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Report on Greenland halibut caught during the 2017 trawl survey in Divisions 0A

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Abstract

A stratified-random otter trawl survey was conducted in southern Division 0A (0A-South) in 2017. A survey of Division 0B had also been planned but due to a mechanical problem on the research vessel there was only enough time in the remaining schedule to survey 0A-South. The 0A-South survey extended to approximately 72° N. The survey took place from October 27 to November 8. An Alfredo III trawl was used at randomly selected stations between 401 m and 1500 m. Stations assigned to the most northern portion of the depth strata could not be completed due to ice conditions. However, these stations were randomly re-assigned to the southern portions of the depth strata and 74 of 77 planned stations were completed. The Broughton Island transect line was sampled. However, ice blocked access to the oceanographic stations along the Cape Christian line. Near-bottom temperatures were similar to previous surveys varying between -0.09 °C and 2.86 °C with the mean declining with depth from 1.5 °C to 0.1 °C. Greenland halibut were distributed throughout the survey area and were present in all but one tow. A majority of both females (97%) and males (61%) were immature. The 2017 estimate of biomass was 58,812 t (S.E. 18,103), a significant decrease compared to last year and similar to the low observed in 1999. In 2016 biomass estimates across depths 801 m to 1200 m were the highest in the time series. One year later at depths 1201-1500 m the biomass was the highest or second highest in the time series but at all other depths it was now the lowest or near lowest in the time series. Abundance in 2017 was 9.0 x 107 (S.E. 1.3 x 107) also a significant decrease compared to 2016 and the lowest in the time series. The overall length distribution in 2017 ranged from 12 cm to 90 cm with modes observed at 27 and 45 cm. The proportion of fish <45cm was 62% similar to what was seen in 2016. Abundance at length for depths 401-600 m was bi-modal and at lengths <15-30 cm it was comparable to previous surveys. However, there was a marked decline in abundance at lengths 30-50 cm for all depth strata less than 1000 m. At depths 1001-1200 m there was an increase in abundance of fish 25-35 cm but a decrease for fish >45 cm and for both of the deepest strata there was a significant increase in abundance of fish 35-55 cm compared to previous years. We began to age the back log of Greenland halibut otoliths prior to the completion of the 2017 survey and provide results from the 2014 survey as representative of the age-length relationship for Greenland halibut in Div. 0A. Female ages ranged from 3-35 years and males from 3-23 years.

Introduction

A multi-species bottom trawl survey was carried out in the Northwest Atlantic Fisheries Organization Subarea 0 during October 27 to November 8, 2017. A survey of Division 0B had also been planned but due to a mechanical problem on the research vessel there was only enough time in the remaining schedule to survey 0A-South. The survey covered southern 0A (0A-South) (to approximately 72° N). 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 was intended that both these areas would be surveyed annually in order to build an index that could 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).

The survey area between 401m and 1500 m in Div. 0A-South (to approximately 72° N) is 47,924 km^2 (Table 1) within which there are 77 sets randomly assigned.

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 survey area adjusted accordingly for those years (Table 2).

Set selection is based on a coverage level of approximately 1 set per 750 km^2. A minimum of two sets are 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.

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 measure the distance between the trawl doors. Wingspread, taken as the distance between the outer bobbins, is calculated as: distance between outer bobbins=10.122 + distance between trawl doors (m) x 0.142. This relationship is 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 Broughton Island transect line was sampled. However, ice blocked access to the oceanographic stations along the Cape Christian line.

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. Otolith samples were not analyzed for this survey. However, an age determination method has been developed and we have started to age samples from previous surveys.

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

Stations assigned to the most northern portion of the depth strata could not be completed due to ice conditions. However, these stations were randomly re-assigned to the southern portions of the depth strata and 74 of 77 planned stations were completed. All the depth strata had at least two sets so there was no adjustment made to the survey area (Table 2). Near-bottom temperatures were similar to previous surveys varying between -0.09 ^oC and 2.86 ^oC. There was a slight increase in mean temperature between 400-600 m and 600-800m, then a decline with depth from 1.5 ^oC to 0.1 ^oC. It was noted that mean temperatures for 800m to 1200m were slightly colder than in previous surveys (Table 3). Also, the extent of warm bottom temperatures (>2 degrees) in the SE portion of the survey area was greater than previously observed (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

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

Greenland halibut were present in all but one tow in 2017 (Fig. 3 and Appendix 1). It was noted that there were 8 sets where the catch weight was <1kg, compared to 0-3 sets in previous surveys. Distribution of biomass has not changed substantially across years, with the largest catches located along the shelf slope between 67^o N and 72^o N (Fig. 4). The number of fish caught in 0A-South varied from 0-677. Catch weight ranged from 0-995 kg (Appendix 1). The catch was comprised of 48% males and 52% females, similar to proportions observed in previous surveys (Table 4). A majority of both females (97%) and males (61%) were immature. The proportion mature for males (6-68%) is more variable than that observed for females (1-21%) during surveys conducted from 2012 to 2017 with no clear link to survey timing (Table 4).

The 2017 estimate of biomass was 58,812 t (S.E. 18,103) (Table 6) a significant decrease compared to last year and similar to the low observed in 1999 (Fig. 5). Mean catch per tow also declined from a high of 2.83 t/km^2 in 2016 to 1.23 t/km^2 (Table 5). In 2016 biomass estimates across depths 801 m to 1200 m were the highest in the time series. In 2017 biomass at depths 1201-1500 were the highest or second highest in the time series while biomass at all other depths were now at the lowest or near lowest levels (Table 6, Fig. 6).

The impact of the removal of the 1400-1500m 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 had contained only 1-3% of the overall biomass prior to this most recent 2017 survey (13%). However, the reduced

coverage (only 3 sets) in depths 1200-1400 in the 2006 survey is considered to have had an effect on the mean biomass/km^2 and the total biomass for this strata that year compared to estimates in 2004 and 2008 (Table 8), therefore, the overall biomass and abundance is considered an under-estimated for 2006 (Fig. 5).

Abundance in 2017 was 9.0 x 10^7 (S.E. 1.3 x 10^7) (Table 4) a significant decrease compared to 2016 and the lowest in the time series (Table 7 and Fig. 5). The pattern in abundance at depth is similar to that observed for biomass, at the highest or near highest levels for the 2 deepest strata and at the lowest or near lowest for the others.

Abundance of fish 40-60 cm is similar to that for fish <40 cm (Fig. 7). There is no observable pattern to the variation in abundance among size of fish.

The overall length distribution in 2017 ranged from 12 cm to 90 cm with modes observed at 27 and 45 cm (Table 8, Fig. 8 and 9). Overall the abundance was reduced compared to previous years at lengths 30-50 cm and was comparable to 2015 levels for fish >50 cm. A trend to increased numbers of larger fish was observed from 1999 to 2004, 2008 to 2014 (Fig. 9). In 2015 the distribution had shifted left with increased numbers at smaller sizes (e.g. 18-36 cm) then in 2016 the distribution shifted right with a modal length more similar to 2012 and 2014 but with greater abundance (Fig. 9). The proportion of fish <45cm is 62% similar to what was seen in 2016 (Table 8).

Aabundance at length for depths 401-600 m was bi-modal and at lengths <15-30 cm was comparable to previous surveys. However, there was a marked decline in abundance at lengths 30-50 cm for all depth strata less than 1000 m (Fig. 10). Generally, the number of fish at larger length classes increases with depth. At depths 1001-1200 m there was an increase in abundance of fish 25-35 cm but a decrease for fish >45 cm. For both of the deepest strata there was a significant increase in abundance of fish 35-55 cm compared to previous years (Fig. 10).

Our age determination lab has begun to age Greenland halibut otoliths using the left section method (ICES 2017). We began prior to the completion of the 2017 survey and provide results from the 2014 survey samples as representative of the age-length relationship for Greenland halibut in Div. 0A. Female ages ranged from 3-35 years and males from 3-23 years.

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References

ICES. 2017. Report of the Workshop on age reading of Greenland halibut 2 (WKARGH2), 22-26 August 2016, Reykjavik, Iceland. ICES CM 2016/SSGIEOM:16. 40 pp.

JØRGENSEN, O. A. 1998. Survey for Greenland halibut in NAFO Division 1C-1D. NAFO SCR Doc. 98/25. Serial No. N3010, 26 pp.

