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Report on Greenland halibut caught during the 2015 trawl survey in Divisions 0A and 0B

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Abstract

A stratified-random otter trawl survey was conducted in southern Division 0A (0A-South) and Division 0B (0B) in 2015. The 0A-South survey extended to approximately 72° N. The survey took place from September 11 to October 11, 2015. An Alfredo III trawl was used at randomly selected stations between 401 m and 1500 m. Ice and weather conditions did not interfere with the 0A-South portion of the survey and were not significant factors in 0B. There were 76 stations completed in 0A-South (77 planned) and 70 in 0B (92 planned). All of the stations missed in 0B were from the shallow strata (401-600 m. Mean near-bottom temperatures were similar to previous surveys for 0A-South, declining with depth from 1.4 °C to 0.0 °C. Bottom temperatures in 0B were warmer, 2.7 °C to 3.8 °C, with the warmest temperatures at depths 800 m to 1000 m. Greenland halibut were distributed throughout the survey area and were present in all tows. A majority of the fish, both male and female in 0A-South were immature (80%). However, in 0B 64% of the catch was mature, comprised primarily of mature males. The 2015 estimate of biomass in Div. 0A-South was 104,187 t (S.E. 12,640) similar to estimates in 2012 and 2013. These last three estimates are greater than previous index values which had varied from 58,320 t to 85,769 t. Abundance for Div. 0A-South in 2015 was estimated at 1.16×10^8 (S.E. 1.6×10^7) an increase compared to 2014 but within the range of earlier estimates, resulting in a stable trend in abundance over the time series. The overall length distribution in 2015 ranged from 6 cm to 81 cm with modes observed at 18, 33 and 42 cm. Abundance of fish <40 cm has been variable while abundance for 40-60 cm fish has declined since 2012. The proportion of fish <45cm increased to 76%, compared to 64% and 54% in 2012 and 2014, respectively. Biomass and abundance for Div. 0B in 2015 were 67,194 t and 5.9×10^7, respectively, both slightly greater than the 2014 estimates. Overall lengths in 2015 ranged from 6 cm to 96 cm with a mode at 48 cm, similar to that observed in previous Div. 0B surveys. 32% of fish were <45 cm, similar to that observed in 2011 and 2013. Abundance at length continued to decrease in the 1401-1500 m depth strata. However, there was a substantial increase in abundance in the 801-1000 m depth strata.

Introduction

A multi-species bottom trawl survey was carried out in the Northwest Atlantic Fisheries Organization Subarea 0 during September 11 to October 11, 2015. The survey covered both southern 0A (0A-South) (to approximately 72° N) as well as Division 0B (0B). An Alfredo III trawl was used at randomly selected stations between 400 m and 1500 m. Deep-water surveys began in 0A-South in 1999 and were completed every second year between 2004 and 2012. Surveys in 0B have been less frequent with surveys in 2000, 2001, 2011 and 2013. In 2014 surveys became annual in 0A-South and 0B (Treble 2015). It is intended that both these areas will be surveyed annually in order to build an index that can improve the assessment of Greenland Halibut in Subarea 0 and 1A (offshore) + 1B-F.

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

A stratification scheme similar to that used by the Greenland Institute of Natural Resources for the Division 1CD survey was developed in 2008 (Table 1, part i and Figure 1) to facilitate comparisons between surveys conducted in Canadian and Greenland waters. The depth bins are slightly different from those used in surveys conducted between 1999 and 2006. The area in Div. 0B between 401m and 1500 m is 68,367 km^2 (Table 2). The area in 0A-South (to approximately 72^o N) between 401 m and 1500 m encompassed by this re-vised stratification scheme is 56,445 km^2 (Table 1, part i). In 2014 it was decided to remove stratum B1, a portion of the stratified area that falls within a fishery closure that was partially closed in 1998 to Greenland halibut fishing vessels to protect Narwhal over-wintering grounds and then fully closed in 2006 to protect deep-water coral habitat. The 0A-South survey scheme now covers 47,924 km^2 (Table 1, part ii). Note that this is revised from the area reported in the 2015 survey report as the areas for two strata, B1-8 and B2-8 had been reversed and the actual for B2-8 km^2 was 1779 km^2 not 3330 km^2 (Treble 2015).

Set selection is based on a coverage level of approximately 1 set per 750 km^2. A minimum of two sets were randomly selected from numbered units within each sub-stratum (the depth strata are sub-divided into multiple sub-strata in 0A and parts of 0B) using a buffered random design (Kingsley et al. 2004). 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.

The 0A-South survey has 77 sets allocated and 0B has 92.

Vessel and Gear

The surveys were conducted by the RV 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 head-rope and was used to determine temperature, depth and 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 to determine bottom temperature.

The survey lost time due to poor weather and ice conditions and so the oceanographic stations along the Cape Christian transect line were not sampled.

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 calculated as the great-circle distance between 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 containing 2 or more sets. An estimate of total abundance and biomass was then calculated for each depth strata (mean x area surveyed (km^2)) as well as for all depth strata combined. Standard error values were 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 (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 survey in 0A-South covered the full area (47,924 km^2) with 76 successful tows (Table 2). Sets completed in surveys conducted from 1999 to 2006 were assigned to the new strata post-hoc in order to establish consistency with subsequent surveys that used the new depth stratification scheme and any sets that fell within strata B1 (area included in the fishery closure) were removed from surveys completed prior to 2014 (Table 2). The survey area was adjusted and indexes recalculated for the full time series to address the error discovered in the assigned area for stratum B2-8 during preparation for this 2016 assessment. The 1400-1500 m depth strata was poorly covered in 1999, 2001 and 2006 and so the area contained in this strata was removed from the survey area for those years (Table 2).

There were 70 successful sets in the 0B survey (Table 3). All the strata had at least two sets so there was no adjustment made to the survey area (68,367 km^2). As above for 0A-South, the 2000 and 2001 surveys were re-stratified post-hoc in order to establish consistency with subsequent surveys. There were problems completing the 2001 survey (36 of 76 planned tows completed) but each strata had 2 or more sets in them which allowed mean values to be estimated. However, biomass and abundance may not be as precise as for surveys that had more complete coverage.

Mean near-bottom temperatures were similar to previous surveys for 0A-South, ranging from 1.4 ^{o}C to 0.0 ^{o}C and declining with depth (Table 4, Fig. 4). Bottom temperatures in 0B were warmer, 2.7 ^{o}C to 3.8 ^{o}C with the warmest temperatures at depths 800 m to 1000 m (Table 5, Fig. 3).

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

Greenland Halibut

<u>Division 0A-South</u>

Greenland halibut were present in all successful tows in 2015 (Fig. 5 and Appendix 1). The number of fish caught in 0A-South varied from 5-1272 and catch weight from 9-674 kg (Appendix 1). The catch was comprised of 49% males and 50% females. Both males and females were primarily immature (80% of the catch). These values for male and female maturities are similar to previous observations in 0A.

The 2015 estimate of biomass was 104,187 t (S.E. 12,640) (Table 6) similar to estimates in 2012 and 2013. Mean catch per tow standardized to km^2 was 2.17 t in 2015, similar to what was observed in 2012 (Table 7).These last three estimates are greater than previous index values which had varied from 58,320 t to 85,769 t (Fig. 9 and Table 8). For depths 401-600 m an increasing trend in biomass has been observed since 2010 (Table 8, Fig. 11a).

The impact of the removal of the 1400-1500 m strata to the overall estimate of Greenland Halibut biomass and abundance in 1999, 2001 and 2006 was considered minor as this stratum does not cover a large area and has contained only 2-3% of the overall biomass in recent years. However, the reduced coverage (only 3 sets) in depths 1200-1400 in the 2006 survey may have led to an under-estimate of mean biomass/ km^2 and the reduced estimate of biomass for the strata that year (5,410 t) compared to estimates in 2004 (13,997 t) and 2008 (23,155 t) (Table 8), therefore, the overall biomass and abundance is likely under-estimated for 2006 (Fig. 9).

Abundance in 2015 was 1.16 x 10^8 (S.E. 1.6 x 10^7) (Table 6) an increase compared to 2014 but within the range of earlier estimates, resulting in a stable trend in abundance over the time series (Table 9 and Fig. 9). Abundance of fish <40 cm has been variable while abundance for 40-60 cm fish has declined since 2012 (Fig. 12).

The abundance at length for depths 401-600 m increased considerably in 2015 compared to previous years (Fig. 13). The first mode shifted from 18 to 24 cm and the second mode from 33 to 39 cm. This may reflect growth in the abundant 2011 and 2013 year classes. Generally, the number of fish at larger length classes increases with depth. There has been a decrease in abundance and shift to larger fish in the distribution for depths 801-1000 m since 2010.

The overall length distribution in 2015 ranged from 6 cm to 81 cm with modes observed at 18, 33 and 42 cm (Table 10). A trend to increased numbers of larger fish was observed from 2008 to 2014. In 2015 the distribution had shifted left with increased numbers at smaller sizes (e.g. 18-36 cm) compared to previous years (Fig. 15). The proportion of fish <45cm increased to 76%, compared to 64% and 54% in 2012 and 2014, respectively (Table 10).

Division 0B

Greenland halibut were present in all successful tows in 2015 (Fig. 7 and Appendix 1). The number of fish caught varied from 1-485 and catch weight from 0.6 kg to 608.4 kg (Appendix 1). The catch was comprised of 67% males and 32% females. A majority of the catch (64%) was mature fish and most of these were male. The proportion of mature females increased from 6% in 2013 and 2014 to 14% of the catch in 2015. The 2015 biomass was 67,194 t (S.E. 5,487), an increase over the 2013 (53,109 t) and 2014 (64,873 t) estimates but less than that observed in 2011(80,476 t) (Table 8 and Figure 10). Mean catch per tow standardized to km^2 was 0.98 t in 2015, similar to what was observed in 2014 (Table 7). Biomass was greater at depths 801-1000 m while biomass at 1201-1400 m was lower compared to previous estimates (Fig. 11b, Table 8).

The 2015 abundance index was estimated at 5.9×10^7 (S.E. 5.2×10^6) (Table 6). This is a small increase over 2014 (5.5×10^7) but still considerably lower than was estimated for 2011 (7.9×10^7) and earlier estimates (Table 9, Fig. 10). The abundance of fish 4-60 cm has declined since 2011 while the abundance of fish <40 cm has been relatively stable since then (Fig. 12).

Overall lengths in 2014 ranged from 6 cm to 96 cm (Table 11, Figure 15) with a mode at 48 cm, similar to that observed in previous surveys. 32% of fish were <45 cm, similar to that observed in 2011 and 2013 (Table 11). Abundance at length continued to decrease in the 1401-1500 m depth strata. However, there was a substantial increase at 801-1000 m (Fig. 14).

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Table 1. Stratification scheme for Division 0A-South; left (i) - full stratification; right (ii) – strata B1 removed.

Stratum	Depth (m)	Area (km2)	Assigned Sets (1/750km2)
A1-4	400-600	2151.56	3
A2-4	400-600	4649.39	6
A3-4	400-600	784.79	2
A4-4	400-600	1921.58	3
B1-4	400-600	936.25	2
B2-4	400-600	2519.44	3
		12963.01	19
A1-5	600-800	794.75	2
A2-5	600-800	2250.41	3
A3-5	600-800	759.93	2
A4-5	600-800	2483.22	3
B1-5	600-800	741.28	2
B2-5	600-800	5107.81	7
		12137.39	19
A1-6	800-1000	603.81	2
A2-6	800-1000	1144.81	2
A3-6	800-1000	1020.40	2
A4-6	800-1000	1375.61	2
B1-6	800-1000	1190.02	2
B2-6	800-1000	2656.17	4
		7990.82	14
A1-7	1000-1200	745.21	2
A2-7	1000-1200	1873.10	2
A3-7	1000-1200	1306.99	2
A4-7	1000-1200	1635.65	2
B1-7	1000-1200	1288.00	2
B2-7	1000-1200	1788.51	2
		8637.46	12
A1-8	1200-1400	812.76	2
A2-8	1200-1400	2151.49	3
A3-8	1200-1400	1145.95	2
A4-8	1200-1400	1071.88	2
B1-8	1200-1400	3329.50	4
B2-8	1200-1400	1778.91	2
		10290.49	15
A1-9	1400-1500	497.50	2
A2-9	1400-1500	1153.19	2
A3-9	1400-1500	683.94	2
A4-9	1400-1500	709.73	2
B1-9	1400-1500	1035.21	2
B2-9	1400-1500	345.99	2
		4425.56	12
Total		56444.73	91

Stratum	Depth (m)	Area (km2)	Assigned Sets (1/750km2)
A1-4	400-600	2152	3
A2-4	400-600	4649	6
A3-4	400-600	785	2
A4-4	400-600	1922	3
B2-4	400-600	2519	3
		12027	17
A1-5	600-800	795	2
A2-5	600-800	2250	3
A3-5	600-800	760	2
A4-5	600-800	2483	3
B2-5	600-800	5108	7
		11396	17
A1-6	800-1000	604	2
A2-6	800-1000	1145	2
A3-6	800-1000	1020	2
A4-6	800-1000	1376	2
B2-6	800-1000	2656	4
		6801	12
A1-7	1000-1200	745	2
A2-7	1000-1200	1873	2
A3-7	1000-1200	1307	2
A4-7	1000-1200	1636	2
B2-7	1000-1200	1789	2
		7349	10
A1-8	1200-1400	813	2
A2-8	1200-1400	2151	3
A3-8	1200-1400	1146	2
A4-8	1200-1400	1072	2
B2-8	1200-1400	1779	2
		6961	11
A1-9	1400-1500	498	2
A2-9	1400-1500	1153	2
A3-9	1400-1500	684	2
A4-9	1400-1500	710	2
B2-9	1400-1500	346	2
		3390	10
Total		47924	77

Table 2. 0A-South set distribution. Depth stratum removed from the survey area due to incomplete set coverage (sets <2) are highlighted.

