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Report on Greenland halibut caught during the 2016 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 2016. The 0A-South survey extended to approximately 72° N. The survey took place from October 7 to November 5, 2016. 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 81 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 1.3 °C to 0.1 °C. Bottom temperatures in 0B were warmer, 2.2 °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 females in 0A-South and 0B were immature, 95% and 81%, respectively. In 2015 80% of males in 0A-South were immature while in 2016 only 31% were immature. This change in male maturities may be influenced by the change in the timing of the survey from September to October. The proportion of mature females in 0B increased from 6% in 2013 and 2014 to 14% of the catch in 2015 and 19% in 2016. The 2016 estimate of biomass in Div. 0A-South was 135,837 t (S.E. 18,103) an increase compared to previous years and the highest in the time series. Abundance for Div. 0A-South in 2016 was estimated at 1.69×10^8 (S.E. 2.9×10^7), also an increase compared to previous years. The overall length distribution in 2016 ranged from 6 cm to 90 cm with modes observed at 21 and 42 cm. Abundance of fish <40 cm has been variable while abundance for 40-60 cm fish has increased compared to previous years. The proportion of fish <45cm declined to 62%, compared to 76% in 2015. Biomass and abundance for Div. 0B in 2016 were 87,354 t and 7.4×10^7, respectively, both greater than the 2015 estimates. Overall lengths in 2016 ranged from 6 cm to 99 cm with modes at 18 and 51 cm. 22% of fish were <45 cm, a decline compared to 2015 and similar to that observed in 2012. Abundance at length increased in the 601-800 m depth strata in both 0A and 0B and also in the 801-1000 m depth strata in 0A.

Introduction

A multi-species bottom trawl survey was carried out in the Northwest Atlantic Fisheries Organization Subarea 0 during October 7 to November 5, 2016. 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 2014. Surveys in 0B have been less frequent with surveys in 2000, 2001, 2011 and 2013 to 2015. 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 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. 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 (Table 1 and Figure 1).

In 2014 it was decided to remove stratum B1 from the 0A-South survey area, a portion of this stratum fell within a fishery closure that was partially closed to Greenland halibut fishing in 1998 to protect Narwhal over-wintering grounds and fully closed in 2006 to protect deep-water coral habitat. Sets that fell within strata B1 were removed from further analysis of surveys completed prior to 2014 (Treble 2015). In 2016 it was discovered that the area for two strata B1-8 and B2-8 had been reversed (actual value for B2-8 was 1779 km^2 not 3330 km^2), therefore, the survey area was adjusted and indexes recalculated for the full time series to correct for this error (Treble 2016). The 1400-1500 m depth strata were poorly covered in 1999, 2001 and 2006 and the area for this depth strata was removed from the survey area for those years (Table 2).

As above for 0A-South, the 2000 and 2001 surveys in 0B were re-stratified post-hoc in order to establish consistency with subsequent surveys.

The survey area between 401m and 1500 m in Div. 0A-South (to approximately 72^o N) is 47,924 km^2 and in 0B is 68,367 km^2 (Table 1 and 3).

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 to a crew member emergency and poor weather and so the oceanographic stations along the Cape Christian and Broughton Island transect lines 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). There were 81 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). Mean near-bottom temperatures were similar to previous surveys. Ranging from 0.0 ^oC to 1.4 ^oC and declining with depth for 0A-South (Table 4, Fig. 2). Bottom temperatures in 0B were warmer, 2.2 ^oC to 3.8 ^oC with the warmest temperatures at depths 800 m to 1000 m (Table 5, Fig. 2).

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

Greenland Halibut

Division 0A-South

Greenland halibut were present in all successful tows in 2016 (Fig. 3 and Appendix 1). Distribution of biomass has not changed substantially across years (Fig. 4). The number of fish caught in 0A-South varied from 12-2107 and catch weight from 18-1123 kg (8 sets had catch weight >500kg, Appendix 1). The catch was comprised of 50% males and 50% females, similar to proportions observed in 2015. A majority (95%) of females were immature. In 2015 80% of males in were immature while in 2016 only 31% were immature. This change from one year to the next in the maturity status for male Greenland Halibut may be influenced by the change in the timing of the survey from September to October.

The 2016 estimate of biomass was 135,837 t (S.E. 18,103) (Table 6) an increase over recent years and the highest in the time series (Fig. 6). Mean catch per tow standardized to km^2 was 2.83 t (Table 7). Biomass estimates across depths 801-1200m were the highest in the time series (Table 8, Fig. 8a).

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 compared to estimates in 2004 and 2008 (Table 8), therefore, the overall biomass and abundance is likely under-estimated for 2006 (Fig. 6).

Abundance in 2016 was 1.69×10^8 (S.E. 2.9×10^7) (Table 6) an increase compared to 2015 and also the highest in the time series (Table 9 and Fig. 6). Abundance of fish <40 cm has been variable while abundance for 40-60 cm fish has increased (Fig. 9).

The abundance at length for depths 401-600 m and 601-800 m have been variable with two modes shifting between 18-24 cm and 33-42 cm (Fig. 10) which may reflect growth of incoming year classes (e.g. the 2011 and 2013 year classes (Nygaard and Jørgensen 2016)). Generally, the number of fish at larger length classes increases with depth. There has been an increase in abundance of fish 30-42cm at depths 1001-1200 m in 2016 compared to previous years (Fig. 10).

The overall length distribution in 2016 ranged from 6 cm to 90 cm with modes observed at 21 and 42 cm (Table 10, Fig. 12 and 13). A trend to increased numbers of larger fish was observed from 2008 to 2014 (Fig. 13). In 2015 the distribution had shifted left with increased numbers at smaller sizes (e.g. 18-36 cm) but in 2016 the

distribution has shifted right and is more comparable to length frequencies observed in 2012 and 2014 (Fig. 12). The proportion of fish <45cm declined to 62%, compared to 76% in 2014 (Table 10).

Division 0B

Greenland halibut were present in all successful tows in 2016 (Fig. 5 and Appendix 1). Distribution of biomass has not changed substantially across years (Fig. 5). The number of fish caught varied from 7-360 and catch weight from 8 kg to 475 kg (Appendix 1). The catch was comprised of 71% males and 29% females, similar proportions to 2015. A majority of the males (98%) were mature. while a majority of females were immature (81%). The proportion of mature females in 0B increased from 6% in 2013 and 2014 to 14% of the catch in 2015 and 19% in 2016. The 2016 biomass was 87,354 t (S.E. 5,134), an increase over previous estimates and the highest in the time series (Table 8 and Figure 6). Mean catch per tow standardized to km^2 was 1.28 t (Table 7). Biomass was greater at depths 401-800 m compared to previous estimates (Table 8, Fig. 8b).

The 2016 abundance index was estimated at 7.4×10^7 (S.E. 4.0×10^6) (Table 6). This is an increase over 2013-2015 estimates but slightly lower than the 2011 (7.9×10^7) and 2001 (8.0×10^7) estimates (Table 9, Fig. 7). The abundance of fish <40 cm and 40-60 cm have varied without trend across the time series (Fig. 9).

Overall lengths in 2016 ranged from 6 cm to 99 cm with modes at 18 and 51 cm, an increase over previous peak modes of 45 and 48 cm (Table 11, Figure 12). Percent of fish <45 cm declined to 21.5% from 32% in 2015 (Table 11). There are fewer fish at depths 401-800 m in 0B than in 0A-South and the abundance at length is more stable across most depth strata (Fig. 11). In 2016 there was a slight shift to larger fish in the deepest depth strata (1401-1500 m).

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.

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Table 1. Stratification scheme for Division 0A-South.

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 (km^2)	1999	2001	2004	2006	2008	2010	2012	2014	2015	2016
A1-4	400-600	2152	4	0	6	4	3	3	3	3	3	3
A2-4	400-600	4649	2	3	1	6	6	6	6	4	5	6
A3-4	400-600	785	3	0	0	2	2	2	2	2	2	1
A4-4	400-600	1922	0	2	0	0	3	3	3	2	3	3
B2-4	400-600	2519	2	0	1	2	3	3	2	6	3	3
		12027	11	5	8	14	17	17	16	17	16	16
A1-5	600-800	795	3	2	1	3	2	2	2	2	2	2
A2-5	600-800	2250	0	3	1	3	3	3	3	3	3	3
A3-5	600-800	760	1	1	1	2	2	2	2	2	2	2
A4-5	600-800	2483	1	1	3	0	1	3	3	3	3	3
B2-5	600-800	5108	7	6	5	8	7	7	7	8	7	7
		11396	12	13	11	16	15	17	17	18	17	17
A1-6	800-1000	604	1	1	1	2	2	2	2	1	2	2
A2-6	800-1000	1145	2	0	1	2	2	2	2	2	2	2
A3-6	800-1000	1020	3	2	3	1	2	2	2	2	2	2
A4-6	800-1000	1376	1	1	2	0	1	2	2	3	2	2
B2-6	800-1000	2656	4	3	5	1	4	4	4	6	4	4
		6801	11	7	12	6	11	12	12	14	12	12
A1-7	1000-1200	745	2	0	1	1	2	2	2	1	2	2
A2-7	1000-1200	1873	3	2	2	5	2	2	2	4	2	2
A3-7	1000-1200	1307	2	0	4	0	2	2	2	2	2	2
A4-7	1000-1200	1636	0	0	0	0	2	2	2	3	2	2
B2-7	1000-1200	1789	2	3	3	0	2	2	2	4	2	2
		7349	9	5	10	6	10	10	10	14	10	10
A1-8	1200-1400	813	2	3	1	0	2	2	2	2	2	2
A2-8	1200-1400	2151	3	4	4	3	3	3	3	4	3	3
A3-8	1200-1400	1146	2	0	2	0	2	2	2	2	2	2
A4-8	1200-1400	1072	1	0	4	0	2	2	2	2	2	2
B2-8	1200-1400	1779	2	2	1	0	4	2	2	2	2	2
		6961	10	9	12	3	13	11	11	12	11	11
A1-9	1400-1500	498	0	0	0	0	2	2	2	2	2	2
A2-9	1400-1500	1153	0	0	1	1	2	2	2	2	2	2
A3-9	1400-1500	684	0	0	0	0	2	2	2	2	2	2
A4-9	1400-1500	710	0	0	0	0	0	2	2	2	2	2
B2-9	1400-1500	346	1	0	1	0	2	2	1	0	2	2
		3390	1	0	2	1	8	10	9	8	10	10
Total		47924	54	39	55	46	74	77	75	83	76	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	2016
D4-1	400-600	17396.93	23	9	7	17	16	6	14	15
D4-2	400-600	19276.73	26	15	4	22	24	9	16	23
D5-1	600-800	2282.96	3	6	3	3	3	2	2	3
D5-2	600-800	8052.15	11	7	3	13	12	12	11	11
D6-1	800-1000	8053	11	13	8	11	11	11	10	11
D7-1	1000-1200	6586	9	8	6	9	9	9	9	9
D8-1	1200-1400	4754	6	3	2	6	6	6	5	6
D9-1	1400-1500	1965	3	3	3	3	3	3	3	3
Totals		68367	92	64	36	84	84	58	70	81

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)
2016	1.3 (.08)	1.2 (0.09)	0.8 (0.07)	0.6 (0.06)	0.3 (0.05)	0.1 (0.04)

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)
2016	2.2 (0.07)	2.8 (0.22)	3.8 (0.03)	3.7 (0.02)	3.6 (0.01)	3.5 (0.02)

Table 6. Greenland halibut biomass, abundance with standard error by stratum for the Subarea 0 survey, 2016.

