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Discarded by-catch in shrimp fisheries in Greenlandic offshore waters 2006-2007

by

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**Abstract**

The discard levels of fish in the shrimp fishery within the Greenlandic Exclusive Economic Zone were in 2006 and 2007 examined during 12 commercial trips on 9 different vessels. Normally the captain or onboard observer, representing the authorities, reports the discard based on visual estimates. In 332 hauls in NAFO Div. 1B-1E and in ICES XIVB all fish were collected in baskets and weighed by a scientific observer before the fish were discarded.

Captain and the authorities observer often agreed on the same amount of by-catch however not necessary at the right level. The average discard of fish ranged by area from 1.6 % of the shrimp catch in NAFO 1B to 5.8 % in ICES XIVb. On the same hauls the captain's estimates ranged from 4.4 % to 1.2% for the same areas. This is somewhat higher than what has been reported in the later years where the discard level on average has remained well below 1% for several years (Kingsley 2007). This suggests that the reporting of the by-catch has been affected by the presence of the scientific assistant.

Still the level of discard in the shrimp fishery with an average discard percentage on 2.2% must be considered low.

**Introduction**

The quota of Northern shrimp (*Pandalus borealis*) in the Greenlandic Exclusive Economic Zone (EEZ) were in 2006 divided into 74.100 tons on the Greenlandic west coast and 12.400 tons off the east Greenlandic coast. The fishery is only targeted towards the shrimp and is not allowed to land fish, therefore all by-catch of fish are discarded. To minimize by-catch the trawls have since November 2002 been equipped with grid separators (G.H. 2001), the 22 mm spacing between the bars in the separator however allows small fish to enter the codend.

Mandatory haul-by-haul logbooks are used by the vessels giving start and end position of each haul along with the amount of catch of shrimp and discard of shrimp and fish. Normally the person in charge on the bridge fills these logbooks. Approximately in 30 % of the fishing days an observer from Greenland Fishery License Control (GFLK) is onboard and filling out an observers logbook with own estimates of the catch data. If by-catch of fish exceeds 10% of the catch of shrimp, the vessel is supposed to change fishing grounds with minimum 5 nautical miles.

In this study scientific assistants from the Greenland Institute of Natural Resources (GINR) were on board the fishing vessels, with their major priority on weighing and determining the species of the fish caught as by-catch, in order to compare these values with those estimated by the captain and the observer from GFLK.

## Materials and Methods

In 2006 and 2007 scientific assistants were in 12 trips on board 9 different trawlers from 4 nations. The vessels used both single trawl and double trawl with a minimum mesh size at 40 mm.

In 332 hauls the by-catch of fish were collected in baskets and weighed by a scientific assistant. Both the east coast (ICES XIVb) the west coast (NAFO 1B, 1C, 1D and 1E) were covered. (Table 1, Figure 1). The captains and observers estimate of the by-catch are in most cases based only on eye estimation of the catch composition and size when on deck of the vessel.

The weights of the total catch of shrimp that are filed in the logbook are based on the onboard factory scales.

In most of the hauls the weight and length frequencies (TL in cm below) of cod (*Gadus morhua*), redfish (*Sebastes* sp.) or Greenland halibut (*Reinhardtius hippoglossoides*) were found in a sub sample. In 74 hauls the scientific assistant determined the complete species composition in the sub sample on board. For some species this was not possible and then the fish were allocated to family. E.g. the small redfish were only noted as *Sebastes* sp. If possible, the samples were frozen and brought back to the lab. The 74 stations were chosen randomly and before the haul was on deck.

The results obtained from the actual weighing of by-catch by the scientific assistant were planned not to be available to either captain or observer when they were filling out their logbooks. However in a few not planned occasions they accessed the raw data before filling out the logbook.

## Results and Discussion

In general the amounts of by-catch of fish, here presented as %, weight of total fish by-catch per total catch weight of shrimp, are low with a total average for all 332 hauls of 2.2 % (Table 1) and only few hauls were above the 10 % given in the law (Figure 2). The by-catch ranges from 1.6 % in NAFO 1B to 5.8 % in ICES XIVb (Table 2). The 3 most economically interesting species, redfish, cod and Greenland halibut are only found in relatively small proportions of the by-catch (Tables 3, 4 and 5).

