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Survey for Greenland Halibut in NAFO Divisions 1C-1D, 2013

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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. In 2013 only Div. 1D was covered with 27 valid hauls which makes comparison with previous years results difficult. The biomass of Greenland halibut was estimated as 43454 tons which is at the same low level as in Div. 1D in 2012. The length distribution had a mode at 50 cm as seen in previous years. The biomass of roundnose grenadier was low and is still at a 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). In 2013 the survey only covered Div. 1D

Materials and Methods

The survey in 2013 was planned to cover Div. 1CD at depths between 400 and 1500 m, but due to technical problems only Div. 1D was covered during 12/9-17/9.

Stratification

The survey covered NAFO Div. 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 only covered Div. 1D and the coverage was relatively poor with 27 successful hauls in total of 70 planned (46 in Div. 1D). The results should hence be treated with caution. All strata in Div. 1D were covered although there was only 1 haul in stratum 400-600 and 600-800 m. Haul by haul information about catches, depth, temperature etc. is given in Appendix 1 and the distribution of hauls by strata is given in Table 2.

In total 62 species or groups of fish species were recorded (Appendix 2).

One haul was conducted in Div. 1C at depths < 400 m in order to take samples for a eDNA experiment, this hauls is not included in the calculations.

Greenland halibut (*Reinhardtius hippoglossoides*)

Greenland halibut was caught in all hauls (Fig. 1, Appendix 1) and the biomass in Div. 1D 400-1500 m was estimated at 43 457.5 tons (Table 1 and 2) which is at the same low level as in 2012 (42 370.6 tons). The distribution of the biomass was generally the same as in 2012 with the largest biomass at depths between 1000 and 1200 m (Table 2, Fig. 2). The highest densities (in weight) were found at depths > 800 m. The weighted mean catch per tow showed an increased from 1.24 tons km^{-2} in 2012 to 1.66 tons km^{-2} in 2013 but the 2013 figure only includes Div. 1D (Table 1).

In recent years a smaller fraction of the biomass has been located in Div 1D. During 1997-2009 in average 76% was located there while 65-69% of the biomass has been located in Div. 1D during 2010-2012 (Fig. 2a). Assuming that 67% of the biomass was located in Div. 1D a rough estimate of the biomass in the total survey area would be 64862 tons.

The abundance in was estimated at $32.372*10^6$ (Table 3). The density increased gradually to about 1760 specimens km^{-2}, at 1001-1200 m to decrease again at 1200-1400 m and further at 1400-1500 m.

Estimated abundance by age in Div. 1CD is given in Table 4 (not updated in 2013, 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 33 cm to 105 cm. The overall length distribution (weighted by stratum area) was dominated by a mode at 50 which is similar to previous years (Fig. 6a). Generally the length distributions in the different depth strata were dominated by a single mode and fish size increased with 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. NB! Data from 2013 is from Div. 1D only.

Year	Biomass	S.E.	Mean	S.E.	Abundance ($*10^6$)	S.E.	Biomass Div. 1D
1997	56260.2	4 399.6	1.07	0.08	53.613	4.118	45750.5
1998	70473.5	8 391.7	1.34	0.16	67.677	7.687	53232.0
1999	64398.0	6 912.1	1.27	0.14	61.366	6.265	52461.4
2000	59092.4	5 543.3	1.28	0.11	61.710	5.976	47927.7
2001	77554.0	13 013.6	1.57	0.26	80.814	14.221	51895.3
2002	71932.4	5 613.9	1.56	0.12	71.510	6.223	60511.3
2003	68717.2	6 411.9	1.39	0.13	72 556	7.764	48696.6
2004	75869.4	5 186.3	1.48	0.10	74.859	5.445	51070.6
2005	80865.4	8 365.7	1.54	0.16	73.001	7.317	62832.7
2006	77010.3	6 259.6	1.47	0.12	70.715	5.622	54449.3
2007	74356.8	9 455.4	1.48	0.19	67.427	8.492	60186.2
2008	83465.4	5 456.3	1.60	0.10	72.804	5.334	60364.8
2009	70966.2	5 110.3	1.36	0.10	62.507	4.419	53243.2
2010	75522.5	5 382.4	1.44	0.10	64.868	5.389	50343.3
2011	86591.4	5210.4	1.66	0.10	74.978	4.723	60331.0
2012	64948.8	7379.3	1.24	0.14	54.271	6.815	42370.6
2013	43457.5	4107.1	1.66	0.16	32.372	2.881	43457.5

Table 2. Mean catch per km^2 and biomass (tons) with Standard Error of Greenland halibut in Division 1D by depth stratum, 2013. Note that Standard Division is = biomass in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1D	401-600	903	1	0.0400	36.1	.
	601-800	1940	1	0.5293	1026.9	.
	801-1000	3874	4	1.6970	6574.1	1106.9
	1001-1200	10140	11	2.1849	22155.2	2981.9
	1201-1400	6195	7	1.4777	9154.2	2174.4
	1401-1500	3091	3	1.4580	4506.8	983.4
All				1.6621	43453.5	4107.1

Table 3. Mean catch per km^2 and abundance with Standard Error of Greenland halibut in Division 1D by depth stratum, 2013. Note that Standard Division is = abundance in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1D	401-600	903	1	51.8	46731.3	.
	601-800	1940	1	174.4	338279.1	.
	801-1000	3874	4	1381.6	5352157.1	833475.6
	1001-1200	10140	11	1762.0	17866481.5	2482354.8
	1201-1400	6195	7	1003.4	6215976.6	1144098.9
	1401-1500	3091	3	825.9	2552706.2	138860.2
All				1238.3	32372331.8	2881254.6

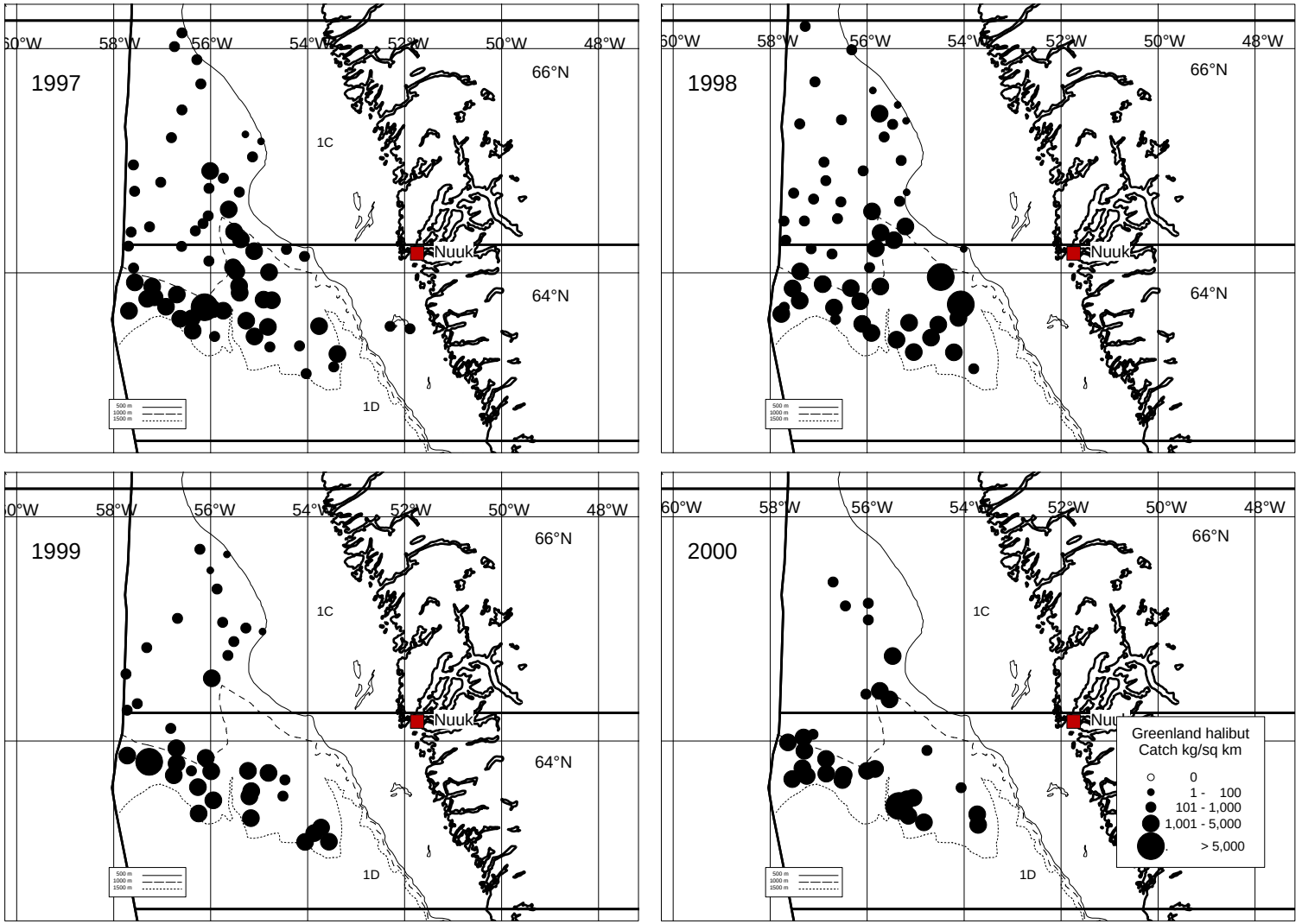


Fig. 1 Distribution of catches of Greenland halibut during 1997-2000 in kg km^{-2}.

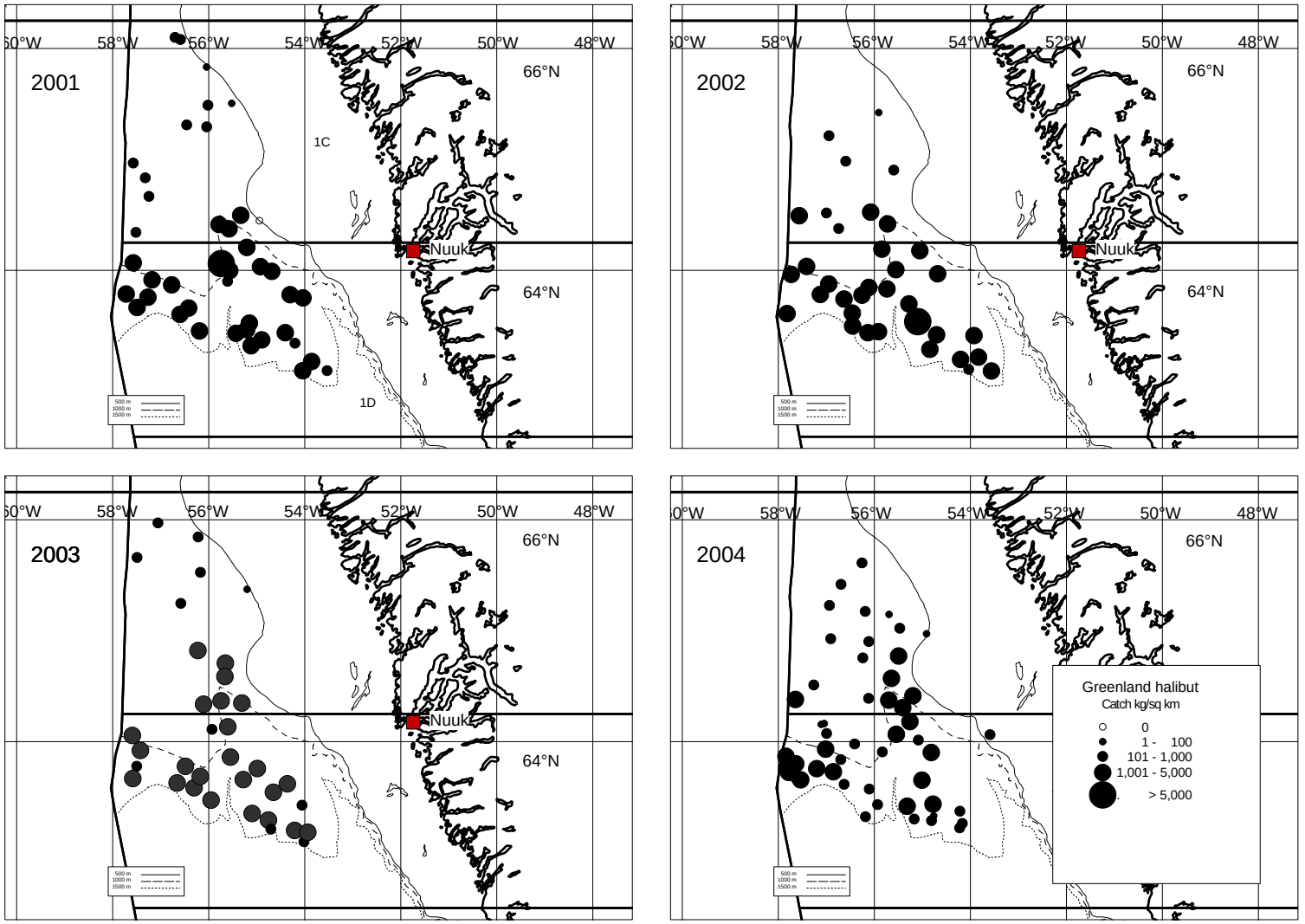


Fig. 1 (cont). Distribution of catches of Greenland halibut in 2001 - 2004 in kg km^{-2}

