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An assessment of Greenland Halibut Stock Component in NAFO Division 1A Inshore.

by

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Abstract

This paper presents catch information, results from data collection from commercial landings and CPUE indices based on logbook data.

The 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. 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 of adult individuals between inshore and offshore and between the districts and a separate TAC is set for each area. Quota regulations were introduced as in each area in 2008 as a shared quota for all fishermen, but in 2012 the TAC was split in two components with ITQ's for vessels and shared quota for open boats. In 2014, "quota free" areas within each subarea were set by the Government of Greenland, and in these areas catches were not drawn from the total quota. Length frequencies in the landings has systematically been collected by the Greenland institute of Natural Resources since 1993. Logbooks have been mandatory for vessels larger than 30'ft since 2008.

Introduction

Greenland halibut can be found in all waters around Greenland both offshore and inshore but the highest concentrations has always been found in NAFO division 1A inshore. The stock 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 do not contribute significantly 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) and only sporadic spawning has been observed in the inshore area (Jørgensen and Boje, 1994). The inshore component is assumed not to be self-sustainable, but dependent on recruits and immigration from the offshore area (Bech, 1995). In 1994, NAFO agreed to separate the assessment and advice on the inshore stock components from the offshore component in the Davis Strait and Baffin Bay. Settlement occurs both inshore and offshore, but large concentrations of recruits are yearly found inshore in the Disko bay and on the Banks West of Greenland particularly in NAFO division 1B and 1A. Less is known about recruitment to the other inshore in other areas. 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 dependent 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 have led to a reduction in fishing mortality in the Disko Bay since 2011. Besides the Disko Bay and a small area inshore in Division 1B, there is no trawl fishery in other inshore areas.

Description of the fishery

The inshore fishery targeting Greenland halibut started in the beginning of the 1900 century with the introduction of the longline to Greenland (figure 1). The fishery started in the Disko Bay and gradually spread to the Uummannaq and Upernavik districts and inshore areas in South West Greenland. The fishery is traditionally performed with longline from small open boats or dog sledges through a hole in the sea ice. In the 1980s, small vessels entered the fishery and the use of gillnets increased 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, limiting gillnet fishery to the winter season. Competence to regulate seasons and areas open to gillnet fishery, was transferred to municipalities 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) although increased illegal use of cod gillnets (80mm) used to target Greenland halibut has been observed since 2008. 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 ITQ and total quota set for each district.

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 2014, areas west of the important Ilulissat Icefjord bank were set as quota free area for all vessels along with the inner parts of the Kangia Icefjord when transporting the catch with dog sledges. The fishery in Uummannaq is scattered all over the fjord near settlements (fig.14) 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. The Upernavik area consists of several large ice fjords, but the main fishing grounds are the deep Ikeq fjord (Upernavik Icefjord) and Gulteqarffik (Giesecke Icefjord (Gulteqarffik is the Inuit word for "where the gold is collected")) and the shallower fjords surrounding Upernavik and the settlements in the area 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 data to GFLK on a weekly basis. The high resolution of the landings allows for a breakdown of catches by area (fig 2) gear season.

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 (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 or several years without observations were excluded. In general the longline Logbook GLM 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.

Length frequencies by season and gear

Individual samples of length in landings has been collected in the areas for decades by Grønlands fiskeri-undersøgelser (GF) and later by the Greenland Institute of Natural Resources (GINR). In general, samples are collected several times during the seasons and at various locations during sampling expeditions or under research surveys. 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. 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 **Uummannaq** and **Upernavik** 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 length distributions are observed.

ALK – Age Length Key

Age reading of Greenland halibut has been suspended since 2011 at GINR due to low quality of the age readings and lack of an internationally agreed method. The most recent age readings was however performed on frozen otoliths which apparently is a better method for ageing Greenland halibut. Otoliths are still collected during the annual gillnet and trawl surveys and archived for future reading. In order to complete the CAA tables and calculate the total number of fish caught in the areas, an ALK was constructed using age readings from whole frozen otoliths from all 3 inshore areas collected from 2008, 2009 and 2010.

CAA

Since it is known that Greenland halibut caught in the deep Kangia Icefjord are considerably larger than in the rest of the Disko Bay, recent catches were split on both gear (longline and gillnet) and location (Disko Bay and the Ilulissat icefjord (Kangia)). The numbers in each cm category was calculated and the ALK finally applied. Therefore, although the ages are likely underestimated particularly for the larger individuals, the total number of fish caught should be valid.

Research surveys

The Greenland Shrimp and Fish survey in West Greenland has included the Disko Bay since 1991 and has throughout the time series been conducted with the 722 GRT stern trawler M/Tr 'Pâmiut'. In 2005 the gear was changed in this survey, but since then the area coverage and the trawl and its rigging has been unchanged. See SCR 16/010 for details. Although calibration experiments indicated an almost 1:1 ratio in the catchability of age 1 (12-16 cm) individuals which constitute the majority of the survey catches

Assessment methods

No analytical assessment was performed.

Assessment Disko Bay

In the Disko Bay**, catches** increased during the 1980s and peaked in 2004 to 2006 with catches of more than 12.000 tons per year (figure 2). Thereafter, catches were halved in 3 years to just 6.300 tons in 2009 without quota ceiling being met, to explain the decrease although prices did rise in the period (table 2.). After 2009 catches gradually increased to about 9000 tons but decreased but decreased from 9.177 tons in 2014 to 8674 tons in 2015. Although the total landings in tons have decreased, the estimated total number of fish caught, has increased (figure 2). The reported distribution has shifted slightly westward to the "quota free areas", but a small fishery is also developing in the deep trenches North of Aasiaat (figure 3). **Mean length in the landings** gradually decreased for more than a decade in the area in both the winter longline fishery (a mixture of Greenland halibut from the Disko Bay and Kangia) and the summer longline fishery and in the overall gear and area weighted mean length (figure 4,right). The significant drop in the mean length from gillnet landings is without question related to illegal use of cod gillnets (80mm) used to target Greenland halibut in the area (figure 3,left). The decreasing size in the landings can also be seen as a general shift of the length distribution towards smaller fish and a narrower distribution in the longline landings (figure 5). The **CAA bubble plot** indicates a general movement towards younger fish since 2002 when the highest catches occurred (figure 6). The **exploitation rate of ages 10** or less has likewise gradually increased, indicating that larger and older fish in the stock has decreased, indicating higher dependence of incoming year classes (figure 7).

The **Disko bay logbook CPUE** index reveals little year to year variation and slow but gradual decrease in yield per effort after 2009, and the 2015 CPUE is the lowest observed (fig 8). However the GLM explained little of the variance observed in the data. 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 9). After the gear change in 2005 the biomass index has been in a decreasing trend with the two lowest values found in 2014-15 and 4 of the 5 lowest estimates found in the most recent 4 years (fig 9). The trawl 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 and 2013 (2010 and 2012 YC) (fig 10). The length distribution in the survey reveals that particularly the 2011 and 2014 YC seems small, whereas the 2013 is closer to average levels (fig 10). The number summed numbers in the likely size classes representing age 1-3 reveals that particularly the 2010 YC seems dominating at both age 1, 2 and 3 (figure 11). The **Gillnet survey** NPUE has been below average levels for 3 years in a row, although in these years' fewer than normal stations were taken (Figure 12). The high correlation between the gillnet survey NPUE and the summed number of Greenland halibut larger than 35 cm in the trawl survey results, however adds credibility to both surveys (figure 12).
The summed impression of the indices is a further decreasing stock, among which the continuous decrease in the size distribution for more than a decade is the most serious.

Assessment Uummannaq

In **Uummannaq**, catches increased during the 1980s and peaked in 1999 at more than 8.000 tons (tab.1 and fig.13). Since then, catches have stabilized around 6000 tons, but since 2014 annual landings have increased to 8200 tons. The fishery is spread over a large area but most concentrated in the south Eastern parts (Figure 14). **Mean length in the landings** have gradually decreased during two decades, but at a very slow rate (figure 15) and particularly the overall yearly mean weighted by gear has shown high stability in the most recent 6 years. The Gillnet mean length in the landings do not indicate any use of fine meshed gillnets which indicates that large fish are available (figure 15). The length distributions of the longline fishery reveals a wide size range of both small and large fish and a distribution which not much different in recent years and a decade ago (figure 16). The **CAA bubble plot** does not reveal any particular strong year-classes (figure 17). The **exploitation rate of ages 10** or less reveals a high level of stability and that old fish still constitute a significant part of the stock (figure 18). The **logbook CPUE** index reveals little year to year variation and a high level of stability in the CPUE (figure 19). The Gillnet survey relies few sets, but the estimated CPUE and NPUE is higher than in the Disko Bay (figure 20).

The overall impression of the indices is a stable stock, which shows high resilience towards the recent level of fishery.

Assessment Upernavik

In **Upernavik**, catches increased from the mid 1980’s and peaked in 1998 at a level of 7.000 tons (tab.1, fig.21). Landings then decreased sharply, for unknown reasons, but during the past 15 years landings have gradually returned to the high level. In 2014, factory vessels was deploied in the area and 7381 tons were landed but in 2015 catches returned to about 6300 tons which at the level of the current advice. The fishery is scattered all over the area, although limited by the distance to the nearest factory (figure 22). **Mean length in the landings** initially decreased and remained stable for almost two decades (figure 23). However, the overall weighted mean length by gear decreased in both 2014 and 2015 (figure 23). Mean lengths in the gillnet landings gradually increased until 2004 but has stabilized since then and the use of fine meshed gillnets seems to have occurred (fig 23). The length frequencies from the longline landings reveal a shift towards smaller fish for two consecutive years in a row (figure 24). The **CAA bubble plot** does not reveal any particular strong year-classes (figure 25). The **exploitation rate of ages 10** or less indicates that old fish still constitute significant part of the stock (figure 26). 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 27). 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 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 periodically limits the access to the areas.

The overall impression of the stock is a stable stock which for a large part is still made up of large and old fish. In the two most recent years, the size distribution however seems to have shifted slightly towards smaller size.

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

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).

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.

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 of Greenland halibut by area and gear.

	Disko Bay		Disko Kangia		total	Uummannaq			Upernavik		
Year	Longline	Gillnet	Longline	Gillnet	Catch	Longline	Gillnet	Catch	Gillnet	Longline	Catch
1987					2258			2897			1634
1988					2670			2920			777
1989					2781			2859			1253
1990					3821			2779			1245
1991					5372			3045			1495
1992					6577			3067			2156
1993					5367			3916			3805
1994					5201			4004			4844
1995					7400			7234			3269
1996					7837			4579			4846
1997					8601			6293			4879
1998					10671			6912			7012
1999					10593			8425			5258
2000					7574			7568			3764
2001					7072			6558			3239
2002					11718			5339			3019
2003					11571			5039			3884
2004					12857			5248			4573
2005					12451			4856			4839
2006					12114			5984			5132
2007					10000			5318			4877
2008					7700			5426			5478
2009					6321			5451			6497
2010	6954	1505	332	86	8458	5617	610	6226	411	5443	5941
2011	5592	1367	451	1	8005	5046	1179	6397	362	6176	6471
2012	6145	968	756	28	7755	5847	357	6151	514	6204	6830
2013	6867	1520	678	4	9073	6639	369	7007	433	5606	6039
2014	6675	1979	518	0	9177	7800	407	8199	409	6964	7381
2015	6383	1541	746	5	8674	7279	962	8244	782	5491	6274

Table 2. Landings of Greenland halibut by area Gear and month in tons 2015.