Accordingly to logbooks provided to Greenland Fishery License Control (GFLK) were 1157 tons fish caught as by-catch in the shrimp fishery in NAFO subarea 1 in 2006 and a projection gives a fish discard in 2007 at 708, corresponding to respectively 0.8 and 0.5 % of the shrimpcatches (Kingsley 2007). In 2006 and 2007 the captains involved in the project estimated that they had discarded 1.1 % and 2.9% fish of the total catch of shrimp (Table 2). The difference however small, from the percentages given in table 2 suggests that the captain's estimations of the by-catches are affected by the presence of the scientific assistant from GINR. The actual discard levels on the involved vessels these years were found by the scientific observer to be 3.1 % and 1.6 % respectively (Table 2). If this behavioural difference are significant has to be examined more closely in a later investigation when logbook information on observer values is provided.

A large similarity between the observer and captain's estimate of by-catch is noticed. This is probably due that part of the observer's job is to bring irregularities to attention to the captain of the vessel. Therefore normally the amounts of by-catch estimated by the observer is accepted and copied by the captain.

One vessel logbook page should be filled every day by the captain. Since there are only fields for two species of fish in the logbook these two spaces are most often typed as "Mixed fish" and redfish (Table 3). Even if the largest proportion in a haul have been of another species of fish. That is why there is no captains or observers estimate on the amount of Greenland halibut or cod in table 4 and 5. It is evident that the highest by-catch rates (0.17 % in NAFO Div. 1E vs. 0.02% in 1B) of Cod are found in the southern areas (Table 5) while the highest levels of Greenland halibut discards are found in the northern areas (0.34% in NAFO Div. 1B vs. 0.04% in 1E) (Table 4). These different levels reflects the geographical distribution of the two species, as cod in 2006 and 2007 are found

very southerly distributed (Sünksen 2007) while small Greenland halibut are primarily found on the nursery grounds in NAFO Div. 1B. Although the actual levels are low it should be kept in mind that NAFO Div. 1B is the area where the majority of the shrimp fishery has moved to in the later years (Kingsley 2007).

In 74 hauls the composition of the by-catch were found by examining a subsample of each haul. The far most discarded fish is the redfish and therefore the only “species” that regularly are being reported separately in its own field in the logbook. (Table 6) As seen in the table the 7 most dominating species or families were Redfish (*Sebastes* sp.), Capelin (*Mallotus villosus*), Goiter blacksmelt (*Bathylagus euryops*), American plaice (*Hippoglossus platessoides*), Elpouts (*Lycodes* sp.), Greenland halibut (*Reinhardtius hippoglossoides*) and Cod (*Gadus morhua*). The Goiter blacksmelt has however only been found in dense concentrations on the east coast of Greenland. No mammals were caught in any of the 332 hauls.

The use of grid separators in front of the codend gives only by-catch of relatively small fish. The lengths (TL) are given in figure 3 and 4 in cm below). The modes of the length distribution of cod, Greenland halibut and redfish caught in ICES XIVb are at 20-21, 18-22 and 13-14 cm respectively (Figure 3). Both the Greenlandic and the German survey in the same area indicate that larger fish are present in the area. (ICES 2007). The length distributions for the three species in the NAFO area (Figure 4) differ somehow from those in the ICES area. The fish caught in the codend are still relatively small, very few fish larger than 25 cm were caught. Due to the more flattened appearance, it seems that longer Greenland halibut goes through the grids than the roundfishes; cod and redfish.

The length distribution for redfish shows a mode at 8-12 cm while Greenland halibut has two, first at 13 cm and the other around 23 cm. Finally it seems that part of a 2007 year class of cod were found in the shrimp fishery in the first half of 2007. Two distinct modes are seen. The first at 8 cm and the other (which most likely the 2006 year class) at 18 cm. These length modes are in agreement with those found from the Greenlandic combined shrimp and fish survey, except that no large fish were found in this investigation due to the sorting grids (Sünksen & Jørgensen 2007).

### Acknowledgements

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**Table 1.** Number of hauls by area and trip, covered by GINR on 12 trips with 9 different vessels. Catch of shrimp based on captain's logbook

<sup>1)</sup> Percentage discarded by-catch of all fish species from total catch of shrimp. Based on weight estimate by GINR

