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Bottom trawl survey in Baffin Bay, NAFO Divisions 1A, 2010

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Abstract

Greenland has conducted surveys primarily aimed at Greenland halibut in the Baffin Bay in 2001, 2004 and 2010. The biomass and abundance of Greenland halibut was in 2010 estimated as 79.332 tons and $1.04*10^8$ specimens, respectively. The surveys did not cover the same areas but a comparison of the abundance and biomass in areas covered both in 2001 and 2010 showed a small increase in biomass from 46.521 tons in 2001 to 52.428 tons in 2010 while there was a decrease in abundance from 101.8 mill. in 2001 to 63.5 mill. in 2010. The biomass has hence been relatively constant while there were significantly more and smaller fish in 2001. The biomass in the area covered both in 2004 and 2010 was estimated to 47.244 tons and 38.632 tons, respectively while the abundance was estimated at 58.8 mill. and 54.4 mill., respectively.

Introduction

The fish fauna and the hydrographic conditions in the Baffin Bay is generally poorly descried, but in 2001 Greenland and Canada conducted bottom trawl surveys in the southern part of the Baffin Bay covering the area to about 73°N at depths down to 1500 m (Jørgensen 2002, Treble 2002). In 2004 there were conducted two additional surveys by the two countries covering the northern part of the Baffin Bay between 73°N and 78°N (Jørgensen 2005, Treble 2005). In both years there were found significant amounts of Greenland halibut and NAFO first advised a TAC on 8.000 tons for Div. 0A and 1AB. Based on the surveys in 2004 this advised was increased to a TAC on13.000 tons for 2006. This advice has been in place since then.

The primary aim of the survey in 2010 was to investigate the status of the Greenland halibut stock in the area regarding stock distribution, stock size and size composition.

The survey covered the Greenlandic part of the Baffin Bay between 68.50°N and 75.30°N. The area is very large and the effort was focused on depths > 400 m. (A part of the area at depths < 400 m is covered by the combined fish/shrimp survey conducted by Greenland (see SCR this meeting). There was planned 120 hauls between the baseline and the midline towards Canada at depths down to 1500 m.

Canada conducted a similar survey in the Canadian part of the area with the same vessel and gear immediately after the Greenland survey (see SCR this meeting).

Materials and Methods

The survey in 2010 covered the Baffin Bay between 68.50°N and 75.30°N (NAFO Div. 1A) at depths between 400 and 1500 m and took place during September 25 and October 12.

Stratification

The survey covered NAFO Div. 1A between 68.50°N and 75.30°N and between the 3-nm line and the midline to Canada at depths between 400 and 1 500 m. The survey area was stratified in 5 depth strata 401-600, 601-800, 801-1 000, 1 001-1 200, 1 201-1 500 m. The depth stratification was based on depth contour maps from NOAA and the area of each stratum was measured using "MapInfo Version 7.0" (Table 1).

The survey was planned as a Stratified Random Bottom Trawl Survey with in total 120 hauls. Basically the number of hauls allocated to each stratum was proportional to the stratum area, but as the survey was aimed at Greenland halibut, the number of haul allocated to the shallower depth strata were reduced while the number of hauls allocated to deeper strata was increased. The hauls in each stratum were distributed according to Kingsley *et al*., 2004 by a method that combines the use of a minimum between-stations-distance rule (buffer zone) with a random allocation scheme.

Vessel and gear

The survey was conducted by the 722 GRT trawler PAAMIUT, using an ALFREDO III trawl with a mesh size on 140 mm and a 30-mm mesh-liner in the cod-end as in previous years. The ground gear was of the rock hopper type. The trawl doors were Greenland Injector weighing 2 700 kg. Further information about trawl and gear is given in Jørgensen, 1998b.

A Furuno net sonde mounted on the head rope measured net height. Scanmar sensors measured the distance between the trawl doors. Wingspread, taken as the distance between the outer bobbins, was calculated as:

distance between outer bobbins = 10.122 + distance between trawl doors * 0.142

This relationship was estimated based on flume tank measurements of the trawl and rigging used in the survey (Jørgensen, 1998b).

Trawling procedure

Towing time was usually 30 min, but towing time down to 15 min was accepted. Average towing speed was 3.0 kn. Towing speed was estimated from the start and end positions of the haul, or in a few cases based on GPS observations (mean of records made every 5 min. during the haul). Trawling took place day and night.

Near-bottom temperatures were measured, by 0.1^{o}C, by a Seastar sensor mounted on an otter door.

Handling of the catch

After each haul the catch was sorted by species and weighed and the number of specimens recorded. Most fish species were sexed and measured as total length (TL) to 1.0 cm below. Grenadiers were measured as pre anal fin length (AFL) to 1.0 cm below. In case of large catches subsamples of the catch were measured.

Sponges and corals were identified according to NAFO identification manuals.

Biomass and abundance estimates were obtained by applying the swept area method (estimated trawling speed * estimated bobbin spread*trawling time) taking the catchability coefficient as 1.0. All catches were standardized to 1 km^2 swept prior to further calculations.

Results and Discussion

In total 93 successful hauls were made and all depth strata were covered. Haul by haul information on catches of Greenland halibut, depth, temperature etc. is given in Appendix 1 and the distribution of hauls by strata is given in Table 1.

In total 47 species or groups of fish species were recorded (Appendix 2).

Greenland halibut (*Reinhardtius hippoglossoides*)

Greenland halibut was caught in all hauls (Fig. 1, Appendix 1) and the biomass at 400-1500 m was estimated at 79332 tons (Table 1). The abundance was estimated at $1.04*10^8$ (Table 2). The highest densities in terms of weight (2.132 tons km^{-2}) were found at depths between 1001 and 1200 m, while the highest densities in terms of number (2170.4 specimens km^{-2}) were found at depths between 801 and 1000 m.