	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OKT	NOV	DEC	Total
Gillnet catch	1A Upernavik	12	12	2	56	32	0	51	289	167	0	108	53	782
	1A Uummannaq	74	38	59	43	1	0	617	95	2	0	23	10	962
	1A Disko Bay	192	278	161	788	93	0	7	1	4	5	9	3	1541
	1A Disko kangia	4	1	0	0	0	0	0	0	0	0	0	0	5
	Gillnet total	282	329	222	887	126	0	675	385	173	5	140	66	3290
Longline catch	1A Upernavik	209	376	626	392	241	537	937	769	650	557	99	98	5491
	1A Uummannaq	173	462	701	598	211	494	1428	1068	1060	657	314	113	7279
	1A Disko Bay	18	32	43	60	541	1670	1167	1012	761	530	310	239	6383
	1A Disko kangia	199	39	174	114	26	11	4	0	15	13	111	40	746
	Longline total	599	909	1544	1164	1019	2712	3536	2849	2486	1757	834	490	19899
Total catch	1A Upernavik	221	388	628	448	273	537	988	1058	817	557	207	151	6273
	1A Uummannaq	247	500	760	641	212	494	2045	1163	1062	657	337	123	8241
	1A Disko Bay	210	310	204	848	634	1670	1174	1013	765	535	319	242	7924
	1A Disko kangia	203	40	174	114	26	11	4	0	15	13	111	40	751
	1A inshore total	881	1238	1766	2051	1145	2712	4211	3234	2659	1762	974	556	23189

Table 3. CAA – Catch at age for the Disko bay.

Year/Age	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1988	0	0	0	1	9	59	182	173	132	73	63	65	38	33	828
1989	0	0	0	0	0	14	106	121	94	49	33	39	31	41	528
1990	0	0	0	0	1	24	141	185	188	126	80	59	42	44	890
1991	0	5	5	11	279	806	535	333	238	76	45	67	57	44	2501
1992	0	34	92	122	332	476	390	451	532	309	140	92	18	0	2988
1993	0	7	15	62	280	479	339	280	240	122	91	112	75	86	2188
1994	0	0	3	15	112	281	539	396	190	91	50	45	41	36	1799
1995	0	0	0	0	45	459	639	798	463	185	127	27	36	27	2806
1996	0	0	8	1	47	323	941	651	454	273	145	75	44	69	3031
1997	0	0	0	21	132	646	1113	1168	607	185	69	19	10	6	3976
1998	0	0	0	74	397	775	944	1248	754	346	132	68	27	6	4770
1999	0	1	4	41	360	619	836	1028	786	426	136	72	29	2	4340
2000	0	0	9	98	535	729	780	636	478	223	52	28	12	1	3583
2001	0	1	15	33	224	390	521	450	485	280	78	33	31	16	2557
2002	0	0	2	54	283	561	771	421	575	393	398	175	112	0	3745
2003	0	0	2	64	425	722	1187	610	847	422	158	146	135	89	4808
2004	0	0	2	56	409	691	1083	634	730	311	144	130	152	89	4431
2005	0	1	48	287	516	703	868	423	481	213	100	97	122	83	3943
2006	0	0	10	211	882	1001	1008	522	582	231	105	89	125	85	4852
2007	0	0	2	56	459	1073	754	749	151	94	4	166	126	60	3694
2008	0	0	2	46	363	825	552	548	105	66	2	114	86	40	2751
2009	0	1	26	199	904	962	515	337	147	79	55	40	26	13	3303
2010	21	17	148	467	1218	1187	460	402	194	119	114	78	70	0	4495
2011	1	14	172	558	1196	1153	430	356	136	67	57	34	40	0	4213
2012	5	54	457	829	1333	1047	400	359	154	77	59	28	48	0	4851
2013	3	35	368	765	1611	1333	438	374	175	101	68	35	60	0	5368
2014	3	36	379	844	1731	1493	514	420	159	70	49	23	32	0	5753
2015	8	120	718	1098	1685	1303	436	356	130	58	43	21	28	0	6002

Table 4. CAA – Catch at age for Greenlan halibut in the Uummannaq district.

age/year	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1988	0	0	0	1	5	20	52	121	143	121	96	49	23	17	648
1989	0	0	0	0	2	9	35	98	120	99	76	38	19	20	516
1990	0	0	0	1	3	15	47	108	121	101	82	42	20	21	561
1991															
1992															
1993	0	0	0	9	45	200	202	142	138	104	158	93	28	20	1139
1994	0	0	0	24	105	226	271	346	139	105	34	12	0	3	1265
1995	0	0	0	6	217	564	601	413	414	219	138	49	28	22	2671
1996	0	1	0	6	76	308	279	286	232	142	69	28	11	15	1453
1997	0	0	0	0	69	377	793	702	460	206	75	32	10	6	2732
1998	0	0	0	0	0	235	566	657	586	355	138	39	15	5	2595
1999	0	8	70	218	554	596	690	789	526	295	131	42	12	4	3935
2000	0	0	19	86	357	441	543	669	487	311	170	68	24	8	3184
2001	0	0	65	113	674	507	315	492	303	178	121	60	28	12	2868
2002															
2003	0	0	3	21	127	360	321	235	220	158	78	145	150	94	1911
2004	0	0	1	10	105	197	249	198	163	118	82	103	78	59	1364
2005	0	1	17	101	108	192	142	115	109	74	58	80	67	50	1115
2006	0	1	32	12	47	243	70	284	127	324	49	108	9	9	1315
2007	0	3	40	181	221	340	273	192	149	94	64	82	71	56	1767
2008	0	4	46	203	249	381	304	213	166	104	71	91	79	63	1974
2009	0	3	9	25	238	525	470	415	243	157	90	42	20	11	2248
2010	0	1	8	77	484	822	459	458	235	128	79	32	21	0	2804
2011	0	0	11	94	465	743	432	441	242	141	91	43	26	0	2730
2012	0	0	6	61	347	627	393	422	260	168	114	57	37	0	2492
2013	0	1	9	72	397	730	494	531	302	173	108	49	31	0	2896
2014	0	1	20	120	622	1026	613	608	308	163	107	46	32	0	3667
2015	0	2	26	112	489	828	545	582	354	211	144	68	41	0	3403

Table 5. CAA – Catch at age for Greenlan halibut in the Uummannaq district.

age/year	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1988	0	0	0	0	0	6	33	55	80	74	68	62	31	22	431
1989	0	0	0	0	0	2	16	34	59	66	69	73	40	31	390
1990	0	0	0	0	0	2	17	41	62	57	52	48	25	17	321
1991															
1992															
1993	0	0	0	0	0	2	16	86	252	268	143	95	40	46	948
1994	0	0	0	2	51	188	316	217	239	154	155	51	23	0	1396
1995	0	0	0	0	13	55	84	128	133	147	117	103	45	42	867
1996	0	0	3	0	16	114	359	275	238	206	151	90	48	39	1539
1997	0	0	4	25	142	428	500	430	278	175	67	37	19	8	2111
1998	0	0	0	116	343	538	535	505	410	275	112	84	39	10	2968
1999	0	14	55	172	449	619	566	343	229	138	51	36	16	5	2679
2000	0	0	2	108	420	446	302	160	133	116	48	38	17	9	1800
2001	0	0	28	144	404	422	258	103	104	87	36	14	9	3	1611
2002															
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	4	65	197	429	274	788	372	135	10	6	0	6	2284
2009	0	0	5	51	333	579	465	421	262	187	112	65	94	7	2579
2010	0	0	3	47	376	707	471	484	242	126	70	27	15	0	2579
2011	0	5	51	175	555	772	468	484	260	141	80	31	18	0	2579
2012	0	2	28	111	375	620	445	504	312	188	117	50	27	0	2778
2013	0	12	42	107	387	581	368	401	259	161	113	55	34	0	2520
2014	3	31	177	349	773	919	483	475	243	131	88	45	27	0	3743
2015	5	25	98	205	574	752	405	388	200	117	92	52	43	0	2957

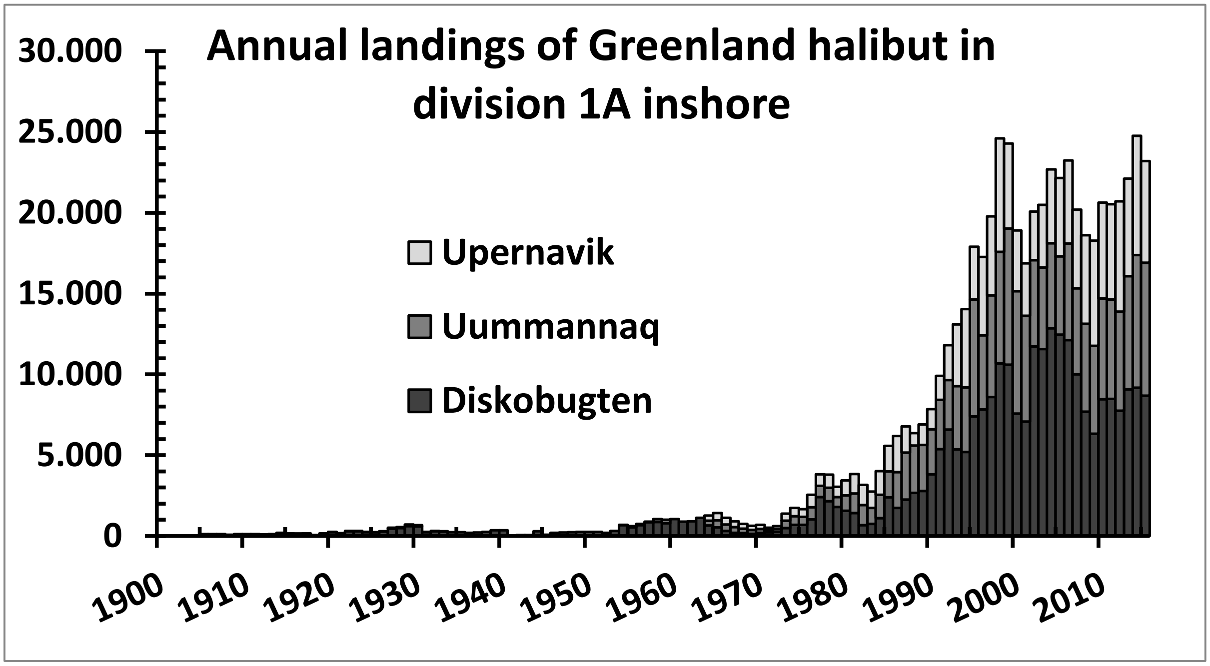

Fig. 1. Catches of Greenland halibut in NAFO Subarea 1 Division 1Ainshore since 1904 for NAFO division 1A inshore in North West Greenland.

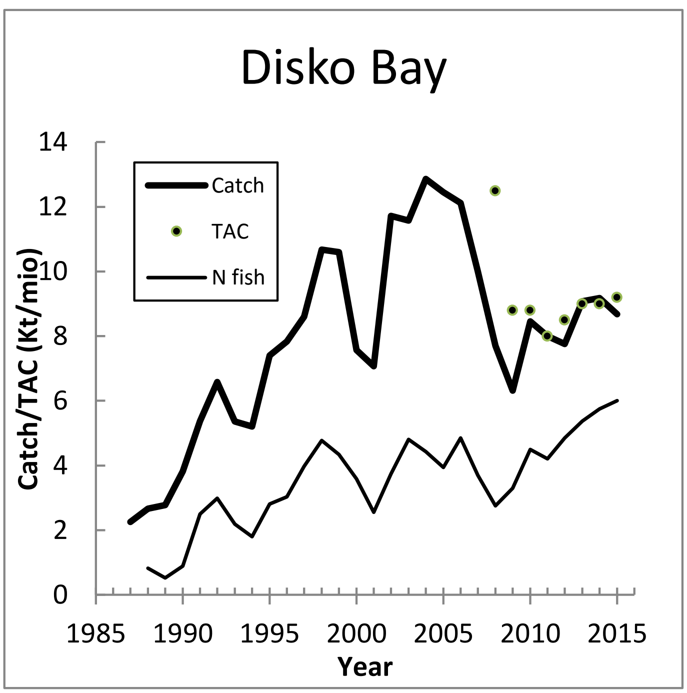

Fig. 2. Greenland halibut in NAFO division 1A inshore: Catches since 1987 in Disko bay (Kt), TAC (Kt) set by the Greenland authorities and total number of fish landed (mio).

