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Northwest Atlantic Fisheries Organization

Serial No. N7421 **NAFO SCR Doc. 23/032REV**

SCIENTIFIC COUNCIL MEETING – JUNE 2023

Comparison of vessels used for the Greenland shallow fish and shrimp survey in NAFO Division 1A-F

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Abstract

A stratified random bottom trawl survey series has been established in NAFO Divisions 1A to 1F (from 1991). Since the beginning of the time series the survey was conducted 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, i.e. C/V Sjurdarberg in 2018 and C/V Helga Maria in 2019 and 2020. In 2022 a new research vessel, R/V Tarajoq, was used for the survey. To standardize the fishing operations the Greenland Institute of Natural Resources (GINR) ensured the same gear (trawl, bridle, warps, ground gear, and distance from blocks) as used on R/V Paamiut were used on the commercial vessels and on R/V Tarajoq. This paper compares the characteristics of the four ships and analyzes trawl gear parameters (with a focus on net height and door spread) to assess impacts of the change in vessel. Survey length frequencies are also examined to assess possible effects of the vessel change. The differences in mean net height (<5%) and door spread (<12%) for the 1A-F survey in 2018, 2019-2020, and 2022 compared to the mean for 2005-2017 was considered to be low suggesting the vessel changes had minimal impact on trawl performance. No clear shifts in biomass and length frequency distributions that would directly correspond with vessel change could be observed. We conclude that the 2018, 2019-2020 and 2022 Div. 1A-F surveys could be comparable to estimates from previous surveys conducted by R/V Paamiut and results could be used for NAFO Subarea 1 shrimp and finfish assessments.

Introduction

The Greenland shallow water (50-600 m) fish and shrimp survey in NAFO Division 1A-F has been conducted by R/V Paamiut, a converted shrimp trawler, since 1991 (Nygaard and Nogueira, 2023). The survey initially used a Skjervoy trawl, which was replaced by a Cosmos trawl in 2005. 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. For 2019 and 2020, another commercial vessel, C/V Helga Maria, was chartered, and in 2022 the survey was performed by the new research vessel owned by the Greenland Institute of Natural Resources (GINR), R/V Tarajoq. The trawl gear did not change throughout this period. With the sudden retirement of 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). Comparative analyses between R/V Paamiut, C/V Sjurdarberg, and C/V Helga Maria were conducted and reported previously (Nogueira and Treble, 2020). This paper is intended to expand on the comparison conducted in 2020 and describe all four vessels, the steps taken to standardize fishing procedures, review several gear performance measures, and scan biomass and length frequency estimates for signals of vessel change effects. The goal is to determine if the recent survey results are

comparable to previous years making it possible to use the survey indices for Greenland halibut, golden redfish, beaked or deep-sea redfish, Atlantic cod, American plaice, spotted wolfish, and Atlantic wolfish for catch advice.

Materials and Methods

Gear Description:

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 was established for shrimp (Rosing and Wieland, 2005). For this reason, we compare gear parameters for the Div. 1A-F shallow fish and shrimp survey only for the period 2005 to 2017 (R/V Paamiut), with 2018 (C/V Sjurdarberg), 2019-2020 (C/V Helga Maria), and 2022 (R/V Tarajoq).

Vessel Comparison:

Vessel characteristics were compiled and are presented in Table 1. Steps were taken to standardize fishing procedures for 2018 (C/V Sjurdarberg), 2019-2020 (C/V Helga Maria), and 2022 (RV Tarajoq) 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:

- Among R/V Paamiut (2005 to 2017), C/V Sjurarberd (2018), C/V Helga Maria (2019, 2020), and R/V Tarajoq (2022) for the 1A-F shallow fish and shrimp survey, using the Cosmos trawl.

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, 2019-2020, and 2022 values to assess percent change in the gear performance.

Biomass Indices and Length Frequency Distributions:

Biomass indices and length frequency distributions through time of all commercial species from the surveys were examined. In Greenland halibut, changes related to recruitment are expected in smaller fish, therefore, we focus on larger fish (> age 2 to 60 cm), which are expected to have more similar length distributions from year to year. The range in size for age 2 Greenland halibut caught in the 1A-F shallow fish and shrimp survey is 15-20 cm to 21-29 cm. Differences, if any, between 2018, 2019-2020, and 2022 and previous years could help us assess potential effects of the gear performance.

Results

Vessel and Gear Comparison:

The research vessel R/V Paamiut, and the two chartered vessels C/V Helga Maria and C/V Sjurdarberg, and the new R/V Tarajoq have similar dimensions. Paamiut is 58 m long and 11.2 m wide, Sjurdarberg is 60 m long and 13.0 m wide, Helga Maria is 57 m long and 12.62 m wide, and Tarajoq is 61.4 m long and 16.3 m wide (Table 1). Tarajoq has the largest Gross Registered Tonnage (2841), followed by Sjurdarberg (1856), then by Helga Maria (1470) and Paamiut (1084). The new R/V has much more power and the two chartered vessels have also more power than R/V Paamiut, but this factor does not necessarily affect trawl performance. GINR standardized survey vessel operations as much as possible.

The trawl gear was not changed, a Cosmos trawl is used in the 1A-F shallow fish and shrimp survey. 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 R/V Paamiut. The Greenland survey has sensors on the head rope and doors, while the Canadian survey adds a sensor to the wings. The R/V Paamiut skipper and engineer spent two weeks on the C/V Sjurdarberg , C/V Helga Maria, and R/V Tarajoq prior to the beginning of the survey 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 R/V Paamiut.

Timing

Surveys with R/V Paamiut, C/V Helga Maria, C/V Sjurdarberg, and the new R/V Tarajoq took place in the same period of the year (Table 2).

Gear Performance:

The net height difference was -1.7%, +0.03%, and +4% for each of the three latest vessels compared to R/V Paamiut, respectively (Table 4). The highest difference was with R/V Tarajoq, but we do not consider net height to have a big impact on catchability. Furthermore, the absolute differences were relatively small with mean height ranging from 11.80 to 12.49 m between the four vessels (Table 3). The mean annual trawl net observed with C/V Sjurdardberg, C/V Helga Maria, and R/V Tarajoq all fall within observed values with R/V Paamiut between 2005 and 2017 (Table 5). Door spread was +7%, +12%, and +6%, respectively, and wing spread is calculated from door spread, so the pattern is similar (+7%, +11%, and +5%, respectively) (Table 4, Fig. 2 & 3). Door spread and wing spread annual mean values from the three more recently used vessels are consistently higher than what has been observed on R/V Paamiut (Table 5). However, these values should translate into slightly higher swept area estimates, which then account for small increases in wing/door spread when calculating the total biomass or abundance per area. Indeed, swept area estimates were higher in 2019-2020 (+7%) and in 2022 (+2%) compared to the mean for the period 2005-2017 (Table 4, Fig. 4). Only for C/V Sjurdarberg in 2018 was the mean swept area lower (-2%) than in the period 2005-2017 (Table 4, Fig. 4). Yet, this is only a single value and it is higher than the mean value observed on R/V Paamiut in the years 2011, 2012, 2014, and 2015 (Table 5). In addition, variations in towing speed may affect the swept area calculations.

Biomass Indices and Length Frequency Distributions:

The biomass estimates for Greenland halibut vary between years and no remarkable change can be observed with the introduction of new survey vessels, as the estimate lie well within the previously observed estimates (Fig. 5). Length frequency distributions for all halibut (Fig. 6), for age 2 to 60 cm halibut (Fig. 7), and for >60cm halibut (Fig. 8) are all subject to relatively large interannual variability, but with no clear trend apparent for the new survey vessels. Generally, the same applies to other commercial species, i.e. Atlantic cod, golden redfish, beaked redfish, American place, spotted wolffish, and Atlantic wolffish (Fig. 9 -20). In all these species, there are some trends and high interannual variabilities in biomass estimates and length frequency distribution, but in no case these seem to indicate a consistent shift that would likely to be related to the use of a different vessel. Instead, the most likely explanation for certain trends over time is the actual development of that stock. In Atlantic cod for example a biomass peak can be observed in 2015, which is supported by stock assessment models. Another very high biomass estimate was observed in 2019 on C/V Helga Maria, but is accompanied with a very high standard error, which indicates this may be related to a single large catch (Fig. 9). Similarly, high estimates with large standard errors are sometimes observed in both golden and beaked redfish, irrespective of the vessel used, which is a well-known problem related to the schooling behavior of these species.

