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Survey Biomass of Greenland halibut (*Reinhardtius hippoglossoides*) 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 distributions of Greenland halibut based on by-catch data collected during the shrimp trawl survey 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 the 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 divided in depth strata. The size of the strata by subarea in square kilometres 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 Greenland halibut were length measured to the nearest centimetre below. From some of the hauls during the two surveys in 1990 the Greenland halibut were length measured or the average weight per fish were estimated. During the survey in 1991 the Greenland halibut from most of the hauls was length measured. The length compositions of Greenland halibut 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 fish for each strata.

Catch distribution

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

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

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. Therefore, the delta distribution might be more correct. To avoid to take the log of zero 1 gram was added to all catch rates.

3. Results

Biomass, abundance and size distribution

Except for the deeper parts of subarea W2 and W3 there is a general decrease in the mean catch per hour and calculated mean biomass by subarea, depth-stratum and year from 1988 to 1991 (Table 2 and 3). The total biomass and abundance estimates decreases significantly from about 12,000 tonnes and 141 mill. in 1988 to about 3,800 tonnes and 36 mill. in 1990 and increases a little in 1991 to about 5,000 tonnes and 70 mill.,respectively (Table 4 and 5). The largest reductions are seen in area 'NORTH' and 'West'.

The length frequency distributions of the Greenland halibut by subarea and depth-strata in 1991 shows a marked peak at 11-12 cm which is seen in all the surveyed strata north of Subarea W5 (Fig. 2). In subarea C3, W1-W3 a second peak is seen at about 18 cm. In the southern most subarea W5 and W6 a peak in length frequency disributions are seen at 15 cm. Larger Greenland halibut are sparse and they are with a few exceptions only seen in the deeper survey strata (400-600 m) (Fig. 2).

Catch distribution

Analysis of variance on the logarithmic transformed trawl-survey catches (grams/hour) shows significant effects (<0.0001) of subarea, depth and year (Table 6). The model explains 45% of the total variation. The model solution indicate a general increase in

CPUE from shallow to deeper water. The highest CPUE's are generally from subarea W2 followed by C3, N3, W3. The lowest CPUE's are from southern most survey subarea W5 and W6. CPUE decreases from 1988 to 1991.

4. Discussion

Greenland halibut is most frequent on grounds with rich stocks of deep sea prawns (*Pandalus borealis*), and it is an important fish species in by-catch from the prawn fishery (Smidt, 1969). Small Greenland halibut have long been known to occur in rich quantities on nursery grounds in the Disko Bay, off the West Greenland coast north of 66° N and in several fjords of South Greenland at depths between 200-600 m (Jensen, 1935; Smidt, 1969; Riget and Boje, 1988). According to Smidt (1969) the stock of I-group Greenland halibut is very dense on the localities west of Disko compared with other localities, and the vast shallow areas (about 200-250 m in depth) northwest, west and southwest of Disko can be regarded as very important nursery grounds from where the older stocks in the fjords of Disko Bay, Umanak district, and more northern districts are recruited. According to Riget and Boje (1989) little attention have been paid to Greenland halibut on the continental slope and they propose that a stepwise migration and growth occur down the continental slope to the deeper part of the Davis Strait were the Greenland halibut mature and spawn.

The by-catch data presented in this paper confirm that major nursery grounds for Greenland halibut coincide with the distribution area for shrimp (*Pandalus borealis*). Average length and weight data by subarea and depth also indicate a gradual migration and growth of Greenland halibut down the continental slope to the deeper part of the Davis Strait as proposed by Riget and Boje (1989). Average length and weight data collected by Japan Marine Fishery Resource Research Center (JAMARC) in cooperation with Greenland Fisheries Research Institute during stratified-random bottom trawl surveys off West Greenland at depths between 50-1500 m in 1987-90 extent and support these findings (Yamada et al., 1988; Yatsu and Jørgensen, 1989; Due et al., 1991).

