Northwest Atlantic Fisheries Organization

Serial No. N7061 **NAFO SCR Doc. 20/016**

SCIENTIFIC COUNCIL MEETING – JUNE 2020

Trawl, gillnet and longline survey results from surveys conducted by the Greenland Institute of Natural Resources in NAFO Division 1A Inshore

by

Rasmus Nygaard

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

Abstract

This paper presents the updated indices for the surveys performed by the Greenland Institute of Natural resources (GINR) in the Disko Bay, Uummannaq and Upernavik districts, all part of the inshore areas located in NAFO subarea 1. The Disko Bay has previously also been surveyed with longlines, but in 2001 this survey was changed to a gillnet survey. The Disko bay has furthermore been part of the Greenland Shrimp and Fish survey (trawl) since 1992. The Uummannaq and Upernavik districts have previously been surveyed with longline, but from 2011 to 2015 the surveys were gradually changed to gillnet surveys. Since 2016, gillnet have have been used in all 3 areas. In order to also survey commercially sized Greenland halibut a larger meshed section (90mm halfmesh) was added in 2016.

Introduction

Greenland halibut is a dominant fish species in the North-west Greenlandic fjords and of major importance to the people living in the area. In the Disko bay, targeted species include Greenland halibut, shrimp, cod and snow crab, whereas other species like wolffish and redfish are mainly bycatch and occasionally landed. In Uummannaq and Upernavik, Greenland halibut is the only directly targeted species and other species like cod, redfish, spotted wolffish and roughhead grenadier are taken as bycatch. About 1000 people have a license to fish commercially in the areas and the Greenland halibut is therefore of major social and economic importance to the local communities.

Survey area

The *Disko Bay* is characterized by areas of smooth bottom and depths are mostly less than 600 meters. Glaciers are located in the North-Eastern part of the bay at *Torssukattak* and in the central eastern part the *Kangia* Icefjord where deeper waters are located (+900m). The Disko Bay is connected to the Baffin bay in the western part and in the North Western part through the narrow channel *Vejgat*.
The *Uummannaq* fjord is by far the deepest of the three areas, and depths down to 1500 meters can be found in the South-eastern part, with slightly shallower depths towards glacier fronts. Several large iceberg producing glaciers are present with the more dominant glaciers located in the South Eastern part Qarajaq (store bræ) and North Eastern parts (Rinks isbræ). The central parts of the Uummannaq fjord is shallower and with smooth bottom contours at depths of 500-700m and connected to the Baffin Bay to the West.
The *Upernavik* area is characterized by several large iceberg producing glaciers, which extend into deep narrow fjords and depths of more than 900 m. Two of the more important fishing grounds are located in the Upernavik ice fjord and Gieskes ice fjord (Gulteqarffik). Although the main fishing grounds in the Upernavik area are located in the deep ice fjords, the branching fjord systems between the ice fjords are easier to access and survey.

The branching side fjords have more suitable depths and are more protected from icebergs and therefore possible to survey every year, whereas the deep ice fjords with icebergs and glacier ice, are not always accessible to research vessels in the available timeframe.
An overview of the most recent surveys and successful stations by year, vessel and gear is given in table 1 and fig 1.

The surveys

Surveys have been conducted in the area since the mid 1970's, using different types of longlines as gillnets or trawls are harder to use due to bottom contours, very silty and soft bottoms and glacier ice.
In the Disko Bay, it is possible to use trawls and the Disko bay has been part of the Greenland Shrimp and Fish survey (SFW) since 1991. From 1991 to 2017 the survey was conducted with the 722 GRT stern trawler M/Tr 'Pâmiut'. Pâmiut was decommissioned in 2018 and the survey was updated with a chartered vessel using Pâmiut's gear. In 2005 the gear was changed in this survey, but since then the area coverage and the trawl and its rigging has been unchanged. In this survey up to 90% of the Greenland halibut caught in the survey are juveniles at age 1 and 2.
In 2001, a gillnet survey was initiated in the Disko bay. The main objective for starting up the gillnet survey was a well-estimated selectivity and the possibility for targeting pre-fishery sized Greenland halibut (35-55cm TTL). The gillnets were composed of 60m long sections with mesh sizes 46, 55, 60 and 70 mm (knot to knot or half mesh). Sections are separated with a 2m open space to prevent catchability interactions. Soak time is approximately 6-18 hours and fishing takes place both day and night. Stations are paired two and two, close to each other to allow for analysis of within station variability. A similar survey was gradually implemented in Uummannaq and Upernavik in 2011-2014. The target is to fish 50 stations annually in each area. In 2016 a 90mm section was added to all stations in order to survey larger halibut.

Results

The **Disko Bay** part - of the Greenland shrimp and fish trawl survey

The Disko bay part of SFW survey indicated increasing abundance during the 1990s and high abundances (mainly age 1) were found from 1998 to 2005 (fig 1). After 2006 the abundance indices returned to the lower levels with the exception of the high abundances identified in 2011, 2013 and 2016 (2010, 2012 and 2015 YC) (fig 2). However, only the 2010 and 2015 YC can be followed as larger than average in the following years, whereas the 2012 YC seems at average levels already in 2014. The length distribution in the survey reveals that particularly the 2011 and perhaps the 2014 YC seems small (fig 2). The small 2011 YC also seems small as 3 year olds in the 2014 survey (fig 2b). However, in most years there seems to be a tendency for recruitment to be less varying at age 2 and 3.
The biomass indices in the trawl survey indicate a steady increase during the 1990's, with a substantial increase observed in 2003 and 2004 (fig 1). After the gear change in 2005, the biomass index has been in a decreasing trend with the lowest values found in the most recent 5 years except for the increase observed in 2018. The increase in 2018 seems related to a higher than usual number of 3 year old recruits (2015 YC) (fig 1). In the 2019 survey, unusually few commercial sized Greenland halibut are present (fig. 2)