Year	Date	Vessel	Trip	Number of hauls by area					total n by trip	Catch of shrimp (Kg)	Discarded by-catch of fish ( Kg)				SE
				ICES XIVB	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E			Captain	Observer	GINR	% Weight <sup>1)</sup>	
2006	11/2-14/3	A	1	55					55	137072	5895	5672	7738	5.6	1.15
2006	27/4-9/5	B	2	18					18	26679	1560	1560	1272	4.8	1.49
2006	28/7-6/8	C	3			11	5		16	137461	6635	6635	4447	3.2	0.87
2006	18/3-30/8	D	4				25	3	28	212715	6755	6755	6754	3.2	0.63
2006	12/10-24/10	E	5			24			24	189541	2475	2775	4608	2.4	0.32
2006	1/12-11/12	F	6		18	2			20	166087	1635	1640	2166	1.3	1.60
2007	15/1-12/2	E	7	20	3	9	9	1	42	220979	2150	2145	4801	2.2	52.60
2007	24/1-13/2	G	8		18	5	6		29	228683	712	1860	2851	1.2	0.82
2007	10/3-21/3	G	9		25	2			27	193998	3034	3746	4212	2.2	0.35
2007	12/5-28/5	H	10		19	4	10		33	298266	2611	2611	3562	1.2	0.27
2007	18/5-28/5	E	11		16	4			20	129091	3871	3871	4137	3.2	0.75
2007	15/6-24/6	I	12		20				20	190096	1100	1100	697	0.4	0.18
Sum				93	119	61	55	4	332	2130668	38433	40370	47246	2.2	6.74

Table 2. Captain's, observer's and scientific assistant's estimates of weight of discarded by-catch of all fish species. Compared with weight of the total catch of shrimps as given in the captains logbook. Values from a) 2006, b) 2007 and c) 2006 and 2007 together.

<sup>1)</sup> Percentage discarded by-catch of fish from total catch of shrimp. Based on weight estimate by GINR

a) 2006		Catch of shrimp (Kg)	Discarded by-catch of fish ( Kg)				% Weight <sup>1)</sup>	SE
Area	n		Captain	Observer	GINR			
ICES XIVB	73	163751	7455	7232	9010	5.5	0.94	
NAFO 1B	18	151332	1360	1365	1989	1.3	1.78	
NAFO 1C	37	307273	8120	8420	8103	2.6	0.32	
NAFO 1D	30	235017	7810	7810	7583	3.2	0.66	
NAFO 1E	3	12182	210	210	301	2.5	0.44	
Sum	161	869555	24955	25037	26986	3.1	0.51	

b) 2007		Catch of shrimp (Kg)	Discarded by-catch of fish ( Kg)				% Weight <sup>1)</sup>	SE
Area	n		Captain	Observer	GINR			
ICES XIVB	20	31779	1065	1060	2303	7.2	108.62	
NAFO 1B	101	812755	10119	11546	13546	1.7	0.29	
NAFO 1C	24	195583	1028	1248	2059	1.1	1.97	
NAFO 1D	25	220395	1221	1434	2317	1.1	0.37	
NAFO 1E	1	601	45	45	35	5.9	-	
Sum	171	1261113	13478	15333	20260	1.6	13.07	

c) 2006-2007		Catch of shrimp (Kg)	Discarded by-catch of fish ( Kg)				% Weight <sup>1)</sup>	SE
Area	n		Captain	Observer	GINR			
ICES XIVB	93	195530	8520	8292	11313	5.8	23.91	
NAFO 1B	119	964087	11479	12911	15535	1.6	0.36	
NAFO 1C	61	502856	9148	9668	10161	2.0	0.80	
NAFO 1D	55	455412	9031	9244	9900	2.2	0.44	
NAFO 1E	4	12783	255	255	337	2.6	0.93	
Sum	332	2130668	38433	40370	47246	2.2	6.74	

Table 3. Captain's, observer's and scientific assistant's estimates of weight of discarded by-catch of redfish. Compared with weight of the total catch of shrimps as given in the captains logbook. Values from a) 2006, b) 2007 and c) 2006 and 2007 together.

<sup>1)</sup> Percentage discarded by-catch of fish from total catch of shrimp. Based on weight estimate by GINR

a) <b>2006</b>		Catch of shrimp (Kg)	Discarded by-catch of Redfish ( Kg)				% Weight <sup>1)</sup>	SE
Area	n		Captain	Observer	GINR			
ICES XIVB	72	160721	134	132	131	0.1	0.03	
NAFO 1B	18	151332	855	855	1220	0.8	1.73	
NAFO 1C	36	297850	805	1110	1052	0.4	0.10	
NAFO 1D	29	233982	1925	1925	2217	0.9	0.47	
NAFO 1E	3	12182	15	15	19	0.2	0.11	
Sum	158	856067	3734	4037	4638	0.5	0.22	