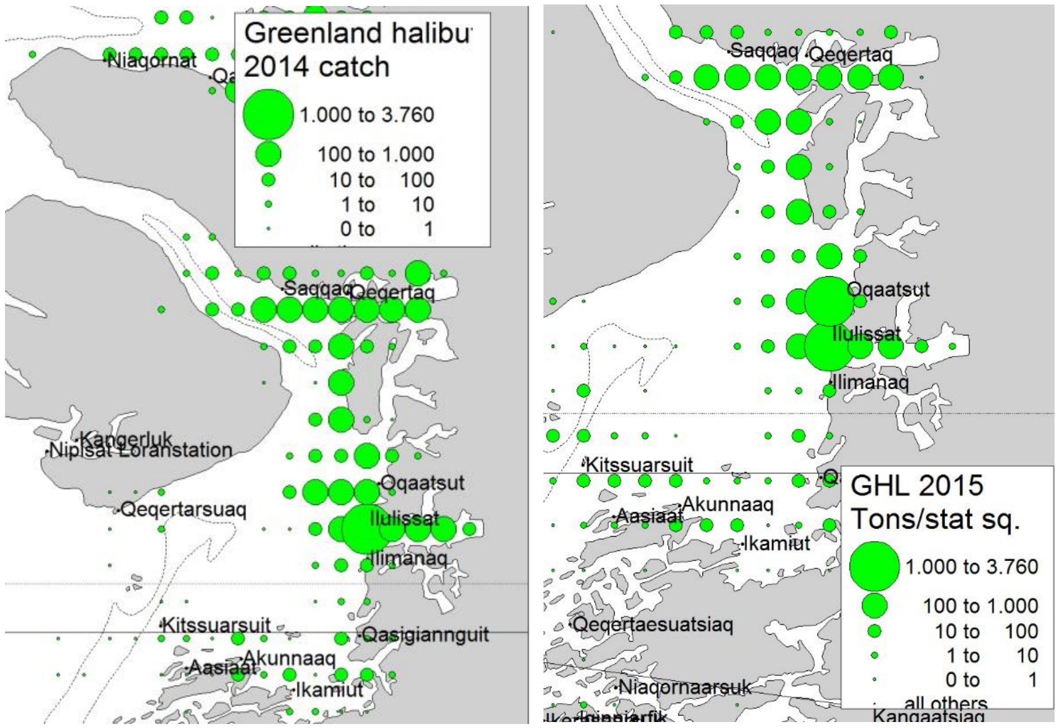

Fig. 3. Greenland halibut catch by statistical square in NAFO division 1A inshore in 2014 and 2015.

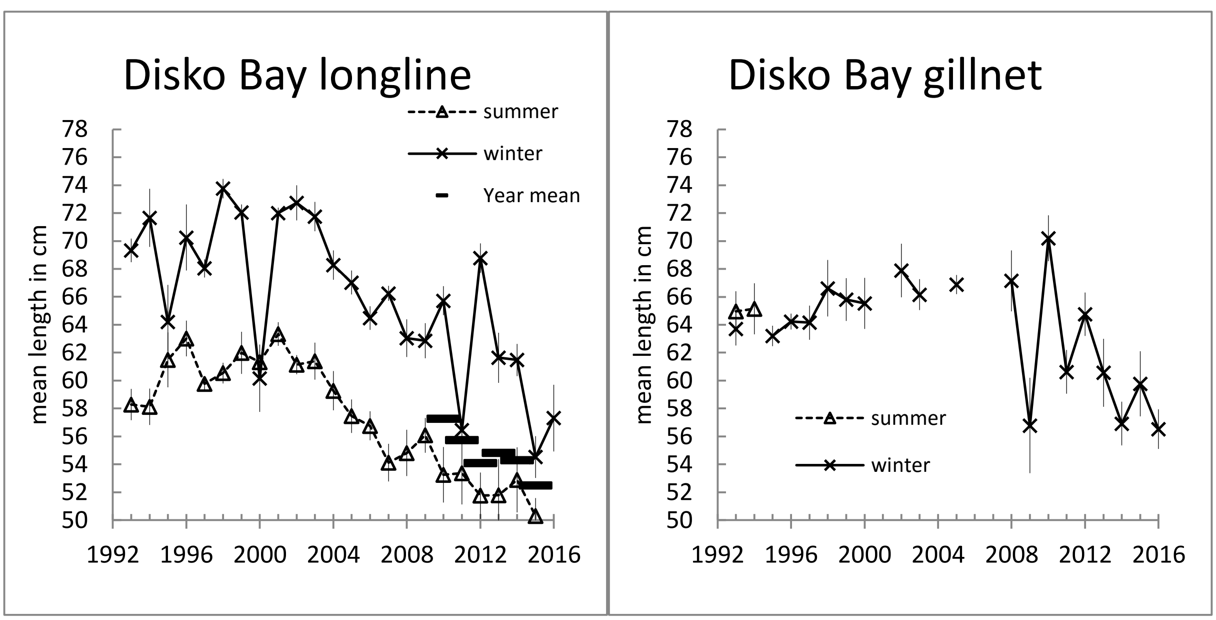

Fig. 4. Mean length in the landings: for longlines (left) and gillnets (right) and weighted overall mean by gear (longline catch and Gillnet catch) area (Disko bay and icefjord).

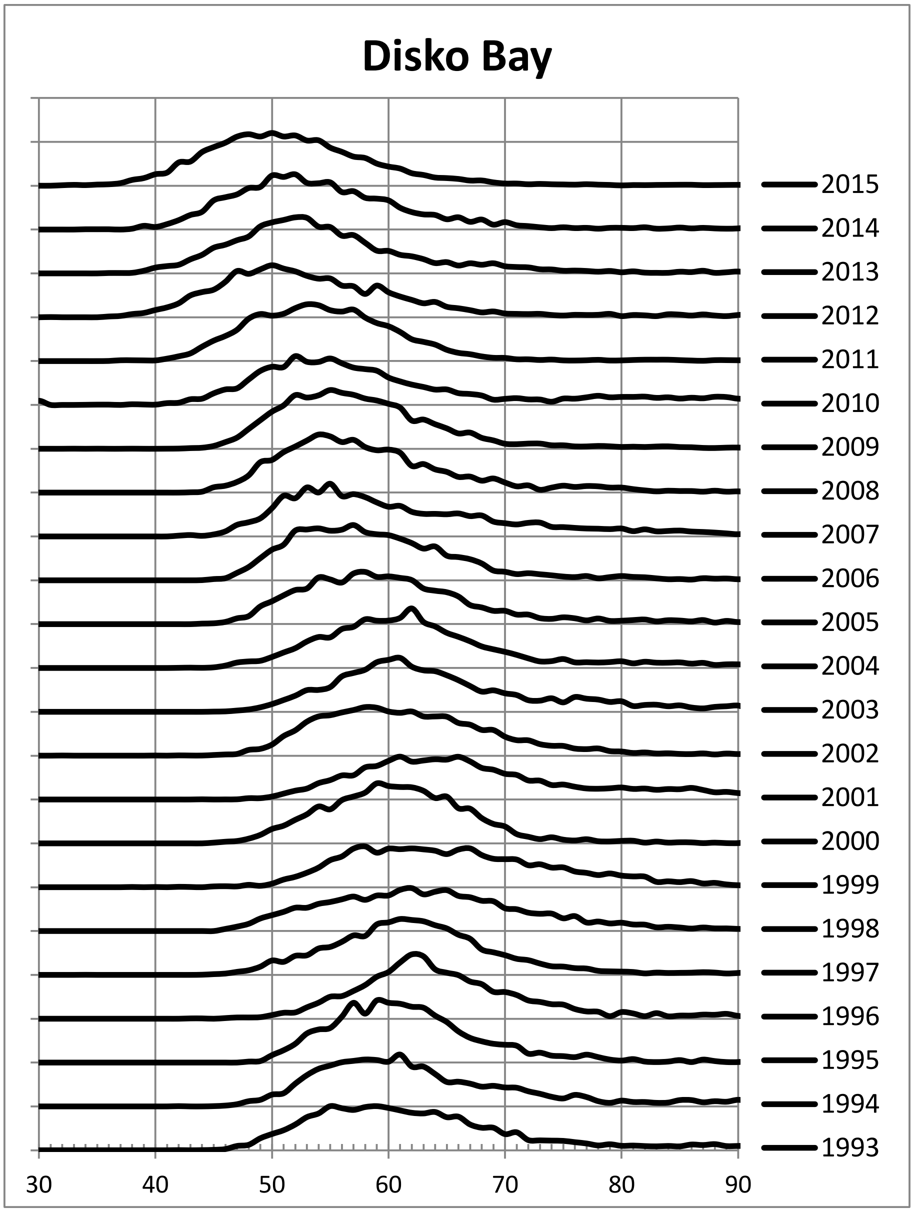

Fig. 5. Disko bay length frequencies in longline landings in % of number measured all months combined.

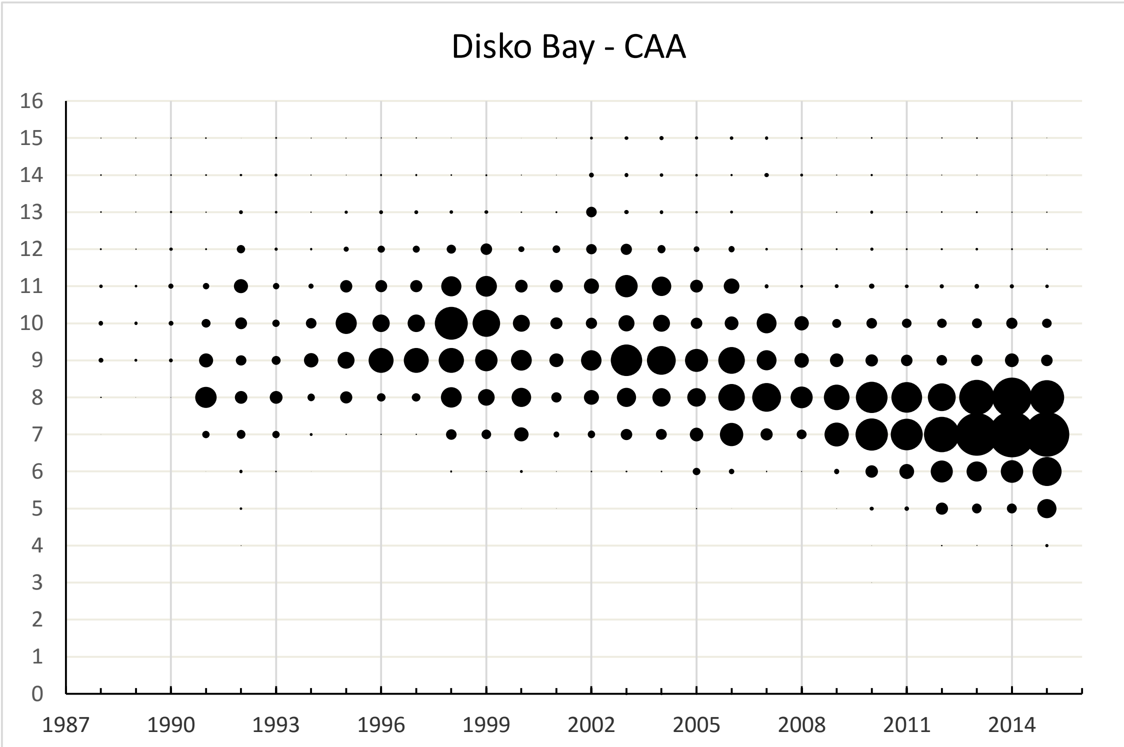

Fig 6. Disko bay catch at age (CAA) bubble plot. For the years 2008-2016 a general ALK key was used based on the age readings from 2008-2010 and all three areas combined.