Stratum	Depth (m)	Area (km²)	1999	2001	2004	2006	2008	2010	2012	2014	2015
A1-4	400-600	2152	4	0	6	4	3	3	3	3	3
A2-4	400-600	4649	2	3	1	6	6	6	6	4	5
A3-4	400-600	785	3	0	0	2	2	2	2	2	2
A4-4	400-600	1922	0	2	0	0	3	3	3	2	3
B2-4	400-600	2519	2	0	1	2	3	3	2	6	3
		12027	11	5	8	14	17	17	16	17	16
A1-5	600-800	795	3	2	1	3	2	2	2	2	2
A2-5	600-800	2250	0	3	1	3	3	3	3	3	3
A3-5	600-800	760	1	1	1	2	2	2	2	2	2
A4-5	600-800	2483	1	1	3	0	1	3	3	3	3
B2-5	600-800	5108	7	6	5	8	7	7	7	8	7
		11396	12	13	11	16	15	17	17	18	17
A1-6	800-1000	604	1	1	1	2	2	2	2	1	2
A2-6	800-1000	1145	2	0	1	2	2	2	2	2	2
A3-6	800-1000	1020	3	2	3	1	2	2	2	2	2
A4-6	800-1000	1376	1	1	2	0	1	2	2	3	2
B2-6	800-1000	2656	4	3	5	1	4	4	4	6	4
		6801	11	7	12	6	11	12	12	14	12
A1-7	1000-1200	745	2	0	1	1	2	2	2	1	2
A2-7	1000-1200	1873	3	2	2	5	2	2	2	4	2
A3-7	1000-1200	1307	2	0	4	0	2	2	2	2	2
A4-7	1000-1200	1636	0	0	0	0	2	2	2	3	2
B2-7	1000-1200	1789	2	3	3	0	2	2	2	4	2
		7349	9	5	10	6	10	10	10	14	10
A1-8	1200-1400	813	2	3	1	0	2	2	2	2	2
A2-8	1200-1400	2151	3	4	4	3	3	3	3	4	3
A3-8	1200-1400	1146	2	0	2	0	2	2	2	2	2
A4-8	1200-1400	1072	1	0	4	0	2	2	2	2	2
B2-8	1200-1400	1779	2	2	1	0	4	2	2	2	2
		6961	10	9	12	3	13	11	11	12	11
A1-9	1400-1500	498	0	0	0	0	2	2	2	2	2
A2-9	1400-1500	1153	0	0	1	1	2	2	2	2	2
A3-9	1400-1500	684	0	0	0	0	2	2	2	2	2
A4-9	1400-1500	710	0	0	0	0	0	2	2	2	2
B2-9	1400-1500	346	1	0	1	0	2	2	1	0	2
		3390	1	0	2	1	8	10	9	8	10
Total		47924	54	39	55	46	74	77	75	83	76
	Adjusted		44534	44534		44534					

Table 3. Stratification scheme for Division 0B and distribution of successful sets.

Strata	Depth (m)	Area (km^2)	Set Design ($1/750km^2$)	2000	2001	2011	2013	2014	2015
D4-1	400-600	17397	23	9	7	17	16	6	14
D4-2	400-600	19277	26	15	4	22	24	9	16
D5-1	600-800	2283	3	6	3	3	3	2	2
D5-2	600-800	8052	11	7	3	13	12	12	11
D6-1	800-1000	8053	11	13	8	11	11	11	10
D7-1	1000-1200	6586	9	8	6	9	9	9	9
D8-1	1200-1400	4754	6	3	2	6	6	6	5
D9-1	1400-1500	1965	3	3	3	3	3	3	3
Totals		68367	92	64	36	84	84	58	70

Table 4. Mean temperature and S.E. in ( ) for Division 0A-South.

Year	Depth Stratum (m) 401-600	601-800	801-1000	1001-1200	1201-1400	1401-1500
1999						
2001						
2004	1.4 (0.18)	1.1 (0.08)	0.9 (0.04)	0.6 (0.05)	0.1 (0.04)	-0.2 (0.09)
2006	1.1 (0.08)	1.3 (0.07)	1.1 (0.05)	0.9 (0.10)	0.2 (0.07)	0.3 (-)
2008	1.1 (0.11)	1.4 (0.03)	1.3 (0.04)	0.8 (0.05)	0.4 (0.03)	0.1 (0.04)
2010	1.3 (0.09)	1.1 (0.13)	0.9 (0.09)	0.7 (0.07)	0.2 (0.05)	0.0 (0.02)
2012	1.4 (0.14)	1.6 (0.06)	1.1 (0.11)	0.7 (0.07)	0.3 (0.07)	0.0 (0.03)
2014	1.7 (0.17)	1.5 (0.05)	1.3 (0.02)	0.8 (0.08)	0.4 (0.04)	0.2 (0.04)
2015	1.4 (0.06)	1.4 (0.04)	1.2 (0.09)	0.7 (0.07)	0.2 (0.04)	0.0 (0.02)

Table 5. Mean temperature and S.E. in ( ) for Division 0B.

Year	Depth Stratum (m) 401-600	601-800	801-1000	1001-1200	1201-1400	1401-1500
2000	2.1 (0.18)	2.6 (0.18)	3.5 (0.04)	3.5 (0.03)	3.3 (0.07)	3.2 (0.03)
2001						
2011						
2013	2.6 (0.15)	3.3 (0.25)	4.1 (0.04)	3.9 (0.02)	3.8 (0.02)	3.8 (0.01)
2014	2.8 (0.19)	3.3 (0.22)	4.0 (0.03)	3.8 (0.04)	3.7 (0.03)	3.6 (0.05)
2015	2.7 (0.22)	3.0 (0.25)	3.8 (0.05)	3.7 (0.01)	3.6 (0.02)	2.8 (0.76)

Table 6. Greenland halibut biomass, abundance with standard error by stratum for the Subarea 0 survey, 2015.

Div.	Stratum (m)	Mean Biomass (t/sq km)	Biomass (tons)	SE	Mean Abundance (#/sq km)	Abundance	SE
0B	401-600	0.2448	8977.8	1442.8	345.0	1.3E+07	2.8E+06
	601-800	0.9084	9388.2	1350.7	899.3	9.3E+06	1.5E+06
	801-1000	3.2646	26290.2	4207.8	2551.1	2.1E+07	3.5E+06
	1001-1200	2.0692	13627.6	2439.0	1575.5	1.0E+07	1.9E+06
	1201-1400	1.5744	7484.6	1566.1	1170.6	5.6E+06	1.2E+06
	1401-1500	0.7255	1425.7	301.7	484.5	9.5E+05	2.3E+05
	Overall	0.9828	67194.0	5486.7	868.6	5.9E+07	5.2E+06
0A-South	401-600	2.3746	28559.2	2392.1	3708.2	4.46E+07	1.3E+07
	601-800	2.0593	23467.7	10216.4	2636.3	3.00E+07	6.8E+06
	801-1000	3.1363	21330.2	4290.4	2888.6	1.96E+07	2.5E+06
	1001-1200	3.2793	24099.7	5120.4	2391.6	1.76E+07	5.5E+06
	1201-1400	0.7930	5520.0	3794.3	490.0	3.41E+06	7.6E+05
	1401-1500	0.3570	1210.3	350.7	212.2	7.19E+05	1.3E+05
	Overall	2.1740	104187.1	12640.3	2420.3	1.16E+08	1.6E+07

Table 7. Mean catch per tow (tons) standardized to km2 of Greenland Halibut from SA0, Divisions 0B and 0A-South during the period 1999-2015.

Division	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015
0B		0.77	0.91					1.18		0.78	0.95	0.98
0A-South	1.31		1.93	1.60	1.11	1.60	1.52		2.22		1.92	2.17

Table 8. Biomass estimates (tons) of Greenland Halibut by depth stratum from SA0, Divisions 0B and 0A-South during the period 1999-2015.

Division	Depth Strata (m)	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015
0B	401-600		6055	7184					15411		9844	17908	8978
	601-800		4186	9883					16150		9992	13579	9388
	801-1000		10531	12789					20185		15981	14005	26290
	1001-1200		13630	15498					16649		8588	10090	13628
	1201-1400		15377	12129					8618		6462	6880	7485
	1401-1500		3171	4659					3463		2240	2411	1426
	Overall		52951	62142					80476		53109	64873	67194
0A-South	401-600	5596		14481	7979	3367	5684	3655		11042		15095	28559
	601-800	12349		24551	11397	6253	10312	9835		35158		30952	23468
	801-1000	10799		22621	17810	7471	16798	17271		23405		20023	21330
	1001-1200	19162		20868	24712	27070	18876	30412		25970		16905	24100
	1201-1400	10414		3249	13997	5410	23155	9285		9327		7484	5520
	1401-1500				908	0	1970	2453		1717		1565	1210
	Overall	58320		85769	76802	49571	76794	72911		106619		92024	104187

Table 9. Abundance estimates for Greenland Halibut by depth stratum from SA0, Divisions 0B and 0A-South during the period 1999-2015.

Div.	Depth Strata (m)	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015
0B	401-600		16925	15670					19779		11817	16154	12651
	601-800		6570	14338					17146		10309	12182	9294
	801-1000		13330	15361					17891		14167	11125	20544
	1001-1200		15685	17086					14462		7709	8120	10376
	1201-1400		17158	13023					7423		5297	5282	5565
	1401-1500		2839	4559					2737		1855	1991	952
	Overall		72507	80037					79438		51154	54854	59382
0A-South	401-600	17207		22540	23372	13442	15900	10134		26533		22008	44598
	601-800	33792		51821	23016	17839	23730	24497		54365		45381	30043
	801-1000	24233		27888	23360	15753	30033	34352		27343		20819	19645
	1001-1200	30329		28836	25583	40264	27710	34445		21397		12308	17576
	1201-1400	9540		3300	10100	5210	22300	7670		6740		4840	3411
	1401-1500	0		0	660	0	1563	1661		1120		1027	719
	Overall	115101		134385	106091	92508	121236	112759		137498		106383	115992

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

Length Class (3cm)	2001	2004	2008	2010	2012	2014	2015
6				57		48	118
9	10			55			145
12		69	8	42	130	48	454
15	33	1518	338	319	133	108	1163
18	204	865	949	586	5717	**1983**	**3263**
21	887	2628	2181	1566	**6388**	1261	2544
24	2741	3108	2703	3592	2192	2052	3261
27	3360	7647	6419	6897	4105	3570	6771
30	6014	7036	11312	11026	7102	7424	13511
33	10961	8369	**17461**	12460	10345	**11324**	**17526**
36	20188	9658	16467	14320	14054	9177	13403
39	**25928**	10321	15574	**15958**	18210	9088	12285
42	26912	12462	13859	14302	**20637**	11461	**13381**
45	18027	**13697**	11816	11300	18256	**14580**	11856
48	10721	12176	8765	6999	13052	13558	7954
51	4892	8418	5548	5279	8284	10131	4089
54	1762	4036	3529	3532	3835	5553	2020
57	834	1988	2180	2079	2074	2483	1202
60	503	937	1234	1074	1175	1167	535
63	169	509	459	848	876	675	213
66	105	306	314	290	544	365	103
69	103	103	61	80	186	172	124
72	28	125	24	24	110	122	59
75		41	16	24	36	30	6
78		51		15	31	6	
81		20			17		7
84	19	6	15	17			
87		26					
90		7			10		
93			9				
96		6					
99			9	12			
Total	134402	106134	121249	112755	137498	106384	115992
Total <45 cm	97239	63682	87270	81180	89013	57544	87826
% <45 cm	72.35	60.00	71.98	72.00	64.74	54.09	75.72

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

Length Class (3cm)	2001	2011	2013	2014	2015
6	142	14	37	165	20
9	217	0	141		423
12	0	**1657**	**589**	29	302
15	47	703	164	25	368
18	241	554	141	**873**	1153
21	740	565	480	279	**1915**
24	**1712**	586	923	231	977
27	1373	629	559	310	677
30	2416	750	616	917	981
33	3315	1423	970	653	1438
36	4476	2095	1533	965	1636
39	9689	4496	2715	1769	2849
42	15038	9178	5636	3832	6230
45	**17875**	15831	9905	9050	12058
48	11086	**16391**	**10744**	**12587**	**12942**
51	6013	11925	7397	10990	7492
54	2387	6099	3761	5580	3404
57	1429	2936	2005	2628	1793
60	703	1546	1120	1538	1064
63	478	828	739	976	598
66	197	460	340	632	371
69	213	272	154	252	213
72	142	118	124	155	211
75	14	143	141	95	98
78	22	54	72	138	31
81	26	62	42	68	41
84	8	29	45	35	19
87	8	31	23	27	29
90	0	64	30	44	28
93	0	0	9		9
96	29	0			11
99	0	0			
Total	80037	79439	51153	54844	59382
Total <45 cm	39407	22651	14504	10050	18969
% <45 cm	49.24	28.51	28.35	18.32	31.94

