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Survey for Greenland Halibut in NAFO Divisions 1C-1D, 2010

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Abstract

In 1997 Greenland initiated a survey series covering 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. The biomass of Greenland halibut was estimated as 75523 tons in 2010, which is a slight increase compared to 2009 and a little above average for the time series. The length distribution showed a mode around 49 cm as in previous years. The biomass of roundnose grenadier was estimared as 581 tons, the third lowest in the time series and far below the level seen in the late 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 primarily aimed 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, that 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 survey to 75.30°N (SCR 11/009, this meeting)

Materials and Methods

The survey in Div. 1CD in 2010 covered depths between 400 and 1500 m and took place during 11/9-22/9.

Stratification

The survey covered NAFO Div. 1C-1D between the 3-nm line and the 200-nm line or 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 an otter door.

Handling of the catch

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

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

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

Results and Discussion

In total 66 successful hauls were made and all depth strata were covered by at least two stations. 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 67 species or groups of fish species were recorded (Appendix 2).

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 75 522.5 tons (Table 2) which is an increase compared to 70 966.2 tons in 2009 and slightly aboce the average for the time series (72 000 tons) (Table 1, Fig. 2). The increase in biomass was seen in most strata

except in in Div. 1D depth stratum 1201-1400 m (-5.000 tons). The estimate from 2010 is not statistically different (95% level) from previous years estimates. The highest densities (in weight) were found at depths > 800 m. The weighted mean catch per tow also showed an increase from 1.36 tons km^{-2} in 2009 to 1.44 tons km^{-2} in 2010 (Table 1, Fig 3).

The abundance in was estimated at $64.868*10^6$ which is an increase compared to $62.507*10^6$ in 2009 but still slightly below the average for the time series ($68.000 *10^6$) (Table 3, Fig 4). The highest density (in numbers) was seen in Div. 1C 1001-1200 m, and in 801-1000 m in Div. 1C and 1D.

Estimated abundance by age in Div. 1CD is given in Table 4 (not updated in 2010, the otolith reading procedure is under revision).

The length ranged from 21 cm to 107 cm (excluding a few larvae < 9 cm). The overall length distribution (weighted by stratum area) was totally dominated by a mode at 49 cm, where the mode uses to be around 47- 50 cm, and very few fish < 40 cm were observed as in the previous years (Fig. 5). 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. 6) 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

Table 2. Mean catch per km^2 and biomass (tons) of Greenland halibut by Division and depth stratum, 2010.

Div.	Depth (m)	Area	Hauls	Mean	Biomass	SE
1C	401-600	3366	2	0.058	193.8	86.2
	601-800	16120	4	0.518	8356.5	2596.8
	801-1000	6066	12	2.209	13401.5	3556.0
	1001-1200	611	2	5.282	3227.4	420.4
1D	401-600	903	2	0.030	26.6	26.6
	601-800	1940	2	0.737	1429.2	114.7
	801-1000	3874	5	2.476	9593.2	1450.0
	1001-1200	10140	19	2.040	20685.6	1281.4
	1201-1400	6195	13	1.979	12257.0	2033.0
	1401-1500	3091	5	2.055	6351.7	1227.3
All				1.444	75522.5	5382.4

Table 3. Mean catch per km^2 and abundance of Greenland halibut by Division and depth stratum, 2010.

Division	Depth (m)	Area	Hauls	Mean sq/km	Abundance	SE
1C	401-600	3366	2	31.9	107285	30415
	601-800	16120	4	564.9	9105849	3157954
	801-1000	6066	12	2092.0	12690328	3690294
	1001-1200	611	2	4260.7	2603280	572092
1D	401-600	903	2	26.2	23642	23642
	601-800	1940	2	767.6	1489124	143302
	801-1000	3874	5	2074.5	8036567	1106048
	1001-1200	10140	19	1581.1	16032364	959719
	1201-1400	6195	13	1526.5	9456936	1313885
	1401-1500	3091	5	1722.1	5322984	1110202
All				1240.2	64868357	5389202

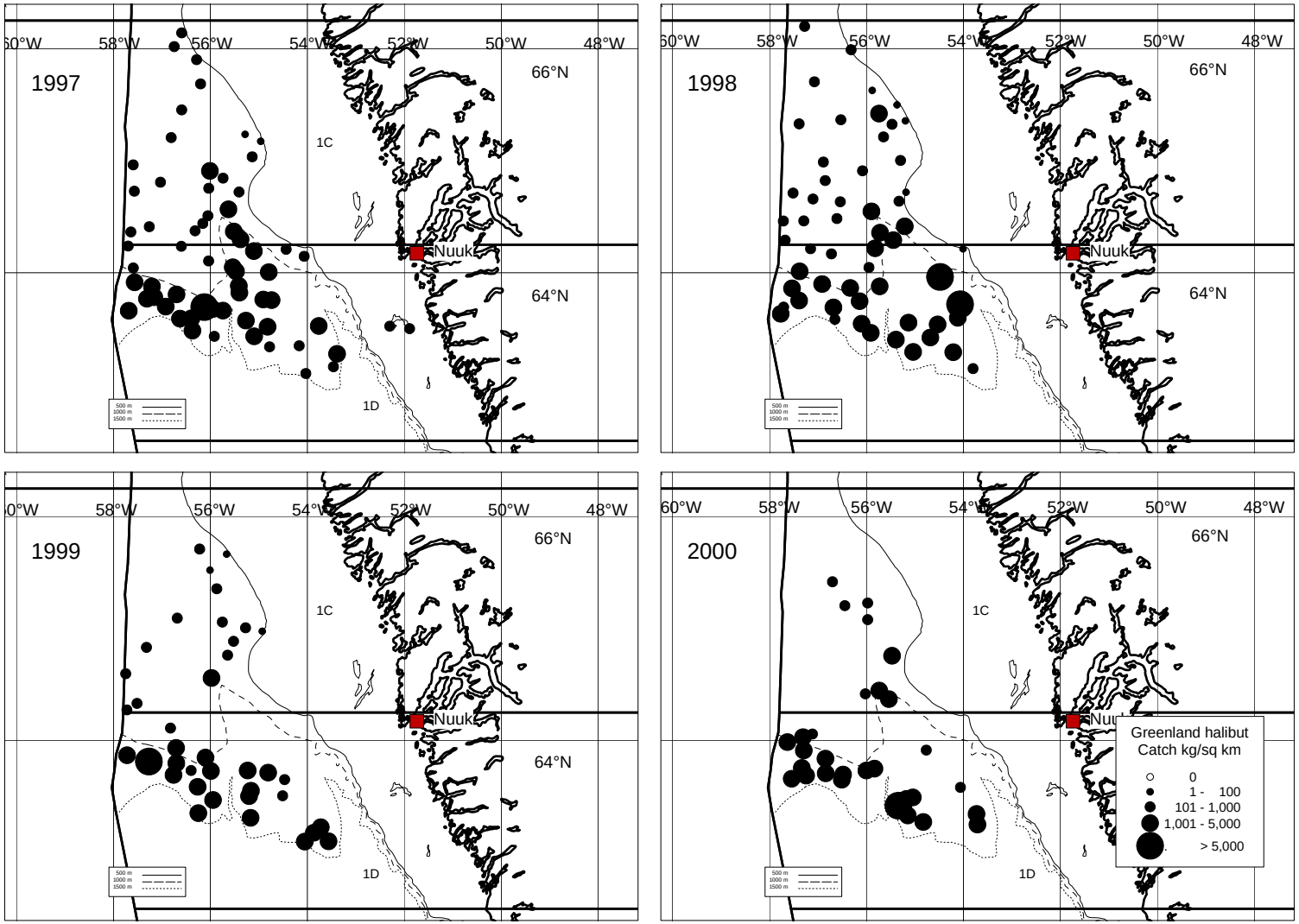

Fig. 1 Distribution of catches of Greenland halibut during 1997-2000 in kg km^{-2}.

