B	-0.23	0.8206	1.07420421
	N1	-7.16979065 B	-6.74	0.0001	1.06381421
	N2	-8.17598830 B	-7.54	0.0001	1.08492512
	N3	-6.80105715 B	-5.31	0.0001	1.28175669
	N4	-8.13278432 B	-7.19	0.0001	1.13039514
	N5	-3.86109838 B	-3.90	0.0001	0.98906211
	N6	-4.78710081 B	-4.42	0.0001	1.08421253
	N7	-5.09137133 B	-3.78	0.0002	1.34701952
	W1	-3.72789559 B	-4.14	0.0001	0.90123553
	W2	-1.32586335 B	-1.39	0.1661	0.95587909
	W3	-0.66726654 B	-0.74	0.4618	0.90603486
	W4	-0.21369791 B	-0.23	0.8186	0.93133579
	W5	-0.33420153 B	-0.36	0.7172	0.92221876
	W6	0.00000000 B	.	.	.
DEPTH	150-200	-5.64426768 B	-12.64	0.0001	0.44641183
	200-300	-2.94150164 B	-7.21	0.0001	0.40780424
	300-400	0.00265862 B	0.01	0.9947	0.39828361
	400-600	0.00000000 B	.	.	.
YEAR	88	0.77295977 B	2.03	0.0429	0.38073016
	89	0.76327005 B	1.99	0.0475	0.38407415
	90	-1.11866871 B	-2.86	0.0044	0.39117927
	91	0.00000000 B	.	.	.