When comparing the biomass estimates calculated from the trawl survey data, it is important that the catch data is collected with similar ships and trawl gear, during the same time period etc. This has not completely been fulfilled during the three years shrimp trawl surveys off West Greenland, 1988-90. 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 Greenland halibut. The biomass estimates derived from these surveys are therefore merely indices. However, the decrease in the total biomass and abundance estimates from about 12,000 tonnes and 141 mill. in 1988 to about 5,000 tonnes and 70 mill. in 1991 is an indication for a reduction in the stock size from 1988 to 1991.

5. References

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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 Greenland halibut (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	
		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR														
200-600	88	7.4	5	16.3	7	6.5	3	43.2	5	9.7	4	15.6	10	0.5	2
	89	4.6	6	2.3	6	1.6	3	7.1	4	2.1	16	.	.	0.0	2
	90	3.6	6	0.1	4	13.6	2	2.0	2	4.9	7	0.1	4	0.9	2
	91	1.0	5	0.0	3	0.4	2	8.2	5	0.5	8	5.9	5	0.8	2

AREA=CANADA

KG PR HOUR		SUBAREA			
		C1		C3	
		GRL. HALIBUT		GRL. HALIBUT	
		MEAN	N	MEAN	N
DEPTH	YEAR				
200-300	90	.	.	0.5	2
	91	.	.	1.3	1
300-400	88	2.3	3	13.9	3
	89	2.3	3	6.7	3
	90	3.2	2	21.3	2
	91	4.8	2	6.2	3
400-600	88	33.0	1	.	.
	89	1.0	1	21.6	3
	90	.	.	8.5	2
	91	13.4	1	17.1	1

AREA=WEST

KG PR HOUR		SUBAREA											
		W1		W2		W3		W4		W5		W6	
		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR												
150-200	88	0.0	3	0.5	4	0.4	4	0.6	7	0.4	4	.	.
	89	1.0	2	0.1	3	0.4	4	0.4	8	0.0	4	.	.
	90	0.5	2	0.0	2	0.4	3	0.0	6	0.0	3	0.0	2
	91	0.0	4	0.1	2	0.0	3	0.2	5	0.7	2	0.0	2
200-300	88	11.0	9	2.6	4	4.5	9	1.2	3	1.1	7	.	.
	89	4.8	4	3.8	5	0.6	10	1.3	3	0.4	7	.	.
	90	0.9	8	2.0	3	0.3	5	0.6	2	0.1	5	0.0	1
	91	0.2	6	4.0	3	0.6	6	4.7	2	0.2	4	3.7	1
300-400	88	28.6	14	39.3	2	12.5	2	60.1	2	1.4	3	.	.
	89	8.7	11	2.3	3	13.1	3	5.5	2	3.9	4	.	.
	90	11.6	11	8.2	2	7.2	5	2.4	2	0.1	2	0.9	2
	91	12.1	10	40.1	3	5.7	3	8.1	2	4.0	2	0.0	1
400-600	88	17.5	1	43.4	2	50.1	8	53.8	3	25.3	4	.	.
	89	1.6	1	18.2	2	3.5	4	1.5	3	5.7	5	.	.
	90	0.5	2	75.8	2	30.3	4	10.2	3	3.4	4	5.4	1
	91	3.8	2	97.0	1	50.3	5	8.6	2	3.7	3	3.4	3

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

AREA=NORTH

BIOMASS TONS		SUBAREA													
		N1		N2		N3		N4		N5		N6		N7	
		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR														
200-600	88	232	5	1506	7	24	3	838	5	793	4	1730	10	5	2
	89	213	6	332	6	8	3	174	4	246	16	.	.	0	2
	90	112	6	9	4	39	2	33	2	410	7	10	4	9	2
	91	26	5	0	3	1	2	147	5	26	8	715	5	6	2

AREA=CANADA

BIOMASS TONS		SUBAREA			
		C1		C3	
		GRL. HALIBUT		GRL. HALIBUT	
		MEAN	N	MEAN	N
DEPTH	YEAR				
200-300	90	.	.	2	2
	91	.	.	7	1
300-400	88	11	3	136	3
	89	16	3	91	3
	90	18	2	185	2
	91	24	2	63	3
400-600	88	75	1	.	.
	89	4	1	157	3
	90	.	.	45	2
	91	31	1	76	1