The **Disko bay** gillnet survey

The survey uses fixed positions of stations arranged in transects towards the important fishing grounds West of Ilulissat city and Torssukattak ice fjord in the northern part of the Disko Bay (fig 3). The gillnet survey CPUE and NPUE indicated low levels of pre-fishery recruits in 2006 and 2007, but returned to above average levels in 2008 and 2010. The increase in 2011 NPUEs was observed in the northern area of the Bay, while in the main fishing grounds at the Ice fjord bank around Ilulissat the NPUEs remained low (fig 3). The high numbers of larger fish in 2011, did not seem to have any origin in the previous year estimated populations. This may either be due to migration/movements of the larger fish in the area or just reflecting the uncertainty of the estimates. Since 2013, indices have been below average levels.
As the survey uses gillnets with narrow selection curves there is not a major difference between the trends of the CPUE and NPUE indices (fig 4). If comparing the gillnet NPUE (all sizes) to the trawl survey indices of

Greenland halibut larger than 35 cm, the surveys seems to be correlated to some extent (fig 4, right), leading to increased credibility in the indices of both surveys (see discussion). In 2019, the survey was incomplete as all transects south of the icefjord was not conducted. Since these stations normally have a lower catch the 2019 gillnet CPUE and NPUE is likely an overestimate, partly explaining the discrepancy between the surveys.

Length distribution in the 2018 Gillnet survey revealed unusually high numbers of Greenland halibut in the interval 30-40 cm (fig. 7), which was also found in the trawl survey fig 2.b. The 90mm section added in 2016, has in general not impacted the overall length distribution in the Disko bay, indicating few larger individuals in the surveyed area (55-70 cm)(fig 7).
From 2013, significant numbers of cod have also been taken in the survey, composed of several YC's (fig 7).

The **Uummannaq** gillnet survey

A few experimental gillnet stations were set in Uummannaq from 2011 to 2014, but these are hardly representative of changes in the stock (table 1). Overall the experimental station revealed NPUE similar to the Disko bay and CPUE' higher than in the Disko Bay (Fig 5). To allow for comparison with the Disko bay, catches from the 90mm section were not included in the CPUE and NPUE calculations (fig 5). The size distribution in the survey reveals that pre-fishery recruits are present in the area and that there is an overweight of large individuals compared to the Disko bay (fig 8). The 90mm section added in 2016 caught high numbers of Greenland halibut in the size range 55-65 cm in Uummannaq indicating higher numbers of larger individuals in the area (fig 8). After 2015, both the both the NPUE and CPUE has decreased (fig 5), with a gradual change towards smaller fish caught in the survey (fig 8). The gradual decrease in size can also be observed as a gradual lower number of Greenland halibut caught in the 90mm mesh targeting larger fish. Increasing numbers of cod have also increasingly caught in the survey in Uummannaq (fig 8 right). In 2018 the cod were between 50 and 90 cm, potentially leading to a saturating effect on the gillnets.

The **Upernavik** gillnet survey

Since 2011, some experimental gillnet stations have been set every year and in 2015 gillnets have been fully implemented (Tab 1). The gillnet stations indicate CPUE and NPUE comparable to the level observed in the Disko Bay (fig 6). The length distributions indicates the presence of pre-fishery recruits at sizes rarely seen in landings from the Upernavik area (fig 9). In 2015, a 90 mm section was added to all stations (fig 9), although exclude in the CPUE and NPUE calculation (fig 6). After 2015, survey NPUE has been fairly stable while the CPUE seems to be decreasing (fig 6). The length distribution reveals that the Greenland halibut caught in the survey has gradually changed towards smaller fish (fig 9).

The longline surveys

Longline surveys have been conducted in the area for more than five decades, but the longline setup and equipment have changed several times throughout the time series. (for further details see Simonsen *et al*. 2000). The longline was changed from a 7mm thick mainline to a thinner type of longline also used by professional fishermen (5,5mm) in 2012. In general, professional fishermen prefers as thin a longline as possible and during the winter fishery they often use longlines as thin as 1 mm. Professional fishermen also have a far higher CPUE (50-100 kg/100 hooks) than observed in the survey (5-15kg/100hooks). The longline surveys were highly variable from year to year and not easily interpreted. For these reasons the longline surveys stopped in 2016.

Biological samples
Length, weight, gutted weight, otoliths and occasionally DNA samples are regularly collected during the surveys. In general Length-Weight varies little from year to year (Table 2).

Climatic conditions

A well documented temperature increase occurred in 1997 along the west coast of Greenland and bottom temperatures has remained at a higher level until 2016 (fig 10). The temperature increase has been related to both increased glacier retrieval (Holland et al, 2008, Motyka et al. 2011) and increased growth of one year old

Greenland halibut (Sünksen et al 2009). From 2016, the size of 1 and 2 year old Greenland halibut seems smaller than observed from 2007-2017 mean length distribution (fig 2.a and 2.b).

Discussion

In the beginning of the Disko Bay gillnet survey time series commercial landed Greenland halibut were larger in the area and fish smaller than 55 cm were regarded pre-fishery recruits. However, in the recent decade smaller and smaller Greenland halibut have been landed and nowadays the fishery targets Greenland halibut as small as 30 cm with smaller hooks and illegal use of finer meshed gillnets (80mm) selecting fish around 1 kg most efficiently. Therefore the gillnet survey is increasingly surveying both recruits and the fished stock. The fishery may therefore directly be impacting the gillnet survey indices.
Trawl calibration experiments indicated that the difference in catchability between the gears was length dependant for Greenland halibut and was at equilibrium at lengths around 12 cm, but twice as high at 40 cm. Since the abundance is highly driven by 1 year old recruits (15 cm) which normally constitute 80-90% of the abundance in the survey, there is little impact the abundance index whether calibrating or not. This is not true for the biomass where calibrating has a higher impact on the indices. However since the calibration experiments revealed an almost 1:1 relationship between the most abundant individuals, but a stronger difference individuals that must have been rare in the experiments, this could also imply that the catchability difference between the trawls are overestimated. Likewise the fact that indices prior to and non-calibrated indices after the gear change are at the same level for Greenland halibut (but also other species) indicate that the effect of the gear change on the indices may be overestimated.
The 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 surveys generally occur separated by a month or less and in the same overall areas at the same depth intervals. The trawl survey covers most of the bay and relies on randomly distributed stations, whereas the gillnet survey relies on fixed stations. 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. The increase in survey trends in both surveys were mainly related to Greenland halibut between 30-40 cm. However, both surveys show 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 be interpreted as indices only and indicators of the overall development of the stock.
It is uncertain how the increasing number of large cod caught in the survey in both the Disko Bay and in Uummannaq has influenced the Greenland halibut CPUE and NPUE. Since the cod caught in the survey are so large it is possible that the large cod has a saturating effect of the Gillnets.

