REPORT MA 11-14

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Species composition and length frequency of bycatch from exploratory longlines surveys targeting Greenland halibut in East Greenland

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Title	Species composition and length frequency of bycatch from exploratory longlines surveys targeting Greenland halibut in East Greenland
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Report no.	MA 11-14
Pages	30
Project no.	54591
Project title	**Blåkveite ved Grønland; utbredelse, biologi og seleksjon/ bidødelighet i trål**
Source of funding	Norwegian Research Council.
Reference	1706909, Nina Hedlund.
ISSN	0804-54380
Distribution	Open
Keywords	Bycatch; East Greenland; Elasmobranch; Greenland halibut; longline; teleost
Approved by	Director Roar Tobro
Approved date	09.11.2011

Abstract
Bycatch is a major problem in fisheries management as can lead to a high mortality of wide array of organisms. There is little documentation of the bycatch from the Greenland halibut (*Reinhardtius hippoglossoides*) fishery in East Greenland. This study involved the analysis of the catch composition of exploratory longline surveys targeting Greenland halibut in East Greenland in order to assess the species composition, catch rates and length composition which are likely to be caught in the commercial fishery in this area. A total of 40 species were identified to species level. The numbers of non-targeted fish caught per Greenland halibut on the continental slope were 35, 7 and 6 for depth bands of 400-799, 800-1199 and 1200-1600 m respectively, defining the Greenland halibut longline fishery as a fishery with elevated bycatch levels. The composition of the bycatch varied with depth but primarily consisted of *Macrourus berglax*, *Centroscyllium fabricii* and *Antimora rostrata* with *M. Berglax* making up approximately 80 % of the bycatch at depths between 800 and 1199 m.

PREFACE

This study was funded by the Norwegian Research Council projects 113157, 170690, 122930, 133313, 170650, the Greenlandic Government as well as Møreforsking Marine Dept. The authors would like to thank the scientific staff at Møreforsking and Greenland Institute of Natural Resources, and not the least the owners and crew of the Norwegian longliners M/S Skarheim, M/S Loran, and M/S Fjellmøy.

Ålesund 09.11.2011

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SUMMARY

Bycatch is a major problem in fisheries management as can lead to a high mortality of wide array of organisms. There is little documentation of the bycatch from the Greenland halibut (*Reinhardtius hippoglossoides*) fishery in East Greenland. This study involved the analysis of the catch composition of exploratory longline surveys targeting Greenland halibut in East Greenland in order to assess the species composition, catch rates and length composition which are likely to be caught in the commercial fishery in this area. A total of 40 species were identified to species level. The numbers of non-targeted fish caught per Greenland halibut on the continental slope were 35, 7 and 6 for depth bands of 400-799, 800-1199 and 1200-1600 m respectively, defining the Greenland halibut longline fishery as a fishery with elevated bycatch levels. The composition of the bycatch varied with depth but primarily consisted of *Macrourus berglax*, *Centroscyllium fabricii* and *Antimora rostrata* with *M. Berglax* making up approximately 80 % of the bycatch at depths between 800 and 1199 m.

This study shows that the longline fishery for Greenland halibut has elevated levels of bycatch, however data on discard levels are currently lacking. Many of the species which were caught are slow growing, with low fecundity and their populations are likely to be sensitive to the effects of fishing mortality. Also any discarded fish are very unlikely to survive. There is a clear need for increased knowledge on the species caught in this fishery to provide understanding on the effects this fishing mortality will have on the population.

1 INTRODUCTION

Bycatch is regarded as a major problem in the world fisheries and can encompass a huge array of organisms including marine mammals, sea birds, turtles, invertebrates and even juveniles of the target species. It also encompasses a huge number of fish species, which may or may not have any commercial value. For a variety of economic or regulatory reasons, the bycatch may be thrown back to sea, often dead or dying. These discarded fish represent both an economic and ecological waste and sometimes the number of discarded species can be much greater than the number of species retained. A preliminary investigation into the deepwater French trawl fishery off the west coast of the British Isles showed that only 8 of 52 species caught were retained (Allain *et al.*, 2003). Bycatch was originally defined as the incidental capture of species towards which there is no directed effort (Saila, 1983). However, factors such as shifts in market preferences or catch levels can result in species which were originally designated as bycatch becoming the targeted species. In order to give a clearer definition, Davies *et al.* (2009) suggested that bycatch should be regarded as "catch that is either unused or unmanaged".