AREA=WEST

BIOMASS TONS		SUBAREA											
		W1		W2		W3		W4		W5		W6	
		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT		GRL. HALIBUT	
		MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N	MEAN	N
DEPTH	YEAR												
150-200	88	0	3	8	4	8	4	16	7	7	4	.	.
	89	25	2	2	3	11	4	20	8	0	4	.	.
	90	11	2	0	2	8	3	1	6	0	3	0	2
	91	0	4	1	2	0	3	7	5	11	2	0	2
200-300	88	425	9	58	4	163	9	19	3	38	7	.	.
	89	298	4	116	5	35	10	28	3	14	7	.	.
	90	41	8	45	3	11	5	10	2	4	5	0	1
	91	6	6	78	3	23	6	76	2	7	4	46	1
300-400	88	2091	14	459	2	277	2	318	2	19	3	.	.
	89	950	11	35	3	430	3	45	2	96	4	.	.
	90	943	11	114	2	193	5	15	2	1	2	12	2
	91	870	10	456	3	120	3	48	2	55	2	0	1
400-600	88	118	1	167	2	1255	8	794	3	479	4	.	.
	89	14	1	114	2	143	4	34	3	212	5	.	.
	90	3	2	362	2	996	4	140	3	87	4	42	1
	91	26	2	470	1	1292	5	137	2	84	3	24	3

Table 4 Total estimated biomass of Greenland halibut (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)	5068	56%	961	45%	622	44%	921	162%
CANADA(C1+C3)	216	120%	256	63%	250	72%	201	33%
WEST (W1-W6)	6656	26%	2528	27%	2992	22%	3832	35%
Total	11940		3745		3864		4963	

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

Area\year	1988 Abundance	1990 Abundance	1991 Abundance
NORTH (N1-N7)	47	5	12
CANADA(C1+C3)	1.6	2	2
WEST (W1-W6)	92	29	56
Total	140.6	36	70

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

General Linear Models Procedure

Dependent Variable: LOGGHL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	3296.181894	164.809095	20.14	0.0001
Error	484	3961.274912	8.184452		
Corrected Total	504	7257.456806			

R-Square	C.V.	Root MSE	LOGGHL Mean
0.454179	47.60656	2.860848	6.00935666

Source	DF	Type I SS	Mean Square	F Value	Pr > F
SUBAREA	14	770.446023	55.031859	6.72	0.0001
DEPTH	3	2142.388842	714.129614	87.25	0.0001
YEAR	3	383.347029	127.782343	15.61	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SUBAREA	14	499.833686	35.702406	4.36	0.0001
DEPTH	3	2156.041611	718.680537	87.81	0.0001
YEAR	3	383.347029	127.782343	15.61	0.0001

Parameter		Estimate		T for H0: Parameter=0	Pr > ¦T¦	Std Error of Estimate
INTERCEPT		6.544107351	B	7.74	0.0001	0.84555283
SUBAREA	C1	1.470717499	B	1.28	0.2006	1.14752782
	C3	2.325624333	B	2.25	0.0251	1.03479934
	N1	1.864481748	B	1.82	0.0695	1.02479047
	N2	0.311194268	B	0.30	0.7660	1.04512698
	N3	2.283026176	B	1.85	0.0651	1.23473820
	N4	1.140857612	B	1.05	0.2953	1.08892902
	N5	0.346328565	B	0.36	0.7164	0.95278049
	N6	0.751860513	B	0.72	0.4720	1.04444053
	N7	0.071558632	B	0.06	0.9560	1.29760700
	W1	1.244291811	B	1.43	0.1524	0.86817564
	W2	2.818023934	B	3.06	0.0023	0.92081472
	W3	2.167229442	B	2.48	0.0134	0.87279891
	W4	1.950529178	B	2.17	0.0302	0.89717173
	W5	-0.446341345	B	-0.50	0.6156	0.88838915
	W6	0.000000000	B	.	.	.
DEPTH	150-200	-6.433426446	B	-14.96	0.0001	0.43003618
	200-300	-3.580483284	B	-9.11	0.0001	0.39284482
	300-400	-1.098013336	B	-2.86	0.0044	0.38367343
	400-600	0.000000000	B	.	.	.
YEAR	88	1.988333052	B	5.42	0.0001	0.36676389
	89	0.975994775	B	2.64	0.0086	0.36998521
	90	-0.240726475	B	-0.64	0.5232	0.37682970
	91	0.000000000	B	.	.	.

