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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 capital 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 strait 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 (ref).

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 however 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 correspond 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 and 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 ecosounders and a Seabat T50 sidescan zonar from 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 sensors 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 (mostly *S mentella*), 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° colder than in both the Nuuk fjord and in the Qarajat area (Table 4).

Shrimp (*Pandalus borealis*)

The shrimp biomass index (mostly *pandalus borealis*) seems to have decreased from 2015-2022 (table 6 and figure 3). The maps of biomass densities show that shrimp are distributed over several locations, but mainly in the deeper parts of the fjord (Figure 26). 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.

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 7 and 8, figure 3). In all years, one-year old recruits have been identified (figure 7.) 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 14 and 15).

Cod (*Gadus morhua*)

Since the fishery for cod in the fjord are several times greater than the survey index, any conclusion based on cod indices are tentative. Instead, juvenile cod are surveyed with gillnets along the beaches and with a pelagic survey and acoustics also from RV Sanna. Cod 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. Cod abundance (Table 9) and biomass (Table 10) indices are shown in figure 4. 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 16 and 17).

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 11 and 12, figure 5). Length frequencies show that only deep-sea redfish in the size range from 25 to 44 cm are present in the fjords (figure 11). 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 18 and 19).

Golden Redfish (*S. Norvegicus*)

Very few golden redfish were found in the survey and the abundance (table 13) and biomass (table 14) indices are low in all years (figure 6). 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 12). Distribution of the few Golden redfish observed are similar to deep-sea redfish distribution (figure 20 and 21).

Juvenile redfish (unknown species)

Until 2020, no juvenile redfish were observed in the survey (Table 15 and 16, figure 7). 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). Few pregnant females with live larvae are observed in the spring surveys. Few, one-year-old recruits were observed in 2020 (figure 13). However in 2021 a clear mode of one year old redfish around 7-8 cm is seen and in 2022 atleast 3 new cohorts are visible. The same cohorts are identified in the similar offshore surveys where strong recruitment of redfish has been identified. The juvenile redfish are found on 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 22 and 23).

American plaice

Biomass and abundance indices for American plaice have been stable throughout the timeseries (Table 17 and 18, figure 8). American plaice are taken as unexploited bycatch in other fisheries. American plaice are mainly found in the shallower stations (figure 24 and 25).

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.

Redfish in the fjords have mainly been believed to be Golden redfish. However, the survey indicates an overweight of deep-sea redfish in the fjord about one order of magnitude greater than golden redfish in all years. The fluctuating nature of the redfish indices and the stable length frequencies is in good agreement with the lag of recruitment from a 10 year decade. Redfish are slow growing and presumably the same cohorts of old fish close to L_{max} are observed yearly.

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 Document 18/055.
- Cochran, W. G. 1977: Sampling Techniques, Third edition, 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				April 16-21

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

Year	Ameralik Fjord			Godthåb fjord				Qarajat fjord	
	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		

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	

Table 5. Number of samples collected in the survey.

Year	RED	Other sample				Otolith		
		REB	COD	GHL	SampType	REB	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	26	68	106	1	DNA	68	107	378

Table 6. 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

Table 7. 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

Table 8. 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

Table 9. 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

Table 10. 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

Table 11. 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	0.53	0.55	54
2021	0.53	0.71	1.24	61
2022	0,04	0,32	0,36	32

Table 12. 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	207	646	59
2022	23	246	269	31

Table 13. 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

Table 14. 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

Table 15. Juvenile redfish *Sebastes sp.* Abundance (Mio.)

Year	Ameralik	Nuuk fjord	Total	CV
2015	0.00	0.00	0.00	0
2016		No survey		
2017	0.00	0.00	0.00	0
2018	0.00	0.00	0.00	0
2019	0.00	0.00	0.00	0
2020	0.00	0.01	0.01	58
2021	0.01	0.61	0.62	61
2022	0,04	0,62	0,66	38

Table 16. Juvenile redfish *Sebastes sp.* biomass (t)

Year	Ameralik	Nuuk fjord	Total	CV
2015	0	0	0	0
2016		No survey		
2017	0	0	0	0
2018	0	0	0	0
2019	0	0	0	0
2020	0	0	0	58
2021	0	5	5	64
2022	1	12	13	38

Table 17. 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

Table 18. 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

Table 19. 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

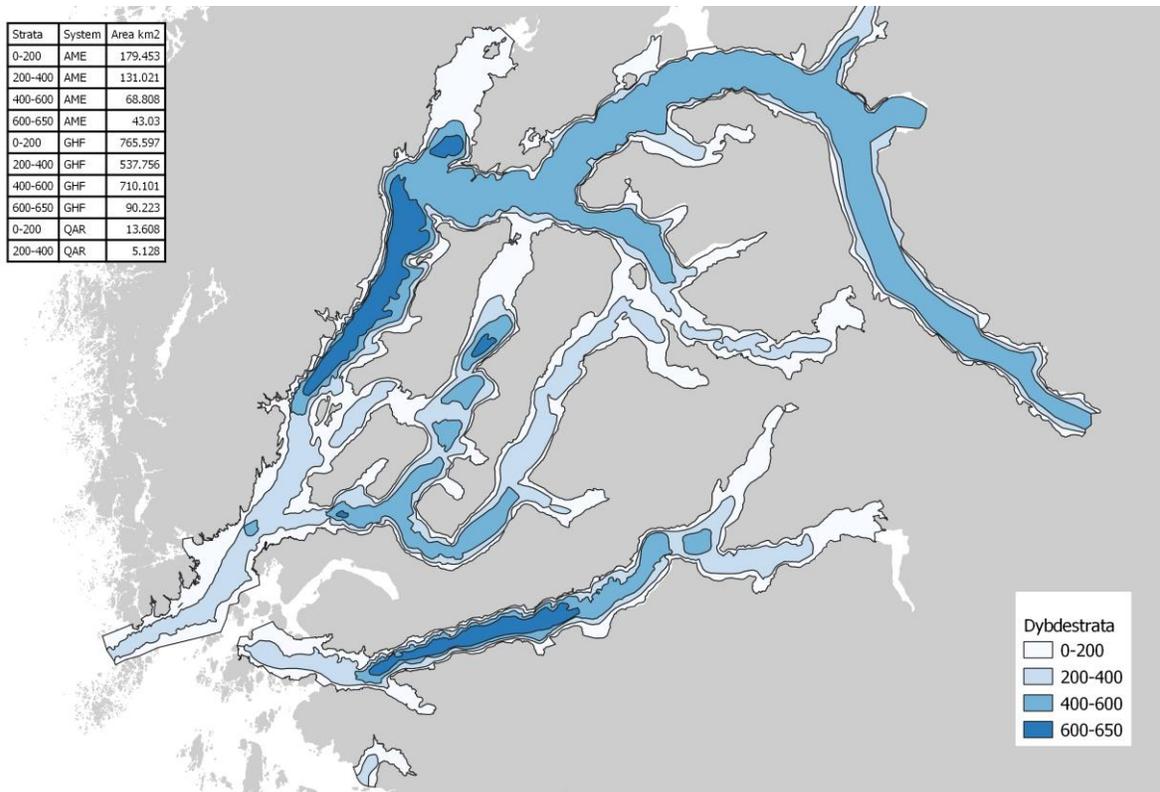


Figure 1. The Stratification areas used in the Shrimp and Fish inshore trawl survey in the Nuuk Fjord and the Ameralik fjord in West Greenland. Each Strata is divided in depth strata of 0-200m, 200-400m, 400-600m and deeper than 600m. The Nuuk fjord (GHF) is the larger fjord in the northern part of the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

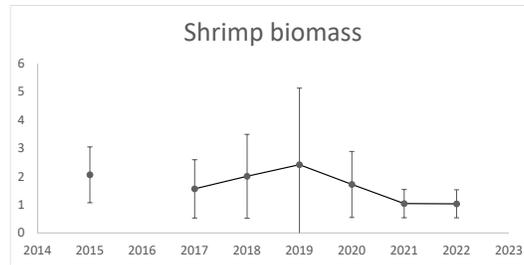


Figure 2. Shrimp biomass indices for the Nuuk fjord and Ameralik combined.