Recruitment
Although recruitment seems to vary from year to year, this does not seem to be the case at age 2 or 3. Often estimates strong or weak YC at age one seems close to average levels a year or two later. It has been suggested that this may be related to density dependant mortality at in years of extra high recruitment (Sünksen et al. 2009).

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Table 1. Number of stations by gear and Area (Table is incomplete)

	Disko Bay		Disko Bay			Uummannaq			Upernavik		
Year	Trawl	vessel	Longline	Gillnet	Vessel	Longline	Gillnet	Vessel	Longline	Gillnet	Vessel
1990	*	Pa			AJ						
1991	41	Pa			AJ						
1992	39	Pa			AJ						
1993	31	Pa	31	-	AJ	21	-	AJ			
1994	27	Pa	32	-	AJ	-	-	AJ	30	-	AJ
1995	33	Pa	-	-	--	19	-	AJ	32	-	AJ
1996	33	Pa	29	-	AJ	24	-	AJ	-	-	-
1997	34	Pa	24	-	AJ	-	-	-	-	-	-
1998	33	Pa	-	-	-	23	-	AJ	31	-	AJ
1999	34	Pa	26	-	AJ	10	-	AJ	-	-	-
2000	23	Pa	35	-	AJ	-	-	-	30	-	AJ
2001	23	Pa	15	8	AJ	4	-	AJ			
2002	22	Pa		55	AJ						
2003	19	Pa		56	AJ						
2004	14	Pa	8	50	AJ						
2005	16	Pa	9	47	AJ	21	0	AJ	-	-	-
2006	21	Pa	3	44	AJ	16	0	AJ	-	-	-
2007	18	Pa	2	30	AJ	21	-	AJ	-	-	-
2008	16	Pa	0	35	Ch	-	-	-	-	-	-
2009	24	Pa	-	-	-	-	-	-	-	-	-
2010	25	Pa	0	48	AJ	-	-	-	15	-	AJ
2011	26	Pa	0	50	AJ	16	4	AJ	13	-	AJ
2012	21	Pa	0	41	Sa	28	3	Sa	7	21	Sa
2013	17	Pa	0	27	Sa	28	7	Sa	16	19	Sa
2014	21	Pa	0	37	Sa	23	4	Sa	16	13	Sa
2015	17	Pa	0	26	Sa	18	28	Sa	0	48	Sa
2016	12	Pa	0	54 (76)	Sa	0	49	Sa	0	47	Sa
2017	30	Pa	0	36	Sa	0	48	Sa	0	41	Sa
2018	20	Ch	0	42	Sa	0	54	Sa	0	52	Sa
2019		Ch	0	32	Sa	0	44	Sa	0	31	Sa

NOTES:
Research vessels: (PA: RV Pâmiut, AJ: Adolf Jensen, Ch: Chartered commercial, SA: RV Sanna)
2001 – Longline survey in Disko bay changed to Gillnet survey (46,55,60,70 mm halfmesh).
2012 – Disko bay gillnet survey had defect 60 mm gillnet section.
2013 – Disko bay gillnet survey had stations with large catches of cod (fishing effect may have been affected)
2014 – Disko bay gillnet survey moved to May to reduce problems with glacier ice and icebergs.
2015 – Experimental 90mm mesh added in Uummannaq (partly) and Upernavik (all stations).
2016 – 90mm section fully implemented in all areas (46,55,60,70,90 mm halfmesh) on all stations. 54 normal GHL stations and 22 ekstra stations to survey cod.
2018 – Chartered vessel is Sjurdaberg using Paamiut doors, trawl and assistant crew.
2019 – Chartered vessel is Helga Maria using Paamiut doors, trawl and assistant crew.

Table 2. modelled Length-Weight relationship for Greenland halibut.

Year	Area	Number fish	Log a	b	R^2
2012	Uummannaq	357	-12,708	3,259	0,984
2013	Uummannaq	313	-12,666	3,252	0,983
2014	Uummannaq	209	-12,692	3,251	0,992
2015	Uummannaq	197	-13,093	3,37	0,982
2016	Uummannaq	421	-12,73	3,262	0,991
2017	Uummannaq	581	-12,916	3,326	0,975
2018	Uummannaq	393	-12,54	3,224	0,988
2019	Uummannaq	397	-12,17	3,137	0,986
2012	Upernavik	267	-13,326	3,431	0,985
2013	Upernavik	294	-12,853	3,299	0,988
2014	Upernavik	333	-12,978	3,33	0,984
2015	Upernavik	407	-12,696	3,267	0,991
2016	Upernavik	453	-12,607	3,255	0,984
2017	Upernavik	361	-12,445	3,216	0,985
2018	Upernavik	378	-12,722	3,283	0,989
2019	Upernavik	326	-12,421	3,205	0,986
2008	Disko Bay	578	-12,616	3,244	0,989
2009	Disko Bay	827	-12,516	3,224	0,997
2010	Disko Bay	348	-12,687	3,27	0,994
2011	Disko Bay	563	-12,595	3,246	0,99
2012	Disko Bay	513	-12,541	3,235	0,987
2013	Disko Bay	564	-12,479	3,212	0,995
2014	Disko Bay	628	-12,275	3,144	0,992
2015	Disko Bay	523	-12,515	3,221	0,995
2016	Disko Bay	778	-12,626	3,256	0,996
2017	Disko Bay	813	-12,344	3,189	0,986
2018	Disko Bay	1210	-12,557	3,241	0,994
2019	Disko Bay	733	-12,589	3,249	0,995

