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# Assessment Greenland Halibut Stock Component in NAFO Division 1A Inshore

by

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## Abstract

Inshore fishery for Greenland halibut developed in the beginning of the twentieth century, with the introduction of the longline to Greenland in 1910. The majority of the inshore fishery is concentrated in the Disko Bay and the districts surrounding Uummannaq and Upernavik. The fishing grounds are concentrated near cities and settlements in the area, but also tends to concentrate in areas of iceberg producing glaciers where better fishery is obtained. Access to the ice fjords is limited in some seasons, and varies from year to year. The stocks are believed to recruit from the spawning stock in the Davis Strait, and no significant spawning has so far been documented inshore. Therefore, the stocks are believed to be dependent on recruitment from the offshore spawning areas. There is little migration between inshore and offshore and between the districts and a separate TAC is set for each area. Quota regulations were introduced as a shared total quota in 2008, but in 2012 the TAC was split in two components with ITQ's for vessels and shared quota for open boats.

Total landings in Subarea 1A-inshore for the three areas combined were less than 1.000 tons until 1955 but gradually increased to a level of 5.000 tons by 1985 (fig 2.1). After the mid 1980s landings increased to 25.000 tons in 1999 and have remained at a level of 20.000 to 25.000 since then. In the **Disko bay**, landings increased from about 2 000 t in the mid 1980's and peaked from 2004 to 2006 at more than 12.000 tons. After 2006, landings were halved in just three years without any restrictions on effort, TAC or decreased prizes to explain the decrease. Landings have however gradually increased since then and in 2013 9.073 tons was landed. During the high catch levels from 2004 mean length in the landings and the overall length distribution decreased. The persistent decrease and the shift in length distribution towards smaller size, means that the fishery is currently more dependent on new incoming year classes than a decade ago. In the **Uummannaq** district, landings increased from 3.000 tons in the mid 1980's and peaked in 1999 at more than 8.000 t. Landings then decreased to a level of 5.000 to 6.000 t. In 2013, 7.007 tons were landed from the district which is an increase compared to recent years. Mean length in the longline landings and the overall length distribution have been stable has been stable for almost a decade, suggesting that the contribution of new incoming year classes to the stock is small compared to the total stock and that changes, in the stock both increases and decreases, until now has happened at a slow rate. In the **Upernavik** district, landings increased from the mid 1980's and peaked in 1998 at a level of 7 000 t. This was followed by a period of decreasing landings, but since 2002 catches have gradually increased. In 2013, 6.039 tons were landed from the district, which is less than the set TAC quota, but this can largely be explained by the transition to the ITQ system. Mean length in the longline landings and the overall length distribution have been stable since 1999, suggesting that the contribution of new incoming year classes to the stock is small compared to the total stock and that changes, in the stock both increases and decreases, until now has happened at a slow rate. Total catches has however increased at a higher rate in Upernavik, than in Uummannaq in recent years.

## Introduction

Greenland halibut can be found in all waters around Greenland both offshore and inshore. Settlement occurs both inshore and offshore, but large concentrations of 1 year old recruits are mainly found inshore in the Disko bay and on the Banks West of Greenland particularly in NAFO division 1B and 1A. The Disko bay normally receives large quantities of recruits, but less is known about recruitment inshore in other areas. Large quantities of juvenile Greenland halibut is however yearly observed in trawl surveys, West of Uummannaq and Upernavik.

The Greenland halibut stock component in Div. 1A inshore is considered to be recruited from the stock in the Davis Strait, but the adults appear resident in the fjords and are isolated from the offshore spawning stock (Riget and Boje, 1989). As a result, the inshore component probably does not contribute to the spawning stock in the Davis Strait (Boje, 1994). In samples from Disko Bay <10% of females in the reproductive age, were mature during the assumed peak spawning period in spring (Simonsen and Gundersen 2005). Also in former times only sporadic spawning was observed in the inshore area (Jørgensen and Boje, 1994) and the inshore component is therefore not assumed to be self-sustainable, but dependent on recruits and immigration from the offshore area (Bech, 1995). Evidence that supported this stock structure in 1994 caused NAFO to separate the assessment and advice on the inshore stock components from the offshore component in the Davis Strait and Baffin Bay.

The Disko Bay is of major importance to the shrimp fishing industry and earlier studies of the by-catch of Greenland halibut in the commercial shrimp fishery (Jørgensen and Carlsson, 1998) suggest that the by-catch is considerable and could have a negative effect on recruitment to the inshore stock component. To minimize by-catch of fish in the shrimp fishery, offshore shrimp trawlers have been equipped with grid separators since 2002 and inshore shrimp trawlers (Disko Bay) since 2011. The implementation of sorting grids in the shrimp fishery has led to a protection of juvenile fish species dependant on size and shape. Greenland halibut is in this sense less protected by the sorting grids due to the flat shape than other species with a more round body shape (SCR 07/88). A study of the by-catch in the offshore fishery suggested that grid separators currently used in the shrimp trawl offers high protection for Greenland halibut larger than 25 cm (SCR 07/88). The implementation of grid separators in the inshore component after 2011 may therefore have led to a reduction in fishing mortality in the Disko bay. Besides the Disko bay and a small area inshore in Division 1 B there is no trawl fishery in other inshore areas.

## Description of the fishery

The inshore fishery for Greenland halibut started in the beginning of the 1900 century with the introduction of the longline technique to Greenland. The fishery started in the Disko Bay and gradually spread to the Uummannaq and Upernavik districts. The fishery is traditionally performed with longline from small open boats or from dog sledges through a hole in the sea ice. In recent decades small vessels have entered the fishery. In the mid 1980s gillnets were introduced to the inshore fishery, and were used more frequently in the following years. Longline fishery still constitutes the majority of the total landings. In the late 1990s, the first regulations limiting areas open to gillnet fishery were introduced in order to limit effort to the winter season.

Competence to regulate seasons and areas open to gillnet fishery was transferred to local administrations in 2004, and areas open to gillnet fishery has expanded since then. The gillnet fishery is regulated by a minimum mesh-size of 110 mm (half meshes). In general, gillnets have narrow selection curves and only targeting fish at certain size intervals. Estimated selection curves for Greenland halibut suggests that 110 mm gillnets has maximal selectivity of Greenland halibut in the size interval 70-80 cm but fish poorly in the size interval 50 to 60 cm. Licences requirements were introduced in 1998 and in 2008 TAC and quota regulations were introduced for the inshore fishery. In 2012 the TAC was split in two components with ITQ’s for vessels and a shared quota for open boats. The ITQ system currently does not specify catch to a certain district which causes a discrepancy between the total Individual Transferable Quota and total quota set for each district.

## Description of the Catches

Although the fishery started in 1910, catches were less than 1.000 tons until 1960 and during the 1970’s catches gradually increased to around 3.000 tons. In the 1980’s and 1990’s catches increased further to above 20.000 and peaked at the end 1990s at about 25.000 tons. Since then catches have stabilized to a but has for more than two decades supported catches of more than 20.000 tons per year for the districts combined. Some inter district variation in the catches has however been observed (table 1, fig 2). In **Disko Bay,** catches increased during the 1980s and peaked in 2004 to 2006 with catches of more than 12.000 tons per year. Catches were thereafter halved in 3 years to just 6.300 tons in 2009 (table 1.). The decrease in the landings of Greenland halibut in the Disko Bay was in this period not quota regulated and no significant reduction in prices or effort was observed. The most likely explanation for the decrease from 2006 to 2009 is therefore the fishery was less favourable during this period. Since 2009 catches has increased and in 2013, 9.073 tons was landed from the area. The fishery in the Disko bay has always been highly concentrated around the bank just south of Ilulissat and typically more than one third of the Disko Bay catches are from small area (fig.3). Other important fishing grounds in the Disko Bay is the deep Kangia ice fjord (>900m) and the northern part of the Disko Day concentrated around the settlements Saqqaq and Qeqertaq and the ice fjord Torssukattak east of the settlements. In **Uummannaq**, catches increased during the 1980s and peaked in 1999 at more than 8.000 tons (tab.1 and fig.1). Since then, catches have stabilized around 6000 tons but in 2013 more than 7.007 tons was landed. The fishery in Uummannaq is scattered all over the fjord near settlements (fig.3) Particular in the deep South-eastern part of the fjord from Uummannaq and towards East where depths of more than 1500 meters are common and large iceberg producing glaciers are located holds the more important fishing areas. In **Upernavik**, catches increased from the mid 1980’s and peaked in 1998 at a level of 7.000 tons (tab.1 and fig.1). This was followed by a period of decreasing catches that could be due to a reduced effort. In 2012, 6.039 tons were caught in the Upernavik area, but a part of these catches were landed in the Disko bay. The area consists of several large ice fjords, but the main fishing grounds are Ikeq (Upernavik Ice fjord) and Gulteqarffik (Giesecke Ice fjord) and the shallower fjords surrounding Upernavik and the settlements in the area (fig 3). Use of gillnets have been prohibited in Upernavik but derogations have been given for a fishery outside the Icefjords since 2002.

## Commercial data

### *Catch data*

Data on the all inshore landings are reported to the Greenland Fishery Licence Authority (GFLK). Factories receiving the catch gather information on the fishery, including effort and location on individual fishing events and send the raw data to GFLK on a weekly basis. The high resolution of the landings therefore currently allows for a breakdown of catches by area (fig 3) gear season and likewise.

### *Mean length in landings*

Individual samples of length in landings has been collected in the areas for decades by Grønlands fiskeri-undersøgelser (GF) and the Greenland Institute of Natural Resources (GINR). In general samples are collected several times during the seasons. In **Disko bay** mean length in the longline landings of Greenland halibut caught in summer are generally smaller than fish caught during winter, and winter mean size in general shows higher inter annual variation (fig 2). The winter fishery conducted from the Sea ice is highly dependent on ice coverage allowing access to the inner parts of the Kangia icefjord, where larger fish are accessible at greater depths. In Disko Bay mean length in landings, have decreased since 2001 and the 2013 summer fishery landings and the 2014 winter fishery landings has a mean length among the smallest observed (fig.4). Mean length in the gillnet landings gradually increased until 2004 but suddenly changes to a lower values in 2009 (fig 5). The sudden decrease in the gillnet landings is likely caused by a failing fishing success of the 110mm Greenland halibut gillnets and an increased use small meshed gillnets used to target Greenland halibut. The decreasing mean length can also be observed in the plotted length distributions from longline landings as a general decrease of all sizes particularly after 2002 (fig 6).

