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Biomass and Abundance of Demersal Fish Stocks in the Nuuk fjord and Ameralik fjord derived from The GINR Shrimp and fish inshore (SFI) survey.

By

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Abstract

In 2015, the Greenland Institute of Natural Resources initiated a trawl survey in the inshore area of NAFO subarea 1D. The fjords surround the capitol of Greenland, Nuuk and supports several fisheries including Cod and Greenland halibut. The survey is performed with the 458 GT and 32m long research vessels RV Sanna, equipped with a 1440 mesh bacalao trawl. The survey is based on a depth stratification of the fjords using fixed stations where bottom conditions allow bottom trawling. This paper includes biomass and abundance estimates for the Nuuk fjord and Ameralik fjord for Greenland halibut, shrimp, cod, American plaice, deep-sea redfish and Golden redfish.

Introduction

The survey area

The survey initially covered 3 fjord areas in NAFO division 1D located in West Greenland (Fig. 1). Nuup Kangerdlua (the Nuuk fjord or Godthåbsfjorden) is the larger of the fjords. It is connected to the Davis trait through a narrow channel in the western part and bottom temperatures are influenced by influx of warmer water from the Davis strait. The fjord branches in 3 channels that meet again in the eastern part of the fjord. An icefjord is located in the North-eastern part of the system with 3 smaller iceberg producing glaciers. Glacier activity and tidal currents allows exchange of water masses with the Davis strait and the fjord is known to be highly productive, with both a spring and autumn bloom supplemented with secondary blooms driven by glacier activity.

The Ameralik fjord is a long narrow and fjord branching in two shallow areas in the eastern part. Ameralik is about 7 times smaller than Nuup Kangerdlua. It is connected to the Davis strait through a shallow archipelago in the western part. Ameralik is generally colder than the Godthåb fjord. Large amounts of highly silty glacier water flows into the fjord in the eastern part partly limiting primary production.

The Qarajat fjord is a more open coastal zone or archipelago surrounded basin south of the other larger fjords. The area was only surveyed in the first years, as bottom conditions and kelp debris makes bottom trawling difficult in the area. However, the few stations in the area revealed higher numbers of juvenile one and two-year-old Greenland halibut in the area. The stations were omitted from the survey indices.

Materials and Methods

Survey design, stratification and area coverage

The survey area is divided into primary strata (fjord) and secondary strata (depth). The survey primary stratum corresponds to the fjords. The primary stratum is further subdivided into secondary (depth) strata at 0–200 m, 200-400 m, 400-600 m and deeper than 600 m (Table 1).

Survey period and daily sampling period

The trawl survey was in 2015, 2017 and 2018 an autumn survey. In 2019 the survey shifted to the spring (Table 2). Trawling is carried out in the daytime. It takes 4- 5 days to complete the survey every year. Towing time is 30 min on most stations, but hauls down to 10 minutes are accepted. Towing speed is about 2-2.5 knots.

Survey vessel, gear and trawl.

The vessel used is the 458 GT and 32m long and 10 m wide research vessel *RV Sanna* (GINR). Since *RV Sanna* was built in 2012, the vessels has gone through several equipment updates. In 2015, no trawl sensors were installed on the vessel and tow start was estimated from vessel movement and skippers experience (vessel speed and wire vibration). In 2017, Sanna was equipped with marport trawlsensors, 3 Simrad EK80 eccosounders and a Seabat T50 sidescan zonar (Teledyne). The trawl is a 1440 mesh bacalao trawl supplied by Vónin. The bacalao trawl is a fish trawl with an overhanging headrope but modified with a finer meshed codend and bell for scientific purposes to also select shrimp and juvenile fish.

Swept area calculation

Nominal swept area for each tow is calculated as the straight-line distance between its GPS start and end positions multiplied by the wingspread. The distance between the trawl doors is recorded up to 5 times during each tow; provided it was recorded at least 3 times, wingspread for a tow was calculated from the mean door spread and the geometry of the trawl. For the year without trawl censors a modelled door spread is calculated based on depth and door spread in 2017-2019 trawl survey. The length of the bacalao 1440 mesh trawl is estimated to 32m and the length of the bridles (30m), chains and front wings 41,7m. (see appendix I)

Biomass estimation

The catch in each haul is divided by the estimated swept area calculated from wingspread and track length to estimate a biomass density. Unweighted mean stratum densities were multiplied by the stratum area (table 1) to calculate stratum biomass, and a corresponding error variance for the stratum biomass estimate was also calculated for strata with two or more accepted hauls. For strata with only one accepted haul, an average error of variance for all strata was assigned. If a strata has no stations in a given year, the neighbouring strata with stations in that year is geographically enhanced to include the un-surveyed strata. This way the total area surveyed is kept constant across years.

Biological sampling

The catch is sorted by species for each tow and a total catch weight and a length distribution for each species is registered. Otoliths are collected from redfish, Cod and Greenland halibut.

Results

The number of valid hauls by year and strata are listed in table 2 and by depth strata in table 3. Although the survey is based on fixed stations, some stations have been moved every year due to bottom conditions active commercial fishing gear. Only hauls in the Nuuk fjord and Ameralik were used in the biomass and abundance calculations and in the length frequencies. The Qarajat stations were only completed in the initial years, and therefore not used in the indices. For illustrative purposes, the biomass and abundance densities from Qarajat were included on the maps. Bottom temperatures in Amaralik is about 2 to 3 degrees C^{o} colder than in both the Nuuk fjord and in the Qarajat area (Table 4).

Greenland halibut (*Reinhardtius hippoglossoides*).

Both the abundance and biomass estimate for the initial survey year in 2015 had high CV and the index from the initial year is somewhat uncertain. Since 2017 the abundance and biomass index has increased slightly (table 6 and 7, figure 2). In all years, one-year old recruits have been identified (figure 8.) In 2019 high numbers of Greenland halibut from 28-38 cm were found (3, 4 and 5 Year old) also present in the 2017 and 2018 survey as (2014, 2015 and 2016 YC). Greenland halibut larvae (age 0) is seen in the autumn survey, but not in the spring surveys (2019-2021). Greenland halibut are found in all areas of the fjords but higher biomass densities are found in the deeper areas near Sardloq (figure 13 and 14).

Cod (Gadus morhua)

Cod are in the fjords are known to migrate to shallow water during the summer and to swim pelagic in the area year around and are therefore not easy to survey with bottom trawl in the area .The fishery for cod in the fjord are several times greater than the survey index, any conclusion based on cod indices are tentative. Juvenile cod are surveyed with gillnets along the beaches and with a pelagic survey and

acoustics also from RV Sanna. Cod abundance (Table 8) and biomass (Table 9) indices are shown in figure 3. In all years, cod were in the south eastern part of the Nuuk fjord (towards the Kapisillit settlement) and in the north eastern branch of Ameralik mainly from 200-400 m (figure 15 and 16).

Juvenile redfish (S. Norwegicus or S. mentella)

Until 2020, no juvenile redfish were observed in the survey. (This is in agreement with similar surveys from both East Greenland (ices NWWG, anon) and West Greenland indicating poor redfish recruitment from 2010 to 2019 (Nygaard and Nogueira 2020). Since 2021 increasing numbers of juvenile redfish have been observed. Previously juvenile redfish smaller than 20 cm were not identified at a species level and just registered as Sebastes sp. In 2022, DNA tissue samples were collected from 72 juvenile redfish. All of these (72/72, sizes from 7-17 cm with 55 individuals between 11 and 12 cm) were genetically assigned to S. mentella (personal communication with Ian Bradbury DFO in 2024, unpublished). In the 2023 survey all juveniles were visually identified as S. Mentella with the size of the eye mainly being used to determine species. Based on these findings all juvenile redfish are now identified at a species level and the survey juvenile estimates of biomass and abundance is now included in the indices for S mentella.

Deep-sea redfish (Sebastes mentella).

Both the abundance index and the biomass index of deep-sea redfish fluctuate without a clear trend from 2015 to 2020 (table 10 and 11, figure 5). Length frequencies reveal deep-sea redfish in the size range from 25 to 44 cm in all years corresponding to old redfish close to L_{max} (figure 10). New yearclasses can can be seen in the most recent years (figure 10). The same cohords are identified in the similar offshore surveys where strong recruitment of redfish has been identified. Deepsea redfish are yearly found on the same shallower stations in the south eastern parts of the Nuuk fjord towards the settlement kapisillit and in the north-eastern branch of the ameralik fjord (figure 17 and 18). Few pregnant females with live larvae are observed in the spring surveys.