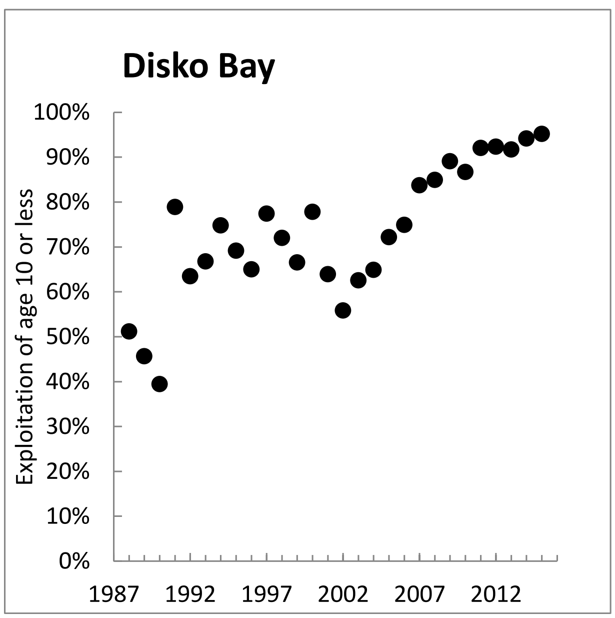

Fig. 7. Exploitation rate of age 10 and younger. For the years 2008-2016 a general ALK key was used based on the age readings from 2008-2010 and all three areas combined.

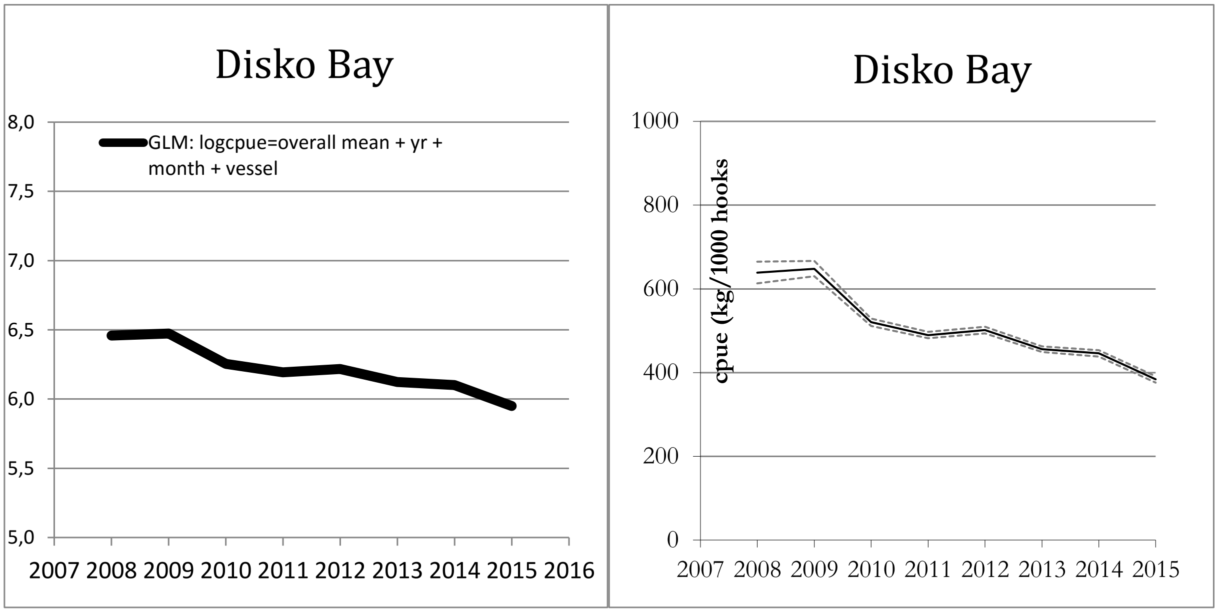

Fig 8. Standardized CPUE series for for commercial longLine (thick line) . + indicate logCPUE(kg/1000hooks) by date.

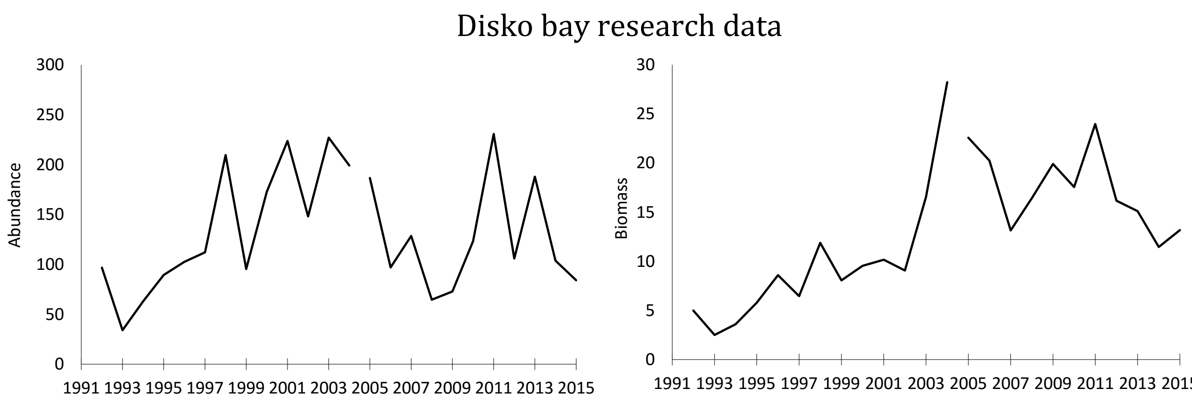

Fig. 9. Trawl survey (SFW) in Disko bay: Abundance (left) and biomass (right).

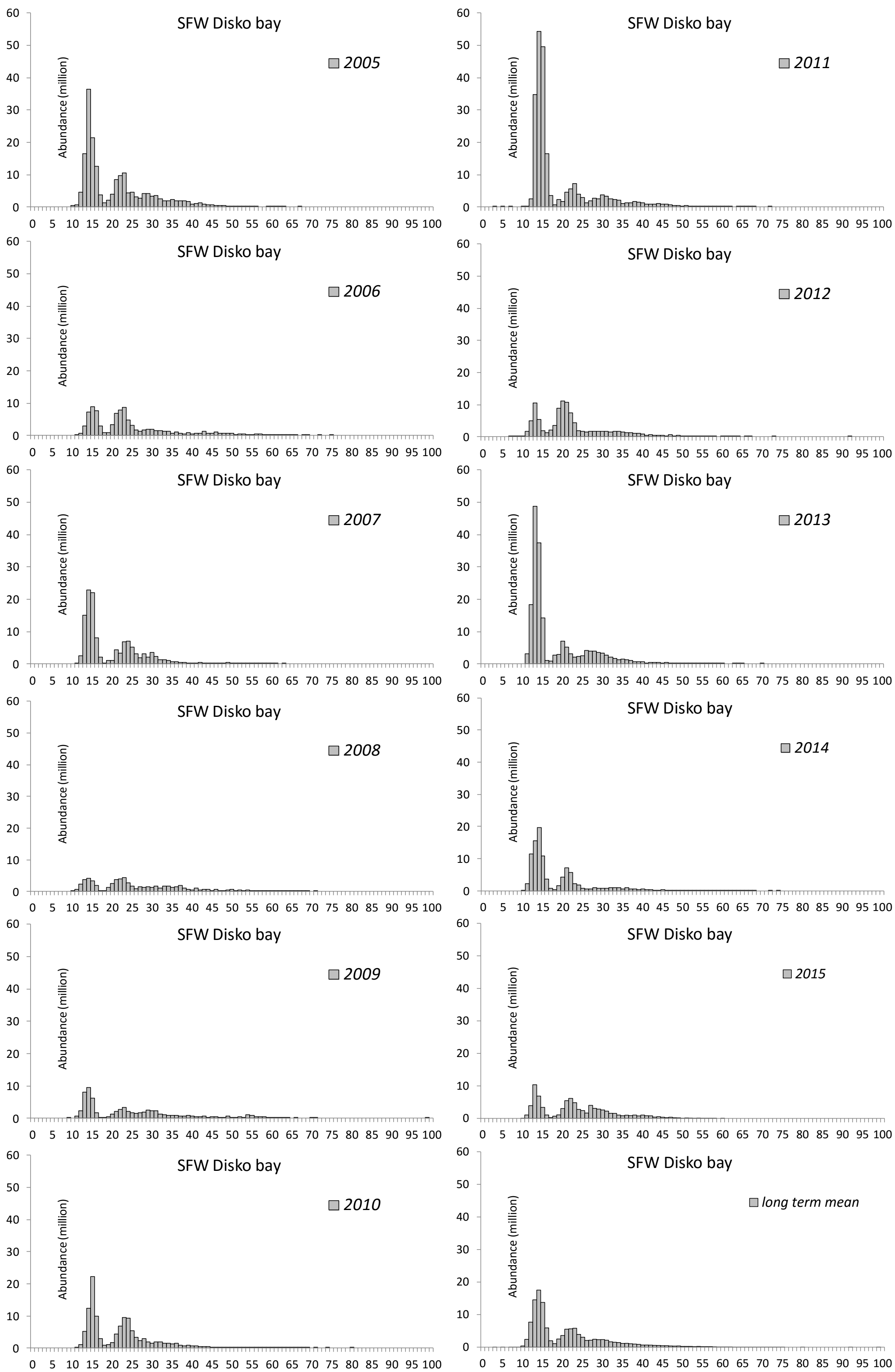

Fig. 10. Greenland halibut trawl survey length frequencies (SFW).

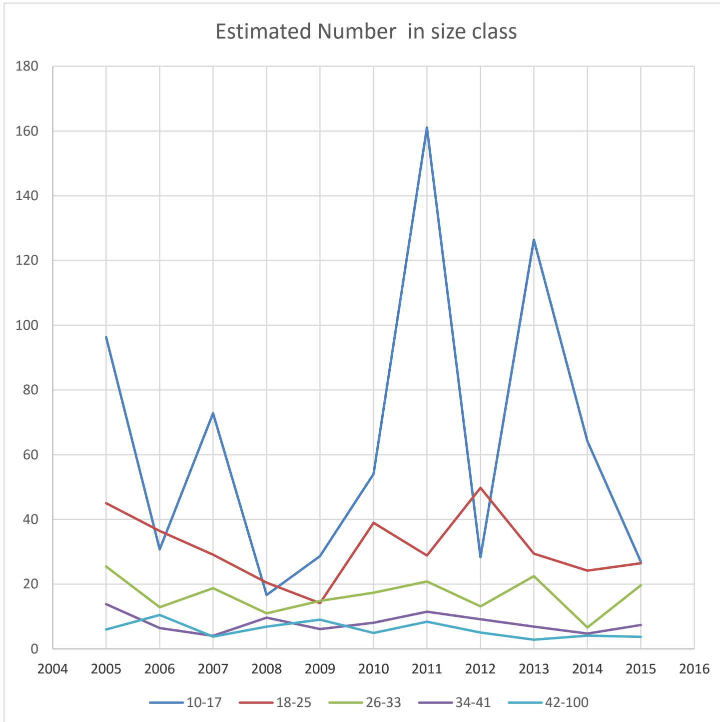

Fig. 11. Greenland halibut trawl survey length frequencies (SFW).