In **Uummannaq** there is not the same difference between summer and winter fishing grounds as in the Disko bay and only small differences in the summer and winter mean lengths from longline landings are observed (fig 4). In 2013, the mean length in longline landings were the same as observed in 2012 for the winter fishery, but the 2014 winter longline landings were slightly below. The 2013 summer fishery mean length was not significantly different from the observations during the most recent 5 years. Mean lengths in the gillnet landings gradually increased until 2004 but has decreased slightly since then (fig 5). The minimum size in the longline landings from Uummannaq has decreased during the past two decades, but the size range has increased and the landings still contain significant numbers of large fish (fig. 7).

In **Upernavik** the summer and winter fishery also to a large degree takes place in the same areas and only minor differences are seen in the length frequencies from summer and winter fishery (fig 4). The mean length in the landings has been stable since 1999, except for a decrease in the 2010 and 2011 summer fishery. However, the mean length in the summer longline fishery increased in 2012 and 2013 to the stable level observed since 1999. The decrease observed in the winter fishery longline mean in 2014 was caused by poor ice conditions during the sampling period. The size range in the longline landings were very wide in the beginning of the 1990s, but gradually turned to a more narrow distribution by 2010 (fig 8). Since then the range has increased and both smaller and larger fish are observed in the longline landings in 2013.

***Logbook CPUE***

Logbooks have been mandatory for vessels greater than 30'ft (9,4m) since 2008. A GLM model was applied to longline fishery logbook data since 2008 (fig 9, appendix I). Raw logbook CPUE observations were log-transformed prior to the GLM analysis and outlier values were excluded from the analysis (5<logCPUE<8). Vessels with less than 200 logbook observations were also excluded. The overall model uses effect of year month and vessel but does so far not information on location, bait depth or other logbook available information. The recalculated average CPUE of 0.424kg/hook in the Disko bay, 0.492kg/hook in Uummannaq and 0.628kg/hook in Upernavik are however not unrealistic.

The **Disko bay logbook CPUE** index reveals little year to year variation and slow but gradual decrease in yield per effort after 2009 (fig 9. Left / fig 10). However the GLM explained little of the variance observed in the data (r-square=0.226). The **Uummannaq logbook CPUE** index was based on far fewer observations, since the Uummannaq >30$^{ft}$ vessels are fewer and a higher proportion of the catch is taken by small open boats (fig 9. / fig 11). The index however indicates an increase in CPUE from 2009 to 2012 and a slight decrease in 2013. Estimated CPUE is also higher than estimated in the Disko Bay. The **Upernavik logbook CPUE** index shows greater inter annual variation and higher recalculated mean CPUE's than observed in Uummannaq and Disko Bay districts (fig 9. right / fig 12). The apparent fluctuation is likely related to the year to year variation in access to the very good fishing grounds in the narrow but deep Gieskes ice fjord (Gulteqarffik is the Inuit word for "where the gold is collected") and Upernavik ice fjord. Both areas are highly productive and always provide a good fishery, but just as at Kangia in the Disko Bay, glacier ice and massive icebergs blocks access to the areas several months per year.

The model explained less than 25 % the variability in the data and only covers 5-30% percent of the total landings. The CPUE series does not account for fishing grounds within the area and shifts in the distribution could also cause changes in the trends. The CPUE series indicated slight increase in the Disko Bay, a decrease in Uummannaq and an increase in Upernavik.

## Research Surveys

The **Greenland shrimp and fish survey** (SFW) has been conducted since 1992 in West Greenland and includes the Disko Bay (SCR 14/003). The survey indicated increasing abundance during the 1990s and until the gear change in the survey (fig 13). In 2005, a new gear was introduced making the tow time series less comparable. Abundance indices gradually increased from 1992 and particularly from 1998 to 2004 very high abundances were observed. After the gear change in 2005 the abundance decreased to low levels in 2008 and 2009, but since then the abundance index has returned to the previous high levels, mainly driven by large 2010 and 2012 YC (SCR 14/038). The biomass indices in the trawl survey indicate a steadily increase during the 1990s, but heavily increasing biomass after 2002 and until the gear change (fig 13). The new gear introduced in 2005, indicated an initial decrease but since 2006 the biomass index has been stable. The 2013 biomass estimate indicates a decrease, but this is not seen in the slightly more correct estimate by the original shrimp strata (See SCR 14/03). Therefore the biomass indices in the Disko Bay trawl survey seem stable during the past decade.

The **Disko bay gillnet survey** was initiated in 2001 where it replaced poorly performing longline survey**.** The gillnet survey in the Disko bay targets pre fishery recruits of Greenland halibut at lengths of 30-50 cm. Since the survey uses gillnets with narrow selection curves there is not a major difference between the trends of the CPUE and NPUE indices (fig 14). If comparing the gillnet NPUE (all sizes) to the trawl survey (SFW) indices of Greenland halibut larger than 35 cm, an unusually high correlation between the surveys is observed (fig 14) leading to increased credibility in the performance and indices of both surveys. Indices between the gillnet and trawl surveys are also in high agreement in comparing NPUE of Greenland halibut less than 50 cm in the gillnet survey to the indices of Greenland halibut of 35-50 cm in the trawl survey (fig 14). The gillnet survey however performs poorly when tracking individuals less than 35 cm and the agreement between the surveys no longer exists if comparing the gillnet indices of fish less than 35 cm to trawl survey indices of fish between 28 and 35 cm. (fig 15).
The gillnet survey CPUE and NPUE indicated low levels of pre-fishery recruits in 2006 and 2007, but returned to average levels in 2008. The survey CPUE and NPUE reached a record high in but decreased has decreased in 2013. The 2012 survey was troubled with a defect gillnet section (60mm) and should be excluded from the analysis.

The **Uummannaq and Upernavik longline survey**s were continued in 2013 (fig 17). The longline surveys perform poorly in regards to catch per unit effort and no general conclusions can be drawn from the trends of these surveys in recent years.

**Gillnet stations in Uummannaq and Upernavik** has been tested since 2011 in attempt to improve the surveys (fig 18). The gillnet stations in Uummannaq indicate a survey CPUE and NPUE at a similar or higher level than observed in the Disko Bay and that pre-fishery recruits can be found in the area. The gillnet stations from Upernavik in 2012 and 2013 indicate CPUE and NPUE comparable to the level observed in the Disko Bay gillnet survey (fig 19) and the presence of pre fishery recruits at sizes rarely observed in landings from the Upernavik area.

## Discussion

The high correlation between the abundance of Greenland halibut larger than 35 cm in the trawl survey and the NPUE indices from the gillnet survey, provides an increased credibility in the survey indices of both surveys. The correlation between the surveys could be caused by an evenly distributed stock with a high overlap in size selectivity of the two very different gears in relation to the present length distribution of the stock. Still both surveys show some inter-annual variation which could be due to shifts in the distribution of the stock in and out of areas that are not covered by the surveys. It seems unlikely that the years with large changes in the indices, indicate a proportional change in the total biomass of the stock. Therefore the surveys should only be interpreted as indices and indicators of the overall development of the stock.

## Analytical assessments

Exploratory analytical assessments were conducted in the 2006 assessment of the Disko Bay area, by separable VPA, XSA and Survey based assessment (SURBA). The output showed a continuous increase in fishing mortality, but none was accepted as providing an accurate assessment an accurate assessment, but suggested that the continuous increase in catches is due to *increased recruitment in combination with an increased fishing mortality However; the assessment is unable to estimate the relative size of these two elements* (SCR 06/35).

## Assessment results

### Disko Bay

The low mean length in the landings and the shift in the length distributions towards smaller fish indicate that the biomass is currently below previous levels. The disappearance of the larger Greenland halibut in the landings and the shift towards smaller fish means that the fishery is currently more dependent on new incoming year classes than a decade ago. However, the stock is believed to receive large numbers of recruits yearly from the offshore spawning stock. The high correlation between the longline and gillnet surveys leads to a high credibility in the results from both surveys. However the high year to year variability observed in the survey are likely related to shifts in distribution of stock with depth or within the area rather than true number changes in the stock. The overall long-term stability in both surveys therefore indicates a steady supply of pre-fishery recruits (35-50 cm) to the stock. The gradual transition towards smaller fish in the landings combined with the increasing catches indicates a higher outtake of fish in numbers. However, the contribution to fishing mortality from the shrimp trawlers is likely reduced since the implementation of sorting grids in the inshore shrimp trawl fishery in 2011.

### Uummannaq:

The long term stability in the mean length in the landings and wide range of sizes in the landings suggests that the contribution of new incoming year classes to the stock is small compared to the total stock and that changes, in the stock both increases and decreases, until now has happened at a slow rate. There are currently no other fisheries in the area contributing to fisheries mortality in the district as trawl fishery is banned in the area and fisheries targeting other species than Greenland halibut are insignificant. The supply of recruits from the spawning stock in the Davis Strait is unknown, but trawl survey results outside the mouth of the Uummannaq fjord suggests good recruitment in recent years.

### Upernavik:

As in Uummannaq the long term stability observed in the mean length in the landings and wide range of sizes in the landings suggests that the contribution of new incoming year classes to the stock is small compared to the total stock and that changes, in the stock both increases and decreases, until now has happened at a slow rate. There are currently no other fisheries in the area contributing to fisheries mortality in the district as trawl fishery is banned in the area and fisheries targeting other species than Greenland halibut are insignificant. The factories in the Upernavik district have so far not wanted to receive other species than Greenland halibut. The supply of recruits from the spawning stock in the Davis Strait is unknown, but trawl survey results close to the area suggests good recruitment in recent years. Total catches has however increased at a higher rate in Upernavik, than in Uummannaq in recent years.

## References

Bech, G., 1995. Recruitment of Greenland halibut at West Greenland. NAFO Scr.Doc. 95/19.

Boje, J. (1994). Migrations of Greenland halibut in Northwest Atlantic based on tagging experiments in Greenland waters 1986-92. NAFO Scr.Doc. 94/18

Boje, J. And Lyberth, B. (2005) Survey Calibration for Greenland Halibut in Division 1A Inshore. NAFO Scr. Doc.05/57 (N5143)

Jørgensen, O. A. and D. M. Carlsson (1998). An estimate of by-catch of fish in the West Greenland shrimp fishery based on survey data. NAFO Scr.Doc. 98/41(N3030)

Jørgensen, O.A. and Boje, J., 1994. Sexual maturity of Greenland halibut in NAFO Subarea 1. NAFO Scr.Doc., 94/42(No. N2412).

Lyberth, B. And Boje, J. 2006 An Assessment of the Greenland Halibut Stock Component in NAFO Division 1A Inshore. NAFO Scr. Doc. 06/35 (N5258)

Nygaard, R. and Jørgensen O. A., 2013. Biomass and Abundance of Demersal Fish Stocks off West Greenland Estimated from the Greenland Shrimp and Survey, 1988-2012. NAFO Scr. doc.13/26.