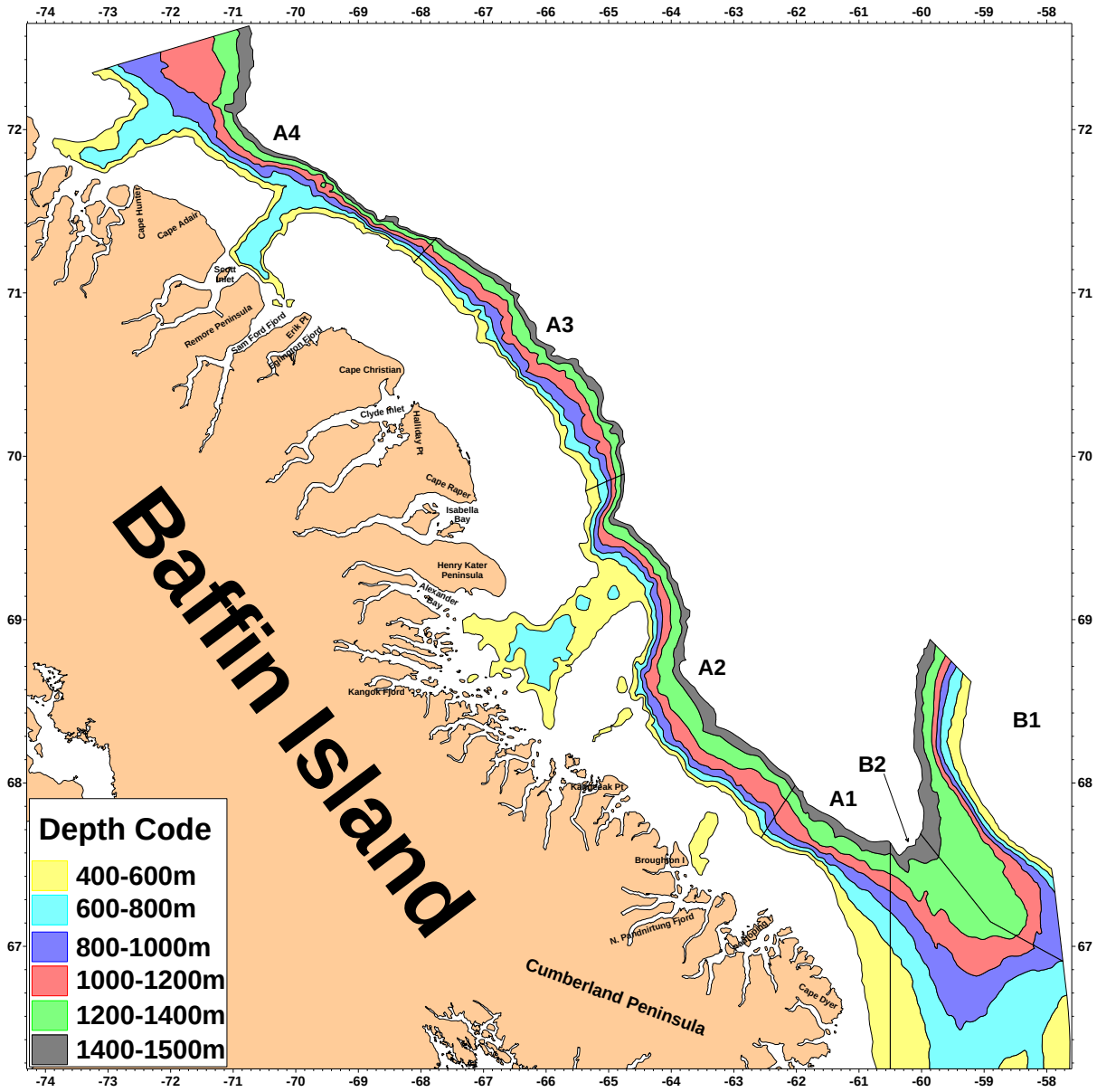


Fig.1. Stratification scheme for Division 0A-South, 66o N to 72o N.

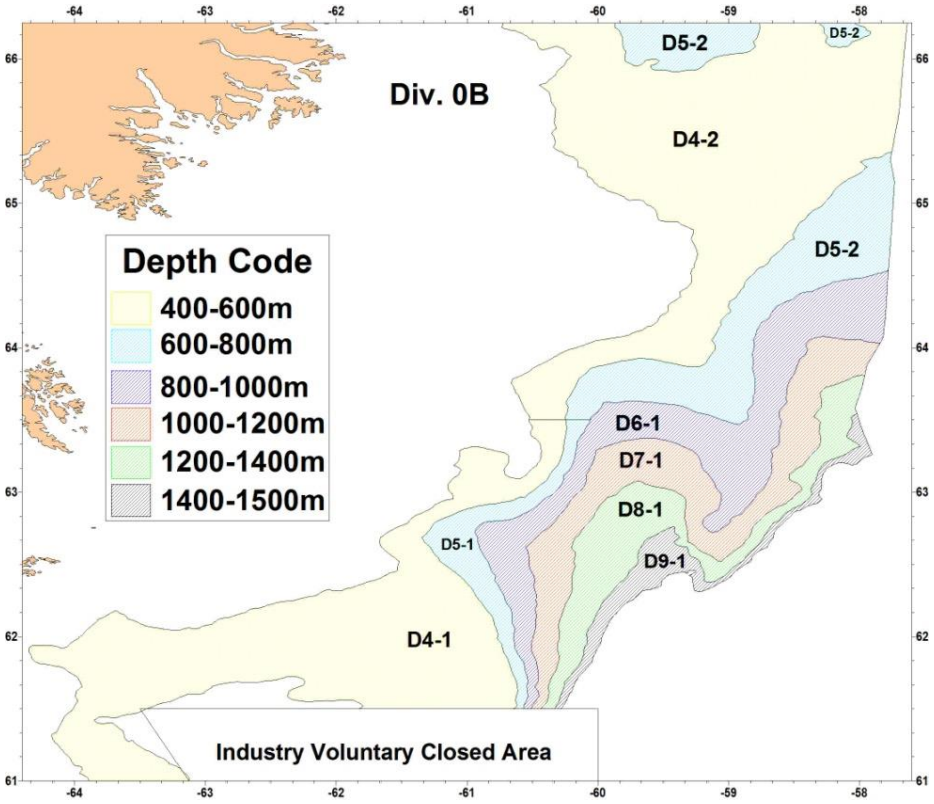


Fig. 2. Stratification scheme for Division 0B, 72o N to 76o N.

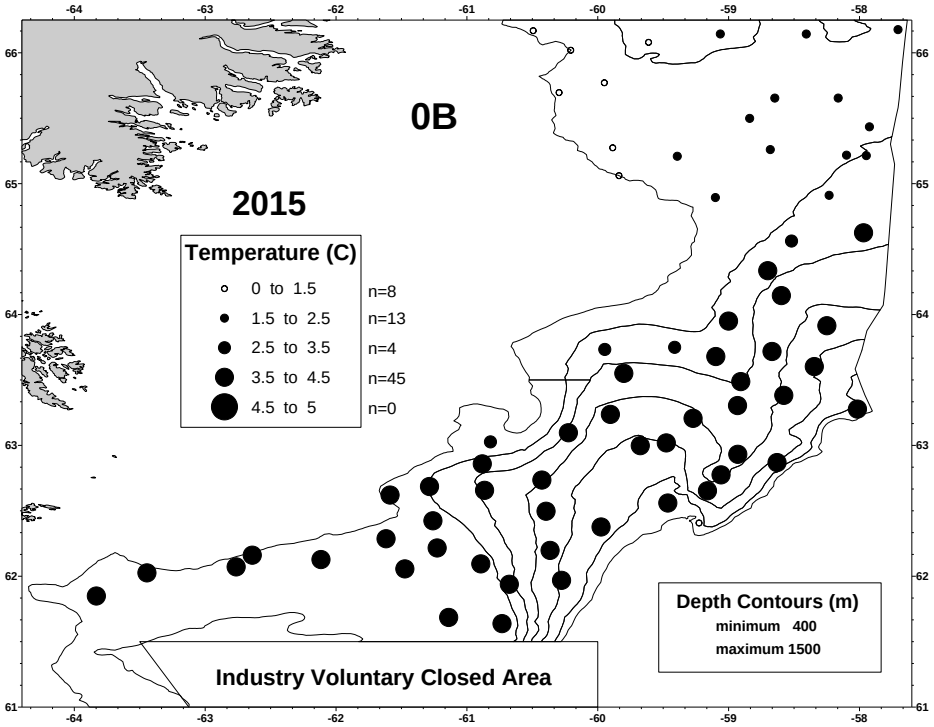


Fig. 3. Bottom temperatures during 2015 survey in Division 0B.

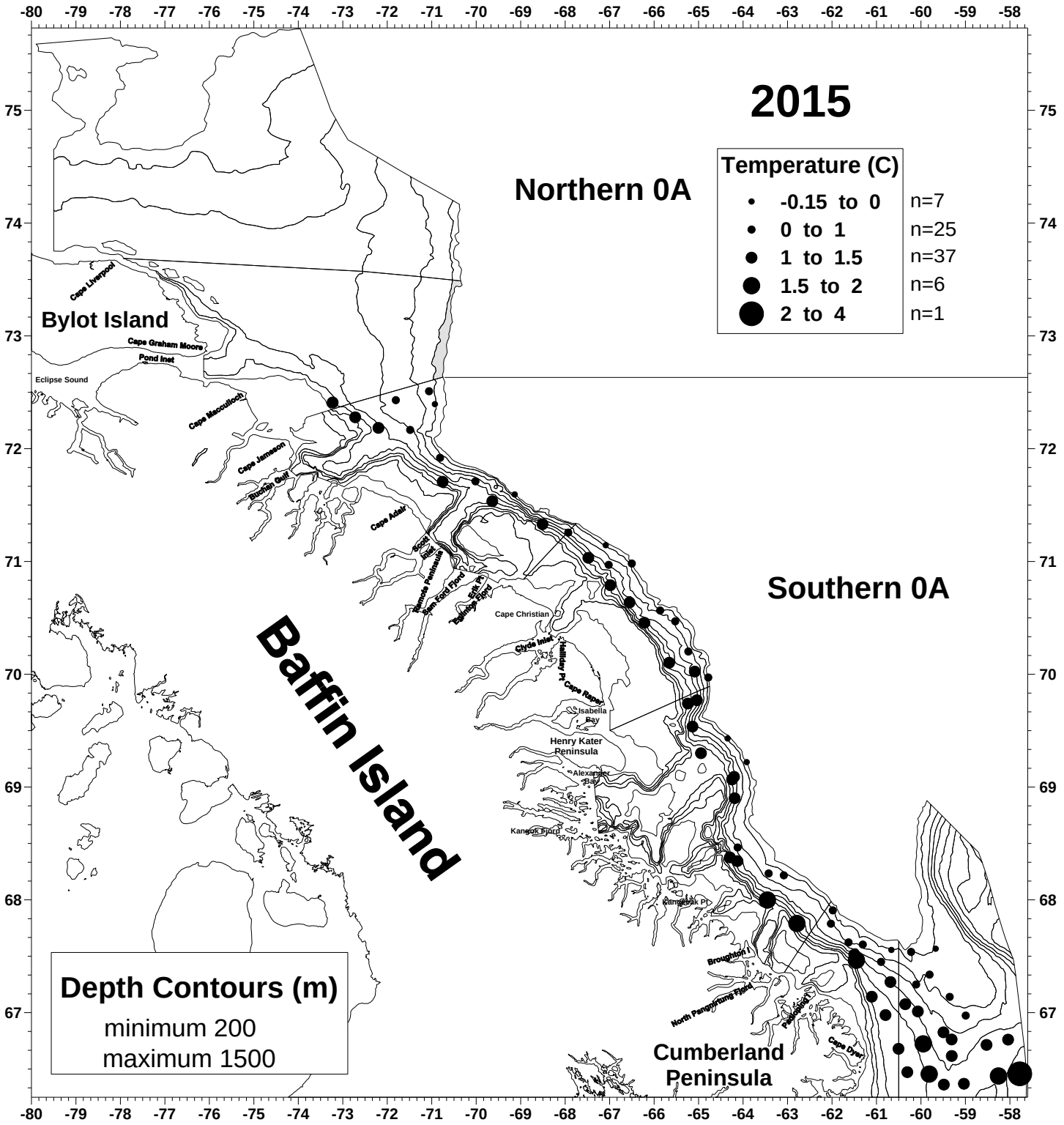


Fig. 4. Bottom temperatures during 2015 survey in Division 0A.

