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Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

Northwest Atlantic Fisheries Organization

Serial No. N6155 **NAFO SCR Doc. 13/006**

SCIENTIFIC COUNCIL MEETING – JUNE 2013

Survey for Greenland Halibut in NAFO Divisions 1C-1D, 2012

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Abstract

Greenland initiated a survey series covering NAFO Divisions 1CD at depths between 400 and 1 500 m in 1997. The survey is designed as a Stratified Random Bottom Trawl Survey aimed primarily at Greenland halibut and roundnose grenadier. The paper gives biomass and abundance estimates and length frequencies for Greenland halibut, roundnose and roughhead grenadier, and deep sea redfish. The biomass of Greenland halibut was estimated as 64948 tons in 2012, which is the lowest estimate since 2000. The length distribution showed modes around 47 and 52 cm. The biomass of roundnose grenadier was estimated as 1634 tons, which is the highest estimate since 2000 but still very low compared to the level seen in the 80'ies.

Introduction

During 1987-1995 Japan Marine Fishery Resources Research Center (JAMARC) and Greenland Institute of Natural Resources jointly conducted 12 bottom trawl surveys (Jørgensen, 1998a) and four pelagic surveys (Jørgensen, 1997a) at West Greenland as part of a joint venture agreement on fisheries development and fisheries research in Greenland waters. The bottom trawl surveys were aimed primarily at Greenland halibut (*Reinhardtius hippoglossoides*) in NAFO Div. 1B-1D. In 1997 Greenland Institute of Natural Resources continued the bottom trawl surveys series with the Institute's own vessel PAAMIUT, which had been rigged for deep sea trawling. There has unfortunately not been any comparative trawlings between the Japanese research vessel SHINKAI MARU and PAAMIUT making comparisons between the surveys difficult. The PAAMIUT survey traditionally covers NAFO Div. 1CD, but in 2001 the survey area was expanded to include Div. 1A (to 74°N) and Div. 1B and in 2004 the northern part of the Baffin Bay (73°N-77°N) (Div. 1A) was surveyed. In 2010 Div.1A was surveyed to 75.30°N (SCR 11/010).

Materials and Methods

The survey in Div. 1CD in 2012 covered depths between 400 and 1500 m and took place during 12/9-22/9.

Stratification

The survey covered NAFO Div. 1C-1D between the 3-nm line and the midline to Canada at depths between 400 and 1 500 m. The survey area was stratified in NAFO divisions and subdivided in 6 depth strata 401-600, 601-800, 801-1 000, 1 001-1 200, 1 201-1 400 and 1 401-1 500 m. The depth stratification was based on Greenland Geological Survey's 10 m depth contour maps, Canadian maps and depth soundings made during previous surveys. The area of each stratum was measured using "MapInfo Version 4.0" (Table 2).

The survey was planned as a Stratified Random Bottom Trawl Survey with in total 70 hauls. Each stratum was allocated at least two hauls. The remaining hauls were allocated in order to minimize the variance in the estimation of the biomass of Greenland halibut. *i.e.* strata with great variation in the catches of Greenland halibut in the previous years surveys have got relatively more hauls than strata with little variation in the catches. In 2004 a new method of selecting stations was introduced. The method combines the use of a minimum between-stations-distance rule (buffer zone) with a random allocation scheme (Kingsley et al. 2004).

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. The ground gear was of the rock hopper type. The trawl doors were Greenland Injector weighing 2 700 kg. The Injector otter doors replaced the Perfect doors that have been used until 2003. The average net height was 20 cm higher with the new doors compared to the old, but the difference was not statistically significant (95% level) and it was concluded that the net performance has not changed by the introduction of new doors. 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 5 records made 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 one of the otter doors.

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.

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

In strata with one haul only SD was estimated as: SD= biomass or abundance.

Results and Discussion

The survey coverage was relatively poor and only total 50 successful hauls were made out of 70 planned but all depth strata were covered. Haul by haul information on catches, depth, temperature etc. is given in Appendix 1 and the distribution of hauls by strata is given in Table 2.

In total 74 species or groups of fish species were recorded (Appendix 2).

Three hauls were conducted at depths < 400 m in order to take samples for a eDNA experiment, these hauls are not included in the calculations

Greenland halibut (*Reinhardtius hippoglossoides*)

Greenland halibut was caught in all hauls except one (Fig. 1, Appendix 1) and the biomass in Div. 1CD 400-1500 m was estimated at 64 948.8 tons (Table 1 and 2) which is a decrease compared to 86 591.4 tons in 2011 and the lowest in the time series since 2000 (Table 1, Fig. 2). The decrease in biomass is primarily seen in the three deep strata (1000-1500 m) in Div. 1D where the biomass was almost halved in all three strata (Fig 3). The biomass increased in the three shallow strata (400-1000 m) in Div. 1D and in 1000-1200 m in Div. 1C, but these are all strata with small areas and few hauls. The estimate from 2012 is not statistically different (95% level) from the estimates since 2000. The highest densities (in weight) were found at depths > 800 m and in Div. 1D 600-800 m (1 haul). The weighted mean catch per tow showed a decrease from 1.66 tons km^{-2} in 2011 to 1.24 tons km^{-2} (Table 1, Fig 4).

The abundance in was estimated at $54.271*10^6$ which is a decrease compared to $74.978*10^6$ in 2011 and the lowest since 1997 (Table 3, Fig 5). The decrease in abundance was primarily seen in the three deep strata in Div. 1D and in Div. 1C 800-1000 m. The highest density, about 2800 specimens km^{-2}, was seen in Div. 1C 1001-1200 m

Estimated abundance by age in Div. 1CD is given in Table 4 (not updated in 2012, because the otolith reading procedure is under revision).

The offshore recruitment was high in 2005 and 2006 while it was relatively low in 2007 and 2008 (Nygaard and Jørgensen 2012). Whether the decrease in abundance and biomass is a reflection of a decreased recruitment is not clear due to the lack of reliable age data.

The length ranged from 18 cm to 105 cm (excluding a few larvae < 9 cm). The overall length distribution (weighted by stratum area) was dominated by two modes at 52 and 47-48 cm, respectively, where the length distribution uses to be monomodal with a mode around 49 cm. The mode at 52 cm probably reflects the distinct mode at 49 cm in 2011. Very few fish < 40 cm were observed as in the previous years (Fig. 6). Generally the length distributions in the different depth strata were dominated by a single mode and fish size increased with depth and from north to south at the same depth (Fig. 7) as seen in previous surveys (Jørgensen, 1997b).

Table 1. Biomass (tons), mean catch per tow (tons) standardized to km^2 and abundance of Greenland halibut in Div. 1CD and with S.E.

Year	Biomass	S.E.	Mean	S.E.	Abundance ($*10^6$)	S.E.
1997	56 260.2	4 399.6	1.07	0.08	53.613	4.118
1998	70 473.5	8 391.7	1.34	0.16	67.677	7.687
1999	64 398.0	6 912.1	1.27	0.14	61.366	6.265
2000	59 092.4	5 543.3	1.28	0.11	61.710	5.976
2001	77 554.0	13 013.6	1.57	0.26	80.814	14.221
2002	71 932.4	5 613.9	1.56	0.12	71.510	6.223
2003	68 717.2	6 411.9	1.39	0.13	72 556	7.764
2004	75 869.4	5 186.3	1.48	0.10	74.859	5.445
2005	80 865.4	8 365.7	1.54	0.16	73.001	7.317
2006	77 010.3	6 259.6	1.47	0.12	70.715	5.622
2007	74 356.8	9 455.4	1.48	0.19	67.427	8.492
2008	83 465.4	5 456.3	1.60	0.10	72.804	5.334
2009	70 966.2	5 110.3	1.36	0.10	62.507	4.419
2010	75 522.5	5 382.4	1.44	0.10	64.868	5.389
2011	86591.4	5210.4	1.66	0.10	74.978	4.723
2012	64948.8	7379.3	1.24	0.14	54.271	6.815

Table 2. Mean catch per km^2 and biomass (tons) of Greenland halibut by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1C	401-600	3366	2	0.0160	53.9	53.9
	601-800	16120	3	0.5589	9009.5	3168.5
	801-1000	6066	11	1.8277	11087.0	2735.2
	1001-1200	611	2	3.9733	2427.7	738.5
1D	401-600	903	2	0.1162	104.9	54.2
	601-800	1940	1	2.7743	5382.2	.
	801-1000	3874	3	1.7125	6634.3	239.9
	1001-1200	10140	14	1.7356	17599.1	2336.9
	1201-1400	6195	9	1.5749	9756.3	1282.4
	1401-1500	3091	3	0.9362	2893.8	500.9
All				1.2417	64948.8	7379.3

Table 3. Mean catch per km^2 and abundance of Greenland halibut by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1C	401-600	3366	2	41.6	139914.8	139914.8
	601-800	16120	3	588.1	9479827.6	3017143.2
	801-1000	6066	11	1641.5	9957624.1	2441723.2
	1001-1200	611	2	2807.3	1715287.5	286667.5
1D	401-600	903	2	98.1	88617.8	57892.4
	601-800	1940	1	2709.0	5255459.3	.
	801-1000	3874	3	1474.6	5712695.2	323677.0
	1001-1200	10140	14	1217.0	12340601.7	1557597.2
	1201-1400	6195	9	1217.3	7541193.7	1031594.6
	1401-1500	3091	3	659.9	2039764.7	242680.5
All				1037.6	54270986.5	6814989.4

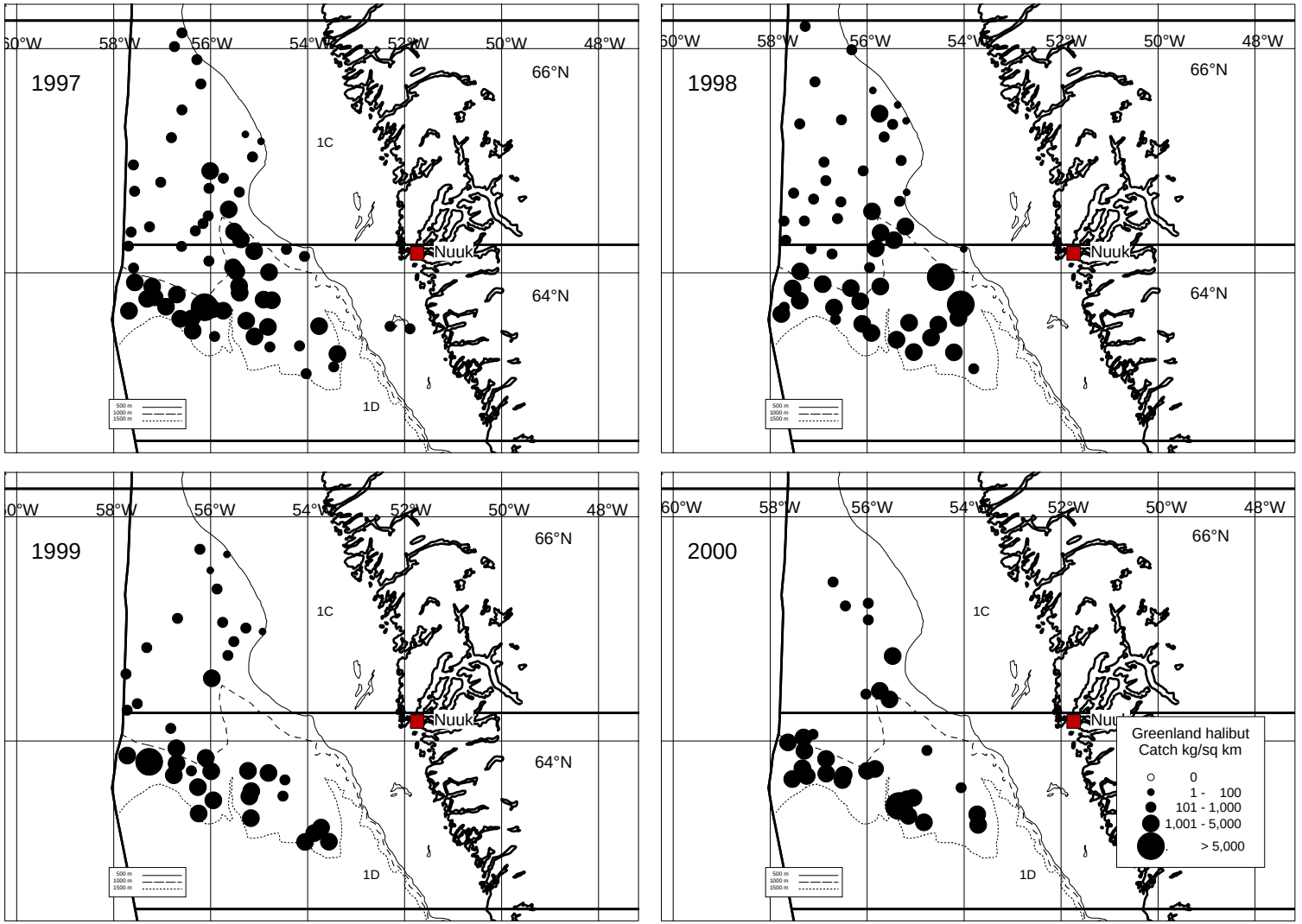

Fig. 1 Distribution of catches of Greenland halibut during 1997-2000 in kg km^{-2}.

