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Comparison of vessels used and survey timing for the 1CD and 0A-South deep-water surveys and the 1A-F west Greenland shelf surveys

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Abstract

Three stratified random bottom trawl survey series have been established in NAFO Subarea 0 and 1(offshore): a Canadian survey in Division 0A-South (from 1999), a Greenland survey in Divisions 1C and 1D (from 1997) and in Divisions 1A to 1F (from 1991). Since the beginning of the time series the surveys were carried out with R/V Paamiut. In 2017, R/V Paamiut was retired and two different charter vessels were used to conduct the survey in Div. 1A-F, C/V Sjurdarberg in 2018 and C/V Helga Maria in 2019. The C/V Helga Maria conducted surveys in 1CD and 0A-South in 2019. To standardize the fishing operations the Greenland Institute of Natural Resources took steps to ensure the same gear (trawl, bridle, warps, ground gear, and distance from blocks) found on the R/V Paamiut were used on the commercial vessels. In addition to the change in vessel, the 2019 surveys in 1CD and 0A-South took place during late July-August, about 6 weeks earlier than was typical for previous surveys. This paper compares the characteristics of the three ships, analyzes trawl gear parameters (with a focus on net height and door spread) to assess impacts of the change in vessel, and looks at fishery catch distribution and rates to assess the change in survey timing. Survey length frequencies are also examined to assess possible effects of both the vessel change and survey timing. The difference in mean net height (<-2%) and door spread (< 10%) for the 1A-F survey in both 2018 and 2019 compared to the mean for 2005 to 2017 was considered low, suggesting the vessel changes had minimal impact on trawl performance. The difference in mean net height (23-27%) and door spread (-7 to -10%) for the 0A-South and 1CD surveys in 2019 compared to 2005 to 2017 suggest a greater impact of the vessel change on this survey. Gear geometry for the Alfredo III trawl gear was examined for the 1CD survey at depths 401-700 m, 701-1000 m and 1001-1500 m. The difference in net height and door distance increased between 701-1000 m and 1001-1500 m from 22% to 36% and from -9 to -12%, respectively. The R/V Paamiut and the C/V Helga Maria seemed to be fishing differently at depths beyond 701 m and this could have an effect on catchability. There is stability in the length frequency distribution for fish > 35 cm in 1CD suggesting the timing of the surveys in this area may not be affecting catch, but there are differences in Div. 0A-South that could be related to survey timing. We conclude that the 2018 and 2019 Div. 1A-F commercial vessel surveys could be comparable to estimates from previous surveys conducted by R/V Paamiut and results could be used for SA1 shrimp and finfish assessments. However, there is sufficient uncertainty in the gear performance at depths >701 m (where Greenland halibut are known to be abundant) to question the direct comparability between 2019 and previous surveys of 1CD and 0A-South. As a result we do not recommend using the combined survey biomass index and the harvest control rule (HCR) (ICES data limited stocks guidance) as the basis for TAC advice in 2019.

Introduction

Surveys in NAFO Subarea 0 and 1 have been conducted by the R/V Paamiut, a converted shrimp trawler, since 1997. Deepwater (400-1500 m) depth stratified random surveys in Divisions 1CD and 0A-South used an Alfredo trawl and a shallow water (50-601 m) fish and shrimp survey in 1A-F used a Cosmos trawl. In early 2018 the Greenland government determined that it was no longer feasible to invest in the repairs needed for R/V Paamiut to pass inspections. In 2018, the 1A-F Fish and Shrimp survey was carried out with a chartered commercial vessel C/V Sjurdarberg while the Canadian survey in 0A-South and the Greenlandic survey in 1CD were not conducted. For 2019 another commercial vessel C/V Helga Maria was chartered for all three surveys. The trawl gear did not change throughout this period. With the sudden retirement of the R/V Paamiut it was not possible to conduct a paired tow study to compare vessel fishing power and catch rates as is recommended when the survey is used to estimate abundance and assess trends through time (Pelletier 1998, Wilderbuer and Kapenmann 1998). This paper is intended to describe the two vessels, the steps taken to standardize fishing procedures, and review several gear performance measures, in an effort to determine if the 2019 survey results can be compared to previous years to formulate advice for the SA0 +1A (offshore) and 1B-F Greenland halibut assessment and several other SA1 finfish and shrimp assessments.

In addition to the question of change in survey vessel, there was also a shift in the timing of the 1CD and 0A-South surveys. They took place about 6 weeks earlier than was typical for these surveys. This paper will also attempt to examine what we know of the seasonal distribution for the SA0 and 1 Greenland halibut stock in order to determine if survey timing is a factor that needs to be considered when comparing the 2019 survey results to previous years.

Materials and Methods

Gear Description:

Fish and Shrimp survey in Div. 1A-F: The survey initially used a Skjervoy 3000/20 trawl with steel bobbin gear and double bag. In 2005, the skjervoy trawl was replaced by a Cosmos trawl (Wieland and Bergström, 2005). Until 2003, Greenland Perfect trawl doors were used (9.25 m^2, 2.4 tons), but they were replaced in 2004 by Injector International trawl doors (7.5 m^2, 2.8 tons) to facilitate the trawl change in 2005. Calibration experiments were conducted in the main shrimp areas in 2004 and 2005 and a formal analysis of conversion factors were established for shrimp (Rosing and Wieland, 2005). Preliminary conversion factors for a few commercial fish species were derived as described by Rosing and Wieland (2005). For this reason, we compare the gear parameters for the Div. 1A-F surveys from 2005 to 2017 (RV Paamiut), with 2018 (CV Sjurdarberg) and 2019 (CV Helga Maria).

Greenlandic survey in Div. 1CD and Canadian survey in Div. 0A-South: Surveys were conducted using an Alfredo III trawl with a mesh size of 140 mm and a 30-mm mesh-liner in the cod-end. The trawl has rock hopper ground gear and the trawl doors are Injector International weighing (7.5 m^2, 2.8 tons). The Injector doors replaced the Greenland Perfect doors that had been used until 2003. The average net height was, in 2004, 20 cm higher with the new doors compared to the old, but the difference was not statistically significant (95% level) and it was concluded that the net performance had not changed with the introduction of the new doors. Further information about trawl and gear is given in Jørgensen (1998). MarPort net sensors measured net height and the distance between the trawl doors in both surveys. An additional Marport sensor measured wing spread in the Div. 0A-South survey.

Vessel Comparison:

Vessel characteristics were compiled and are presented in Table 1. Steps were taken to standardize fishing procedures for 2018 (C/V Sjurdarberg) and 2019 (C/V Helga Maria) and these are described in Annex 1.

Gear Performance:

The average wing spread, door spread, net height and swept area, and their corresponding standard error (S.E.) among sets for each year and survey have been calculated to compare the gear performance:

1. Among the R/V Paamiut (2005 to 2017), C/V Sjurarberd (2018) and C/V Helga Maria (2019) for the 1A-F survey, using the Cosmos trawl.
2. Between the R/V Paamiut (1997 to 2017) and Helga Maria (2019) for the 1CD survey, using Alfredo III trawl.
3. Between the R/V Paamiut (every second year from 1999 to 2014, 2016-2017) and Helga Maria (2019) for the 0A-South survey, using Alfredo gear III.

Wing spread for the 1CD survey is calculated using door spread and the formula: wingspread= 10.122 + door spread*0.142. Wing spread for the 0A-South survey has been measured directly using Marport sensors since 2010.
Wing spread for the 1A-F survey is calculated using the door spread (L), the length of the bridles (s) and the trawl wings (t), and the formula: V= (t1 * L) / (t1 +St) (Nygaard and Nogueira, 2020).

Average values for all gear parameters for years 2005 to 2017 (following the change in doors in 2004) were calculated and compared to the 2018 and 2019 values to assess percent change in gear performance.

Survey Timing:

Catch and effort obtained from logbook data for the 1CD and 0A fisheries were analyzed by month to assess seasonal distribution for Greenland halibut in this portion of the stock area. A standardized catch rate by month is produced using a General Linear Model. The model explains the variance in log-transformed catch rates including effects of year, season (month), vessel class (grouped using NAFO codes), and area Annex 4. CPUE observations were log-transformed prior to the GLM analysis. The fleets used for standardization of catch rates are grouped using NAFO codes (Annex 4). Data were fit in R v. 4.0.0 (R Core Team, 2020) and least squares means were estimated with package "emmeans" (Lenth et al. 2018).

Subarea 0 and Subarea 1 catch of Greenland halibut is compiled by month, gear and division, for several recent years, to assess periods of peak catch. The distribution of Subarea 1 catch is also plotted by month (August to October) and year (2011 to 2019) using the statistical package "rgdal" (Bivand et al.) in R v. 4.0.0 (R Core Team, 2020).

Length-frequency:

The distribution through time of Greenland halibut length frequency from the surveys is examined. Changes related to recruitment are expected in the smaller fish, therefore, we focus on the bigger fish (> age 2 to 60 cm in Div. 1A-F survey and 35 cm to 70 cm and >70 cm in 1CD and 0A-South surveys), which would normally be expected to have similar length-composition from year to year. The range in size for age 2 Greenland halibut caught in the 1A-F survey is 15-20 cm to 21-29 cm. The 0A-South length data has been aggregated into 3 cm size groups, while the other surveys frequency is based on 1 cm groups. Differences, if any, between 2019 and previous years could help us assess both the gear performance and survey timing questions related to the 2019 survey.

Results

Vessel and Gear Comparison:

The research vessel R/V Paamiut, and the two chartered vessels C/V Helga Maria and C/V Sjurdarberg have similar dimensions. Paamiut is 58 m long and 11.2 m wide, Sjurdarberg is 60 m long and 13.0 m wide, and Helga maria is 57 m long and 12.62 m wide (Table 2). The Sjurdarberg has the largest Gross Registered Tonnage

(1856), followed by the C/V Helga Maria (1470) and R/V Paamiut (1084). The two chartered vessels have more power than R/V Paamiut, but this factor does not necessarily affect trawl performance. The Greenland Institute of Natural Resources (GINR) took steps to standardize the survey vessel operations as much as possible.

The trawl gear was not changed, a Cosmos trawl is used in the 1A-F survey and an Alfredo III trawl in the 1CD and 0A-South surveys. The warps (26 mm in diameter), bridles, and ground line, the distance from the hanging blocks and the Marport gear sensors and bridge equipment were all set up the same as they were on the R/V Paamiut. The Greenland surveys have sensors on the head rope and doors and the Canadian survey adds a sensor to the wings. The R/V Paamiut skipper and engineer spent 2 weeks on the C/V Helga Maria prior to the survey starting and the R/V Paamiut skipper was on the bridge during the surveys to ensure the trawling procedures were conducted according to the protocols used on the R/V Paamiut.

Gear Performance:

Div. 1CD and 0A-South Surveys - Average net height was 23% and 27% greater overall depths for the 0A-South and 1CD surveys, respectively, in 2019 (Fig. 1, Tables 3 and 4). Net height was comparable over depths 401-700 m (5% change), however, greater changes were noted for depths 701-1000 m (+22%) and 1001-1500 m (+36%) (Fig. 2, Tables 3, 6-8). Door spread was 7% and 10% lower overall depths for the 0A-South and 1CD surveys, respectively, in 2019. Depth was also a factor in door spread with changes of -3%, -8% and -12% at depths 401-700m, 701-1000m and 1001-1500m (Fig. 5, Table 3). For the R/V Paamiut mean net height decreased from 5.5 to approximately 5.0 and door spread increased from 134 m to approximately 147 m (beyond 701 m) (Table 3). For the C/V Helga Maria the mean net height increased from 5.8 to 6.2 m (at depths 701-1000 m) and 6.8 m (at depths 1001-1500 m) while door spread remained relatively stable (130 to 134.5 m) (Table 3).

Wing spread was directly measured in the 0A-South survey during 2010 to 2017 and 2019 and was found to be 5% lower in 2019 compared to the average over previous years (Fig. 7 and Table 5). Wingspread for the 1CD survey is calculated from door spread so the pattern for these two variables is similar (Figs. 4, 5, 7 and 8). Swept area differed by +1% for 0A-South and +10% for 1CD in 2019 compared to the 2005-2017 average (Fig. 10, Tables 4 and 5). For 1CD swept area differed by 19% at depths 401-700 m in 2019 compared to the 2005-2017 average and by 10% and 8% at depths 701-1000 m and 1001-1500 m, respectively (Fig. 11, Tables 4 and 5).

Div. 1A-F Survey - Net height (-2% for both years) and door spread (+7 and +10%) were comparable between both 2018 and 2019 1A-F surveys conducted by the commercial vessels and the previous series conducted by R/V Paamiut (Fig. 3 and 6, Table 3 and 9). Wingspread is calculated from door spread so has a similar pattern (Fig. 6 and 9). Swept area was similar with a -2% change for 2018 compared to the 2005-2017 average, and a +2% change for 2019 (Fig. 12, Table 9).

Survey Timing:

Most of the surveys in 1CD and 0A-South have taken place during September and between the end of September and end of October, respectively, with some exceptions. In 2001 and 2004 the 1CD surveys were carried out at the end October-November and the 2017 survey in October. The 0A-South survey took place a few weeks later (late October and early November), in 2006, 2010 and 2017. In 2019 the survey dates for both surveys were about 6 weeks earlier (August) (Table 3).

The Greenland halibut 1CD fishery catch is mostly distributed from August to November (65% to 75% of the catches), with annual variation within these months (Fig. 13, Annex 3). In 2019, higher catches were found in August and in November. Catches were distributed almost equally during the period August-November for years 2007, 2008 and 2015. Catches in August were very low from 1999 to 2004, 2006, 2010 and 2016-2017 in comparison with September- November. The catch distribution for 1CD does not show any seasonal changes from August to October (Fig. 14). In 0A-South catches occur from July to November with catches peaking in August and September (e.g. 27% and 43% of the 2018 catch). This pattern is quite consistent over time and catches for 3 of the last 6 years by area and gear are provided as examples (Annex 2).

Monthly CPUE shows an increasing trend from March to December for 1CD, while there is no real trend for 0A-South (Figure 15, Annex 5, 6, 7). When combined the CPUE for both fisheries has a pattern similar to that of 1CD.

Survey Length Frequencies:

The length frequency for Greenland halibut caught during the 2019 survey of 1CD did not appear to differ from previous surveys for either the 35 cm to 70 cm, or >70 cm size classes (Figures 16 and 17). 0A-South surveys have been more variable over the years and in 2019 the 35 cm to 70 cm frequency is shifted to the right with a mode at 51 cm, compared to previous surveys with modes varying from 36-45 cm (Figure 18). There are fewer fish >70 cm and as in 1CD the length frequency is variable from one year to the next in 0A-South (Figure 19). Of note may be the increase in fish in the 75 cm size group relative to previous years.

The 1A-F survey catches primarily small Greenland halibut < 2 years or around 20 cm (Fig. 20). The 2018 and 2019 surveys caught fewer fish in this size range compared to previous surveys. However, following the 2019 STACREC recommendation (NAFO, 2019), "bigger-fish" length frequencies were investigated. The length frequency distribution for fish aged 2 (approximately 15-20 cm) to 60 cm and that for Greenland halibut > 60 cm were more comparable (Figures 21 and 22).

Discussion and Conclusion

The research vessel R/V Paamiut, and the two chartered vessels C/V Helga Maria and C/V Sjurdarberg are similar in size, but they do have differences in weight and power. To standardize the fishing operations to the extent possible the GINR took steps to ensure the same gear (trawl, bridle, warps, ground gear and distance from blocks) found on the R/V Paamiut were used on the commercial vessels. The Captain and crew of the R/V Paamiut also participated, prior to and during the surveys, to ensure they were conducted according to the protocols previously used on the R/V Paamiut surveys. These actions helped to minimize the impacts of the vessel changes on the surveys and were particularly beneficial for the Div. 1A-F survey.

The Cosmos trawl parameters for the shallow water survey of 1A-F conducted by C/V Sjurdarberg and C/V Helga Maria in 2018 and 2019, respectively, were comparable to previous R/V Paamiut surveys. However, the Alfredo III gear parameters for the deep offshore surveys of 1CD and 0A-South conducted by the Helga Maria in 2019 had larger differences. Since wingspread and swept area rely primarily on calculations using door spread we focused on the parameters that were measured directly. Net height and door spread were considered comparable (3% and 5% differences) at depths 401-700 m. A comparison and calibration experiment conducted by Spain in 2003 and 2004 using the same gear (Lofoten trawl) but different vessels (R/V Cornide de Saavedra and R/V Vizconde de Eza) found that for depths down to 400 fathoms (approx. 730 m) there was only a 1.6% difference in catch of Greenland halibut (González Troncoso and Casas 2005) suggesting that at these shallow depths the impact of a vessel change on gear performance and the catchability of Greenland halibut may be minimal, although they did find larger differences for other species.

