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Report on Greenland halibut (*Reinhardtius hippoglossoides*) caught during the 2022 trawl survey in Subarea 0

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A stratified-random otter trawl survey was conducted in southern Division 0A (0A-South) and Division 0B in 2022. The survey was planned to extend north to 72°N but sea ice limited the northward extent to 68°N in 2022. The 2022 survey added a 200-400 m depth stratum and adjusted previous strata to reflect fishing closures (not surveyed) and recent bathymetric data. The survey took place from October 28 to November 26, 2022. A Bacaloa trawl was used with the new R.V. Tarajoq, replacing the Alfredo III trawl that was previously used with the R.V. Paamiut (1999-2017). Survey stations were randomly located within each depth stratum in Divisions 0A and 0B. Near-bottom temperatures were similar to previous surveys varying between -0.95 to 1.42^∘C in Div. 0A and 0.51 to 3.74^∘C in Div. 0B with the highest mean temperature in the 600-800 m stratum and the coldest means in the 200-400 and 1400-1500 m strata. Greenland halibut were distributed throughout the survey area and were present in all tows. A majority of both females (91%) and males (94%) were immature in Div. 0A, but the ratios were more balanced in 0B, where 64 and 46% of females and males, respectively, were immature. The 2022 biomass estimates for 0A and 0B were 94,152 t (S.E. 20,878) and 67,553 t (S.E. 6,833), respectively. The 2022 abundance estimates for 0A and 0B were 140.0x10^6 (S.E. 30.8x10^6) and 65.6x10^6 (S.E. 5.7x10^6), respectively. These biomass and abundance values cannot be compared directly with the previous time series from the R.V. Paamiut because a calibration is not available to account for the change and vessel and gear.

Introduction

A depth-stratified random multi-species bottom trawl survey was conducted in southern Division 0A (0A-South; to approximately 72°N) and 0B in Northwest Atlantic Fisheries Organization Subarea 0 using the R.V. Tarajoq during October 28 to November 26, 2022. This was the first survey of NAFO Subarea 0 with the R.V. Tarajoq, and it occurred later than previous surveys with R.V. Pâmiut (4 week period between late September to early November; 1). The 2022 survey used a Bacalao trawl instead of the Alfredo III trawl that was used during previous surveys with the R.V. Pâmiut and F.V. Helga Maria. The survey stratification was also altered by adding a 200-400 m depth stratum to the existing strata (400-600, 600-800, 800-1000, 1000-1200, 1200-1400, 1400-1500 m). With the changes in vessel, gear and stratification this represents the start of a new survey time series.

Deep-water surveys in 0A-South started in 1999 and were completed every second year between 2004 and 2014, then annually between 2015 and 2017. Surveys in 0B were less frequent, occurring in 2000, 2001, 2011 and 2013 to 2016. These surveys were all completed using the R.V. Pâmiut. Following retirement of the R.V.

Pâmiut in 2018 the F.V. Helga Maria was used to conduct a survey of 0A-south in 2019, but post-survey analysis identified significant differences in trawl performance below 700 m, therefore the data were not accepted for assessing the status of the NAFO Subarea 0 stock. Detailed descriptions of changes in survey coverage, timing, vessel and gear are provided in Hedges and Raffoul (2023).

The survey objectives were to:
1) Collect data required to establish age structure and estimate the population abundance, biomass, and recruitment of Greenland halibut;
2) Record numbers caught and collect length and weight data on all other commercial species to support by-catch monitoring through the calculation of abundance, biomass indices, and size structure of individual species;
3) Record numbers and collect weight data on all non-commercial species caught, to allow calculation of abundance and biomass indices for individual species;
4) 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);
5) Calculate total biomass caught per tow and per survey as an index of overall ecosystem productivity;
6) Collect temperature data at each fishing station.

Table 1. Survey locations, dates, vessels and gear used since 1999 in NAFO Subarea 0.

Year	0A-North	0A-South	0B	Vessel	Gear	Accepted
1999		X		Paamiut	Alfredo III	Y
2000			X	Paamiut	Alfredo III	Y
2001		X	X	Paamiut	Alfredo III	Y
2002						
2003						
2004	X	X		Paamiut	Alfredo III	Y
2005						
2006		X		Paamiut	Alfredo III	Y
2007						
2008		X		Paamiut	Alfredo III	Y
2009						
2010	X	X		Paamiut	Alfredo III	Y
2011			X	Paamiut	Alfredo III	Y
2012	X	X		Paamiut	Alfredo III	Y
2013			X	Paamiut	Alfredo III	Y
2014		X	X	Paamiut	Alfredo III	Y
2015		X	X	Paamiut	Alfredo III	Y
2016		X	X	Paamiut	Alfredo III	Y
2017		X		Paamiut	Alfredo III	Y
2018						
2019		X		Helga Maria	Alfredo III	N
2020						
2021						
2022		X	X	Tarajoq	Bacalao	TBD

Methods

Stratification and Set Selection

A depth 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 were redefined in 2022 using updated bathymetric data, resulting in slight differences from the depth bins used in surveys conducted between 1999 and 2017. Therefore, sets completed during 1999-2017 were re-assigned to the new depth strata post-hoc to allow consistent spatial extrapolation when calculating abundance and biomass indices across years (figures 1, 2 and 3, and table 2). Previous revisions to the survey strata and changes to earlier index calculations are described in Treble (2020).

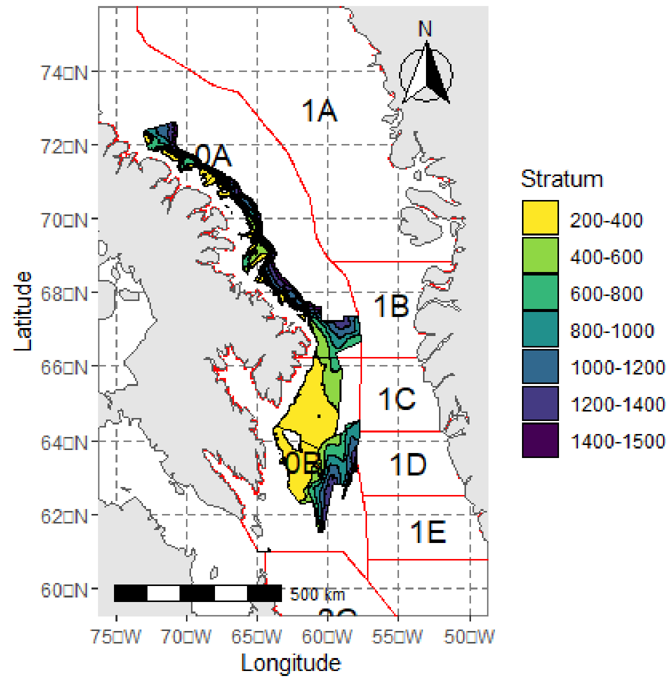

Figure 1. Map of NAFO areas and survey strata.

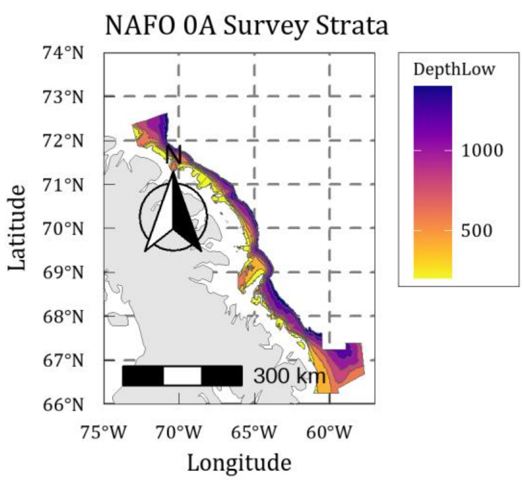

Figure 2. Stratification scheme for Division 0A-South

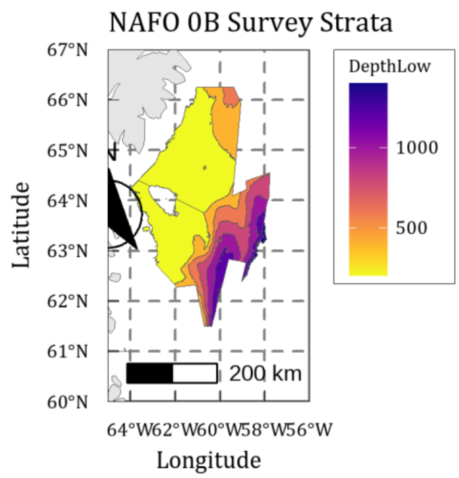

Figure 3. Stratification scheme for Division 0B

Table 2. Survey stratification scheme for NAFO Subarea 0.

Survey Area	Stratum	Depth Stratum (m)	Area (km2)	Assigned Sets (1/750km2)
0A	A1-200	200-400	2441.000	2
0A	A1-400	400-600	2151.560	6
0A	A1-600	600-800	794.750	7
0A	A1-800	800-1000	603.810	5
0A	A1-1000	1000-1200	745.210	3
0A	A2-1000	1000-1200	1873.100	2
0A	A1-1200	1200-1400	812.760	3
0A	A1-1400	1400-1500	497.500	2
0B	B1-200	200-400	11284.853	21
0B	B2-200	200-400	25878.841	37
0B	B1-400	400-600	17396.930	15
0B	B1-600	600-800	2282.965	8
0B	B1-800	800-1000	8053.127	11
0B	B1-1000	1000-1200	6585.633	8
0B	B1-1200	1200-1400	4753.855	5
0B	B1-1400	1400-1500	1964.565	2

The survey area between 200 and 1500 m in Div. 0A-South (to approximately 72°N) is 47,924 km2 (Table 1) within which there are 79 sets randomly assigned to 28 sub-strata (4 sub-stratum in each of 7 depth strata). In Div. 0B, 110 survey statsion are divided among 8 sub-strata (2 sub-strata within the 200-400 m depth stratum; all other depth strata were not subdivided). 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 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 sub-stratum as feasible given the conditions. When this is not possible the tow may be re-located to an area of the sub-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 prior to 2019 were conducted by the RV Pâmiut, a 1084 GRT stern trawler measuring 53 m in length. An Alfredo III bottom otter trawl with rock hopper ground gear was used. 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 and since 2010 the wingspread.
The 2019 vessel, FV Helga Maria, was 1470 GRT and 57 m in length. The trawl gear and rigging as described above remained unchanged. The warps, bridle, ground gear and distance from the hanging blocks were kept the same as on the RV Paamiut. The fishing procedures were also the same, the RV Paamiut captain and crew were involved prior to and during the survey. See Treble and Nogueira (2020) for additional information on vessel comparison and gear performance.
In 2022 the survey was conducted using the RV Tarajoq, which is 2841 GRT and 61.4 m long stern trawler. The RV Tarajoq used a Bacalao trawl but followed the same fishing procedures as the RV Paamiut and had the same captain and crew.

