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Survey for Greenland Halibut in NAFO Divisions 1C-1D, 2014

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Abstract

Greenland initiated a survey series in 1997covering NAFO Divisions 1CD at depths between 400 and 1 500 m. 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 2014 there were conducted 58 valid hauls out of 70 planned in Div. 1CD. The biomass and abundance of Greenland halibut has been decreasing gradually since 2011 was estimated as 58424 tons and 44.7 mill, individuals respectively, which is the second lowest biomass and the lowest abundance observed in the time series. The length distribution had a mode around 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. The biomass and abundance estimates of deep sea redfish was among the highest in the time series but the estimates are based on very few hauls.

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 trawling 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 2014 covered Div. 1CD at depths between 400 and 1500 m, and took place during 31/8 – 16/9.

Stratification

The survey covered NAFO Div. 1CD between the 3-nm line and the midline to Canada at depths between 400 and 1500 m. The survey area was stratified in NAFO divisions and subdivided in 6 depth strata 401-600, 601-800, 801-1000, 1001-1200, 1201-1400 and 1401-1500 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).

Near-bottom temperatures were measured, by 0.1^{o}C, by a Seastar sensor mounted on one of the otter doors.

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.

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

In total 58 successful hauls were made and 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 82 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 in Div. 1CD 400-1500 m was estimated at 58 424.6 tons (Table 1 and 2) which is the lowest level since 1997 and a continuation of the gradual decrease seen since the record high estimate on 86591.4 tons in 2011.

The survey in 2013 only covered Div. 1D and the biomass (and abundance) in Div. 1C has been estimated by an GLM (model: lnbiomass= year*division) using data from 2010-2014 where the distribution of the biomass has been rather stable with 63-69% of the biomass found in Div. 1D. The 1CD biomass and abundance in 2013 was estimated to 64049.0 tons and $51.160*10^6$, respectively.

The distribution of the biomass in 2014 was generally the same as in 2012 with the largest biomass at depths between 1000 and 1200 m in Div. 1D (Table 2, Fig. 2). The highest densities (in weight) were found at depths > 800 m with 2.54 tons km^{-2} in Div. 1C 1000-1200 m and 2.00 tons km^{-2} in Div. 1D 800-1000 m. The weighted mean catch per tow has shown a gradual decrease from the record high 1.66 tons km^{-2} in 2011 to 1.12 km^{-2} in 2014 (Table 1).

The abundance in was estimated at $44.773*10^6$ (Table 3) which is the lowest observed in the time series that dates back to 1997 (Table 2). The highest abundance was found in between 1000 and 1200 m in Div. 1D and he highest densities (in number t) were found in Div. 1C 1000-1200 m and Div. 1D 800-1000 m.

Estimated abundance by age in Div. 1CD is given in Table 4 (not updated in 2014, because the otolith reading procedure is under revision).

Although aging is uncertain it is believed that fish age 6 and 7 dominates the catches. 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 27 cm to 104 cm, except from a few larvae on 7-8 cm. The overall length distribution (weighted by stratum area) was dominated by a mode at 50 which where there were two modes at 46 and 52 cm in 2012 (Fig. 6a). The overall length distribution has throughout the years been dominated by a single distinct mode at 47-50 cm. 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. The biomass and abundance in Div. 1C in 2013 is estimated by a GLM including data from 2010-2014.

Year	Biomass	S.E.	Mean	S.E.	Abundance ($*10^6$)	S.E.	Biomass Div. 1D
1997	56260.2	4399.6	1.07	0.08	53.613	4.118	45750.5
1998	70473.5	8391.7	1.34	0.16	67.677	7.687	53232.0
1999	64398.0	6912.1	1.27	0.14	61.366	6.265	52461.4
2000	59092.4	5543.3	1.28	0.11	61.710	5.976	47927.7
2001	77554.0	13013.6	1.57	0.26	80.814	14.221	51895.3
2002	71932.4	5613.9	1.56	0.12	71.510	6.223	60511.3
2003	68717.2	6411.9	1.39	0.13	72 556	7.764	48696.6
2004	75869.4	5186.3	1.48	0.10	74.859	5.445	51070.6
2005	80865.4	8365.7	1.54	0.16	73.001	7.317	62832.7
2006	77010.3	6259.6	1.47	0.12	70.715	5.622	54449.3
2007	74356.8	9455.4	1.48	0.19	67.427	8.492	60186.2
2008	83465.4	5456.3	1.60	0.10	72.804	5.334	60364.8
2009	70966.2	5110.3	1.36	0.10	62.507	4.419	53243.2
2010	75522.5	5382.4	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	64049.0		1.22		51.160		42376.7
2014	58424.6	4117.7	1.12	0.08	44,773	3.246	36634.2

Table 2. Mean catch per km^2 and biomass (tons) with Standard Error of Greenland halibut in Division 1CD by depth stratum, 2014. 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
1C	401-600	3366	1	0.2511	845.3	.
	601-800	16120	5	0.5947	9586.5	2428.6
	801-1000	6066	12	1.6166	9806.0	1290.9
	1001-1200	611	2	2.5411	1552.6	999.2
1D	401-600	903	1	0.0186	16.8	.
	601-800	1940	2	0.7844	1521.7	446.0
	801-1000	3874	3	1.9960	7732.4	774.3
	1001-1200	10140	15	1.5413	15628.5	1759.4
	1201-1400	6195	13	1.1631	7205.6	1107.5
	1401-1500	3091	4	1.4653	4529.3	1599.2
All				1.1170	58424.6	4117.7

Table 3. Mean catch per km^2 and abundance with Standard Error of Greenland halibut in Division 1CD by depth stratum, 2014. 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
1C	401-600	3366	1	198.6	668392.9	.
	601-800	16120	5	495.7	7990824.2	1624107.8
	801-1000	6066	12	1313.8	7969638.1	1125064.7
	1001-1200	611	2	1762.3	1076778.4	623342.5
1D	401-600	903	1	17.3	15660.6	.
	601-800	1940	2	602.2	1168204.9	458433.3
	801-1000	3874	3	1540.4	5967484.0	752403.8
	1001-1200	10140	15	1107.6	11230830.6	1526395.9
	1201-1400	6195	13	861.0	5333670.4	949991.9
	1401-1500	3091	4	1084.2	3351315.6	1338791.0
All				856.0	44772799.8	3246544.3

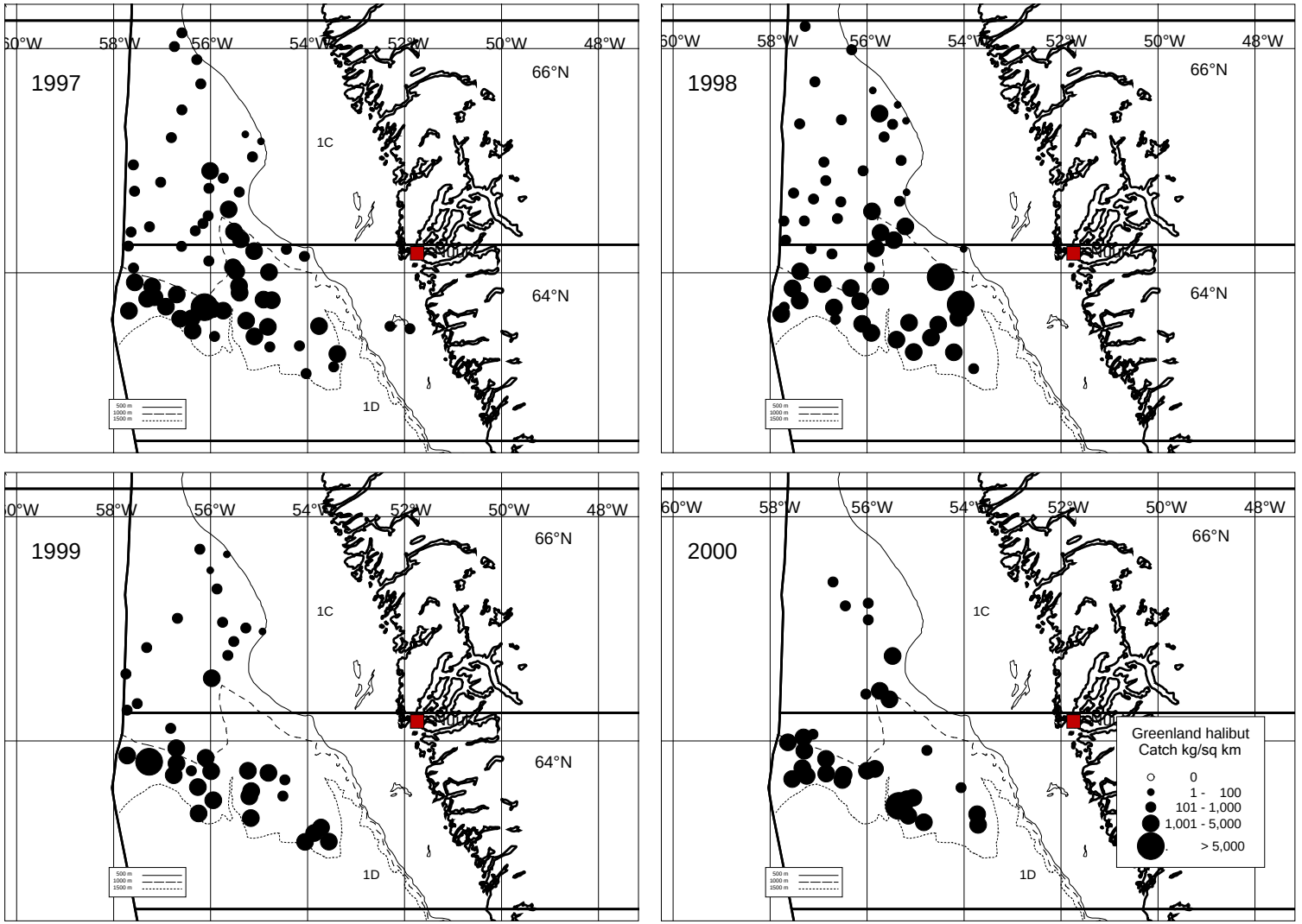

Fig. 1 Distribution of catches of Greenland halibut during 1997-2000 in kg km^{-2}.

