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Assessment of the Greenland Halibut Stock Component in NAFO Subarea 0 + 1 (Offshore)

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Abstract

The paper presents background and the input parameters for Greenland halibut in NAFO Subarea 0 and 1 (offshore) from research survey and commercial fisheries data. Since 1995 catches have been near the TAC, increasing in step with increases in the TAC, reaching a high of 36,446 t in 2019. Greenland and Canada have been conducting buffered stratified random bottom trawl surveys in Div. 1CD and 0A-South which are combined for the stock assessment. In 2019 the vessel used for these surveys since 1997 was changed and the timing of the survey was about 6 weeks earlier. These changes have had an effect on the results of the survey such that the 2019 index is not directly comparable to previous years. The combined 1CD-0A-South biomass index had been relatively stable from 1999 to 2017 with increased variability observed in the last few years and all values were above B_{lim}. Abundance has followed a similar pattern. An index of abundance of age 1 Greenland halibut from the Greenland Shrimp and Fish Survey was generally increasing from 1988 to 2003 and since then there has been a general declining trend with high values observed in 2011, 2013 and 2017. Length frequency distribution for the overall 1CD and 0A-South survey show a trend toward larger sizes with the mode increasing from 42-43 cm in 1999 and 2001 to a high of 51 cm in 2015. Secondary modes are present in 2008 and 2012-2017. Modes in the length frequency distribution for fisheries in Baffin Bay (0A and 1AB) fluctuate between 45-51 cm while modes in Davis Strait fisheries (0B and 1CD) tend to be slightly higher, 45-53 cm. Longline fisheries typically catch a broader size range of fish and in 1CD the modal length was relatively stable at 55 cm during 2001-2016. Gillnets are more selective than longline gear but also tend to catch larger fish and in the SA0 gillnet fishery the modal size for 2006-2014 was around 63 cm; since then the mode has decreased to around 58 cm. A standardized CPUE index for trawlers fishing in SA 0+1 has been increasing since 1997 and for gillnets in SA0 the index increased from the beginning of the time series in 2003 to 2015 and since then it has been relatively stable. However, CPUE is known to have limitations as an index of population status and has less weight relative to other indexes in the current assessment.

1. Description of the Fishery, Catches and TAC

TAC Regulation

Greenland halibut in Subarea 0+1, including 1A inshore, came under quota regulation in 1976 when a TAC of 20,000 t was established (Fig. 1). TAC was increased to 25,000 t in 1979. In 1994 analysis of tagging and other biological information resulted in the creation of separate management areas for inshore Div. 1A and Subarea 0+1A (offshore) and 1B-F. The portion of the TAC allocated to Subarea 0+1A (offshore) and 1B-F was 11,000 t and the TAC remained at this level from 1995-2001, during which time the TAC was fished almost exclusively in Div. 0B and Div. 1CD. A series of surveys took place during 1999-2004 in areas of Div. 0A and 1AB that had not been surveyed before. This new information on biomass in the overall stock area resulted in an increase in the overall TAC of 4,000 t in both 2001 and 2003 and 5,000 t in 2006 that were allocated to Div. 0A and 1AB. From 2006 to 2009 the advised TAC in Div. 0A+1AB was 13,000 tons and the TAC for 0B and 1C-F remained at 11,000. Based on an observed positive trend in the 1CD survey index the TAC for Div. 0B+Div. 1CF was increased by 3,000 t in 2010 and the overall TAC for Subarea 0+1 remained at 27,000 t from 2011-2013. In 2014 the TAC for Div. 0A+Div. 1AB was increased by 3,000 tons to 16,000 t based on positive trends in the survey indices and the overall TAC of 30,000 t remained through 2016. In 2016 an index based harvest control rule (HCR) was accepted as the basis for TAC advice and an increase of 2,300 t was advised for the overall Subarea 0+1A (offshore) and 1B-F stock area for 2017 and 2018. Scientific Council allocated the increase equally to 0A+1A(offshore) and 1B, and 0B+1C-F. In 2018 the HCR was used to advise an increase of 4,070 t to the whole of SA0+1A(offshore) and 1B-F. Figure 1 contains the plot of TAC over time.

Catches in Subarea 0 + 1

In 2020 catches have been updated based on clarification of catch for inshore areas. In addition a review of tagging research and fishery data has resulted in the separation of the inshore areas of 1B-F from the offshore catch has been adjusted accordingly. Catches were first reported in 1964 and rose to 18,303 t in 1975 before declining to 187 t in 1986 (Fig. 1). Catches then increased to 17,888 t in 1992 due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands, and an expansion of the 1CD fishery with participation by Japan, Norway and Faeroe Islands (Tables 1 and 2). Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC, increasing in step with increases in the TAC reaching a high of 36,446 t in 2019 (Fig. 1).

Inshore fisheries in the fjords of Div. 1A-F and in Cumberland Sound in Div. 0B are not included in the catch. However, there is no way to differentiate or separate these inshore catches from the total reported catches for these divisions in STATLANT so it is necessary to rely on the Greenland and Canadian authorities to determine the offshore catch for Subareas 0 and 1.

Bottom otter trawl gear is primarily used in the Subarea 1 fishery while the Subarea 0 fishery is a mix of trawl and gillnet (between 30-40% of the catch in recent years). Longline gear is used occasionally in both Subareas. The trawlers have been using both single and double trawl configurations since about 2000. The gillnet fishery in Subarea 0 began in 2005 and has been using baited gillnets since about 2015. These baited gillnets have recently been reported to increase catch of Greenland halibut by 150% to 250%, depending on how the bait was attached to the gear (Bayse and Grant 2020).

Bycatch and Discards

Reported discards of Greenland halibut in the trawl fishery in both Subareas is small, normally < 1% of the total catch. Discards in the Subarea 0 gillnet fishery are slightly higher but usually not more than 2% of the total catch.

By-catch is estimated by observers on board vessels in Subarea 0 where targeted at-sea observer coverage is 100% for both the trawl and gillnet fisheries in Div. 0A, 100% for the trawl fishery in Div. 0B and 20% for the gillnet fishery in Div. 0B. A summary of by-catch was done for 2019. Bycatch was <2 % of the observed Greenland halibut catch in all but the 0B trawl fishery where it was 5% (Table 3). The Div. 0B trawl bycatch is mainly comprised of 4 species, Greenland shark, roughhead grenadier, spinytail skate and northern wolffish. The 0B gillnet bycatch is very low, likely due to reduced sampling and is not considered representative, In Div. 0A the trawl bycatch was comprised mainly of Greenland shark, skate species, and roughhead grenadier. The 0A gillnet bycatch is primarily roughhead grenadier (Table 3).

2. Research Survey Data

2.1 Surveys conducted during 1987 to 1996

Surveys began in SA0 and SA1 in the mid 1980's with surveys conducted in 0B by Russia and Germany and in 1BCD jointly by Greenland and Japan (Fig. 2). Since 1997 surveys have been conducted in 0B and 0A-South by Canada and in 1CD by Greenland using the same research vessel (Fig. 2).

2.2 Greenland and Canada Surveys in Divisions 1CD (Davis Strait) and 0A-South (Baffin Bay)

Greenland and Canada have conducted buffered stratified random bottom trawl surveys at depths 400 m to 1500 m in Div. 1CD (since 1997) and in Div. 0A-South (to approximately 72^{o} N) (since 1999) using the Greenland Institute of Natural Resources research vessel R/V Paamiut (Treble 2020, Nogueira and Estevez-Barcia 2020). The 0A-South area was re-stratified in 2008 to include the full extent of Division 0A and to match the depth categories used in the Greenland Subarea 1 stratification. No survey was conducted in 2018. In 2019 there was a change in the research vessel (C/V Helga Maria) and in the survey timing; August instead of Sept for Div. 1CD and August instead of September-October for 0A-South.

General Additive Models (GAMs) were used to examine the abundance relative to depth and distance from shore for the survey time series. If the stock distribution is different in 2019 compared to previous years this could affect how the results are used and interpreted in the assessment (Wheeland et al. 2020). There was no indication of a difference in distribution for the 2019 Div. 1CD survey. However, for Div. 0A-South abundance was highest in the shallow, inshore areas in 2019 and the proportion of biomass in the shallowest strata (400-600, 601-800 m) were the highest in the series. Also, the fish in the shallower depth strata were larger in 2019 than in previous years (Treble 2020, Nogueira and Treble 2020). The species distribution is known to extend inshore, with inshore/offshore movements, therefore this analysis suggests an unknown portion of the stock may have been beyond the 0A-South survey area during the 2019 survey.

The effect of the vessel change on the 2019 survey was examined by looking at gear performance variables (e.g. net height and door distance) and survey length frequency of fish 35-70 cm and >70 cm (Nogueira and Treble 2020). The difference in mean net height (23 and 27%) and door spread (-7 and -10%) for 0A-South and 1CD surveys, respectively, in 2019 compared to 2005 to 2017 suggests an impact of the vessel change on the gear performance. Data reviewed for the 1CD survey suggests 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. When the R/V Paamiut was fishing, mean net height typically decreased from 5.5 m to approximately 5.0 m and door spread increased from 134 m to approximately 147 m (at depths > 701 m), this is considered typical trawl behaviour when depth of fishing changes (Table 4). For the C/V Helga Maria the mean net height increased from 5.8 to 6.2 (at depths 701-1000 m) and 6.8 (at depths 1001-1500 m) while door spread remained relatively stable (130 to 134.5 m) (Table 4) (Nogueira and Treble 2020). This data suggest the R/V Paamiut could have been fishing with better bottom contact in deeper waters, and if this is true it may have some effects on catchability, depending on species and their behavior, but quantifying this difference in catchability is difficult (Truong Nguyen, DFO, pers. Comm.). 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). The stability in the length frequency distribution for the 1CD survey suggests the gear catchability at deeper depths may not be affecting overall selectivity for Greenland halibut. However, the 0A-South frequency distribution has been more variability in previous surveys and it is harder to determine whether the changes observed in 2019 are due to natural variation and/or an effect due to the changes in vessel or survey timing.

Given the common research vessel and survey protocols it is possible to develop a combined biomass and abundance index for 1CD and 0A-South for years 1999, 2001, 2004, 2008, 2012, 2014-2017 and 2019 (Figs. 3 and 4) (see Nogueira and Estévez-Barcia 2020 and Treble 2020 for individual survey details). Biomass in 1CD and 0A-South combined was relatively stable from 1999 to 2014, varying between 124,000 t and 172,000 t (Fig. 3). It then increased to 213,000 t in 2016, followed by a decline to 138,000 t in 2017. In 2019 biomass was 164,000 t. Abundance has followed a similar trend (Fig. 4) varying between $15.1*10^7$ and $22.8*10^7$. In 2019 abundance was $14.5*10^7$.