Golden Redfish (S. Norvegicus)

Very few golden redfish were found in the survey and the abundance (table 12) and biomass (table 13) indices are low in all years (figure 5). Previously it was thought that most of the redfish in the fjord were mainly golden redfish, but in all years, less than 10% of the redfish biomass in the fjord was estimated to be golden redfish in the bottom trawl survey. Only large golden redfish were caught in the survey in a similar size range as observed in the nearby offshore area (figure 11). Distribution of the few Golden redfish observed are similar to deep-sea redfish distribution (figure 19 and 20). No juvenile golden redfish have been seen in the survey.

American plaice

Biomass and abundance indices for American plaice have been stable throughout the timeseries (Table 14 and 15, figure 6). American plaice are taken as unexploited bycatch in other fisheries. American plaice are mainly found in the shallower stations (figure 21 and 22).

Shrimp (*Pandalus borealis*)

The shrimp biomass index (mostly pandalus borealis) seems to have decreased from 2015-2023 (table 17 and figure 7). The maps of biomass densities show that shrimp are distributed over several locations, but mainly in the deeper parts of the fjord (Figure 23). There is no commercial fishery targeting Shrimp

in the fjord and the stock is unexploited. Shrimp carapace length is measured in the survey and length information is available although not processed at present.

Other species

Species like wolffish, grenadiers, decapods, and non-commercial species are also found, but in lower densities.

Discussion

Catchability is set at 1 for all species. However, since swept area is calculated for the trawl only, excluding doors and bridles, catchability may be higher than 1 for some species and below 1 for other species, implying that both biomass and abundance should be regarded as index values only, not absolute values.

References

Anon., 2016. Report of the North-Western Working Group (NWWG). *ICES CM 2016.*

Burmeister, A. and Rigét F. The West Greenland trawl for Pandalus borealis, 2018, with reference to earlier results. NAFO Scientific Research Documeent 18/055.

Cochran, W. G. 1977: Sampling Techniques, Third edtion, Wiley & Sons.

Table 1. The survey area (km2) in the Greenland Shrimp and Fish Survey.

Stratum1	Stratum2	Area in Km2
GHF – Nuuk fjord	0001-0200	765,597
GHF – Nuuk fjord	0201-0400	537,756
GHF – Nuuk fjord	0401-0600	710,101
GHF – Nuuk fjord	0601-0700	90,223
Sum		2103,667
AME – Ameralik	0001-0200	179,453
AME – Ameralik	0201-0400	131,021
AME – Ameralik	0401-0600	68,808
AME – Ameralik	0601-0700	43,030
Sum		422,312
Total area		2525,989

Table 2. Numbers of valid hauls in the Nuuk fjord and Ameralik excluding Qarajat and survey period.

Year	Vessel	Trip	Ameralik	Nuuk fjord	Total	Date
2015	Sanna	12	5	16	21	SEP 25-31
2016		-	-	-	-	No survey
2017	Sanna	13	5	14	19	OKT 05-11
2018	Sanna	9	5	16	21	SEP 13-19
2019	Sanna	6	5	16	21	May 14-18
2020	Sanna	5	4	14	18	May 06-11
2021	Sanna	3	4	16	20	May 11-16
2022	Sanna	3	3	14	17	May 9-14
2023	Sanna	2	5	14	19	April 16-21

Table 3. Numbers of valid hauls in the Nuuk fjord, Ameralik and Qarajat by depth strata.

	Ameralik Fjord			Godthåb fjord				Qarajat fjord	
Year	0-200	200-400	400+	0-200	200-400	400-600	600+	0-200	200-400
2015	1	2	2	2	6	3	5		4
2016									
2017	1	3	1	1	4	4	5		2
2018	1	3	1	1	6	4	5		1
2019	1	3	1	1	6	4	5		
2020	1	2	1	1	4	4	5		
2021	1	2	1	2	5	5	4		
2022	0	2	1	2	5	4	3		
2023	1	2	2	2	4	4	4		

Note: Ameralik 400-600 strata and 600+ combined.

Table 4. Mean bottom temperature in degrees C.

Year	Ameralik fjord	Godthåb fjord	Qarajat fjord
2015	-0,17	1,23	2,26
2016	-	-	-
2017	-0,32	1,37	3,00
2018	-0,01	1,69	3,10
2019	-0,17	1,08	
2020	0,24	1,19	
2021	0,35	1,14	
2022	0,30	0,95	
2023	0.35	1.03	

Table 5. Number of samples collected in the survey.

		Other sample				Otolith			
Year	RED	REB	COD	GHL	SampType	REB	REG	COD	GHL
2015		0	0	0		50		99	230
2016									
2017		16	97	76	Stomach	47		106	124
2018		0	0	0		0		126	488
2019		0	0	0		79		51	325
2020		0	0	0		45		51	490
2021		38	80	0	DNA	78		160	423
2022	72 DNA	68 DNA	106 DNA	1	DNA	68		107	378
2023		73 DNA	195 DNA	167 DNA		72	9	198	433

Table 6. **Greenland halibut** *Reinhardtius hippoglossoides* Abundance (Mio.)

Year	Ameralik	Nuuk fjord	Total	CV
2015	0.33	4.85	5.18	36
2016		No survey		
2017	0.4	2.37	2.76	37
2018	0.61	2.58	3.19	20
2019	0.5	4.97	5.47	18
2020	0.72	2.09	2.81	20
2021	0.75	2.34	3.09	28
2022	1,28	2,80	4,09	21
2023	0.73	4.14	4.87	20

Table 7. **Greenland halibut** *Reinhardtius hippoglossoides* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	307	2709	3015	44
2016		No survey		
2017	282	981	1263	23
2018	351	1204	1556	18
2019	253	2187	2441	12
2020	358	1039	1397	17
2021	695	1162	1857	33
2022	679	1337	2016	17
2023	501	1791	2292	19

Table 8. **Cod** *Gadus morhua* abundance (Mio.)

Year	Ameralik	Nuuk fjord	Total	CV
2015	0,24	1,45	1,69	85
2016		No survey		
2017	0,21	1,53	1,74	75
2018	0,28	0,30	0,59	81
2019	0,04	0,36	0,40	66
2020	0.06	0.36	0.42	89
2021	0.53	0.71	1.24	61
2022	0,00	1,12	1,13	82
2023	0.04	2.41	2.45	78

Table 9. **Cod** *Gadus morhua* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	550	3081	3632	89
2016		No survey		
2017	195	1082	1277	88
2018	362	416	779	83
2019	32	237	269	62
2020	21	190	211	110
2021	251	456	707	61
2022	4	650	654	81
2023	44	1820	1864	82

Table 10. **Deep-sea redfish** *Sebastes mentella* abundance (Mio.)

Year	Ameralik	Nuuk fjord	Total	CV
2015	0.05	0.32	0.37	30
2016		No survey		
2017	0.01	0.26	0.26	49
2018	0.08	0.86	0.94	56
2019	0.18	0.27	0.44	40
2020	0.02	0.54	0.56	53
2021	0.57	0.89	1.46	46
2022	0.08	0.94	1.02	33
2023	0.32	2.84	3.16	31

Table 11. Deep-sea redfish *Sebastes mentella* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	29	192	221	30
2016		No survey		
2017	3	151	154	45
2018	58	608	666	59
2019	127	164	291	44
2020	15	445	460	57
2021	440	211	651	59
2022	24	258	282	31
2023	256	810	1065	35

Table 12. Golden redfish *Sebastes norvegicus* abundance (Mio.)

Year	Ameralik	Nuuk fjord	Total	CV
2015	0.04	0.00	0.05	170
2016		No survey		
2017	0.00	0.02	0.02	187
2018	0.00	0.03	0.03	70
2019	0.01	0.00	0.02	120
2020	0.00	0.02	0.02	100
2021	0.04	0.03	0.07	110
2022	0,00	0,01	0,01	83
2023	0.03	0.05	0.08	47

Table 13. Golden redfish *Sebastes norvegicus* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	61	11	72	159
2016	.	.	.	.
2017	0	43	43	195
2018	2	59	61	79
2019	11	9	20	88
2020	0	47	47	100
2021	47	52	99	98
2022	5	26	31	68
2023	40	157	197	37

Table 14. American plaice. abundance (Mio.)