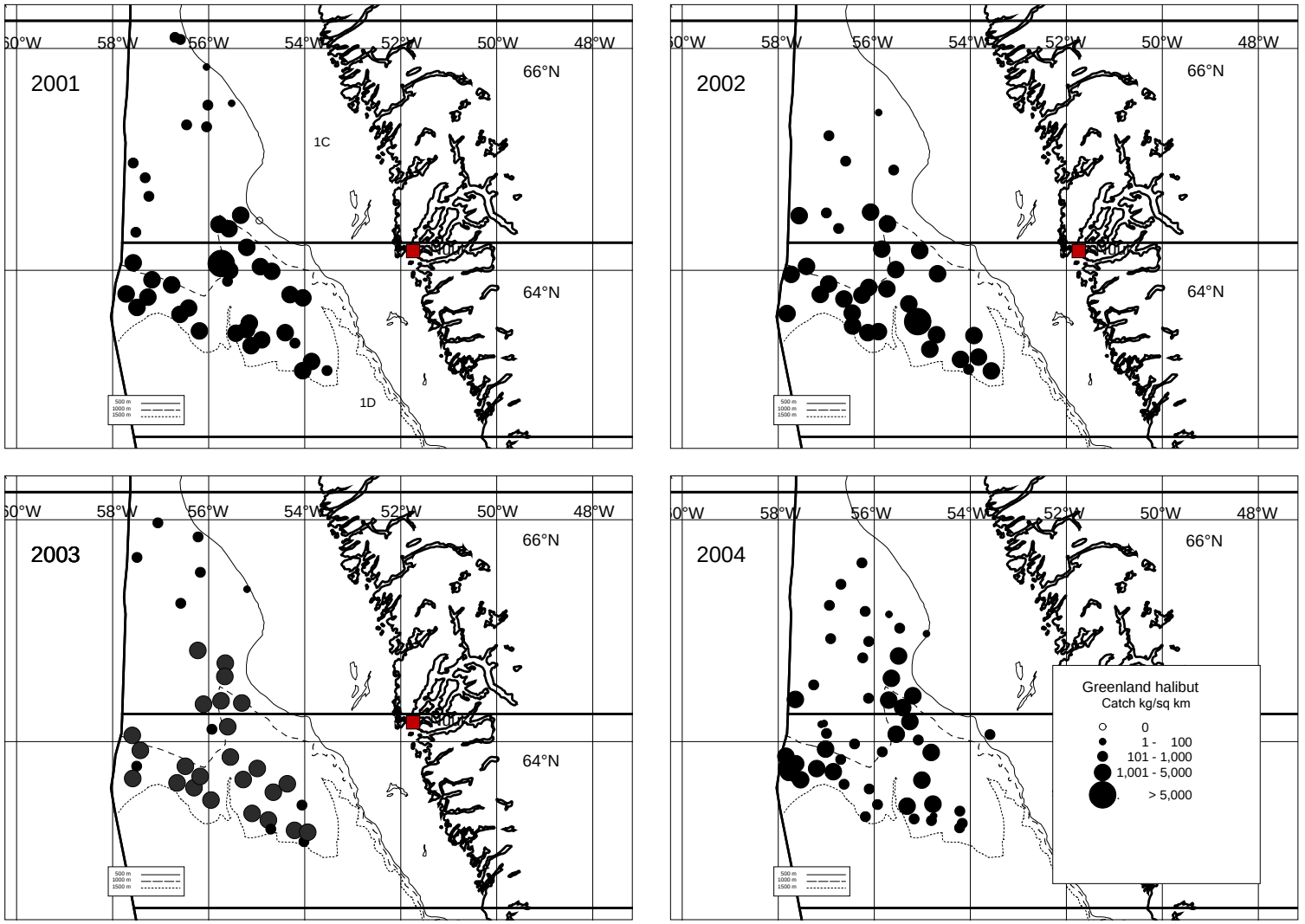

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2001 - 2004 in kg km^{-2}

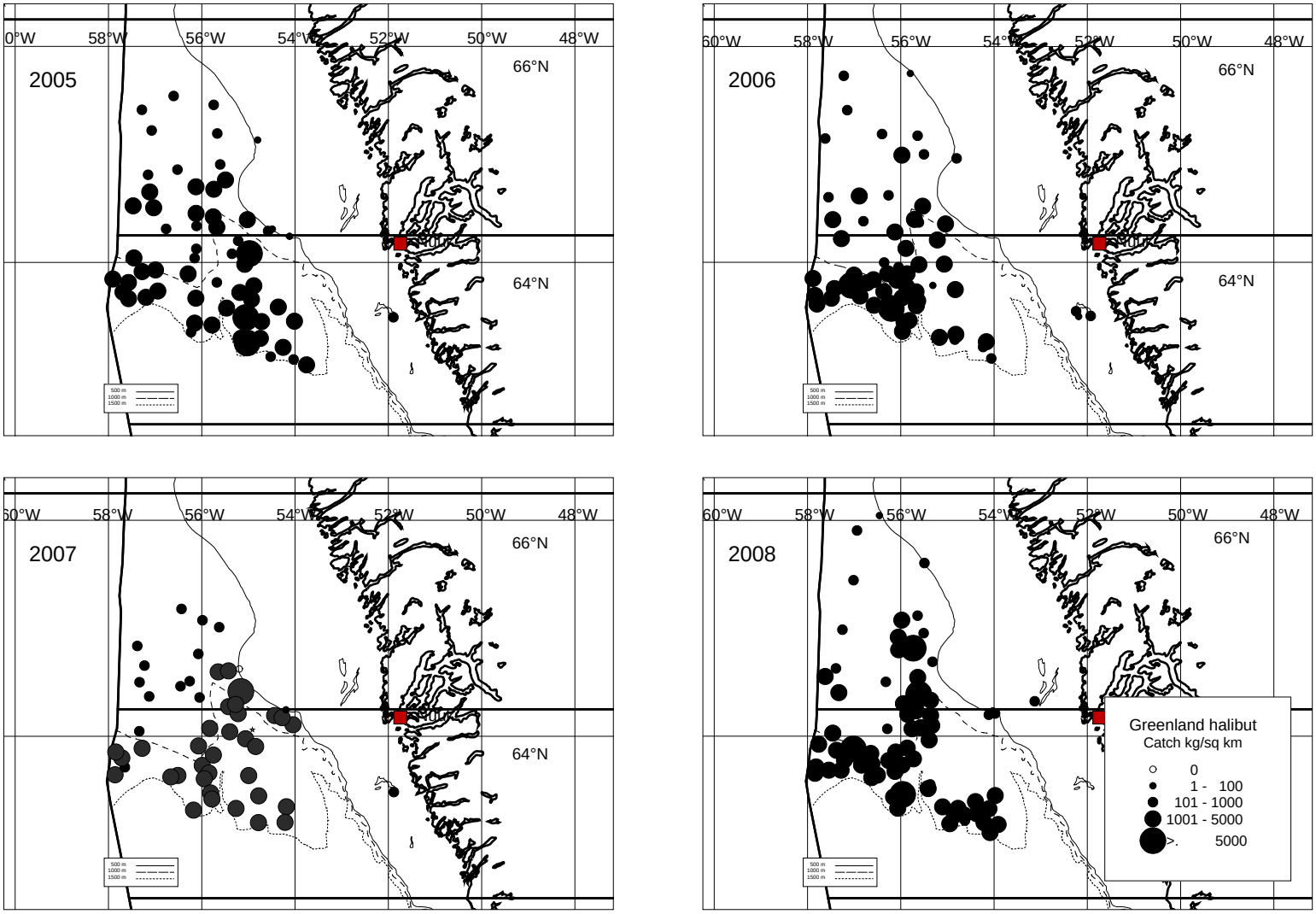

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2005 - 2008 in kg km^{-2}

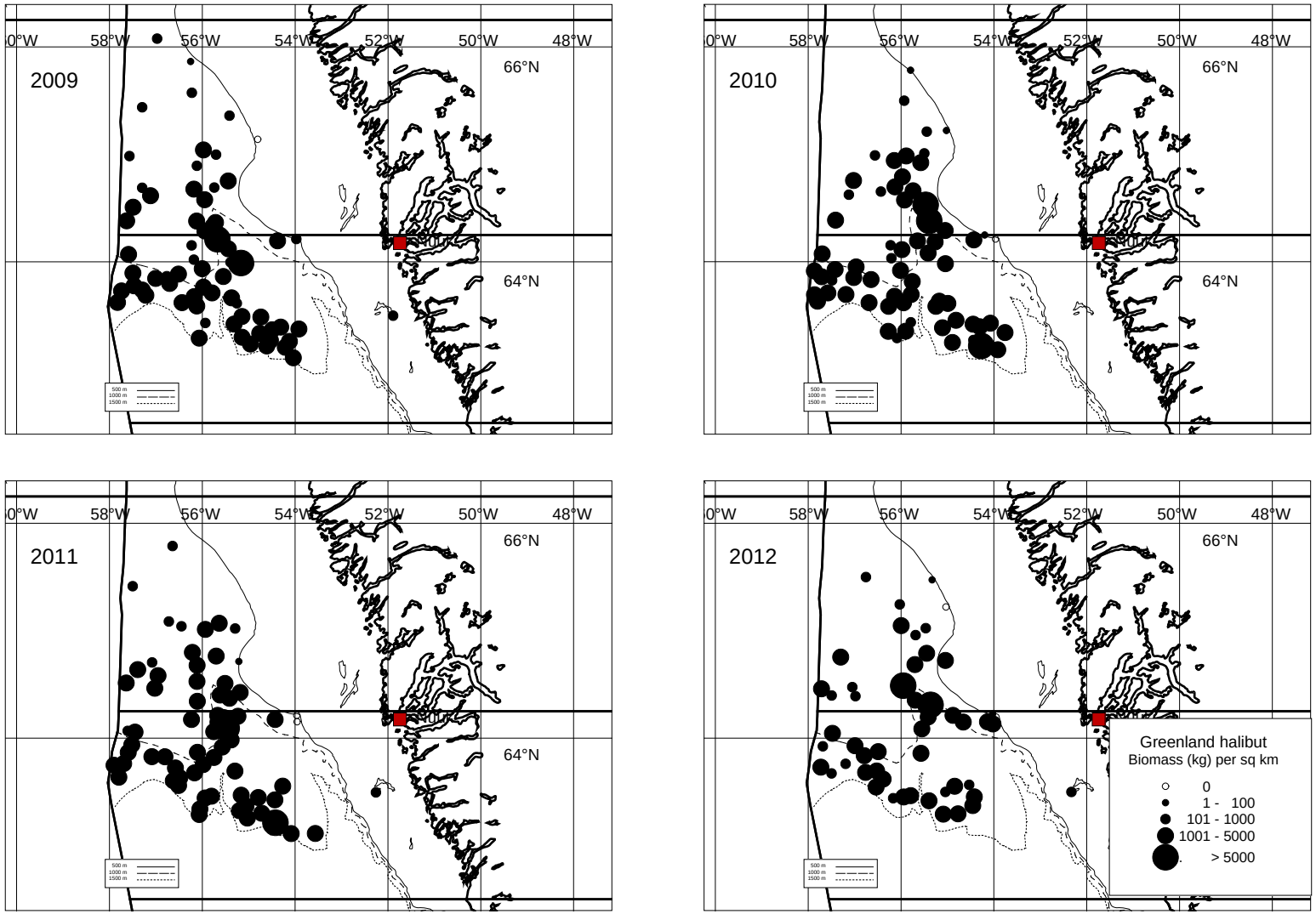

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2009 - 2012 in kg km^{-2}

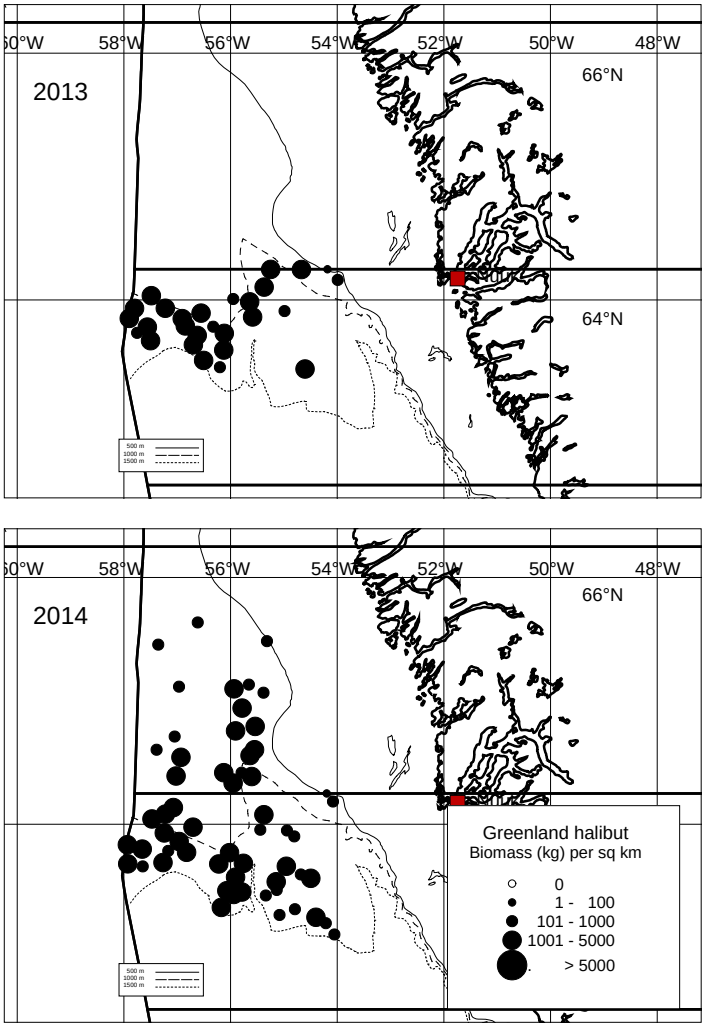

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2013 and 2014 in kg km^{-2}

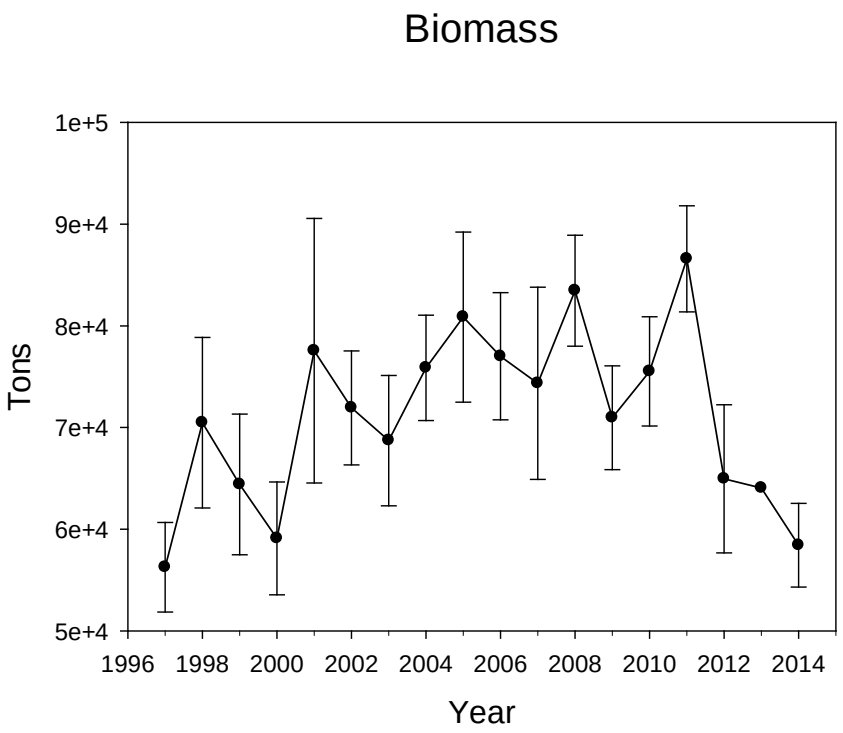

Fig. 2. Biomass (tons) of Greenland halibut in Div. 1CD by year with 1*S.E. No data from Div. 1C in 2013. The biomass in Div. 1C in 2013 is estimated by a GLM including data from 2010-2014.

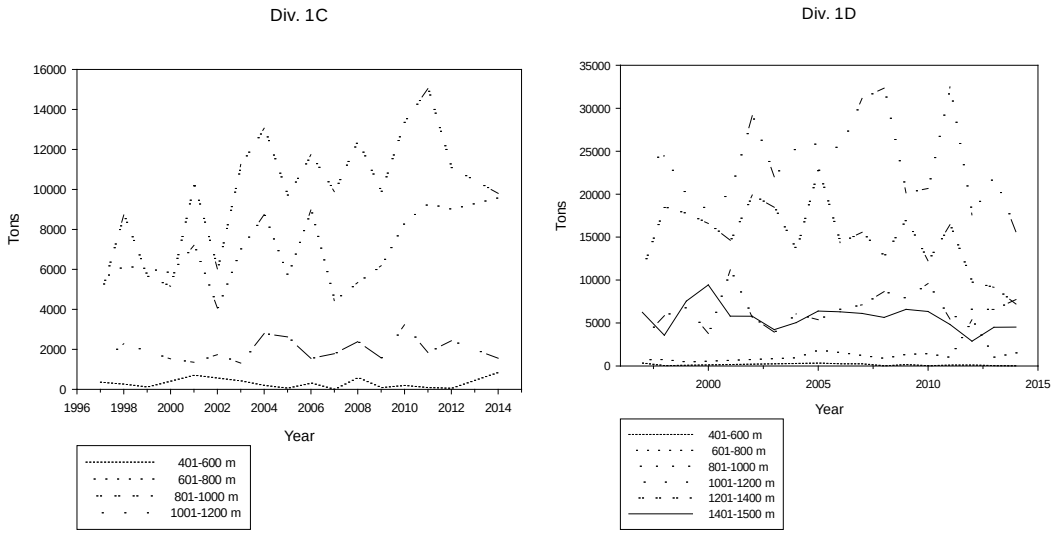

Fig.3 Biomass by Division, depth stratum and year. No data from Div. 1C in 2013

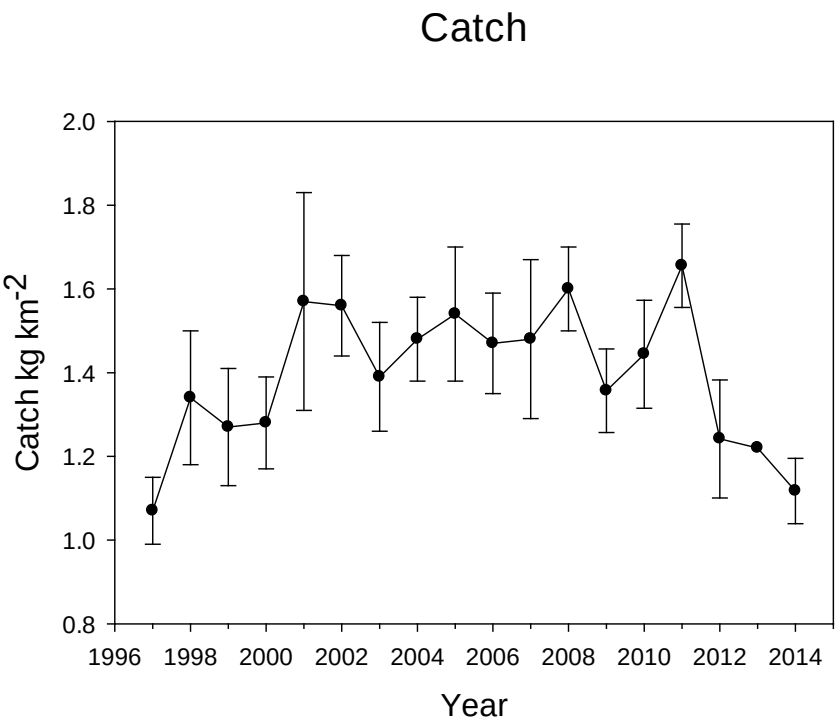

Fig. 4. Mean catch of Greenland halibut km^{-2} (tons) in Div. 1CD standardized by stratum area with 1*S.E. No data from Div. 1C in 2013. The biomass in Div. 1C in 2013 is estimated by a GLM including data from 2010-2014.