b) <b>2007</b>		Catch of shrimp (Kg)	Discarded by-catch of Redfish ( Kg)				% Weight <sup>1)</sup>	SE
Area	n		Captain	Observer	GINR			
ICES XIVB	20	31779	335	335	351	1.1	26.06	
NAFO 1B	101	812755	4239	4828	5099	0.6	0.15	
NAFO 1C	24	195583	373	423	352	0.2	1.10	
NAFO 1D	25	220395	601	624	552	0.3	0.08	
NAFO 1E	1	601	5	5	16	2.6	-	
Sum	171	1261113	5553	6215	6369	0.5	3.14	

c) <b>2006-2007</b>		Catch of shrimp (Kg)	Discarded by-catch of Redfish ( Kg)				% Weight <sup>1)</sup>	SE
Area	n		Captain	Observer	GINR			
ICES XIVB	92	192500	469	467	482	0.3	5.81	
NAFO 1B	119	964087	5094	5683	6319	0.7	0.30	
NAFO 1C	60	493433	1178	1533	1404	0.3	0.44	
NAFO 1D	54	454377	2526	2549	2769	0.6	0.26	
NAFO 1E	4	12783	20	20	34	0.3	0.62	
Sum	329	2117180	9287	10252	11007	0.5	1.64	

Table 4. Weight of discarded Greenland halibut. Neither the captain nor observer gives information on their estimate on Greenland halibut; therefore the weights are compared with their estimates on by-catch of all fish.

<sup>1)</sup> Percentage discarded by-catch of fish from total catch of shrimp. Based on weight estimate by GINR

2006-2007 Area	n	Catch of shrimp (Kg)	Discarded by-catch of fish ( Kg)			Discarded by-catch of Grl. Halibut (Kg)		
			Captain	Observer	GINR	GINR	% Weight <sup>1)</sup>	SE
ICES XIVB	92	192500	8490	8262	11250	364	0.19	0.04
NAFO 1B	113	908107	10944	12376	14620	3098	0.34	0.18
NAFO 1C	60	499365	9113	9578	10051	1164	0.23	0.07
NAFO 1D	53	433337	7491	7704	8451	195	0.04	0.03
NAFO 1E	4	12783	255	255	337	5	0.04	0.04
Sum	322	2046092	36293	38175	44709	4825	0.24	0.07

Table 5. Weight of discarded cod. Neither the captain nor observer gives information on their estimate on cod; therefore the weights are compared with their estimates on by-catch of all fish.

<sup>1)</sup> Percentage discarded by-catch of fish from total catch of shrimp. Based on weight estimate by GINR

2006-2007 Area	n	Catch of shrimp (Kg)	Discarded by-catch of fish ( Kg)			Discarded by-catch of Cod (Kg)		
			Captain	Observer	GINR	GINR	% Weight <sup>1)</sup>	SE
ICES XIVB	83	180352	7718	7490	10650	29	0.02	0.03
NAFO 1B	118	950933	11414	12846	15364	151	0.02	0.01
NAFO 1C	61	502856	9148	9668	10161	287	0.06	0.09
NAFO 1D	53	433337	7491	7704	8451	389	0.09	0.07
NAFO 1E	4	12783	255	255	337	21	0.17	0.06
Sum	319	2080261	36026	37963	44963	877	0.04	0.02

Table 6. Haul and species composition in 74 hauls distributed on NAFO Div. 1B, 1C, 1D, 1E and ICES XIVB.