Oceanographic Sampling

A Seabird 19°C CTD (conductivity, temperature and depth recorder) was mounted on the head-rope beginning in 2010 and was used to determine temperature, depth and time spent on the bottom. In the few cases where there were no data from the CTD, data from the Furuno trawl eye sensor was used to determine bottom temperature.
There are two oceanographic lines that cross the shelf and slope at Broughton Island (near 68°N) and Cape Christian (near 71°N). These transect lines are completed when conditions (time and/or ice) allow. The transect lines were not completed in 2022.

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 use of the ship's 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 Greenland halibut, redfish 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, 5 per 3 cm length group per sex per set. Otolith samples have not yet been analyzed from the 2022 survey. 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. Prior to 2022, when wingspread (aka outer bobbin distance) was not available it was calculated as: 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). In 2022 when wingspread was not available for a set the mean wingspread value for sets in the depth stratum was imputed. If neither wingspread or doorspread was available and the tow was valid then the mean wingspread value for that trip was used. 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

A sub-stratum area may be included in the analysis even if it contains less than 2 sets, if the total number of sets for the depth stratum is greater than 2. In other words, sets are assigned at the sub-strata level but the analysis and threshold for inclusion is done at the depth strata level. This approach to the analysis was reviewed in 2014 and considered acceptable, given the index based nature of the assessment. The biomass index for 0A-South and 1CD for 1999-2017 calculated using the 6 depth strata were compared to the index calculated using the 30 smaller strata used to assign survey sets during those years and was found to be comparable for 2 of the 4 years examined. Work will be completed to assess the impact of this approach and adjust analysis of future surveys accordingly.

Mean and standard error for abundance and biomass were calculated for each depth strata containing 2 or more sets. As noted above these estimates are not calculated at the finer sub-strata level but at the larger depth strata level. Estimates of total abundance and biomass were then calculated for each depth strata (mean x area surveyed (km^2)) and summed over all depth strata. 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. Note that the 1400-1500 m depth strata was poorly covered in 1999, 2001 and 2006 and the survey area was adjusted (reduced) accordingly for those years (table 3).

Results and Discussion

The 2022 survey was scheduled later in the year than any preceding surveys, occurring from October 28 to November 28, 2023. The vessel encountered sea ice in NAFO Div. 0A near the start of the survey and was generally not able to complete survey sets north of 68°N. The number of stations completed per survey strata in each year is presented in table 3.

There was insufficient time during the 2022 survey to complete oceanographic profiles at the stations along the Broughton Island and Cape Christian transect lines.

Survey Timing

Most of the 0A surveys have taken place between late September and early November. An analyses of effects of survey timing was conducted int 2020 (Wheeland et al. 2020). The analysis found that in 2019, when the survey occurred in August, Greenland halibut were located shallower than was typical. TheT analysis also suggested that in the 2017m when the survey occurred approximate 4 weeks later than usual, catches were higher in the deepest strata than was typical for previous surveys. These findings demonstrate the importance of keeping survey timing as consistent as possible, to reduce the uncertainty around results which is often difficult to understand.

The 2022 survey occurred from October 28 to November 28, which was the latest the survey has occurred. The survey design for future years is to maintain consistency in survey timing, occurring over a 30 days period between mid-October and late November.

Table 3. Distribution of survey sets among strata in Subarea 0 by year. Areas with fewer than 2 completed survey sets were removed due to incomplete set coverage.

Survey Area	Stratum	Depth Stratum (m)	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2019	2022
0A	A1-400	400-600	8			6	5	4	5		4		6	4	5	6	3	6
0A	A2-400	400-600	2		3		7	3	5		5		4	5	5	3	6	
0A	A3-400	400-600	3				4	2	2		2		2	2		2	2	
0A	A1-600	600-800	4		5	5	7	7	7		7		8	7	7	9	7	7
0A	A4-600	600-800	2			2			3		3		2	3	3		3	
0A	A1-800	800-1000	5		3	6	4	8	8		7		7	6	6	5	6	5
0A	A2-800	800-1000	2					2	2		2		2		3	4	2	
0A	A3-800	800-1000	3		2	3		2	2		2		2	2	2	3	2	
0A	A1-1000	1000-1200	2		3	4	2	4	4		4		5	5	4	4	3	3
0A	A2-1000	1000-1200	4		2	2	5	2	2		3		4	2		5	2	2
0A	A3-1000	1000-1200	2			4			2		2		2	3	2	2	2	
0A	A1-1200	1200-1400	3		4	3		4	5		5		5	2	3	3	3	3
0A	A2-1200	1200-1400	2		5	5	3	3	3		3		4	3	3	5	4	

Survey Area	Stratum	Depth Stratum (m)	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2019	2022
0A	A3-1200	1200-1400	2			2		3	2		2		2	3	2	2	2	
0B	B1-400	400-600		4	2					12		12	7	12	11			15
0B	B1-600	600-800		8	6					8		10	7	9	8			8
0B	B1-800	800-1000		12	8					11		11	11	9	11			11
0B	B1-1000	1000-1200		6	5					8		8	8	8	8			8
0B	B1-1200	1200-1400		4	2					5		4	6	4	6			5
0A	A2-600	600-800			3		3	4	3		3		3	4	3	3	2	
0A	A4-800	800-1000				2			2		2		3	2	2		2	
0A	A4-1200	1200-1400				4		2	3		4		2	3	3		2	
0A	A4-400	400-600						3	3		3		2	2	3		2	
0A	A3-600	600-800						2	2		2		2	2	2	2	2	
0A	A4-1000	1000-1200						2	2		2		3		2		2	
0A	A1-1400	1400-1500						2			2			2	2	2	2	2
0A	A2-1400	1400-1500						2	2				2		2	3		
0A	A3-1400	1400-1500						2	2		2		2	2	2	2		

Survey Area	Stratum	Depth Stratum (m)	1999	2000	2001	2004	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2019	2022
0A	A4-1400	1400-1500											2				2	
0B	B1-1400	1400-1500													2			2
0A	A1-200	200-400																2
0B	B1-200	200-400																21
0B	B2-200	200-400																37

Near-bottom temperature, recorded by a CTD mounted on the trawl just behind the trawl eye, were similar to previous years, ranging from -0.95 to 1.42°C in Div. 0A and 0.51 to 3.74°C in Div. 0B (tables 4 and 5, and figure 4).

Table 4. Mean temperature and S.E. in C by Depth Stratum for Division 0A-South.

Survey Area	Year	200	400	600	800	1000	1200	1400
0A	1999		- (-)	- (-)	- (-)	- (-)	- (-)	
0A	2001		- (-)	- (-)	- (-)	- (-)	- (-)	
0A	2004		- (-)	- (-)	0.7 (-)	- (-)	0.035 (0.065)	
0A	2006		1.044 (0.057)	1.3 (0.026)	1.3 (0.242)	0.9 (0.082)	0.2 (0.058)	
0A	2008		1.182 (0.109)	1.377 (0.037)	1.218 (0.046)	0.799 (0.084)	0.394 (0.048)	0.1 (0.046)
0A	2010		1.209 (0.039)	1.169 (0.06)	1.02 (0.039)	0.692 (0.07)	0.236 (0.055)	0.028 (0.045)
0A	2012		1.531 (0.059)	1.507 (0.039)	1.182 (0.052)	0.692 (0.065)	0.277 (0.047)	-0.005 (0.013)
0A	2014		1.444 (0.075)	1.398 (0.049)	1.297 (0.024)	0.82 (0.078)	0.369 (0.041)	0.147 (0.049)
0A	2015		1.397 (0.022)	1.376 (0.036)	1.139 (0.113)	0.737 (0.076)	0.197 (0.056)	-0.032 (0.04)
0A	2016		1.232 (0.035)	1.158 (0.08)	0.865 (0.066)	0.589 (0.059)	0.301 (0.055)	0.157 (0.049)
0A	2017		1.265 (0.034)	1.302 (0.126)	0.732 (0.068)	0.446 (0.033)	0.316 (0.024)	0.074 (0.074)
0A	2019		1.282 (0.094)	1.165 (0.076)	0.961 (0.069)	0.631 (0.051)	0.166 (0.032)	-0.078 (0.051)
0A	2022	-0.945 (0.215)	1.347 (0.106)	1.423 (0.017)	1.15 (0.137)	0.723 (0.041)	0.435 (0.045)	0.17 (-)

Table 5. Mean temperature and S.E. in C by Depth Stratum for Division 0B.