It is known that depth can play a role in gear geometry and the data reviewed here suggest the change in vessel in 2019 had an effect on the performance of the Alfredo III trawl gear at depths > 701 m, where Greenland halibut are known to be abundant. The C/V Helga Maria had a positive difference for net opening (height) and a negative difference for door spread compared to the R/V Paamiut, which increased with depth. We consulted with Truong Nguyen, a gear technologist with Fisheries and Oceans Canada in St. John's, Newfoundland who noted that the R/V Paamiut and the C/V Helga Maria seemed to be fishing differently at depths beyond 701 m. Typically as fishing depths increase the door spread will increase as the gear makes contact with the bottom, and the net height will decrease, as is seen for the R/V Paamiut. We do not see this same pattern for the C/V Helga Maria. When the Helga Maria went from shallower to deeper depths, the observed opening increased while the door spread was relatively unchanged. Mr. Nguyen suggests the R/V Paamiut could have been fishing with better bottom contact in deeper water, and if this is true it may have some effects on catchability,

depending on species and their behavior. Greenland halibut are known to be associated with the bottom and their abundance generally increases with depth, particularly in the Div. 1CD survey area (Nogueira and Estévez-Barcia 2020; Treble 2020) but how to quantify this difference in catchability is another question.

Greenland halibut are known to move within Baffin Bay and Davis Strait (Bowering 1984, Boje 2002, and DFO and GINR unpublished data). Jorgensen (1997) examined surveys in SA1 that had taken place from April to December, during 1988 to 1993, and noted Greenland halibut tended to occupy shallow depths in 1B during Aug-Sept. and were more widely dispersed in Sept.-October, including deeper depths to the south in 1D. During Nov.-Dec. and in April-May they tended to be aggregated in the deeper waters of 1D. These changes in distribution are considered to be related to feeding and spawning migrations (Jorgensen 1993, Boje 2002). It is not known if Greenland halibut in 0A-South would also move between shallow and deeper depths with the seasons, either within 0A-South, or between 0A-South, 0B and/or 1CD to the south. There was no pattern to the distribution of catches during August to October in 1CD. However, catch rates did increase from March to December. In 0A-South catch rates were relatively stable from June to December. The increase in CPUE from spring to fall for 1CD may reflect the aggregating behavior observed by Jorgensen (1997) but may also be influenced by other factors, in particular access to fishing grounds and fleet dynamics. For example, the seasonal distribution of catches in both the Greenlandic and Canadian fisheries can be affected by the presence of ice in Baffin Bay, which can result in variable effort from year to year, particularly during spring and late fall; therefore, catch distribution may not be that useful in this case, to assess seasonal changes in the distribution of Greenland Halibut. Despite some uncertainty in seasonal movements within 0A-South, in 1CD we know the 2019 and earlier surveys have taken place during the time period prior to the winter aggregation described by Jorgensen (1997) and they cover a broad range of depths (401-1500 m), therefore, the 2019 surveys could be comparable in regards to survey timing. A more detailed analysis of the survey timing question can be found in Wheeland et al. (2020).

The examination of survey catch length frequencies could be one method with which to assess vessel and/or seasonal effects on a survey. In order to minimize the effect of recruitment (strong year classes could influence or cause annual variation in the smallest size classes), length frequencies for the larger size classes of fish caught in all three surveys were examined. Length frequencies for 35 cm to 70 cm and >70 cm fish in the 2019 1CD survey were similar to those for previous surveys. The 2018 and 2019 1A-F surveys also had similar length frequencies for Greenland halibut between 20 cm and 60 cm, and >60 cm. However, the frequency distribution for the 2019 0A-South survey was shifted slightly towards higher abundances of larger fish for both these size groups, compared to previous surveys. The stability in the length frequency distributions for the 1CD and 1A-F surveys suggests the timing of the surveys in these areas may not be affecting catch, and gear performance at deeper depths (where larger Greenland halibut are caught) may not be affecting overall selectivity for Greenland halibut. Given the 0A-South frequency distribution has been more variability in previous surveys, it is harder to determine whether the change observed in 2019 is due to natural variation and/or an effect due to the changes in vessel or survey timing.

Based on the above analysis, we conclude that the 2018 and 2019 estimates of age 1 Greenland halibut derived from the 1A-F survey could be comparable to estimates from previous surveys conducted by R/V Paamiut. However, there is sufficient uncertainty in the gear performance at depths >701 m (where Greenland halibut are known to be abundant) to question the direct comparability between 2019 and previous surveys of 1CD and 0A-South. As a result, we do not recommend using the combined 1CD and 0A-South survey biomass index as the basis for TAC advice in 2019.

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Table 1. Vessel specifications for the R/V Paamiut, C/V Sjurdarberg and C/V Helga Maria.

Name	R/V Paamiut	C/V Sjurdarberg	C/V Helga Maria
Vessel Type- Generic	Research (former Fishing)	Fishing	Fishing
Vessel Type - Detailed	Trawler	Trawler	Trawler
Status	Stopped	Active	Active
Call sign	OYZC	UBHR2	TFDJ
Flag	Greenland	Faroe Islands	Iceland
Gross Tonnage (t)	1084	1856	1470
Net tonnage	325	556	441
Machinery power (Kw)	1471	1978	2200
Length Overall (m)	58.61	60	56.88
Maximum Breadth (m)	11.21	13.03	12.62
Maximum draught (m)	4.2	5.62	6
Propulsion (BHP)	2000	2700	2992
Fuel type and capacity (m3)	Diesel 257	MGO 573	Diesel 238.4
Year Built	1971	1985	1988

Table 2. Survey information for Div. 1CD and Div. 0A-South.

Year	Vessel	Div. 1CD	Div. 0A-South
1997	R/V Paamiut	September 24-October 08	
1998	R/V Paamiut	September 23-October 07	
1999	R/V Paamiut	September 23-October 01	October 7-19
2000	R/V Paamiut	September 27-October 04	
2001	R/V Paamiut	November 05-November 15	September 16-23
2002	R/V Paamiut	September 17-September 23	
2003	R/V Paamiut	September 17-September 24	
2004	R/V Paamiut	October 28-November 05	October 14-24
2005	R/V Paamiut	August 31-September 11	
2006	R/V Paamiut	October 11-October 22	October 27-Nov. 7
2007	R/V Paamiut	September 19-September 30	
2008	R/V Paamiut	September 19-October 01	October 8-Nov. 4
2009	R/V Paamiut	September 19-September 30	
2010	R/V Paamiut	September 07-September 20	October 17-Nov. 8
2011	R/V Paamiut	September 01-September 17	
2012	R/V Paamiut	September 12-September 22	September 29-Oct. 27
2013	R/V Paamiut	September 12-September 17	
2014	R/V Paamiut	August 31-September 16	September 22-Oct. 18
2015	R/V Paamiut	August 26-September 05	September 26-Oct. 9
2016	R/V Paamiut	August 31-September 12	October 7-20
2017	R/V Paamiut	October 10-October 21	October 27-Nov. 8
2018			
2019	C/V Helga Maria	July 31-August 12	August 15-25

Table 3. Trawl height and door spread mean values for 2005-2017 for surveys conducted by R/V Paamiut and by C/V Helga Maria (1CD and 0A-South) in 2019 (top) and C/V Sjurdarberg and C/V Helga Maria (1A-F) in 2018 and 2019 (bottom).

		Trawl Height (m)			Door Spread (m)		
		Paamiut 2005-2017	Helga Maria		Paamiut 2005-2017	Helga Maria	
Survey	Depths	(mean)	2019	% difference	(mean)	2019	% difference
0A-south	401-1500 m	4.9	9.0	23.3	149.5	139.1	-6.9
1CD	401-1500 m	5.1	6.5	27.2	145.9	131.9	-9.7
1CD	401-700 m	5.5	5.8	5.4	134.4	130.8	-2.7
1CD	701-1000 m	5.1	6.2	21.8	146.9	134.5	-8.5
1CD	1001-1500 m	5.0	6.8	35.7	147.5	130.4	-11.6

		Trawl Height (m)			Door Spread (m)		
		Paamiut 2005-2017	2018 or	%	Paamiut 2005-2017	2018 or	%
Survey	Depths	(mean)	2019	difference	(mean)	2019	difference
1A-F 2018 (Sjurdarberg)	51-600 m	12.0	11.8	-1.6	48.0	53.0	10.4
1A-F 2019 (Helga Maria)	51-600 m	12.0	11.8	-1.8	48.0	51.6	7.4

Table 4. Gear parameters for Div. 1CD survey. Height of the trawl, door spread, wing spread and swept area (N = sample size; Mean in m; S.E) from 1997 to 2017 with RV Paamiut, and 2019 with CV Helga Maria. Depth range is 401-1500 m. n.r = no record.

		Trawl height			Doors spread			Wings spread			Sweptarea		
Year	Vessel	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E
1997	Paamiut	58	6.036	0.134	63	123.302	1.037	63	27.631	0.147	63	0.071	0.002
1998	Paamiut	55	5.291	0.073	48	125.131	1.102	53	28.094	0.166	56	0.071	0.002
1999	Paamiut	38	5.313	0.085	36	124.087	1.315	37	27.781	0.186	38	0.071	0.003
2000	Paamiut	n.r	n.r	n.r	16	124.507	1.655	30	28.831	0.239	31	0.062	0.003
2001	Paamiut	64	5.038	0.040	64	135.859	1.045	64	29.414	0.148	64	0.071	0.002
2002	Paamiut	35	5.523	0.067	35	135.143	1.564	35	29.312	0.222	35	0.073	0.002
2003	Paamiut	35	5.286	0.053	35	138.030	0.640	35	29.722	0.091	35	0.075	0.003
2004	Paamiut	51	5.042	0.075	50	154.566	1.182	51	31.988	0.180	51	0.080	0.002
2005	Paamiut	61	5.426	0.062	61	142.443	1.152	61	30.326	0.163	61	0.070	0.002
2006	Paamiut	60	6.060	0.080	60	138.444	1.077	61	29.773	0.151	61	0.067	0.002
2007	Paamiut	50	4.978	0.076	49	145.987	0.975	50	30.969	0.179	50	0.076	0.004
2008	Paamiut	69	4.847	0.069	67	146.280	1.294	70	30.840	0.179	70	0.069	0.002
2009	Paamiut	68	5.214	0.064	68	145.096	0.834	68	30.748	0.114	68	0.071	0.002
2010	Paamiut	66	5.011	0.071	66	141.221	0.882	66	30.175	0.125	66	0.071	0.002
2011	Paamiut	66	4.894	0.068	64	147.328	0.809	67	30.966	0.119	67	0.070	0.002
2012	Paamiut	52	5.316	0.084	49	138.249	1.666	53	29.693	0.225	53	0.061	0.002
2013	Paamiut	27	4.534	0.058	27	140.426	0.643	27	29.862	0.102	27	0.067	0.002
2014	Paamiut	n.r	n.r	n.r	48	150.430	1.114	58	31.043	0.148	58	0.071	0.002
2015	Paamiut	67	4.979	0.079	65	151.337	0.884	67	31.628	0.140	67	0.075	0.002
2016	Paamiut	70	4.757	0.078	67	152.820	1.112	70	31.907	0.174	70	0.072	0.002
2017	Paamiut	53	4.987	0.072	52	157.300	1.131	52	32.459	0.161	53	0.073	0.003
2019	Helga Maria	69	6.467	0.102	69	131.852	0.921	70	28.758	0.155	70	0.077	0.001

Table 5. Gear parameters for the Div. 0A-South survey. Height of the trawl, door spread, wing spread and swept area (N = sample size; Mean in m; S.E) from 1999 to 2014 every second year, 2016-2017 with RV Paamiut, and 2019 with CV Helga Maria. n.r = no record.

		Trawl height			Doors spread			Wings spread			Sweptarea		
Year	Vessel	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E
1999	Paamiut	n.r	n.r	n.r	65	122.85	1.273	n.r	n.r	n.r	65	0.073	0.002
2001	Paamiut	48	5.01	0.087	48	135.87	1.048	n.r	n.r	n.r	45	0.082	0.003
2004	Paamiut	n.r	n.r	n.r	54	157.39	1.279	n.r	n.r	n.r	52	0.085	0.002
2006	Paamiut	62	6.22	0.083	62	138.43	0.92	n.r	n.r	n.r	62	0.077	0.003
2008	Paamiut	78	5.08	0.105	83	146.19	1.137	n.r	n.r	n.r	86	0.080	0.002
2010	Paamiut	91	4.64	0.116	86	144.04	0.982	8	27.63	0.521	91	0.080	0.001
2012	Paamiut	89	4.79	0.101	83	146.49	1.595	76	27.89	0.163	89	0.077	0.001
2014	Paamiut	81	4.53	0.075	66	148.56	1.2	45	27.68	0.214	83	0.079	0.001
2015	Paamiut	76	4.52	0.057	76	155.77	1.037	71	28.92	0.119	76	0.081	0.001
2016	Paamiut	76	4.22	0.063	76	159.61	1.356	74	28.99	0.139	76	0.083	0.001
2017	Paamiut	73	5	0.122	73	156.68	0.989	67	28.13	0.166	73	0.086	0.001
2019	Helga Maria	72	6.01	0.052	72	139.09	0.933	61	26.69	0.192	72	0.079	0.0005

Table 6. Gear parameters for the Div. 1CD survey. Height of the trawl, doors spread, wings spread and sweptarea (N = sample size; Mean in m; S.E) from 1997 to 2017 with RV Paamiut, and 2019 with CV Helga Maria. Depth range is 401-700 m. n.r = no record.

		Trawl height			Doors spread			Wings spread			Sweptarea		
Year	Vessel	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E
1997	Paamiut	9	6.633	0.266	9	113.444	0.944	9	26.231	0.134	9	0.004	0.004
1998	Paamiut	11	5.591	0.128	11	118.708	2.402	11	26.978	0.341	11	0.003	0.003
1999	Paamiut	5	5.960	0.280	4	115.300	1.923	5	27.027	0.573	5	0.002	0.002
2000	Paamiut	n.r	n.r	n.r	1	130.667	-	1	28.677	-	1	-	-
2001	Paamiut	20	5.300	0.083	20	131.800	1.943	20	28.838	0.276	20	0.005	0.005
2002	Paamiut	2	5.650	0.050	2	121.000	0.000	2	27.304	0.000	2	0.006	0.006
2003	Paamiut	5	4.987	0.209	5	134.933	1.078	5	29.283	0.153	5	0.009	0.009
2004	Paamiut	3	6.287	0.292	3	144.889	10.017	3	30.696	1.422	3	0.021	0.021
2005	Paamiut	8	5.502	0.174	8	133.131	3.503	8	29.027	0.497	8	0.003	0.003
2006	Paamiut	8	6.324	0.151	8	130.138	5.004	8	28.275	0.666	8	0.004	0.004
2007	Paamiut	3	5.641	0.604	3	132.933	5.797	3	28.999	0.823	3	0.016	0.016
2008	Paamiut	8	5.437	0.288	8	126.087	4.095	8	28.026	0.582	8	0.007	0.007
2009	Paamiut	7	5.388	0.072	7	133.812	3.482	7	29.123	0.494	7	0.006	0.006
2010	Paamiut	5	6.149	0.248	5	128.987	3.318	5	28.438	0.471	5	0.007	0.007
2011	Paamiut	7	5.606	0.127	5	137.300	3.749	7	29.431	0.391	7	0.005	0.005
2012	Paamiut	8	5.678	0.320	7	119.981	3.899	8	27.308	0.631	8	0.005	0.005
2013	Paamiut	2	4.633	0.367	2	131.900	1.800	2	28.286	0.925	2	0.008	0.008
2014	Paamiut	n.r	n.r	n.r	4	137.267	4.240	5	29.540	0.472	5	0.007	0.007
2015	Paamiut	8	5.560	0.307	8	141.813	3.145	8	30.259	0.447	8	0.002	0.002
2016	Paamiut	10	5.119	0.223	10	143.776	3.173	10	30.538	0.451	10	0.005	0.005
2017	Paamiut	7	5.026	0.183	7	150.057	5.548	7	31.430	0.788	7	0.007	0.007
2019	Helga Maria	8	5.801	0.130	9	130.751	2.541	9	28.689	0.361	9	0.001	0.001

Table 7. Gear parameters for the Div. 1CD survey. Height of the trawl, doors spread, wings spread and sweptarea (N = sample size; Mean in m; S.E) from 1997 to 2017 with R/V Paamiut, and 2019 with C/V Helga Maria. Depth range is 701-1000 m. n.r = no record.