The overall length distribution (weighted by stratum area) in 1CD was dominated by a mode at 51cm from 2006 to 2017, an increase from a mode of 45 cm observed in 2000. In 2019 the mode was 53 cm (Nogueira and Estévez-Barcia 2020). There has been more variability in the 0A-south length frequency, with a primary mode around 45 cm and secondary modes varying between 20 and 30 cm (Treble 2020). The frequency distribution for 1CD and 0A-South combined typically ranges from 5 cm to just over 100 cm. In 2019 length ranged from 5 to 108 cm. Modal length has varied between lows of 42 cm and 43 cm in 1999 and 2001, respectively, to a high of 51 cm in 2015. In 2019 the modal length was 51cm. Secondary modes are clearly present in 2008, 2012-2017 (Fig. 5).

Survey Age distribution

There has been uncertainty in the accuracy of age determination methods for Greenland halibut which were resolved at a workshop held in Iceland in 2016 (ICES 2017). Effort is currently under way to age the back log of otoliths in order to provide age data for future assessments. Growth curves for male and female Greenland halibut based on the 2017 0A-South survey sample is given in Treble (2020). In 2017 female ages ranged from 3-32 years and males from 3-28 years. Age at 45 cm was approximately 10 years for both males and females.

Survey Length-at-maturity

Maturity information collected during surveys in SA0 were examined in 2006 and updated in 2009 (Harris et al. 2009). Few fish were found to be mature. For females in 0A-South and 0B the length at 50% maturity (L50) ranged from 67-84 cm and 62-67 cm, respectively. Males don't grow to be as large as females and their L50s in 0A-South were 54-65 cm and in 0B it was 39-43 cm.

2.3 Greenland Shrimp and Fish Survey

Since 1988 surveys with a shrimp trawl have been conducted off West Greenland during July-September. The survey covers the area between 59° N and 72° 30' N (Div. 1A-1F) from 50 m to 600m. The survey area was re-stratified in 2004 based on better information about depths. All biomass and abundance indices have been re-calculated. The re-calculation did not change the trends in the development of the different stocks. The Skjervoy trawl was changed to a Cosmos trawl in 2005. Calibration experiments were conducted (Rosing and Wieland, 2005), and data from 1988 to 2004 were converted so the time series are comparable. The R/V Paamiut was used for the survey from 1991 to 2017. In 2018 and 2019 the C/V Sjuderberg and the C/V Helga Maria, respectively, were used to conduct the survey. An examination of gear parameters found that the effects of these vessel changes had a minimal effect on trawl performance (Nogueira and Treble 2020).

Greenland halibut is widely distributed throughout the 1A-F survey area, but highest concentrations are found in nursery areas in Division 1A, 1B-North and Disko Bay. The biomass and abundance indices increased gradually until 2005 (Fig. 6). Since then biomass has varied with a general decline from 2005 to 2014, followed by a slightly increasing trend. The abundance index has had a generally declining trend since 2004, with the exception of high abundance in 2011, 2013 and 2017. Abundance is mainly driven by year to year variability in the number of one- and two-year old recruits, which typically constitute 80-90% of the Greenland halibut caught during the survey (Nygaard and Nogueira, 2020b).

Clear modes can be found in the length distribution at 12-15 cm and 23 cm, corresponding to year-classes 1 and 2 (Nygaard and Nogueira, 2020b), allowing for the development of a recruitment index using the Petersen-method. The general trend in estimated biomass of age 1 Greenland halibut in the offshore (including available sets in Div. 0A) and inshore (including Disko Bay) areas combined was generally increasing from 1988 to 2003. Since then the index has had an overall declining trend, with the exception of three large year classes producing high abundances of age 1 fish in 2011, 2013 and 2017 (Fig. 7). The index of age 1 in the last two years is considerably lower than in previous years. It is unclear if the age 1 abundance index is representative of future recruitment but it is considered to contribute to the perception of overall stock status.

3. Commercial Fishery Data

In 2019 information on fisheries and sampling in SA1 are available from Greenland (Nygaard and Nogueira 2020a), Russian (Fomin and Pochtar 2020) and German (Fock and Stransky 2020) research reports. Catch data has also been provided directly from Norway. 2019 catch distribution for SA1 and SA0 have been plotted (Figs. 15 and 16).

3.1 Length Distribution

Trawler

Length frequencies from the SA1 trawl fishery were available from the Greenlandic and Russian fisheries in 1AB, since 2002, and from Greenlandic, Norwegian and Russian trawl fisheries in 1CD, since 1987, although sampling effort has varied from year to year. Length frequencies from Canadian trawlers are also available for SA0 from 1997 to 2019. These length frequencies have been combined to create overall length frequency plots for the whole SA0 and SA1, and for Div. 0A+Div. 1AB and Div. 0B+Div. 1CD separately. In SA0 and SA1 the modal length has varied from 49 to 51 cm (Fig. 8). In the Baffin Bay area (0A+1AB) the length frequency range is typically 20 to 90 cm with a mode fluctuating between 45-51 cm (Figure 9). In the Davis Strait area (0B+1CD) the length frequency range is typically 30 to 100 cm with a mode varying between 45 and 53 cm (Figure 10).

Longline

There is occasionally a longline fishery in SA1. Length frequencies were available from Greenland for Divs. 1AB (2001 and 2016) and 1CD (2001, 2005-2009 and 2013). The longline length frequencies have been combined for the whole SA1. Longlines typically catch larger fish (40 to 100+ cm) and in Div. 1CD the modal length has been relatively stable at approximately 55 cm (Figure 11).

Gillnet

Length distributions were available from gillnet fisheries in Div. 0A (2006-2019) and 0B (2012-2016, 2018). Lengths typically range from 40 to 90 cm. Prior to 2014 modal size was approximately 61 cm and since then has varied around 59 cm (Figure 12).

3.2 Catch rate-Standardization

Subarea 0 + Div. 1A (offshore) and Divs. 1B-F Trawl CPUE

A standardized catch rate is produced using a General Linear Model. The fleets used for standardization of catch rates are grouped using NAFO codes (Appendix 1). We aggregated data by Year, Month, Gear and Country code, catches (t) and hours fished. Values less than 10 are removed. CPUE observations were log-transformed prior to the GLM analysis. Data were fit in R v. 4.40.40. (R Core Team, 2020) and least squares means were estimated with package "emmeans" (Lenth et al. 2018).

Catch rates for SA1 were available from logbooks submitted by all countries to the Greenland authorities. Until 2008 the fleets in the catch rate analysis have been grouped by nation, but information about gross tonnage is now available in the Greenland logbook database and the fleets are grouped based on size and gear. This has not changed the trends in the CPUE series, but the SE and CV of the estimates have been reduced significantly.

The standardized CPUE for SA0 and 1 increased from 1999 to 2017 and since then has been relatively stable (Fig. 13) (Appendix 2).

The standardized CPUE for gillnets has been increasing since the series began in 2003 but since 2015 has been relatively stable (Fig. 14) (Appendix 3).

CPUE indices should be interpreted with caution:

1) It is not known how the technical development of fishing gear has influenced the catch rates. For example the catch from single and double trawl gear was often aggregated as "otter trawl" catch when this gear was first introduced to the fishery in the early 2000s and bait has been attached to the gill nets in SA0 beginning in 2015;
2) Coding of gear type in the log books is not always reliable, which can influence the estimation of the catch rates;
3) Changes in fleets and fishing grounds have occurred in both SA0 and SA1.

4. Assessment

Age based analysis are not available for this stock due to the challenges concerning age determination for Greenland halibut. Several workshops have been held over the years to investigate the problems and examine methods. In 2015 agreement was reached on the comparability of methods and labs are now starting to address the back-log of ageing (ICES 2016).

Several attempts have been made over the years to model the stock but none have been accepted:

1) Yield per Recruit Analysis – 1994-1996 (SCR 96/67);
2) XSA – 1996, 1999, 2002 (SCR 02/68), 2003 (SCR 03/54);
3) ASPIC – 1999, 2009, 2012 (SCR 12/031);
4) Schaefer model – 2014 (SCR 14/027).

Previous assessments were based on an index of biomass from surveys conducted in 1CD and 0A-South (following comment from an ICES benchmark meeting on Greenland halibut stocks (ICES 2013) (Fig. 3). The application of the ICES guidance on data limited stocks (DLS) method 3.2 (ICES 2012a and 2012b, ICES 2014) was adopted by SC in 2016 as the basis for advice on SA0+1A (Offshore) and 1B-F Greenland Halibut. This harvest control rule (HCR) was developed and tested as an empirical approach that uses the trend in the stock response to fishing pressure (ICES 2012a, Jardim et al. 2015). The empirical basis was given a generic expression $C_{y+1}=Catch_{recent}*r$ where:

$Catch_{recent}$ is the average catch over some period

r is the trend in development of the stock (normally SSB) over some period (e.g. 7 year time frame, r=mean of recent 3 year/mean of next 4 years).

When the HCR was first applied in 2016 the current TAC was used for the $Catch_{recent}$ term, as catches had been at or very near the TAC in recent years (Jørgensen and Treble 2016). In 2018 the HCR was applied using the advised catch level for 2018 ($Cy+1=Catch_{advised}*r$), according to more recent guidance on the implementation of the ICES Data Limited Stocks 3.2 (Magnusson et al. 2018).

Given the uncertainties described above in Section 2 the comparability between 2019 and previous surveys of 1CD and 0A-South is questionable. As a result we do not recommend using the 2019 combined survey biomass in the assessment and the data are not available to apply the harvest control rule (HCR) (ICES data limited stocks guidance) as a basis for 2019 TAC advice.

5. Reference Points

B_{msy} is not known for this stock. However, SC has recommeded that a proxy for B_{lim} could be estimated based on a survey index that is used as the primary basis for advice. If the highest value of the index coincides with what is thought to be the unexploited state of the stock, then an 85% decline is considered to be an appropriate Blim. If, on the other hand, the highest value of the index is consistent with when the stock is thought to have been fully exploited, i.e. at Bmsy, then a 70% decline would be appropriate (Report of the NAFO Study Group on Limit Reference Points Lorient, France, 15-20 April, 2004 (NAFO 2012)).

In the case of Subarea 0 and 1 (offshore), given the stability in the survey indices during the period 1997-2012 for Div. 1CD and 1999 to 2012 for Div. 0A-South, the stock was considered to be near B_{msy} and the survey indices a proxy for B_{msy}. In 2013 a B_{lim} of 30% of the survey means for Div. 1CD and 0A-South was established for Div. 1CD+0B and Div. 1AB +0A, respectively. In 2014 these two surveys were combined to create a single index for the stock and B_{lim} was recalculated for the period 1999-2012 for this overall stock index (Fig. 22).