Div.	Stratum (m)	Mean Biomass (t/sq km)	Biomass (tons)	SE	Mean Abundance (#/sq km)	Abundance	SE
0B	401-600	0.569	20866	2568	570	2.1E+07	2.3E+06
	601-800	1.721	17788	2039	1669	1.7E+07	1.4E+06
	801-1000	2.858	23015	3267	2114	1.7E+07	2.4E+06
	1001-1200	2.237	14730	1746	1654	1.1E+07	1.3E+06
	1201-1400	1.762	8376	1221	1368	6.5E+06	1.1E+06
	1401-1500	1.313	2579	87	909	1.8E+06	9.0E+04
	Overall	1.278	87354	5134	1088	7.4E+07	4.0E+06
0A-South	401-600	1.740	20923	7432	3353	4.03E+07	1.7E+07
	601-800	2.842	32388	10839	4593	5.23E+07	2.1E+07
	801-1000	4.770	32442	8092	5356	3.64E+07	9.4E+06
	1001-1200	4.748	34891	8180	3890	2.86E+07	6.6E+06
	1201-1400	1.843	12826	4744	1365	9.50E+06	3.9E+06
	1401-1500	0.698	2368	367	432	1.46E+06	2.6E+05
	Overall	2.834	135837	18103	3520	1.69E+08	2.9E+07

Table 7. Mean catch per tow (tons) standardized to km2 of Greenland Halibut from SA0, Divisions 0B and 0A-South during the period 1999-2016.

Division	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015	2016
0B		0.77	0.91					1.18		0.78	0.95	0.98	1.28
0A-South	1.31		1.93	1.60	1.11	1.60	1.52		2.22		1.92	2.17	2.83

Table 8. Biomass (tons) of Greenland Halibut by depth stratum from SA0, Divisions 0B and 0A-South during the period 1999-2016.

Division	Depth Strata (m)	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015	2016
0B	401-600		6055	7184					15411		9844	17908	8978	20866
	601-800		4186	9883					16150		9992	13579	9388	17788
	801-1000		10531	12789					20185		15981	14005	26290	23015
	1001-1200		13630	15498					16649		8588	10090	13628	14730
	1201-1400		15377	12129					8618		6462	6880	7485	8376
	1401-1500		3171	4659					3463		2240	2411	1426	2579
	Overall		52951	62142					80476		53109	64873	67194	87354
0A-South	401-600	5596		14481	7979	3367	5684	3655		11042		15095	28559	20923
	601-800	12349		24551	11397	6253	10312	9835		35158		30952	23468	32388
	801-1000	10799		22621	17810	7471	16798	17271		23405		20023	21330	32442
	1001-1200	19162		20868	24712	27070	18876	30412		25970		16905	24100	34891
	1201-1400	10414		3249	13997	5410	23155	9285		9327		7484	5520	12826
	1401-1500				908	0	1970	2453		1717		1565	1210	2368
	Overall	58320		85769	76802	49571	76794	72911		106619		92024	104187	135837

Table 9. Abundance 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	2016
0B	401-600		16925	15670					19779		11817	16154	12651	20903
	601-800		6570	14338					17146		10309	12182	9294	17252
	801-1000		13330	15361					17891		14167	11125	20544	17021
	1001-1200		15685	17086					14462		7709	8120	10376	10893
	1201-1400		17158	13023					7423		5297	5282	5565	6501
	1401-1500		2839	4559					2737		1855	1991	952	1786
	Overall		72507	80037					79438		51154	54854	59382	74356
0A-South	401-600	17207		22540	23372	13442	15900	10134		26533		22008	44598	40330
	601-800	33792		51821	23016	17839	23730	24497		54365		45381	30043	52336
	801-1000	24233		27888	23360	15753	30033	34352		27343		20819	19645	36423
	1001-1200	30329		28836	25583	40264	27710	34445		21397		12308	17576	28588
	1201-1400	9540		3300	10100	5210	22300	7670		6740		4840	3411	9500
	1401-1500	0		0	660	0	1563	1661		1120		1027	719	1463
	Overall	115101		134385	106091	92508	121236	112759		137498		106383	115992	168640

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	2016
6				57		48	118	9
9	10			55			145	9
12		69	8	42	130	48	454	27
15	33	1518	338	319	133	108	1163	38
18	204	865	949	586	5717	**1983**	**3263**	2527
21	887	2628	2181	1566	**6388**	1261	2544	**5107**
24	2741	3108	2703	3592	2192	2052	3261	2659
27	3360	7647	6419	6897	4105	3570	6771	6052
30	6014	7036	11312	11026	7102	7424	13511	9338
33	10961	8369	**17461**	12460	10345	**11324**	**17526**	11016
36	20188	9658	16467	14320	14054	9177	13403	14785
39	**25928**	10321	15574	**15958**	18210	9088	12285	23757
42	26912	12462	13859	14302	**20637**	11461	**13381**	**29326**
45	18027	**13697**	11816	11300	18256	**14580**	11856	21642
48	10721	12176	8765	6999	13052	13558	7954	15514
51	4892	8418	5548	5279	8284	10131	4089	10106
54	1762	4036	3529	3532	3835	5553	2020	7865
57	834	1988	2180	2079	2074	2483	1202	4258
60	503	937	1234	1074	1175	1167	535	2220
63	169	509	459	848	876	675	213	1256
66	105	306	314	290	544	365	103	666
69	103	103	61	80	186	172	124	238
72	28	125	24	24	110	122	59	167
75		41	16	24	36	30	6	22
78		51		15	31	6		
81		20			17		7	
84	19	6	15	17				13
87		26						4
90		7			10			26
93			9					
96		6						
99			9	12				
Total	134402	106134	121249	112755	137498	106384	115992	168646
Total <45 cm	97239	63682	87270	81180	89013	57544	87826	104650
% <45 cm	72.35	60.00	71.98	72.00	64.74	54.09	75.72	62.05

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	2016
6	142	14	37	165	20	140
9	217	0	141		423	8
12	0	**1657**	**589**	29	302	108
15	47	703	164	25	368	154
18	241	554	141	**873**	1153	**1364**
21	740	565	480	279	**1915**	945
24	**1712**	586	923	231	977	614
27	1373	629	559	310	677	1021
30	2416	750	616	917	981	1223
33	3315	1423	970	653	1438	1202
36	4476	2095	1533	965	1636	1546
39	9689	4496	2715	1769	2849	2541
42	15038	9178	5636	3832	6230	5123
45	**17875**	15831	9905	9050	12058	9860
48	11086	**16391**	**10744**	**12587**	**12942**	15399
51	6013	11925	7397	10990	7492	**15880**
54	2387	6099	3761	5580	3404	8710
57	1429	2936	2005	2628	1793	3674
60	703	1546	1120	1538	1064	1910
63	478	828	739	976	598	936
66	197	460	340	632	371	737
69	213	272	154	252	213	377
72	142	118	124	155	211	267
75	14	143	141	95	98	209
78	22	54	72	138	31	143
81	26	62	42	68	41	64
84	8	29	45	35	19	49
87	8	31	23	27	29	46
90	0	64	30	44	28	49
93	0	0	9		9	37
96	29	0			11	
99	0	0				17
Total	80037	79439	51153	54844	59382	74356
Total <45 cm	39407	22651	14504	10050	18969	15991
% <45 cm	49.24	28.51	28.35	18.32	31.94	21.51

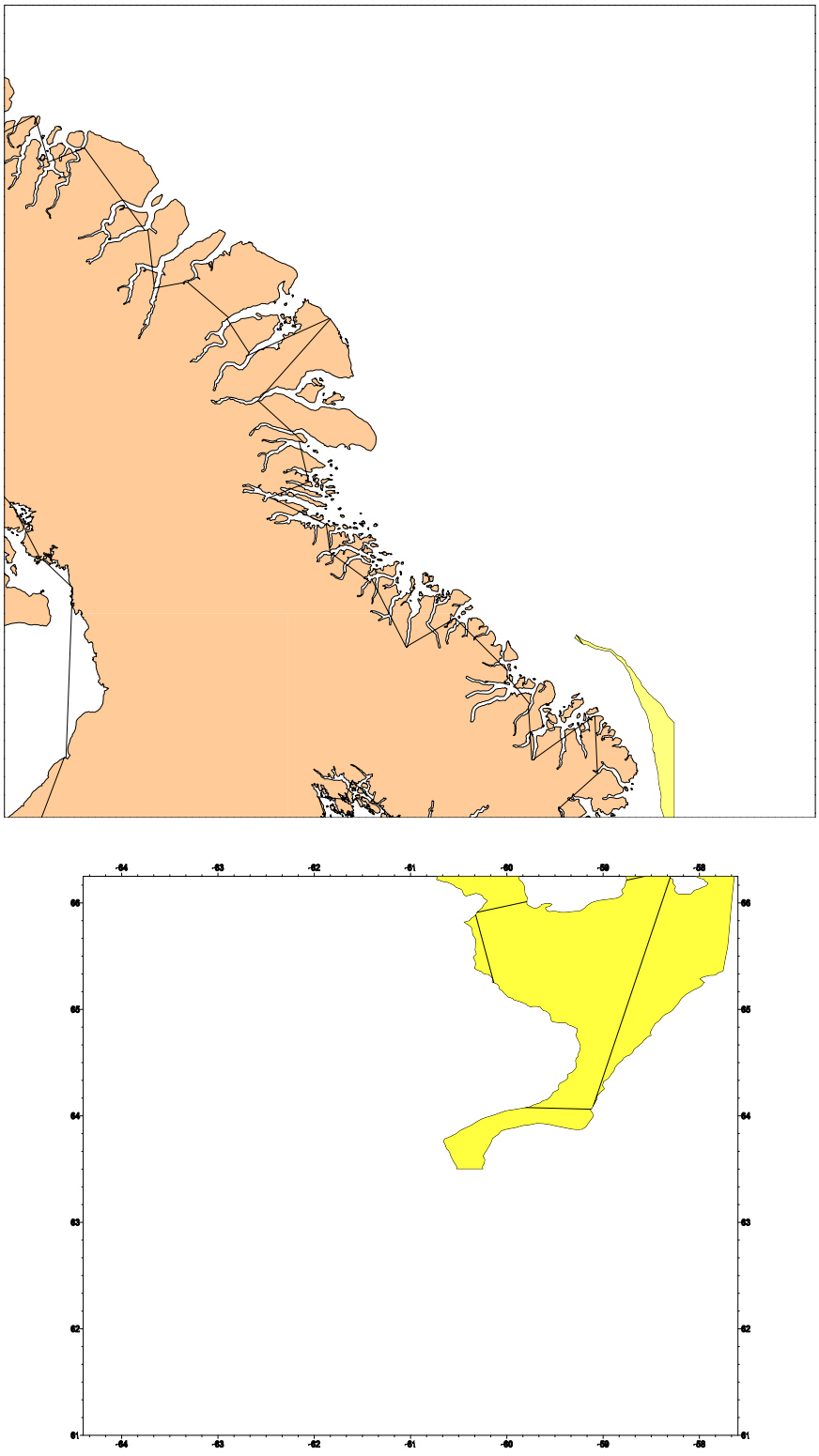
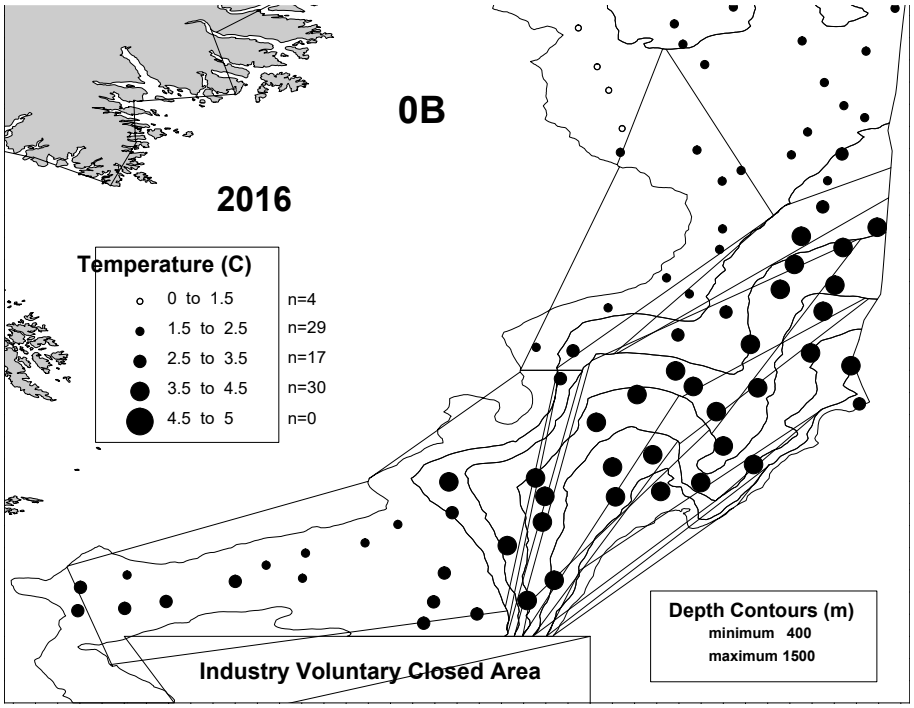