The survey area covered more then 6.5 degrees latitude (> 700 km). A GLM based on the standardized catches in the 93 trawl hauls (model: log(weight)=position depths-stratum, Class depth-stratum), where position is northern latitude and depth stratum are the five dept strata given in Table 1, showed that there was no correlation between latitude and catch neither in terms of weight (p=0.255) (Appendix 3) nor numbers (p=0.278) (Appendix 4) indicating that the biomass and abundance is rather evenly distributed in the area. The differences in catches by depth stratum was, however, highly significant, both in terms of weight and number (p< 0.0001).

There were conducted surveys in the area in 2001 (Fig. 2) and 2004 but the surveys did not cover the exactly the same area and depths as in 2010. The survey in 2001 (Jørgensen 2002) covered the area to 74° N. If the area covered in 2001 and 2010 are compared, the biomass was estimated at 46.521 tons (S.E. 5.234) in 2001 compared to 52.428 tons (S.E. 9.646) in 2010 while the abundance was estimated at 101.8 mill. (S.E. 14.0 mill.) and 63.5 mill. (S.E. 11. 8 mill), respectively. The biomass has hence been relatively constant while there were more and smaller fish in 2001.

In 2004 the Northern Baffin Bay was surveyed (Jørgensen 2005) (Fig. 3). The biomass in the area covered both in 2004 and 2010 (73°N - 75°30’N, 400-1500 m) was estimated to 47.244 tons (S.E 6.201) in 2004 compared to 38.632 tons (S.E. 3.306) in 2010, while the abundance was estimated at 58.8 mill. (S.E. 6.6 mill.) and 54.4 mill. (S.E. 3.8 mill.), respectively. The 2004 estimate was, however, to some extend driven by a few large catches.

The biomass seams to have been relatively stable during the years, while the abundance seems to have decreased somewhat.

Table 1. Biomass (tons) and mean catch per tow standardized to km^2 (tons) of Greenland halibut with S.E by depth stratum. Number of planned hauls in ().

Depth	Area	Hauls	Mean km^{-2}	Biomass	S.E.
401-600	35191	10 (15)	0.350	12310.0	1979.0
601-800	33522	15 (25)	0.666	22333.8	5442.3
801-1000	10088	25 (30)	1.719	17338.2	2134.1
1001-1200	6191	21 (25)	2.132	13198.6	1802.4
1201-1500	9107	22 (25)	1.554	14151.5	2678.1
All	94099	93 (120)	0.843	79332.0	6964.9

Table 2. Abundance and mean catch per tow standardized to km^2 of Greenland halibut with S.E by depth stratum. Number of planned hauls in ().

Depth	Area	Hauls	Mean km^{-2}	Abundance	S.E.
401-600	35191	10 (15)	700.4	24647097	3623067
601-800	33522	15 (25)	1020.8	34218683	6463344
801-1000	10088	25 (30)	2170.4	21895079	2881261
1001-1200	6191	21 (25)	2021.2	12513484	1619093
1201-1500	9107	22 (25)	1202.5	10951601	2115866
All	94099	93 (120)	1107.6	1.04E+08	8384596

The length ranged from 20 cm to 105 cm (excluding a few larvae on 7-8 cm). The overall length distribution (weighted by stratum area) was totally dominated by a mode at 45 cm, while the mode was at 46 cm at depths > 800 m (Fig. 4). Generally the length distributions in the deeper depth strata were dominated by a single mode and fish size increased with depth (Fig. 5) as seen in previous surveys (Jørgensen, 1997b). Fig. 6 shows the length distribution in comparable areas in.

Temperature

The bottom temperature ranged from -0.2°C to 4.5°C (Appendix 1) and the mean temperature was gradually decreasing by depth (Table 3).

Table 3. Mean temperature, S.E and number of observations by depth stratum.

Div.	Depth stratum (m)														
	401-600			601-800			801-1000			1001-1200			1201-1500		
	°C	SE	n	°C	SE	n	°C	SE	n	°C	SE	n	°C	SE	n
1A	2.3	.07	10	1.7	.21	15	1.1	.05	25	0.7	.05	21	0.2	.04	22