Riget, F. and J. Boje (1989). Fishery and some biological aspects of Greenland halibut (*Reinhardtius hippoglossoides*) in West Greenland waters. NAFO Sci.Council Studies(13): 41-52.

Rosing, M.& K. Wieland, 2005: Preliminary results from shrimp trawl calibration experiments off West Greenland (2004, 2005) with notes on encountered design/analyses problems. NAFO SCR Doc. 05/92.

Simonsen, C.S. and Roepstorff, A., 2000. Udvikling og adfærd af fisk & fiskere i Diskobugt området. In: H. M. and O.R. Rasmussen (Editors), Innusuk -Arktisk Forsknings Journal. Direktoratet for Kultur, Uddannelse og Forskning, Nuuk, Grønland, pp. 29-43. *In danish*

Simonsen, C.S., Boje, J. and Kingsley, M.C.S., 2000. A Review Using Longlining to Survey Fish Populations with Special Emphasis on an Inshore Longline Survey for Greenland Halibut (*Reinhardtius hippoglossoides*) in West Greenland, NAFO Division 1A. NAFO Scr.Doc., 00/29

Simonsen C.S. and Gundersen A.C. (2005) Ovary development in Greenland halibut *Reinhardtius hippoglossoides* in west Greenland waters J. Fish Biol. 67 1299-1317

Table 1. Landings and Greenland halibut ('000t) in Div. 1A inshore distributed on the main fishing areas: Disko Bay, Uummannaq and Upernavik.

| | Disko Bay | Uummannaq | Upernavik | Unknown/other | Total in Div. 1A inshore: | STATLANT 21 SA1 Excl offsh. 1BCDEF | STACFIS SA1 Div 1A inshore |
|---|---|---|---|---|---|---|---|
| 1987 | 2,3 | 2,9 | 1,6 | 0,4 | 7,2 | 6,7 | 7,2 |
| 1988 | 2,7 | 2,9 | 0,8 | 0,6 | 7,0 | 6,4 | 7,0 |
| 1989 | 2,8 | 2,9 | 1,3 | 0,6 | 7,5 | 6,9 | 7,5 |
| 1990 | 3,8 | 2,8 | 1,2 | 0,5 | 8,4 | 7,5 | 8,4 |
| 1991 | 5,4 | 3,0 | 1,5 | 0,0 | 9,9 | 9,2 | 9,9 |
| 1992 | 6,6 | 3,1 | 2,2 | 0,1 | 11,9 | 11,9 | 11,9 |
| 1993 | 5,4 | 3,9 | 3,8 | 0,0 | 13,1 | 13,2 | 13,1 |
| 1994 | 5,2 | 4,0 | 4,8 | 0,0 | 14,0 | 14,1 | 14,0 |
| 1995 | 7,4 | 7,2 | 3,3 | 0,0 | 17,9 | 17,0 | 17,0 |
| 1996 | 7,8 | 4,6 | 4,8 | 0,0 | 17,3 | 17,3 | 17,3 |
| 1997 | 8,6 | 6,3 | 4,9 | 0,0 | 19,8 | 20,8 | 19,8 |
| 1998 | 10,7 | 6,9 | 7,0 | 0,0 | 24,6 | 19,7 | 24,6 |
| 1999 | 10,6 | 8,4 | 5,3 | 0,1 | 24,3 | 24,3 | 24,3 |
| 2000 | 7,6 | 7,6 | 3,8 | 2,2 | 21,1 | 21,0 | 21,1 |
| 2001 | 7,1 | 6,6 | 3,2 | 0,0 | 16,9 | 16,5 | 16,9 |
| 2002 | 11,7 | 5,3 | 3,0 | 0,0 | 20,1 | 17,6 | 20,1 |
| 2003 | 11,6 | 5,0 | 3,9 | 0,0 | 20,5 | 21,5 | 20,5 |
| 2004 | 12,9 | 5,2 | 4,6 | 0,0 | 22,7 | 25,2 | 22,7 |
| 2005 | 12,5 | 4,9 | 4,8 | 0,8 | 22,9 | 21,6 | 22,9 |
| 2006 | 12,1 | 6,0 | 5,1 | 0,0 | 23,2 | 24,2 | 23,2 |
| 2007 | 10,0 | 5,3 | 4,9 | 0,0 | 20,6 | 0,0 | 20,6 |
| 2008 | 7,7 | 5,4 | 5,5 | 0,3 | 18,9 | 0,0 | 18,9 |
| 2009 | 6,3 | 5,5 | 6,5 | 0,0 | 18,3 | 0,0 | 18,3 |
| 2010 | 8,5 | 6,2 | 5,9 | 0,0 | 20,6 | 0,0 | 21,0 |
| 2011 | 8,0 | 6,4 | 6,5 | 0,0 | 20,9 | 0,0 | 20,9 |
| 2012 | 7.8 | 6,2 | 6,8 | 0,1 | 20,7 | 21,3 | 20,7 |
| 2013 | 9,1 | 7,0 | 6,0 | 0,0 | 22,1 | 22,1 | 22,1 |

# COMMERCIAL DATA

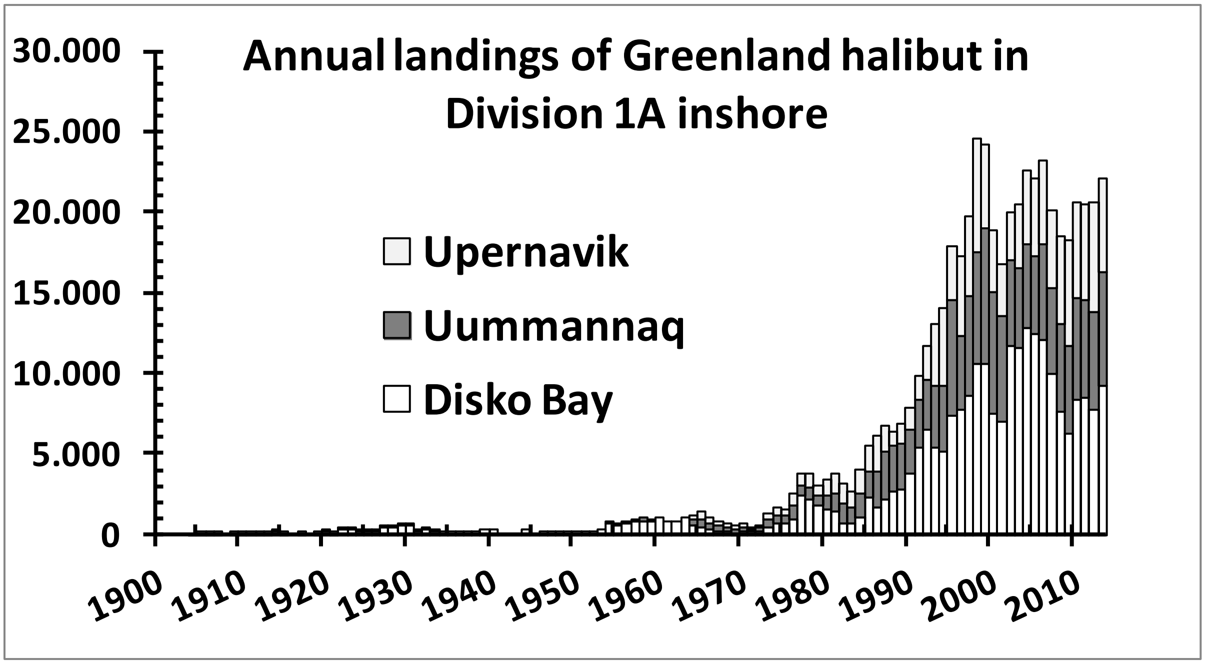


Fig. 1. Catches of Greenland halibut in NAFO Subarea 1 Division 1Ainshore since 1904 for NAFO division 1A inshore in North West Greenland.

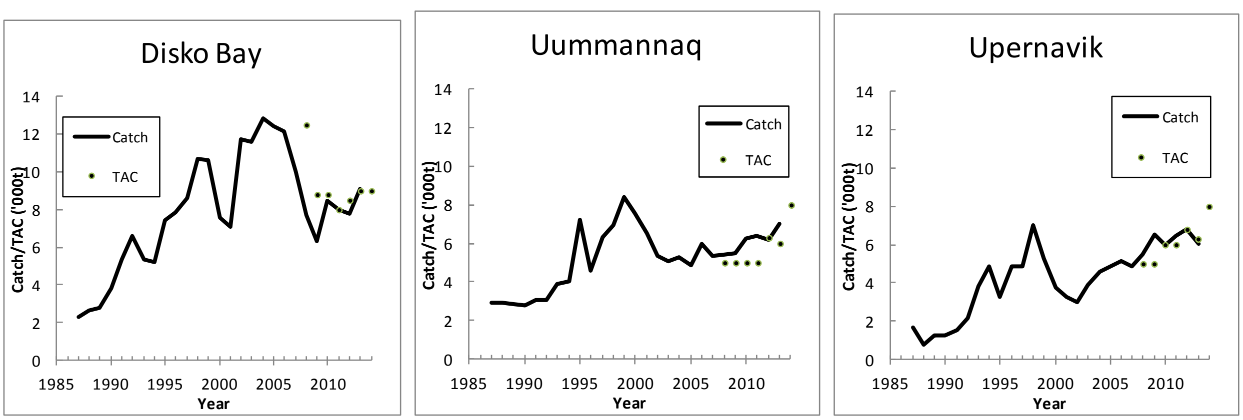


Fig. 2. Catches of Greenland halibut in NAFO Subarea 1 Division 1Ainshore since 1987 by district. Disko bay (left), Uummannaq (center) and Upernavik (right).

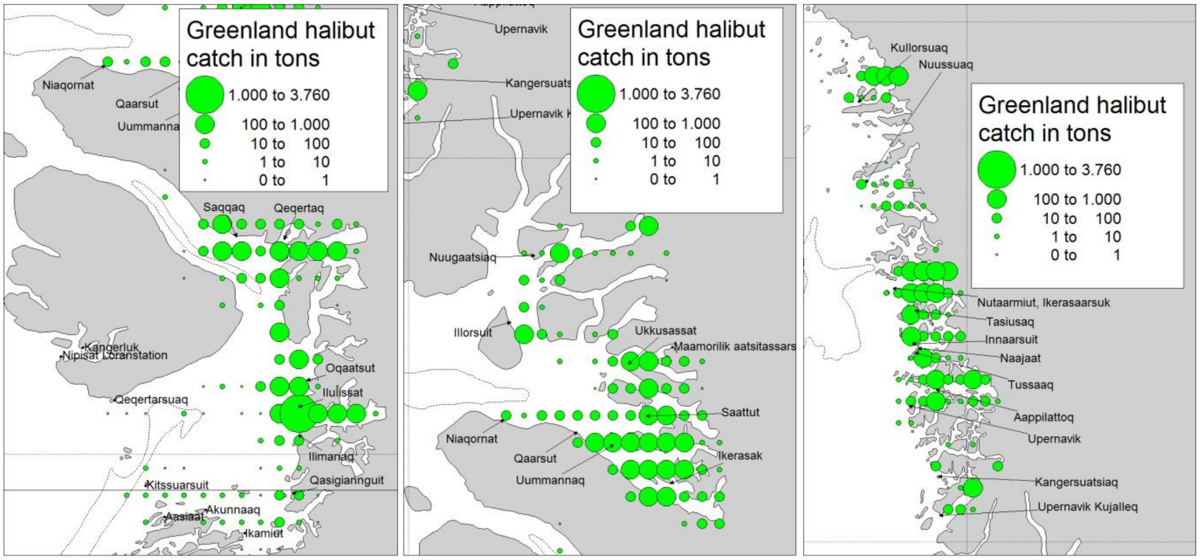


Figure 3 Catch in 2013 by statistical catch square in the Disko bay (left), Uummannaq (center) and Upernavik (right).