		Trawl height			Doors spread			Wings spread			Sweptarea		
Year	Vessel	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E
1997	Paamiut	20	6.875	0.122	21	118.810	1.020	21	26.993	0.1449	21	0.072	0.002
1998	Paamiut	21	5.138	0.147	22	126.814	1.403	22	28.130	0.1993	22	0.075	0.002
1999	Paamiut	13	5.408	0.051	12	122.449	1.786	12	27.510	0.2536	13	0.074	0.007
2000	Paamiut	n.r	n.r	n.r	7	125.936	2.446	8	28.217	0.3683	8	0.062	0.008
2001	Paamiut	16	5.063	0.045	16	137.500	0.719	16	29.647	0.1021	16	0.071	0.005
2002	Paamiut	10	5.710	0.146	10	137.400	2.093	10	29.633	0.2973	10	0.076	0.001
2003	Paamiut	7	5.440	0.114	7	138.886	0.882	7	29.844	0.1253	7	0.090	0.008
2004	Paamiut	18	5.053	0.118	18	154.865	1.559	18	31.994	0.2606	18	0.081	0.004
2005	Paamiut	19	5.501	0.119	19	143.926	0.937	19	30.560	0.1330	19	0.071	0.003
2006	Paamiut	17	5.903	0.128	18	139.956	1.548	18	30.099	0.1864	18	0.068	0.004
2007	Paamiut	19	4.925	0.117	19	146.005	1.454	19	30.855	0.2064	19	0.072	0.006
2008	Paamiut	18	4.805	0.100	16	148.246	1.895	19	30.931	0.2618	19	0.065	0.004
2009	Paamiut	21	5.224	0.093	21	145.124	0.899	21	30.730	0.1277	21	0.075	0.002
2010	Paamiut	22	5.215	0.114	22	140.099	1.104	22	30.016	0.1567	22	0.075	0.003
2011	Paamiut	22	5.143	0.121	22	147.865	1.251	22	31.119	0.1777	22	0.068	0.004
2012	Paamiut	16	5.375	0.147	15	141.057	2.624	17	30.067	0.3278	17	0.062	0.005
2013	Paamiut	4	4.626	0.068	4	137.825	0.206	4	29.839	0.0168	4	0.070	0.005
2014	Paamiut	n.r	n.r	n.r	19	151.819	0.961	19	31.578	0.1834	19	0.077	0.003
2015	Paamiut	21	4.985	0.079	21	151.731	0.908	21	31.603	0.1540	21	0.076	0.003
2016	Paamiut	23	4.922	0.163	22	154.806	1.675	23	32.004	0.2484	23	0.078	0.003
2017	Paamiut	14	4.689	0.132	14	161.708	1.524	14	33.085	0.2164	14	0.081	0.004
2019	Helga Maria	24	6.221	0.110	24	134.457	1.129	24	29.215	0.1603	24	0.079	0.001

Table 8. Gear parameters for the survey Div. 1CD survey. Height of the trawl, doors spread, wings spread and sweptarea (N = sample size; Mean in m; S.E) from 1997 to 2017 with R/V Paamiut, and 2019 with C/V Helga Maria. Depth range is 1001-1500 m. n.r = no record.

		Trawl height			Doors spread			Wings spread			Sweptarea		
Year	Vessel	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E
1997	Paamiut	29	5.272	0.134	33	128.848	1.146	33	28.418	0.163	33	0.071	0.003
1998	Paamiut	23	5.287	0.083	15	127.374	1.693	20	28.668	0.255	23	0.069	0.004
1999	Paamiut	20	5.090	0.113	20	126.828	1.794	20	28.132	0.255	20	0.068	0.003
2000	Paamiut	n.r	n.r	n.r	8	122.488	2.395	21	29.072	0.300	22	0.063	0.004
2001	Paamiut	28	4.836	0.035	28	137.821	1.767	28	29.693	0.251	28	0.073	0.003
2002	Paamiut	23	5.430	0.075	23	135.391	2.020	23	29.348	0.287	23	0.071	0.002
2003	Paamiut	23	5.303	0.051	23	138.442	0.860	23	29.781	0.122	23	0.072	0.003
2004	Paamiut	30	4.911	0.071	29	155.381	1.479	30	32.113	0.225	30	0.081	0.003
2005	Paamiut	34	5.366	0.080	34	143.805	1.656	34	30.501	0.234	34	0.069	0.003
2006	Paamiut	35	6.076	0.115	34	139.598	1.091	35	29.948	0.150	35	0.066	0.002
2007	Paamiut	28	4.943	0.088	27	147.426	1.030	28	31.258	0.246	28	0.081	0.006
2008	Paamiut	43	4.754	0.079	43	149.306	1.023	43	31.323	0.145	43	0.073	0.002
2009	Paamiut	40	5.178	0.097	40	147.057	0.903	40	31.042	0.115	40	0.070	0.002
2010	Paamiut	39	4.750	0.054	39	143.423	1.035	39	30.488	0.147	39	0.070	0.003
2011	Paamiut	37	4.611	0.056	37	148.365	0.903	38	31.160	0.128	38	0.070	0.002
2012	Paamiut	28	5.180	0.091	27	141.425	1.565	28	30.147	0.211	28	0.061	0.003
2013	Paamiut	21	4.507	0.069	21	141.733	0.422	21	30.017	0.010	21	0.069	0.003
2014	Paamiut	n.r	n.r	n.r	25	151.479	1.586	34	30.966	0.187	34	0.069	0.002
2015	Paamiut	38	4.854	0.107	36	153.223	1.088	38	31.929	0.184	38	0.073	0.003
2016	Paamiut	37	4.556	0.079	35	154.155	1.391	37	32.216	0.235	37	0.071	0.003
2017	Paamiut	32	5.110	0.089	31	156.945	1.055	31	32.408	0.150	32	0.067	0.003
2019	Helga Maria	37	6.772	0.156	36	130.390	1.425	37	28.479	0.252	37	0.075	0.002

Table 9. Gear parameters for the Div. 1A-F survey. Height of the trawl, doors spread, wings spread and sweptarea (N = sample size; Mean in m; S.E) from 2005 to 2017 with R/V Paamiut, 2018 with C/V Sjudarberd and 2019 with CV Helga Maria. Depth range is 50 – 600 m.

		Trawl height			Doors spread			Wings spread			Sweptarea		
Year	Vessel	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E	N	Mean	S.E
2005	Paamiut	214	12.324	0.063	216	50.041	0.332	218	29.238	0.1840	218	0.033	0.0003
2006	Paamiut	249	12.095	0.066	249	48.130	0.329	249	28.182	0.1881	249	0.033	0.0004
2007	Paamiut	262	11.787	0.062	260	47.516	0.342	262	27.802	0.1944	262	0.032	0.0003
2008	Paamiut	258	11.664	0.064	240	47.741	0.332	258	27.809	0.1858	258	0.032	0.0003
2009	Paamiut	277	11.905	0.058	268	46.871	0.322	279	27.564	0.1779	279	0.031	0.0003
2010	Paamiut	298	11.202	0.050	286	48.529	0.298	299	28.451	0.1632	299	0.032	0.0002
2011	Paamiut	216	12.579	0.074	199	46.551	0.358	216	27.520	0.1916	216	0.030	0.0003
2012	Paamiut	219	11.891	0.076	213	46.968	0.340	220	27.598	0.1906	220	0.030	0.0003
2013	Paamiut	209	11.482	0.074	205	48.876	0.431	211	28.594	0.2385	211	0.031	0.0004
2014	Paamiut	224	12.040	0.070	220	46.681	0.448	226	27.367	0.2504	226	0.028	0.0003
2015	Paamiut	221	12.814	0.081	215	48.766	0.381	222	28.553	0.2108	222	0.029	0.0004
2016	Paamiut	193	12.589	0.089	191	48.011	0.397	193	28.146	0.2227	193	0.031	0.0003
2017	Paamiut	257	11.738	0.068	258	49.729	0.381	258	29.084	0.2175	258	0.032	0.0003
2018	Sjurdarberg	224	11.795	0.099	222	51.586	0.443	224	30.064	0.2544	224	0.031	0.0004
2019	Helga Maria	196	11.819	0.065	198	53.033	0.458	198	30.968	0.2612	198	0.032	0.0003

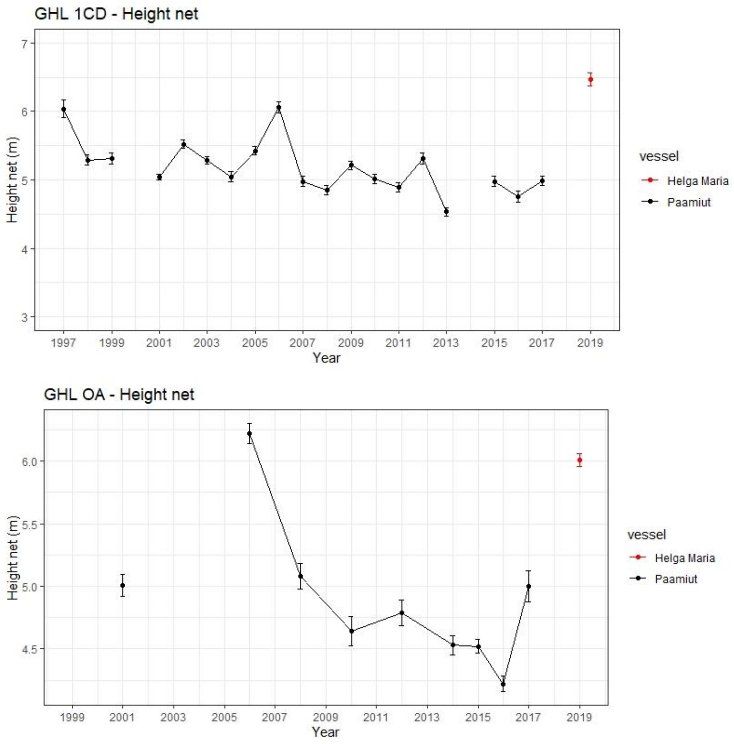

Figure 1. Mean of the trawl height in (m) and S.E. for Alfredo III trawl in Div. 1CD survey and in Div. 0A-South surveys.

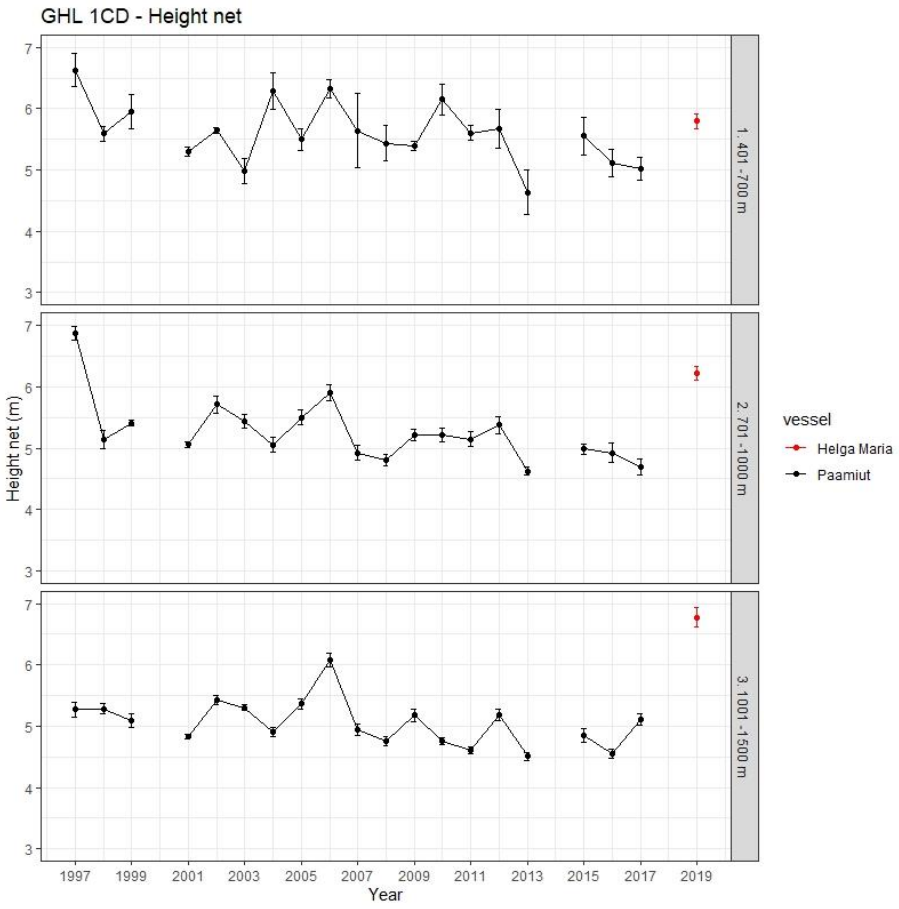

Figure 2. Mean of the trawl height in (m) and S.E. for Alfredo III trawl in Div. 1CD survey by depth zones (401-700 m; 701-1000 m; 1001-1500 m).

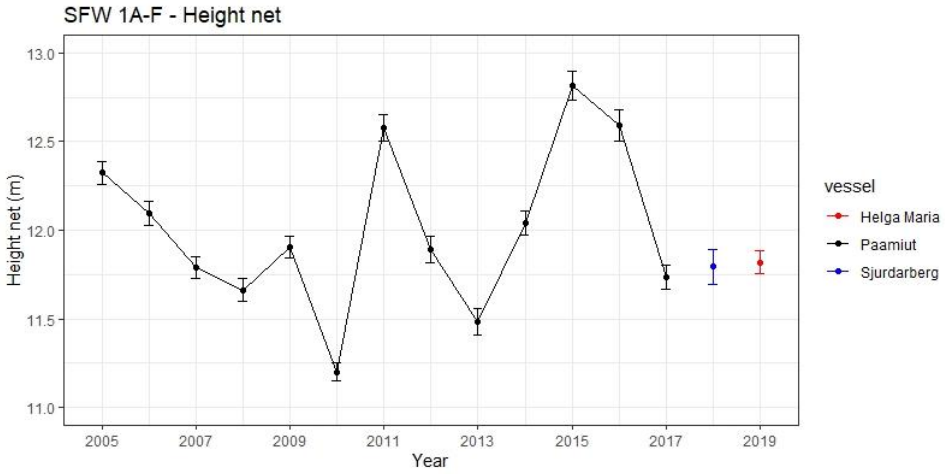

Figure 3. Mean of the trawl height in (m) and S.E. for Cosmos trawl in Div. 1A-F.

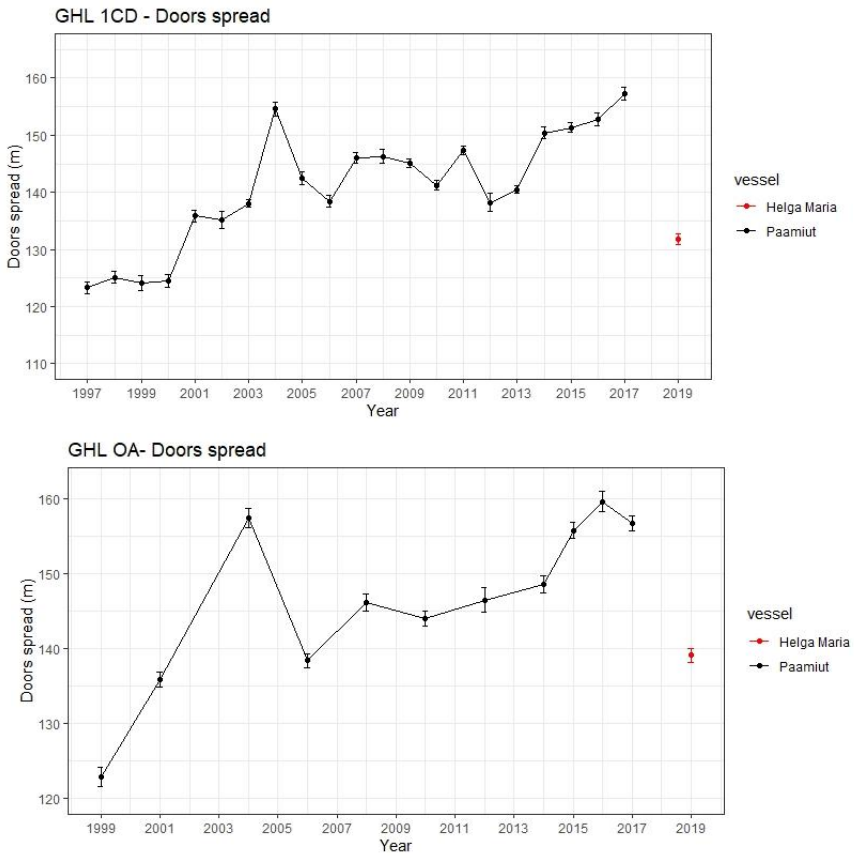

Figure 4. Mean of the doors spread in (m) and S.E. for Alfredo III trawl in Div. 1CD survey and in Div. 0A-South survey during the time series for Paamiut and Helga Maria.

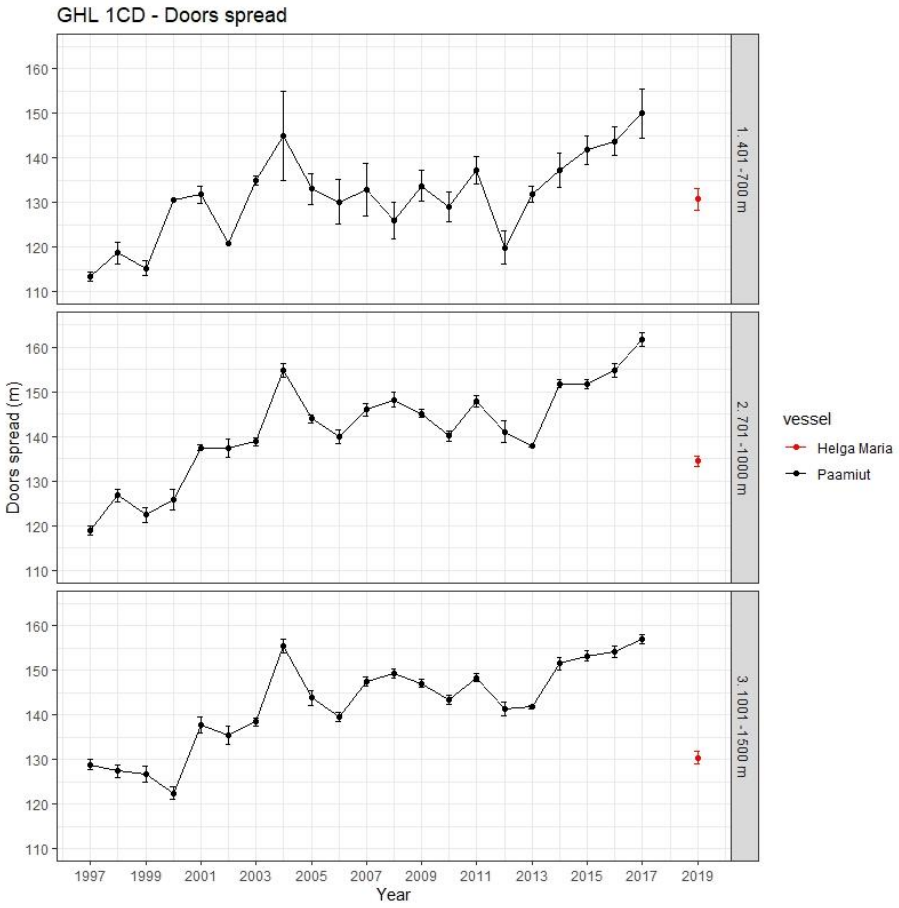

Figure 5. Mean of the doors spread in (m) and S.E. for Alfredo III trawl in Div. 1CD survey by depth zones (401-700 m; 701-1000 m; 1001-1500 m).