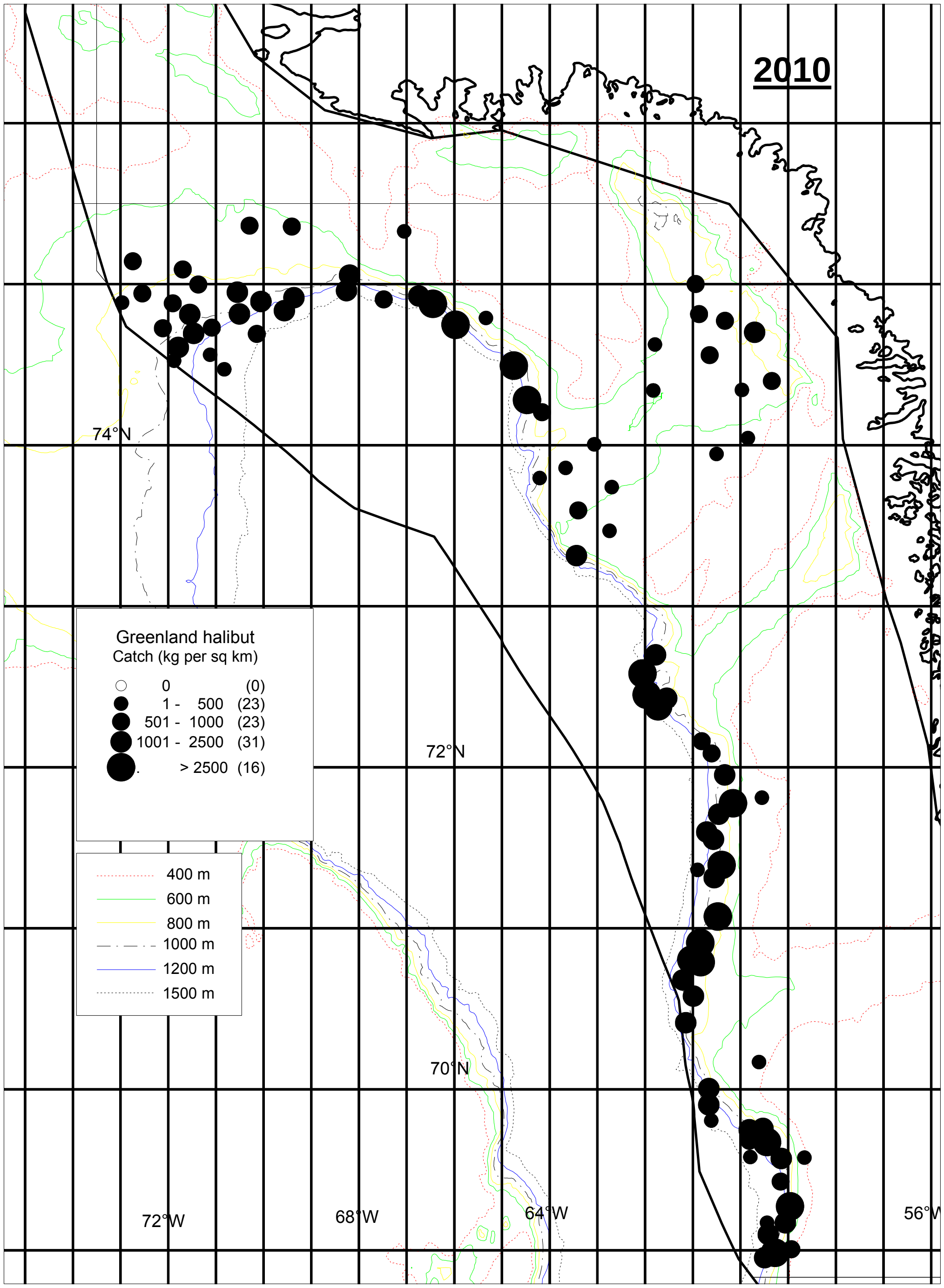

Fig. 1 Distribution of catches of Greenland halibut in 2010 in kg km^{-2}.