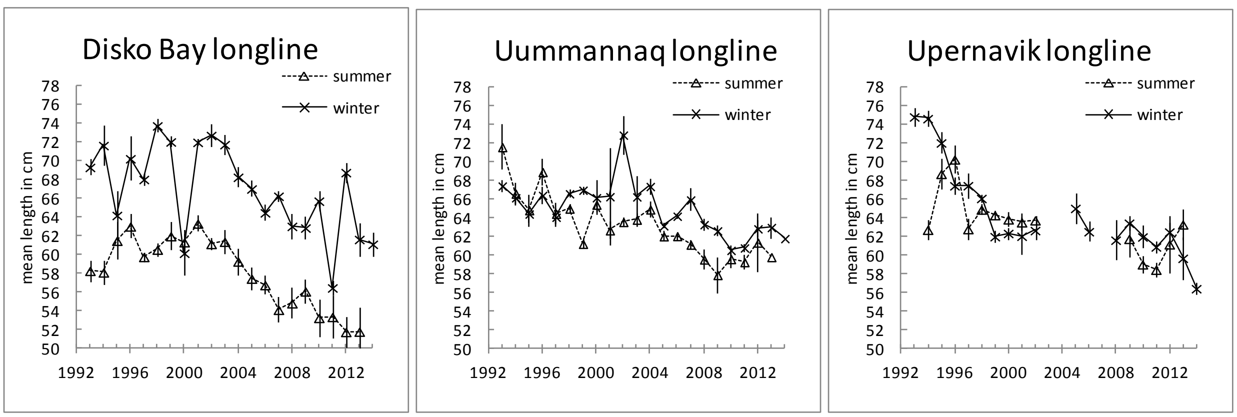


Fig. 4. Longline mean length in landings from in the Disko bay (left), Uummannaq (center) and Upernavik (right) +CL.

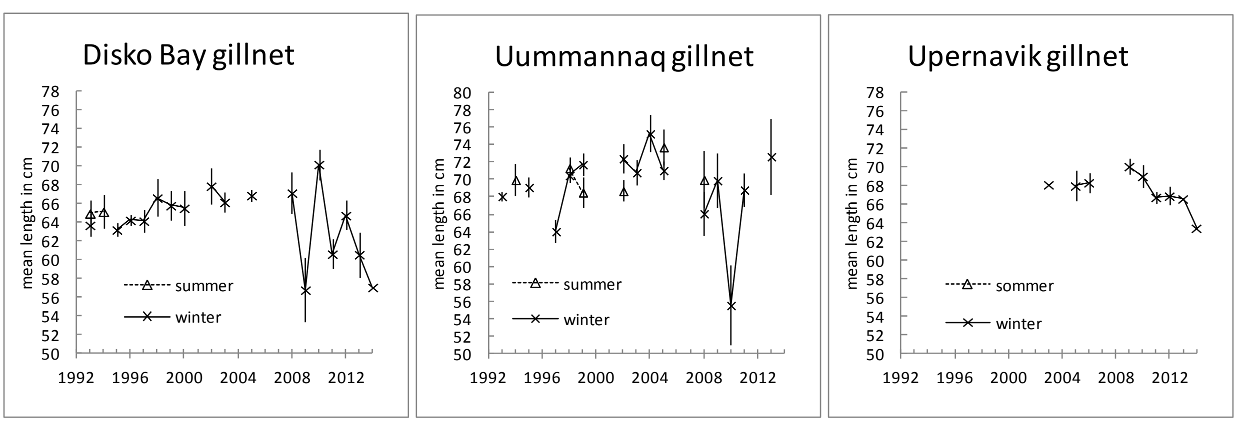


Fig. 5. Gillnet mean length in landings from in the Disko bay (left), Uummannaq (center) and Upernavik (right) +CL.

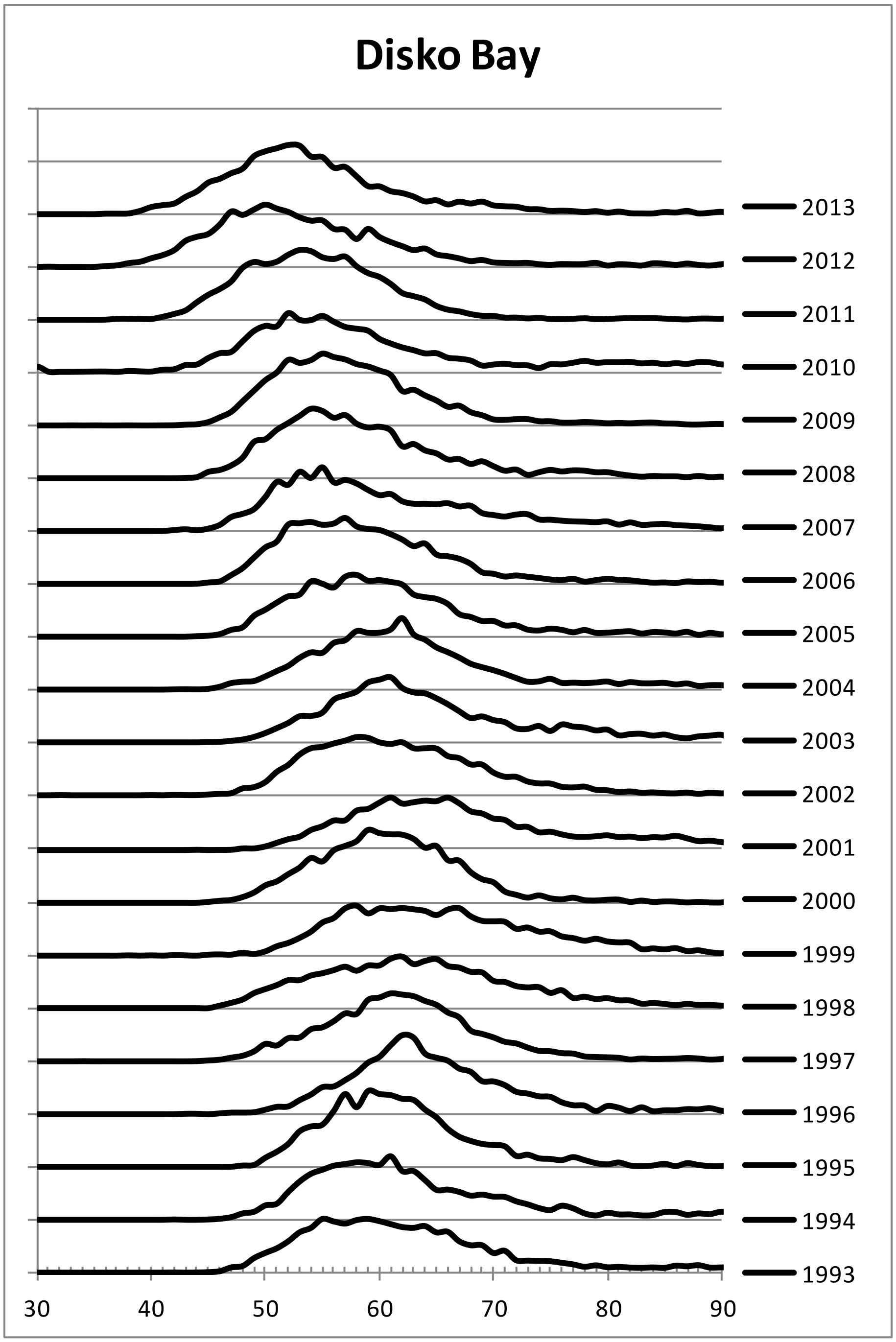


Fig 6 Disko bay length frequencies in longline landings in % of number measured all months combined.