Year	Ameralik	Nuuk fjord	Total	CV
2015	3.06	0.85	3.91	113
2016		No survey		
2017	0.04	0.32	0.36	54
2018	1.72	0.59	2.31	76
2019	1.05	0.92	1.97	59
2020	0.99	0.77	1.76	55
2021	1.30	1.20	2.49	55
2022	0,09	1,38	1,46	33
2023	2.66	2.97	5.63	44

Table 15. American plaice *Sebastes sp.* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	337	180	518	89
2016		No survey		
2017	15	82	97	49
2018	306	125	431	65
2019	177	179	356	54
2020	305	170	475	55
2021	335	258	594	60
2022	33	249	281	28
2023	541	631	1172	46

Table 17. Shrimp (mainly *Pandalus borealis)* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	152	1910	2061	24
2016		No survey		
2017	203	1360	1564	33
2018	294	1715	2009	37
2019	142	2279	2421	56
2020	559	1160	1719	34
2021	173	868	1040	24
2022	306	726	1033	24
2023	267	641	908	16

Table 18. Length weight relationship for Greenland halibut in Nuuk fjord and Ameralik

Year	Area	Number of fish	Log a	b	R^2
2015	Nuuk	-	-	-	-
2016			No survey		
2017	Nuuk	124	-12.242	3.146	0.996
2018	Nuuk	488	-12.159	3.091	0.996
2019	Nuuk	324	-12.387	3.181	0.989
2020	Nuuk	490	-12.045	3.088	0.997
2021	Nuuk	420	-12.159	3.118	0.996
2022	Nuuk	378	-11.957	3.061	0.996

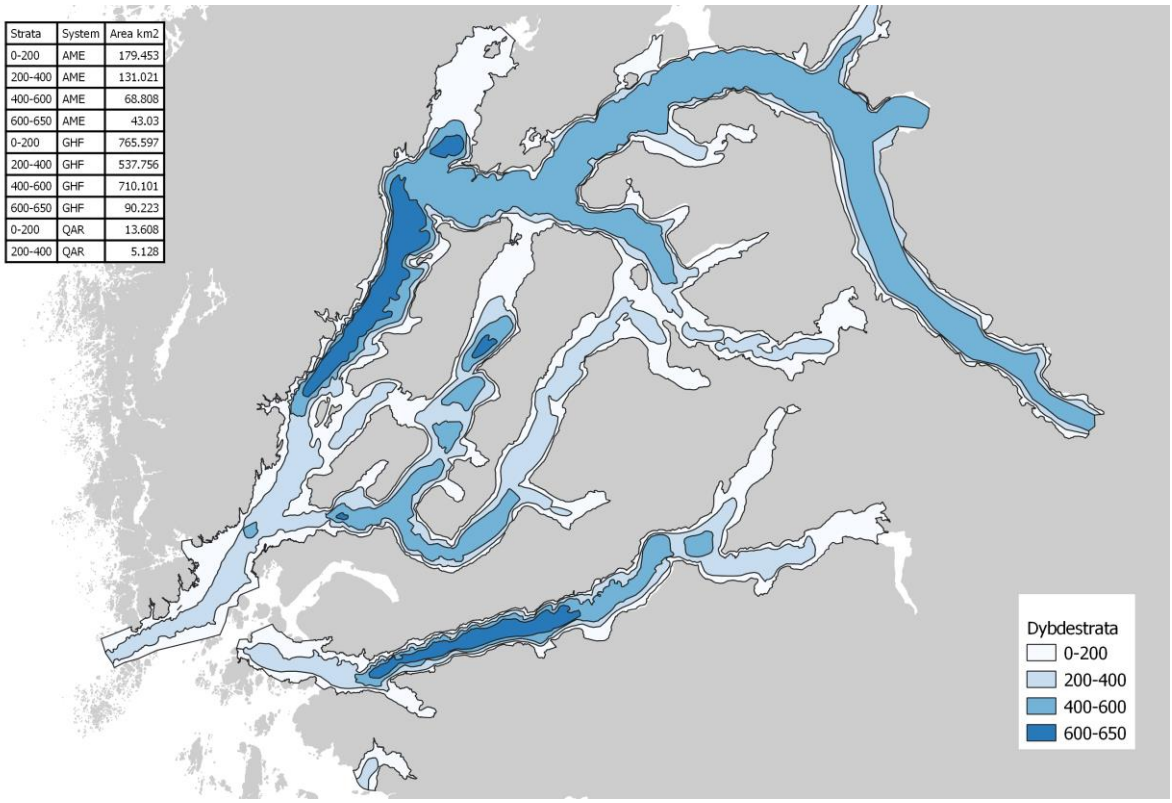


Figure 1. The Stratification areas used in the Shrimp and Fish inshore trawl survey in the Nuuk Fjord and the Ameralik fjord in West Greenland. Each Strata is divided in depth strata of 0-200m, 200-400m, 400-600m and deeper than 600m. The Nuuk fjord (GHF) is the larger fjord in the northern part of the area only open to the west through a narrow chanel. The ameralik fjord is a long narrow fjord branching to the east and only open the west through shallow chanels. Qarajat is the small coastal area south of Ameralik.

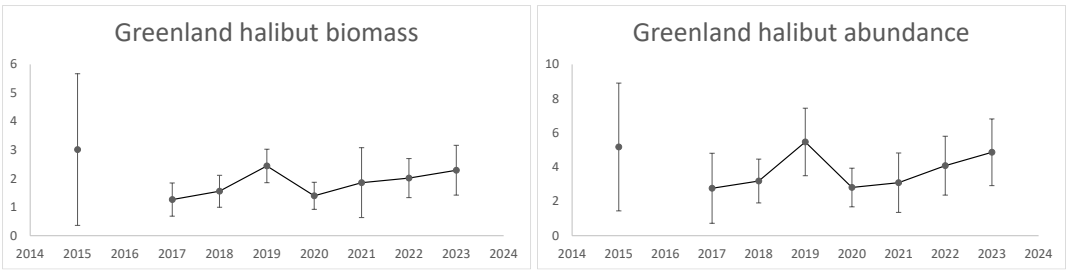


Figure 2. Greenland halibut biomass and abundance indices for the Nuuk fjord and Ameralik combined.

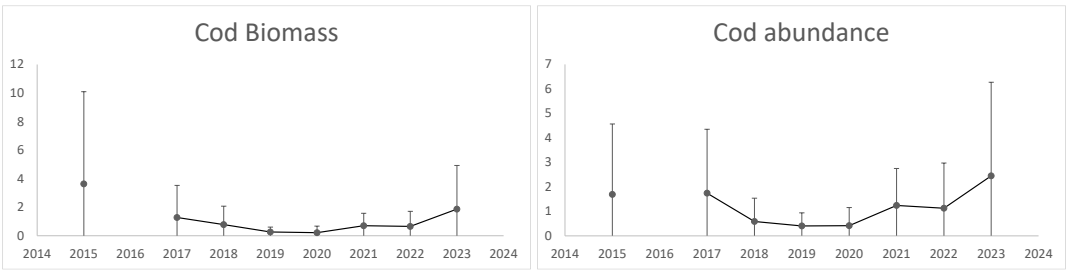


Figure 3. Cod biomass and abundance indices for the Nuuk fjord and Ameralik combined.

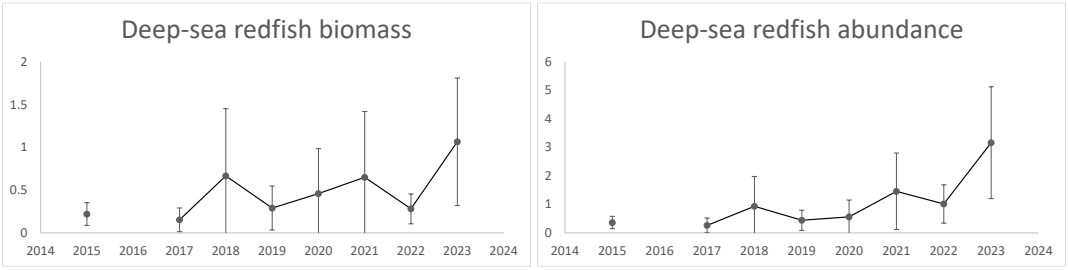


Figure 4. Deep-sea redfish biomass and abundance indices for the Nuuk fjord and Ameralik combined.

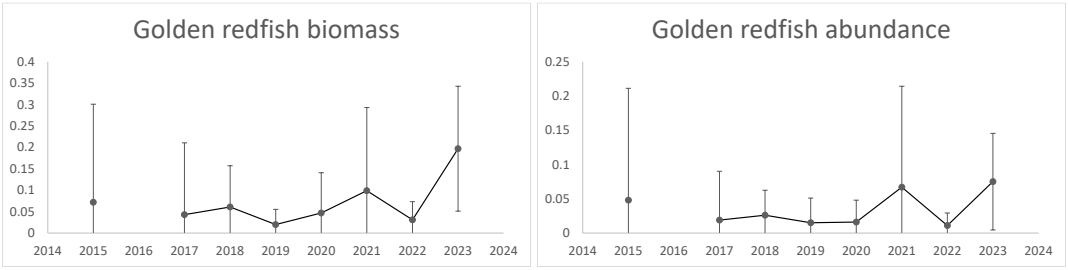


Figure 5. Golden redfish biomass and abundance indices for the Nuuk fjord and Ameralik combined.