6. Conclusions

Given the uncertainties described above in Section 2 the comparability between 2019 and previous surveys of 1CD and 0A-South is questionable. As a result we do not recommend using the 2019 combined survey biomass in the assessment and the data are not available to apply the harvest control rule (HCR) (ICES data limited stocks guidance) as a basis for 2019 TAC advice.

Since 1995, catches have been near the TAC, increasing in step with increases in the TAC, reaching a high of 36,446 t in 2019.

The 0A-South+1CD combined survey biomass index had been relatively stable from 1999 to 2017 with more variability observed in recent years. All values were above B_{lim}. In 2019 biomass was near the series average while abundance was below. However, given the uncertainties in the estimation of the 2019 value it cannot be directly compared to the previous values or B_{lim}.

An index of age 1 Greenland halibut has been developed using the Petersen method applied to the length frequency of Greenland halibut caught in the Div. 1A-F Shrimp and Fish survey (50-600m). Although the survey experienced vessel changes in 2018 and 2019, the results are considered to be comparable with those from earlier years. Since 2003 the index has had an overall declining trend, with the exception of three large year classes producing high abundances of age 1 fish in 2011, 2013 and 2017 (Fig. 11). The index of age 1 in the last two years is considerably lower than in previous years. It is unclear if the age 1 abundance index is representative of future recruitment but it is considered to contribute to the perception of overall stock status.

Based on length frequencies from both the surveys and the commercial fisheries, Greenland halibut in Divisions 0A and 1AB are relatively smaller in size than in Divisions 0B and 1CD. The surveys and trawl fisheries have almost all seen slight increases in modal lengths over the last 10 to 15 years.

A standardized CPUE index for trawlers fishing in SA 0+1 has been increasing since 1997 and for gillnets in SA0 the index increased from the beginning of the time series in 2003 to 2015 and since then has been relatively stable. However, CPUE is known to have limitations as an index of population status.

7. References

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Table 1. Greenland halibut catches (metric tons) by year and country for Subarea 0, 1987 to 2019. Based on STATLANT, with information from Canada used to exclude 0B inshore catch.

	0A			0B			SA0
Year	CAN	Other[a]	TOT 0A	CAN	Other[a]	TOT 0B	Total
1987					388	388	388
1988					1022	1024	1024
1989					907	907	907
1990				589	8255	8844	8844[b]
1991				256	8350	8606	8606
1992				2194	10164	12358	12358
1993	681		681	202	6605	6807	7488[c]
1994					4274	4274	4274
1995	82		82	1574	1292	2866	2948
1996		576[d]	576	2293	1678	3971	4547
1997	3		3	3802	452	4254	4257
1998				3861		3861	3861
1999	517		517	4232		4232	4749
2000	290		290	3893		3893	4183[e]
2001	2628	445[f]	2628	4907		4907	7535
2002	3561		3561	3802		3802	7363[g]
2003	4142		4142	4817		4817	8959
2004	3751		3751	5710		5710	9461
2005	4209		4209	5780		5780	9989
2006	6634		6634	5515		5515	12149
2007	6173		6173	5318		5318	11491
2008	5257		5257	5175		5175	10432
2009	6627		6627	5622		5622	12249
2010	6390		6390	6816		6816	13206
2011	6365		6365	6814		6814	13179
2012	6365		6365	6965		6965	13330
2013	6314		6314	7037		7037	13351
2014	7939		7939	6981		6981	14920
2015	7922		7922	7490		7490	15412
2016	7559		7559	6589		6589	14148
2017	8458		8458	7477		7477	15935
2018	8894		8894	7550		7550	16444
2019	9641		9641	8785		8785	18426

[a] Other countries may include Faroe Islands, Poland, Russia, Estonia, Latvia, Japan, or Norway.
[b] Norwegian catch adjusted for double reporting.
[c] The Russian catch is reported as area unknown, but has previously been reported from Div. 0B.
[d] Caught under a Canadian exploratory fishery charter.
[e] STACFIS estimate was 5438t but Ole had no record of how this was compiled. When I checked I could only confirm 4228 t based on C&A section of 2001 Canada Research Report (including 45 t from Cumberland Sound).
[f] Caught under a Canadian charter, also reported in Canadian catch, so not included in total.
[g] Excluding 782 t reported for 0B in error by Norway to 21A and 239 t missing from 0A

Table 2. Greenland halibut catches (metric tons) by year and country for Subarea 1 from 1987 to 2019, not including inshore areas. Based on STATLANT, with information from Greenland used to exclude 1A-F inshore catch.

	1AB			Total	1CF						Total	SA1
Year	GRL	RUS	FRO	1AB	GRL	RUS	FRO	EU	NOR	JPN	1CF	Total
1987				0	917					855	1772	1772
1988				0	32					1576	1608	1608
1989				0	0					1300	1300	1300
1990				0	613		54			985	1652	1652
1991				0	838		123		611	673	2245	2245
1992				0	52		151		2432	2895	5530	5530
1993				0	0	5	128	46	2344	1161	3684	3684
1994				0	614		780	266	3119	820	5599	5599
1995				0	1320	296		527	2472	323	4938	4938
1996				0	1772	254		455	1785		4266	4266
1997				0	2305		127	446	1893		4771	4771
1998			117	117	2287	543	125	350	1338		4643	4760
1999				0	2524	552	116	330	1360		4882	4882[a]
2000			96	96	2053	792	147	444[b]	1590		5026	5121
2001	338	85	150	573	1981	829	150	537[b]	1550		5047	5620
2002	1609	279	150	2038	2252	654	150	536	1734		5326	7364
2003	3538	259	117	3914	1938	1328	135	543	1423		5367	9354[cd]
2004	3460	241	153	3854	1992	1214	150	665[f]	1364		5385	9380[ce]
2005	3340	549	125	4014	2271	1147	149	549	1456[b]		5572	9586[e]
2006	5512	565	128	6205	1986	1222	147	544	1379		5278	11483[e]
2007	5595	575	125	6295	1661	689	150	1516	1441		5457	11752[e]
2008	5522	570	149	6241	1421	763	184	1517	1452[b]		5337	11578
2009	6093	517	124	6734	1212	1057	149	1511	1514		5443	12177
2010	5681	654	126	6461	2129	1214	152	1818	1581		6894	13355
2011	5708	648	102	6458	2254	865		1824	1720		6663	13121[e]
2012	5807	546	103	6456	2256	1227		1784	1761		7028	13484
2013	5852	546	102	6500	2257	1223		2017	1496		6993	13493[e]
2014	7315	550	102[b]	7967	2269	1224		1751	1464		6708	14675[f]
2015	7295	548	102	7945	2379	1215		1880	1503		6977	14921[f]
2016	7641	550	103	8294[g]	2380	1215		1885	1382		6862	15156[f]
2017	7918	549	103	8570	2971	1224		1929	1495		7619	16189[f]
2018	7953	550	104	8607	3079	1121		1878	1488		7566	16173[f]
2019	8821	549	103	9473	3995	1122		1927	1503		8547	18020[f]

[a] Excluding 7603 t reported to STATLANT in error.
[b] Catch reported to the Greenland Fisheries License Control Authority.
[c] Includes Spanish research fishery catch, 75 t in 2003 and 141 t in 2004.
[d] Excludes 1366 t reported for Div. 1A in error.
[e] STATLANT 21A data for Div. ICD from Greenland includes double reporting.
[f] STATLANT unknown catches for Greenland were distributed based on information from Greenland Authorities or assumed to come from Div. 1A inshore.
[g] Norway reported catch in 1A that was actually caught in 1D.

Table 3. By-catch (tons) as reported by at-sea observers in the 2019 Canadian Greenland halibut fishery, by gear and Div. Species selected based on reported catches > 1t. Corresponding catch of Greenland Halibut and bycatch relative to Greenland Halibut catch (%) is also given.

	0A		0B	
Species	**Trawl**	**Gillnet**	**Trawl**	**Gillnet**
Greenland shark (*S. microcephalus*)	20.547	0.197	69.411	
Black Dogfish (*C. fabricii*)			5.092	
Skates sp.	6.427	2.681	3.454	
Spinytail skate (*R. spinicauda*)	13.337		27.464	
Arctic skate (*A. hyperborea*)	12.298	2.012		
Jensen's skate *(R. Jenseni)*	11.635	1.88		
Roughhead grenadier (*M. berglax*)	10.006	11.92	42.344	
Roundnose grenadier (*C. rupestris*)			5.373	0.821
Grenadier sp.			7.626	
Blue Hake (*A. rostrata*)	2.301		8.145	
Spiny Eel (*N. chemnitzi*)			2.351	
Redfish (Sebastes)	1.771	2.876	5.273	
Northern wolffish (*A. denticulatus*)	5.006	0.762	79.722	0.165
Spotted wolffish (*A. Minor*)	0.439		0.127	
Sponge (Porifera)			2.312	
TOTAL	83.767	22.328	256.382	0.986
Greenland halibut (*R. hippoglossoides*)	5390.383	3010.947	5115.992	174.371
% of Greenland Halibut catch	1.6	0.7	5.0	0.6

Table 4. 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)		
Survey	Depths	Paamiut 2005-2017 (mean)	Helga Maria 2019	% difference	Paamiut 2005-2017 (mean)	Helga Maria 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)		
Survey	Depths	Paamiut 2005-2017 (mean)	2018 or 2019	% difference	Paamiut 2005-2017 (mean)	2018 or 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

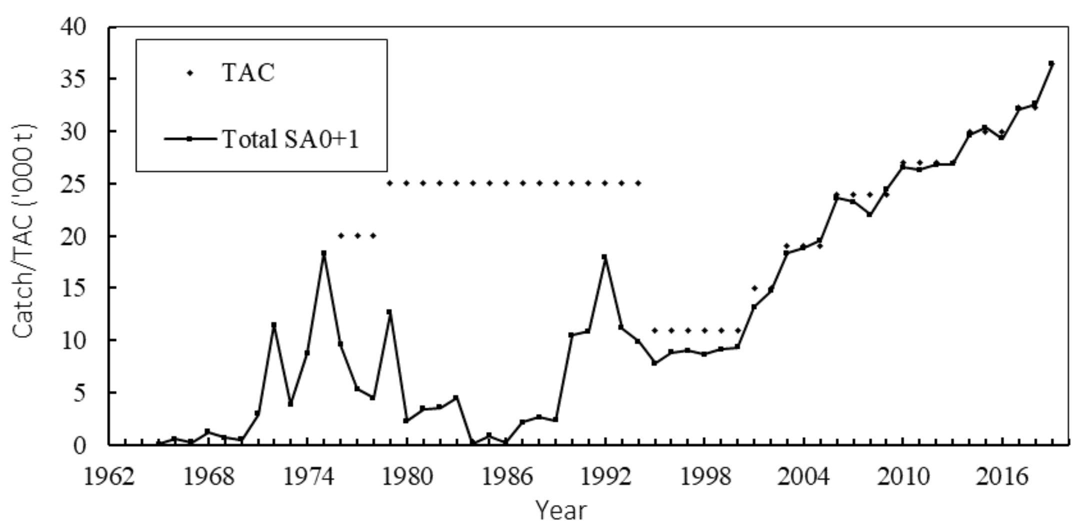

Figure 1. Catches in SA0 and 1 (offshore) and recommended TAC. For information on the TAC before 1995 see text.