Survey Area	Year	200	400	600	800	1000	1200	1400
0B	2000		- (-)	- (-)	- (-)	- (-)	- (-)	
0B	2001		- (-)	- (-)	- (-)	- (-)	- (-)	
0B	2011		2.441 (0.406)	3.464 (0.297)	4.018 (0.024)	3.84 (0.019)	3.714 (0.022)	
0B	2013		2.224 (0.184)	3.619 (0.244)	4.117 (0.043)	3.905 (0.024)	3.767 (0.034)	
0B	2014		2.757 (0.297)	3.381 (0.305)	3.96 (0.031)	3.825 (0.041)	3.667 (0.026)	
0B	2015		2.292 (0.351)	3.378 (0.267)	3.823 (0.05)	3.671 (0.015)	3.585 (0.024)	
0B	2016		1.863 (0.143)	2.731 (0.287)	3.772 (0.026)	3.659 (0.026)	3.57 (0.014)	3.505 (0.015)
0B	2022	0.508 (0.126)	2.227 (0.213)	3.642 (0.184)	3.677 (0.132)	3.744 (0.009)	3.547 (0.044)	3.515 (0.055)

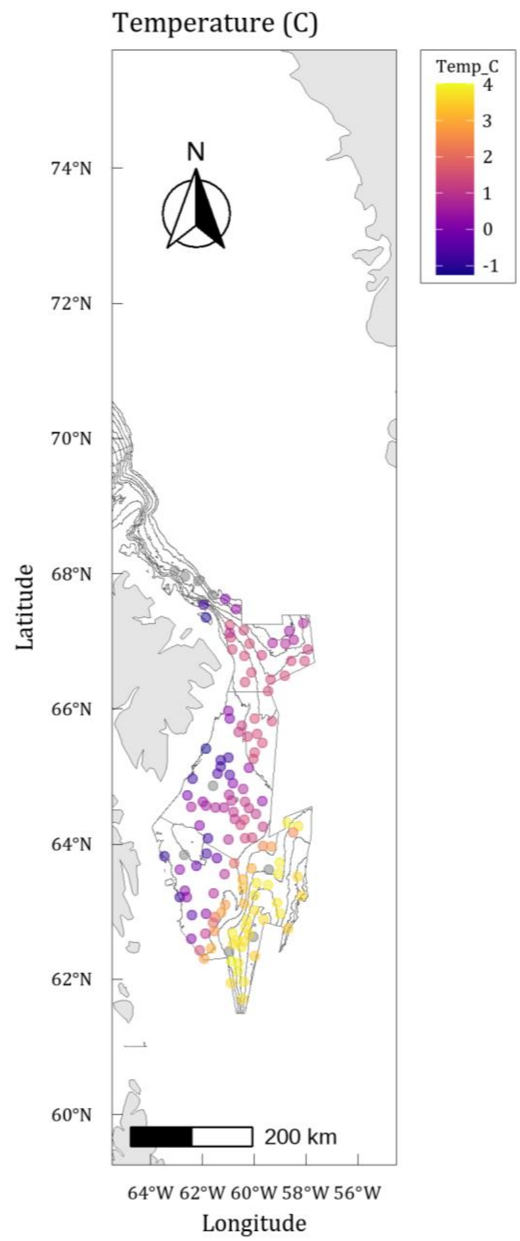

Figure 4. Bottom temperatures in Division 0A during the 2022 survey.

Greenland Halibut

The catch in 2022 was comprised of 48% females and 50% males, with 2% unknown, in Div. 0A and 36% female, 60% male and 4% unknown in Div. 0B, similar to proportions observed in previous surveys (table 6). In Div. 0A, 94% and 91% of females and males were immature, and in 0B 64% and 46% of females and males were immature, respectively. The pattern of maturity in in both Divisions matches observations in previous years.

Table 6. Sex and maturity proportions, for Subarea 0.

StudyArea	Year	Sex	SexPercent	Maturity	SexMatPercent
0A	2015	Female	49	Immature	82
0A	2015	Female	49	Mature	18
0A	2015	Male	51	Immature	84
0A	2015	Male	51	Mature	16
0A	2015	Unsexed or Unsexable	0	Immature	100
0A	2016	Female	48	Immature	97
0A	2016	Female	48	Mature	3
0A	2016	Male	52	Immature	31
0A	2016	Male	52	Mature	69
0A	2016	Male	52	Uncertain	0
0A	2016	Unsexed or Unsexable	0	Uncertain	100
0A	2017	Female	53	Immature	97
0A	2017	Female	53	Mature	3
0A	2017	Male	47	Immature	58
0A	2017	Male	47	Mature	42
0A	2017	Unsexed or Unsexable	0	Immature	100
0A	2019	Female	52	Immature	91
0A	2019	Female	52	Mature	9
0A	2019	Male	48	Immature	87
0A	2019	Male	48	Mature	13
0A	2019	Male	48	Uncertain	0
0A	2019	Unsexed or Unsexable	0	Uncertain	100
0A	2022	Female	48	Immature	94
0A	2022	Female	48	Mature	6
0A	2022	Male	50	Immature	91
0A	2022	Male	50	Mature	9
0A	2022	Unsexed or Unsexable	2	Uncertain	100
0B	2015	Female	31	Immature	56
0B	2015	Female	31	Mature	44
0B	2015	Male	68	Immature	23
0B	2015	Male	68	Mature	77
0B	2015	Unsexed or Unsexable	1	Immature	74
0B	2015	Unsexed or Unsexable	1	Uncertain	26
0B	2016	Female	27	Immature	82
0B	2016	Female	27	Mature	18
0B	2016	Male	73	Immature	3
0B	2016	Male	73	Mature	97
0B	2016	Unsexed or Unsexable	0	Uncertain	100

StudyArea	Year	Sex	SexPercent	Maturity	SexMatPercent
0B	2022	Female	36	Immature	64
0B	2022	Female	36	Mature	36
0B	2022	Male	60	Immature	46
0B	2022	Male	60	Mature	54
0B	2022	Unsexed or Unsexable	4	Immature	0
0B	2022	Unsexed or Unsexable	4	Uncertain	100

In 2022 biomass and abundance were both highest in the 1000-1200 m depth stratum in Div. 0A, showing increasing values as depth increased to 1000-1200 m and then declining at deeper depths (table 7). In Div. 0B biomass and abundance were much more variable among depth strata, with the highest biomass value observed in the 600-800 m stratum, and the highest abundance observed in the 400-600 m stratum (table 7). The addition of the 200-400 m depth strata represented a notable increase in survey area, but the strata had the lowest mean biomass and a moderate mean abundance, compared to other depth strata, suggesting the catches in that strata were largely composed of smaller Greenland halibut.

Table 7. Greenland halibut biomass and abundance with standard error by stratum for the 2022 survey.

SurveyArea	Strata	Mean Abundance (/km2)	Abundance (000s)	SE
0A	200-400	0.0000	0	0
0A	400-600	3451.5659	7e+06	2e+06
0A	600-800	3641.6840	3e+06	6e+05
0A	800-1000	8897.0624	5e+06	1e+06
0A	1000-1200	9173.4472	1e+07	3e+06
0A	1200-1400	818.2420	7e+05	13807
0A	1400-1500	833.7239	4e+05	1e+05
0B	200-400	545.6455	1e+07	1e+06
0B	400-600	2762.6228	5e+07	4e+06
0B	600-800	3035.9796	7e+06	5e+05
0B	800-1000	2004.8491	2e+07	1e+06
0B	1000-1200	1483.9517	1e+07	6e+05
0B	1200-1400	1969.4020	9e+06	7e+05
0B	1400-1500	2477.9396	5e+06	1e+05

Mean catch per tow (kg) in both Divs.0A and 0B in 2022 were similar to values in preceding years, being 2.37 in Div. 0A and 1.33 in Div. 0B (table 8).

Table 8. Mean catch-per-tow (tons) standardized to km2 of Greenland Halibut from SA0 by Division and year.

Year	0A	0B
1999	1.465075	
2000		1.319851
2001	2.117991	1.751651
2004	2.033940	
2006	1.073484	
2008	1.689792	
2010	1.597244	
2011		1.675027
2012	2.007876	
2013		1.180442
2014	2.594008	1.552975
2015	2.442057	1.680659
2016	2.906261	1.851830
2017	1.448271	
2019	1.667890	
2022	2.374909	1.331860

Greenland Halbiut biomass values in Divs. 0A and 0B were comparable within depth strata to values from previous years (table 9, figure 5). In Div. 0A, Biomass values showed a domed pattern, increasing with depth to the 800-1000 m stratum and declining thereafter.In Div. 0B the pattern in biomass was less clear, with high values observed from 400-1000 m.

Table 9. Biomass (tons) of Greenland Halibut by depth stratum for Subarea 0.

StudyArea	Year	200	400	600	800	1000	1200	1400
0A	1999		8972	6429	18057	20858	13077	
0A	2001	7	5833	29999	20002	14065	4223	
0A	2004		7027	8524	31405	33518	25291	
0A	2006		5275	6882	6697	25765	1541	
0A	2008		4490	13304	28732	22539	38778	3683
0A	2010		4248	13892	36472	41403	16393	4190
0A	2012		10913	45922	39035	33106	14081	1509
0A	2014		19872	74826	45664	42761	13158	3458
0A	2015		34240	50921	36492	33417	9064	1926
0A	2016		24625	46171	64654	40065	19668	5350
0A	2017		2436	10181	11436	22902	24572	22611
0A	2019		27429	40497	27140	8015	3532	1800
0A	2022	0	7987	11268	32203	14178	3755	1857
0B	2000		521	4278	17503	12865	9708	
0B	2001		751	5932	13570	14522	5122	2143
0B	2011		7534	17326	24359	17600	7125	1434
0B	2013		3881	12011	21857	10465	5268	818
0B	2014		4854	13232	20528	13257	8695	
0B	2015	330	5739	13110	30271	17457	6119	924
0B	2016		8280	13636	31437	18666	10571	2593
0B	2022	4928	32115	31909	32045	20296	13826	7390