Name English	Latin	Area					Sum
		ICES XIVB	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	
Redfish sp.	<i>Sebastes sp.</i>	71.7	1332.8	144.5	1119.3	15.5	2683.8
Capelin	<i>Mallotus villosus</i>	604.6	45.8	60.4	1007.6	3.3	1721.6
Goiter blacksmelt	<i>Bathylagus euryops</i>	1145.5	0.1	0.0	0.0	0.0	1145.6
American plaice	<i>Hippoglossoides platessoides</i>	389.8	309.7	68.2	176.2	2.6	946.4
Eelpouts	<i>Lycodes sp.</i>	589.9	87.4	1.4	2.0	1.5	682.1
Greenland halibut	<i>Reinhardtius hippoglossoides</i>	117.6	160.4	88.1	38.4	0.0	404.5
Cod	<i>Gadus morhua</i>	5.5	43.3	35.9	271.1	0.6	356.4
Thorny skate	<i>Raja radiata</i>	41.4	32.7	10.3	68.0	8.8	161.1
Daubed shanny	<i>Leptoclinius maculatus</i>	0.0	64.8	3.0	13.2	0.0	81.0
Glacier Lanternfish	<i>Benthoosema glasiatale</i>	0.0	0.8	0.3	57.2	0.2	58.4
Snakeblenny	<i>Lumpenus lampretaeformis</i>	0.0	46.8	4.0	6.7	0.0	57.5
Squid	<i>Squid</i>	36.1	16.5	1.4	3.0	0.0	57.0
Polar cod	<i>Boreagadus saida</i>	34.0	13.7	0.2	5.6	0.1	53.6
Slickheads	<i>Alepocephalidae</i>	51.2	0.4	0.0	0.6	0.1	52.4
Veiled anglemouth	<i>Cyclothone microdon</i>	49.9	0.0	0.0	0.0	0.1	50.0
Atlantic wolffish	<i>Anarhicas lupus</i>	4.7	19.7	5.6	9.9	0.9	40.8
Rockling	<i>Gaidropsarus sp.</i>	30.3	0.0	0.0	1.2	0.0	31.5
Blue whiting	<i>Micromesistius poutassou</i>	0.0	0.4	1.1	29.2	0.2	30.9
Rakery beaconlamp	<i>Lampanyctus macdonaldi</i>	0.0	0.0	0.0	26.6	0.0	26.6
Bean's sawtoothed eel	<i>Serrivomer beani</i>	21.9	0.0	0.0	0.0	0.9	22.8
Scaly dragonfish	<i>Stomias boa</i>	19.4	0.0	1.4	1.6	0.3	22.7
Barracudinas	<i>Paralepididae</i>	7.9	6.3	0.2	7.4	0.0	21.8
Sculpin sp.	<i>Triglops sp.</i>	7.0	6.8	0.1	0.4	0.2	14.6
Sea tadpole	<i>Careproctus reinhardti</i>	13.0	0.0	0.0	0.0	0.0	13.0
Hookear sculpins	<i>Artedilius sp.</i>	7.1	4.9	0.0	0.0	0.0	12.0
Snaggletooth	<i>Astronesthinae</i>	10.1	0.0	0.0	0.0	0.0	10.1
Bigscale fishes	<i>Melamphaidae</i>	8.6	0.0	0.0	0.0	0.0	8.6
Deepsea lizardfish	<i>Bathysaurus ferox</i>	8.4	0.0	0.0	0.0	0.0	8.4
Atlantic herring	<i>Clupea harengus</i>	0.0	0.0	0.8	6.9	0.0	7.7
Skates	<i>raja sp.</i>	4.5	0.0	0.0	0.0	0.0	4.5