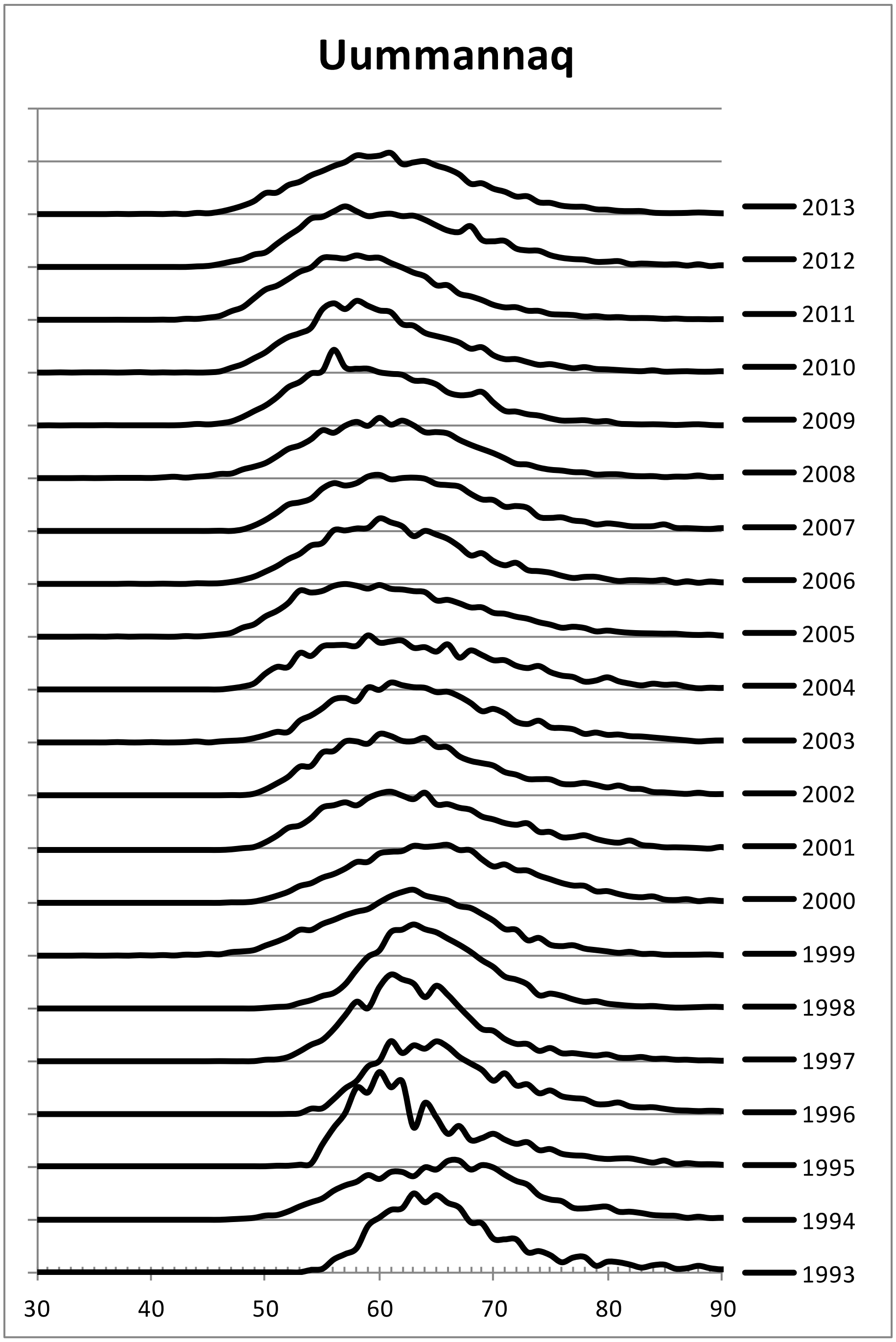


Fig. 7. Uummannaq length frequencies in longline landings in % of number measured all months combined.

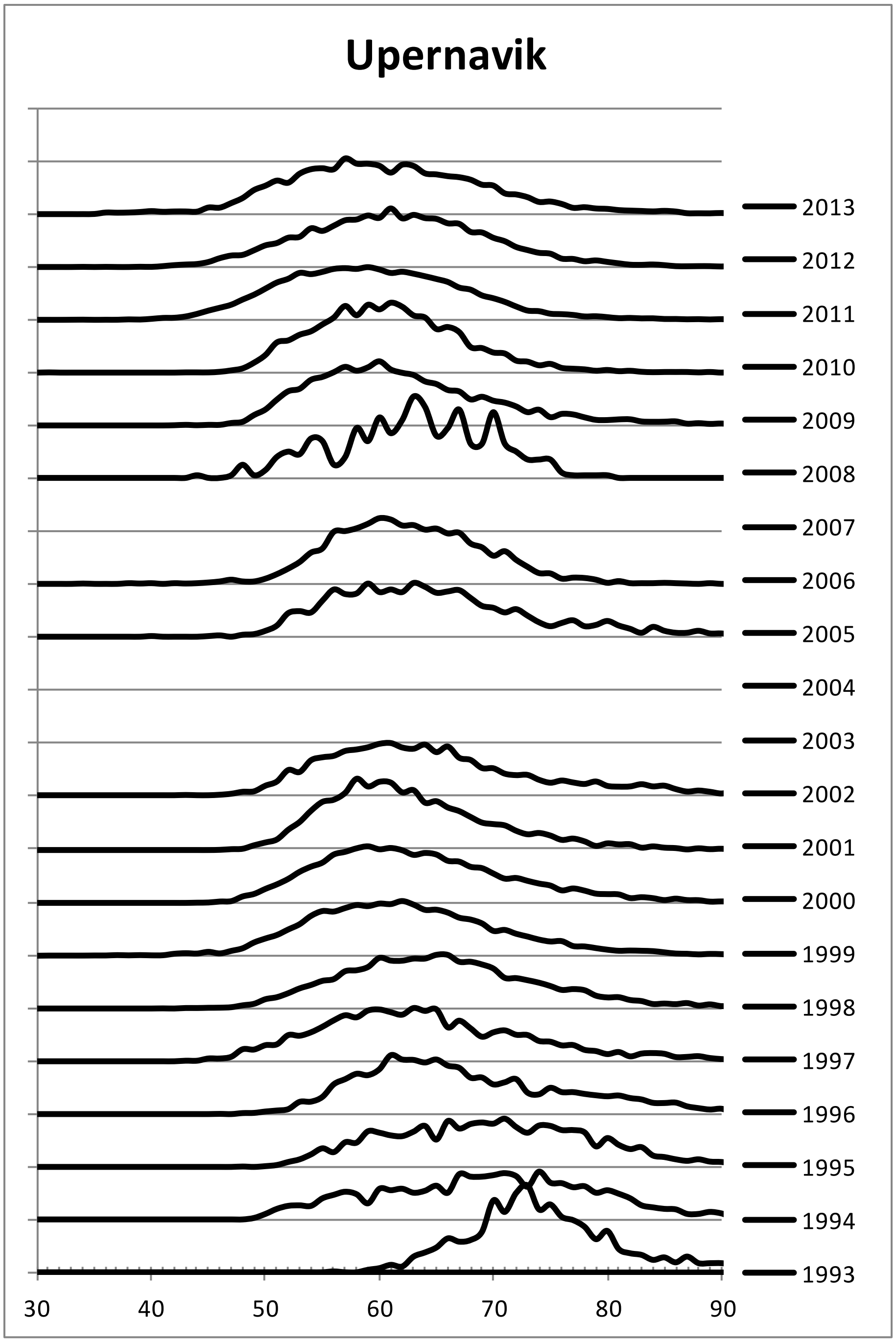


Figure 8 Upernavik length frequencies in longline landings in % of number measured all months combined.

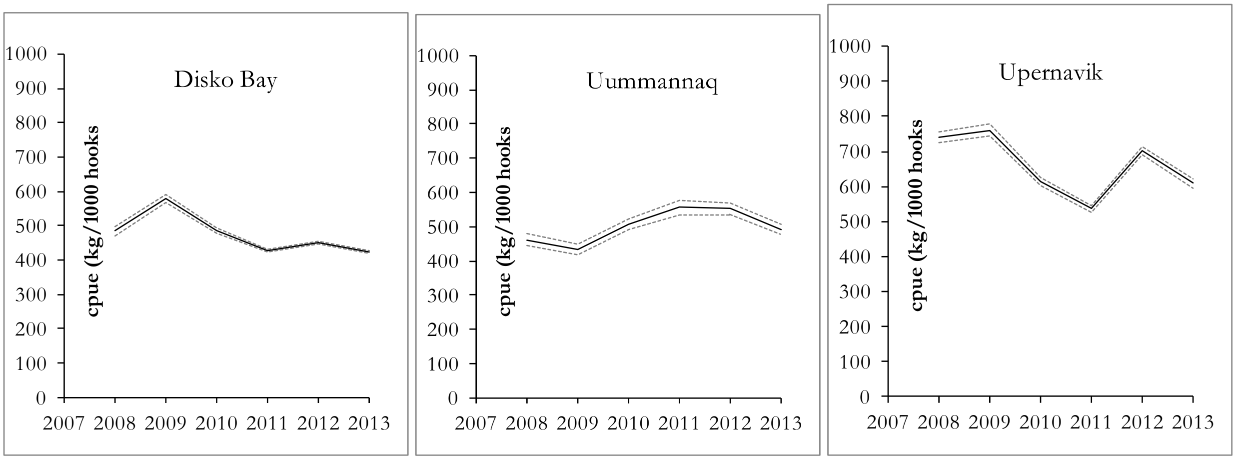


Fig 9. Standardized CPUE series for for commercial LongLine catches.

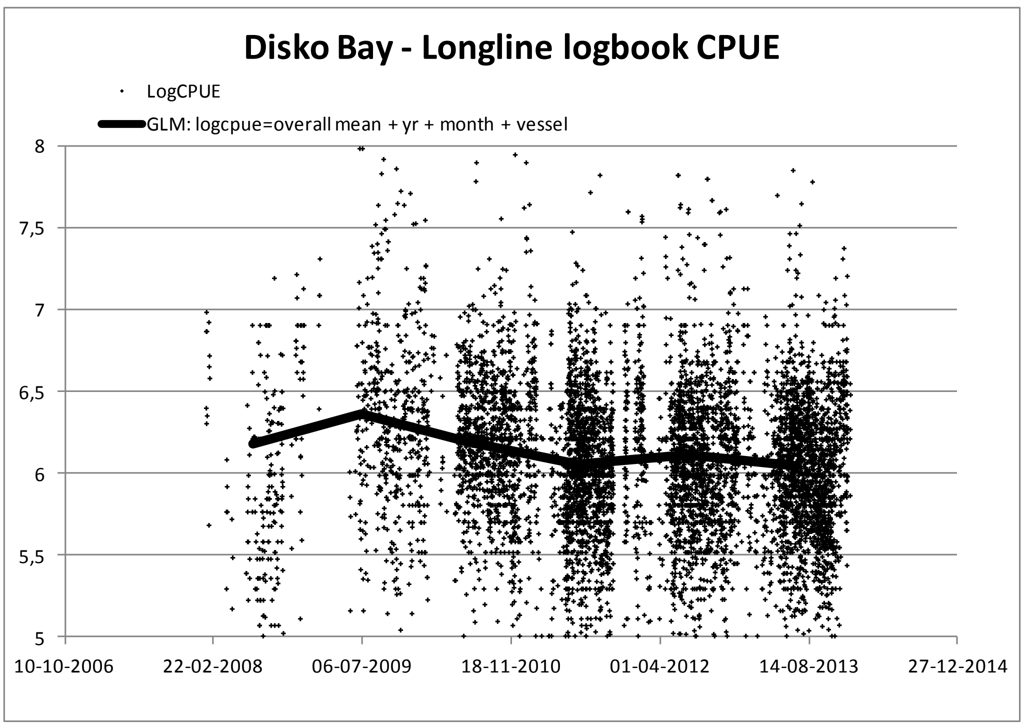


Fig 10.Standardized CPUE series for for commercial longLine (thick line) . + indicate logCPUE(kg/1000hooks) by date.