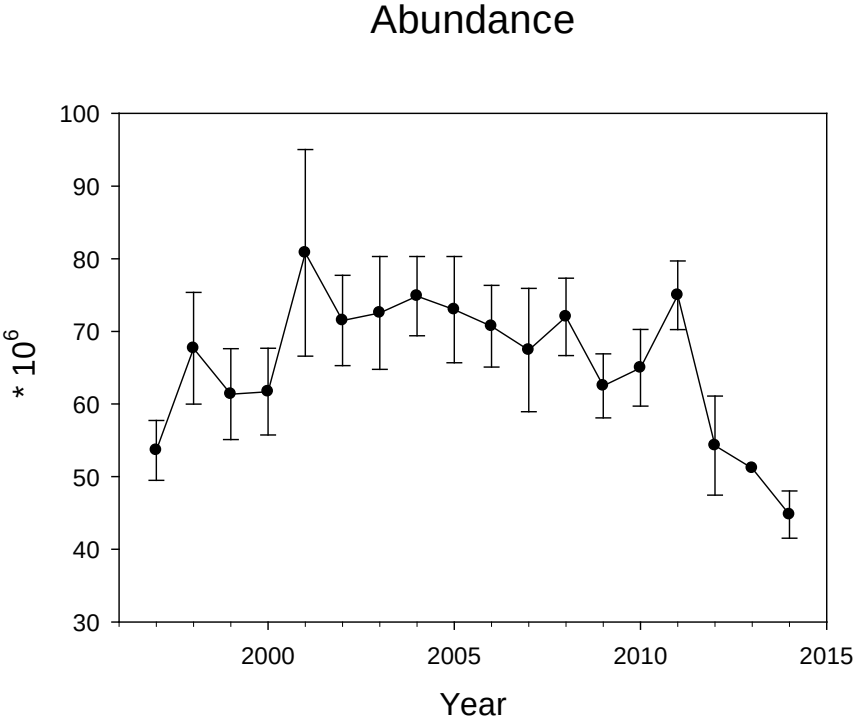

Fig. 5. Abundance (millions) of Greenland halibut in Div. 1CD by year with 1*S.E. No data from Div. 1C in 2013. The abundance in Div. 1C in 2013 is estimated by a GLM including data from 2010-2014.

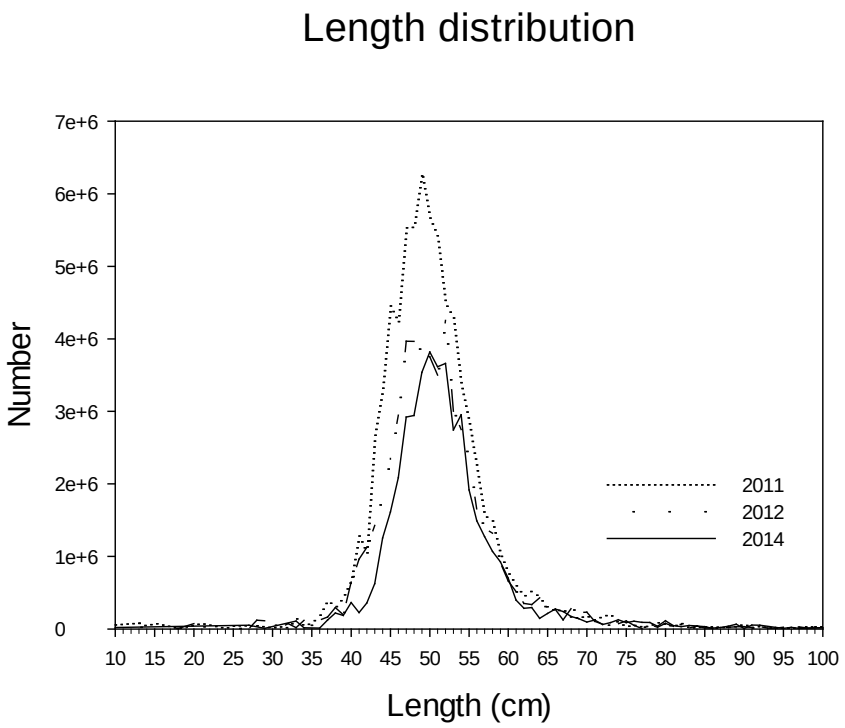

Fig. 6. Overall length distribution of Greenland halibut in numbers (weighted by stratum area) in Div. 1CD by year No data from 2013.

Table 4. Number by age by year of Greenland halibut (excluding larvae, age 0). No data from 2008 and 2010-2014.

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

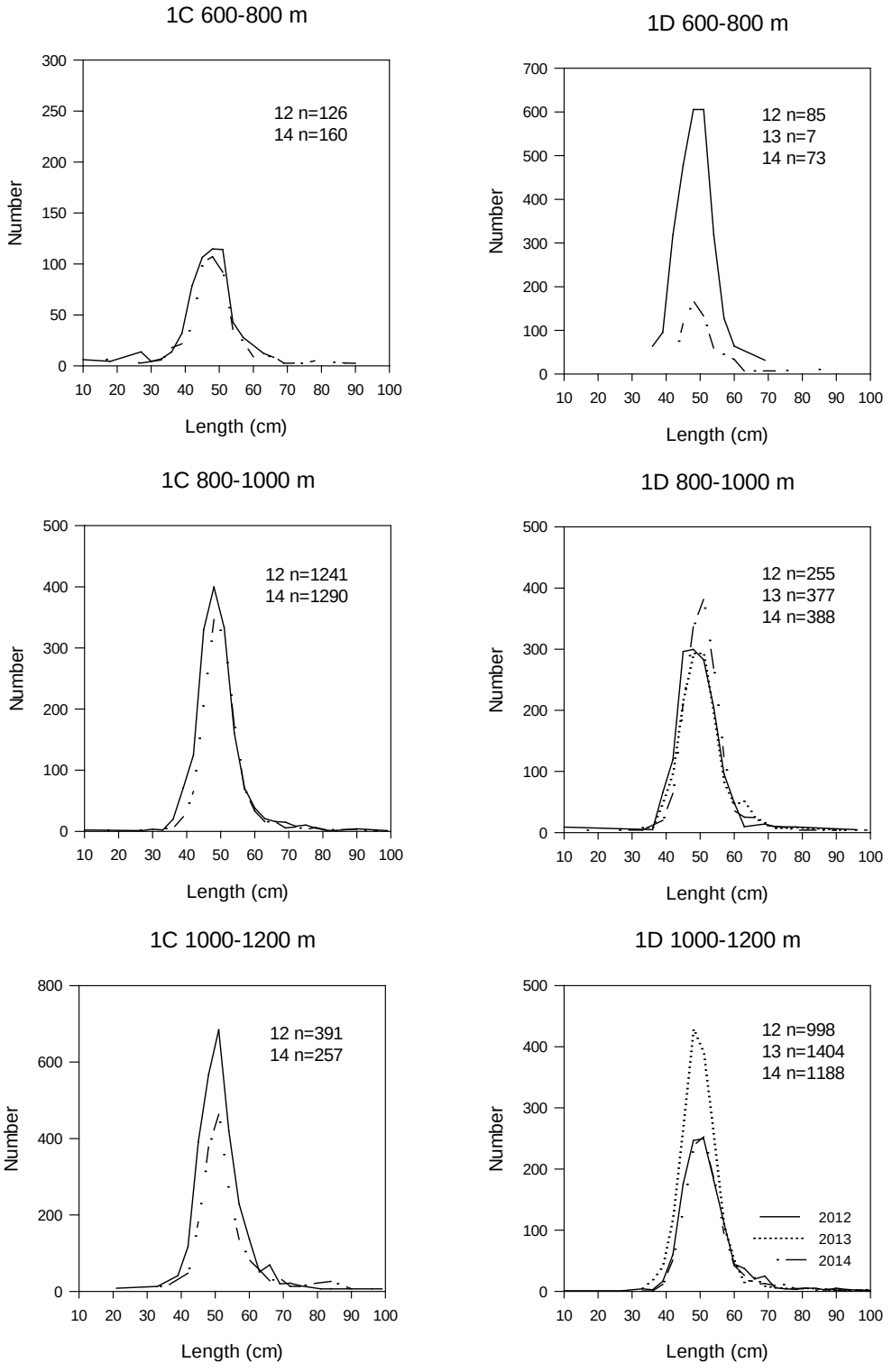

Fig. 7. Length distribution of Greenland halibut in numbers km^{-2} by year, division and depth stratum. Div 1CD 600-1200 m. No data from Div. 1C in 2013.

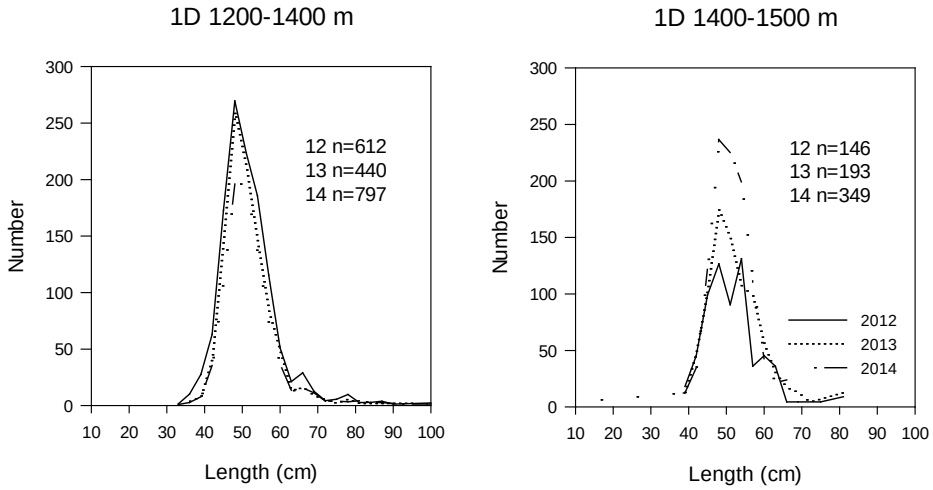

Fig. 7. cont. Length distribution of Greenland halibut in numbers km^{-2} by year, division and depth stratum. Div. 1D 1200-1500 m.

Table 5. Mean weight and length by year and age. No data 2008 and 2010-2014.

	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 52 of the 58 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 2014 was estimated as 596.9 tons which is the second lowest estimate in the time series that dates back to 1997. Most of the biomass wass found in Div. 1D at depths > 600 m with highest densities at 600-800 m but this figure is based on two hauls only (Table 7).

The abundance was estimated at $5.08*10^6$ specimens in 2014, which is the second lowest estimate in the time series.

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
2014	596.9	215.8	5.08	2.11

Pre anal fin length ranged from 2 to cm 9 cm. The grenadiers were generally small and the overall length distribution (weighted by stratum area) was dominated by fish at 7-9 cm (Fig. 9).

