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Report on Greenland Halibut caught during the 2010 Trawl Survey in NAFO Division 0A

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Abstract

A stratified-random otter trawl survey was conducted in Division 0A (Baffin Bay) in 2010. The survey covered both the southern strata (below 73° N) as well as the northern strata (to 75° 35' N) which had not been surveyed since 2004. The survey took place from October 17 to November 6, 2010. An Alfredo III trawl was used at randomly selected stations between 400 m and 1500 m. In order to facilitate comparison to previous surveys the survey stations were plotted against the old stratification scheme and the number of stations present in each strata was determined post-hoc. Heavy ice covered parts of the northern strata so the survey was not complete in this area. There were 81 stations successfully completed in 0A-South and 39 in 0A-North. Mean near-bottom temperatures were similar to previous surveys, varying from 1.7 °C to 0.1 °C and declining with depth. Greenland halibut were distributed throughout the survey area and were present in all tows. Biomass and abundance for 0A-South were estimated to be 74272 t (S.E. 10463) and 1.10×10^8 (S.E. 1.3×10^7), respectively. Mean biomass per tow was 1.53 t/km^2 and mean abundance per tow was 2274 per km^2, both are lower than was found in previous surveys. The overall length distribution ranged from 6 cm to 99 cm with a mode at 39 cm and is most similar to that seen in 2006 and 2008. Biomass and abundance for 0A-North were estimated to be 46689 t (S.E. 4639 t) and 6.74×10^7 (S.E. 8.76×10^6), respectively. Mean biomass per tow was 1.18 t/km^2 and mean abundance per tow was 895 per km^2, both are higher than was found in the 2004 survey. Lengths ranged from 21 cm to 78 cm with a single mode at 39 cm. There were considerably more fish at lengths 24-40 cm in 2010 than in 2004.

Introduction

A multi-species bottom trawl survey was carried out in the North West Atlantic Fisheries Organization (NAFO) Division 0A (Baffin Bay) during October 17 to November 6, 2010. The survey covered both the southern strata (below 72° N) as well as the northern strata which had not been surveyed since 2004. An Alfredo III trawl was used at randomly selected stations between 400 m and 1500 m. Deep-water surveys were conducted in Div. 0A in 1999 (Treble et al., 2000), 2001 (Treble 2002), 2004 (Treble 2005), 2006 (Treble 2007) and 2008 (Treble 2009).

The objectives were:

1. Collect the data required to establish age structure, estimate population abundance, biomass, and recruitment of Greenland halibut;
2. Collect the data required to establish age structure, estimate population abundance, biomass, and recruitment of shrimp;
3. Record numbers caught and collect length and weight data on all other commercial species caught, to allow calculation of abundance, biomass, and size structure of these species;

4. Record numbers and collect weight data on all non-commercial species caught, to allow calculation of abundance and biomass of these species;
5. Collect additional data and biological samples as desired and as time permits (e.g. lengths for by-catch, maturity information, coral samples, other special requests);
6. Collect temperature data at each fishing station;
7. Collect oceanographic data at pre-determined standard stations.

Materials and Methods

Stratification and Set Selection

Set selection was based on a coverage level of approximately 1 set per 750 km^2 used in previous surveys and allocated proportionally to stratum size using a new stratification scheme developed in 2008 (Treble 2009). This change was made in order to match the stratification scheme used in Greenland surveys of Subarea 1 which will facilitate comparisons between surveys conducted in Canadian and Greenland waters in the future. However, due to time restrictions it was found to be most efficient to assign the sets from this single survey to the previous stratification scheme rather than assign the sets from the five previous surveys to the new scheme. It is important that the stratification scheme is consistent across years and work will be undertaken in the future to standardize all surveys against the new strata.

Table 1 and 2 list the strata used in the analysis of data from surveys conducted in Div. 0A. The stratification schemes are also shown in Fig. 1 and Fig. 2. The total area between 401 m and 1500 m encompassed by the strata in Div. 0A-South (to 72^o N) is 49,834 km^2 and in Div. 0A-North (to 75^o 35'N) it is 77,634 km^2. Sets were randomly selected from numbered units within each stratum. If a set cannot be fished due to bad bottom, ice, etc. then the tow is taken in an adjacent unit as close to the missed site within the stratum as feasible given the conditions. When this is not possible then the tow may be re-located to an area of the stratum where there are "holes" in the set coverage and a unit location selected at random from those available in that area. In the 2010 survey 90 sets were selected for 0A-North and 91 sets for 0A-South. Using the previous stratification scheme we have 98 sets for 0A-North and 81 sets for 0A-South with two sets falling outside the area.

Vessel and Gear

The surveys were conducted by the M/Tr Pâmiut, a 722 GRT stern trawler measuring 53 m in length. An Alfredo III bottom otter trawl with rock hopper ground gear was used for the deep water survey. Mesh size was 140 mm with a 30 mm mesh liner in the cod end. Trawl doors were Injector International, measuring 7.5 m^2 and weighing 2800 kg. These doors replaced the Greenland Perfect doors (9.25 m^2 and 2420 kg) in 2004. The average net height was 20 cm higher with the new doors but the overall net performance was not significantly different (95% level) (Jørgensen personal communication). More information about the trawl and gear can be found in Jørgensen 1998. A Furuno based system mounted on the head rope measured net height and was used to determine bottom contact and the start/finish of each tow. 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 (m) x 0.142. This relationship was based on flume tank measurements of the trawl and rigging (Jørgensen 1998).

Oceanographic Sampling

A Seabird 19© CTD (conductivity, temperature and depth recorder) was mounted on the headrope and was used to determine temperature, depth and confirm the time spent on the bottom. In the few cases where there was no data from the CTD data from the Furuno trawl eye sensor was used.

A Seabird 19© CTD system equipped with a fluorometer was deployed at 5 to 6 stations on sections at Cape Christian and Broughton Island. Readings were taken to the bottom or within the top approx. 700 m of the water column at the deepest stations. These data have not yet been analyzed and so are not presented here.

Trawling Procedure

The targeted tow duration was 30 minutes, however, tows down to 15 minutes in length were considered acceptable. Average towing speed was 3.0 knots. Trawling took place throughout a 24 hr period in order to maximize the ships time and complete the necessary tows.

Biological Data Collection and Analysis

Numbers and total weight caught were recorded on a set by set basis for each species. Detailed sampling was carried out on Greenland halibut and shrimp. For other commercial species (e.g. redfish, grenadiers, skates) sexed length measurements were collected. Lengths were measured to the lowest 1 cm total length (0.5 cm pre anal fin length for grenadiers) using a standard meter board. Large catches of either Greenland halibut or shrimp were sub-sampled. Sub-samples of Greenland halibut were comprised of at least 200 fish. Adjustments were made during analysis to estimate total number caught in each case.

Greenland halibut sampling consisted of a visual assessment of maturity for all individuals based on maturity stages described in Riget and Boje 1989. For each sampled fish the whole weight was recorded at sea using an electronic balance. Otoliths for age determination were collected, 10 per 1 cm length group per sex. However, research on age determination methods for Greenland halibut is on-going so the otolith samples were not analyzed.

Various species from the catch were collected or had tissue samples taken for use by other researchers within DFO.

Biomass and Abundance Indices

The swept area method was used in the estimation of biomass and abundance for Greenland halibut: Swept area (km^2) = (wingspread (m) x haul-length)/1,000,000. The haul-length used in the sweptarea calculations was estimated from the start and end positions of the tow. Abundance and biomass were calculated for each set and standardized to 1 km^2:

Abundance (n/km^2)=catch (n)/sweptarea (km^2)
Biomass ($tons/km^2$)=catch (kgs)/swept area (km^2)/1000.

Mean and standard error for abundance and biomass were calculated for each depth strata. An estimate of total abundance and biomass was then calculated for each depth strata (mean x area surveyed within each depth strata (km^2)) as well as over all depths. Standard error values were also calculated for the overall total.

Abundance at length was calculated for each depth strata (standardized to km^2 and weighted by tow), and a total abundance at each length (weighted by the area within each depth strata) was calculated (mean number/ km^2 x area surveyed within each depth strata (km^2)). The sum across all lengths and depth categories was calculated and compared to the overall abundance value determined above as a means of confirming the results.

Results and Discussion

The northern portion of Div. 0A had not been surveyed since 2004 and 2010 was only the second time this area had been included since surveys began in 1999. A total of 179 stations were assigned to strata in Div. 0A, 122 were successfully completed and of these 2 from 0A-North were found to lie outside the old stratification scheme leaving 120 valid sets.

For Div. 0A-South 81 sets were successfully completed (Table 3). Three strata were missed when sets were applied to the previous stratification scheme; two in the 401-500 m and one in the 501-750 m depth strata. As a result the survey covered 48442 km^2 of a possible 49834 km^2. This is slightly greater than previous survey areas of 46333 km2, 44915 km^2, 44484 km^2, 40475 km^2 and 44580 km^2 in 2008, 2006, 2004, 2001 and 1999, respectively. The post-hoc stratification resulted in similar coverage compared to previous surveys for most depth strata (Table 6). Coverage of the depth strata (501-750 m) was slightly better than in previous surveys.

Ice covered much of Div. 0A-North and as a result only 39 of the 98 sets planned were successful. Half of the strata were missed with particularly poor coverage at depths below 1000 m (Table 4). As a result the survey covered 39688 km^2 of a possible 77634 km^2. The 751-1000 m depth strata was not surveyed to the same extent in 2010 as it was in 2004.

Mean near-bottom temperatures were similar to previous surveys, varying from 1.7 ^oC to 0.1 ^oC and declining with depth (Table 5). The majority of tows (97%) were at temperatures less than or equal to 2.0 ^oC (Appendix 1).

Catches of most species other than Greenland halibut were small in number and so detailed analysis of these species is not presented here.

Greenland Halibut

Greenland halibut were present in all tows; number of fish caught varied from 10-1084 and catch weight from 13-1257 kg (Appendix 1). Catch distribution for years 1999, 2001, 2004, 2006 and 2008 are shown in Figures 9 to 16.

Division 0A-South

The 2010 estimate of biomass is 74272 t (S.E. 10463) (Table 6). This compares to 77182 t in 2008, 52271 t in 2006, 86176 t in 2004, 81002 t in 2001 and 68760 t in 1999 (Fig. 3). Biomass estimates at all depths are similar to those observed in previous years.

It should be noted that in 2006 there were problems with survey coverage with two important strata missing from depths 1001-1500 m that was a contributing factor to the lower estimate for that year (Treble 2007). There were also stratum missed in 1999, 2001 and 2004 but these were primarily at shallow depths (<750 m) which typically contain smaller fish and less biomass.

Mean biomass per tow or density in 2010 was 1.53 t/km^2, lower than previous surveys (excluding 2006) which ranged from 1.54 to 2.00 t/km^2 (Table 6). Density was highest (2.3 to 3.3 t/ km^2) between 751 m and 1250 m as was the case in previous surveys. For depth strata 1001-1250 m density was similar to levels seen in surveys since 2004.

Abundance in 2010 is estimated at 1.10×10^8 (S.E. 1.3×10^7) (Table 7). This is similar to that observed in previous surveys (Table 7 and Fig. 3).

Mean abundance per tow was 2274 per km^2, a decrease over previous estimates (excluding 2006) which ranged from 2497 to 2933 (Table 7). For depth strata 1001-1250 m mean abundance was also similar to that seen in previous surveys, except for 2006 (Table 7).

Length frequency distributions by depth strata for 2004, 2006 and 2008 are given in Figure 4. The number of fish at larger length classes increases with depth. In 2010 the number of fish at lengths 42-60 cm in depth strata 1251-1500 has increased compared to 2006 and 2008 but in all other depth strata the length frequency distribution is similar between these two years.

The overall length distribution in 2010 ranged from 6 cm to 99 cm with a mode at 39 cm which is similar to that seen in previous surveys (Table 10, Fig. 6 and Fig. 8). Slightly higher modes were seen in 2001 (42 cm) and 2004 (45 cm) (Table 10 and Fig. 8). 69.5% of fish were <45 cm, similar to 2008 and 2001 levels (Table 10).

Note that the 1999 total abundance by length class in Table 7 does not match the overall abundance calculated for 1999 shown in Table 7 but it is reasonably close. The 1999 length frequency data were in a different format so the SAS© programs used in subsequent years for biomass, abundance and length frequency calculations could not be applied. Instead the Excel© spreadsheet program was used and so the difference observed could be due to rounding or errors in performing the Excel calculations.

Division 0A-North

The 2010 estimate of biomass was 46689 t (S.E. 4639 t) up from 45877 t estimated in 2004 (Table 8 and Fig. 3). There would also be a certain amount of additional biomass in that portion of the 751-1000 m depth strata that could not be surveyed due to severe ice conditions.