KINGSLEY, M.C.S., KANNEWORFF, P. AND CARLSSON, D.M. 2004. Buffered random sampling: a sequential inhibited spatial point process applied to sampling in trawl survey for northern shrimp *Pandalus borealis* in West Greenland waters. ICES J. Mar. Sci. 61:12-24.

RIGET, F., BOJE, J. 1989. Fishery and some biological aspects of Greenland halibut (*Reinhardtius hippoglossoides*) in West Greenland waters. NAFO Sci. Con. Studies 13:41-52.

TREBLE, M. A. 2016. Report on Greenland halibut caught during the 2015 trawl survey in NAFO Divisions 0A and 0B. NAFO SCR Doc. 16/025, Serial No. N6568, 33 pp.

TREBLE, M. A. 2015. Report on Greenland halibut caught during the 2014 trawl survey in NAFO Divisions 0A and 0B. NAFO SCR Doc. 15/030, Serial No. N6454, 35 pp.

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	2017
A1-4	400-600	2152	4	0	6	4	3	3	3	3	3	3	4
A2-4	400-600	4649	2	3	1	6	6	6	6	4	5	6	4
A3-4	400-600	785	3	0	0	2	2	2	2	2	2	1	2
A4-4	400-600	1922	0	2	0	0	3	3	3	2	3	3	0
B2-4	400-600	2519	2	0	1	2	3	3	2	6	3	3	4
		12027	11	5	8	14	17	17	16	17	16	16	14
A1-5	600-800	795	3	2	1	3	2	2	2	2	2	2	2
A2-5	600-800	2250	0	3	1	3	3	3	3	3	3	3	4
A3-5	600-800	760	1	1	1	2	2	2	2	2	2	2	2
A4-5	600-800	2483	1	1	3	0	1	3	3	3	3	3	0
B2-5	600-800	5108	7	6	5	8	7	7	7	8	7	7	9
		11396	12	13	11	16	15	17	17	18	17	17	17
A1-6	800-1000	604	1	1	1	2	2	2	2	1	2	2	2
A2-6	800-1000	1145	2	0	1	2	2	2	2	2	2	2	3
A3-6	800-1000	1020	3	2	3	1	2	2	2	2	2	2	3
A4-6	800-1000	1376	1	1	2	0	1	2	2	3	2	2	0
B2-6	800-1000	2656	4	3	5	1	4	4	4	6	4	4	4
		6801	11	7	12	6	11	12	12	14	12	12	12
A1-7	1000-1200	745	2	0	1	1	2	2	2	1	2	2	2
A2-7	1000-1200	1873	3	2	2	5	2	2	2	4	2	2	4
A3-7	1000-1200	1307	2	0	4	0	2	2	2	2	2	2	2
A4-7	1000-1200	1636	0	0	0	0	2	2	2	3	2	2	0
B2-7	1000-1200	1789	2	3	3	0	2	2	2	4	2	2	2
		7349	9	5	10	6	10	10	10	14	10	10	10
A1-8	1200-1400	813	2	3	1	0	2	2	2	2	2	2	2
A2-8	1200-1400	2151	3	4	4	3	3	3	3	4	3	3	5
A3-8	1200-1400	1146	2	0	2	0	2	2	2	2	2	2	2
A4-8	1200-1400	1072	1	0	4	0	2	2	2	2	2	2	0
B2-8	1200-1400	1779	2	2	1	0	4	2	2	2	2	2	2
		6961	10	9	12	3	13	11	11	12	11	11	11
A1-9	1400-1500	498	0	0	0	0	2	2	2	2	2	2	2
A2-9	1400-1500	1153	0	0	1	1	2	2	2	2	2	2	4
A3-9	1400-1500	684	0	0	0	0	2	2	2	2	2	2	2
A4-9	1400-1500	710	0	0	0	0	0	2	2	2	2	2	0
B2-9	1400-1500	346	1	0	1	0	2	2	1	0	2	2	2
		3390	1	0	2	1	8	10	9	8	10	10	10
Total		47924	54	39	55	46	74	77	75	83	76	76	74
	Adjusted		44534	44534		44534							

Table 3. Mean temperature and S.E. in ( ) for Division 0A-South.

	Depth Stratum (m)					
Year	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 (0.08)	1.2 (0.09)	0.8 (0.07)	0.6 (0.06)	0.3 (0.05)	0.1 (0.04)
2017	1.3 (0.42)	1.5 (0.65)	0.7 (0.24)	0.4 (2.21)	0.3 (0.06)	0.1 (0.17)

Table 4. Sex and maturity proportions, for Division 0A-South.

Year	Survey Dates	Sex	% of catch	Mat	% of Sex
2012	Sept. 29-Oct. 27	F	47	Immature	99
				Mature	1
		M	52	Immature	94
				Mature	6
2014	Sept. 22-Oct. 18	F	48	Immature	98
				Mature	2
		M	51	Immature	87
				Mature	13
2015	Sept. 26-Oct. 9	F	51	Immature	79
				Mature	21
		M	49	Immature	82
				Mature	18
2016	Oct. 7-Oct. 20	F	52	Immature	96
				Mature	4
		M	48	Immature	32
				Mature	68
2017	Oct. 27-Nov. 8	F	52	Immature	97
				Mature	3
		M	48	Immature	61
				Mature	39

Table 5. Greenland halibut biomass, abundance with standard error by stratum for the 2017 survey.

Div.	Stratum (m)	Mean Biomass (t/sq km)	Biomass (tons)	SE	Mean Abundance (#/sq km)	Abundance	SE
0A-South	401-600	0.349	4198	1225	1397	1.7E+07	6.1E+06
	601-800	0.699	7961	1388	1725	2.0E+07	6.8E+06
	801-1000	0.953	6481	2164	1639	1.1E+07	3.3E+06
	1001-1200	2.206	16214	3374	2788	2.0E+07	4.2E+06
	1201-1400	2.316	16122	6169	2280	1.6E+07	6.0E+06
	1401-1500	2.312	7837	4678	1691	5.7E+06	3.2E+06
	Overall	1.227	58812	10751	1871	9.0E+07	1.3E+07

Table 6. Mean catch-per-tow (tons) standardized to km2 of Greenland Halibut from SA0, Divisions 0B and 0A-South during the period 1999-2017.

Division	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017
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	1.23

Table 7. Biomass (tons) of Greenland Halibut by depth stratum from SA0, Divisions 0B and 0A-South during the period 1999-2016.

Biomass 0A-South	Year	Survey Dates	Depth Strata (m) 401-600	601-800	801-1000	1001-1200	1201-1400	1401-1500	Total
	1999	Oct. 7-19	5596	12349	10799	19162	10414	0	58320
	2001	Sept. 16-23	14481	24551	22621	20868	3249	0	85769
	2004	Oct. 14-24	7979	11397	17810	24712	13997	908	76802
	2006	Oct. 27-Nov. 7	3367	6253	7471	27070	5410	0	49571
	2008	Oct. 8-Nov. 4	5684	10312	16798	18876	23155	1970	76794
	2010	Oct. 17-Nov. 6	3655	9835	17271	30412	9285	2453	72911
	2012	Sept. 29-Oct. 27	11042	35158	23405	25970	9327	1717	106619
	2014	Sept. 22-Oct. 18	15095	30952	20023	16905	7484	1565	92024
	2015	Sept. 26-Oct. 9	28559	23468	21330	24100	5520	1210	104187
	2016	Oct. 7-20	20923	32388	32442	34891	12826	2368	135837
	2017	Oct. 27-Nov. 8	4197	7961	6481	16214	16122	7837	58812

Table 8. Abundance of Greenland Halibut by depth stratum from SA0.