Fig. 1. Stratification scheme for Division 0A-South, 66° N to 72° N (top) and 0B, 72° N to 76° N (bottom).



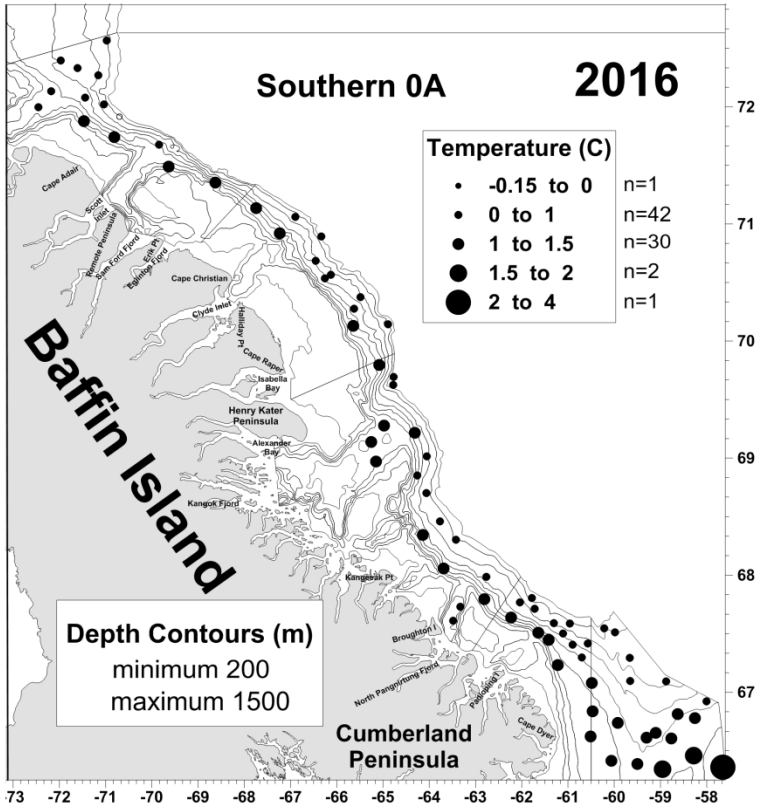


Fig. 2. Bottom temperatures during 2016 survey in Div. 0B (top) and 0A (bottom).

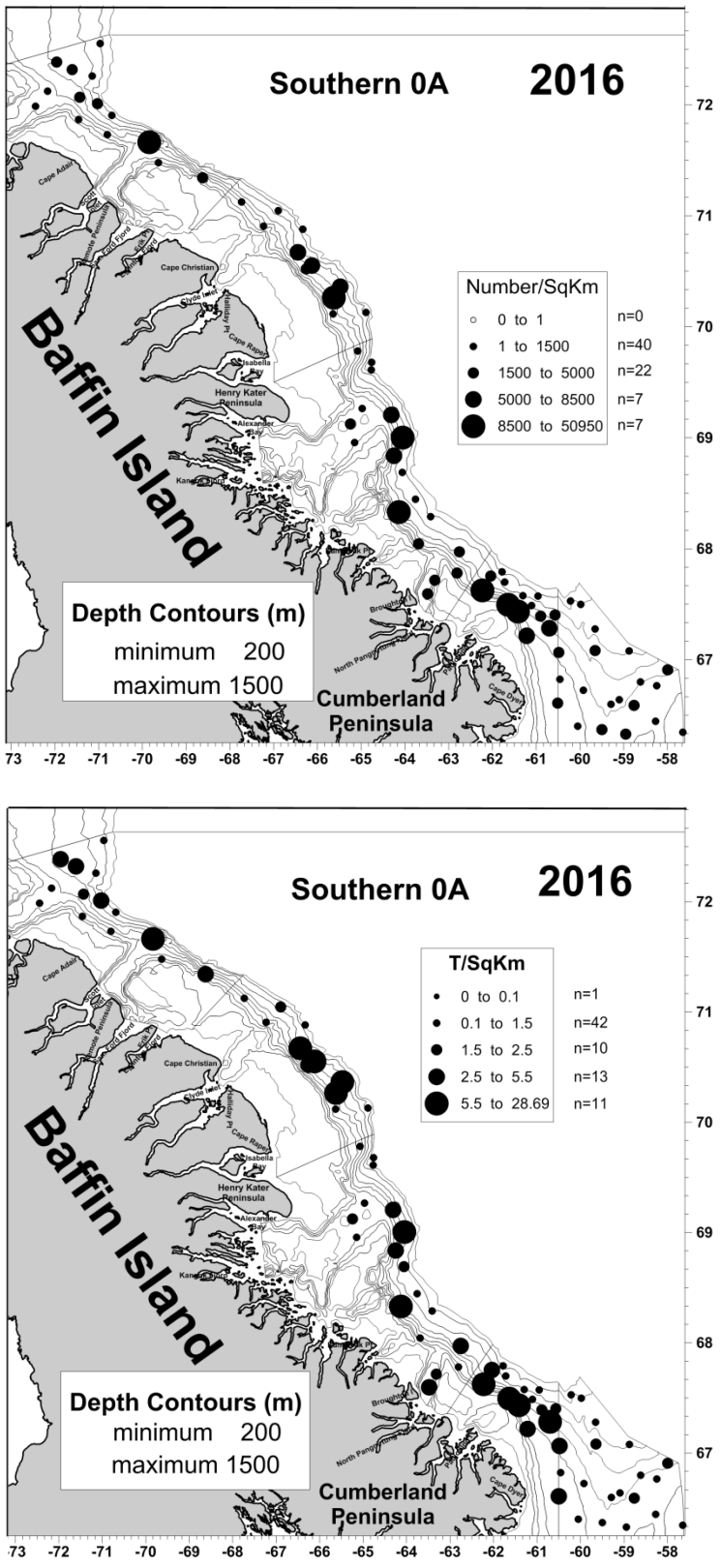


Fig. 3. Biomass (top) and abundance (bottom) distribution for Greenland halibut in Division 0A, 2016.