Discussion and Conclusion

R/V Paamiut, the two chartered vessels C/V Helga Maria and C/V Sjurdarberg, and R/V Tarajoq are similar in size, but differ in weight and power. To standardize the fishing operations to the extent possible GINR ensured the same gear (trawl, bridle, warps, ground gear and distance from blocks) as on R/V Paamiut were used on

the other vessels. The skipper and crew of R/V Paamiut also participated prior to and during 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 shallow shrimp and fish survey.

The Cosmos trawl parameters for the Div. 1A-F shallow shrimp and fish survey conducted with C/V Sjurdarberg, C/V Helga Maria, and R/V Tarajoq in 2018, 2019-2020, and 2022, respectively, were comparable to previous R/V Paamiut surveys. There are some variations between years, but often these do not exceed the amount of variability observed in the R/V Paamiut time series from 2005-2017. In addition, the slight increase in door/wing spread with the most recently used vessels compared to R/V Paamiut is largely also reflected in the swept area estimates. The wider spread of the trawl doors might be related to the lower power of R/V Paamiut, but can be considered marginal, given that the extrapolation in space is also considering these differences.

In 2020, the difference of the years 2018 and 2019 compared to 2005-2017 was already reviewed and no differences were found regarding the Div. 1A-F shallow shrimp and fish survey. Here, we find also no strong differences when including the 2020 survey with C/V Helga Maria and the 2022 survey with R/V Tarajoq in the comparison.

The examination of survey biomass estimates and length frequency distributions could be one method to assess vessel and/or seasonal effects on a survey. However, we must consider that natural or fishery-related interannual variations are to be expected. In that sense, only very strong, consistent shifts could be considered a likely signal of a vessel change effect. Some changes in biomass estimates are apparent but roughly correspond to what is known/expected from stock assessment, such as for example a biomass peak of offshore Atlantic cod in 2015. In no species biomass estimates were consistently shifted with one specific vessel or with all more recent vessels, and rather in most cases the biomass estimates were well within the range of estimates previously observed with R/V Paamiut.

In order to minimize the effect of recruitment (strong year classes could influence or cause annual variation in the smallest size classes), length frequency distributions for the larger size classes of fish were compared. For Greenland halibut, the length frequency distributions were assessed in three size ranges: all, 20 -60 cm, and >60 cm, but all were very relatively similar between years with some regular variability. Also for the remaining commercial species that have been analyzed we consider length frequency distributions relatively comparable over time and find no clear indications of a vessel change effect. Instead, some multiannual trends such as a shift towards larger individuals and the recent appearance of new recruits in redfish is consistent with patterns of stock development as observed elsewhere.

Therefore, based on the above analysis we conclude that the 2018-2020 and 2022 estimates of Greenland halibut, Atlantic cod, golden redfish, beaked redfish, American plaice, spotted wolfish, and Atlantic wolffish derived from the 1A-F shallow fish and shrimp survey could be comparable to estimates from previous surveys conducted by R/V Paamiut, and the indices could be used for stock assessment.

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

Name	Paamiut	Sjurdarberg	Helga Maria	Tarajoq
Survey Fish and Shrimp 1A-F	1991-2017	2018	2019-2020	2022
Vessel Type- Generic	Research (former Fishing)	Fishing	Fishing	Research
Vessel Type - Detailed	Trawler	Trawler	Trawler	Trawler
Status	Stopped	Active	Active	Active
Call sign	OYZC	UBHR2	TFDJ	OYLD
Flag	Greenland	Faroe Islands	Iceland	Greenland
Gross Tonnage (t)	1084	1856	1470	2841
Net tonnage	325	556	441	852
Machinery power (Kw)	1471	1978	2200	2900/3600
Length Overall (m)	58.61	60	56.88	61.4
Maximum Breadth (m)	11.21	13.03	12.62	16.3
Maximum draught (m)	4.2	5.62	6	6.4
Propulsion (BHP)	2000	2700	2992	3943/4896
Fuel type and capacity (m3)	Diesel 257	MGO 573	Diesel 238.4	Diesel 475
Year Built	1971	1985	1988	2021

Table 2. Survey information for the Div. 1A-F shallow fish and shrimp survey.

Year	Vessel	Valid tows	Depth strata covered (m)	Dates
2005	PA	218	74-587	June 06-August 23
2006	PA	249	62-595	June 29-August 21
2007	PA	262	68-584	June 28-August 21
2008	PA	258	54-596	June 16-August 08
2009	PA	279	64-594	June 10-August 04
2010	PA	299	52-591	June 09-July 31
2011	PA	216	54-594	June 11-July 26
2012	PA	220	55-566	June 06-August 02
2013	PA	211	55-573	June 06-July 28
2014	PA	226	53-592	June 07-July 22
2015	PA	222	54-562	May 29-July 13
2016	PA	192	60-569	June 03-July 20
2017	PA	257	64-558	May 28-July 17
2018	SJ	224	57-589	June 05-July 13
2019	HM	198	55-574	June 15-July 28
2020	HM	251	52-590	June 04-July 14
2022	TJ	331	57-595	June 25-July 17

Table 3. Trawl height, door spread (doors), wing pread (wings), and swept area mean values for surveys conducted by R/V Paamiut in 2005-2017, by C/V Sjurdarberg in 2018, by C/V Helga Maria in 2019-2020, and by R/V Tarajoq in 2022.

Year	Vessel	Mean height	Mean doors	Mean wings	Mean sweptarea
2005-2017	R/V Paamiut	12.01	48.07	27.43	0.0304
2018	C/V Sjurdarberg	11.80	51.52	29.27	0.0298
2019-2020	C/V Helga Maria	12.01	53.80	30.56	0.0324
2022	R/V Tarajoq	12.49	50.92	28.92	0.0311

Table 4. Percentage of difference between R/V Paamiut between 2005 and 2017 and C/V Sjurdarberg in 2018, the difference between R/V Paamiut between 2005 and 2017 and C/V Helga Maria in 2019-2020, and the difference between R/V Paamiut between 2005 and 2017 and R/V Tarajoq in 2022 for the mean height, the mean door spread, the mean wing spread, and the mean swept area.

	Depth	% Difference height	% Difference Door spread	% Difference wingspread	% Difference sweptarea
Paamiut-Sjurdarberd	50-600 m	-1.71	7.20	6.68	-2.17
Paamiut-Helga Maria	50-600 m	0.03	11.92	11.38	6.55
Paamiut-Tarajoq	50-600 m	4.00	5.94	5.43	2.16

Table 5. Gear parameters for the Div. 1A-F shallow fish and shrimp survey. Height of the trawl, door spread, wing spread, and swept area (N = sample size; Mean in m; S.E) from 2005 to 2017 with R/V Paamiut, 2018 with C/V Sjurdarberg, 2019 -2020 with C/V Helga Maria, and 2022 with R/V Tarajoq.