Abundance 0A-South	Year	Depth Strata (m) 401-600	601-800	801-1000	1001-1200	1201-1400	1401-1500	Total
	1999	17207	33792	24233	30329	9540	0	115101
	2001	22540	51821	27888	28836	3300	0	134385
	2004	23372	23016	23360	25583	10100	660	106091
	2006	13442	17839	15753	40264	5210	0	92508
	2008	15900	23730	30033	27710	22300	1563	121236
	2010	10134	24497	34352	34445	7670	1661	112759
	2012	26533	54365	27343	21397	6740	1120	137498
	2014	22008	45381	20819	12308	4840	1027	106383
	2015	44598	30043	19645	17576	3411	719	115992
	2016	40330	52336	36423	28588	9500	1463	168640
	2017	16801	19657	11143	20485	15867	5732	89688

Table 9. 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	2017
6				57		48	118	9	
9	10			55			145	9	
12		69	8	42	130	48	454	27	223
15	33	1518	338	319	133	108	1163	38	359
18	204	865	949	586	5717	**1983**	**3263**	2527	3199
21	887	2628	2181	1566	**6388**	1261	2544	**5107**	4119
24	2741	3108	2703	3592	2192	2052	3261	2659	5474
27	3360	7647	6419	6897	4105	3570	6771	6052	**9411**
30	6014	7036	11312	11026	7102	7424	13511	9338	5547
33	10961	8369	**17461**	12460	10345	**11324**	**17526**	11016	5499
36	20188	9658	16467	14320	14054	9177	13403	14785	6550
39	**25928**	10321	15574	**15958**	18210	9088	12285	23757	7107
42	26912	12462	13859	14302	**20637**	11461	**13381**	**29326**	8491
45	18027	**13697**	11816	11300	18256	**14580**	11856	21642	**11229**
48	10721	12176	8765	6999	13052	13558	7954	15514	10376
51	4892	8418	5548	5279	8284	10131	4089	10106	6039
54	1762	4036	3529	3532	3835	5553	2020	7865	2838
57	834	1988	2180	2079	2074	2483	1202	4258	1400
60	503	937	1234	1074	1175	1167	535	2220	870
63	169	509	459	848	876	675	213	1256	434
66	105	306	314	290	544	365	103	666	296
69	103	103	61	80	186	172	124	238	125
72	28	125	24	24	110	122	59	167	25
75		41	16	24	36	30	6	22	
78		51		15	31	6			38
81		20			17		7		24
84	19	6	15	17				13	7
87		26						4	
90		7			10			26	7
93			9						
96		6							
99			9	12					
Total	134402	106134	121249	112755	137498	106384	115992	168646	89689
Total <45 cm	97239	63682	87270	81180	89013	57544	87826	104650	55978
% <45 cm	72.35	60.00	71.98	72.00	64.74	54.09	75.72	62.05	62.41

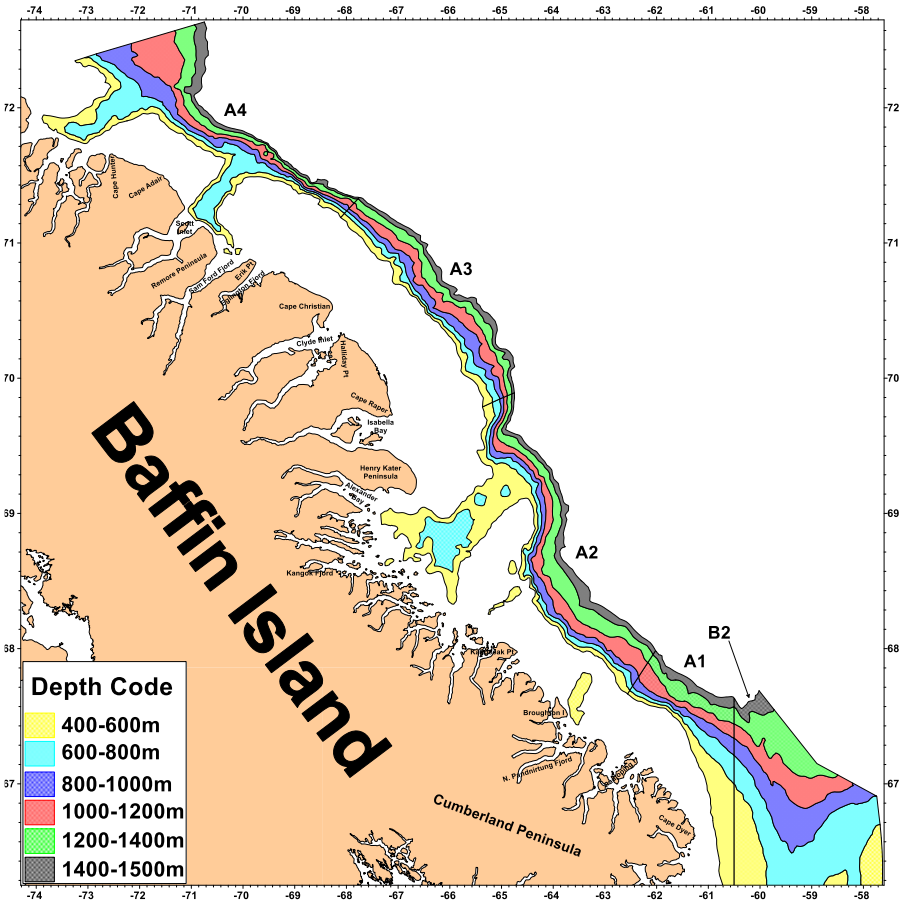


Fig. 1. Stratification scheme for Division 0A-South, 66° N to 72° N.

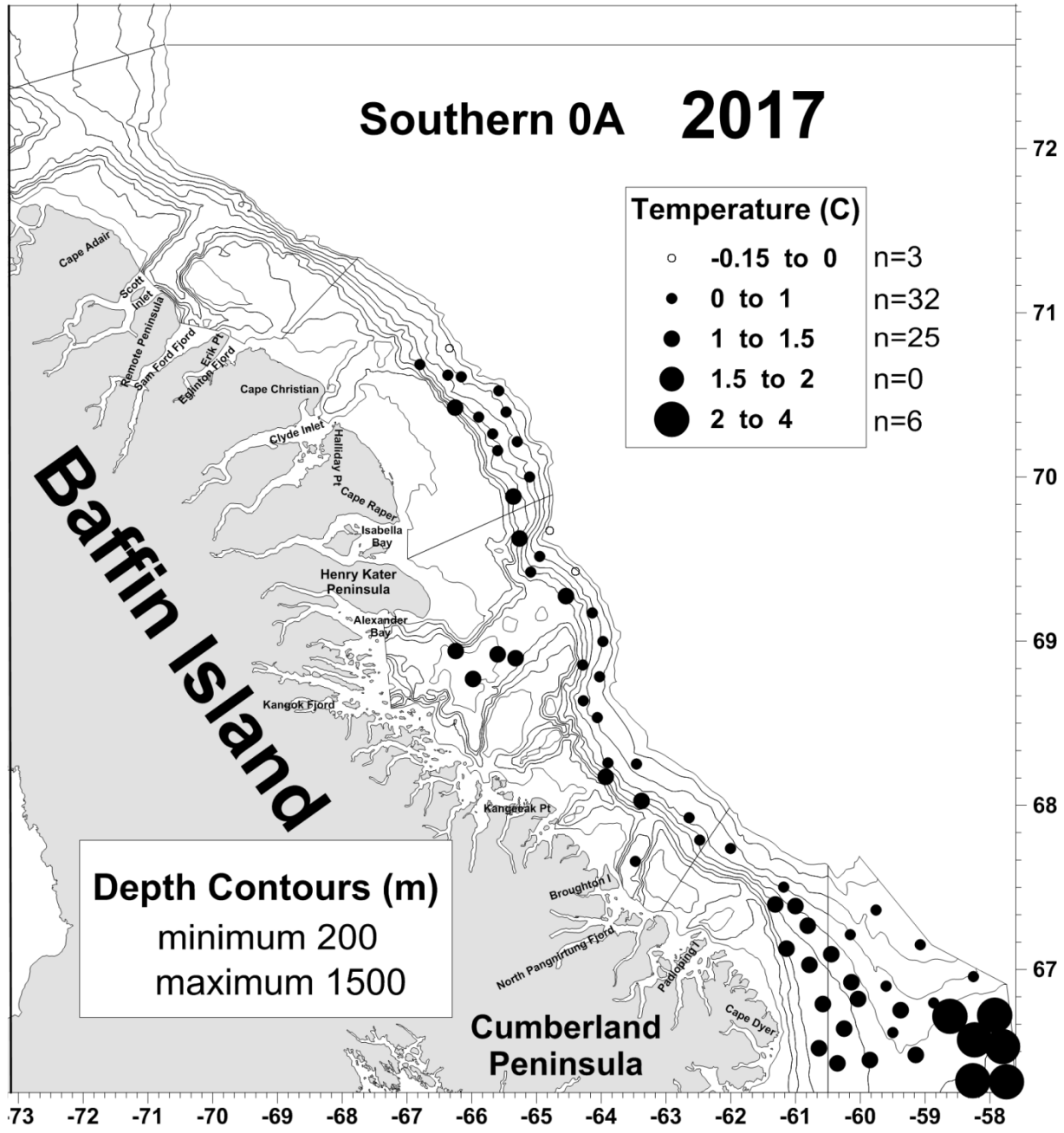


Fig. 2. Bottom temperatures in Division 0A during 2017 survey.