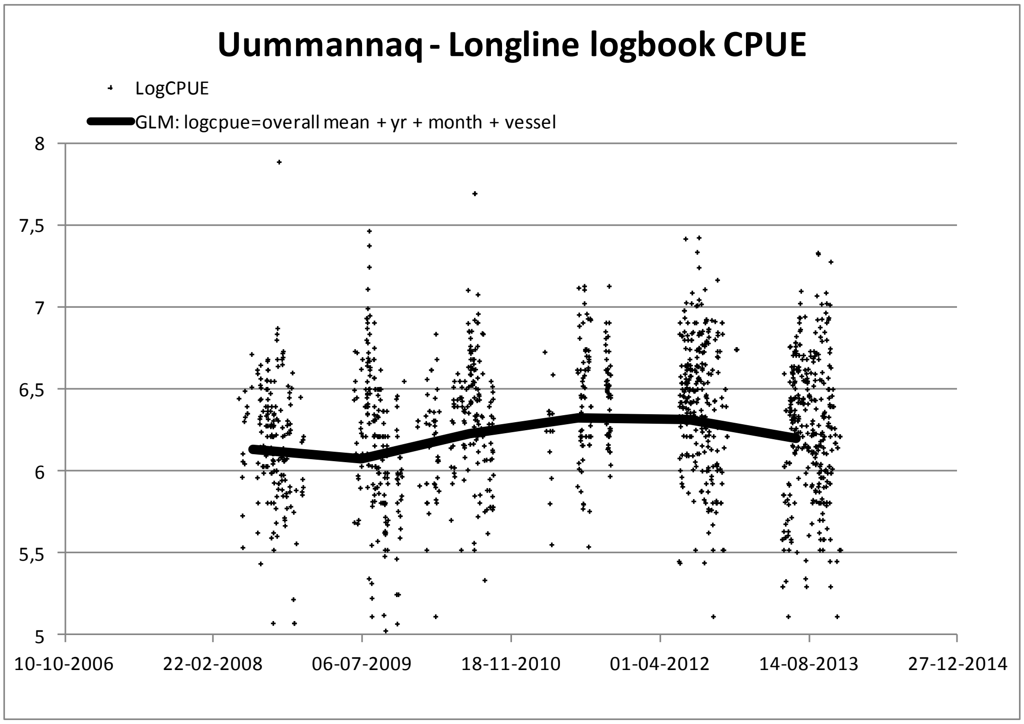


Fig 11. Standardized CPUE series for for commercial longLine (thick line) . + indicate logCPUE(kg/1000hooks) by date.

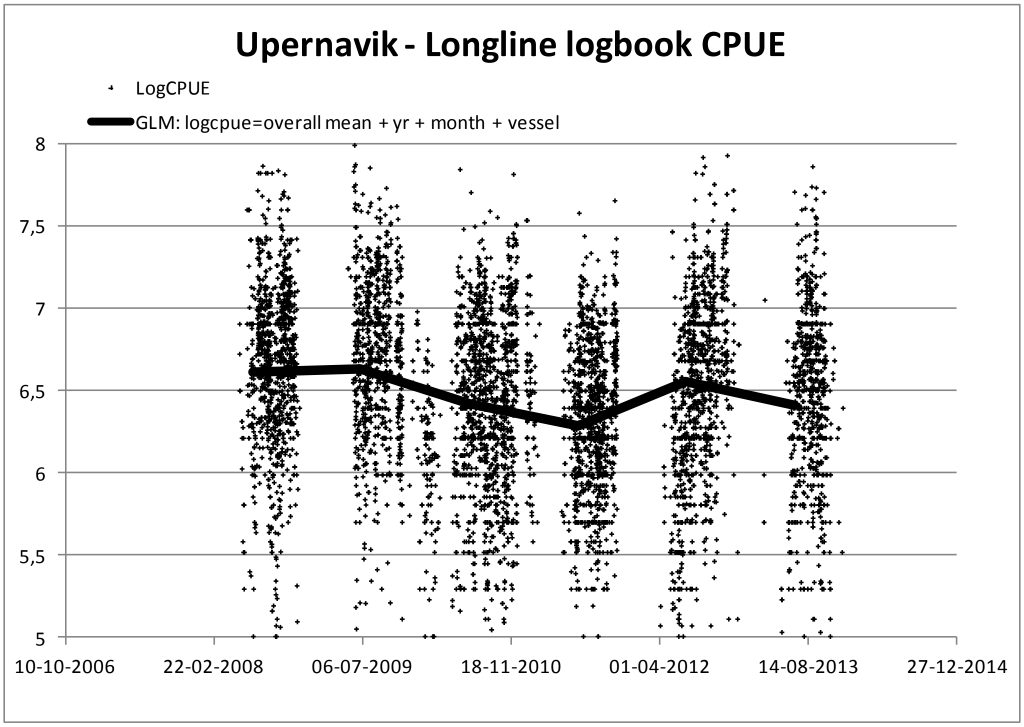


Fig 12. Standardized CPUE series for for commercial longLine (thick line) . + indicate logCPUE(kg/1000hooks) by date.

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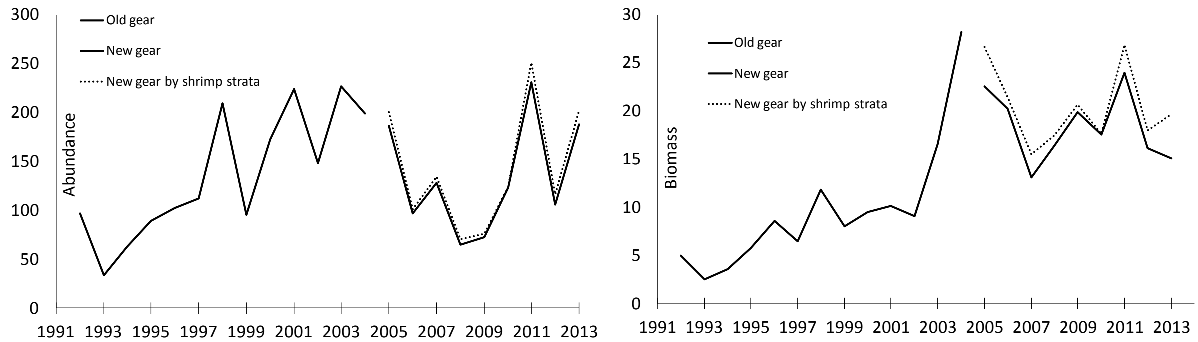


Fig. 13. Abundance in million and Biomass in kt ('000 t) indices of Greenland halibut from the Paamiut trawl survey in Disko Bay. A new survey trawl was introduced in 2009.

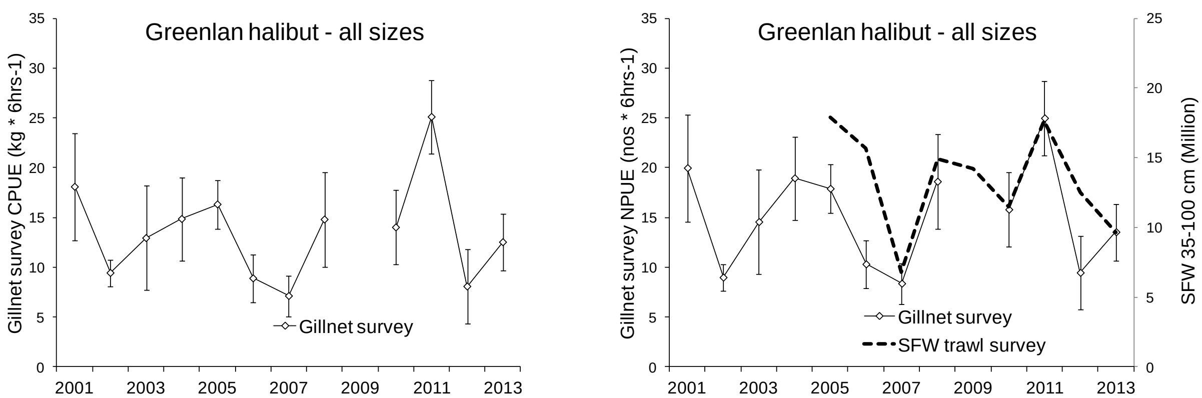


Fig. 14. Disko Bay longline and gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (all sizes) and abundance estimates for the Disko Bay part of the Greenland shrimp and fish survey (right) of halibut larger than 35 cm.

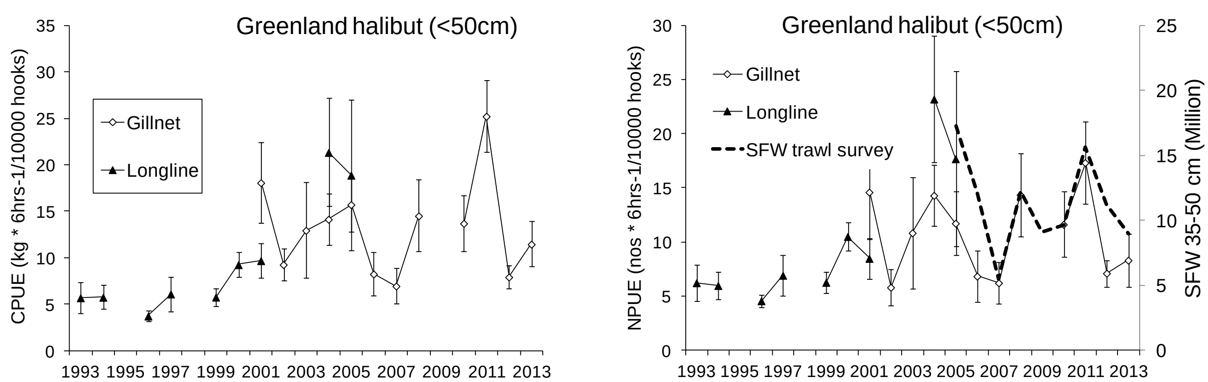


Fig. 15. Disko Bay longline and gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (< 50cm) and abundance estimates for the Disko Bay part of the Greenland shrimp and fish survey (right) of halibut (35-50 cm.).

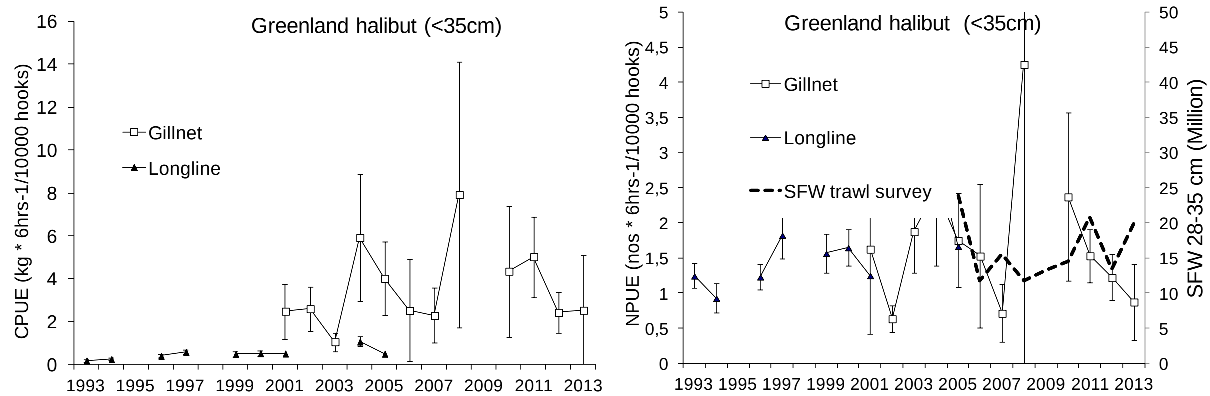


Fig. 16. Disko Bay longline and gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (< 50cm) and abundance estimates for the Disko Bay part of the Greenland shrimp and fish survey (right) of halibut (28-35 cm.).