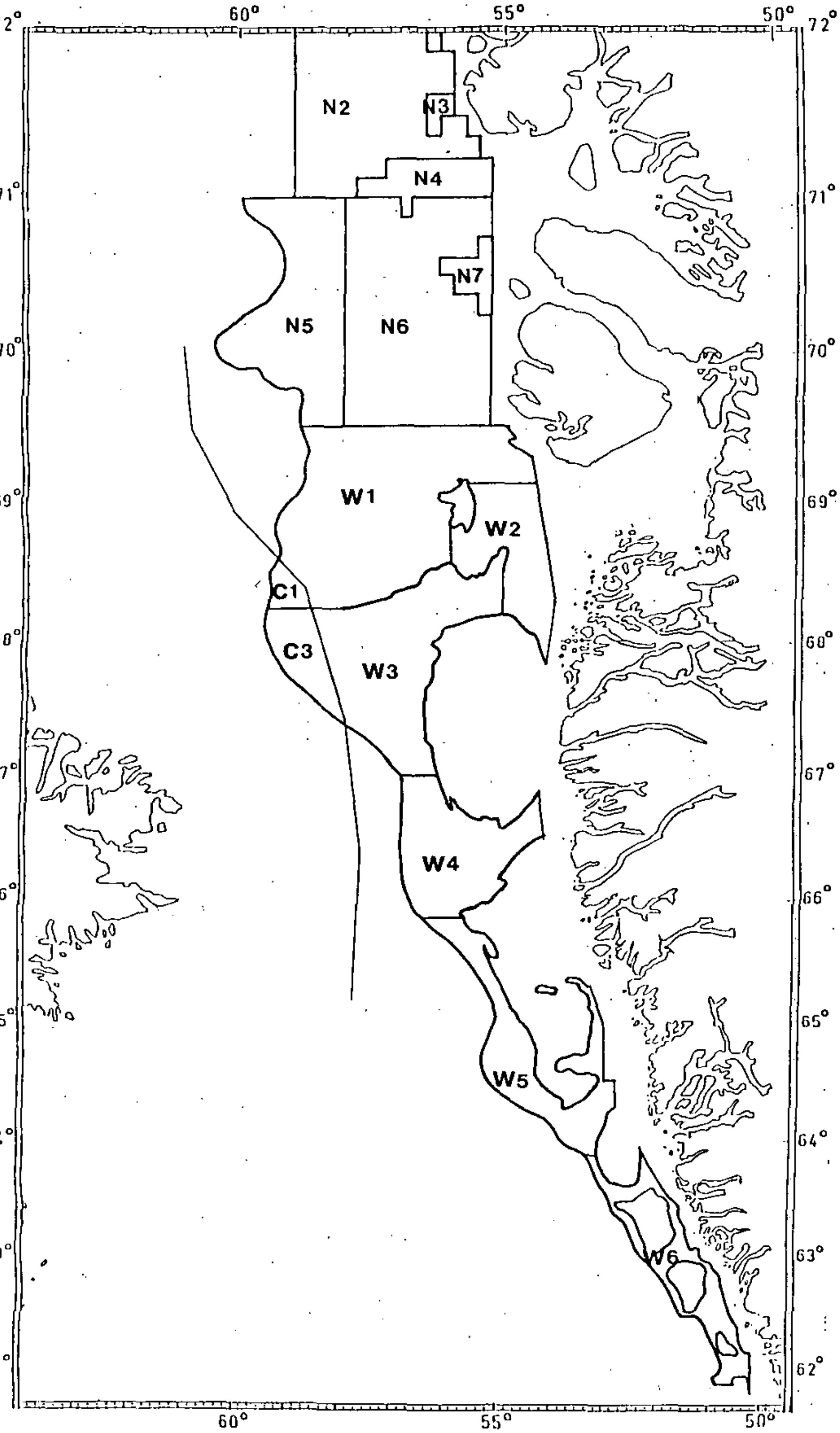

Fig. 1 Area stratification used for the yearly shrimp-trawl-survey off West Greenland conducted by GFRI since 1988.