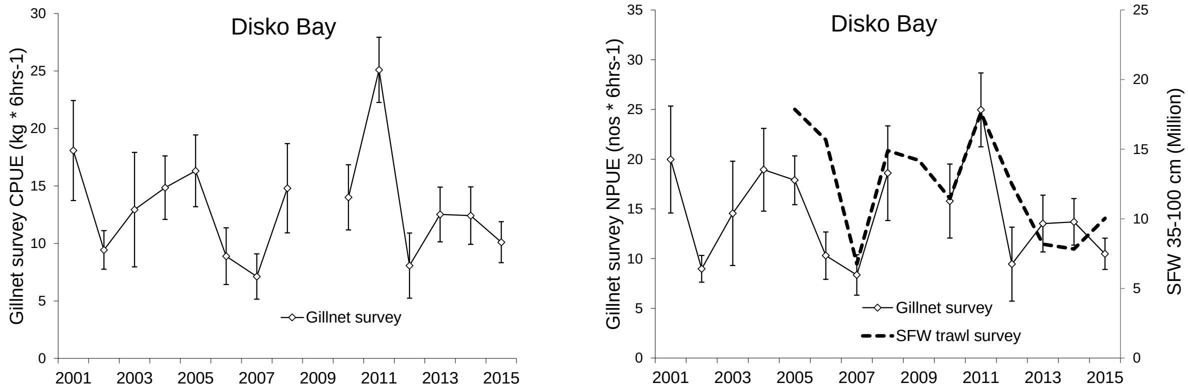

Fig. 12. Disko Bay gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (all sizes) combined with SFW trawl survey abundance estimate of Greenland halibut sizes 35-100 cm.

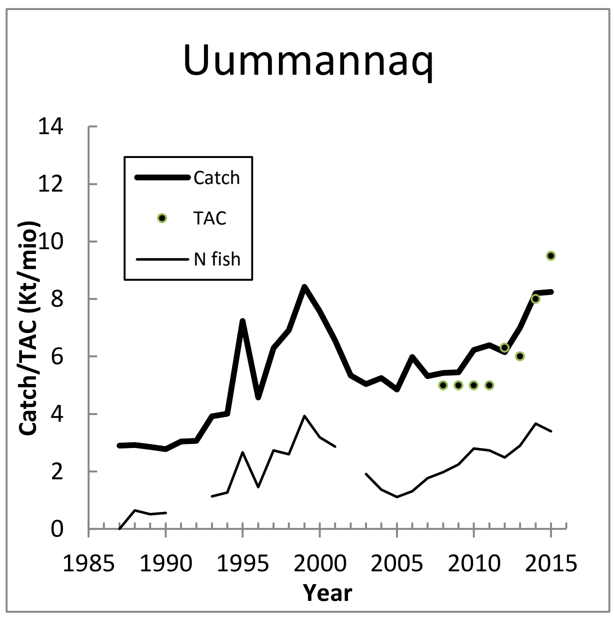

Fig. 13. Greenland halibut in NAFO division 1A inshore: Catches since 1987 in Uummannaq (Kt), TAC (Kt) set by the Greenland authorities and total number of fish landed (mio).

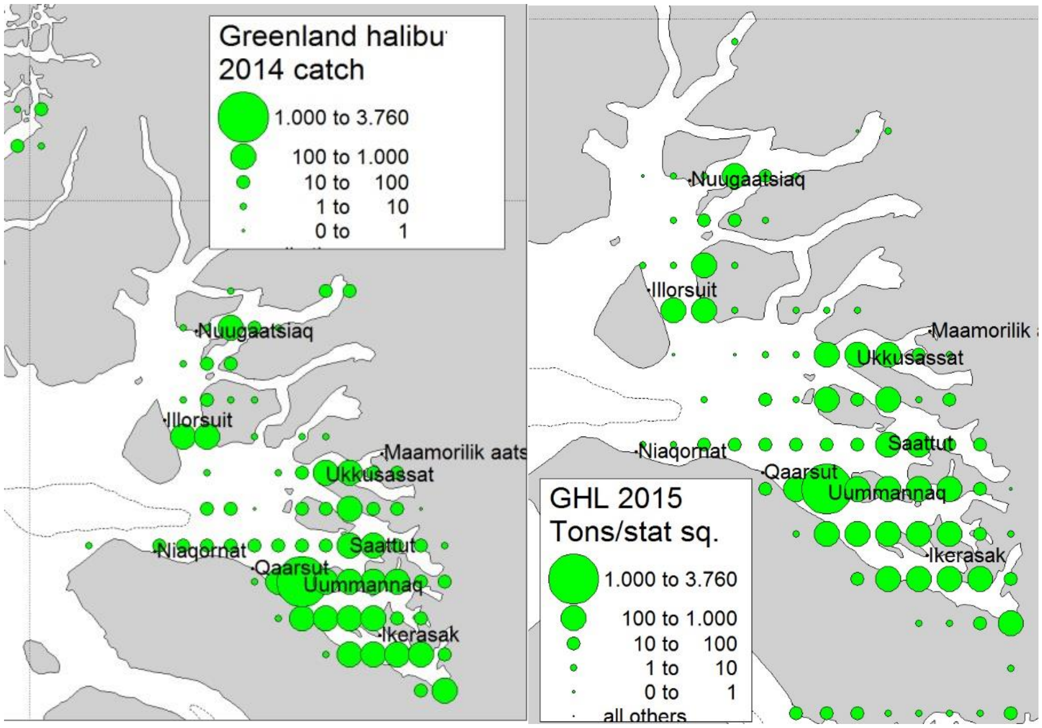

Fig. 14. Greenland halibut catch by statistical square in Uummannaq (1A inshore) in 2014 and 2015.

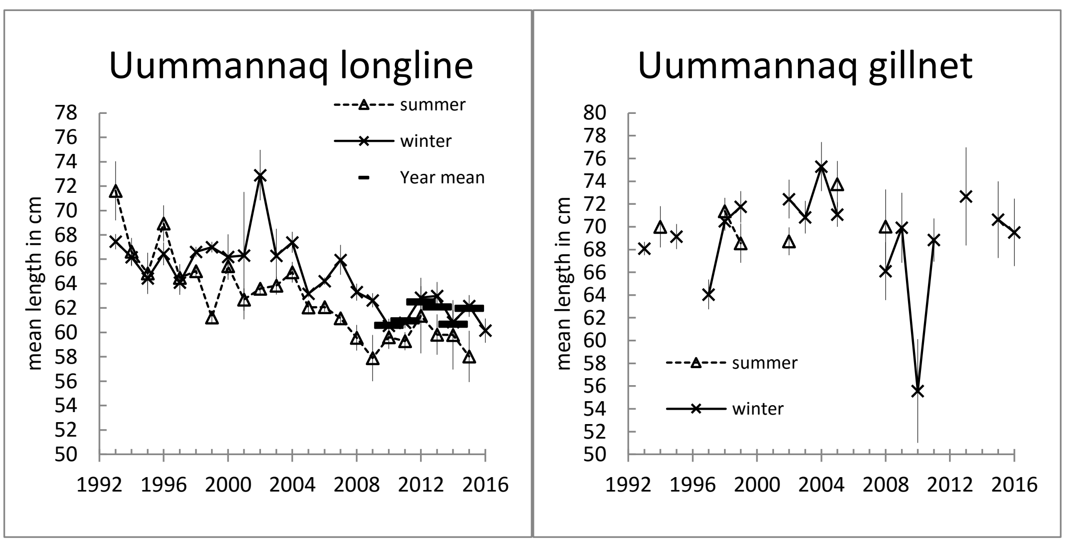

Fig. 15. Mean length in the landings: for longlines (left) and gillnets (right) and weighted overall mean by gear (longline catch and Gillnet catch) in Uummannaq .

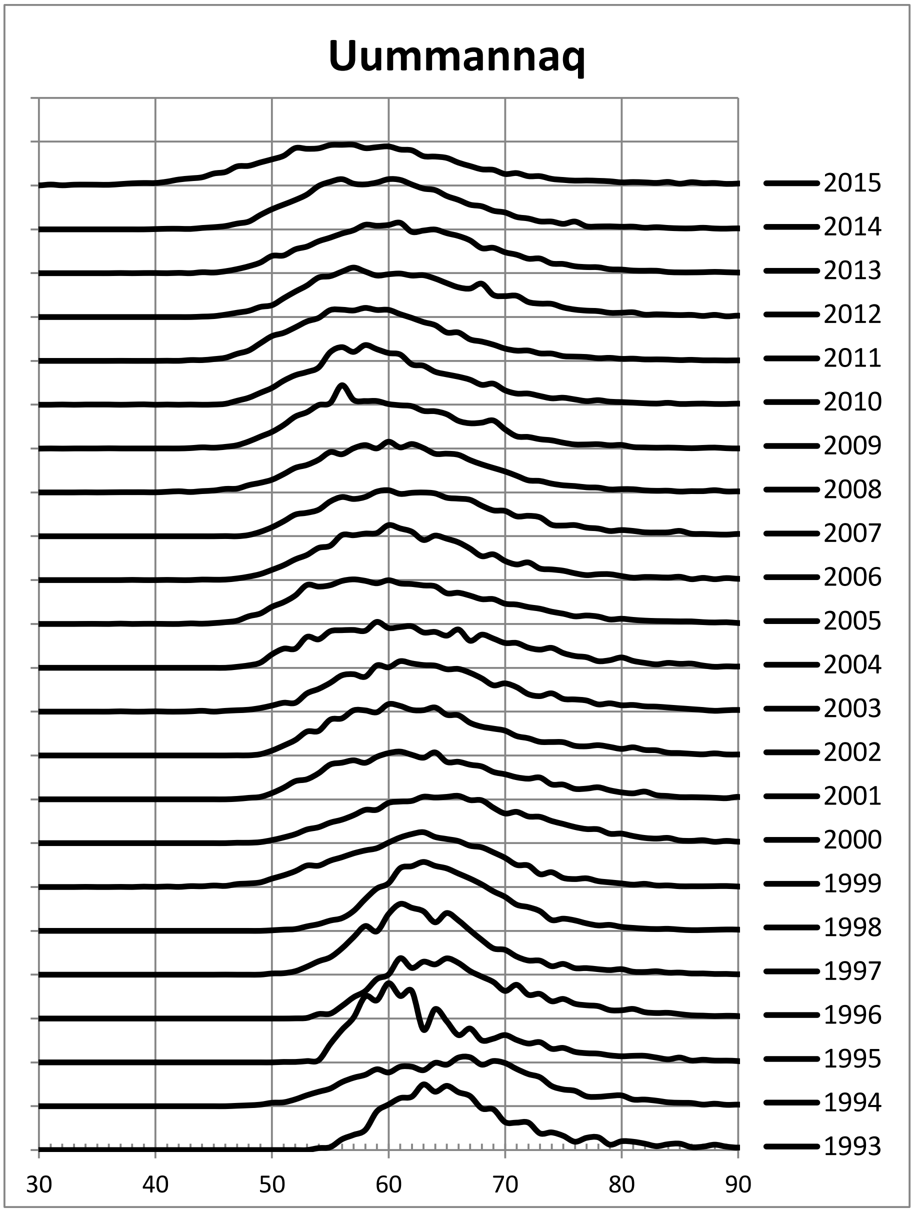

Fig. 16. Uummannaq length frequencies in longline landings in % of number measured all months combined.