Greenland halibut (*Reinhardtius hippoglossoides*) is a deepwater flatfish found throughout the North-Atlantic and is divided into several management units. The West-Nordic management unit encompasses Greenland halibut in the waters around East Greenland, Iceland and the Faroe Islands and is the target of a major international fishery. The fishery is carried out on the edge of the continental shelf of Greenland, Iceland and the Faroe Islands between 500 and 1500 m (ICES, 2009a). Greenland halibut display the typical characteristics of deep-water fish i.e. long-lived, slow growth and low fecundity (Albert *et al.*, 2009, Gundersen *et al.*, 1999, 2000, 2001, 2009, Kennedy *et al.*, 2009). It is thus likely that many of the species caught together with Greenland halibut will have similar characteristics. Species with these characteristics are considered to be particularly vulnerable to fishing pressure due to their long generation times (Clarke *et al.*, 2003). Knowledge on many deep water species is lacking in respect to biological processes such as growth, maturation, feeding and fecundity in comparison to exploited fish species inhabiting shelf areas (Large *et al.*, 2003). This makes it extremely difficult to assess the impact of fishing pressure on these populations.

There are currently no reports pertaining to the bycatch in the Greenland halibut fishery in East Greenland. Durán *et al.* (1997) reported bycatch levels for the Spanish Greenland halibut trawl fishery in NAFO fishing area 3LMNO. The most commonly caught species were roughhead grenadier (*Macrourus berglax*), roundnose grenadier (*Coryphaenoides rupestris*), skate (*Raja species*), American plaice (*Hippoglossoides platessoides*), redfish (*Sebastes species*), witch flounder (*Glyptocephalus cynoglossus*) and blue antimora (*Antimora rostrata*). The catch of each species was affected by month, year, area and boat size. The proportion of these species which were discarded and retained varied between species and also between large and small vessels. However, discarded deep-water species are very unlikely to survive due to the large changes in pressure between the sea bottom and surface. A comparison of longline and trawl catches in a deep water fishery in the Rockall trough has shown that the catch composition of the longlines is dominated by elasmobranchs, whereas the trawl catches are dominated by teleosts. Longlines were also found to catch fewer small teleosts in comparison to trawls (Connolly & Kelly, 1996, Clarke *et al.*, 2005).

In order to fill gaps in the knowledge in the variety, catch levels and length composition of the species likely to be caught when targeting Greenland halibut using longlines in East Greenland, catch data taken from several exploratory longline surveys carried out in East Greenland were examined. These were carried out using commercial longline vessels and were carried out in a manner similar of how the vessel would operate during commercial fishing targeting Greenland halibut.

2 MATERIAL AND METHODS

The data for this study is taken from four exploratory longline surveys targeting Greenland halibut, which took place in East Greenland between 1994 and 2000 using commercial fishing vessels and fishing gear commonly used for the commercial fishing of Greenland halibut. The fishing performance in East Greenland water is affected by rough bottom and strong currents and longlines were set along the continental slope to avoid gear loss. Each setting usually consisted of two magazines which had between 1300 and 2600 hooks. In a commercial fishery, fishing is often conducted using about 4000 hooks. The hooks used were Mustad EZ 12/0 with either mackerel or squid bait.

The areas of the surveys are shown in Fig. 2.1 and cover areas on the continental slope, continental shelf and in several of the Fjords in East Greenland. The Skarheim 1994 survey was carried out in the Fjords and inshore area around 65˚N. The Skarheim 1996 survey was carried out in three areas 60, 62 and 63˚N. The areas at 63˚N covered only offshore areas whereas the areas at 60 and 62˚N covered both fjord and offshore areas. All other surveys were carried out in offshore areas. Details of the surveys are summarised in Table 2.1.