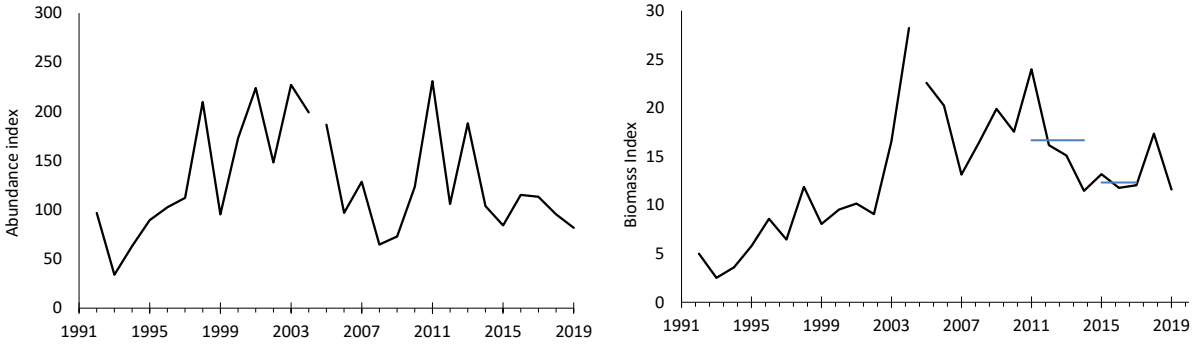

Figure 1. Trawl survey (SFW) in Disko bay: Abundance (left) and biomass (right).

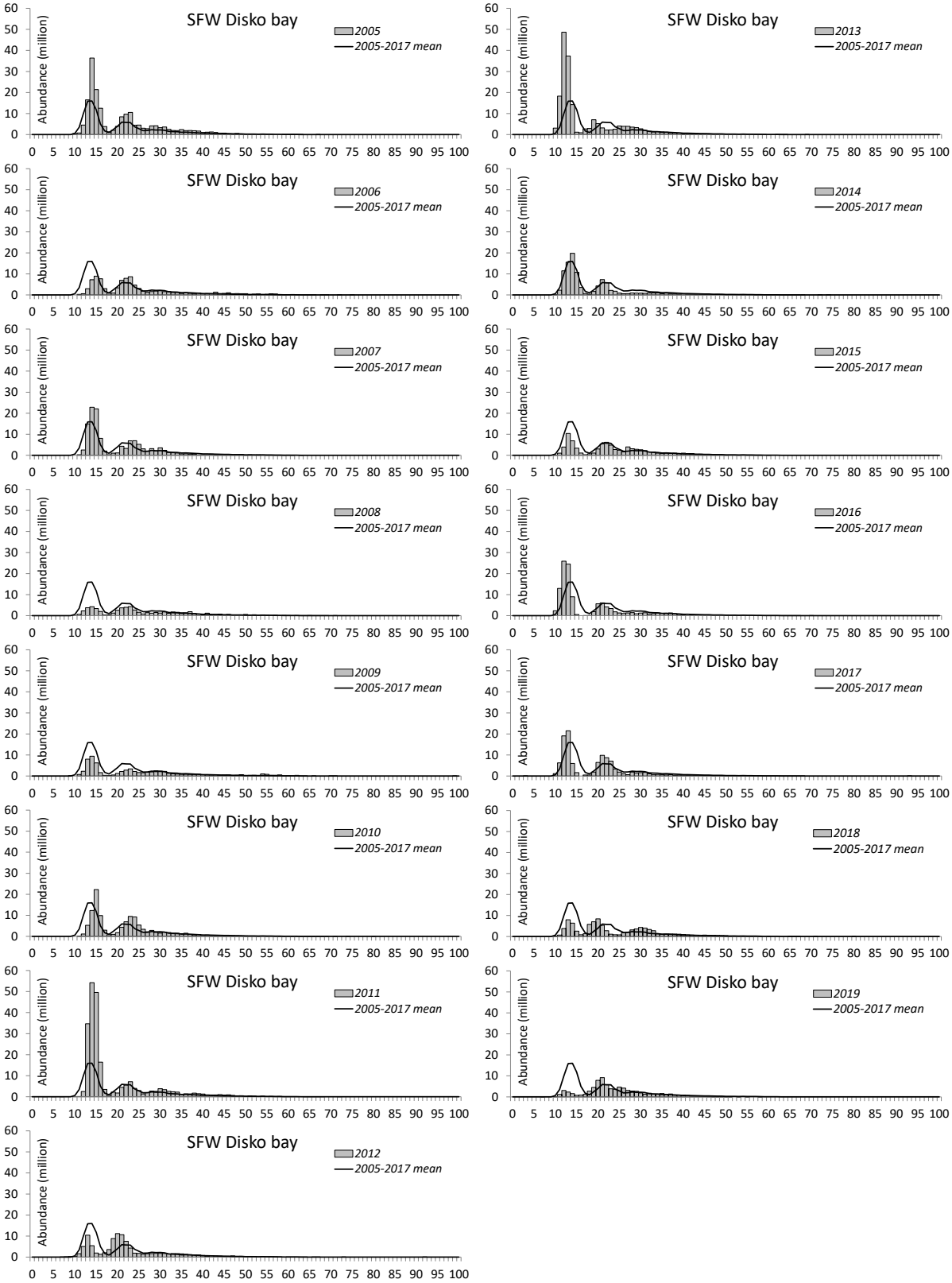

Figure 2.a Greenland halibut trawl survey length frequencies (SFW).