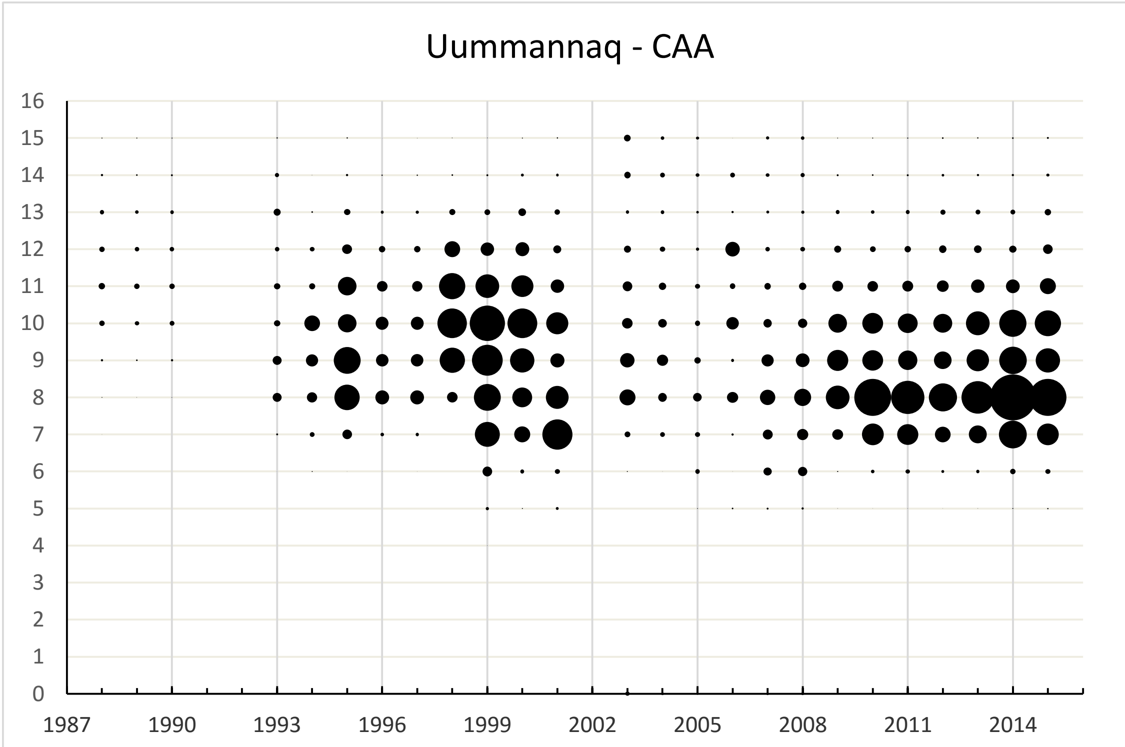

Fig. 17. Uummannaq catch at age (CAA) bubble plot. For the years 2008-2016 a general ALK key was used based on the age readings from 2008-2010 and all three areas combined.

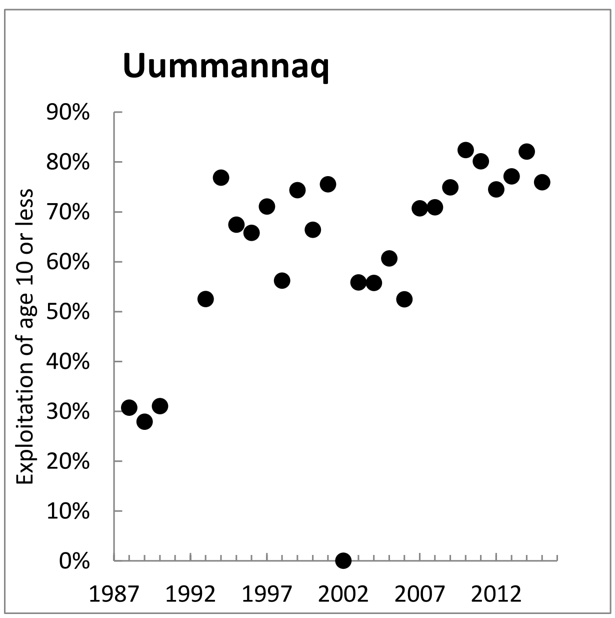

Fig. 18. Exploitation rate of age 10 and younger. For the years 2008-2016 a general ALK key was used based on the age readings from 2008-2010 and all three areas combined.

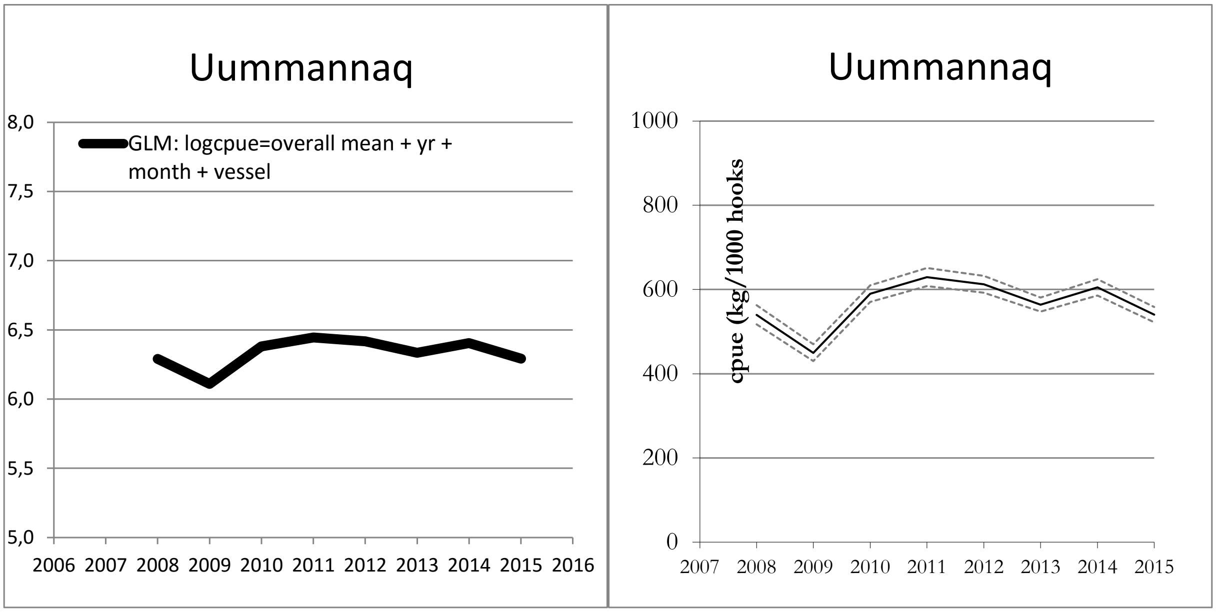

Fig 19. Standardized CPUE series for for commercial longLine (thick line) . + indicate logCPUE(kg/1000hooks) by date.

Research survey data

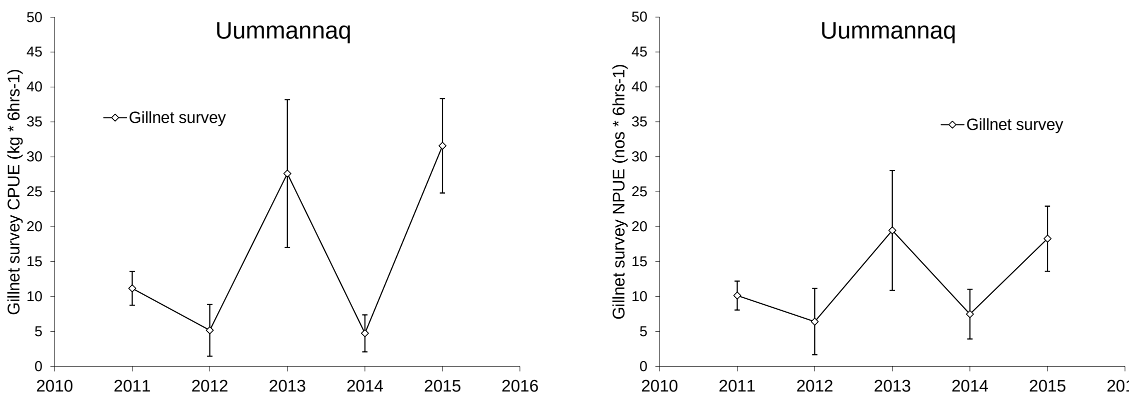

Fig. 20. Uummannaq gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (all sizes). Numbers of stations

UPERNAVIK

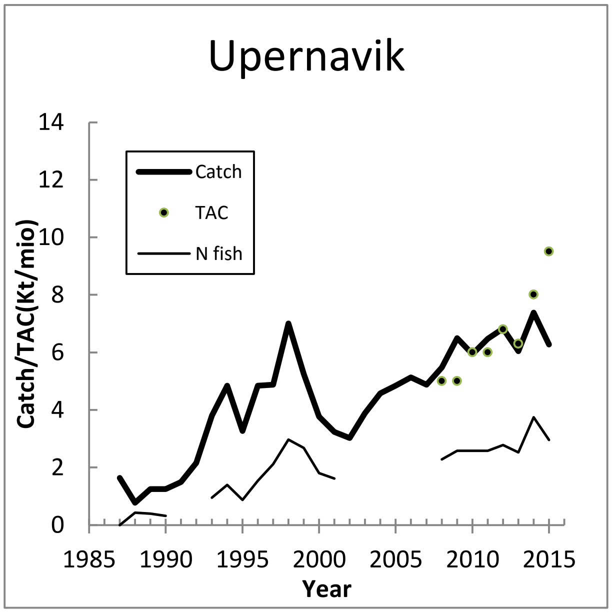

Fig. 21. Greenland halibut in NAFO division 1A inshore: Catches since 1987 in Upernavik (Kt), TAC (Kt) set by the Greenland authorities and total number of fish landed (mio).

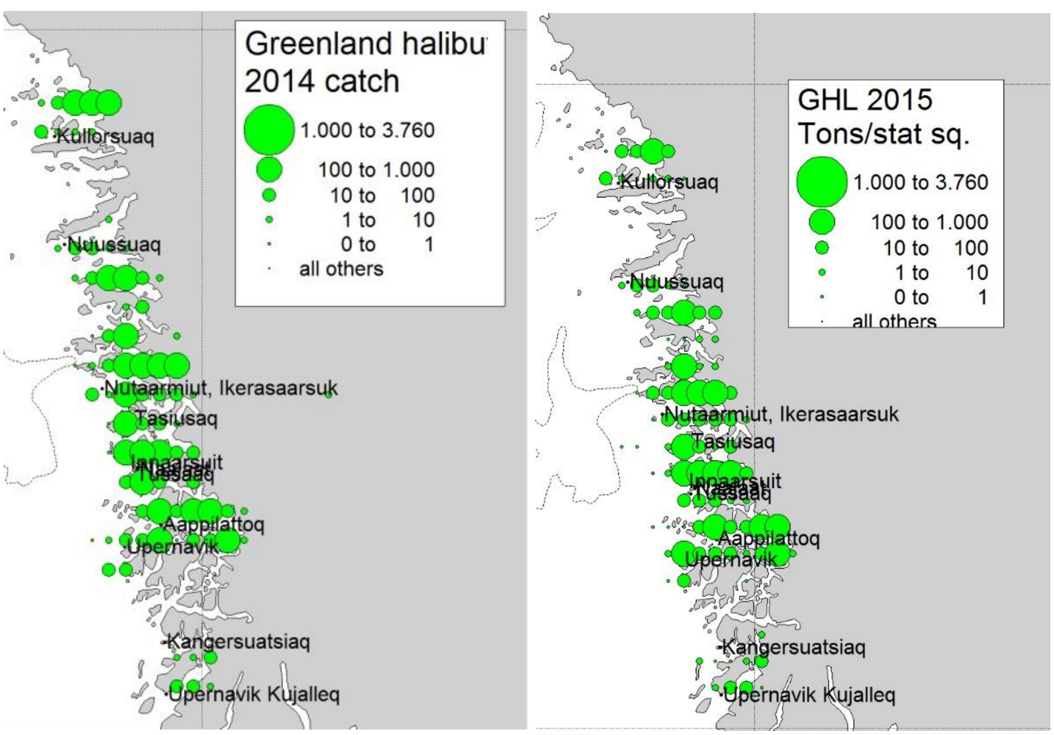

Fig. 22 Greenland halibut catch by statistical square in the Upernavik district (NAFO division 1A inshore) in 2014 and 2015.

