Distribution of the commercial fishery for Greenland halibut and Northern shrimp in Baffin Bay

Jørgensen, Ole A.; Arboe, Nanette Hammeken

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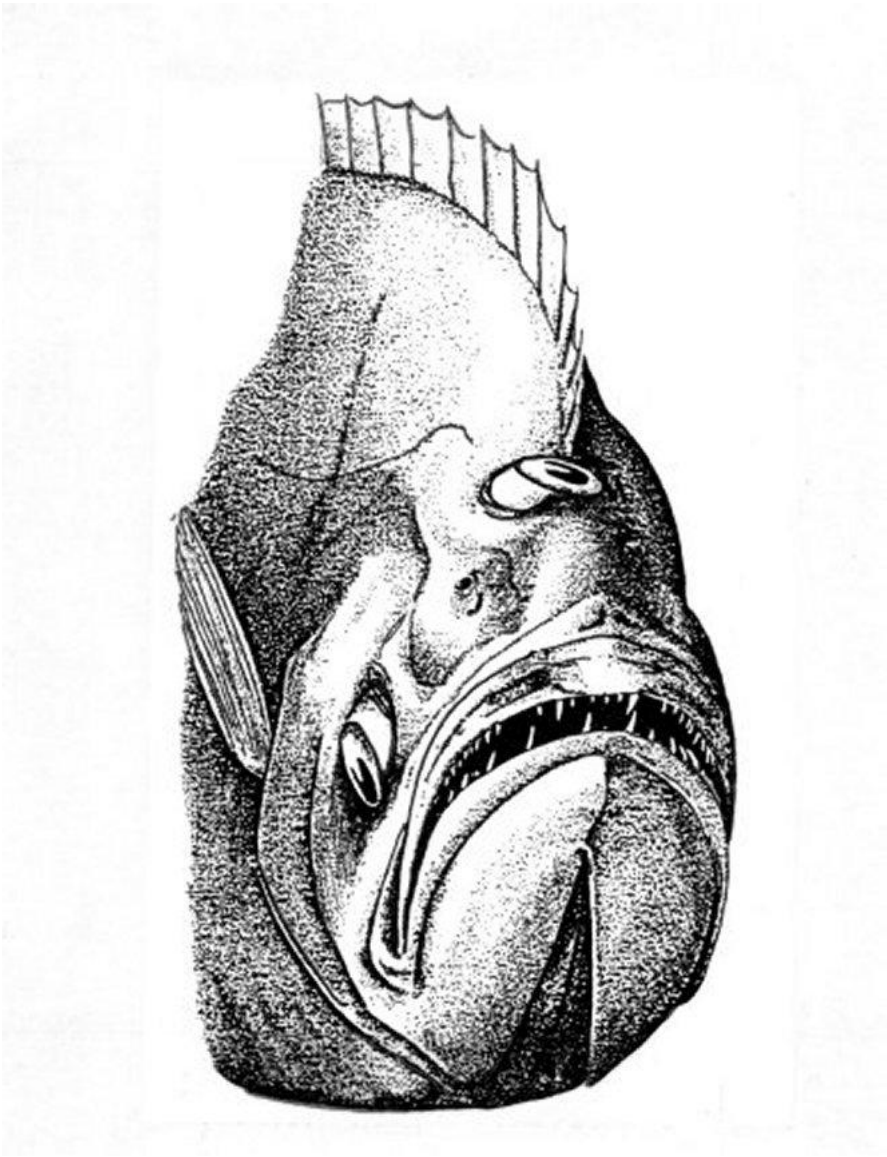

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Pinngortitaleriffik, Greenland Institute of Natural Resources
P.O. Box 570
3900 Nuuk
Greenland

Phone: +299 32 10 95
Fax: +299 32 59 57
E-mail: info@natur.gl

www.natur.gl

Distribution of small Greenland halibut in Baffin Bay

by

Ole A. Jørgensen

Technical report no. 89, 2013
Pinngortitaleriffik, Greenland Institute of Natural Resources

Eqqikaaneq

Qalerallit avataani amerliartornissaannut periarfissat pitsaanersaat Qeqertarsuup kitaani Disko Bank-ip Store Hellefiske Bank-illu akornanniippoq, tamaani qalerallit ukiumik ataatsimik pisoqaassusillit km2-imut 10.000-it sinnerlugit amerlassuseqartarlutik. Qalerallilli ukioq ataaseq missiliorlugu pisoqaassusillit minnerpaamik avannarpasissuseq 72º 30`N immaqalu aamma tassanngaanniit suli avannarpasinnerusumi 300 aamma 500 m-inik itissusilimmi amerlalluinnartarput (km2-imi ataatsimi aalisakkat >1000-it), avannarpasinnerusunili itissutsit ilimanaatillit annikitsuinnarmik misissuiffigineqarsimapput. Qalerallit ukiumik ataatsimik pisoqaassusillit amerlassusaat ukiumiit ukiumut allanngorartorujussuusarpoq, peroriartorfigisinnaasaasalu pingaarnersaasa sumiissusaat aamma ukiummit ukiumut nikeralaarsinnaasarput. Qalerallit peroriartornerminni peroriartorfiusinnaasunut itinerusunut nuuttarput - Baffin Bugt-imut nunattaluunniit kitaata avannaani kangerlunnut, qaleralinniarfiusartunut. Qaleraleeqqat unnuami immap qaatungaanut, pingaartumik assagiarsuaqarluartartunut neriniariartortaput. Taamaalillutillu uuliamik mingutsitsinermit ulorianartorsiortinneqarsinnaasarlutik.