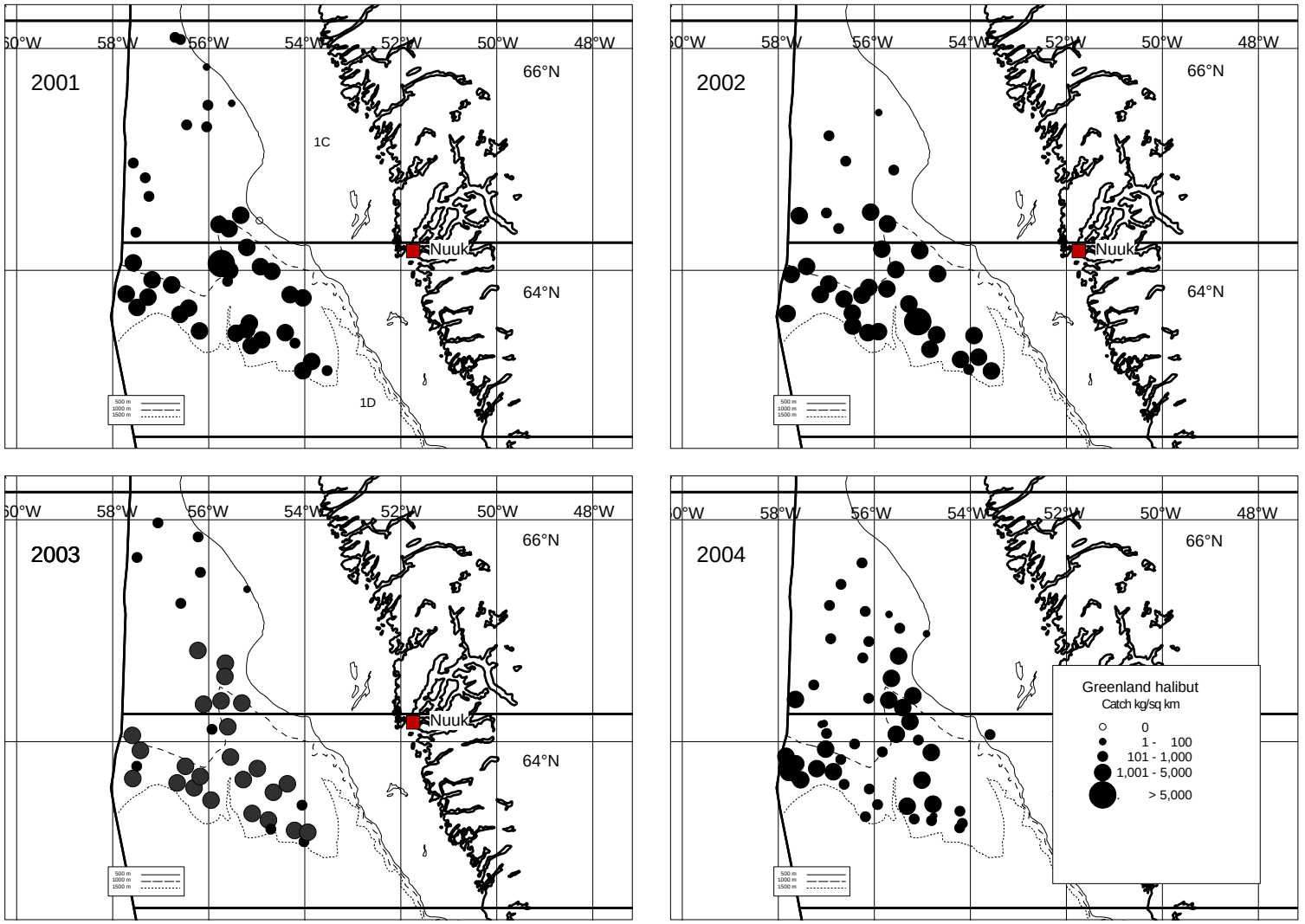

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2001 - 2004 in kg km^{-2}

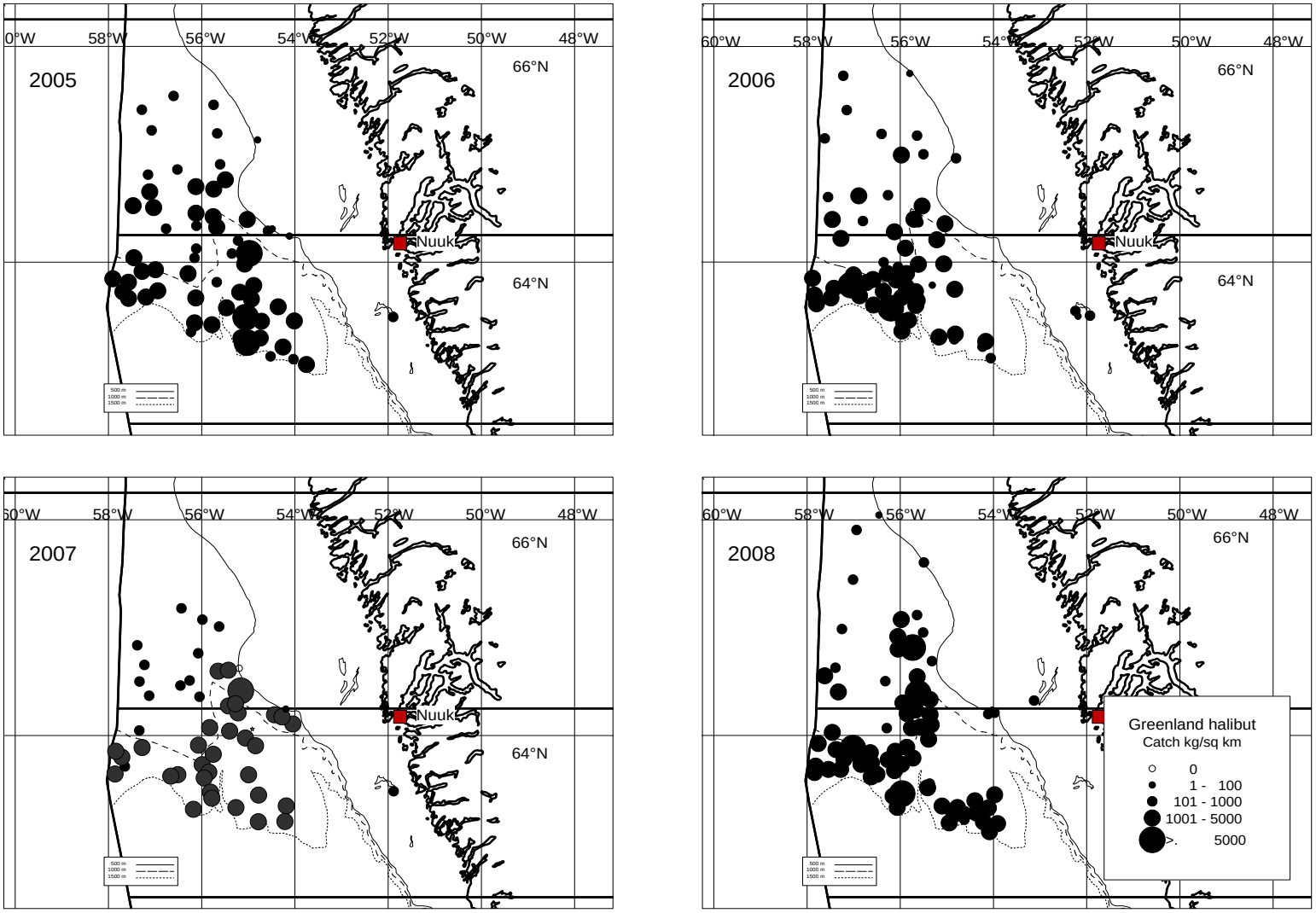

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2005 - 2008 in kg km^{-2}

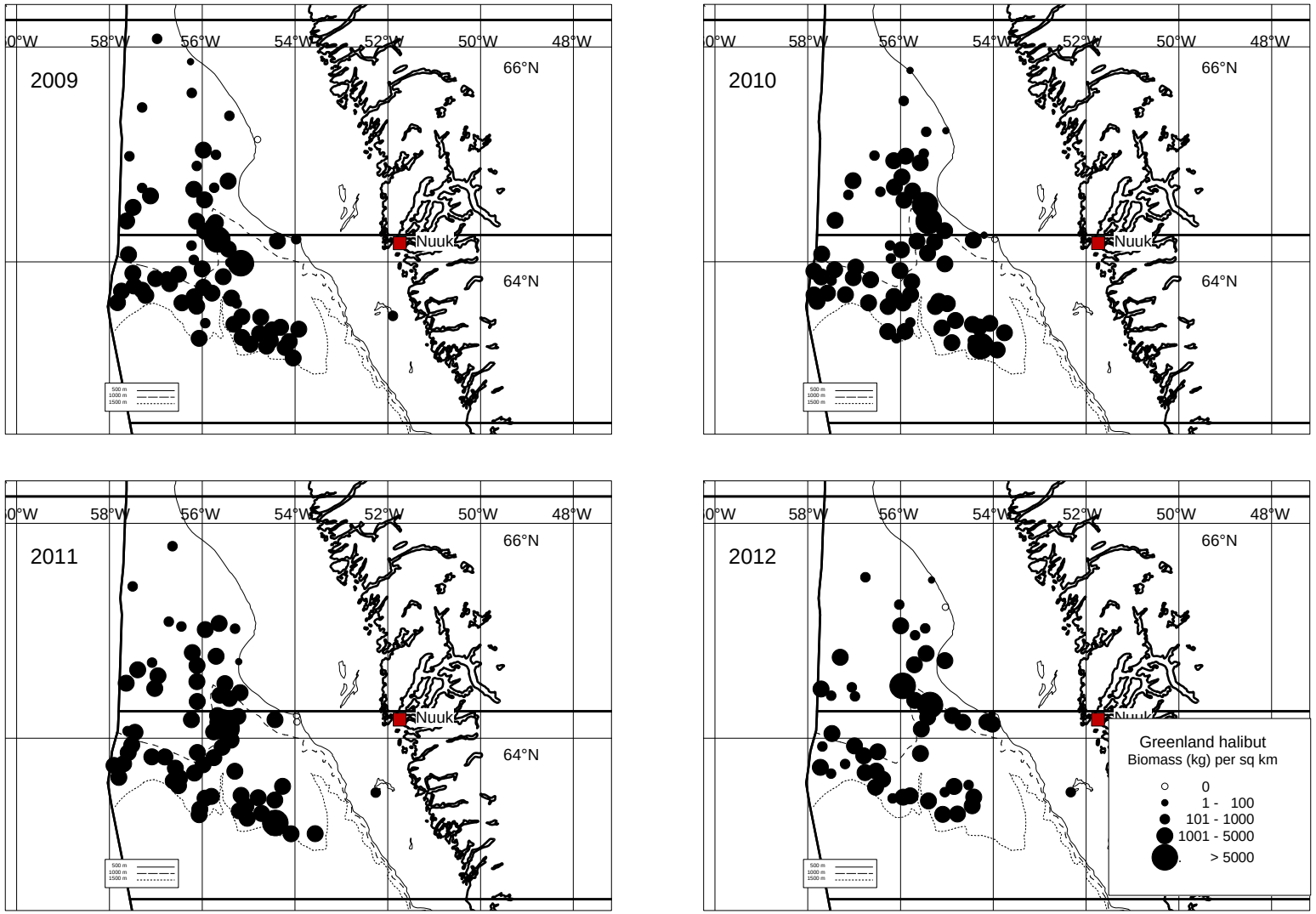

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2009 - 2012 in kg km^{-2}

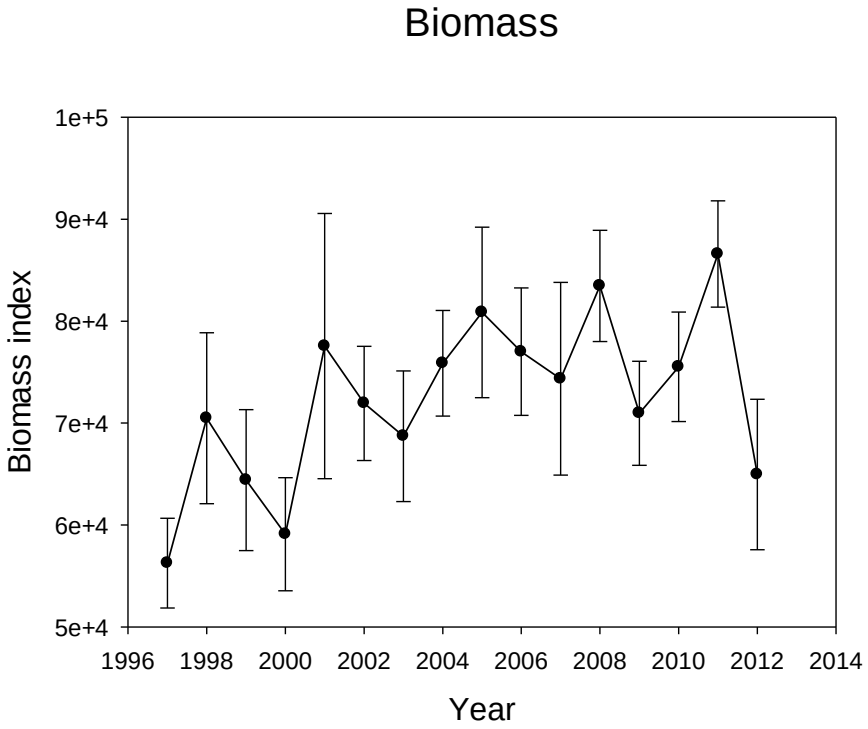

Fig. 2. Biomass (tons) of Greenland halibut in Div. 1CD by year with 1*S.E.

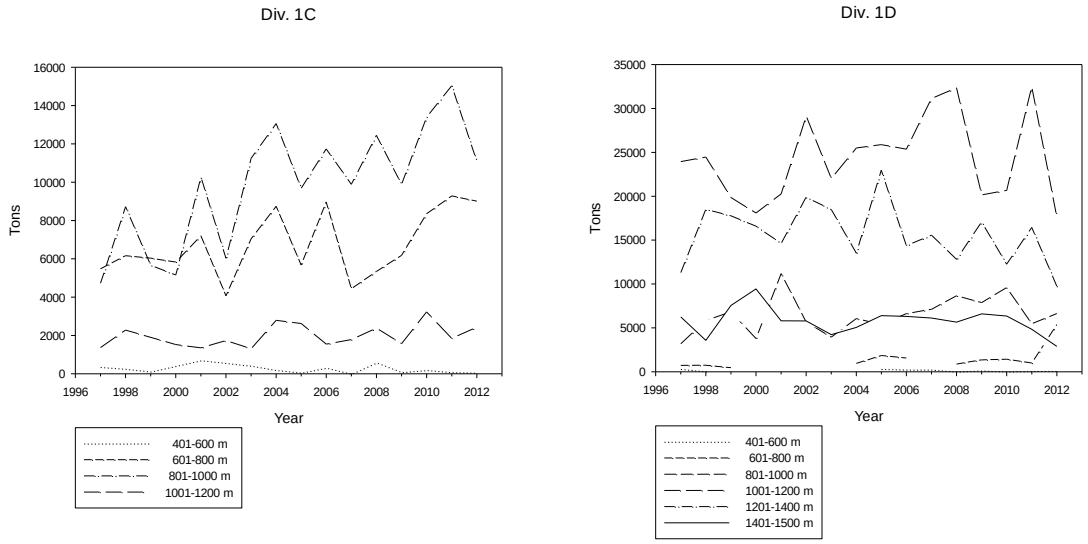

Fig.3 Biomass by Division, depth stratum and year.