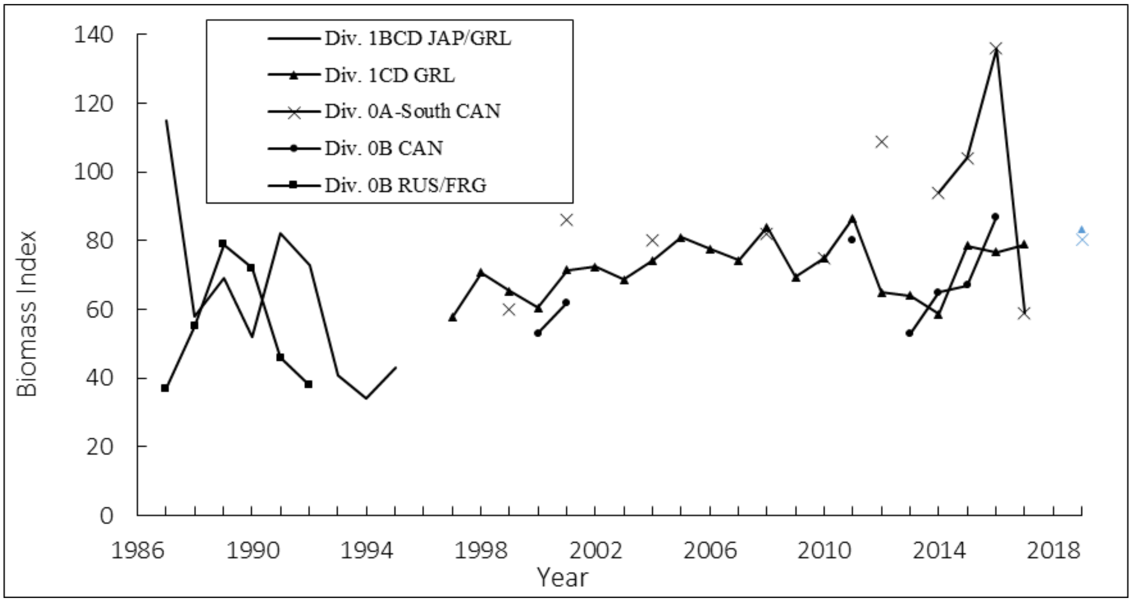

Figure 2. Biomass estimates from surveys conducted in SA 0 and 1 since 1986. There was a change in vessel for the 2019 surveys in 1CD and 0A-South and these estimates are not considered comparable to previous years.

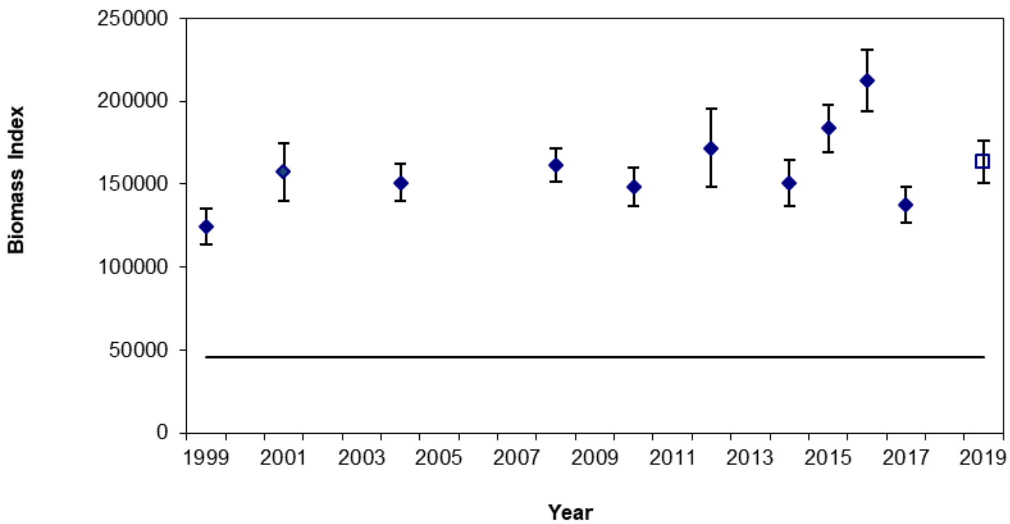

Figure. 3. Combined survey biomass index for Div. 0A-South+Div. 1CD and the series B_{lim} (30% of the mean biomass from 1999 to 2012).

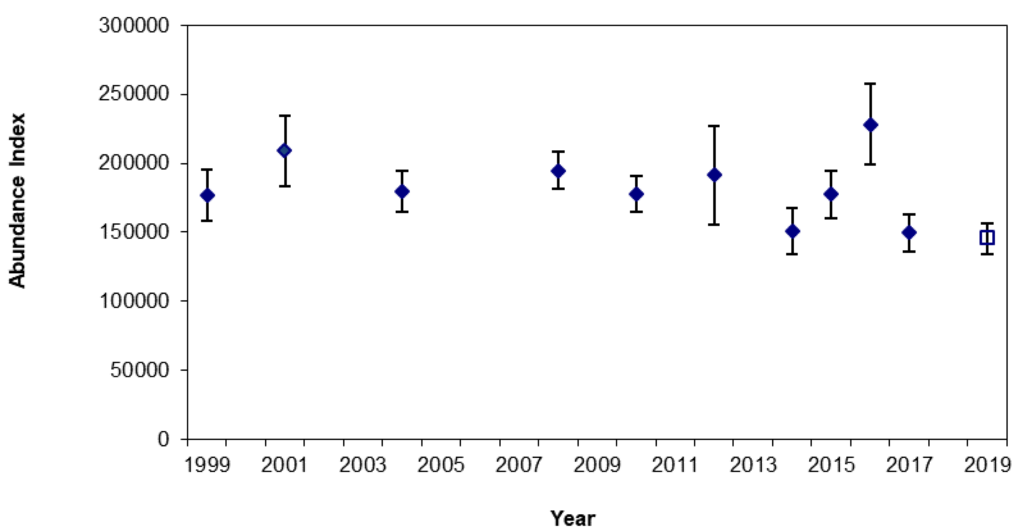

Figure 4. Combined survey abundance index for Div. 0A-South+Div. 1CD.

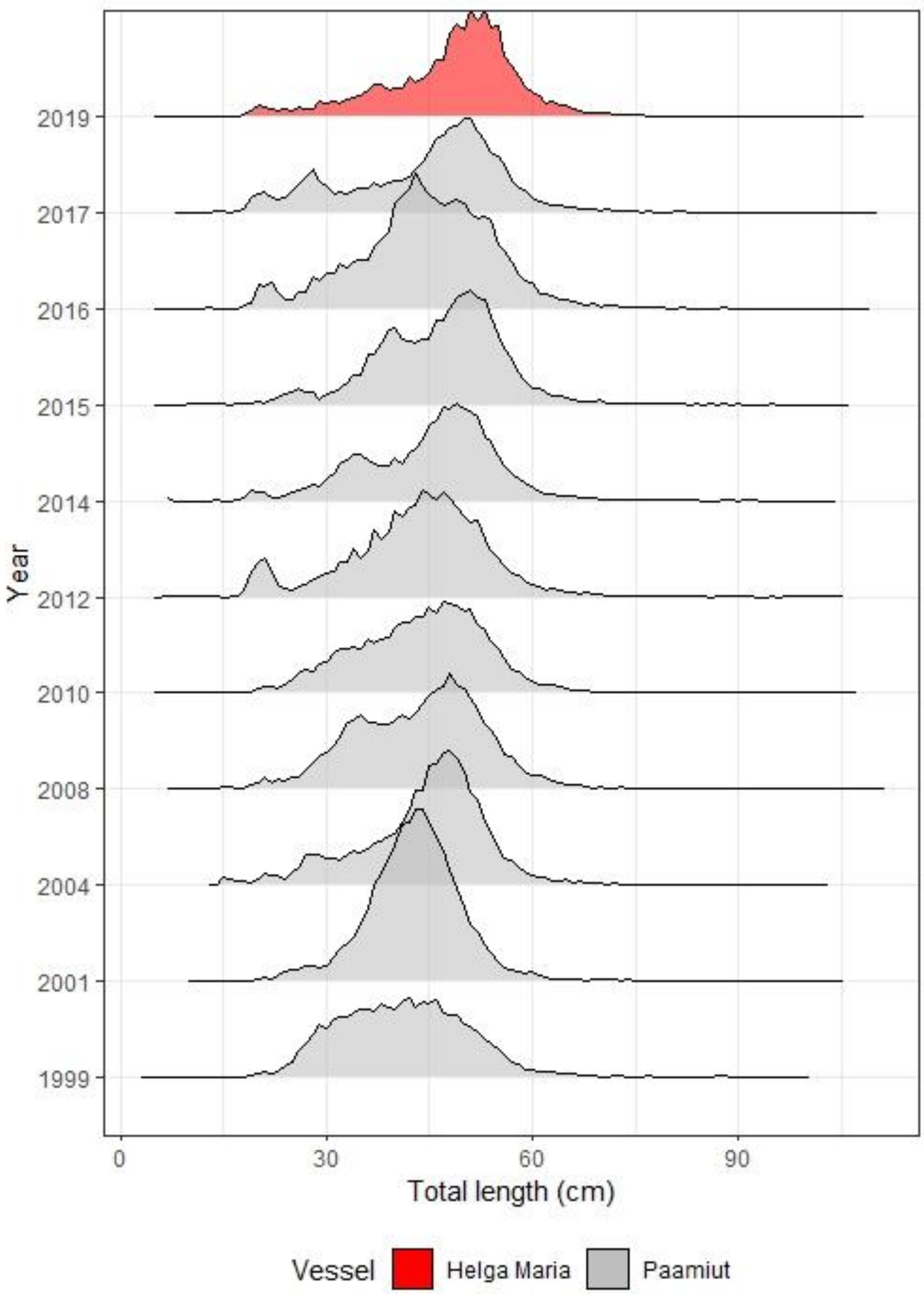

Figure 5. Length distribution of Greenland halibut (numbers weighted by stratum area) for the Div. 1CD and 0A-South surveys.