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Sammenfatning

Det vigtigste udenskærs opvækstområde for hellefisk ligger vest for Disko mellem Disko Banke og Store Hellefiske Banke, hvor tætheden af et-årige fisk overstiger 10.000 individer per km². Et-årige hellefisk er imidlertid talrige (> 1000 individer per km²) på dybder mellem 300 og 500 m mod nord til mindst 72° 30′ N og sandsynligvis nord herfor, men der er foretaget meget få undersøgelser på de relevante dybder i nordligere områder. Der er stor årlig variation i antallet af et-årige hellefisk, og der er en vis årlig variation i beliggenheden af det vigtigste opvækstområde. Hellefisk søger fra opvækstområdet mod større dybde, mens de vokser – enten ud mod Baffin Bugten eller ind i de nordvestgrønlandske fjorde, hvor de efterhånden rekrutteres til fiskeriet. Små hellefisk vandrer op i vandsøjlen om natten, hvor de fouragerer først og fremmest på små krebsdyr tæt ved overfladen. De er således sårbare over for olieforurening.

Fiskeriet efter hellefisk er en vigtig indtægtskilde og har stor betydning for den lokale økonomi i de indenskærs områder. En meget stor del af befolkningen – først og fremmest deltidsfiskere – deltager i fiskeriet.

Summary

The main off shore nursery area for Greenland halibut is located west of Disko between St. Hellefiske Bank and Disko Bank where one year old fish are found in

large numbers (> 10000 specimens per km^2). Young Greenland halibut are, however, abundant (> 1000 specimens km^2) at depths between 300 and 500 m up to at least 72° 30′ N (very little research activities at relevant depths further north). There is great annual variation in the number of one year old Greenland halibut and some annual variation in the distribution of the main settling area. From the nursery area Greenland halibut migrate towards greater depth as they grow, either towards the central Baffin Bay or the fjords at Northwest Greenland, where they eventually recruit to the fishery. Small Greenland halibut make vertical migrations into the water column during night time where they feed primarily on crustaceans close to the surface. They are therefore vulnerable to oil spill.

The fishery for Greenland halibut contributes substantially to the local economy in the inshore areas. A very large fraction of the male population participates in the fishery, mainly as part time fishers, and the fishery serves to provide income needed in the cash economy.

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1. Introduction

The Greenland halibut (*Reinhardtius hippoglossoides*) is a flatfish species, widely distributed in the North Atlantic. At West Greenland it is found from Cape Farewell in south to Qaanaaq in north (77°30'N) both inshore and off shore at depths down to at least 2000 m.

The main spawning area is believed to be located in the Davis Strait on the southern slope of the ridge between Greenland and Baffin Island probably at depths > 1500 m. Spawning peaks in February – March (Gundersen et al. 2010). Spawning is probably not taking place inshore and in the Baffin Bay. If spawning occurs here it is believed to be sporadic and not sufficient to maintain the population (Simonsen & Gundersen 2005).

Early egg stages are found between 240 and 640 m (Smidt 1969) while the larvae are primarily found at 13-400 m (Simonsen et al. 2006). The eggs and larvae drift in the water mass for more than half a year before they settle to the bottom (Jensen 1935, Smidt 1969). Consequently egg and larvae have the potential to drift long distances (Steenberg et al. 2013).

From the spawning area eggs and larvae drifts along the west coast of Greenland or are brought into Canadian waters by a flection of the West Greenland current. The proportion of larvae that ends up in West Greenland waters is dependent of the longitudinal position of the spawning area. This distribution pattern is supported by the observation of drift buoys (Pedersen et al. 2002) and egg larvae drift model simulations (Steenberg et al. 2013).

The larvae that drift northward along the west coast of Greenland reach the settling area in September- November and settle (goes from pelagic stage to a bottom dwelling stage) at 250-400 m depth when they are about 7-9 cm. Traditionally larvae settle in Disko Bay, on the shelves of northern part of St. Hellefiske Bank, Disko Bank (Smidt 1969, Jørgensen 1997a, Steenberg et al. 2013), and probably on the banks in Baffin Bay to a varying extent, depending of the hydrographic conditions (water temperature and the velocity of the West Greenland current).

From the settling areas the Greenland halibut gradually migrates towards deeper water as they grow (Jørgensen 1997a, Steenberg et al. 2013). Offshore in the Davis Strait (Jørgensen 1997a) and in the Baffin Bay (Unpublished tagging data from Greenland Institute of Natural Resources) Greenland halibut migrates gradually towards the spawning area in the Davis Strait.

The Greenland halibut stocks located in the inshore areas are probably composed of fish that originally have settled or migrated on the inside of the banks in the Baffin Bay and gradually moved into the fjords as they grow. The Greenland halibut that end up in the Disko Bay and Northwest Greenland fjords remains there and do not contribute the spawning in Davis Strait and (Boje 2002). No significant spawning has been observed in the area, and the stocks are dependent on recruitment from offshore spawning areas.