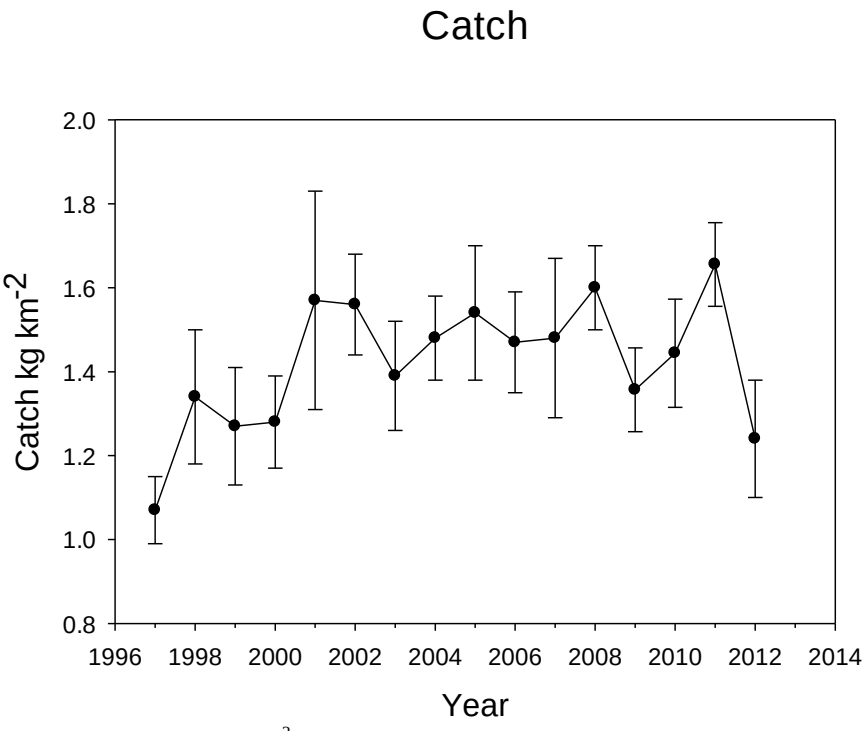

Fig. 4. Mean catch of Greenland halibut km^{-2} km (tons) in Div. 1CD standardized by stratum area with 1*S.E.

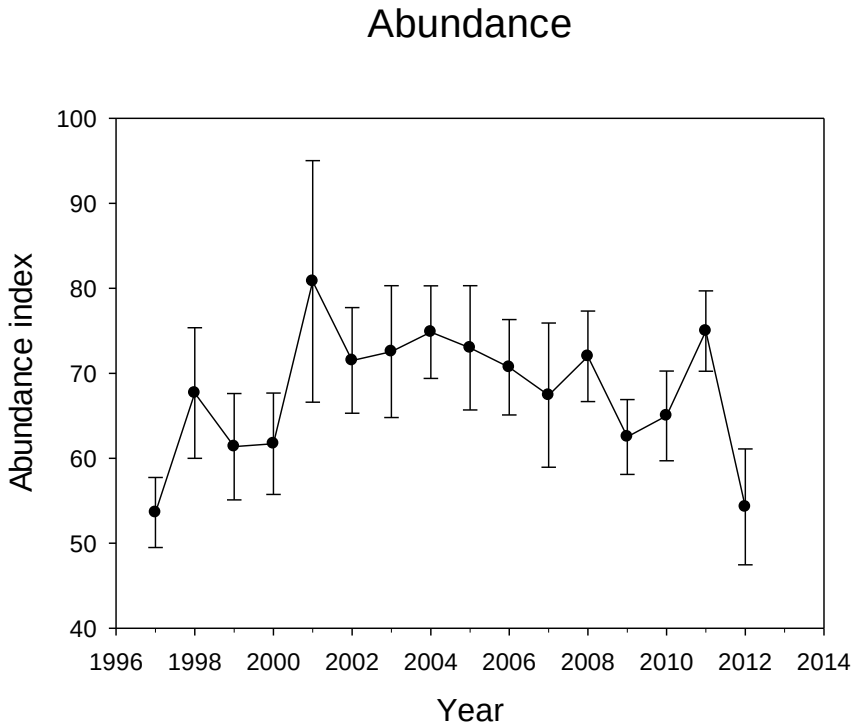

Fig. 5. Abundance (millions) of Greenland halibut in Div. 1CD by year with 1*S.E.

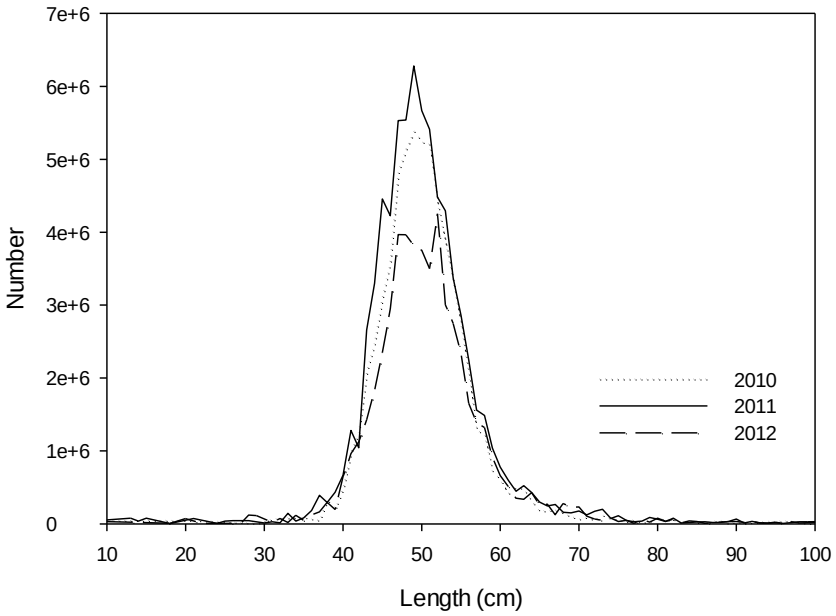

Fig. 6. Overall length distribution of Greenland halibut in numbers (weighted by stratum area) in Div. 1CD by year.

Table 4. Number by age by year of Greenland halibut (excluding larvae, age 0). No data from 2008 and 2010-2012.

AGE	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009
1	0	0	0	78826	15585	71512	833452	314358	200672	132147	0	
2	536130	609093	184098	109496	281013	214536	3187890	255511	201882	641030	99520	613665
3	1704893	3722237	920490	479059	511722	285367	1468105	274564	569831	524114	268062	773577
4	3023773	4662948	4172888	3074341	4835796	2361529	2417001	4465950	1749900	2959669	802718	704747
5	9961295	14760362	11291344	15090231	20601616	11779876	12348567	14877198	12218823	13324592	12509462	7823793
6	15370847	19057854	15893794	16838191	26595603	26697300	21816458	30067732	19867351	20210890	18237159	12339572
7	13558728	14083592	19759852	14711646	17922784	18561065	18499540	14298142	21303055	15509156	19469186	22722253
8	5436358	5766084	4786548	5026106	4674899	6201987	6534966	6252194	12674030	13224793	11815872	9358562
9	1200931	1515966	859124	3214208	2550178	1857799	2403542	1724259	385774	731747	360855	3065130
10	948950	1211419	920490	1040152	780082	1340261	1244102	944766	1881136	1342871	1960085	2058523
11	584382	764751	613660	717770	705656	905723	581491	392534	158664	362986	0	1095209
12	466433	527881	675026	350292	369836	166242	224915	230820	1044342	958082	1030110	741972
13	187646	351921	429562	318336	345397	257412	264203	158687	36861	122337	26403	558339
14	96503	155657	429562	122157	195607	143024	207745	163836	410090	459693	502253	346258
15	262704	236870	184098	230208	225277	263139	67270	218713	85460	114617	27483	199826
16	187646	115051	61366	128242	91540	178780	206590	71775	13547	102977	182091	50494
17	64336	128586	61366	95352	80275	107268	72546	96352	118365	28973	49422	26348
18	16084	0	61366	57045	22628	35756	41219	6650	35465	0	26001	
19	0	0	0	27474	32325	83431	58531	37874	45452	0	0	
20	0	0	0	0	8081	0	22258				46549	
21						0	7419					
SUM	53607639	67670271	61304634	61709132	80845900	71512007	72507812	74851915	73000702	70750676	67413231	62478267

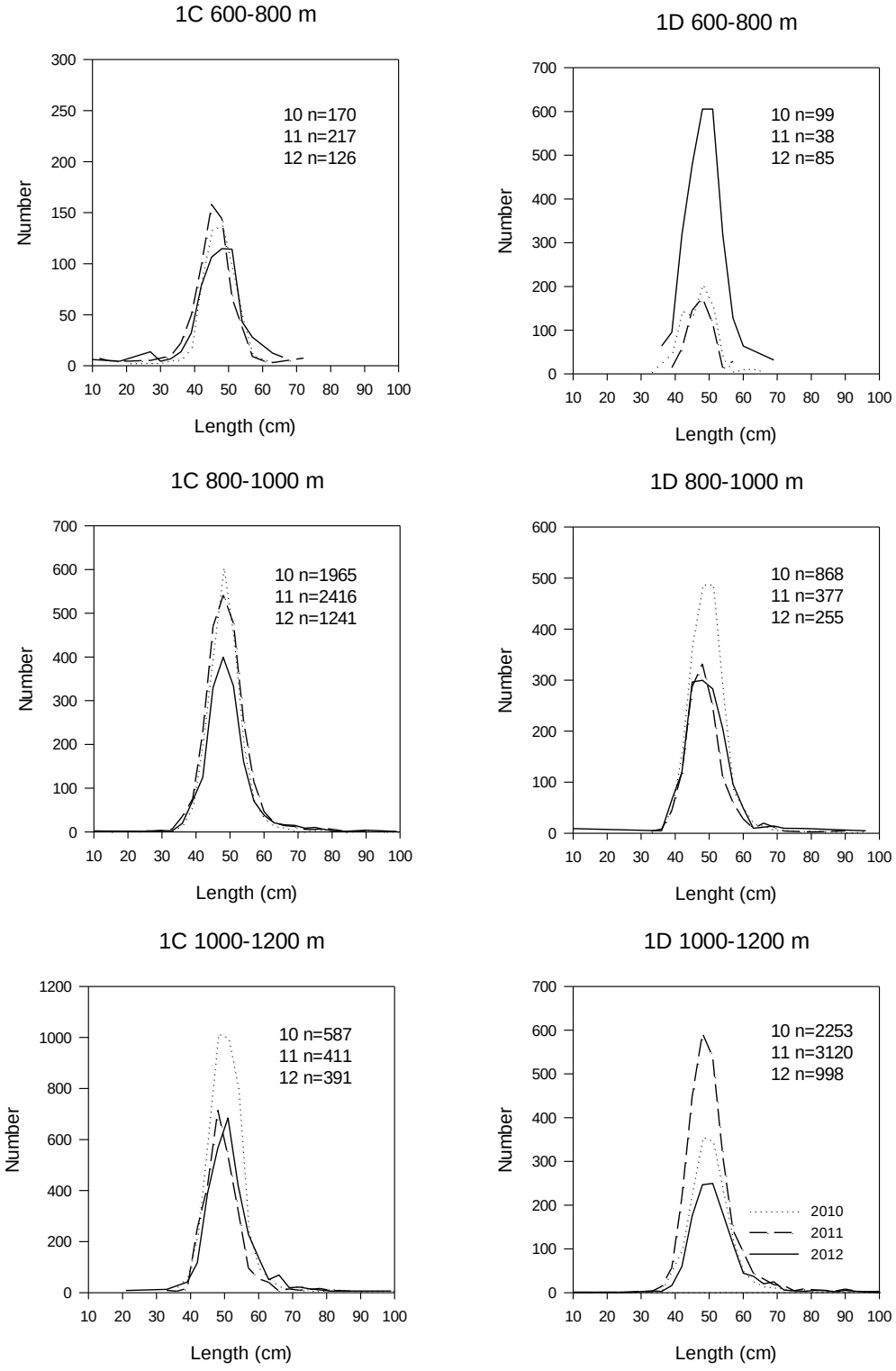

Fig. 7. Length distribution of Greenland halibut in numbers km^{-2} by year, Division and depth stratum. Div 1CD 600-1200 m.