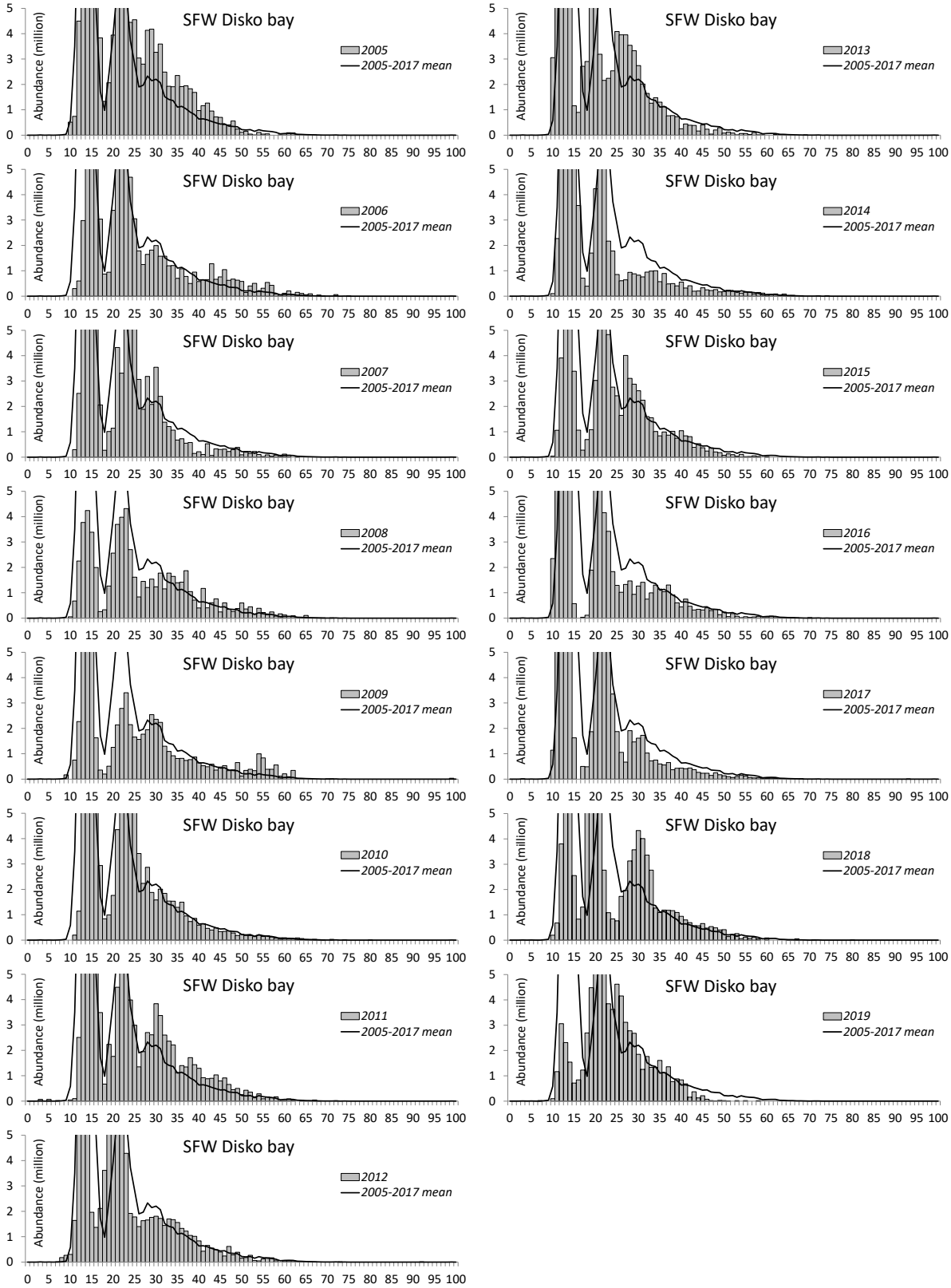

Figure 2.b Greenland halibut trawl survey length frequencies (SFW) Y-axis zoomed.

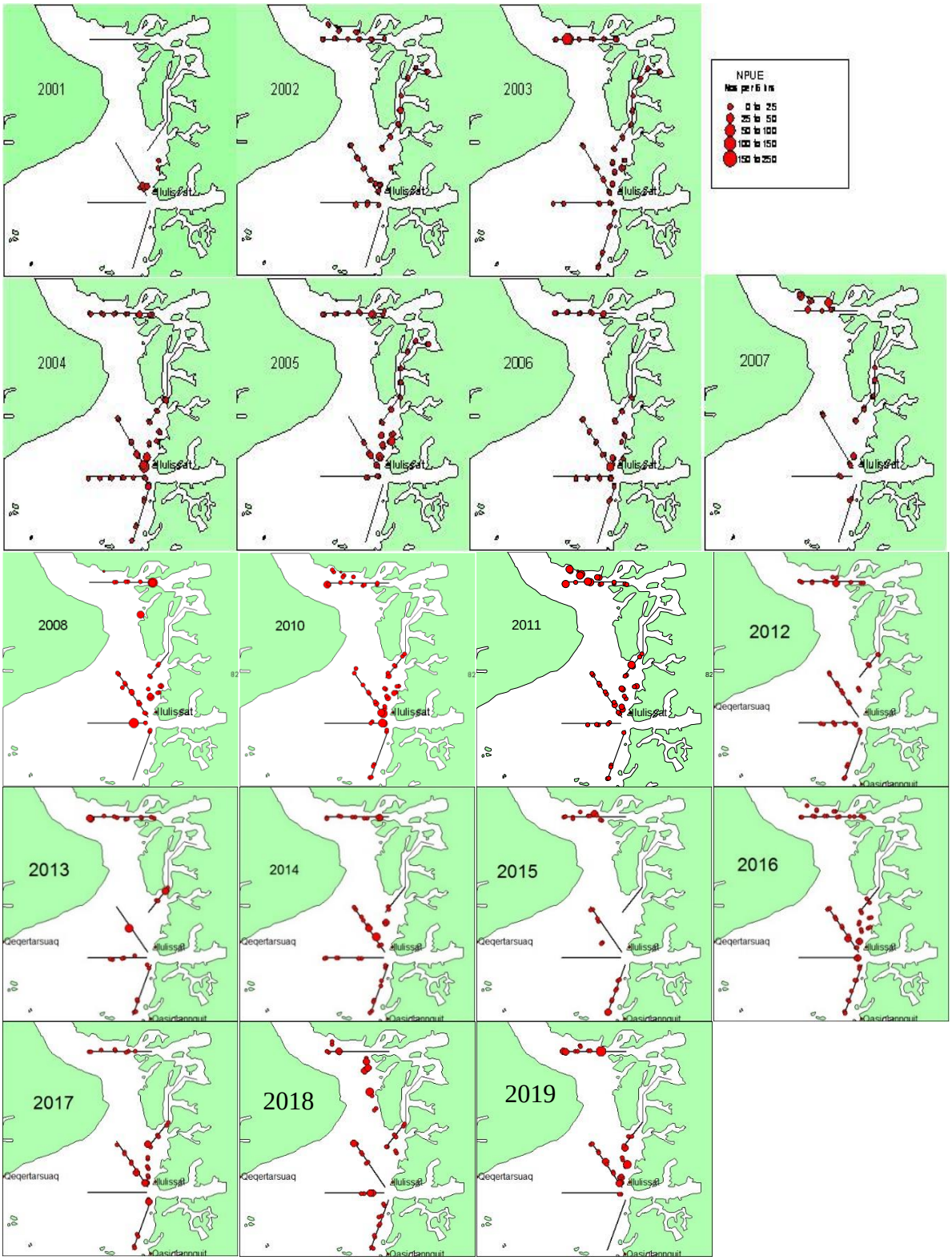

Figure 3. Gillnet survey in Disko Bay by year. Lines indicate transects and dots the distribution of NPUE (Nos Greenland halibut per 6 hrs of setting).