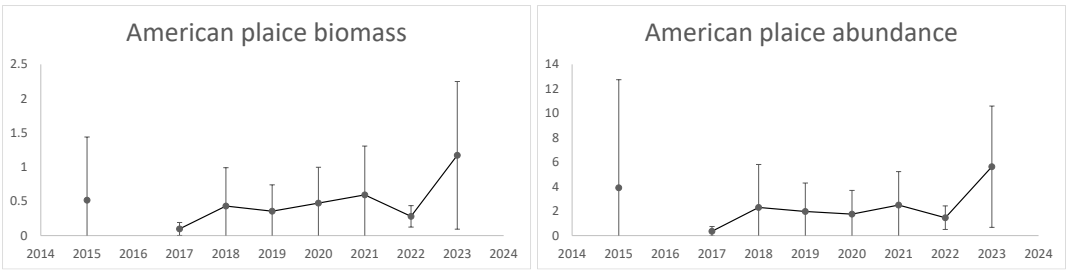


Figure 6. American plaice biomass and abundance indices for the Nuuk fjord and Ameralik combined.

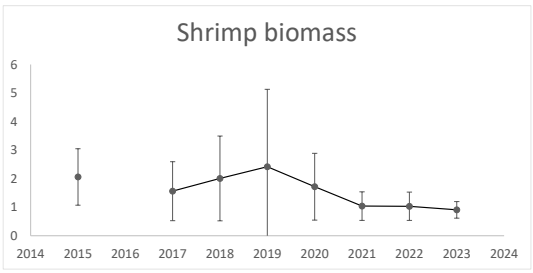


Figure 7. Shrimp biomass indices for the Nuuk fjord and Ameralik combined.

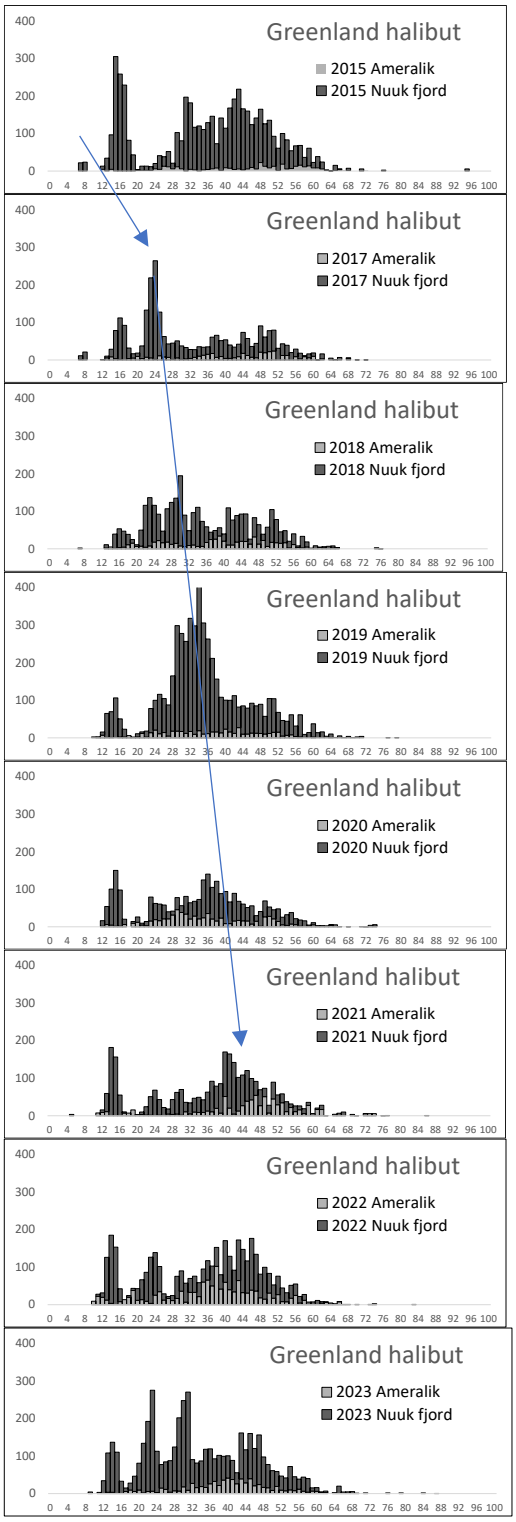


Figure 8. Stacked length frequencies for Greenland halibut in the Nuuk fjord and Ameralik.

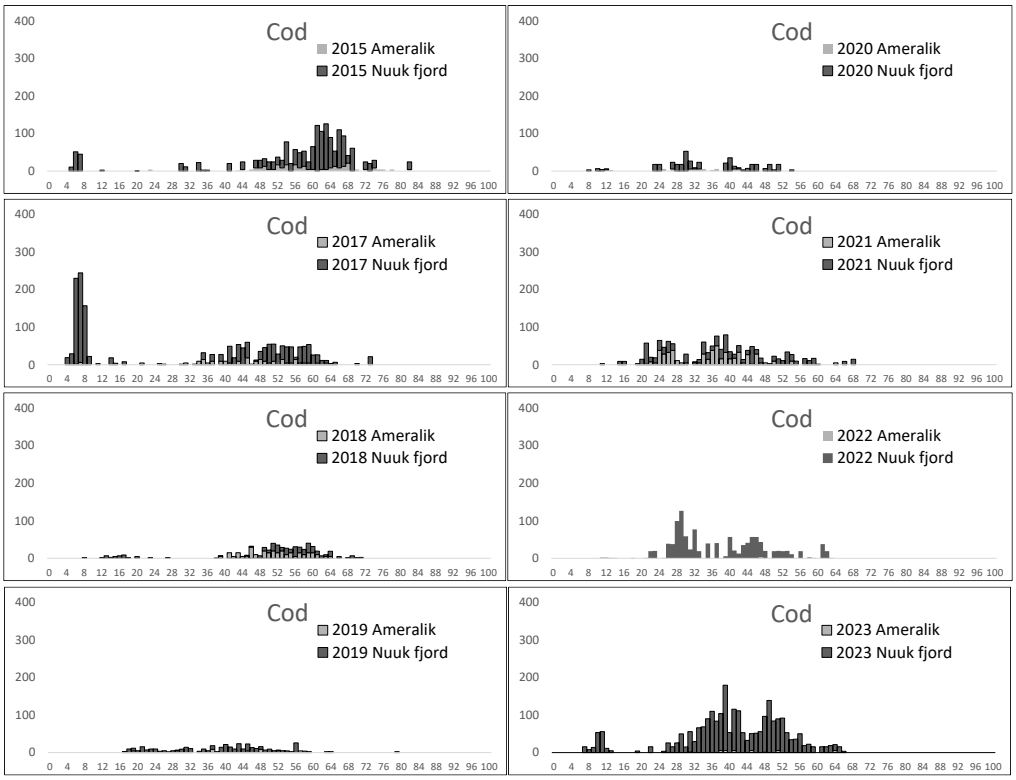


Figure 9. Stacked length frequencies for Cod in the Nuuk fjord and Ameralik.