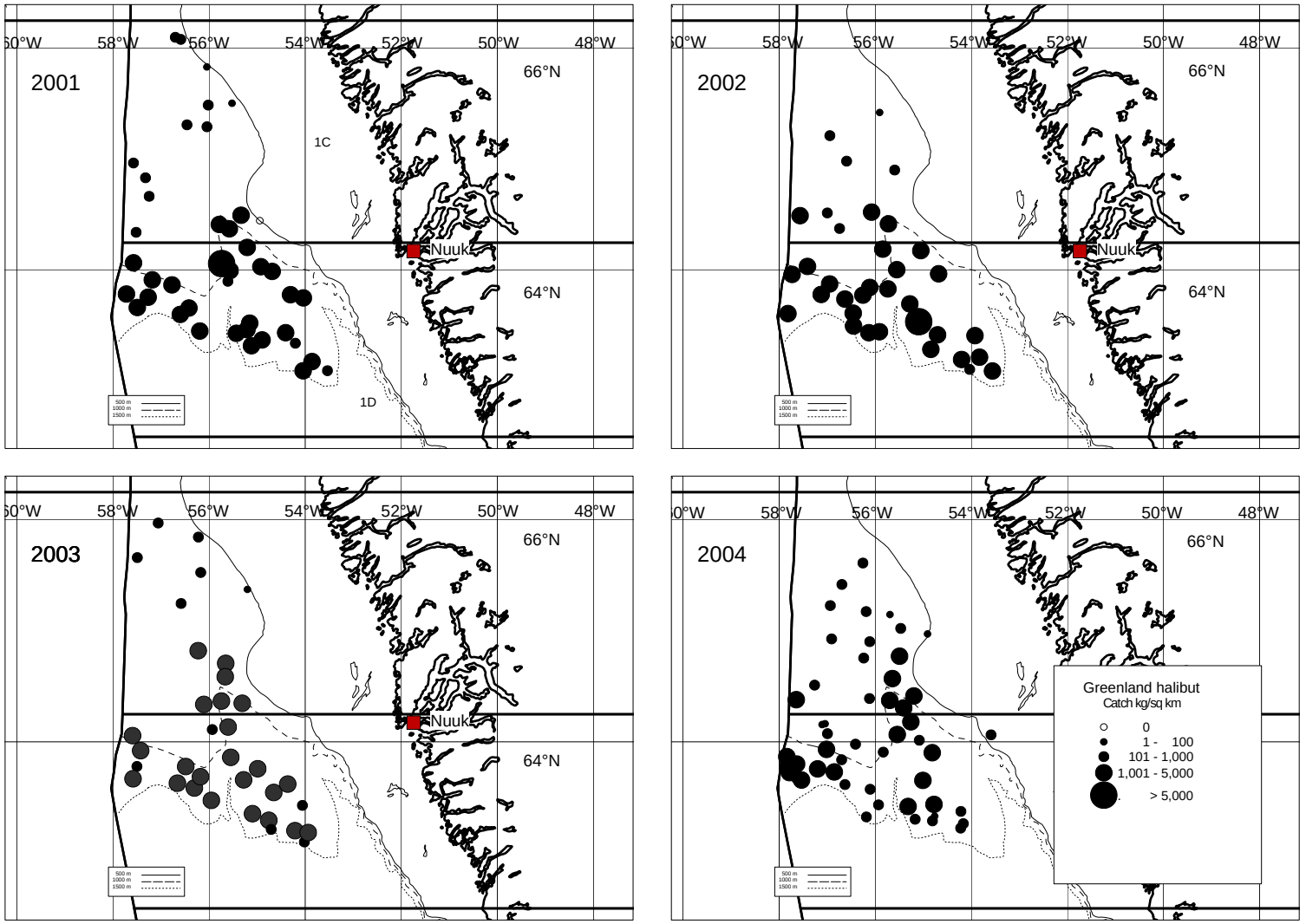

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2001 - 2004 in kg km^{-2}

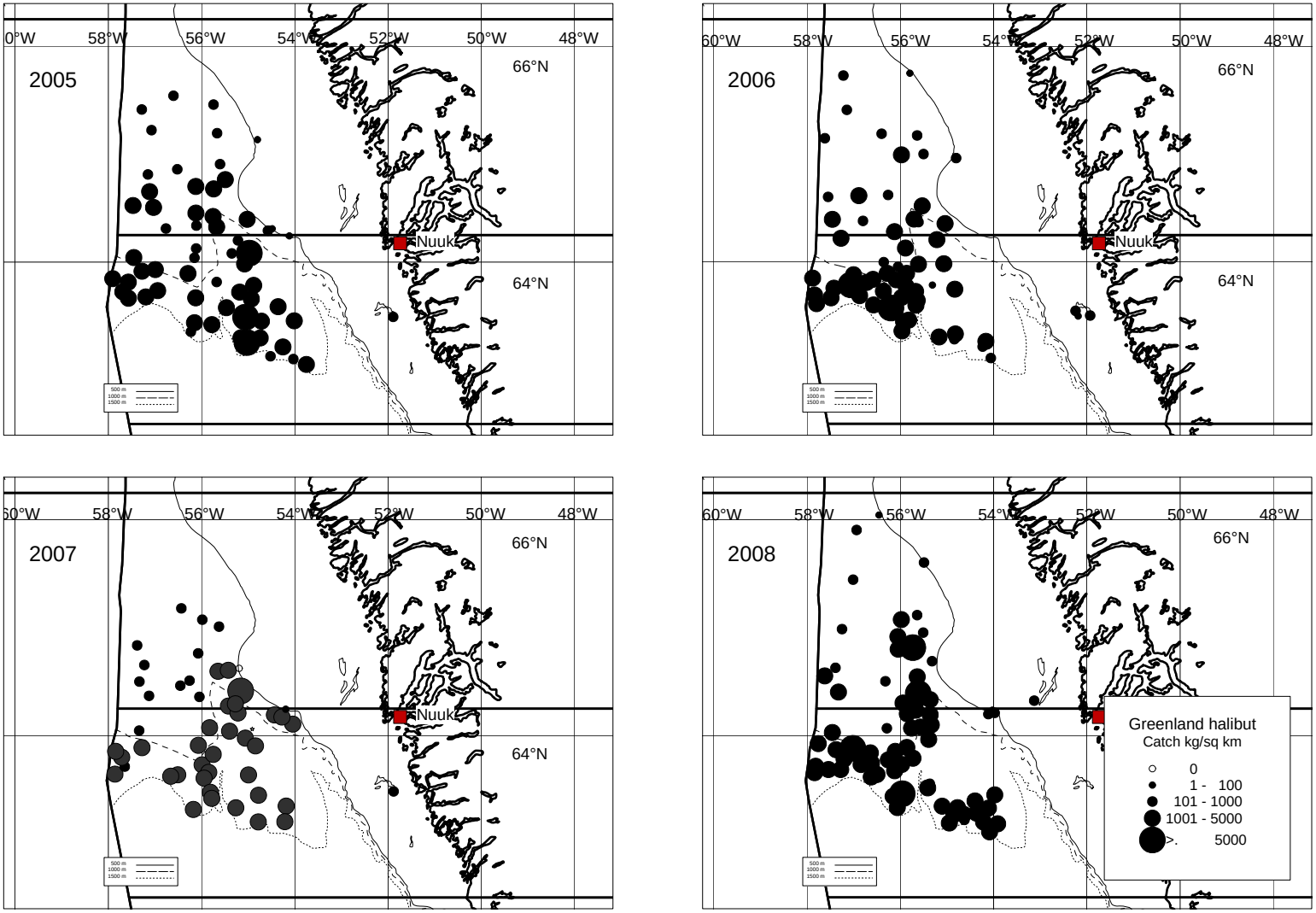

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2005 - 2008 in kg km^{-2}

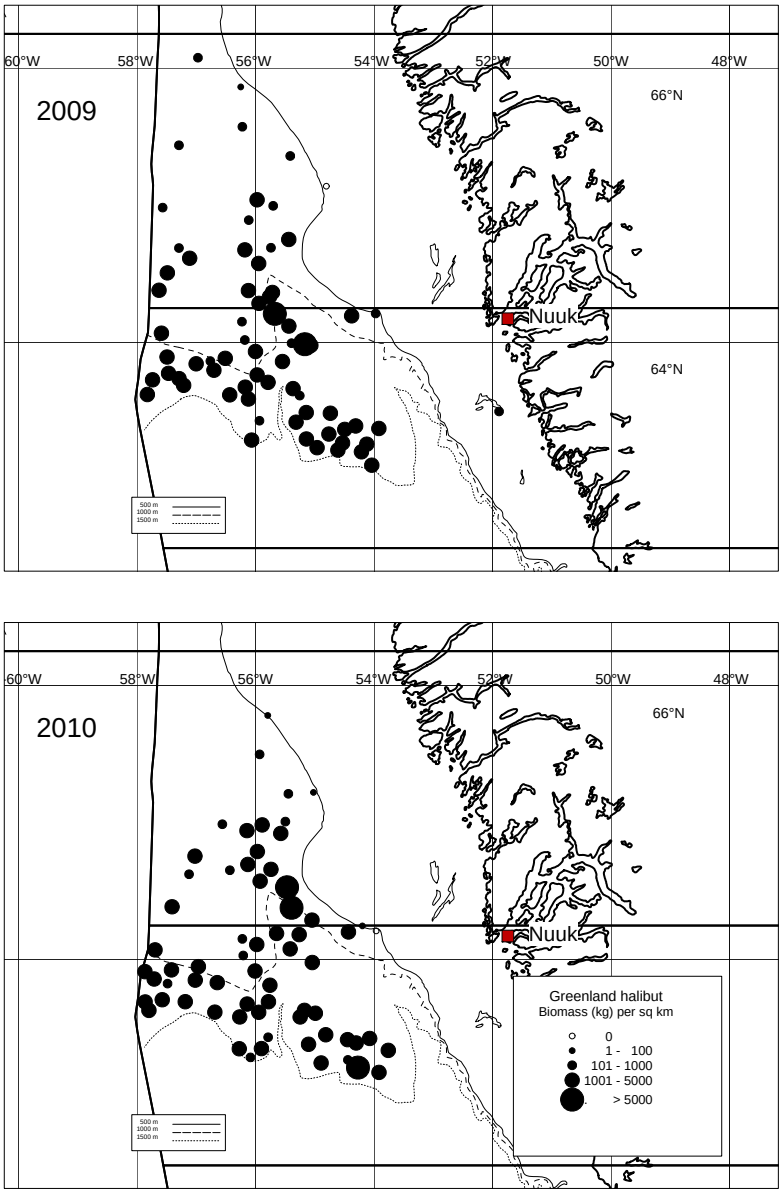

Fig. 1 (cont). Distribution of catches of Greenland halibut in 2009 and 2010 in kg km^{-2}

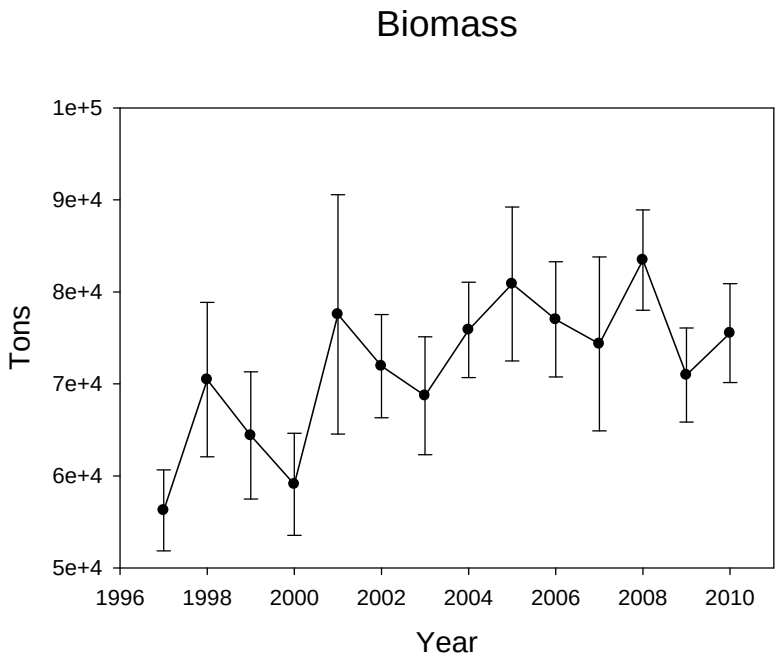

Fig. 2. Biomass (tons) of Greenland halibut in Div. 1CD by year with S.E.

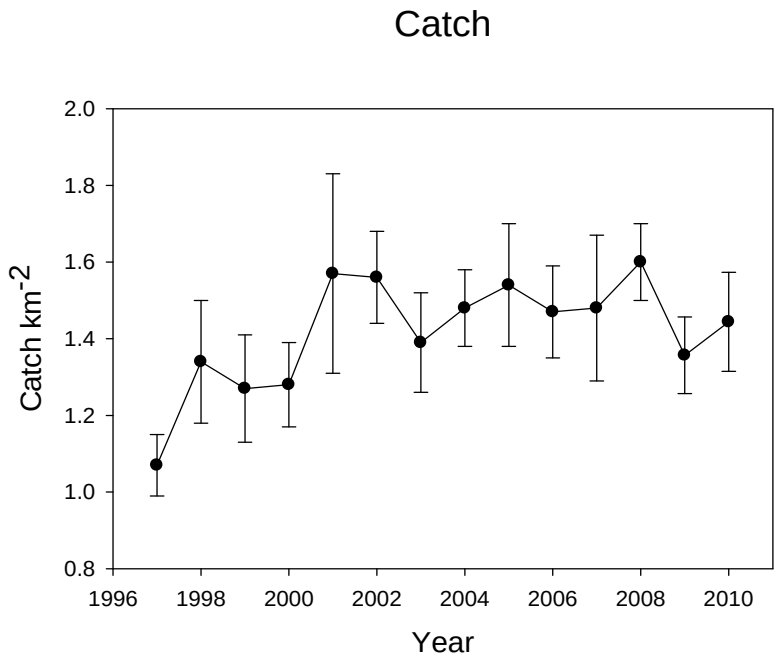

Fig. 3. Mean catch of Greenland halibut km^{-2} km (tons) in Div. 1CD standardized by stratum area with S.E.

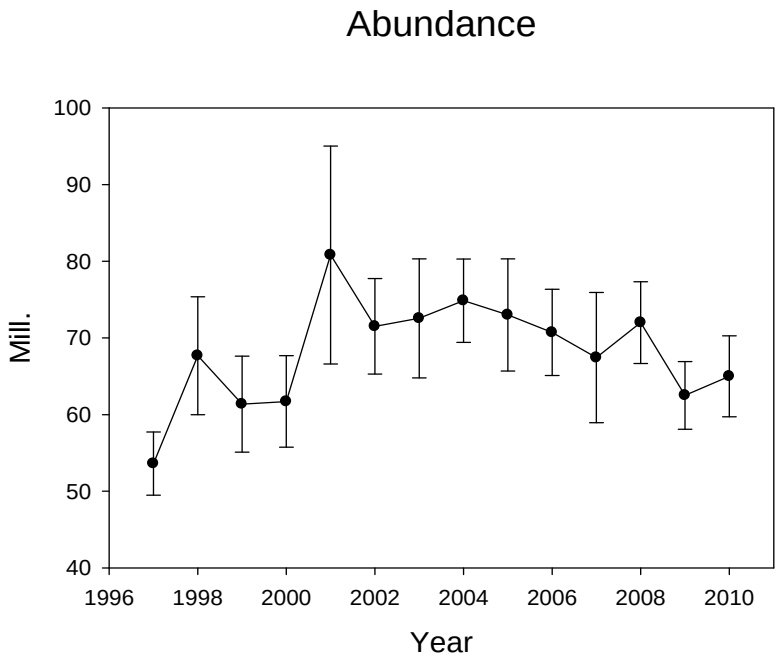

Fig. 4. Abundance (millions) of Greenland halibut in Div. 1CD by year with S.E.