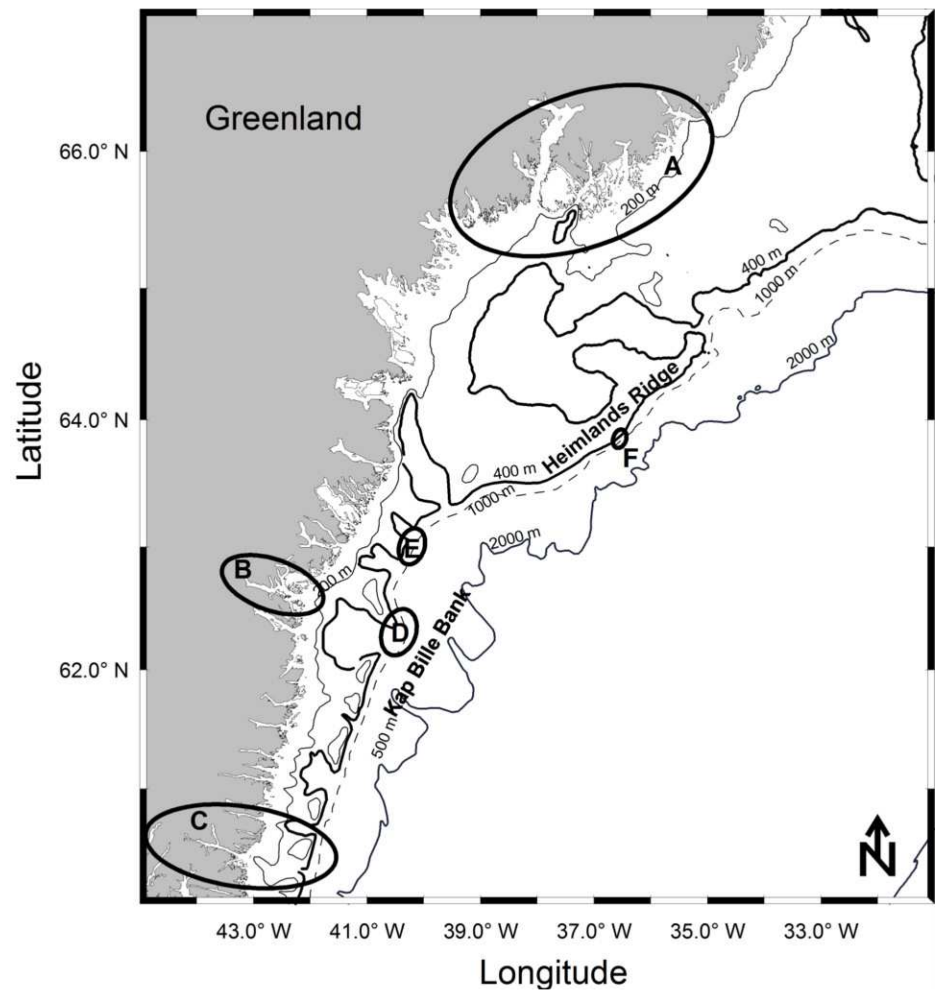

Figure 2.1. Areas surveyed in East Greenland during the 1994 (A), 1996 (B-E), 1997 (D) and 2000 (D and F) longline surveys. 200, 400, 1000 and 2000 m depth contours are shown. 400 m Depth contour shows approximate border between continental shelf and continental slope.

During the sampling, each fish was identified to species level and total length was measured, except for roughhead grenadier where pre-anal fin length was measured. The majority of rays caught were sexed. The catch per unit effort (CPUE) for each species at each station was defined as the number caught per 1000 hooks. Bycatch was considered to be any fish which was caught, except for Greenland halibut which was the target species. The catch of Greenland halibut from these surveys is described in Gundersen *et al.* (In prep). Stations were split into 2 areas, continental shelf and continental slope, which were divided into 4 depth bands; which were labelled as depth band 1, 2, 3 and 4 for stations between 0-399, 400-799, 800-1199 and 1200-1600 m respectively. Continental shelf areas only had stations in depth bands 1-3 and continental slope only had stations in depth bands 2-4.

Table 2.1. Details of the survey in East Greenland showing the year, vessel name, dates of the survey, the number of stations (St.), depth range of the stations, thickness of the fishing line (L) and distance between hooks (D).

Year	Vessel	Dates	St.	Depth	L(mm)	D(m)
1994	M/S ”Skarheim”	3 Aug-20 Aug	62	56-900	7	1.4
1996	M/S ”Skarheim”	25 Jul-12 Aug	49	176-1518	9	1.4
1997	M/S ”Loran”	19 Jul–27 Jul	17	1157-1486	11	1.3
2000	M/S ”Fjellmøy”	20 Aug-30 Aug	28	380-1423	9	1.4

3 RESULTS

A total of 40 species were identified to species level (Tab. 3.1). A large number of unidentified fish of the *Lycodes* genus, skates (Rajidae family) and 2 unidentified sharks were also caught but not identified to species level. In terms of numbers, bycatch made up between 9 and 100 % of the catch, however this dependent on area and depth (Fig. 3.1). The number of species caught at each station varied between 1 and 15 and with an average of 6, 6 and 9 species at depth bands 1, 2 and 3 respectively on the continental shelf and 11, 5 and 6 species at depth bands 2, 3 and 4 on the continental slope area respectively (Fig. 3.2). The higher percentage of bycatch at depths less than 1000 m was due to lower catches of Greenland halibut. The average ratio of the number of individual fish caught as bycatch to the number of Greenland halibut caught was 12, 10 and 8 for depth bands 1, 2 and 3 respectively on the continental shelf and 35, 7 and 6 for depth bands 2, 3 and 4 on the continental slope. The CPUE of bycatch (excluding the three most common species; *Macrourus berglax*, *Centroscyllium fabricii* and *Antimora rostrata*) varied with depth but was generally higher in depths shallower than 1000 m (Fig. 3.2).