			Trawl height		Doors spread		Wing spread		Sweptarea	
Year	Vessel	N	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
2005	R/V Paamiut	210	12.32	0.06	49.93	0.34	28.50	0.19	0.0323	0.0003
2006	R/V Paamiut	245	12.10	0.07	48.07	0.33	27.44	0.19	0.0321	0.0004
2007	R/V Paamiut	257	11.80	0.06	47.44	0.35	27.08	0.20	0.0316	0.0003
2008	R/V Paamiut	255	11.66	0.06	47.42	0.33	27.07	0.19	0.0312	0.0003
2009	R/V Paamiut	272	11.90	0.06	46.99	0.32	26.82	0.18	0.0300	0.0003
2010	R/V Paamiut	291	11.20	0.05	48.63	0.29	27.75	0.17	0.0316	0.0003
2011	R/V Paamiut	212	12.58	0.08	46.83	0.35	26.73	0.20	0.0292	0.0003
2012	R/V Paamiut	216	11.87	0.08	47.14	0.34	26.91	0.19	0.0296	0.0003
2013	R/V Paamiut	208	11.49	0.07	48.97	0.42	27.95	0.24	0.0308	0.0004
2014	R/V Paamiut	219	12.05	0.07	46.86	0.45	26.75	0.25	0.0273	0.0003
2015	R/V Paamiut	217	12.80	0.08	48.80	0.38	27.85	0.22	0.0288	0.0004
2016	R/V Paamiut	191	12.56	0.08	48.04	0.40	27.42	0.23	0.0298	0.0003
2017	R/V Paamiut	254	11.74	0.07	49.70	0.39	28.37	0.22	0.0313	0.0003
2018	C/V Sjurdarberg	221	11.80	0.10	51.52	0.45	29.27	0.26	0.0298	0.0004
2019	C/V Helga Maria	192	11.81	0.07	53.20	0.46	30.22	0.26	0.0309	0.0003
2020	C/V Helga Maria	247	12.21	0.06	54.40	0.40	30.90	0.23	0.0339	0.0003
2022	R/V Tarajoq	328	12.49	0.05	50.92	0.33	28.92	0.19	0.0311	0.0003

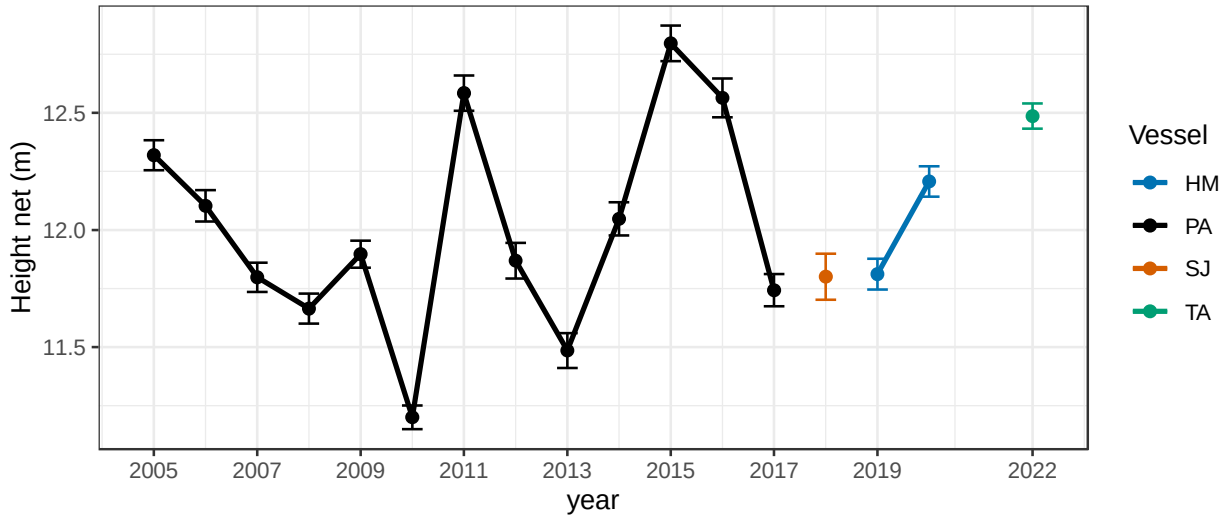

Figure 1. Mean of the trawl height (in m) and S.E. for Cosmos trawl in Div. 1A-F with R/V Paamiut for the period 2005-2017, with C/V Sjurdarberg in 2018, C/V Helga Maria in 2019 and 2020, and R/V Tarajoq in 2022.

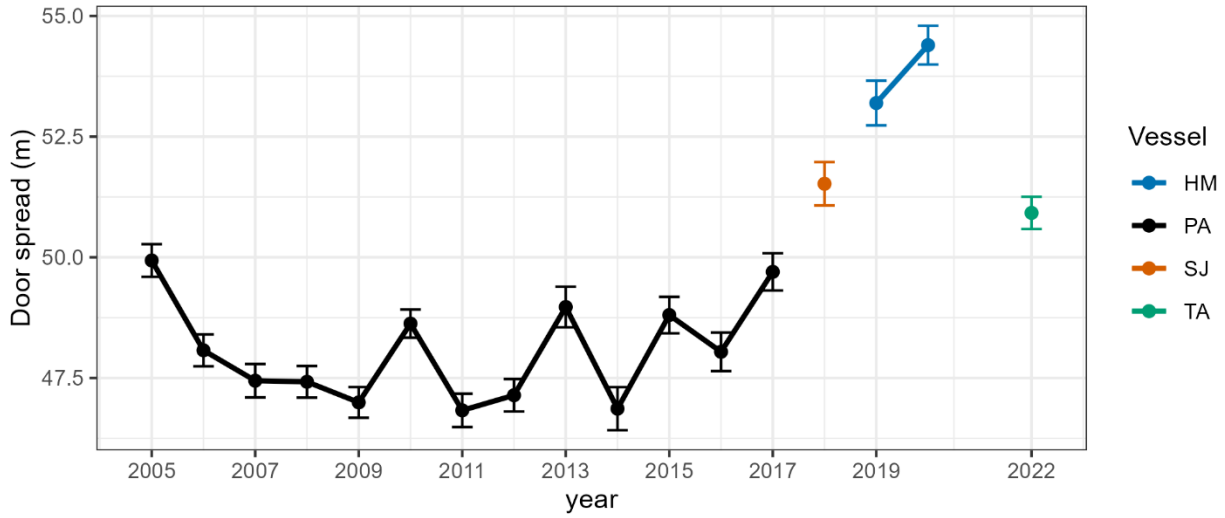

Figure 2. Mean of the door spread (in m) and S.E. for Cosmos trawl in Div. 1A-F in (m) and S.E with R/V Paamiut for the period 2005-2017, with C/V Sjurdarberg in 2018, C/V Helga Maria in 2019 and 2020, and R/V Tarajoq in 2022.

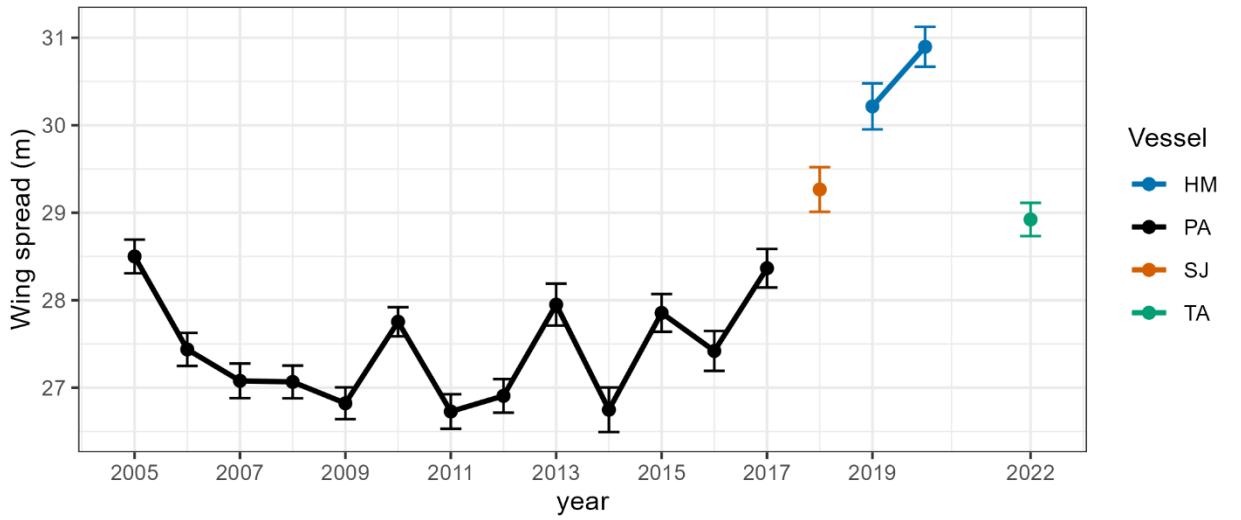

Figure 3. Mean of the wing spread (in m) and S.E. for Cosmos trawl in Div. 1A-F in (m) with R/V Paamiut for the period 2005-2017, with C/V Sjurdarberg in 2018, C/V Helga Maria in 2019 and 2020, and R/V Tarajoq in 2022.