Table 7. Mean catch per km^2 and biomass (tons) with Standard Error of roundnose grenadier in Division 1CD by depth stratum, 2014. 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
1C	401-600	3366	1	0.0040	13.5	.
	601-800	16120	5	0.0036	57.8	32.3
	801-1000	6066	12	0.0046	27.7	4.1
	1001-1200	611	2	0.0074	4.5	3.4
1D	401-600	903	1	0.0000	0.0	.
	601-800	1940	2	0.1137	220.6	209.7
	801-1000	3874	3	0.0087	33.6	13.4
	1001-1200	10140	15	0.0069	70.3	16.1
	1201-1400	6195	13	0.0192	119.2	23.3
	1401-1500	3091	4	0.0161	49.7	18.1
All				0.0114	596.9	215.8

Table 8. Mean catch per km^2 and abundance with Standard Error of roundnose grenadier in Division 1CD by depth stratum, 2014. 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
1C	401-600	3366	1	11.7	39317.2	.
	601-800	16120	5	56.0	902072.7	451843.9
	801-1000	6066	12	89.7	543882.9	118313.3
	1001-1200	611	2	43.0	26268.9	5658.2
1D	401-600	903	1	0.0	0.0	.
	601-800	1940	2	1115.6	2164209.2	2050059.2
	801-1000	3874	3	51.6	200010.4	76555.1
	1001-1200	10140	15	53.8	545553.1	125929.6
	1201-1400	6195	13	70.9	439348.8	97670.6
	1401-1500	3091	4	69.4	214619.9	88458.6
All				97.0	5075283.1	2112241.7

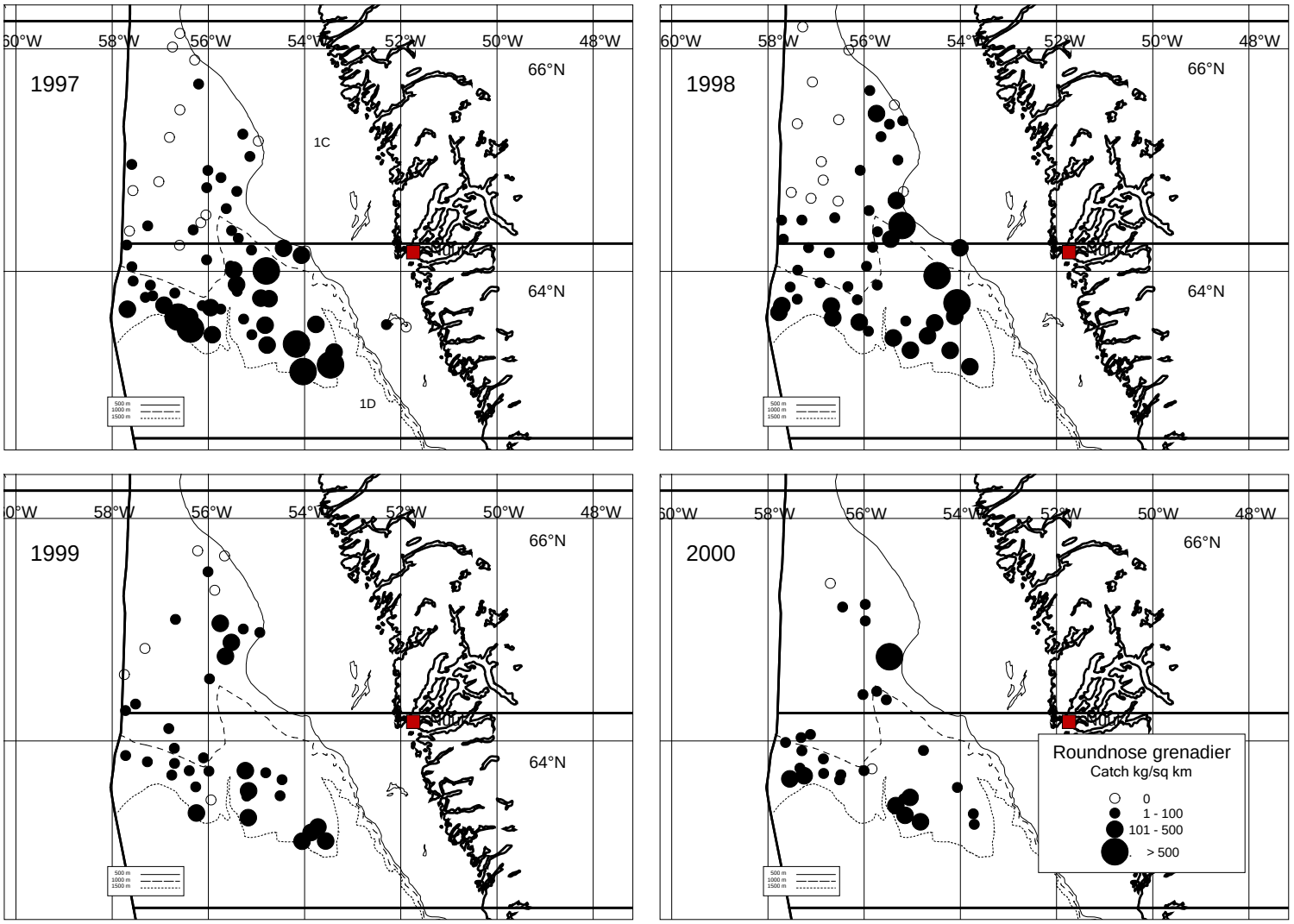

Fig. 8. Distribution of catches of roundnose grenadier in 1997-2000 in kg km^{-2}

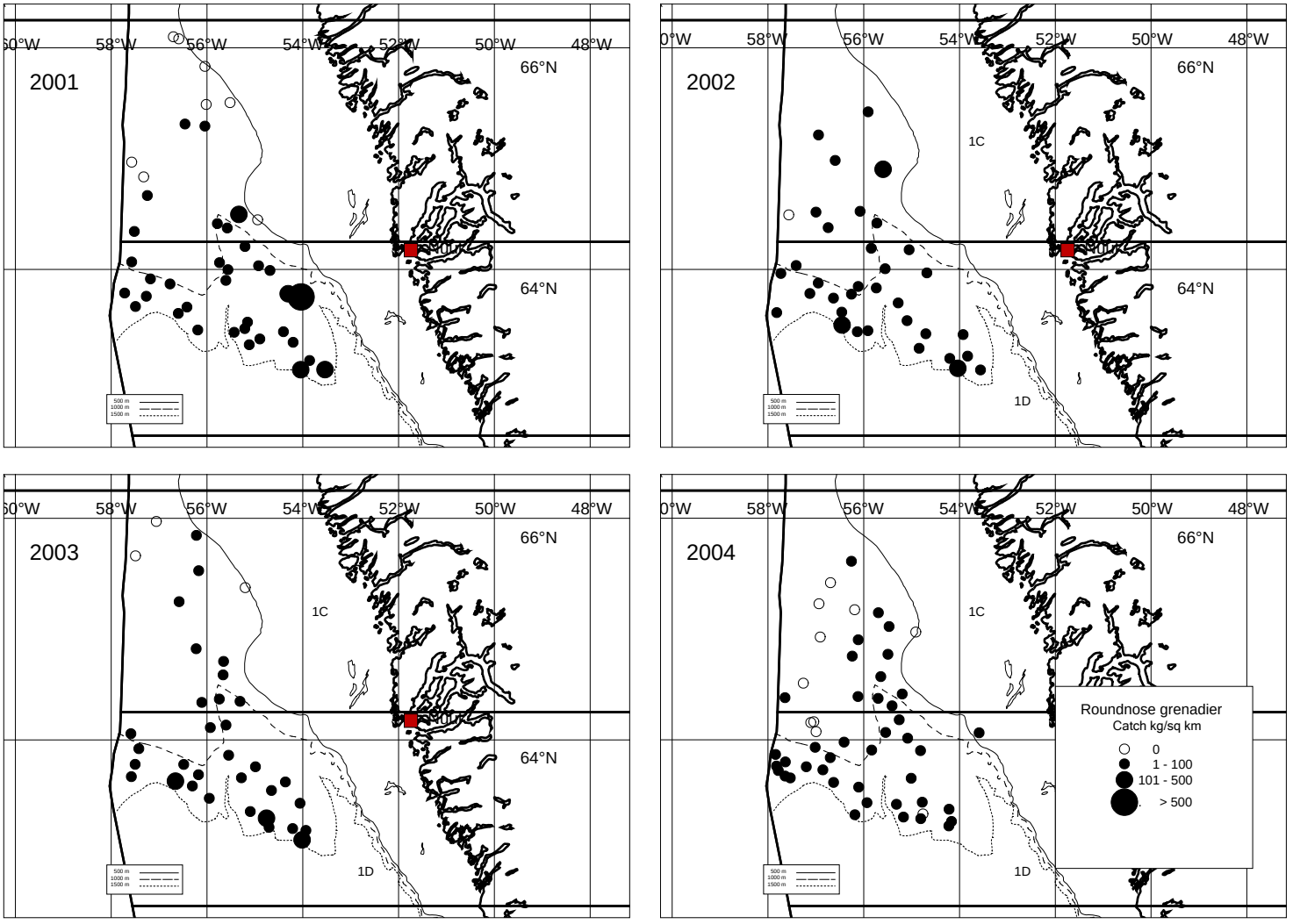

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Fig. 8. cont. Distribution of catches of roundnose grenadier in 2001-2004 in kg km^{-2}.

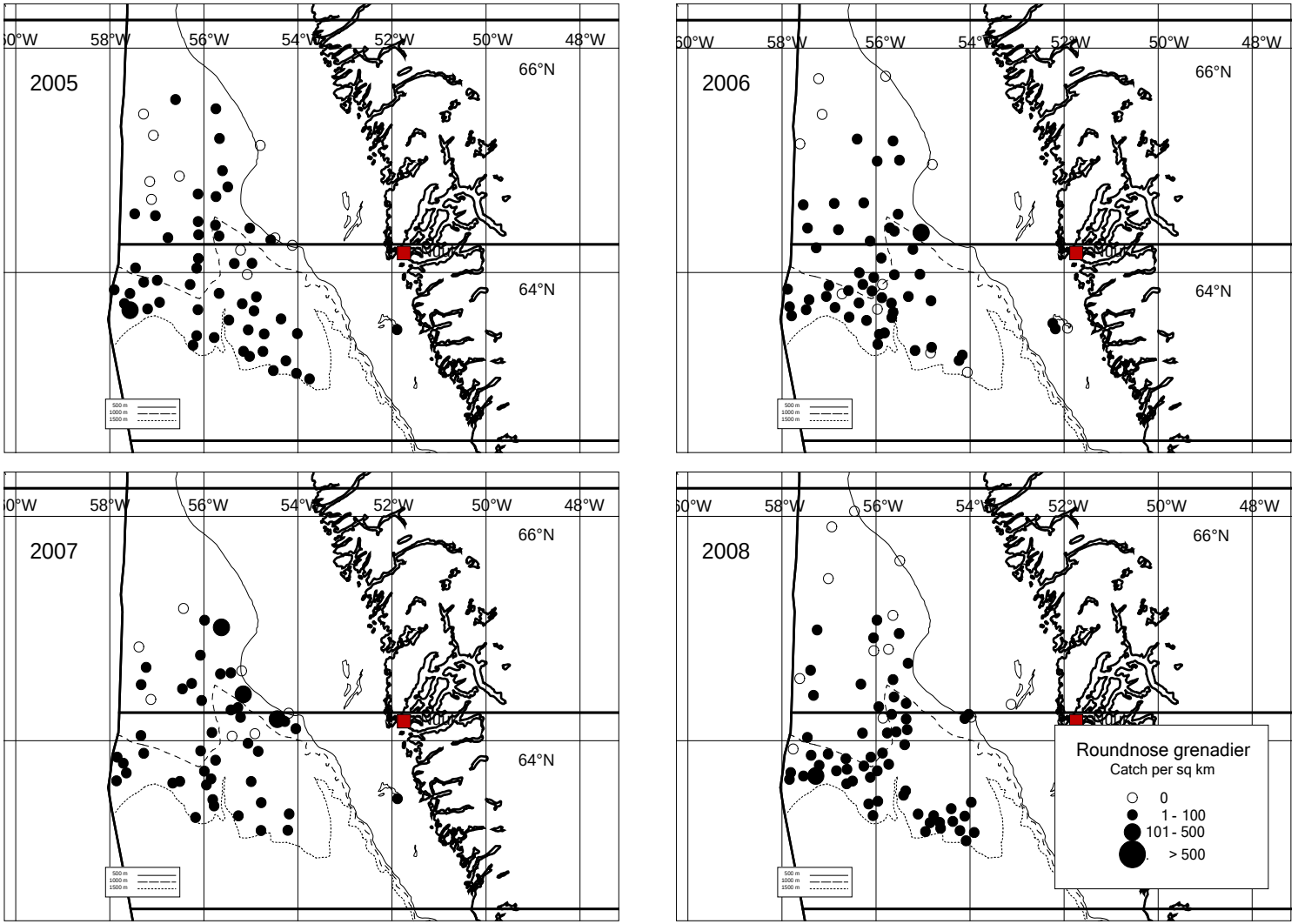


Fig. 8 cont. Distribution of catches of roundnose grenadier in 2005-2008 in kg km^{-2}.

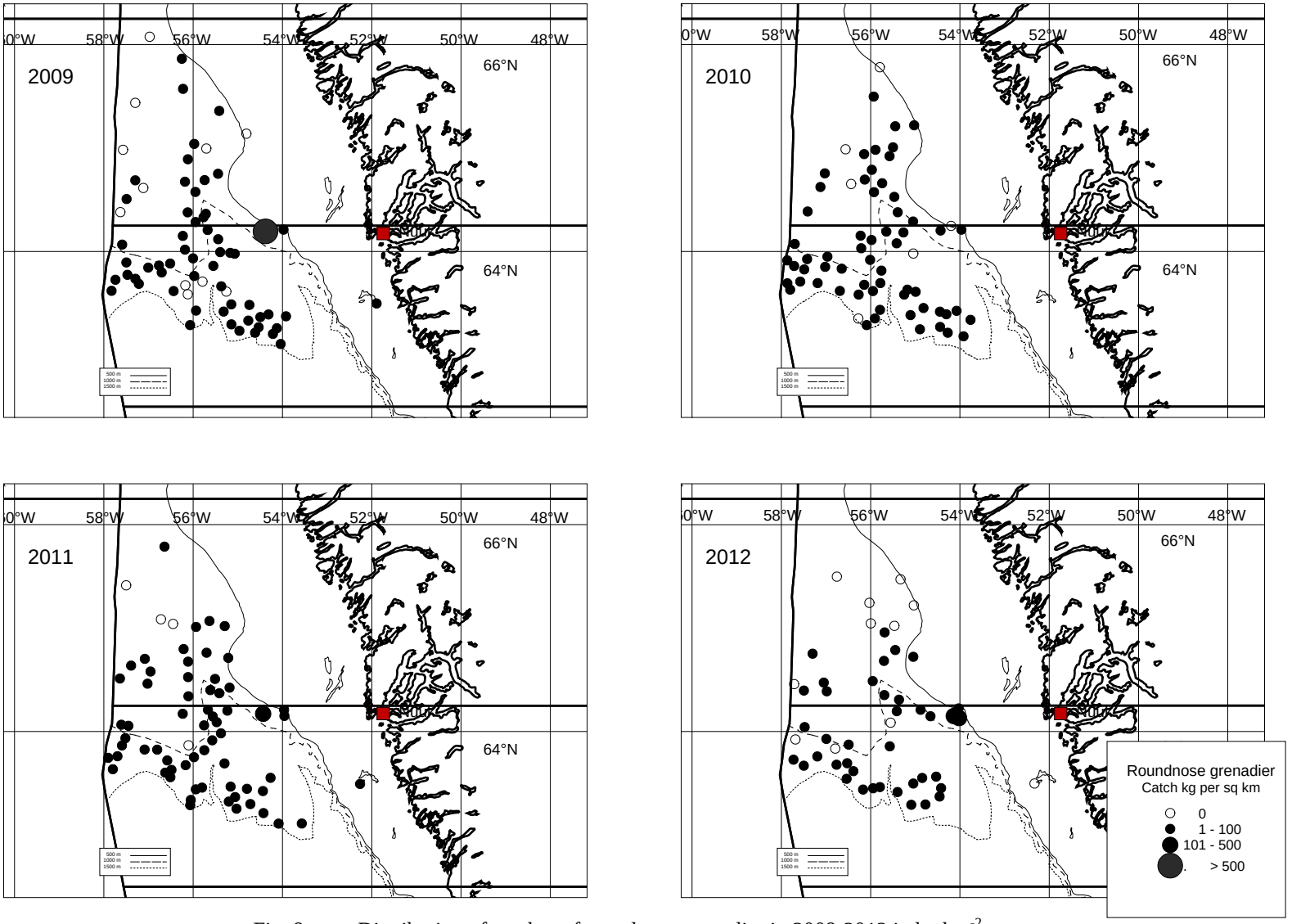


Fig. 8 cont. Distribution of catches of roundnose grenadier in 2009-2012 in kg km^{-2}.