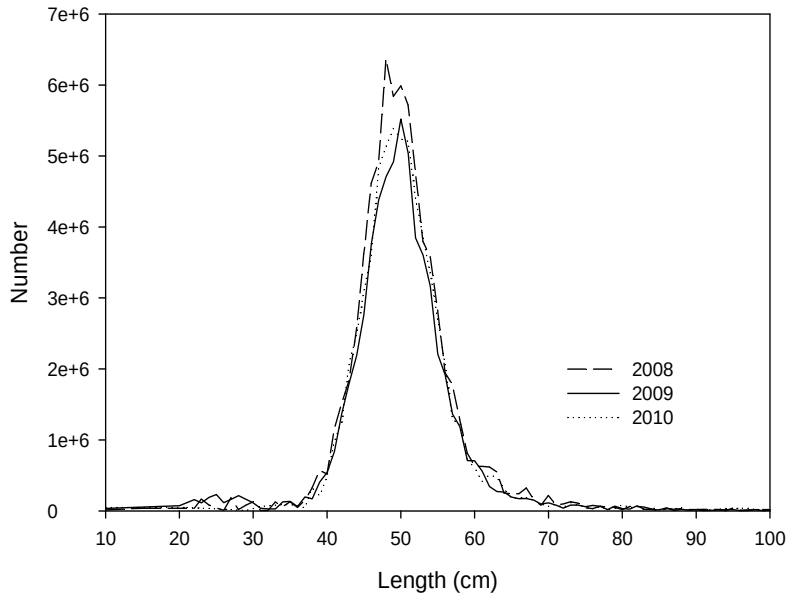

Fig. 5. Overall length distribution of Greenland halibut in numbers (weighted by stratum area) in Div. 1CD by year.

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

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

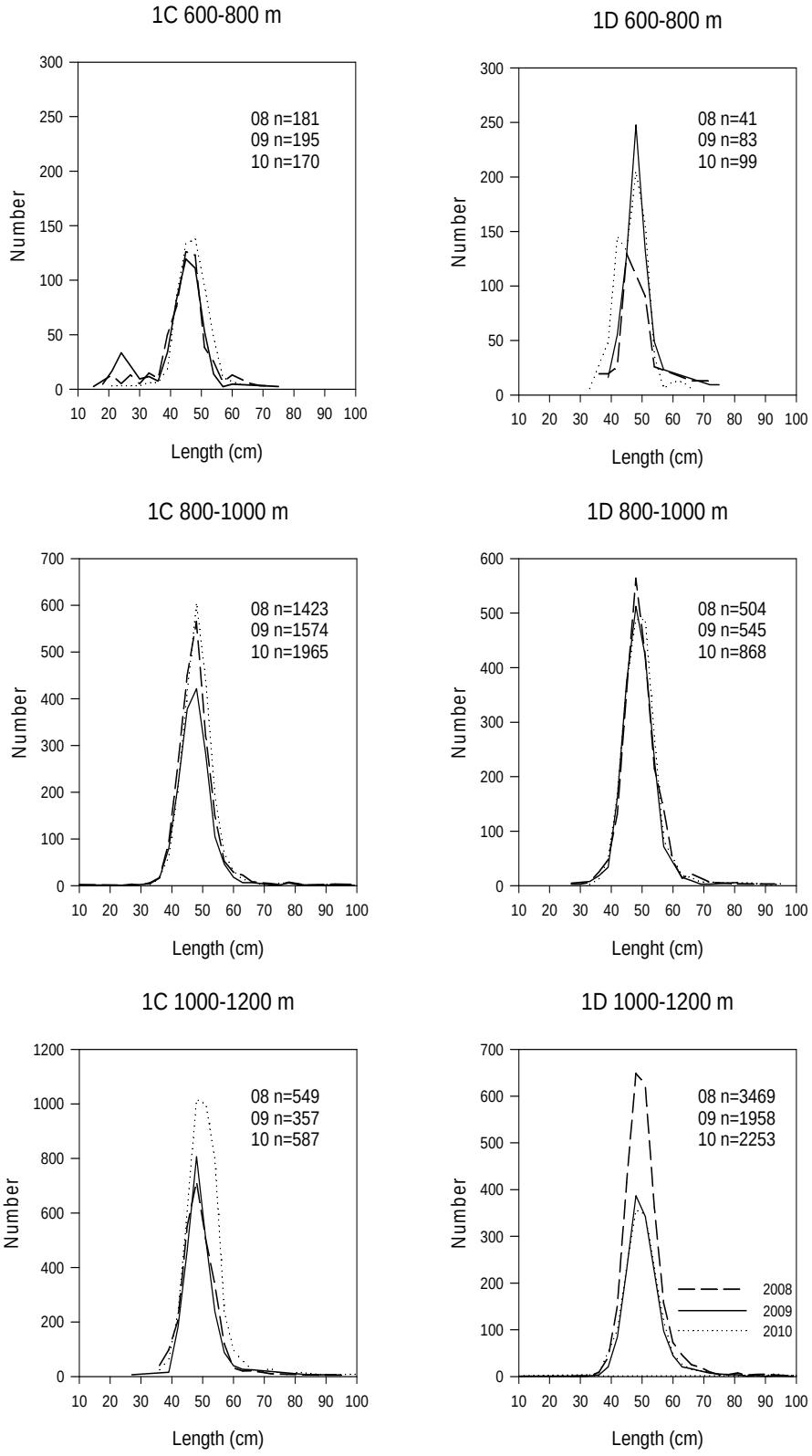

Fig. 6. Length distribution of Greenland halibut in numbers km^{-2} by Division and depth stratum. Div 1CD 600-1200 m.

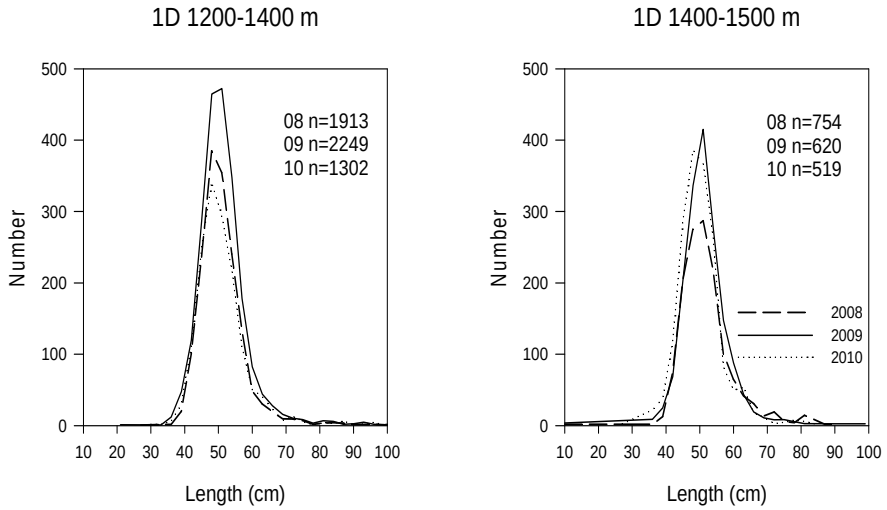

Fig. 6. cont. Length distribution of Greenland halibut in numbers km^{-2} by Division and depth stratum. Div. 1D 1200-1500 m.

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

	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 most of the survey area but the catches were very low (Fig. 7, 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 2010 was estimated as 580.7 tons compared to 1151.1 tons in 2009 and the second lowest estimate on record. Most of the biomass was found in Div 1D at depths greater than 801 m (Table 7).

The abundance decreased from $16.58*10^6$ in 2009 to $6.78*10^6$ in 2010, which is also the second lowest estimate on record. The highest densities were found in Div. 1D 801-1000 m (Table 8).

Table 6. Biomass (tons) and abundance of roundnose grenadier with 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

Table 7. Mean catch per km^2 and biomass (tons) of roundnose grenadier by Division and depth stratum, 2010.

Div.	Depth (m)	Area	Hauls	Mean	Biomass	SE
1C	401-600	3366	2	0.001	2.1	2.1
	601-800	16120	4	0.003	52.5	40.7
	801-1000	6066	12	0.006	36.8	6.5
	1001-1200	611	2	0.015	9.0	3.3
1D	401-600	903	2	0.004	4.0	4.0
	601-800	1940	2	0.001	2.6	0.7
	801-1000	3874	5	0.020	79.2	43.1
	1001-1200	10140	19	0.017	168.8	30.8
	1201-1400	6195	13	0.024	148.1	28.2
	1401-1500	3091	5	0.025	77.8	35.2
All				0.011	580.7	81.1

Table 8. Mean catch per km^2 and abundance of roundnose grenadier by Division and depth stratum, 2010.

Div.	Depth (m)	Area	Hauls	Mean	Abundance	SE
1C	401-600	3366	2	20.5	68850	68850
	601-800	16120	4	112.7	1817242	1373955
	801-1000	6066	12	80.9	490825	102386
	1001-1200	611	2	246.7	150744	6452
1D	401-600	903	2	20.1	18143	18143
	601-800	1940	2	24.2	47024	1041
	801-1000	3874	5	334.8	1296949	1027001
	1001-1200	10140	19	160.3	1625697	448709
	1201-1400	6195	13	157.9	977992	246776
	1401-1500	3091	5	94.0	290544	91913
All				129.7	6784010	1796877

Pre anal fin length ranged from 3 to cm 18 cm. The grenadiers were generally small and the over all length distribution (weighted by stratum area) showed a mode at 6 cm (Fig. 8).

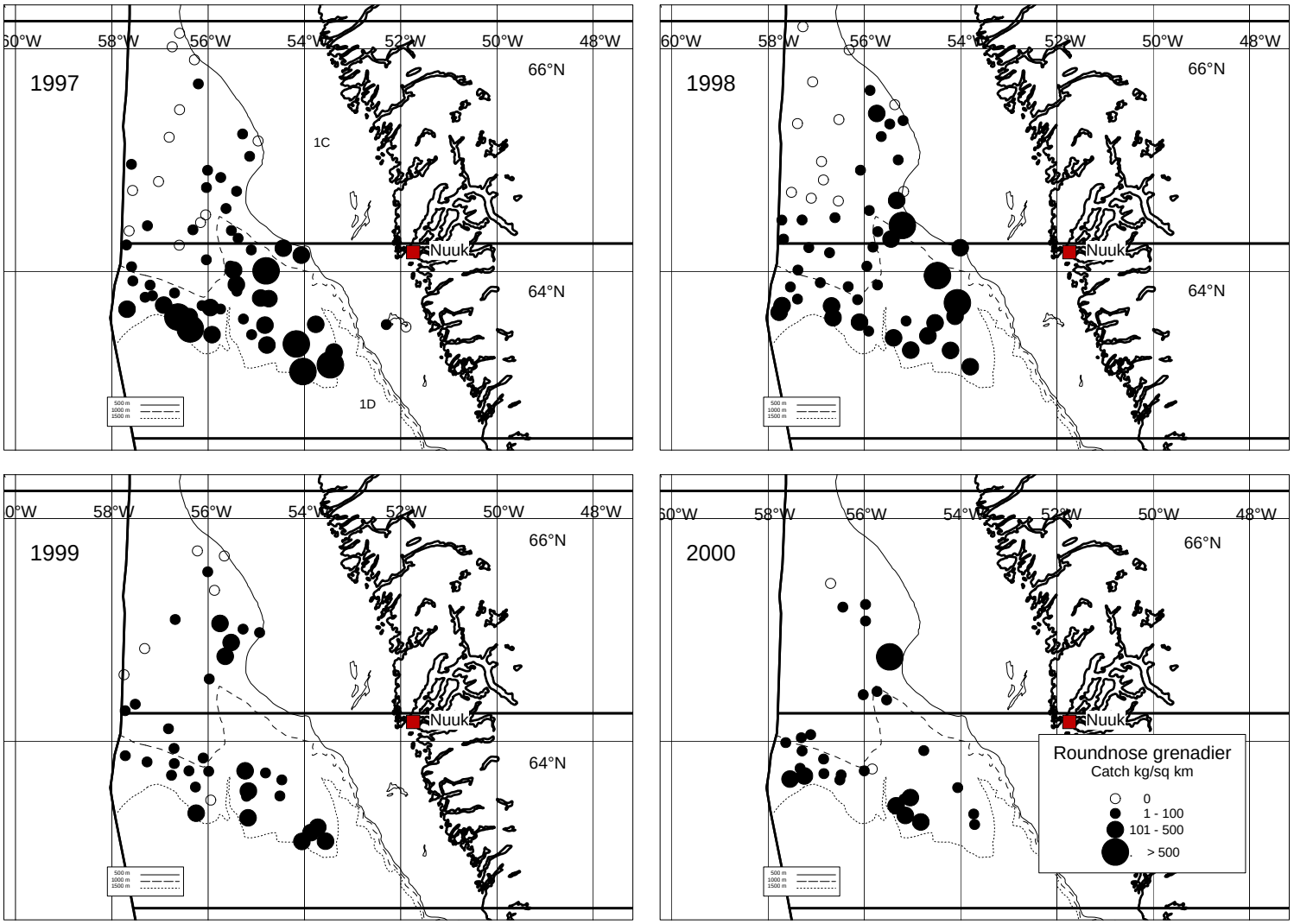

Fig. 7. Distribution of catches of roundnose grenadier in 1997-2000 in kg km^{-2}