There is little information on spawning in the Baffin Bay (Simonsen & Gundersen 2005) and all though spawning may take place in Baffin Bay it was estimated that the egg and larval mortality is so high due to the low water temperatures that the chance of successful spawning in Baffin Bay is considered low (Steenberg et al. 2013).

Greenland halibut make frequent migrations into the water column to feed. This is especially pronounced for 1-year-old fish and to some extent 2-year-old fish that

undertake vertical feeding migrations at night to feed on pelagic Crustaceans close to the surface. The head-rope in the research trawl was 50 below the surface, but the small Greenland halibut is probably found even closer to the surface (Jørgensen 1997b) because Christensen and Lear (1977) reported about catches of Greenland halibut taken in salmon that drifts at the surface.

Since the collapse of the cod stock the Greenland halibut resource comprised the major groundffish resource in recent years and the export of Greenland halibut constitute about 25 % of the total export from Greenland only exceeded by the export of shrimp (Statistics Greenland, Statistics for 2011).

The catches in Northwest Greenland have been relatively constant in recent years (Anon. 2012):

Offshore Baffin Bay: 6.700 tons (same amount in Canadian waters).
Upernavik: 6.500 tons.
Uummannaq: 6.500 tons.
Disko Bay: 8.000 tons.

The contribution from the fishery to the local economy in the three inshore areas is substantial. In Upernavik, where the socio-economic impact of the Greenland halibut fishery has been analyzed in details (Delaney et al. 2012)) there are only 33 full time fishers but 385 sellers, which is close to half of the adult male population. In the settlements almost all males to some extend participate in the fishery. For the part time fishers fishing serves to provide income needed in the cash economy (acquisition of fuel, ammunition etc.) while hunting meets household obligations and subsistence needs (Delaney et al. 2012).

2. Material and methods

Outline of bottom trawl surveys

The data on Greenland halibut distribution are sampled during annual bottom trawl surveys carried out by Greenland Institute of Natural Resources along the West coast of Greenland including the southern and central part of Baffin Bay at depths between 50 and 600 m since 1988.

The survey covers the offshore areas at West Greenland between 59°15'N and 72°30'N from the 3-mile limit to the 600 m depth contour line and the inshore area Disko Bay and Julianehåb Bay. The survey area is divided into NAFO Divisions, which were further subdivided into five depth strata (50-100, 101-150, 151-200, 20-400 and 401-600) on basis of depth contour lines. The area surveyed has, however, changed throughout the years. From 1988 to 1990 the survey area included Div. 1AN to 1D. In 1991 Div. 1AN was not covered. In 1992 the survey area was extended to include Div. 1AN to 1F and Disko Bay (Div. 1AX), and this area is now surveyed annually. The survey was originally designed as a shrimp survey and sampling of Greenland halibut data was not complete in the period 1989-1991. Since 1992 the sampling of fish has improved and the survey is now considered as a combined shrimp and fish survey. The survey period is June to August. The survey is designed as a stratified-random trawl survey. A minimum of two hauls per stratum is always planned. Due to new information on the bottom topography in Div.

1AN and Disko Bay a re-stratification has been conducted and the historic data has been recalculated according to the new stratum areas. Total numbers of stations have been fluctuating between 179 and 289 per year. For further information about allocation of hauls and survey design, see Kingsley et al. 2004.

The surveys have been conducted with trawlers of the same size throughout the years. Since 1991 the 722 GRT stern trawler M/Tr 'Pâmiut' has been used. Until 2004, a Skjervoy 3000/20 trawl with steel bobbin gear and double bag was used. The mesh size in the codend was 40 mm from 1988 to 1992. From 1993 the mesh size in the codend has been 20 mm. The changes of mesh size did not influence the catchability of fish except for redfish. In 2005 the Skjervoy trawl was replaced with a Cosmos trawl. Calibration experiments with the two trawls were conducted in 2004 and 2005. To allow comparison of abundance and biomass throughout the time series, the indices after 2005 have been divided by conversion factors to adjust the Cosmos trawl catches to the former Skjervoy trawl standard. From 1988 through 2003 the trawl doors were of the type Greenland Perfect, measuring 9.25 m^2 and weighing 2 420 kg. They were replaced in 2004 by Injector International 7.5 m^2 trawl doors with a weight of 2 800 kg to facilitate the change of survey trawl in 2005.

The standard trawling time has been changed through the years. During 1988 to 1997 it was 60 min and thereafter stepwise shortened to a mixture of 30 and 15 min tows. Finally in 2005, standard tow duration was set to 15 minutes at all stations. Towing speed has been about 2.5 knots throughout the years. The trawling operations are performed during daytime only.

After each haul the catch was sorted by species or lowest taxonomic level and weighed to 0.1 kg and the number recorded. Fish was measured as total length to 1 cm below. All catches have been standardized to catch km^{-2} before further calculations. The coefficient of catchability was set at 1.0, implying that estimates are merely indices of abundance.