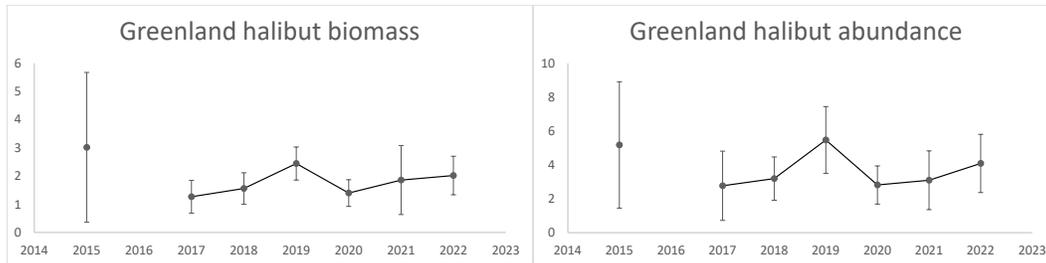


Figure 3. Greenland halibut biomass and abundance indices for the Nuuk fjord and Ameralik combined.

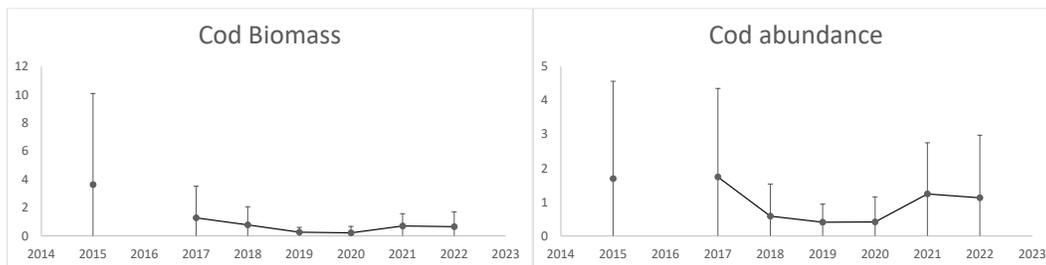


Figure 4. Cod biomass and abundance indices for the Nuuk fjord and Ameralik combined.

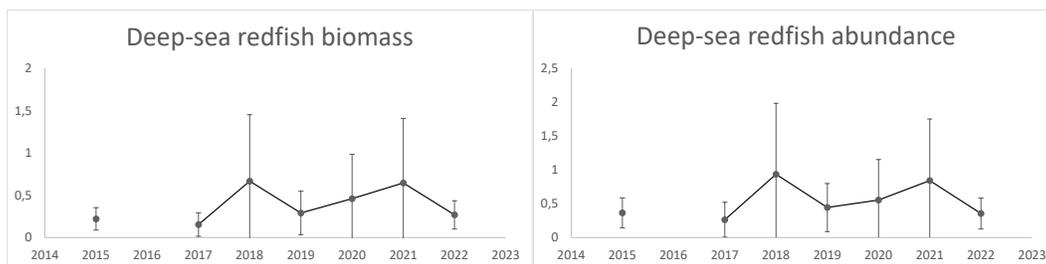


Figure 5. Deep-sea redfish biomass and abundance indices for the Nuuk fjord and Ameralik combined.

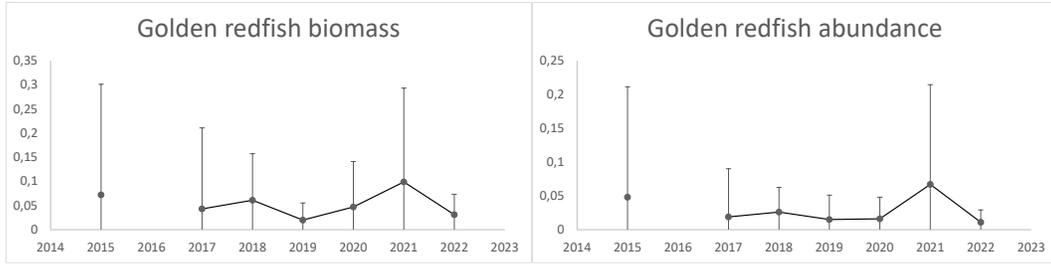


Figure 6. Golden redfish biomass and abundance indices for the Nuuk fjord and Ameralik combined.

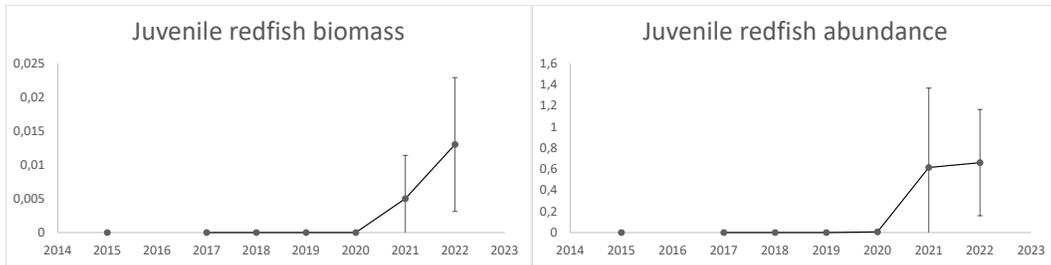


Figure 7. Juvenile redfish (non specified redfish <20 cm) biomass and abundance indices for the Nuuk fjord and Ameralik combined.

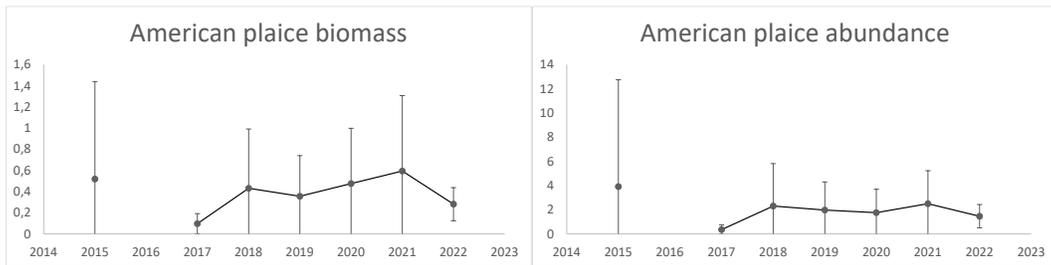


Figure 8. American plaice biomass and abundance indices for the Nuuk fjord and Ameralik combined.