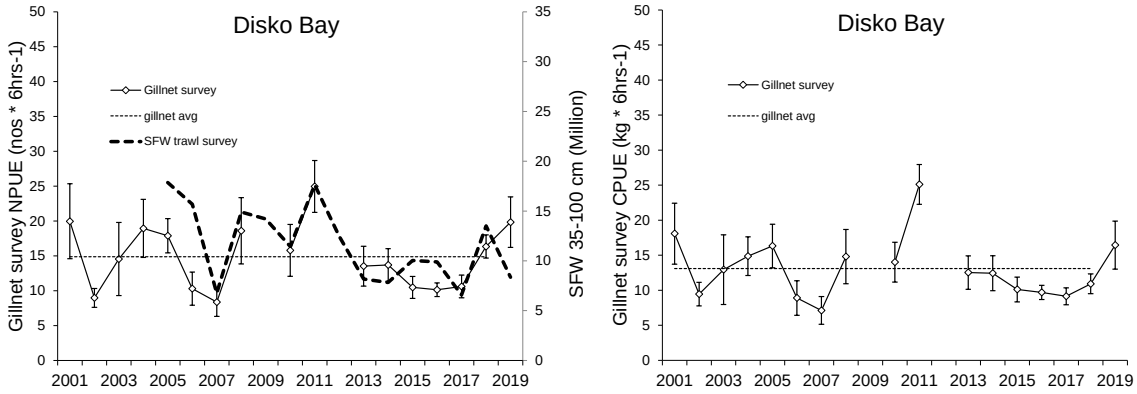

Figure 4. Disko Bay gillnet survey NPUE (right) of Greenland halibut (all sizes) combined with SFW trawl survey abundance estimate of Greenland halibut sizes 35-100 cm and gillnet survey CPUE (left).

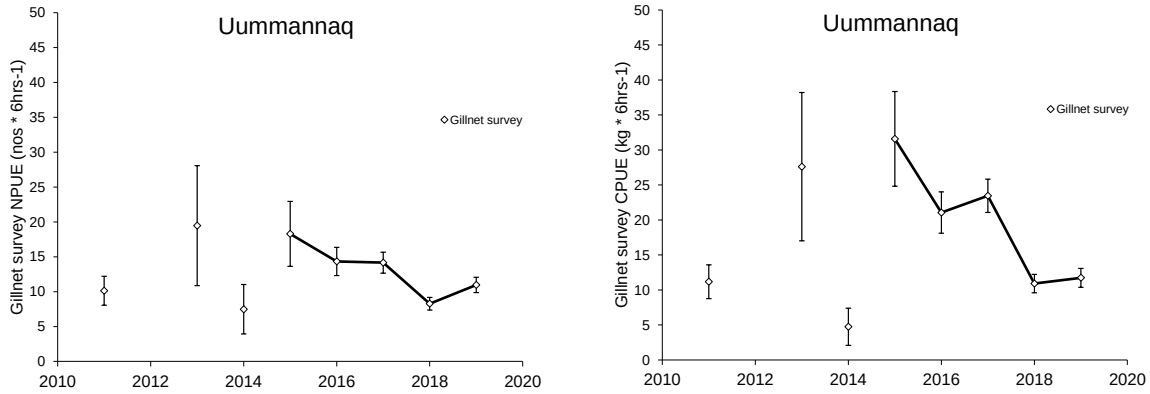

Figure 5. Uummannaq gillnet survey NPUE (left) and CPUE (right) and of Greenland halibut (all sizes). Low number of stations before 2015.

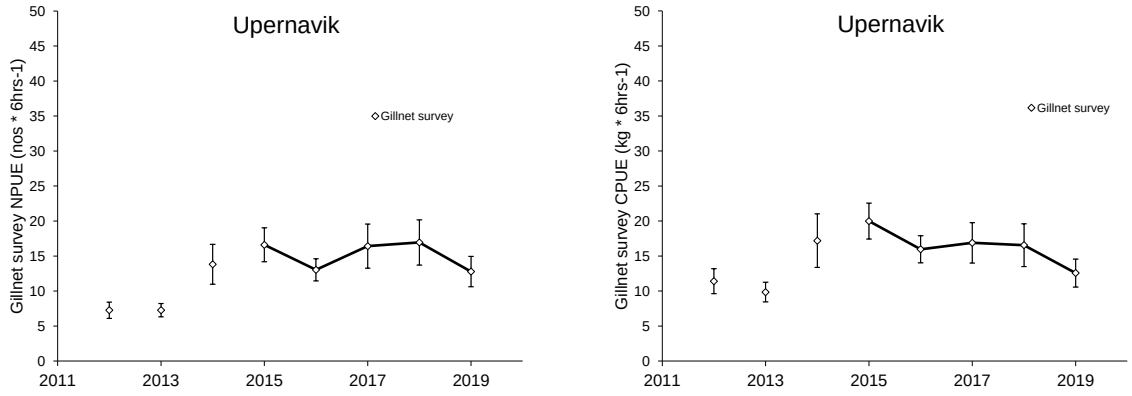

Figure 6. Upernavik gillnet survey NPUE (left) and CPUE (right) and of Greenland halibut (all sizes).