Plots of distribution

The distribution plots were made in MapInfo v.7 using survey bottom trawl catches standardized to catch by age in number per km^2 based on estimated wings-spread in the trawl and trawled distance. The data points were interpolated by the Inverse Distance Weighting (IDW) interpolation method. MapInfo settings were: cell size 3 km, Search radius 99 km and Grid border 24 km.

Aging of Greenland halibut

It is difficult and cumbersome to age Greenland halibut from otoliths. In this report aging is based on the "Petersen method" where the modes in the length distribution are considered to represent cohorts (Bowering & Nederaas 2001). In all length frequency samples what is considered as age one comes out very distinct and the split between age one and age two is very clear (Fig. 1). The split between age 2 and age 3+ (three years and older) is less distinct but in all length frequency samples there is a detectable local minimum around 26-28 cm which is considered as the maximum length for age 2.

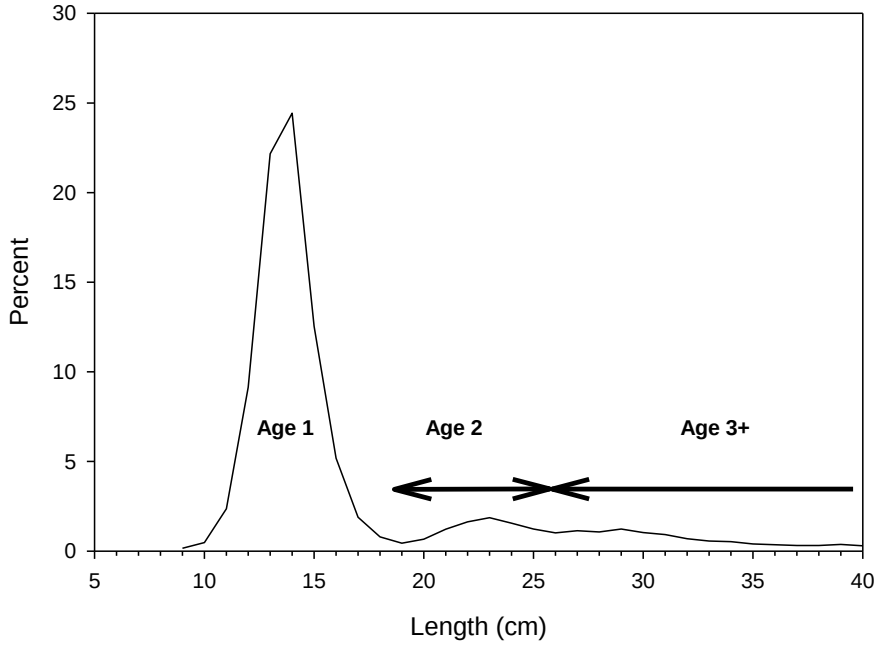

Fig. 1. Typical length distribution of Greenland halibut split in age groups by the Petersen method.

3. Results

Distribution of small Greenland halibut

The Greenland halibut larvae settle (go from a pelagic stage to a bottom living stage) in September – October when they are about 7-9 months old. A plot of the overall distribution in June-July including data from the recent 10 years (2003-2012) shows that Greenland halibut at age one is found in the highest concentrations west of Disko Bank and in the Disko Bay at depths around 300 – 400 m (Fig. 2). The age one Greenland halibut are, however, also found in great numbers, > 1000 km^{-2}, at depths above app. 300 m in the area up to at least 72°30'N, the northern boundary of the area covered by the bottom trawl surveys, but probably even further north (Fig. 2). Small Greenland halibut have also been observed between 73°N and 77°N but the information is scarce, due to very few survey bottom trawl hauls at relevant depths (Jørgensen 2005). There seems to be relatively few Greenland halibut on the top of the banks and there is observed very few age one Greenland halibut south of 66°N.

The same distribution pattern is seen when data from the last three years are combined, but with a relatively higher density in Disko Bay (Fig. 3). Generally about 65% of the recruitment at age one is found in the offshore areas, but with some inter annual variation (Fig. 4)

There is a great variation in the recruitment (Fig. 5) between years probably caused by minor changes in the main currents (Stenberg et al. 2013) and variation in natural mortality of the eggs and larvae.

Examples of low recruitment is seen in Fig. 6 where the distribution pattern of the one year old fish generally is the same as the overall distribution, but the 2011 year-class is poor in the 2012 survey (preliminary data). Another example is the 1987 year class which was even lower (Fig. 7). On the other hand was the 2010 year class the highest on record (Fig. 8).

The distribution of the main nursery area also shows some variation between years. In 2011 for example the one-year old fish offshore were distributed more northerly than generally seen (Fig 8.) with the main abundance found in Div. 1AN and 1AS.

As the Greenland halibut become older they gradually migrate towards deeper water either towards the deeper areas between and outside the banks or towards the deep fjords and the inner part of the Disko Bay (Fig. 9). At the same time the numbers are reduced significantly probably due to natural mortality but also due to migration into deeper water outside the depths (max 600 m), covered by the surveys. Age 3 – 5 were hence abundant in test hauls west of Disko at depths 600-900 m conducted in the research area with the same trawl (Nygaard & Jørgensen 2010).