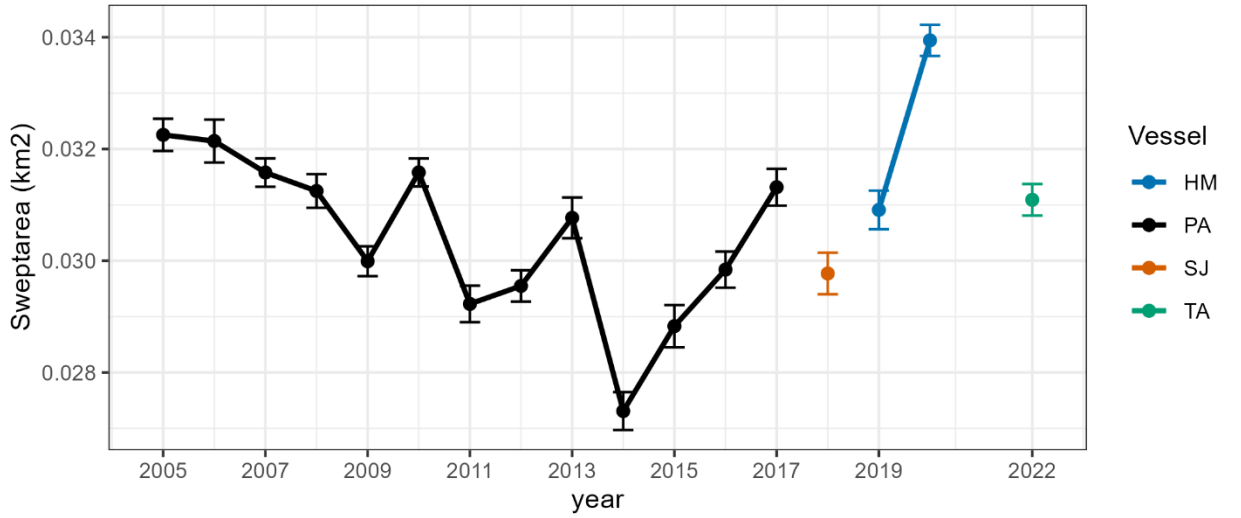

Figure 4. Mean of the swept area (in km^2) and S.E. for Cosmos trawl in Div. 1A-F in (m) with R/V Paamiut for the period 2005-2017, with C/V Sjurdarberg in 2018, C/V Helga Maria in 2019 and 2020, and R/V Tarajoq in 2022.

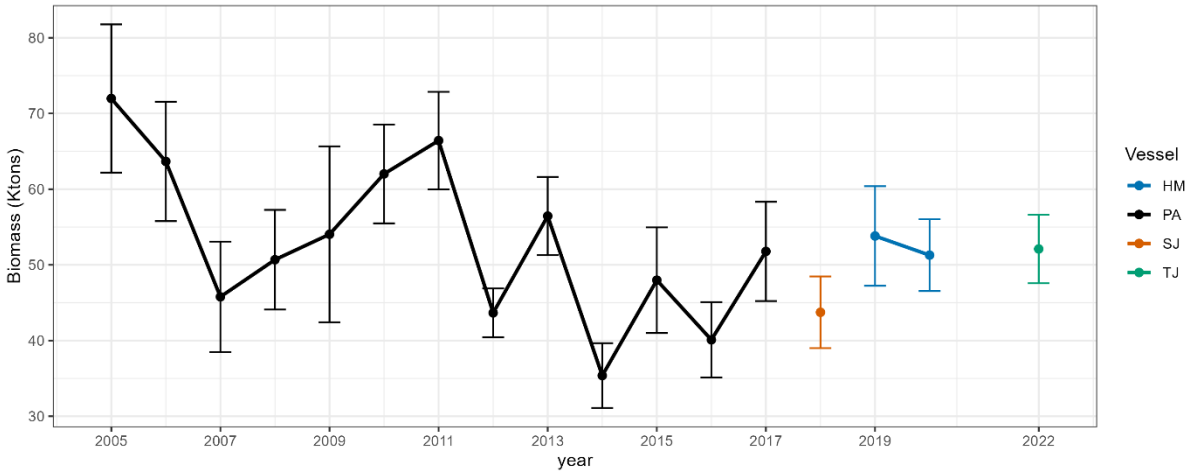

Figure 5. Biomass for Greenland halibut (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

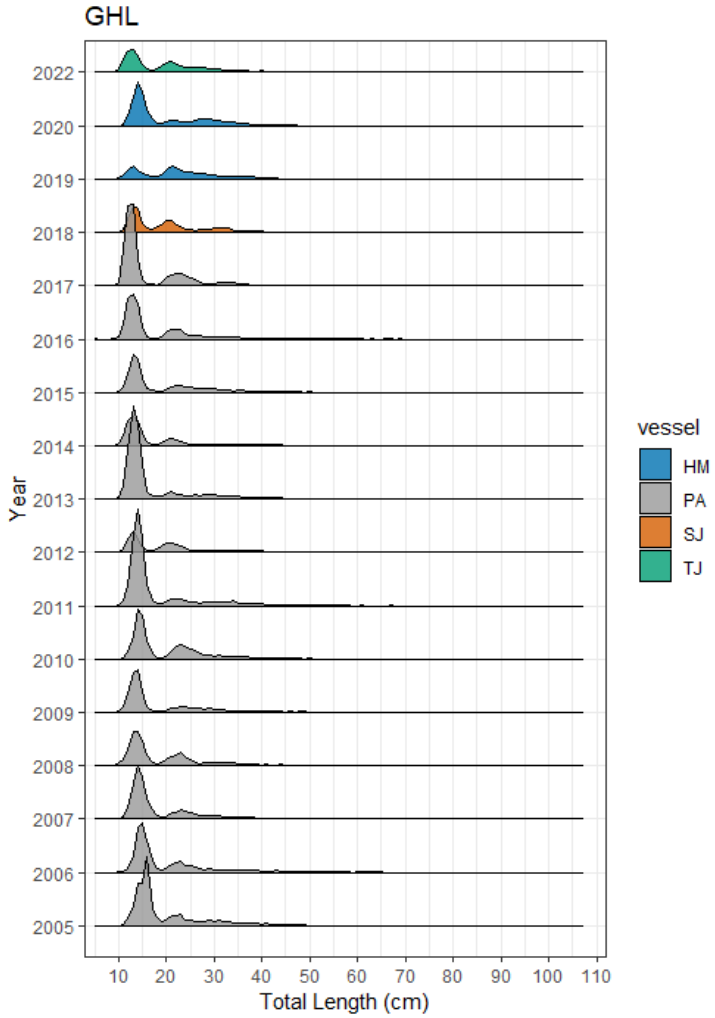

Figure 6. Length distribution of Greenland halibut in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue= C/V Helga Maria; Green = R/V Tarajoq.