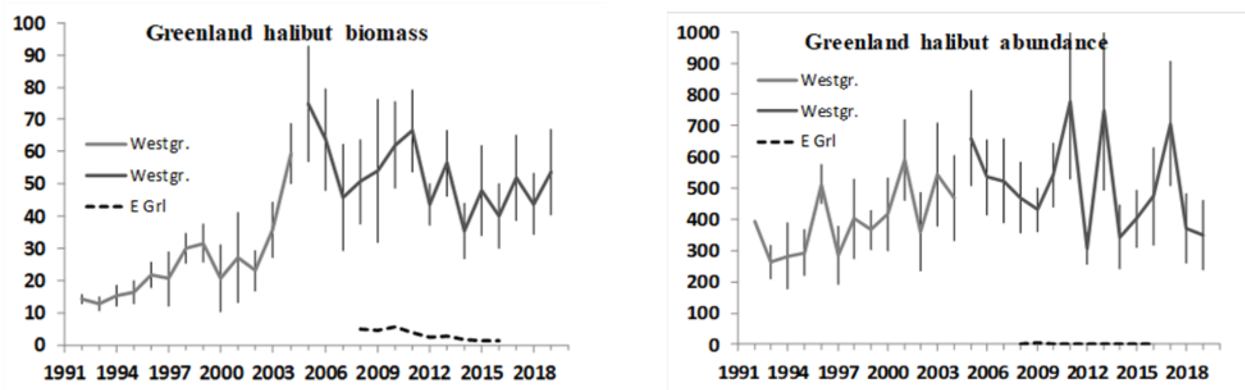

Figure 6. Greenland halibut abundance and biomass indices from the Greenland Fish and Shrimp Survey in 1A-F (50-600 m).

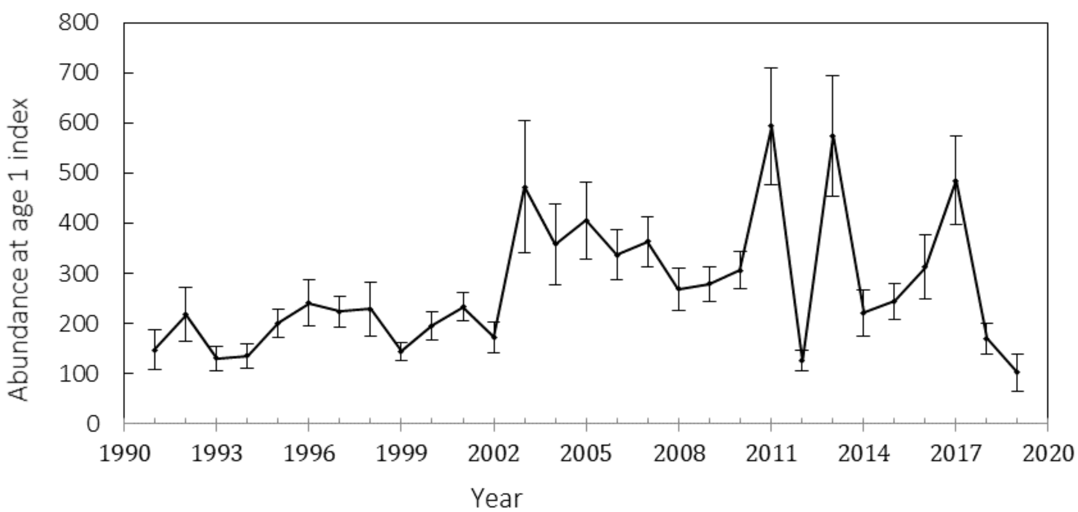

Figure 7. Abundance of age 1 Greenland halibut from the Greenland Fish and Shrimp Survey, for the entire survey area, including inshore Disko Bay, Div. 1A (North of 70°37.5'N) and several sets on the adjacent shelf in 0A.

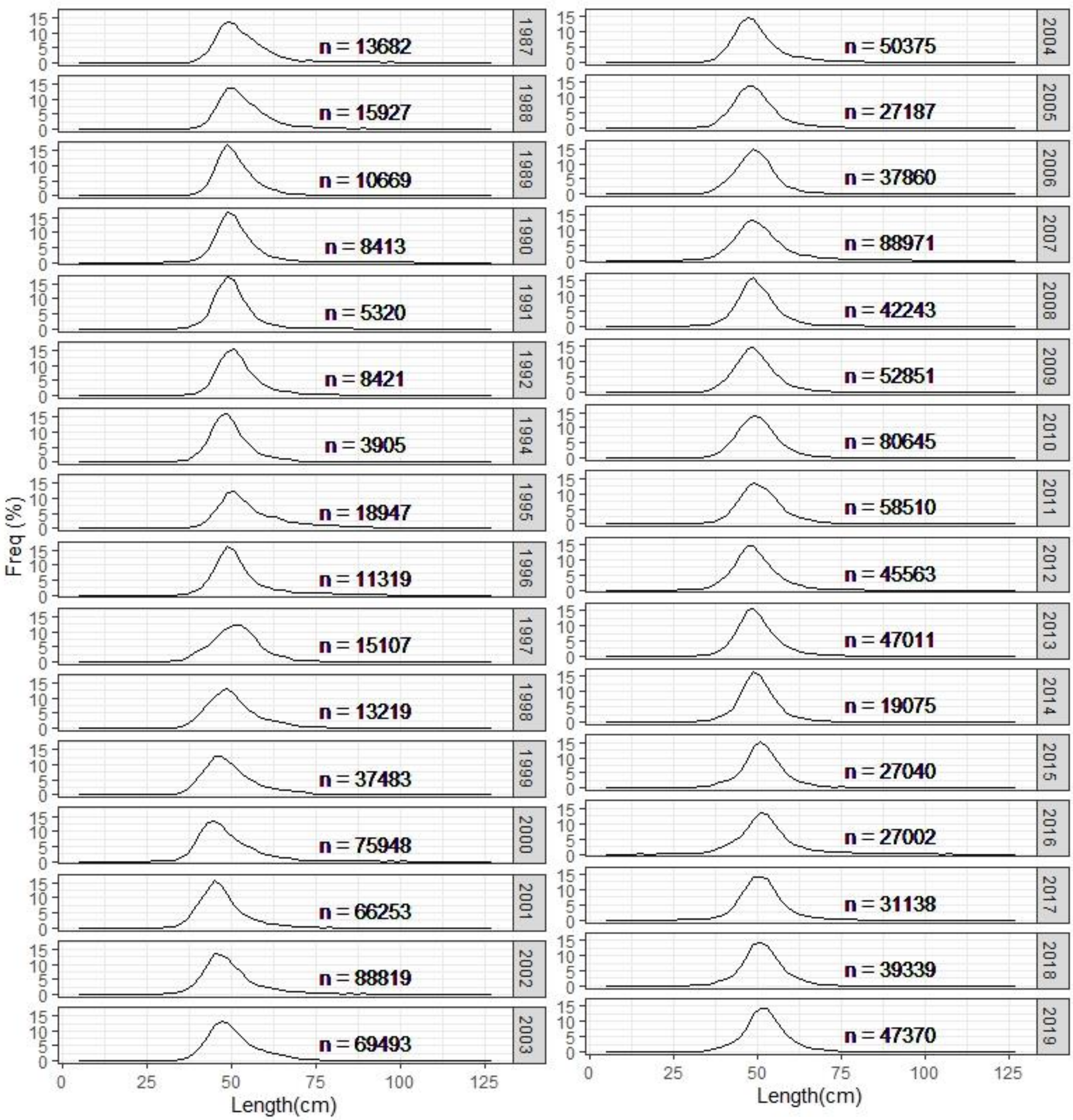

Figure 8. Length distribution from the trawl fisheries in Subarea 0 and Divisions 1A-D offshore. Note data available at this time for Div.0A-1AB begins in 1997.

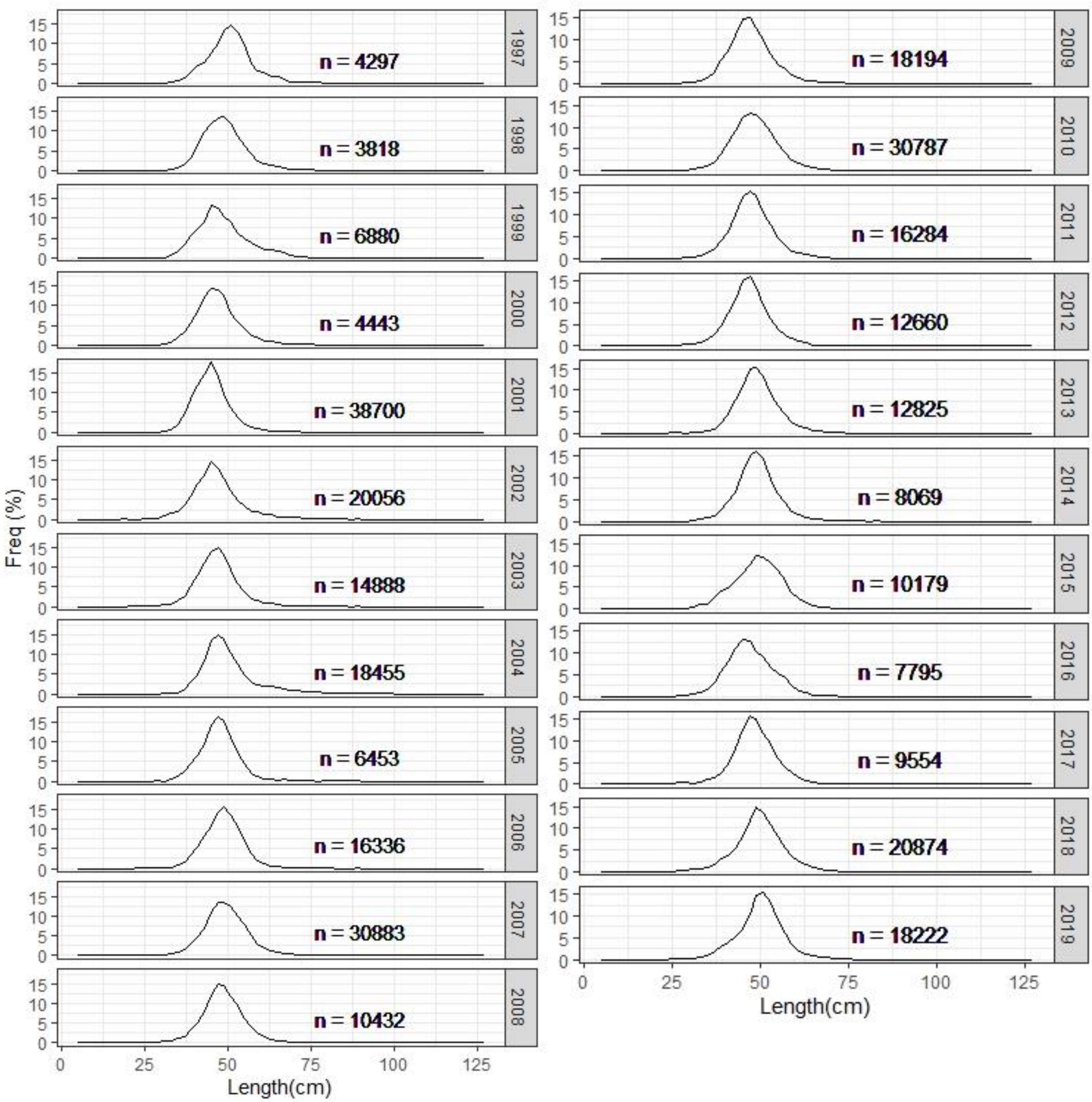

Figure 9. Length frequencies in commercial catches from trawlers in Div. 0A and 1AB .