Snailfishes	<i>Liparidae</i>	4.1	0.2	0.0	0.0	0.0	4.2
Spotted wolffish	<i>Anarhicas minor</i>	0.0	4.2	0.0	0.0	0.0	4.2
Shortfinned tadpole	<i>Careproctus micropus</i>	3.5	0.5	0.0	0.0	0.0	4.1
Sand lances	<i>Ammodytidae</i>	0.0	3.8	0.0	0.0	0.0	3.8
Mirror lanternfish	<i>Lampadena speguligera</i>	0.4	0.0	0.0	2.9	0.0	3.3
Threadfin rockling	<i>Gaidropsarus ensis</i>	0.0	0.0	0.0	3.2	0.0	3.2
Alligatorfish	<i>Aspidophoroides monopterygius</i>	0.0	2.4	0.2	0.1	0.0	2.6
Tubeshoulders	<i>Platyroctidae</i>	2.1	0.0	0.0	0.0	0.0	2.1
Fourbeard rockling	<i>Enchelyopus cimbrius</i>	0.0	0.0	1.9	0.0	0.0	1.9
Sloane's viperfish	<i>Chauliodus sloani</i>	1.4	0.0	0.0	0.0	0.0	1.4
Stoplight loosejaw	<i>Malacostens niger</i>	1.3	0.0	0.0	0.0	0.0	1.3
Atlantic poacher	<i>Leptagonus decagonus</i>	0.9	0.1	0.0	0.0	0.0	1.1
Atlantic spiny lumpsucker	<i>Eumicrotremus spinosus</i>	0.0	0.9	0.0	0.0	0.0	0.9
Bristlemouth	<i>Gonostoma bathyphilum</i>	0.9	0.0	0.0	0.0	0.0	0.9
Tusk	<i>Brosme brosme</i>	0.0	0.0	0.0	0.8	0.0	0.8
Thorned sculpins	<i>Icelus sp.</i>	0.1	0.1	0.1	0.4	0.0	0.8
Northern wolffish	<i>Anarhicas denticulatus</i>	0.0	0.5	0.0	0.0	0.0	0.5
Greater argentine	<i>Argentina silus</i>	0.0	0.0	0.0	0.4	0.0	0.4
Deep-sea spiny eels	<i>Notacanthidae</i>	0.4	0.0	0.0	0.0	0.0	0.4
Rock gunnel	<i>Pholis gunnellus</i>	0.0	0.3	0.0	0.0	0.0	0.3
Grenadiers	<i>Macrouridae</i>	0.3	0.0	0.0	0.0	0.0	0.3
Pelican eel	<i>Eurypharynx pelacanooides</i>	0.2	0.0	0.0	0.0	0.0	0.2
Moustache sculpin	<i>Triglops murray</i>	0.0	0.0	0.2	0.0	0.0	0.2
Arctic rockling	<i>Gaidropsarus argentatus</i>	0.0	0.0	0.0	0.2	0.0	0.2
Haddock	<i>Melanogrammus aeglefinus</i>	0.1	0.0	0.0	0.1	0.0	0.2
Bluntnout smooth-head	<i>Xenodermichthys copei</i>	0.0	0.0	0.0	0.1	0.0	0.1
Fatheads	<i>Cottunculus sp.</i>	0.1	0.0	0.0	0.0	0.0	0.1
Dreamers	<i>Oneirodidae</i>	0.1	0.0	0.0	0.0	0.0	0.1
Bristlemouths	<i>Conostomatidae</i>	0.1	0.0	0.0	0.0	0.0	0.1
	Number of hauls	35	23	5	10	1	74
	Catch of shrimp (kg)	84735	215905	29154	69937	601	400332
	Sum of discarded fish (kg)	3296	2206	429	2860	35	8827