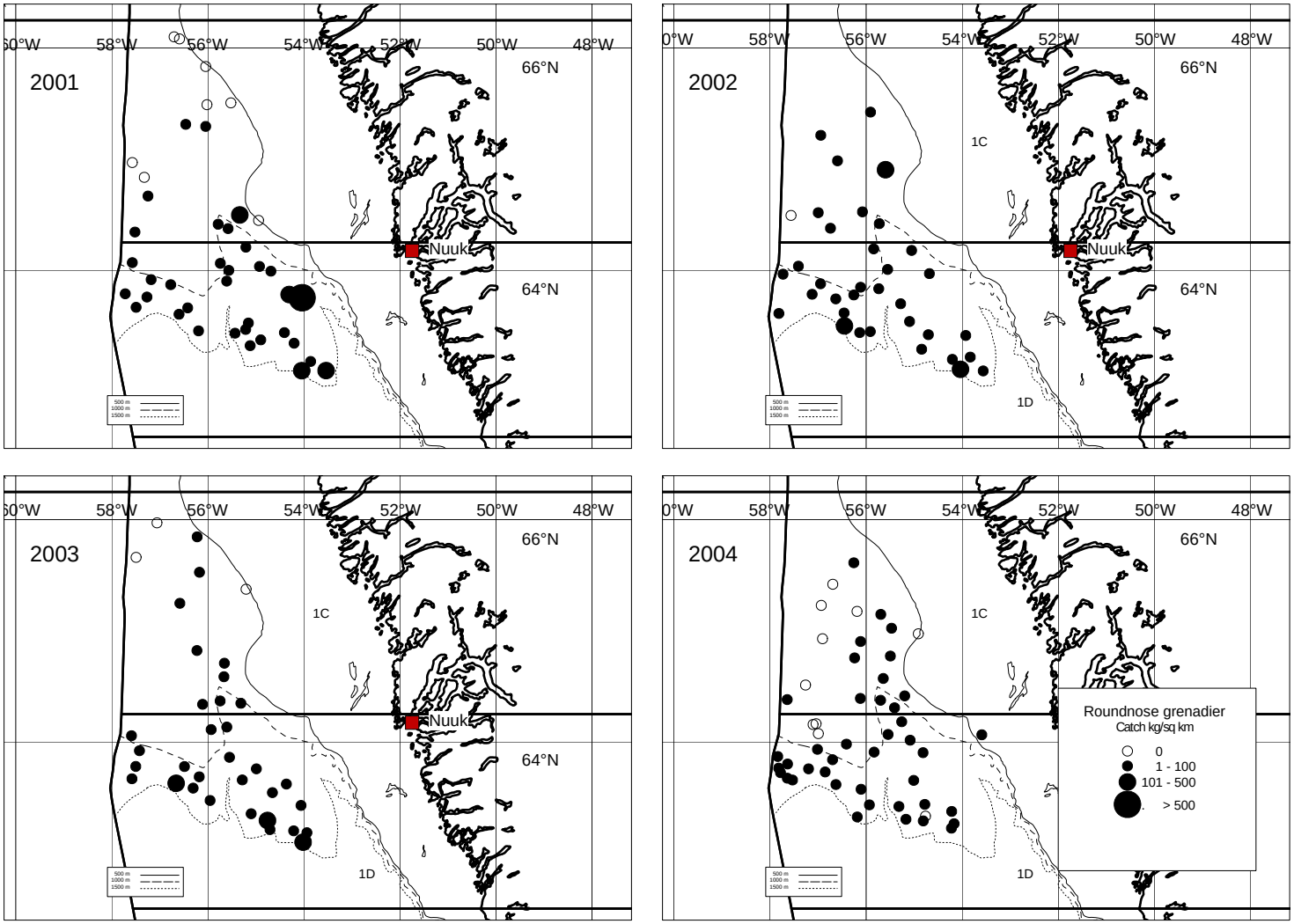

Fig. 7 cont. Distribution of catches of roundnose grenadier during 2001-2004 in kg km^{-2}.

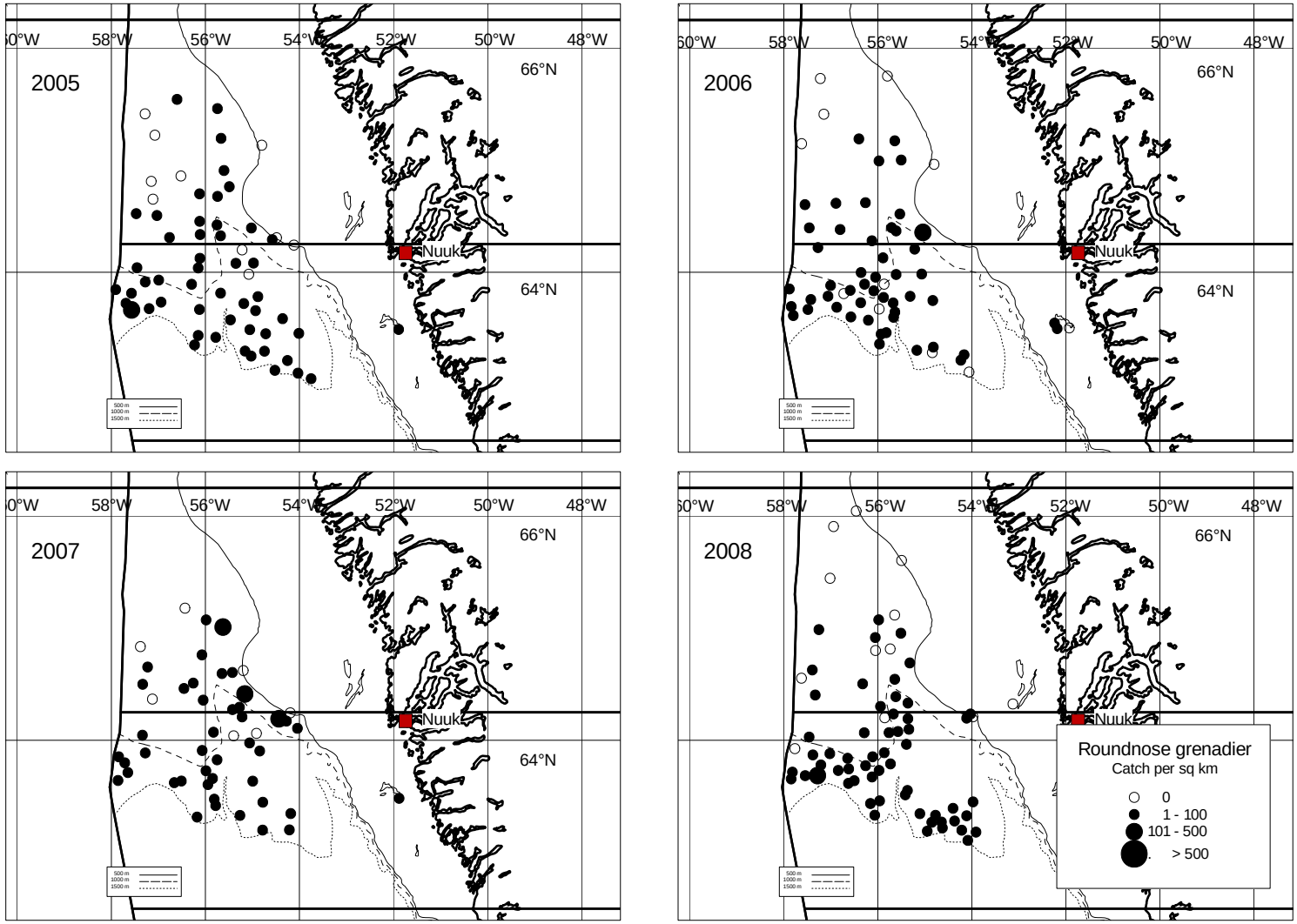

Fig. 7 cont. Distribution of catches of roundnose grenadier during 2005-2008 in kg km^{-2}.

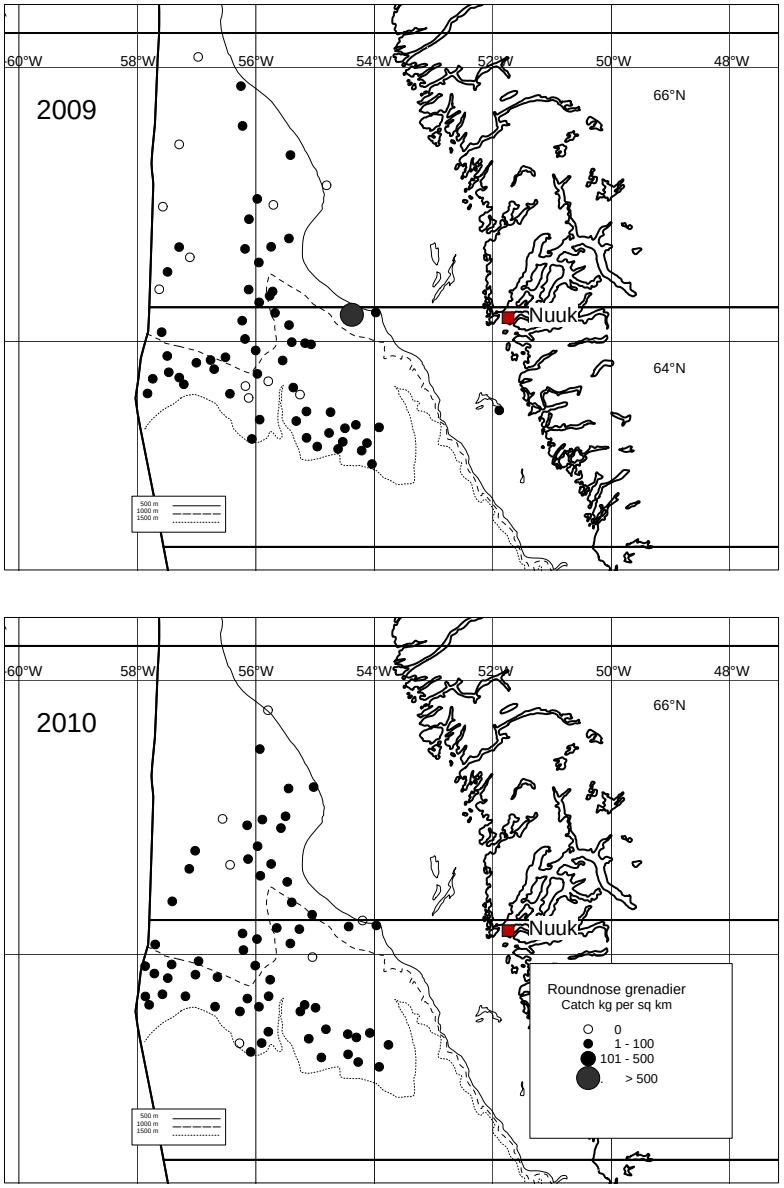

Fig. 7 cont. Distribution of catches of roundnose grenadier during 2009 and 2010 in kg km^{-2}.