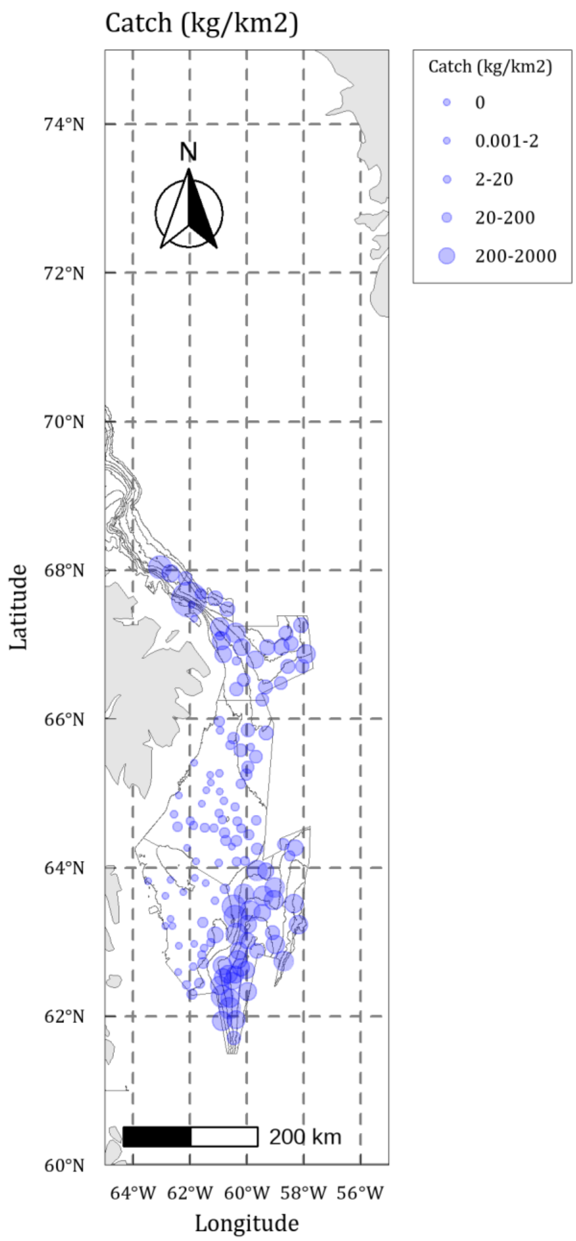

Figure 5. Biomass distribution for Greenland halibut in Division 0A, 2022.

Greenland halibut abundance by stratum within Div. 0A was similar in 2022 to preceding years, showing a domed pattern with depth similar to biomass (table 10, figure 6). In Div. 0B, abundance was highest in the 400-600 m stratum and declined steadily with depth (table 10, figure 6). This pattern differed from previous years in 0B, where abundance did not show clear trends with depth.

Table 10. Abundance of Greenland Halibut by depth stratum for Subarea 0.

StudyArea	Year	200	400	600	800	1000	1200	1400
0A	1999		21804.284	18296.911	39865.64	27236.132	11329.295	
0A	2001	16.85073	9100.198	60872.834	25210.75	19405.224	4360.651	
0A	2004		20041.590	13051.504	41228.45	34231.544	18073.324	
0A	2006		17193.431	19519.939	13493.69	38180.688	1460.714	
0A	2008		12169.975	31605.938	50871.88	33269.681	39074.546	2906.8989
0A	2010		11899.261	34877.494	66779.72	46892.792	13425.312	2740.0293
0A	2012		25222.218	69471.693	45780.81	27306.330	9926.393	1107.0751
0A	2014		28563.707	112831.358	47669.18	30239.330	8493.470	2285.4590
0A	2015		53568.655	64644.764	33094.49	24319.310	5567.190	1183.1998
0A	2016		47927.460	75272.505	72883.45	30278.850	14607.124	3538.7161
0A	2017		12393.082	27135.078	19666.48	28845.722	24052.963	16619.6114
0A	2019		29099.867	45113.840	22363.49	6210.367	2237.939	994.1897
0A	2022	0.00000	20709.396	25491.788	44485.31	22753.003	2454.726	1667.4477
0B	2000		3564.206	6180.261	21838.97	15043.362	10403.572	
0B	2001		1399.908	8664.201	16375.95	15701.327	5497.567	2077.7034
0B	2011		10429.090	17830.587	21592.41	15411.597	5975.477	1338.1173
0B	2013		5252.770	11658.364	19375.40	9453.539	4485.850	727.0420
0B	2014		4312.408	11780.720	16298.94	10695.147	6674.530	
0B	2015	618.18859	9258.909	11880.139	23498.46	13339.072	4524.601	647.5920
0B	2016		8974.005	13296.207	23245.94	13843.761	8206.111	1727.6482
0B	2022	17668.72038	41439.342	24287.837	22053.34	11871.613	9847.010	4955.8792

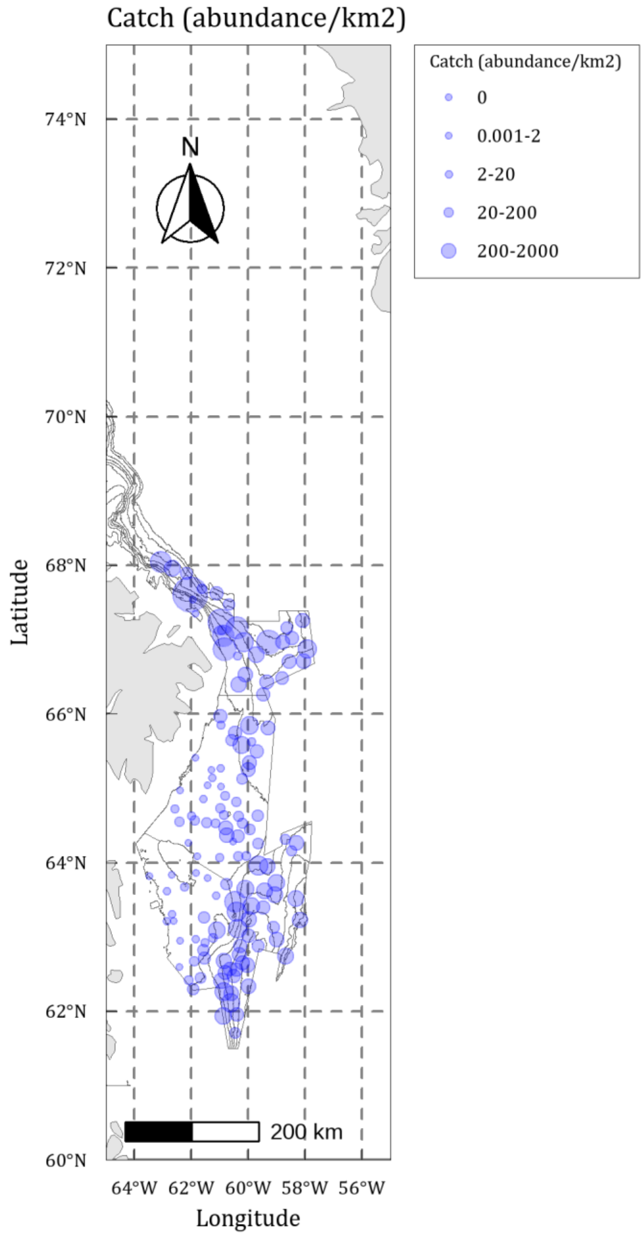

Figure 6. Abundance distribution for Greenland halibut in Division 0A, 2022.

The overall length distribution in 2022 ranged from 9 to 75 cm a mode at 42 cm, representing a leftward shift in the length frequency distribution compared to previous years (table 11). The Bacalao trawl used in 2022 had a smaller mesh size than the Alfredo III trawl used previously with the RV Paamiut and FV Helga Maria. The combination of the Bacalao trawl and the addition of the 200-400 m strata were expected to increase the number of small fish captured during the survey, which was observed.

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

Length	1999	2001	2004	2006	2008	2010	2012	2014	2015	2016	2017	2019	2022
3	1												
6						5		2					
9		1				2							1
12	11		2	2	1	4	3	5	10		16		11
15	1	3	61	39	8	31	4	8	12	4	26	1	27
18	34	13	43	90	81	54	258	156	38	81	219	96	227
21	57	63	125	409	168	144	327	71	84	152	253	86	238
24	281	193	163	353	207	305	129	121	224	110	395	60	143
27	806	246	415	459	448	589	168	214	168	213	680	94	198
30	1136	422	425	503	816	982	246	563	200	378	494	138	210
33	1365	747	596	560	1252	1087	427	923	441	402	537	161	149
36	1299	1318	751	630	1243	1335	701	746	998	595	668	243	230
39	1178	1596	918	615	1319	1492	1038	762	1457	1054	757	203	409
42	914	1551	1186	542	1289	1381	1318	1004	1249	1469	908	271	488
45	662	1085	1375	385	1111	1130	1285	1327	1215	1217	1170	330	433
48	394	621	1274	247	854	730	955	1299	1315	979	1079	455	374
51	237	300	923	135	549	510	618	1036	1203	732	626	469	259
54	149	116	448	75	342	352	309	583	867	584	307	370	195
57	89	50	225	34	207	188	190	286	445	345	140	218	121
60	46	26	107	1	119	118	100	139	211	169	89	136	73
63	33	10	58	3	46	82	79	85	119	89	46	91	40
66	10	7	34	2	26	29	50	46	61	44	31	44	15
69	5	5	14	1	6	13	20	17	26	18	11	27	9
72	4	2	15	2	3	6	9	15	11	10	2	10	3
75		1	6		2	4	4	5	9	3	4	4	1
78			6			2	3	1	5			2	

Length	1999	2001	2004	2006	2008	2010	2012	2014	2015	2016	2017	2019	2022
81			5				1		1		2	1	
84		1	2		2	2					1	2	
87			4						1	1		2	
90			1				1			1	1		
93	1		1		1								
96			1										
99						1							

During 2014 to 2017 the survey focused on Div. 0A-south (south of 72°N) and only extended in Div. 0B when weather and time permitted. Consequently, Div. 0B was survey in 2014-2016 and again in 2022 (figure 7). With revision of the survey stratification in 2022 the survey will now be undertaken in both Divs. 0A and 0B each year. The addition of the 200-400 m depth stratum in 2022 also added a significant area to survey (2022 panel in figure 7).