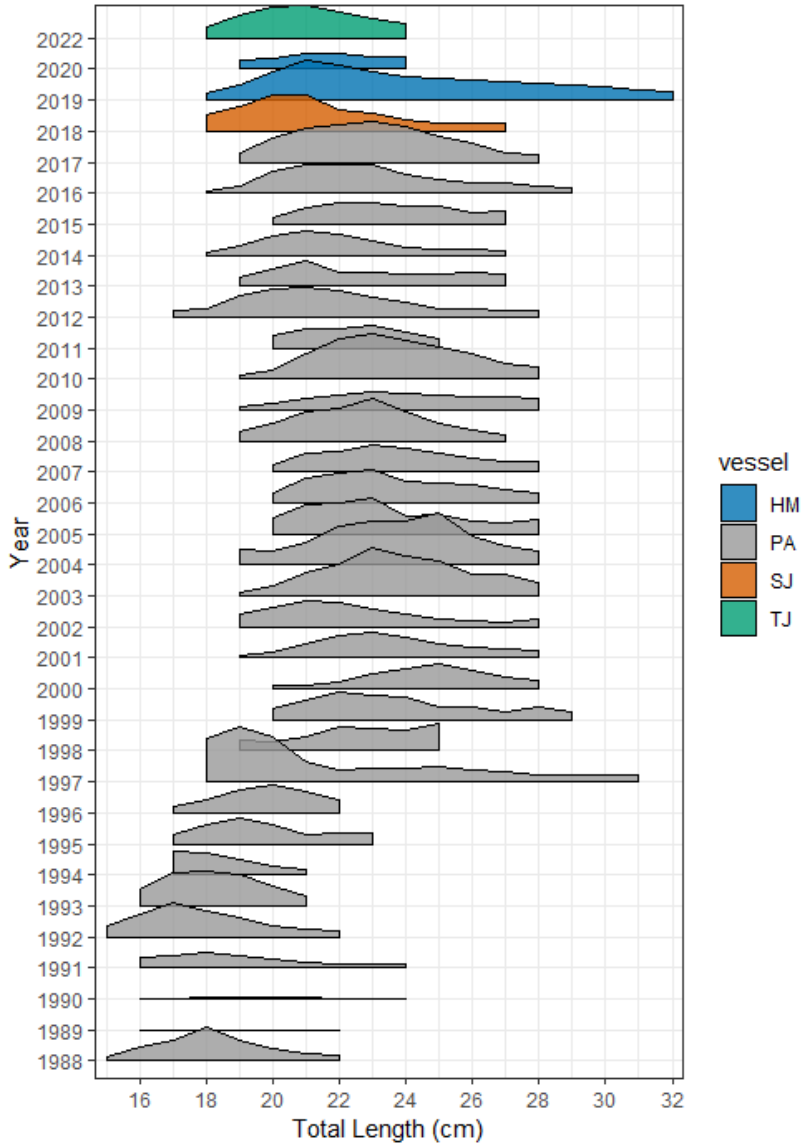

Figure 7. Length distribution of individuals from age 2 (11pprox.. 15-20 to 21-29 cm) to 60 cm of Greenland halibut (numbers weighted by stratum area) in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue= C/V Helga Maria; Green = R/V Tarajoq.

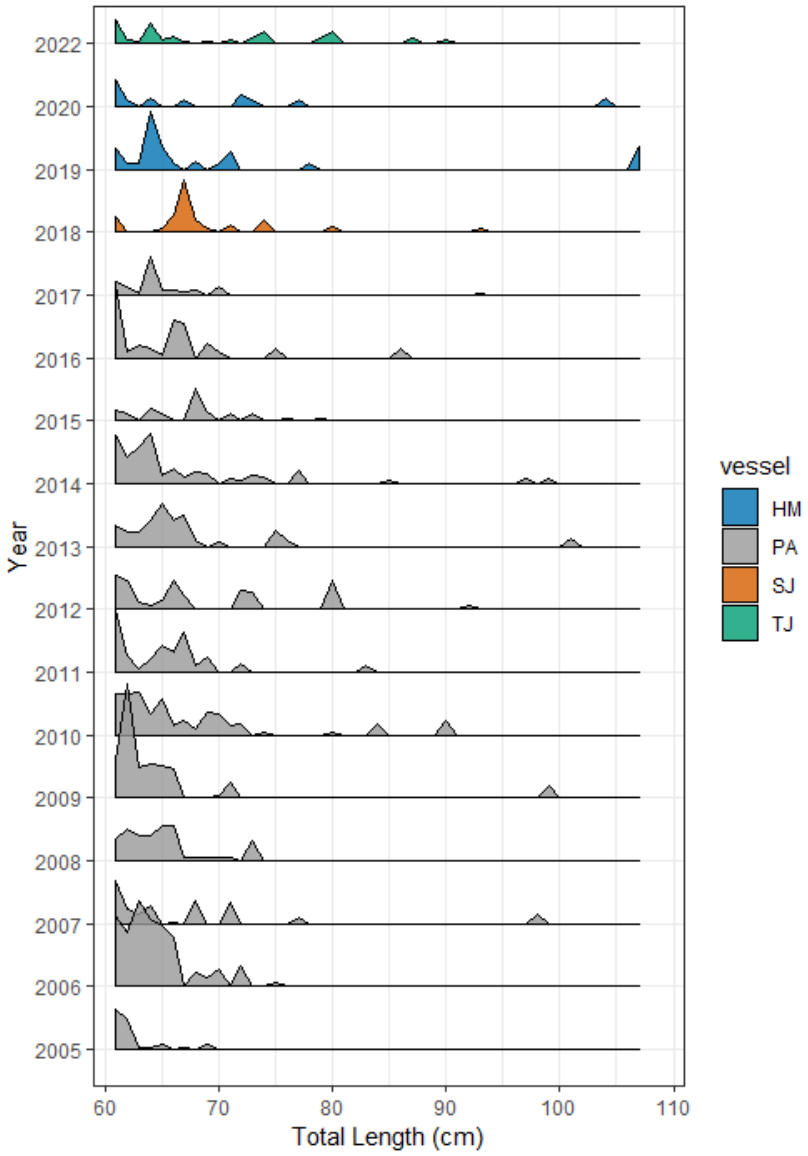

Figure 8. Length distribution of individuals bigger than 60 cm of Greenland halibut (numbers weighted by stratum area) in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue= C/V Helga Maria; Green = R/V Tarajoq.

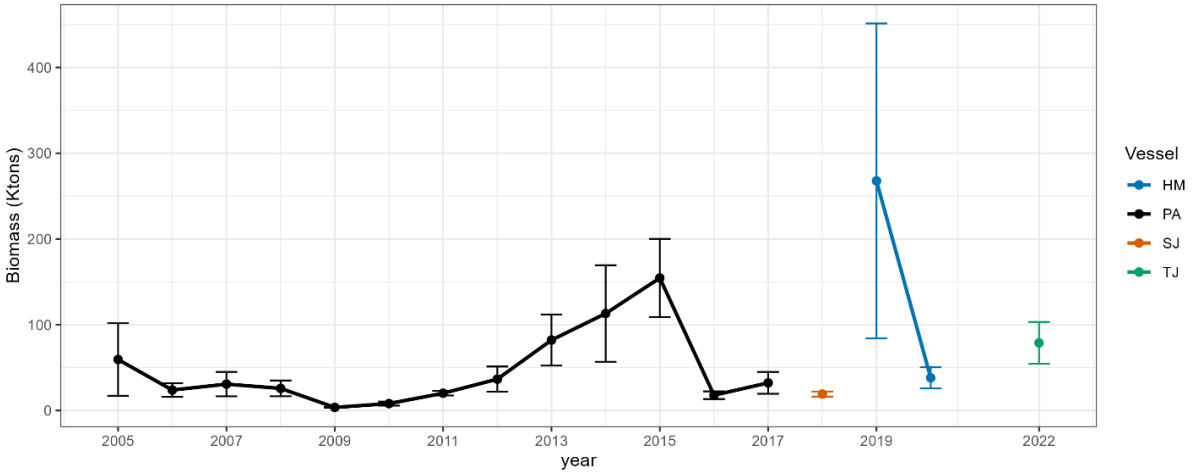

Figure 9. Biomass for Atlantic cod (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