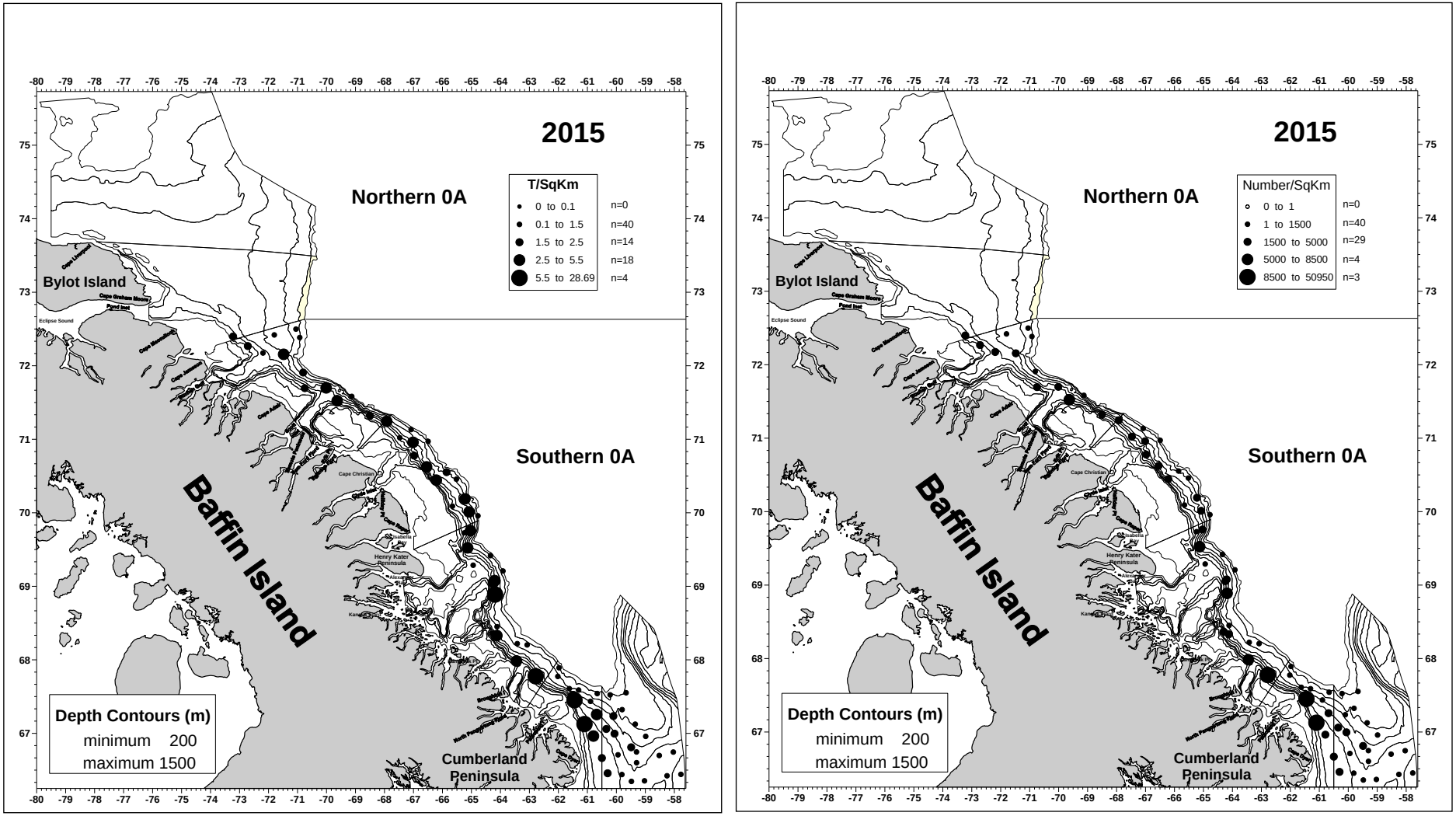


Fig. 5. Biomass (left) and abundance (right) distribution for Greenland halibut in Division 0A, 2015.

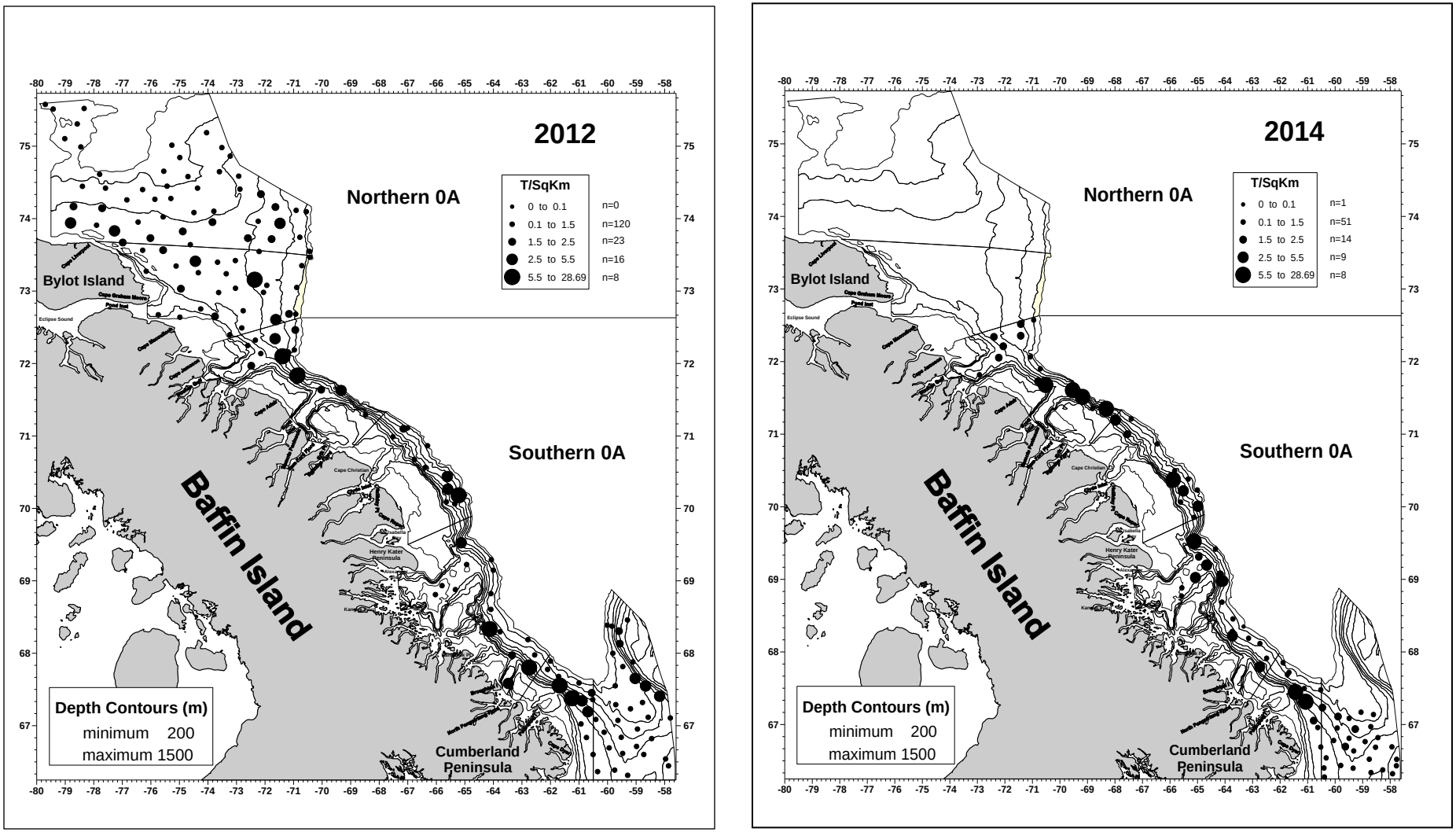


Fig.6. Biomass distribution (t/sq km) for Greenland halibut in Division 0A, 1999 to 2014.

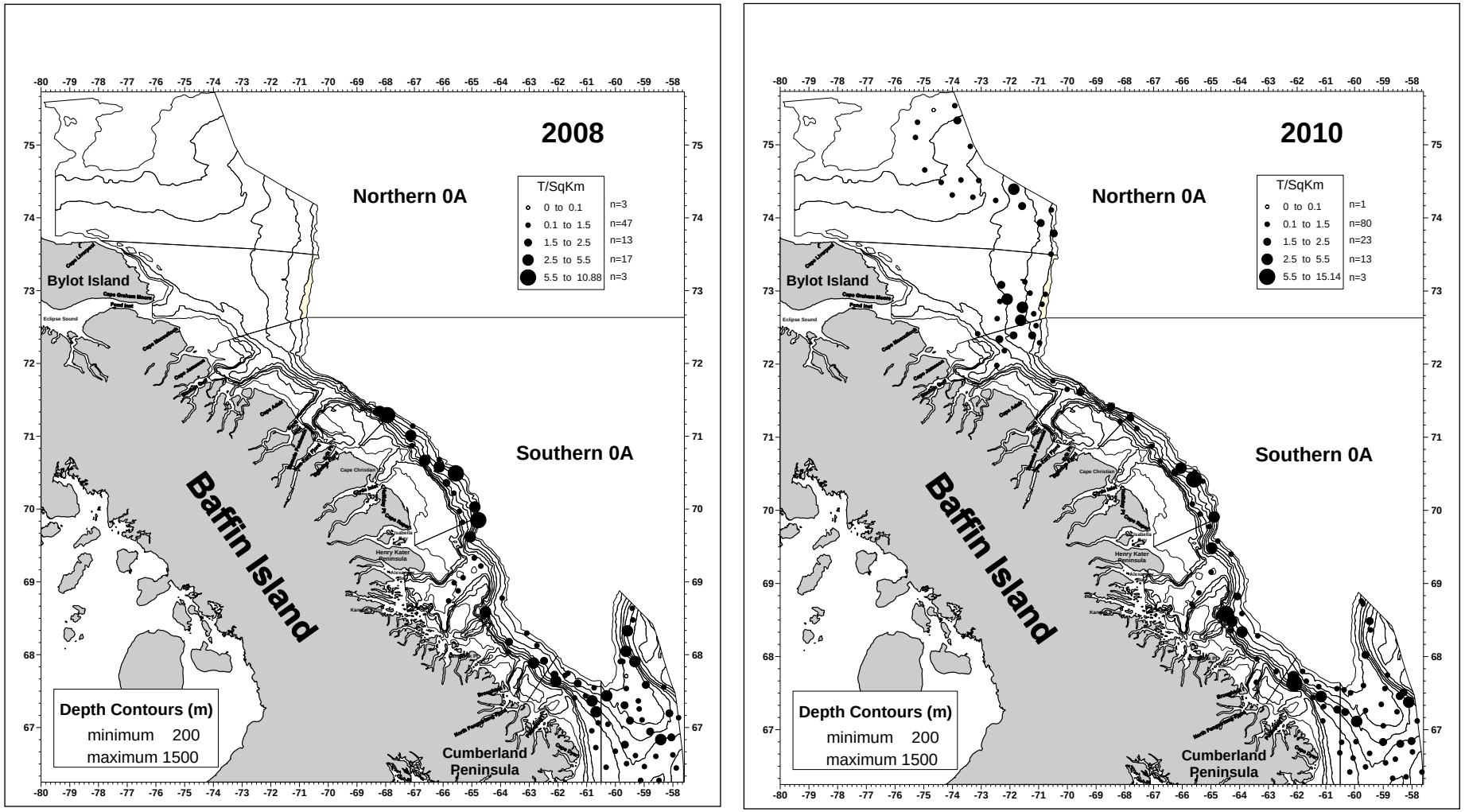

2008
Northern 0A
Southern 0A
Baffin Island
Bylot Island
Cumberland Peninsula
T/SqKm
0 to 0.1 n=3
0.1 to 1.5 n=47
1.5 to 2.5 n=13
2.5 to 5.5 n=17
5.5 to 10.88 n=3
Depth Contours (m)
minimum 200
maximum 1500
2010
Northern 0A
Southern 0A
Baffin Island
Bylot Island
Cumberland Peninsula
T/SqKm
0 to 0.1 n=1
0.1 to 1.5 n=80
1.5 to 2.5 n=23
2.5 to 5.5 n=13
5.5 to 15.14 n=3
Depth Contours (m)
minimum 200
maximum 1500

Fig. 6 (Con't).