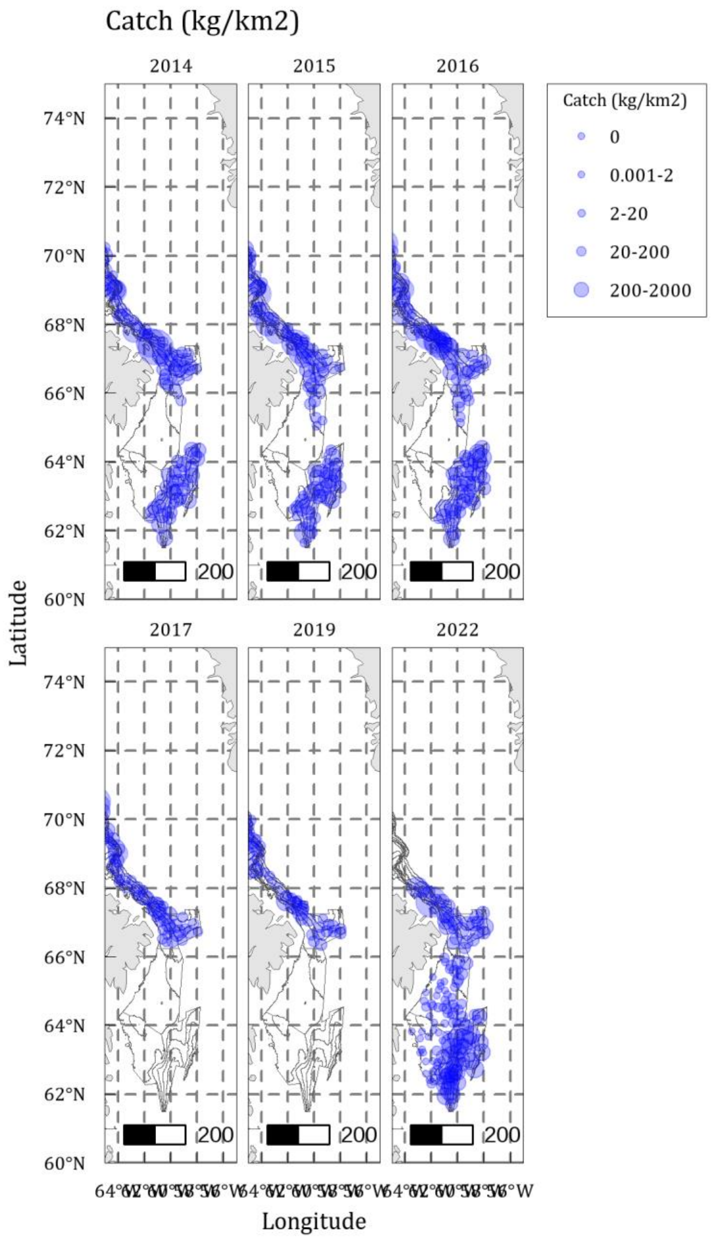

Figure 7. Distribution of Greenland halibut catch by year.

Biomass and abundance indices were calculated separately for Divs. 0A and 0B for 2022 (figures 8 and 9). Given the use of a new survey vessel and gear in 2022, the current index values cannot be put in context with previous index values, and represent the start of a new time series. Calibration experiments could not be completed between the vessels and gears, but a model-based approaches to survey standardization is being explored (Huynh and Carruthers, 2023).

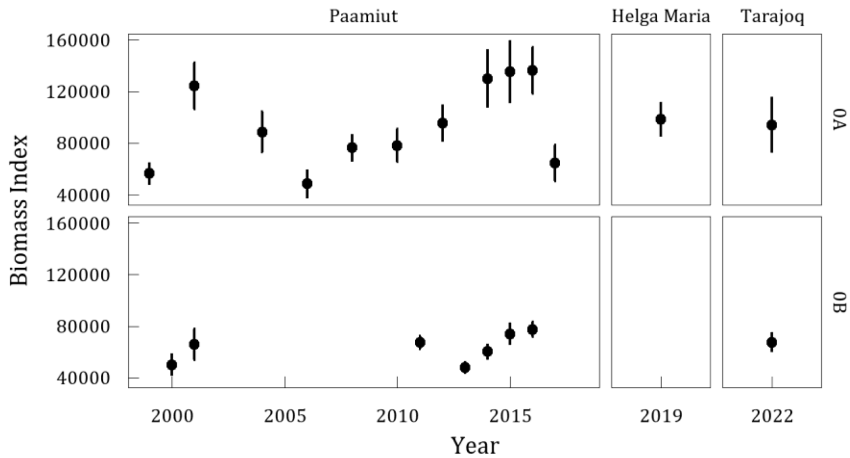

Figure 8. Biomass estimates (with SE) for Greenland halibut in Subarea 0.

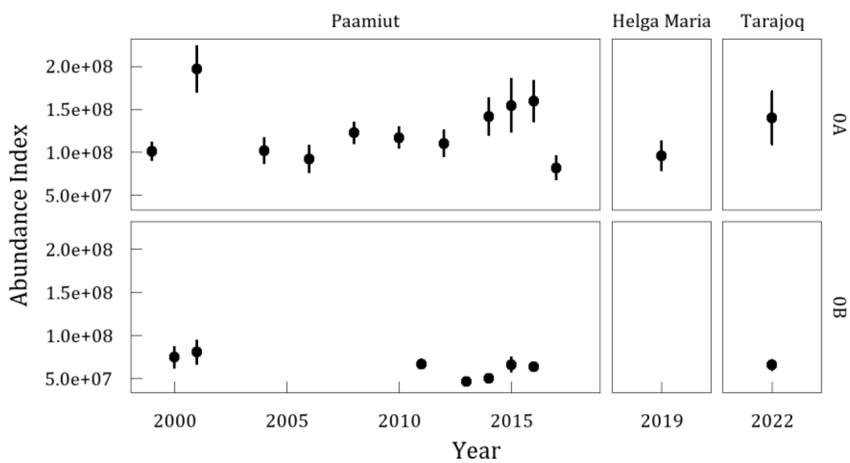

Figure 9. Abundance estimates (with SE) for Greenland halibut in Subarea 0.

Biomass and abundance by depth in 2022 showed similar patterns to previous years with the R.V. Paamiut, with biomass being highest between 600 and 1200 m (figures 10 and 11) in Div. 0A. In Div. 0B biomass and abundance were more evenly distributed among the depth strata.

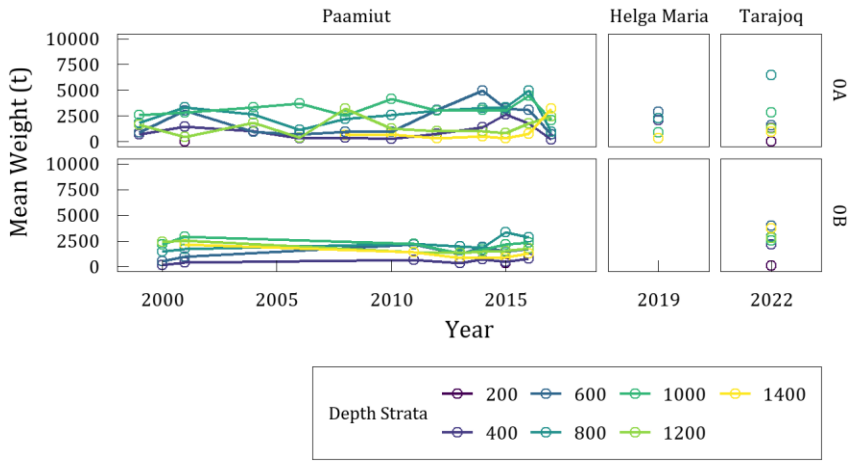

Figure 10. Biomass trends by depth strata for Subarea 0

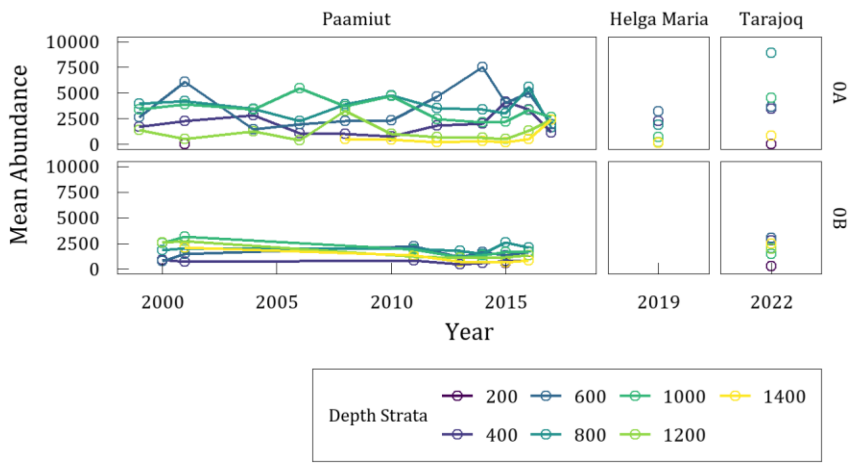

Figure 11. Biomass trends by depth strata for Subarea 0

The abundance of Greenland halibut <40 cm was similar to the abudance of 40-60 cm in Div. 0A, while fish >60 cm fork length were lower in abundance (figure 12). In Div. 0B, 40-60 cm fish were more abundant than either <40 cm or >60 cm fish.

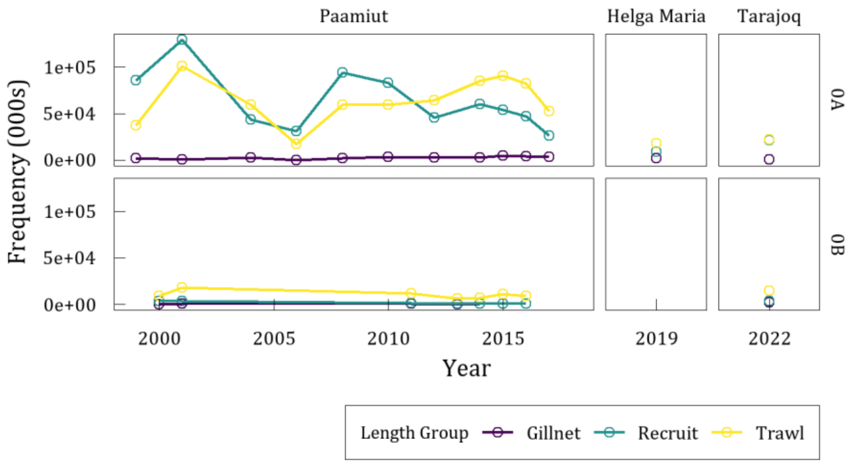

Figure 12. Abundance by size class for Divisions 0A: <40 cm (recruitment, left axis); 40-60 cm (size range for trawl catches, left axis); >60 cm (size range for gillnet catches, right axis).