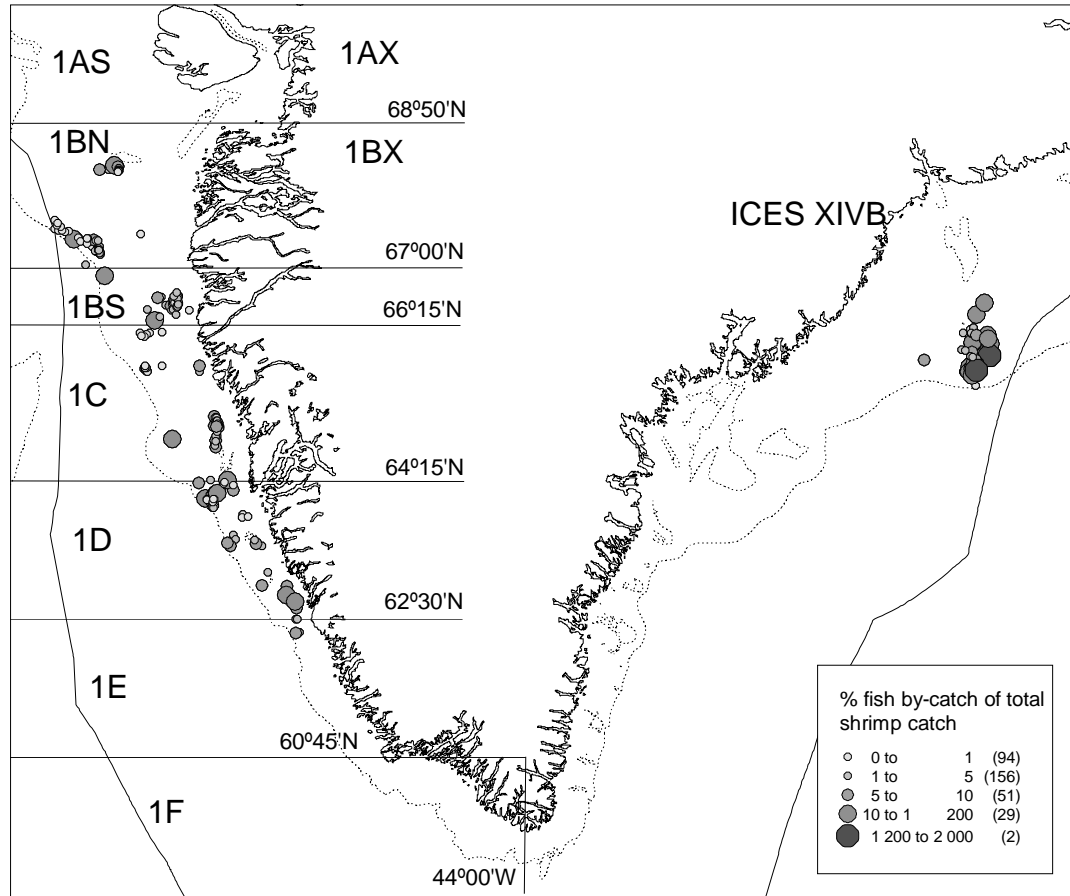


Figure 1. Distribution of hauls (n=332). Dots varies in size equal to the percentage fish by-catch of the total catch of shrimps. Dotted line: 500 m depth line, Solid line: The 200 nm EEZ line. The two hauls with very high percentages were due to few kilo's of shrimp caught in these hauls.

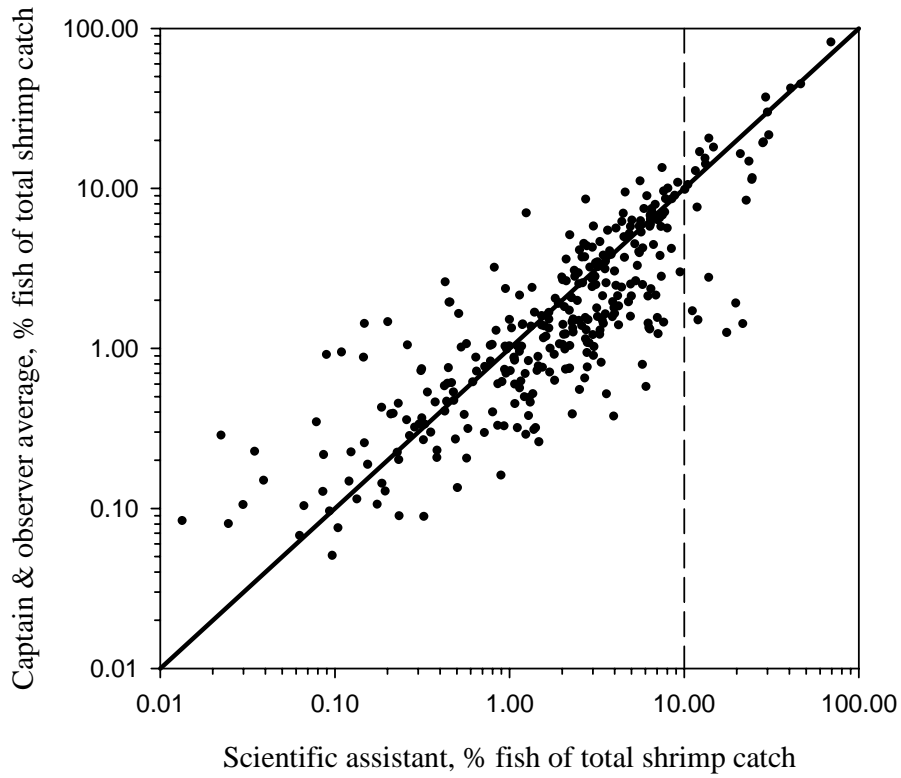


Figure 2. Percentage fish by-catch of total shrimp catch found by scientific assistant plotted against an average of the same percentage estimated by captain and GFLK observer. Dotted line: 10 % of total shrimp catch. If by-catch rates are above 10 % fishing ground should be changed by at least 5 nautical miles. Solid line: 1:1 accordance between logbook value and scientific assistant. Note the logarithmic scale.