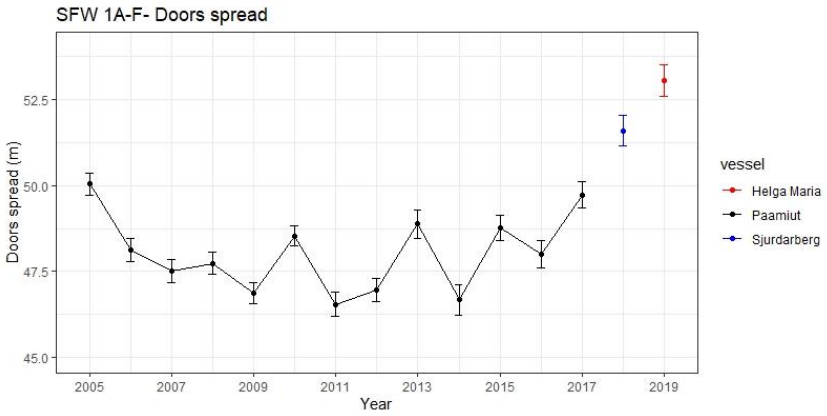

Figure 6. Mean of the door spread in (m) and S.E. for Cosmos trawl in Div. 1A-F in (m) and S.E.

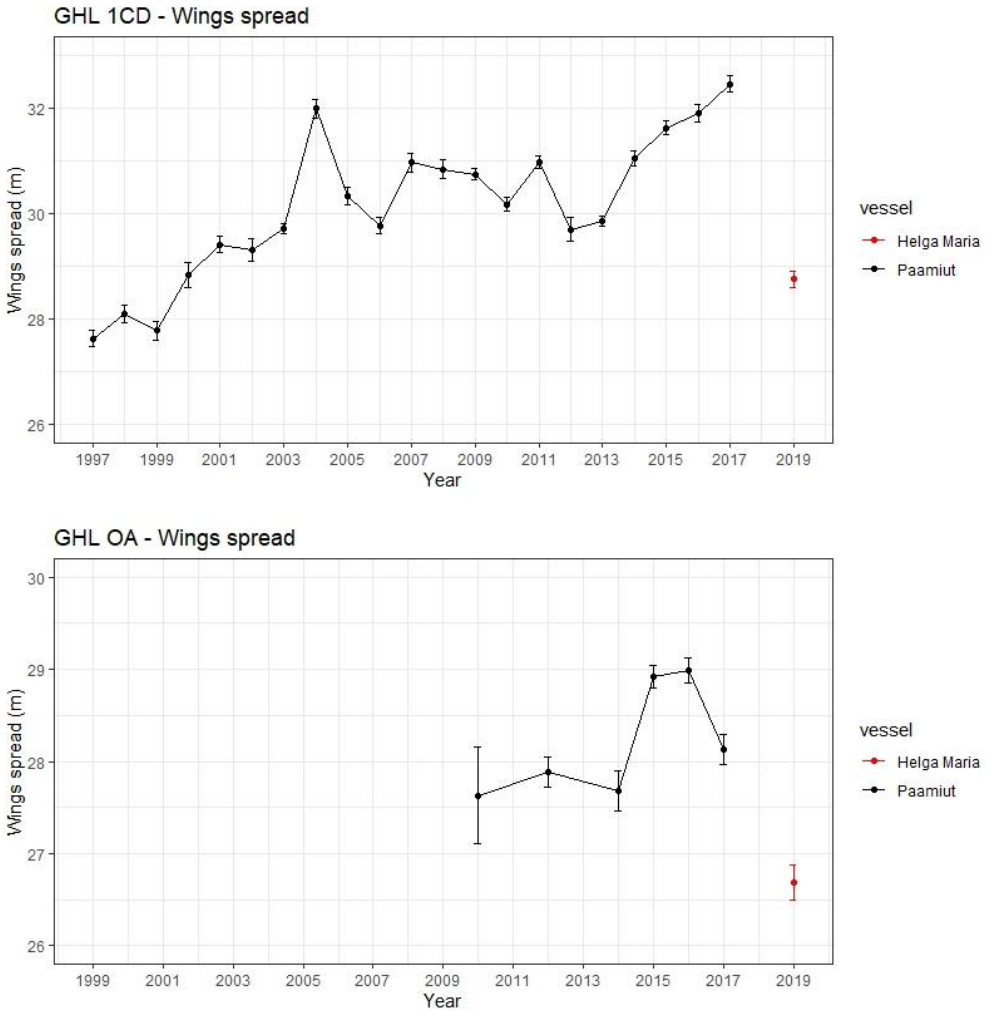

Figure 7. Mean of the wings spread in (m) and S.E. for Alfredo III trawl in Div. 1CD survey and in Div. 0A-South survey during the time series for Paamiut and Helga Maria.

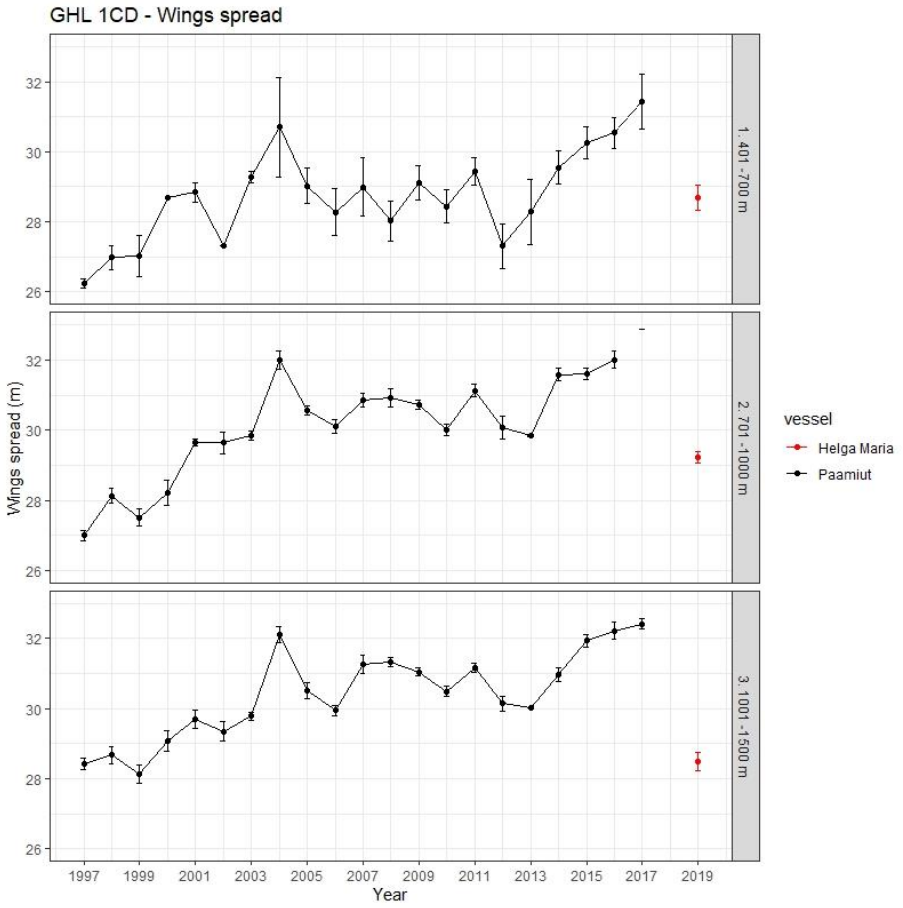

Figure 8. Mean of the wing spread in (m) and S.E. for Alfredo III trawl in Div. 1CD survey by depth zones (401-700 m; 701-1000 m; 1001-1500 m) for years 1997-2017 (Paamiut) and 2019 (Helga Maria).

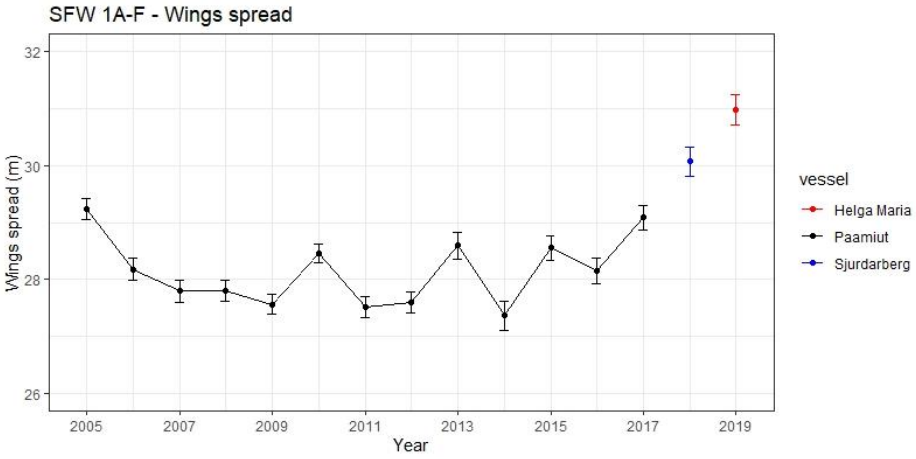

Figure 9. Mean of the wings spread in (m) and S.E. for Cosmos trawl in Div. 1A-F in (m) and S.E.

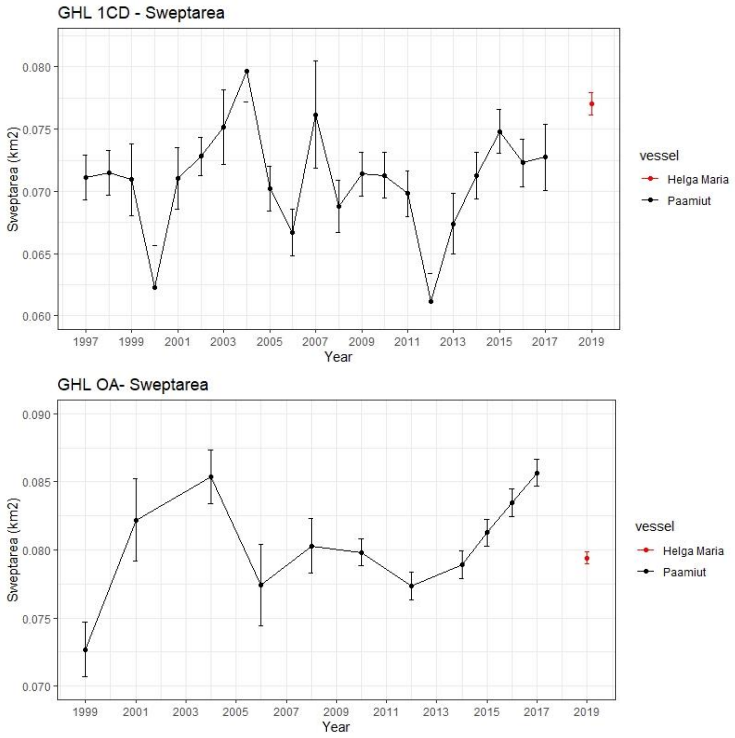

Figure 10. Mean of the swept area in (m) and S.E. for Alfredo III trawl in Div. 1CD survey and in Div. 0A-South survey during the time series for Paamiut and Helga Maria.

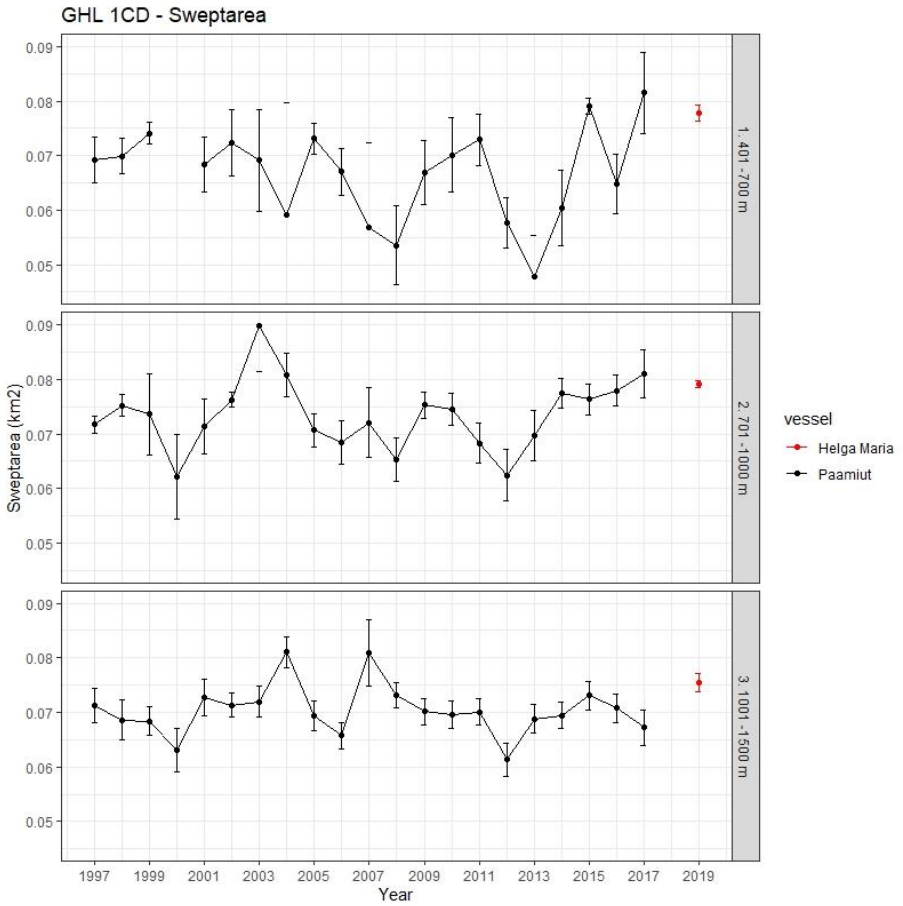

Figure 11. Mean of the swept area in (m) and S.E. for Alfredo III trawl in Div. 1CD survey by depth zones (401-700 m; 701-1000 m; 1001-1500 m) for years 1997-2017 (Paamiut) and 2019 (Helga Maria).

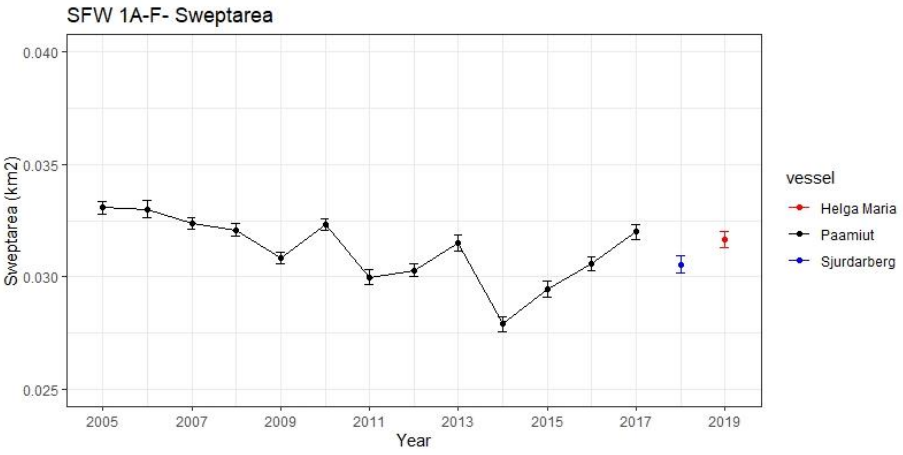

Figure 12. Mean of the swept area in (m) and S.E. for Cosmos trawl in Div. 1A-F.