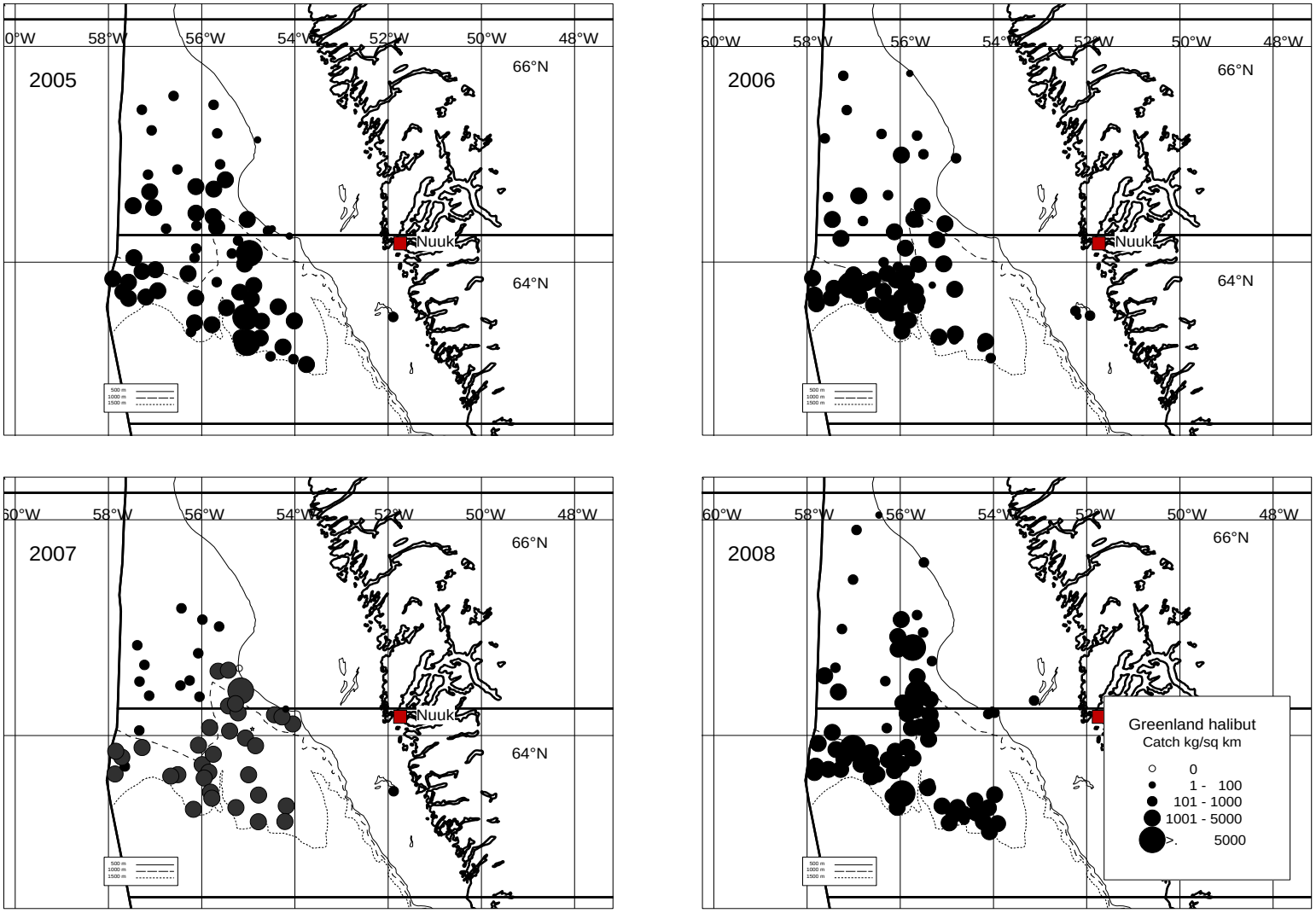


Fig. 1 (cont). Distribution of catches of Greenland halibut in 2005 - 2008 in kg km^{-2}

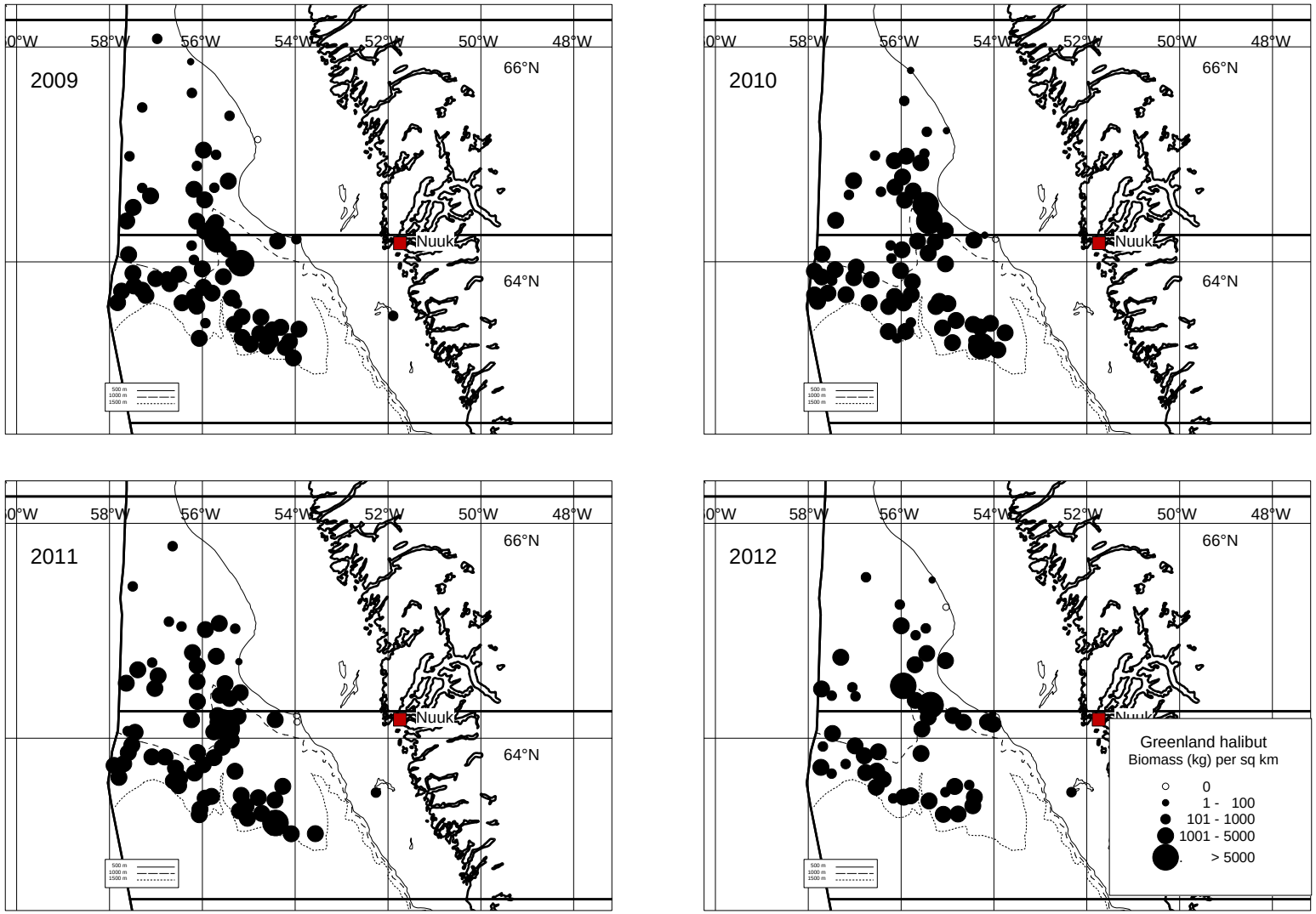


Fig. 1 (cont). Distribution of catches of Greenland halibut in 2009 - 2012 in kg km^{-2}

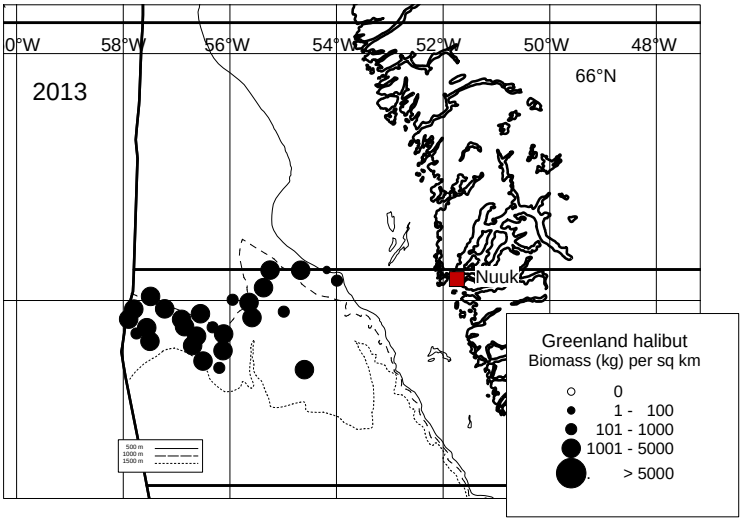


Fig. 1 (cont). Distribution of catches of Greenland halibut in 2013 in kg km^{-2}

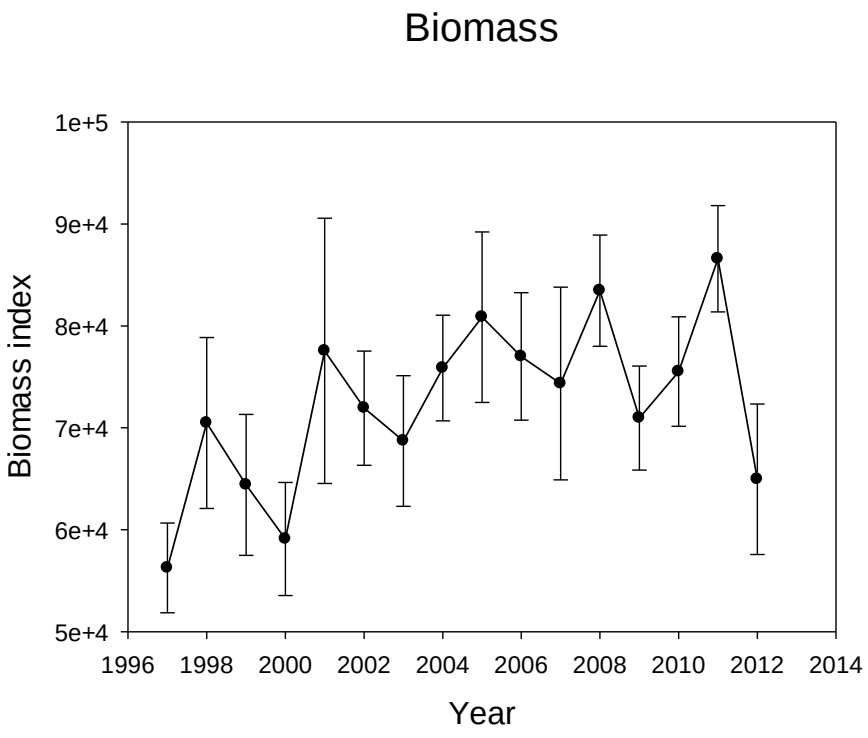


Fig. 2. Biomass (tons) of Greenland halibut in Div. 1CD by year with 1*S.E. No data from 2013.

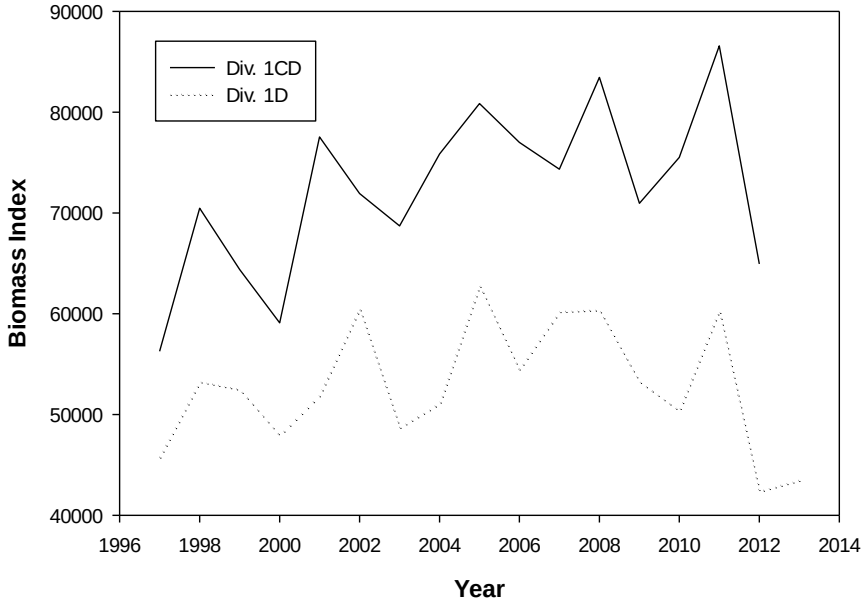


Fig 2a. Biomass (tons) of Greenland halibut in Div. 1CD and div. 1D, respectively, by year.