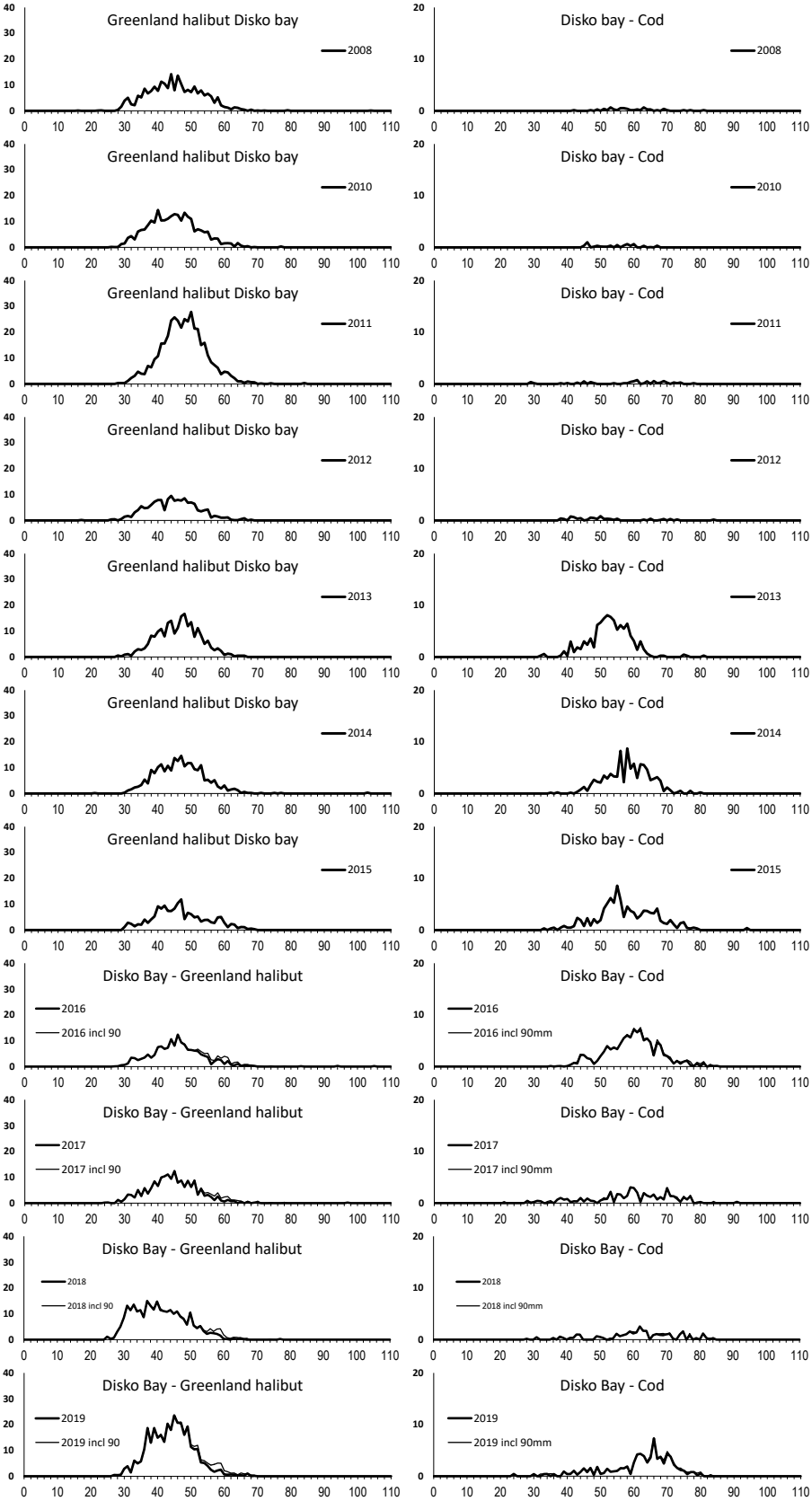

Figure 7. Disko bay: Observed LF (N/100hr) for Greenland halibut (left) and cod (right).

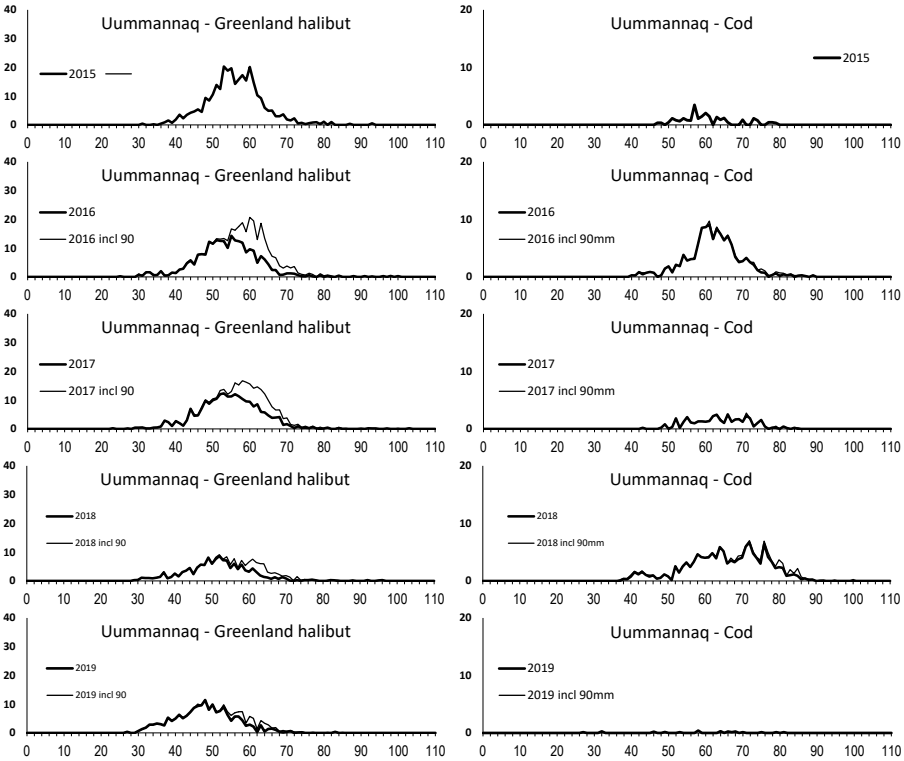

Figure 8. Uummannaq. Observed LF (N/100hr) for Greenland halibut (left) and cod (right).