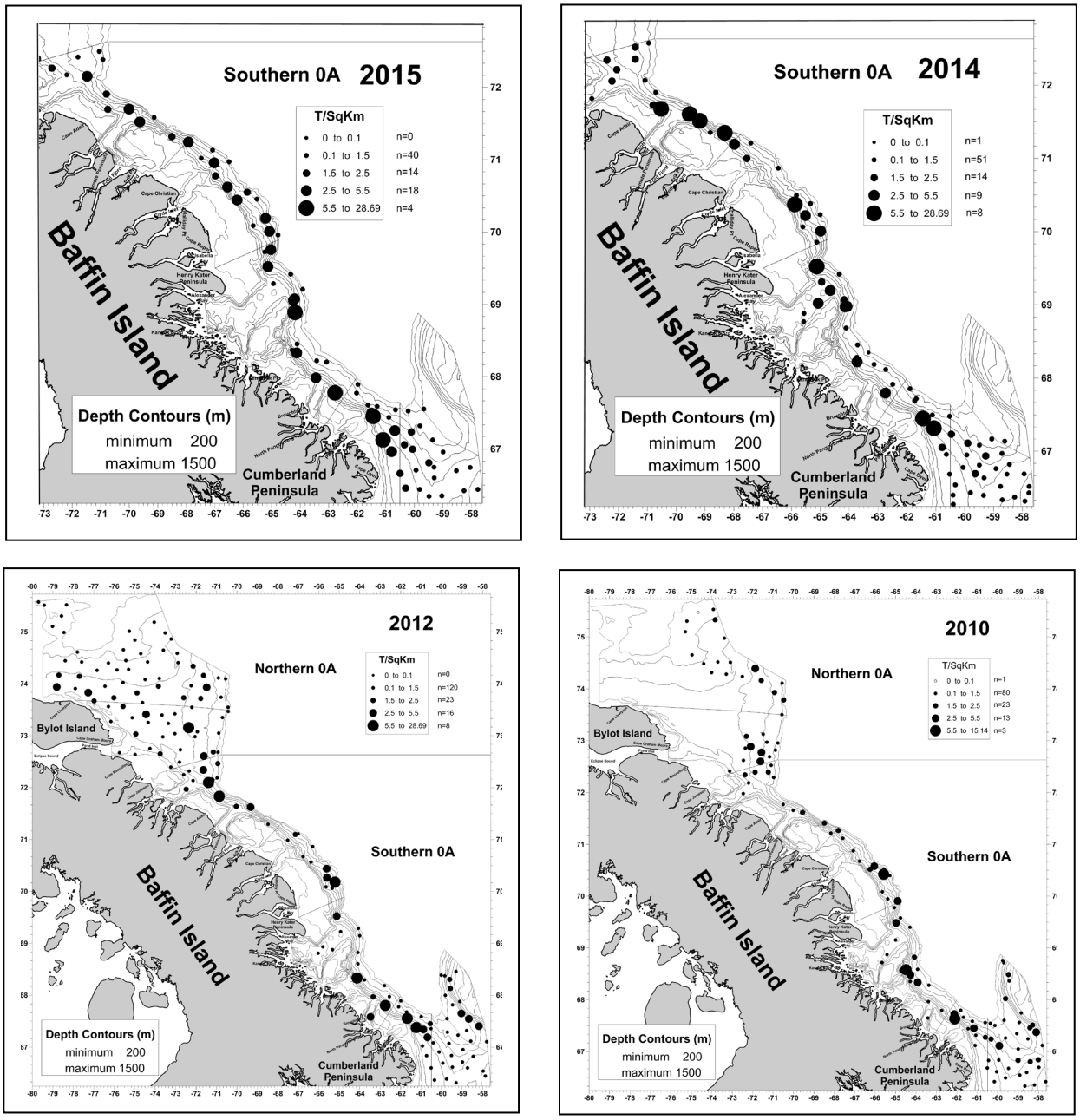
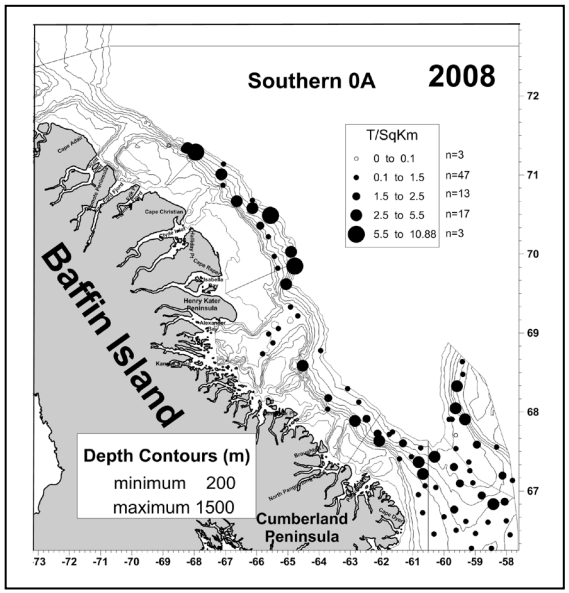
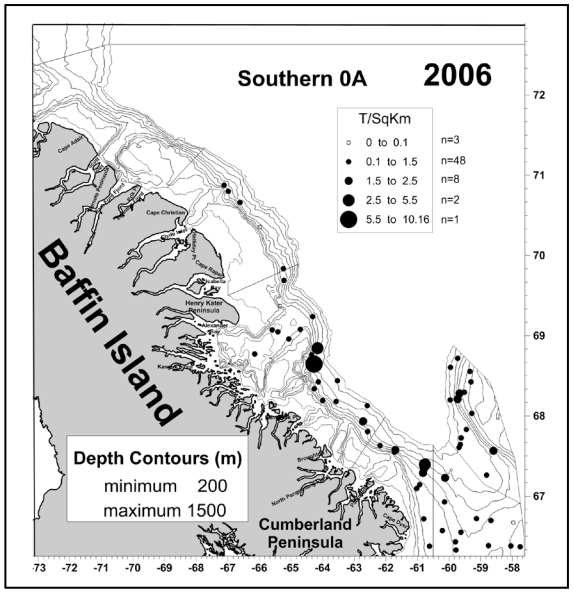
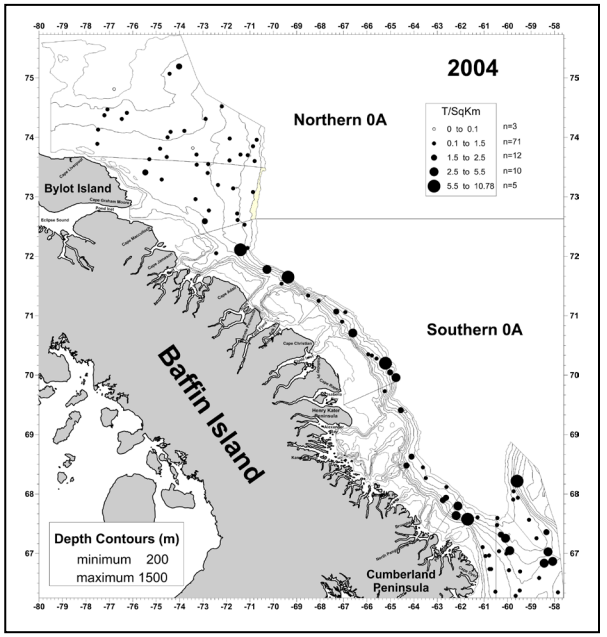
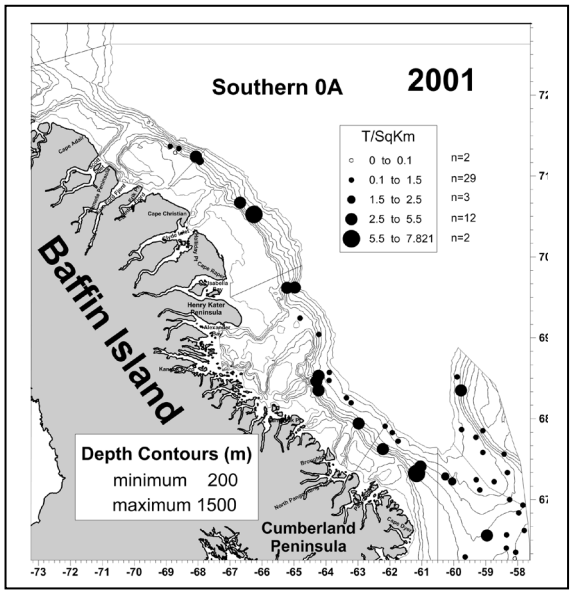


Fig. 4. Biomass distribution (t/sq km) for Greenland halibut in Division 0A, 1999 to 2015.


Southern 0A
2008
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
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula


Southern 0A
2006
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
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula


2004
Northern 0A
Bylot Island
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
Southern 0A
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula


Southern 0A
2001
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
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula

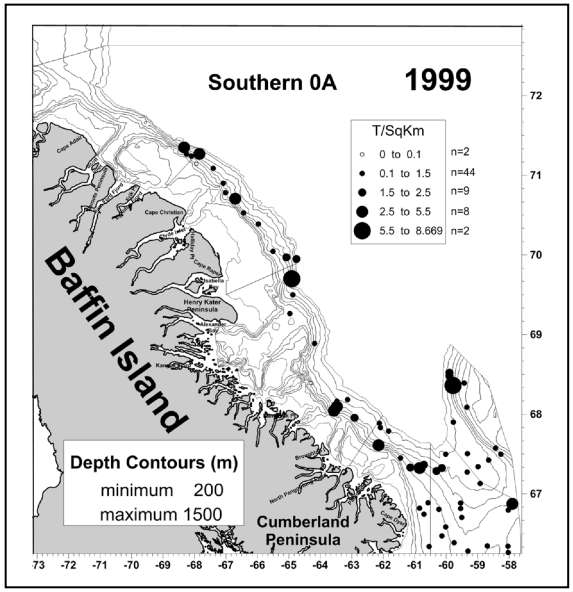

Southern 0A
1999
T/SqKm
0 to 0.1 n=2
0.1 to 1.5 n=44
1.5 to 2.5 n=9
2.5 to 5.5 n=8
5.5 to 8.669 n=2
Baffin Island
Depth Contours (m)
minimum 200
maximum 1500
Cumberland Peninsula

Fig.4 (Con't).

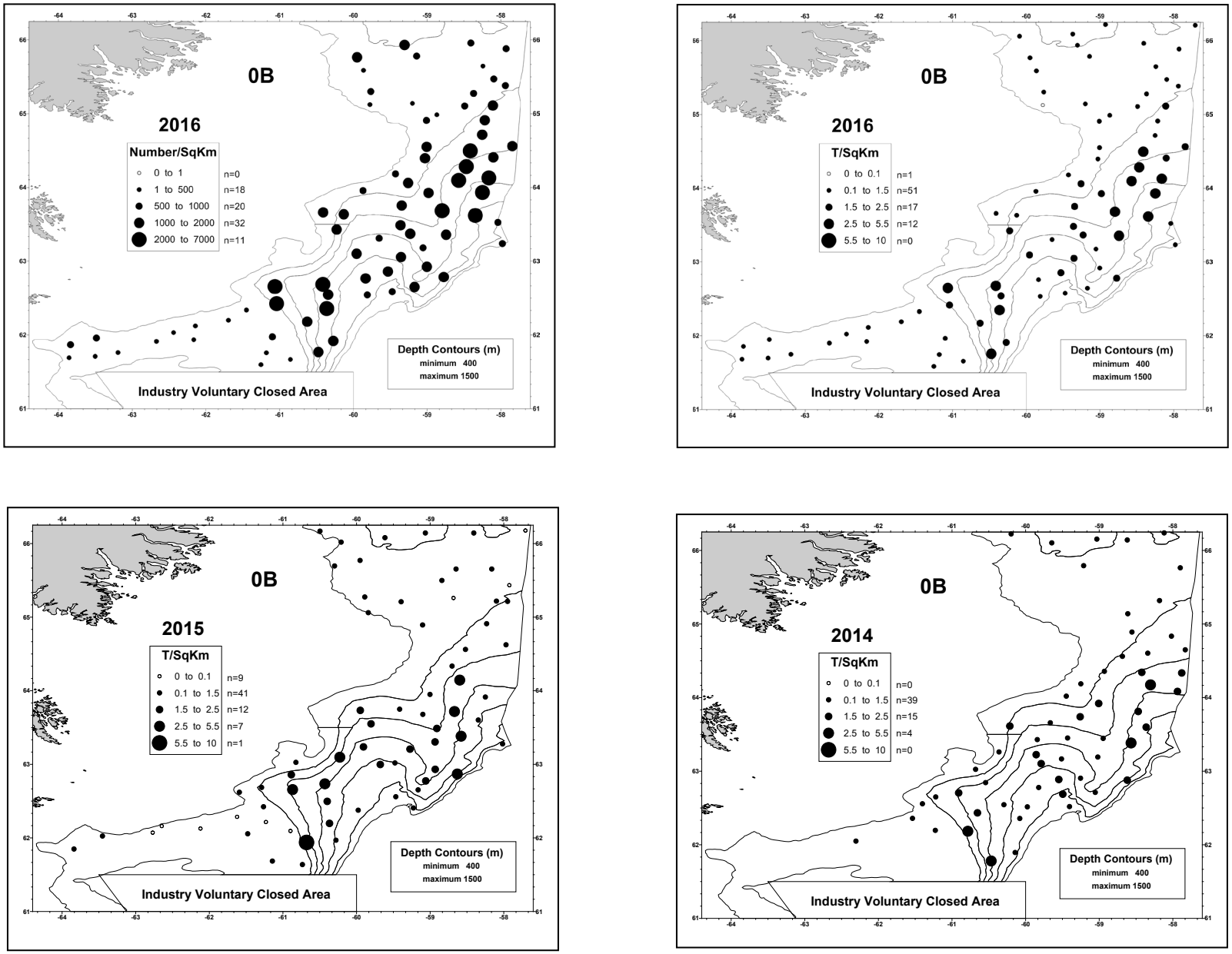


Fig. 5. Biomass (t/sq km) and abundance distribution for Greenland halibut in Division 0B 2016 (top); and biomass for 2014 and 2015 (bottom).