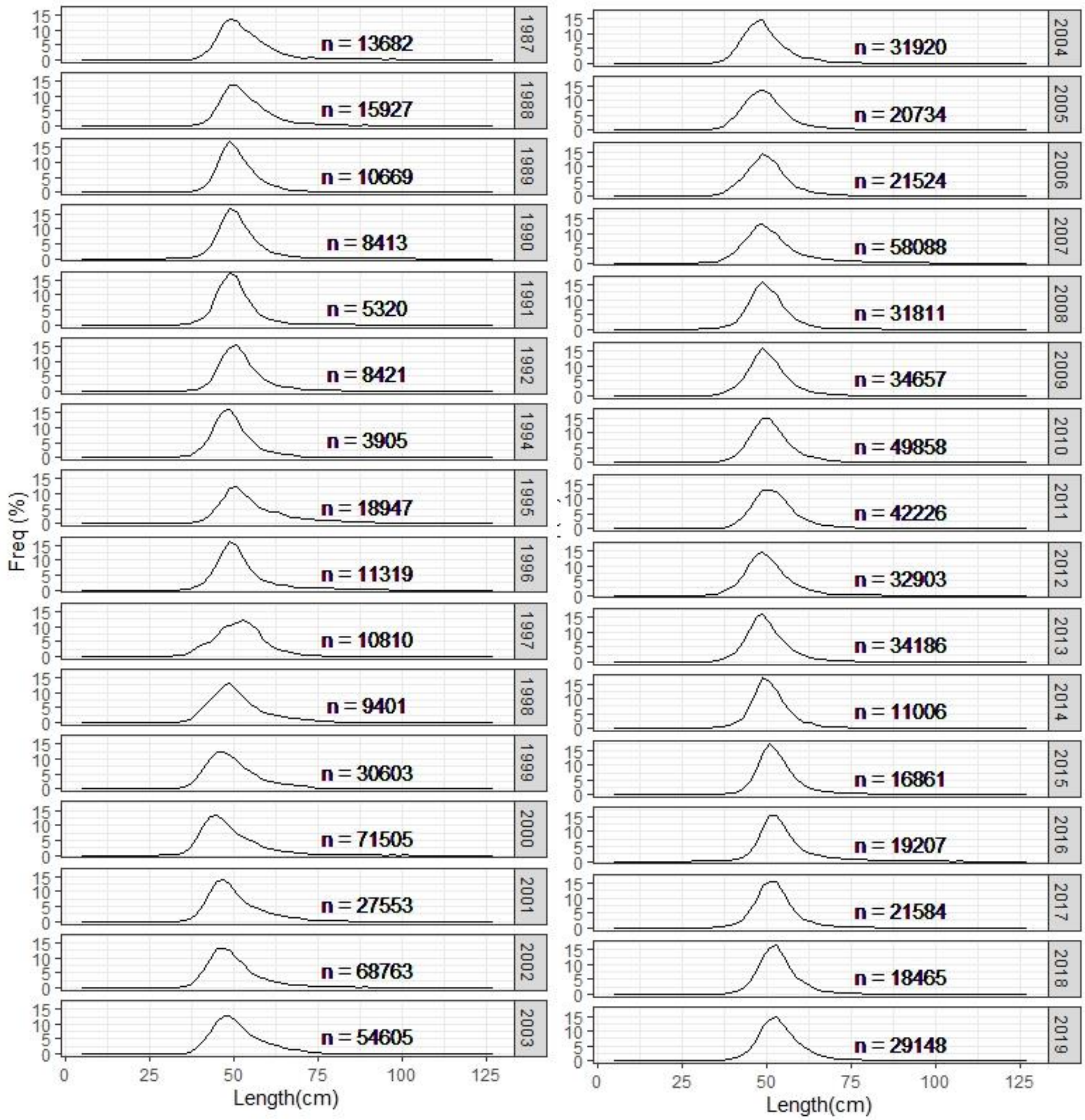

Figure 10. Length frequencies in commercial catches from trawl gear for Div. 0B and 1CD.

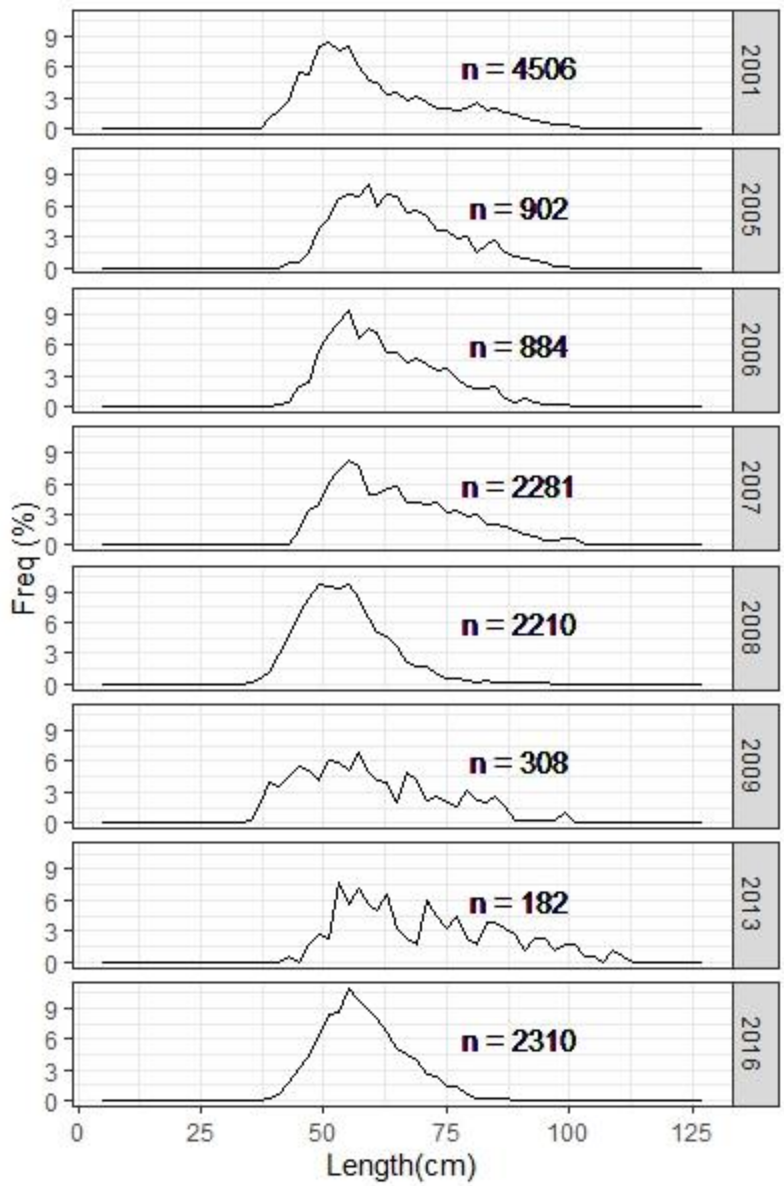

Figure 11. Length frequencies in commercial catches from longline gear for Division 1A-D .

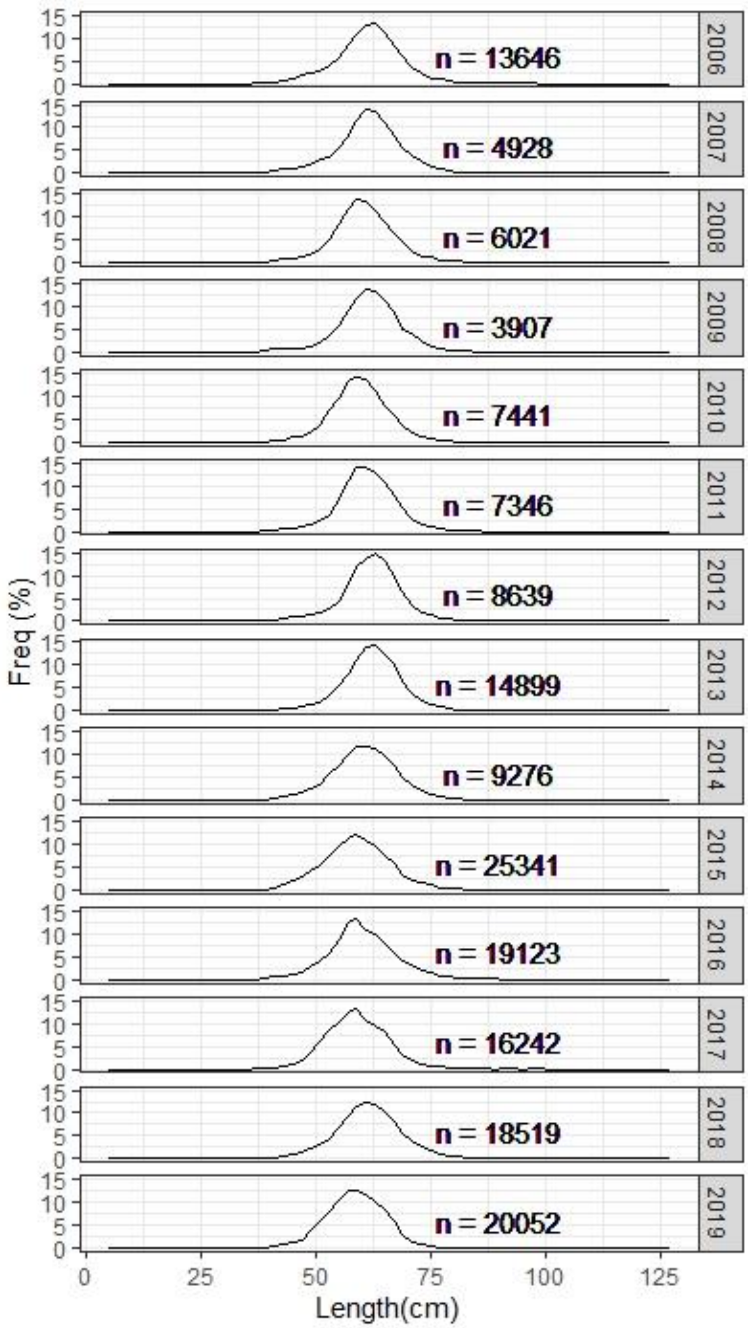

Figure 12. Length frequencies in commercial catches from gillnet gear for Subarea 0.