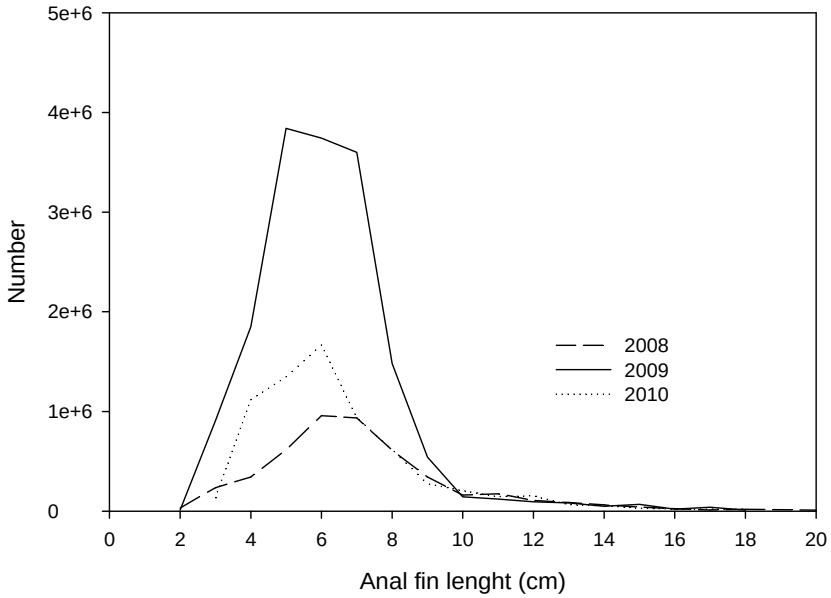

Fig. 8. Overall length distribution of roundnose grenadier (pre anal fin length) in numbers (weighted by stratum area) in Div. 1CD by year.

Roughhead grenadier (*Macrourus berglax*)

Roughead grenadier was caught in all hauls except two. The catches were, however, generally low (Fig. 9, Appendix 1). The biomass was estimated at 4025.8 tons compared to 3795.7 tons in 2009 and the 2010 estimate is the third lowest in the time series (Table 9).

The highest densities were found between at depths at 1401-1500 m in Div. 1D but the largest biomass was found in Div. 1D 1001-1200 m (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	2 258.6	250.1	4.60	0.45
1998	4 314.1	377.9	11.62	1.01
1999	5 166.2	854.1	14.07	2.04
2000	7 178.1	2 226.5	20.28	7.18
2001	4 576.6	456.3	13.87	1.55
2002	7 907.6	823.6	19.62	1.76
2003	5 657.5	700.8	15.37	2.57
2004	4 314.3	452.6	11.16	1.32
2005	5 602.6	419.5	14.00	1.31
2006	5 148.2	621.2	11.84	1.09
2007	3 467.6	374.6	8.18	1.08
2008	4 533.7	970.2	9.94	1.35
2009	3 795.7	299.2	8.21	0.67
2010	4 025.8	564.5	8.21	1.10

Table 10. Mean catch km^{-2} and biomass (tons) of roughhead grenadier by Division and depth stratum, 2010.

Div.	Depth (m)	Area	Hauls	Mean	Biomass	SE
1C	401-600	3366	2	0.022	72.3	72.3
	601-800	16120	4	0.065	1054.4	509.4
	801-1000	6066	12	0.056	338.8	47.0
	1001-1200	611	2	0.071	43.4	10.4
1D	401-600	903	2	0.037	33.6	5.2
	601-800	1940	2	0.048	92.9	51.3
	801-1000	3874	5	0.050	193.5	30.9
	1001-1200	10140	19	0.107	1080.9	120.3
	1201-1400	6195	13	0.112	694.8	128.4
	1401-1500	3091	5	0.136	421.2	130.6
All				0.077	4025.8	564.5

Table 11. Mean catch per km^{-2} and abundance of roughhead grenadier by Division and depth stratum, 2010.

Div.	Depth (m)	Area	Hauls	Mean	Abundace	SE
1C	401-600	3366	2	40.9	137700	137700
	601-800	16120	4	145.8	2350366	1009060
	801-1000	6066	12	125.2	759574	112093
	1001-1200	611	2	192.6	117685	15507
1D	401-600	903	2	66.5	60066	24603
	601-800	1940	2	85.1	165106	27154
	801-1000	3874	5	136.6	529174	103255
	1001-1200	10140	19	216.6	2196000	254011
	1201-1400	6195	13	210.7	1305028	251535
	1401-1500	3091	5	189.1	584380	151779
All				156.9	8205077	1101272

The total abundance was estimated at $8.21*10^6$ as in 2010 and among the lowest in the time series (Table 9). The highest densities were found in Div. 1D 1001-1400 m (Table 11).

Pre anal fin length ranged from 3 to 42 cm and the over all length distribution showed mode at 15 cm (Fig. 10).

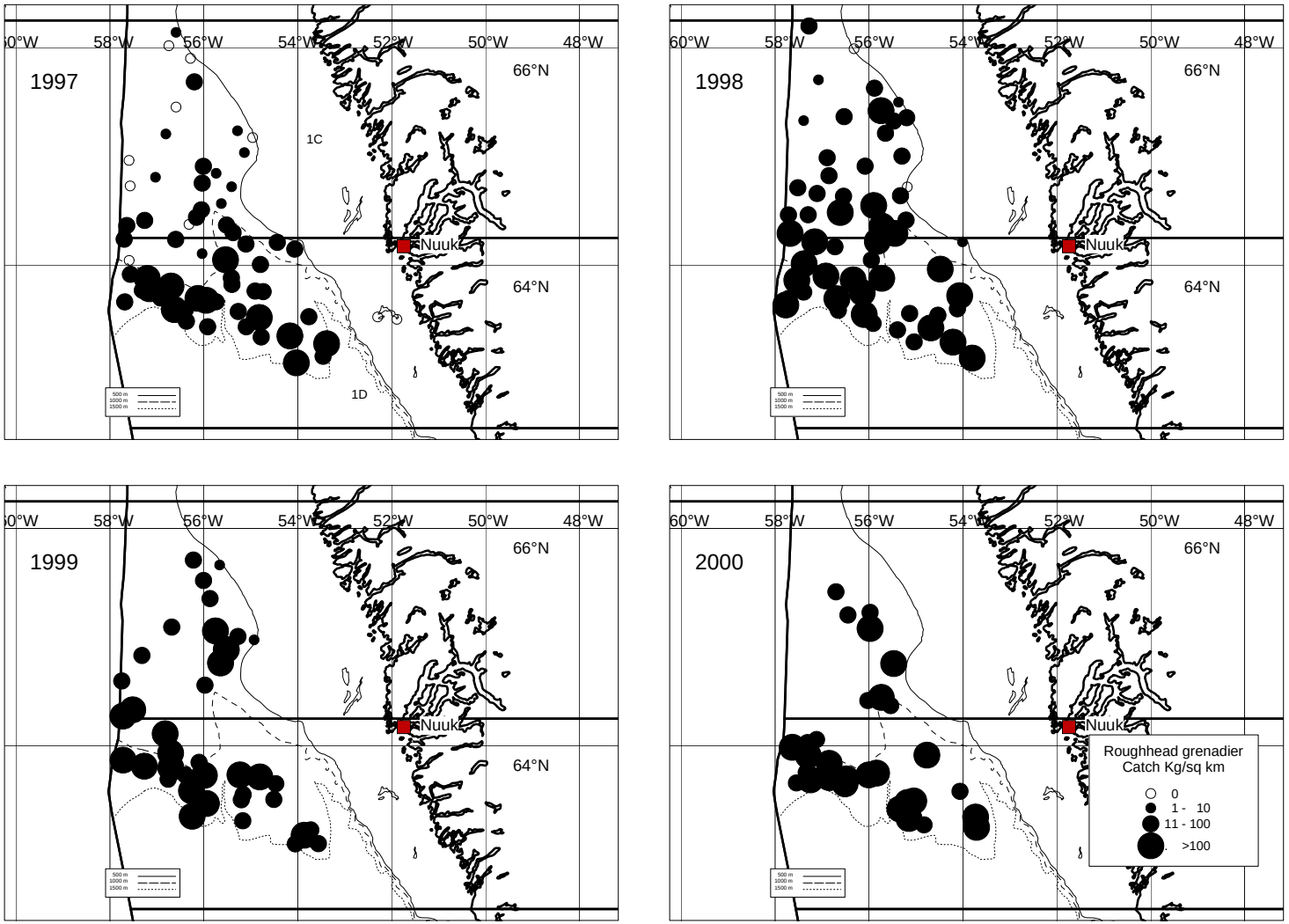

Fig. 9 Distribution of catches of roughhead grenadier in 1997-2000 in kg km^{-2}.

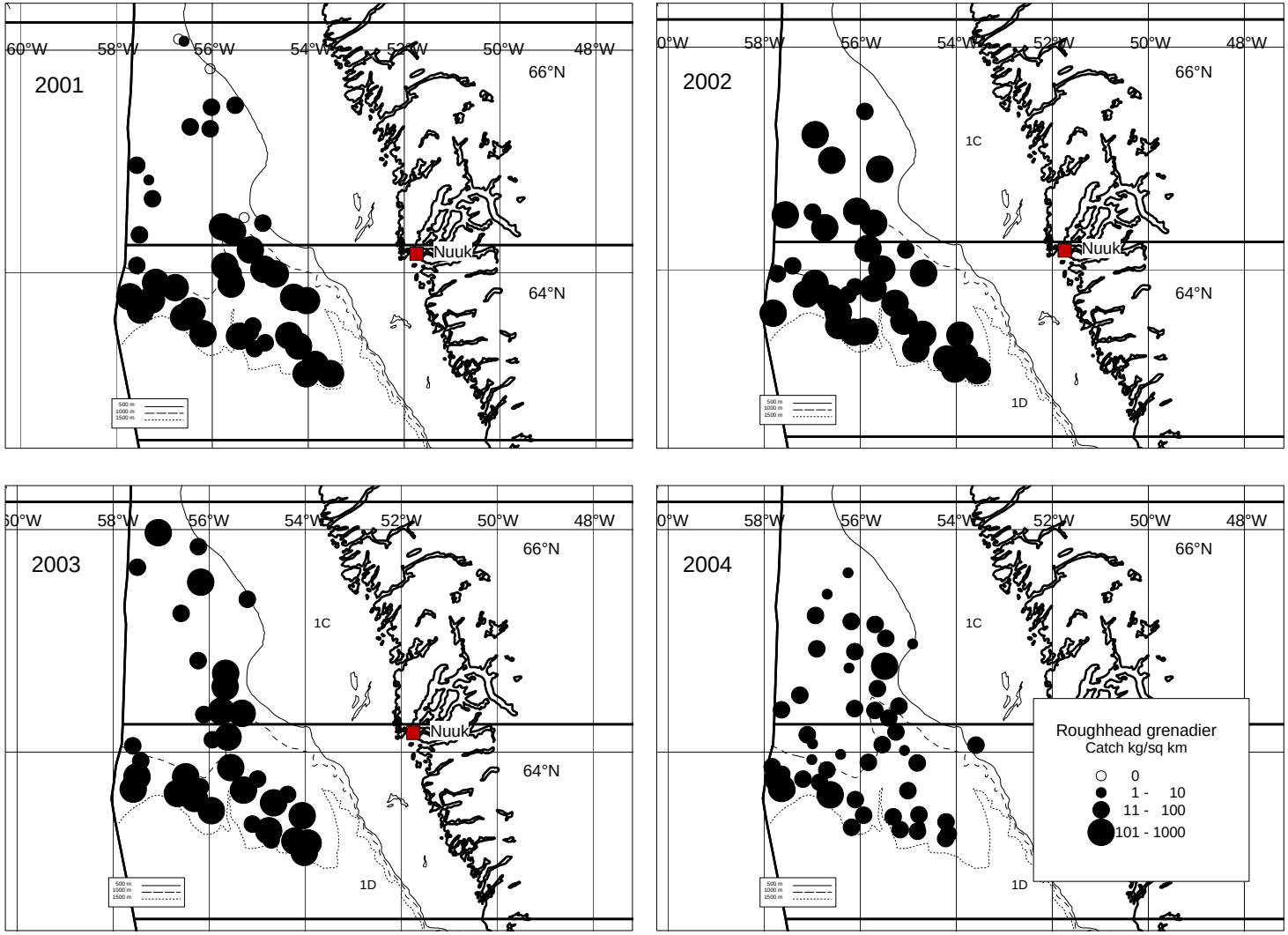

Fig. 9 cont. Distribution of catches of roughhead grenadier during 2001-2004 km^{-2}.