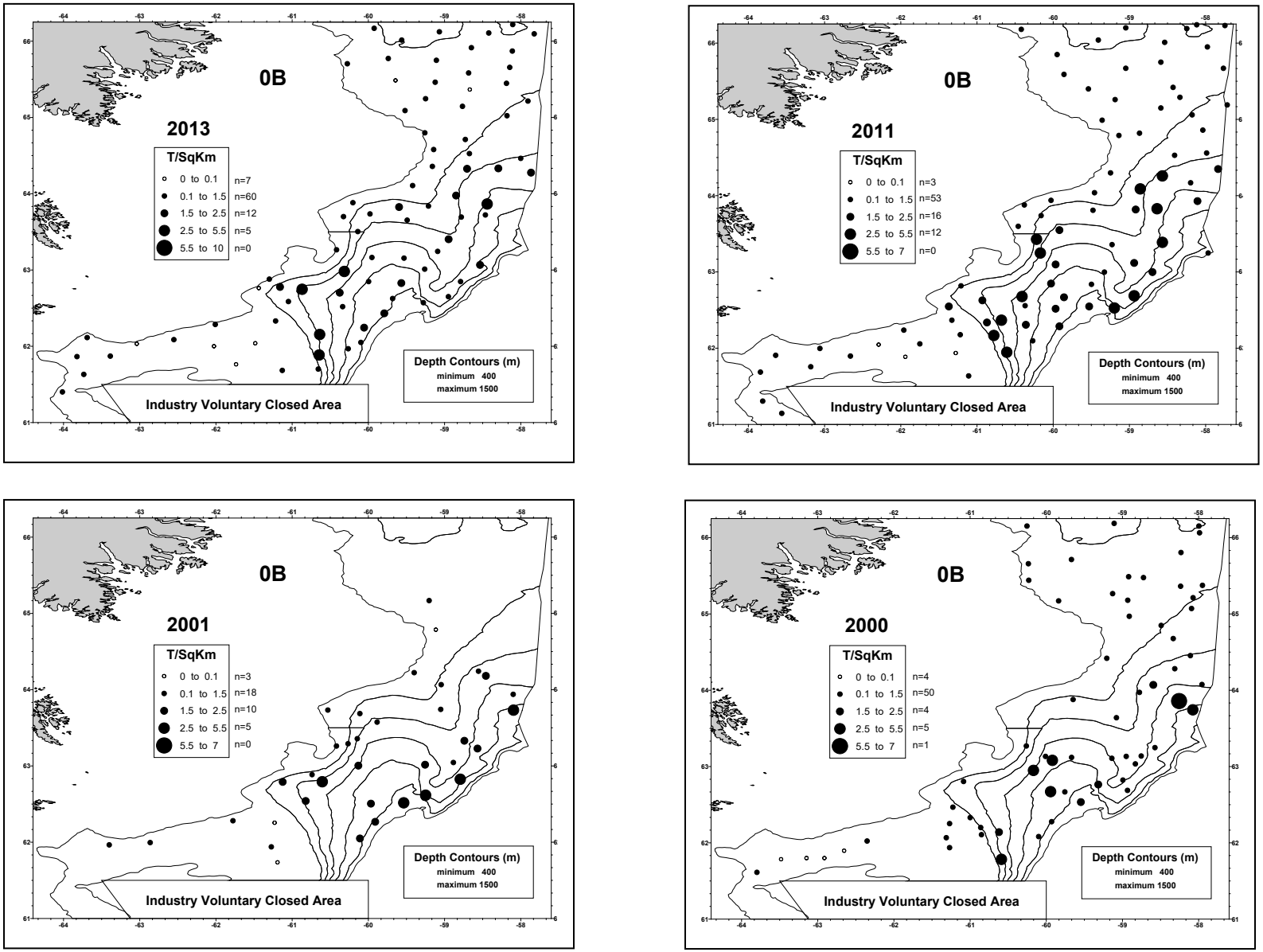


Fig. 5. (Con't). Biomass distribution (t/sq km) for Greenland Halibut in Division 0B for 2000, 2001, 2011 and 2013.

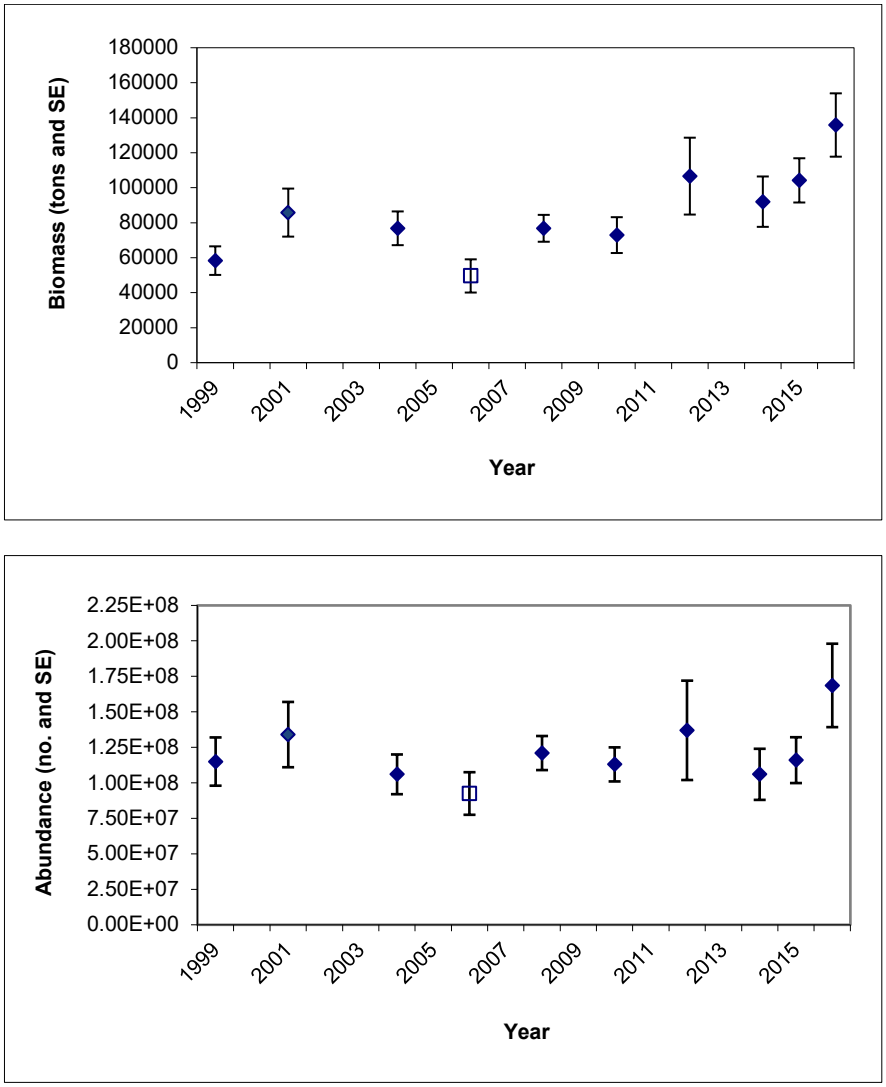


Fig. 6. Biomass (top) and abundance (bottom) estimates (with SE) for Greenland halibut in Division 0A-South. The 2006 biomass and abundance may be under-estimated due to reduced coverage in the 1200-1500 m depth strata.

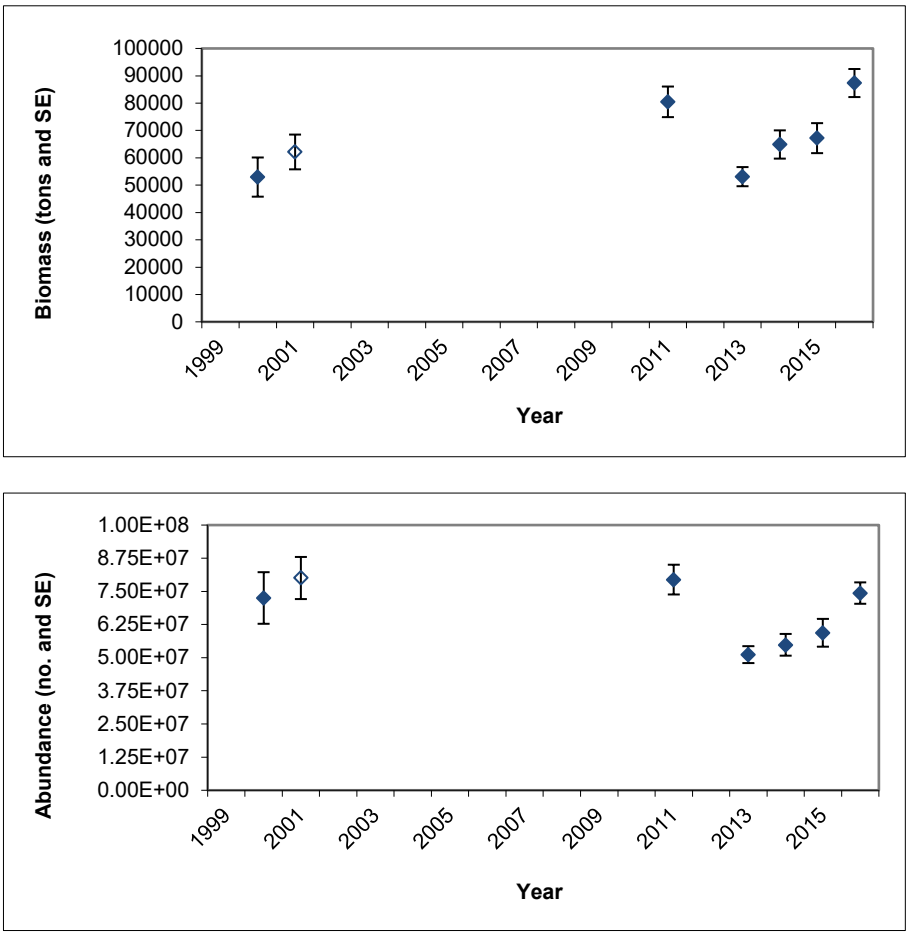


Fig. 7. Biomass (top) and abundance (bottom) estimates (with SE and linear trend line) for Greenland halibut in Division 0B. Reduced coverage in 2001particularly in sets <800 m.

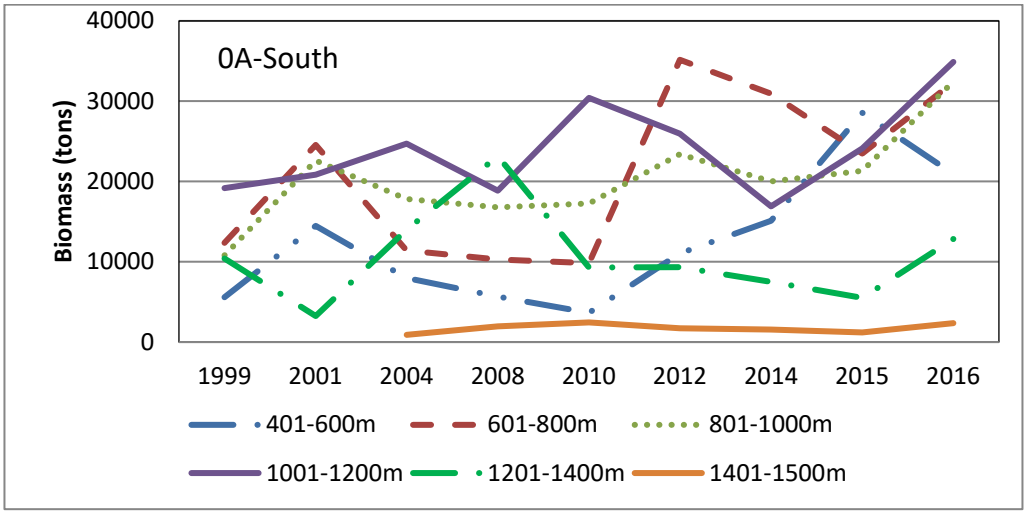


Fig. 8a. Biomass trends by depth strata for Division 0A-South.