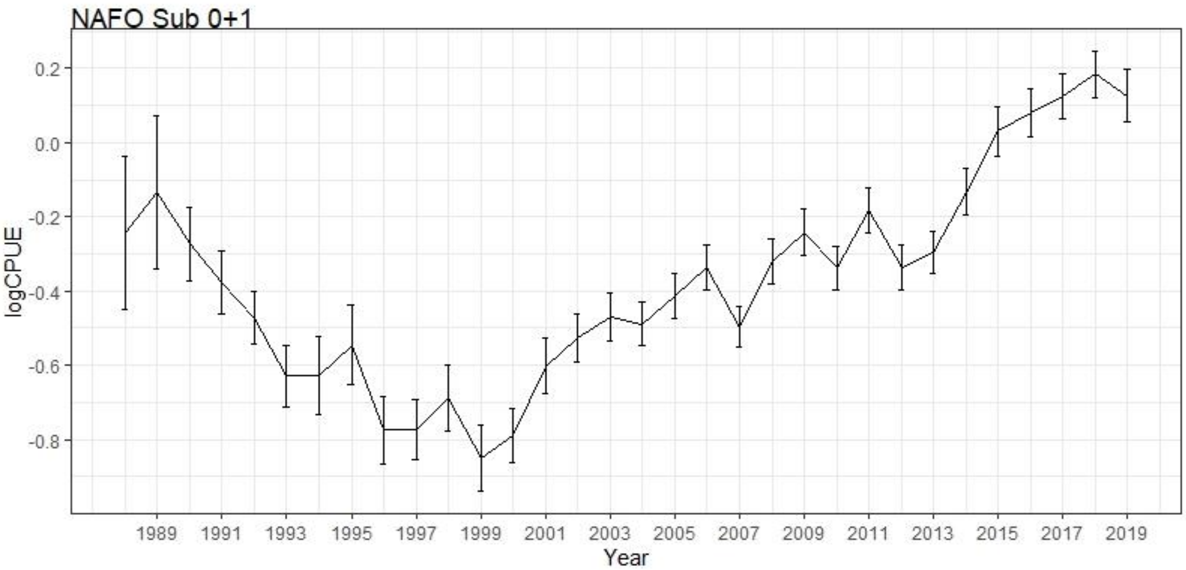

Figure 13. Combined standardized trawl CPUE index from trawlers in SA 0+1, with S.E. Data from 0A in 2019 are not included.

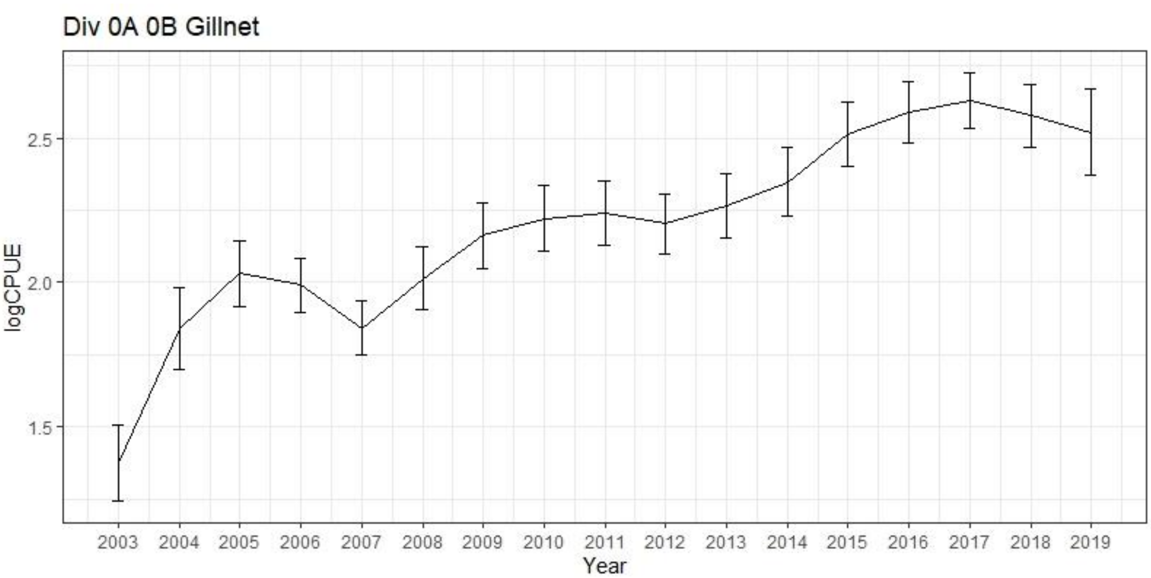

Figure 14. Combined standardized trawl CPUE index from gillnets in SA 0, with S.E.

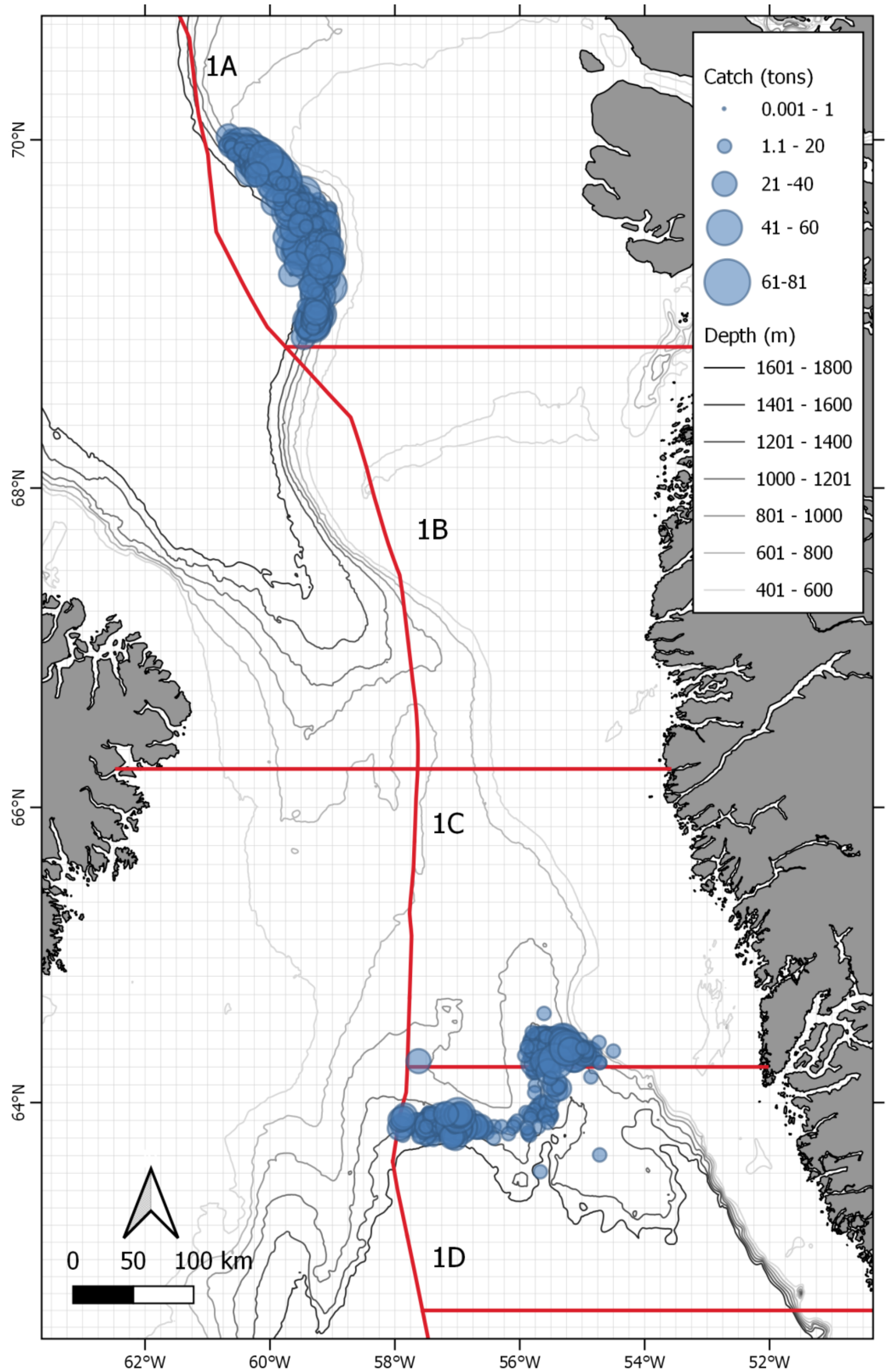

Figure 15. Greenland halibut commercial catch distribution for offshore Subarea 1 in 2019.