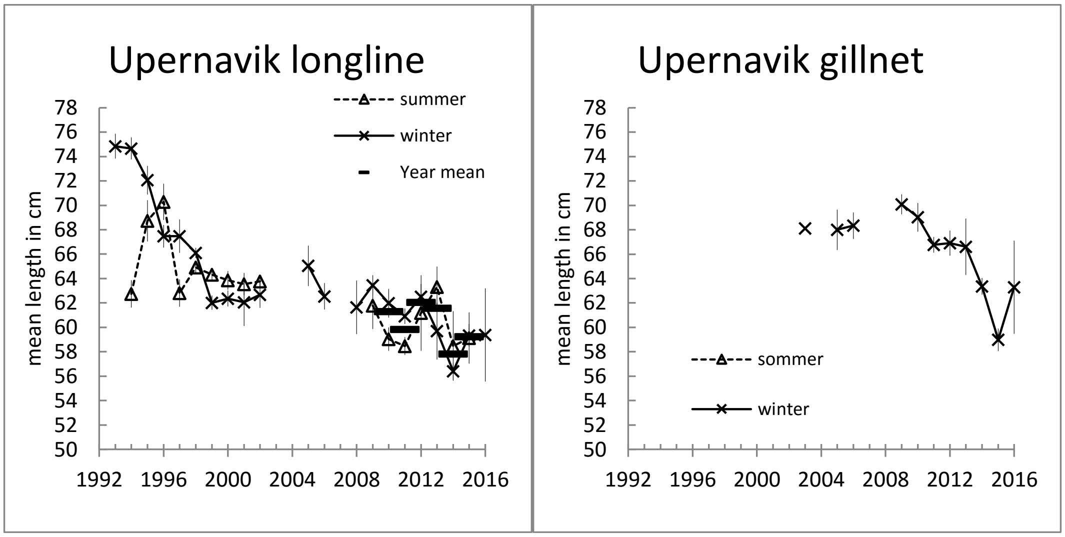

Fig. 23. Mean length in the landings: for longlines (left) and gillnets (right) and weighted overall mean by gear (longline catch and Gillnet catch).

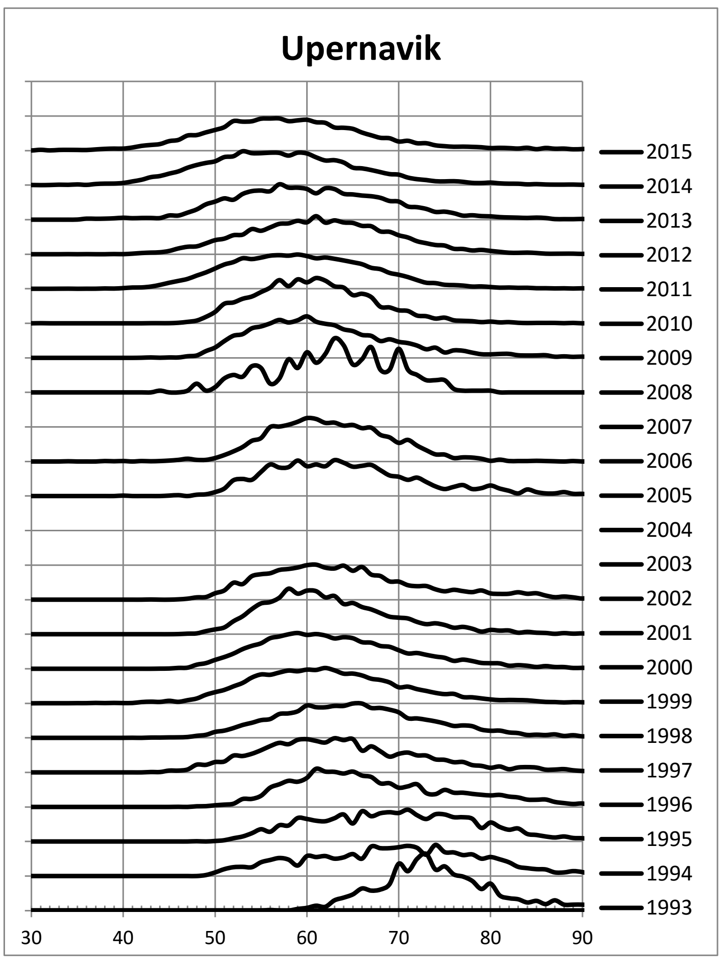

Fig 24 Upernavik length frequencies in longline landings in % of number measured all months combined.

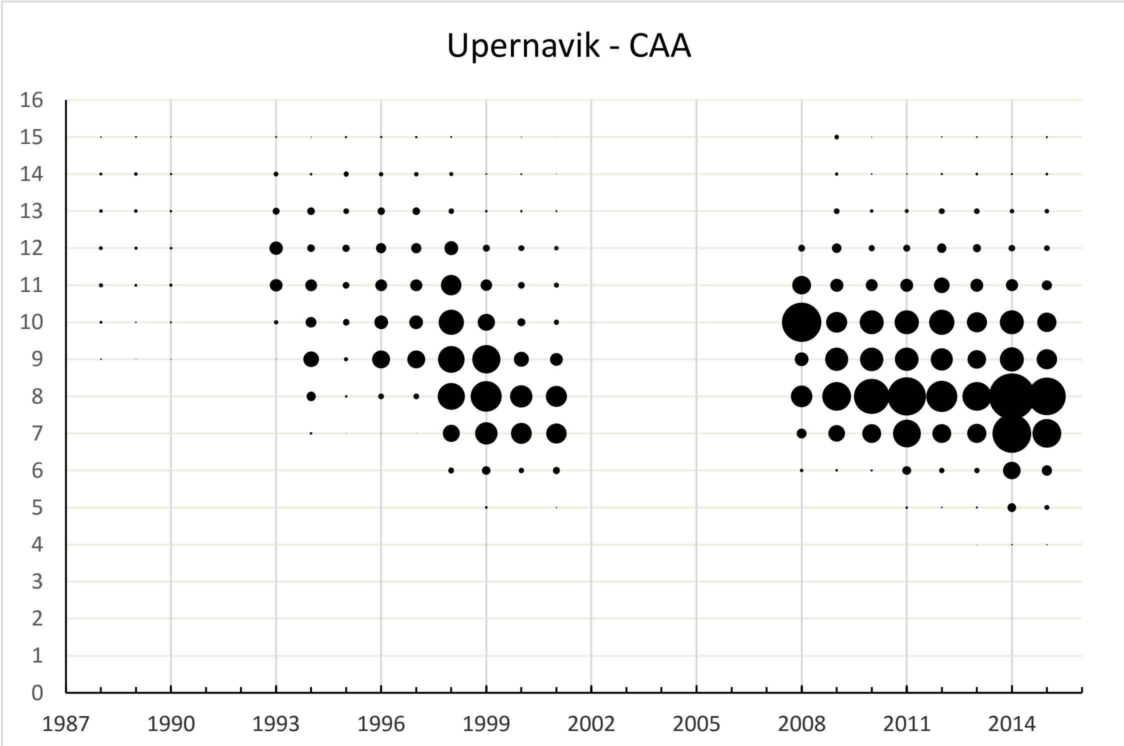

Fig 25 Upernavik catch at age (CAA) bubble plot. For the years 2008-2016 a general ALK key was used based on the age readings from 2008-2010 and all three areas combined.

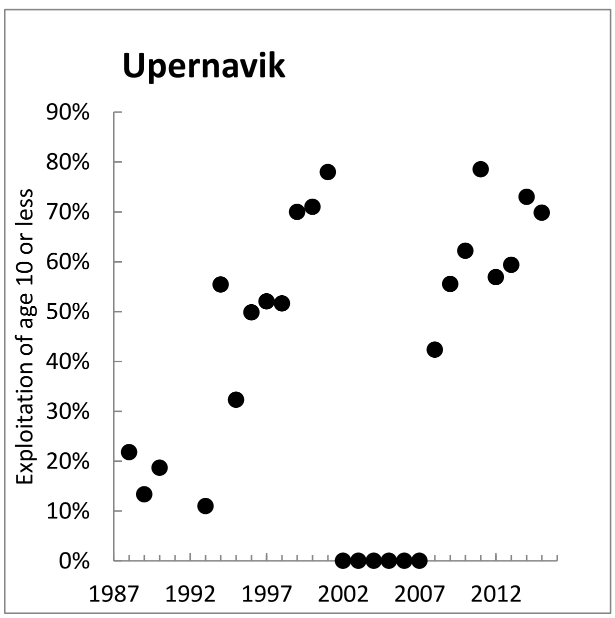

Fig. 26. Exploitation rate of age 10 and younger. For the years 2008-2016 a general ALK key was used based on the age readings from 2008-2010 and all three areas combined.

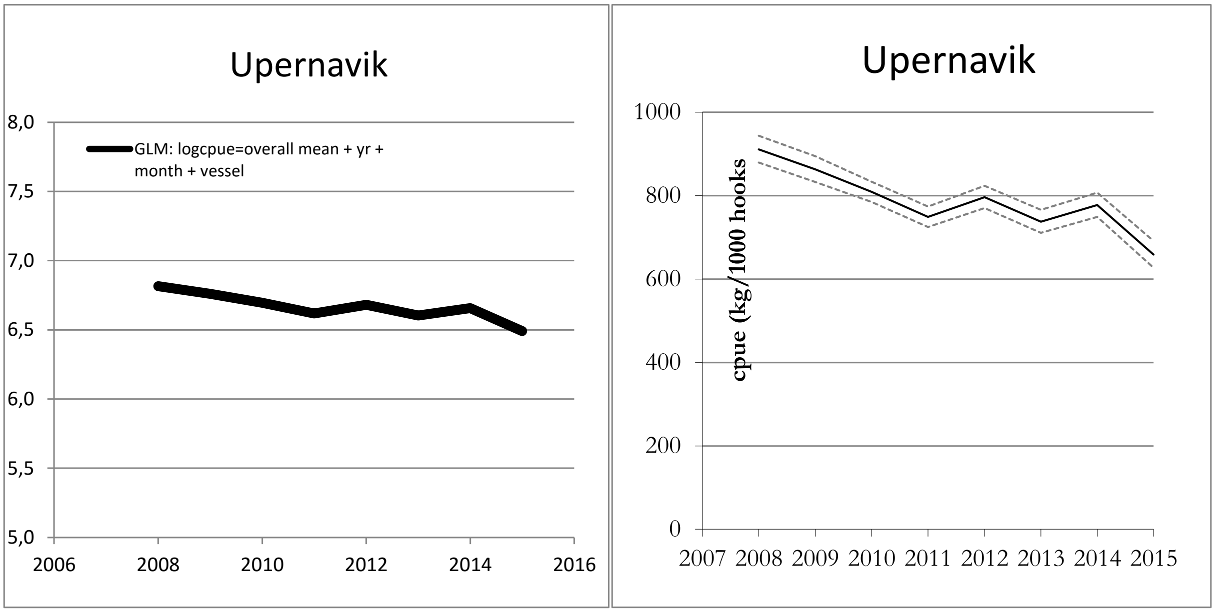

Fig 27. Standardized CPUE series for for commercial longLine (thick line) . + indicate logCPUE(kg/1000hooks) by date.

Research surveys

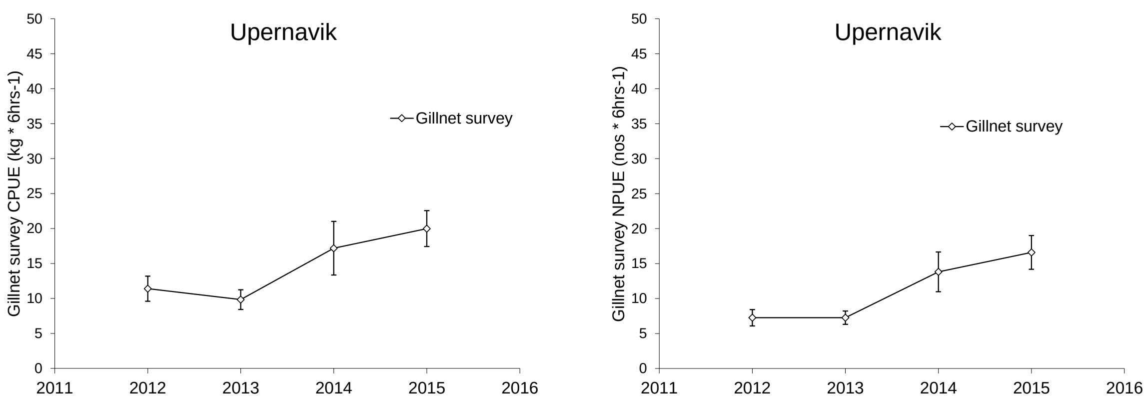

Fig. 28. Upernavik gillnet survey CPUE (left) and NPUE (right) of Greenland halibut (all sizes).