There has been an increasing trend in the numbers of age one Greenland halibut in the northernmost area covered by the surveys (Div. 1AN) (Nygaard & Jørgensen 2012) and water temperatures (Ribergaard 2012). In Fig. 10 the numbers at age one in Div. 1AN is plotted against the surface temperature (0-40 m) at the top of Fylla Bank (off Nuuk), the year before when eggs and larvae have passed through the area. There is no statistically significant (95% level) correlation between the two (short) data series. It seems, however, that Div. 1AN becomes an increasingly more important nursery area whatever is causing it.

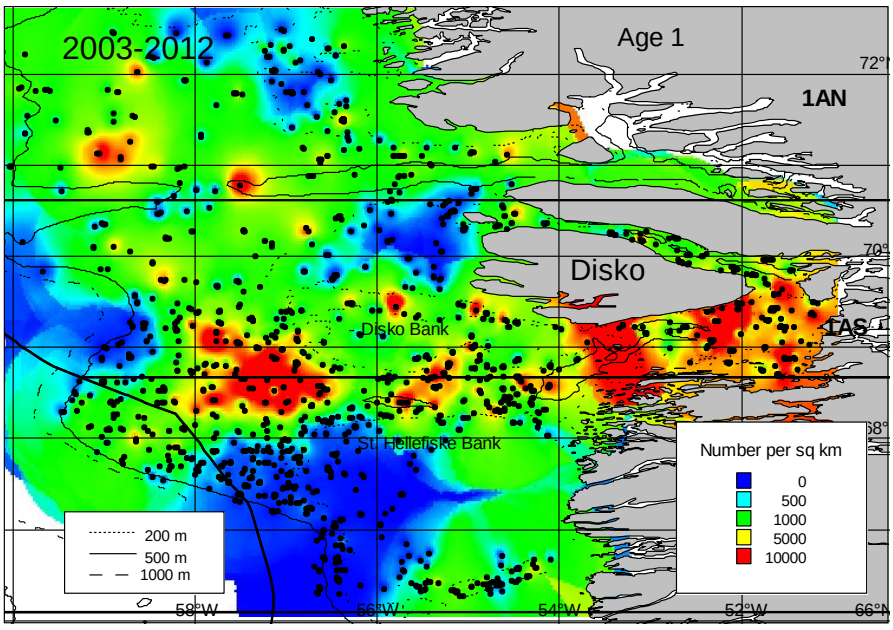

Fig. 2. Distribution of Greenland halibut age one including all stations from 2003-2012.

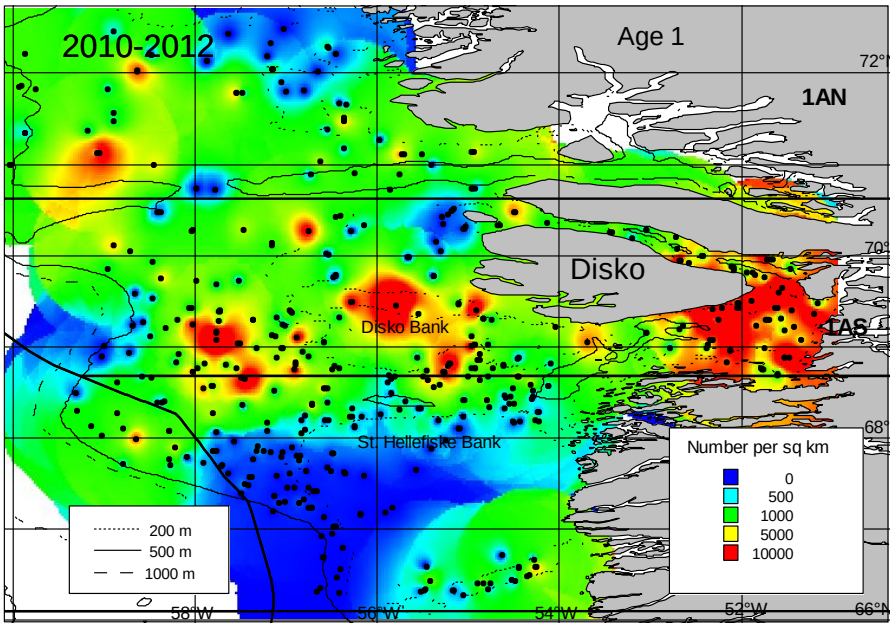

Fig 3. Distribution of age one Greenland halibut data including all stations from 2010-2012.