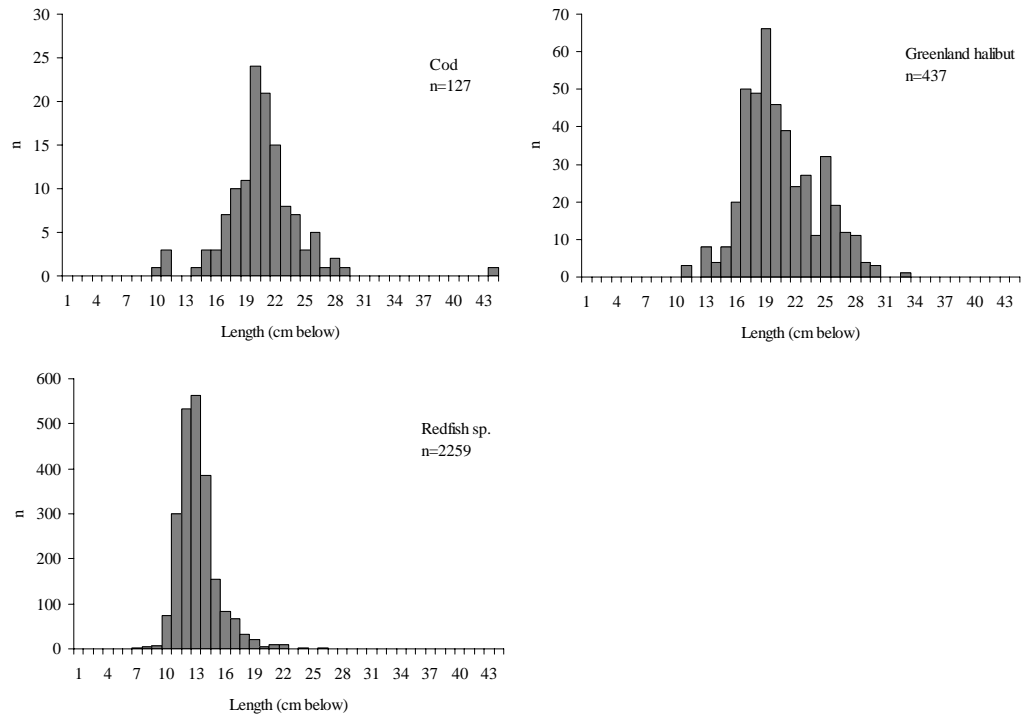


Figure 3.  
Length distributions of Cod (n=127), Greenland halibut (n=437) and redfish (*Sebastes* sp.) (n=2259) from ICES XIVb (trip 1,2 and 7). Note different scale on y-axis.

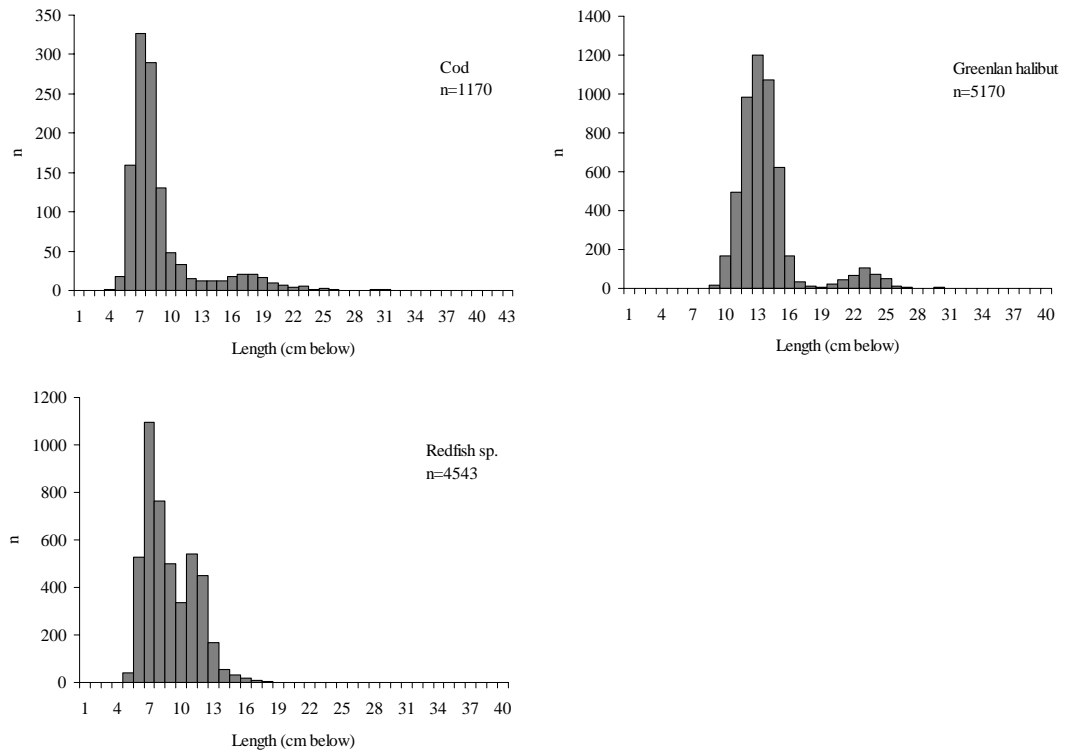


Figure 4.  
 Length distributions of Cod (n=127), Greenland halibut (n=437) and redfish (*Sebastes* sp.) (n=2259) from NAFO Div. 1B, 1C and 1D (trip 8, 9, 10, 11 and 12) all in spring 2007. Note different scale on y-axis.