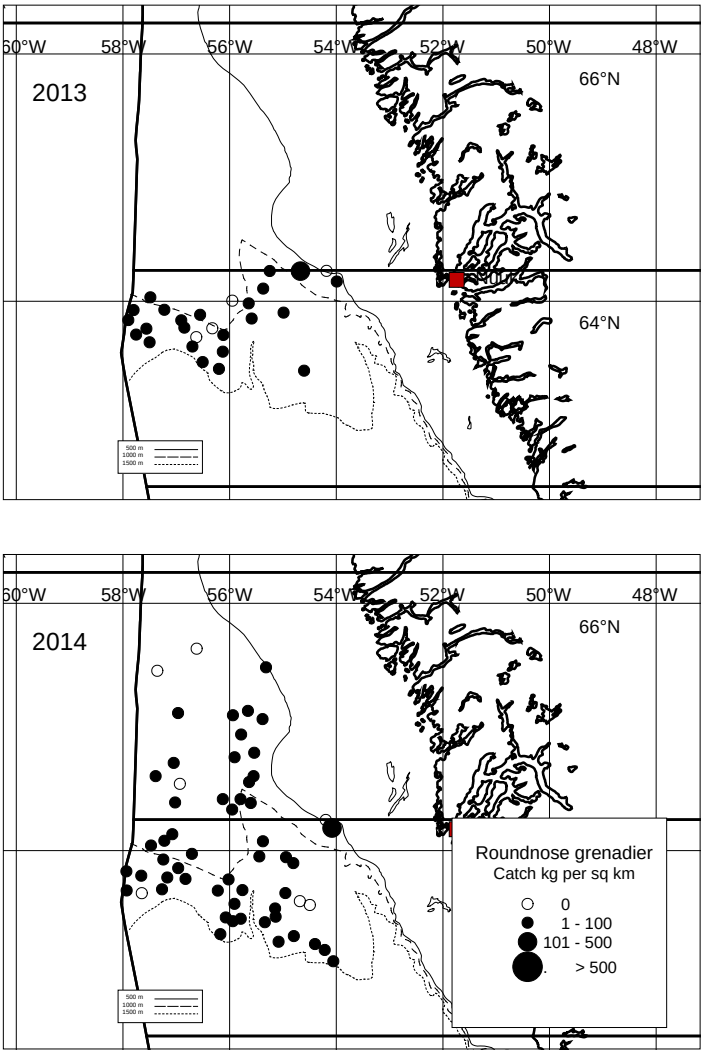


Fig. 8 cont. Distribution of catches of roundnose grenadier in 2013 and 2014 in kg km^{-2}.

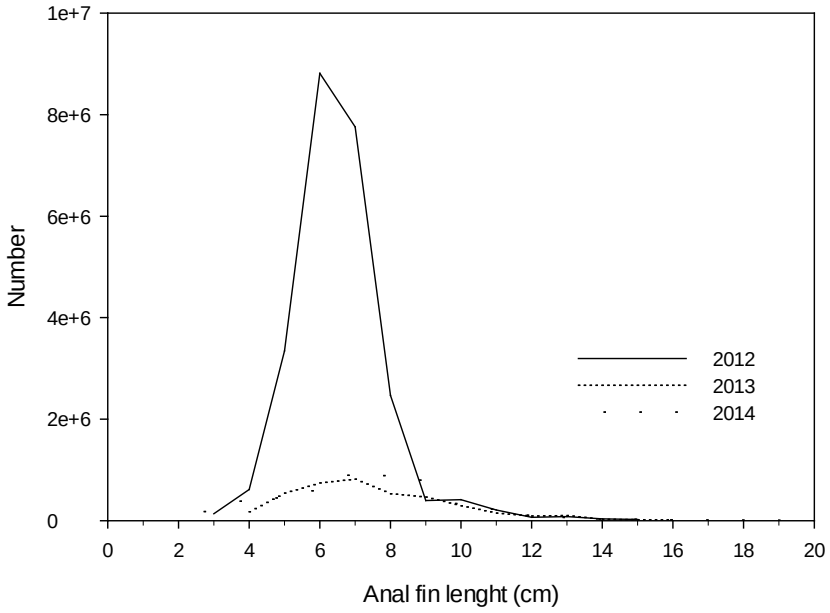


Fig. 9. Overall length distribution of roundnose grenadier (pre anal fin length) in numbers (weighted by stratum area) in Div. 1CD in 2011 and 2012 and Div.1D in 2013.

Roughhead grenadier (*Macrourus berglax*)

Roughhead grenadier was caught in all 58 valid hauls. The catches were, however, generally low (Fig. 11, Appendix 1). The biomass was estimated at 2907.4 tons which is the lowest estimate since 1997 (Table 9). The abundance was estimated as 7. 80 $*10^6$, which is also among the lowest in the time series. 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
2014	2907.4	251.0	7.80	0.61

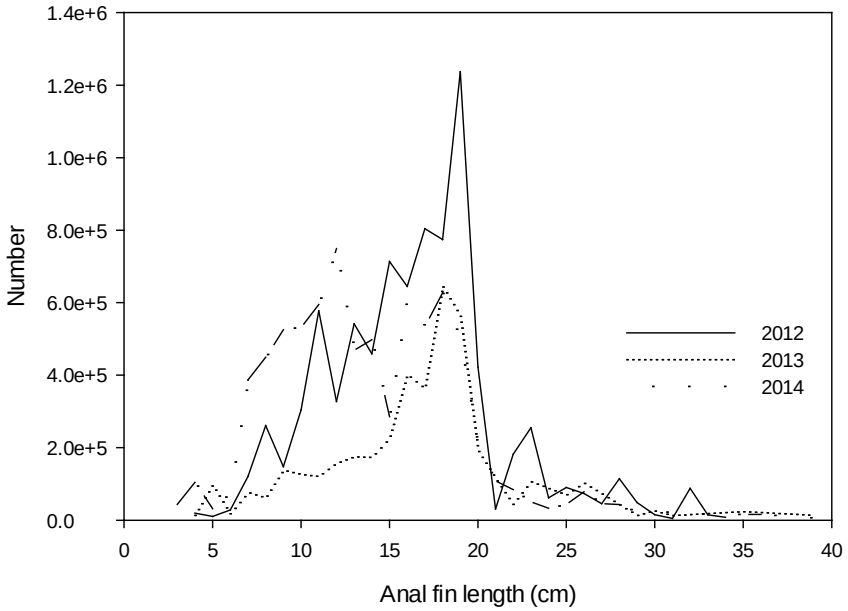


Fig. 10. Overall length distribution (pre anal fin length) of roughhead grenadier in numbers (weighted by stratum area) in Div. 1CD in 2012 and 2014 and in Div. 1D in 2013.

Table 10. Mean catch km^{-2} and biomass (tons) with Standard Error of roughhead grenadier in Division 1CD by depth stratum, 2014. 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
1C	401-600	3366	1	0.0148	49.9	.
	601-800	16120	5	0.0265	427.3	130.0
	801-1000	6066	12	0.0498	302.3	38.7
	1001-1200	611	2	0.0869	53.1	32.8
1D	401-600	903	1	0.0409	37.0	.
	601-800	1940	2	0.0895	173.6	69.1
	801-1000	3874	3	0.0584	226.2	45.2
	1001-1200	10140	15	0.0772	783.1	107.8
	1201-1400	6195	13	0.0871	539.6	85.6
	1401-1500	3091	4	0.1020	315.4	117.9
All				0.0556	2907.4	251.0

Table 11. Mean catch per km^{-2} and abundance and Standard Error of roughhead grenadier in Division 1CD by depth stratum, 2014. 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
1C	401-600	3366	1	46.7	157268.9	.
	601-800	16120	5	131.9	2126096.4	445119.2
	801-1000	6066	12	168.9	1024722.7	132015.3
	1001-1200	611	2	206.5	126192.0	33443.8
1D	401-600	903	1	86.7	78303.2	.
	601-800	1940	2	243.4	472284.1	15683.9
	801-1000	3874	3	134.0	519020.7	151848.4
	1001-1200	10140	15	187.4	1900519.6	200250.3
	1201-1400	6195	13	159.9	990693.5	163081.3
	1401-1500	3091	4	129.6	400476.2	186980.9
All				149.0	7795577.4	610331.0

Pre anal fin length ranged from 3 to 39 cm and the over all length distribution showed mode at 12 cm and two minor modes at 16 and 18 cm, respectively, and there were generally more small roughhead grenadies, < 14 cm, than seen in previous years.(Fig.10).

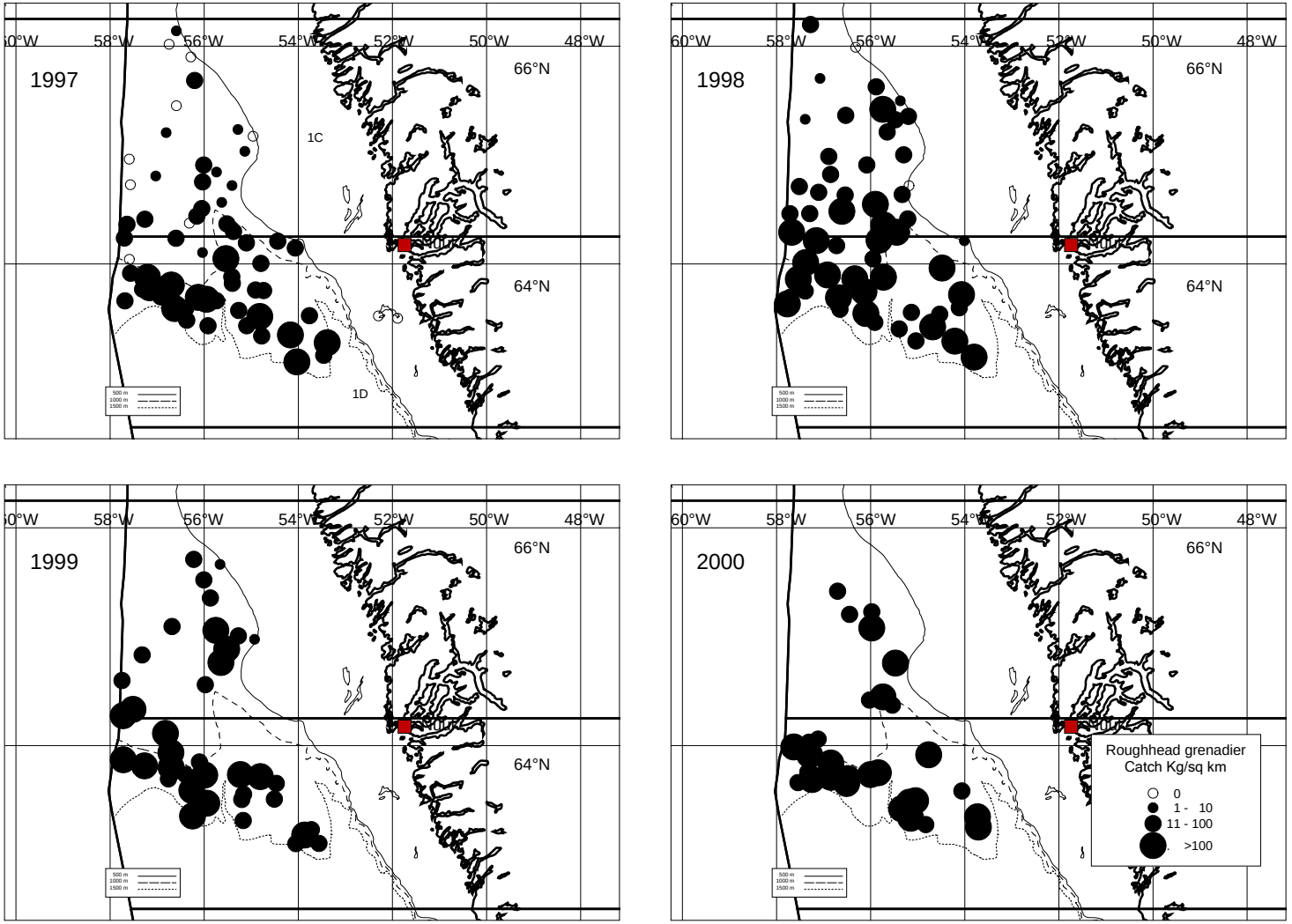


Fig.11 Distribution of catches of roughhead grenadier in 1997-2000 in kg km^{-2}.