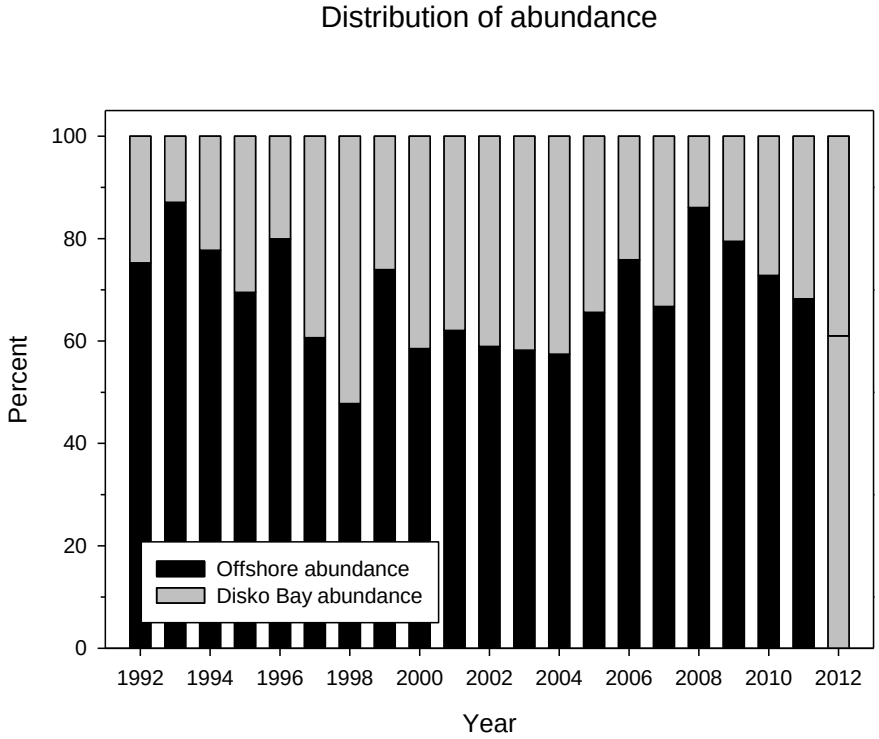

Fig. 4. Relative distribution of one year old Greenland halibut in Disko Bay and off shore, relatively.

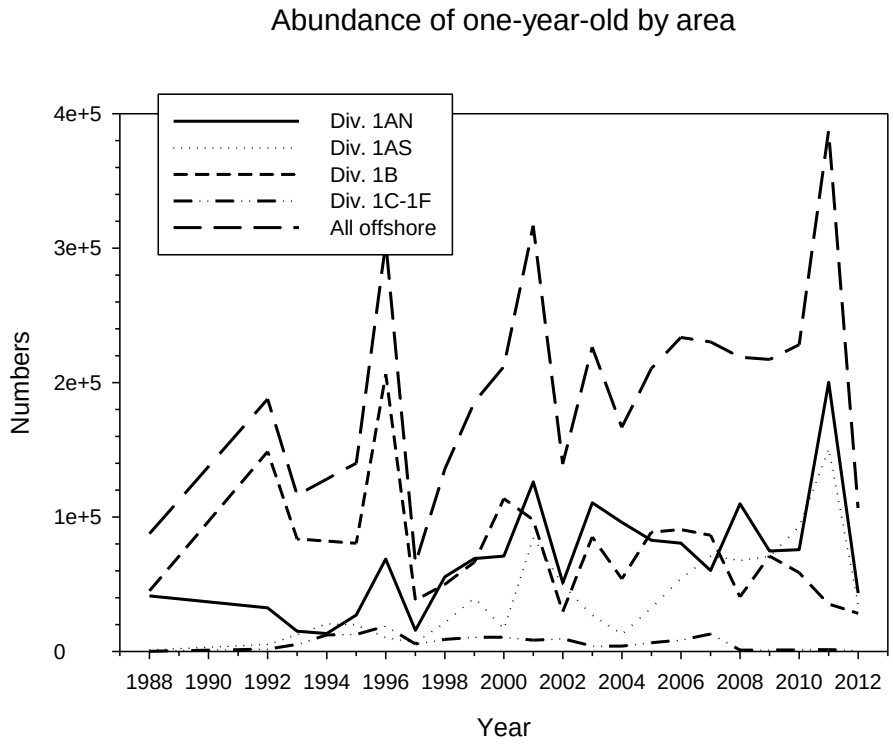

Fig. 5. Abundance of one year old Greenland halibut by NAFO Divisions.

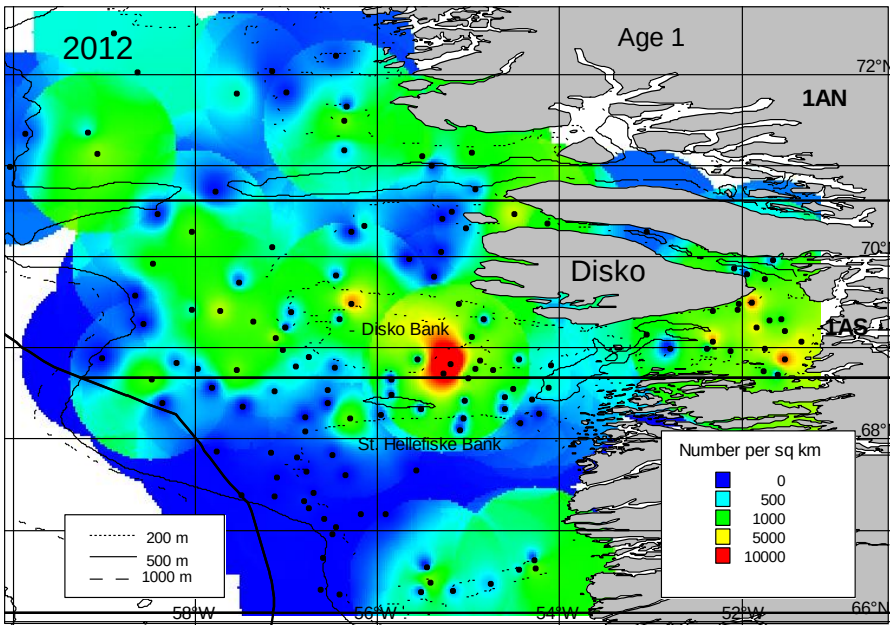

Fig 6. Distribution of age one Greenland halibut in 2012 (preliminary data).