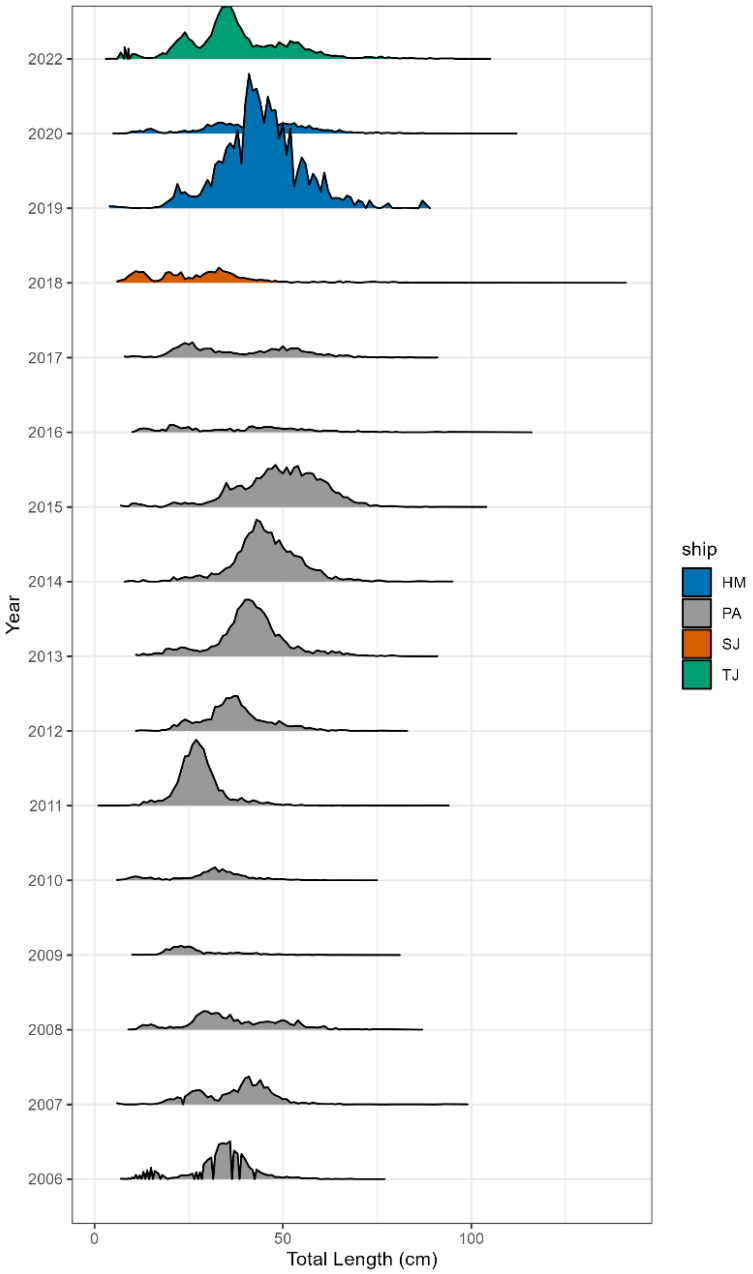

Figure 10. Length distribution of Atlantic cod in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue = C/V Helga Maria; Green = R/V Tarajoq.

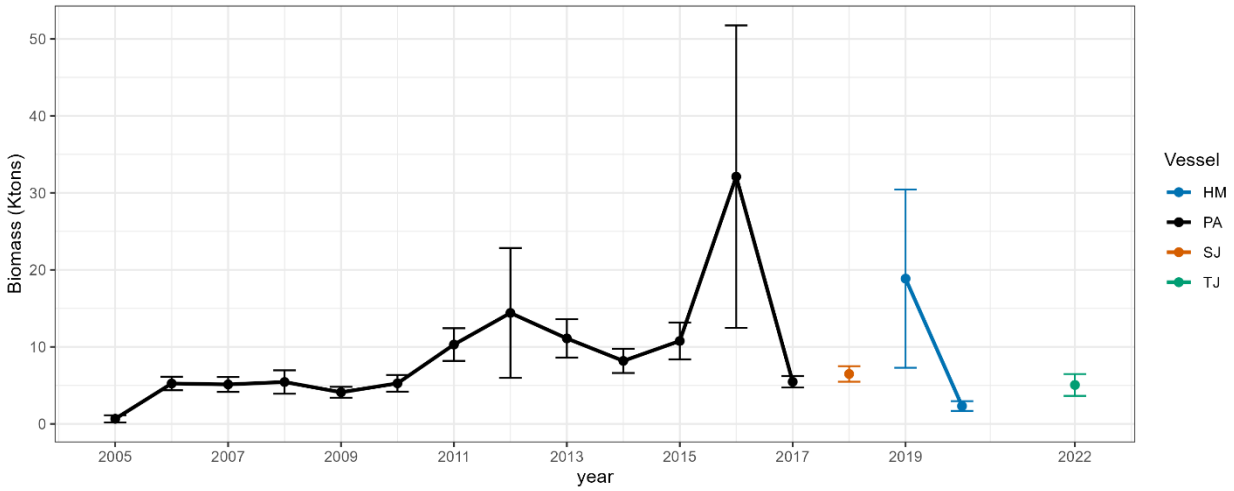

Figure 11. Biomass for golden redfish (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

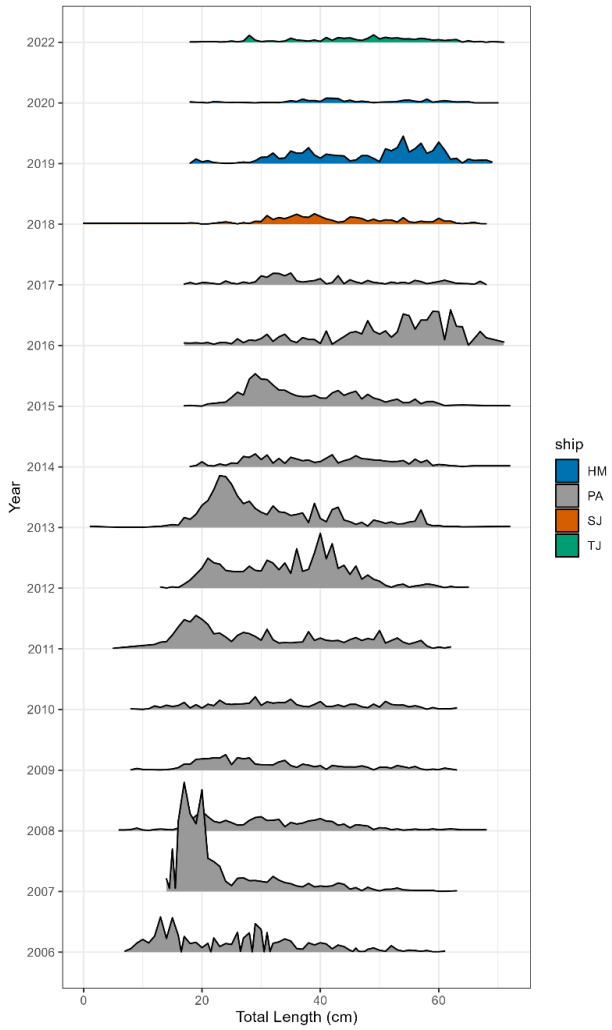

Figure 12. Length distribution of golden redfish in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue = C/V Helga Maria; Green = R/V Tarajoq.