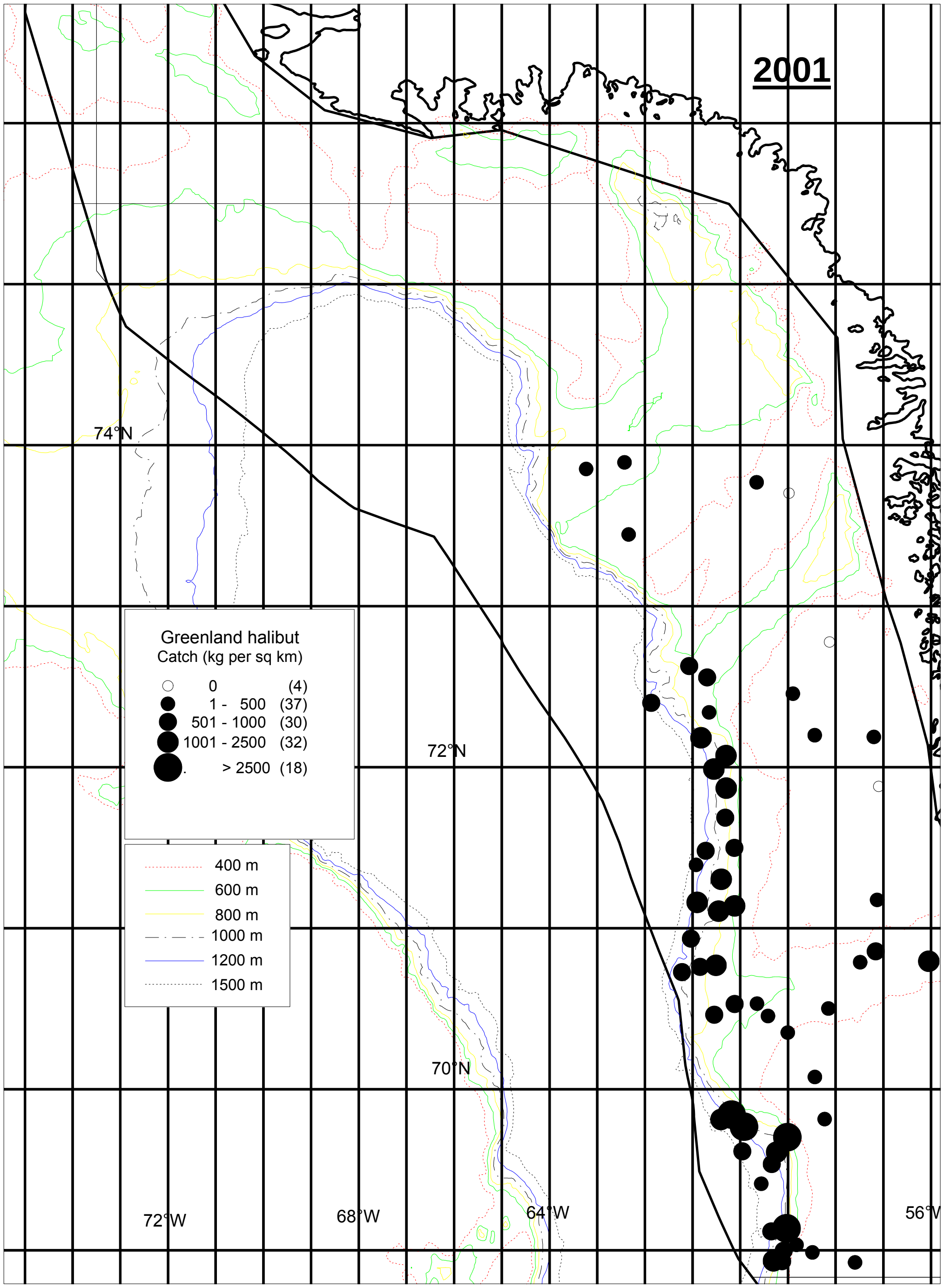

Fig. 2 Distribution of catches of Greenland halibut in 2001 in kg km^{-2}

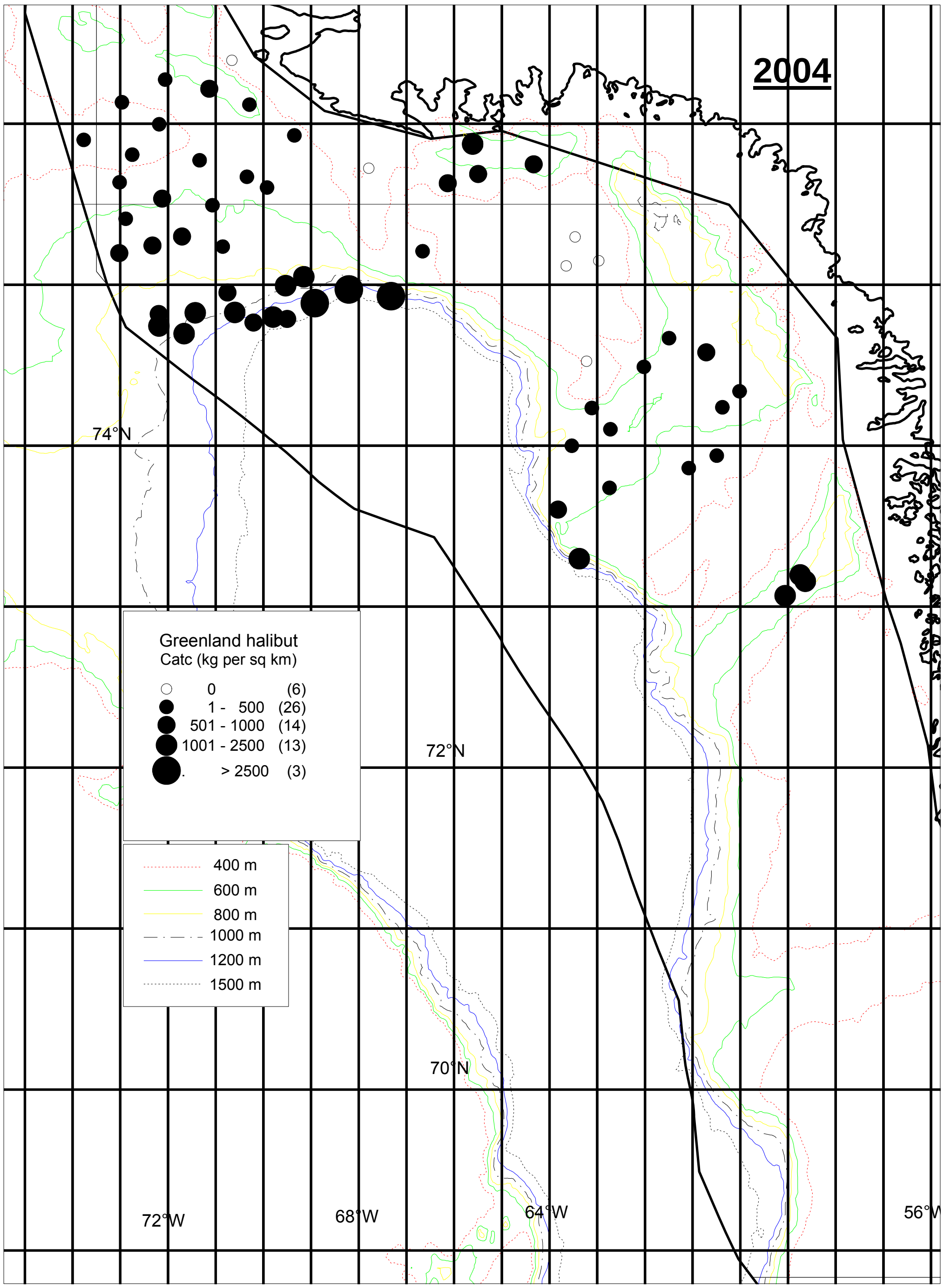