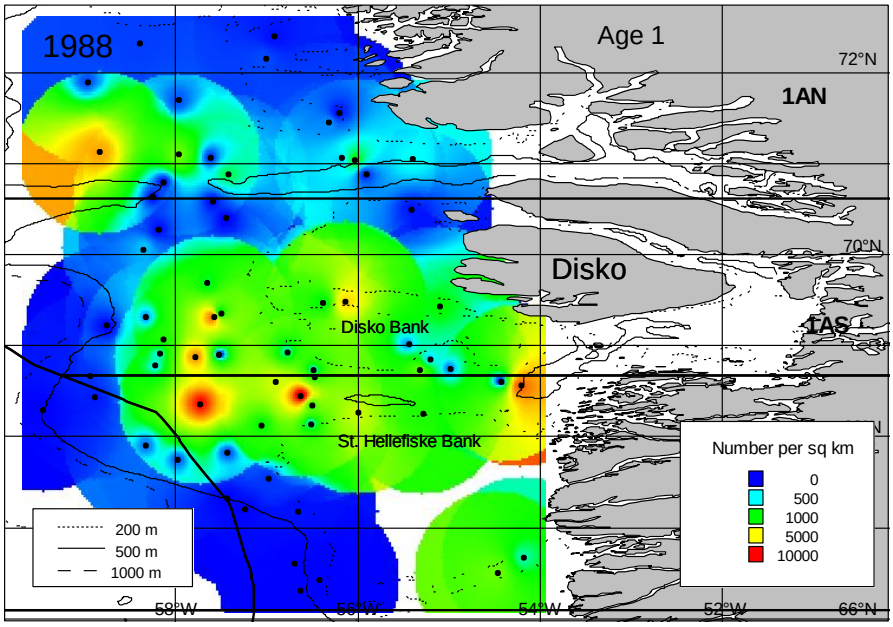

Fig. 7. Distribution of one year old Greenland halibut in 1988. No survey in Disko Bay.

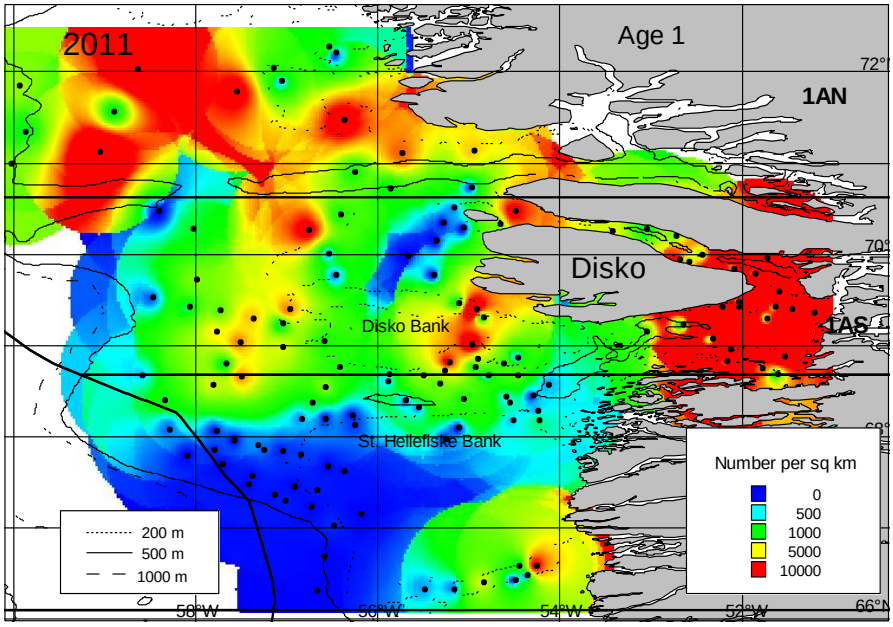

Fig. 8. Distribution of one year old Greenland halibut in 2011.