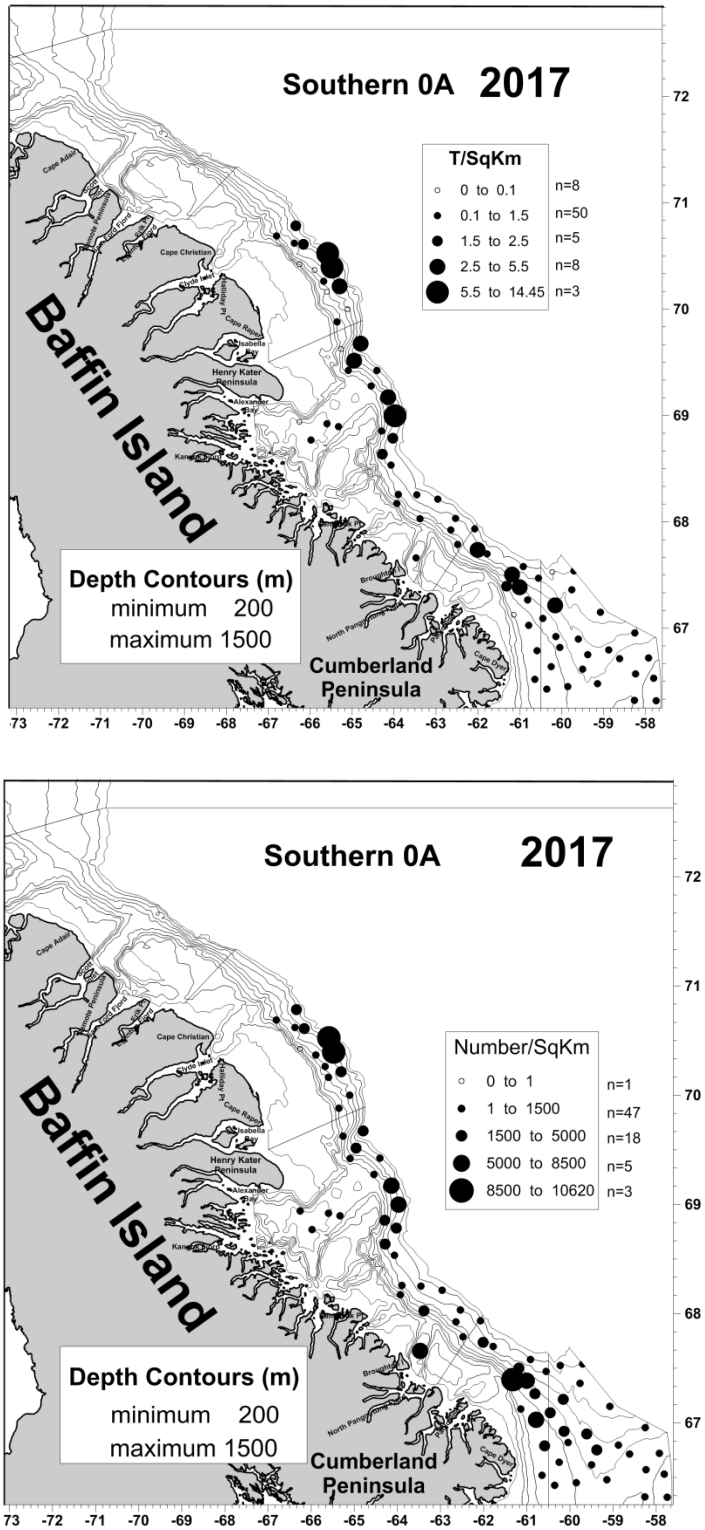


Fig. 3. Biomass (top) and abundance (bottom) distribution for Greenland halibut in Division 0A, 2017.