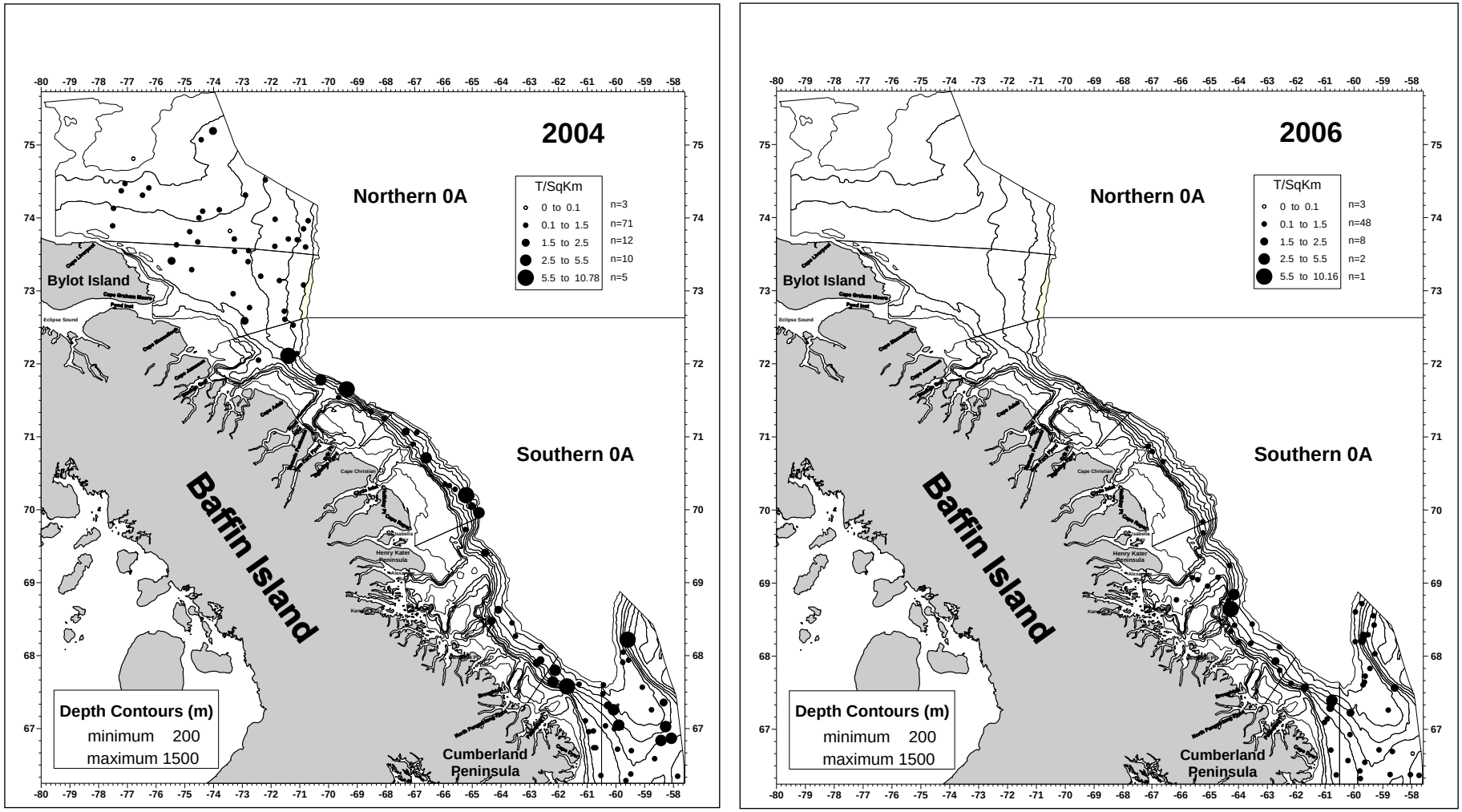

2004
Northern 0A
Southern 0A
Bylot Island
Baffin Island
Cumberland Peninsula
T/SqKm
0 to 0.1 n=3
0.1 to 1.5 n=71
1.5 to 2.5 n=12
2.5 to 5.5 n=10
5.5 to 10.78 n=5
Depth Contours (m)
minimum 200
maximum 1500
2006
Northern 0A
Southern 0A
Bylot Island
Baffin Island
Cumberland Peninsula
T/SqKm
0 to 0.1 n=3
0.1 to 1.5 n=48
1.5 to 2.5 n=8
2.5 to 5.5 n=2
5.5 to 10.16 n=1
Depth Contours (m)
minimum 200
maximum 1500

Fig. 6 (Con't).

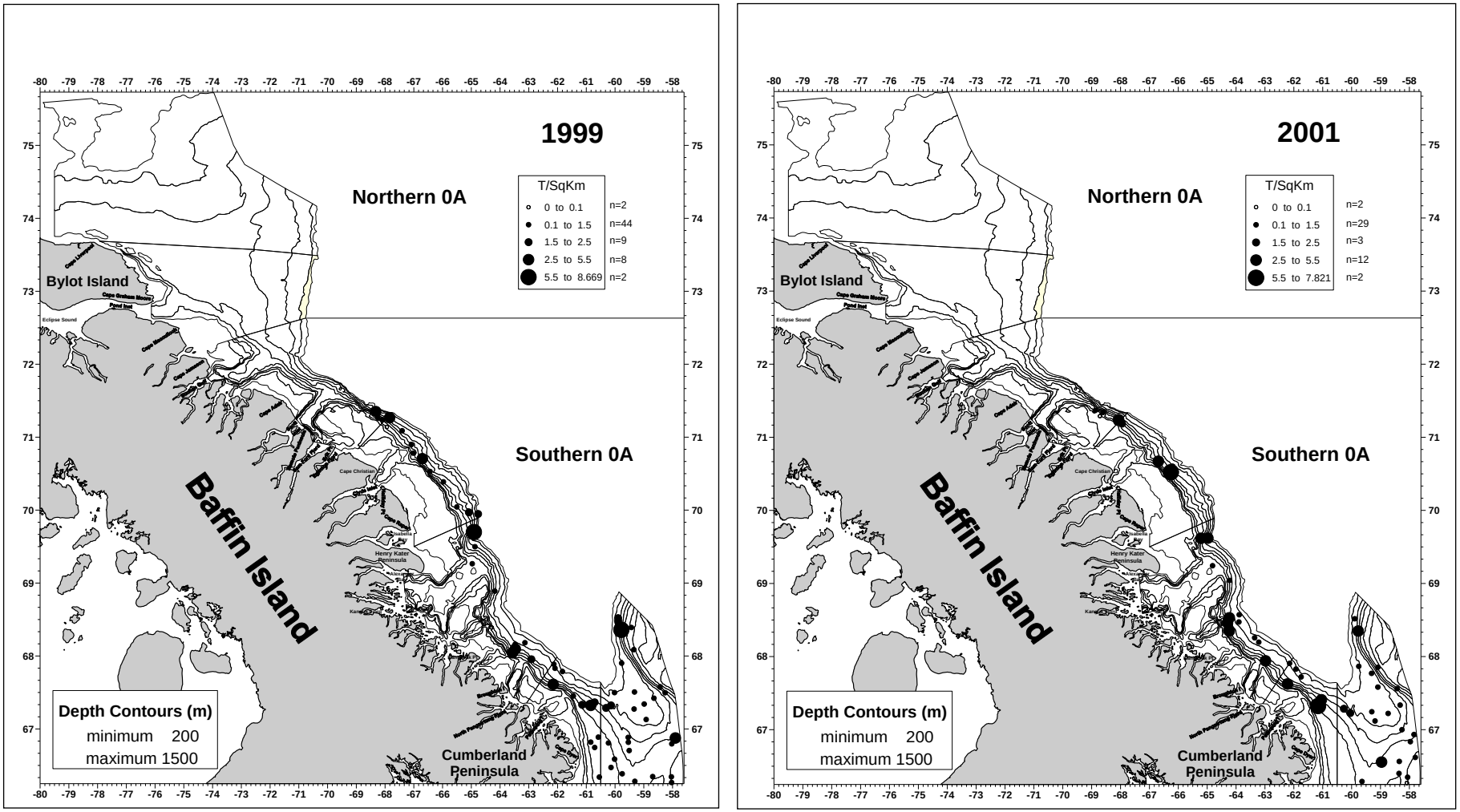

1999
Northern 0A
Southern 0A
T/SqKm
0 to 0.1 n=2
0.1 to 1.5 n=44
1.5 to 2.5 n=9
2.5 to 5.5 n=8
5.5 to 8.669 n=2
Bylot Island
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula
2001
Northern 0A
Southern 0A
T/SqKm
0 to 0.1 n=2
0.1 to 1.5 n=29
1.5 to 2.5 n=3
2.5 to 5.5 n=12
5.5 to 7.821 n=2
Bylot Island
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula

Fig. 6 (Con't).

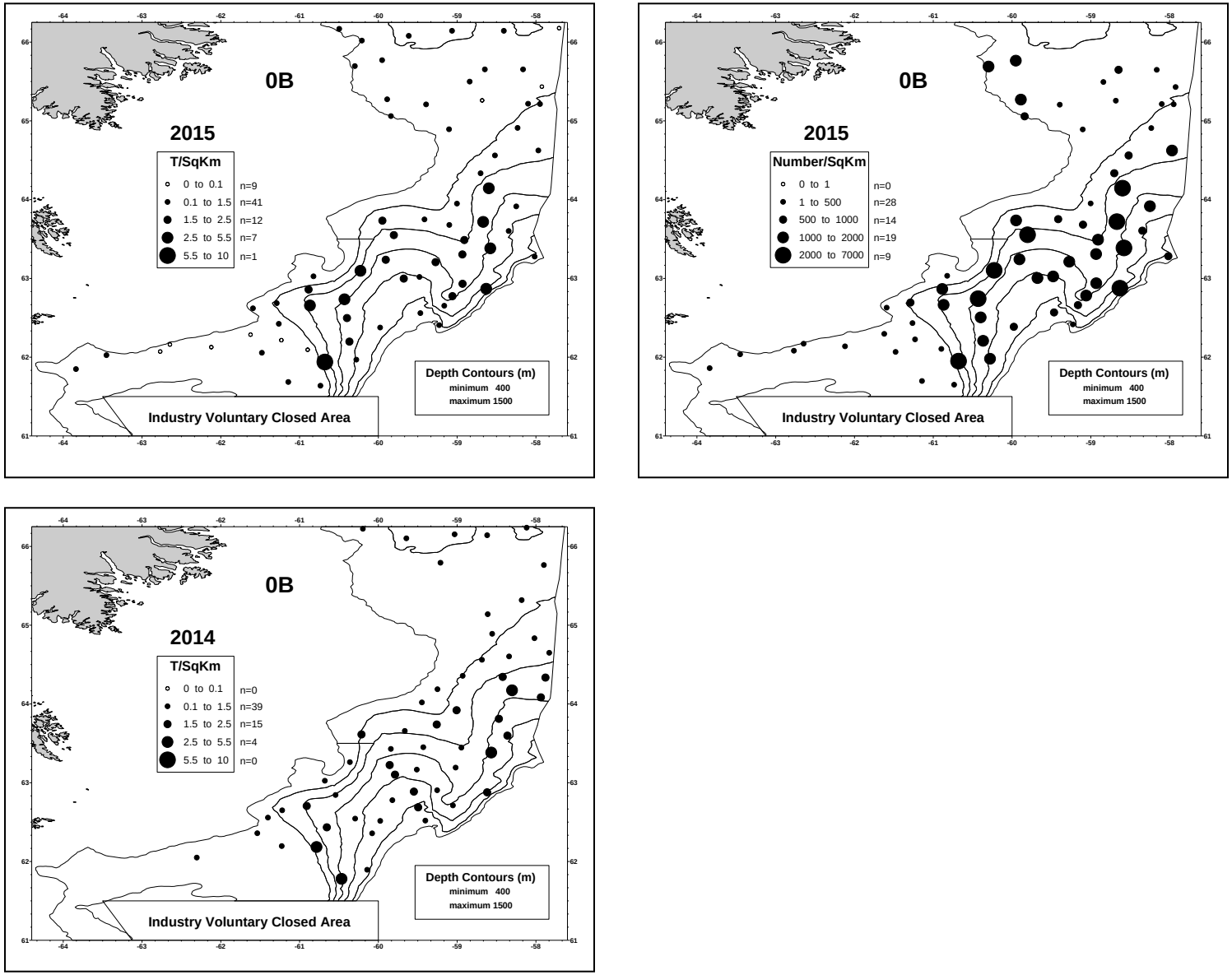


Fig. 7. Biomass and abundance distribution (top) for Greenland Halibut in Division 0B 2015; and biomass for 2014.