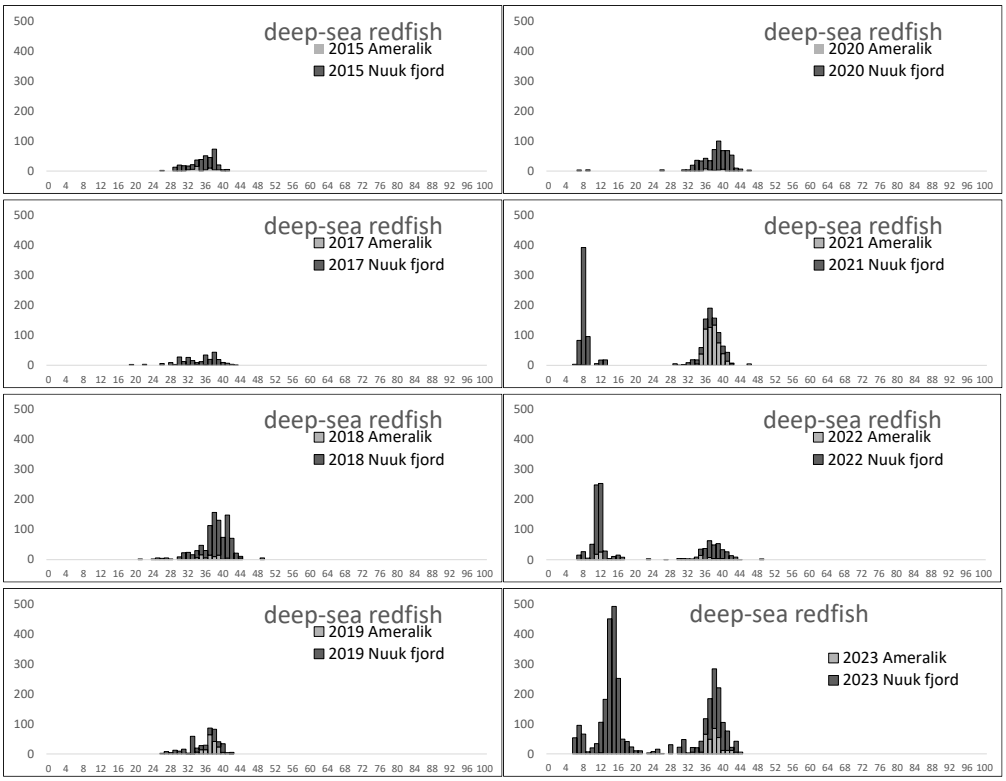


Figure 10. Stacked length frequencies for deep-sea redfish in the Nuuk fjord and Ameralik.

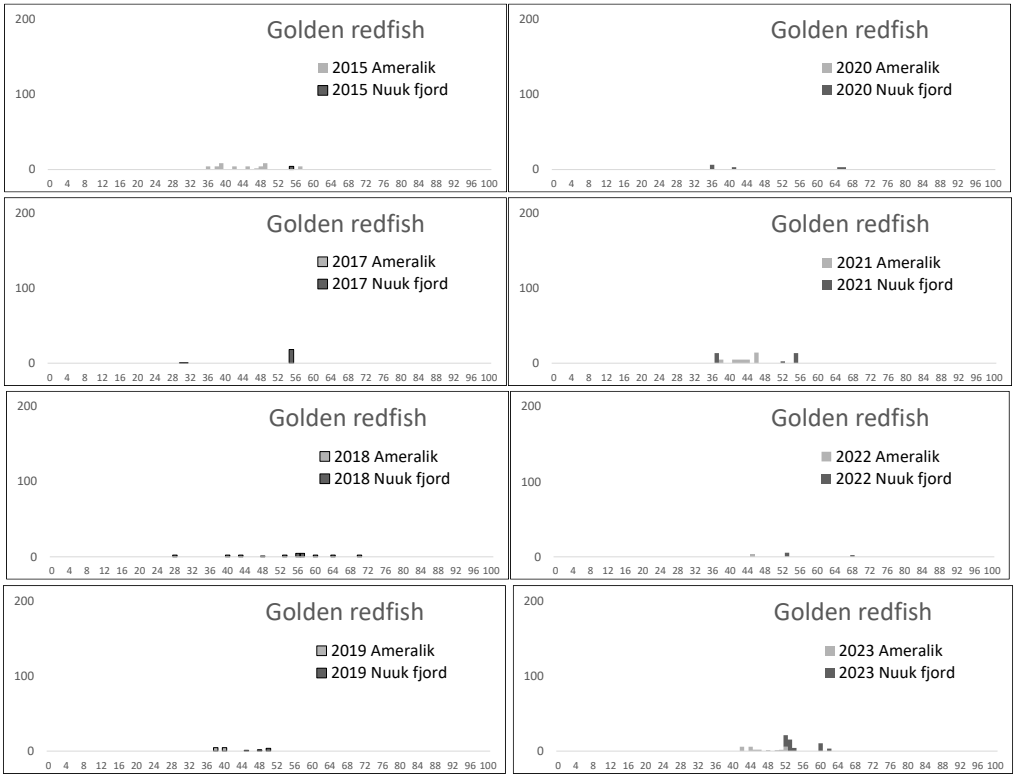


Figure 11. Stacked length frequencies for golden redfish in the Nuuk fjord and Ameralik.

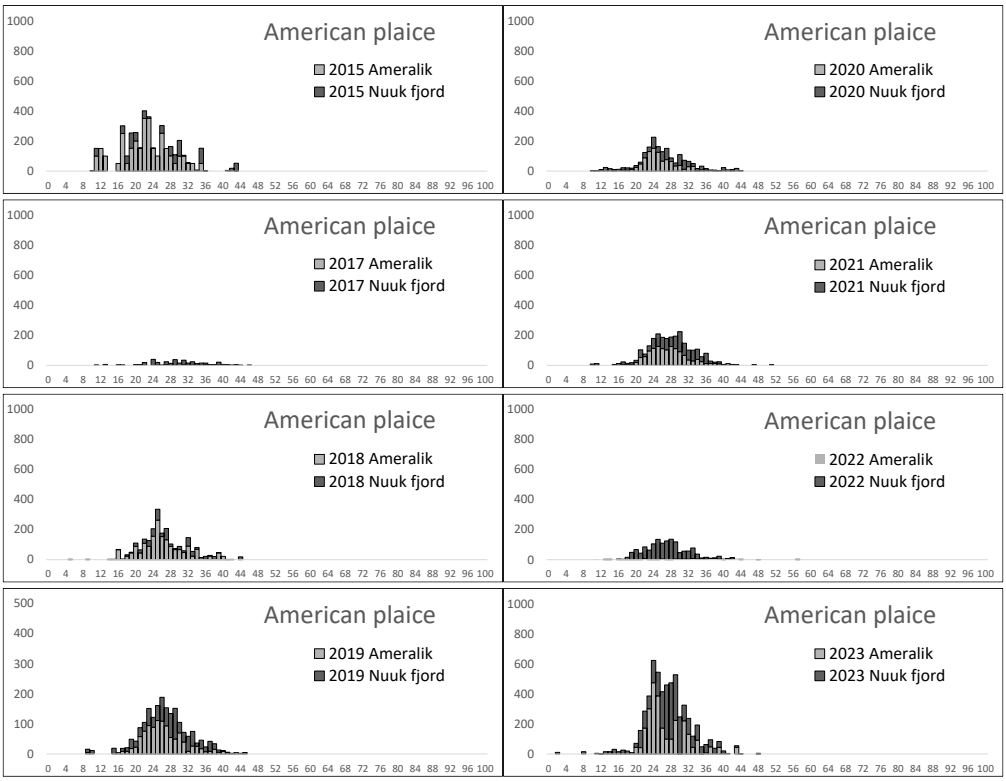


Figure 12. Stacked length frequencies for golden redfish in the Nuuk fjord and Ameralik.

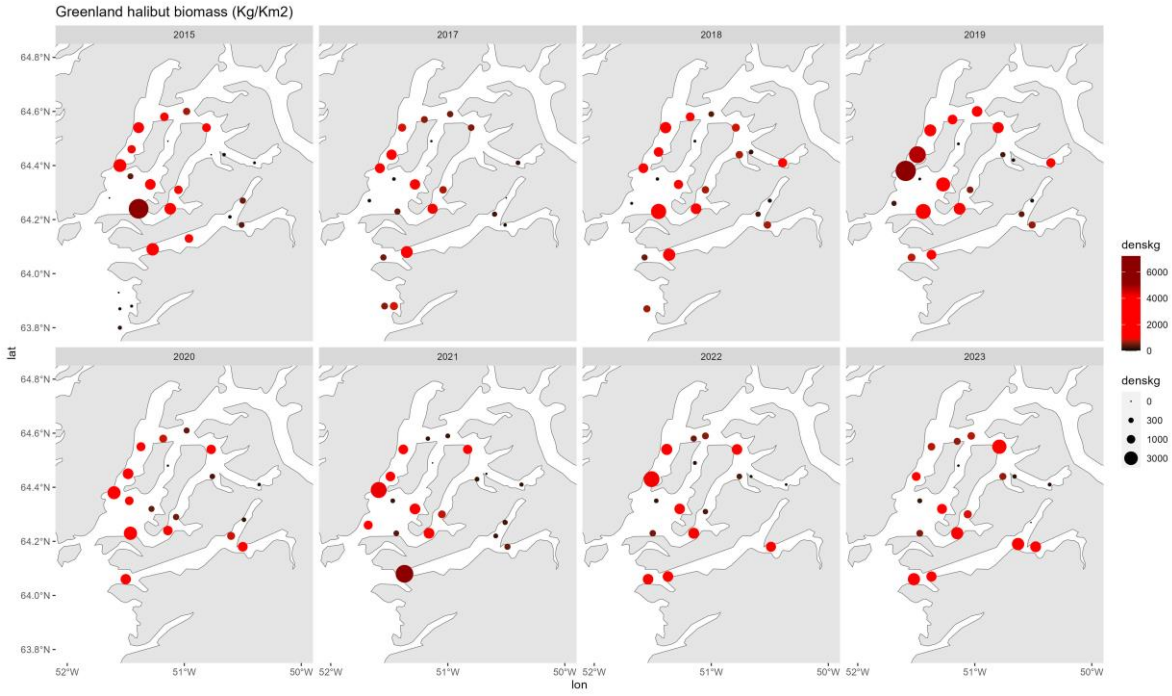


Figure 13. Greenland halibut survey biomass (kg/km2).