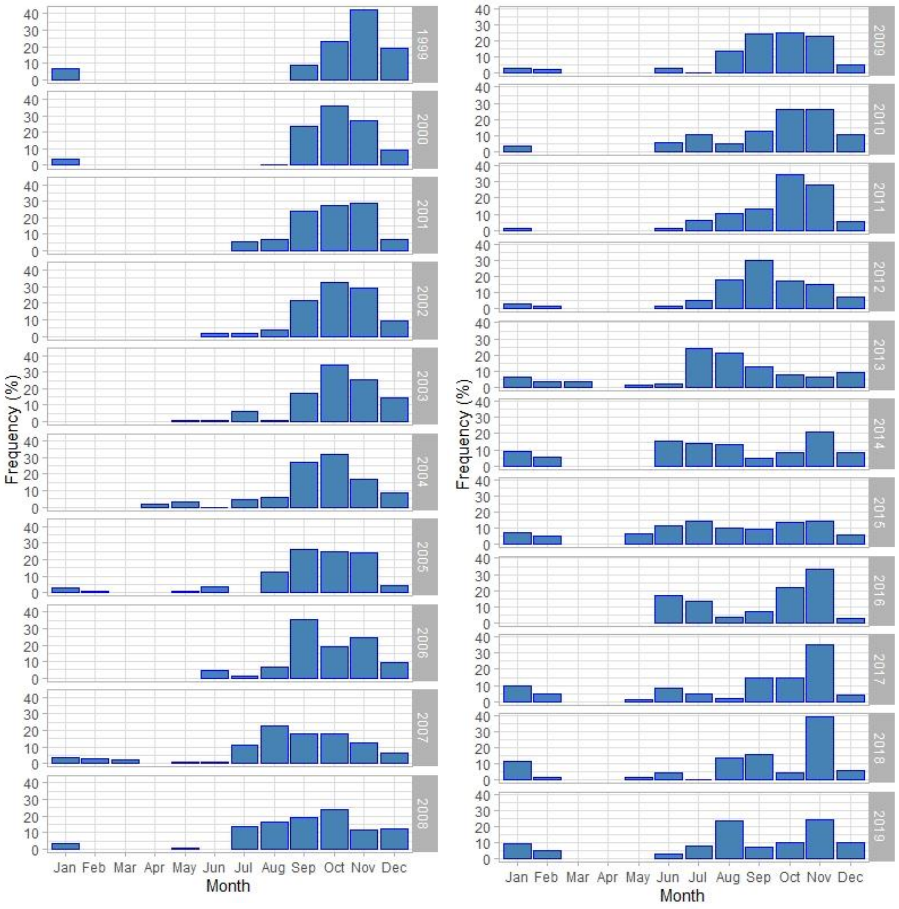

Figure 13. Average seasonal distribution of catches in West Greenland, NAFO 1CD (1999-2019).

Fig. 14 a

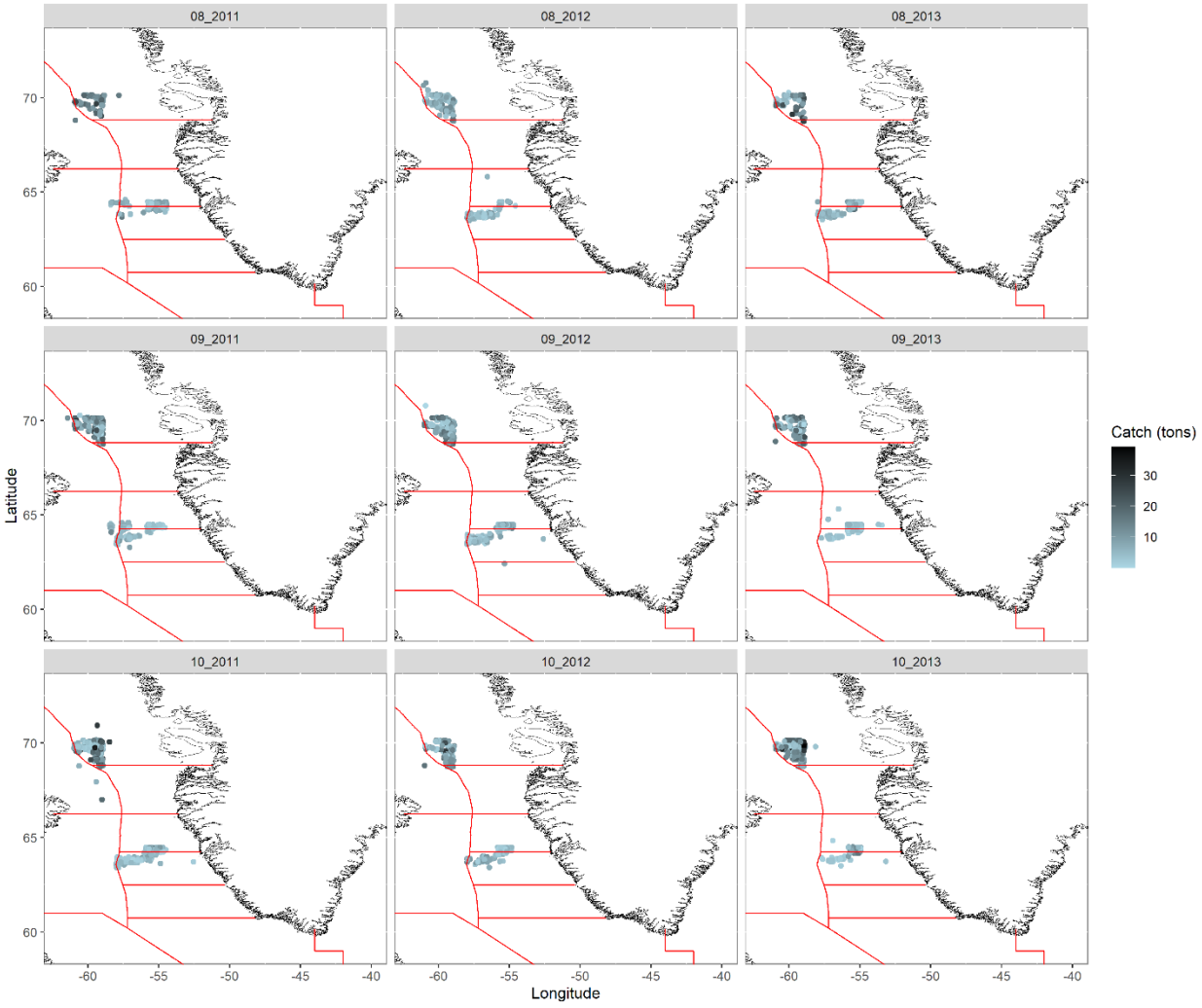
08_2011
08_2012
08_2013
09_2011
09_2012
09_2013
10_2011
10_2012
10_2013
Latitude
Longitude
70
65
60
-60
-55
-50
-45
-40
Catch (tons)
30
20
10

Fig.14 b.

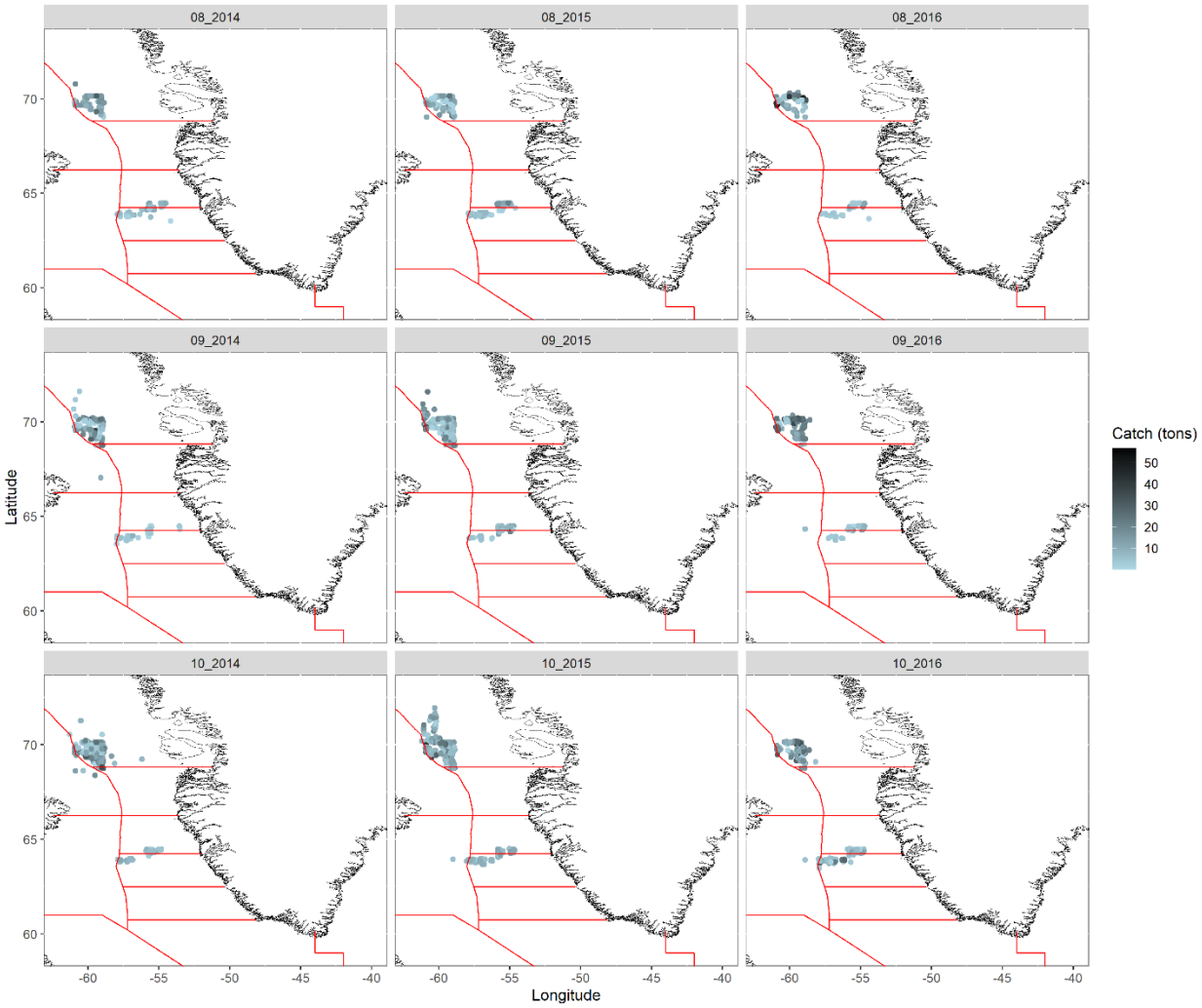
08_2014
08_2015
08_2016
09_2014
09_2015
09_2016
10_2014
10_2015
10_2016
Latitude
Longitude
70
65
60
-60
-55
-50
-45
-40
Catch (tons)
50
40
30
20
10

Fig. 14 c.

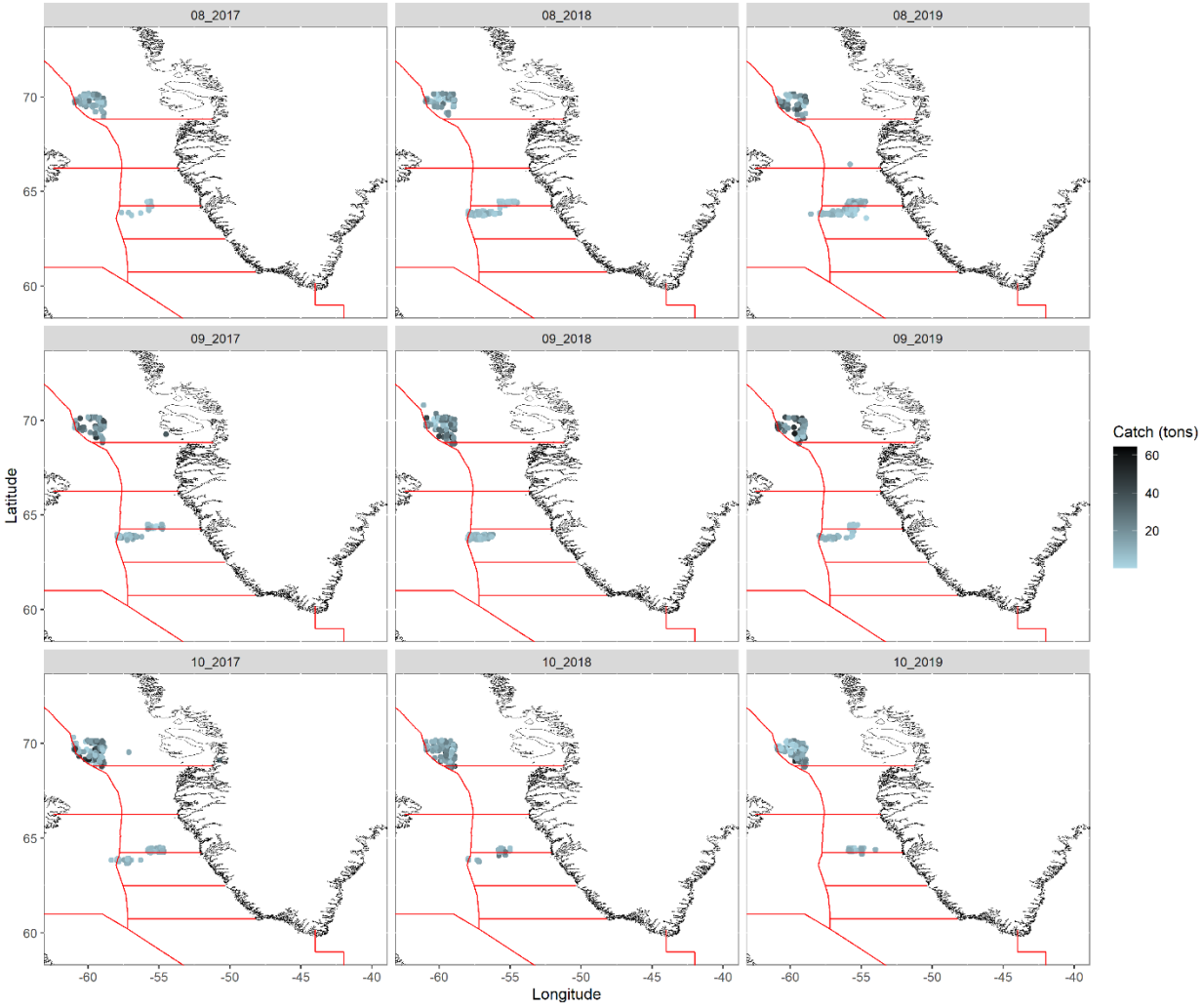

Figure 14. Distribution of the Greenland halibut fishery during August, September and October in West Greenland expressed as catches in tons, from logbooks provided by the Greenland Office of Fisheries Licenses (GFLK) over the following years; a) 2011-2013; b) 2014-2016; c) 2017-2019.

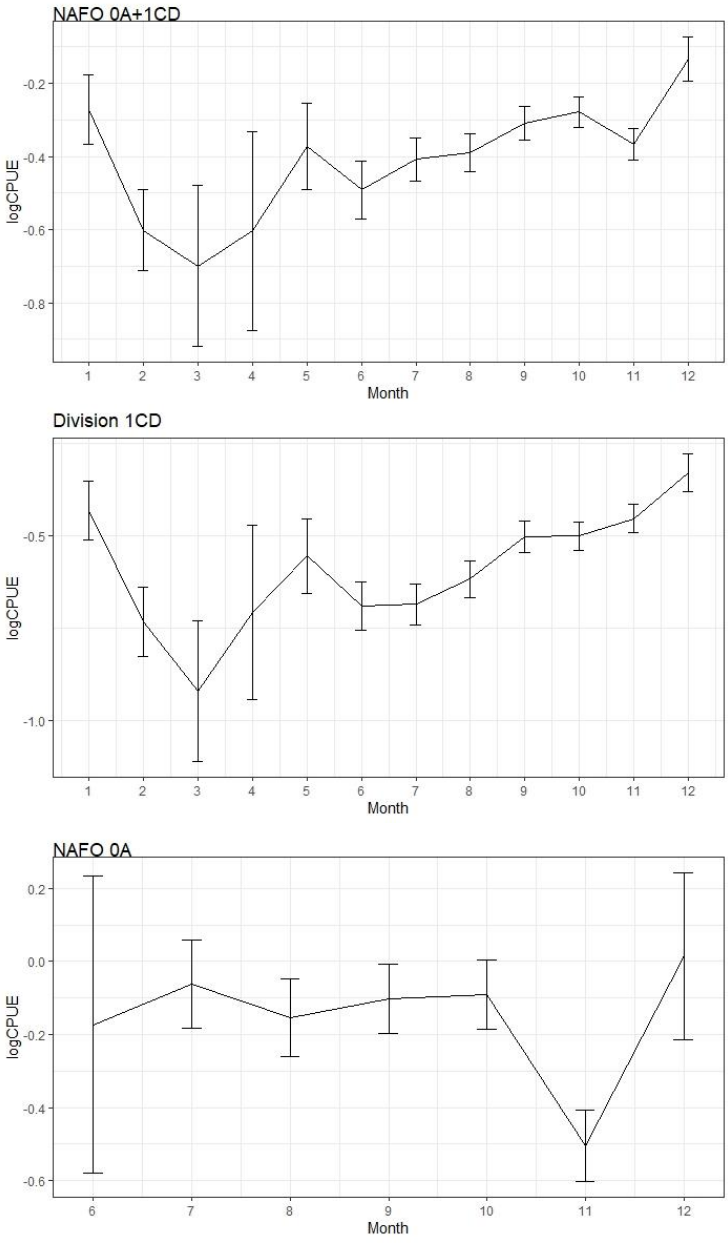

Figure 15. Standardised catch rates (CPUE) given as catch per hour trawling, with respective 95% confidence intervals in subdivision 0A-South-1CD combine, and 1CD and 0A-South. Data from 1CD are provided from the Greenland Office of Fisheries Licenses (GFLK) logbooks over the time period January to December. Data from 0A-South are from Fisheries and Oceans Statistics branches.