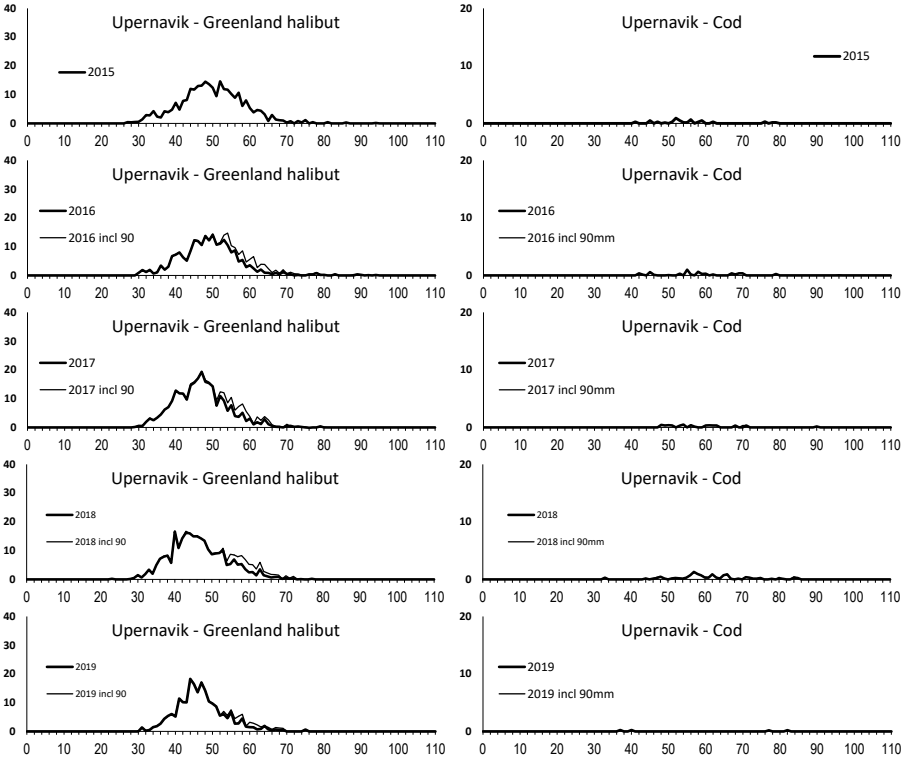

Figure 9. Upernavik: Observed LF (N/100hr) for Greenland halibut (left) and cod (right).

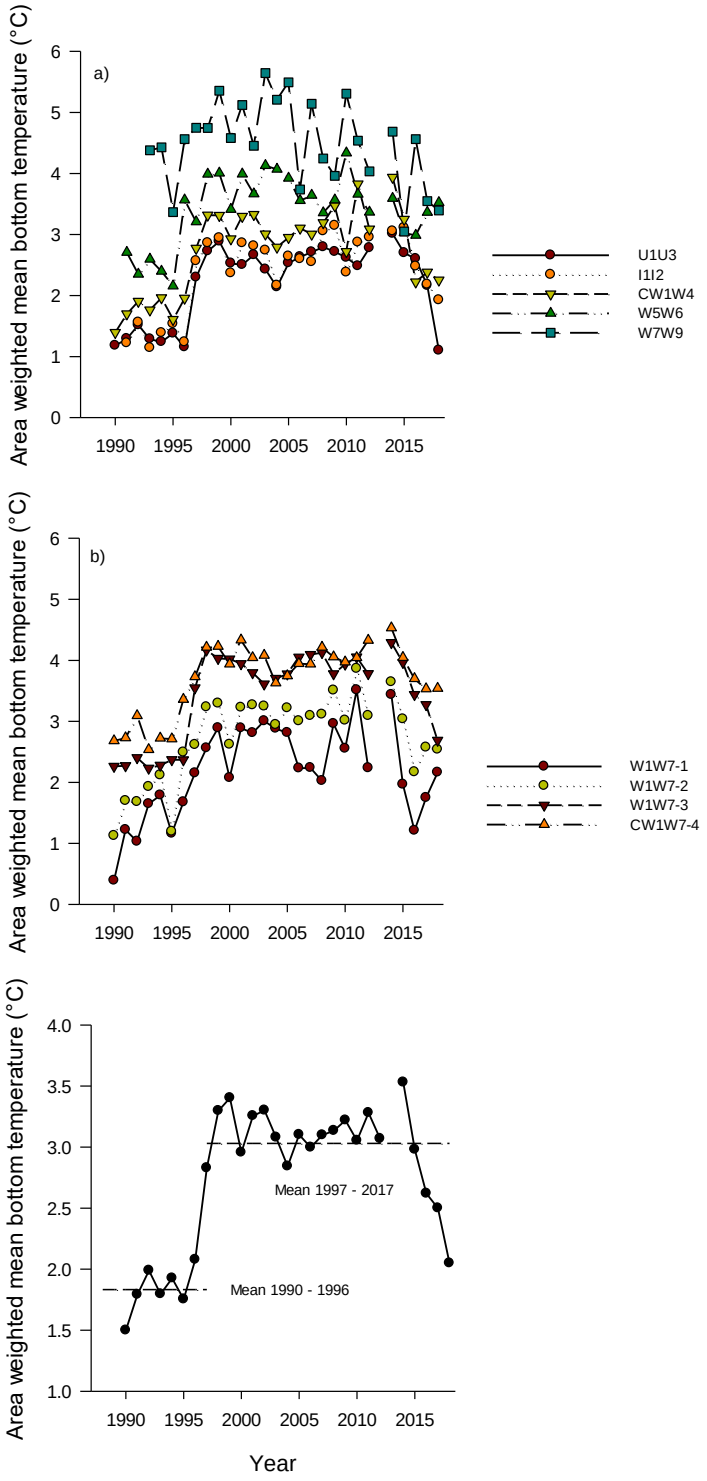

Figure 10. Area weighted mean bottom temperature in along West Greenland from the Greenland shrimp and fish survey. I1I2 represents the Disko Bay.