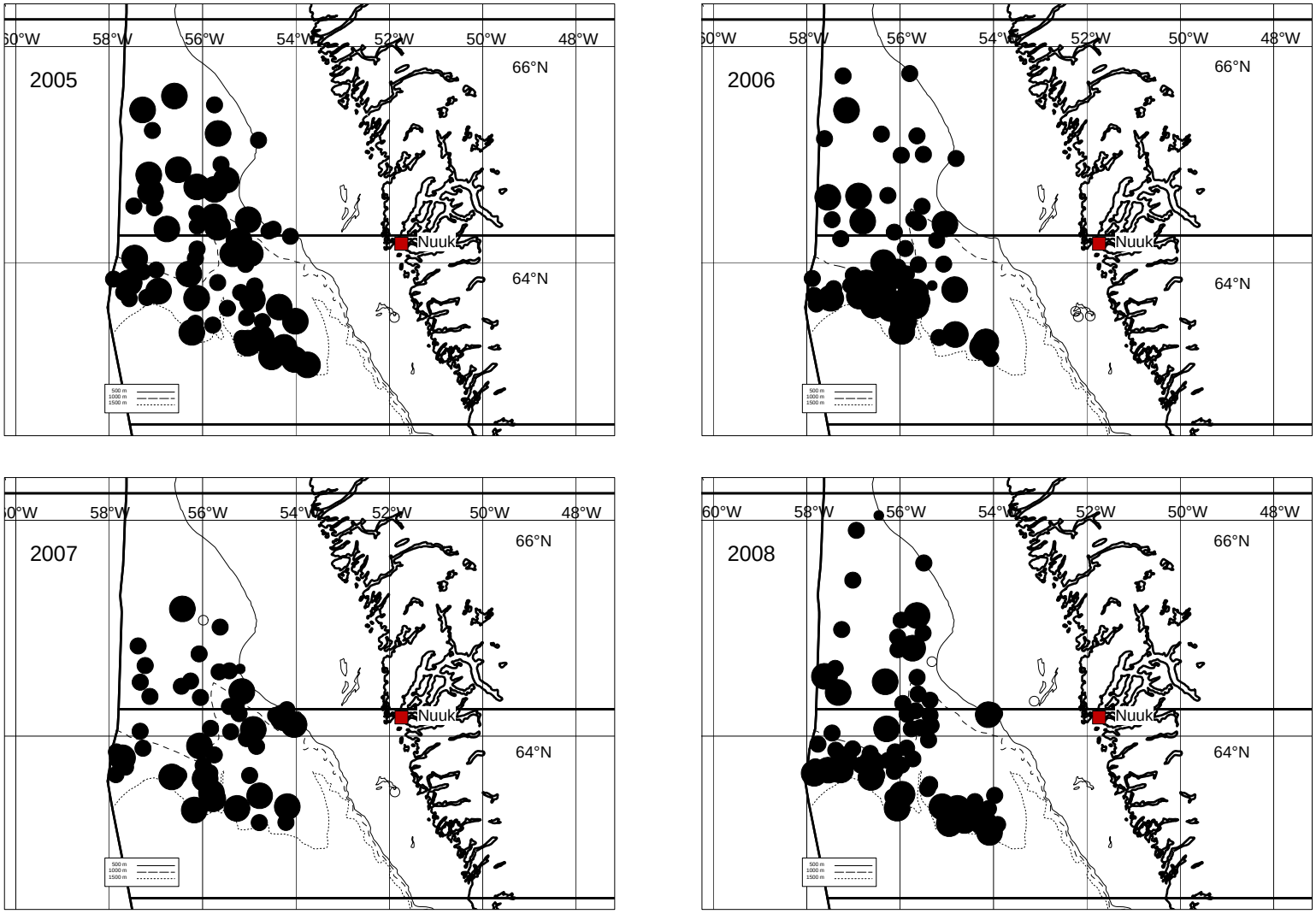

Fig. 9 cont.. Distribution of catches of roughhead grenadier during 2005-2008 km^{-2}.

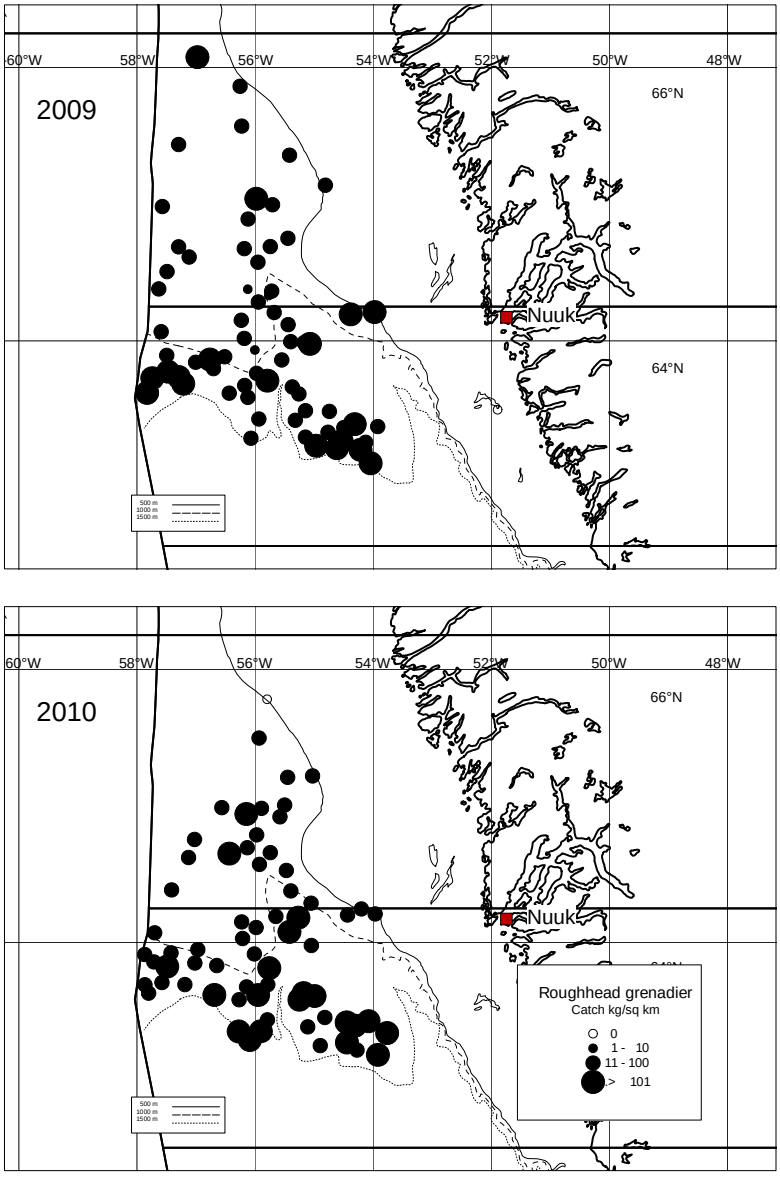

Fig. 9 cont.. Distribution of catches of roughhead grenadier during 2009 and 2010 ion kg km^{-2}.

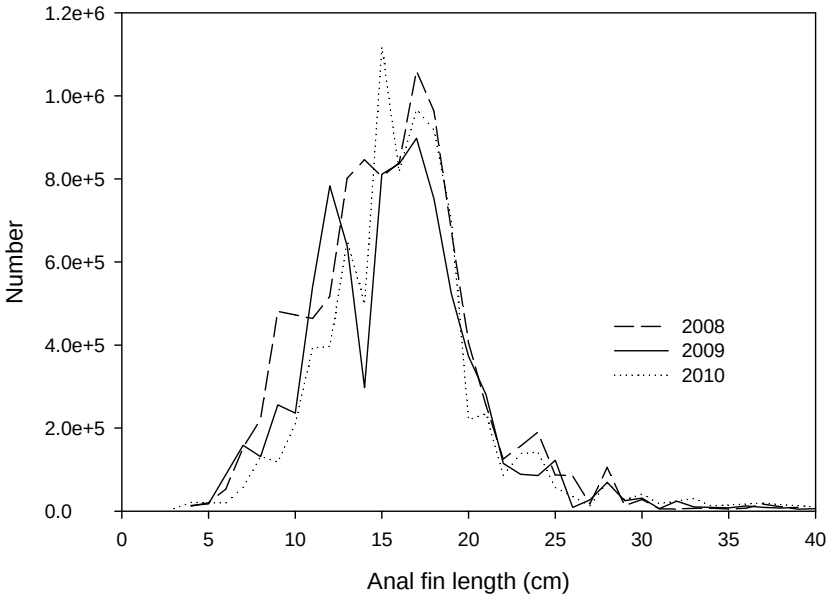

Fig. 10. Overall length distribution (pre anal fin length) of roughhead grenadier in numbers (weighted by stratum area) in Div. 1CD by year.

Deep-sea redfish (*Sebastes mentella*)

Deep-sea redfish + *Sebastes* sp. was caught in 21 of the 66 valid hauls (Fig 11). The biomass was estimated at 4065.6 tons compared to 7796.4 tons and 13199.0 tons in 2009 and 2008, respectively (Table 12). The Biomass estimate is to a large extend driven by a few large catches (Appendix 1). Almost all the biomass was found at depths < 600 m and more than half was found in Div. 1C 401-600 m, while the highest density was found in Div. 1D 401-600 m (Table 13)

The abundance was estimated at $17.83*10^6$ compared to $35.04*10^6$ and $52.94*10^6$ in 2009 and 2008, respectively. 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.

The length ranged from 15 to 42 cm with a mode at 24 cm. Modes were seen at 17 cm and 19-21 in 2008 and 2009 respectively. The deep-sea redfish have not been aged, but the 24 cm mode probably represents age 4, but there were no sign of them as age one in 2007 (Fig. 12).

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

Year	Biomass	S.E.	Abundance $*10^6$	S.E.$*10^6$
1997	2 464.3	787.1	14.69	5.50
1998	2 408.1	503.9	18.83	4.50
1999	2 484.9	1 007.7	12.93	4.09
2000[1)]				
2001	2 063.4	873.5	16.34	6.47
2002[1)]				
2003	1 493.4	684.5	7.13	3.08
2004	2 329.1	1 986.8	13.34	11.31
2005	2 546.2	1 683.3	7.28	3.16
2006	2 188.4	700.7	18.20	8.40
2007[1)]	574.2	230.0	3.00	1.31
2008	13 199.0	6 482.9	52.94	17.70
2009	7 796.4	3 916.8	35.04	17.72
2010	4 065.6	1 329.4	17.83	3.17

[1)] Poor coverage of relevant depths.

Table 13. Mean catch km^{-2} and biomass (tons) of Deep Sea Redfish by division and depth stratum, 2010.