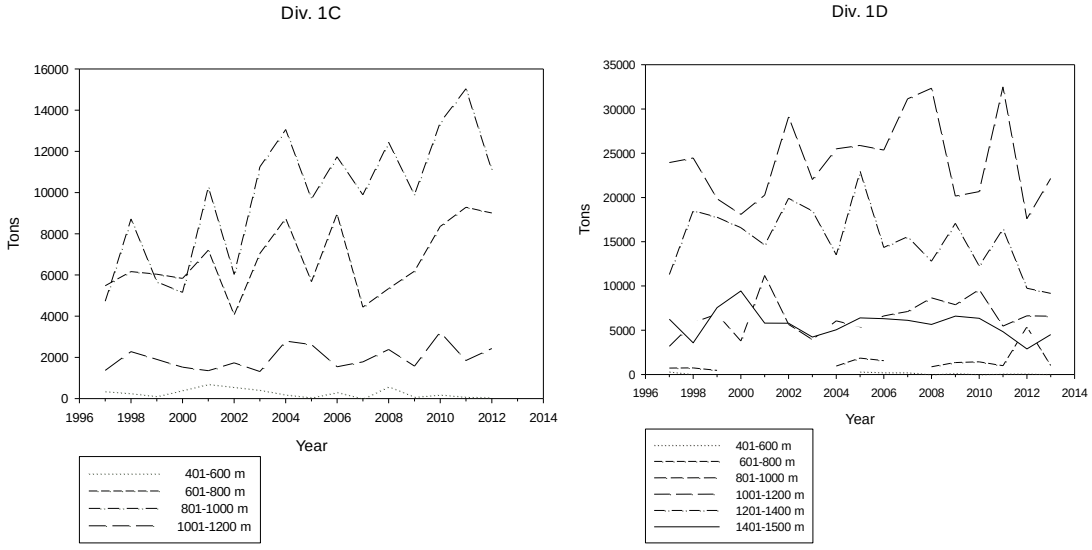


Fig.3 Biomass by Division, depth stratum and year. No data from Div. 1C in 2013

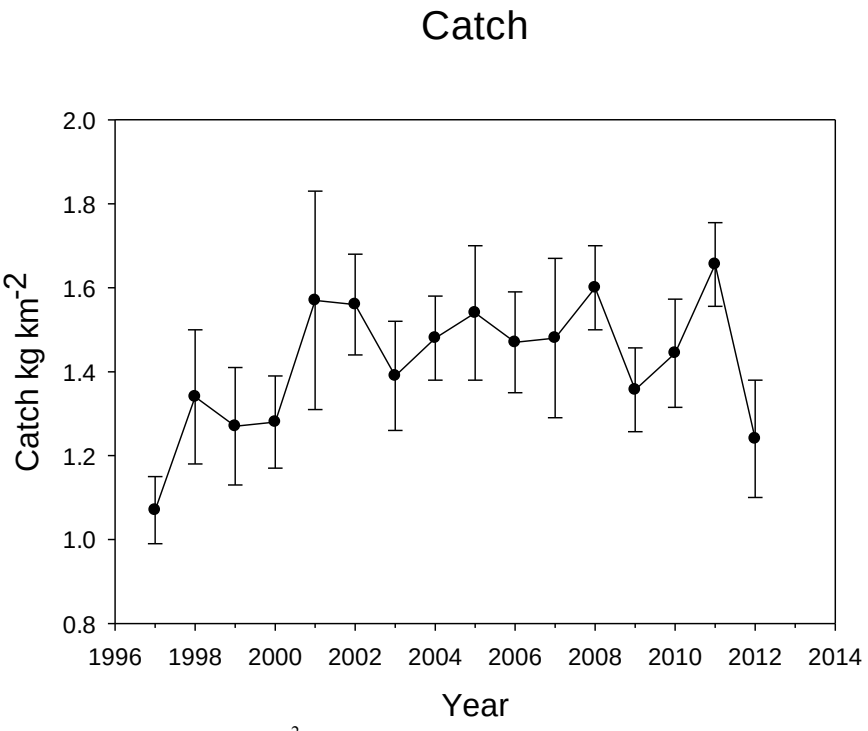


Fig. 4. Mean catch of Greenland halibut km^{-2} (tons) in Div. 1CD standardized by stratum area with 1*S.E. No data from 2013.

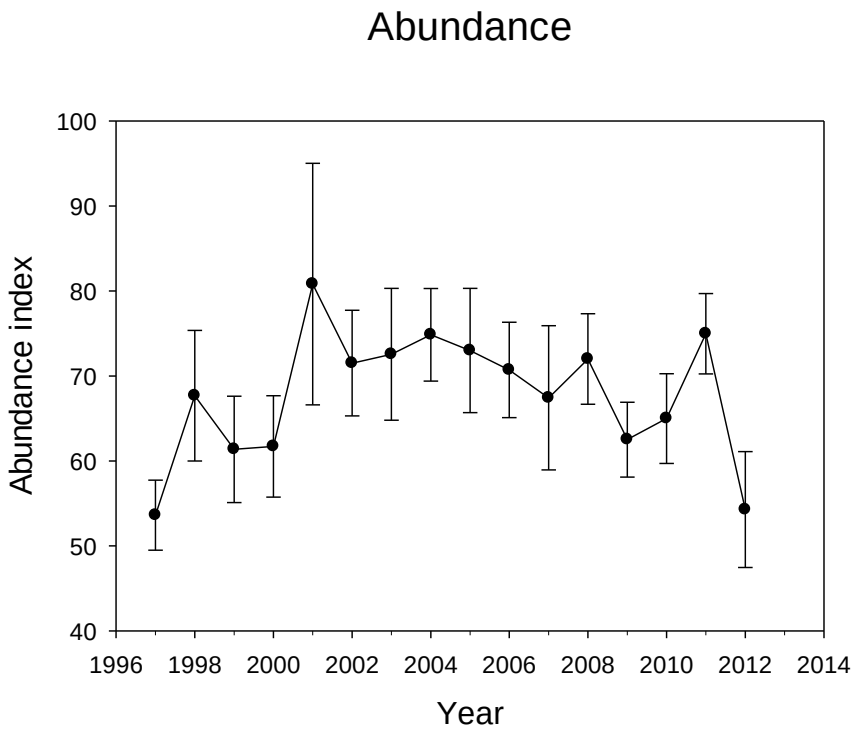


Fig. 5. Abundance (millions) of Greenland halibut in Div. 1CD by year with 1*S.E. No Data from 2013.

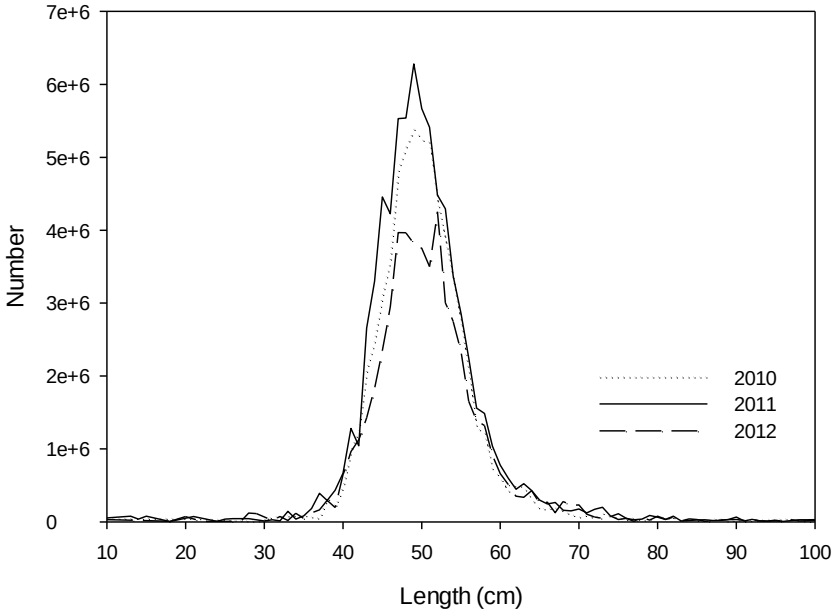


Fig. 6. Overall length distribution of Greenland halibut in numbers (weighted by stratum area) in Div. 1CD by year No data from 2013.

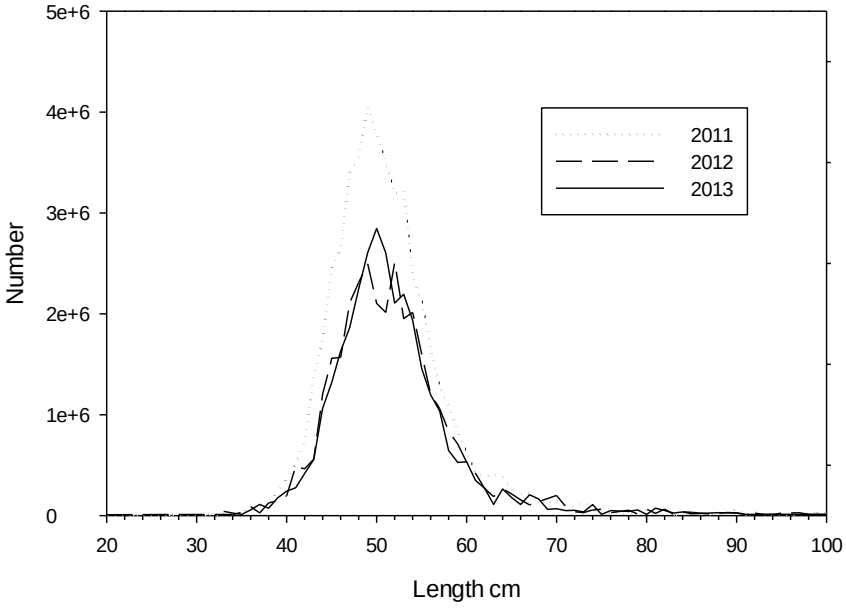


Fig. 6a. Length distribution in Div. 1D (weighted by stratum area) 2011-2013

Table 4. Number by age by year of Greenland halibut (excluding larvae, age 0). No data from 2008 and 2010-2013.

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

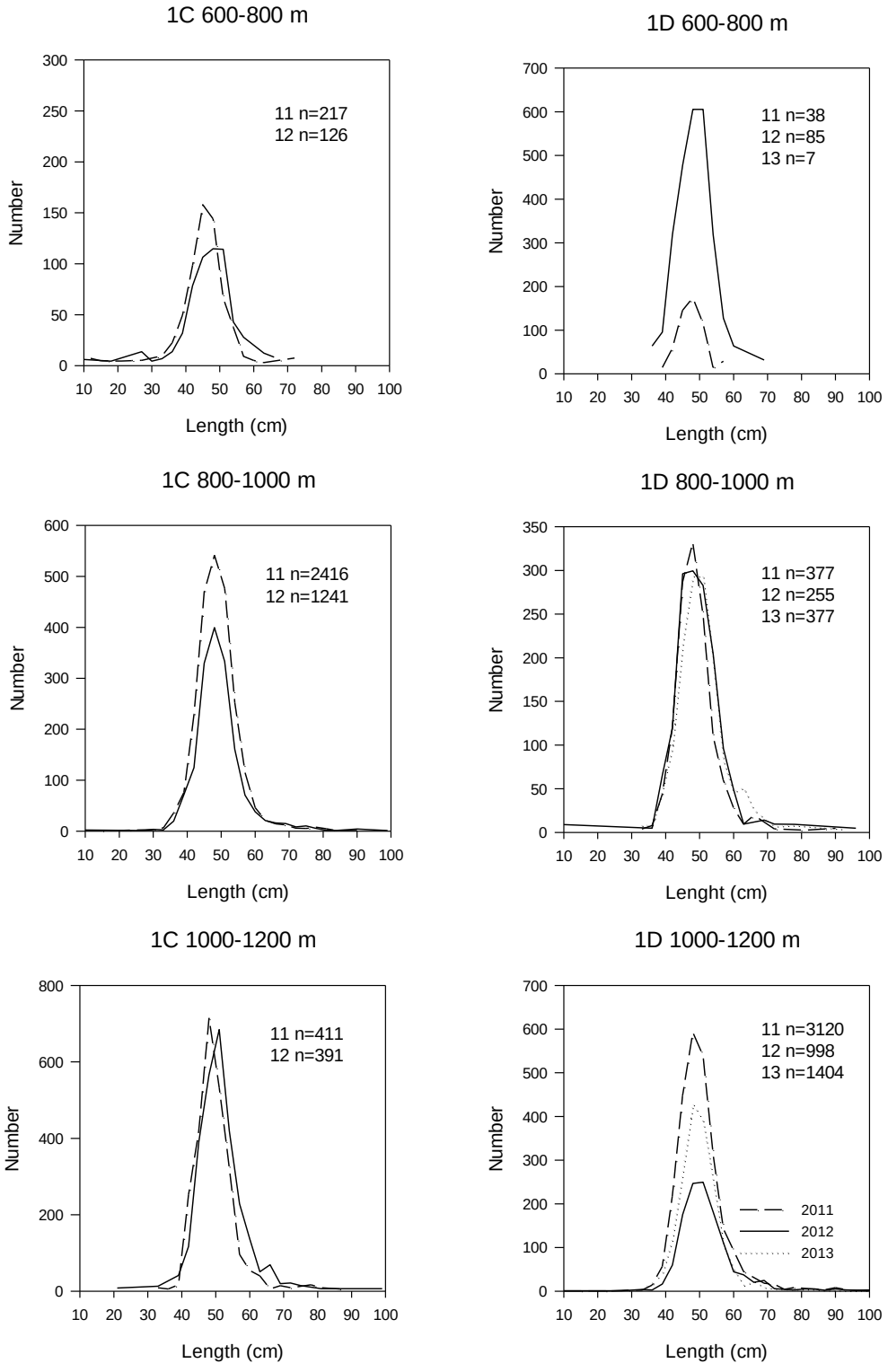


Fig. 7. Length distribution of Greenland halibut in numbers km^{-2} by year, Division and depth stratum. Div 1CD 600-1200 m. No data from Div. 1C in 2013.