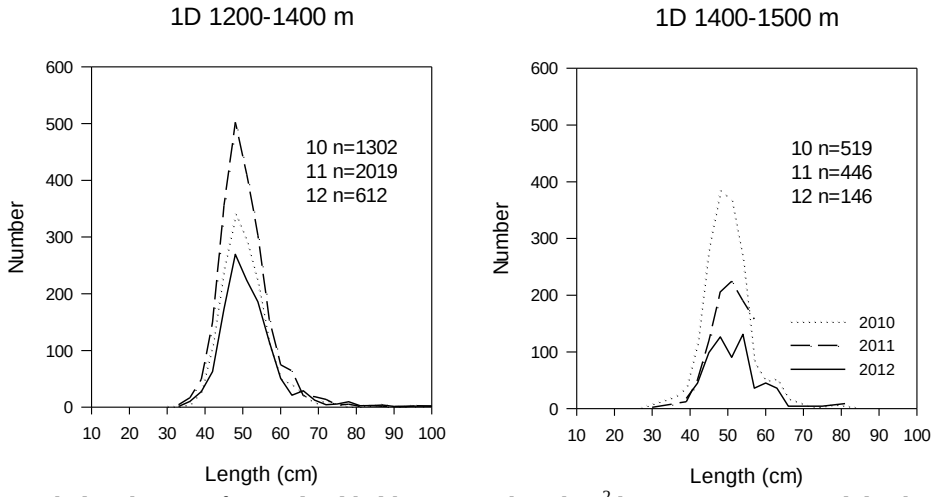

Fig. 7. cont. Length distribution of Greenland halibut in numbers km^{-2} by year, Division and depth stratum. Div. 1D 1200-1500 m.

Table 5. Mean weight and length by year and age. No data 2008 and 2010-2012.

	1997		1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2009	
AGE	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length	weight	length
1							25	13.5	28	14.4	20	16.0							18	13.3				
2	23	15.3	38	18.7	64	21.0	75	21.0	85	21.0	60	21.7	85	23.0			69	21.5	71	21.1	70	22.0	91	23.3
3	58	19.8	176	28.5	206	27.4	146	26.3	173	26.7	200	29.6	192	29.4			169	28.5	180	28.6	181.7	28.7	162	27.1
4	137	26.1	348	35.3	342	34.4	329	33.6	366	34.2	341	35.5	355	35.7	487	39.1	382	36.6	397	36.8	352.6	35.9	377	36.6
5	272	32.8	551	40.9	571	40.3	528	39.5	574	39.7	487	39.9	522	40.2	646	42.8	550	41.3	594	41.8	565.8	41.6	544	40.7
6	444	38.0	854	46.8	793	45.6	764	44.5	849	44.9	747	45.6	763	45.4	917	47.5	831	46.7	867	47.0	859.6	47.2	771	45.4
7	737	43.9	1218	51.9	1196	51.4	1074	49.8	1159	49.9	1132	51.7	1116	51.2	1293	52.5	1137	51.6	1142	51.4	1072	51.1	1025	50.0
8	1070	49.9	1572	56.8	1665	57.9	1376	53.7	1541	54.8	1370	55.6	1419	55.9	1638	56.5	1569	56.5	1531	56.1	1541	56.6	1540	56.3
9	1454	55.6	2075	60.6	2057	61.1	1631	56.8	1844	58.0	1844	60.7	1861	59.8	1942	60.2	1754	58.8	2189	61.2	1635	57.5	1856	59.8
10	2043	61.2	2293	63.1	2441	64.1	2077	61.5	2259	61.8	2037	62.5	2115	62.6	2191	62.3	2301	63.8	2502	64.2	2123	62.4	2208	62.9
11	2815	66.7	2867	66.5	2812	66.9	2503	63.9	3316	65.0	2508	66.0	2668	66.8	2924	67.8	2878	68.0	3588	70.9			2816	67.7
12	3828	72.6	3453	69.9	4000	72.9	3014	67.5	3450	68.7	3011	69.7	3190	70.4	3237	68.2	3464	71.2	3450	70.2	3049	68.6	3492	70.9
13	4840	77.3	4538	74.7	5679	79.5	3612	70.4	3866	71.3	3558	71.6	3178	70.6	3683	72.4	4617	77.0	4951	77.5	3300	70.0	4019	73.3
14	6679	84.0	5112	77.6	7613	86.7	3893	72.8	5257	77.8	4650	78.5	3845	75.5	3889	71.1	5305	79.1	5324	79.0	4548	76.4	5586	79.8
15	7711	87.8	7141	85.1	8477	91.2	5409	78.3	6324	81.9	5149	79.0	4340	76.0	4740	74.8	6468	86.0	7029	86.1	6443	85.5	6709	83.9
16	9166	94.6	8385	88.9	9925	88.5	6873	85.5	7203	86.0	6786	84.8	5747	81.3			13320	100.0	8415	89.3	8402	90.8	9700	94.0
17	10797	97.8	10684	95.4			8492	91.8	8954	92.4	8520	90.3	6200	84.0	6498	82.0			9588	95.0	9565	92.5	9198	93.0
18					12500	99.0	8590	92.3	8760	93.0	9385	93.0			893	93.0	9570	97.0			9200	95.0		
19			12850	99.0			9645	91.5	11500	102.0	8553	90.3			10220	93.0	14150	101.0						
20									14400	105.0											12330	102.0		

Roundnose grenadier (*Coryphaenoides rupestris*)

Roundnose grenadier was caught in 42 of the 50 valid hauls but the catches were very low (Fig. 8, Appendix 1). The biomass has been very low for more than a decade (Table 6) and far below the level seen in the late 80'. The biomass in the 2012 was estimated as 1634.1 tons compared to 939.8 tons 2011. Most of the biomass was found in Div 1D at depths greater than 801 m (Table 7).

The abundance increased from $11.57*10^6$ specimens in 2011 to $24.36*10^6$. The highest densities were found in Div. 1D 801-1000 m (Table 8) as in recent years.

Table 6. Biomass (tons) and abundance of roundnose grenadier with 1*S.E. by year.

Year	Biomass	S.E.	Abundance ($*10^6$)	S.E. ($10*^6$)
1997	5 686.5	926.4	32.44	7.06
1998	7 263.3	2 530.2	75.24	27.36
1999	2 771.8	445.5	29.10	8.96
2000	5 593.7	2 616.8	99.52	67.31
2001	1 577.2	516.4	24.70	8.80
2002	1 593.1	462.7	18.61	8.91
2003	774.2	144.0	6.90	1.27
2004	633.0	98.2	10.56	2.53
2005	733.0	116.0	12.18	3.75
2006	658.6	192.2	10.83	4.28
2007	838.0	206.4	13.16	4.50
2008	546.1	81.3	4.75	0.70
2009	1 151.1	516.1	16.58	10.01
2010	580.7	81.1	6.78	1.80
2011	939.8	244.9	11.57	4.64
2012	1634.1	936.3	24.36	15.63

Pre anal fin length ranged from 2 to cm 21 cm. The grenadiers were generally small and the overall length distribution (weighted by stratum area) showed a mode at 6-7 cm (Fig. 9).

Table 7. Mean catch per km^2 and biomass (tons) of roundnose grenadier by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1C	401-600	3366	2	0.0000	0.0	0.0
	601-800	16120	3	0.0053	86.0	86.0
	801-1000	6066	11	0.0099	60.3	17.7
	1001-1200	611	2	0.0123	7.5	2.3
1D	401-600	903	2	0.0054	4.8	4.8
	601-800	1940	1	0.4318	837.8	.
	801-1000	3874	3	0.1126	436.3	406.9
	1001-1200	10140	14	0.0072	73.2	19.0
	1201-1400	6195	9	0.0167	103.7	32.2
	1401-1500	3091	3	0.0079	24.5	13.3
All				0.0312	1634.1	936.3

Table 8. Mean catch per km^2 and abundance of roundnose grenadier by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1C	401-600	3366	2	0.0	0.0	0.0
	601-800	16120	3	54.6	880047.2	880047.2
	801-1000	6066	11	116.1	703961.9	294621.8
	1001-1200	611	2	149.8	91535.2	59375.3
1D	401-600	903	2	17.0	15362.7	15362.7
	601-800	1940	1	6909.5	13404512.7	.
	801-1000	3874	3	2089.1	8093045.7	7980344.8
	1001-1200	10140	14	60.1	609010.4	135435.4
	1201-1400	6195	9	79.7	493877.1	116706.5
	1401-1500	3091	3	22.6	69932.7	14256.6
All				465.7	24361285.8	15628950.0

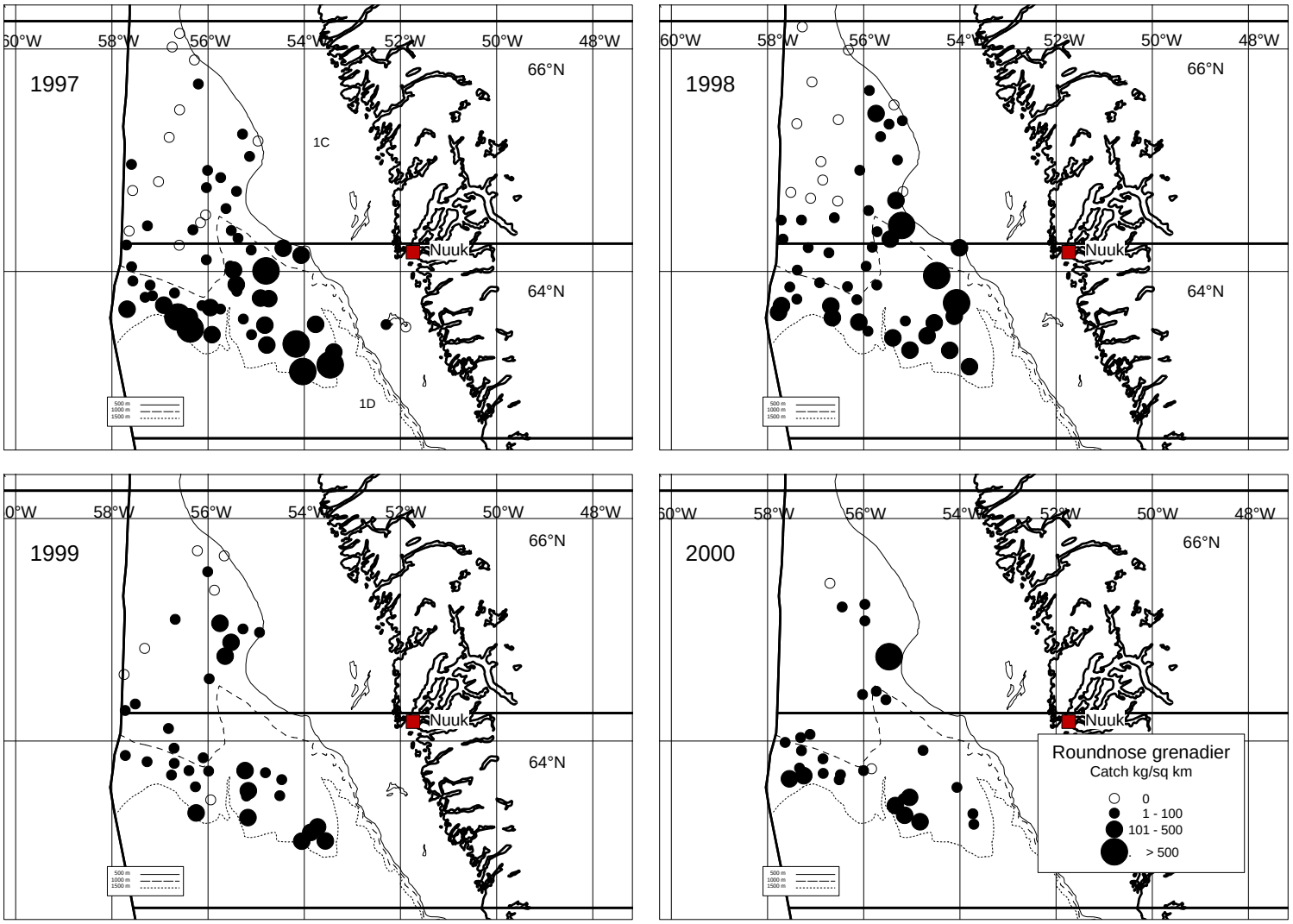

Fig. 8. Distribution of catches of roundnose grenadier in 1997-2000 in kg km^{-2}

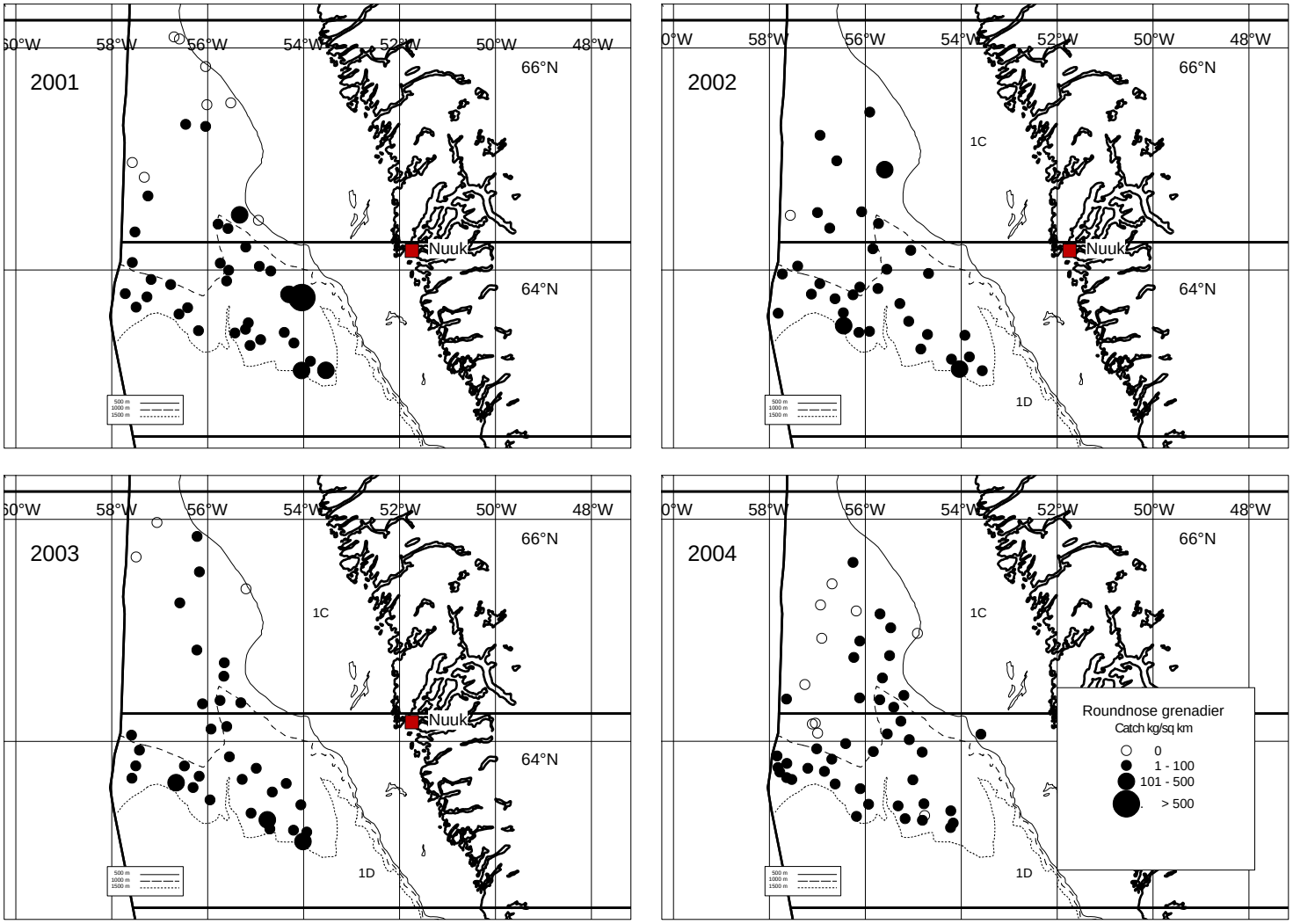

Fig. 8. cont. Distribution of catches of roundnose grenadier during 2001-2004 in kg km^{-2}.