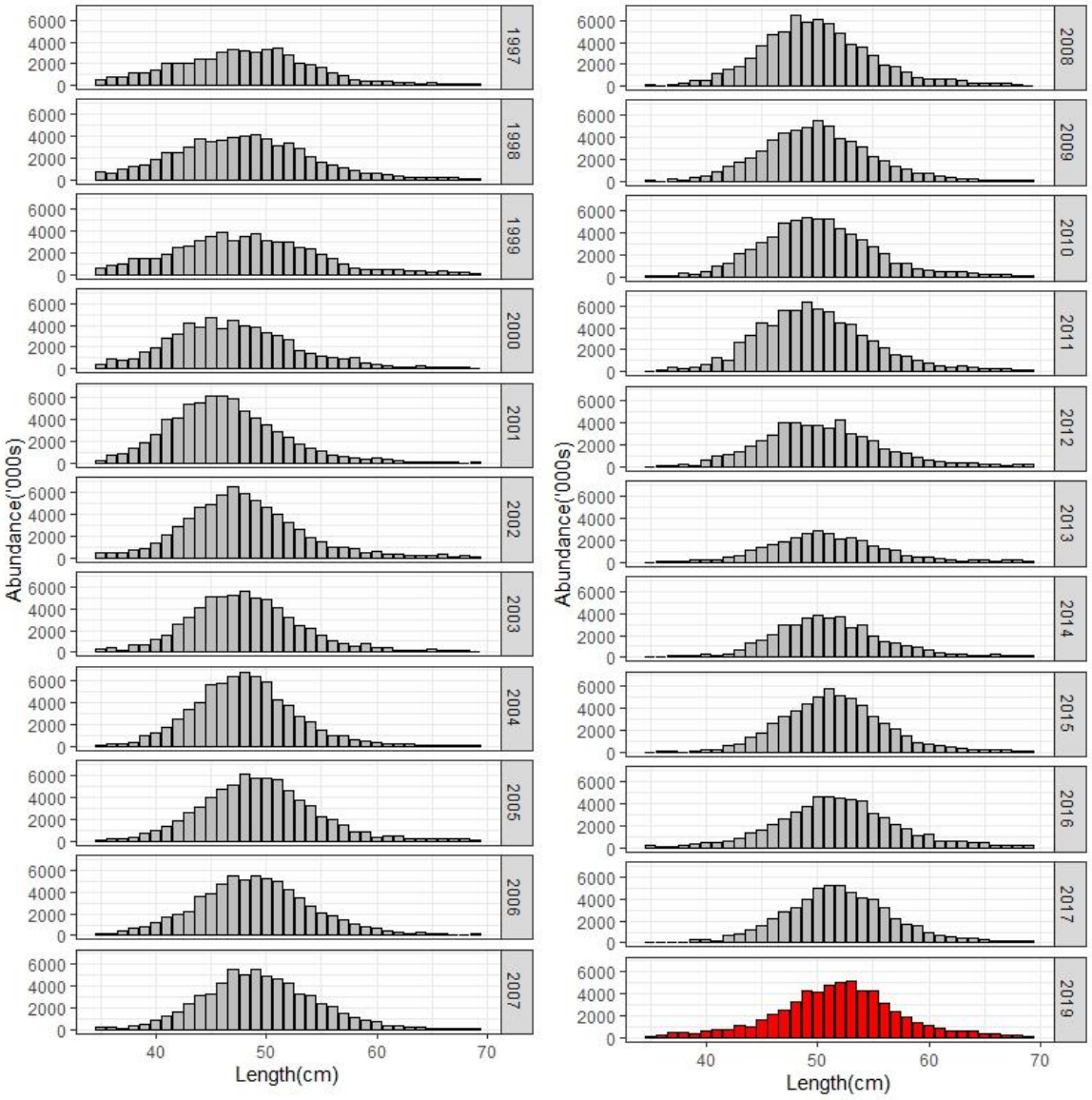

Figure 16. Length distribution of individuals from 35 to 70 cm of Greenland halibut (numbers weighted by stratum area) for the Div. 1CD survey for 1997-2017 and 2019. Grey = RV Paamiut; Red = CV Helga Maria.

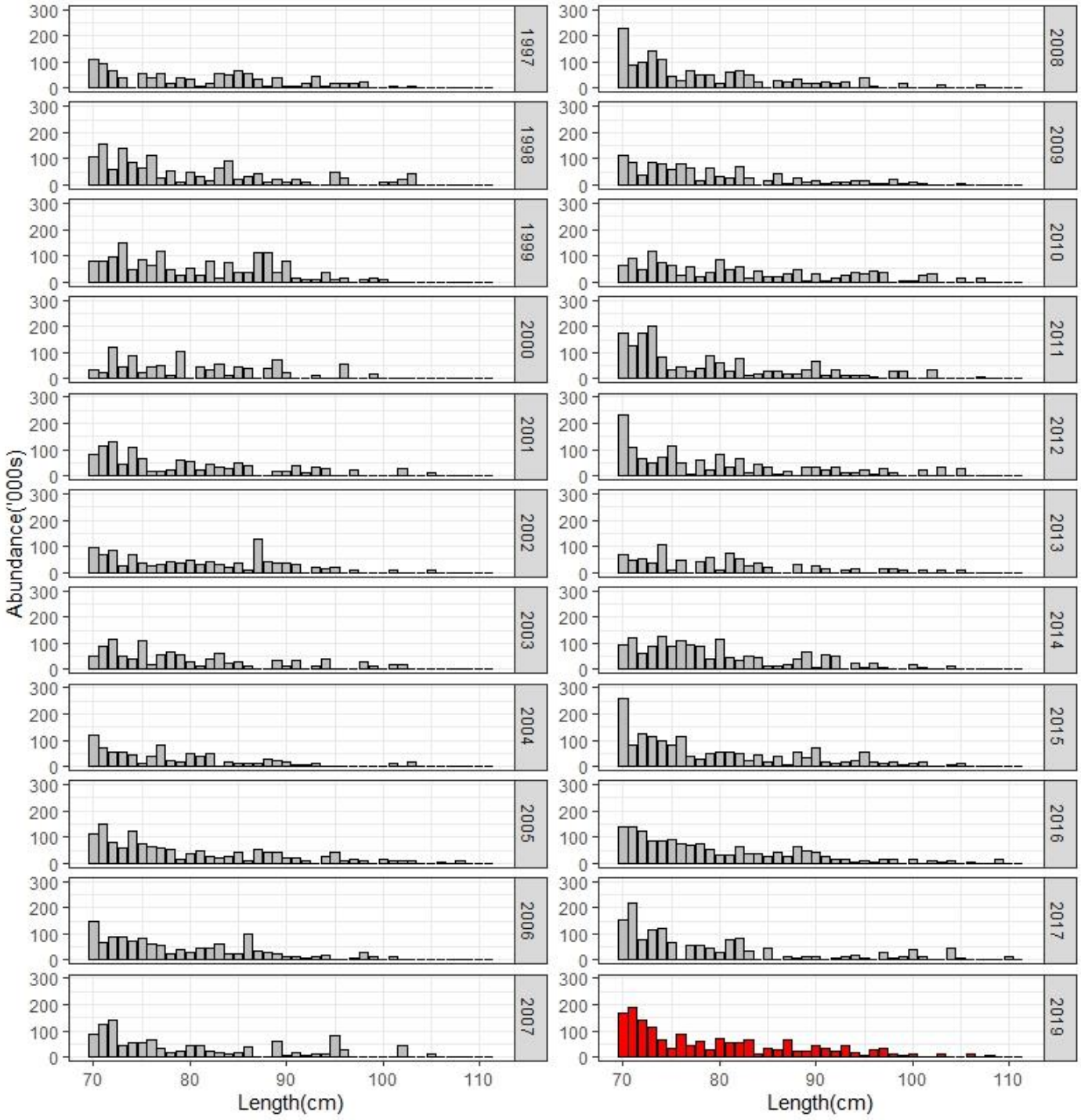

Figure 17. Length distribution of individuals bigger than 70 cm of Greenland halibut (numbers weighted by stratum area) for the Div. 1CD survey for 1997-2017 and 2019. Grey = RV Paamiut; Red = CV Helga Maria.

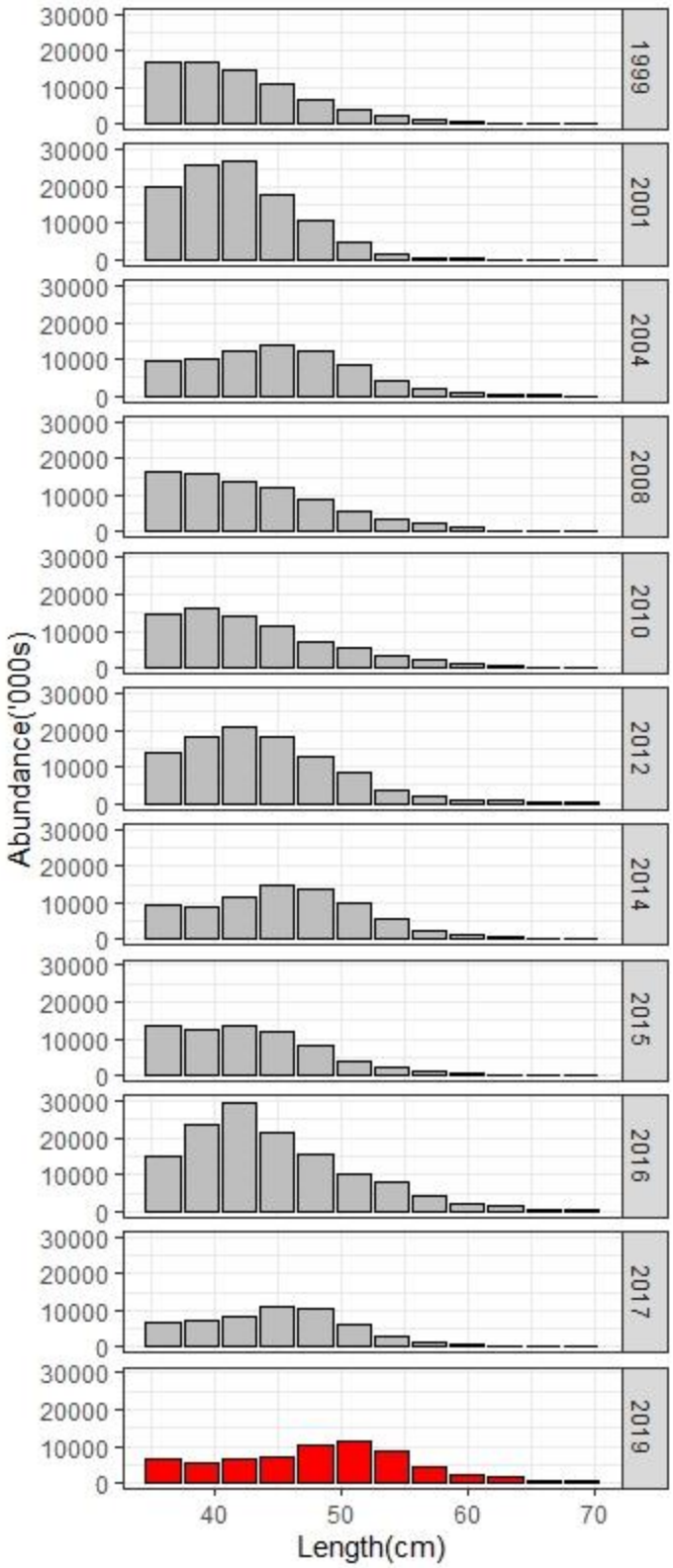

Figure 18. Length distribution of individuals from 35 to 70 cm of Greenland halibut (3 cm size groups, numbers weighted by stratum area) for the Div. 0A-South survey for 1999-2017 and 2019. Grey = RV Paamiut; Red = CV Helga Maria.

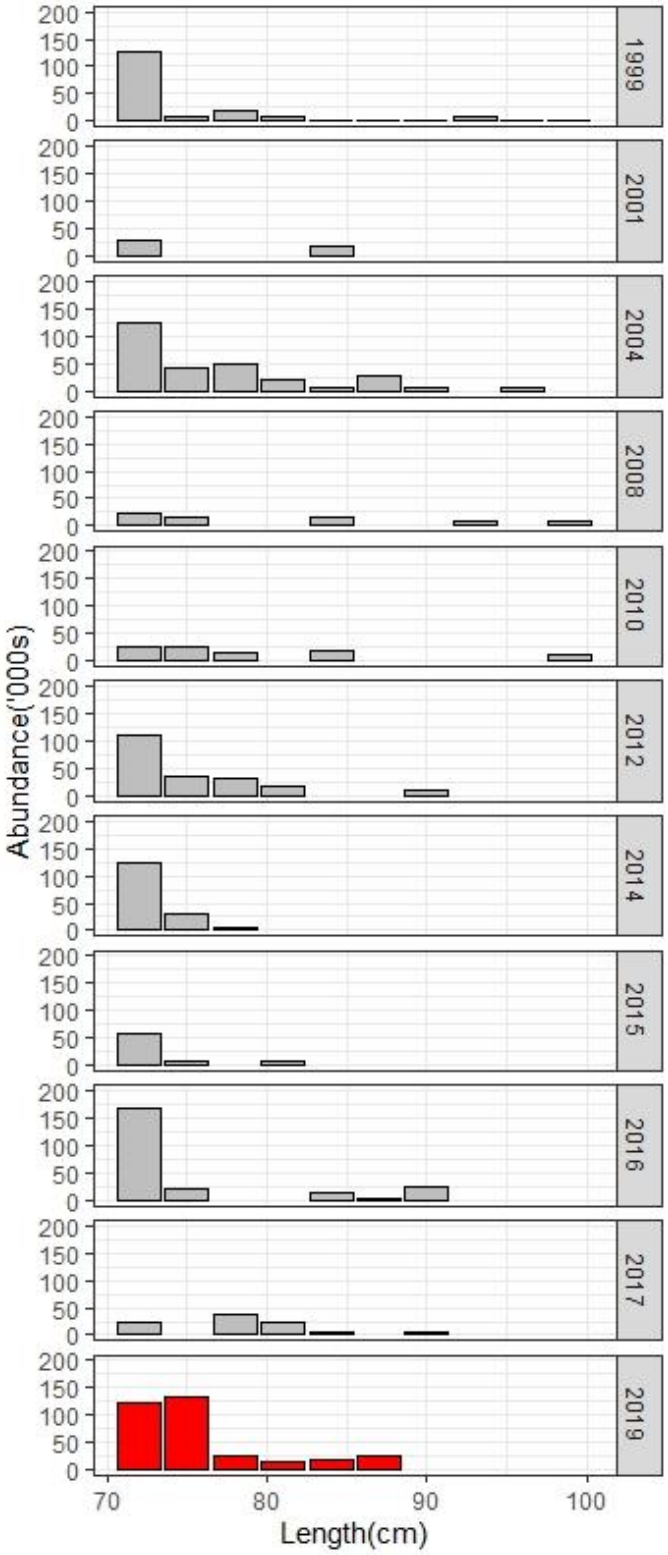

Figure 19. Length distribution of individuals bigger than 70 cm of Greenland halibut (3 cm size groups, numbers weighted by stratum area) for the Div. 0A-South survey for 1999-2017 and 2019. Grey = RV Paamiut; Red = CV Helga Maria.