Appendix

INSH 1AX

Catch in Logbooks and number of logbooks used

The GLM Procedure

Dependent Variable: LogCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	30	287.992096	9.599737	54.59	<.0001
Error	5653	994.104749	0.175854		
Corrected Total	5683	1282.096845			

R-Square	Coeff Var	Root MSE	LogCPUE Mean
0.224626	6.796361	0.419350	6.170213

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	7	58.6420115	8.3774302	47.64	<.0001
MD	11	50.3581038	4.5780094	26.03	<.0001
FTJ_ID	12	178.9919804	14.9159984	84.82	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	7	73.0201379	10.4314483	59.32	<.0001
MD	11	47.0794772	4.2799525	24.34	<.0001
FTJ_ID	12	178.9919804	14.9159984	84.82	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		5.918488667	B	0.03471905	170.47	<.0001
YEAR	2008	0.508792389	B	0.04340788	11.72	<.0001
YEAR	2009	0.523805615	B	0.03218717	16.27	<.0001
YEAR	2010	0.304123242	B	0.02330719	13.05	<.0001
YEAR	2011	0.243483406	B	0.02271672	10.72	<.0001
YEAR	2012	0.267523242	B	0.02233990	11.98	<.0001
YEAR	2013	0.172606104	B	0.02153657	8.01	<.0001
YEAR	2014	0.149929827	B	0.02293952	6.54	<.0001
YEAR	2015	0.000000000	B	.	.	.
MD	1	0.154522616	B	0.03504862	4.41	<.0001
MD	2	-0.132991118	B	0.05591962	-2.38	0.0174
MD	3	-0.132834796	B	0.08065812	-1.65	0.0996
MD	4	-0.260984781	B	0.05316052	-4.91	<.0001
MD	5	-0.169541343	B	0.02940584	-5.77	<.0001
MD	6	0.041761444	B	0.02658035	1.57	0.1162
MD	7	-0.027656429	B	0.02667182	-1.04	0.2998
MD	8	-0.088473387	B	0.02670280	-3.31	0.0009
MD	9	-0.181596719	B	0.02688879	-6.75	<.0001
MD	10	-0.151384809	B	0.02692997	-5.62	<.0001

MD	11	-0.060477877 B	0.02851136	-2.12	0.0339
MD	12	0.000000000 B	.	.	.
FTJ_ID	1204	0.498198469 B	0.03048316	16.34	<.0001
FTJ_ID	1342	0.018084073 B	0.03033814	0.60	0.5511
FTJ_ID	1451	0.013558067 B	0.02920180	0.46	0.6425
FTJ_ID	1543	0.166639407 B	0.03261687	5.11	<.0001
FTJ_ID	1553	0.111559145 B	0.03142590	3.55	0.0004
FTJ_ID	1555	-0.205949327 B	0.02840419	-7.25	<.0001
FTJ_ID	1711	-0.062806953 B	0.03084308	-2.04	0.0418
FTJ_ID	1714	0.176276127 B	0.02924935	6.03	<.0001
FTJ_ID	1741	0.039905585 B	0.02807441	1.42	0.1552
FTJ_ID	2060	0.343200974 B	0.03001831	11.43	<.0001
FTJ_ID	15112	0.157374245 B	0.03013528	5.22	<.0001
FTJ_ID	15126	0.250996007 B	0.03126848	8.03	<.0001
FTJ_ID	45274	0.000000000 B	.	.	.

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	6.45906879	0.04073437	<.0001
2009	6.47408202	0.02818309	<.0001
2010	6.25439964	0.01721398	<.0001
2011	6.19375981	0.01606721	<.0001
2012	6.21779964	0.01570077	<.0001
2013	6.12288250	0.01476078	<.0001
2014	6.10020623	0.01696113	<.0001
2015	5.95027640	0.01979405	<.0001

INSH 1AUM
Catch in Logbooks and number of logbooks used

The GLM Procedure

Dependent Variable: LogCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	26	121.2246807	4.6624877	21.95	<.0001
Error	2144	455.4502987	0.2124302		
Corrected Total	2170	576.6749795			

R-Square	Coeff Var	Root MSE	LogCPUE Mean
0.210213	7.150846	0.460901	6.445412

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	7	17.77739399	2.53962771	11.96	<.0001
MD	11	42.73178012	3.88470728	18.29	<.0001
FTJ_ID	8	60.71550663	7.58943833	35.73	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	7	13.57914290	1.93987756	9.13	<.0001
MD	11	43.19288466	3.92662588	18.48	<.0001
FTJ_ID	8	60.71550663	7.58943833	35.73	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.679933809	B	0.09254132	72.18	<.0001
YEAR	2008	-0.000937149	B	0.04683850	-0.02	0.9840
YEAR	2009	-0.183313242	B	0.04874169	-3.76	0.0002
YEAR	2010	0.087864333	B	0.04463385	1.97	0.0491
YEAR	2011	0.152873225	B	0.04188791	3.65	0.0003
YEAR	2012	0.125127836	B	0.03872041	3.23	0.0012
YEAR	2013	0.043199374	B	0.03636136	1.19	0.2349
YEAR	2014	0.113027784	B	0.03854460	2.93	0.0034
YEAR	2015	0.000000000	B	.	.	.
MD	1	-0.151012347	B	0.12246669	-1.23	0.2177
MD	2	-0.106875982	B	0.13155936	-0.81	0.4167
MD	3	-0.233210057	B	0.14091418	-1.65	0.0981
MD	4	0.174391682	B	0.13674820	1.28	0.2023
MD	5	-0.184985972	B	0.09540474	-1.94	0.0526
MD	6	0.087937854	B	0.08557424	1.03	0.3042
MD	7	0.250657044	B	0.08556262	2.93	0.0034
MD	8	0.188834640	B	0.08587346	2.20	0.0280
MD	9	0.010832471	B	0.08586014	0.13	0.8996
MD	10	-0.083776810	B	0.08597612	-0.97	0.3300
MD	11	-0.185283910	B	0.09140251	-2.03	0.0428
MD	12	0.000000000	B	.	.	.
FTJ_ID	1540	-0.565345382	B	0.04033747	-14.02	<.0001
FTJ_ID	1910	-0.488297619	B	0.04471067	-10.92	<.0001
FTJ_ID	1923	-0.576624425	B	0.04805762	-12.00	<.0001
FTJ_ID	1981	-0.295551802	B	0.04371693	-6.76	<.0001
FTJ_ID	27847	-0.283200576	B	0.04049548	-6.99	<.0001
FTJ_ID	32390	-0.363196290	B	0.04225862	-8.59	<.0001
FTJ_ID	32893	-0.263272613	B	0.04289759	-6.14	<.0001
FTJ_ID	34516	-0.482619720	B	0.04665413	-10.34	<.0001
FTJ_ID	60647	0.000000000	B	.	.	.

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	6.29094366	0.04191234	<.0001
2009	6.10856757	0.04452766	<.0001
2010	6.37974515	0.03349313	<.0001
2011	6.44475404	0.03431900	<.0001
2012	6.41700865	0.03275287	<.0001
2013	6.33508019	0.02969419	<.0001
2014	6.40490860	0.03244111	<.0001
2015	6.29188081	0.03379103	<.0001

INSH 1AUP
Catch in Logbooks and number of logbooks used

The GLM Procedure
Dependent Variable: LogCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	41	279.791528	6.824184	20.77	<.0001
Error	4914	1614.305244	0.328511		
Corrected Total	4955	1894.096772			

R-Square	Coeff Var	Root MSE	LogCPUE Mean
0.147718	8.341762	0.573159	6.870961

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	7	36.3175799	5.1882257	15.79	<.0001
MD	11	98.5427184	8.9584289	27.27	<.0001
FTJ_ID	23	144.9312292	6.3013578	19.18	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	7	27.4150614	3.9164373	11.92	<.0001
MD	11	86.0478067	7.8225279	23.81	<.0001
FTJ_ID	23	144.9312292	6.3013578	19.18	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.573406450	B	0.09940731	66.13	<.0001
YEAR	2008	0.324757462	B	0.04698280	6.91	<.0001
YEAR	2009	0.270475579	B	0.04738153	5.71	<.0001
YEAR	2010	0.205593075	B	0.04519705	4.55	<.0001
YEAR	2011	0.128483514	B	0.04537113	2.83	0.0046
YEAR	2012	0.190449789	B	0.04634899	4.11	<.0001
YEAR	2013	0.113600904	B	0.04775711	2.38	0.0174
YEAR	2014	0.166271557	B	0.04793549	3.47	0.0005
YEAR	2015	0.000000000	B	.	.	.
MD	1	-0.036079853	B	0.10578353	-0.34	0.7331
MD	2	-0.457875064	B	0.10169604	-4.50	<.0001
MD	3	-0.889914850	B	0.17576657	-5.06	<.0001
MD	4	-0.892575886	B	0.23131579	-3.86	0.0001
MD	5	-0.403677226	B	0.08348538	-4.84	<.0001
MD	6	-0.176852600	B	0.07613733	-2.32	0.0202
MD	7	0.029423766	B	0.07460638	0.39	0.6933
MD	8	0.049326683	B	0.07423071	0.66	0.5064
MD	9	-0.163290517	B	0.07425208	-2.20	0.0279
MD	10	-0.060794465	B	0.07546848	-0.81	0.4205

MD	11	0.078189850 B	0.07651468	1.02	0.3069
MD	12	0.000000000 B	.	.	.
FTJ_ID	1228	-0.005442420 B	0.07024836	-0.08	0.9382
FTJ_ID	1344	0.097379350 B	0.07635051	1.28	0.2022
FTJ_ID	1475	-0.018535519 B	0.06311475	-0.29	0.7690
FTJ_ID	1498	0.073807961 B	0.06303531	1.17	0.2417
FTJ_ID	1568	0.228679232 B	0.07089235	3.23	0.0013
FTJ_ID	1739	0.254779660 B	0.06217724	4.10	<.0001
FTJ_ID	1805	0.415376809 B	0.06380686	6.51	<.0001
FTJ_ID	1926	0.519988946 B	0.08266371	6.29	<.0001
FTJ_ID	1946	0.383294406 B	0.06727537	5.70	<.0001
FTJ_ID	1954	0.211759202 B	0.06533318	3.24	0.0012
FTJ_ID	1978	0.259629785 B	0.06257409	4.15	<.0001
FTJ_ID	10021	-0.035149916 B	0.06759062	-0.52	0.6031
FTJ_ID	11261	-0.001891646 B	0.06521974	-0.03	0.9769
FTJ_ID	11835	0.492429651 B	0.06349886	7.75	<.0001
FTJ_ID	12517	0.155103952 B	0.06455089	2.40	0.0163
FTJ_ID	13432	0.284210741 B	0.07152147	3.97	<.0001
FTJ_ID	13597	0.041016597 B	0.07713330	0.53	0.5949
FTJ_ID	17339	0.185391635 B	0.07509680	2.47	0.0136
FTJ_ID	23971	-0.040120314 B	0.07083751	-0.57	0.5712
FTJ_ID	23972	-0.082114635 B	0.07622918	-1.08	0.2814
FTJ_ID	32390	0.053106729 B	0.07298954	0.73	0.4669
FTJ_ID	32893	-0.014878738 B	0.07434062	-0.20	0.8414
FTJ_ID	33843	0.393169425 B	0.08388810	4.69	<.0001
FTJ_ID	34516	0.000000000 B	.	.	.

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	6.81494519	0.03521676	<.0001
2009	6.76066330	0.03561232	<.0001
2010	6.69578080	0.03008656	<.0001
2011	6.61867124	0.03270191	<.0001
2012	6.68063751	0.03340500	<.0001
2013	6.60378863	0.03733178	<.0001
2014	6.65645928	0.03722784	<.0001
2015	6.49018772	0.04894685	<.0001