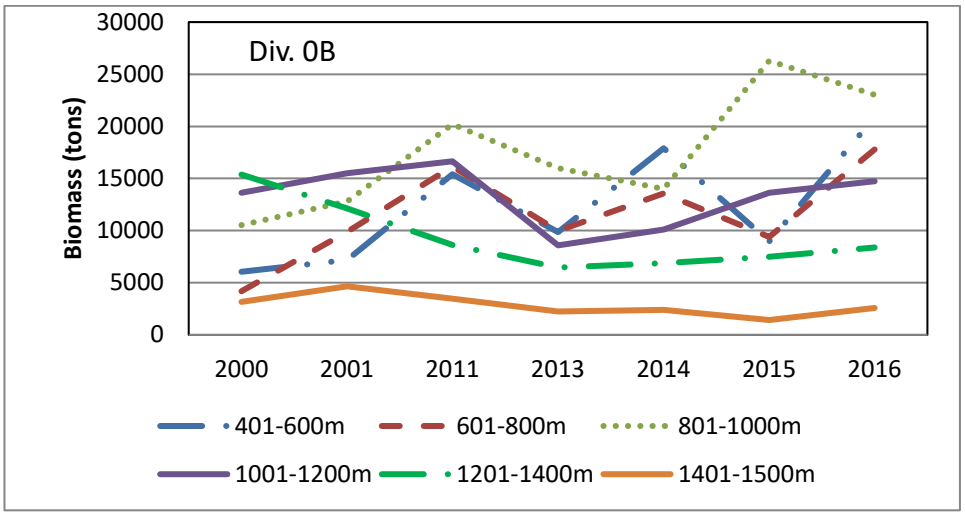
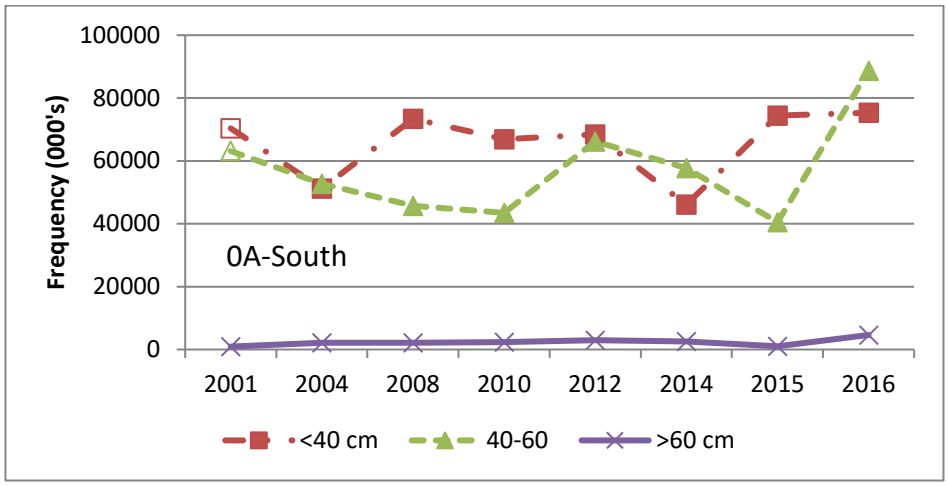


Fig. 8b. Biomass trends by depth strata for Division 0B.



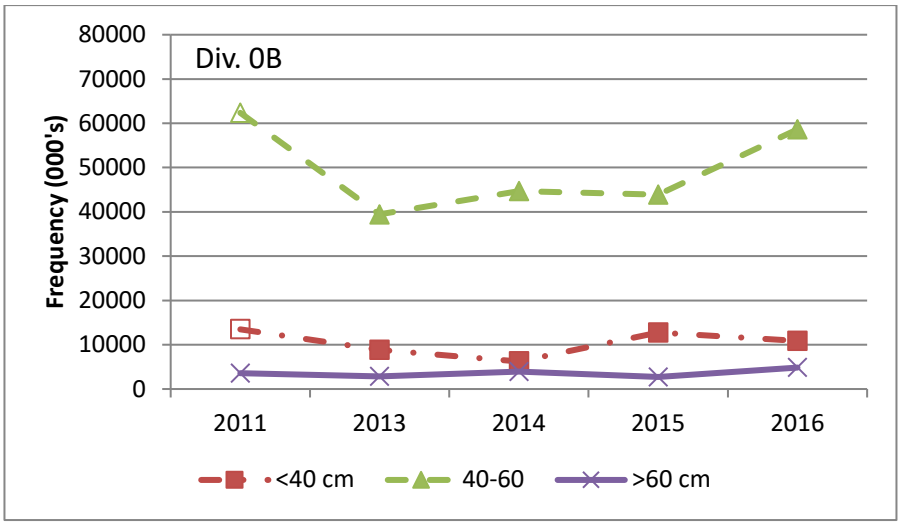


Fig. 9. Abundance by size class for Divisions 0A-South (top) and 0B (bottom): <40 cm (recruitment); 40-60 cm (size range for trawl catches); >60 cm (size range for gillnet catches).

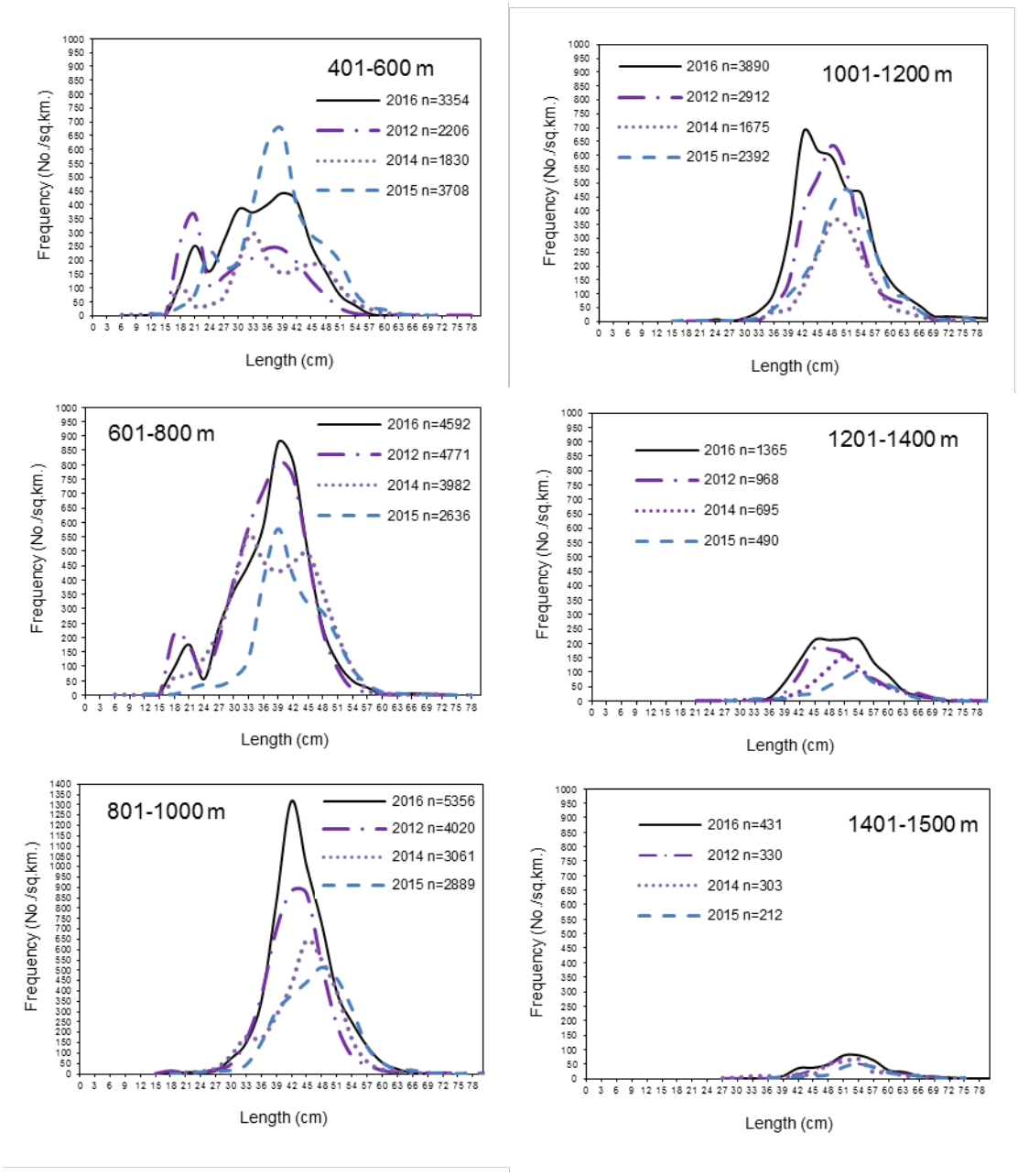


Fig. 10. Greenland halibut length distribution by depth for Divisions 0A-South, 2012 to 2016.