Fig. 3. Distribution of catches of Greenland halibut in 2004 in kg km^{-2}

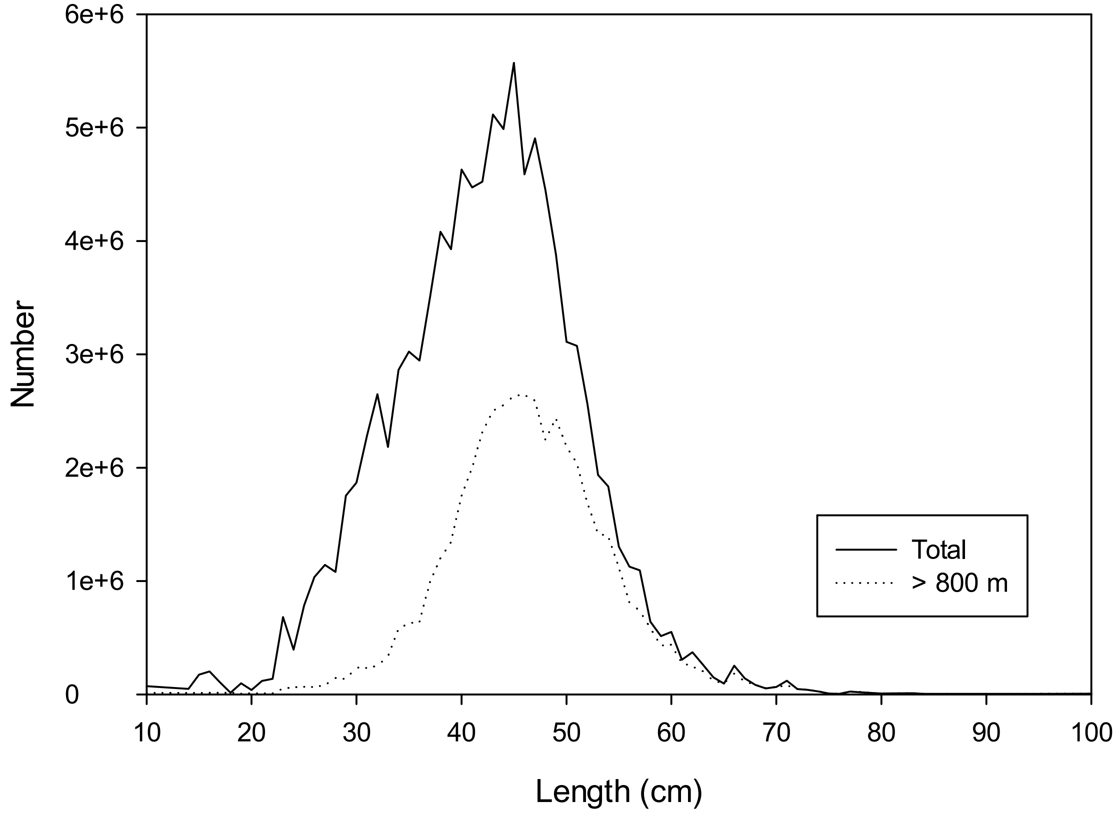

Fig. 4. Length distribution of Greenland halibut in 2010. Total 400-1500 m, > 800m 800-1500 m.