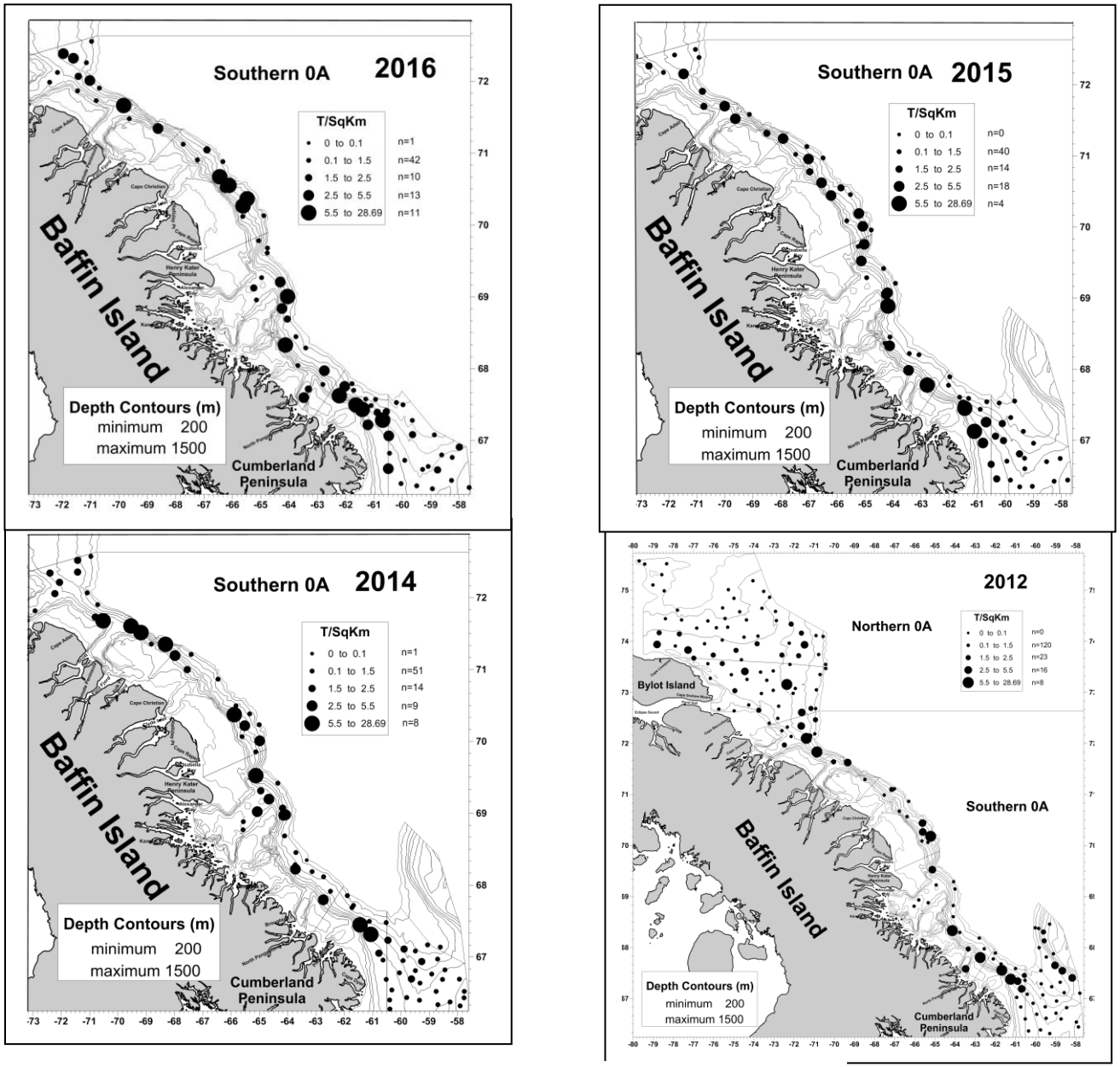
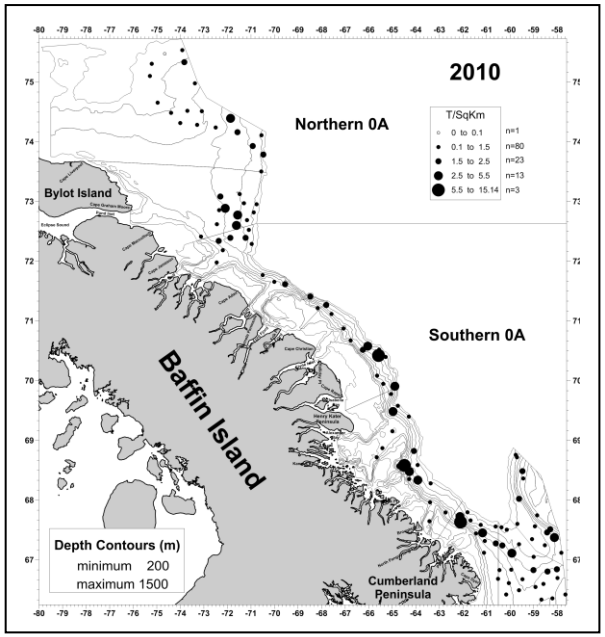
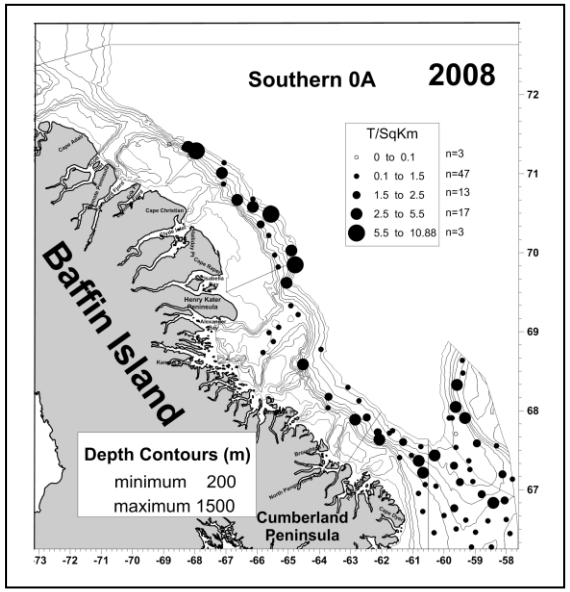
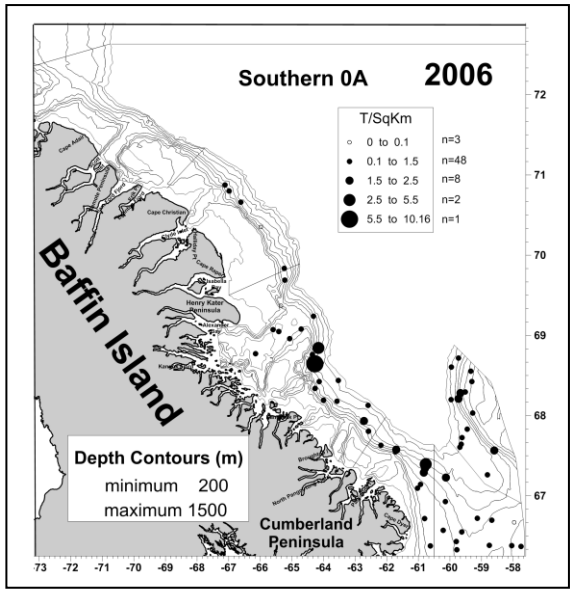
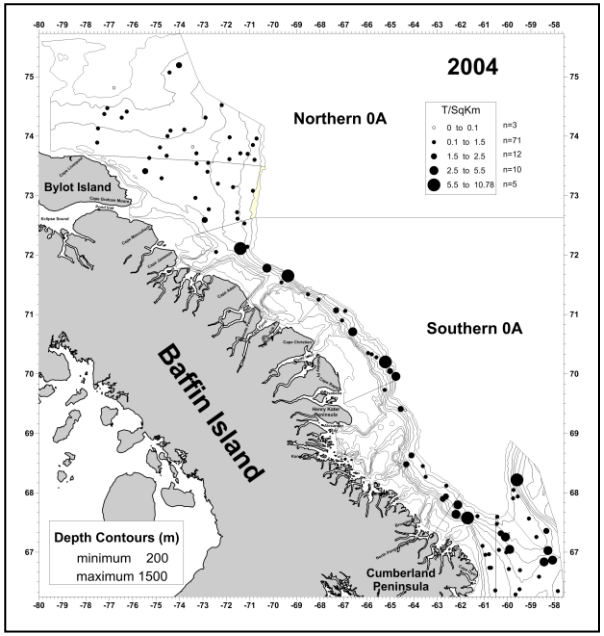


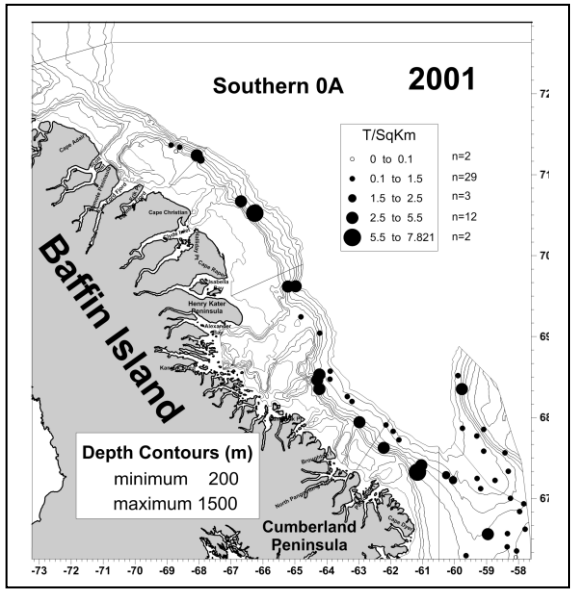
Fig. 4. Biomass distribution (t/sq km) for Greenland halibut in Division 0A, 1999 to 2016.


2010
Northern 0A
Southern 0A
Bylot Island
Baffin 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


2008
Southern 0A
Baffin 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


2006
Southern 0A
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


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


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

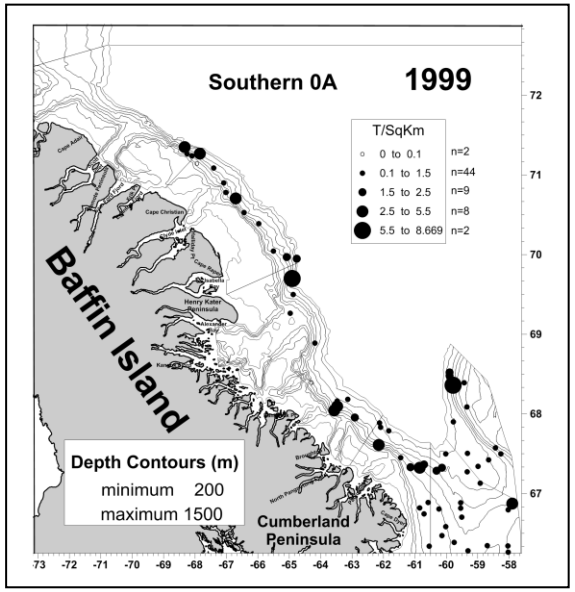

1999
Southern 0A
Baffin Island
Cumberland Peninsula
T/SqKm
0 to 0.1 n=2
0.1 to 1.5 n=44
1.5 to 2.5 n=9
2.5 to 5.5 n=8
5.5 to 8.669 n=2
Depth Contours (m)
minimum 200
maximum 1500

Fig.4 (Con't).