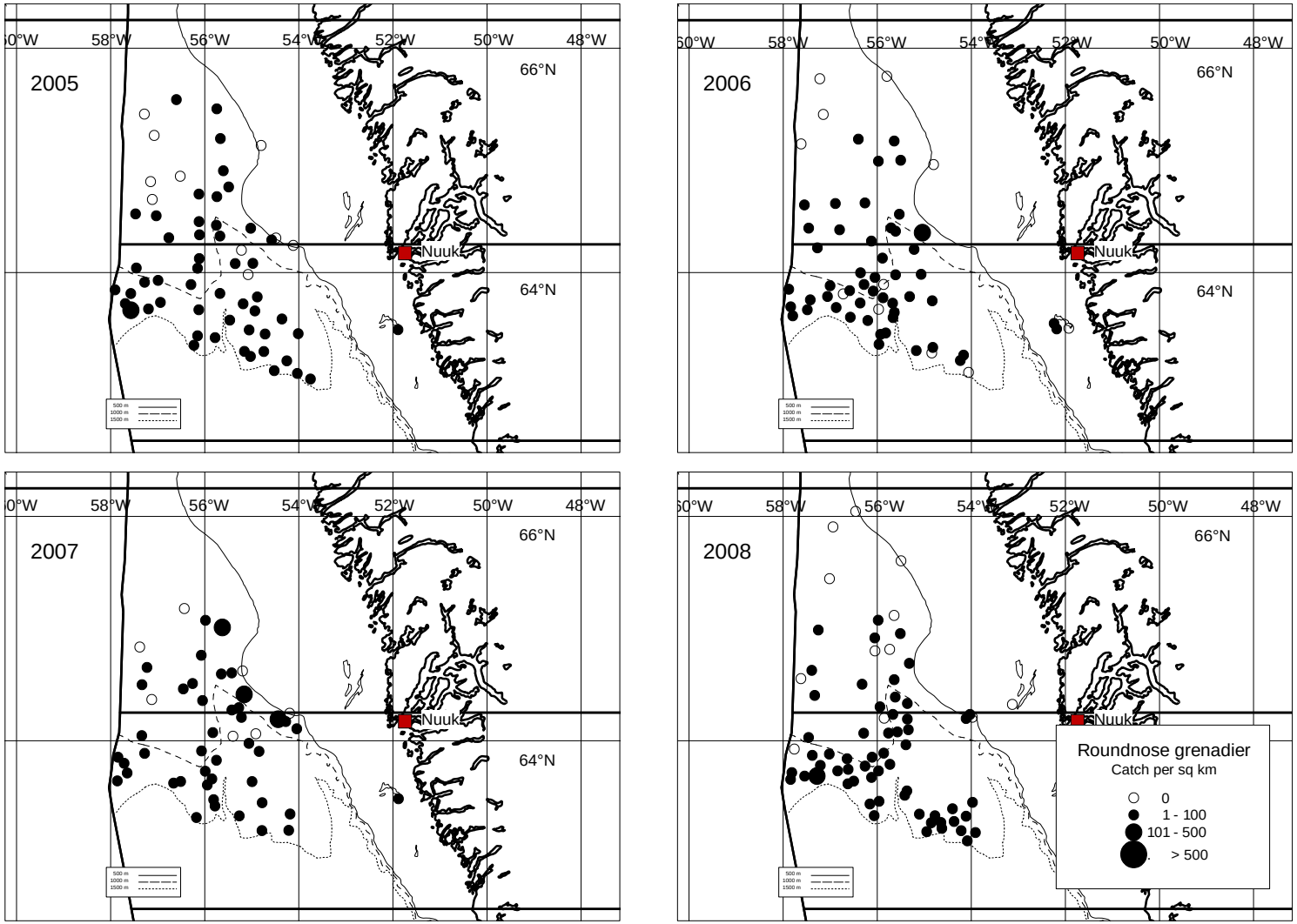

Fig. 8 cont. Distribution of catches of roundnose grenadier during 2005-2008 in kg km^{-2}.

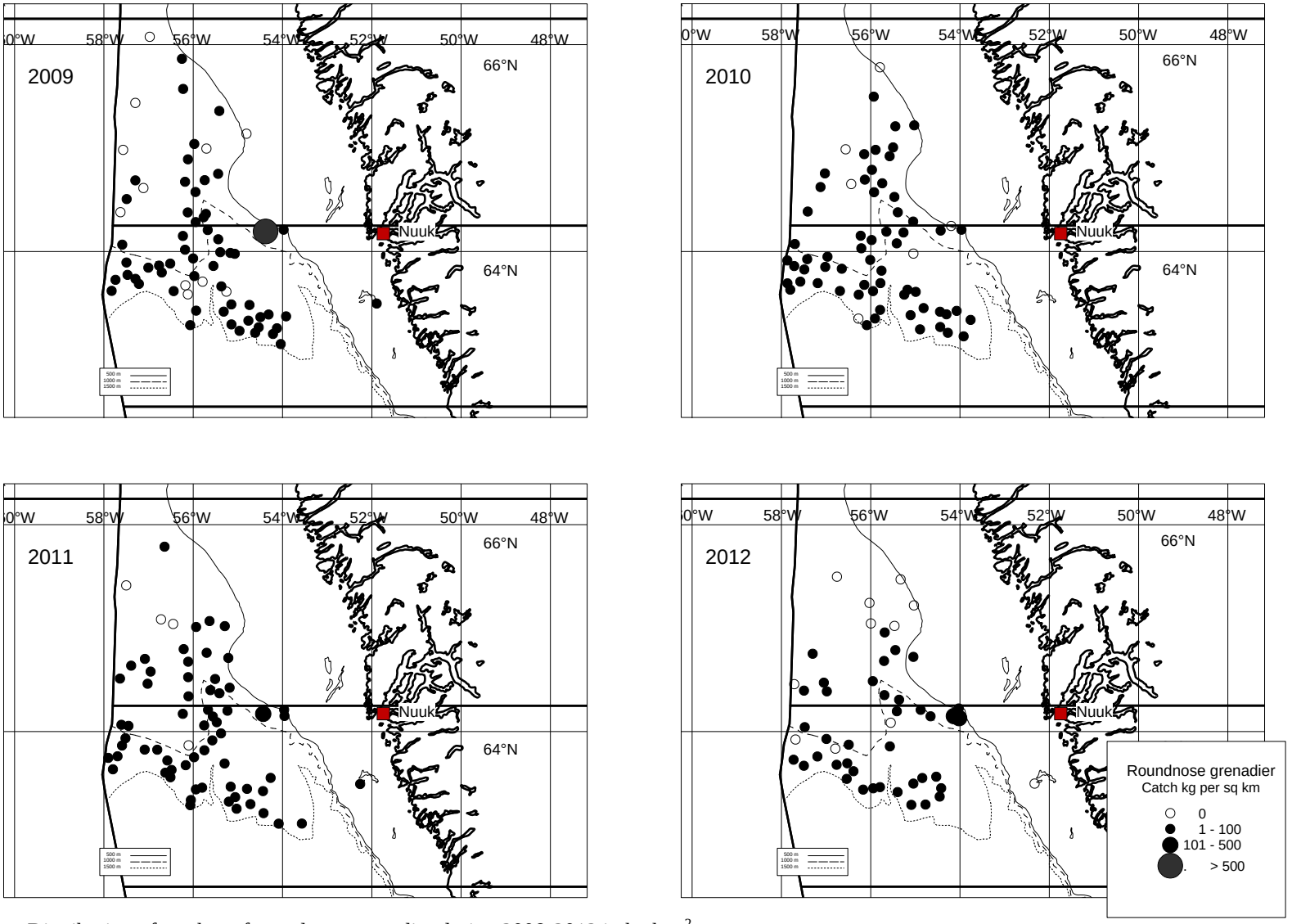

Fig. 8 cont. Distribution of catches of roundnose grenadier during 2009-2012 in kg km^{-2}.

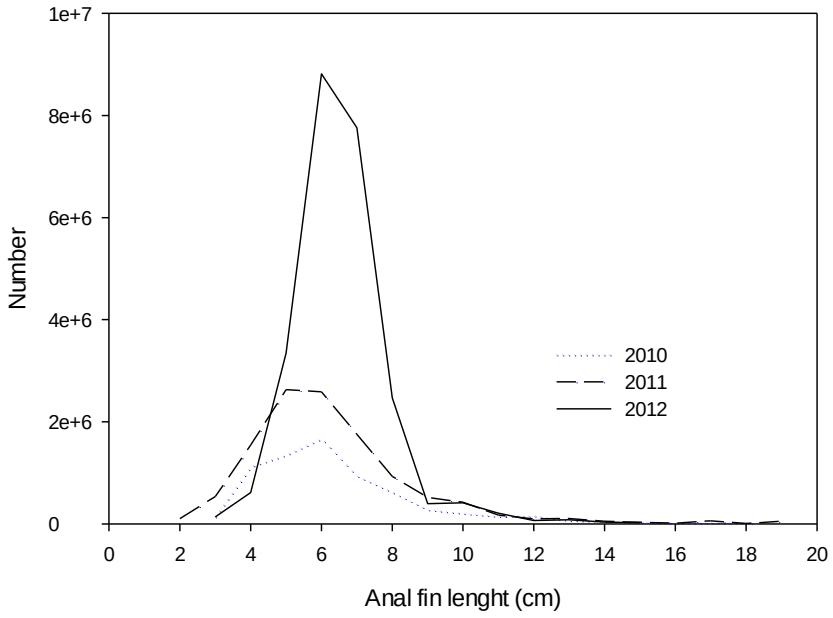

Fig. 9. Overall length distribution of roundnose grenadier (pre anal fin length) in numbers (weighted by stratum area) in Div. 1CD by year.

Roughhead grenadier (*Macrourus berglax*)

Roughead grenadier was caught in all hauls except one. The catches were, however, generally low (Fig. 11, Appendix 1). The biomass was estimated at 6303.4 tons compared to 3084.5 tons 2011 (Table 9).

The highest densities were found at depths between 600-1400 m in Div. 1D and the largest biomass was found in Div. 1D 1001-1200 m, apart from an estimate from Div.1D based on one haul that contributes with little less than half of the total biomass (Table 10).

Table 9. Biomass and abundance of roughhead grenadier by year in Div. 1CD with S.E.

Year	Biomass	S.E.	Abundance ($*10^6$)	S.E. ($*10^6$)
1997	2258.6	250.1	4.60	0.45
1998	4314.1	377.9	11.62	1.01
1999	5166.2	854.1	14.07	2.04
2000	7178.1	2226.5	20.28	7.18
2001	4576.6	456.3	13.87	1.55
2002	7907.6	823.6	19.62	1.76
2003	5657.5	700.8	15.37	2.57
2004	4314.3	452.6	11.16	1.32
2005	5602.6	419.5	14.00	1.31
2006	5148.2	621.2	11.84	1.09
2007	3467.6	374.6	8.18	1.08
2008	4533.7	970.2	9.94	1.35
2009	3795.7	299.2	8.21	0.67
2010	4025.8	564.5	8.21	1.10
2011	3084.5	265.3	7.39	0.65
2012	6303.4	2774.2	8.437	1.21

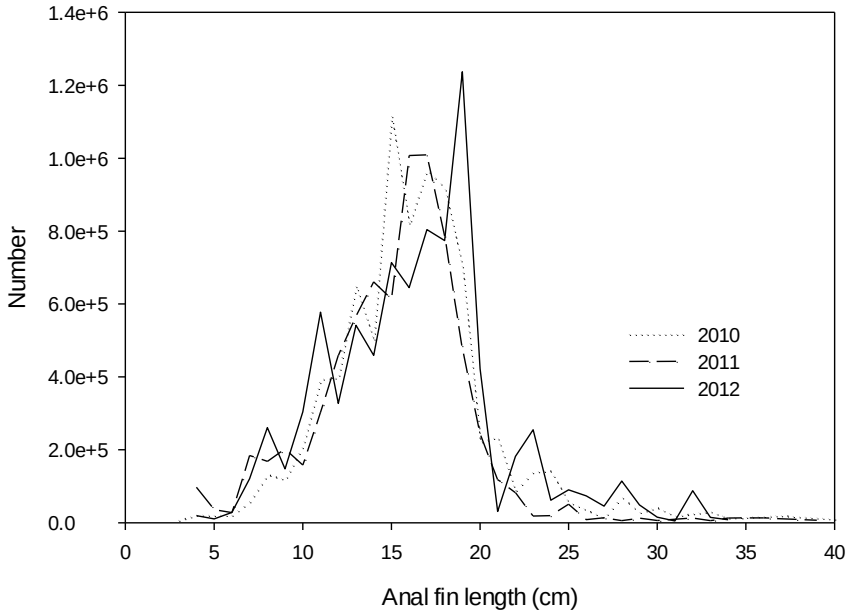

Fig. 10. Overall length distribution (pre anal fin length) of roughhead grenadier in numbers (weighted by stratum area) in Div. 1CD by year.