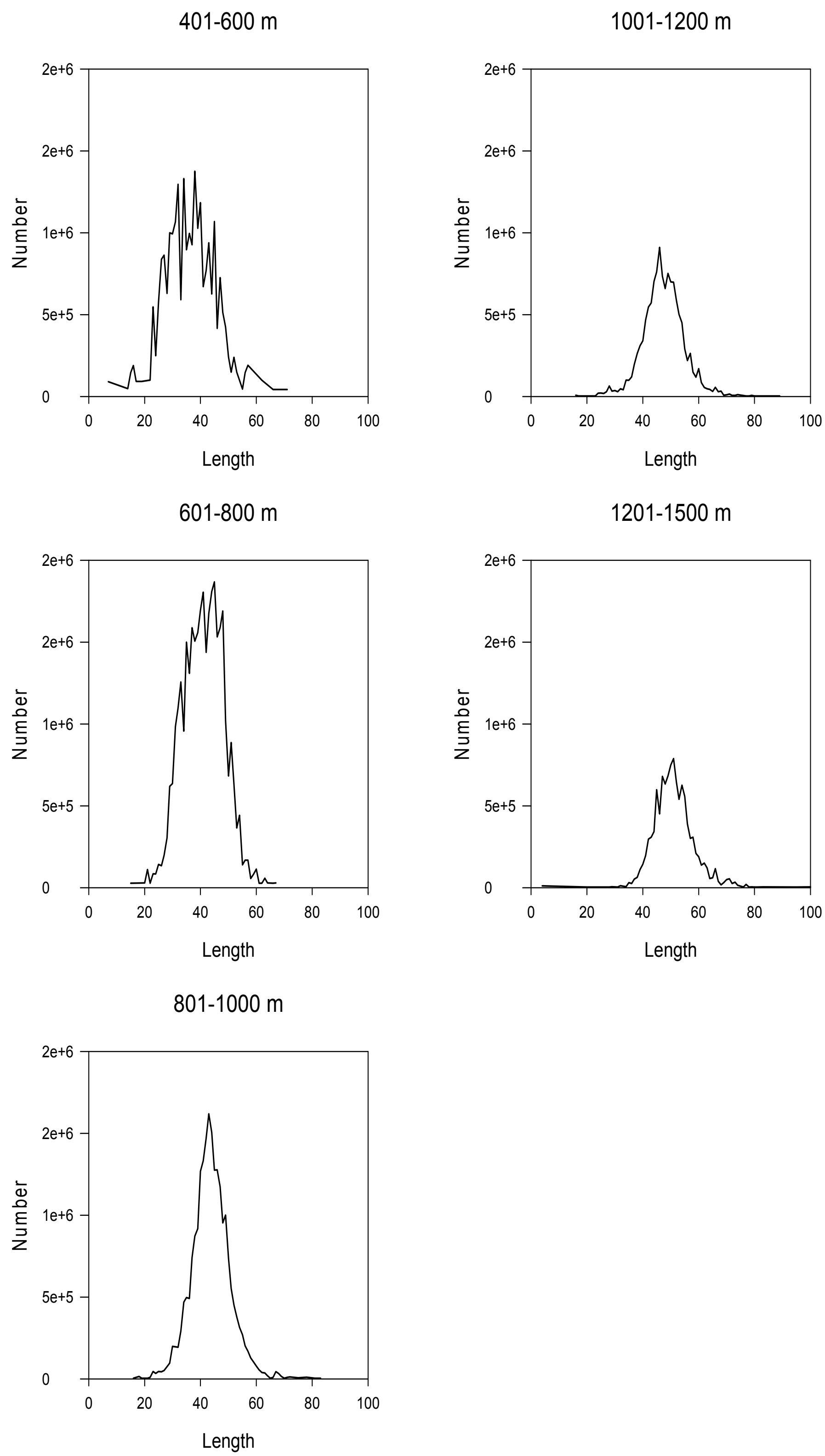

Fig. 5. Length distribution of Greenland halibut by depth stratum.

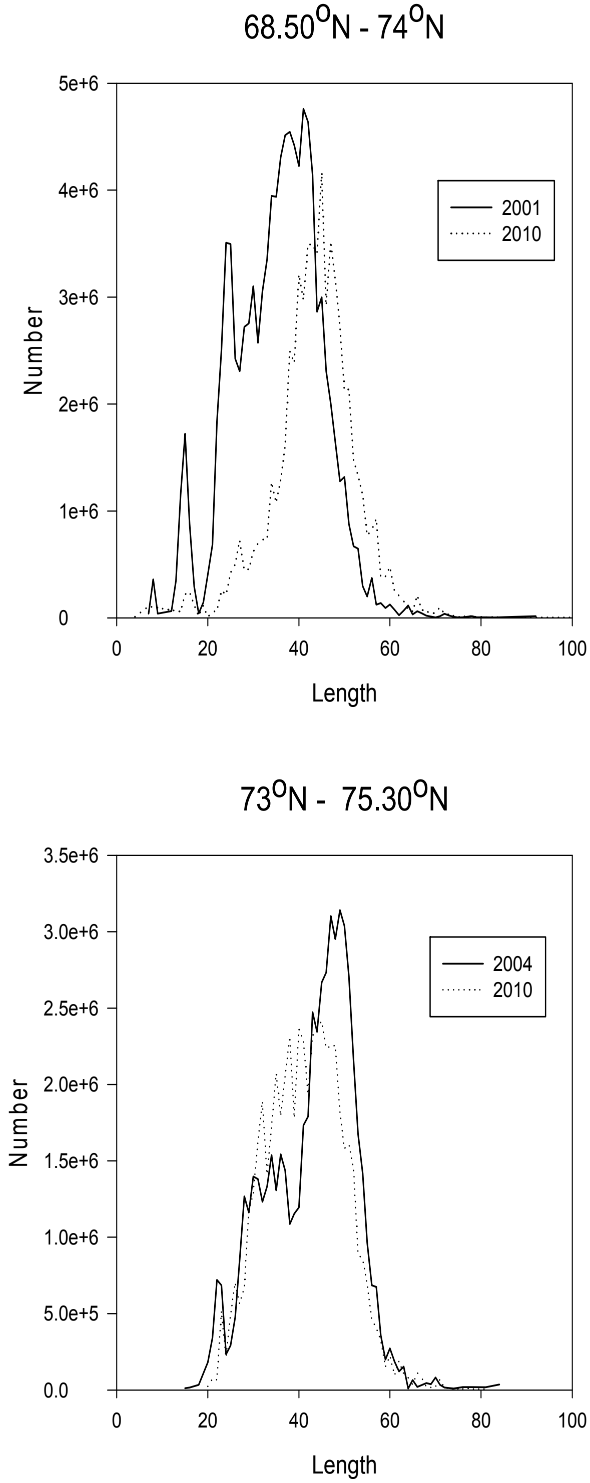

Fig. 6. Length distribution of Greenland halibut in different surveys in comparable areas and depths.

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Appendix 1. Catch weight and - numbers (not standardized to kg/km^2) of Greenland halibut by haul. Depth in m, swept area (Area) in km^2 and bottom temperature in °C. (Temp)   Invalid stations are excluded.

Station no	Area	Depth	Temp	Greenland halibut Weight	Greenland halibut Number
1	0.0723	484	2.1	49.1	81
2	0.0471	828	1.2	119.8	184
3	0.0819	1266	0.4	117.6	85
4	0.0859	1360	0.2	117.3	78
5	0.0825	1436	0.0	12.7	11
6	0.0763	1015	1.1	97	146
7	0.0820	886	1.2	304.3	479
8	0.0826	1309	0.3	56.8	46
9	0.0392	412	2.6	3.6	7
10	0.0823	1070	0.9	146.3	151
11	0.0838	1401	0.0	22.1	19
12	0.0550	1253	0.5	32.6	25
13	0.0760	1074	0.8	237.9	228
14	0.0862	862	1.0	163.1	203
15	0.0828	1055	0.8	190.7	198
16	0.0776	1451	-0.2	29	21
17	0.0786	1258	0.5	124.8	81
19	0.0809	906	1.0	181.1	223
20	0.0782	447	2.1	11.4	27
21	0.0536	913	1.2	84.7	110
22	0.0825	897	1.1	175.6	220
23	0.0431	1161	0.7	75.7	88
24	0.0783	1149	0.7	259.8	237
25	0.0400	865	1.1	183.7	241
26	0.0831	1135	0.7	241.7	204
27	0.0828	954	1.2	260.8	268
28	0.0771	1137	0.7	110	109
29	0.0816	966	1.0	230.4	219
30	0.0798	1426	0.0	30.6	27
31	0.0862	1147	0.7	118.6	93
32	0.0786	1271	0.4	124.3	97
33	0.0805	1030	1.0	139.5	135
34	0.0814	706	1.9	233.1	284
35	0.0812	489	2.7	26.7	56
37	0.0844	931	1.3	168.4	171
39	0.0814	1160	0.6	72.9	56
40	0.0410	1317	0.2	23.1	16
42	0.0334	1238	0.5	156.6	114
43	0.0808	835	1.3	126.2	160
44	0.0802	1349	0.2	263.4	198
45	0.0360	1346	0.2	127.4	103
46	0.0758	917	1.2	131.8	159
48	0.0852	1015	1.1	182.1	196
49	0.0386	511	2.5	12.2	22
50	0.0760	634	1.9	52.3	66
51	0.0459	654	1.5	18.6	24
52	0.0758	743	1.3	13.6	18