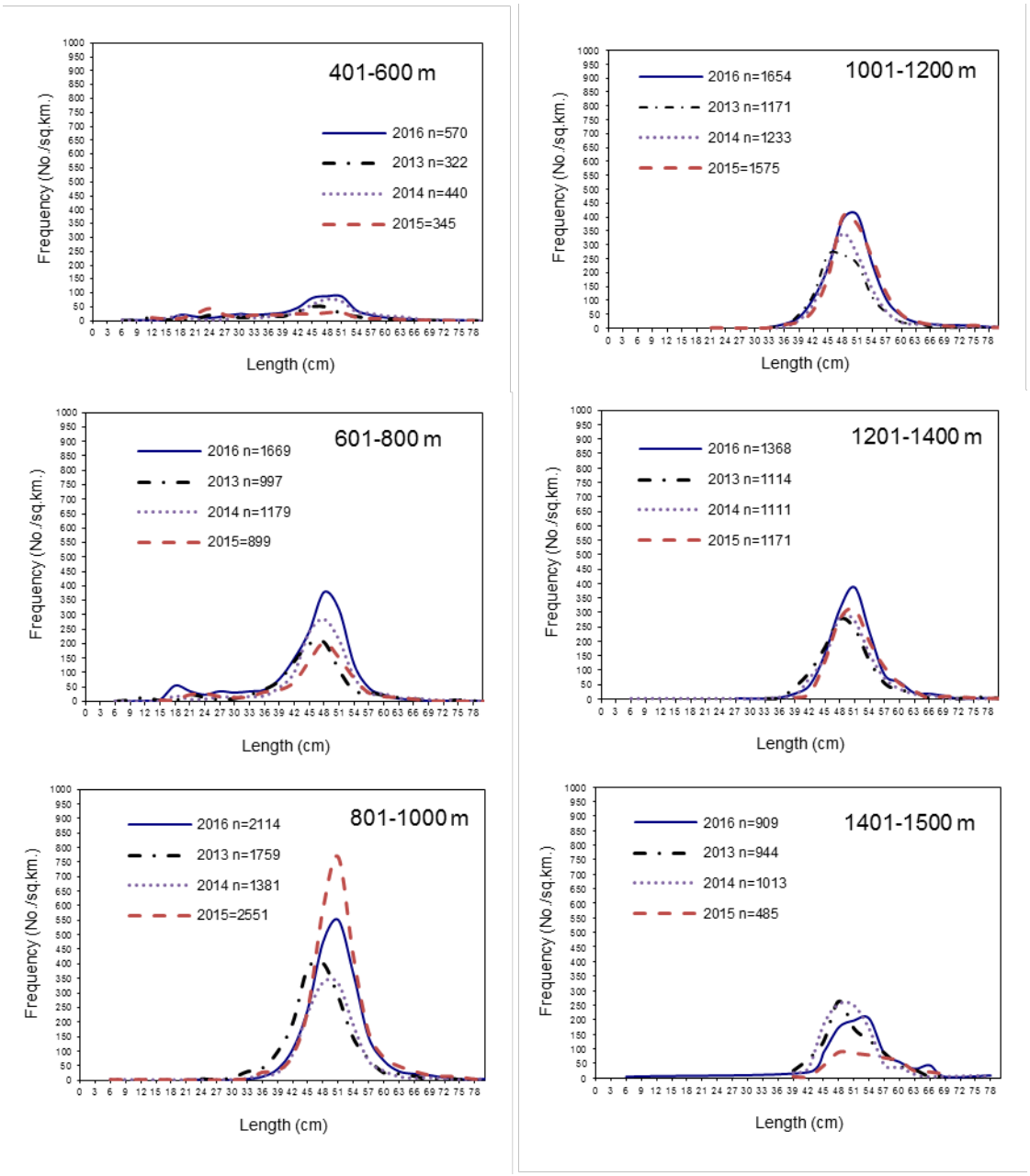
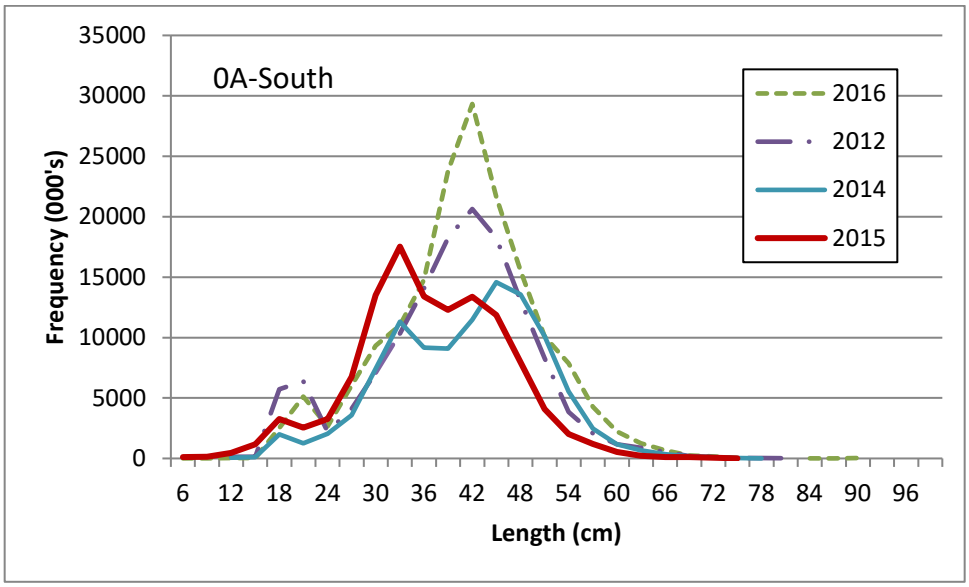


Fig. 11. Greenland halibut length distribution by depth for Divisions 0B, 2013 to 2016.



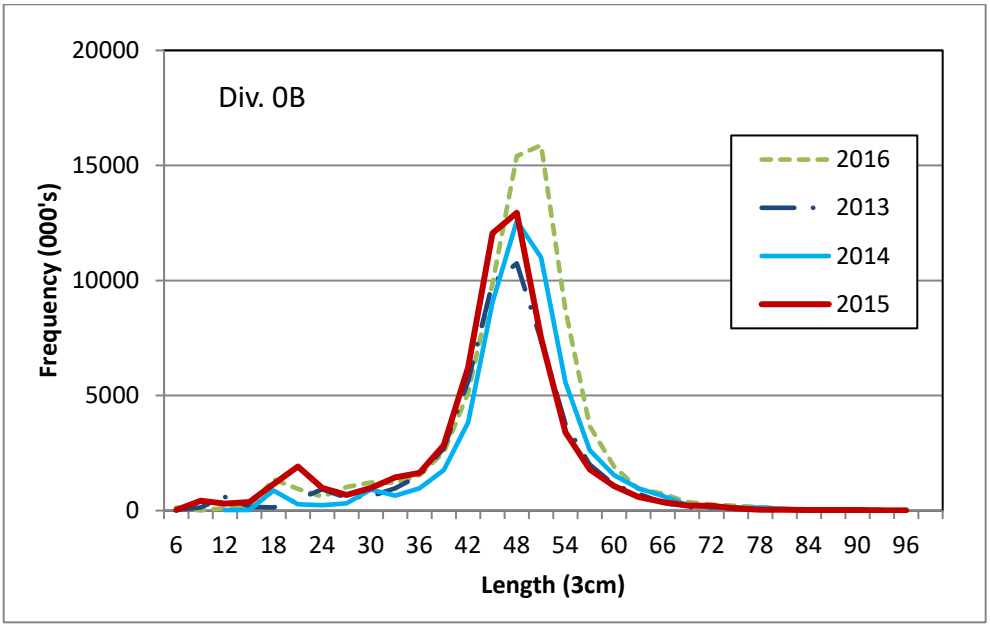


Fig. 12. Abundance-at-length for Greenland halibut in Divisions 0A-South (top) and 0B (bottom), weighted by stratum area.

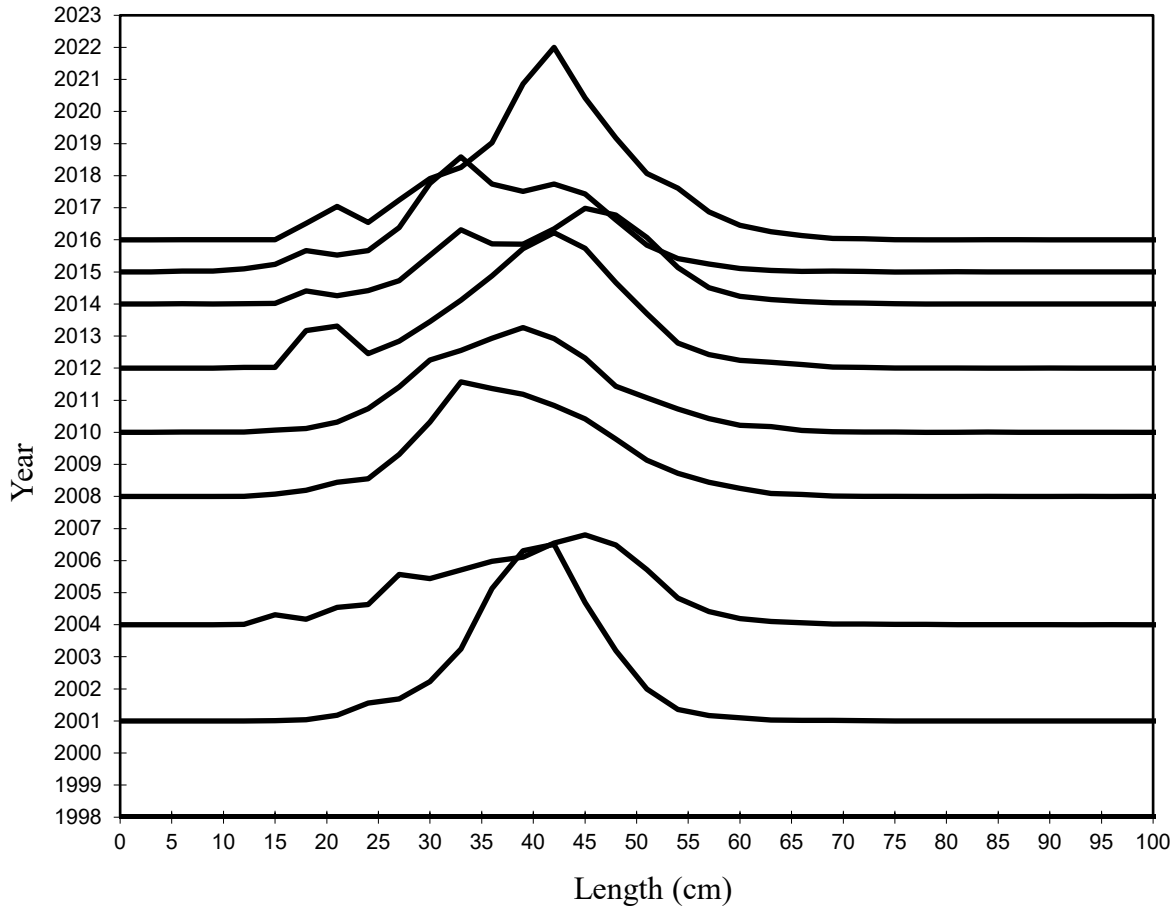


Fig. 13. Length frequency distribution for Division 0A-South 2001-2016 (numbers/km2 weighted by stratum area).

Appendix 1. Greenland halibut raw catch weight, numbers (not standardised to kg/km2), temperature and depth for each set in the 2016 survey of Divisions 0A-South and 0B.