Table 10. Mean catch km^{-2} and biomass (tons) of roughhead grenadier by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1C	401-600	3366	2	0.0244	82.1	13.1
	601-800	16120	3	0.0578	931.0	120.3
	801-1000	6066	11	0.0420	254.5	62.0
	1001-1200	611	2	0.0655	40.0	19.3
1D	401-600	903	2	0.0296	26.7	26.7
	601-800	1940	1	1.4213	2757.3	.
	801-1000	3874	3	0.0925	358.5	22.5
	1001-1200	10140	14	0.0941	953.7	239.8
	1201-1400	6195	9	0.1179	730.2	123.3
	1401-1500	3091	3	0.0548	169.3	23.2
All				0.1205	6303.4	2774.2

Table 11. Mean catch per km^{-2} and abundance of roughhead grenadier by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1C	401-600	3366	2	89.2	300133.1	20303.6
	601-800	16120	3	128.1	2065715.4	133715.1
	801-1000	6066	11	116.3	705681.6	131201.4
	1001-1200	611	2	118.5	72402.7	8082.9
1D	401-600	903	2	68.1	61450.9	61450.9
	601-800	1940	1	573.7	1112920.8	.
	801-1000	3874	3	186.1	720910.1	56444.4
	1001-1200	10140	14	201.4	2042467.3	423012.2
	1201-1400	6195	9	163.0	1009995.2	97919.2
	1401-1500	3091	3	108.5	335232.9	26047.5
All				161.1	8426910.0	1212572.4

The total abundance was estimated at $8.43*10^6$ compared to $7.39*10^6$ in 2011. (Table 9). The highest densities were found in Div. 1D 1001-1200 m apart from an estimate from Div. 1D 600-800 m based on one haul (Table 11).

Pre anal fin length ranged from 4 to 34 cm and the over all length distribution showed mode at 19 (Fig.10).

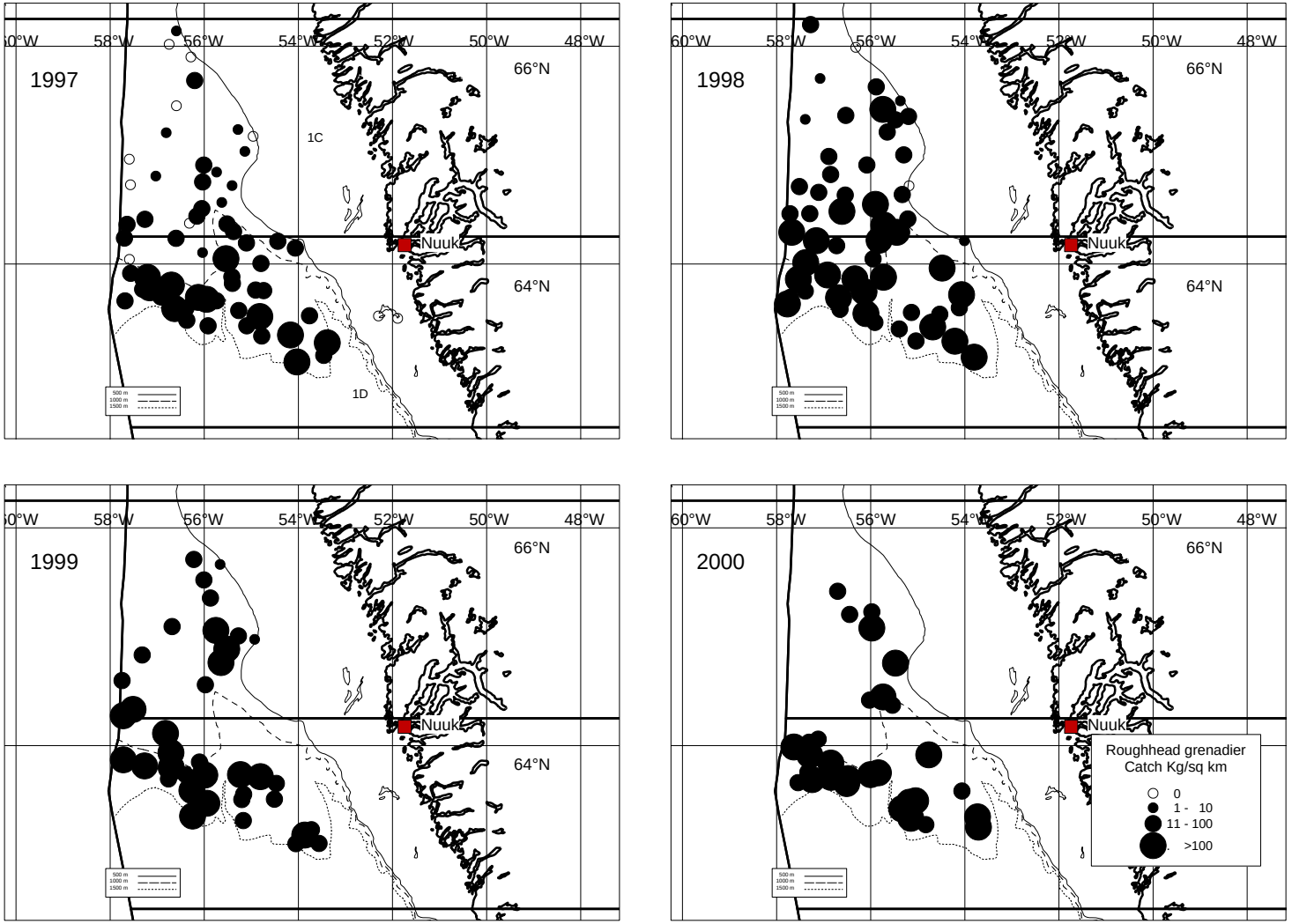

Fig.11 Distribution of catches of roughhead grenadier in 1997-2000 in kg km^{-2}.

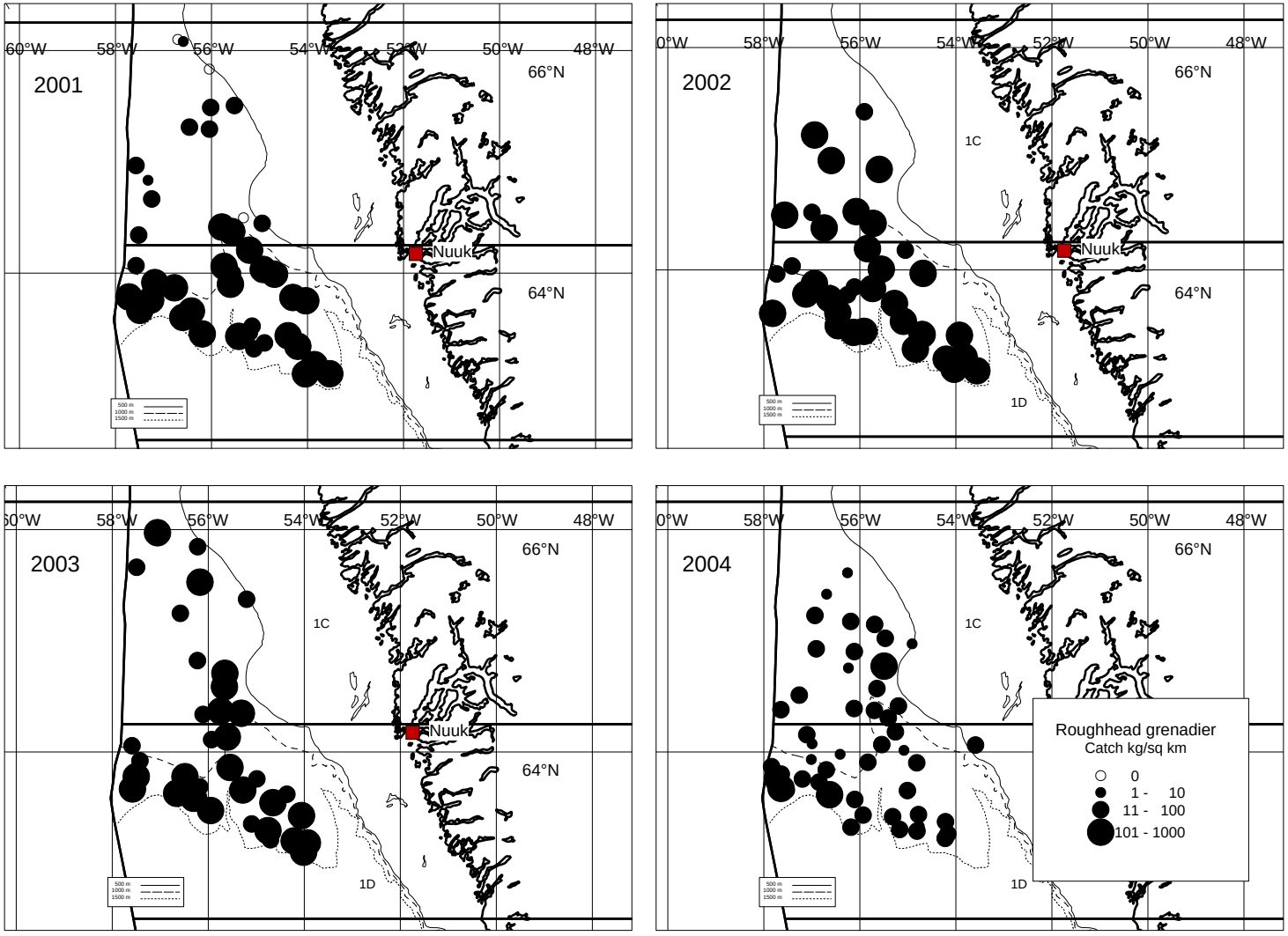

Fig. 11 cont. Distribution of catches of roughhead grenadier during 2001-2004 km^{-2}.

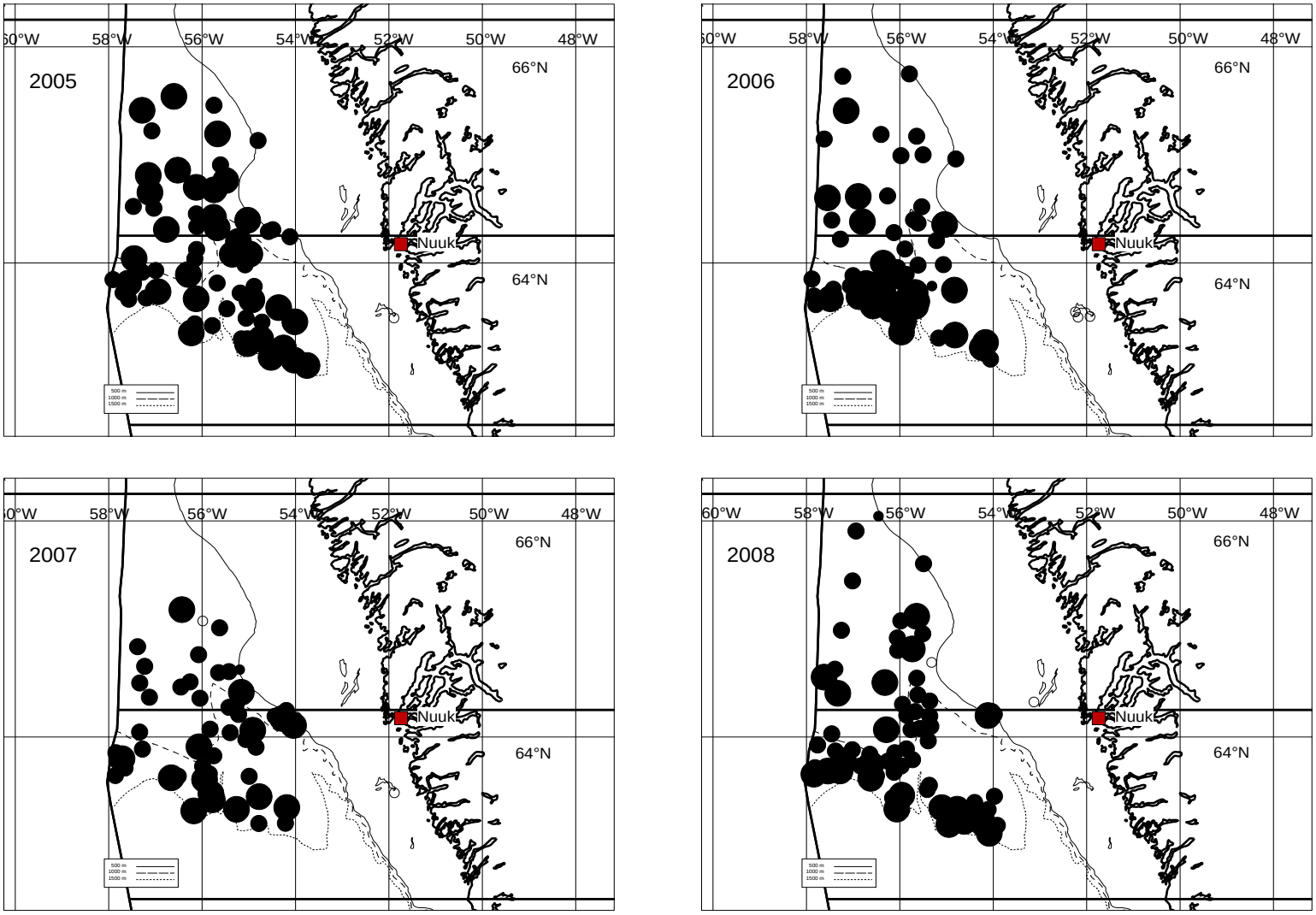

Fig.11 cont.. Distribution of catches of roughhead grenadier during 2005-2008 km^{-2}.