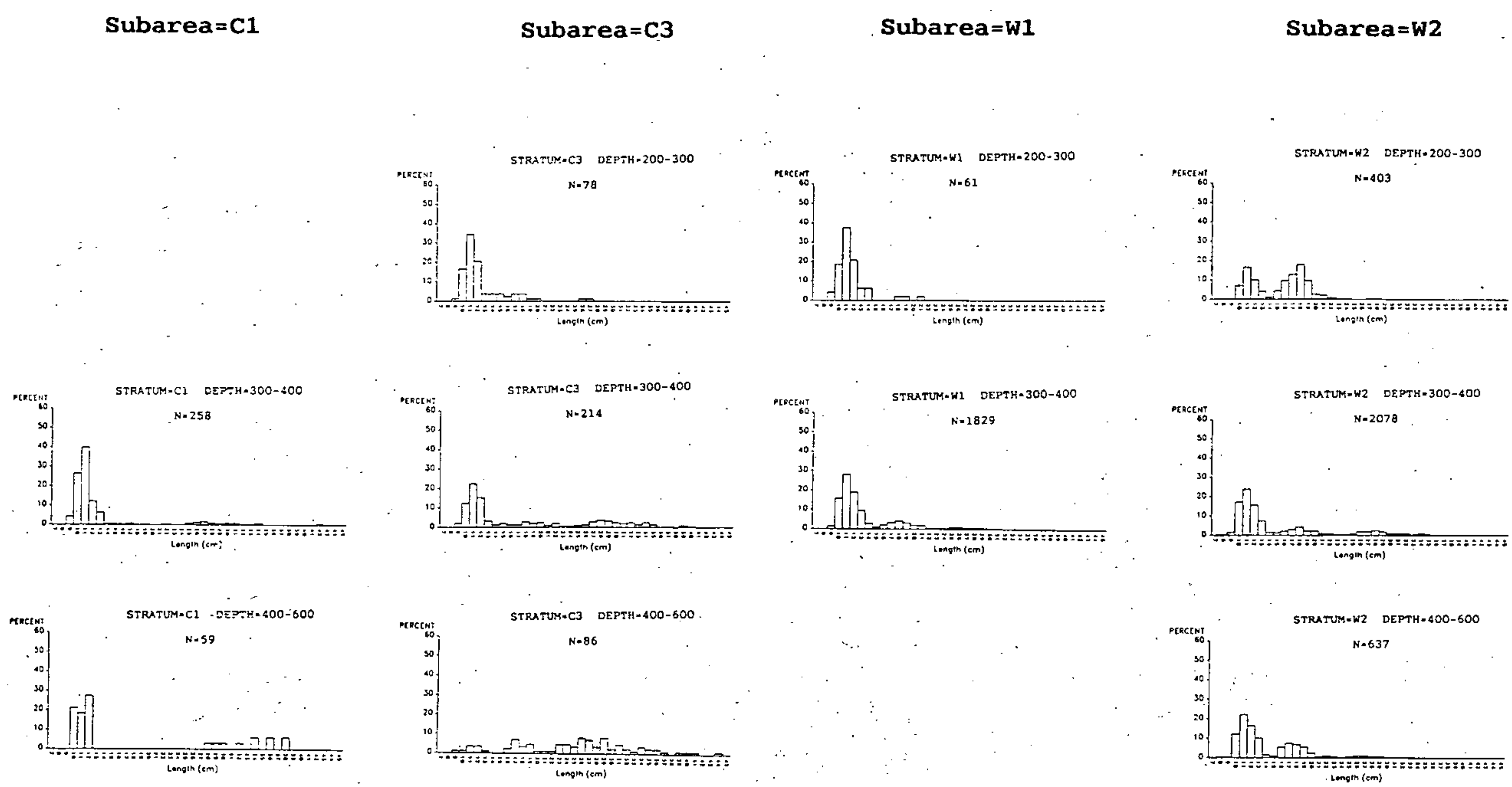

Fig. 2 Frequency distribution of total length by subarea and depth-stratum of Greenland halibut caught during the shrimp-trawl-survey in 1991.