Mean biomass per tow was also higher in 2010, 1.18 t/km^2 compared to 0.85 t/km^2 in 2004. There was an increase in mean biomass per tow at both the deepest strata (1001-1250 m and 1251-1500 m) in 2010 (2.35 and 1.09 t/km^2) compared to 2004 (0.48 and 0.51 t/km^2) while at depths <1000 m the rate was similar or slightly lower in 2010 (0.72 and 1.0 t/km^2) compared to 2004 (0.96 and 0.97 t/km^2) (Table 8).

Abundance was 6.74 x 10^7 (S.E. 8.76 x 10^6) in 2010 compared to 4.85 x 10^7 (S.E. 9.0 x 10^6) in 2004 (Table 9). There would also be a certain amount of additional abundance in that portion of the 751-1000 m depth strata that could not be surveyed.

Mean abundance per tow had also increased from 895 per km^2 in 2004 to 1698 per km^2 in 2010 (Table 9). There were increases in mean abundance in all the depth strata. For depth strata 501-750 mean abundance had increased while mean biomass had declined suggesting a larger number of smaller fish in the strata in 2010 compared to 2004 which is confirmed by the length frequency data (Figs. 5 and 7).

Lengths ranged from 21 cm to 78 cm with a single mode at 39 cm (Table 11 and Fig. 7). There were considerably more fish at lengths 24-40 cm in 2010 than in 2004. Length increases with depth as is common for most Greenland halibut stocks (Fig. 5). The length frequency was shifted to the left, with a greater number of fish <40 cm at depths 501-1000 m compared to 2004 while there was an overall increase in abundance at depth strata 1001-1250 m in 2010 compared to 2004. 66% of fish were <45 cm in 2010 compared to 36% in 2004.

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Table 1. Stratification scheme for Division 0A-South. Errors made in the original calculation of area within these strata were corrected in 2004. Both the original value and the corrected value are given. A conversion factor of 3.430 was used to calculate square kilometres from square nautical miles.

Stratum	Original Sq. N Miles	Corrected Sq. N Miles	Units	Corrected Sq. Km.	Depth Range (m)
First roughed out by hand in 1986 and corrected in May 2004					
024	457	281	90	963.8	401-500
025	1780	1527	510	5237.6	501-750
030	1099	1004	330	3443.7	751-1000
031	496	832	280	2853.8	1001-1250
032	301	391	130	1341.1	1251-1500
033	184	305	100	1046.2	501-750
034	75	156	50	535.1	401-500
	4,392	**4,496**		**15,421**	
First done in March 1999 and corrected in May 2004					
040	1671	1296	480	4445.3	1251-1500
041	698	546	200	1872.8	1001-1250
042	577	443	160	1519.5	751-1000
043	609	472	170	1619.0	501-750
044	375	289	110	991.3	401-500
045	348	268	100	919.2	501-750
046	370	281	110	963.8	751-1000
047	883	686	250	2353.0	1001-1250
048	843	653	240	2240.0	1251-1500
049	712	547	200	1876.2	1251-1500
050	650	491	190	1684.1	1001-1250
051	574	437	160	1499.0	751-1000
052	635	477	180	1636.1	501-750
053	276	214	80	734.0	401-500
054	852	649	240	2226.1	501-750
055	334	253	100	867.8	401-500
056	200	125	60	428.8	401-500
057	652	416	190	1426.9	501-750
058	350	220	100	754.6	501-750
059	600	377	170	1293.1	751-1000
060	671	422	190	1447.5	1001-1250
061	730	471	210	1615.5	1251-1500
	13,610	**10,033**		**34,413**	
TOTAL		**14,529**		**49,834**	

Table 2. Stratification scheme for Division 0A-North, developed in 2004. A conversion factor of 3.430 was used to calculate square kilometres from square nautical miles.

Stratum	Sq. N Miles	Units	Sq. Km	Depth Range (m)
062	114	40	391.0	401-500
063	569	190	1951.7	501-750
064	1586	530	5440.0	751-1000
065	683	230	2342.7	1001-1250
066	576	190	1975.7	1251-1500
067	674	220	2311.8	501-750
068	1051	350	3604.9	751-1000
069	1602	540	5494.9	751-1000
070	507	170	1739.0	751-1000
071	81	30	277.8	1001-1250
072	1274	420	4369.8	1001-1250
073	421	140	1444.0	1251-1500
	9,138		**31,343**	
074	1429	520	4901.5	751-1000
07 5	53	20	181.8	1001-1250
076	999	360	3426.6	751-1000
077	898	330	3080.1	751-1000
078	732	270	2510.8	1001-1250
079	401	150	1375.4	1250-1500
080	1033	380	3543.2	501-750
081	1224	450	4198.3	501-750
082	968	350	3320.2	501-750
083	583	210	1999.7	751-1000
084	320	120	1097.6	401-500
085	822	300	2819.5	301-400
086	302	110	1035.9	401-500
087	494	180	1694.4	501-750
088	348	130	1193.6	401-500
089	1234	450	4232.6	301-400
090	838	310	2874.3	401-500
091	818	300	2805.7	501-750
	13,496		**46,291**	
TOTAL	**22,634**		**77,634**	

Table 3. Depth stratum areas with the number of planned and successful sets for 0A-South 2010 (based on assignment of stations to old depth strata). Variation in previous coverage (sets planned) is due to corrections made in 2004 to measured area (see Table 1 above).

Depth Stratum (m)	401-500	501-750	751-1000	1001-1250	1251-1500	Total
Area (sq. km)	4521	14866	8719	10211	11518	49835
Sets planned in previous surveys	7 to 12	22 to 28	13 to 16	13 to 20	15 to 20	75 and 90
Sets planned in 2010	6	24	16	15	20	81
Sets completed in 2010	6	24	16	15	20	81

Table 4. Depth stratum areas with the number of planned and successful sets for 0A-North 2010 (based on assignment of stations to old depth strata).

Depth Stratum (m)	301-400	401-500	501-750	751-1000	1001-1250	1251-1500	Total
Area (sq. km)	7052	6592	19825	29687	9683	4795	77634
Sets planned in 2004 survey	8	11	20	32	13	6	90
Sets completed in 2004	1	0	7	20	9	6	43
Sets planned in 2010	0	10	25	40	12	11	98
Sets completed in 2010	0	4	8	8	8	11	39

Table 5. Mean temperature and S.E. in ( ) by depth stratum for NAFO Division 0A.

NAFO	Depth Stratum (m)				
Division 0A	401-500	501-750	751-1000	1001-1250	1251-1500
South- 1999	1.6 (0.50)	1.4 (0.16)	1.0 (0.03)	0.6 (0.05)	0.1 (0.04)
2001	0.7 (0.10)	1.5 (0.22)	0.9 (0.07)	0.7 (0.05)	0.2 (0.05)
2004	1.3 (0.21)	1.5 (0.25)	1.0 (0.05)	0.6 (0.05)	0.1 (0.04)
2006	1.5 (0.34)	1.4 (0.12)	1.3 (0.09)	0.9 (0.08)	0.4 (0.25)
2008	1.6 (0.39)	1.5 (0.10)	1.3 (0.05)	0.6 (0.05)	0.2 (0.03)
2010	1.68 (1.34)	1.6 (0.74)	1.09 (0.14)	0.66 (0.19)	0.13 (0.16)
North-2004	.	0.9 (0.04)	0.6 (0.04)	0.2 (0.04)	0.1 (0.06)
2010	0.12 (.16)	1.3 (0.25)	0.8 (0.14)	0.4 (0.15)	0.1 (0.14)

Table 6. Biomass estimates (tons) of Greenland halibut by depth stratum for NAFO Division 0A.

Year/Division	Stratum (m)	Survey Area (sq. km)	No. Sets	Mean Biomass (t/sq. km)	Biomass (tons)	SE
1999	401-500	2919	8	0.3914	1142.6	431.2
0A-South	501-750	11213	18	0.8232	9230.7	2825.8
	751-1000	8719	12	1.5764	13744.3	2559.2
	1001-1250	10211	12	2.9763	30391.4	7857.9
	1251-1500	11518	15	1.2373	14251.4	4588.4
	Overall	*44580*	*65*	*1.5424*	*68760.4*	*18262.5*
2001	401-500	429	2	0.3621	155.3	153.5
0A-South	501-750	11213	18	1.8865	21153.1	5107.0
	751-1000	8719	7	3.3261	29000.3	7665.9
	1001-1250	10211	7	2.5958	26505.5	7075.2
	1251-1500	9903	14	0.4228	4187.4	869.4
	Overall	*40475*	*48*	*2.0013*	*81001.6*	*20871.1*
2004	401-500	2823	5	0.6149	1735.9	504.2
0A-South	501-750	11213	13	1.4800	16595.5	6040.8
	751-1000	8719	12	2.0645	18000.8	5948.9
	1001-1250	10211	11	3.2376	33058.8	5589.9
	1251-1500	11518	17	1.4573	16785.4	7273.9
	Overall	*44484*	*58*	*1.9372*	*86176.4*	*12501.6*
2006	401-500	4092	10	0.2868	1173.6	197.4
0A-South	501-750	13439	20	0.3531	4745.9	569.4
	751-1000	8719	12	1.2338	10757.4	2020.4
	1001-1250	8763	8	3.4553	30278.4	9470.3
	1251-1500	9902	12	0.5368	5315.4	1052.3
	Overall	*44915*	*62*	*1.1638*	*52270.8*	*9759.0*
2008	401-500	3787	7	0.3396	1285.9	372.6
0A-South	501-750	13439	25	0.9026	12130.2	2914.6
	751-1000	8719	14	2.3468	20461.4	2719.4
	1001-1250	10211	20	3.0100	30734.7	4059.5
	1251-1500	10177	17	1.2352	12570.2	6256.1
	Overall	*46333*	*83*	*1.6658*	*77182.4*	*8464.5*
2010	401-500	3128	6	0.2715	849.2	142.2
0A-South	501-750	14866	24	0.7765	11543.4	1798.4
	751-1000	8719	16	2.3032	20081.3	3830.5
	1001-1250	10211	15	3.2607	33295.5	9386.9
	1251-1500	11518	20	0.7382	8502.7	1445.2
	Overall	*48442*	*81*	*1.5332*	*74272.1*	*10463.3*

Table 7. Abundance estimates (000's) of Greenland halibut by depth stratum for NAFO Division 0A.

Year/Division	Stratum (m)	Survey Area (sq. km)	No. Sets	Mean Abundance (sq. km)	Abundance	SE
1999	401-500	2919	8	1229.90	3.6E+06	1.3E+06
0A-South	501-750	11213	18	2327.80	2.61E+07	8.5E+06
	751-1000	8719	12	3482.70	3.04E+07	5.5E+06
	1001-1250	10211	12	4579.40	4.68E+07	1.3E+07
	1251-1500	11518	15	1045.40	1.2E+07	3.6E+06
	Overall	*44580*	*65*	*2666.22*	*1.19E+08*	*3.2E+07*
2001	401-500	429	2	553.60	2.4E+05	2.3E+05
0A-South	501-750	11213	18	3840.20	4.31E+07	1.0E+07
	751-1000	8719	7	4100.60	3.58E+07	9.9E+06
	1001-1250	10211	7	3456.60	3.53E+07	1.1E+07
	1251-1500	9903	14	439.60	4.4E+06	8.4E+05
	Overall	*40475*	*48*	*2932.65*	*1.19E+08*	*3.3E+07*
2004	401-500	2823	5	1892.90	5.34E+06	2.0E+06
0A-South	501-750	11213	13	2977.10	3.34E+07	1.1E+07
	751-1000	8719	12	3000.40	2.62E+07	9.5E+06
	1001-1250	10211	11	3319.00	3.39E+07	6.2E+06
	1251-1500	11518	17	1066.10	1.23E+07	5.1E+06
	Overall	*44484*	*58*	*2496.53*	*1.11E+08*	*1.7E+07*
2006	401-500	4092	10	1124.92	4.60E+06	1.1E+06
0A-South	501-750	13439	20	1110.16	1.49E+07	2.5E+06
	751-1000	8719	12	2651.23	2.31E+07	4.7E+06
	1001-1250	8763	8	5103.15	4.47E+07	1.4E+07
	1251-1500	9902	12	493.60	4.89E+06	1.0E+06
	Overall	*44915*	*62*	*2053.77*	*9.22E+07*	*1.5E+07*
2008	401-500	3787	7	915.03	3.47E+06	9.2E+05
0A-South	501-750	13439	25	2129.00	2.86E+07	6.5E+06
	751-1000	8719	15	4172.23	3.64E+07	5.5E+06
	1001-1250	10211	19	3735.31	3.81E+07	5.5E+06
	1251-1500	10177	17	945.24	9.62E+06	4.6E+06
	Overall	*46333*	*83*	*2508.26*	*1.16E+08*	*1.1E+07*
2010	401-500	3128	6	861.40	2.69E+06	7.4E+05
0A-South	501-750	14866	24	1864.30	2.77E+07	4.6E+06
	751-1000	8719	16	4221.60	3.68E+07	8.3E+06
	1001-1250	10211	15	3568.30	3.64E+07	8.4E+06
	1251-1500	11518	20	564.40	6.50E+06	1.2E+06
	Overall	*48442*	*81*	*2273.93*	*1.10E+08*	*1.3E+07*

Table 8. Biomass estimates (tons) of Greenland halibut by depth stratum for Division 0A-North.