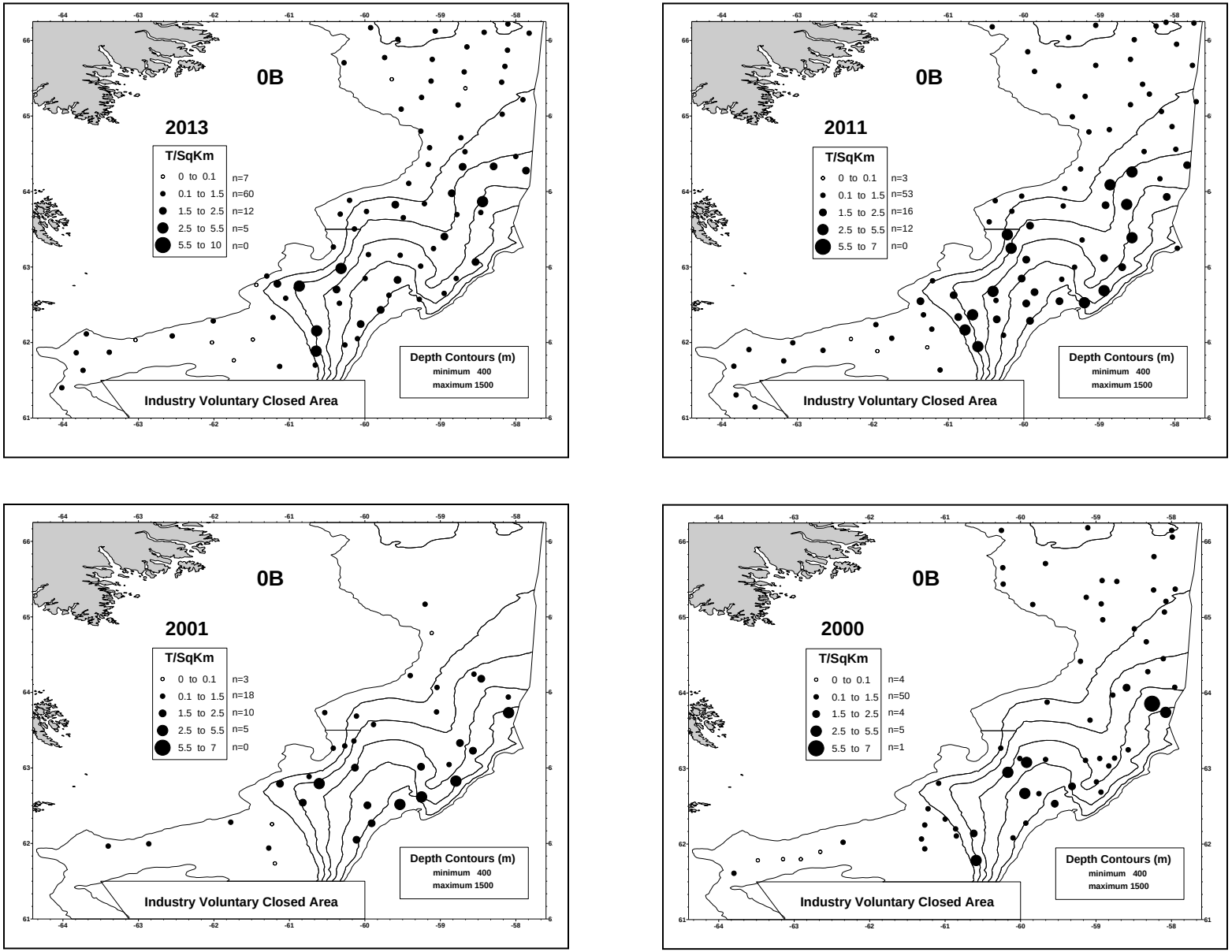


Fig. 8. Biomass (kg/km2) distribution for Greenland halibut in Division 0B, 2000, 2001, 2011 and 2013.

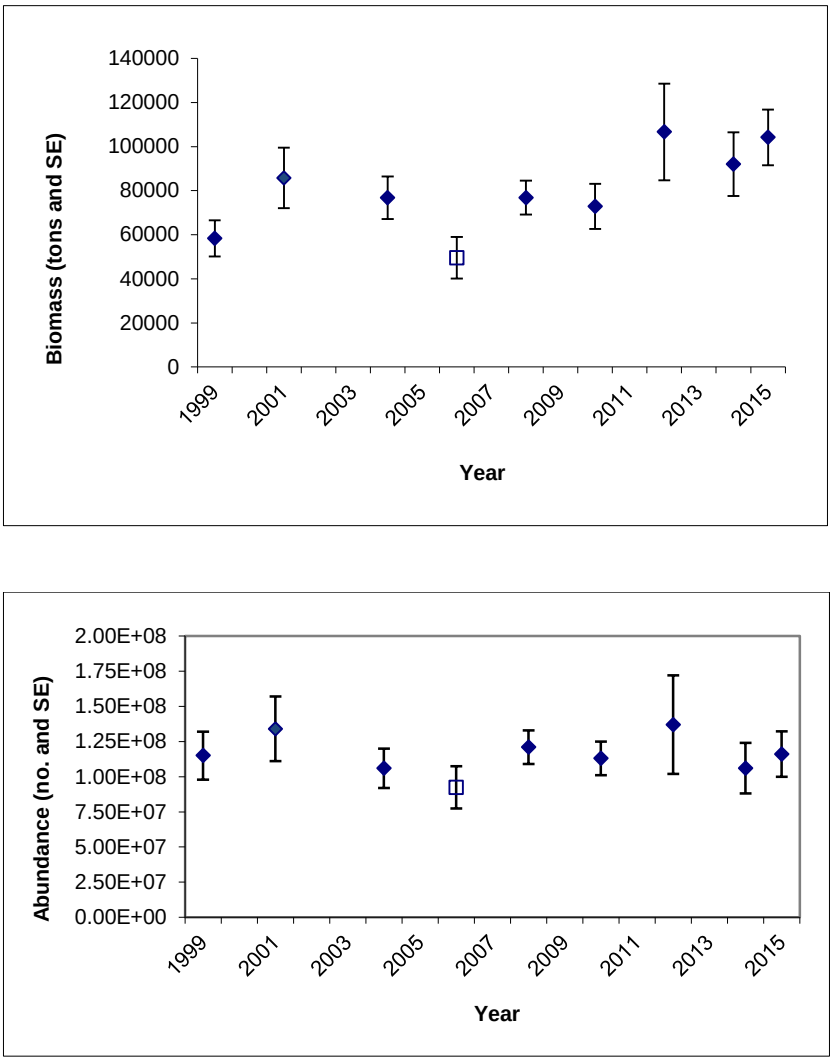
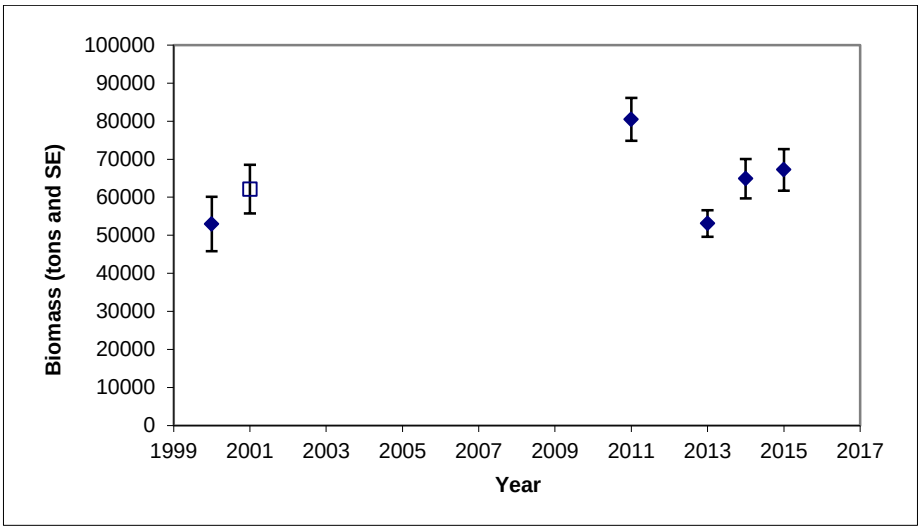


Fig. 9. Biomass (top) and abundance (bottom) estimates (with SE) for Greenland halibut in Division 0A-South. The 2006 biomass and abundance may be under-estimated due to reduced coverage in the 1200-1500 m depth strata.



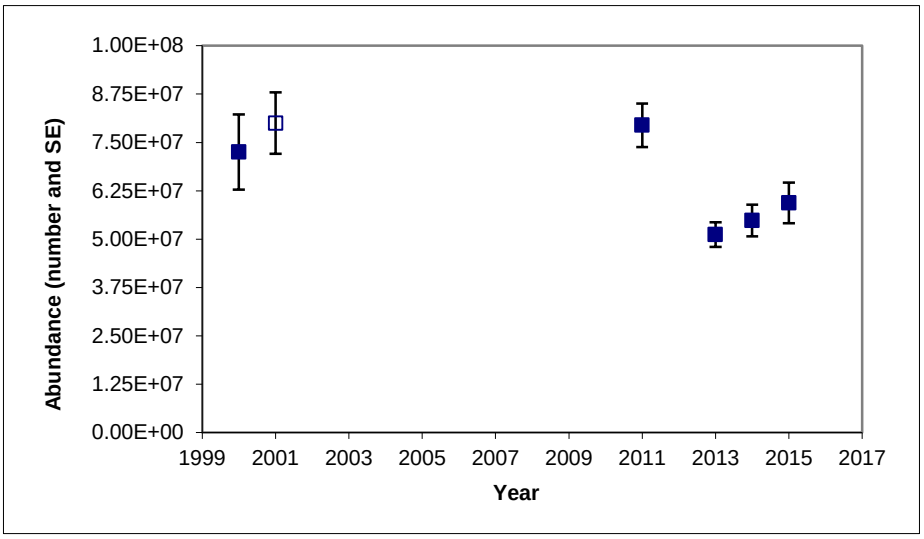


Fig. 10. Biomass (top) and abundance (bottom) estimates (with SE and linear trend line) for Greenland halibut in Division 0B. Reduced coverage in 2001particularly in sets <800 m.

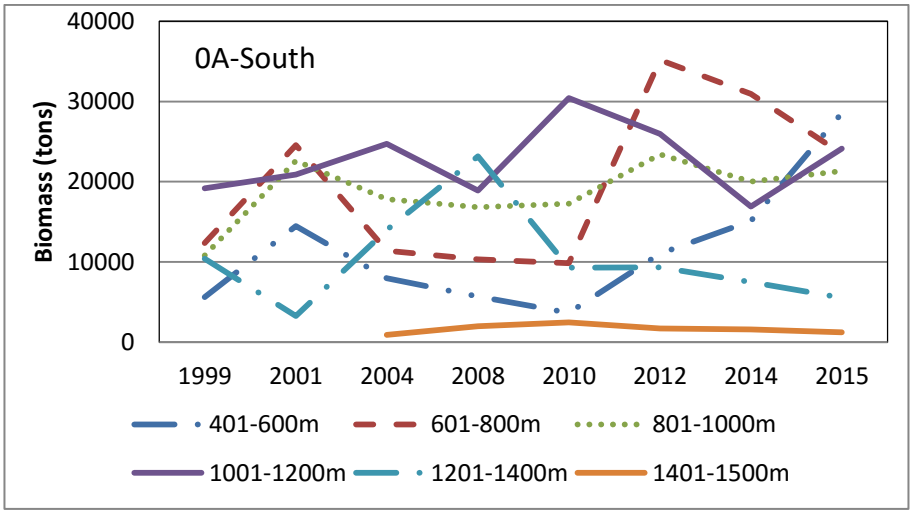


Fig. 11a. Biomass trends by depth strata for Division 0A-South.

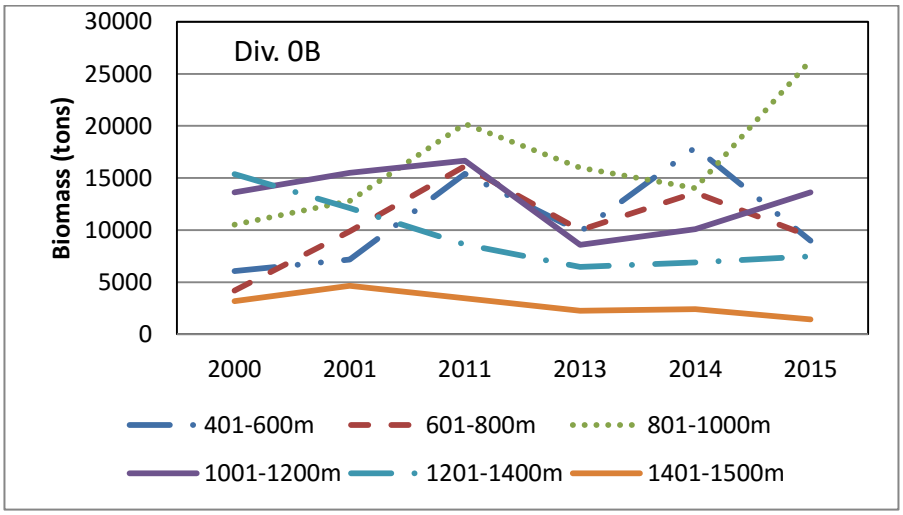


Fig. 11b. Biomass trends by depth strata for Division 0B.