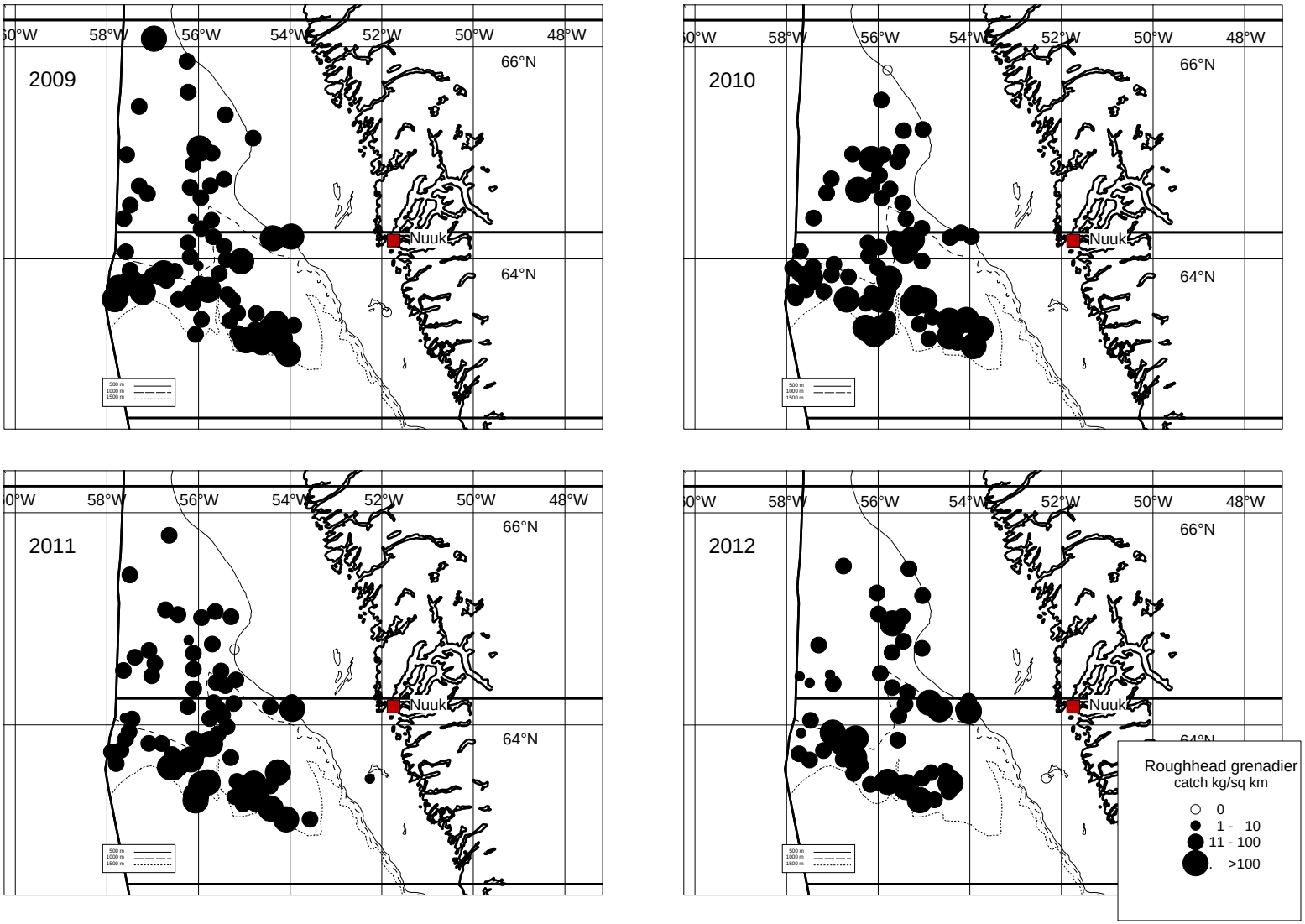

Fig. 11 cont.. Distribution of catches of roughhead grenadier during 2009-2012 km^{-2}.

Deep-sea redfish (*Sebastes mentella*)

Deep-sea redfish was caught in 18 of the 50 valid hauls (Fig 12). The biomass was estimated at 14 010.6 tons compared to 9623.9 tons in 2011 (Table 12). The Biomass estimate is to a large extend driven by a few large catches (Fig. 13, Appendix 1). Almost all the biomass was found at depths <800 m. The highest density was found in Div. 1C 400-600 m apart from a high estimate in Div. 1D 600-800 based on one haul (Table 13).

The abundance was estimated at $40.03*10^6$ compared to $32.42*10^6$ in 2011. All most all the abundance was found in Div. 1C < 800 m with the highest density in Div. 1C 401-600 m (Table 14) as in previous years apart from a high estimate in Div. 1D 600-800 based on one haul..

The length ranged from 19 to 45 cm with a mode at 27 cm (Fig. 12).

Table 12. Biomass and abundance of deep-sea redfish including a few redfish sp. by year in Div. 1CD with 1*S.E.

Year	Biomass	S.E.	Abundance $*10^6$	S.E.$*10^6$
1997	2464.3	787.1	14.69	5.50
1998	2 408.1	503.9	18.83	4.50
1999	2484.9	1007.7	12.93	4.09
2000[1)]				
2001	2063.4	873.5	16.34	6.47
2002[1)]				
2003	1493.4	684.5	7.13	3.08
2004	2329.1	1986.8	13.34	11.31
2005	2546.2	1683.3	7.28	3.16
2006	2188.4	700.7	18.20	8.40
2007[1)]	574.2	230.0	3.00	1.31
2008	13199.0	6482.9	52.94	17.70
2009	7796.4	3916.8	35.04	17.72
2010	4065.6	1329.4	17.83	3.17
2011	9623.9	4883.7	32.42	16.19
2012	14010.6	6795.5	40.27	16.39

[1)] Poor coverage of relevant depths.

Table 13. Mean catch km^{-2} and biomass (tons) of Deep Sea Redfish by division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1C	401-600	3366	2	1.9651	6614.7	2423.8
	601-800	16120	3	0.0377	607.2	462.7
	801-1000	6066	11	0.0023	13.8	7.0
	1001-1200	611	2	0.0000	0.0	0.0
1D	401-600	903	2	0.4272	385.8	345.5
	601-800	1940	1	3.2588	6322.0	.
	801-1000	3874	3	0.0112	43.3	43.3
	1001-1200	10140	14	0.0006	5.7	4.2
	1201-1400	6195	9	0.0024	15.0	11.6
	1401-1500	3091	3	0.0010	3.1	3.1
All				0.2679	14010.6	6795.5

Table 14. Mean catch km^{-2} and abundance of Deep Sea Redfish by Division and depth stratum, 2012.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1C	401-600	3366	2	7329.8	24672221.3	11019086.3
	601-800	16120	3	146.9	2367483.2	1976886.2
	801-1000	6066	11	6.7	40435.1	19451.5
	1001-1200	611	2	0.0	0.0	0.0
1D	401-600	903	2	1218.1	1099985.4	1020070.7
	601-800	1940	1	6145.8	11922763.3	.
	801-1000	3874	3	27.7	107382.7	107382.7
	1001-1200	10140	14	2.0	20211.1	13731.8
	1201-1400	6195	9	3.8	23637.6	16526.7
	1401-1500	3091	3	4.5	13807.2	13807.2
All				769.9	40267927.0	16386998.8

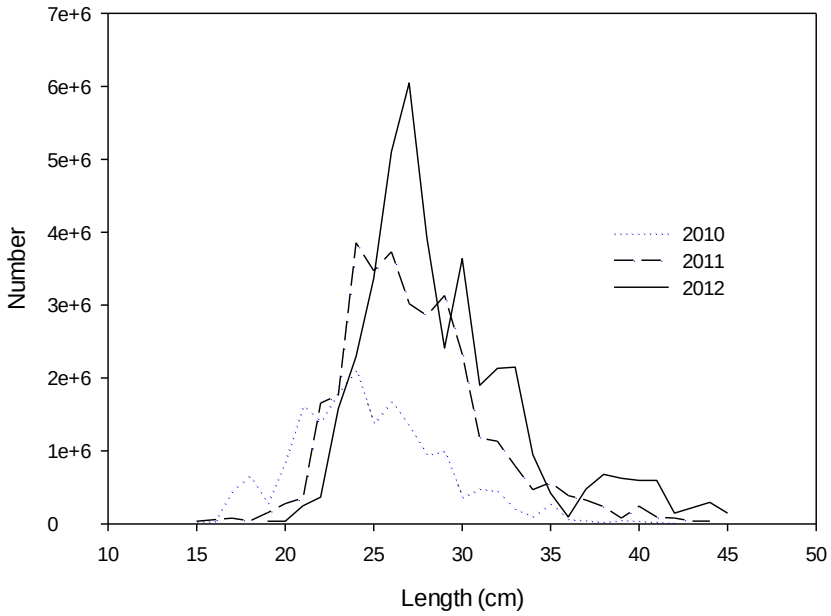

Fig. 12. Overall length distribution of deep sea redfish in numbers (weighted by stratum area) by year.

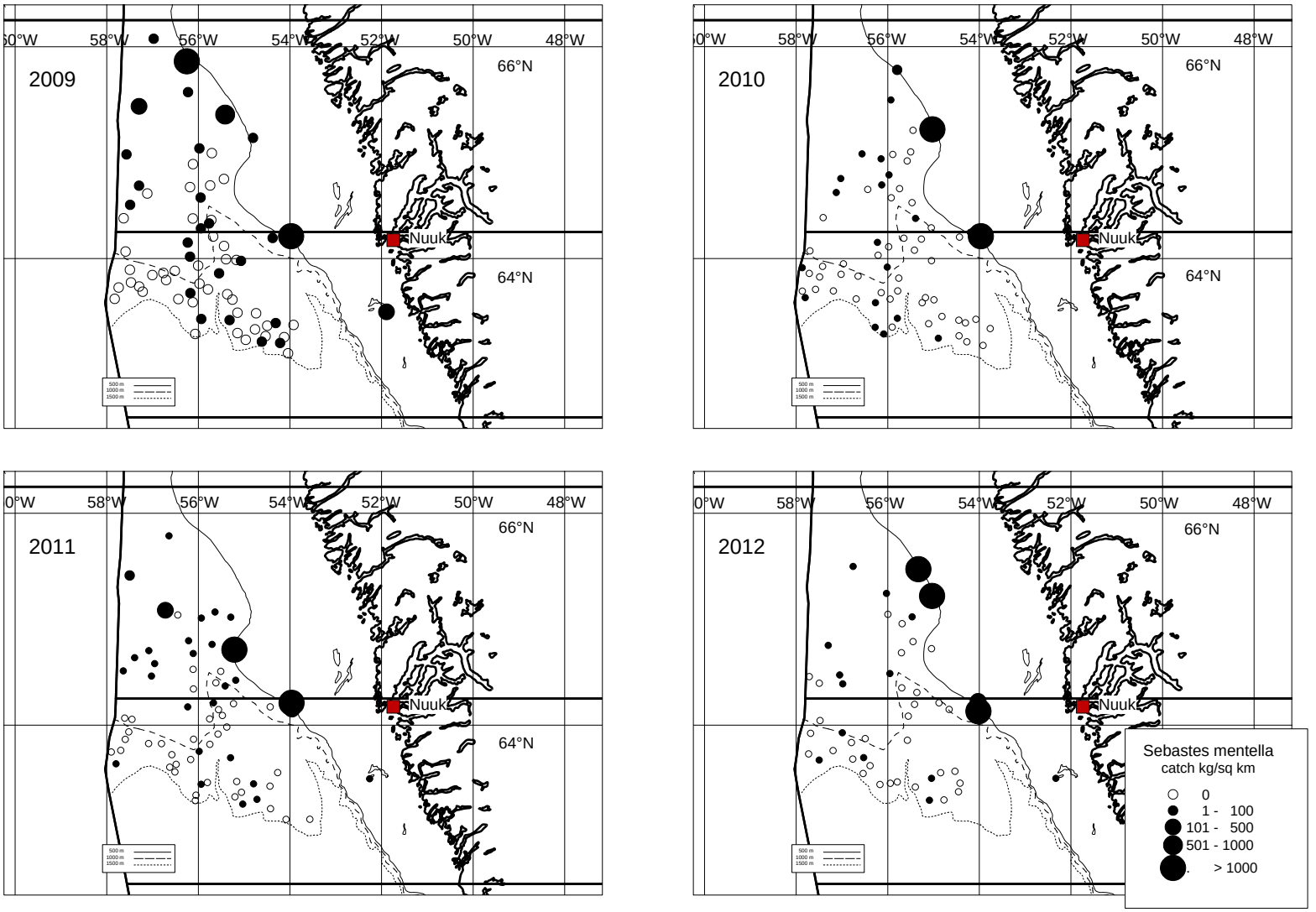

Fig. 13. Distribution of catches of deep sea redfish during 2009-2012 km^{-2}.

Temperature

The bottom temperature ranged from 2.8°C to 4.6°C. The mean temperature was generally decreasing by depth as in previous years (Table 15).

The mean temperatures have been relatively constant in recent years except at depths between 400 and 600 m where the mean temperature has shown a minor decrease in the last couple of years. The temperature figures are however based on very few observations (Fig. 14).

Table 15. Mean temperature, S.E and number of observations by NAFO Division and depth stratum.