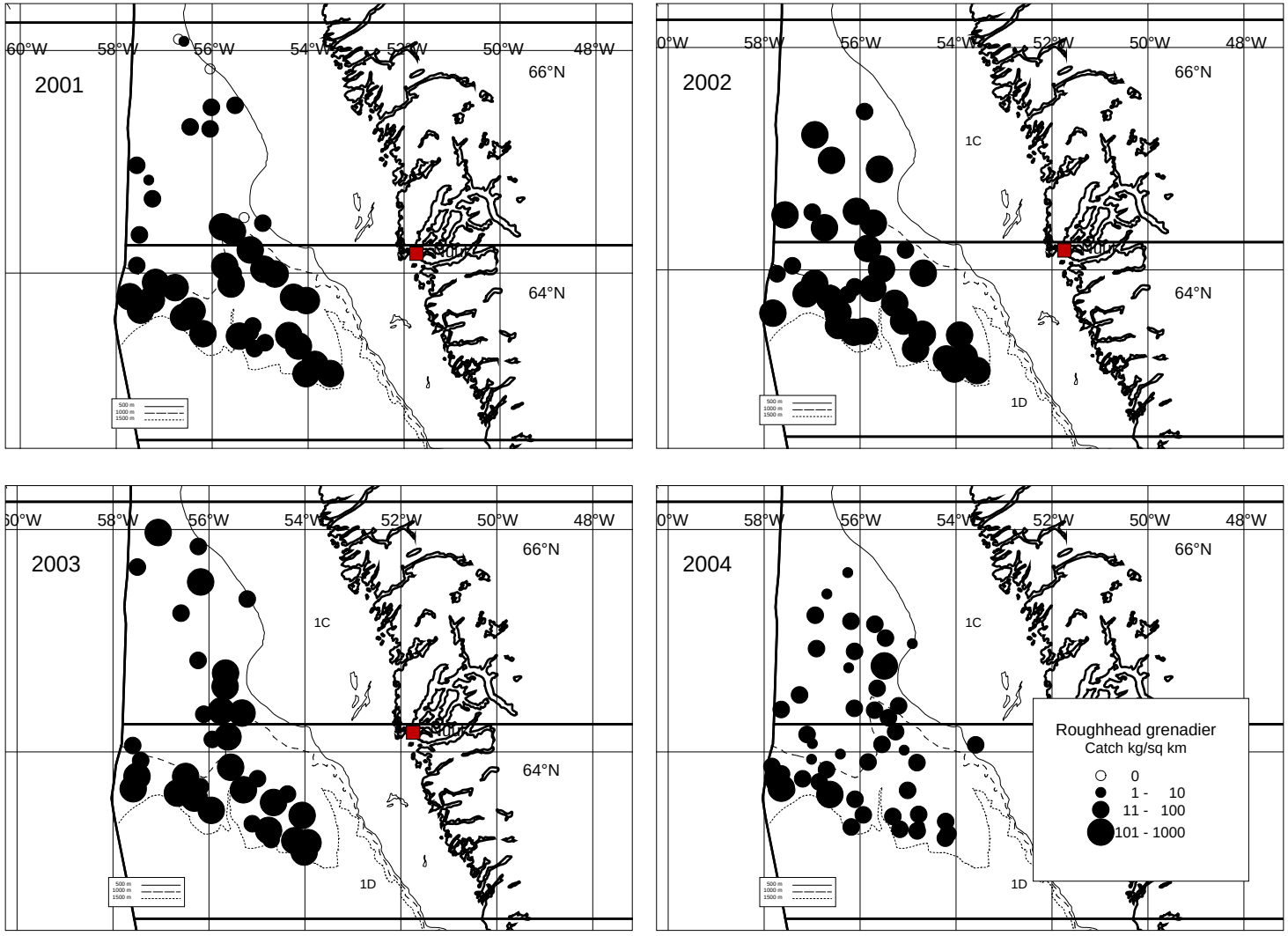


Fig. 11 cont. Distribution of catches of roughhead grenadier during 2001-2004 km^{-2}.

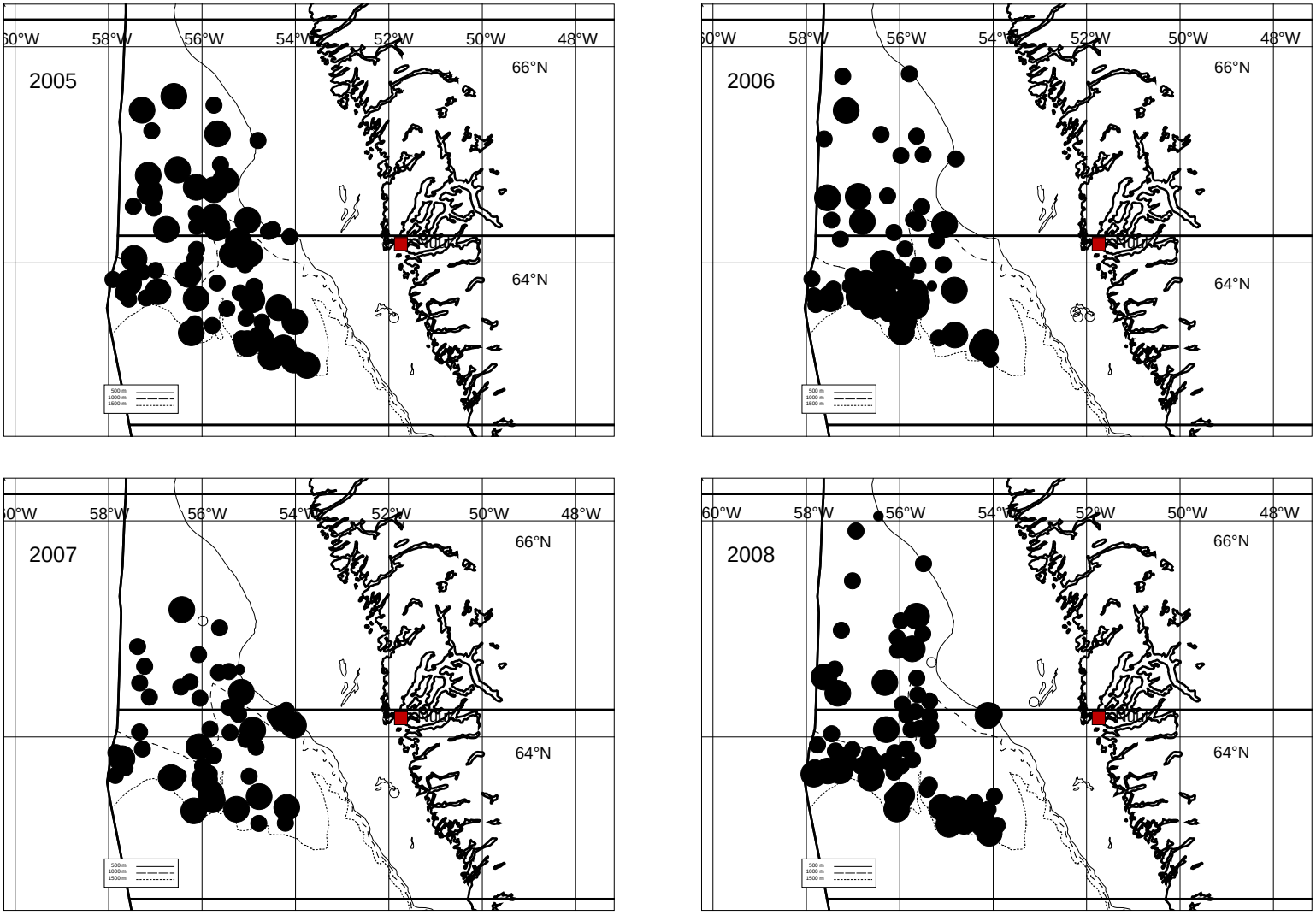


Fig.11 cont.. Distribution of catches of roughhead grenadier during 2005-2008 km^{-2}.

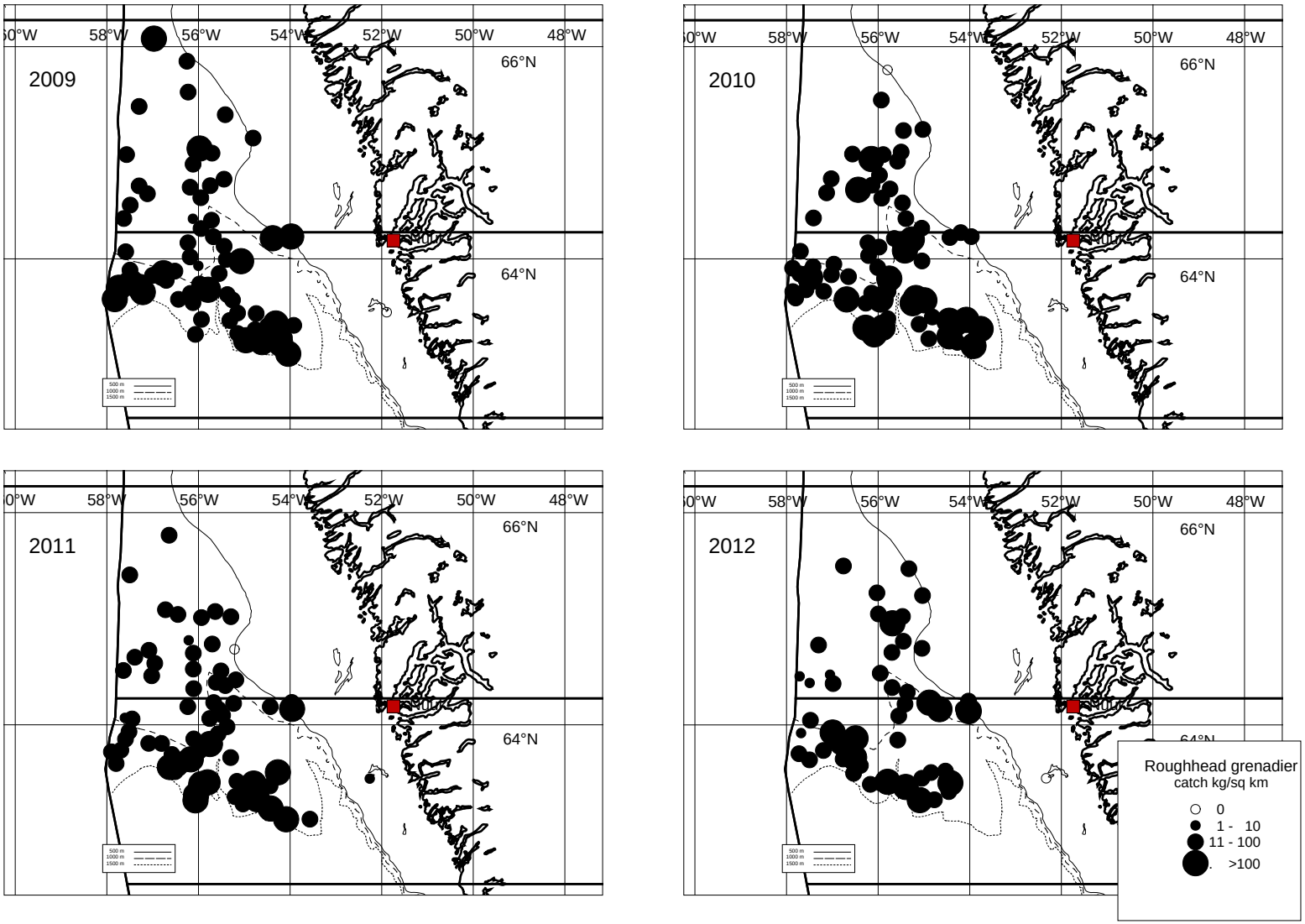


Fig. 11 cont.. Distribution of catches of roughhead grenadier during 2009-2012 in kg km^{-2}.

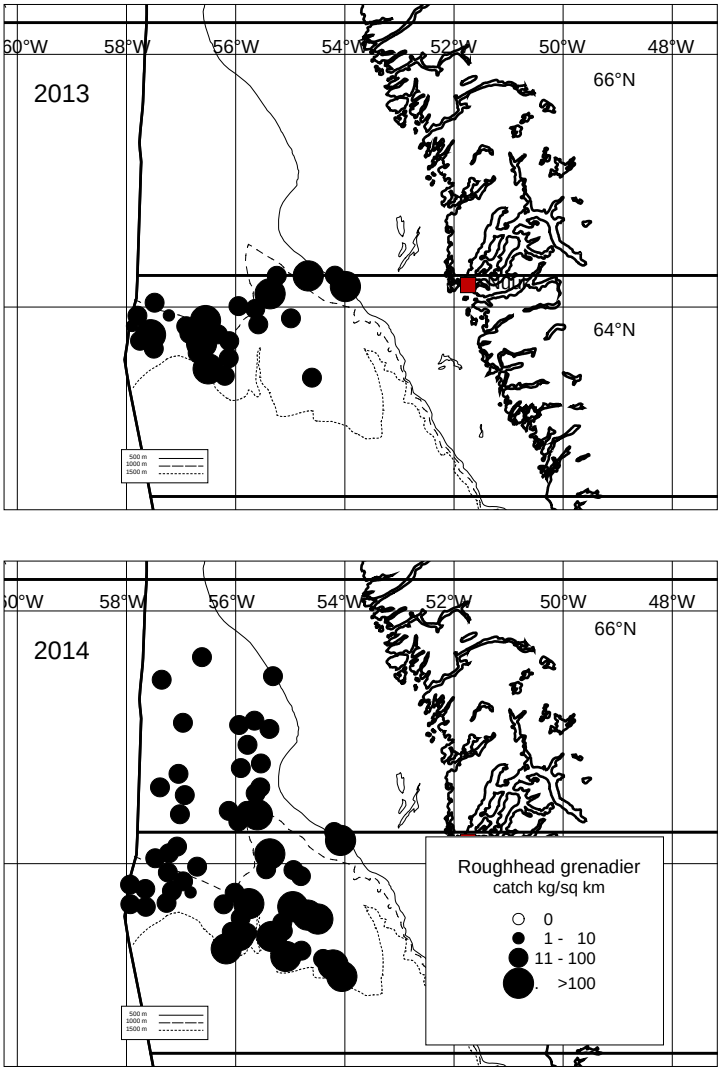


Fig. 11 cont.. Distribution of catches of roughhead grenadier in 2013 and 2014 in kg km^{-2}.