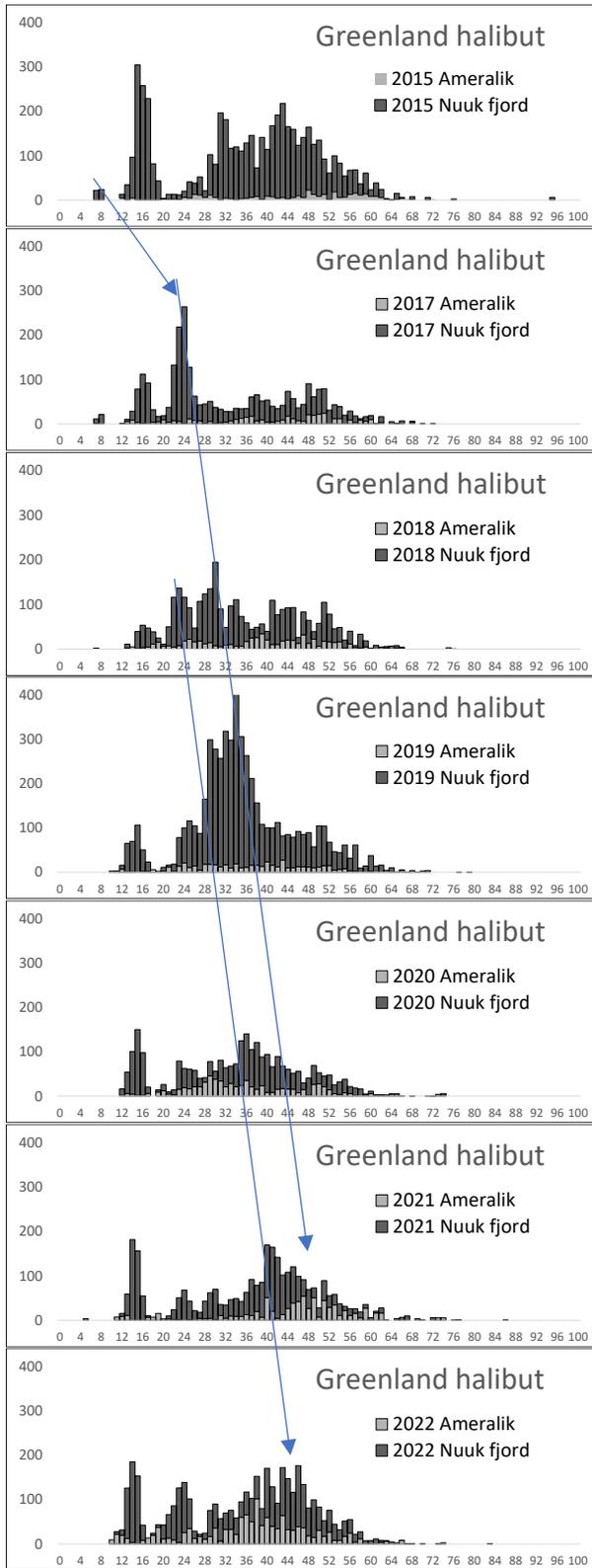


Figure 9. Stacked length frequencies for Greenland halibut in the Nuuk fjord and Ameralik.

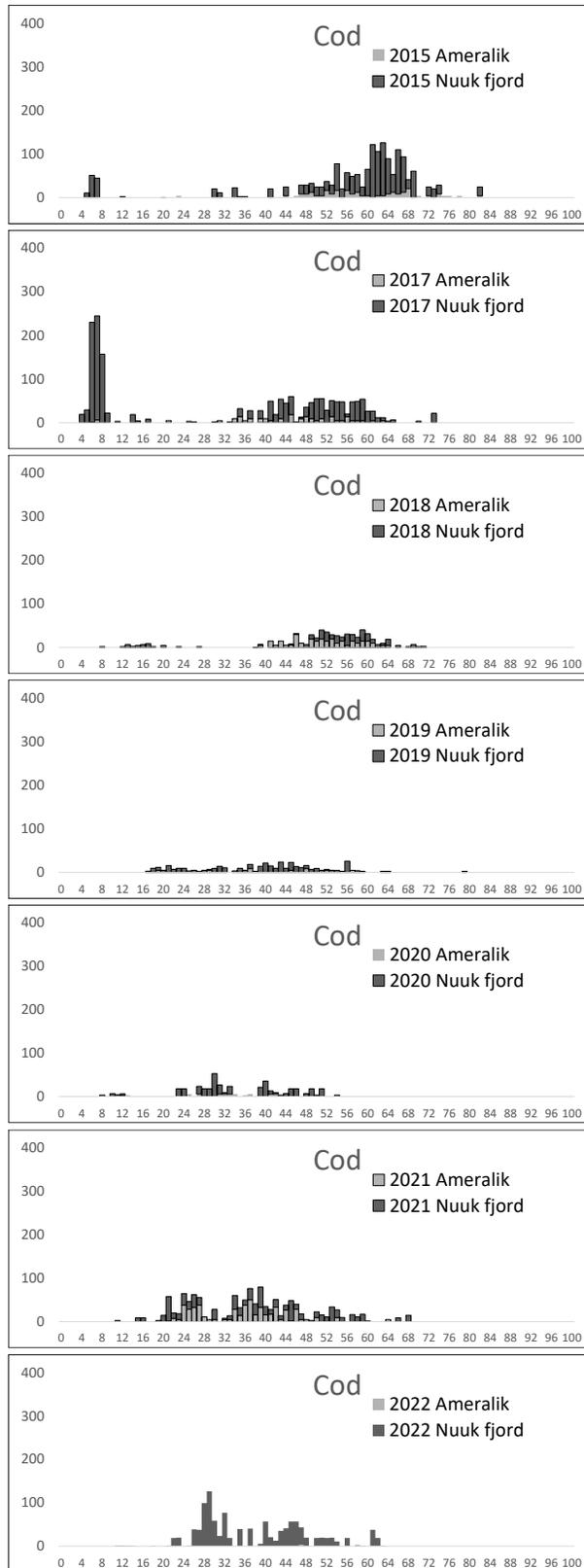


Figure 10. Stacked length frequencies for Cod in the Nuuk fjord and Amealik.

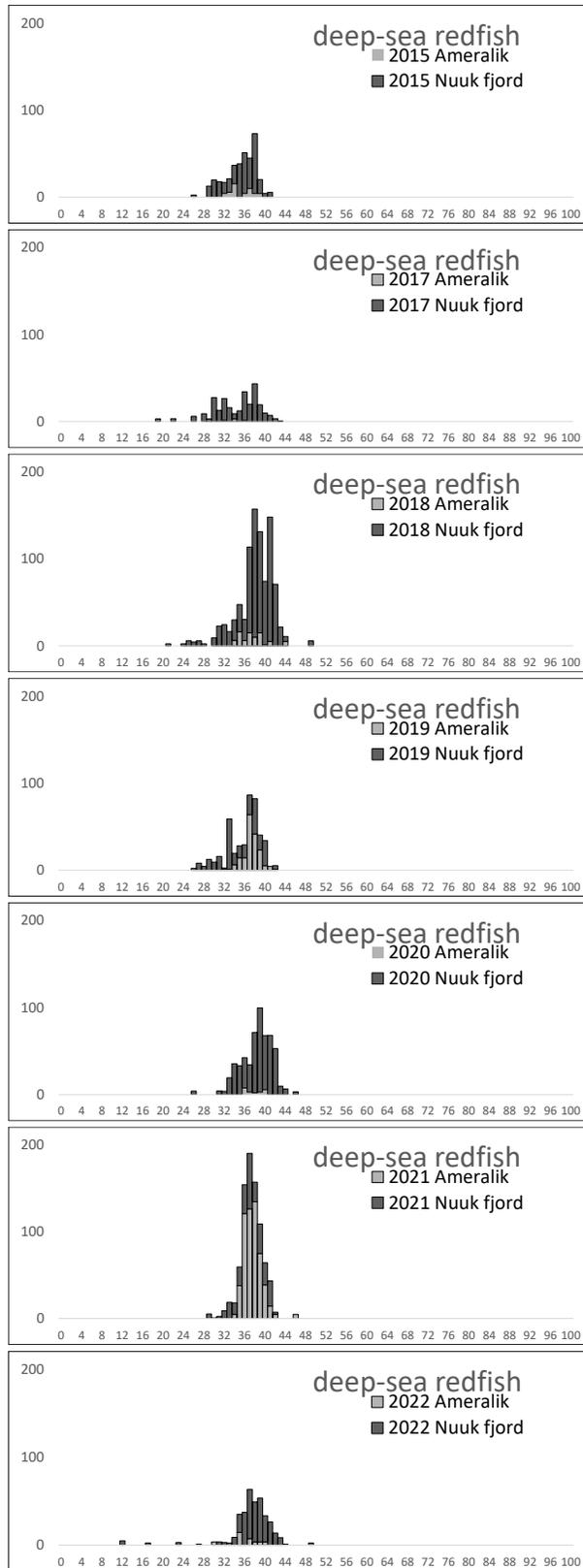


Figure 11. Stacked length frequencies for deep-sea redfish in the Nuuk fjord and Ameralik.