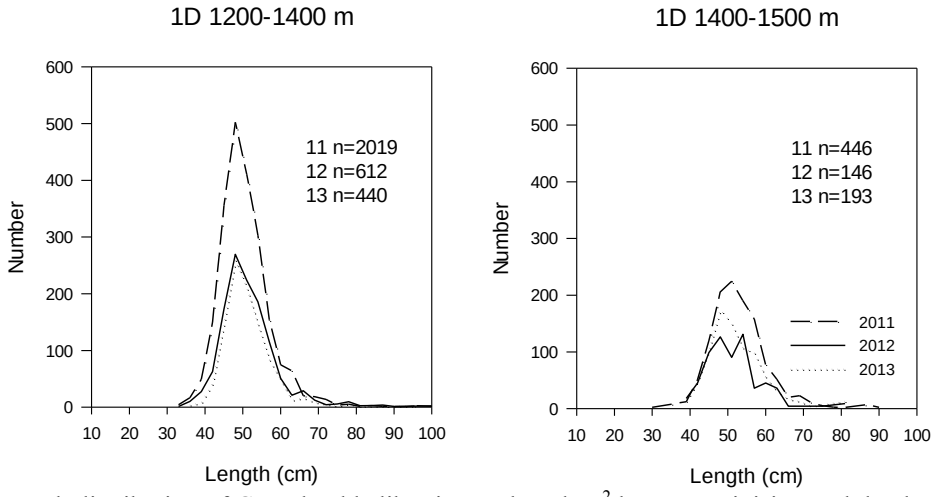


Fig. 7. cont. Length distribution of Greenland halibut in numbers km^{-2} by year, Division and depth stratum. Div. 1D 1200-1500 m.

Table 5. Mean weight and length by year and age. No data 2008 and 2010-2013.

	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 23 of the 27 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 2013 was estimated as 487.5 tons compared to 1634.1 tons in 2012. The 2012 figure also includes Div. 1C, but generally most of the biomass is found in Div. 1D. In 2013 Roundnose grenadier was most abundante between 601 and 1000 m (Table 7).

The abundance was estimated at $3.94*10^6$ specimens in 2013. 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. NOTE! Data from 2013 only includes Div. 1D.

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	1 634.1	936.3	24.36	15.63
2013	487.5	190.8	3.94	2.31

Pre anal fin length ranged from 4 to cm 16 cm. The grenadiers were generally small and the overall length distribution (weighted by stratum area) was dominated by fish at 5-8 cm (Fig. 9).

Table 7. Mean catch per km^2 and biomass (tons) with Standard Error of roundnose grenadier in Division 1D by depth stratum, 2013. Note that Standard Division is = biomass in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1D	401-600	903	1	0.0000	0.0	.
	601-800	1940	1	0.0648	125.6	.
	801-1000	3874	4	0.0430	166.4	140.5
	1001-1200	10140	11	0.0094	95.3	14.4
	1201-1400	6195	7	0.0132	81.6	25.6
	1401-1500	3091	3	0.0060	18.6	1.8
All				0.0186	487.5	190.8

Table 8. Mean catch per km^2 and abundance with Standard Error of roundnose grenadier in Division 1D by depth stratum, 2013. Note that Standard Division is = abundance in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1D	401-600	903	1	0.0	0.0	.
	601-800	1940	1	423.5	821535.0	.
	801-1000	3874	4	584.8	2265675.6	2155614.8
	1001-1200	10140	11	40.5	410891.5	91223.7
	1201-1400	6195	7	53.7	332578.7	95394.2
	1401-1500	3091	3	34.2	105643.0	26217.7
All				150.6	3936323.9	2310780.0

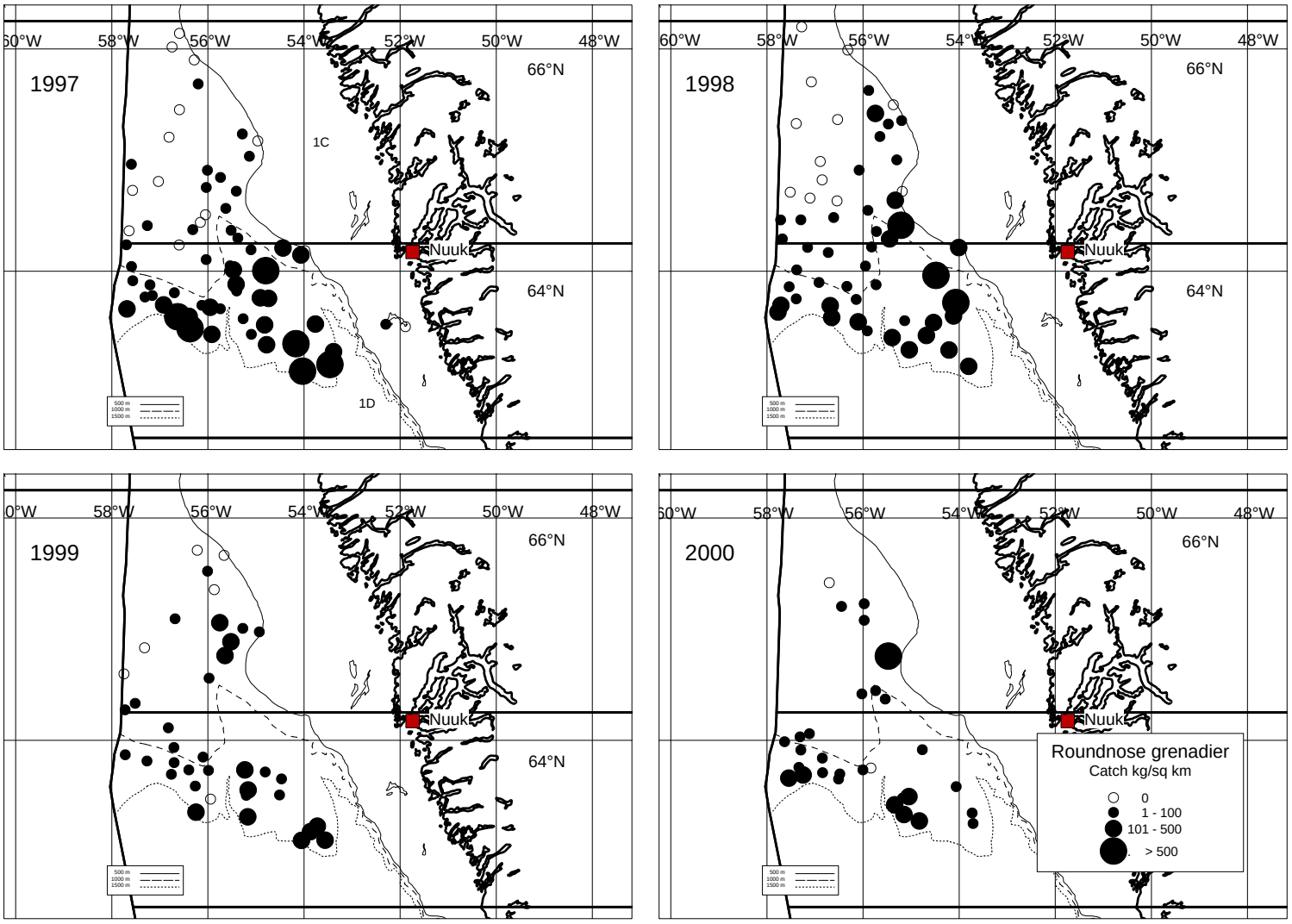


Fig. 8. Distribution of catches of roundnose grenadier in 1997-2000 in kg km^{-2}

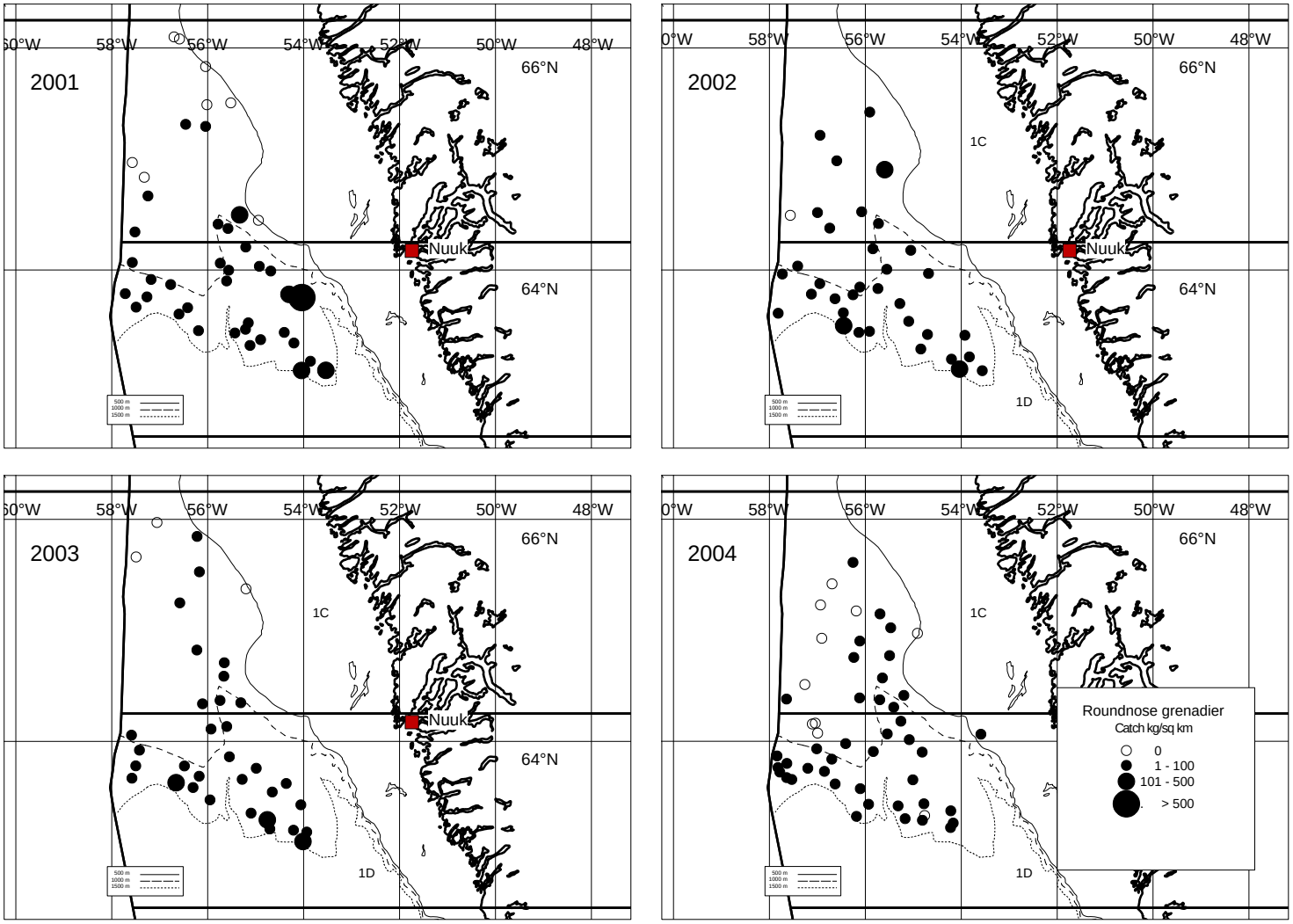


Fig. 8. cont. Distribution of catches of roundnose grenadier during 2001-2004 in kg km^{-2}.

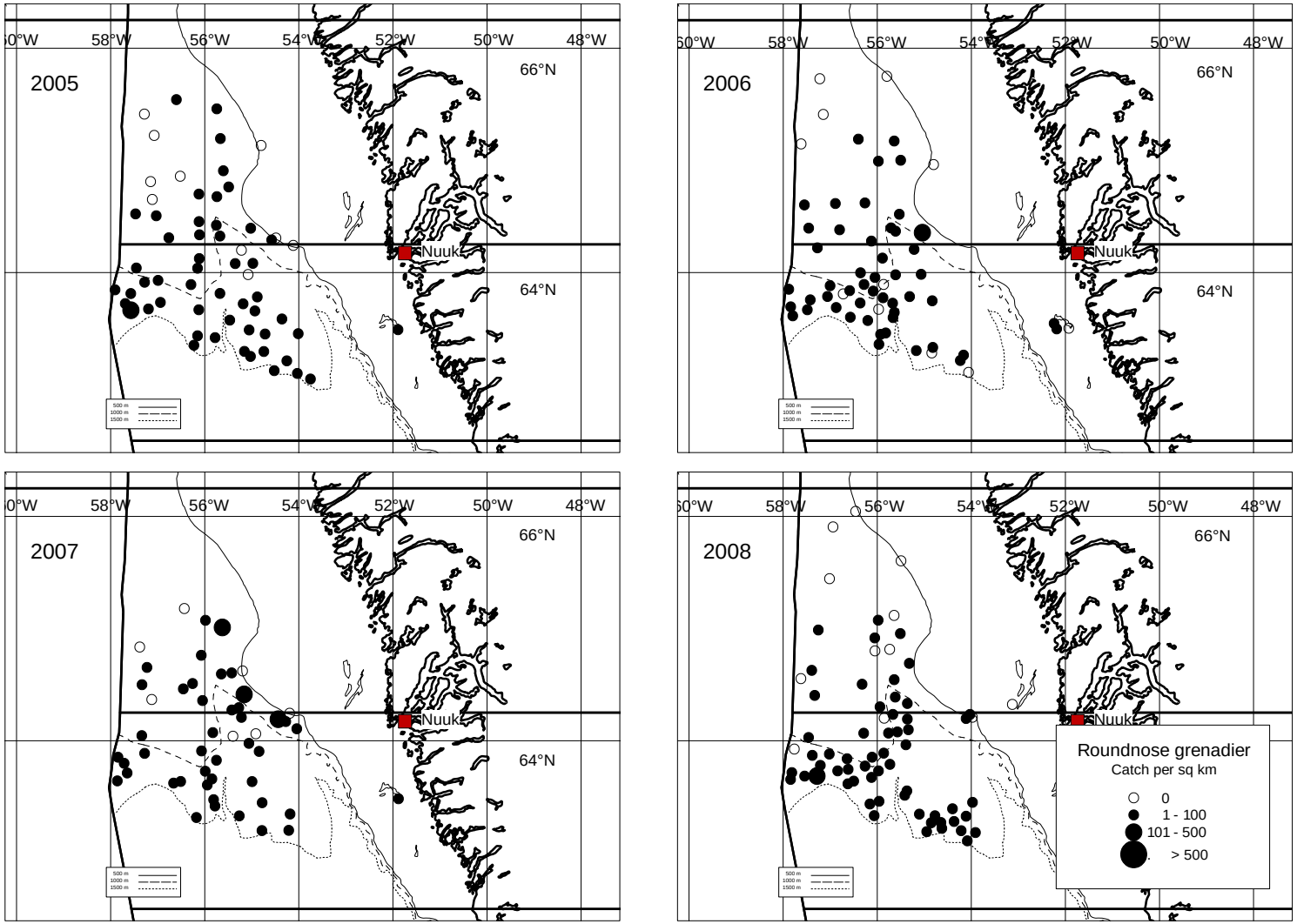


Fig. 8 cont. Distribution of catches of roundnose grenadier during 2005-2008 in kg km^{-2}.