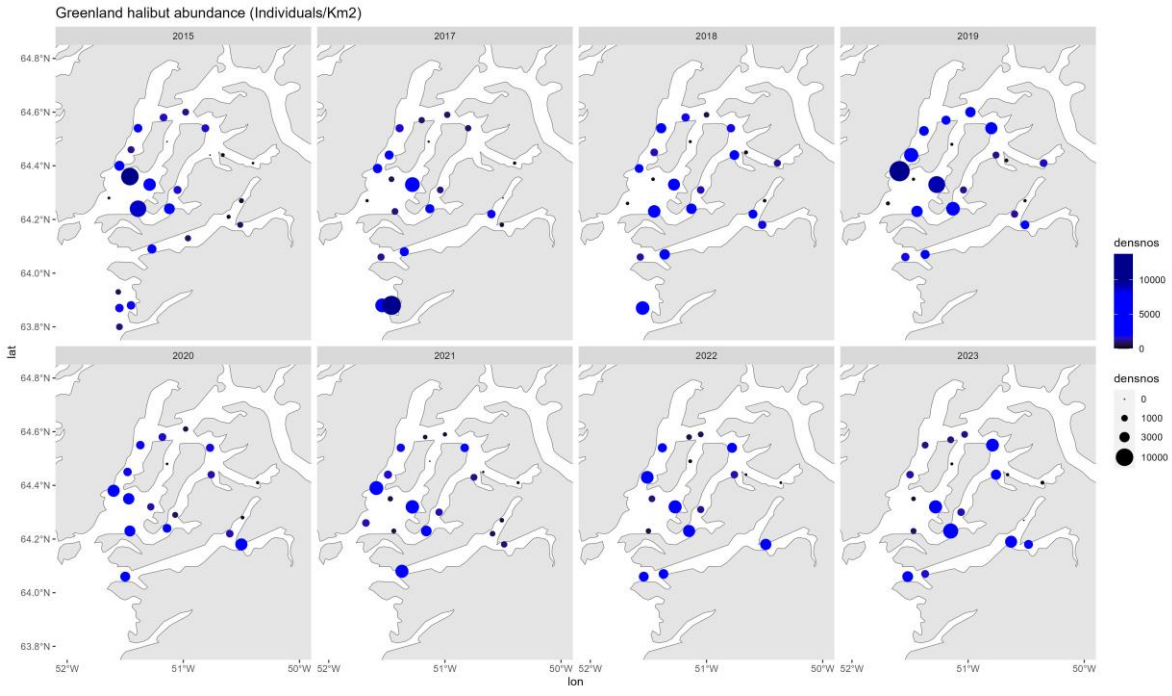


Figure 14. Greenland halibut survey abundance (individuals/km2).

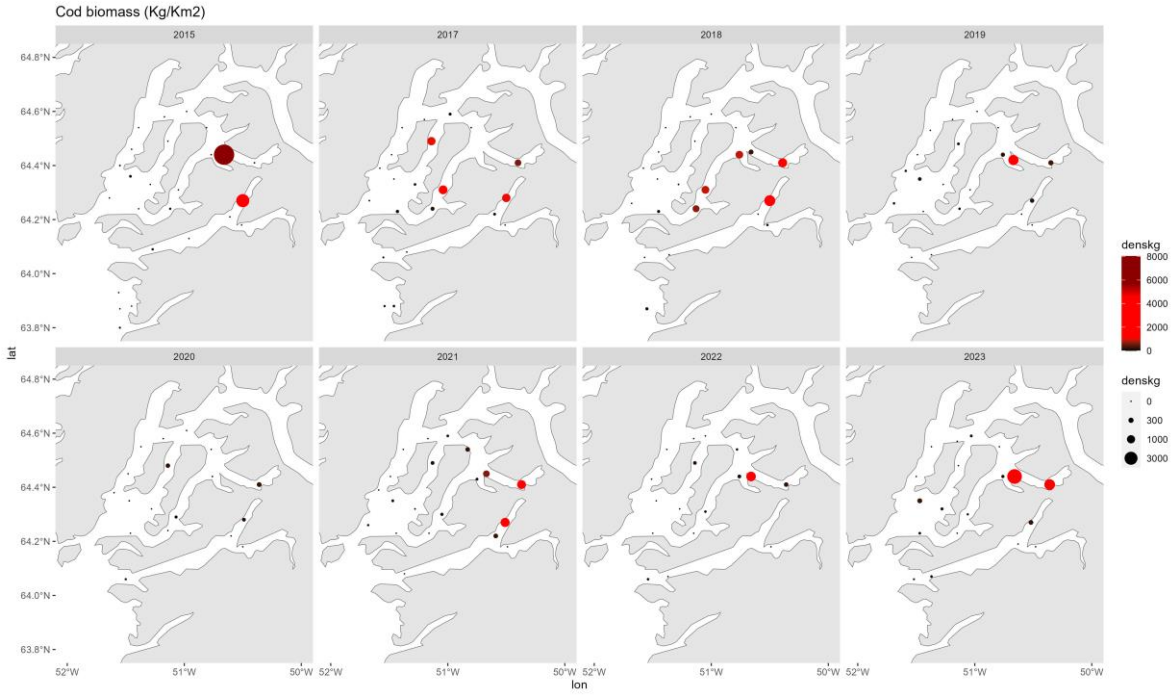


Figure 15. Survey biomass densities for Cod.

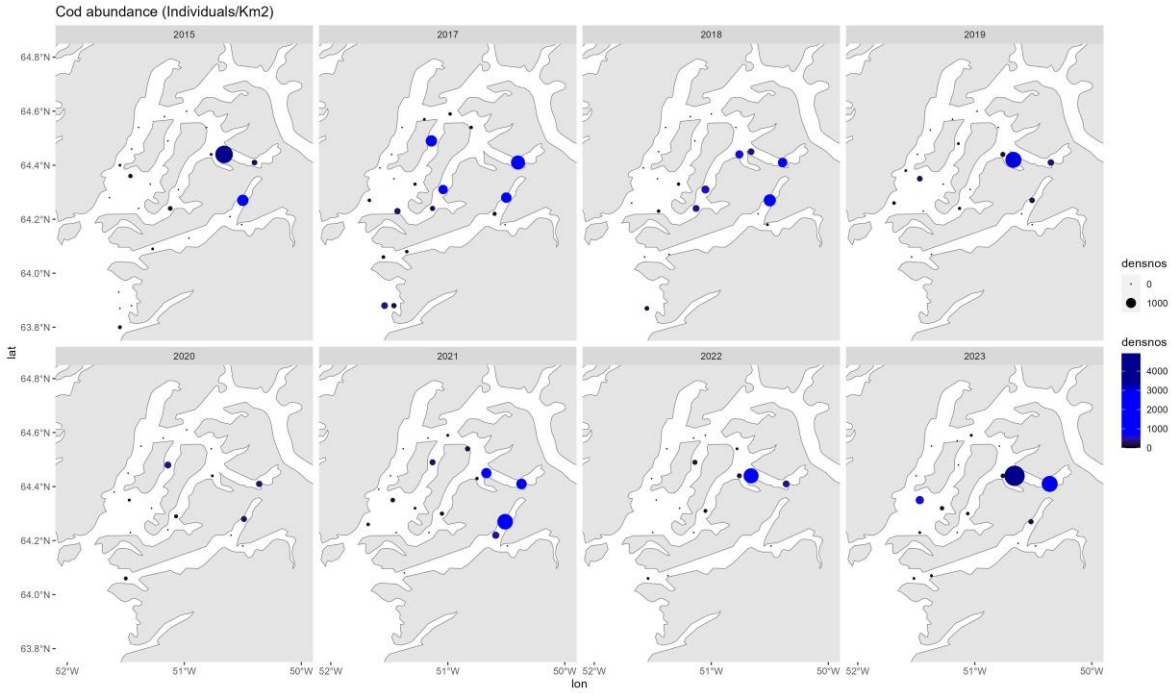


Figure 16. Survey abundance densities for Cod.