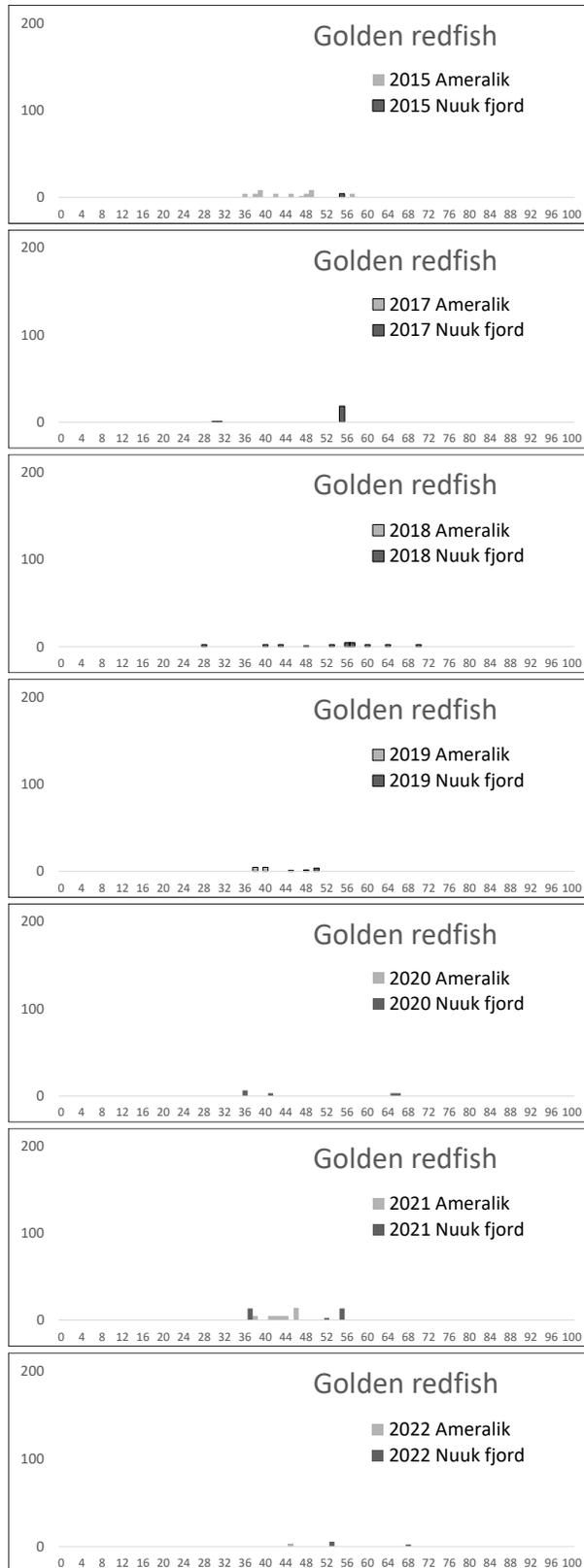


Figure 12. Stacked length frequencies for golden redfish in the Nuuk fjord and Ameralik.

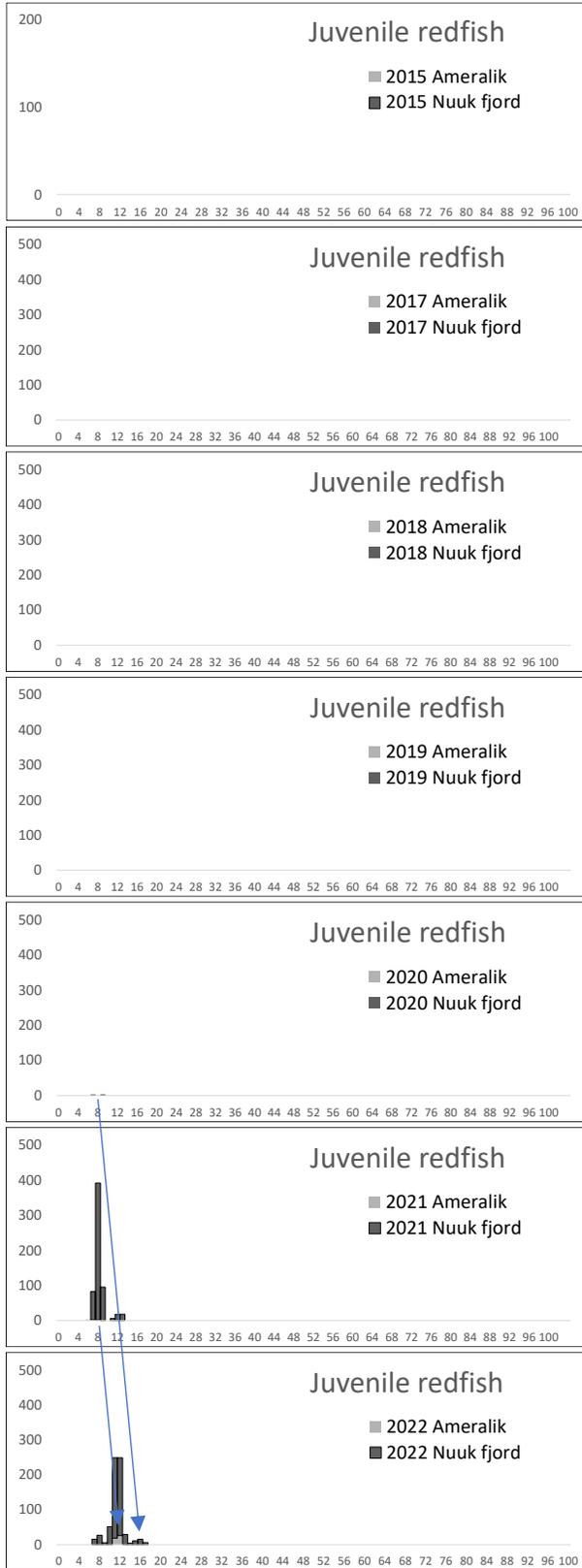


Figure 13. Stacked length frequencies for juvenile redfish in the Nuuk fjord and Ameralik.

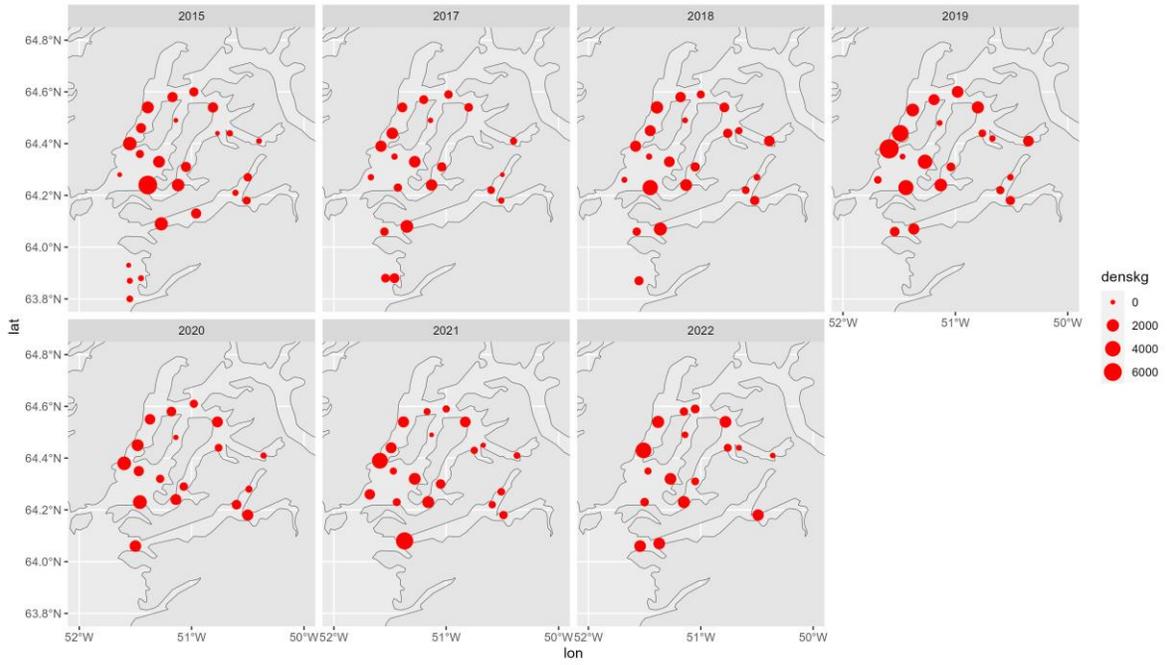


Figure 14. Survey biomass densities for Greenland halibut.