Greenland halibut fork length ranged from 3 to 105 cm with a mean 0f 4.211 cm. Length-frequency distributions for Divs. 0A and 0B (figure 13) each showed a single large peak in 2022 and were skewed to the left.

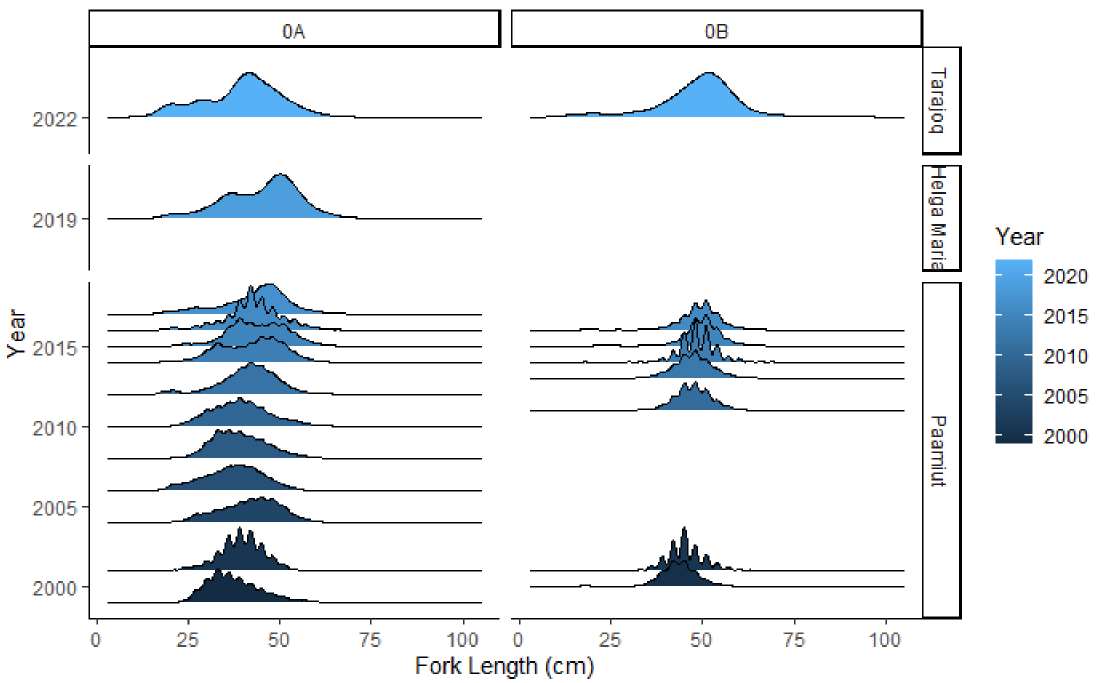

Figure 13. Length frequency distribution for Subarea 0 (numbers/km2 weighted by stratum area).

In both Divs. 0A and 0B, Greenland halibut length frequencies shifted to the right with depth from 200-800 m, but distributions were relative similar across 1000-1500 m (Figure 14).

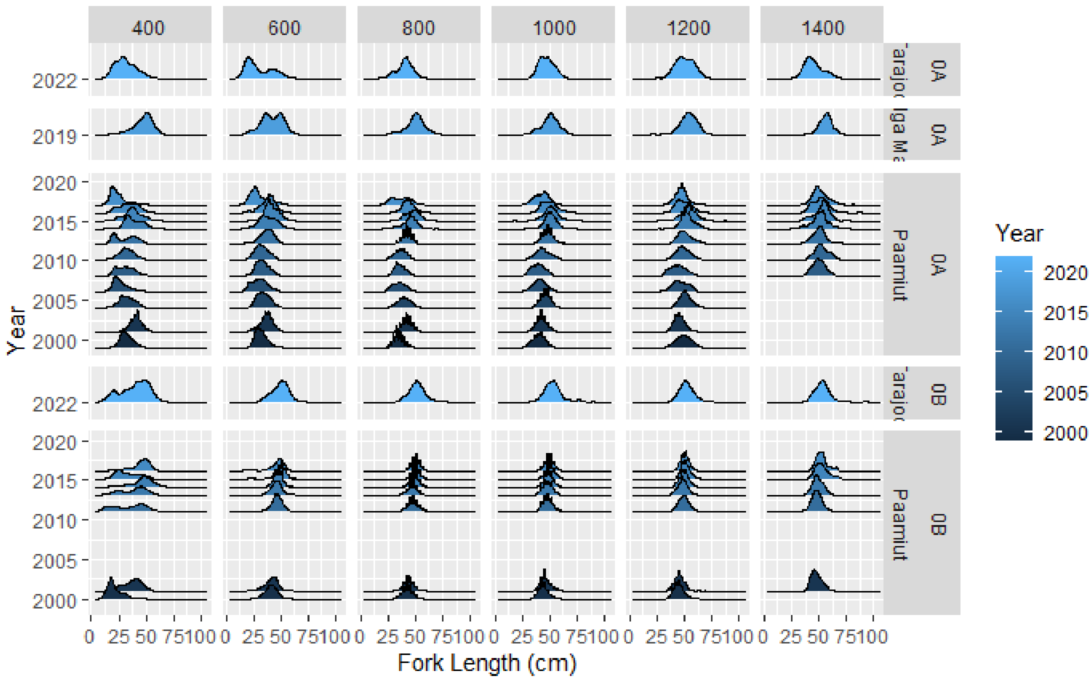

Figure 14. Greenland halibut length distribution by depth for Division 0A. Abundance values are per sqkm and weighted by set.

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Appendix A

Table 12. Greenland halibut raw catch weight, numbers (not standardised to kg/km2), temperature and depth for each set in the 2022 survey of Subarea 0.

Survey Area	Year	Set	Date	Mean Depth (m)	Depth Stratum (m)	Swept Area (sq km)	Temperature (C)	Weight (kg)	Number
0A	2022	1	2022-11-03	1130	1000-1200	0.0863165		568.420	592
0A	2022	2	2022-11-03	1132	1000-1200	0.0863165		241.260	231
0A	2022	3	2022-11-03	1279	1200-1400	0.0863165		89.920	72
0A	2022	4	2022-11-03	1414	1400-1500	0.0756867		29.040	19
0A	2022	5	2022-11-04	822	800-1000	0.0751241		1542.200	2055
0A	2022	6	2022-11-04	1441	1400-1500	0.0762490	0.17	112.340	108
0A	2022	7	2022-11-04	1249	1200-1400	0.0889679	0.39	129.780	67
0A	2022	8	2022-11-04	276	200-400	0.0863165	-0.73	0.000	0
0A	2022	9	2022-11-04	266	200-400	0.0863165	-1.16	0.000	0
0A	2022	11	2022-11-05	667	600-800	0.0910759	1.48	318.680	1109
0A	2022	12	2022-11-05	853	800-1000	0.0857730	1.35	357.600	695
0A	2022	13	2022-11-05	560	400-600	0.0773476	1.47	250.260	563
0A	2022	14	2022-11-05	515	400-600	0.0797070	1.42	202.220	709
0A	2022	15	2022-11-05	571	400-600	1.6314629	1.47	96.720	151
0A	2022	16	2022-11-05	899	800-1000	0.0785224	1.30	202.520	220
0A	2022	17	2022-11-05	755	600-800	0.0853858	1.48	194.800	434
0A	2022	18	2022-11-06	1060	400-600	1.3607244	0.82	145.460	126
0A	2022	19	2022-11-06	1136	1000-1200	0.0889541	0.66	151.810	908
0A	2022	20	2022-11-06	1098	1000-1200	0.0824646	0.80	148.880	140
0A	2022	21	2022-11-06	1236	1200-1400	0.0829966	0.48	104.100	72
0A	2022	22	2022-11-06	958	800-1000	0.0797334	0.75	114.720	136
0A	2022	23	2022-11-06	1121	1000-1200	0.0822473	0.71	105.740	108
0A	2022	24	2022-11-06	826	800-1000	0.0849490	1.20	296.200	384