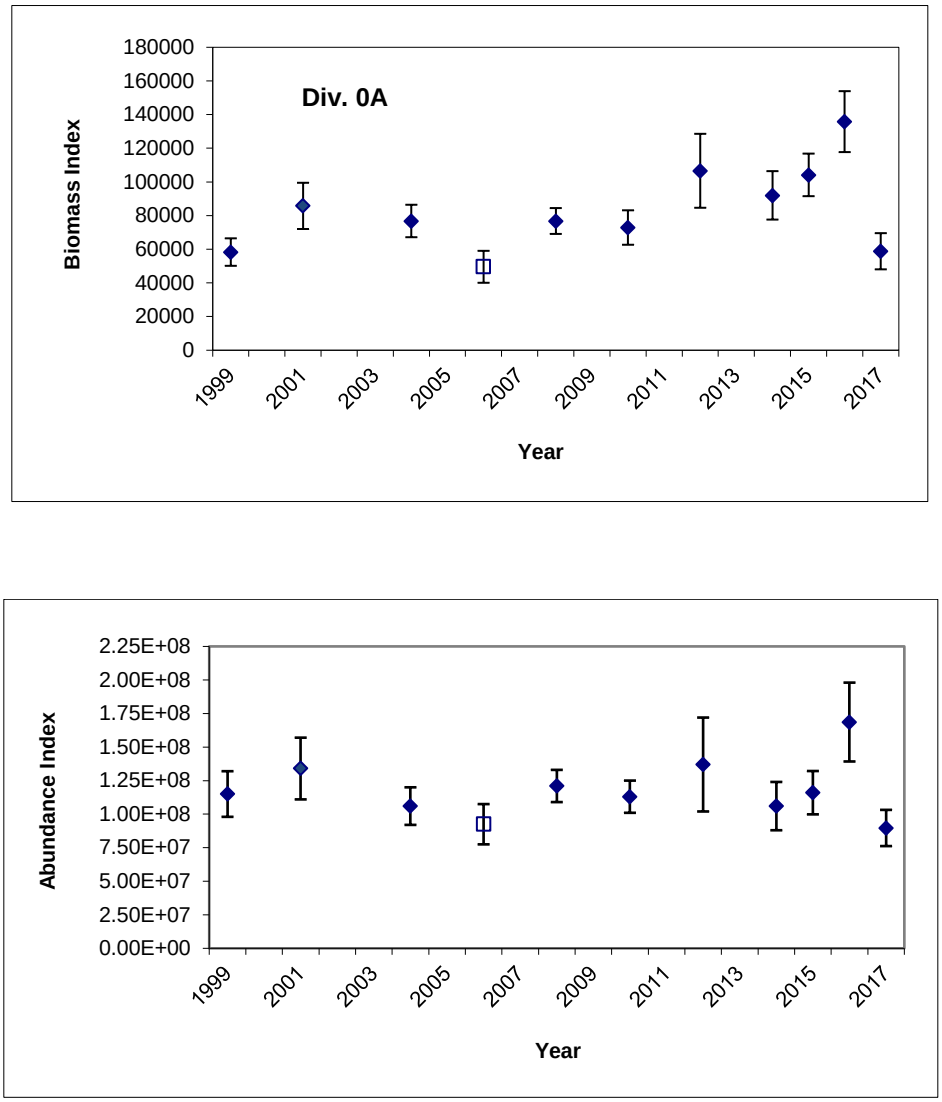


Fig. 5. Biomass (top) and abundance (bottom) estimates (with SE) for Greenland halibut in Division 0A-South. The 2006 biomass and abundance may be under-estimated due to reduced coverage in the 1200-1400 m depth strata.

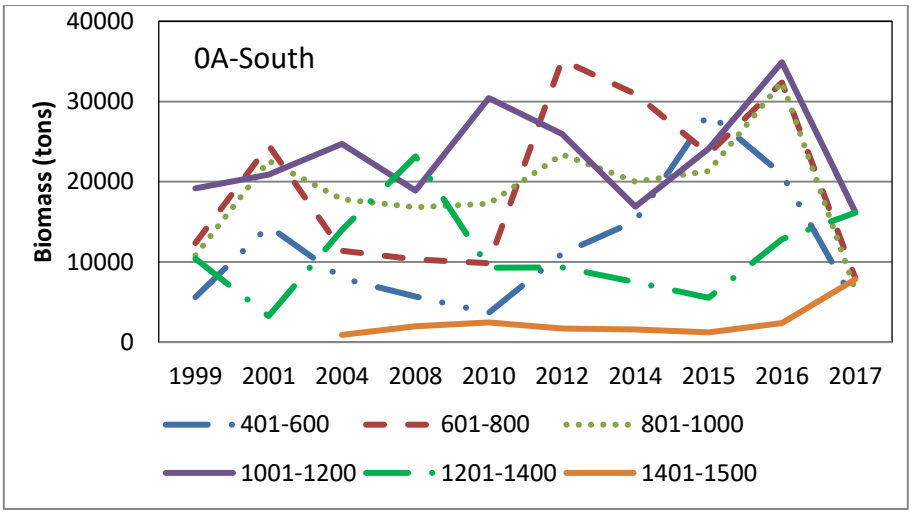


Fig. 6. Biomass trends by depth strata for Division 0A-South.

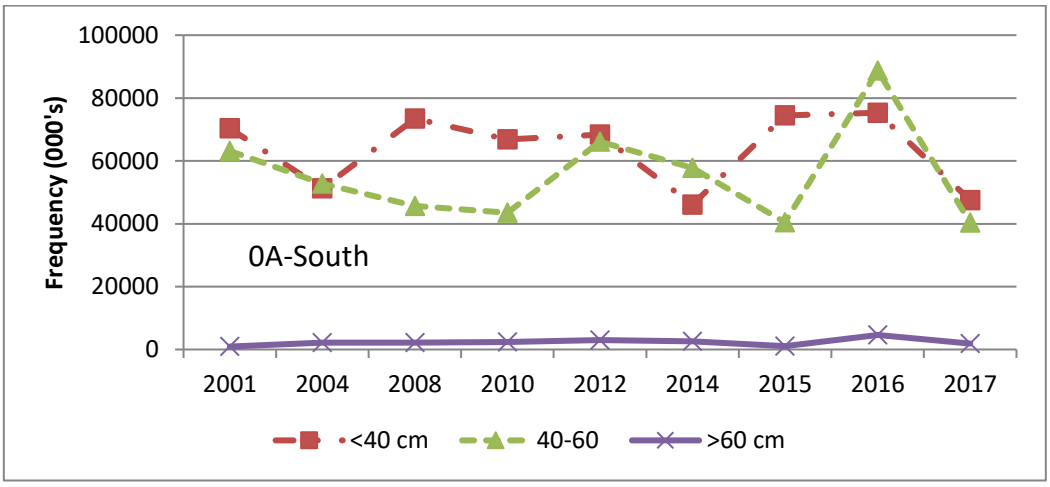


Fig. 7. Abundance by size class for Divisions 0A-South: <40 cm (recruitment); 40-60 cm (size range for trawl catches); >60 cm (size range for gillnet catches).

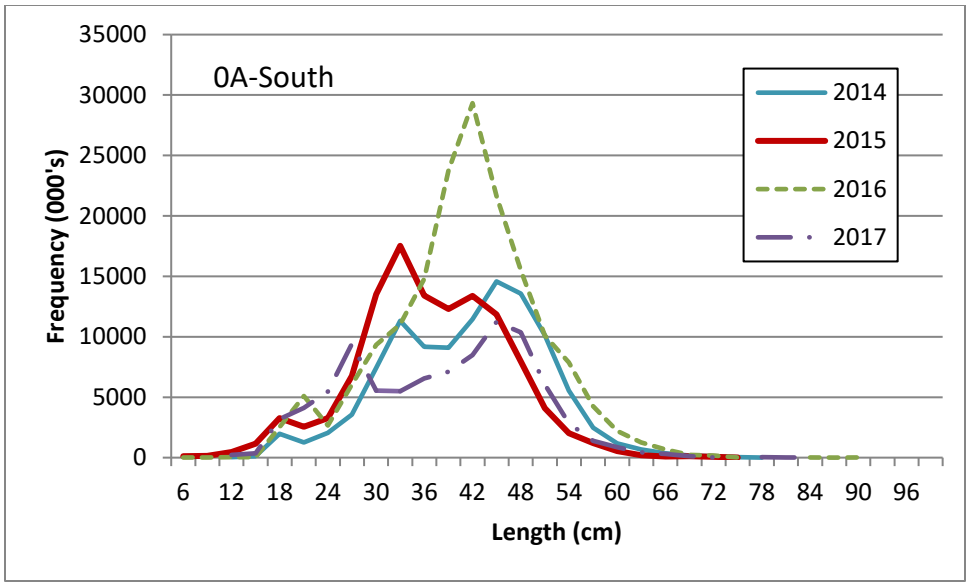


Fig. 8. Abundance-at-length for Greenland halibut in Divisions 0A-South, weighted by stratum area.