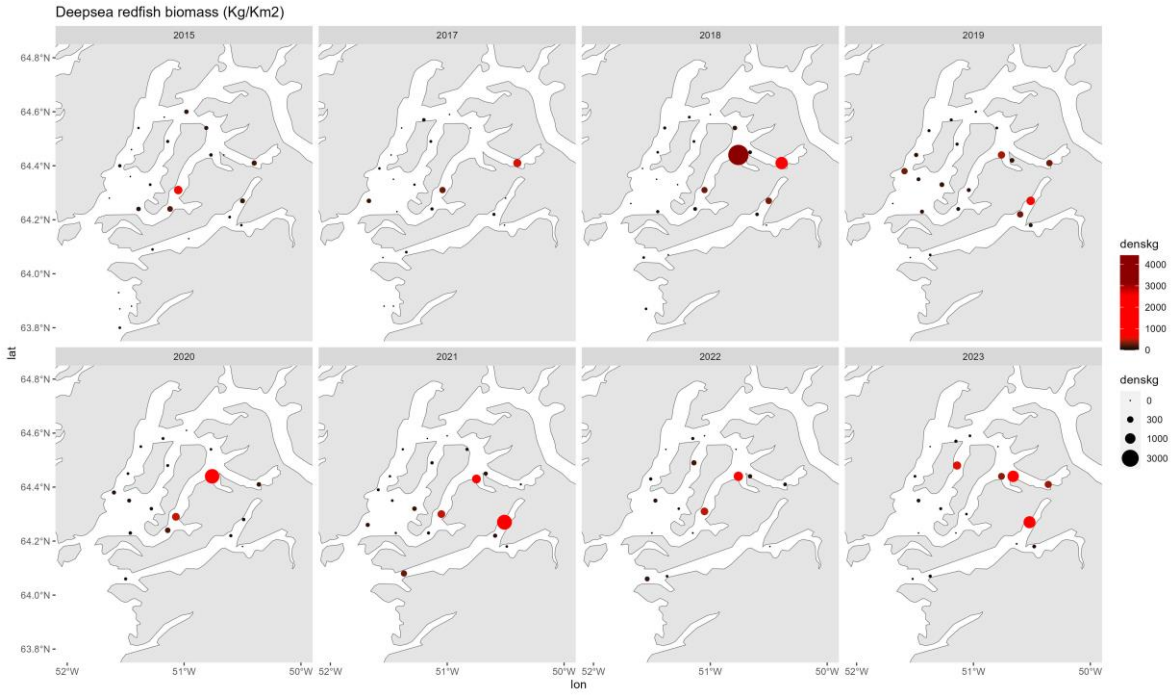


Figure 17. Survey biomass densities for deep-sea redfish.

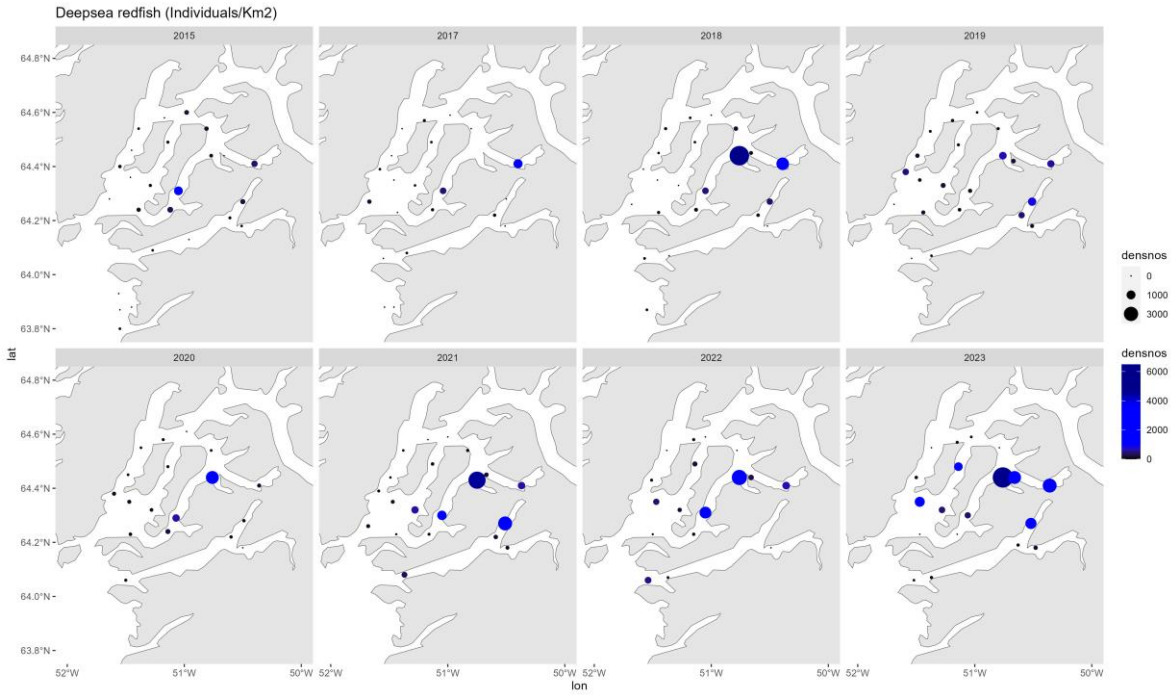


Figure 18. Survey abundance densities for deep-sea redfish.

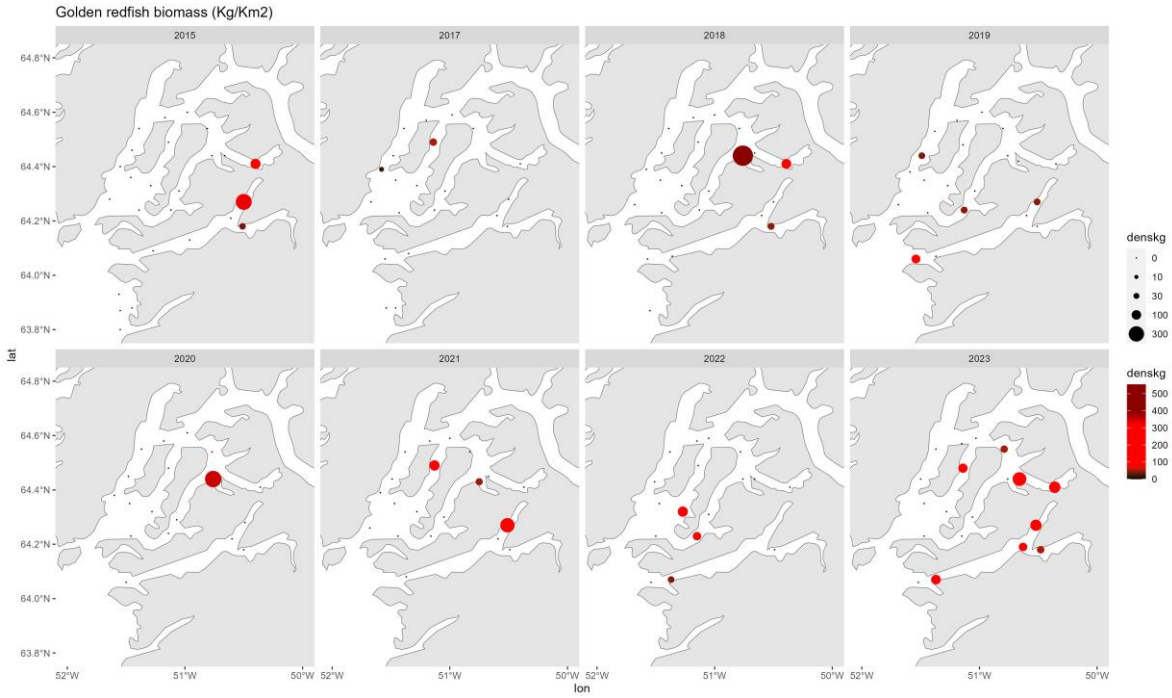


Figure 19. Survey biomass densities for Golden redfish.

Figure 20. Survey abundance densities for Golden redfish.