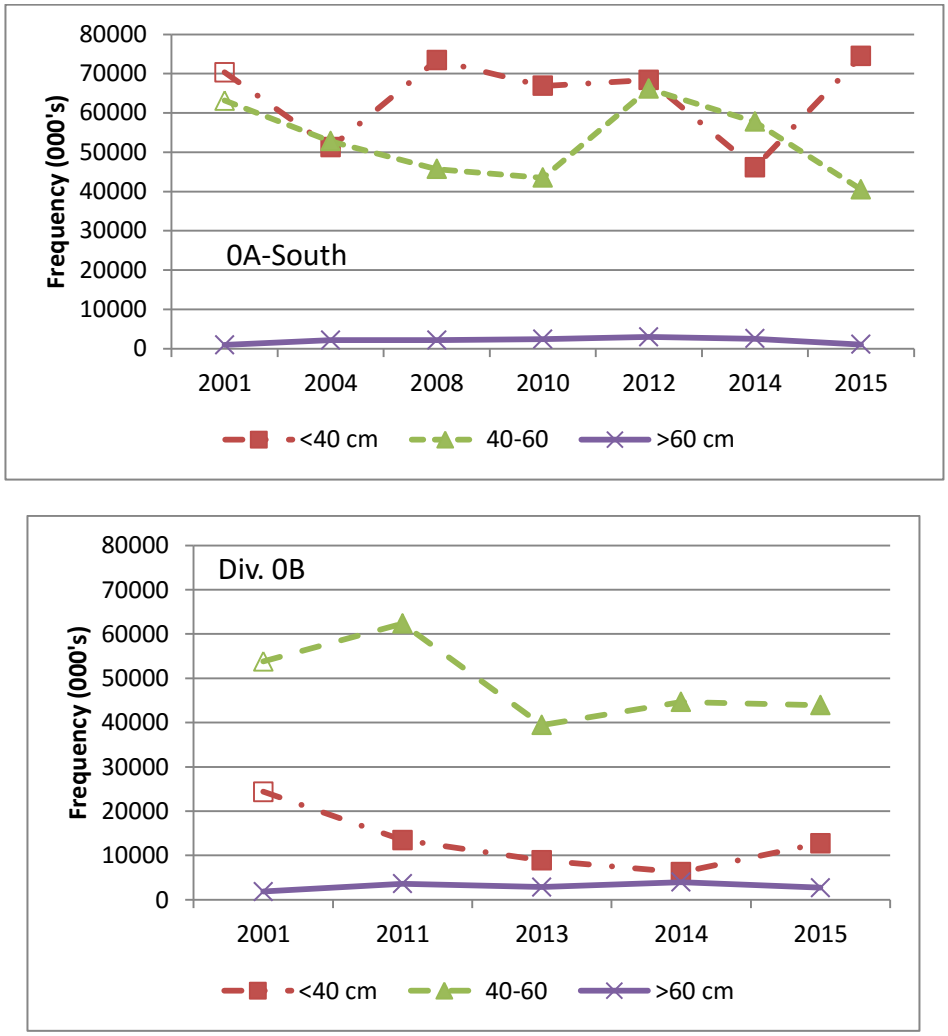


Fig.12. Abundance by size class for Divisions 0A-South (top) and 0B (bottom): <40 cm (recruitment); 40-60 cm (size range for trawl catches); >60 cm (size range for gillnet catches).

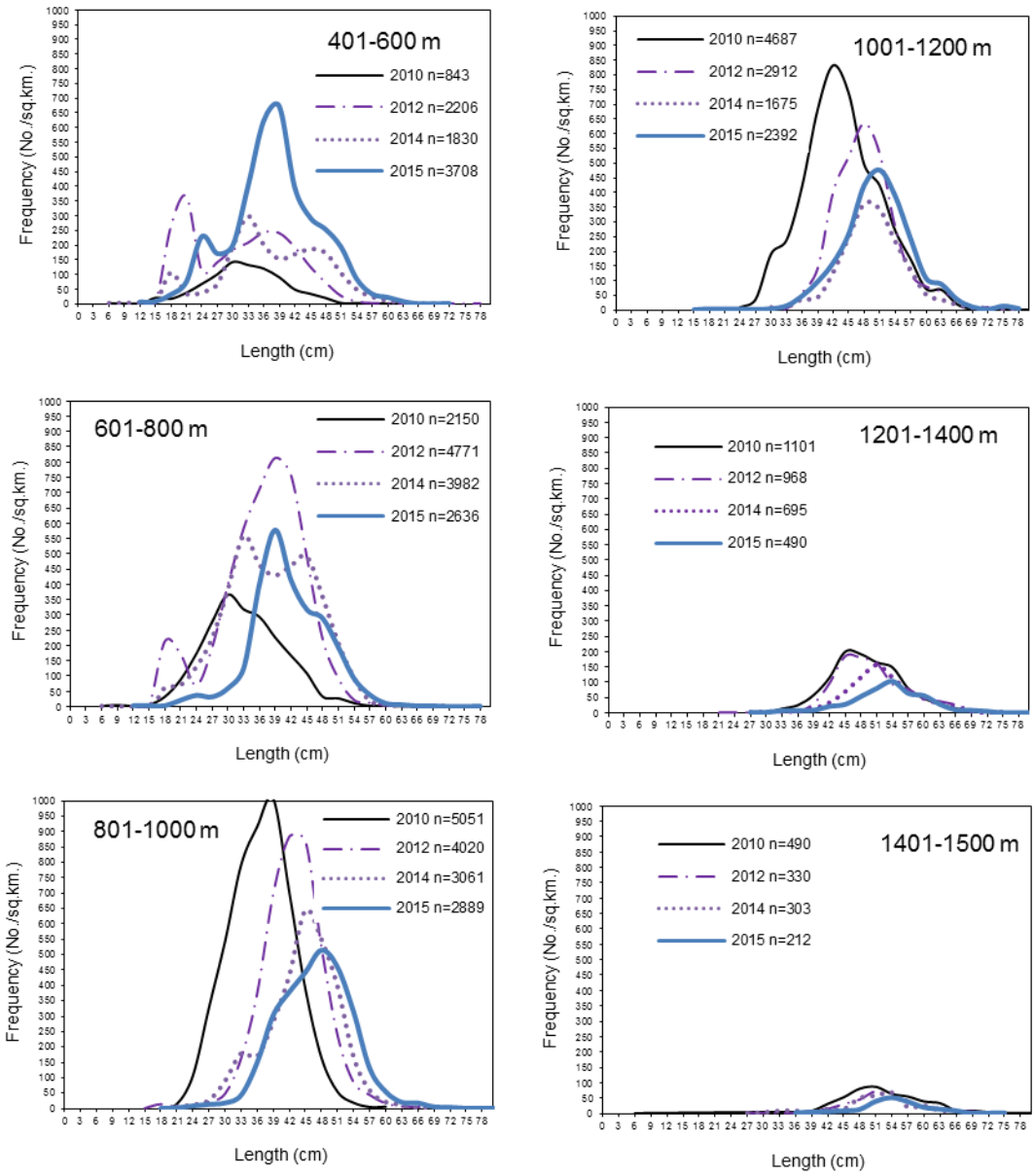


Fig.13. Greenland halibut length distribution by depth for Divisions 0A-South, 2010 to 2015. Note a very large catch (3,650 fish 2.1t) in the 600-800 m depth strata in 2012 is influencing that frequency.

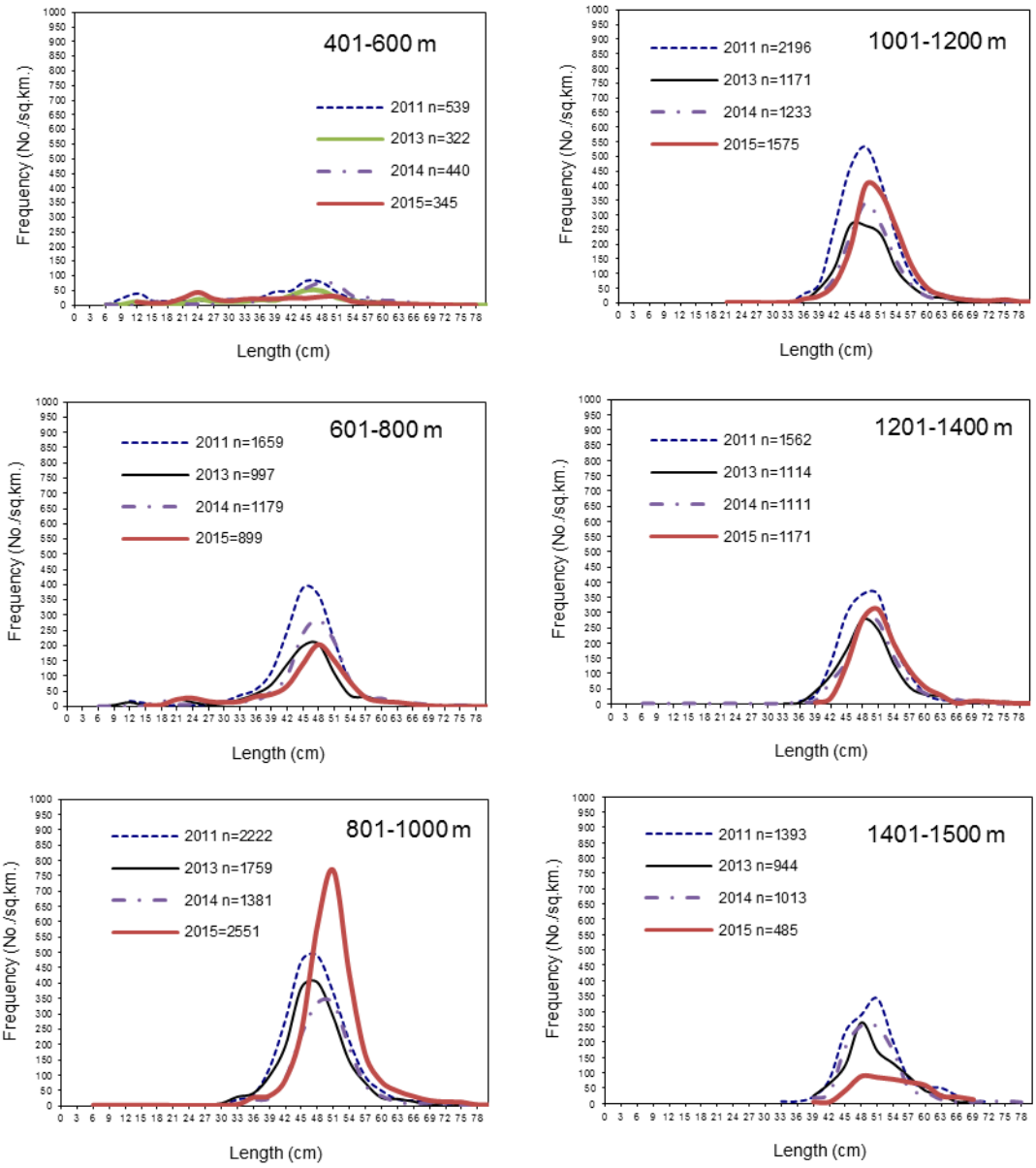


Fig. 14. Greenland halibut length distribution by depth for Divisions 0B, 2011, 2013, 2014 and 2015.

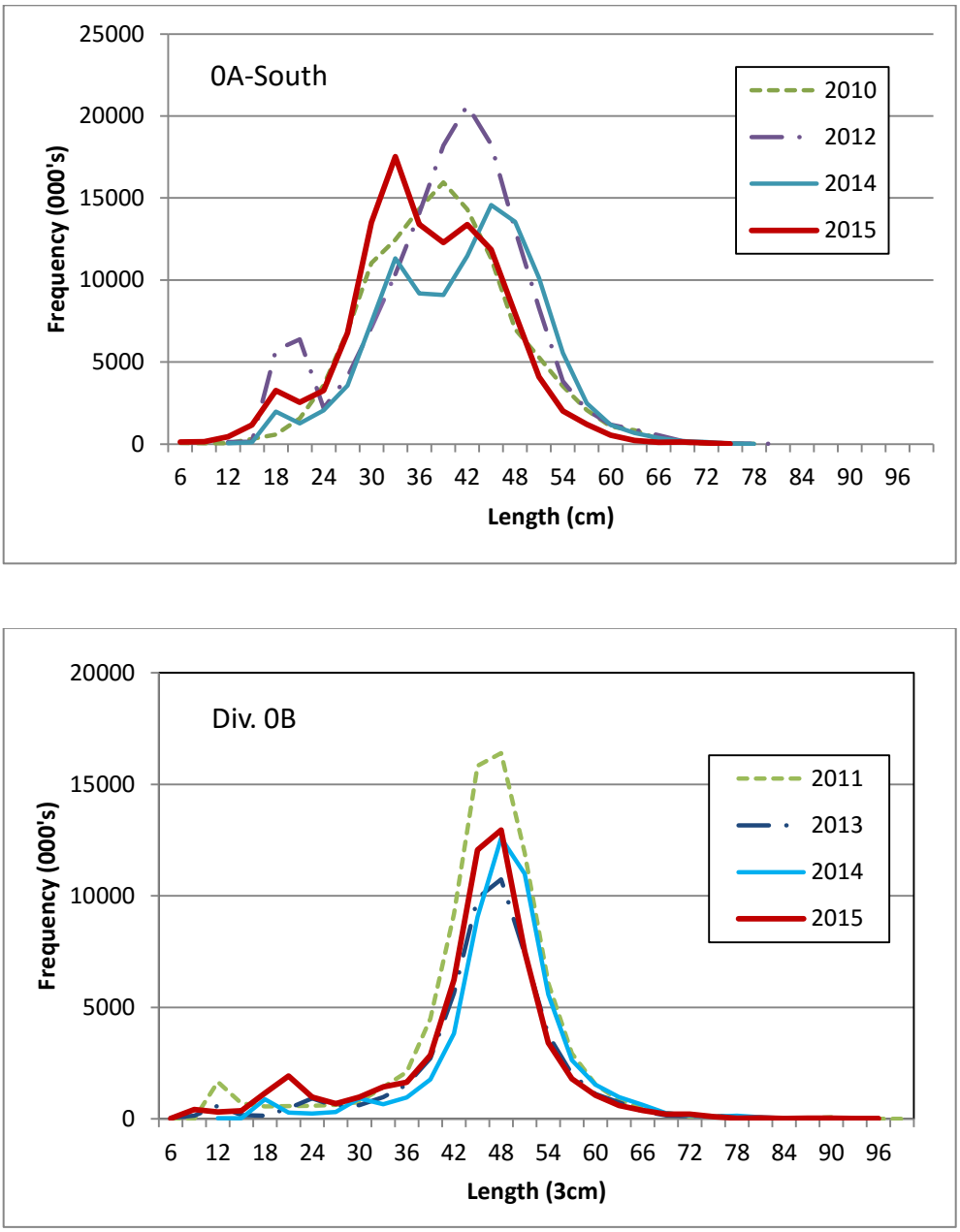


Fig.15. Abundance-at-length for Greenland halibut in Divisions 0A-South (top) and 0B (bottom), weighted by stratum area. Note: 0A 2012 is influenced by very large set from 600-800 m depth strata.