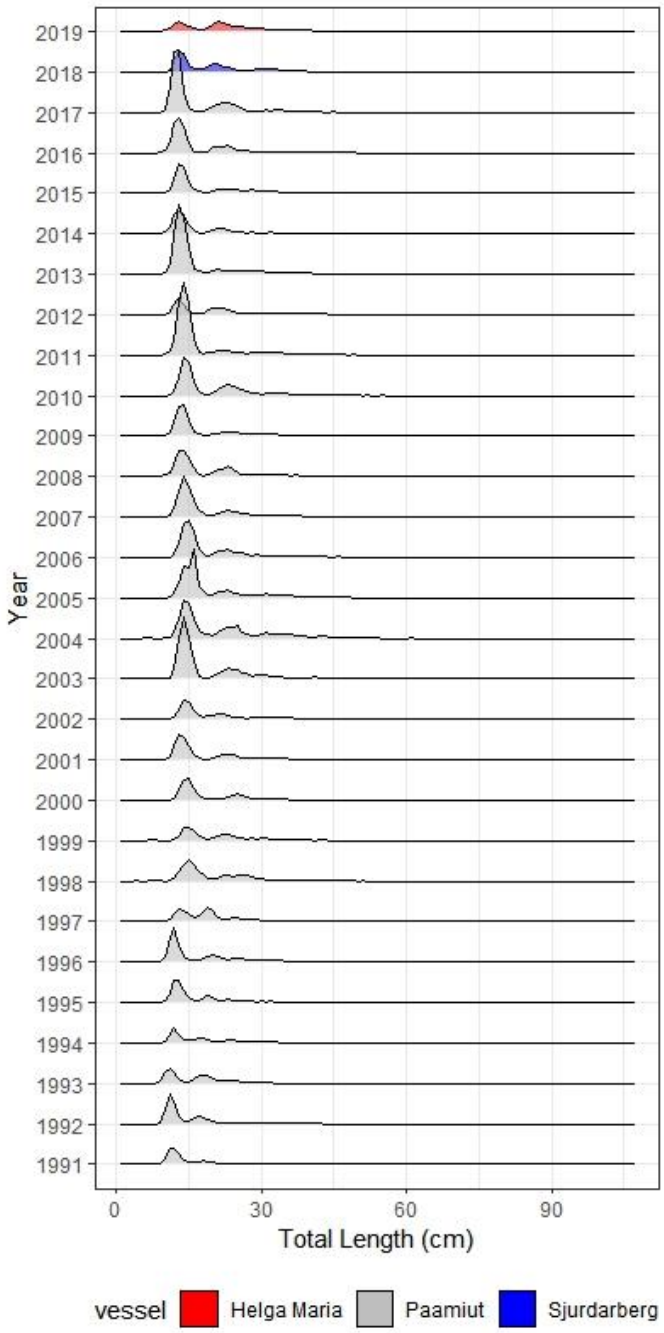

Figure 20. Length frequencies for Greenland halibut in the Div. 1A-F survey for 1991-2019. Grey = RV Paamiut; Blue : Sjurdarberg; Red = CV Helga Maria

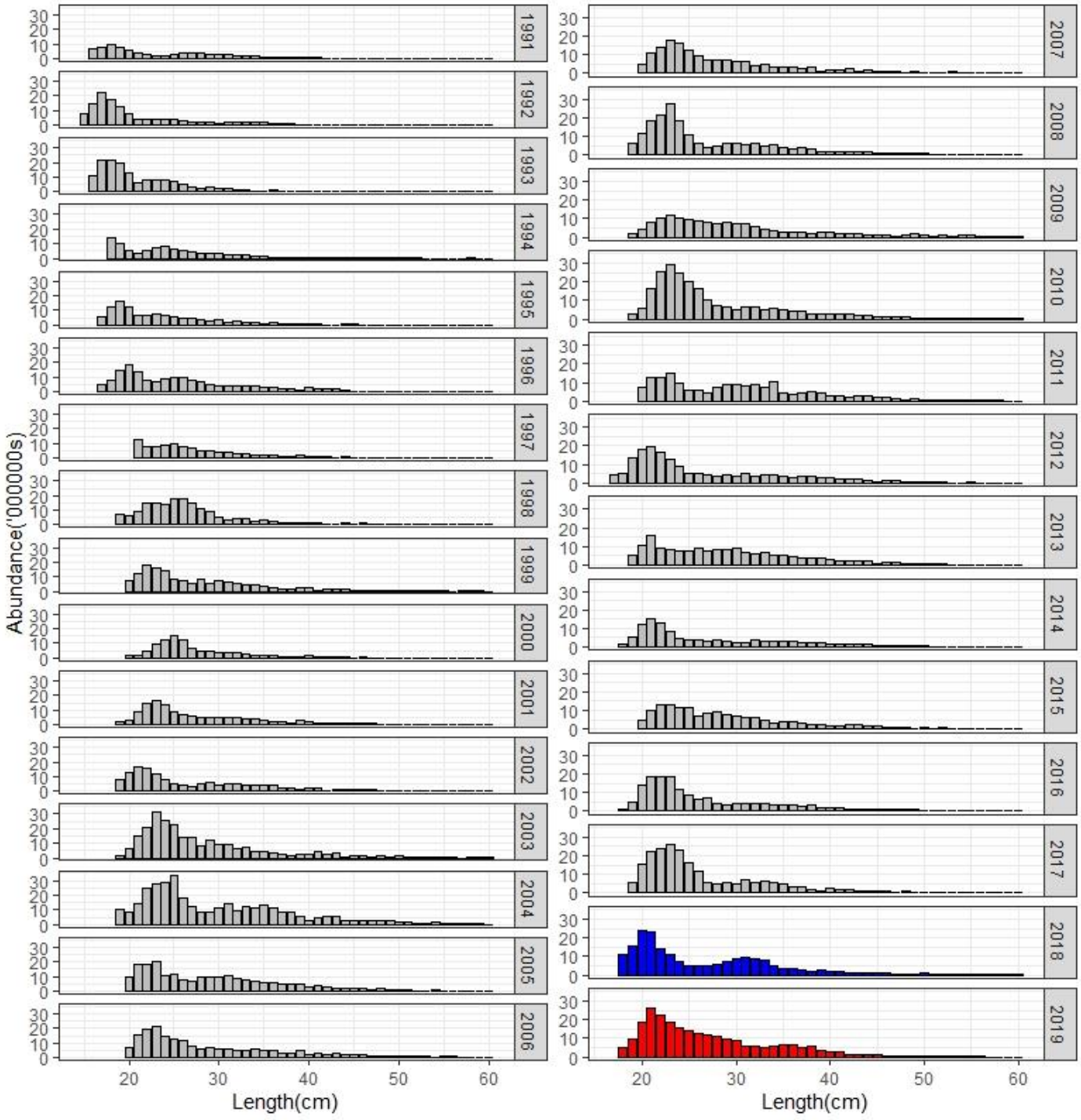

Figure 21. Length distribution of individuals from age 2 (approx. 15-20 to 21-29 cm) to 60 cm of Greenland halibut (numbers weighted by stratum area) in the Div. 1A-F survey for 1991-2019. Grey = RV Paamiut; Blue : Sjurdarberg; Red = CV Helga Maria.

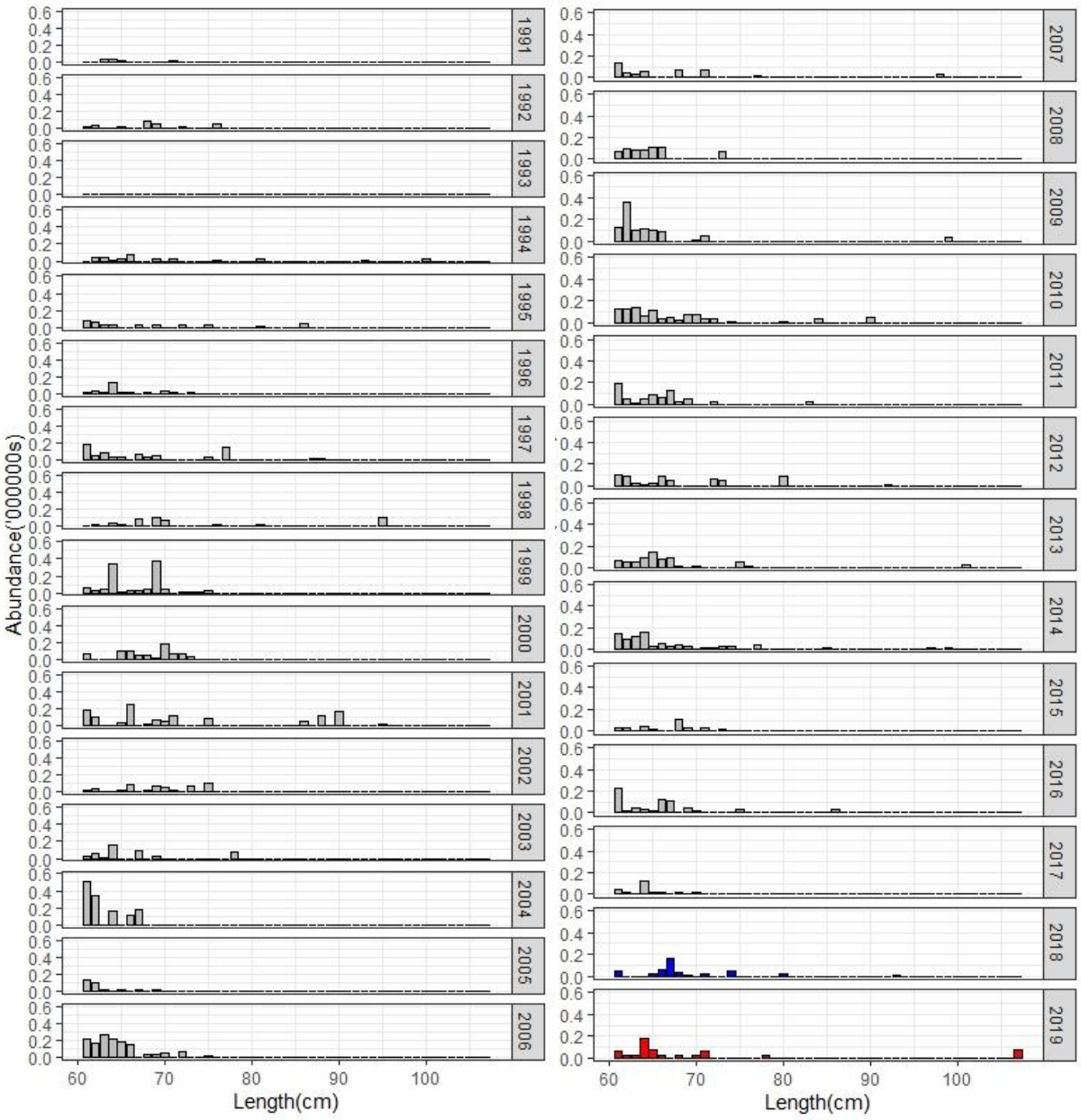

Figure 22. Length distribution of individuals bigger than 60 cm of Greenland halibut (numbers weighted by stratum area) in the Div. 1A-F survey for 1991-2019. Grey = RV Paamiut; Blue : Sjurdarberg; Red = CV Helga Maria.

Annex 1. Description of steps taken to ensure standardization of fishing procedures during surveys conducted by C/V Sjurdarberg (2018) and C/V Helga Maria (2019).

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Statement regarding using M/Tr Sjúrðarberg to carry out the same surveys as R/V Paamiut

In November 2017 R/V Paamiut failed to comply with DNVGL standards for working in Artic waters. The management of Greenland Institute of Natural Resources (GN) decided not to spend more money on the vessel, but to go for building a new ship.

For the 2018-season, GN decided to charter Sjúrðarberg, a Faroese trawler of almost same dimensions as Paamiut, doing the normal surveys on the Greenland west coast.

To make the surveys as identical as possible this equipment was used from R/V Paamiut:

- Cosmos trawls
- All other equipment, such as bridles etc.
- Doors
- Marport sensors on doors and headline

Other steps taken ensuring the validity of received data:

- The wires/warps on Sjúrðarberg were same dimension (26mm) as used on Paamiut
- The distance between the hanging blocks was the same
- The Marport equipment on the bridge was set up and calibrated as on Paamiut
- All data from the tows were logged as normal procedure on Paamiut
- Skipper on Paamiut (Birgir Sivertsen) was on the bridge as supervisor, taking care of that all of the trawling was carried out as on Paamiut
- Chief Engineer from Paamiut was on board ensuring that all technical equipment performed as normal
- Crew from Paamiut worked together with the rest of the crew, ensuring that all maintenance of trawls etc. were carried out exactly as normal

To my best conviction regarding comparism, the surveys were executed in the best possible way, and I have absolutely no thoughts that this could be done otherwise or better.

Best regards

Kári Hansen, Chief Engineer

KÁRI HANSEN, MASKINCHEF

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Greenland Institute of Natural Resources
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Statement regarding using M/Tr Helga Maria to carry out the same surveys as R/V Paamiut for 2019
In November 2017 R/V Paamiut failed to comply with DNVGL standards for working in Artic waters. The management of Greenland Institute of Natural Resources (GN) decided not to spend more money on the vessel, but to go for building a new ship.

For the 2019-season, GN decided to charter Helga Maria, a Islandic trawler of almost same dimensions as Paamiut, doing the normal surveys on the Greenland west coast and Canada east coast.

To make the surveys as identical as possible this equipment was used from R/V Paamiut:
Alfredo trawls with 96 mtr bridles, as with R/V Paamiut
Cosmos trawls with 48 mtr bridles, as with R/V Paamiut
- All other equipment, such as bridles ,gear etc.
- Doors
- Marport sensors on doors and headline

Other steps taken ensuring the validity of received data:
- The wires/warps on Helga Maria were same dimension (26mm) as used on Paamiut
- The distance between the hanging blocks was the same
- The Marport equipment on the bridge was set up and calibrated as on Paamiut
- All data from the tows were logged as normal procedure on Paamiut
- Skipper on Paamiut (Jakup G.Mikkelsen) and Chief Engineer Kari Hansen was on Island ,used 14 days onboard Helga Maria, before departure to Greenland, to prepare and make the right arrangement on deck and factory for trawl equipment, and what else the Scientifics need, to make the surveys as simular as possible compare with R/V Paamiut. Skipper Jakup G.Mikkelsen also was onboard for one month, working on the bridge and deck as supervisor, taking care of that all of the trawling and equipment was carried out as on Paamiut
- Crew from Paamiut worked together with the rest of the crew, ensuring that all maintenance of trawls etc. were carried out exactly as normal

To our best conviction regarding comparison, the surveys were executed in the best possible way, and we have absolutely no thoughts that this could be done otherwise or better.

Best regards

Jakup G Mikkelsen — Captajn
Kàri Hansen — Chief Engineer 1

Jákup G. Mikkelsen

Annex 2. Subarea 0 catch summary by month, gear and Division for 2018, 2016 and 2014.

2018

	DIVISION 0B								DIVISION 0A				SA 0		
	Can (N)			Can (C&A)					Can (C&A)						
	Single Trawl	Double Trawl	Gillnet	Single Trawl	Double Trawl	Gillnet	Hook & Line	**Total**	Single Trawl	Double Trawl	Gillnet	**Total**	**Total**	**0A (%)**	**0B (%)**
Jan				203	168			**371**				**0**	**371**		0.05
Feb								**0**				**0**	**0**		
Mar								**0**				**0**	**0**		
Apr								**0**				**0**	**0**		
May				494	25	30		**548**				**0**	**548**		0.07
June	405		812	609	360	782		**2968**				**0**	**2968**		0.39
July	576		592	29	68	393		**1659**	247	115	22	**383**	**2043**	0.04	0.22
Aug	69	627	251				6	**954**	487	806	1073	**2366**	**3320**	0.27	0.13
Sep	65	428		9	74	73	3	**653**	1188	1482	1118	**3788**	**4441**	0.43	0.09
Oct						7		**7**	286	494	884	**1664**	**1671**	0.19	0.00
Nov					59			**59**	69	481	143	**693**	**752**	0.08	0.01
Dec				284	77			**360**				**0**	**360**		0.05
Total	**1115**	**1055**	**1656**	**1627**	**831**	**1286**	**10**	**7579**	**2276**	**3378**	**3240**	**8894**	**16473**	**1**	**1**

2016

	DIVISION 0B									DIVISION 0A					SA 0
	Can (N)				Can (C&A)					Can (C&A)					
	Single Trawl	Double Trawl	Trawl unspec.	GN	Single Trawl	Double Trawl	GN	Pots	**Total**	Single Trawl	Double Trawl	GN	Pots	**Total**	**Total**
Jan									**0**					**0**	**0**
Feb					111	83			**195**					**0**	**195**
Mar									**0**					**0**	**0**
Apr									**0**					**0**	**0**
May	273				371	20	89		**753**					**0**	**753**
June	213	680		901	106	162	440		**2503**					**0**	**2503**
July	757		272	314	271	564	332		**2510**	26	39	71		**136**	**2646**
Aug	25		182	370	42				**619**	1431	558	709		**2698**	**3317**
Sep				7	11	91			**108**	763	682	951		**2397**	**2505**
Oct				113			5	0	**118**	616	569	848	11	**2045**	**2163**
Nov								2	**2**	124	10	143		**277**	**279**
Dec					4	108			**112**	7				**7**	**119**
Total	**1268**	**680**	**454**	**1705**	**917**	**1028**	**865**	**2**	**6920**	**2967**	**1859**	**2721**	**11**	**7559**	**14479**

2014

	DIVISION 0B							DIVISION 0A					SA 0
	Can (N)			Can (C&A)				Can (C&A)					
	Single Trawl	Double Trawl	GN	Single Trawl	Double Trawl	GN	**Total**	Single Trawl	Double Trawl	GN	LL	**Total**	**Total**
Jan							**0**					**0**	**0**
Feb							**0**					**0**	**0**
Mar							**0**					**0**	**0**
Apr							**0**					**0**	**0**
May							**0**					**0**	**0**
June	187	347	324	14	765	488	**2125**					**0**	**2125**
July	58	548	750	93	577	462	**2488**	29	442	9		**480**	**2968**
Aug	334	264	301			77	**976**	451	965	920		**2336**	**3312**
Sep	121	124	154				**399**	1	1648	1196		**2845**	**3244**
Oct	78			79	37		**194**	85	642	1155	1	**1883**	**2077**
Nov				115	371		**486**	53		342		**395**	**881**
Dec				213	122		**335**					**0**	**335**
Total	**778**	**1283**	**1529**	**514**	**1872**	**1027**	**7003**	**619**	**3697**	**3622**	**1**	**7939**	**14942**

Annex 3. Division 1CD catch summary by month, gear and Division for years 2019- 2016, data are from Greenland Office of Fisheries Licenses (GFLK) logbooks.