Div.	Depth (m)	Area	Hauls	Mean	Biomass	SE
1C	401-600	3366	2	0.754	2538.3	853.7
	601-800	16120	4	0.027	439.5	333.0
	801-1000	6066	12	0.003	15.2	6.4
	1001-1200	611	2	0.005	3.2	3.2
1D	401-600	903	2	1.146	1034.5	963.0
	601-800	1940	2	0.003	5.1	5.1
	801-1000	3874	5	0.001	5.2	5.2
	1001-1200	10140	19	0.000	1.7	1.7
	1201-1400	6195	13	0.001	5.2	2.8
	1401-1500	3091	5	0.006	17.5	9.4
All				0.078	4065.5	1329.4

Table 14. Mean catch km^{-2} and abundance of Deep Sea Redfish by Division and depth stratum, 2010

Div.	Depth (m)	Area	Hauls	Mean	Abundace	SE
1C	401-600	3366	2	3858.3	12987004	1379639
	601-800	16120	4	115.1	1855569	1336498
	801-1000	6066	12	9.5	57685	26695
	1001-1200	611	2	12.9	7860	7860
1D	401-600	903	2	3120.5	2817793	2522268
	601-800	1940	2	5.9	11496	11496
	801-1000	3874	5	4.9	18857	18857
	1001-1200	10140	19	0.6	5985	5985
	1201-1400	6195	13	2.9	17961	9467
	1401-1500	3091	5	17.4	53787	26166
All				341.0	17833996	3170732

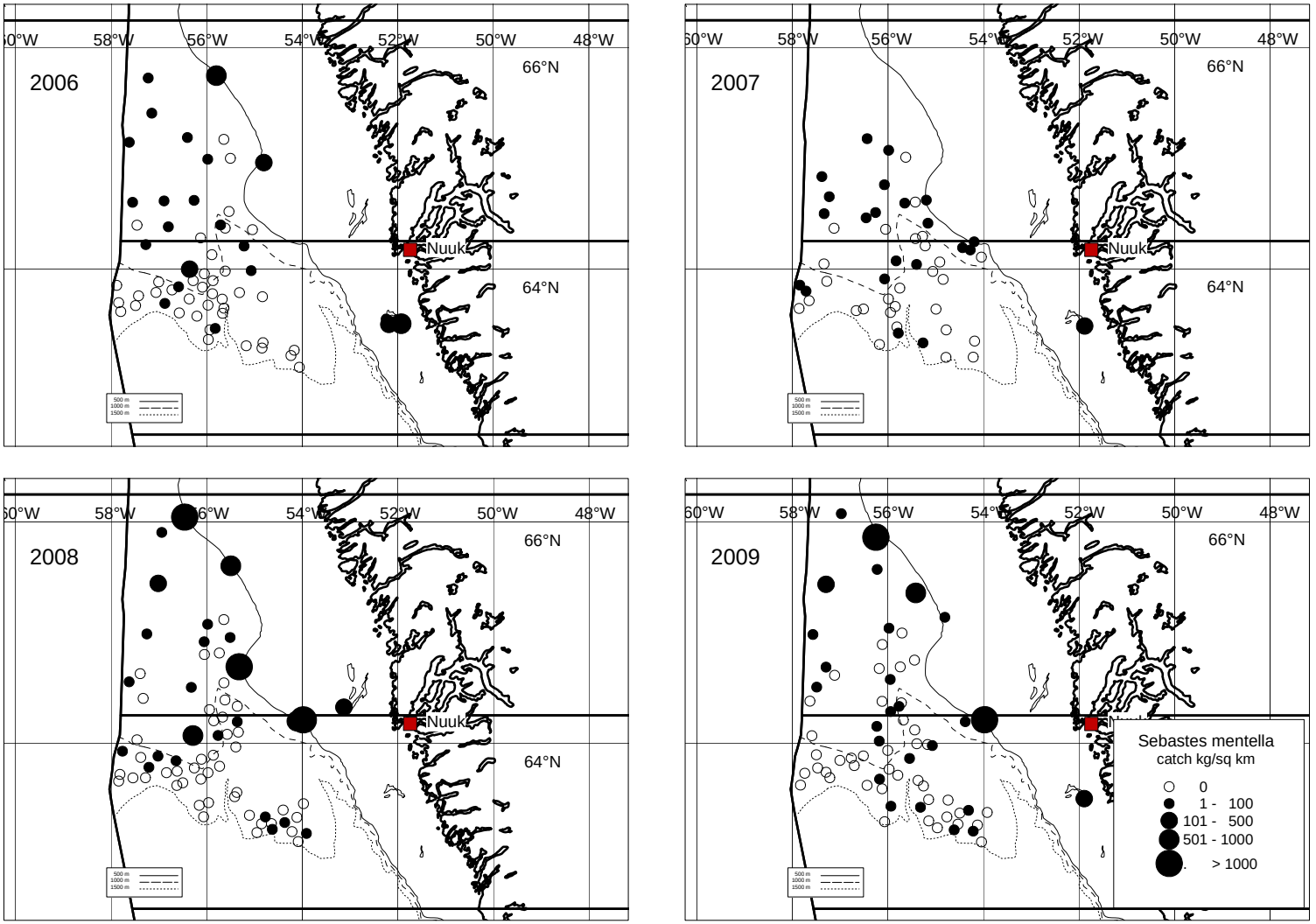

Fig. 11. Distribution of catches of deep sea redfish during 2006-2009 km^{-2}.

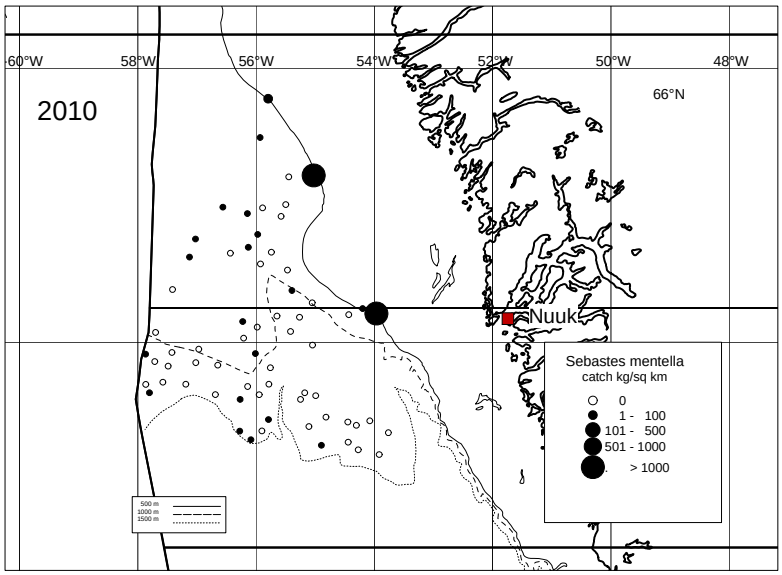

Fig. 11. Distribution of catches of deep sea redfish during 2010 in kg km^{-2}.

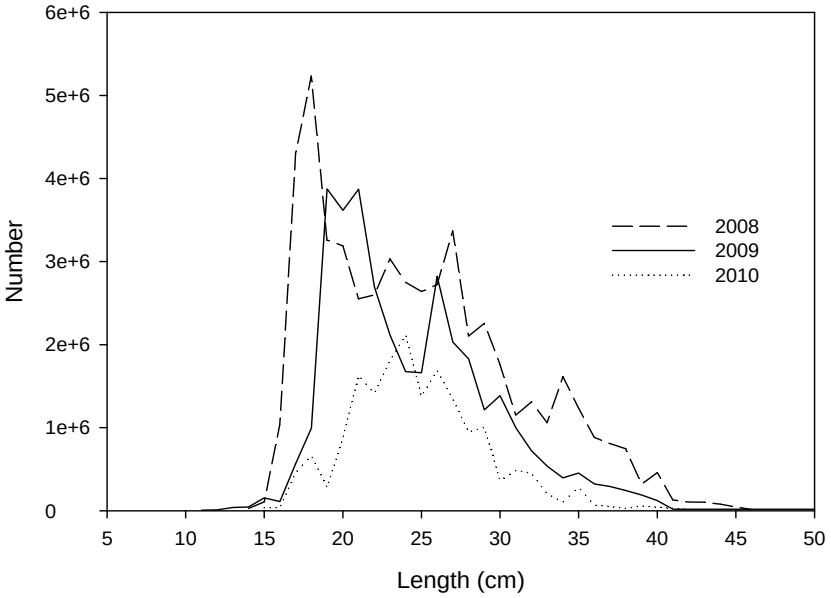

Fig. 12. Overall length distribution of deep sea redfish in numbers (weighted by stratum area) by year

Temperature

The bottom temperature ranged from 3.0°C to 5.5°C. The mean temperature was generally decreasing by depth as in previous years (Table 15).

The mean temperatures increased in all strata except in Div. 1D 1201- 1500, where the temperature has been stable. The increase was between 0.1 and 0.3 °C except in Div. 1A 401-600 m where the mean temperature increased 1.0°C. Temperatures by Division, depth stratum and year is given in Fig. 13

Table 16. 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	4.8	.06	2	3.7	.31	4	4.1	.05	12	3.9	.12	2						
1D	5.4	.15	2	4.0	.06	2	4.0	.13	5	3.8	.02	19	3.7	.03	13	3.5	.02	5

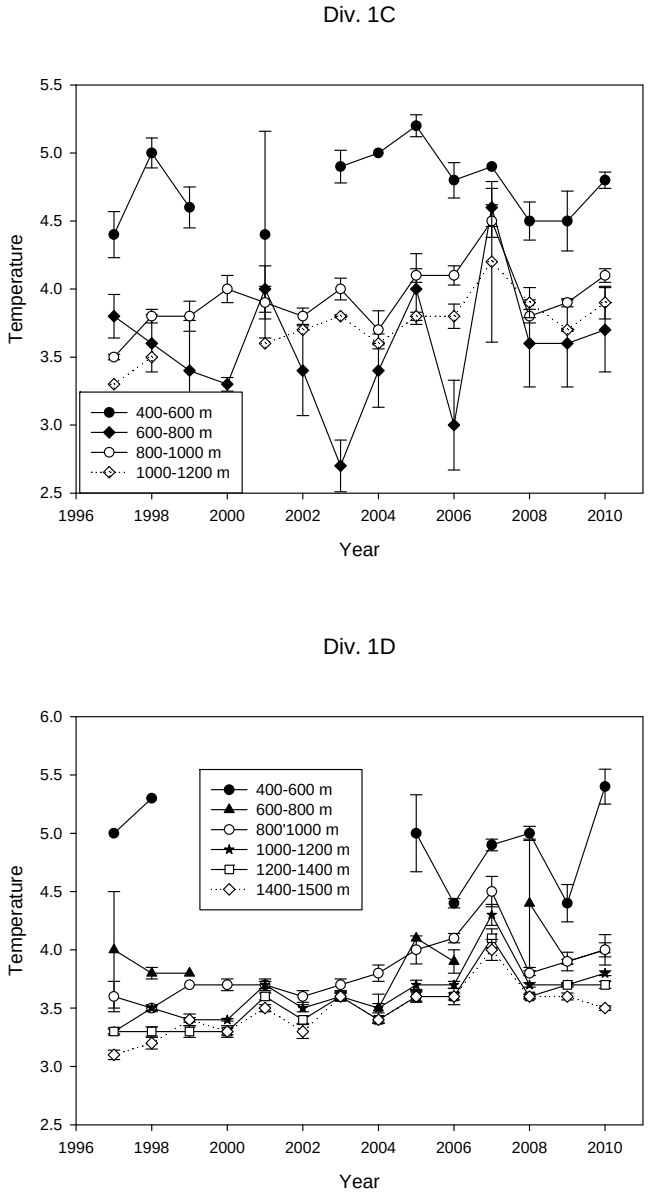

Fig 15. Mean temperatures by division depth stratum and year with S.E.