Obs	Div.	Set	Date	Mean Depth (m)	Sweptarea (sq km)	Temp (oC)	Number	Weight (kg)
1	0A	1	10/07/2016	1288	0.09636	0.41	56	94.70
2	0A	2	10/07/2016	1487	0.08933	0.02	26	45.70
3	0A	3	10/07/2016	1436	0.09220	0.10	28	68.18
4	0A	4	10/07/2016	1152	0.08815	0.70	137	165.90
5	0A	5	10/07/2016	883	0.06006	0.97	443.667	503.30
6	0A	6	10/08/2016	987	0.08979	0.86	181	214.35
7	0A	7	10/08/2016	1469	0.09111	0.00	64	91.70
8	0A	8	10/08/2016	1122	0.08800	0.64	72	94.05
9	0A	9	10/08/2016	1340	0.08387	0.43	63	92.50
10	0A	10	10/08/2016	1317	0.08956	0.30	60	88.45
11	0A	11	10/08/2016	1109	0.08994	0.84	279.35	354.30
12	0A	12	10/08/2016	1143	0.09389	0.60	197.246	257.10
13	0A	13	10/08/2016	1351	0.09598	0.09	21	27.80
14	0A	14	10/11/2016	1340	0.09679	0.37	50	73.25
15	0A	15	10/11/2016	1330	0.08944	0.42	99	136.95
16	0A	16	10/11/2016	899	0.06637	0.86	425.376	297.90
17	0A	17	10/11/2016	1012	0.04981	0.94	429.24	369.20
18	0A	19	10/11/2016	696	0.05873	1.14	339.45	269.20
19	0A	20	10/11/2016	1430	0.08972	0.22	42.271	61.90
20	0A	21	10/11/2016	1458	0.06831	0.26	36	63.50
21	0A	22	10/12/2016	1423	0.08934	0.05	18	29.90
22	0A	23	10/12/2016	1104	0.06459	0.51	547.8	830.50
23	0A	24	10/12/2016	1103	0.08010	0.53	488.075	562.05
24	0A	26	10/12/2016	1265	0.09807	0.43	667.36	812.70
25	0A	27	10/12/2016	1428	0.09157	0.30	73	118.13
26	0A	28	10/12/2016	1333	0.06306	0.12	90	124.82
27	0A	29	10/13/2016	697	0.08758	1.20	121	86.75
28	0A	30	10/13/2016	652	0.09631	1.17	361.9	262.85
29	0A	31	10/13/2016	826	0.06230	0.50	917.724	789.50
30	0A	32	10/13/2016	1449	0.08742	-0.03	62	78.40
31	0A	33	10/13/2016	1329	0.09280	0.35	183.056	273.50
32	0A	34	10/13/2016	1315	0.09558	0.08	35	61.20
33	0A	35	10/13/2016	1422	0.09428	0.09	17	36.15
34	0A	36	10/14/2016	1111	0.08899	0.37	275.064	409.20
35	0A	37	10/14/2016	1039	0.06248	0.39	182	225.05
36	0A	39	10/14/2016	765	0.07687	0.46	77	59.95
37	0A	40	10/14/2016	745	0.08377	0.43	89	64.95
38	0A	42	10/14/2016	870	0.09362	0.32	217.967	183.80
39	0A	43	10/14/2016	497	0.07253	1.18	48	37.04
40	0A	45	10/14/2016	587	0.08195	1.14	43.344	30.80
41	0A	46	10/15/2016	475	0.08609	1.13	57	39.65
42	0A	47	10/15/2016	686	0.07727	1.12	61	42.25
43	0A	49	10/15/2016	904	0.08599	0.72	297	234.80
44	0A	51	10/15/2016	945	0.08631	0.80	978.588	873.25
45	0A	52	10/15/2016	540	0.08387	1.22	62	34.75

46	0A	55	10/15/2016	673	0.08391	1.24	91	61.75
47	0A	56	10/16/2016	536	0.08134	1.29	96	73.35
48	0A	57	10/16/2016	637	0.07784	1.19	256	172.05
49	0A	58	10/16/2016	509	0.08676	1.17	90	58.00
50	0A	59	10/16/2016	888	0.08610	1.08	966.42	777.72
51	0A	60	10/16/2016	498	0.08395	1.27	227	98.40
52	0A	61	10/16/2016	578	0.08153	0.95	405.088	223.05
53	0A	62	10/16/2016	587	0.06262	0.96	182	101.45
54	0A	63	10/17/2016	473	0.08120	1.32	259	98.15
55	0A	64	10/17/2016	619	0.08067	1.25	1658.62	865.40
56	0A	66	10/17/2016	1464	0.09011	0.11	12	18.22
57	0A	67	10/17/2016	531	0.08514	1.36	1978.02	876.65
58	0A	68	10/17/2016	683	0.07644	1.24	2107.48	1122.90
59	0A	69	10/17/2016	463	0.08192	1.16	507.234	283.70
60	0A	70	10/18/2016	688	0.09016	1.30	337.896	260.60
61	0A	71	10/18/2016	1105	0.09925	0.73	211	234.30
62	0A	72	10/18/2016	1235	0.07200	0.63	43	54.95
63	0A	73	10/18/2016	951	0.08615	0.92	147	168.30
64	0A	74	10/18/2016	775	0.06458	1.46	78	72.29
65	0A	75	10/18/2016	904	0.09788	1.12	131	130.20
66	0A	76	10/18/2016	761	0.08460	1.46	134	128.10
67	0A	77	10/18/2016	925	0.08572	1.03	99	91.56
68	0A	78	10/19/2016	888	0.09421	1.12	111	105.20
69	0A	79	10/19/2016	724	0.08913	1.22	72	58.90
70	0A	80	10/19/2016	564	0.09850	1.26	104	54.65
71	0A	81	10/19/2016	511	0.06536	1.33	210.824	163.90
72	0A	82	10/19/2016	510	0.08294	1.44	51	38.90
73	0A	83	10/19/2016	746	0.08628	1.49	143	105.05
74	0A	85	10/20/2016	691	0.08893	1.74	139	104.65
75	0A	88	10/20/2016	658	0.08620	1.83	106	83.40
76	0A	89	10/20/2016	486	0.08251	2.43	62	39.15
77	0B	87	10/20/2016	660	0.08361	1.55	95	73.95
78	0B	90	10/20/2016	578	0.07959	2.42	38	21.30
79	0B	91	10/21/2016	569	0.08905	1.91	60	59.30
80	0B	93	10/21/2016	517	0.06459	1.61	41	33.65
81	0B	94	10/21/2016	632	0.08976	1.61	177	89.70
82	0B	95	10/21/2016	668	0.08778	1.55	94	64.85
83	0B	96	10/21/2016	454	0.08618	1.26	99	87.10
84	0B	98	10/21/2016	553	0.09532	1.49	139	116.05
85	0B	99	10/21/2016	505	0.08654	1.29	39	34.84
86	0B	100	10/21/2016	460	0.08243	1.45	46	24.75
87	0B	101	10/22/2016	429	0.08814	1.75	33	6.00
88	0B	102	10/22/2016	459	0.05954	2.15	23	13.80
89	0B	103	10/22/2016	480	0.07055	2.07	43	38.60
90	0B	104	10/26/2016	637	0.08620	2.71	162	164.40
91	0B	105	10/26/2016	680	0.08716	2.36	137	117.40
92	0B	106	10/26/2016	706	0.08185	3.43	118	115.95
93	0B	107	10/26/2016	793	0.08327	3.83	117	154.60
94	0B	108	10/26/2016	851	0.08586	3.74	156	191.75
95	0B	109	10/26/2016	763	0.08748	3.75	231	266.55

96	0B	110	10/26/2016	876	0.08887	3.65	217	270.15
97	0B	111	10/26/2016	950	0.08863	3.71	360	475.19
98	0B	112	10/26/2016	975	0.08698	3.75	321.343	463.80
99	0B	113	10/27/2016	1088	0.08894	3.53	178	225.90
100	0B	114	10/27/2016	1218	0.08698	3.51	186.914	233.45
101	0B	115	10/27/2016	1459	0.08575	3.52	73	105.10
102	0B	116	10/27/2016	1486	0.08330	3.49	73	113.90
103	0B	117	10/27/2016	982	0.08779	3.84	168	229.14
104	0B	118	10/27/2016	875	0.09541	3.65	211.95	272.85
105	0B	120	10/28/2016	728	0.08766	3.44	127	149.85
106	0B	121	10/28/2016	666	0.08849	2.63	132	155.05
107	0B	122	10/28/2016	877	0.08850	3.85	158	219.50
108	0B	123	10/28/2016	932	0.08419	3.80	118	203.30
109	0B	124	10/28/2016	944	0.08637	3.75	78	111.95
110	0B	125	10/28/2016	958	0.09184	3.82	102	123.00
111	0B	126	10/28/2016	1255	0.08730	3.56	121	138.50
112	0B	127	10/29/2016	1458	0.09007	3.56	90	121.15
113	0B	128	10/29/2016	1034	0.08828	3.62	92	129.15
114	0B	129	10/29/2016	1357	0.09092	3.61	168	213.00
115	0B	130	10/29/2016	1068	0.08927	.	131	165.80
116	0B	131	10/29/2016	1039	0.09050	3.73	59	85.35
117	0B	132	10/29/2016	1139	0.08627	3.66	127	184.75
118	0B	133	10/29/2016	1373	0.08824	3.59	89	117.05
119	0B	134	10/30/2016	1390	0.08521	3.57	54	87.15
120	0B	135	10/30/2016	1173	0.08783	3.61	136	180.10
121	0B	136	10/30/2016	1160	0.08707	3.68	177	220.25
122	0B	137	10/30/2016	930	0.08743	3.93	166	215.95
123	0B	138	10/31/2016	1308	0.08474	3.58	100	136.35
124	0B	139	10/31/2016	572	0.07789	2.63	7	10.16
125	0B	141	10/31/2016	556	0.08052	3.09	29	36.34
126	0B	142	10/31/2016	551	0.06769	2.55	12	21.85
127	0B	143	11/01/2016	1064	0.07107	3.71	137.004	215.05
128	0B	144	11/01/2016	518	0.08799	2.71	56	91.80
129	0B	145	11/01/2016	469	0.05302	2.39	17	26.05
130	0B	147	11/01/2016	489	0.07436	3.02	20	15.70
131	0B	148	11/02/2016	479	0.08094	2.74	8	10.30
132	0B	150	11/02/2016	504	0.04643	2.67	12	14.85
133	0B	151	11/02/2016	590	0.07791	2.84	68	56.20
134	0B	152	11/02/2016	506	0.06366	2.49	34	37.60
135	0B	153	11/02/2016	486	0.05926	2.68	7	8.10
136	0B	154	11/02/2016	453	0.07707	2.44	9	8.55
137	0B	155	11/03/2016	445	0.08113	2.34	18	23.45
138	0B	157	11/03/2016	448	0.07828	2.37	10	11.05
139	0B	158	11/03/2016	441	0.08338	2.44	14	20.10
140	0B	159	11/03/2016	702	0.08168	2.91	170	172.90
141	0B	160	11/03/2016	763	0.08709	3.76	229.89	290.15
142	0B	161	11/03/2016	1193	0.08570	3.69	235	306.70
143	0B	162	11/04/2016	684	0.07901	3.32	99	118.55
144	0B	163	11/04/2016	701	0.07999	2.63	107	119.00
145	0B	164	11/04/2016	540	0.08370	2.28	84	95.90

146	0B	166	11/04/2016	565	0.08515	2.41	50	49.75
147	0B	167	11/04/2016	568	0.08605	2.40	145	168.00
148	0B	168	11/04/2016	496	0.08504	2.11	77	71.15
149	0B	169	11/04/2016	565	0.05819	2.45	73	87.15
150	0B	170	11/04/2016	526	0.08846	2.42	98	111.15
151	0B	171	11/05/2016	483	0.08481	2.10	24	19.65
152	0B	172	11/05/2016	530	0.08620	2.14	52	46.14
153	0B	174	11/05/2016	535	0.08872	2.12	45	40.90
154	0B	175	11/05/2016	591	0.08185	1.86	78	85.70
155	0B	176	11/05/2016	559	0.08452	2.09	55	51.30
156	0B	177	11/05/2016	536	0.07146	1.68	33	30.00
157	0B	178	11/05/2016	553	0.09138	2.21	47	44.30