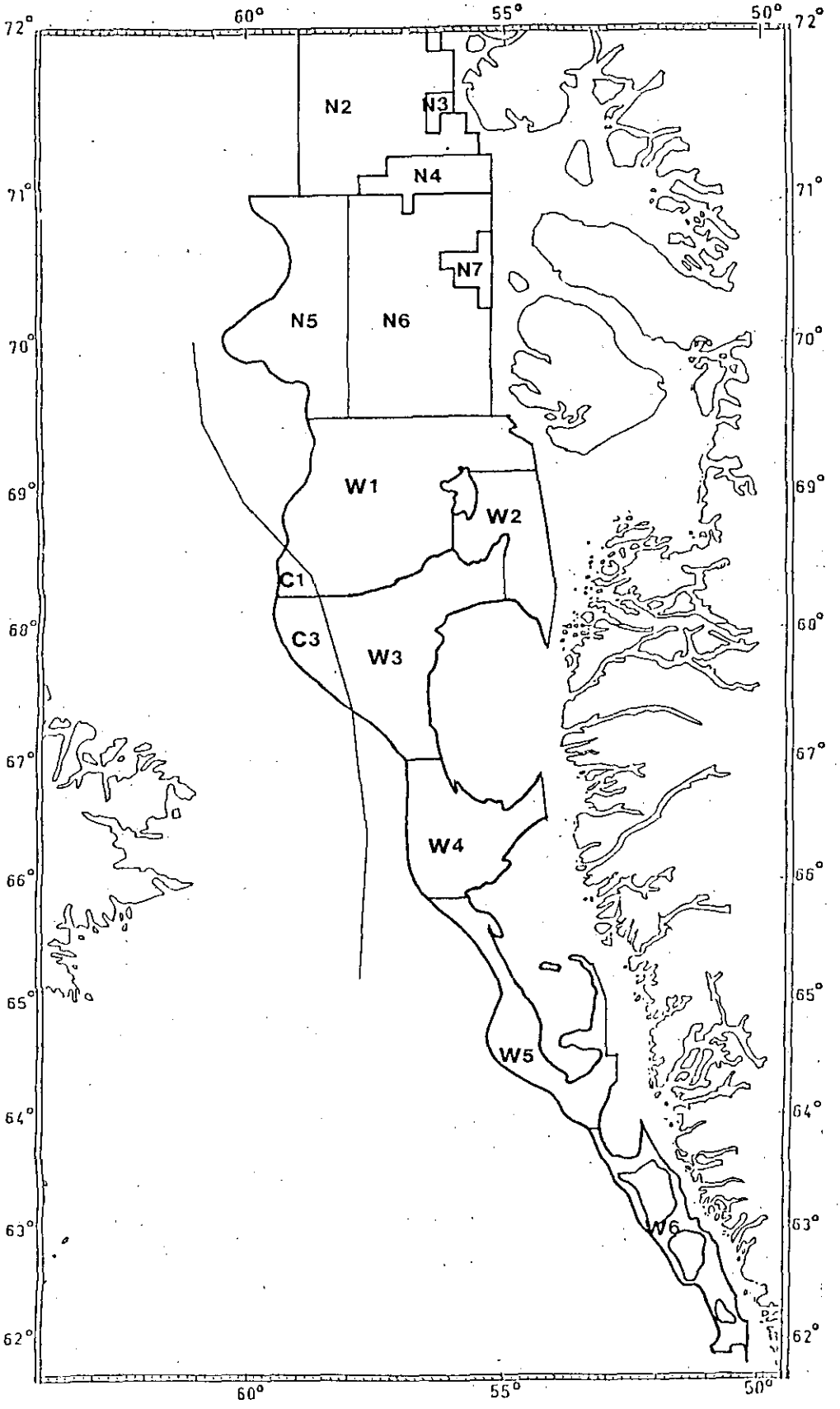

Fig. 1 Area stratification used for the yearly shrimp-trawl-survey off West Greenland conducted by GFRI since 1988.

Subarea=C1 Subarea=C3 Subarea=W1 Subarea=W2

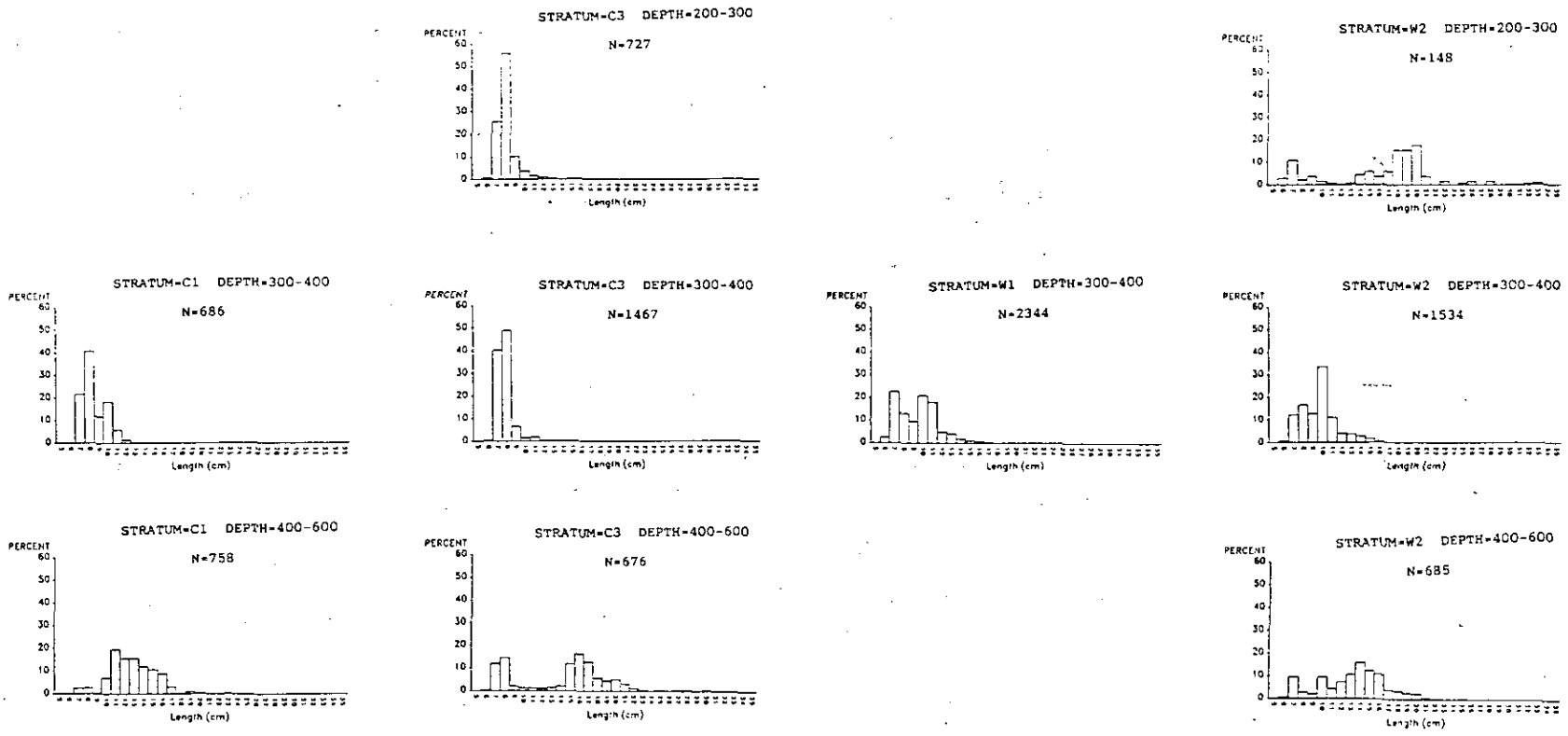

Fig. 2 Frequency distribution of total length by subarea and depth-stratum of redfish caught during the shrimp-trawl-survey in 1991.