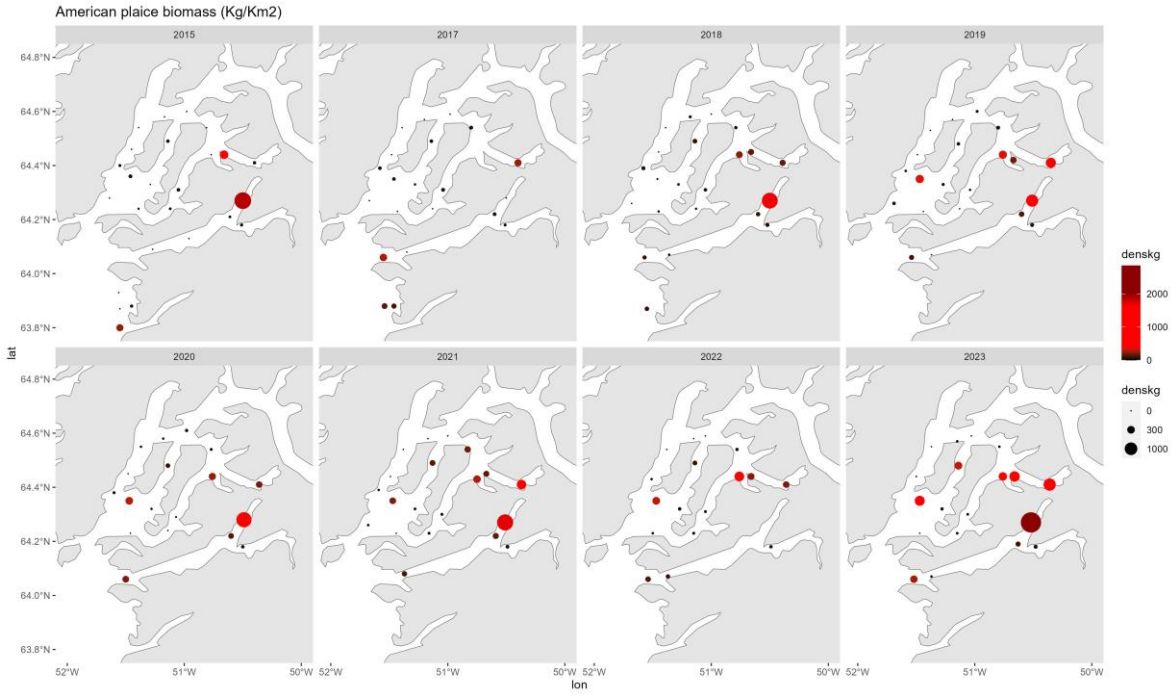


Figure 21. Survey biomass densities for American plaice.

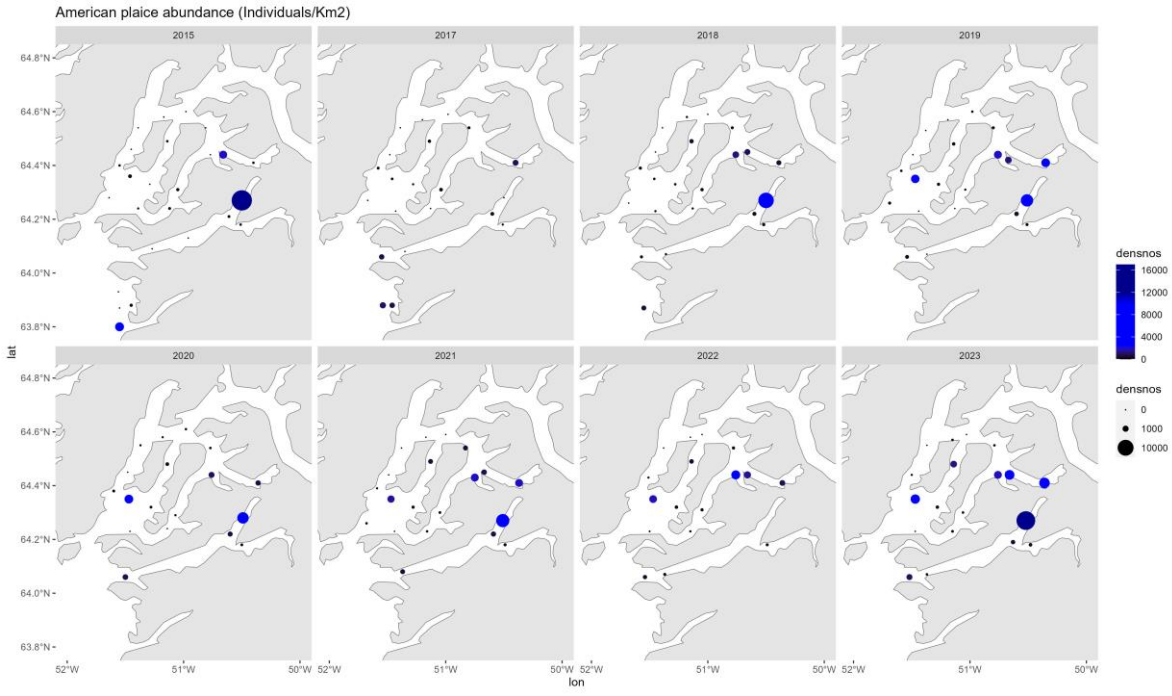
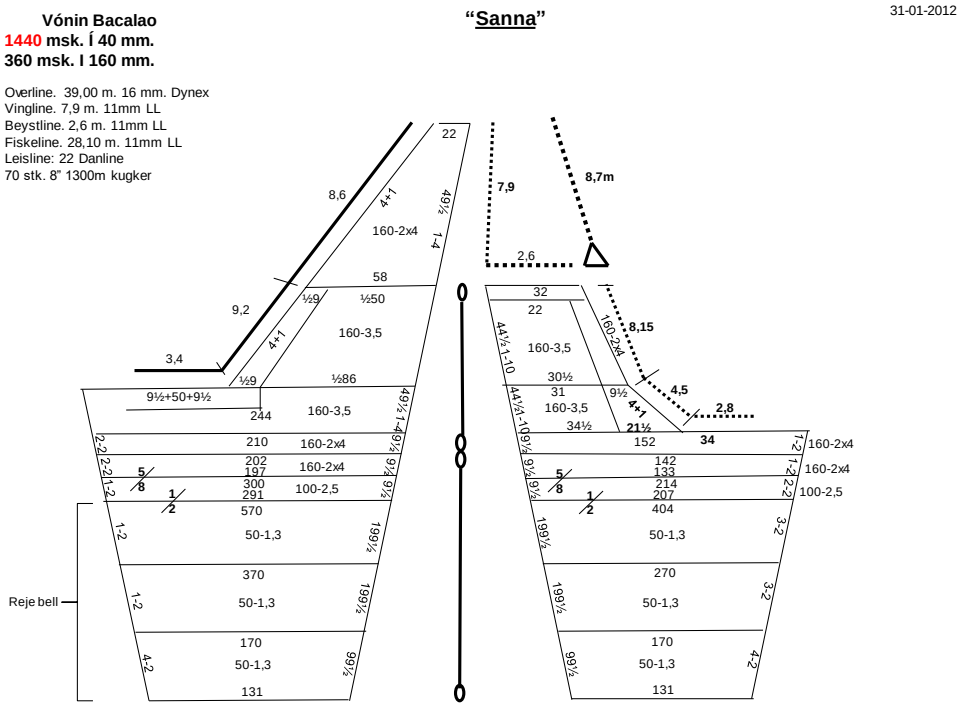


Figure 22. Survey abundance densities for American plaice.

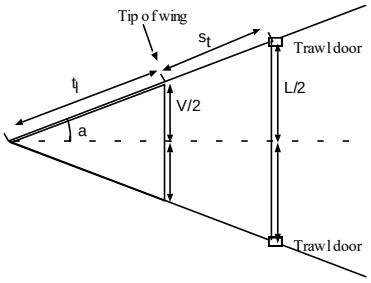
Figure 23. Survey biomass densities for shrimp.

Appendix I.



Drawings of the 1440 mesh Bacalau trawl. The trawl is a fish-trawl combined with a fine meshed shrimp codend. Notice the overhanging headline and front wings.

The wingspread (i.e. the width of the swept area) V has been calculated by assuming that the trawl and the trawl plus bridles form two similar triangles making a straight line.



Headrope	39 m
Ground gear + chain	28.1m + 8.7m
Bridles+ chain	30m+4m
Front wing	7.9m
codend	8 m
Wing tip to codend	48 m
t_l (Trawl length)	48m-7.9m-8m=32
s_t (dorchain)	34m+8.7m=42,7m

The wingspread (V) is: $V = (t_l * L) / (t_l + s_t)$

where L is the distance between the doors (doorspread). In most cases the distance between the doors varies from 40-50 m giving a typical estimated wingspread of (32m*45m/(74.7m)=19m. This is in the range also reported for other studies 0.4, 0.5 or up to 0.66 multiplied with the length of the headrope. The length of the gear is 28.1 m+8.7 m meters of chain in both sides and the length of the headrope is 39m.