Deep-sea redfish (*Sebastes mentella*)

Deep-sea redfish was caught in 25 of the 58 valid hauls (Fig 12). The biomass was estimated at 22 1945.8 tons in 2014 compared to 25 356.014 tons in 2013 (Table 12) when the survey did not cover Div. 1C where almost all the usually is found. The 2014 estimate is the second largest in the time series. The survey only covers the deepest part of the distribution area and the coverage is poor (< = 4 hauls at depths between 400 and 600 m and <11 hauls at depth between 600 and 800 m) and the biomass and abundance estimates are often driven by 1-3 large hauls. This was also the case in 2014 (Fig. 13, Table 13 and Appendix 1).

The abundance was estimated at $65.81*10^6$ which is the largest estimate in the time series. Allmost 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 51 cm with modes at 27 and 30 cm, respectively cm (Fig. 12). The relatively large proportion of fish 37-45 cm seen in 2013 has apparently disappeared..

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
2014	21945.8	14079.3	65.81	46.04

[1)] Poor coverage of relevant depths.

Table 13. Mean catch km^{-2} and biomass (tons) with Standard Error of deep sea redfish in Division 1CD by depth stratum, 2014.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
1C	401-600	3366	1	4.0608	13668.6	.
	601-800	16120	5	0.3146	5071.7	2566.3
	801-1000	6066	12	0.0101	61.1	24.9
	1001-1200	611	2	0.0000	0.0	0.0
1D	401-600	903	1	1.5522	1401.6	.
	601-800	1940	2	0.8755	1698.4	1686.3
	801-1000	3874	3	0.0035	13.5	6.8
	1001-1200	10140	15	0.0012	12.7	7.7
	1201-1400	6195	13	0.0015	9.6	5.3
	1401-1500	3091	4	0.0028	8.6	2.9
All				0.4196	21945.8	14079.3

Table 14. Mean catch km^{-2} and abundance with Standard Error of deep sea redfish by Division and depth stratum, 2014. 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
1C	401-600	3366	1	13407.4	45129458.1	.
	601-800	16120	5	881.0	14202033.1	7946206.0
	801-1000	6066	12	22.6	137253.7	47973.1
	1001-1200	611	2	0.0	0.0	0.0
1D	401-600	903	1	4249.0	3836858.1	.
	601-800	1940	2	1230.7	2387567.3	2359029.8
	801-1000	3874	3	7.9	30431.1	15293.6
	1001-1200	10140	15	3.5	35012.0	21023.3
	1201-1400	6195	13	4.8	29660.5	17214.1
	1401-1500	3091	4	9.2	28393.5	9525.7
All				1258.3	65816667.3	46044544.2

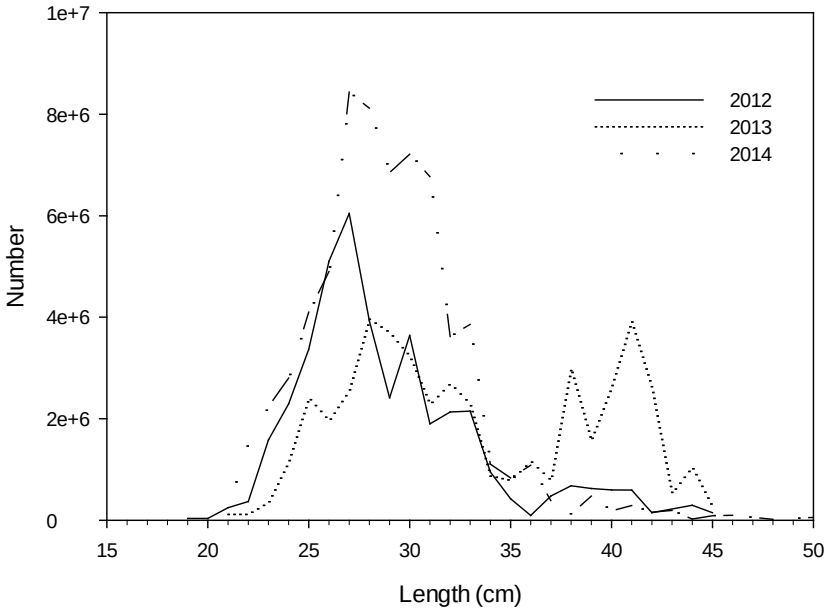


Fig. 12. Overall length distribution of deep sea redfish in numbers (weighted by stratum area) in Div. 1CD in 2012 and 2014 and in Div. 1D in 2013.

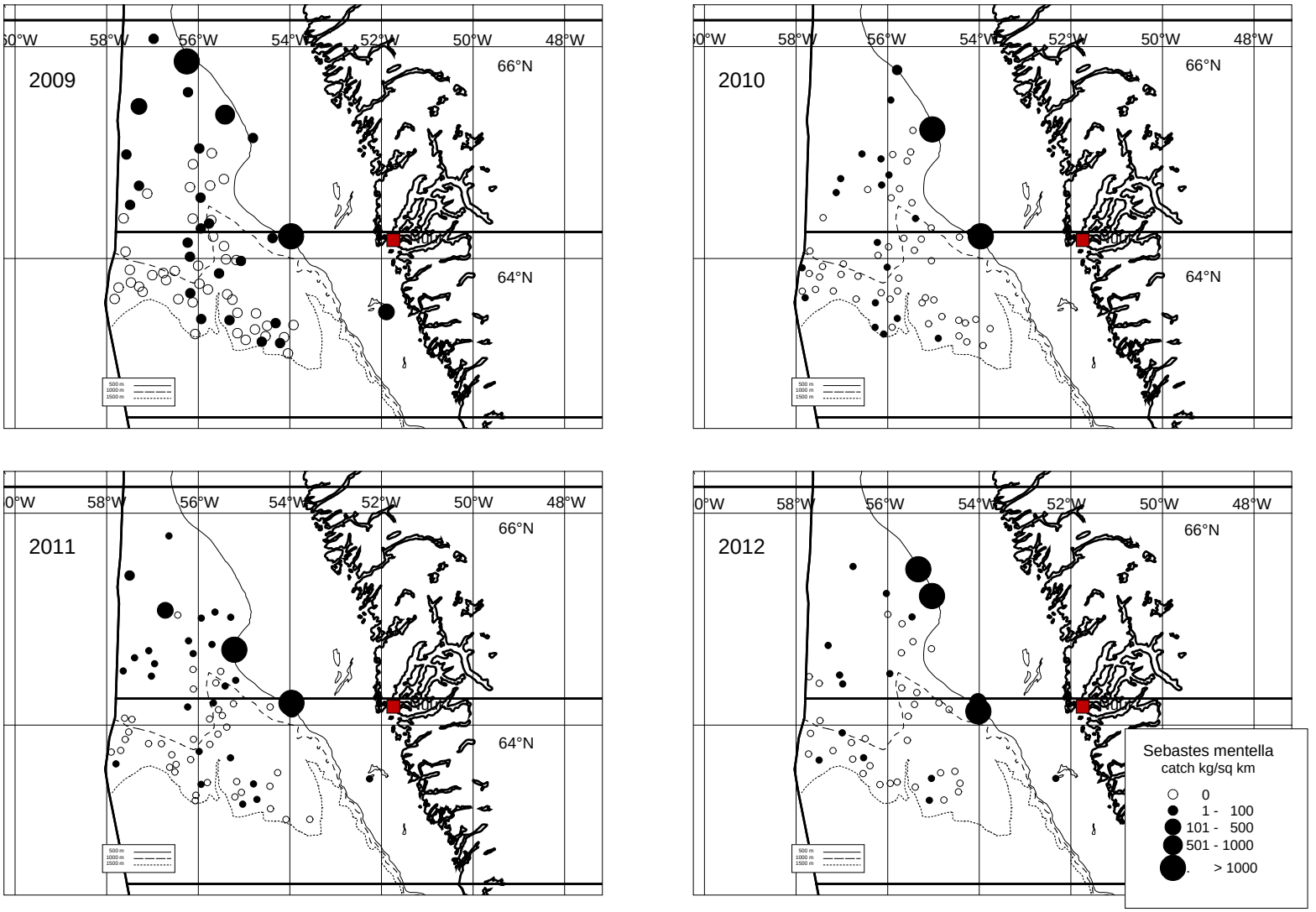


Fig. 13. Distribution of catches of deep sea redfish during 2009-2012 km^{-2}.

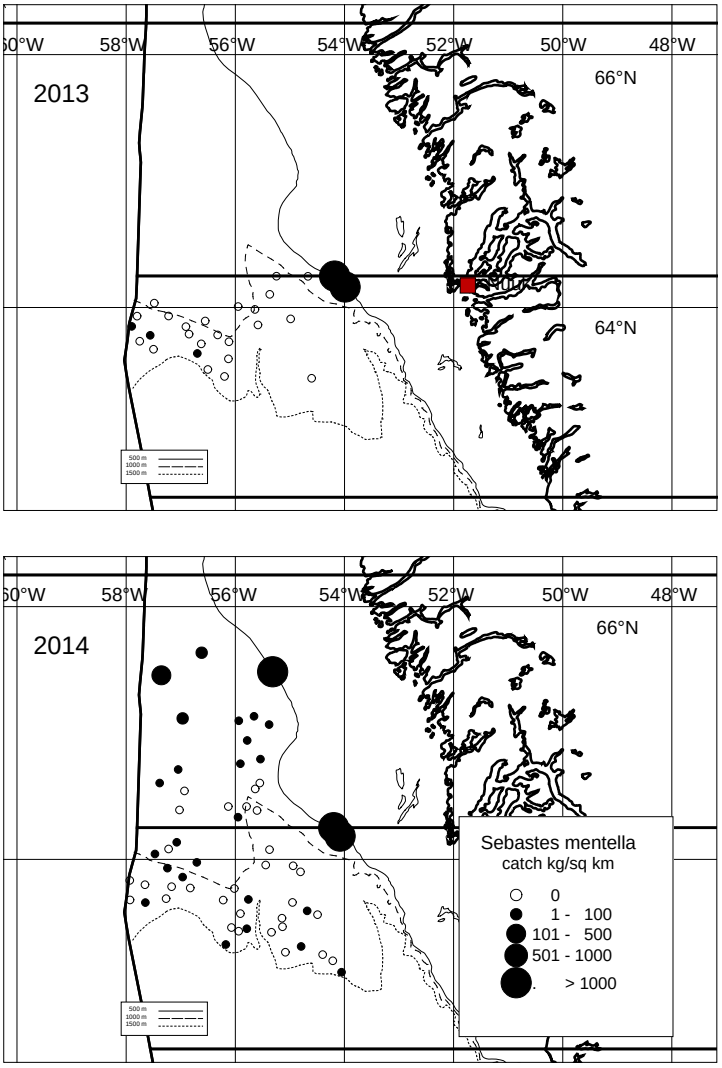


Fig. 13. Distribution of catches of deep sea redfish during 2013 and 2014 in kg km^{-2}

Temperature

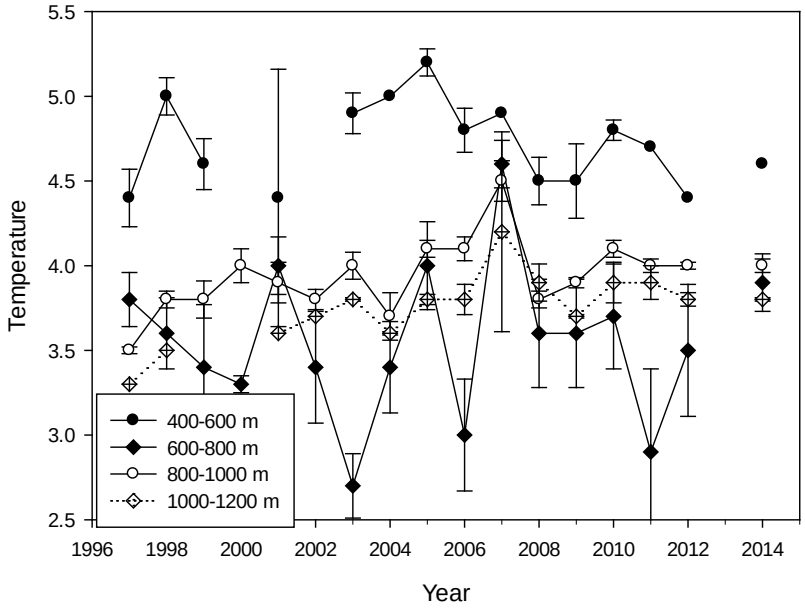
The bottom temperature ranged from 3.6°C to 4.1°C. The mean temperature was generally decreasing by depth as in previous years (Table 15).