Year/Division	Stratum (m)	Survey Area (sq. km)	No. Sets	Mean Biomass (t/sq. km)	Biomass (tons)	SE
2004	301-400	0	1	.	.	.
0A-North	401-500	0	0	.	.	.
	501-750	12499	7	0.9620	12024.1	2174.1
	751-1000	27687	20	0.9737	26959.3	9091.1
	1001-1250	9223	9	0.4843	4466.4	682.6
	1251-1500	4795	6	0.5061	2426.9	789.8
	Overall	*54204*	*43*	*0.8464*	*45876.8*	*9405.6*
2010	301-400	0	0	.	.	.
0A-North	401-500	2874	4	0.1432	411.6	91.9
	501-750	12276	8	0.7215	8857.3	2678.3
	751-1000	10520	8	0.9989	10508.3	1608.5
	1001-1250	9223	8	2.3517	21689.3	3299.3
	1251-1500	4795	11	1.0892	5222.7	701.5
	Overall	*39688*	*39*	*1.1764*	*46689.2*	*4638.54*

Table 9. Abundance estimates (000's) of Greenland halibut by depth stratum for Division 0A-North.

Year/Division	Stratum (m)	Survey Area (sq. km)	No. Sets	Mean Abundance (sq. km)	Abundance	SE
2004	301-400	0	1	0.00	0.00E+00	0.0E+00
0A-North	401-500	0	0	.	.	.
	501-750	12499	7	1422.90	1.78E+07	4.2E+06
	751-1000	27687	20	948.80	2.63E+07	7.8E+06
	1001-1250	9223	9	316.10	2.92E+06	5.6E+05
	1251-1500	4795	6	322.60	1.55E+06	5.4E+05
	Overall	*54204*	*43*	*895.08*	*4.85E+07*	*9.0E+06*
2010	301-400	0	0	.	.	.
0A-North	401-500	2874	4	337.2	9.69E+05	2.57E+05
	501-750	12276	8	1845.9	2.27E+07	7.85E+06
	751-1000	10520	8	1764.9	1.86E+07	2.57E+06
	1001-1250	9223	8	2306.7	2.13E+07	2.66E+06
	1251-1500	4795	11	815.2	3.91E+06	5.69E+05
	Overall	*39688*	*39*	*1697.75*	*6.74E+07*	*8.76E+06*

Table 10. Length distribution (3cm groups) estimated total number (000's) for Greenland halibut from NAFO Division 0A-South surveys (weighted by survey area).

Length Class (3cm)	1999	2001	2004	2006	2008	2010
0						
3						
6	73.240			1.707	22.507	59.497
9	26.119	7.370		10.101	0.000	62.640
12	61.248	16.925	25.854	24.231	6.104	44.868
15	21.036	192.867	722.746	463.183	318.896	289.178
18	322.593	181.545	443.925	1045.423	852.031	528.557
21	639.739	766.476	1408.294	4342.790	1913.626	1420.035
24	2902.035	2130.242	1881.047	3895.186	2645.373	3346.695
27	8512.532	2464.872	5011.075	5402.579	5381.191	6189.182
30	12473.322	4327.508	5605.143	6754.058	9745.802	10041.157
33	15944.903	8561.021	8367.771	9331.157	15021.200	11575.091
36	16947.771	16223.824	10617.731	13128.299	15193.625	13474.216
39	***17014.003***	22102.681	13436.041	***14054.939***	**15541.288**	**15482.199**
42	14621.133	***23835.554***	15697.215	12623.585	14147.428	14076.101
45	10750.969	17459.631	***15979.390***	9052.162	12127.768	11699.580
48	6443.782	10695.541	13845.141	6147.754	8814.899	7480.094
51	4122.988	5219.180	9238.186	2945.622	5907.879	5665.117
54	2247.477	2096.945	4329.138	1826.323	3844.472	3796.586
57	1250.561	1189.117	2095.964	655.492	2321.885	2218.884
60	704.208	592.811	976.217	141.346	1366.325	1240.089
63	471.663	255.268	532.397	91.726	495.987	936.146
66	242.111	140.190	317.073	77.932	366.032	293.719
69	117.638	131.897	141.182	30.591	90.544	106.277
72	127.133	40.866	126.200	24.271	37.175	61.583
75	9.577	23.947	69.875		20.238	29.215
78	18.739		45.719		6.290	6.968
81	9.427		42.088		0.000	0.000
84	0.000	28.336	17.519		13.601	18.843
87	0.000		33.085		0.000	0.000
90	0.000		14.255		0.000	0.000
93	9.290		10.644		6.423	0.000
96			6.874		0.000	0.000
99		14.516			6.804	11.243
missing				175.886		
Total	116085.240	118699.128	111037.788	92246.343	116215.394	110153.762
Total <45 cm	89559.675	80810.884	63216.842	71077.237	80789.071	76589.416
% <45 cm	77.150	68.080	56.933	77.052	69.517	69.530
% <=35 cm	35.299	15.711	21.133	33.899	30.897	30.464

Table 11. Length distribution (3cm groups) estimated total number (000's) for Greenland Halibut from Division 0A-North surveys (weighted by survey area).

Length Class (3cm)	2004	2010
0		
3		
6		
9		
12	27.59	
15	0.00	
18	28.15	
21	134.18	495.46
24	415.79	1952.23
27	1685.96	3877.30
30	2696.23	6778.50
33	**2807.35**	7206.02
36	2382.81	8016.51
39	2556.34	**8302.15**
42	4727.47	7755.44
45	7958.06	7698.48
48	**9516.25**	5687.84
51	6810.91	4002.09
54	3469.21	2263.84
57	1589.42	1415.14
60	734.08	928.80
63	365.44	601.37
66	288.20	280.94
69	70.24	60.32
72	187.24	33.26
75	37.75	0.00
78	8.85	24.48
81	19.18	
84		
87		
90		
93		
96		
99		
Total	48516.71	67380.16
Total <45 cm	17461.87	44383.61
% <45 cm	35.99	65.87
% <=35 cm	16.07	30.14

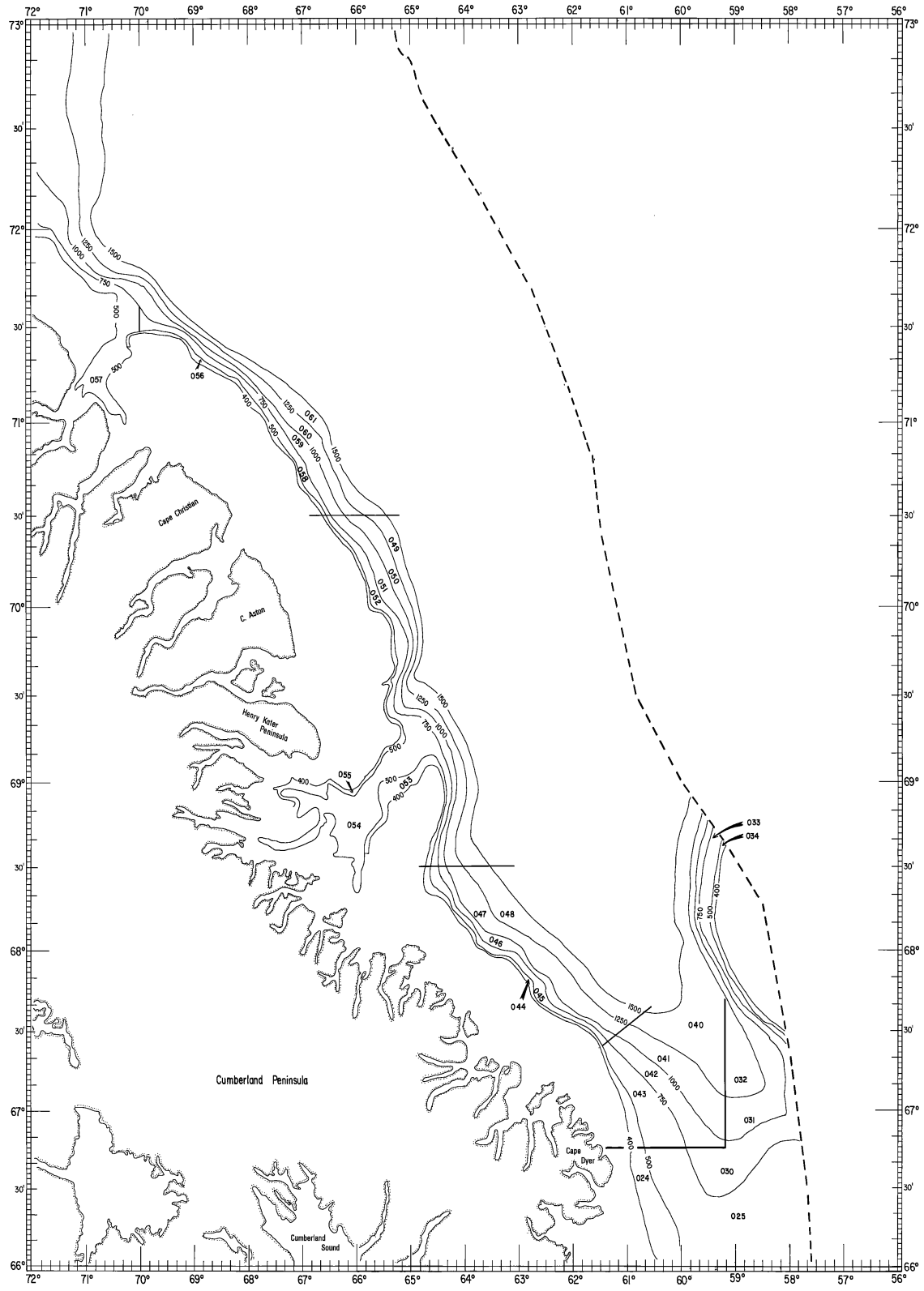


Figure 1. Stratification scheme for North Atlantic Fisheries Organization Division 0A, 66^{o} N to 72^{o} N.