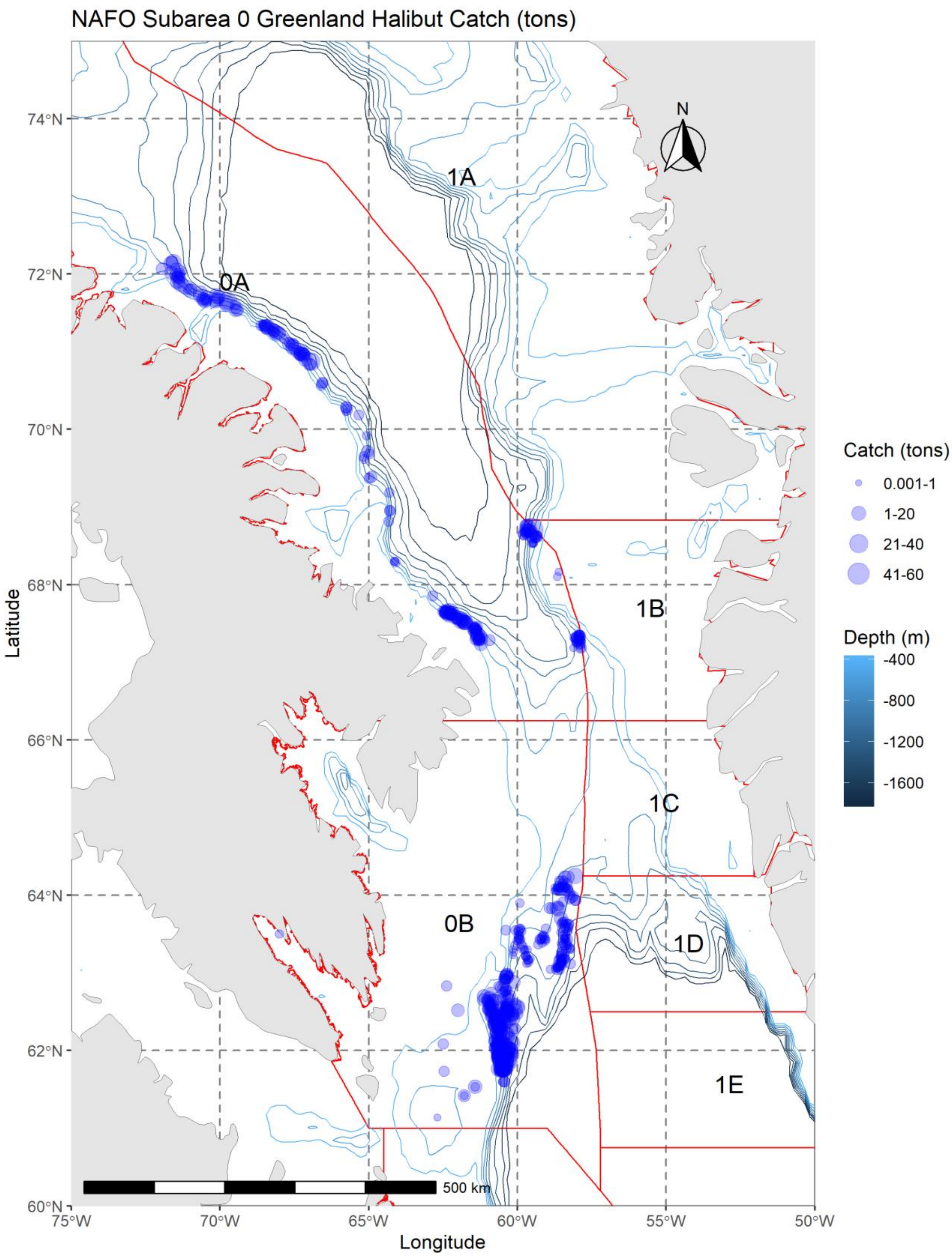

Figure 15. Greenland halibut commercial catch distribution for Subarea 0 in 2019.

Appendix 1. 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

Appendix 2. Standardized CPUE index for trawlers in SA 0+1

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

Residuals:
    Min       1Q   Median       3Q      Max
-1.62233 -0.19269 -0.00021  0.21358  2.67991

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.0005283  0.2443034  -0.002 0.998275
Year1989     0.1092455  0.2409412   0.453 0.650329
Year1990    -0.0304303  0.2181959  -0.139 0.889106
Year1991    -0.1341900  0.2120131  -0.633 0.526891
Year1992    -0.2298091  0.2093872  -1.098 0.272615
Year1993    -0.3866192  0.2147436  -1.800 0.072037 .
Year1994    -0.3834212  0.2185793  -1.754 0.079644 .
Year1995    -0.3028039  0.2205564  -1.373 0.170021
Year1996    -0.5317687  0.2241809  -2.372 0.017837 *
Year1997    -0.5308584  0.2202217  -2.411 0.016068 *
Year1998    -0.4442075  0.2235309  -1.987 0.047110 *
Year1999    -0.6077050  0.2236681  -2.717 0.006677 **
Year2000    -0.5461062  0.2182244  -2.502 0.012456 *
Year2001    -0.3586382  0.2193998  -1.635 0.102372
Year2002    -0.2823186  0.2154505  -1.310 0.190308
Year2003    -0.2271967  0.2145567  -1.059 0.289840
Year2004    -0.2456238  0.2131973  -1.152 0.249497
Year2005    -0.1702171  0.2133888  -0.798 0.425201
Year2006    -0.0950308  0.2148232  -0.442 0.658298
Year2007    -0.2543747  0.2132507  -1.193 0.233152
Year2008    -0.0757647  0.2138597  -0.354 0.723193
Year2009     0.0011099  0.2142051   0.005 0.995867
Year2010    -0.0954139  0.2134588  -0.447 0.654958
Year2011     0.0594780  0.2141443   0.278 0.781251
Year2012    -0.0938082  0.2139656  -0.438 0.661151
Year2013    -0.0544651  0.2132068  -0.255 0.798411
Year2014     0.1103511  0.2143555   0.515 0.606779
Year2015     0.2726840  0.2155894   1.265 0.206162
Year2016     0.3217698  0.2152512   1.495 0.135198
Year2017     0.3676863  0.2143792   1.715 0.086565 .
Year2018     0.4257739  0.2150908   1.980 0.047973 *
Year2019     0.3688688  0.2168173   1.701 0.089132 .
Month2      -0.3113443  0.1097190  -2.838 0.004616 **
Month3      -0.3560666  0.2058469  -1.730 0.083913 .
Month4       0.0416117  0.1200037   0.347 0.728834
Month5       0.2597948  0.0857108   3.031 0.002486 **
Month6      -0.2410840  0.0799269  -3.016 0.002609 **
Month7      -0.2880829  0.0760606  -3.788 0.000159 ***
```

Month8	-0.1963899	0.0728503	-2.696	0.007114	**
Month9	-0.1286865	0.0719206	-1.789	0.073805	.
Month10	-0.1271160	0.0720078	-1.765	0.077750	.
Month11	-0.1753198	0.0726099	-2.415	0.015894	*
Month12	0.0264947	0.0770291	0.344	0.730935	
Boat2127	0.1910864	0.1481429	1.290	0.197326	
Boat3124	-0.4543957	0.2961183	-1.535	0.125152	
Boat3125	-0.8755212	0.1719390	-5.092	4.07e-07	***
Boat3126	-0.0467123	0.1480740	-0.315	0.752459	
Boat3127	-0.2077465	0.1291778	-1.608	0.108033	
Boat5126	-0.6222463	0.1778053	-3.500	0.000482	***
Boat5127	0.0440046	0.1344084	0.327	0.743423	
Boat6125	-1.7027799	0.3020856	-5.637	2.13e-08	***
Boat6126	-0.2553010	0.1290525	-1.978	0.048112	*
Boat6127	0.2829973	0.1270160	2.228	0.026051	*
Boat14124	-0.4002410	0.1557586	-2.570	0.010293	*
Boat14125	-0.0876590	0.2367767	-0.370	0.711281	
Boat14126	-0.1255960	0.1814108	-0.692	0.488856	
Boat14127	0.1877020	0.1635612	1.148	0.251350	
Boat15125	-0.5392537	0.1528030	-3.529	0.000432	***
Boat15126	-0.1299505	0.1299664	-1.000	0.317559	
Boat15127	0.0019241	0.1316279	0.015	0.988340	
Boat16127	-0.2828398	0.2613969	-1.082	0.279442	
Boat20125	-0.4350780	0.4074289	-1.068	0.285784	
Boat20126	-0.7433255	0.1487802	-4.996	6.66e-07	***
Boat20127	-0.6104584	0.1641084	-3.720	0.000208	***
Boat21926	0.5001719	0.2261439	2.212	0.027161	*
Boat21927	0.5304512	0.1448103	3.663	0.000259	***
Boat27126	-0.3219945	0.2260566	-1.424	0.154575	
Boat27127	0.2610453	0.1366021	1.911	0.056229	.
Boat31126	-0.1577412	0.3011215	-0.524	0.600477	
Boat31926	0.4844523	0.1738671	2.786	0.005409	**
Boat31927	0.1190641	0.1309094	0.910	0.363249	
Boat32125	-0.3358216	0.2613969	-1.285	0.199123	
Boat33126	-0.1670696	0.3040271	-0.550	0.582743	
Boat34126	-0.3766593	0.1295375	-2.908	0.003703	**
Boat34127	-0.3135878	0.1690154	-1.855	0.063772	.
Boat38125	-0.1557493	0.1828689	-0.852	0.394541	
Boat38126	-0.0984622	0.1294294	-0.761	0.446952	
Boat38127	0.0553842	0.1470509	0.377	0.706509	
Boat40126	-0.0028083	0.2010005	-0.014	0.988855	
Boat40127	0.0889722	0.1306038	0.681	0.495845	
Boat51926	0.1050626	0.3049876	0.344	0.730541	
Boat51927	-0.0582050	0.1669413	-0.349	0.727405	
Boat61926	0.0057583	0.1467907	0.039	0.968715	
Boat61927	0.2955618	0.1294828	2.283	0.022615	*
Boat151927	-0.1708567	0.2298995	-0.743	0.457509	
Boat271927	0.1865309	0.4066110	0.459	0.646495	
Boat401926	0.5345296	0.1875524	2.850	0.004442	**

Boat401927	0.4020769	0.1304687	3.082	0.002102	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3795 on 1280 degrees of freedom
Multiple R-squared: 0.5885, Adjusted R-squared: 0.5606
F-statistic: 21.04 on 87 and 1280 DF, p-value: < 2.2e-16

Appendix 3. Standardized CPUE index for gillnets in SA 0

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

Residuals:

Min	1Q	Median	3Q	Max
-1.35510	-0.13218	0.01288	0.14656	1.53727

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.52258	0.35155	4.331	2.55e-05	***
Year2004	0.46596	0.16264	2.865	0.004708	**
Year2005	0.65479	0.15025	4.358	2.29e-05	***
Year2006	0.61486	0.14236	4.319	2.68e-05	***
Year2007	0.46717	0.13529	3.453	0.000702	***
Year2008	0.63745	0.13974	4.562	9.78e-06	***
Year2009	0.78656	0.14234	5.526	1.24e-07	***
Year2010	0.84631	0.14234	5.946	1.56e-08	***
Year2011	0.86386	0.14234	6.069	8.37e-09	***
Year2012	0.82687	0.13819	5.983	1.29e-08	***
Year2013	0.88934	0.14234	6.248	3.33e-09	***
Year2014	0.97287	0.14767	6.588	5.56e-10	***
Year2015	1.13899	0.14234	8.002	1.96e-13	***
Year2016	1.21290	0.14051	8.632	4.58e-15	***
Year2017	1.25485	0.13985	8.973	5.76e-16	***
Year2018	1.20152	0.14451	8.315	3.08e-14	***
Year2019	1.14473	0.17332	6.605	5.09e-10	***
Month5	-0.02299	0.31055	-0.074	0.941087	
Month6	-0.37243	0.31005	-1.201	0.231371	
Month7	-0.52122	0.30939	-1.685	0.093916	.
Month8	-0.11156	0.30834	-0.362	0.717950	
Month9	-0.08604	0.30851	-0.279	0.780671	
Month10	-0.05388	0.31072	-0.173	0.862544	
Month11	-0.17970	0.31272	-0.575	0.566310	
Month12	-0.35379	0.42897	-0.825	0.410695	
Boat3414	-0.28592	0.11553	-2.475	0.014330	*
Boat3415	0.22620	0.15246	1.484	0.139794	
Boat40413	0.20017	0.20402	0.981	0.327960	
Boat40414	0.06722	0.11937	0.563	0.574144	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2917 on 167 degrees of freedom
Multiple R-squared: 0.6935,   Adjusted R-squared: 0.6421
F-statistic: 13.5 on 28 and 167 DF, p-value: < 2.2e-16