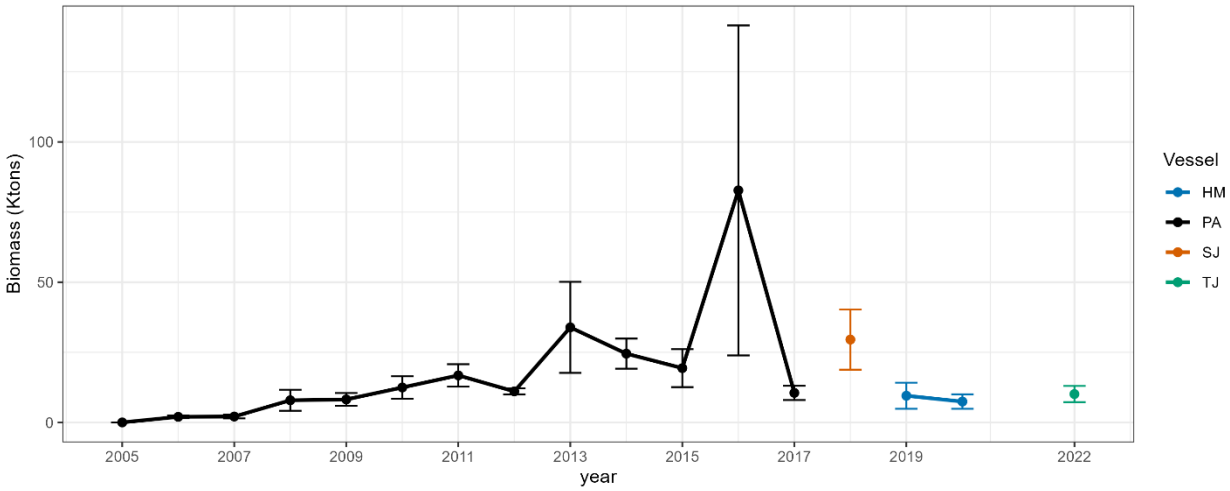

Figure 13. Biomass for beaked or deep-sea redfish (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

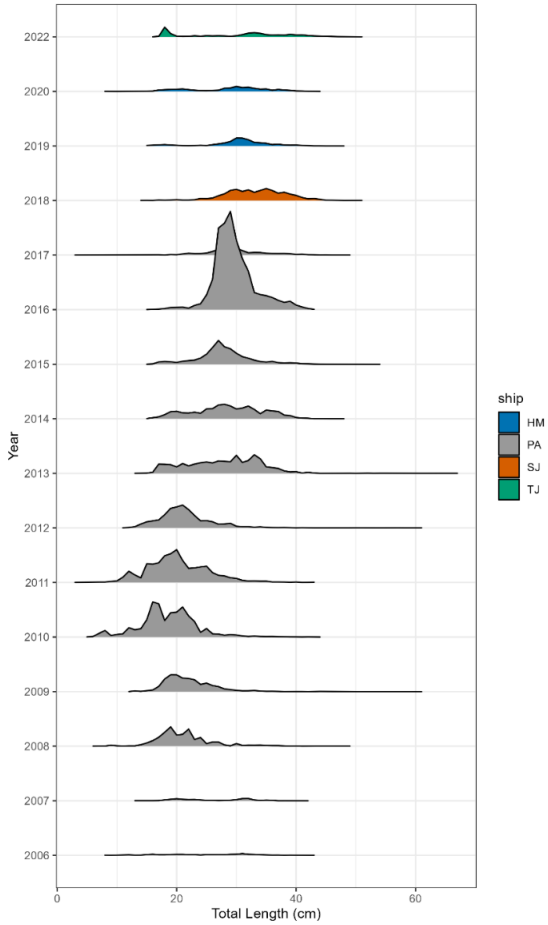

Figure 14. Length distribution of beaked redfish in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue = C/V Helga Maria; Green = R/V Tarajoq.

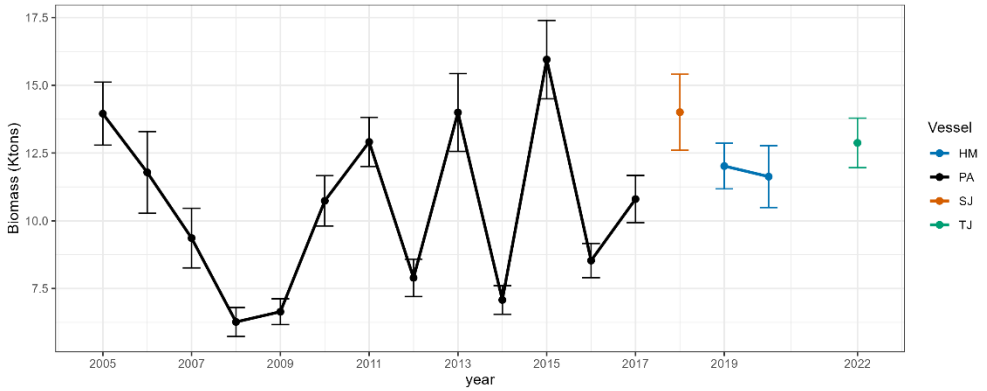

Figure 15. Biomass for American plaice (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

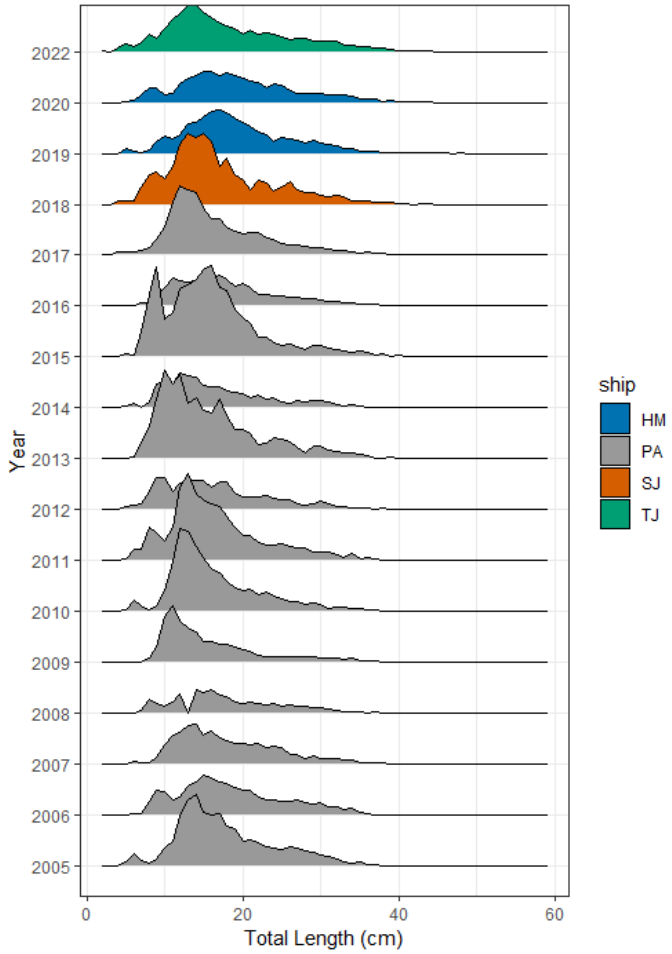

Figure 16. Length distribution of American plaice in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = Sjurdarberg; Blue = C/V Helga Maria; Green = R/V Tarajoq.