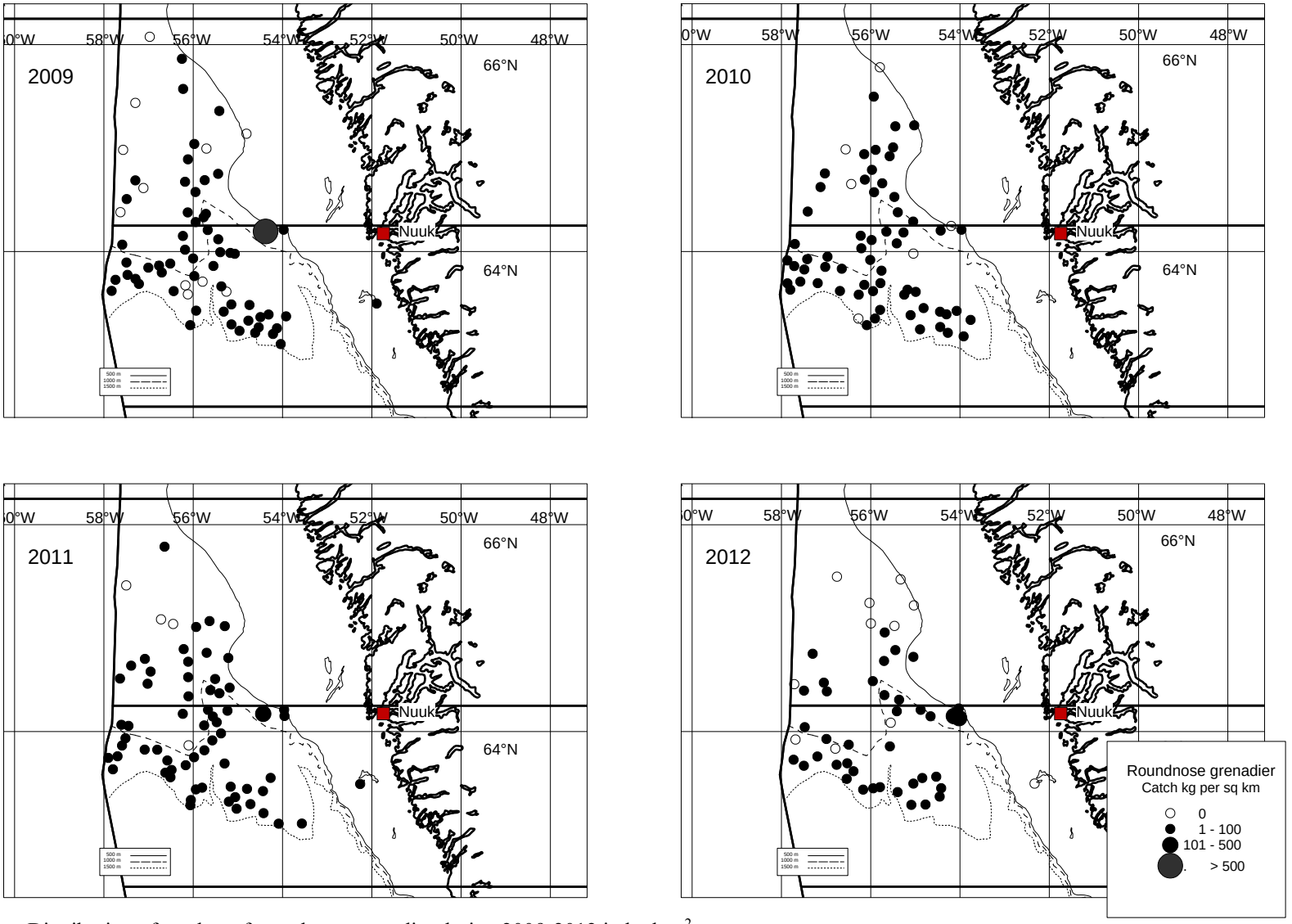


Fig. 8 cont. Distribution of catches of roundnose grenadier during 2009-2012 in kg km^{-2}.

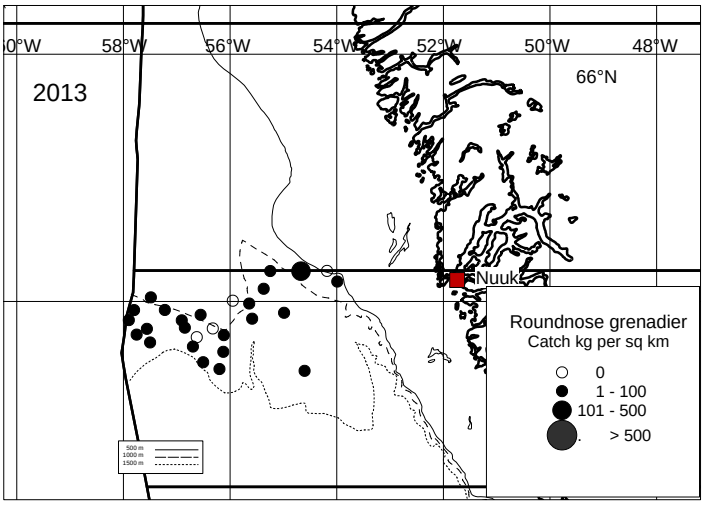


Fig. 8 cont. Distribution of catches of roundnose grenadier during in 2013 in kg km^{-2}.

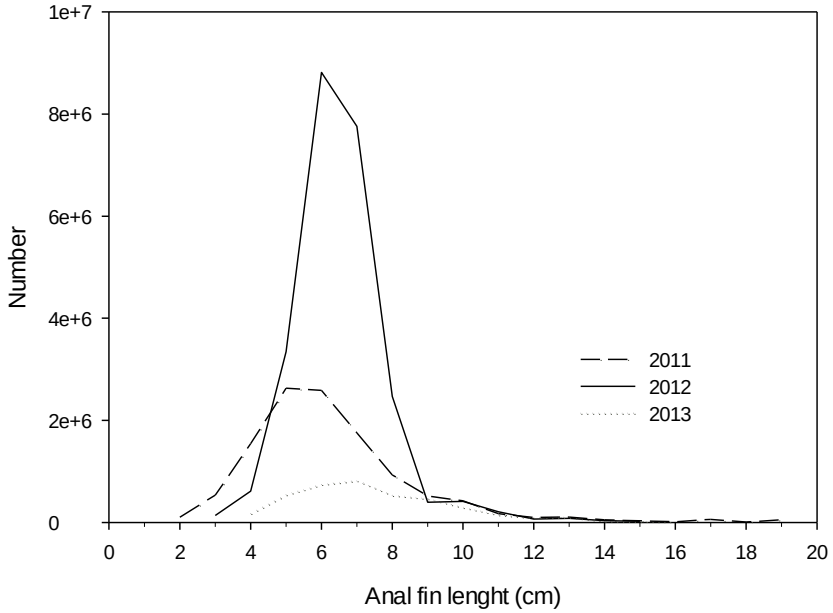


Fig. 9. Overall length distribution of roundnose grenadier (pre anal fin length) in numbers (weighted by stratum area) in Div. 1CD in 2011 and 2012 and Div.1D in 2013.

Roughhead grenadier (*Macrourus berglax*)

Roughead grenadier was caught in all 27 valid hauls. The catches were, however, generally low (Fig. 11, Appendix 1). The biomass was estimated at 2241.1 compared to 6303.4 tons 2012 (Table 9). The 2012 figure also includes Div. 1C but generally most of the biomass is found in Div. 1D

The densities in numbers per km^{-2} were fairly even distributed at depths > 600 m. s (Table 10 and 11).

Table 9. Biomass and abundance of roughhead grenadier by year in Div. 1CD with S.E. NOTE! Data from 2013 only includes Div. 1D.

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	8.44	1.21
2013	2241.1	507.2	4.14	0.96

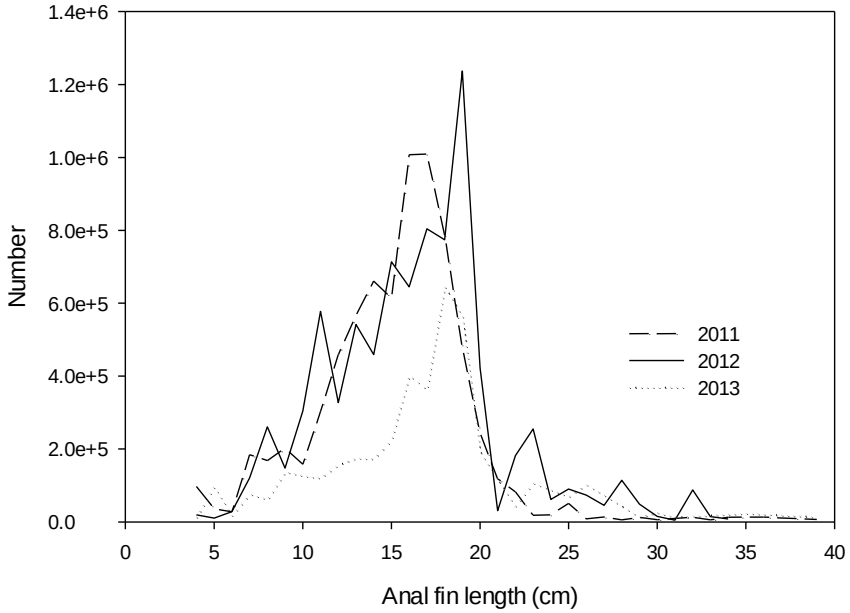


Fig. 10. Overall length distribution (pre anal fin length) of roughhead grenadier in numbers (weighted by stratum area) in Div. 1CD in 2011 and 2012 and in Div. 1D in 2013.

Table 10. Mean catch km^{-2} and biomass (tons) with Standard Error of roughhead grenadier in Division 1D by depth stratum, 2013. Note that Standard Division is = biomass in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1D	401-600	903	1	0.0407	36.8	.
	601-800	1940	1	0.2035	394.8	.
	801-1000	3874	4	0.0838	324.6	90.4
	1001-1200	10140	11	0.0561	568.9	172.7
	1201-1400	6195	7	0.0943	583.9	154.5
	1401-1500	3091	3	0.1075	332.1	195.4
All				0.0857	2241.1	507.2

Table 11. Mean catch per km^{-2} and abundance and Standard Error of roughhead grenadier in Division 1D by depth stratum, 2013. Note that Standard Division is = abundance in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1D	401-600	903	1	86.3	77885.5	.
	601-800	1940	1	373.7	724883.9	.
	801-1000	3874	4	146.6	567745.3	191457.5
	1001-1200	10140	11	141.6	1435580.8	298294.9
	1201-1400	6195	7	146.8	909733.2	183848.5
	1401-1500	3091	3	136.8	422785.6	206705.9
All				158.3	4138614.2	856554.8

The total abundance was estimated at $4.14*10^6$ (Table 9). The highest densities was found in Div. 1D 601-800 m, but the figure is based on one haul only. Otherwise roughead grenadier was even distributed down to 1500 m (Table 11).

Pre anal fin length ranged from 4 to 39 cm and the over all length distribution showed mode at 18 (Fig.10).