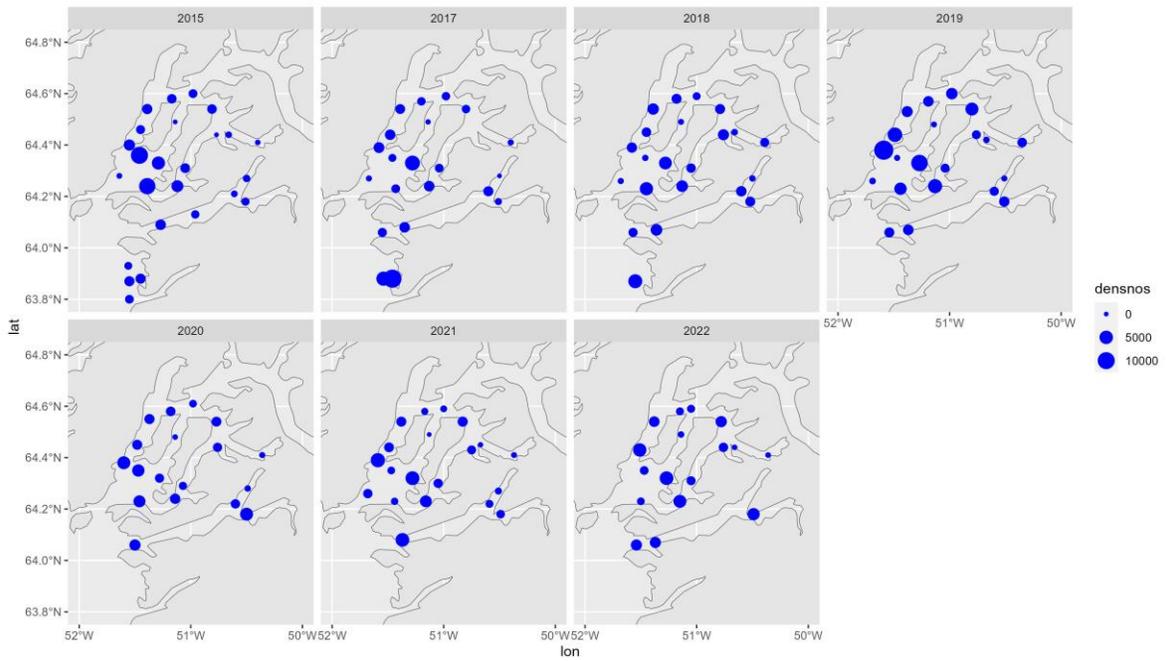


Figure 15. Survey abundance densities for Greenland halibut.

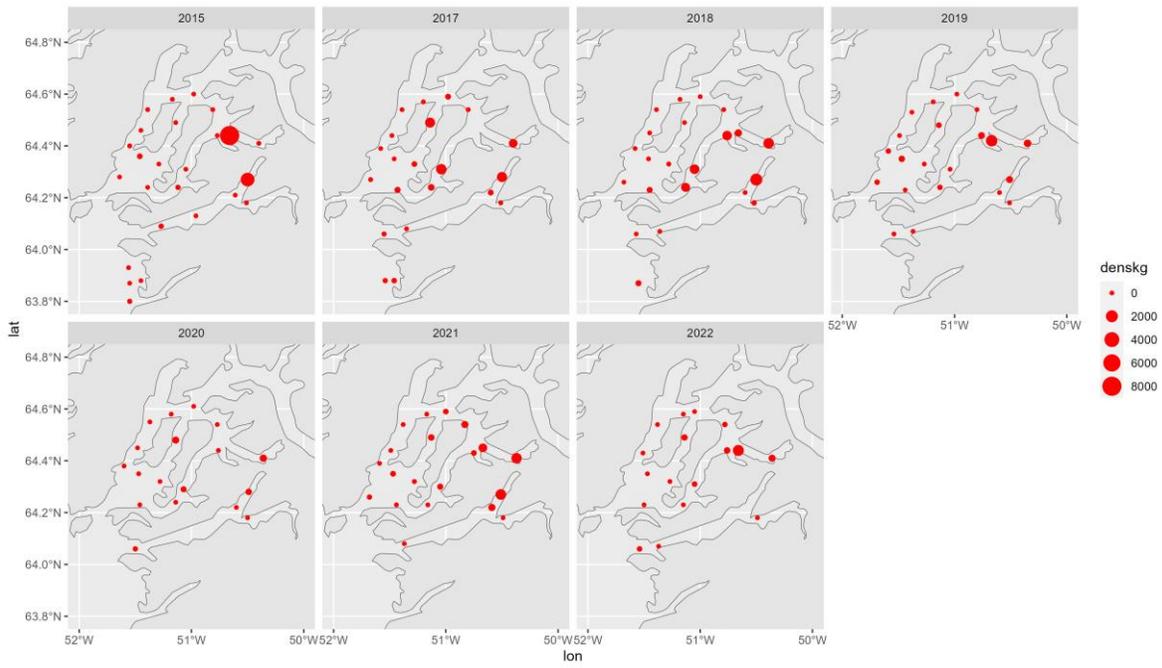


Figure 16. Survey biomass densities for Cod.

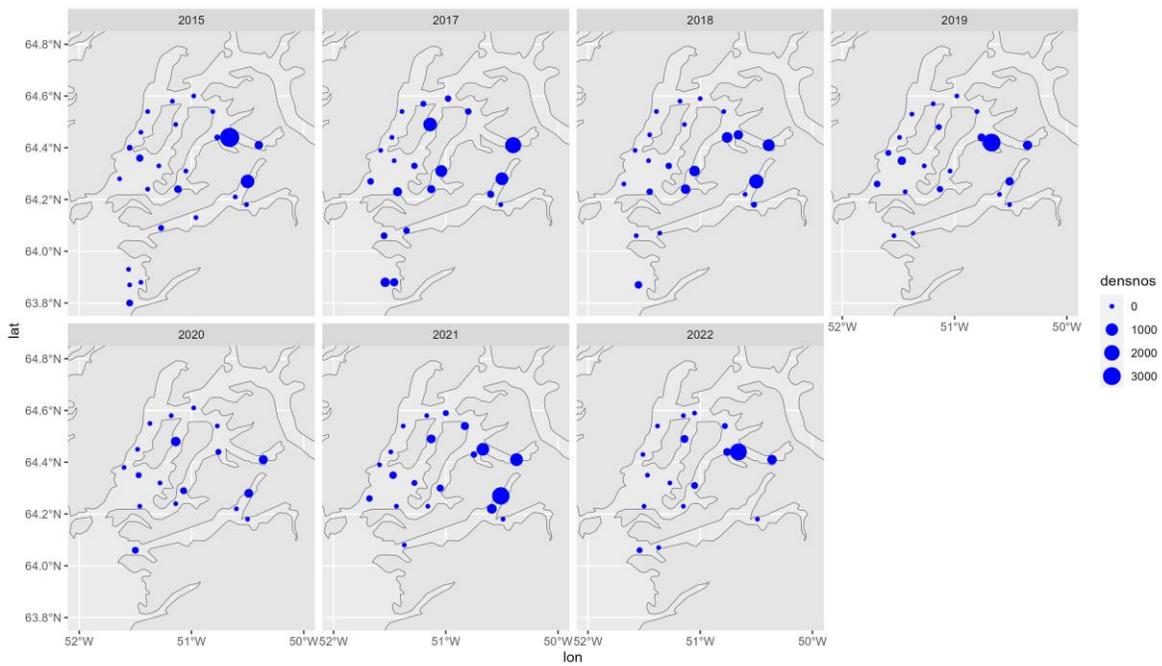


Figure 17. Survey abundance densities for Cod.