Station no	Area	Depth	Temp	Greenland halibut	
				Weight	Number
53	0.0813	763	1.4	14.8	18
54	0.0845	837	1.4	35.2	42
55	0.0788	763	1.4	44.2	81
56	0.0386	1105	0.8	123.7	115
57	0.0392	1306	0.3	145.4	121
58	0.0353	489	2.3	16.1	27
59	0.0502	1355	0.1	183.2	153
60	0.0379	1133	0.5	260.8	234
61	0.0785	883	0.6	129.3	148
62	0.0783	1281	0.2	60.4	44
63	0.0697	1249	0.4	151.6	126
64	0.0803	1110	0.7	159.5	143
65	0.0909	1279	0.3	190.6	149
66	0.0877	1450	0.1	46.5	34
67	0.0832	1365	0.0	28.3	22
68	0.0830	1272	0.2	34.9	28
69	0.0845	840	1.6	67.8	95
70	0.0778	720	1.5	38.4	65
71	0.0817	756	1.5	41.1	70
72	0.0763	865	1.5	141.8	194
73	0.0816	762	4.5	48.1	77
74	0.0768	785	1.5	50.1	101
75	0.0836	823	1.5	56.4	118
76	0.0678	439	2.1	12	43
77	0.0802	627	1.4	46.5	77
78	0.0783	644	1.2	49.8	85
80	0.0850	784	1.2	44	79
81	0.0802	750	1.1	58.9	91
82	0.0865	845	1.0	60.2	85
83	0.0386	859	0.8	18.1	23
84	0.0782	983	0.7	51.8	54
85	0.0840	1146	0.3	33.3	30
86	0.0386	1144	0.5	53.6	49
87	0.0809	1133	0.5	141.2	128
88	0.0771	1157	0.4	74.8	71
89	0.0895	967	0.8	102.5	95
90	0.0790	870	1.0	63.1	75
91	0.0831	837	1.0	52.4	80
92	0.0816	888	0.8	97.7	121
93	0.0789	1109	0.5	155.2	123
94	0.0764	1069	0.6	168.7	153
95	0.0487	870	1.0	98.3	119
96	0.0676	541	2.2	31.2	84
97	0.0407	676	1.7	16.8	36
98	0.0823	579	2.2	31.9	46
99	0.0333	558	2.1	15.3	30

Appendix 2. List of species and groups of species recorded in Div. 1A in 2010 with observed maximum catch weight (kg), maximum number per tow, minimum and maximum depth (m), minimum and maximum bottom temperature (°C) and most northern observation, respectively.