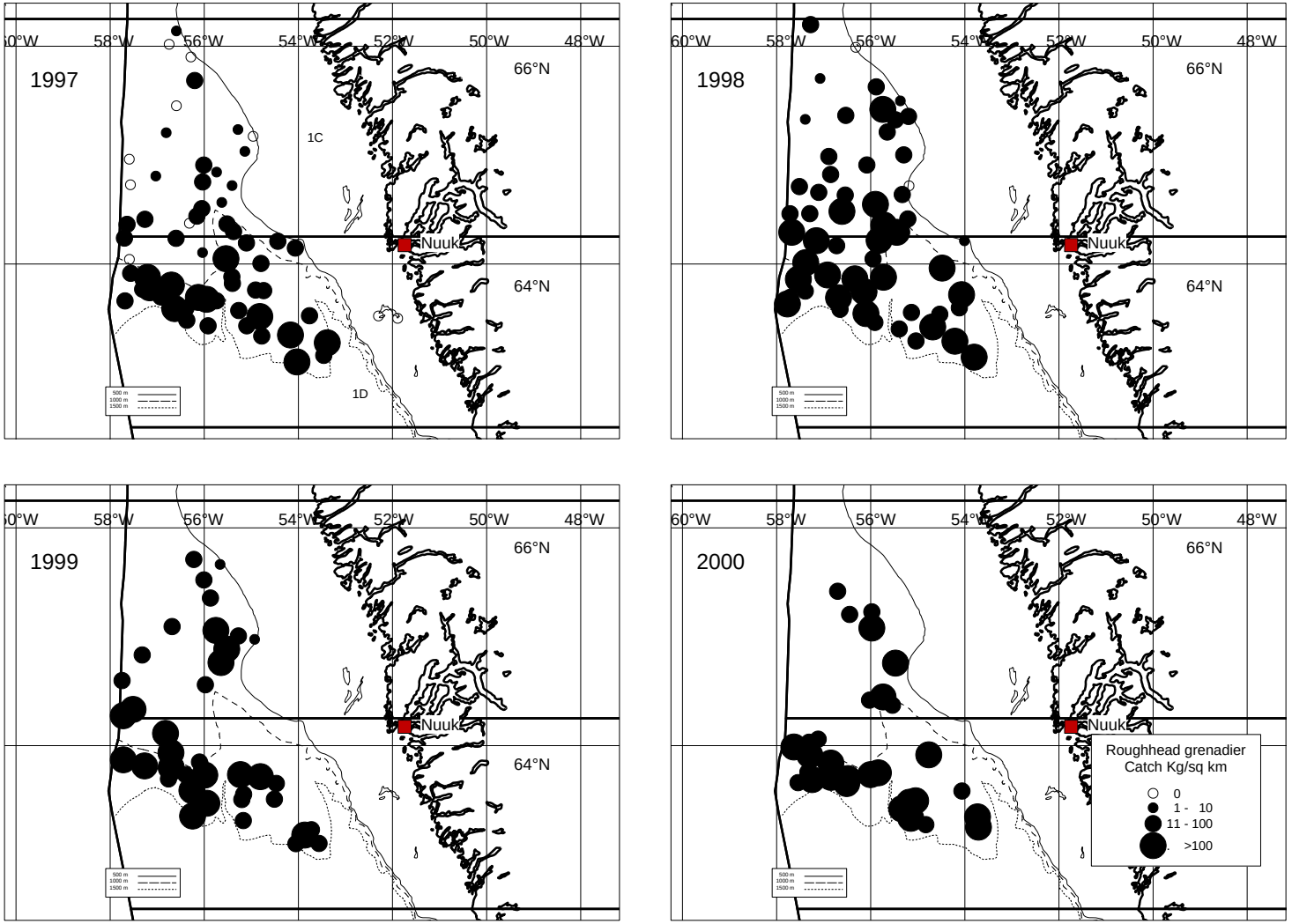


Fig.11 Distribution of catches of roughhead grenadier in 1997-2000 in kg km^{-2}.

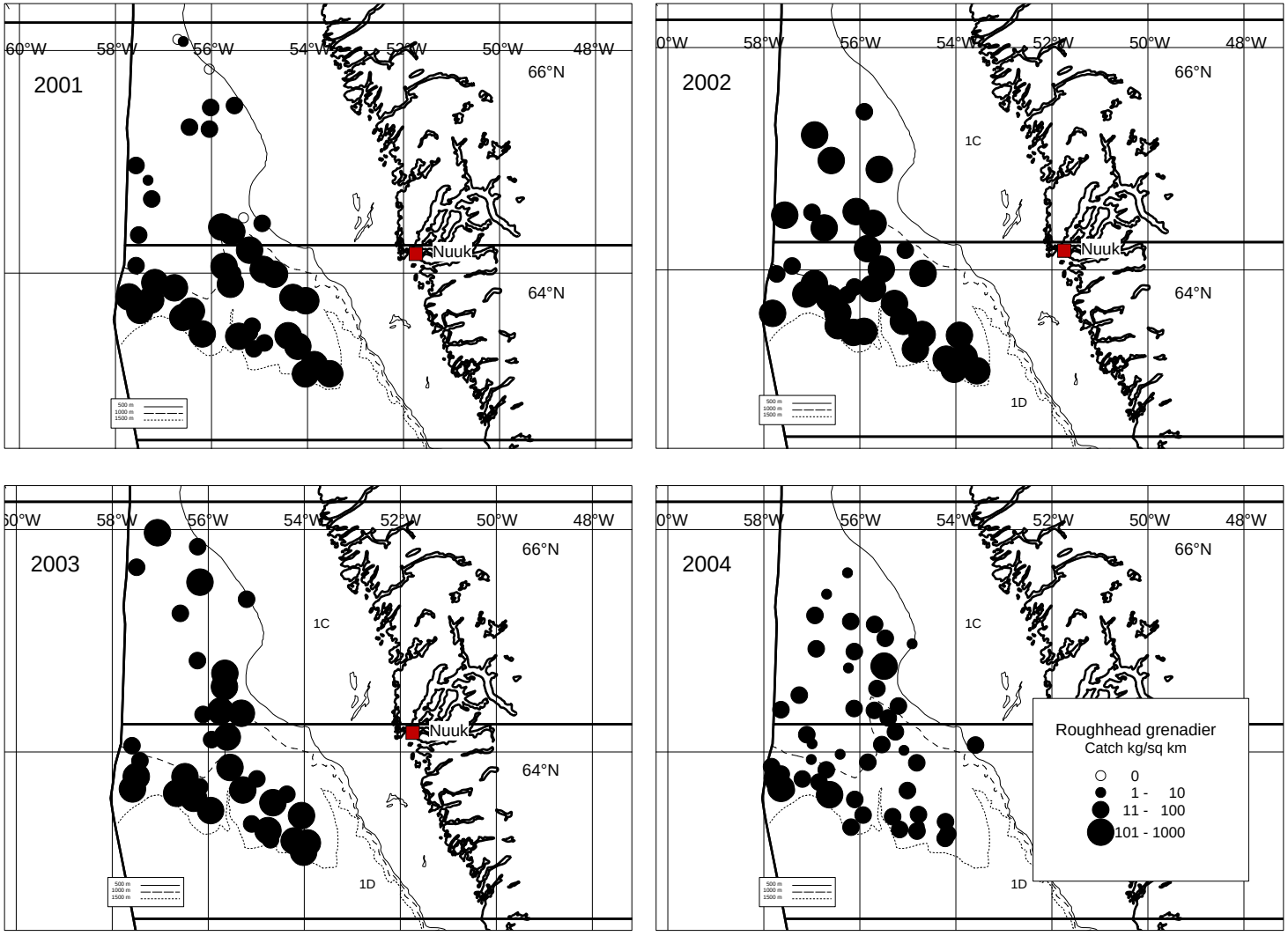


Fig. 11 cont. Distribution of catches of roughhead grenadier during 2001-2004 km^{-2}.

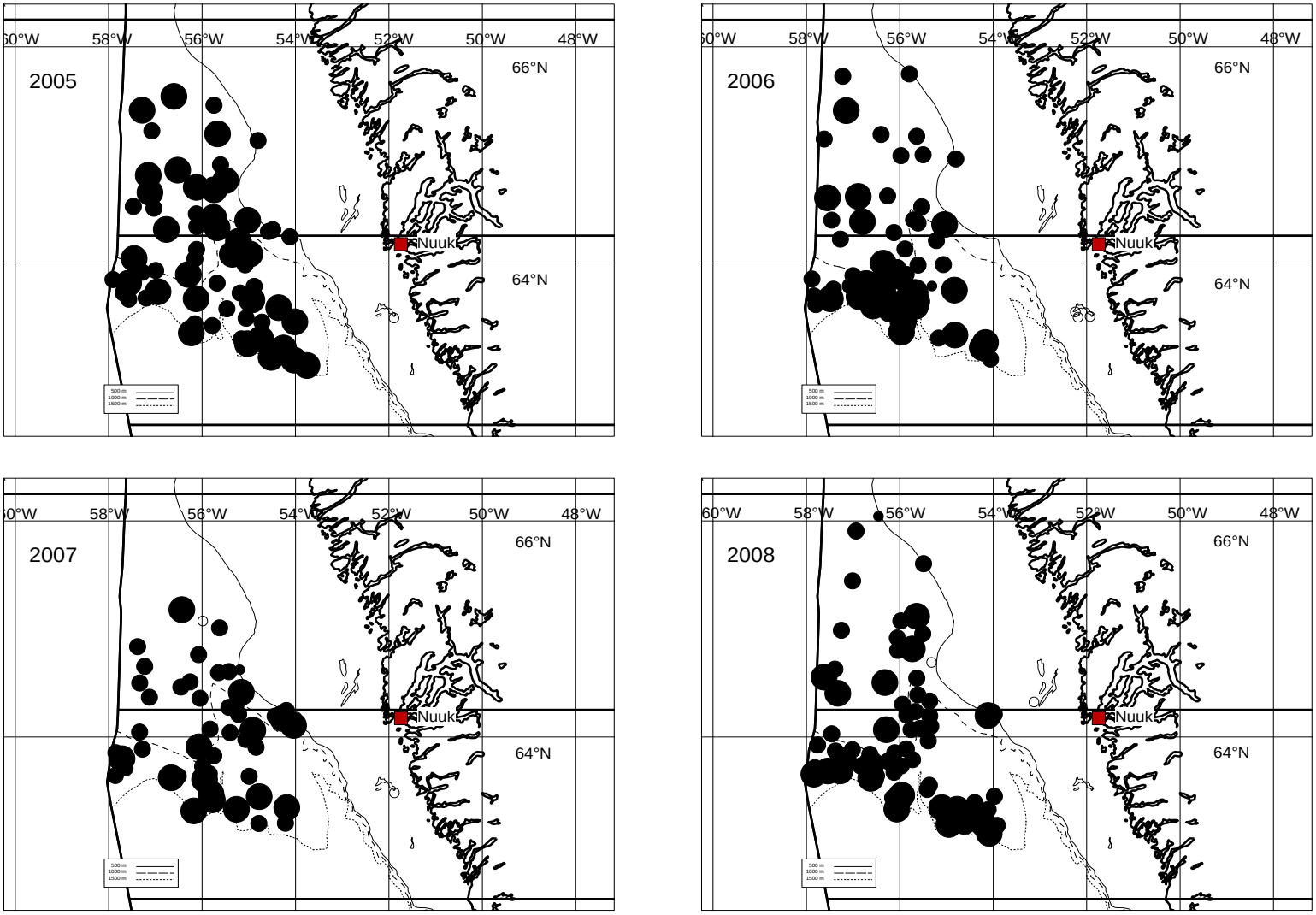


Fig.11 cont.. Distribution of catches of roughhead grenadier during 2005-2008 km^{-2}.

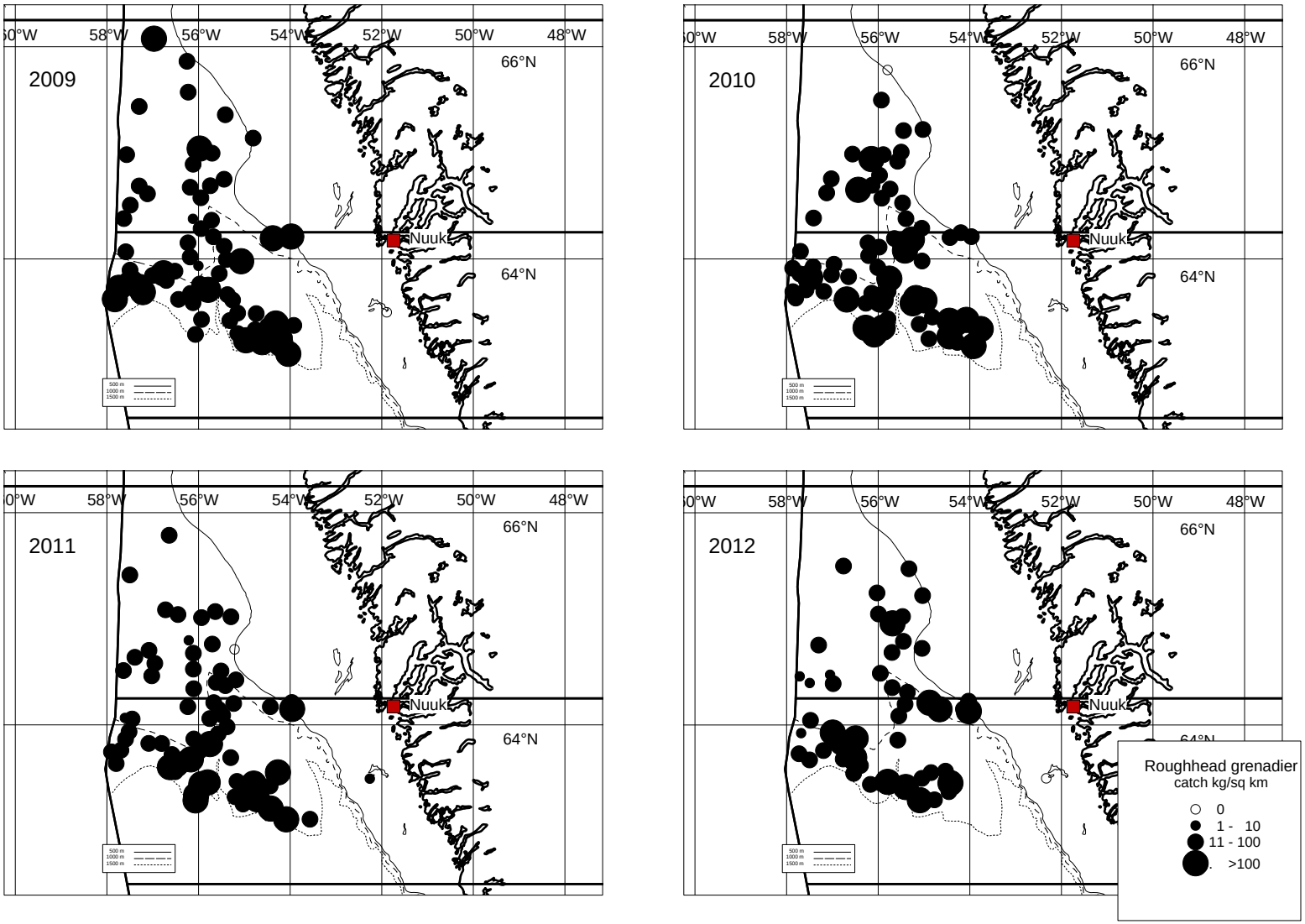


Fig. 11 cont.. Distribution of catches of roughhead grenadier during 2009-2012 in kg km^{-2}.