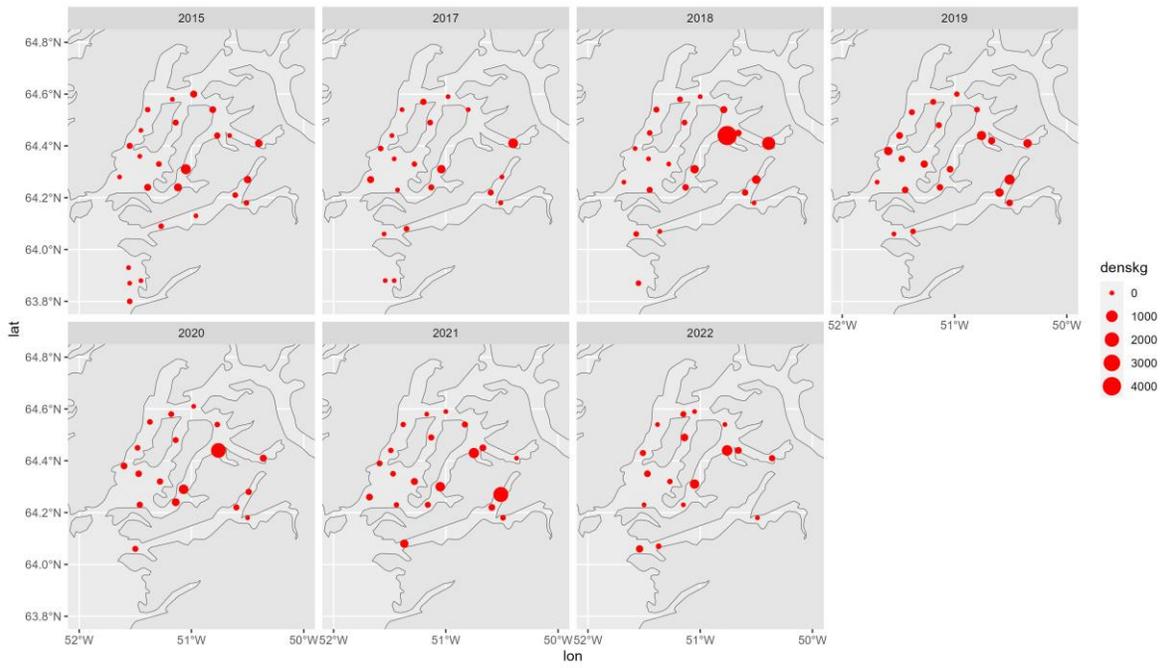


Figure 18. Survey biomass densities for deep-sea redfish.

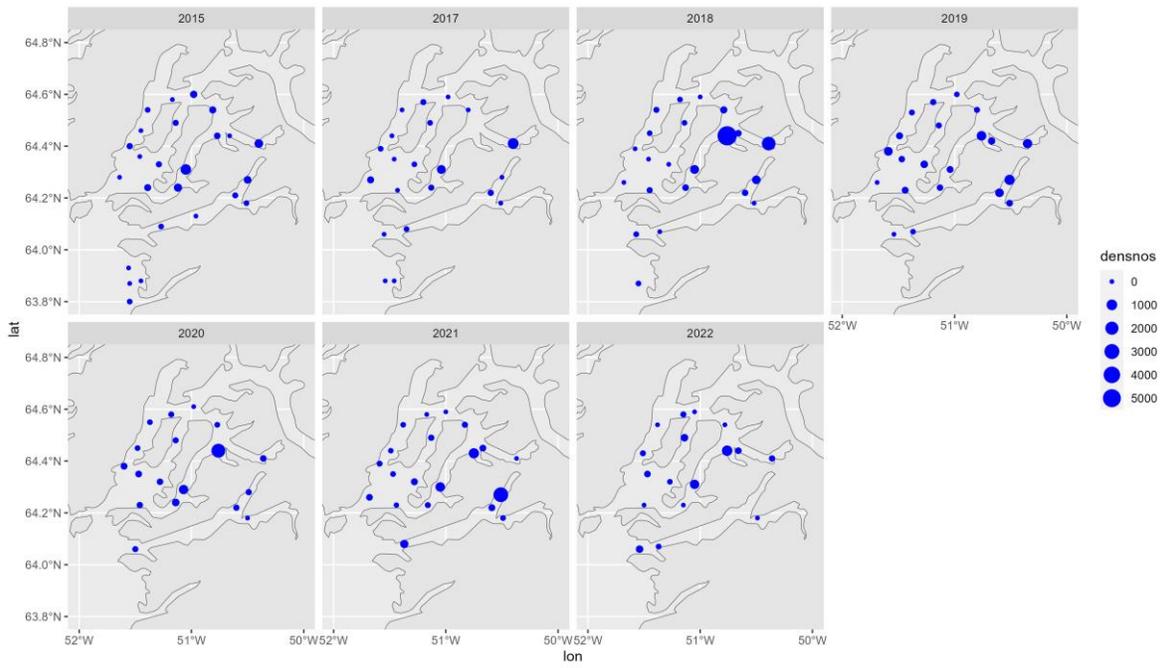


Figure 19. Survey abundance densities for deep-sea redfish.

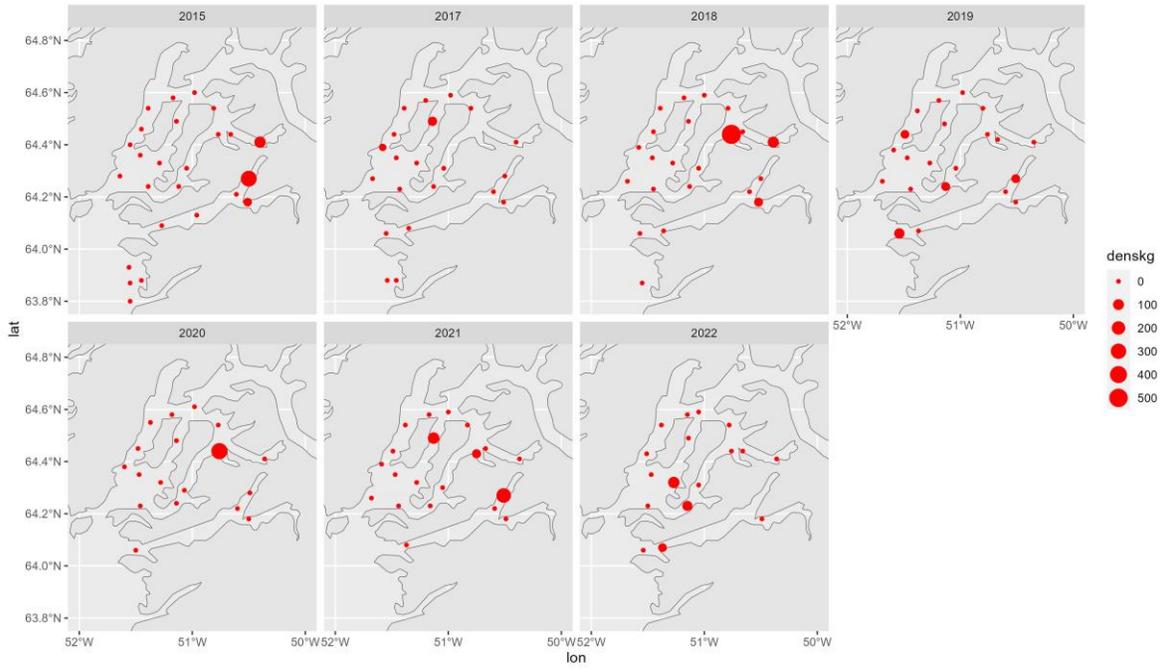


Figure 20. Survey biomass densities for Golden redfish.