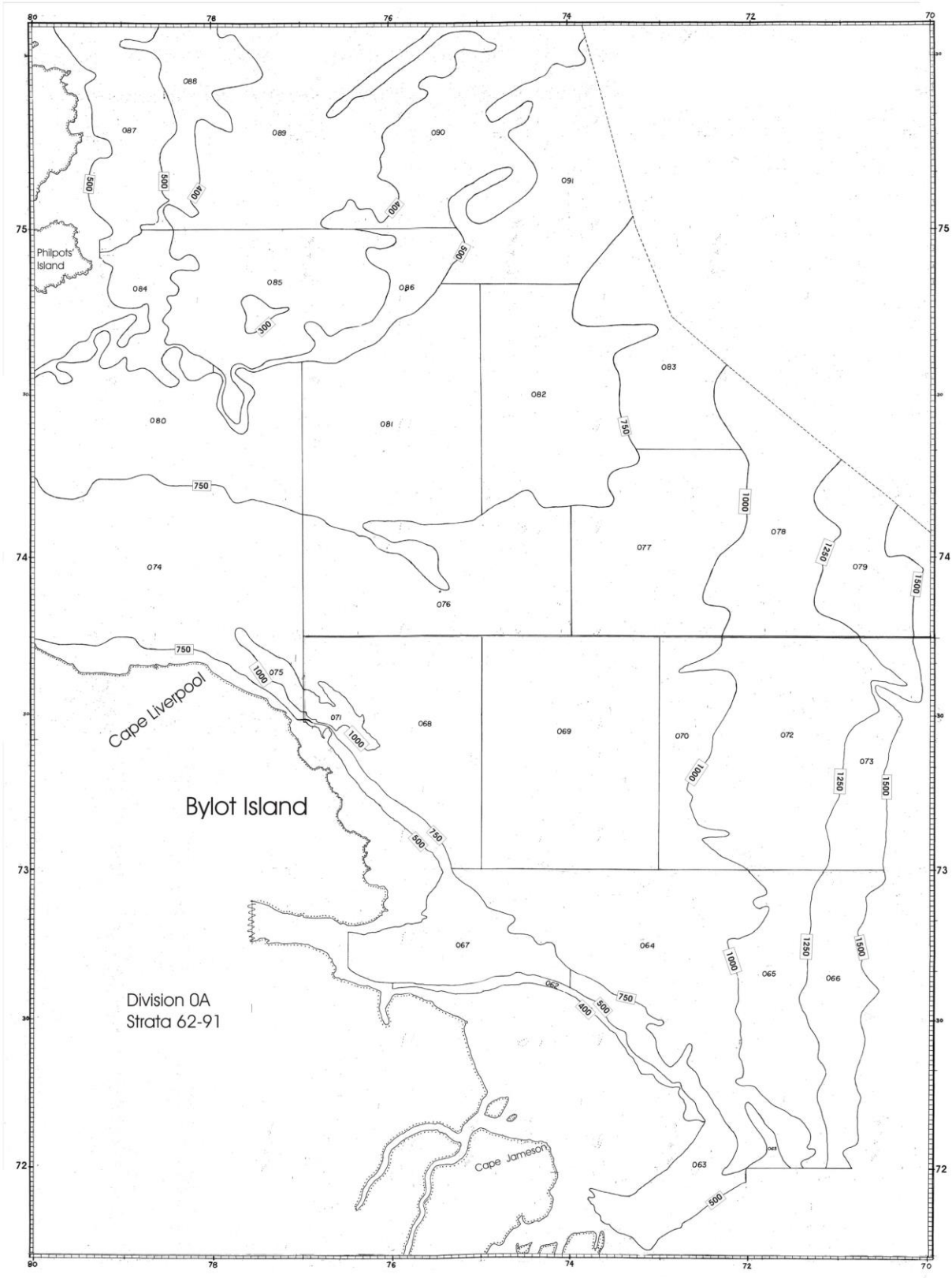
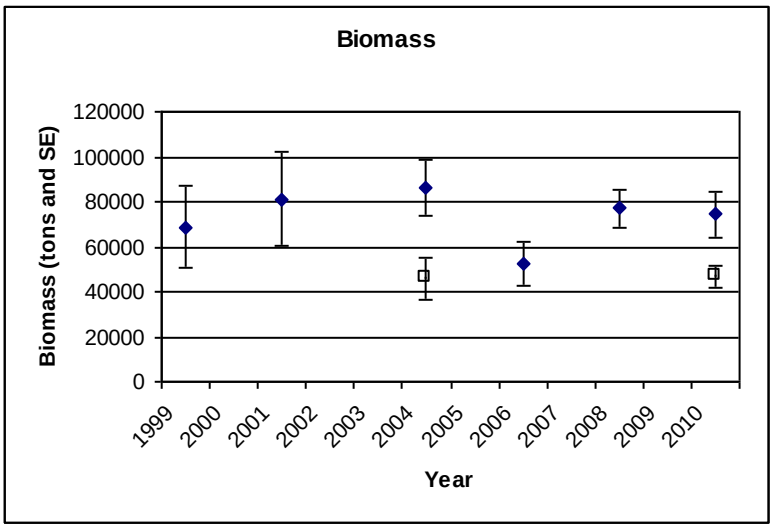


Figure 2. Stratification scheme for North Atlantic Fisheries Organization Division 0A, 72^{o} N to 76^{o} N.



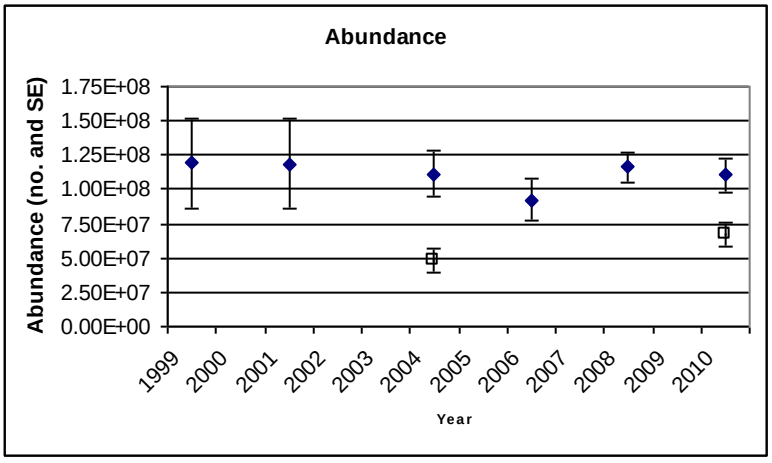


Figure 3. Biomass (top) and abundance (bottom) estimates for Greenland halibut in Division 0A-South (solid points) and 0A-North (open points).

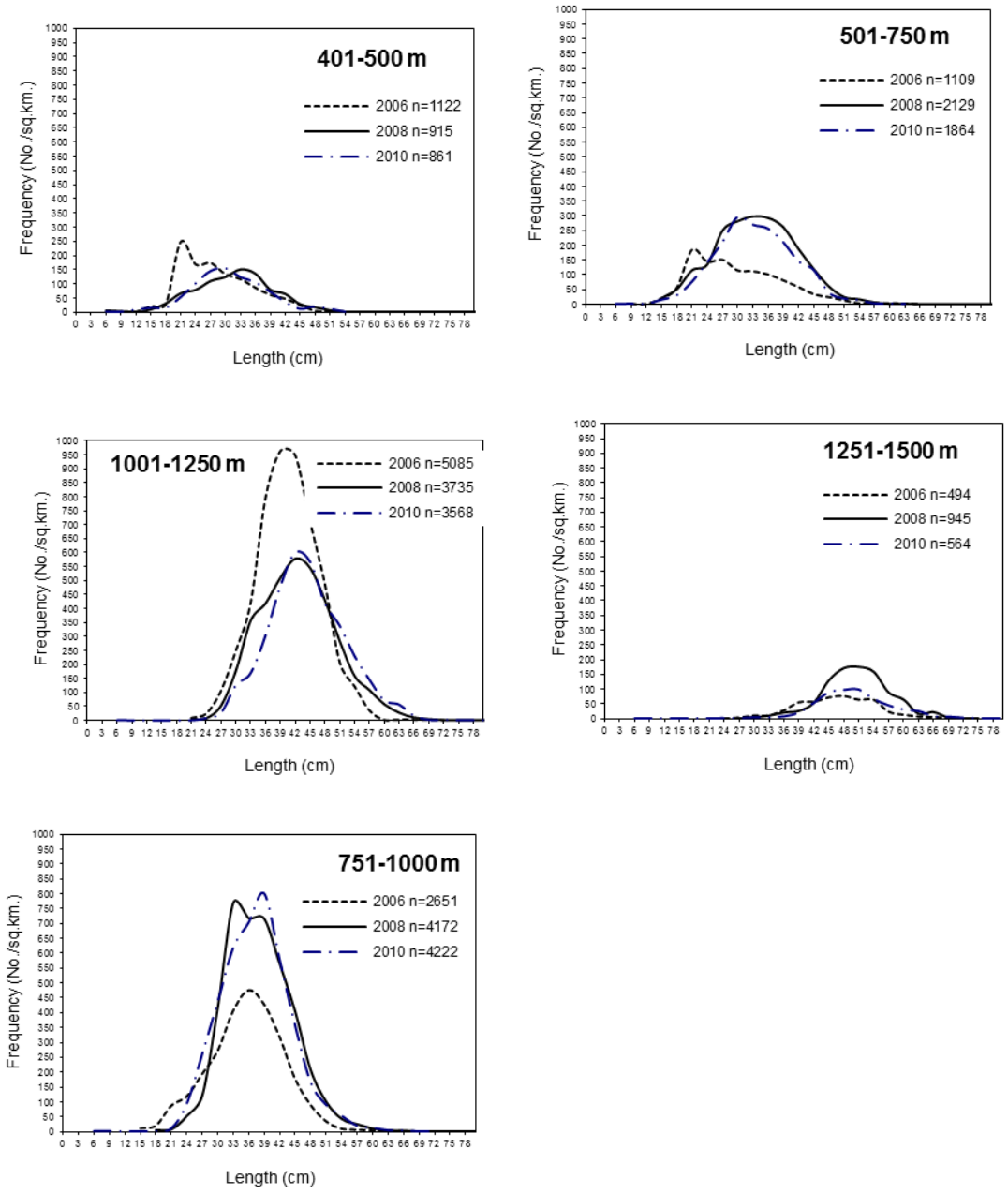


Figure 4. Greenland halibut length distribution, by depth for Division 0A-South, 2006, 2008 and 2010.

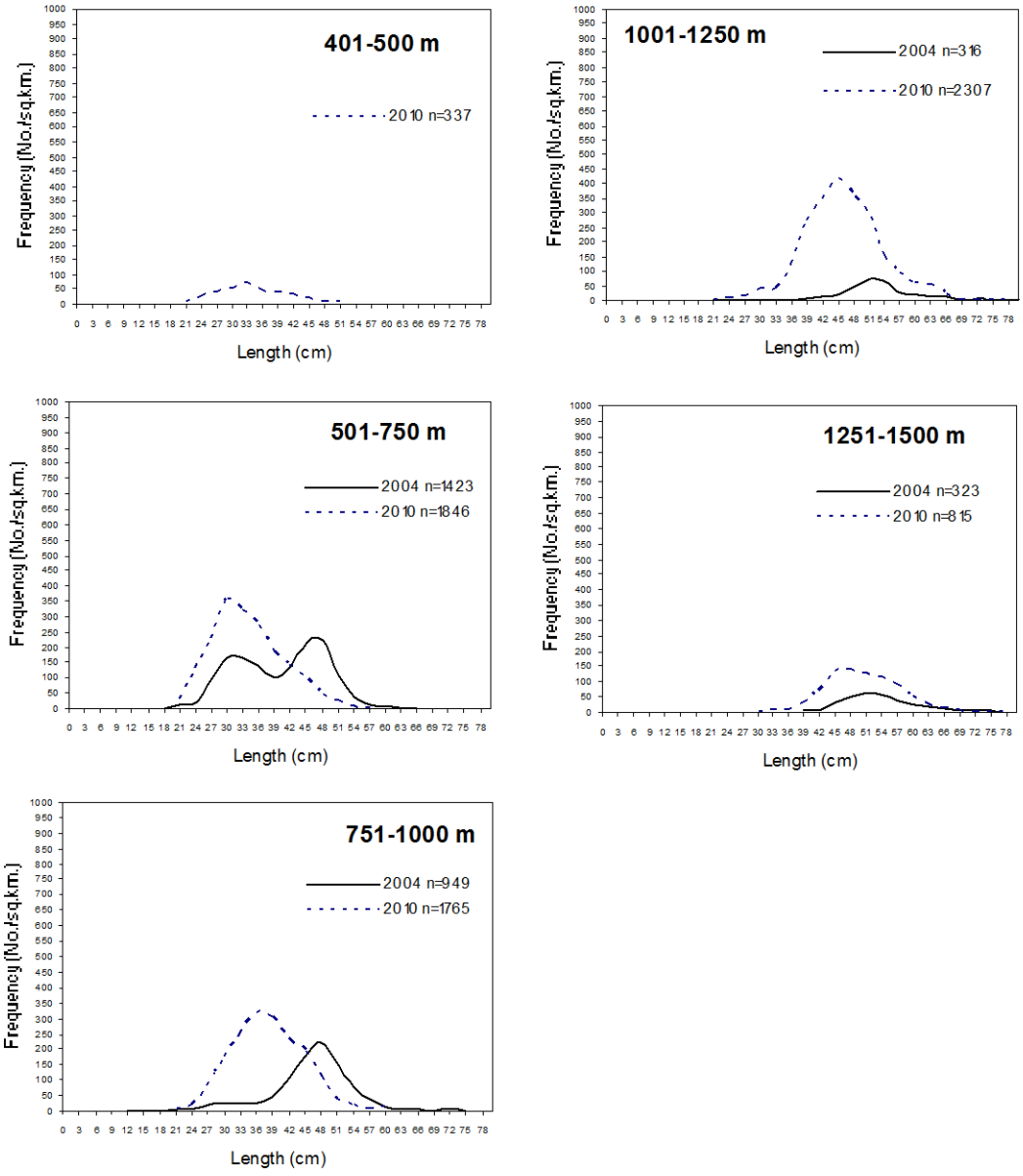


Figure 5. Greenland halibut length distribution, by depth for Division 0A-North, 2004 and 2010.