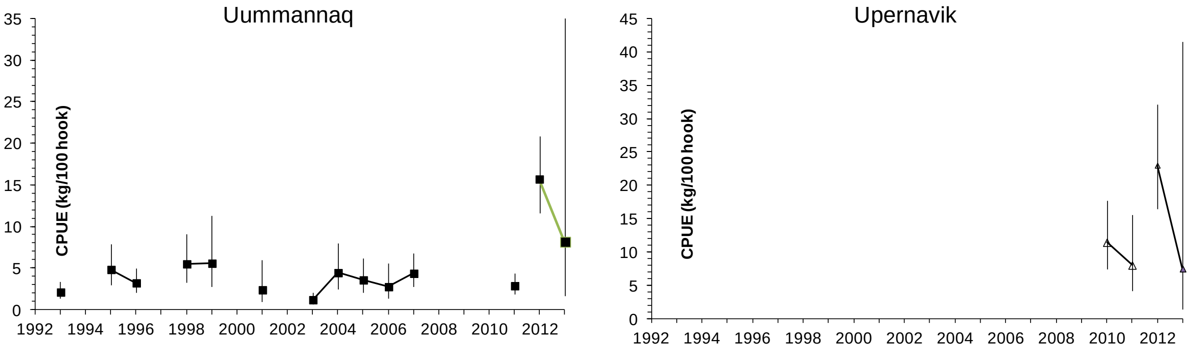


Fig. 17. Longline survey indices with CI for Uummannaq (left) and Upernavik (right). New survey logline introduced in 2012.

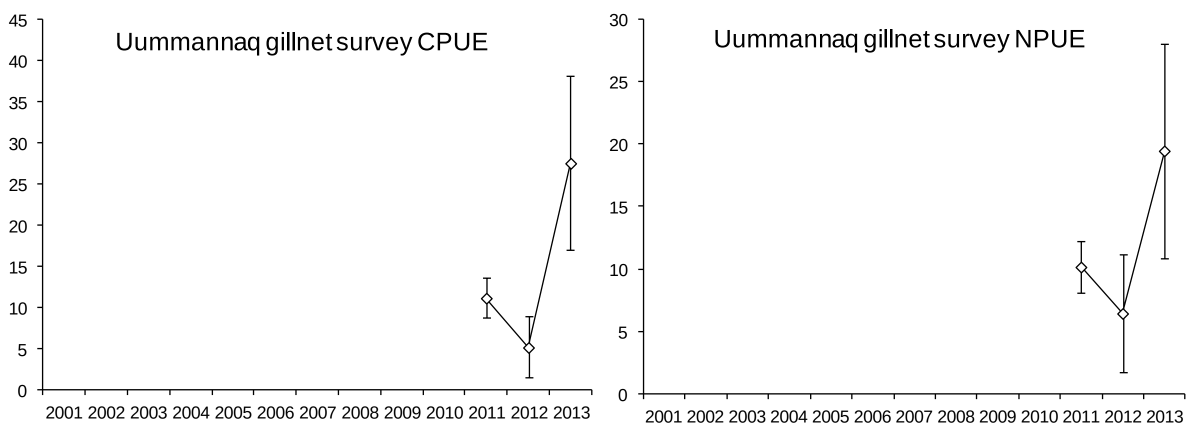


Fig. 18. Uummannaq gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (all sizes).

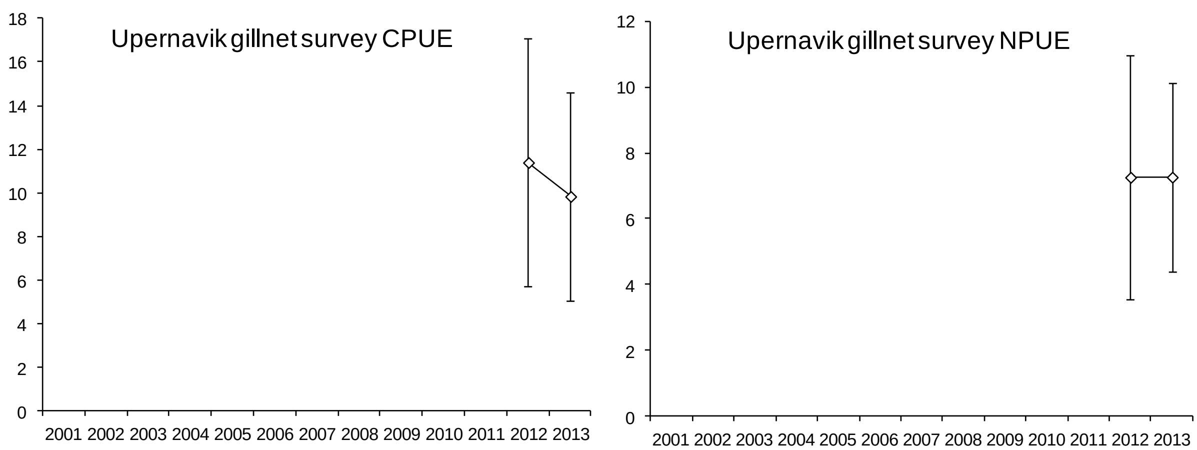


Fig. 19. Upernavik gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (all sizes).

# Appendix

## INSH 1AX

### Catch in Logbooks and number of logbooks used

**The GLM Procedure**
**Number of observations used 7887**

**Dependent Variable: LogCPUE**

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 39 | 348.276605 | 8.930169 | 58.87 | <.0001 |
| Error | 7847 | 1190.336916 | 0.151693 | | |
| Corrected Total | 7886 | 1538.613521 | | | |

| R-Square | Coeff Var | Root MSE | LogCPUE Mean |
|---|---|---|---|
| 0.226357 | 6.388330 | 0.389478 | 6.096713 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 5 | 53.6407131 | 10.7281426 | 70.72 | <.0001 |
| MD | 11 | 53.8140928 | 4.8921903 | 32.25 | <.0001 |
| FTJ_ID | 23 | 240.8217994 | 10.4705130 | 69.02 | <.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 5 | 43.4279525 | 8.6855905 | 57.26 | <.0001 |
| MD | 11 | 47.2734190 | 4.2975835 | 28.33 | <.0001 |
| FTJ_ID | 23 | 240.8217994 | 10.4705130 | 69.02 | <.0001 |

| Parameter | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| Intercept | 6.058866590 | B | 0.03033961 | 199.70 | <.0001 |
| YEAR 2008 | 0.132346968 | B | 0.03038571 | 4.36 | <.0001 |
| YEAR 2009 | 0.309486622 | B | 0.02116628 | 14.62 | <.0001 |
| YEAR 2010 | 0.135612626 | B | 0.01452615 | 9.34 | <.0001 |
| YEAR 2011 | 0.006545646 | B | 0.01260867 | 0.52 | 0.6037 |
| YEAR 2012 | 0.059026734 | B | 0.01270306 | 4.65 | <.0001 |
| YEAR 2013 | 0.000000000 | B | . | . | . |
| MD 1 | 0.107311615 | B | 0.02739438 | 3.92 | <.0001 |
| MD 2 | -0.017188164 | B | 0.03502639 | -0.49 | 0.6236 |
| MD 3 | -0.082736775 | B | 0.04529408 | -1.83 | 0.0678 |
| MD 4 | -0.126661023 | B | 0.03573516 | -3.54 | 0.0004 |
| MD 5 | -0.159926599 | B | 0.02395287 | -6.68 | <.0001 |
| MD 6 | -0.020087348 | B | 0.02205753 | -0.91 | 0.3625 |
| MD 7 | -0.105292251 | B | 0.02191366 | -4.80 | <.0001 |
| MD 8 | -0.065444589 | B | 0.02208341 | -2.96 | 0.0031 |
| MD 9 | -0.192682051 | B | 0.02253998 | -8.55 | <.0001 |
| MD 10 | -0.184304170 | B | 0.02269147 | -8.12 | <.0001 |
| MD 11 | -0.075490909 | B | 0.02473446 | -3.05 | 0.0023 |
| MD 12 | 0.000000000 | B | . | . | . |
| FTJ_ID A | 0.606476442 | B | 0.03271139 | 18.54 | <.0001 |

| | | | | |
|---|---|---|---|---|
| FTJ_ID B | 0.028546515B | 0.03079274 | 0.93 | 0.3539 |
| FTJ_ID C | 0.222490630B | 0.03055135 | 7.28 | <.0001 |
| FTJ_ID D | 0.032475225B | 0.03078655 | 1.05 | 0.2915 |
| FTJ_ID E | -0.110916480B | 0.03312163 | -3.35 | 0.0008 |
| FTJ_ID F | 0.215581679B | 0.03441842 | 6.26 | <.0001 |
| FTJ_ID G | 0.091205390B | 0.03152247 | 2.89 | 0.0038 |
| FTJ_ID H | -0.139492670B | 0.02915969 | -4.78 | <.0001 |
| FTJ_ID I | 0.036000908B | 0.02851076 | 1.26 | 0.2067 |
| FTJ_ID J | -0.082345002B | 0.03051965 | -2.70 | 0.0070 |
| FTJ_ID K | -0.059862121B | 0.03318084 | -1.80 | 0.0713 |
| FTJ_ID L | -0.058438003B | 0.03055353 | -1.91 | 0.0558 |
| FTJ_ID M | 0.243264628B | 0.03075723 | 7.91 | <.0001 |
| FTJ_ID N | -0.106581769B | 0.03449804 | -3.09 | 0.0020 |
| FTJ_ID O | 0.031362372B | 0.03377483 | 0.93 | 0.3531 |
| FTJ_ID P | 0.124023773B | 0.02905018 | 4.27 | <.0001 |
| FTJ_ID Q | 0.128494410B | 0.03202694 | 4.01 | <.0001 |
| FTJ_ID R | -0.116492169B | 0.03501361 | -3.33 | 0.0009 |
| FTJ_ID S | 0.340833854B | 0.03193153 | 10.67 | <.0001 |
| FTJ_ID T | -0.222047583B | 0.03649585 | -6.08 | <.0001 |
| FTJ_ID U | 0.220120792B | 0.03106847 | 7.09 | <.0001 |
| FTJ_ID V | 0.290225202B | 0.03172563 | 9.15 | <.0001 |
| FTJ_ID X | -0.095205026B | 0.03453656 | -2.76 | 0.0059 |
| FTJ_ID Y | 0.000000000B | . | . | . |