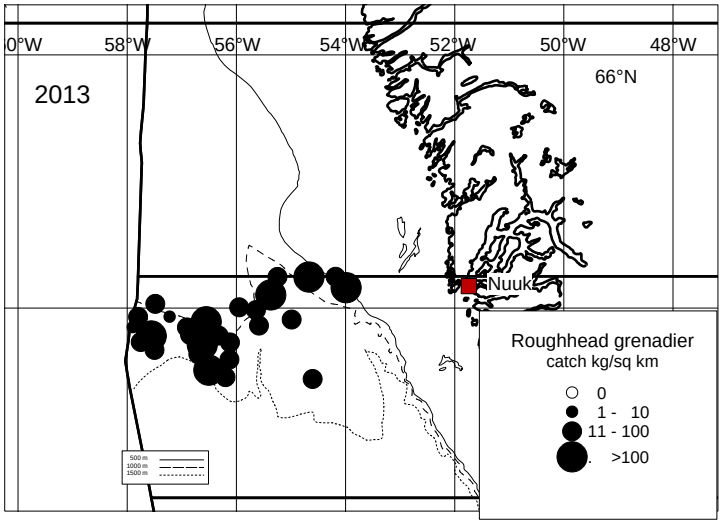


Fig. 11 cont.. Distribution of catches of roughhead grenadier in 2013 in kg km^{-2}.

Deep-sea redfish (*Sebastes mentella*)

Deep-sea redfish was caught in 5 of the 27 valid hauls (Fig 12). The biomass was estimated at 25 356.0 tons compared to 14 010.6 tons in 2012 (Table 12) where almost all the biomass was found in Div. 1C. The Biomass estimate is driven by two large hauls (Fig. 13, Appendix 1). Almost all the biomass was found at depths <800 m (Table 13).

The abundance was estimated at $45.90*10^6$. All most all the abundance was found at depths < 800 m with the highest density at 401-600 m (Table 14).

The length ranged from 21 to 45 cm with modes at 28 and 41 cm, respectively 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. NOTE! Data from 2013 only includes Div. 1D.

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
2013[1)]	25356.0	21231.2	45.90	33.54

[1)] Poor coverage of relevant depths.

Table 13. Mean catch km^{-2} and biomass (tons) with Standard Error of Deep Sea Redfish in Division 1D by depth stratum, 2013.Note that Standard Division is = biomass in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Biomass	SE
1D	401-600	903	1	5.1182	4621.7	.
	601-800	1940	1	10.6815	20722.0	.
	801-1000	3874	4	0.0000	0.0	0.0
	1001-1200	10140	11	0.0003	3.0	3.0
	1201-1400	6195	7	0.0007	4.5	4.5
	1401-1500	3091	3	0.0015	4.7	4.7
All				0.9699	25356.0	21231.2

Table 14. Mean catch km^{-2} and abundance with Standard Error of Deep Sea Redfish by Division and depth stratum, 2013. Note that Standard Division is = abundance in the estimation of overall SE when there is only 1 haul.

Div.	Stratum(m)	Area	Hauls	Mean sq km	Abundance	SE
1D	401-600	903	1	18692.5	16879341.3	.
	601-800	1940	1	14941.9	28987315.2	.
	801-1000	3874	4	0.0	0.0	0.0
	1001-1200	10140	11	1.3	12848.7	12848.7
	1201-1400	6195	7	2.0	12242.0	12242.0
	1401-1500	3091	3	4.2	13056.2	13056.2
All				1755.9	45904803.4	33543659.5

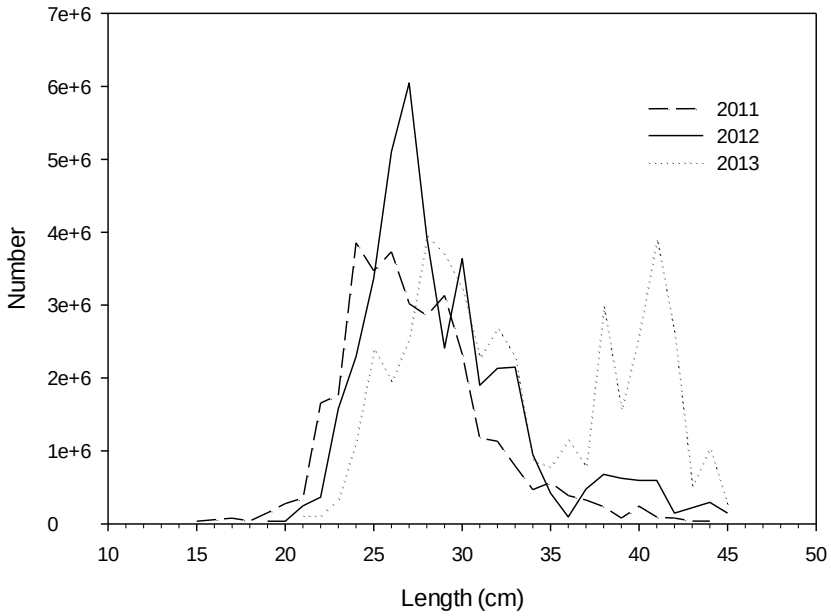


Fig. 12. Overall length distribution of deep sea redfish in numbers (weighted by stratum area) in Div. 1CD in 2011 and 2012 and in Div. 1D in 2013.

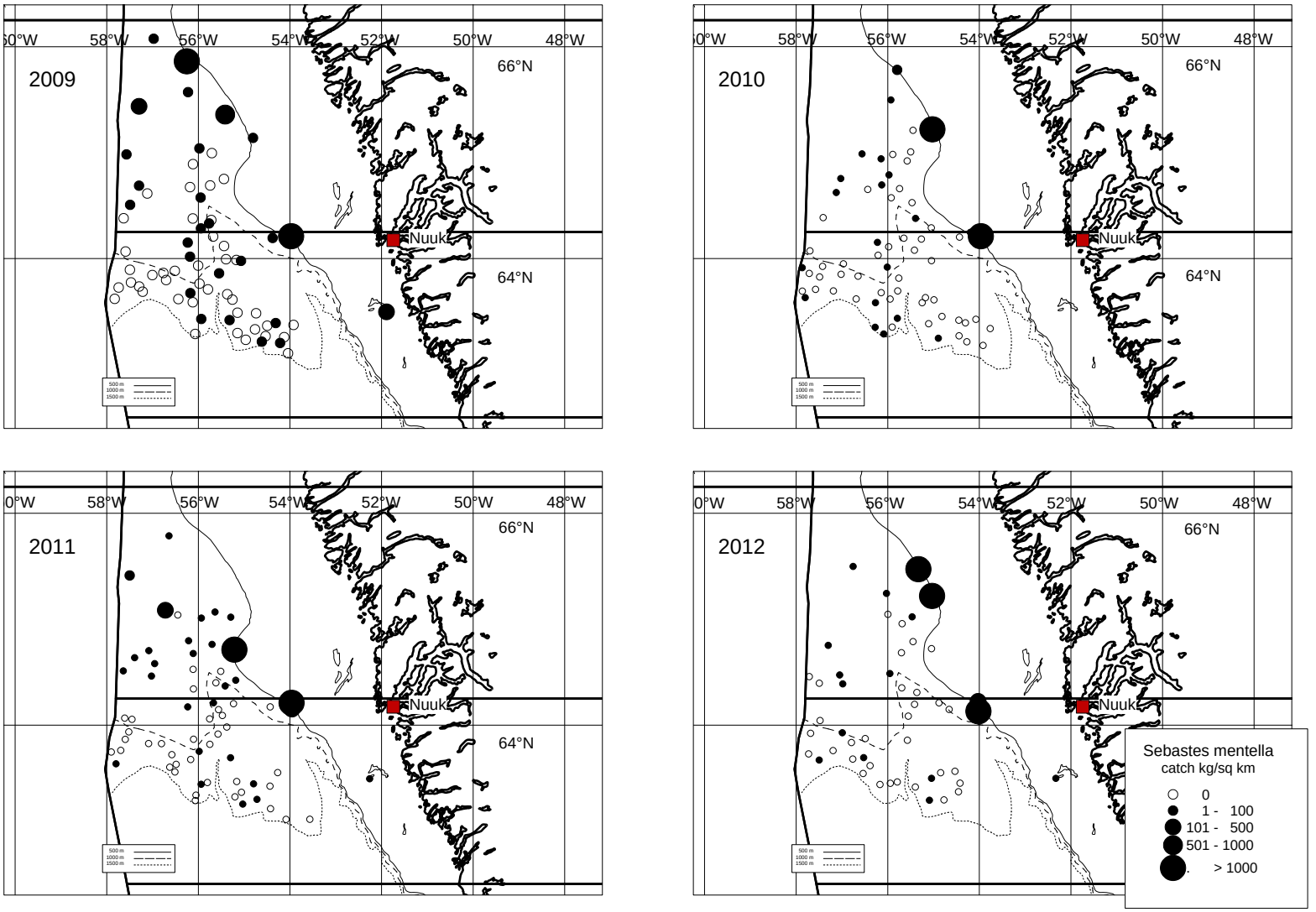


Fig. 13. Distribution of catches of deep sea redfish during 2009-2012 km^{-2}.

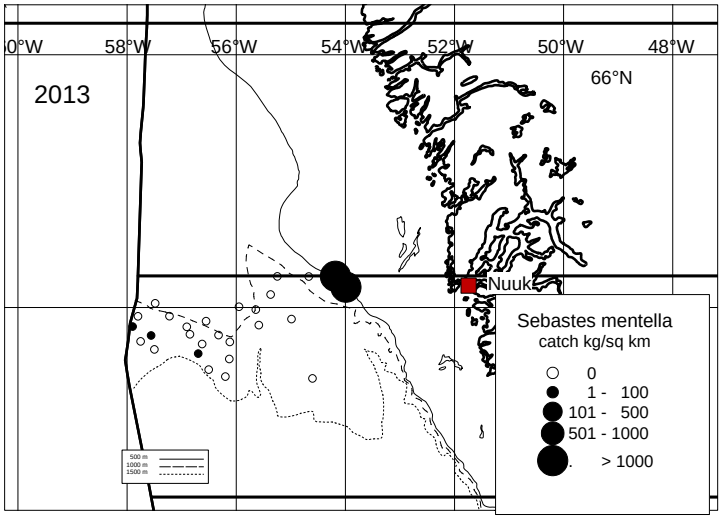


Fig. 13. Distribution of catches of deep sea redfish during in 2013 in kg km^{-2}

Temperature

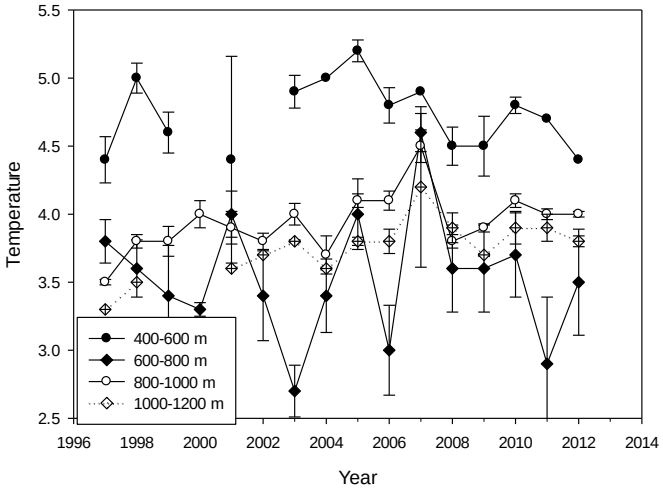
The bottom temperature ranged from 3.6°C to 5.1°C. The mean temperature was generally decreasing by depth as in previous years (Table 15).

The mean temperatures have been relatively constant in recent years except at depths between 400 and 600 m where the mean temperature has fluctuated during the 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. No data from Div. 1C in 2013.

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																		
1D	5.1		1	4.4		1	3.9	.08	4	3.8	.01	11	3.7	.03	7	3.6	.01	3

Div. 1C



Div. 1D

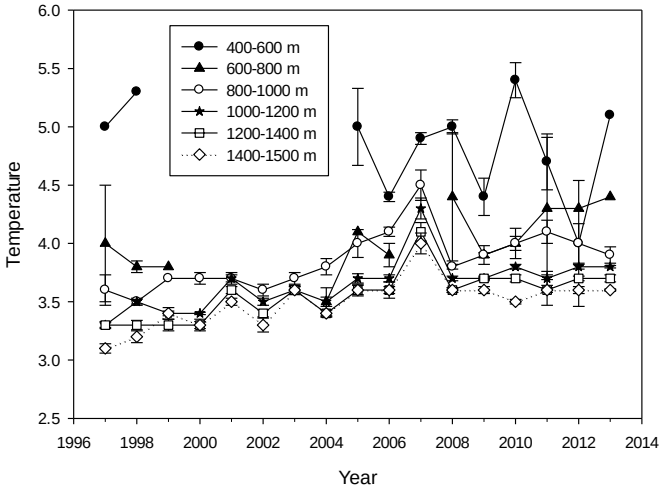


Fig 14. Mean temperatures by division depth stratum and year with 1*S.E. No data from Div. 1C in 2013

References

Jørgensen, O A. 1997b. Movement patterns of Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum.) at West Greenland, as inferred from Trawl Survey Distribution and Size Data.. *J. Northw. Atl. Fish. Sci*.; **21**:23-37.