2019

	Div. 1CD			Div. 1AB		
Month	Single trawl	Double trawl	TOTAL	Single trawl	Double trawl	TOTAL
Jan	-	-	0	795	-	795
Feb	-	-	0	417	-	417
Mar	-	-	0	-	-	0
Apr	-	-	0	-	-	0
May	-	-	0	-	-	
Jun	-	-	0	142	87	229
Jul	79	98	177	601	93	694
Aug	331	853	1184	2009	-	2009
Sep	444	2165	2609	608	-	608
Oct	391	3345	3736	825	-	825
Nov	362	922	1284	898	1181	2079
Dec	-	-	0	201	671	872

2018

	Div. 1AB			Div. 1CD		
Month	Single trawl	Double trawl	TOTAL	Single trawl	Double trawl	TOTAL
Jan	-	-	0	708	103	811
Feb	-	-	0	138	-	138
Mar	-	-	0	-	-	0
Apr	-	-	0	-	-	0
May	-	-	0	134	-	134
Jun	-	-	0	328	-	328
Jul	-	-	0	31	-	31
Aug	220	763	983	955	-	955
Sep	236	2479	2715	1126	-	1126
Oct	225	3182	3407	239	84	323
Nov	148	725	873	1674	1115	2789
Dec	-	-	0	448	-	448

2017

	Div. 1AB			Div. 1CD		
Month	Single trawl	Double trawl	TOTAL	Single trawl	Double trawl	TOTAL
Jan	-			729	-	729
Feb	-	-		349	-	349
Mar	-	-		-	-	0
Apr	-	-		-	-	0
May	-	-		98	-	98
Jun	-	-		630	-	630
Jul	-	55	55	314	51	365
Aug	247	989	1236	151	-	151
Sep	1405	707	2112	1072	23	1095
Oct	600	2539	3139	610	498	1108
Nov	82	1161	1243	1695	897	2592
Dec	-	-	0	31	253	284

2016

	Div. 1AB			Div. 1CD		
Month	Single trawl	Double trawl	TOTAL	Single trawl	Double trawl	TOTAL
Jan	-	-		-	-	
Feb	-	-		-	-	
Mar	-	-		-	-	
Apr	-	-		-	-	
May	-	-		-	-	
Jun	-	-		788	416	1204
Jul	-	203	203	955	-	955
Aug	211	901	1112	269	-	269
Sep	304	2871	3175	494	-	494
Oct	821	2215	3036	1194	309	1503
Nov	-	87	87	1182	1100	2282
Dec	-	-	0	204	-	204

Annex 4. NAFO codes used in the CPUE standardization.

Code for country

2	CAN-MQ	Canada Maritimes & Quebec
3	CAN-N	Canada Newfoundland
5	FRO	Faroe Islands
6	GRL	Denmark Greenland
7	E/DNK	Denmark Mainland
8	E/FRA-M	France Mainland
9	FRA-SP	France St. Pierre et Miquelon
10	E/DEU	Federal Republic of Germany
14	JPN	Japan
15	NOR	Norway
16	E/POL	Poland
18	ROM	Romania
19	E/ESP	Spain
20	SUN	Union Soviet Socialist Republics
27	CAN-M	Canada Maritimes
28	CAN-Q	Canada Quebec
31	E/LVA	Latvia
32	E/EST	Estonia
33	E/LTU	Lithuania
34	RUS	Russia
38	EU	European Union
39	CAN	Canada
40	CAN-CA	Canada Central & Arctic

Code for Trawl Gear

Bottom otter trawl (charters), 8, OTB
Bottom otter trawl (side or stern not specified), 10, OTB
Bottom otter trawl, 12, OTB-2
Otter twin trawl, 192, OTT

Code for Vessel Tonnage

0	Not known
2	0-49.9
3	50-149.9
4	150-499.9
5	500-999.9
6	1000-1999.9
7	2000 and over

Example is 401927: where 40=Canada Central & Arctic, 192= Otter twin trawl, 7=Over 2000 Gross Tonnage

Annex 5. Standardized CPUE index for trawlers in Div 0A-South+1CD.

Call:
lm(formula = lcpue ~ Year + Month + Boat)

Residuals:
Min	1Q	Median	3Q	Max
-1.29516	-0.18351	-0.00802	0.18448	2.66392

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.403535	0.355390	1.135	0.256553	
Year1989	0.004016	0.231986	0.017	0.986194	
Year1990	-0.374038	0.305431	-1.225	0.221115	
Year1991	-0.321913	0.268083	-1.201	0.230221	
Year1992	-0.294055	0.229839	-1.279	0.201167	
Year1993	-0.508722	0.244930	-2.077	0.038152	*
Year1994	-0.626644	0.245737	-2.550	0.010975	*
Year1995	-0.571811	0.243830	-2.345	0.019289	*
Year1996	-0.644407	0.249350	-2.584	0.009951	**
Year1997	-0.844094	0.244820	-3.448	0.000598	***
Year1998	-0.444271	0.246108	-1.805	0.071460	.
Year1999	-0.698885	0.245713	-2.844	0.004576	**
Year2000	-0.565278	0.241612	-2.340	0.019574	*
Year2001	-0.412311	0.239582	-1.721	0.085685	.
Year2002	-0.325082	0.237507	-1.369	0.171509	
Year2003	-0.292806	0.238798	-1.226	0.220534	
Year2004	-0.341761	0.236055	-1.448	0.148104	
Year2005	-0.374009	0.236845	-1.579	0.114741	
Year2006	-0.209315	0.237166	-0.883	0.377762	
Year2007	-0.319581	0.236468	-1.351	0.176963	
Year2008	-0.072819	0.236619	-0.308	0.758363	
Year2009	-0.110929	0.237077	-0.468	0.639994	
Year2010	-0.198704	0.236088	-0.842	0.400260	
Year2011	-0.072229	0.237998	-0.303	0.761606	
Year2012	0.017426	0.237436	0.073	0.941515	
Year2013	0.115880	0.236106	0.491	0.623719	
Year2014	0.233244	0.236661	0.986	0.324676	
Year2015	0.485824	0.237236	2.048	0.040934	*
Year2016	0.294882	0.237472	1.242	0.214727	
Year2017	0.453266	0.236118	1.920	0.055293	.
Year2018	0.584761	0.236985	2.468	0.013836	*
Month2	-0.331366	0.129336	-2.562	0.010606	*
Month3	-0.429431	0.227281	-1.889	0.059233	.
Month4	-0.333489	0.281884	-1.183	0.237168	
Month5	-0.101418	0.142172	-0.713	0.475858	
Month6	-0.221124	0.112023	-1.974	0.048771	*
Month7	-0.137034	0.100225	-1.367	0.171968	
Month8	-0.119378	0.097890	-1.220	0.223045	
Month9	-0.037697	0.096695	-0.390	0.696756	
Month10	-0.008305	0.094568	-0.088	0.930044	
Month11	-0.095085	0.093276	-1.019	0.308356	
Month12	0.137643	0.098096	1.403	0.161002	
Boat2127	-0.232077	0.274490	-0.845	0.398118	
Boat3126	-0.272586	0.274737	-0.992	0.321446	

```
Boat3127    -0.320131   0.300024  -1.067 0.286318
Boat5126    -1.789130   0.311119  -5.751 1.31e-08 ***
Boat5127    -0.429270   0.277980  -1.544 0.122963
Boat6125    -1.870607   0.375312  -4.984 7.79e-07 ***
Boat6126    -0.777306   0.266281  -2.919 0.003619 **
Boat6127    -0.273827   0.263160  -1.041 0.298437
Boat14126   -0.607469   0.315587  -1.925 0.054634 .
Boat14127   -0.112899   0.301854  -0.374 0.708498
Boat15125   -0.977075   0.272112  -3.591 0.000352 ***
Boat15126   -0.606554   0.264721  -2.291 0.022232 *
Boat15127   -0.454534   0.266329  -1.707 0.088312 .
Boat16127   -0.729908   0.339973  -2.147 0.032127 *
Boat21926    0.209064   0.356408   0.587 0.557663
Boat21927    0.108966   0.270607   0.403 0.687307
Boat31126   -0.614733   0.368151  -1.670 0.095394 .
Boat31926    0.198550   0.283432   0.701 0.483826
Boat31927   -0.075814   0.290665  -0.261 0.794297
Boat32125   -0.782890   0.339973  -2.303 0.021572 *
Boat33126   -0.622360   0.370245  -1.681 0.093204 .
Boat34126   -0.853592   0.263449  -3.240 0.001249 **
Boat34127   -0.876183   0.282408  -3.103 0.001993 **
Boat38125   -0.584401   0.291686  -2.004 0.045492 *
Boat38126   -0.582603   0.263253  -2.213 0.027201 *
Boat38127   -0.447916   0.272762  -1.642 0.100992
Boat40126   -0.430481   0.319635  -1.347 0.178468
Boat40127   -0.369342   0.266050  -1.388 0.165488
Boat51926   -0.090665   0.374386  -0.242 0.808717
Boat51927   -0.228858   0.309173  -0.740 0.459402
Boat61926   -0.469838   0.284955  -1.649 0.099619 .
Boat61927   -0.255762   0.265633  -0.963 0.335948
Boat151927  -0.698540   0.318450  -2.194 0.028583 *
Boat401926   0.243797   0.311244   0.783 0.433707
Boat401927  -0.103961   0.265662  -0.391 0.695671
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3564 on 726 degrees of freedom
Multiple R-squared:  0.6556,         Adjusted R-squared:  0.6195
F-statistic: 18.18 on 76 and 726 DF,  p-value: < 2.2e-16
```

Annex 6. Standardized CPUE index for trawlers in Div 1CD.

Call:
lm(formula = lcpue ~ Year + Month + Boat)

Residuals:
Min	1Q	Median	3Q	Max
-1.22167	-0.16862	-0.00255	0.16525	1.22597

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-1.46728	0.25970	-5.650	2.58e-08	***
Year1989	0.03892	0.20154	0.193	0.84696	
Year1990	-0.32549	0.26548	-1.226	0.22071	
Year1991	-0.31343	0.23291	-1.346	0.17895	
Year1992	-0.25125	0.19980	-1.258	0.20910	
Year1993	-0.43812	0.21319	-2.055	0.04034	*
Year1994	-0.60357	0.21405	-2.820	0.00498	**
Year1995	-0.54727	0.21205	-2.581	0.01011	*
Year1996	-0.63040	0.22054	-2.858	0.00442	**
Year1997	-0.70424	0.21495	-3.276	0.00112	**
Year1998	-0.38515	0.21499	-1.791	0.07377	.
Year1999	-0.64817	0.21657	-2.993	0.00289	**
Year2000	-0.46519	0.21225	-2.192	0.02882	*
Year2001	-0.44592	0.21104	-2.113	0.03506	*
Year2002	-0.45457	0.20882	-2.177	0.02991	*
Year2003	-0.33596	0.21059	-1.595	0.11121	
Year2004	-0.40682	0.20810	-1.955	0.05110	.
Year2005	-0.27031	0.20960	-1.290	0.19773	
Year2006	-0.15776	0.21096	-0.748	0.45491	
Year2007	-0.11968	0.21031	-0.569	0.56956	
Year2008	-0.02569	0.20796	-0.124	0.90175	
Year2009	-0.10831	0.20836	-0.520	0.60339	
Year2010	-0.11545	0.20683	-0.558	0.57695	
Year2011	-0.03150	0.20902	-0.151	0.88028	
Year2012	0.05096	0.20954	0.243	0.80796	
Year2013	0.17475	0.20780	0.841	0.40073	
Year2014	0.20767	0.20793	0.999	0.31835	
Year2015	0.57084	0.20883	2.734	0.00647	**
Year2016	0.36756	0.20962	1.753	0.08008	.
Year2017	0.53751	0.20729	2.593	0.00977	**
Year2018	0.66407	0.20901	3.177	0.00157	**
Year2019	0.59800	0.20886	2.863	0.00435	**
Month2	-0.30215	0.10880	-2.777	0.00567	**
Month3	-0.49005	0.19815	-2.473	0.01370	*
Month4	-0.27703	0.24520	-1.130	0.25904	
Month5	-0.12409	0.12264	-1.012	0.31206	
Month6	-0.26025	0.09514	-2.735	0.00643	**
Month7	-0.25508	0.08790	-2.902	0.00386	**
Month8	-0.18668	0.08653	-2.157	0.03140	*
Month9	-0.07101	0.08507	-0.835	0.40421	
Month10	-0.06958	0.08194	-0.849	0.39618	
Month11	-0.02219	0.08019	-0.277	0.78206	
Month12	0.10204	0.08385	1.217	0.22414	
Boat5127	1.47371	0.17739	8.308	7.67e-16	***

```
Boat6125    0.07426    0.28111   0.264  0.79176
Boat6126    1.04691    0.16130   6.491 1.91e-10 ***
Boat6127    1.58239    0.15279  10.357  < 2e-16 ***
Boat14126   1.23261    0.21468   5.742 1.55e-08 ***
Boat14127   1.75666    0.19940   8.810  < 2e-16 ***
Boat15125   0.95244    0.16805   5.668 2.34e-08 ***
Boat15126   1.25327    0.15358   8.160 2.30e-15 ***
Boat15127   1.32566    0.15740   8.422 3.24e-16 ***
Boat34126   1.00774    0.15346   6.567 1.19e-10 ***
Boat34127   1.08239    0.17904   6.046 2.75e-09 ***
Boat38125   1.23896    0.18248   6.790 2.92e-11 ***
Boat38126   1.27004    0.15327   8.286 9.00e-16 ***
Boat38127   1.36968    0.16454   8.324 6.77e-16 ***
Boat51927   1.59639    0.26949   5.924 5.56e-09 ***
Boat61926   1.35836    0.18198   7.464 3.30e-13 ***
Boat61927   1.57412    0.15722  10.012  < 2e-16 ***
Boat151927  1.21564    0.22028   5.519 5.27e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3095 on 549 degrees of freedom
Multiple R-squared:  0.728,          Adjusted R-squared:  0.6983
F-statistic: 24.49 on 60 and 549 DF,  p-value: < 2.2e-16
```

Annex 7. CPUE index for trawlers in Div 0A-South.

Call:
lm(formula = lcpue ~ Year + Month + Boat)

Residuals:
Min	1Q	Median	3Q	Max
-1.3391	-0.1557	0.0000	0.1485	1.5959

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.416561	0.718642	0.580	0.56291	
Year1997	-1.545830	0.593035	-2.607	0.00995	**
Year1998	-1.101927	0.648278	-1.700	0.09099	.
Year1999	-0.954257	0.571539	-1.670	0.09682	.
Year2000	-1.200621	0.552897	-2.172	0.03127	*
Year2001	-0.017211	0.467471	-0.037	0.97067	
Year2002	-0.428657	0.543909	-0.788	0.43173	
Year2003	-0.209804	0.541760	-0.387	0.69904	
Year2004	-0.281856	0.536327	-0.526	0.59990	
Year2005	-0.480114	0.538599	-0.891	0.37396	
Year2006	-0.349260	0.535006	-0.653	0.51475	
Year2007	-0.709309	0.535616	-1.324	0.18718	
Year2008	-0.268643	0.553180	-0.486	0.62785	
Year2009	-0.158113	0.555121	-0.285	0.77612	
Year2010	-0.666182	0.553224	-1.204	0.23018	
Year2011	-0.361496	0.555974	-0.650	0.51643	
Year2012	-0.241052	0.552367	-0.436	0.66310	
Year2013	-0.111691	0.551164	-0.203	0.83965	
Year2014	0.227665	0.554527	0.411	0.68191	
Year2015	0.166016	0.555121	0.299	0.76526	
Year2016	0.036527	0.551730	0.066	0.94729	
Year2017	0.114818	0.552222	0.208	0.83554	
Year2018	0.232504	0.551730	0.421	0.67399	
Month7	0.111296	0.405367	0.275	0.78399	
Month8	0.020154	0.402998	0.050	0.96017	
Month9	0.071304	0.402053	0.177	0.85944	
Month10	0.082672	0.402037	0.206	0.83732	
Month11	-0.331924	0.403830	-0.822	0.41226	
Month12	0.188124	0.455657	0.413	0.68022	
Boat2127	0.007926	0.314267	0.025	0.97991	
Boat3126	-0.255023	0.299460	-0.852	0.39562	
Boat3127	-0.332676	0.339795	-0.979	0.32894	
Boat5127	-0.954729	0.531573	-1.796	0.07425	.
Boat15127	0.653568	0.411974	1.586	0.11449	
Boat16127	-1.125747	0.429575	-2.621	0.00957	**
Boat21926	0.209064	0.377261	0.554	0.58019	
Boat21927	0.165028	0.302172	0.546	0.58568	
Boat31126	-0.431005	0.449849	-0.958	0.33936	
Boat31926	0.113531	0.309398	0.367	0.71412	
Boat31927	-0.042099	0.332179	-0.127	0.89930	
Boat32125	-1.178729	0.429575	-2.744	0.00672	**
Boat33126	-1.130475	0.456465	-2.477	0.01424	*
Boat40126	-0.366064	0.375143	-0.976	0.33054	
Boat40127	-0.192257	0.332186	-0.579	0.56351	

```
Boat51926    0.498056   0.481985   1.033  0.30290
Boat51927   -0.580088   0.429575  -1.350  0.17868
Boat401926   0.300516   0.366091   0.821  0.41286
Boat401927   0.065653   0.332409   0.198  0.84367
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3773 on 171 degrees of freedom
Multiple R-squared:  0.632,          Adjusted R-squared:  0.5309
F-statistic:  6.25 on 47 and 171 DF,  p-value: < 2.2e-16
```