Div.	Depth stratum (m)																	
	401-600			601-800			801-1000			1001-1200			1201-1400			1401-1500		
	°C	SE	n	°C	SE	n	°C	SE	n	°C	SE	n	°C	SE	n	°C	SE	n
1C	4.4		1	3.5	.40	3	4.0	.03	11	3.8	.04	2						
1D	4.0	.54	2	4.3		1	4.0	.17	3	3.8	.02	14	3.7	.02	9	3.6	.03	3

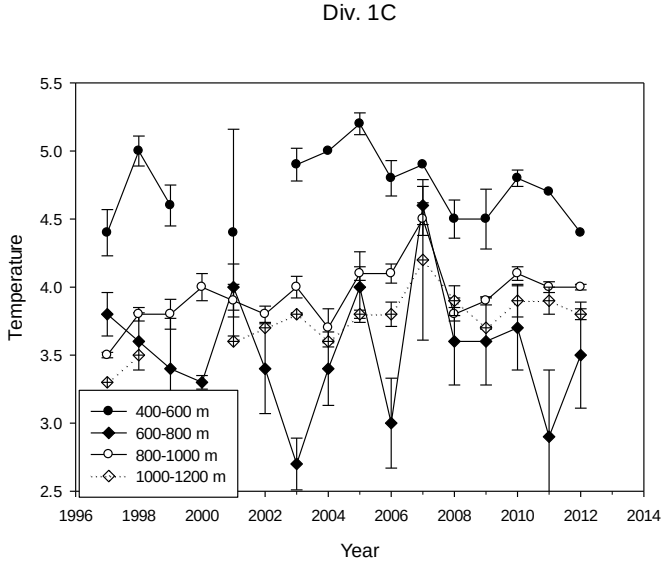

Fig 14. Mean temperatures by division depth stratum and year with 1*S.E.

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Appendix 1. Catch weight and - numbers (not standardized to kg/km^2) of Greenland halibut, roundnose and roughhead grenadier and deep-sea redfish by haul. Depth in m, swept area in km^2 and bottom temperature in °C.

					Grl. halibut		Roundnose gre.		Roughhead gre.		*S. mentella*	
St. No	S. Area	Div.	Depth	Temp.	Weight	Number	Weight	Number	Weight	Number	Weight	Number
1	0.073531	1C	585	.	0	0	0	0	2.08	7	91.55	298.3
2	0.048115	1C	571.5	4.35	1.54	4	0	0	0.986	4	129.2	510.2
4	0.048491	1C	672.5	2.77	10.46	17	0	0	2.851	7	4.591	19
5	0.073114	1C	781.5	3.65	65.55	70	0	0	3.242	9	0.242	1
6	0.07285	1C	833.5	4.12	115.3	118	0	3	1.98	8	0	0
7	0.042736	1C	863	4.06	27.65	24	1.185	24	4.738	11	0	0
8	0.030576	1C	814	4.06	28	31	0	0	1.75	3	0.171	1
9	0.070713	1C	843	4.08	114.4	93	1.2	13	5.71	11	0	0
11	0.059518	1C	951	3.9	126	132	0.9	4	2.69	10	0	0
13	0.083303	1C	917.5	3.96	219.3	174	0.09	3	5.51	15	0	0
14	0.073962	1C	801.5	3.94	141.6	118	0.2	1	1.28	5	0.305	1
15	0.08267	1C	846.5	3.92	130.1	122	0.035	1	0.611	3	0	0
17	0.035301	1C	851.5	3.96	24.5	16	0.633	5	0.28	1	0	0
18	0.07568	1C	826	4.09	41.35	37	0.73	4	0.62	3	0.24	1
19	0.08548	1C	792	4.13	48.25	39	1.368	14	5.995	10	1.283	3
21	0.069692	1D	980.5	3.77	116	92	0.321	2	7.091	11	0	0
22	0.072507	1D	1032	3.85	105.1	74	1.063	2	7.289	9	0.183	1
23	0.06783	1D	959.5	3.84	124.5	109	0.72	2	5.55	14	0	0
24	0.059728	1D	1104	3.77	21.3	19	0.023	1	0.225	1	0	0
25	0.073718	1D	1334	3.58	94.35	87	0.26	2	2.19	6	0	0
26	0.074623	1D	1454	3.66	45.95	38	0.27	1	3.14	7	0.225	1
27	0.079363	1D	1356	3.68	75.95	68	0.847	4	6.748	12	0	0
28	0.079844	1D	1156	3.83	170.5	130	0	0	12.3	27	0	0
29	0.083453	1D	1292	3.78	140.8	92	1.62	5	13.7	17	0.42	1
30	0.073173	1D	1473	3.56	83.3	51	1.209	2	4.978	9	0	0
31	0.07369	1D	1434.5	3.66	77.7	57	0.266	2	3.995	8	0	0
32	0.076899	1D	1335	3.65	111.1	92	1.03	4	6.5	13	0	0
33	0.033702	1D	1240	3.72	25.7	20	0.3	2	3.22	4	0	0
34	0.071297	1D	1187.5	3.6	104.9	74	0.142	2	6.74	12	0	0
35	0.045856	1D	1334.5	3.6	78.7	62	0.202	1	9.3	9	0	0
37	0.038039	1D	1238.5	3.69	97.9	82	2.1	7	7.7	9	0	0
38	0.044728	1D	1347.5	3.7	110.9	80	0.652	5	5.3	6	0.75	1
39	0.039715	1D	1287.5	3.68	50.55	29	0.816	6	3.105	7	0	0
40	0.03219	1D	1177.5	3.75	52.75	39	0.203	4	2.7	7	0	0
41	0.037354	1D	1146	3.66	105.1	77	0.285	3	13.45	25	0	0
43	0.070856	1D	1122.5	3.64	54.4	35	0.078	2	3.95	11	0.38	1
45	0.070215	1D	1129	3.76	87.15	76	0.58	8	2.296	8	0	0
46	0.066088	1D	1118	3.75	51.15	28	0.66	9	1.641	7	0	0
48	0.058733	1D	1156	3.83	89.1	74	0.504	3	4.4	12	0	0
49	0.040134	1D	1065.5	3.8	86.9	54	0	0	0.699	3	0	0
50	0.069784	1D	1155	3.86	179.3	100	0.851	3	4.8	13	0	0
51	0.072023	1C	972.5	3.87	422.5	376.4	1.28	12	2.4	10	0.87	1
52	0.060731	1C	1071	3.88	167.9	142	0.98	15	5.9	8	0	0
53	0.075995	1C	1088.5	3.81	393.8	249	0.65	4	2.57	8	0	0
56	0.059695	1D	1041	3.88	211	140	0.28	3	6.33	15	0	0
57	0.056648	1D	1020.5	3.82	105.8	78	1.43	8	7.9	11	0	0
58	0.036077	1D	842.5	4.31	59.1	54	11.64	224	3.393	7	1.211	3
59	0.031377	1D	735	4.34	87.05	85	13.55	216.8	44.6	18	102.3	192.8
60	0.029389	1D	495.5	4.55	1.65	1	0.315	1	1.74	4	23.8	69
64	0.067797	1D	466.5	3.47	11.95	11	0	0	0	0	3.024	6

Appendix 2. List of species and groups of species recorded in Div. 1C-D in 2012 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	species		maxwgt	maxno	mindepth	maxdepth	mintemp	maxtemp	maxpos
1	ALA	Alepocephalus agassizzi	35.6	41	735	1473	3.6	4.3	64.2599
2	RFL	Amblyraja fyllae	0.5	1	673	843	2.8	4.3	65.4980
3	RRD	Amblyraja radiata	6.6	10	188	467	3.1	3.8	63.7558
4	CAD	Anarhichas denticulatus	15.7	3	467	1435	3.5	4.3	65.2439
5	CAS	Anarhichas minor	9.7	1	206	206	3.8	3.8	63.7558
6	ANC	Anopologaster cornuta	0.1	1	843	1239	3.7	4.1	64.7884
7	ANT	Antimora rostrata	30.1	41	782	1473	3.6	4.1	65.2439
8	ARZ	Arctozenus rissoi	0.0	2	918	1066	3.8	4.0	64.7218
9	ARS	Argentina silus	0.3	2	467	496	3.5	4.6	64.2237
10	AGH	Argyropelecus hemigymnus	0.0	1	1129	1129	3.8	3.8	63.5513
11	BAM	Bajacalifornia megalops	0.1	1	1454	1454	3.7	3.7	63.6696
12	BAT	Bathylagus euryops	6.2	117	735	1473	3.6	4.3	65.0464
13	BAS	Bathylagus sp.	0.0	2	834	1348	3.7	4.1	65.0464
14	BSP	Bathyraja spinicauda	35.4	2	792	1155	3.9	4.3	64.6832
15	BEG	Benthosema glaciale	0.0	21	206	1473	2.8	4.3	65.7282
16	POC	Boreogadus saida	0.0	2	206	260	3.6	3.8	63.7558
17	BOA	Borostomias antarcticus	1.1	11	842	1473	3.6	4.0	64.7406
18	CFB	Centroscyllium fabricii	13.7	17	572	1335	3.6	4.3	65.7282
19	CHA	Chauliodus sloani	0.1	2	843	1473	3.6	4.1	64.9585
20	CHN	Chiasmodon niger	0.0	1	1089	1156	3.8	3.8	64.3078
21	CBB	Coryphaenoides brevibarbis	0.1	2	1435	1435	3.7	3.7	63.6788
22	CGR	Coryphaenoides güntheri	2.7	27	735	1473	3.6	4.3	64.3078
23	RNG	Coryphaenoides rupestris	13.6	224	260	1473	3.6	4.6	65.0464
24	COM	Cottunculus microps	0.1	1	834	1071	3.8	4.1	65.0464
25	COT	Cottunculus thomsonii	1.4	1	814	1356	3.7	4.1	65.0224
26	LUM	Cyclopterus lumpus	0.5	1	585	585	.	.	65.2199
27	CYB	Cyclothone braueri	0.0	1	1104	1454	3.7	3.8	63.9230
28	CLM	Cyclothone microdon	0.0	2	847	1118	3.8	3.9	64.6832
29	COD	Gadus morhua	51.0	77	188	467	3.1	3.8	63.7558
30	ONA	Gaidropsarus argentatus	0.5	2	673	852	2.8	4.0	65.4980
31	ONN	Gaidropsarus ensis	4.8	6	673	1454	2.8	4.1	65.4980
32	GOB	Gonostoma bathyphilum	0.0	1	802	951	3.9	3.9	64.7530
33	PLA	Hippoglossoides platessoides	19.6	82	188	792	3.1	4.6	65.4722
34	HOA	Holtbyrnia anomala	0.2	2	960	1473	3.6	3.8	64.0425
35	HAF	Hydrolagus affinis	22.3	2	1240	1473	3.6	3.7	63.6174
36	LYD	Lampanyctus crocodilus	1.1	71	814	1335	3.6	4.1	65.0224
37	LAI	Lampanyctus intricarius	0.1	2	834	918	4.0	4.1	65.0464
38	LMC	Lampanyctus macdonaldi	4.4	243	260	1473	3.5	4.3	65.2439
39	LSP	Lampanyctus sp.	0.6	35	673	1155	2.8	4.0	65.4980
40	LEP	Lepidion eques	0.9	7	496	1104	3.8	4.6	64.9585
41	LPA	Lycodes paamiuti	0.3	1	981	1292	3.8	3.8	63.8734
42	ELZ	Lycodes sp.	0.1	1	960	960	3.8	3.8	64.0425
43	RHG	Macrourus berglax	44.6	27	496	1473	2.8	4.6	65.7282
44	MAA	Magnisudis atlantica	0.1	1	572	1123	3.6	4.3	65.4722
45	CAP	Mallotus villosus	0.8	73	188	260	3.1	3.8	63.7558
46	MAM	Maulisia mauli	0.1	1	918	918	4.0	4.0	64.7218
47	HAD	Melanogrammus aeglefinus	0.1	1	206	260	3.6	3.8	63.7558
48	WHB	Micromesistius poutassou	0.4	5	496	496	4.6	4.6	64.2237
49	BLI	Molva dipterygia	3.6	1	585	843	4.1	4.1	65.2199
50	MYC	Myctophidae	0.0	1	1356	1356	3.7	3.7	63.7590
51	MYP	Myctophum punctatum	0.0	4	792	1454	3.6	4.3	64.7530
52	MYI	Myxine ios	0.2	1	1021	1021	3.8	3.8	64.1479
53	NZB	Nezumia bairdii	0.4	2	792	1129	3.8	4.1	64.9585
54	NOT	Notacanthus chemnitzii	3.8	5	572	1473	3.6	4.3	65.4722
55	NOK	Notoscopelus kroyeri	0.0	3	802	1348	3.6	4.3	65.0464
56	PSP	Paraliparis sp.	.	1	826	826	4.1	4.1	64.4731
57	SKP	Platytroctidae	0.0	2	852	852	4.0	4.0	64.3961
58	POL	Polyacanthonotus rissoanus	0.6	5	960	1454	3.6	3.9	64.4875
59	RLT	Raja lintea	1.7	1	1118	1118	3.8	3.8	63.5637
60	GHL	Reinhardtius hippoglossoides	422.5	376	188	1473	2.8	4.6	65.7282
61	RHD	Rhadinestes decimus	0.0	1	1335	1335	3.6	3.6	63.6174
62	RDL	Rondeletia loricata	0.1	1	1356	1356	3.7	3.7	63.7590
63	SAC	Sccopharynx ampullaceus	0.1	1	1356	1356	3.7	3.7	63.7590
64	SCO	Scopelosaurus lepidus	1.7	12	792	1473	3.6	4.3	65.0464
65	REG	Sebastes marinus	4.2	1	496	496	4.6	4.6	64.2237
66	REB	Sebastes mentella	129.2	510	206	1454	2.8	4.6	65.7282

67	RED	Sebastes sp.	0.9	13	467	467	3.5	3.5	63.4969
68	SEK	Serasia koefoedi	0.0	1	1123	1123	3.6	3.6	63.4970
69	SER	Serrivomer beani	0.6	5	918	1454	3.6	4.0	64.7218
70	GSK	Somniosus microcephalus	430.0	1	496	496	4.6	4.6	64.2237
71	STO	Stomias boa	0.1	2	673	1292	2.8	4.3	65.4980
72	SYN	Synaphobranchus kaupi	2.4	16	735	1473	3.6	4.3	65.2439
73	TRA	Trachyrhynchus murrayi	0.4	1	847	1155	3.8	3.9	64.4584
74	XEC	Xenodermichthys copei	0.0	1	1041	1288	3.7	3.9	64.2102