Obs	art	species	maxwgt	maxno	mindepth	maxdepth	mintemp	maxtemp	maxpos
1	RHB	Amblyraja hyperborea	37.0	23	489	1451	-0.2	2.7	75.3634
2	RRD	Amblyraja radiata	2.0	4	412	931	1.0	2.6	75.3276
3	CAD	Anarhichas denticulatus	8.1	2	897	1306	0.2	1.1	74.9047
4	CAS	Anarhichas minor	7.5	5	412	447	2.1	2.6	75.3276
5	ANT	Antimora rostrata	0.1	1	888	1144	0.5	0.8	74.9501
6	ACT	Arctogadus glacialis	0.2	3	541	845	1.0	2.2	74.9417
7	ARA	Artediellus atlanticus	0.6	21	412	541	2.1	2.7	75.3276
8	ARU	Artediellus unicatus	0.1	2	447	447	2.1	2.1	70.1691
9	BAT	Bathylagus euryops	0.0	1	1109	1109	0.5	0.5	74.8152
10	BSP	Bathyraja spinicauda	14.2	1	1110	1110	0.7	0.7	74.9158
11	BEG	Benthosema glaciale	0.0	5	412	1436	0.0	2.6	74.5237
12	POC	Boreogadus saida	10.0	454	412	1355	0.1	2.7	75.3566
13	CWE	Careproctus kidoi	0.0	2	1070	1272	0.2	0.9	74.5613
14	CAR	Careproctus reinhardti	0.2	5	579	1161	0.7	4.5	75.3634
15	RNG	Coryphaenoides rupestris	4.0	3	1258	1258	0.5	0.5	69.9045
16	COM	Cottunculus microps	2.8	42	412	1365	0.0	4.5	75.3634
17	LUM	Cyclopterus lumpus	1.3	1	1149	1149	0.7	0.7	70.8036
18	CLM	Cyclothone microdon	0.0	2	1451	1451	-0.2	-0.2	69.8058
19	ONA	Gaidropsarus argentatus	1.2	4	447	1365	0.0	2.1	74.9600
20	ONN	Gaidropsarus ensis	7.1	28	579	1451	-0.2	2.2	75.0564
21	WIT	Glyptocephalus cynoglossus	0.3	1	862	862	1.0	1.0	69.7574
22	GOB	Gonostoma bathyphilum	0.0	3	541	1451	-0.2	2.2	75.0010
23	PLA	Hippoglossoides platessoides	2.5	8	412	1070	0.9	2.6	71.7765
24	ICS	Icelus spatula	0.0	1	627	627	1.4	1.4	75.3566
25	LMC	Lampanyctus macdonaldi	0.0	1	886	886	1.2	1.2	69.2725
26	LIF	Liparis fabricii	7.0	165	412	1451	-0.2	4.5	75.3634
27	LIG	Liparis gibbus	0.2	1	412	412	2.6	2.6	69.5760
28	LAD	Lycodes adolfi	0.1	6	756	1450	0.0	1.6	74.9600
29	LYN	Lycodes eudipleurostictus	1.0	3	439	1451	-0.2	2.5	75.3566
30	LFR	Lycodes frigidus	0.1	1	1109	1109	0.5	0.5	74.8152
31	LYP	Lycodes pallidus	0.7	16	489	1451	-0.2	2.7	75.3634
32	LSE	Lycodes seminudus	1.3	8	489	1365	0.0	2.3	75.1419
33	ELZ	Lycodes sp.	0.4	7	886	1015	1.1	1.2	69.2725
34	LYM	Lycodonus mirabilis	0.0	1	1074	1133	0.5	0.8	74.6941
35	RHG	Macrourus berglax	10.7	23	579	1355	0.1	2.2	75.3566
36	MYP	Myctophum punctatum	0.0	1	837	837	1.4	1.4	73.7956
37	NOT	Notacanthus chemnitzii	3.7	3	835	1309	0.3	1.3	72.4294
38	PAB	Paraliparis bathybius	0.7	9	1030	1436	0.0	1.0	74.9047
39	PAC	Paraliparis copei	0.2	3	1279	1450	0.1	0.3	74.8348
40	GHL	Reinhardtius hippoglossoides	304.3	479	412	1451	-0.2	4.5	75.3634
41	RHO	Rhodichtlys regina	0.2	4	1135	1451	-0.2	0.7	72.5818
42	REG	Sebastes marinus	2.2	6	484	484	2.1	2.1	69.0070
43	REB	Sebastes mentella	3.3	38	412	1401	0.0	2.6	70.5785
44	GSK	Somniosus microcephalus	275.0	1	541	541	2.2	2.2	74.6250
45	STO	Stomias boa	0.1	1	654	763	1.4	1.7	74.3404
46	TRM	Triglops murray	0.3	9	484	1070	0.9	2.1	69.5706
47	TRN	Triglops nybelini	1.1	71	412	1070	0.9	2.7	75.3276

Appendix 3. GLM model vgt=npos stdy. Vgt= log catch weight km^{-2}, npos= latitude, Stdy= depth stratum.

The GLM Procedure

Class Level Information

Class	Levels	Values
STDY	5	6 8 10 12 15

Number of Observations Read 93
Number of Observations Used 93

The GLM Procedure

Dependent Variable: vgt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	37.40680107	7.48136021	14.89	<.0001
Error	87	43.72286919	0.50256171		
Corrected Total	92	81.12967026			

R-Square	Coeff Var	Root MSE	vgt Mean
0.461074	16.72542	0.708916	4.238552

Source	DF	Type III SS	Mean Square	F Value	Pr > F
npos	1	0.66025155	0.66025155	1.31	0.2549
STDY	4	35.28709662	8.82177416	17.55	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.224995788	B	2.61809409	2.76	0.0071
npos		-0.041561238		0.03626006	-1.15	0.2549
STDY	6	-1.376728797	B	0.27122466	-5.08	<.0001
STDY	8	-0.469205436	B	0.25098148	-1.87	0.0649
STDY	10	0.440299679	B	0.20912600	2.11	0.0381
STDY	12	0.643071030	B	0.21684960	2.97	0.0039
STDY	15	0.000000000	B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

Appendix 4. GLM model ant=npos stdy. ant= log number km^{-2}, npos= latitude, Stdy= depth stratum.

```
                                The GLM Procedure

                             Class Level Information

                      Class         Levels    Values

                      STDY               5    6 8 10 12 15


                     Number of Observations Read          93
                     Number of Observations Used          93


                                The GLM Procedure

Dependent Variable: ant

                                         Sum of
      Source                      DF          Squares     Mean Square    F Value    Pr > F

      Model                        5      21.89386087      4.37877217       8.82    <.0001

      Error                       87      43.21262802      0.49669687

      Corrected Total             92      65.10648889


                       R-Square     Coeff Var      Root MSE      ant Mean

                       0.336278      16.09897      0.704767      4.377716


      Source                      DF      Type III SS     Mean Square    F Value    Pr > F

      npos                         1       0.59179644      0.59179644       1.19    0.2780
      STDY                         4      21.35224288      5.33806072      10.75    <.0001


                                                      Standard
             Parameter            Estimate               Error    t Value    Pr > |t|

             Intercept         6.805878168 B      2.60277282       2.61      0.0105
             npos             -0.039347753        0.03604786      -1.09      0.2780
             STDY      6      -0.399204040 B      0.26963744      -1.48      0.1423
             STDY      8       0.240468301 B      0.24951271       0.96      0.3378
             STDY      10      0.927849933 B      0.20790218       4.46      <.0001
             STDY      12      0.848867293 B      0.21558058       3.94      0.0002
             STDY      15      0.000000000 B       .                .         .

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve
      the normal equations.  Terms whose estimates are followed by the letter 'B' are not
      uniquely estimable.
```