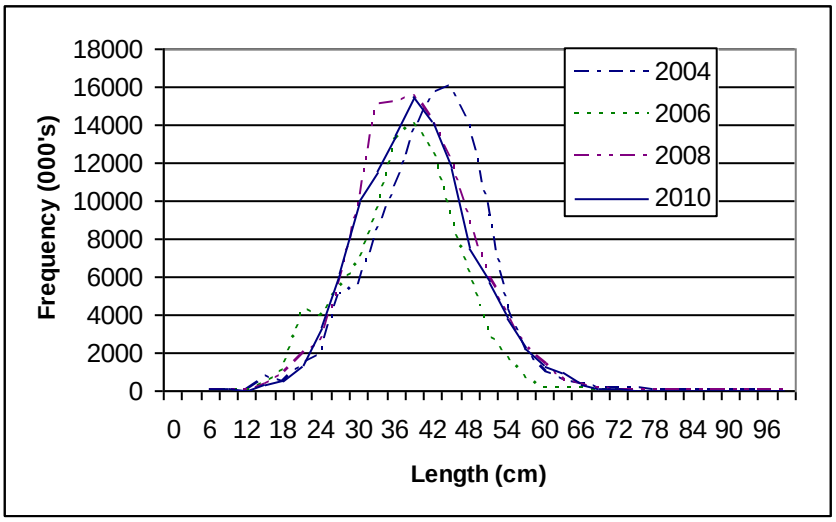


Figure 6. Abundance at length for the Greenland halibut in NAFO Division 0A-South, 2004, 2006, 2008 and 2010 (weighted by stratum area).

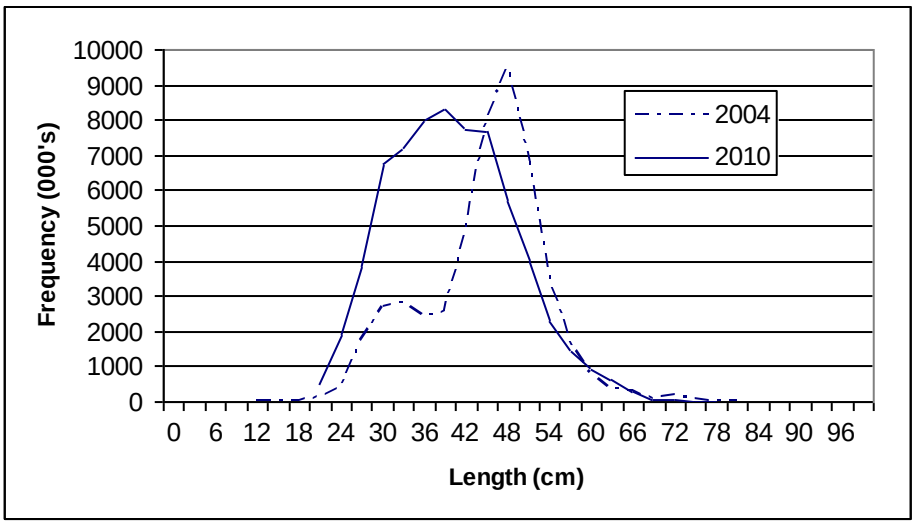


Figure 7. Abundance at length for the Greenland halibut in NAFO Division 0A-North, 2004, 2006, 2008 and 2010 (weighted by stratum area).

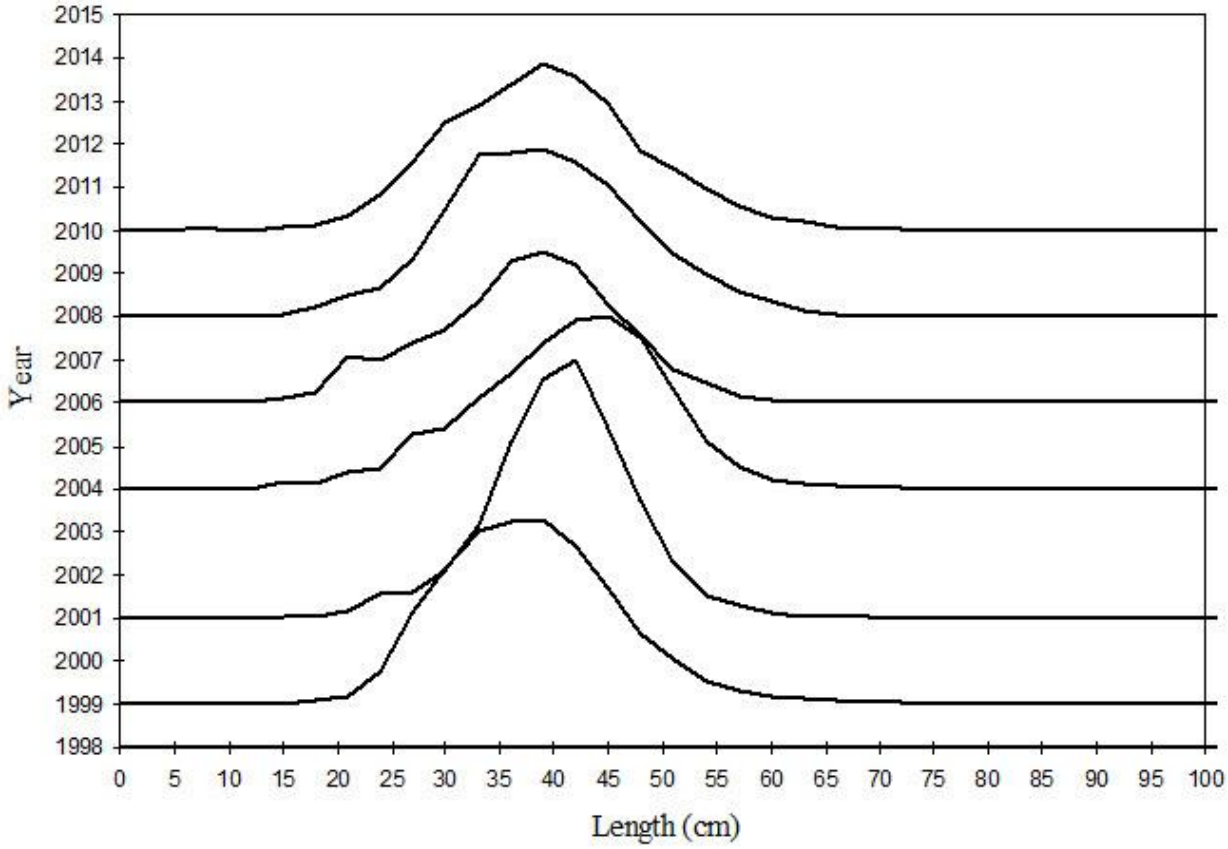


Figure 8. Length frequency distribution for Division 0A-South 1999-2010 (numbers/km^2 weighted by stratum area).

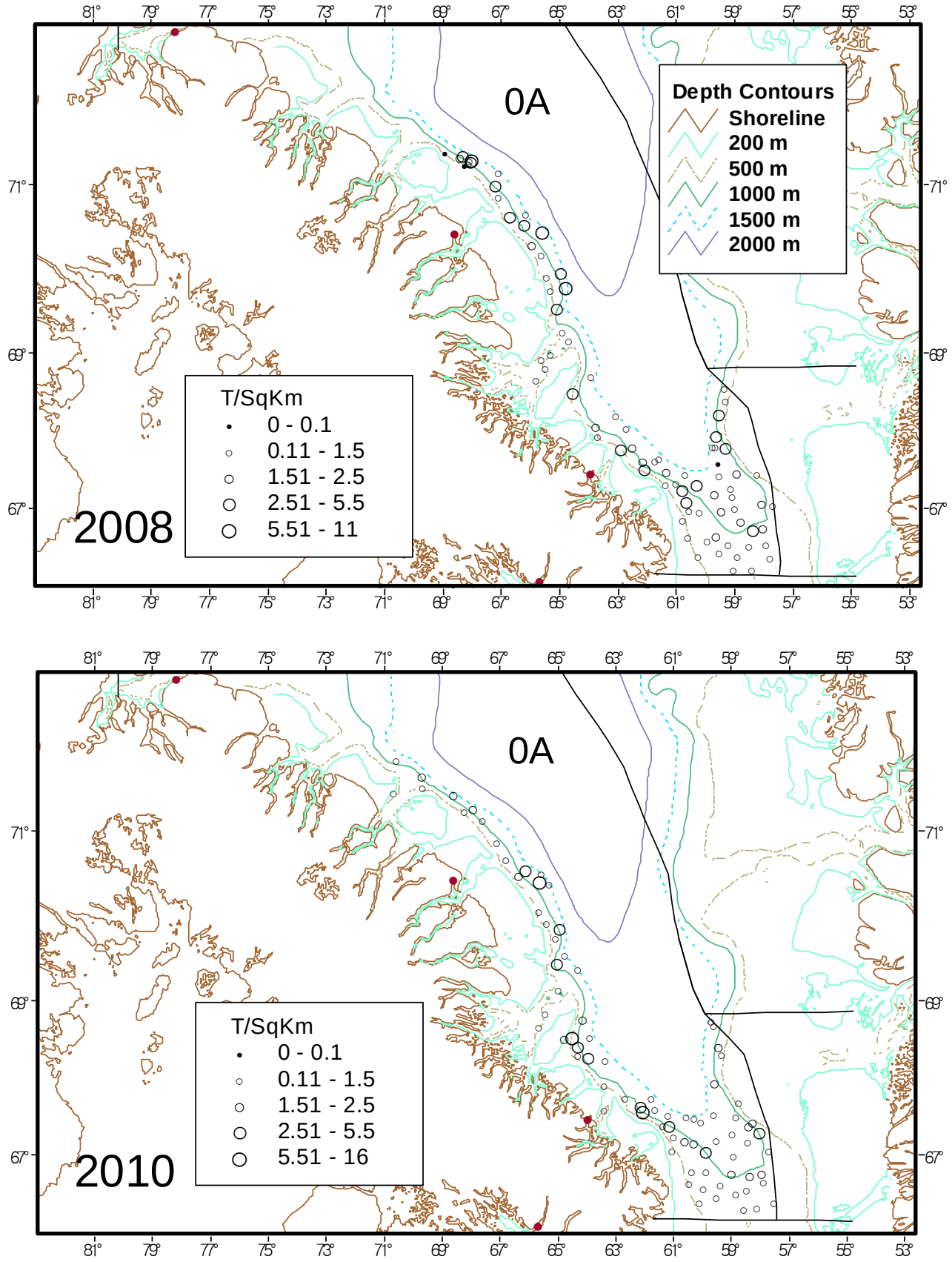


Figure 9. Distribution of catches (t/ km^2) for the 2008 and 2010 Division 0A-South survey.

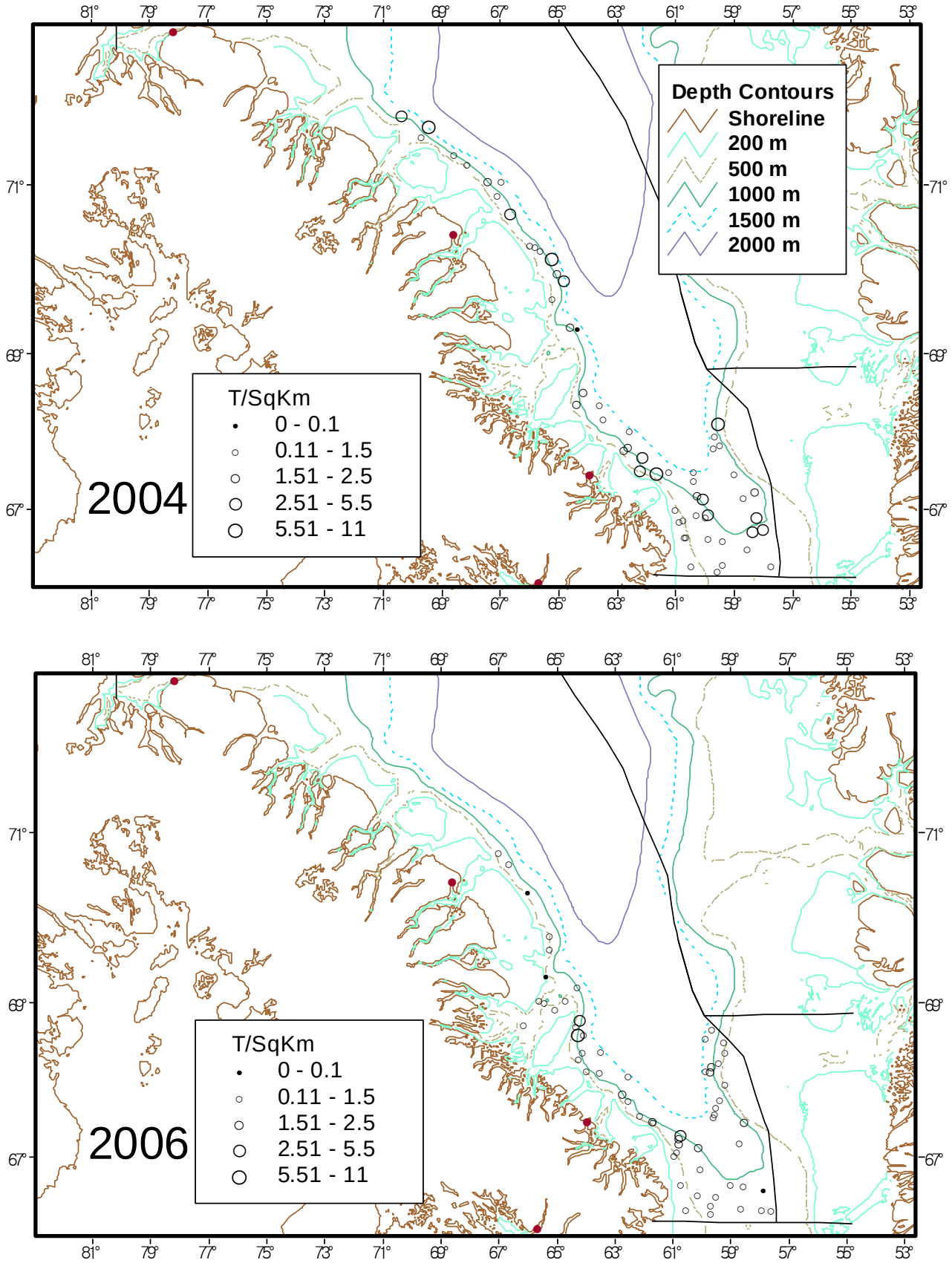


Figure 10. Distribution of catches (t/ km^2 for the 2004 and 2006 Division 0A-South surveys.