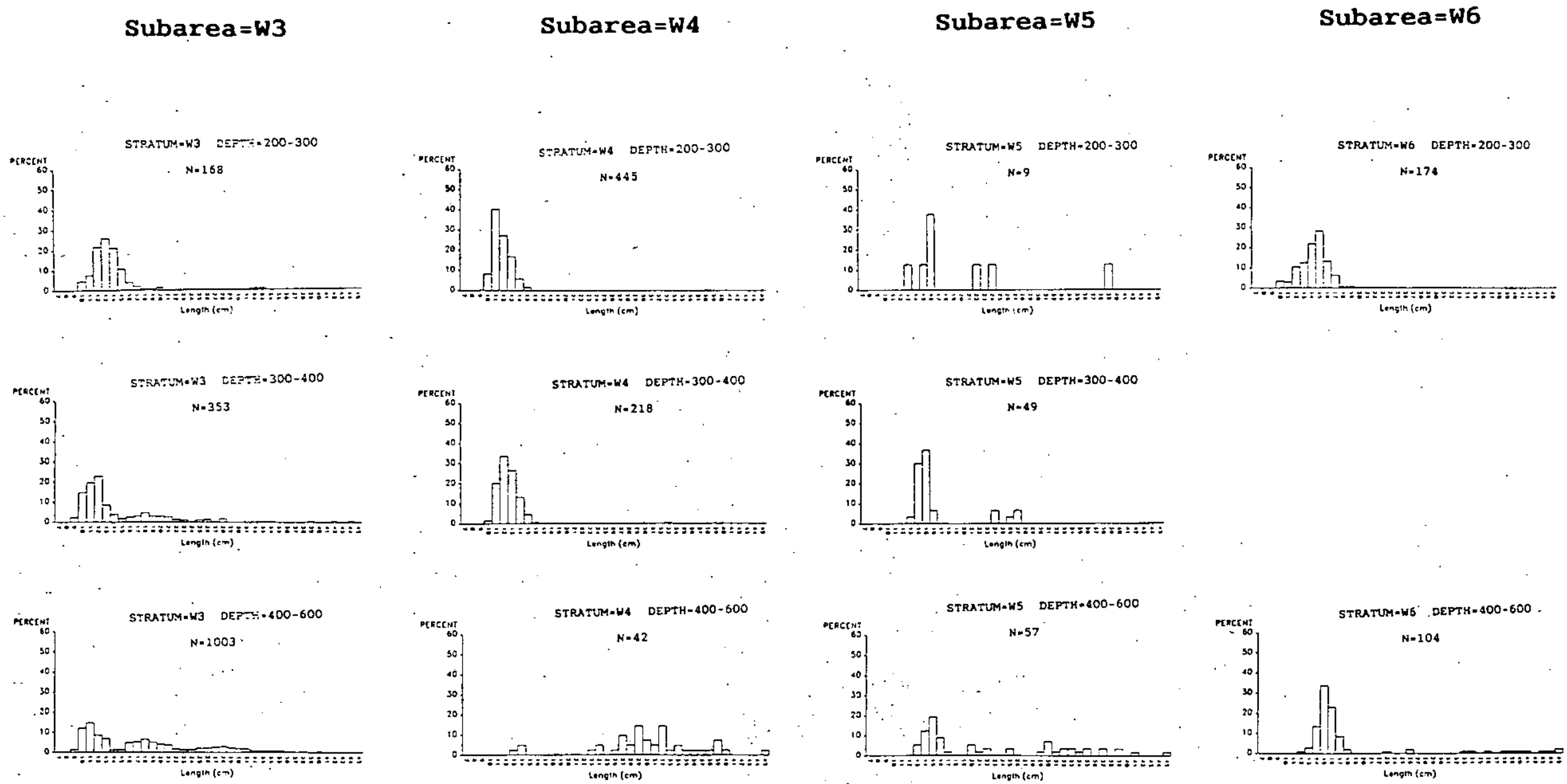

Fig. 2 (Continued) Frequency distribution of total length by subarea and depth-stratum of Greenland halibut caught during the shrimp-trawl-survey in 1991.