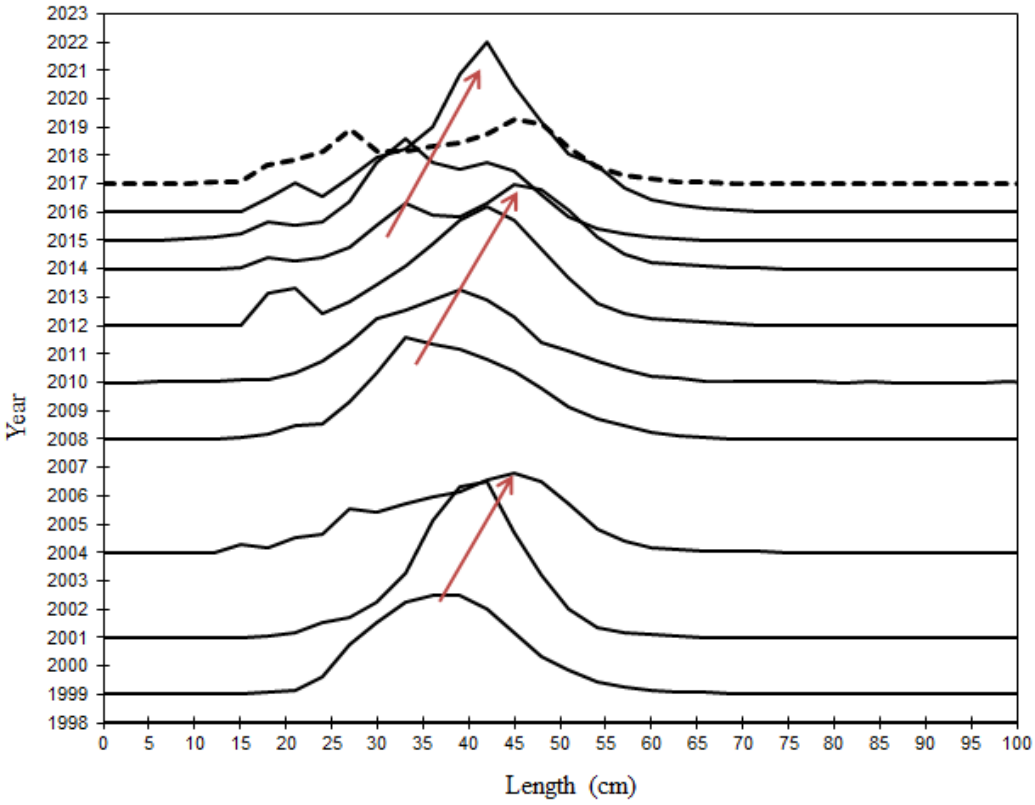


Fig. 9. Length frequency distribution for Division 0A-South 2001-2016 (numbers/km2 weighted by stratum area).

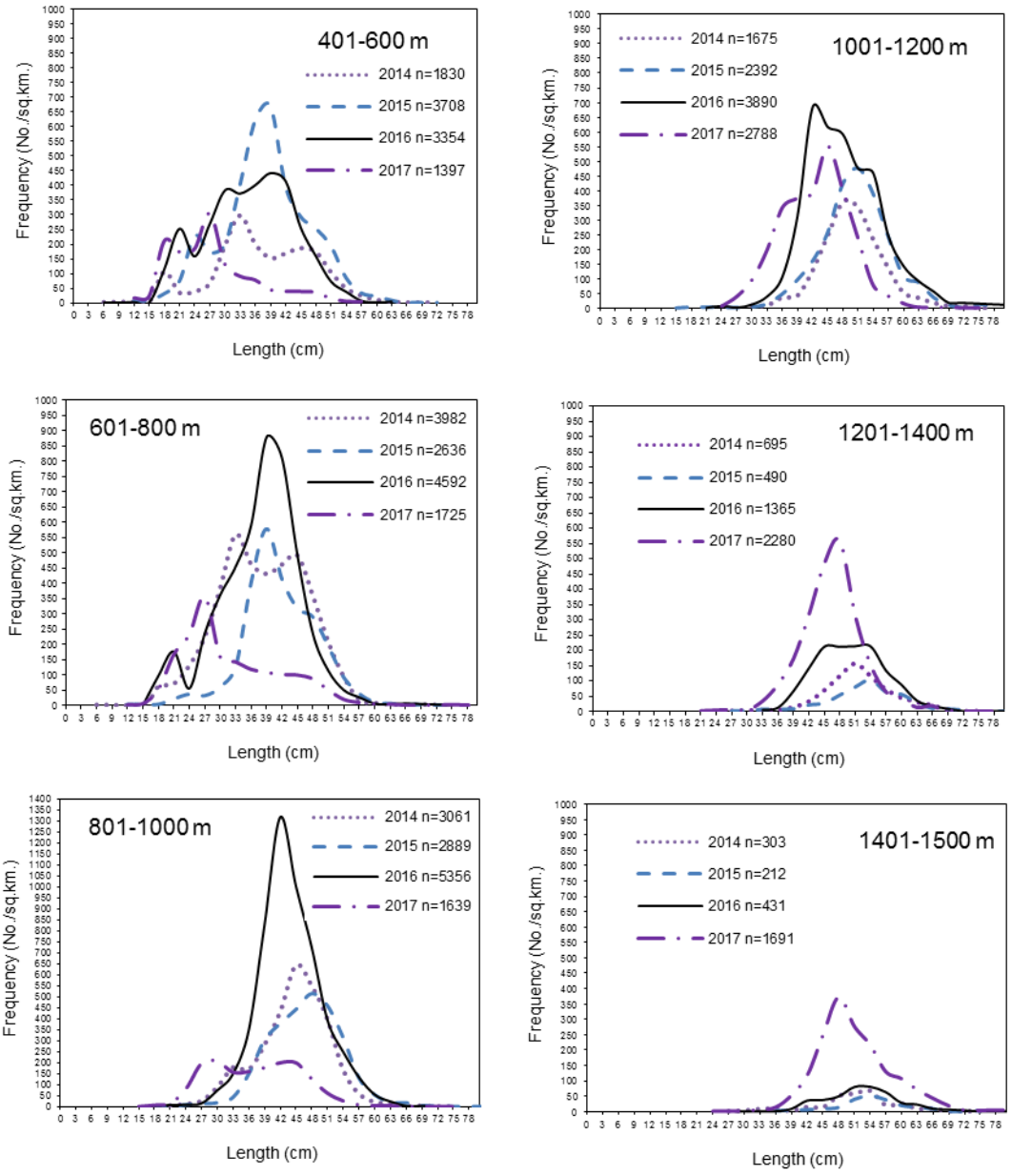


Fig. 10. Greenland halibut length distribution by depth for Divisions 0A-South, 2012 to 2016.