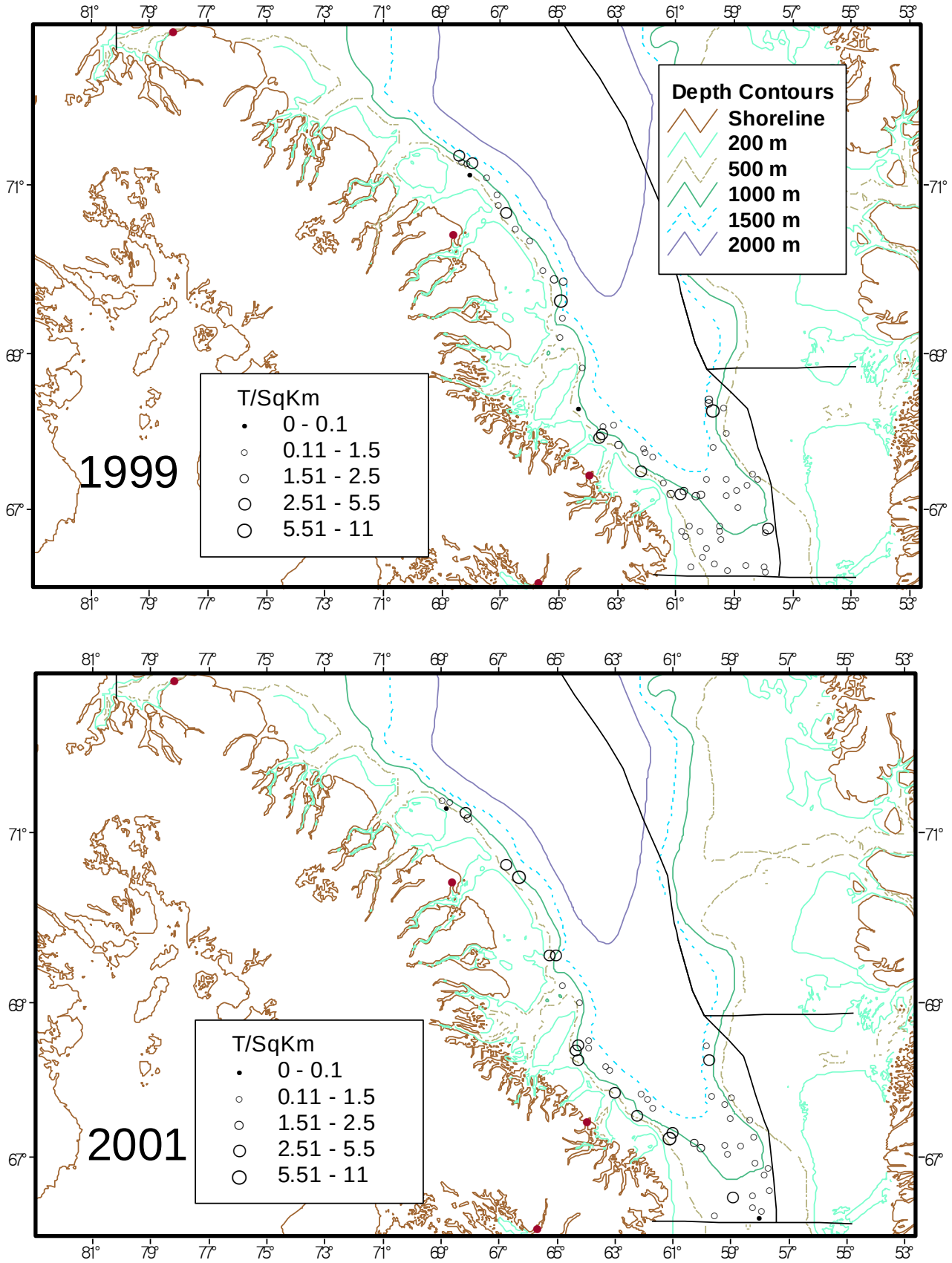


Figure 11. Distribution of catches (t/ km^2) for the 1999 and 2001 Division 0A-South surveys.

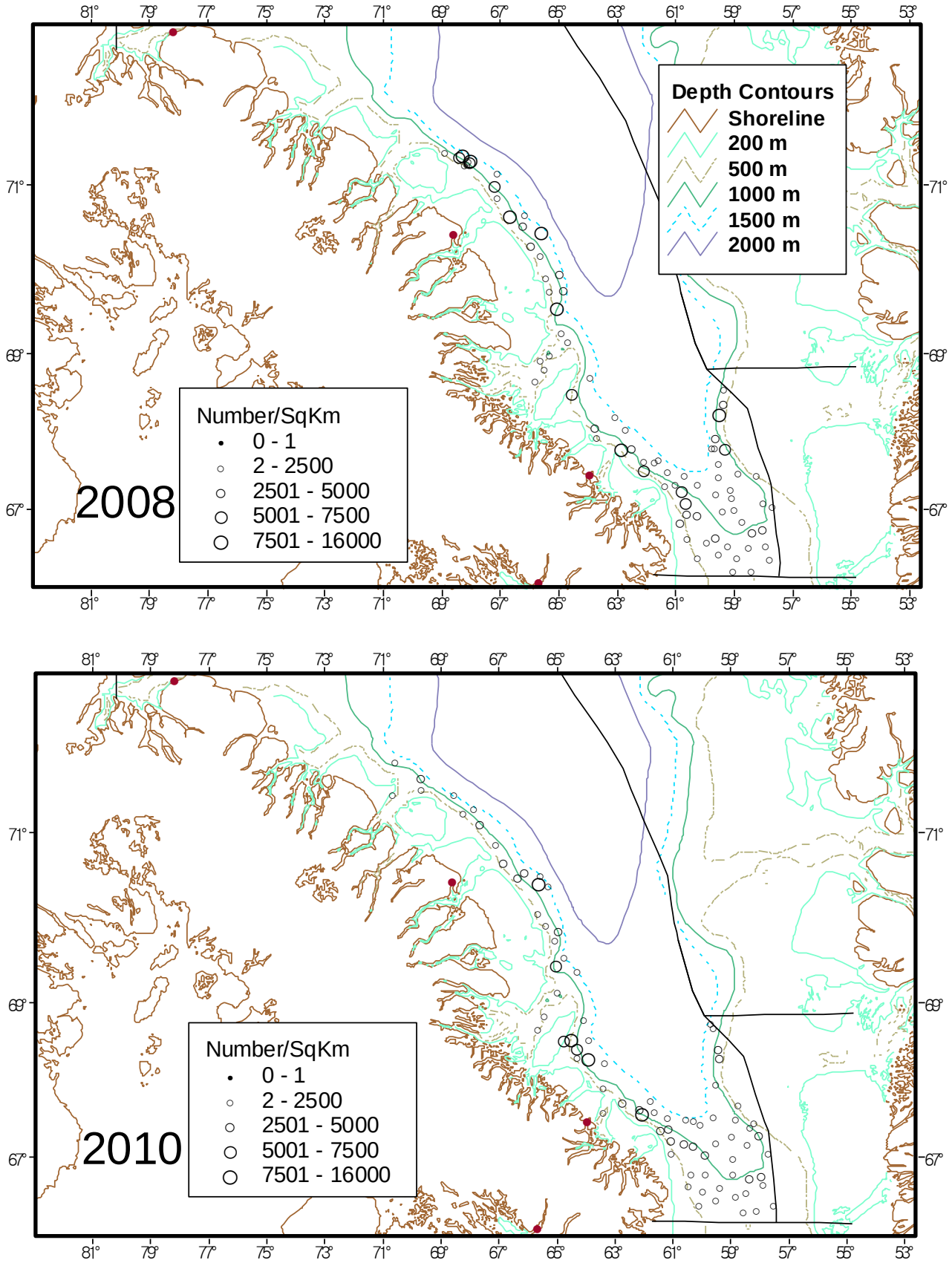


Figure 12. Distribution of catches (numbers/km^2) for the 2008 and 2010 Division 0A-South surveys.

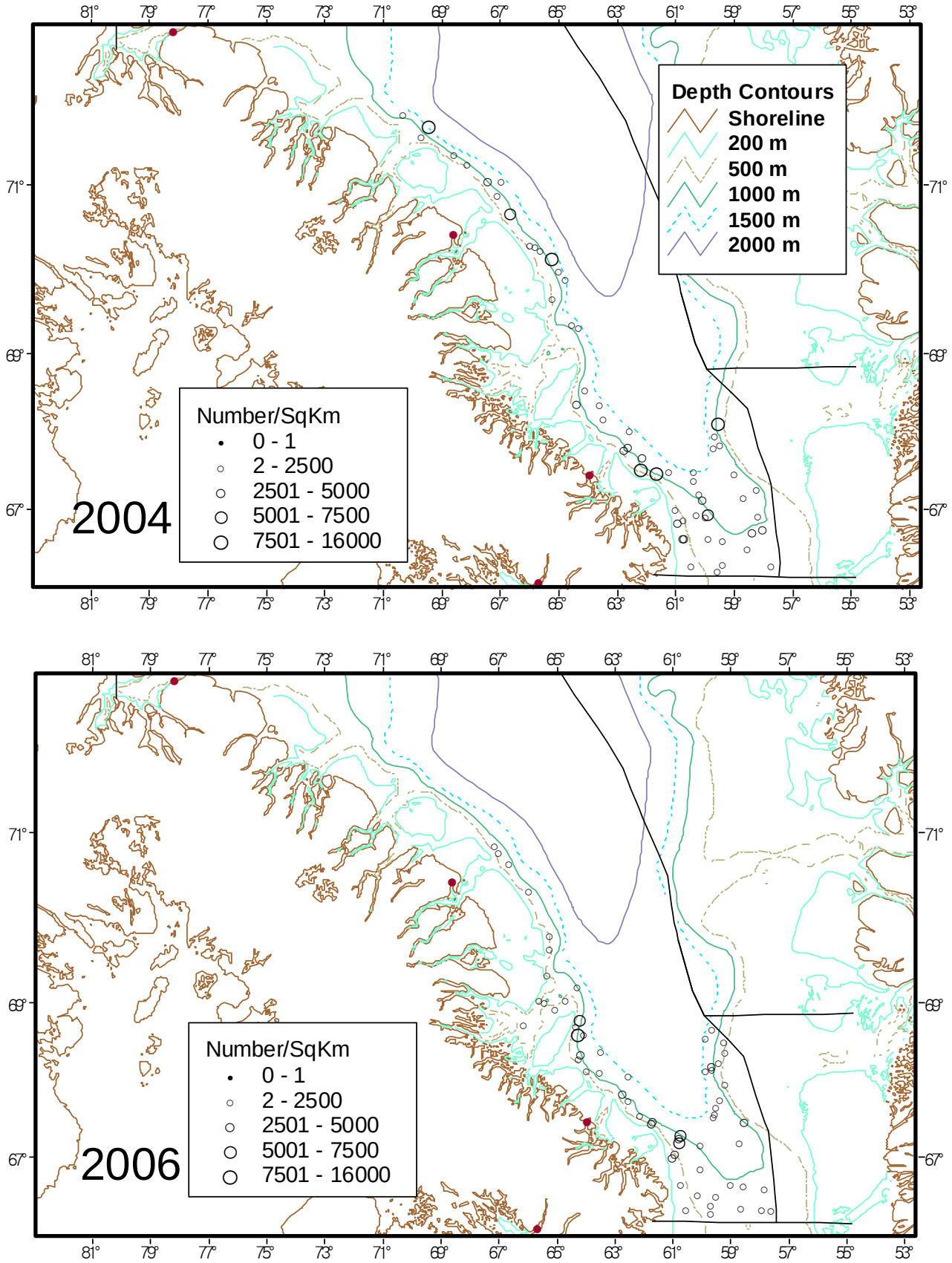


Figure 13. Distribution of catches (numbers/km^2) for the 2004 and 2006 Division 0A-South surveys.