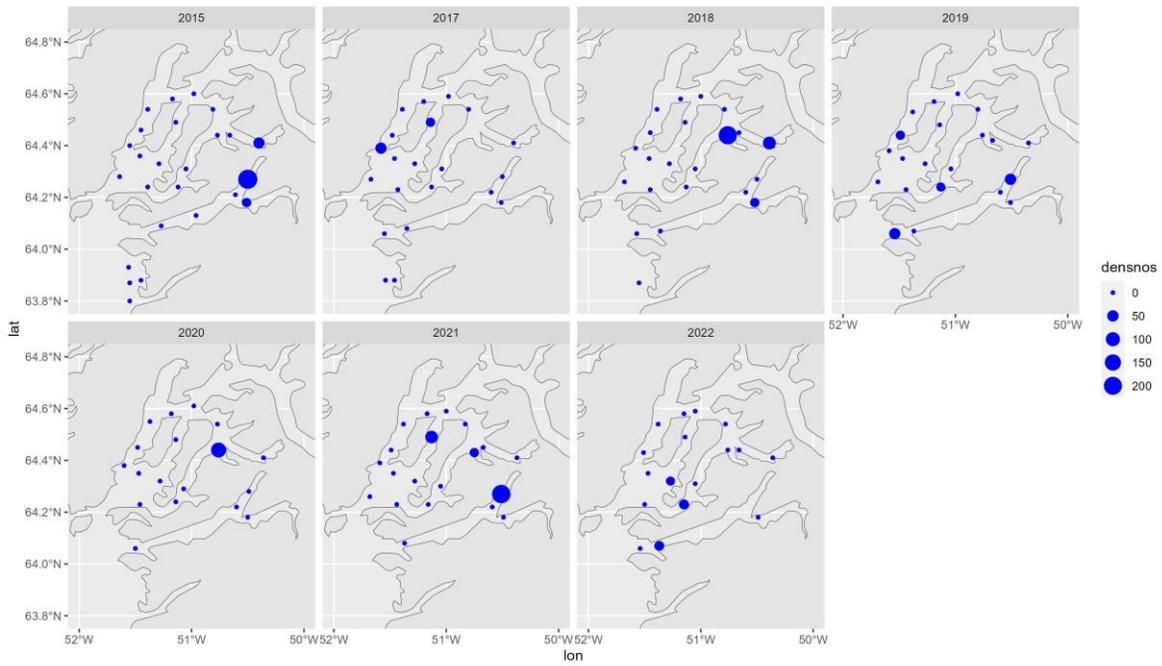


Figure 21. Survey abundance densities for Golden redfish.

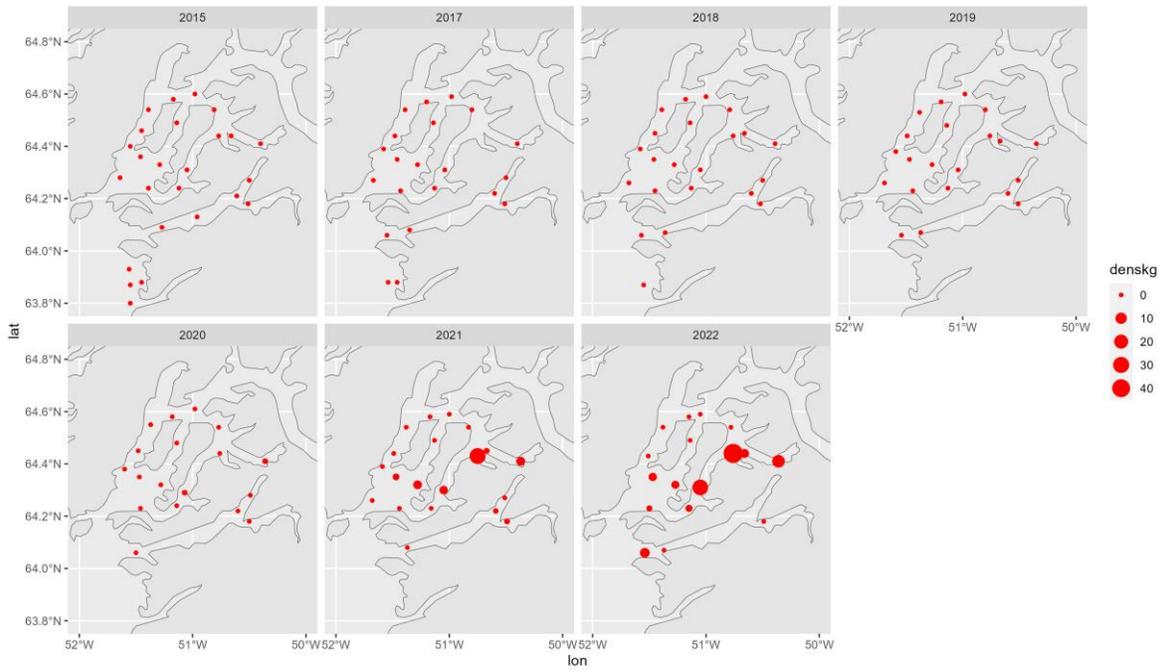


Figure 22. Survey biomass densities for juvenile redfish.

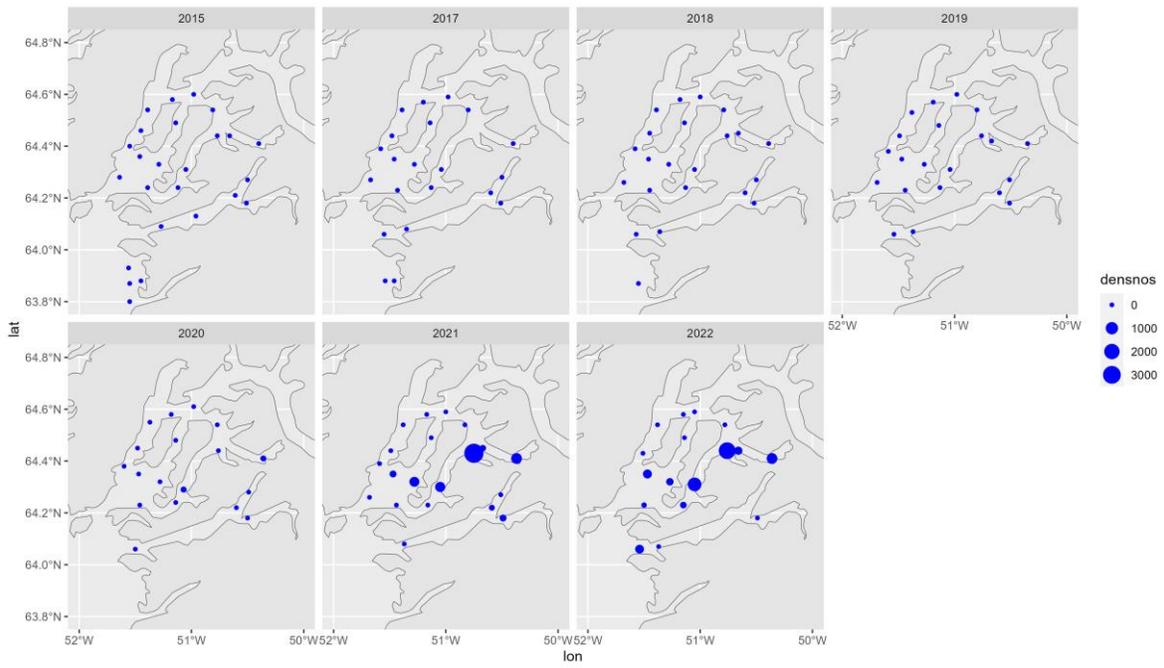


Figure 23. Survey abundance densities for juvenile redfish.