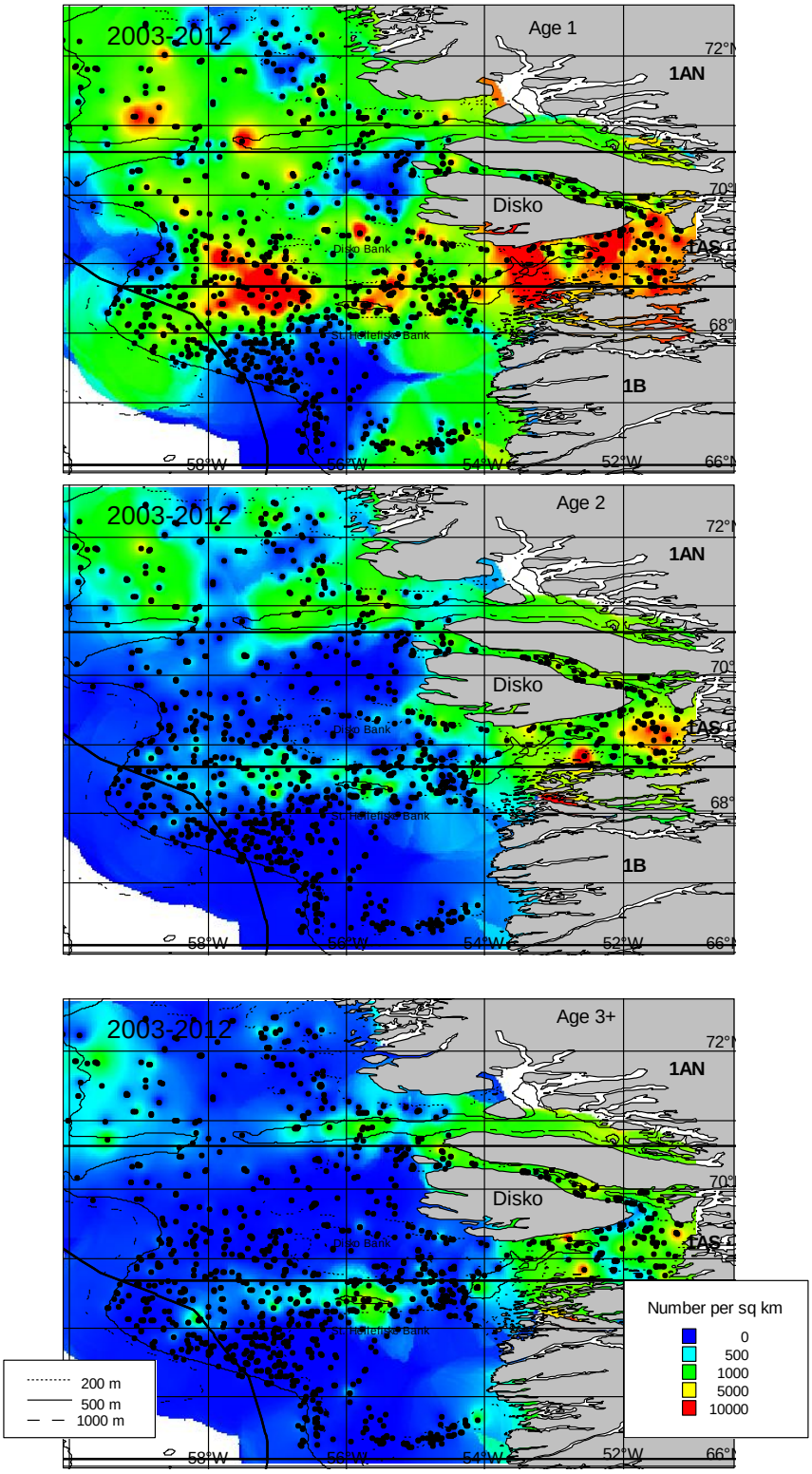

Fig. 9 Distribution of Greenland halibut at age one, age two and age 3+, respectively, including all stations from 2003-2012.

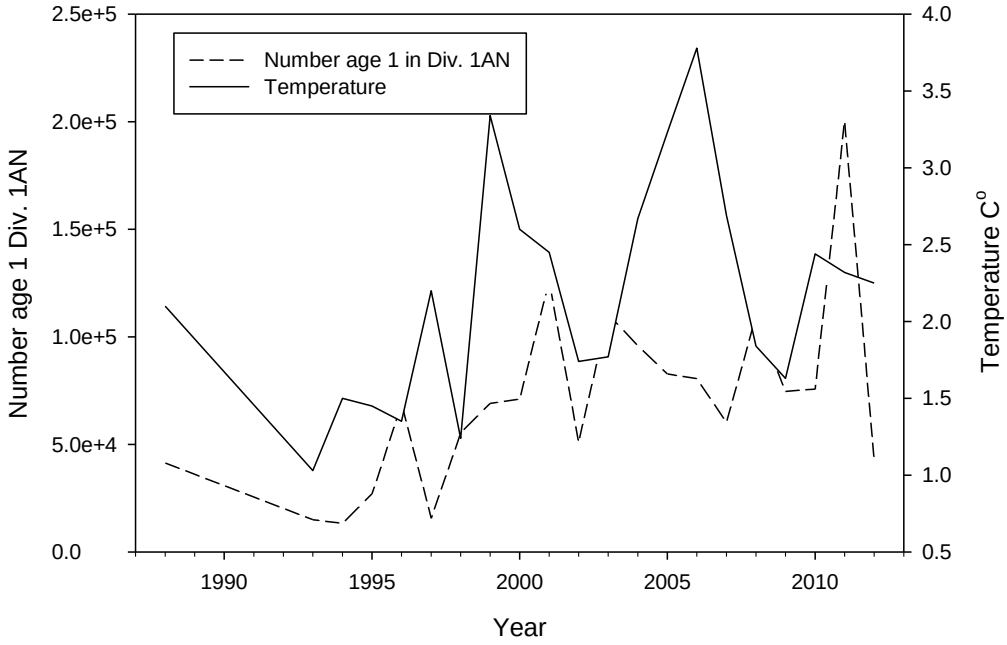

Fig. 10. Temperature on top of Fylla Bank and the number of age one Greenland halibut in Div. 1AN the following year.

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