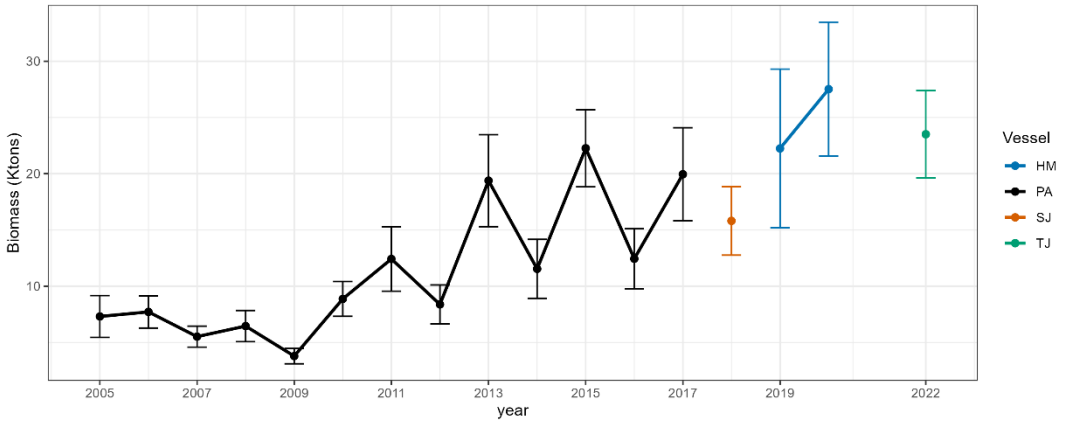

Figure 17. Biomass for spotted wolffish (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

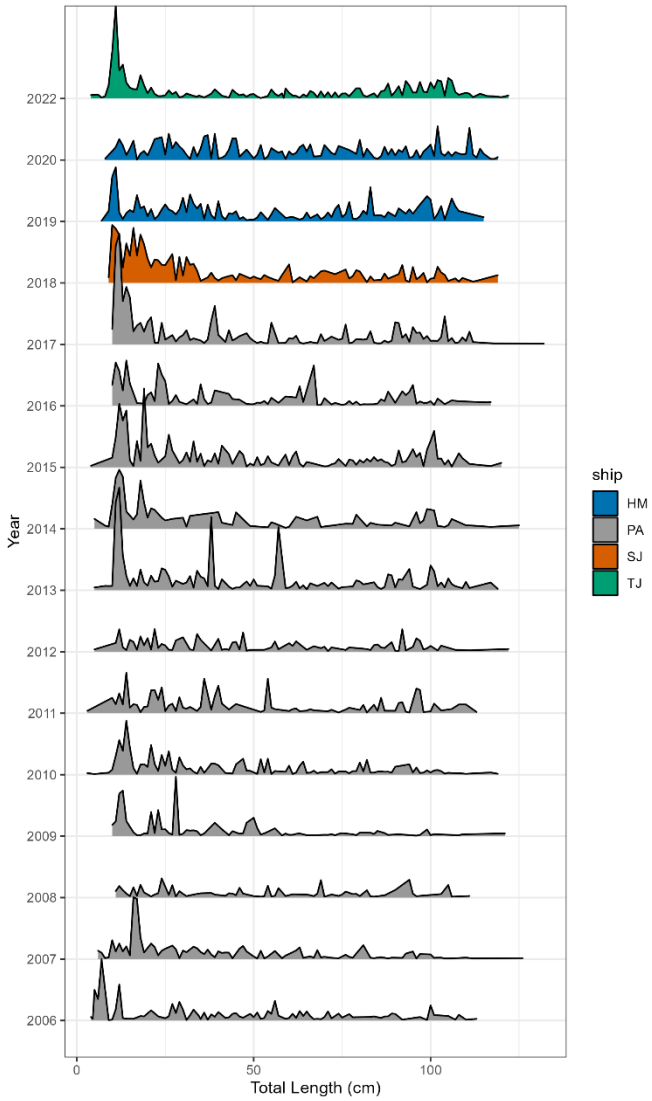

Figure 18. Length distribution of spotted wolfish in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue = C/V Helga Maria; Green = R/V Tarajoq.

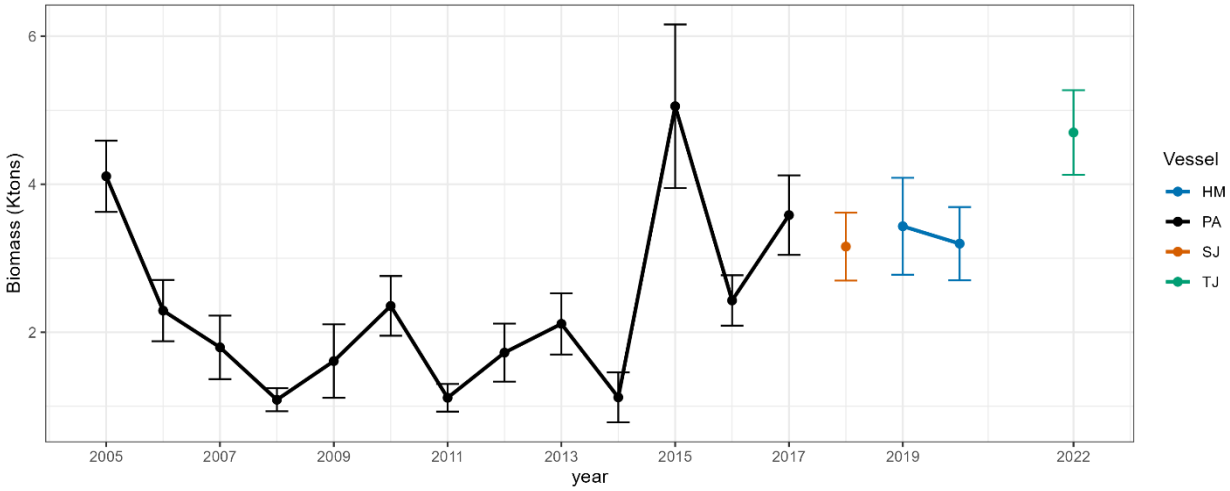

Figure 19. Biomass for Atlantic wolffish (in Ktons) for the period 2005-2017 with R/V Paamiut, in 2018 with C/V Sjurdarberg, in 2019 and 2020 with C/V Helga Maria, and in 2022 with R/V Tarajoq.

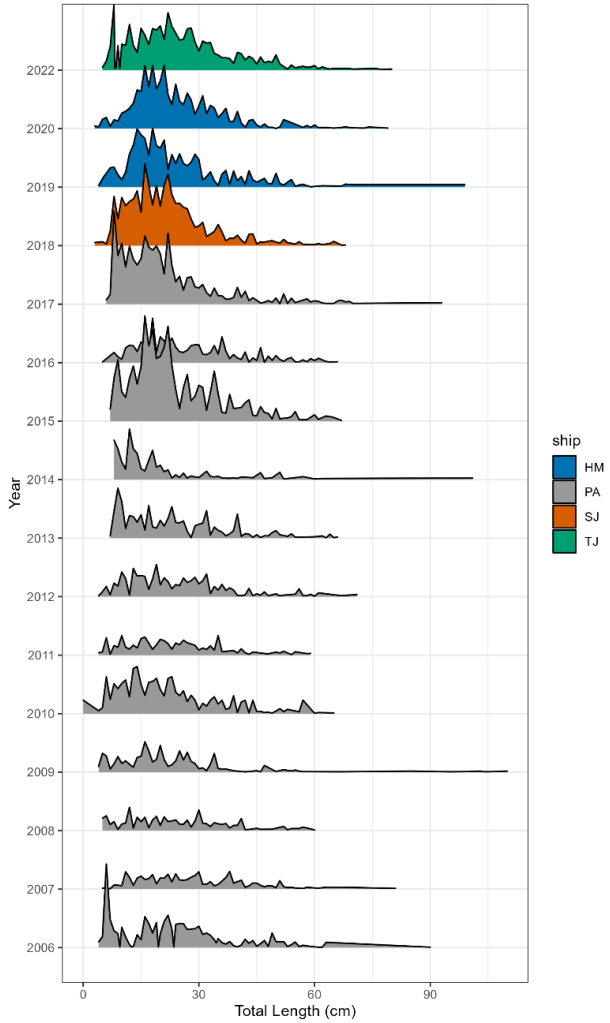

Figure 20. Length distribution of Atlantic wolfish in the Div. 1A-F survey for 2005-2017, 2019 and 2022. Grey = R/V Paamiut; Orange = C/V Sjurdarberg; Blue = C/V Helga Maria; Green = R/V Tarajoq.

Annex 1. Description of steps taken to ensure standardization of fishing procedures during surveys conducted by C/V Sjurdarberg (2018) , C/V Helga Maria (2019-2020) and R/V Tarajoq 2022.

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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

Kåri Hansen, Chief Engineer

KÅRI HANSEN, MASKINCHEF

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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