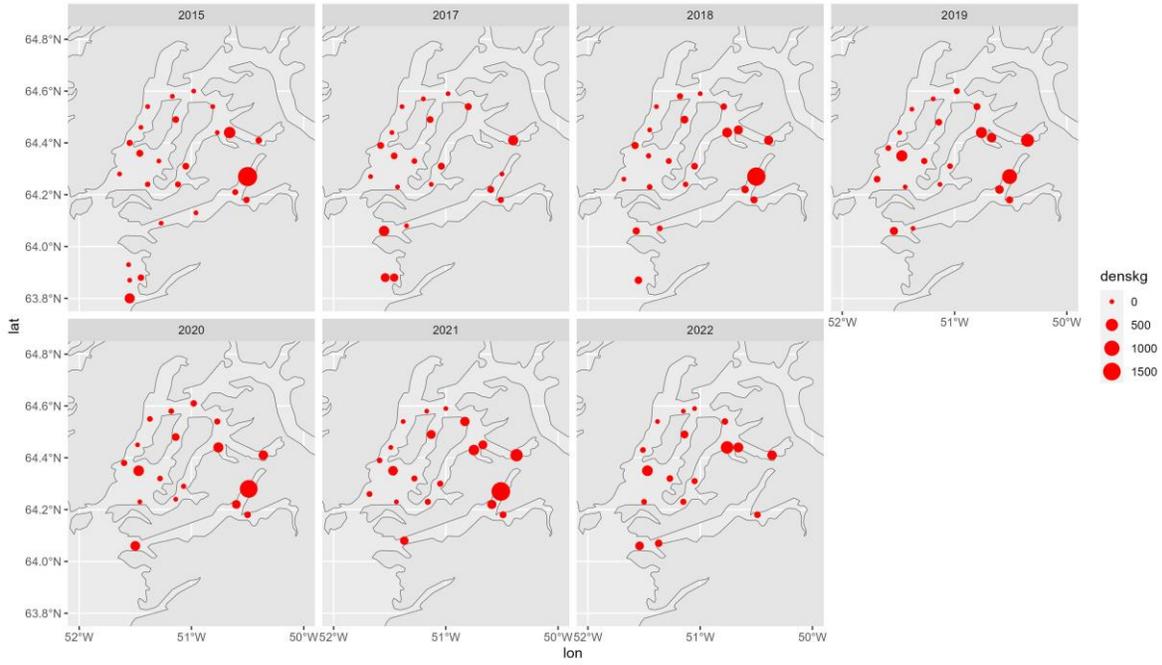


Figure 24. Survey biomass densities for American plaice.

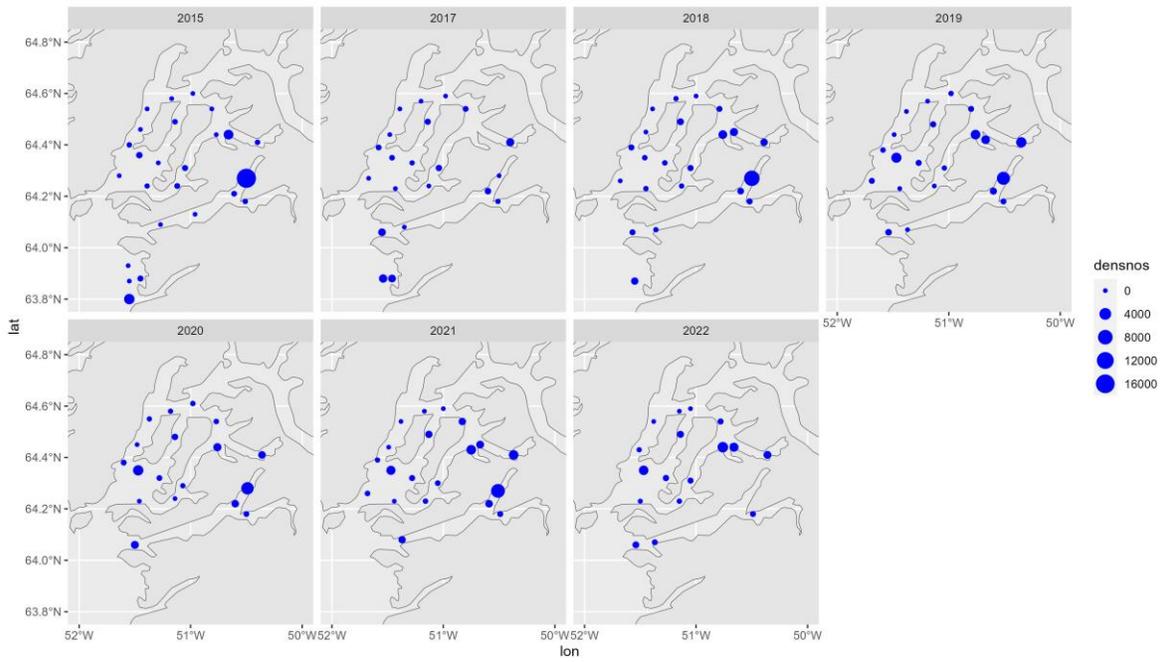


Figure 25. Survey abundance densities for American plaice.

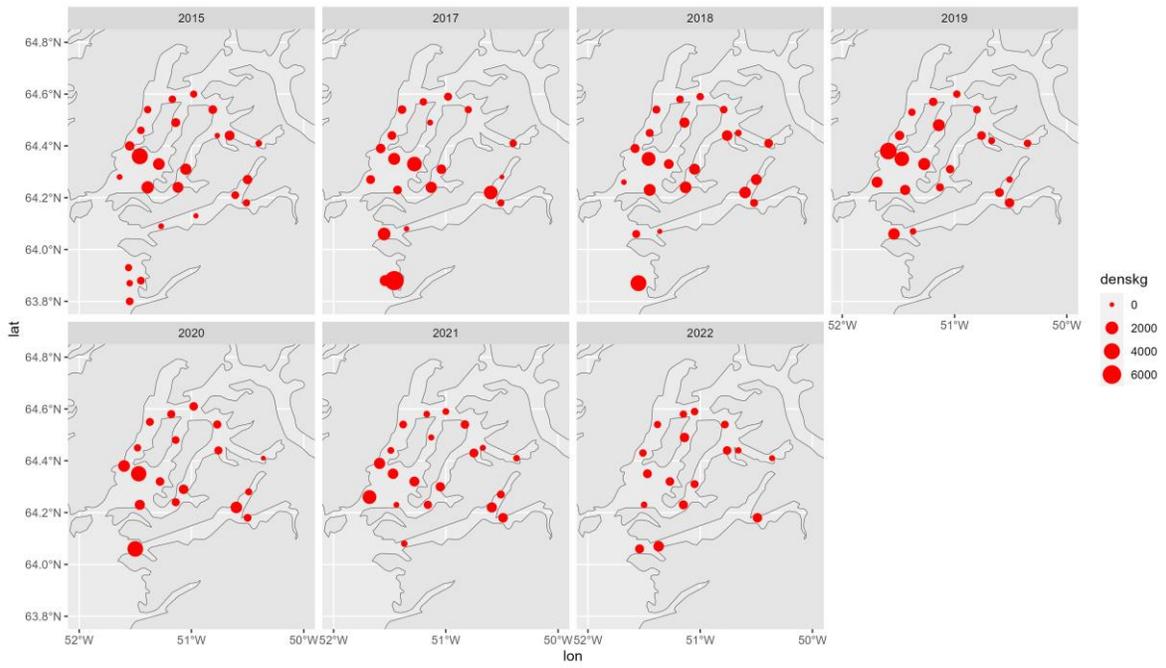


Figure 26. Survey biomass densities for shrimp (mostly).