Survey Area	Year	Set	Date	Mean Depth (m)	Depth Stratum (m)	Swept Area (sq km)	Temperature (C)	Weight (kg)	Number
0A	2022	25	2022-11-06	672	600-800	0.0794785	1.42	88.390	153
0A	2022	26	2022-11-07	748	600-800	0.0808588	1.37	103.780	145
0A	2022	27	2022-11-07	704	600-800	0.0957635	1.39	91.400	120
0A	2022	28	2022-11-07	776	600-800	0.0834110	1.43	112.020	148
0A	2022	29	2022-11-07	552	400-600	0.0831832	1.49	79.340	157
0A	2022	30	2022-11-07	484	400-600	0.0803918	1.41	87.950	198
0A	2022	31	2022-11-07	697	600-800	0.0787036	1.39	62.560	117
0B	2022	32	2022-11-07	598	400-600	0.0797420	1.39	107.960	143
0B	2022	33	2022-11-07	549	400-600	0.0786393	1.53	90.980	329
0B	2022	34	2022-11-08	390	200-400	0.0822194	1.21	44.500	122
0B	2022	35	2022-11-08	361	200-400	0.0727062	0.30	20.950	111
0B	2022	36	2022-11-08	344	200-400	0.0762029	0.09	1.050	3
0B	2022	37	2022-11-08	364	200-400	0.1040584	1.12	13.400	67
0B	2022	38	2022-11-08	432	400-600	0.0779649	1.33	66.060	274
0B	2022	39	2022-11-08	506	400-600	3.4478611	1.48	63.580	185
0B	2022	40	2022-11-08	494	400-600	0.0756052	1.44	69.560	114
0B	2022	41	2022-11-08	452	400-600	0.0870309	1.46	59.000	143
0B	2022	42	2022-11-08	432	400-600	0.0766068	1.43	43.520	139
0B	2022	43	2022-11-09	348	200-400	0.0393366	0.37	6.100	21
0B	2022	44	2022-11-09	280	200-400	0.0785944	-0.77	0.424	1
0B	2022	45	2022-11-09	216	200-400	0.0863165	-1.26	0.000	0
0B	2022	46	2022-11-09	278	200-400	0.0863165	-0.81	0.000	0
0B	2022	47	2022-11-09	266	200-400	0.0632264	-0.83	0.015	1
0B	2022	48	2022-11-09	274	200-400	0.0863165	-0.55	0.000	0
0B	2022	49	2022-11-09	243	200-400	0.0863165	-0.87	0.000	0
0B	2022	50	2022-11-09	311	200-400	0.0754398	-0.09	1.845	3
0B	2022	51	2022-11-09	365	200-400	0.0699824	0.64	9.850	20
0B	2022	52	2022-11-10	316	200-400	0.0821359	0.30	4.820	8

Survey Area	Year	Set	Date	Mean Depth (m)	Depth Stratum (m)	Swept Area (sq km)	Temperature (C)	Weight (kg)	Number
0B	2022	54	2022-11-10	329	200-400	0.0764124	0.62	3.260	17
0B	2022	55	2022-11-10	336	200-400	0.0739528	0.71	7.700	32
0B	2022	56	2022-11-10	264	200-400	0.0725542		0.000	1
0B	2022	57	2022-11-10	290	200-400	0.0863165	-0.71	0.000	0
0B	2022	59	2022-11-10	314	200-400	0.0635254	0.22	0.736	7
0B	2022	60	2022-11-10	347	200-400	0.0775237	0.71	4.180	16
0B	2022	61	2022-11-10	352	200-400	0.0754504	0.79	3.880	18
0B	2022	62	2022-11-11	346	200-400	0.0790076	0.68	3.034	13
0B	2022	63	2022-11-11	353	200-400	0.0764959	0.93	2.592	13
0B	2022	64	2022-11-11	371	200-400	0.0789596	1.13	10.680	24
0B	2022	65	2022-11-11	367	200-400	0.0816989	1.11	8.640	27
0B	2022	66	2022-11-11	348	200-400	0.0711582	1.01	17.160	43
0B	2022	67	2022-11-11	355	200-400	0.0774957	0.34	17.340	48
0B	2022	68	2022-11-11	350	200-400	0.0765195	1.02	19.640	139
0B	2022	69	2022-11-11	349	200-400	0.0822215	1.04	20.900	181
0B	2022	70	2022-11-11	371	200-400	0.0754938	1.39	31.060	89
0B	2022	71	2022-11-15	909	800-1000	0.0731007	3.73	162.540	141
0B	2022	72	2022-11-15	749	600-800	0.6472231	3.91	307.240	266
0B	2022	73	2022-11-15	473	800-1000	1.5749982	2.37	453.160	492
0B	2022	74	2022-11-15	350	200-400	0.0746008	1.13	35.700	45
0B	2022	75	2022-11-15	361	200-400	0.0863165	1.35	0.000	0
0B	2022	76	2022-11-16	357	200-400	0.0832592	1.32	11.000	15
0B	2022	77	2022-11-16	333	200-400	0.0763608	1.32	7.940	16
0B	2022	78	2022-11-16	300	200-400	0.0794946	0.80	1.232	6
0B	2022	79	2022-11-16	218	200-400	0.0863165	-0.88	0.000	0
0B	2022	80	2022-11-16	292	200-400	0.0863165	0.22	0.000	0
0B	2022	81	2022-11-16	250	200-400	0.0863165		0.000	0
0B	2022	82	2022-11-16	207	200-400	0.0863165	-0.92	0.000	0

Survey Area	Year	Set	Date	Mean Depth (m)	Depth Stratum (m)	Swept Area (sq km)	Temperature (C)	Weight (kg)	Number
0B	2022	83	2022-11-17	284	200-400	0.0735680	0.31	0.298	1
0B	2022	84	2022-11-17	209	200-400	0.0391022	-0.25	0.010	2
0B	2022	85	2022-11-17	219	200-400	0.0863165	-0.71	0.000	0
0B	2022	86	2022-11-17	239	200-400	0.0863165	-0.29	0.000	0
0B	2022	87	2022-11-17	301	200-400	0.0634560	0.83	0.380	1
0B	2022	88	2022-11-17	387	200-400	0.0713959	1.86	12.700	52
0B	2022	89	2022-11-17	452	400-600	0.0759268	3.15	555.560	509
0B	2022	90	2022-11-17	728	600-800	0.0704608	2.95	286.060	263
0B	2022	91	2022-11-17	578	400-600	0.0713846	2.34	320.000	357
0B	2022	92	2022-11-18	574	400-600	0.0757800	2.68	154.400	169
0B	2022	93	2022-11-18	708	600-800	0.0823736	3.88	346.065	270
0B	2022	94	2022-11-18	1257	1200-1400	0.0821768	3.58	295.010	234
0B	2022	95	2022-11-18	748	600-800	0.0792758	3.90	301.860	222
0B	2022	96	2022-11-18	784	600-800	0.0799500		342.600	234
0B	2022	97	2022-11-18	962	800-1000	0.0786299	3.84	198.450	122
0B	2022	98	2022-11-18	927	800-1000	0.0751214	3.80	337.500	232
0B	2022	99	2022-11-19	430	400-600	0.0782722	3.32	485.300	386
0B	2022	100	2022-11-19	1046	1000-1200	0.0863724	3.75	255.340	194
0B	2022	101	2022-11-19	656	600-800	0.0724534	3.19	420.500	341
0B	2022	102	2022-11-19	413	400-600	0.0794855	2.69	155.160	269
0B	2022	103	2022-11-19	298	200-400	0.0767012	0.78	21.820	48
0B	2022	104	2022-11-19	278	200-400	0.0683020	0.21	0.225	2
0B	2022	105	2022-11-19	209	200-400	0.0679023	-0.85	0.005	1
0B	2022	106	2022-11-20	271	200-400	0.0863165	0.24	0.000	0
0B	2022	107	2022-11-20	223	200-400	0.0863165	-0.42	0.000	0
0B	2022	108	2022-11-20	272	200-400	0.0698754	0.23	0.020	2
0B	2022	109	2022-11-20	364	200-400	0.0783007	2.00	1.308	3
0B	2022	110	2022-11-20	378	200-400	0.0779042	2.86	2.700	12

Survey Area	Year	Set	Date	Mean Depth (m)	Depth Stratum (m)	Swept Area (sq km)	Temperature (C)	Weight (kg)	Number
0B	2022	111	2022-11-20	345	200-400	0.0781712	1.82	2.935	54
0B	2022	112	2022-11-20	463	400-600	0.0515731	2.64	19.100	48
0B	2022	113	2022-11-20	299	200-400	0.0770248	1.04	2.185	21
0B	2022	114	2022-11-20	261	200-400	3.0707925	0.12	0.950	4
0B	2022	115	2022-11-20	357	200-400	0.0721886	1.40	2.420	12
0B	2022	116	2022-11-20	428	400-600	0.0772905	2.85	22.100	54
0B	2022	117	2022-11-21	388	200-400	0.0754514	3.09	18.850	36
0B	2022	118	2022-11-21	736	600-800	0.0783285		271.180	192
0B	2022	119	2022-11-21	717	600-800	0.0768523	4.02	446.860	306
0B	2022	120	2022-11-21	942	800-1000	0.0784717	3.85	274.040	172
0B	2022	121	2022-11-21	914	800-1000	0.0777566	3.89	428.740	339
0B	2022	122	2022-11-21	533	400-600	0.0268962	3.67	105.600	82
0B	2022	123	2022-11-21	1132	1000-1200	0.0483174	3.73	47.600	22
0B	2022	125	2022-11-22	1163	1000-1200	0.0740799	3.78	219.320	108
0B	2022	126	2022-11-22	1374	1200-1400	0.0780293	3.42	245.440	172
0B	2022	127	2022-11-22	1058	1000-1200	0.0868284	3.77	230.900	135
0B	2022	128	2022-11-22	846	800-1000	0.0812443	3.73	207.670	147
0B	2022	129	2022-11-22	856	800-1000	0.0790222	3.85	273.450	191
0B	2022	130	2022-11-22	975	800-1000	0.0844604	3.81	245.280	119
0B	2022	131	2022-11-23	1123	1000-1200	0.0773091	3.73	210.000	110
0B	2022	132	2022-11-23	1306	1200-1400	0.0801234		229.920	154
0B	2022	133	2022-11-23	1220	1200-1400	0.0755077	3.62	194.660	141
0B	2022	134	2022-11-23	1050	1000-1200	0.0768273	3.73	241.820	140
0B	2022	135	2022-11-23	1029	1000-1200	0.0818916	3.76	219.180	113
0B	2022	136	2022-11-23	1155	1000-1200	0.0756920	3.70	166.120	116
0B	2022	137	2022-11-23	1329	1200-1400	0.0745677	3.57	122.480	75
0B	2022	138	2022-11-24	940	800-1000	0.0708945	3.80	235.315	144
0B	2022	139	2022-11-24	1434	1400-1500	0.0675245	3.46	278.440	177

Survey Area	Year	Set	Date	Mean Depth (m)	Depth Stratum (m)	Swept Area (sq km)	Temperature (C)	Weight (kg)	Number
0B	2022	140	2022-11-24	977	800-1000	0.0744202	3.78	94.620	71
0B	2022	141	2022-11-25	1454	1400-1500	0.0693906	3.57	226.680	162

Colophon

This version of the document was generated on 2023-06-29 17:07:56 using the R markdown template for SCR documents from **NAFOdown**.