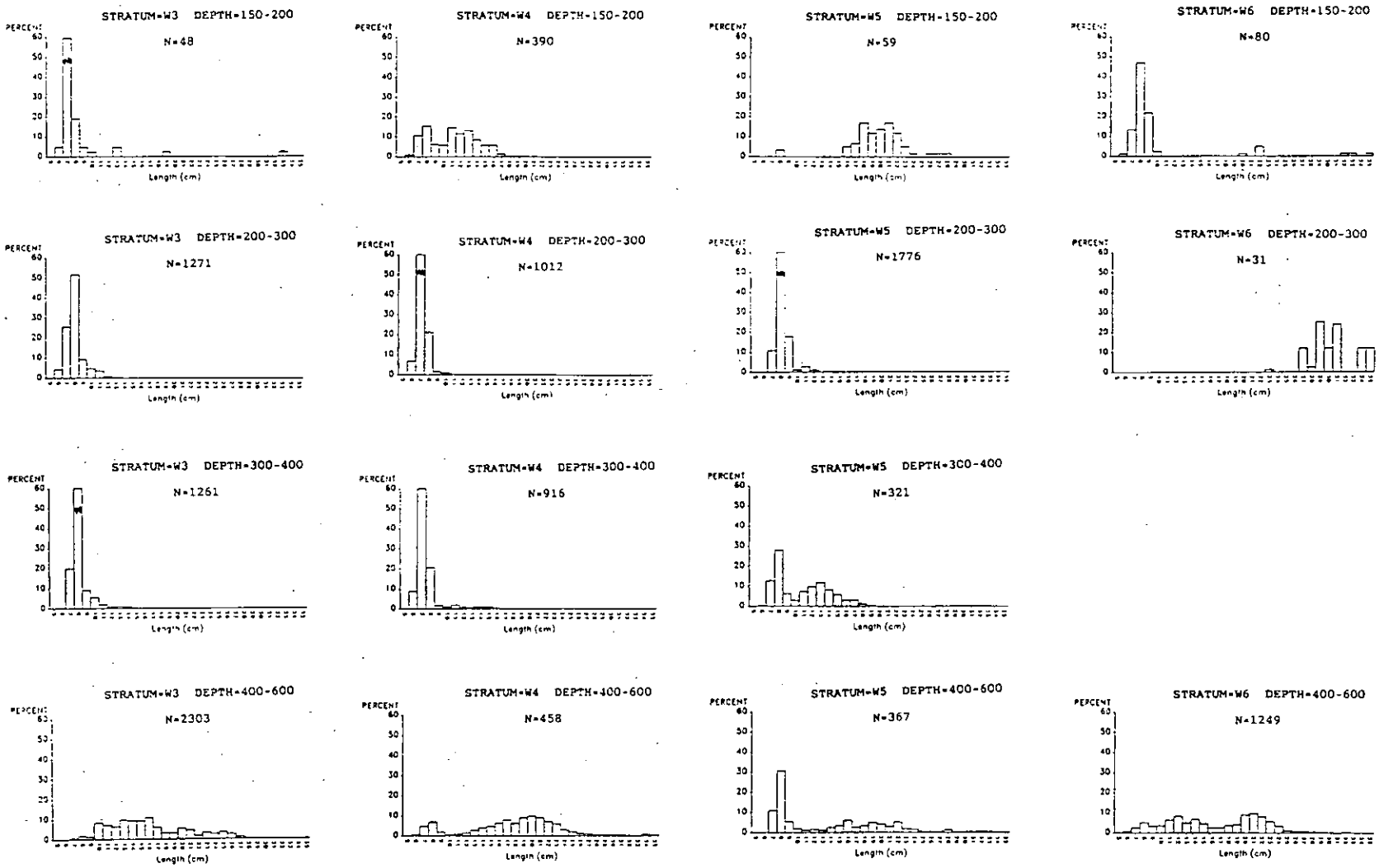

Fig. 2 (Continued) Frequency distribution of total length by subarea and depth-stratum of redfish caught during the shrimp-trawl-survey in 1991.