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

## INSH 1AX

## Catch in Logbooks and number of logbooks used

### The GLM Procedure

### Least Squares Means

| YEAR | LogCPUE LSMEAN | Standard Error | Pr > \|t\| |
|---|---|---|---|
| 2008 | 6.18182674 | 0.02921512 | <.0001 |
| 2009 | 6.35896640 | 0.01989223 | <.0001 |
| 2010 | 6.18509240 | 0.01229904 | <.0001 |
| 2011 | 6.05602542 | 0.01029720 | <.0001 |
| 2012 | 6.10850651 | 0.01023445 | <.0001 |
| 2013 | 6.04947978 | 0.00945724 | <.0001 |

# INSH 1AUM

## Catch in Logbooks and number of logbooks used

### The GLM Procedure
### Number of observations used 1377

**Dependent Variable: LogCPUE**

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 20 | 48.7118994 | 2.4355950 | 19.26 | <.0001 |
| Error | 1356 | 171.4806267 | 0.1264606 | | |
| Corrected Total | 1376 | 220.1925261 | | | |

| R-Square | Coeff Var | Root MSE | LogCPUE Mean |
|---|---|---|---|
| 0.221224 | 5.640588 | 0.355613 | 6.304539 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 5 | 14.97700314 | 2.99540063 | 23.69 | <.0001 |
| MD | 11 | 19.22575531 | 1.74779594 | 13.82 | <.0001 |
| FTJ_ID | 4 | 14.50914090 | 3.62728523 | 28.68 | <.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 5 | 9.15407898 | 1.83081580 | 14.48 | <.0001 |
| MD | 11 | 19.93885581 | 1.81262326 | 14.33 | <.0001 |
| FTJ_ID | 4 | 14.50914090 | 3.62728523 | 28.68 | <.0001 |

| Parameter | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| Intercept | 6.449516010 | B | 0.10191747 | 63.28 | <.0001 |
| YEAR 2008 | -0.064677810 | B | 0.03370547 | -1.92 | 0.0552 |
| YEAR 2009 | -0.129247377 | B | 0.03306694 | -3.91 | <.0001 |
| YEAR 2010 | 0.025547867 | B | 0.03498444 | 0.73 | 0.4654 |
| YEAR 2011 | 0.122700616 | B | 0.03687344 | 3.33 | 0.0009 |
| YEAR 2012 | 0.114840270 | B | 0.02910163 | 3.95 | <.0001 |
| YEAR 2013 | 0.000000000 | B | . | . | . |
| MD 1 | -0.212309174 | B | 0.20502559 | -1.04 | 0.3006 |
| MD 2 | -0.243038833 | B | 0.13164376 | -1.85 | 0.0651 |
| MD 3 | -0.242526857 | B | 0.11924142 | -2.03 | 0.0422 |
| MD 4 | -0.292557504 | B | 0.16084889 | -1.82 | 0.0692 |
| MD 5 | -0.328611090 | B | 0.11006375 | -2.99 | 0.0029 |
| MD 6 | -0.048090637 | B | 0.10001029 | -0.48 | 0.6307 |
| MD 7 | 0.097401810 | B | 0.09936308 | 0.98 | 0.3271 |
| MD 8 | -0.040958760 | B | 0.09905220 | -0.41 | 0.6793 |
| MD 9 | -0.157436868 | B | 0.09957476 | -1.58 | 0.1141 |
| MD 10 | -0.113373220 | B | 0.10004974 | -1.13 | 0.2573 |
| MD 11 | -0.378889451 | B | 0.10862477 | -3.49 | 0.0005 |
| MD 12 | 0.000000000 | B | . | . | . |
| FTJ_ID A | -0.225685698 | B | 0.03184191 | -7.09 | <.0001 |
| FTJ_ID B | -0.195507505 | B | 0.03044382 | -6.42 | <.0001 |
| FTJ_ID C | -0.061200561 | B | 0.03144536 | -1.95 | 0.0518 |
| FTJ_ID D | 0.046099306 | B | 0.03186293 | 1.45 | 0.1482 |

| | | | | |
|---|---|---|---|---|
| FTJ_ID E | 0.000000000B | . | . | . |

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

## INSH 1AUM

## Catch in Logbooks and number of logbooks used

### The GLM Procedure

### Least Squares Means

| YEAR | LogCPUE LSMEAN | Standard Error | Pr > \|t\| |
|---|---|---|---|
| 2008 | 6.13421343 | 0.03549356 | <.0001 |
| 2009 | 6.06964386 | 0.03520037 | <.0001 |
| 2010 | 6.22443910 | 0.03093519 | <.0001 |
| 2011 | 6.32159185 | 0.03788967 | <.0001 |
| 2012 | 6.31373151 | 0.03188320 | <.0001 |
| 2013 | 6.19889124 | 0.03075859 | <.0001 |

# INSH 1AUP

## Catch in Logbooks and number of logbooks used

### The GLM Procedure

### Number of observations used 8654

**Dependent Variable: LogCPUE**

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 36 | 704.833776 | 19.578716 | 107.48 | <.0001 |
| Error | 8617 | 1569.672375 | 0.182160 | | |
| Corrected Total | 8653 | 2274.506151 | | | |

| R-Square | Coeff Var | Root MSE | LogCPUE Mean |
|---|---|---|---|
| 0.309884 | 6.539853 | 0.426802 | 6.526172 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 5 | 164.3784002 | 32.8756800 | 180.48 | <.0001 |
| MD | 11 | 111.3553794 | 10.1232163 | 55.57 | <.0001 |
| FTJ_ID | 20 | 429.0999962 | 21.4549998 | 117.78 | <.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 5 | 118.1687747 | 23.6337549 | 129.74 | <.0001 |
| MD | 11 | 95.0658179 | 8.6423471 | 47.44 | <.0001 |
| FTJ_ID | 20 | 429.0999962 | 21.4549998 | 117.78 | <.0001 |

| Parameter | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| Intercept | 6.431506178 | B | 0.04412547 | 145.75 | <.0001 |
| YEAR 2008 | 0.197929262 | B | 0.01868790 | 10.59 | <.0001 |
| YEAR 2009 | 0.224577468 | B | 0.01901498 | 11.81 | <.0001 |
| YEAR 2010 | 0.010384530 | B | 0.01707322 | 0.61 | 0.5430 |
| YEAR 2011 | -0.126221538 | B | 0.01697988 | -7.43 | <.0001 |
| YEAR 2012 | 0.142814121 | B | 0.01720325 | 8.30 | <.0001 |
| YEAR 2013 | 0.000000000 | B | . | . | . |
| MD 1 | 0.096761981 | B | 0.05318528 | 1.82 | 0.0689 |
| MD 2 | -0.229144065 | B | 0.05832655 | -3.93 | <.0001 |
| MD 3 | -0.629434212 | B | 0.09097347 | -6.92 | <.0001 |
| MD 4 | -0.742558412 | B | 0.14883838 | -4.99 | <.0001 |
| MD 5 | -0.362986846 | B | 0.04450428 | -8.16 | <.0001 |
| MD 6 | -0.364739792 | B | 0.04087883 | -8.92 | <.0001 |
| MD 7 | -0.137595590 | B | 0.04012118 | -3.43 | 0.0006 |
| MD 8 | -0.099819358 | B | 0.03993883 | -2.50 | 0.0125 |
| MD 9 | -0.231401526 | B | 0.04007446 | -5.77 | <.0001 |
| MD 10 | -0.150443712 | B | 0.04079575 | -3.69 | 0.0002 |
| MD 11 | -0.067227530 | B | 0.04068770 | -1.65 | 0.0985 |
| MD 12 | 0.000000000 | B | . | . | . |
| FTJ_ID A | 0.155400439 | B | 0.03262355 | 4.76 | <.0001 |

| | | | | |
|---|---|---|---|---|
| FTJ_ID B | -0.107683789B | 0.02715732 | -3.97 | <.0001 |
| FTJ_ID C | -0.042107175B | 0.02688174 | -1.57 | 0.1173 |
| FTJ_ID D | 0.353582332B | 0.03258206 | 10.85 | <.0001 |
| FTJ_ID E | 0.261964457B | 0.02795321 | 9.37 | <.0001 |
| FTJ_ID F | 0.564820260B | 0.02796931 | 20.19 | <.0001 |
| FTJ_ID G | 0.611226469B | 0.03435565 | 17.79 | <.0001 |
| FTJ_ID H | 0.397729366B | 0.02814180 | 14.13 | <.0001 |
| FTJ_ID I | 0.215835881B | 0.02958572 | 7.30 | <.0001 |
| FTJ_ID J | 0.236127176B | 0.02650669 | 8.91 | <.0001 |
| FTJ_ID K | -0.107328210B | 0.03103432 | -3.46 | 0.0005 |
| FTJ_ID L | -0.152115179B | 0.02940855 | -5.17 | <.0001 |
| FTJ_ID M | 0.519603942B | 0.02740271 | 18.96 | <.0001 |
| FTJ_ID N | 0.207041657B | 0.02911554 | 7.11 | <.0001 |
| FTJ_ID O | 0.495143267B | 0.03439739 | 14.39 | <.0001 |
| FTJ_ID P | 0.275019377B | 0.03245952 | 8.47 | <.0001 |
| FTJ_ID Q | 0.206725772B | 0.03596116 | 5.75 | <.0001 |
| FTJ_ID R | 0.096362441B | 0.03563738 | 2.70 | 0.0069 |
| FTJ_ID S | 0.042214665B | 0.02580558 | 1.64 | 0.1019 |
| FTJ_ID T | 0.439629804B | 0.02736564 | 16.07 | <.0001 |
| FTJ_ID U | 0.000000000B | . | . | . |

Note: The X'X matrix has been found to be singular. and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

## INSH 1AUP

## Catch in Logbooks and number of logbooks used

### The GLM Procedure

### Least Squares Means

| YEAR | LogCPUE LSMEAN | Standard Error | Pr > \|t\| |
|---|---|---|---|
| 2008 | 6.60856221 | 0.01989384 | <.0001 |
| 2009 | 6.63521041 | 0.02042073 | <.0001 |
| 2010 | 6.42101748 | 0.01731409 | <.0001 |
| 2011 | 6.28441141 | 0.01856826 | <.0001 |
| 2012 | 6.55344707 | 0.01845822 | <.0001 |
| 2013 | 6.41063294 | 0.02056990 | <.0001 |