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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	0.0500	1D	1252	3.9	254.2	161	0.6	13	4.4	16	0.0	0
2	0.0607	1D	1258	3.9	93.2	71	3.1	30	9.8	14	0.0	0
3	0.0623	1D	1048	3.7	139.7	118	1.6	13	7.4	11	0.0	0
4	0.0814	1D	1086	3.9	167.9	109	2.2	19	12.5	30	0.0	0
6	0.0743	1D	1146	3.5	252.7	171	0.9	8	7.6	16	0.0	0
7	0.0823	1D	1157	4.0	163.6	118	3.7	52	11.9	22	0.0	0
8	0.0788	1D	1267	3.6	39.1	34	1.1	7	9.8	22	0.0	0
9	0.0795	1D	1348	3.7	228.0	156	1.8	14	6.0	7	0.3	1
12	0.0534	1D	1220	3.8	117.7	84	1.3	20	4.2	10	0.0	0
13	0.0696	1D	1115	3.8	77.9	65	1.5	17	4.4	10	0.0	0
14	0.0791	1D	1152	3.8	144.6	120	1.1	15	8.8	21	0.0	0
15	0.0797	1D	1186	3.8	100.3	82	0.4	7	15.5	18	0.0	0
16	0.0297	1D	1172	3.8	52.6	44	1.4	21	4.1	8	0.0	0
17	0.0801	1D	1237	3.7	166.4	129	0.2	2	5.2	12	0.0	0
18	0.0682	1D	1183	3.7	139.8	84	0.7	4	11.3	14	0.0	0
20	0.0784	1D	1315	3.7	69.5	57	3.6	9	7.5	19	0.3	1
21	0.0423	1D	1306	3.6	86.5	66	2.0	3	12.1	15	0.0	0
22	0.0513	1D	1446	3.5	40.4	28	0.5	3	11.3	15	0.6	2
23	0.0560	1D	1483	3.5	107.4	86	0.0	0	6.8	8	0.8	2
25	0.0692	1D	1483	3.5	144.0	122	4.6	12	17.1	22	0.0	0
26	0.0809	1D	1347	3.6	146.2	121	1.0	3	5.6	10	0.3	1
27	0.0779	1D	1166	3.7	115.1	94	1.7	8	7.5	21	0.0	0
29	0.0435	1D	1450	3.6	142.6	120	1.0	5	1.9	3	0.0	0
30	0.0813	1D	1467	3.6	179.5	163	2.1	10	4.1	10	0.2	1
31	0.0800	1D	1357	3.7	214.5	198	1.8	7	6.2	5	0.0	0
32	0.0808	1D	1381	3.6	166.5	153	2.8	12	5.9	4	0.0	0
33	0.0743	1D	1167	3.8	181.4	164	0.4	3	4.0	10	0.0	0
34	0.0687	1D	1229	3.7	45.3	47	1.7	12	16.6	39	0.0	0
35	0.0808	1D	1169	3.8	150.3	121	0.7	4	4.4	10	0.0	0
36	0.0795	1D	1081	3.8	197.2	169	1.8	7	2.9	12	0.0	0
38	0.0892	1D	1106	3.8	166.0	154	1.0	5	2.7	6	0.3	1
39	0.0837	1D	945	3.9	188.1	157	0.9	8	4.9	14	0.0	0
40	0.0851	1D	989	3.9	279.8	214	0.7	5	5.3	13	0.0	0
43	0.0774	1D	1098	3.8	193.5	153	1.4	8	5.0	11	0.0	0
44	0.0707	1D	1146	3.7	149.9	112	0.4	2	14.0	38	0.0	0
45	0.0822	1D	920	3.9	257.9	209	1.0	7	4.2	17	0.6	2
46	0.0404	1D	752	4.0	27.4	28	0.1	1	3.0	4	0.0	0
47	0.0750	1D	898	3.9	89.4	78	0.4	3	1.4	4	0.0	0
48	0.0844	1D	785	4.1	67.2	71	0.1	2	1.8	6	0.4	1
49	0.0847	1D	1052	3.8	185.7	144	0.2	2	4.5	6	0.0	0
50	0.0803	1D	1150	3.8	222.5	152	0.1	1	8.8	21	0.0	0
52	0.0821	1D	1110	3.7	110.5	79	0.8	6	11.4	18	0.0	0
53	0.0240	1D	1214	3.8	31.6	25	0.0	0	0.6	2	0.0	0
55	0.0875	1D	855	4.6	220.4	210	5.7	122	5.3	9	0.0	0
56	0.0764	1D	417	5.5	4.5	4	0.0	0	2.4	3	6.1	25
57	0.0747	1D	564	5.2	0.0	0	0.7	3	3.2	7	165.2	441
58	0.0550	1C	1022	4.0	252.9	183	0.5	13	4.9	12	0.0	0
59	0.0777	1C	1028	3.8	464.1	404	1.6	20	4.2	13	0.8	2
61	0.0761	1C	955	4.0	626.4	636	0.8	13	4.2	13	0.0	0
62	0.0840	1C	965	4.0	199.4	186	0.7	12	2.9	10	0.0	0
63	0.0822	1C	955	4.0	214.5	203	0.6	8	8.2	0	0.0	0
64	0.0839	1C	888	4.0	217.3	201	0.7	3	6.1	10	0.4	1
65	0.0780	1C	727	3.6	69.2	77	0.0	0	12.0	25	0.0	0
66	0.0821	1C	836	4.0	128.2	122	0.5	5	2.4	6	0.0	0
67	0.0875	1C	821	4.0	74.1	71	0.1	2	2.0	6	0.2	1

68	0.0645	1C	802	4.0	101.8	47	0.4	4	3.9	11	0.3	1
69	0.0825	1C	679	3.0	56.1	66	0.0	0	1.5	7	7.2	29
70	0.0803	1C	831	4.0	174.8	201	0.1	3	8.8	20	0.9	4
71	0.0802	1C	861	4.0	103.6	98	0.2	3	4.8	13	0.0	0
72	0.0785	1C	914	3.9	153.6	123	0.8	5	3.5	11	0.6	2
74	0.0607	1C	846	4.5	60.8	60	0.6	12	2.5	5	0.0	0
75	0.0474	1C	817	4.4	14.0	17	0.1	2	1.9	7	0.0	0
76	0.0611	1C	765	4.5	11.4	10	0.7	22	1.3	2	0.0	0
77	0.0733	1C	578	4.9	6.1	3	0.1	3	3.2	6	73.9	313
78	0.0551	1C	737	3.9	17.7	17	0.1	5	3.9	8	1.2	6
79	0.0438	1C	526	4.8	1.4	1	0.0	0	0.0	0	21.9	151

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

Obs	art	species	maxwgt	maxno	mindepth	maxdepth	mintemp	maxtemp	maxpos
1	ALA	Alepocephalus agassizzi	28.0	32	914	1483	3.5	3.9	64.7895
2	RFL	Amblyraja fyllae	1.5	2	737	1237	3.5	3.9	65.4971
3	RRD	Amblyraja radiata	0.3	1	846	846	4.5	4.5	64.9214
4	CAD	Anarhichas denticulatus	15.2	3	526	1483	3.0	5.2	65.7815
5	ANC	Anopologaster cornuta	0.1	1	965	965	4.0	4.0	64.5726
6	ANT	Antimora rostrata	38.0	60	679	1483	3.0	4.6	65.2103
7	ARZ	Arctozenus rissoi	0.0	1	1157	1348	3.7	4.0	63.6937
8	ARS	Argentina silus	2.9	9	564	564	5.2	5.2	64.2098
9	BAM	Bajacalifornia megalops	0.3	1	989	1467	3.5	3.9	63.9503
10	BAT	Bathylagus euryops	5.9	130	679	1483	3.0	4.6	65.2103
11	BSP	Bathyraja spinicauda	15.1	1	765	1183	3.7	4.5	65.2103
12	BEG	Benthosema glaciale	3.0	49	417	1483	3.0	5.5	65.4971
13	BOA	Borostomias antarctica	0.5	8	817	1483	3.5	4.4	65.0070
14	CFB	Centroscyllium fabricii	11.9	12	526	1348	3.0	4.8	65.7815
15	CHA	Chauliodus sloani	0.1	2	765	1483	3.5	4.5	65.2103
16	CHN	Chiasmodon niger	0.2	3	802	1450	3.6	4.0	64.9832
17	CBB	Coryphaenoides brevibarbis	0.2	3	1450	1483	3.5	3.6	63.6939
18	CGR	Coryphaenoides guntheri	1.8	35	945	1483	3.5	4.0	64.3794
19	RNG	Coryphaenoides rupestris	5.7	122	564	1483	3.5	5.2	65.4971
20	COM	Cottunculus microps	1.5	1	802	1258	3.8	4.0	64.9411
21	COT	Cottunculus thomsonii	1.1	2	821	1267	3.5	4.0	64.6229
22	LUM	Cyclopterus lumpus	0.6	1	765	1081	3.8	4.5	65.2103
23	CLM	Cyclothone microdon	4.0	11	526	1483	3.0	4.9	65.7815
24	EUR	Eurypharynx pelecanoides	0.1	1	1446	1446	3.5	3.5	63.2883
25	COD	Gadus morhua	1.5	1	417	417	5.5	5.5	64.2472
26	ONA	Gaidropsarus argentatus	0.1	2	785	1267	3.5	4.1	64.9832
27	ONN	Gaidropsarus ensis	2.0	3	679	1483	3.0	4.0	64.9877
28	WIT	Glyptocephalus cynoglossus	0.9	1	727	836	3.6	4.5	65.2103
29	GOB	Gonostoma bathyphilum	6.0	2	802	1467	3.5	4.0	64.7545
30	PLA	Hippoglossoides platessoides	1.9	9	526	888	3.0	5.2	65.7815
31	HOA	Holtbyrnia anomala	0.6	8	765	1483	3.5	4.5	65.2103
32	HMC	Holtbyrnia macrops	0.1	1	945	1052	3.8	3.9	64.1918
33	HAF	Hydrolagus affinis	12.5	2	1306	1483	3.5	3.7	63.6312
34	LAI	Lampanyctus intricarius	0.0	1	898	1106	3.8	3.9	64.1918
35	LMC	Lampanyctus macdonaldi	7.5	143	578	1483	3.0	4.9	65.4971
36	LEP	Lepidion eques	1.4	18	417	1048	3.7	5.5	65.2197
37	LIF	Liparis fabricii	0.1	4	679	802	3.0	4.1	65.4971
38	LYS	Lycenchelys sarsi	0.0	1	955	955	4.0	4.0	64.6593
39	LPA	Lycodes paamiuti	0.4	2	945	1229	3.7	3.9	64.0723
40	LYT	Lycodes terraenova	0.1	1	1106	1106	3.8	3.8	63.9127
41	LYM	Lycodonus mirabilis	0.0	1	1267	1267	3.6	3.6	63.2702
42	RHG	Macrourus berglax	17.1	39	417	1483	3.0	5.5	65.4971
43	MAA	Magnisudis atlantica	0.1	1	888	945	3.9	4.0	64.6954
44	MAL	Malacosteus niger	0.1	1	831	1258	3.7	4.0	64.9411
45	WHB	Micromesistius poutassou	0.4	2	417	564	5.2	5.5	64.2472
46	BLI	Molva dypterygia	0.9	2	564	855	4.6	5.2	65.2197
47	MYP	Myctophum punctatum	0.1	16	417	1483	3.0	5.5	64.9877
48	MYJ	Myxine jespersenae	0.1	1	679	679	3.0	3.0	64.9877
49	NEM	Nemichthys scolopaceus	0.0	1	1152	1220	3.8	3.8	63.6098
50	NZB	Nezumia bairdi	1.0	5	564	1229	3.7	5.2	64.9411
51	NOT	Notacanthus chemnitzii	7.0	9	727	1483	3.5	4.5	65.2103
52	NOK	Notoscopelus kroeyri	0.0	2	417	1381	3.6	5.5	65.4971
53	PAC	Paraliparis copei	0.0	1	1150	1450	3.6	3.8	64.1830
54	POL	Polyacanthonotus rissoanus	0.3	2	417	1467	3.6	5.5	65.0070
55	SKA	Raja. sp.	10.3	1	1258	1258	3.9	3.9	63.1790
56	RBT	Rajella bathyphila	10.7	1	1110	1315	3.7	3.7	64.0786
57	GHL	Reinhardtius hippoglossoides	626.4	636	417	1483	3.0	5.5	65.7815
58	ROM	Rouleina maderensis	0.1	1	752	1150	3.8	4.0	64.3794
59	SCO	Scopelosaurus lepidus	2.7	19	727	1483	3.5	4.6	65.4971
60	REG	Sebastes marinus	4.0	2	564	564	5.2	5.2	64.2098
61	REB	Sebastes mentella	165.2	441	417	1483	3.0	5.5	65.7815
62	RED	Sebastes sp.	2.1	7	727	765	3.6	4.5	65.2103
63	SER	Serrivomer beani	0.5	6	737	1483	3.5	4.0	65.4971
64	STO	Stomias boa	0.1	5	679	1483	3.0	4.6	65.2103
65	SYN	Synaphobranchus kaupi	4.3	31	752	1483	3.5	4.6	64.9832
66	TRA	Trachyrhynchus murrayi	1.8	10	417	1167	3.7	5.5	64.2472
67	XEC	Xenodermichthys copei	0.2	1	1081	1483	3.5	3.8	64.0786