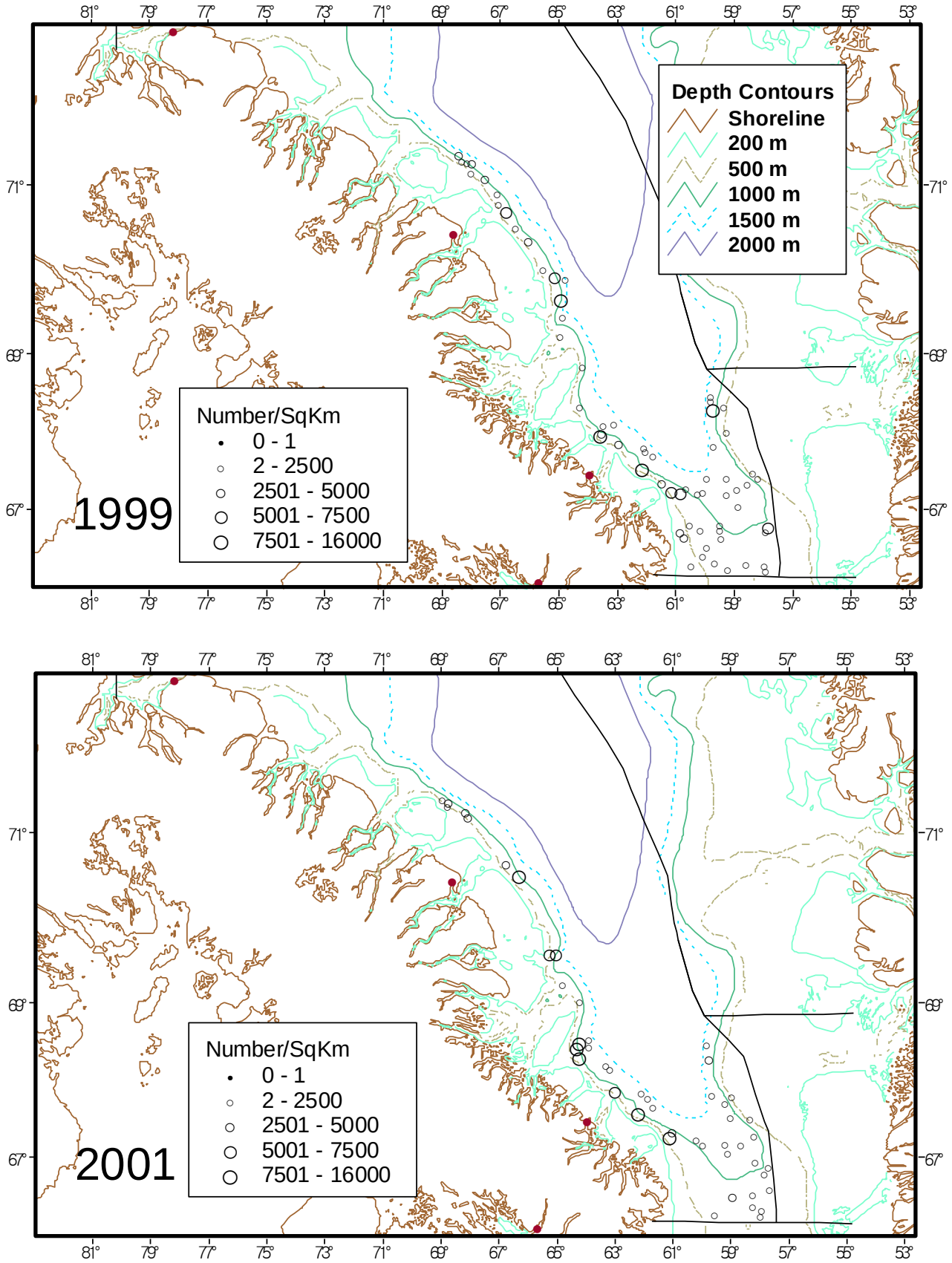


Figure 14. Distribution of catches (numbers/km^2) for the 1999 and 2004 Division 0A-South surveys.

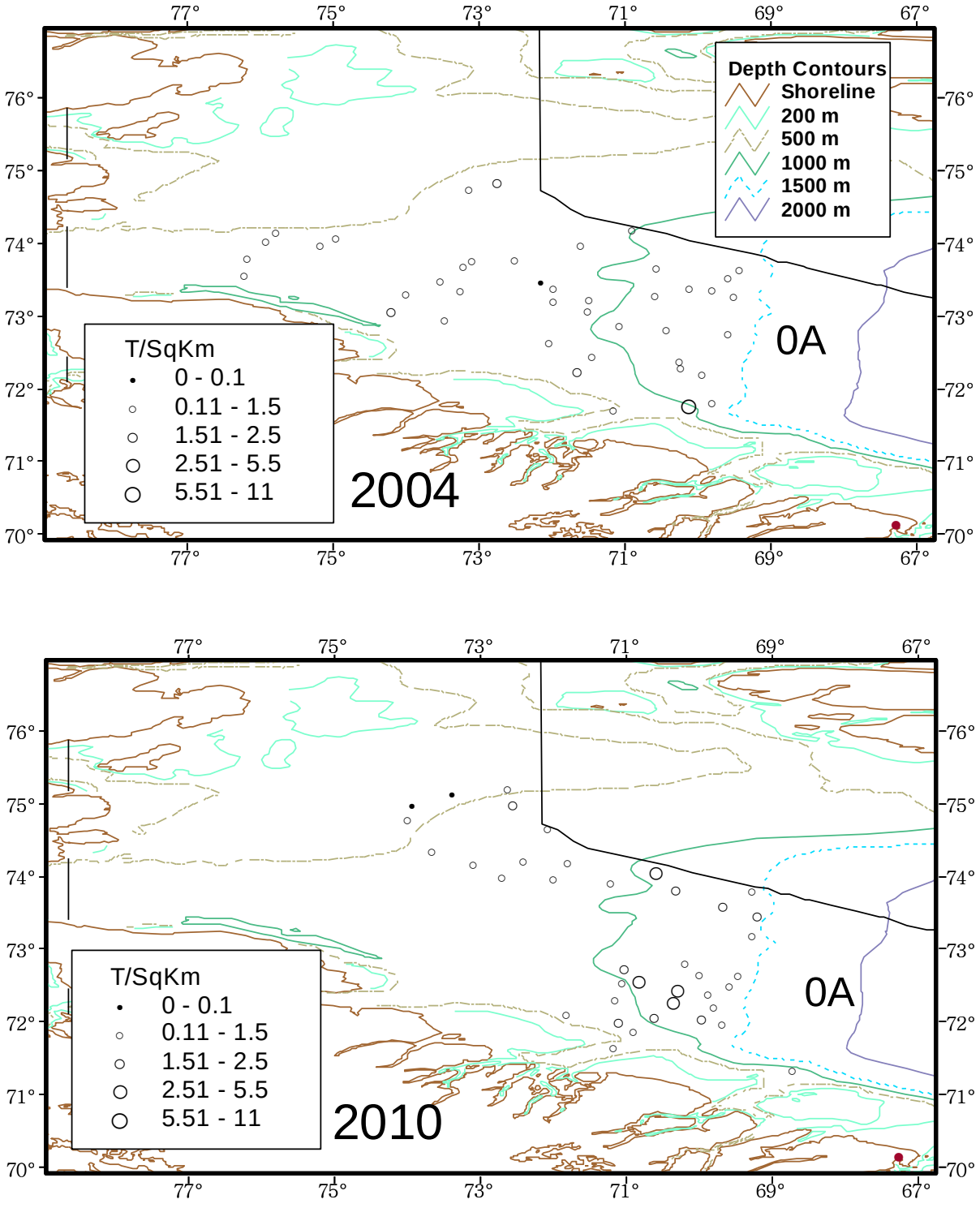


Figure 15. Distribution of catches (t/ km^2) for the 2004 and 2010 Division 0A-North surveys.

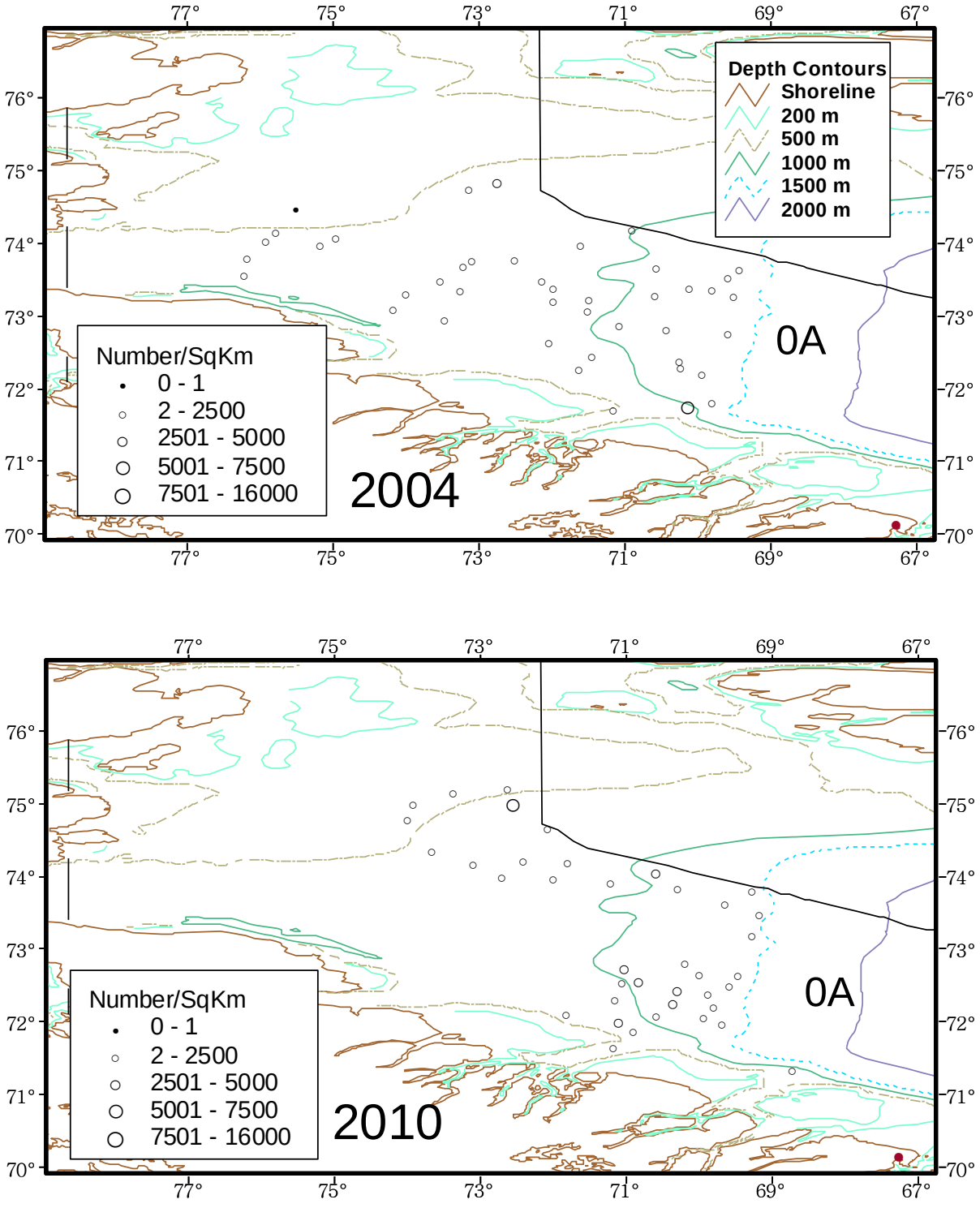


Figure 16. Distribution of catches (numbers/km^2) for the 2004 and 2010 Division 0A-North surveys.