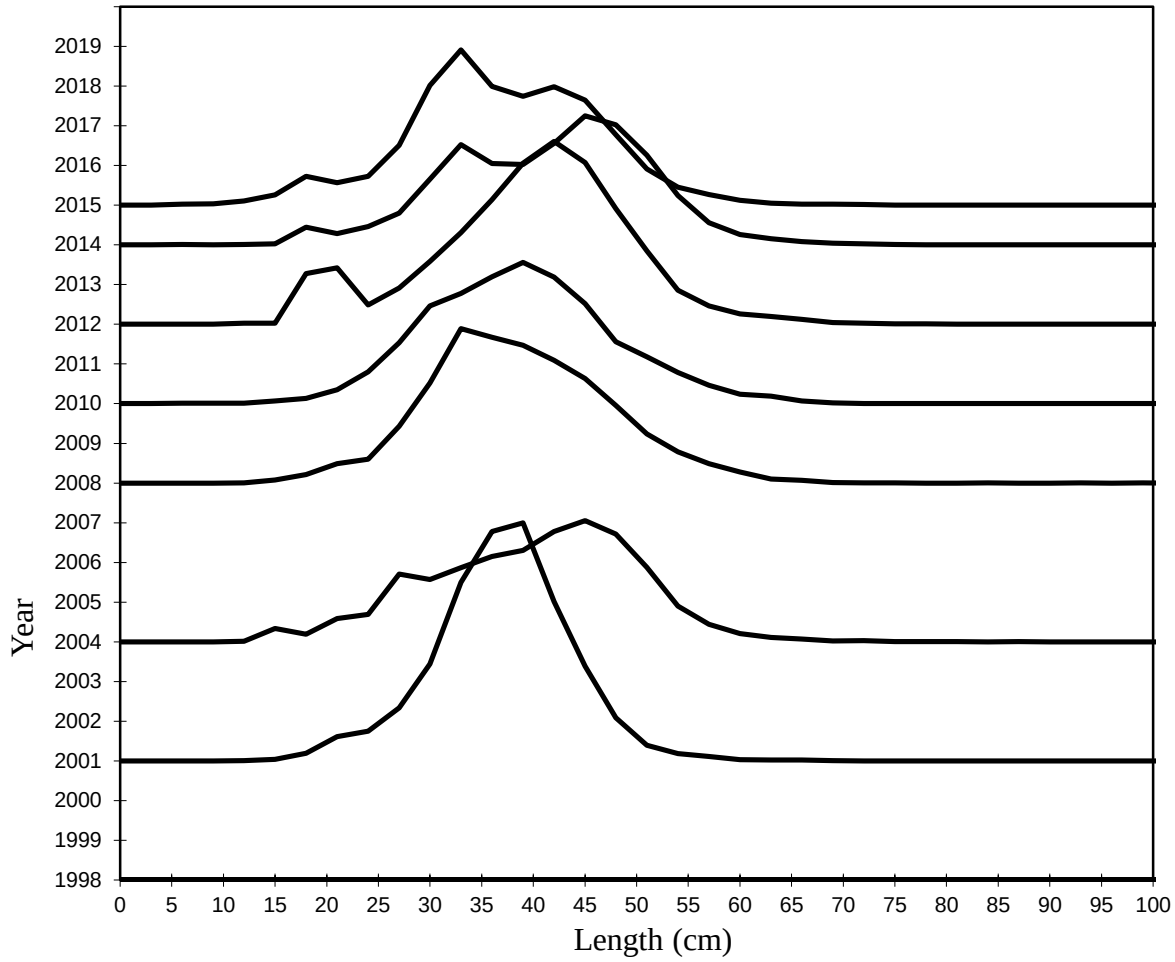


Fig. 16. Length frequency distribution for Division 0A-South 2001-2015 (numbers/km2 weighted by stratum area). Note: Frequency in 2012 is influenced by a very large set in the 600-800 m depth strata.

Appendix 1. Greenland halibut raw catch weight, numbers (not standardised to kg/km2), temperature, and depth for each set in the 2015 survey of Divisions 0A-South and 0B.

Obs	Div.	Set	Mean Depth (m)	Sweptarea (sq km)	Temp (oC)	Number	Weight (kg)
1	0A	77	552	0.09064	1.48	360	283.8
2	0A	78	449	0.08354	1.42	752	498.5
3	0A	79	827	0.08941	1.36	335	407.0
4	0A	80	930	0.08919	1.31	257	312.2
5	0A	82	523	0.06929	1.55	1272	674.5
6	0A	83	1345	0.08538	0.24	38	36.9
7	0A	84	1293	0.08123	0.35	14	26.1
8	0A	85	1084	0.08581	0.84	73	106.1
9	0A	86	1081	0.07667	1.02	646	956.6
10	0A	87	1412	0.07971	-0.03	18	26.9
11	0A	88	1462	0.08812	-0.02	12	22.5
12	0A	90	1281	0.07133	0.32	14	21.5
13	0A	91	961	0.08469	1.15	287	374.7
14	0A	92	1092	0.08445	0.96	204	339.8
15	0A	93	1302	0.08609	0.36	65	108.2
16	0A	94	1246	0.06738	0.37	84	134.4
17	0A	95	1440	0.06913	0.01	21	31.9
18	0A	96	1448	0.07852	-0.15	18	34.7
19	0A	97	1086	0.08062	0.81	299	413.7
20	0A	98	646	0.08095	1.27	231	174.0
21	0A	99	1467	0.07799	-0.08	5	9.0
22	0A	100	975	0.08390	0.93	265	299.7
23	0A	101	1370	0.08316	0	85	143.8
24	0A	102	973	0.08819	0.2	342	471.0
25	0A	103	1415	0.09034	-0.04	43	82.1
26	0A	104	1375	0.08874	0.03	40	70.8
27	0A	105	1072	0.08384	0.3	85	116.3
28	0A	106	535	0.09061	1.26	232	150.1
29	0A	107	517	0.06958	1.29	168	136.0
30	0A	108	761	0.08822	1.16	133	108.6
31	0A	110	514	0.07015	1.28	124	110.1
32	0A	111	721	0.09207	1.11	484	370.5
33	0A	113	683	0.08419	1.24	135	82.7
34	0A	114	1095	0.09018	0.81	300	334.5
35	0A	115	497	0.06289	1.4	174	121.3
36	0A	116	904	0.08544	1.13	243	227.1
37	0A	117	649	0.08130	1.3	364	268.0
38	0A	119	459	0.08284	1.36	39	29.6
39	0A	120	694	0.05472	1.43	235	205.6
40	0A	121	437	0.08376	1.37	55	41.3
41	0A	122	824	0.08447	1.28	451	412.5
42	0A	123	532	0.07206	1.42	101	88.0
43	0A	126	545	0.08324	1.29	368	265.6
44	0A	127	631	0.08125	1.24	272	205.8
45	0A	128	462	0.06788	1.44	158	70.9
46	0A	129	905	0.08329	1.19	310	307.5

47	0A	130	671	0.06095	1.53	397	310.2
48	0A	131	1448	0.08516	0.03	25	31.0
49	0A	132	1131	0.08182	0.66	74	104.0
50	0A	133	1230	0.08918	0.2	33	52.1
51	0A	134	1345	0.08969	0.11	26	40.7
52	0A	135	668	0.08769	1.53	764	584.8
53	0A	136	1064	0.08716	0.51	95	106.1
54	0A	137	1458	0.08388	-0.02	13	24.1
55	0A	138	1425	0.08068	0.01	13	21.4
56	0A	140	1464	0.09084	-0.01	7	12.3
57	0A	142	1352	0.07467	0.19	12	24.7
58	0A	144	1058	0.08993	0.87	133	136.4
59	0A	145	733	0.08543	1.49	196	182.1
60	0A	146	862	0.08706	1.4	172	157.2
61	0A	147	971	0.08409	1.31	142	134.0
62	0A	148	1293	0.08547	0.46	24	44.7
63	0A	149	1142	0.08789	0.69	62	72.6
64	0A	150	753	0.06203	1.42	33	20.7
65	0A	151	706	0.08584	1.48	34	23.0
66	0A	153	569	0.08177	2.28	40	18.0
67	0A	156	652	0.08713	1.62	40	39.8
68	0A	159	702	0.08513	1.45	30	28.7
69	0A	160	733	0.08423	1.48	62	51.5
70	0A	161	674	0.08445	1.51	61	46.9
71	0A	163	891	0.08695	1.35	88	69.3
72	0A	164	975	0.07737	1.25	80	63.4
73	0A	165	690	0.08556	1.54	65	50.1
74	0A	166	531	0.05692	1.47	232	119.6
75	0A	167	504	0.06008	1.39	112	90.4
76	0A	168	452	0.08773	1.43	243	168.7
77	0B	4	537	0.08185	1.99	34	32.8
78	0B	5	512	0.08039	1.65	41	37.4
79	0B	7	543	0.08188	1.4	121	66.3
80	0B	9	427	0.07766	1.26	116	66.7
81	0B	10	406	0.07450	1.15	46	24.6
82	0B	11	425	0.06062	1.13	30	15.6
83	0B	12	663	0.08439	1.48	174	108.9
84	0B	13	661	0.08119	1.51	57	47.5
85	0B	14	587	0.07688	1.74	29	20.9
86	0B	15	556	0.05922	1.81	11	5.8
87	0B	17	584	0.05498	2.19	4	2.7
88	0B	19	596	0.05127	2.18	13	17.6
89	0B	20	631	0.08272	2.05	22	31.9
90	0B	21	673	0.07935	2.34	29	25.3
91	0B	22	752	0.08282	3.9	101	115.9
92	0B	24	905	0.08442	3.72	285	342.7
93	0B	25	1086	0.07580	3.59	76	110.7
94	0B	26	950	0.08359	3.6	239	304.4
95	0B	27	1446	0.08502	3.58	55	78.5
96	0B	28	1063	0.08408	3.66	202	282.6

97	0B	29	1224	0.08705	3.62	81	120.1
98	0B	30	813	0.08577	3.91	150	205.1
99	0B	31	868	0.07949	3.77	137	179.4
100	0B	32	1225	0.07990	3.58	164	216.4
101	0B	33	951	0.08659	3.76	113	178.7
102	0B	34	1016	0.08107	3.72	130	175.2
103	0B	35	1158	0.08147	3.65	85	105.7
104	0B	36	1285	0.08546	3.66	114	150.5
105	0B	37	992	0.07798	3.74	148	170.1
106	0B	38	1052	0.08350	3.64	49	65.8
107	0B	39	1451	0.06168	1.26	16	26.1
108	0B	40	1471	0.07674	3.52	42	63.8
109	0B	41	1370	0.08506	3.52	45	60.8
110	0B	42	1138	0.08307	3.68	98	128.3
111	0B	43	1157	0.08214	3.71	110	147.6
112	0B	44	1286	0.08245	3.62	83	107.9
113	0B	46	548	0.07516	4.08	6	13.4
114	0B	47	830	0.08037	4.01	485	608.4
115	0B	48	546	0.07626	4.09	3	3.7
116	0B	50	474	0.08167	4.26	1	3.9
117	0B	51	490	0.05103	4.09	4	5.7
118	0B	52	559	0.07623	4.08	7	17.8
119	0B	54	583	0.06984	3.96	13	18.3
120	0B	55	405	0.06444	3.79	12	9.2
121	0B	56	431	0.07629	4.03	2	2.3
122	0B	57	422	0.06280	4.08	1	0.6
123	0B	58	441	0.07421	4.15	1	0.8
124	0B	59	438	0.07416	3.93	3	6.3
125	0B	60	542	0.08006	3.65	21	29.2
126	0B	61	502	0.08533	3.52	28	25.3
127	0B	62	662	0.08359	3.73	74	89.2
128	0B	63	848	0.08126	4.07	155	225.5
129	0B	64	670	0.05805	3.53	89	104.8
130	0B	65	428	0.08223	2.68	9	12.6
131	0B	67	1016	0.08938	3.72	310	388.7
132	0B	68	913	0.08399	3.88	215	272.2
133	0B	69	1063	0.06954	3.7	108	129.9
134	0B	70	840	0.08614	3.88	181	212.7
135	0B	71	711	0.08286	2.75	123	124.7
136	0B	72	678	0.08350	3.42	67	74.8
137	0B	73	687	0.08561	3.96	55	61.6
138	0B	74	711	0.08529	3.81	33	38.2
139	0B	76	765	0.08579	3.81	49	50.0
140	0B	169	490	0.06729	1.76	21	15.5
141	0B	170	474	0.06440	1.9	6	5.4
142	0B	172	442	0.08290	1.61	19	9.6
143	0B	173	448	0.08766	1.32	126	51.7
144	0B	174	415	0.08185	1.33	43	11.5
145	0B	175	475	0.08871	1.89	34	30.1
146	0B	177	701	0.08577	2.68	66	69.4