The mean temperatures have been relatively constant in recent years except at depths between 400 and 600 m and to some extend 600-800 m where the mean temperature has fluctuated somewhat during the years. The temperature figures in those depth strata are however based on 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	4.6		1	3.9	.17	5	4.0	.04	12	3.8	.01	2						
1D				4.1	.43	2	3.8	.08	3	3.6	.02	15	3.6	.03	13	3.6	.03	4

Div. 1C



Div. 1D

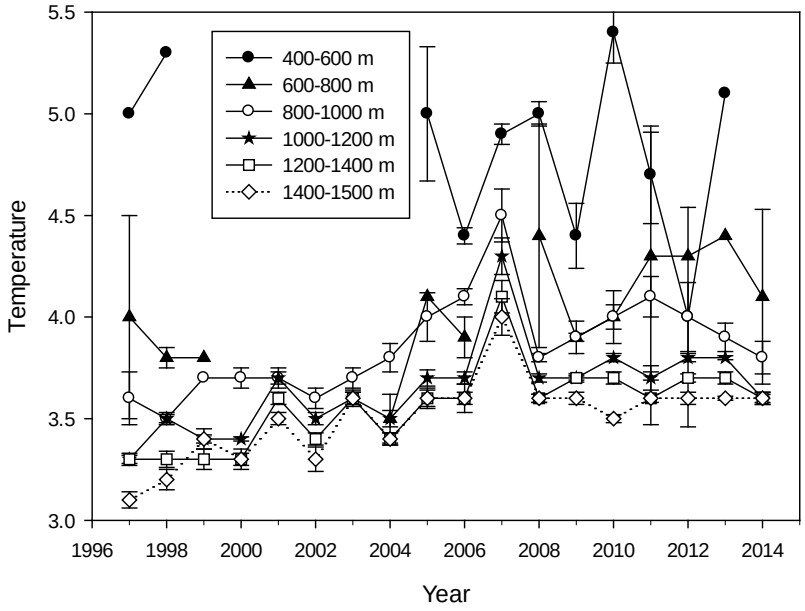


Fig 14. Mean temperatures by division depth stratum and year with 1*S.E. No data from Div. 1C in 2013

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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.	Number	Weight	Number	Weight	Number	Weight	Number	Weight
3	0.0804	1D	1430	3.7	20	39.0	8	1.7	15	10.8	1	0.3
4	0.0614	1D	1266	3.7	21	32.0	11	3.0	17	11.8	0	0.0
5	0.0577	1D	404	.	1	1.1	0	0.0	5	2.4	245	89.5
7	0.0763	1D	1133	3.8	132	196.2	11	0.9	21	8.7	0	0
9	0.0410	1D	702	4.6	16	24.3	95	9.7	11	5.5	107	76.3
10	0.0741	1C	964	3.9	82	124.9	5	0.2	10	3.1	5	3.5
11	0.0833	1C	886	4.0	81	109.0	5	0.6	13	2.8	0	0.0
12	0.0593	1C	1026	3.8	44	53.7	2	0.1	9	2.0	0	0.0
13	0.0765	1C	1055	3.8	213	319.7	4	1.0	20	10.8	0	0.0
14	0.0822	1C	986	3.7	187	220.8	10	0.7	25	6.6	0	0.0
15	0.0746	1C	923	3.8	122	153.7	5	0.2	14	4.0	0	0.0
16	0.0996	1C	928	3.8	220	238.4	10	0.6	32	8.1	1	0.3
17	0.0728	1C	883	4.2	75	94.2	20	0.6	15	4.6	1	0.5
18	0.0851	1C	873	4.1	195	238.1	11	0.5	12	4.0	1	0.3
19	0.0716	1C	826	4.1	98	122.0	3	0.2	8	3.3	1	0.3
20	0.0694	1C	780	4.2	30	39.2	9	0.4	4	1.1	4	1.6
21	0.0736	1C	816	4.1	54	57.8	7	0.3	11	5.2	5	1.7
22	0.0856	1C	558	4.6	17	21.5	1	0.3	4	1.3	1148	347.7
23	0.0424	1C	676	4.1	14	18.7	0	0.0	9	1.3	29	14.3
24	0.0586	1C	631	3.7	16	12.0	0	0.0	8	0.9	159	51.7
25	0.0579	1C	680	3.3	36	37.4	2	0.1	5	0.9	55	19.3
26	0.0781	1C	814	4.1	54	67.7	3	0.3	7	0.9	5	1.6
27	0.0884	1C	810	4.0	44	53.9	6	0.4	8	1.5	2	1.0
28	0.0815	1C	825	4.1	78	98.9	1	0.0	11	4.2	0	0.0
29	0.0779	1C	797	4.1	64	87.2	9	0.8	13	4.4	0	0.0
30	0.0680	1D	791	3.7	57	69.0	4	0.4	16	3.7	1	0.4
31	0.0791	1D	873	3.7	96	128.7	6	1.0	8	6.5	0	0.0
33	0.0902	1D	889	3.9	170	208.6	6	1.0	8	4.5	1	0.4
34	0.0874	1D	1148	3.6	155	190.7	4	0.3	17	7.7	1	0.4
35	0.0825	1D	1308	3.5	53	63.8	4	2.2	10	6.8	0	0.0
36	0.0828	1D	1464	3.6	125	179.7	4	1.3	3	5.7	0	0.0
37	0.0789	1D	1446	3.6	43	59.9	0	0.0	2	1.3	1	0.3
38	0.0765	1D	1366	3.5	87	107.0	3	0.8	6	2.4	0	0.0
39	0.0794	1D	1182	3.6	145	164.9	2	0.2	15	4.5	0	0.0
40	0.0759	1D	1251	3.6	149	174.3	2	0.9	14	4.9	0	0.0
41	0.0802	1D	957	3.7	122	164.1	1	0.1	17	3.6	1	0.4
42	0.0840	1D	1065	3.6	196	235.1	2	0.2	6	1.4	1	0.3
43	0.0542	1D	1275	3.6	46	71.7	7	1.6	1	0.1	0	0.0
44	0.0844	1D	1048	3.7	79	138.0	1	0.1	14	4.4	0	0.0
45	0.0844	1D	1124	3.7	26	38.9	4	0.9	21	7.2	0	0.0
46	0.0633	1D	1210	3.6	36	60.7	1	0.5	10	3.3	0	0.0
47	0.0785	1D	1268	3.6	99	140.2	2	0.2	25	11.3	1	0.3
48	0.0718	1D	1192	3.6	84	127.0	1	0.6	12	3.5	0	0.0
49	0.0808	1D	1191	3.6	53	109.2	7	1.8	14	5.8	0	0.0
50	0.0779	1D	1218	3.9	79	101.8	6	2.0	15	6.6	0	0.0
51	0.0606	1D	1196	3.6	76	97.4	6	0.6	18	7.7	0	0.0
52	0.0770	1D	1439	3.5	161	194.7	10	2.1	21	14.7	1	0.3
53	0.0619	1D	1323	3.5	111	137.8	2	0.6	5	6.0	2	0.5
54	0.0416	1D	1216	3.6	9	11.3	2	0.6	13	5.2	0	0.0
55	0.0479	1D	1139	3.7	52	66.6	3	0.5	3	1.5	0	0.0
56	0.0434	1D	1131	3.6	25	41.2	6	0.5	5	1.7	0	0.0

57	0.0786	1D	1375	3.6	21	30.9	4	0.9	6	9.3	0	0.0
58	0.0582	1D	1262	3.7	27	48.3	4	0.8	9	4.5	1	0.4
59	0.0821	1D	1287	3.7	59	89.6	15	3.3	9	5.3	0	0.0
63	0.0544	1D	1115	3.6	63	98.7	0	0.0	13	7.7	0	0.0
64	0.0352	1D	1122	3.6	23	29.7	0	0.0	7	4.4	1	0.4
65	0.0647	1D	1163	3.7	53	71.2	6	0.4	20	8.4	0	0.0
66	0.0581	1D	1188	3.6	26	43.4	1	0.1	7	2.5	0	0.0

Appendix 2. List of species and groups of species recorded in Div. 1CD in 2014 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	ALA	Alepocephalus agassizzi	158.0	80	702	1464	3.5	4.6	64.1829
2	ALB	Alepocephalus bairdii	1.0	5	883	1323	3.5	4.2	64.7922
3	ALE	Alepocephalus sp.	0.0	1	680	680	3.3	3.3	65.1141
4	RFL	Amblyraja fyllae	0.9	1	826	1196	3.6	4.1	65.0959
5	RRD	Amblyraja radiata	0.6	2	676	873	3.7	4.1	65.6336
6	CAD	Anarhichas denticulatus	27.1	4	404	1464	3.5	4.1	65.4547
7	CAA	Anarhichas lupus	0.0	1	1148	1148	3.6	3.6	63.8587
8	CAS	Anarhichas minor	8.4	3	404	1188	3.6	3.6	64.2487
9	ANC	Anopologaster cornuta	0.2	1	1218	1464	3.5	3.9	63.6880
10	ANT	Antimora rostrata	26.0	55	680	1464	3.3	4.6	65.1141
11	ARZ	Arctozenus rissoi	0.1	1	816	928	3.7	4.1	65.1315
12	ARS	Argentina silus	14.2	115	404	404	.	.	64.2487
13	ARA	Artediellus atlanticus	0.0	3	404	404	.	.	64.2487
14	BAM	Bajacalifornia megalops	0.2	1	1191	1430	3.6	3.7	63.5704
15	BAT	Bathylagus euryops	6.0	113	631	1464	3.3	4.2	65.6336
16	BAS	Bathylagus sp.	0.0	1	1131	1131	3.6	3.6	63.4660
17	BSP	Bathyraja spinicauda	13.8	1	702	1262	3.6	4.6	65.1315
18	BEG	Benthosema glaciale	0.2	101	558	1464	3.3	4.6	65.6336
19	BOA	Borostomias antarcticus	0.1	1	814	1464	3.6	4.1	64.7104
20	CFB	Centroscyllium fabricii	22.2	25	558	1196	3.6	4.6	65.6336
21	CHO	Ceratias holboelli	0.7	1	1216	1216	3.6	3.6	63.4218
22	CHA	Chauliodus sloani	0.1	1	1048	1323	3.5	3.7	63.9542
23	CHH	Chiasmodon harteli	0.0	1	1366	1366	3.5	3.5	63.6781
24	CHN	Chiasmodon niger	0.1	2	797	1464	3.6	4.1	64.3895
25	CBB	Coryphaenoides brevibarbis	0.1	2	1131	1439	3.5	3.6	63.4660
26	CGR	Coryphaenoides güntheri	3.6	22	1122	1464	3.5	3.9	64.0761
27	RNG	Coryphaenoides rupestris	9.7	95	558	1464	3.3	4.6	65.4827
28	COM	Cottunculus microps	0.3	2	631	1048	3.7	4.1	65.4547
29	COT	Cottunculus thomsonii	1.1	2	797	1191	3.6	4.1	64.7558
30	LUM	Cyclopterus lumpus	0.0	1	957	1375	3.6	3.7	64.0425
31	CLM	Cyclothone microdon	0.0	1	680	1124	3.3	4.1	65.1141
32	EUR	Eurypharynx pelecanoides	0.1	1	1182	1182	3.6	3.6	63.8327
33	COD	Gadus morhua	1.0	1	404	404	.	.	64.2487
34	ONA	Gaidropsarus argentatus	0.6	2	631	1216	3.6	3.7	65.4547
35	ONN	Gaidropsarus ensis	2.6	10	631	1464	3.5	4.1	65.4547
36	GOB	Gonostoma bathyphilum	0.0	2	780	1375	3.6	4.2	65.0647
37	PLA	Hippoglossoides platessoides	3.7	25	404	889	3.9	4.6	65.6336
38	HOA	Holtbyrnia anomala	0.2	2	886	1446	3.5	4.0	64.4174
39	HMC	Holtbyrnia macrops	0.0	1	791	791	3.7	3.7	64.1339
40	HAF	Hydrolagus affinis	55.7	8	1323	1439	3.5	3.7	63.4501
41	LAI	Lampanyctus intricarius	0.0	2	928	928	3.8	3.8	64.7558
42	LMC	Lampanyctus macdonaldi	5.3	1539	631	1464	3.3	4.2	65.6336
43	LEP	Lepidion eques	0.6	3	702	1191	3.6	4.6	65.1315
44	LIF	Liparis fabricii	0.0	1	631	680	3.3	4.1	65.6336
45	LIP	Liparis sp.	0.0	2	631	631	3.7	3.7	65.4547
46	LOA	Lophodoles alanthogantus	0.0	1	1139	1139	3.7	3.7	63.5329
47	LYN	Lycodes eudipleurostictus	0.3	1	1251	1268	3.6	3.6	63.7978
48	LMA	Lycodes macallister	0.3	1	1182	1210	3.6	3.6	63.9475
49	LPA	Lycodes paamiuti	0.2	1	1133	1308	3.5	3.8	64.0761
50	ELZ	Lycodes sp.	0.1	1	928	928	3.8	3.8	64.7558
51	LYM	Lycodonus mirabilis	0.0	1	1122	1268	3.6	3.7	63.9542
52	RHG	Macrourus berglax	14.7	32	404	1464	3.3	4.6	65.6336
53	MAA	Magnisudis atlantica	0.3	2	791	1464	3.6	4.2	65.0959
54	MAL	Malacosteus niger	0.1	1	826	1268	3.6	4.1	65.0959
55	CAP	Mallotus villosus	0.0	1	631	676	3.7	4.1	65.6336
56	MAM	Maulisia mauli	0.1	1	889	889	3.9	3.9	63.9754
57	MMI	Maulisia microlepis	0.1	2	1026	1191	3.6	3.8	64.4173
58	MBE	Melanolagus bericoides	0.0	5	873	1308	3.5	4.1	64.9399
59	WHB	Micromesistius poutassou	0.8	5	404	404	.	.	64.2487
60	MYP	Myctophum punctatum	0.0	1	780	1115	3.6	4.2	65.0647
61	NEM	Nemichthys scolopaceus	0.1	2	923	923	3.8	3.8	64.6031
62	NZB	Nezumia bairdii	0.2	1	810	825	4.0	4.1	64.7104
63	NOT	Notacanthus chemnitzii	6.6	10	558	1464	3.3	4.6	65.4827
64	NOK	Notoscopelus kroyeri	0.0	3	404	1430	3.3	4.1	65.4547
65	PAC	Paraliparis copei	0.0	1	964	1268	3.6	3.9	64.3330
66	PAG	Paraliparis garmani	0.1	22	631	1375	3.3	4.1	65.6336
67	POL	Polyacanthonotus rissoanus	0.2	1	957	1464	3.5	3.8	64.0761
68	RBI	Raja bigelowi	0.1	1	1048	1182	3.6	3.7	63.8327

69	RJJ	Raja jenseni	10.3	1	1430	1430	3.7	3.7	63.1061
70	RLT	Raja lintea	4.3	2	1192	1192	3.6	3.6	63.6767
71	SKA	Raja. sp.	0.7	1	1266	1266	3.7	3.7	63.1974
72	GHL	Reinhardtius hippoglossoides	319.7	220	404	1464	3.3	4.6	65.6336
73	RHO	Rhodichthys regina	0.0	1	1026	1026	3.8	3.8	64.4173
74	RAT	Roulina attrita	0.3	1	1192	1268	3.6	3.6	63.6818
75	SCO	Scopelosaurus lepidus	1.9	11	780	1464	3.5	4.2	65.1315
76	REG	Sebastes marinus	2.7	1	558	558	4.6	4.6	65.4827
77	REB	Sebastes mentella	347.7	1148	404	1446	3.3	4.6	65.6336
78	SER	Serrivomer beani	0.4	4	873	1464	3.5	4.0	64.4174
79	STO	Stomias boa	0.2	4	631	1464	3.6	4.2	65.4547
80	SYN	Synaphobranchus kaupi	2.1	13	676	1464	3.3	4.2	65.6336
81	TRA	Trachyrhynchus murrayi	0.6	2	883	1191	3.6	4.2	64.7922
82	XEC	Xenodermichthys copei	0.0	2	780	873	4.1	4.2	65.0647