Jørgensen, O A. 1997a. Pelagic occurrence of Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum) in West Greenland waters. *J. Northw. Atl. Fish. Sci*.; **21**:39-50.

Jørgensen O. A. 1998a. Results of the Joint Japan Greenland Trawl Surveys at West Greenland 1987-1995 on Greenland Halibut (*Reinhardtius hippoglossoides*) and Roundnose Grenadier (*Coryphaenoides rupestris*). *NAFO Sci. Council Studies* No 31. 21-56.

Jørgensen O.A. 1998b. Survey for Greenland Halibut in NAFO Division 1C-1D. NAFO SCR Doc. 98/25. Serial No. N3010, 26 pp.

Jørgensen O.A. 1999. Survey for Greenland Halibut in NAFO Division 1C-1D, 1998. NAFO SCR Doc. 99/30. Serial No. N4086, 25 pp.

Jørgensen O.A. 2000. Survey for Greenland Halibut in NAFO Division 1C-1D, 1999. NAFO SCR Doc. 00/10. Serial No. N4232, 26 pp.

Jørgensen O.A. 2001. Survey for Greenland Halibut in NAFO Division 1C-1D, 2000. NAFO SCR Doc. 01/23. Serial No. N4392, 23 pp.

Jørgensen O.A. 2002. Survey for Greenland Halibut in NAFO Division 1A-1D, 2001. NAFO SCR Doc. 02/30. Serial No. N4637, 31 pp.

Jørgensen O.A. 2003. Survey for Greenland Halibut in NAFO Division 1C-1D, 2002. NAFO SCR Doc. 03/20. Serial No. N4829, 27 pp.

Jørgensen O.A. 2004. Survey for Greenland Halibut in NAFO Division 1C-1D, 2003. NAFO SCR Doc. 04/19. Serial No. N4967, 26 pp.

Jørgensen O.A. 2005. Survey for Greenland Halibut in NAFO Division 1C-1D, 2004. NAFO SCR Doc. 05/13. Serial No. N5052, 28 pp.

Jørgensen O.A. 2006. Survey for Greenland Halibut in NAFO Division 1C-1D, 2005. NAFO SCR Doc. 06/27. Serial No. N5246, 30 pp.

Jørgensen O.A. 2007. Survey for Greenland Halibut in NAFO Division 1C-1D, 2006. NAFO SCR Doc. 07/29. Serial No. N5381, 32 pp.

Jørgensen O.A. 2008. Survey for Greenland Halibut in NAFO Division 1C-1D, 2007. NAFO SCR Doc. 08/17. Serial No. N5510, 31 pp.

Jørgensen O.A. 2009. Survey for Greenland Halibut in NAFO Division 1C-1D, 2008. NAFO SCR Doc. 09/16. Serial No. N5645, 28 pp.

Jørgensen O.A. 2010. Survey for Greenland Halibut in NAFO Division 1C-1D, 2009. NAFO SCR Doc. 010/11. Serial No. N5762, 38 pp.

Jørgensen O.A. 2011. Survey for Greenland Halibut in NAFO Division 1C-1D, 2010. NAFO SCR Doc. 011/09. Serial No. N5889, 37 pp.

Jørgensen O.A. 2012. Survey for Greenland Halibut in NAFO Division 1C-1D, 2011. NAFO SCR Doc. 012/09. Serial No. N6020, 38 pp.

Jørgensen O.A. 2013. Survey for Greenland Halibut in NAFO Division 1C-1D, 2012. NAFO SCR Doc. 013/006. Serial No. N6155 38 pp.

Kingsley, M.C.S., P. Kanneworff and D.M. Carlsson. 2004. Buffered random sampling: a sequential inhibited spatial point process applied to sampling in trawl survey for northern shrimp *Pandalus borealis* in West Greenland waters. ICES J. Mar. Sci. 61:12-24.

Nygaard, R., & O.A. Jørgensen 2012. Biomass and Abundance of Demersal Fish Stocks off West Greenland Estimated from the Greenland shrimp survey, 1988-2011. NAFO SCR. Doc., 12/16.

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	0.076299	1D	1143	3.8	99.0	82	0.8	5	6.6	17	0.0	0
5	0.078222	1D	1493	3.6	163.5	63	0.5	4	18.2	21	0.0	0
6	0.050817	1D	1244	3.7	43.2	33	0.7	4	2.4	3	0.0	0
7	0.076817	1D	1276	3.6	224.9	90	0.4	2	5.1	11	0.0	0
8	0.037806	1D	1282	3.7	51.3	39	0.0	0	8.2	7	0.0	0
9	0.078915	1D	1468	3.6	85.2	60	0.4	2	2.4	4	0.4	1
10	0.076767	1D	1456	3.6	92.5	70	0.5	2	4.6	7	0.0	0
11	0.072656	1D	1324	3.7	40.5	36	1.2	3	4.6	5	0.0	0
12	0.072292	1D	1289	3.7	190.1	141	1.1	6	10.8	18	0.4	1
13	0.071744	1D	1168	3.8	148.1	137	0.8	2	0.7	3	0.2	1
14	0.075710	1D	1094	3.8	129.8	115	1.1	3	3.6	9	0.0	0
15	0.073500	1D	966	3.8	120.6	108	0.1	2	2.3	5	0.0	0
16	0.076807	1D	1055	3.8	230.0	183	0.8	3	0.3	2	0.0	0
17	0.075872	1D	1157	3.7	118.6	78	0.9	3	1.9	4	0.0	0
18	0.068411	1D	1244	3.7	80.7	73	0.5	2	2.2	6	0.0	0
19	0.068489	1D	969	3.8	162.2	125	1.3	4	7.6	11	0.0	0
20	0.073938	1D	1086	3.7	24.0	20	0.0	0	1.6	7	0.0	0
21	0.075759	1D	1102	3.7	186.6	134	0.9	3	5.8	12	0.0	0
22	0.077146	1D	1146	3.8	150.6	119	0.2	1	3.3	10	0.0	0
24	0.042545	1D	1230	3.8	36.0	28	1.4	5	3.7	10	0.0	0
25	0.073737	1D	1134	3.8	273.5	232	1.0	8	15.4	26	0.0	0
26	0.073996	1D	1040	3.8	247.7	198	0.4	1	3.6	9	0.0	0
27	0.078286	1D	911	4.0	76.7	62	0.0	0	4.6	6	0.0	0
29	0.050388	1D	1108	3.7	131.4	104	0.6	3	2.3	12	0.0	0
30	0.056953	1D	937	4.1	102.5	82	8.6	128	7.6	16	0.0	0
31	0.057970	1D	406	5.1	2.3	3	0.0	0	2.4	5	296.7	1084
32	0.040144	1D	660	4.4	21.3	7	2.6	17	8.2	15	428.8	600

Appendix 2. List of species and groups of species recorded in Div. 1D in 2013 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.

	species	maxwgt	maxno	mindepth	maxdepth	mintemp	maxtemp	maxpos
1	ALA Alepocephalus agassizzi	44.8	78	660	1493	3.6	4.4	64.2462
2	RRD Amblyraja radiata	0.1	1	233	233	.	.	64.2744
3	CAD Anarhichas denticulatus	22.0	4	660	1324	3.6	4.4	64.2448
4	ATP Anoptopterus pharo	0.5	1	1456	1456	3.6	3.6	63.6686
5	ANT Antimora rostrata	21.8	28	911	1493	3.6	4.0	64.2462
6	ARS Argentina silus	0.4	2	406	406	5.1	5.1	64.2471
7	BAM Bajacalifornia megalops	0.0	1	1102	1102	3.7	3.7	63.7283
8	BAT Bathylagus euryops	4.0	81	911	1493	3.6	4.1	64.2462
9	BSP Bathyraja spinicauda	17.2	1	937	1108	3.7	4.1	64.2462
10	BEG Benthosema glaciale	0.0	23	660	1493	3.6	4.4	64.2462
11	BOA Borostomias antarcticus	0.4	5	937	1493	3.6	4.1	64.2448
12	CFB Centroscyllium fabricii	22.9	16	660	1230	3.7	4.4	64.2448
13	CHA Chauliodus sloani	0.1	1	966	1134	3.7	3.8	64.1028
14	CHH Chiasmodon harteli	0.1	2	966	1456	3.6	3.8	64.2462
15	CHN Chiasmodon niger	0.1	1	1244	1289	3.7	3.7	63.7788
16	CBB Coryphaenoides brevibarbis	0.0	1	1493	1493	3.6	3.6	63.5090
17	CGR Coryphaenoides güntheri	2.2	17	1086	1493	3.6	3.8	64.1028
18	RNG Coryphaenoides rupestris	8.6	128	660	1493	3.6	4.4	64.2462
19	COM Cottunculus microps	0.0	1	1134	1134	3.8	3.8	64.1028
20	COT Cottunculus thomsonii	1.3	1	1055	1230	3.7	3.8	63.9325
21	LUM Cyclopterus lumpus	0.6	1	1134	1282	3.7	3.8	64.1028
22	CLM Cyclothone microdon	0.0	2	969	1493	3.6	3.8	63.8915
23	EUR Eurypharynx pelecanoides	0.1	1	1289	1289	3.7	3.7	63.7788
24	COD Gadus morhua	4.7	8	233	233	.	.	64.2744
25	ONN Gaidropsarus ensis	2.4	3	1055	1493	3.6	3.8	64.1028
26	GOB Gonostoma bathyphilum	0.0	1	1102	1102	3.7	3.7	63.7283
27	GOS Gonostoma sp.	0.0	1	1157	1157	3.7	3.7	63.8471
28	PLA Hippoglossoides platessoides	0.5	4	233	660	4.4	4.4	64.2744
29	HAL Hippoglossus hippoglossus	2.0	1	233	233	.	.	64.2744
30	HOA Holtbyrnia anomala	0.1	2	969	1168	3.7	3.8	63.8915
31	HAF Hydrolagus affinis	22.2	4	1493	1493	3.6	3.6	63.5090
32	LAI Lampanyctus intricarius	0.0	1	1143	1143	3.8	3.8	63.4386
33	LMC Lampanyctus macdonaldi	2.5	118	911	1493	3.6	4.1	64.2462
34	LEP Lepidion eques	0.6	4	406	1055	3.8	5.1	64.2471
35	LPA Lycodes paamiuti	0.5	1	937	1276	3.6	4.1	64.2462
36	RHG Macrourus berglax	18.2	26	406	1493	3.6	5.1	64.2471
37	MAA Magnisudis atlantica	0.1	1	406	406	5.1	5.1	64.2471
38	MAL Malacosteus niger	0.1	1	1168	1168	3.8	3.8	63.8488
39	MMI Maulisia microlepis	0.0	2	1244	1244	3.7	3.7	63.7880
40	MAT Melanostigma atlanticum	0.0	1	911	911	4.0	4.0	64.0061
41	WHB Micromesistius poutassou	14.3	102	406	406	5.1	5.1	64.2471
42	BLI Molva dipterygia	1.3	1	660	660	4.4	4.4	64.1605
43	MYP Myctophum punctatum	0.0	2	937	1468	3.6	4.1	64.2448
44	NZB Nezumia bairdii	0.2	1	966	1157	3.7	3.8	64.1028
45	PMO Normichthys operosa	0.0	1	1086	1086	3.7	3.7	63.7817
46	NOT Notacanthus chemnitzii	6.6	5	911	1493	3.6	4.1	64.2462
47	NOK Notoscopelus kroyeri	0.0	2	406	1368	3.7	5.1	64.2471
48	PAC Paraliparis copei	0.0	1	1040	1282	3.7	3.8	63.9837
49	POL Polyacanthonotus rissoanus	0.2	1	406	1324	3.7	5.1	64.2471
50	RBI Raja bigelowi	0.8	2	969	1368	3.7	3.8	63.8915
51	RBT Rajella bathyphila	0.7	1	1086	1108	3.7	3.7	64.2462
52	GHL Reinhardtius hippoglossoides	273.5	232	406	1493	3.6	5.1	64.2471
53	ROM Rouleina maderensis	0.1	1	1276	1276	3.6	3.6	63.5928
54	SCO Scopelosaurus lepidus	1.8	14	660	1493	3.6	4.4	64.2462
55	REG Sebastes marinus	3.1	4	406	406	5.1	5.1	64.2471
56	REB Sebastes mentella	428.8	1084	233	1468	3.6	5.1	64.2744
57	SEK Serasia koefoedi	0.0	1	969	969	3.8	3.8	63.8915
58	SER Serrivomer beani	0.3	5	911	1456	3.6	4.0	64.2462
59	STO Stomias boa	0.1	2	937	1299	3.6	4.1	64.2448
60	SYN Synaphobranchus kaupi	1.3	7	937	1456	3.6	4.1	64.2462
61	TRA Trachyrhynchus murrayi	2.9	12	911	1102	3.7	4.1	64.2448
62	XEC Xenodermichthys copei	0.0	1	1167	1493	3.6	3.8	63.5090