The computational environment that was used to generate this version is as follows:

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#> ─ Session info ──────────────────────────────────────────────
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#> setting  value
#> version  R version 4.2.2 (2022-10-31 ucrt)
#> os       Windows 10 x64 (build 19044)
#> system   x86_64, mingw32
#> ui       RTerm
#> language (EN)
#> collate  English_United States.utf8
#> ctype    English_United States.utf8
#> tz       America/Chicago
#> date     2023-06-29
#> pandoc   2.17.1.1 @ C:/Program Files/RStudio/bin/quarto/bin/ (via rmarkdown)
#>
#> ─ Packages ──────────────────────────────────────────────
────
#> package       * version  date (UTC) lib source
#> adehabitatMA    0.3.14   2020-01-13 [1] CRAN (R 4.2.0)
#> anytime       * 0.3.9    2020-08-27 [1] CRAN (R 4.2.0)
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#> assertthat      0.2.1    2019-03-21 [1] CRAN (R 4.2.0)
#> backports       1.4.1    2021-12-13 [1] CRAN (R 4.2.0)
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#> bit64           4.0.5    2020-08-30 [1] CRAN (R 4.2.0)
#> blob            1.2.3    2022-04-10 [1] CRAN (R 4.2.0)
#> bookdown        0.34     2023-05-09 [1] CRAN (R 4.2.3)
#> broom           0.8.0    2022-04-13 [1] CRAN (R 4.2.0)
#> cachem          1.0.6    2021-08-19 [1] CRAN (R 4.2.0)
#> callr           3.7.1    2022-07-13 [1] CRAN (R 4.2.1)
#> cellranger      1.1.0    2016-07-27 [1] CRAN (R 4.2.0)
#> class           7.3-20   2022-01-16 [2] CRAN (R 4.2.2)
#> classInt        0.4-7    2022-06-10 [1] CRAN (R 4.2.1)
#> cli             3.3.0    2022-04-25 [1] CRAN (R 4.2.0)
#> codetools       0.2-18   2020-11-04 [2] CRAN (R 4.2.2)
#> colorspace      2.0-3    2022-02-21 [1] CRAN (R 4.2.0)
#> crayon          1.5.2    2022-09-29 [1] CRAN (R 4.2.3)
#> crul            1.4.0    2023-05-17 [1] CRAN (R 4.2.3)
#> curl            4.3.2    2021-06-23 [1] CRAN (R 4.2.0)
#> data.table      1.14.8   2023-02-17 [1] CRAN (R 4.2.3)
#> DBI             1.1.3    2022-06-18 [1] CRAN (R 4.2.1)
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#> devtools        2.4.4    2022-07-20 [1] CRAN (R 4.2.1)
#> digest          0.6.29   2021-12-01 [1] CRAN (R 4.2.0)
#> dplyr         * 1.0.9    2022-04-28 [1] CRAN (R 4.2.0)
#> e1071           1.7-11   2022-06-07 [1] CRAN (R 4.2.1)
#> ellipsis        0.3.2    2021-04-29 [1] CRAN (R 4.2.0)
#> evaluate        0.21     2023-05-05 [1] CRAN (R 4.2.3)
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#>  fontBitstreamVera  0.1.1    2017-02-01 [1] CRAN (R 4.2.0)
#>  fontLiberation   0.1.0      2016-10-15 [1] CRAN (R 4.2.0)
#>  fontquiver       0.2.1      2017-02-01 [1] CRAN (R 4.2.3)
#>  forcats        * 0.5.1      2021-01-27 [1] CRAN (R 4.2.0)
#>  fs               1.5.2      2021-12-08 [1] CRAN (R 4.2.0)
#>  gdtools          0.3.3      2023-03-27 [1] CRAN (R 4.2.3)
#>  generics         0.1.3      2022-07-05 [1] CRAN (R 4.2.1)
#>  gfonts           0.2.0      2023-01-08 [1] CRAN (R 4.2.3)
#>  ggh4x            0.2.4      2023-04-04 [1] CRAN (R 4.2.3)
#>  ggplot2        * 3.4.2      2023-04-03 [1] CRAN (R 4.2.3)
#>  ggridges       * 0.5.4      2022-09-26 [1] CRAN (R 4.2.2)
#>  ggspatial      * 1.1.5      2021-01-04 [1] CRAN (R 4.2.0)
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#>  glue             1.6.2      2022-02-24 [1] CRAN (R 4.2.0)
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#>  gtable           0.3.3      2023-03-21 [1] CRAN (R 4.2.3)
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#>  httpuv           1.6.5      2022-01-05 [1] CRAN (R 4.2.0)
#>  httr             1.4.3      2022-05-04 [1] CRAN (R 4.2.0)
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#>  magrittr         2.0.3      2022-03-30 [1] CRAN (R 4.2.0)
#>  marmap         * 1.0.6      2021-11-10 [1] CRAN (R 4.2.0)
#>  memoise          2.0.1      2021-11-26 [1] CRAN (R 4.2.0)
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#>  miniUI           0.1.1.1    2018-05-18 [1] CRAN (R 4.2.1)
#>  modelr           0.1.8      2020-05-19 [1] CRAN (R 4.2.0)
#>  munsell          0.5.0      2018-06-12 [1] CRAN (R 4.2.0)
#>  NAFOdown       * 0.0.1.9000 2022-06-11 [1] Github (nafc-assess/NAFOdown@e4067e5)
#>  ncdf4            1.19       2021-12-15 [1] CRAN (R 4.2.0)
#>  officer          0.6.2      2023-03-28 [1] CRAN (R 4.2.3)
#>  openssl          2.0.6      2023-03-09 [1] CRAN (R 4.2.3)
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#>  processx         3.7.0      2022-07-07 [1] CRAN (R 4.2.1)
#>  profvis          0.3.7      2020-11-02 [1] CRAN (R 4.2.1)
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#> promises          1.2.0.1   2021-02-11 [1] CRAN (R 4.2.0)
#> proxy             0.4-27    2022-06-09 [1] CRAN (R 4.2.1)
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#> purrr           * 0.3.4     2020-04-17 [1] CRAN (R 4.2.0)
#> R6                2.5.1     2021-08-19 [1] CRAN (R 4.2.0)
#> ragg              1.2.5     2023-01-12 [1] CRAN (R 4.2.3)
#> raster            3.5-21    2022-06-27 [1] CRAN (R 4.2.1)
#> RColorBrewer    * 1.1-3     2022-04-03 [1] CRAN (R 4.2.0)
#> Rcpp              1.0.9     2022-07-08 [1] CRAN (R 4.2.1)
#> readr           * 2.1.2     2022-01-30 [1] CRAN (R 4.2.0)
#> readxl            1.4.0     2022-03-28 [1] CRAN (R 4.2.0)
#> remotes           2.4.2     2021-11-30 [1] CRAN (R 4.2.0)
#> reprex            2.0.1     2021-08-05 [1] CRAN (R 4.2.0)
#> reshape2          1.4.4     2020-04-09 [1] CRAN (R 4.2.1)
#> rlang             1.1.1     2023-04-28 [1] CRAN (R 4.2.3)
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#> RSQLite           2.2.14    2022-05-07 [1] CRAN (R 4.2.0)
#> rstudioapi        0.13      2020-11-12 [1] CRAN (R 4.2.0)
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#> sessioninfo       1.2.2     2021-12-06 [1] CRAN (R 4.2.0)
#> sf              * 1.0-8     2022-07-14 [1] CRAN (R 4.2.1)
#> shape             1.4.6     2021-05-19 [1] CRAN (R 4.2.0)
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#> sp                1.5-0     2022-06-05 [1] CRAN (R 4.2.1)
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#> terra             1.6-7     2022-08-07 [1] CRAN (R 4.2.1)
#> textshaping       0.3.6     2021-10-13 [1] CRAN (R 4.2.1)
#> tibble          * 3.1.8     2022-07-22 [1] CRAN (R 4.2.1)
#> tidyr           * 1.2.0     2022-02-01 [1] CRAN (R 4.2.0)
#> tidyselect        1.1.2     2022-02-21 [1] CRAN (R 4.2.0)
#> tidyverse       * 1.3.1     2021-04-15 [1] CRAN (R 4.2.0)
#> tzdb              0.3.0     2022-03-28 [1] CRAN (R 4.2.0)
#> units             0.8-0     2022-02-05 [1] CRAN (R 4.2.0)
#> urlchecker        1.0.1     2021-11-30 [1] CRAN (R 4.2.1)
#> usethis           2.1.6     2022-05-25 [1] CRAN (R 4.2.0)
#> utf8              1.2.2     2021-07-24 [1] CRAN (R 4.2.0)
#> uuid              1.1-0     2022-04-19 [1] CRAN (R 4.2.0)
#> vctrs             0.6.2     2023-04-19 [1] CRAN (R 4.2.3)
#> viridis         * 0.6.2     2021-10-13 [1] CRAN (R 4.2.0)
#> viridisLite     * 0.4.2     2023-05-02 [1] CRAN (R 4.2.3)
#> withr             2.5.0     2022-03-03 [1] CRAN (R 4.2.0)
#> wk                0.6.0     2022-01-03 [1] CRAN (R 4.2.0)
#> xfun              0.39      2023-04-20 [1] CRAN (R 4.2.3)
#> xml2              1.3.3     2021-11-30 [1] CRAN (R 4.2.0)
#> xtable            1.8-4     2019-04-21 [1] CRAN (R 4.2.1)
#> yaml              2.3.5     2022-02-21 [1] CRAN (R 4.2.0)
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#>  [1] C:/Users/hedgesk/AppData/Local/R/win-library/4.2
#>  [2] C:/Program Files/R/R-4.2/library
#>
#> ──────────────────────────────────────────────────────────────────────────────
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