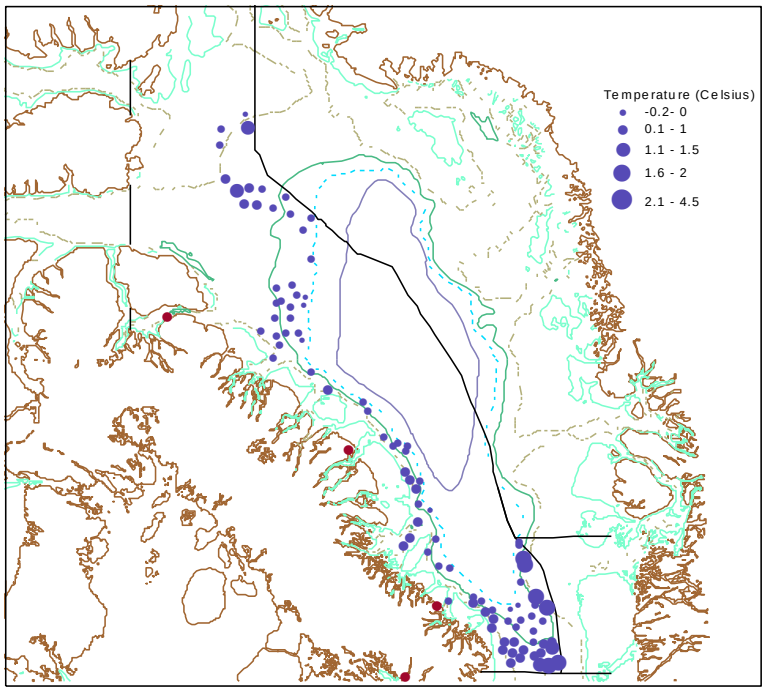


Figure 17. Bottom temperatures during 2010 survey in Division 0A.

Appendix 1. Catch weight and numbers (not standardised to kg/km2) of Greenland halibut, by set, for the 2010 survey of Division 0A.

Area	Set No.	Day-Month	Mean Depth (m)	Sweptarea (sq. km)	Depth Stratum	Temp. (^{o}C)	Greenland Halibut Number	Kg
North 0A	9	18-Oct	741	0.07804	750	0.88	143.00	57.90
North 0A	10	18-Oct	780	0.08552	1000	0.80	171.00	72.70
North 0A	11	18-Oct	946	0.08378	1000	0.72	272.00	143.90
North 0A	12	19-Oct	1045	0.08153	1250	0.29	158.00	138.00
North 0A	13	19-Oct	1251	0.08191	1500	0.26	124.00	164.90
North 0A	14	19-Oct	1413	0.07954	1500	-0.03	41.00	67.80
North 0A	15	19-Oct	1348	0.08111	1500	0.02	62.00	90.64
North 0A	16	19-Oct	1345	0.08003	1500	0.09	35.00	54.96
North 0A	17	19-Oct	1144	0.08144	1250	0.32	238.00	314.92
North 0A	18	19-Oct	904	0.08106	1000	0.75	121.00	80.50
North 0A	20	19-Oct	709	0.08078	750	0.96	86.00	34.00
North 0A	22	20-Oct	1044	0.08484	1250	0.68	259.00	228.31
North 0A	23	20-Oct	947	0.08070	1000	0.79	143.00	97.35
North 0A	24	20-Oct	1077	0.08408	1250	0.62	231.00	177.87
North 0A	25	20-Oct	1245	0.08408	1250	0.41	48.00	59.10
North 0A	26	20-Oct	1286	0.08263	1500	0.28	59.00	70.70
North 0A	27	20-Oct	1173	0.08162	1250	0.29	210.00	274.50
North 0A	28	20-Oct	1440	0.08313	1500	-0.12	27.00	39.75
North 0A	29	20-Oct	1460	0.08144	1500	-0.10	37.00	57.90
North 0A	30	21-Oct	1357	0.07794	1500	0.13	69.00	88.10
North 0A	31	21-Oct	1476	0.08085	1500	0.02	95.00	133.47
North 0A	32	21-Oct	1261	0.07869	1500	0.25	108.00	130.55
North 0A	33	21-Oct	1095	0.08081	1250	0.47	156.00	137.78
North 0A	34	21-Oct	947	0.05422	1000	0.73	98.00	78.15
North 0A	35	21-Oct	749	0.07910	750	1.39	150.00	61.65
North 0A	36	21-Oct	698	0.07741	750	1.34	80.00	34.93
North 0A	37	22-Oct	618	0.05636	750	1.55	36.00	15.85
North 0A	38	22-Oct	559	0.04585	750	1.44	39.00	20.95
North 0A	41	22-Oct	491	0.07835	500	0.27	47.00	17.93
North 0A	42	22-Oct	426	0.07315	500	0.26	17.00	7.35
North 0A	43	22-Oct	457	0.06931	500	0.03	15.00	6.15
North 0A	44	22-Oct	487	0.07331	500	-0.06	22.00	11.35
North 0A	45	22-Oct	629	0.07838	750	1.55	485.00	171.75
North 0A	46	22-Oct	792	0.07851	1000	1.08	119.00	56.74
North 0A	48	22-Oct	677	0.06413	750	1.40	81.00	28.80
North 0A	49	22-Oct	826	0.08275	1000	1.00	69.00	36.55
North 0A	50	22-Oct	1118	0.08385	1250	0.32	228.00	224.40
North 0A	51	23-Oct	1429	0.08398	1500	0.10	68.00	69.40
North 0A	52	23-Oct	758	0.07166	1000	.	104.00	44.30
North 0A	53	23-Oct	497	0.07630		1.11	90.01	35.15
South 0A	1	17-Oct	932	0.07801	1000	0.88	203.00	113.45
South 0A	2	17-Oct	550	0.07298	750	1.09	72.00	38.40
South 0A	3	17-Oct	1319	0.07843	1500	0.25	106.00	146.57
South 0A	4	17-Oct	1445	0.08090	1500	0.04	85.00	128.50
South 0A	5	17-Oct	912	0.08197	1000	.	288.00	191.55
South 0A	6	17-Oct	1131	0.08013	1250	0.35	92.00	97.40

South 0A	7	18-Oct	445	0.07755		1.04	23.99	10.26
South 0A	60	23-Oct	749	0.06220	750	1.06	93.00	40.57
South 0A	61	23-Oct	677	0.08150	750	0.99	242.00	104.25
South 0A	62	23-Oct	903	0.08318	1000	0.91	302.00	174.20
South 0A	63	23-Oct	1207	0.08194	1250	0.41	256.00	302.50
South 0A	64	24-Oct	1411	0.08934	1500	0.12	51.00	98.50
South 0A	65	24-Oct	1425	0.08336	1500	0.07	53.00	72.25
South 0A	66	25-Oct	1107	0.08302	1250	0.64	1008.98	1256.75
South 0A	67	25-Oct	467	0.07810	500	1.13	38.00	15.03
South 0A	68	25-Oct	552	0.07807	750	1.16	64.00	27.85
South 0A	70	25-Oct	1070	0.08358	1250	0.76	285.00	227.00
South 0A	71	25-Oct	688	0.08825	750	1.13	69.00	32.95
South 0A	72	25-Oct	1449	0.08170	1500	0.01	40.00	58.90
South 0A	73	25-Oct	1150	0.08312	1250	0.77	433.44	353.70
South 0A	74	25-Oct	1460	0.08711	1500	-0.09	17.00	19.60
South 0A	75	25-Oct	578	0.07932	750	1.18	81.00	32.79
South 0A	76	25-Oct	540	0.04955	750	1.18	34.00	12.85
South 0A	77	25-Oct	468	0.08320	500	1.12	44.00	16.71
South 0A	78	26-Oct	1371	0.06148	1500	0.29	115.00	120.62
South 0A	79	26-Oct	1371	0.08653	1500	0.01	32.00	36.65
South 0A	80	26-Oct	925	0.08477	1000	0.94	1006.65	494.85
South 0A	81	26-Oct	708	0.08434	750	.	447.02	153.20
South 0A	82	26-Oct	877	0.08133	1000	1.07	603.98	207.20
South 0A	83	26-Oct	454	0.07955	500	1.05	33.00	11.13
South 0A	84	26-Oct	1096	0.08515	1250	0.64	708.03	417.00
South 0A	85	26-Oct	1359	0.08414	1500	0.17	55.00	49.05
South 0A	86	27-Oct	499	0.05206	500	1.08	37.00	15.44
South 0A	87	27-Oct	588	0.07931	750	0.90	162.00	61.95
South 0A	94	27-Oct	729	0.08799	750	1.06	367.15	130.10
South 0A	95	27-Oct	871	0.07773	1000	1.13	1084.05	467.60
South 0A	96	27-Oct	1038	0.08334	1250	0.77	325.64	258.25
South 0A	97	28-Oct	1448	0.07470	1500	0.04	29.00	36.60
South 0A	98	28-Oct	1288	0.08264	1500	0.53	87.00	117.30
South 0A	99	28-Oct	1331	0.07956	1500	0.05	15.00	21.84
South 0A	100	28-Oct	663	0.08427	750	1.21	310.00	98.65
South 0A	101	28-Oct	1018	0.08743	1250	0.97	432.90	303.45
South 0A	102	28-Oct	737	0.09108	750	1.21	442.68	134.70
South 0A	103	28-Oct	439	0.07420	500	1.28	143.00	29.38
South 0A	105	29-Oct	565	0.07927	750	1.40	39.00	10.72
South 0A	107	29-Oct	540	0.07383	750	1.45	76.00	22.77
South 0A	109	29-Oct	514	0.08231	750	1.47	58.00	15.30
South 0A	111	29-Oct	781	0.08745	1000	1.30	61.00	31.45
South 0A	112	29-Oct	899	0.08315	1000	1.20	105.00	54.65
South 0A	113	29-Oct	584	0.08490	750	1.39	49.00	19.75
South 0A	115	30-Oct	779	0.08201	1000	1.30	181.00	84.70
South 0A	116	30-Oct	1054	0.08495	1250	0.88	352.15	265.99
South 0A	117	30-Oct	992	0.08675	1000	0.90	325.00	206.65
South 0A	118	30-Oct	926	0.07680	1000	1.05	314.00	141.95
South 0A	119	30-Oct	1482	0.05768	1500	.	21.00	26.70
South 0A	120	30-Oct	1453	0.09698	1500	.	19.00	29.50
South 0A	122	30-Oct	1432	0.05462	1500	-0.05	27.00	34.10

South 0A	123	31-Oct	1477	0.08184	1500	-0.05	14.00	19.99
South 0A	124	31-Oct	1157	0.06311	1250	0.77	119.00	138.17
South 0A	126	31-Oct	542	0.07705	750	3.91	217.00	108.45
South 0A	128	31-Oct	644	0.08065	750	2.90	305.00	165.68
South 0A	129	31-Oct	1314	0.08241	1500	0.28	36.00	52.10
South 0A	130	31-Oct	1410	0.09002	1500	0.10	10.00	13.25
South 0A	138	01-Nov	431	0.07998	500	4.41	88.00	32.25
South 0A	139	01-Nov	1238	0.08367	1250	0.42	31.00	27.90
South 0A	143	02-Nov	638	0.06765	750	2.54	165.00	109.15
South 0A	144	02-Nov	1042	0.08832	1250	0.79	161.00	150.25
South 0A	146	02-Nov	963	0.08532	1000	1.06	401.70	414.73
South 0A	148	03-Nov	854	0.07729	1000	1.06	89.00	76.25
South 0A	149	03-Nov	1237	0.08581	1250	0.52	63.00	54.75
South 0A	151	03-Nov	1358	0.08650	1500	0.25	11.00	15.07
South 0A	152	03-Nov	1271	0.08234	1500	0.23	47.00	53.55
South 0A	153	03-Nov	1233	0.06256	1250	0.48	41.00	41.80
South 0A	154	03-Nov	1048	0.08423	1250	0.85	142.00	148.80
South 0A	155	03-Nov	846	0.08176	1000	1.18	216.00	153.02
South 0A	156	03-Nov	823	0.08514	1000	1.16	224.00	145.54
South 0A	158	04-Nov	670	0.07654	750	1.66	85.00	49.25
South 0A	160	04-Nov	714	0.07818	750	1.47	72.00	42.80
South 0A	161	04-Nov	780	0.08401	1000	1.24	119.00	71.90
South 0A	164	06-Nov	648	0.08310	750	1.82	86.00	37.00
South 0A	166	06-Nov	645	0.05692	750	2.10	35.00	18.63
South 0A	168	06-Nov	561	0.07861	750	2.61	32.00	17.50