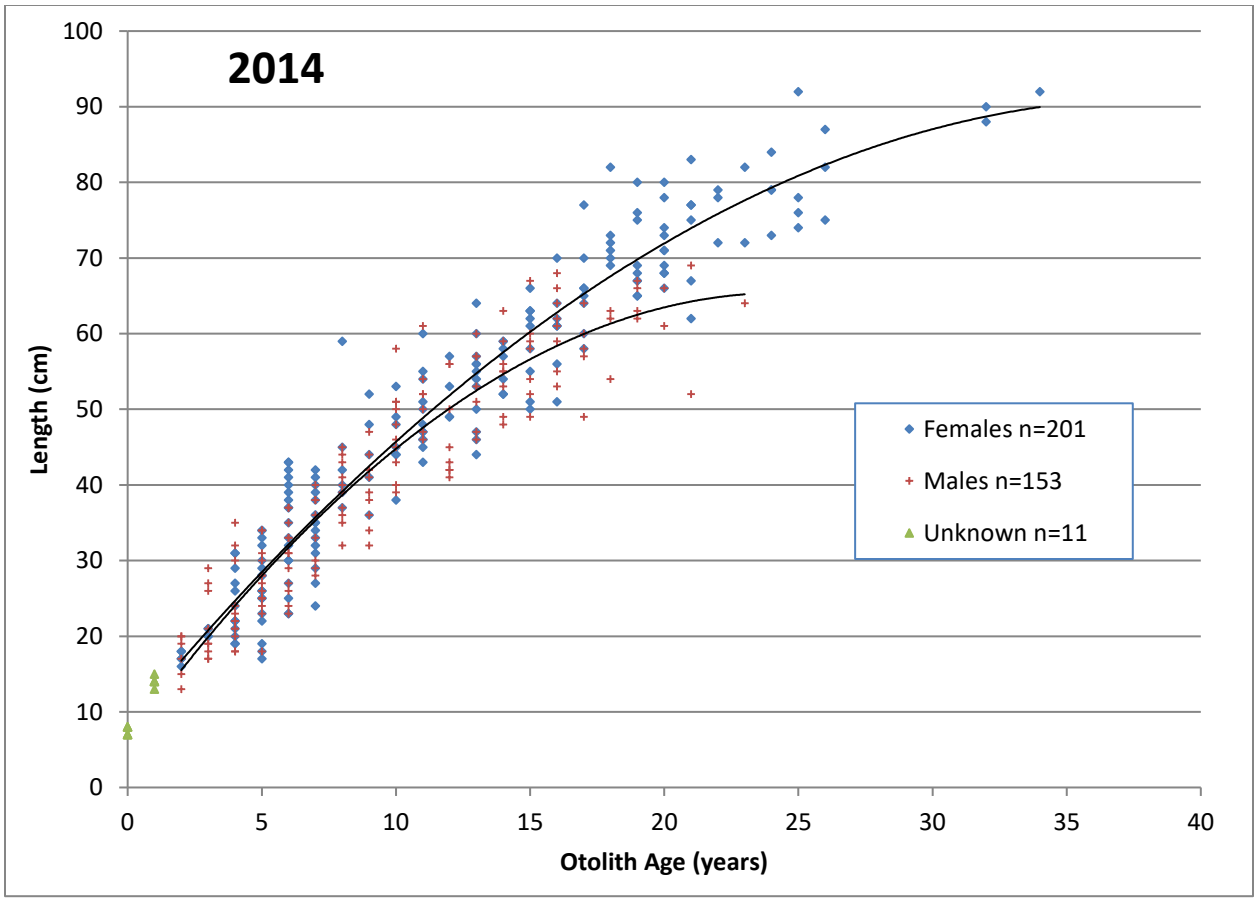


Fig. 11. Growth curves for Greenland halibut, by sex, for the 2014 survey in 0A-South.

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	10/27/2017	542	0.080862	2.04	47	37.55
2	0A	2	10/27/2017	592	0.080091	2.25	87	55.4
3	0A	3	10/28/2017	670	0.080179	2.86	74	66.13
4	0A	4	10/28/2017	686	0.072673	2.24	31	21.35
5	0A	5	10/28/2017	1048	0.084748	0.45	29	42.7
6	0A	6	10/28/2017	778	0.067491	2.49	53	48.1
7	0A	7	10/28/2017	979	0.088906	0.59	39	42.034
8	0A	8	10/28/2017	960	0.087552	1.01	152	116
9	0A	9	10/29/2017	997	0.093038	0.84	175	137.972
10	0A	10	10/29/2017	1317	0.082549	0.33	29	31.2
11	0A	11	10/29/2017	1379	0.086476	0.33	17	25.45
12	0A	12	10/29/2017	1471	0.084783	.	10	19
13	0A	13	10/29/2017	1432	0.084083	.	3	4.45
14	0A	14	10/29/2017	1354	0.087159	.	17	21
15	0A	15	10/29/2017	1474	0.082156	.	12	17.06
16	0A	16	10/30/2017	1286	0.0823	.	91	114.6
17	0A	17	10/30/2017	1459	0.086266	.	17	23.3
18	0A	18	10/30/2017	1428	0.088398	.	12	20.3
19	0A	19	10/30/2017	1320	0.089342	0.31	26	62.75
20	0A	20	10/30/2017	1181	0.091101	0.56	272.764	197.95
21	0A	21	10/31/2017	1248	0.088771	0.42	573	539.2
22	0A	22	10/31/2017	1242	0.090462	0.32	302	255.7
23	0A	23	10/31/2017	1484	0.068932	-0.09	147	193.55
24	0A	24	10/31/2017	959	0.086898	0.48	11	7.7
25	0A	25	10/31/2017	1077	0.07908	0.25	388.539	357.15
26	0A	26	11/01/2017	1249	0.087024	0.25	161	162.348
27	0A	27	11/01/2017	1427	0.090493	-0.03	145	177.5
28	0A	28	11/01/2017	745	0.087997	0.78	20	12.7
29	0A	29	11/01/2017	1055	0.090217	0.37	112	92.5
30	0A	30	11/01/2017	530	0.08567	1.18	0	0
31	0A	31	11/01/2017	941	0.085699	0.45	21	8.05
32	0A	33	11/02/2017	1437	0.068917	0.21	677.16	995.3
33	0A	34	11/02/2017	1255	0.092921	0.23	822	891.2
34	0A	35	11/02/2017	924	0.090621	0.44	56	25.45
35	0A	36	11/02/2017	733	0.086183	0.98	22	5.9
36	0A	37	11/02/2017	524	0.082402	1.21	25	12.1
37	0A	38	11/02/2017	524	0.082727	1.18	4	0.902
38	0A	39	11/02/2017	952	0.088771	0.47	111	67.284
39	0A	40	11/02/2017	1474	0.095729	-0.01	97	125.65
40	0A	41	11/03/2017	675	0.084732	1.05	68	30.25
41	0A	43	11/03/2017	610	0.079639	1.23	30	13.8
42	0A	45	11/03/2017	493	0.079583	1.08	5	3.24
43	0A	46	11/03/2017	744	0.08579	1.25	105	38.7
44	0A	47	11/04/2017	512	0.088911	1.12	40	12.95
45	0A	48	11/04/2017	1072	0.092453	0.33	531	332.6

46	0A	49	11/04/2017	919	0.085501	0.75	195	49.85
47	0A	50	11/04/2017	1446	0.086811	0.29	148	139.7
48	0A	51	11/04/2017	1256	0.08352	0.35	124	106.2
49	0A	52	11/04/2017	1066	0.092341	0.48	63	31.8
50	0A	53	11/04/2017	735	0.082301	1.13	95	24.75
51	0A	54	11/05/2017	895	0.087295	1	254	93.55
52	0A	55	11/05/2017	1223	0.082236	.	79	69.05
53	0A	56	11/05/2017	1124	0.088935	0.45	124	85.3
54	0A	57	11/05/2017	588	0.083972	0.51	488.376	119.85
55	0A	58	11/06/2017	957	0.09203	0.78	91	40.05
56	0A	59	11/06/2017	1111	0.092853	0.49	335	232.25
57	0A	60	11/06/2017	1134	0.093672	0.48	293.56	269.2
58	0A	61	11/06/2017	717	0.084443	1.18	895.81	149.35
59	0A	62	11/06/2017	941	0.087785	1.03	548.64	364.762
60	0A	63	11/06/2017	770	0.097456	1.1	324.394	131.378
61	0A	65	11/06/2017	450	0.089662	1.16	59	8.75
62	0A	66	11/07/2017	1043	0.0885	0.6	338.336	315.75
63	0A	67	11/07/2017	734	0.092736	1.14	237	119
64	0A	68	11/07/2017	587	0.088305	1.38	493.535	53.8
65	0A	69	11/07/2017	748	0.080865	1.14	232	118.3
66	0A	70	11/07/2017	737	0.086649	1.26	97	57
67	0A	71	11/07/2017	551	0.083629	1.45	155	32.5
68	0A	72	11/07/2017	560	0.084533	1.42	77	23
69	0A	73	11/07/2017	465	0.088228	1.31	112	38.2
70	0A	74	11/08/2017	498	0.086141	1.28	80	13.65
71	0A	75	11/08/2017	678	0.090735	1.33	90	73.8
72	0A	76	11/08/2017	874	0.094912	0.94	89	65.39
73	0A	77	11/08/2017	794	0.055789	1.16	44	28.95
74	0A	78	11/08/2017	643	0.086764	2.65	77	60.45