From all stations combined, the bycatch was dominated by three species; *M. berglax, C. fabricii* and *A. rostrata* however, this was affected by depth and area (Tab. 3.2). *M. berglax* was mainly caught at depths of 600 m and deeper (Fig. 3.3) and made up the greatest percentage of the bycatch, accounting for up to 80 %. This species was mainly caught on the continental slope with a peak in CPUE around 1400 m. *M. berglax* had a pre-anal fin length of between 10 and 46 cm with average of 21 cm. The size distribution in accordance with area and depth for this species from the described surveys are documented in detail in Fossen *et al.* (2003). *C. fabricii* was caught throughout the depth range of the surveys with catch rates reaching as high as 240 per 1000 hooks, but this species was only caught at 61 of 160 stations (Fig. 3.4). The size distribution showed a unimodal distribution with a peak at 55-59 cm (Fig. 3.4). *A. rostrata* was only caught at depths greater than 990 m (Fig. 3.4) with a CPUE of up to 124 individuals per 1000 hooks. The size distribution was skewed towards smaller sizes with a peak in sizes between 55 and 59 cm (Fig. 3.4).

A total of 53 Greenland sharks (*Somniosus microcephalus*) were caught during the surveys, these ranged in length from 56 to 380 cm. The majority of these were caught within the fjords and inshore area during the 1994 and 1996 survey at depths between 56 and 850 m. Two were also caught at 1329 m in the offshore area during the 1996 survey. Many species of skates were caught but most were caught infrequently and in low numbers; the three most commonly caught were *Amblyraja radiata*, *Amblyraja hyperborea* and *Bathyraja spinicauda*, *A. radiata* was primarily caught at depths shallower than 1000 m whereas *A. hyperborean* and *B. spinicauda* were caught throughout the depth range of the study but with the majority of the catches being on the continental shelf area (Fig. 3.5). At depths deeper than 1000 m skates made up between 0 and 6 % of the total bycatch; at depths shallower than 1000 m skates made up to 100 % of the bycatch with an average of 23 %. The size distribution differed for the three most commonly caught species of skate with *A. hyperborea* and *A. radiata* both showing a unimodal distribution with a peak of distribution at 55-59 and 50-54 respectively (Fig. 3.5). *B. spinicauda* showed a wider length distribution, varying in size between 41 and 162 cm (Fig. 3.5). The average length differed between males and females for *A. hyperborea* (ANOVA: $p=0.005$) with a peak in distribution at 50-54 and 55-59 for males and females respectively.

The ratio of males to females for *A. hyperborea* differed significantly from 1:1 with a ratio of 0.7:1 (Chi-square test; X2=10.4).

The three *Anarhichas* species showed differing depth distributions (Fig. 3.6). *Anarhichas minor* had the highest CPUE of the three species with a twos peaks in distribution around 200 m and 700m but was only caught at one station deeper than 900m. This species had a unimodal length distribution with a peak in distribution at 55-59 cm (Fig. 3.6). The *Anarhichas denticulatus* had a lower CPUE but was caught at a much greater depth range, being caught as deep as 1518 m (Fig. 3.6). *A. denticulatus* showed a wider length distribution than A. minor with three peaks in the distribution, at 40-44, 65-75 and 105-109 cm (Fig. 3.6). *A. lupus* was rarely caught, being only caught at 7 stations between 81 and 710 m (Fig. 3.6), these varied in length between 26 and 105 cm.

The two *Sebastes* species had a similar depth distribution but differed in CPUE with catches of *S. marinus* being generally higher (Fig 3.7). *S. mentella* had a unimodal length distribution with a peak at 30-34 cm (Fig. 3.7); *S. marinus* had a much wider length distribution with a peak at 45-49 cm Fig. 3.7). *Brosme brosme* and *Gadus morhua* were only caught at depths shallower than 1000 m with catches of *B Brosme* being higher than that of *G. morhua* (Fig. 3.8). G. morhua had a unimodal length distribution with a peak at 50-54 cm. *B. Brosme* had a bimodal length distribution with peaks at 50-54 and 70-74 cm.

Table 3.1. List of the species caught during Longline surveys in East Greenland with the total number caught, and the shallowest (D1) and deepest depth (D2) in which they were caught.

Species	N	D1	D2
Reinhardtius hippoglossoides	18531		
Macrourus berglax	12606	81	1518
Centroscyllium fabricii	2874	81	1516
Antimora rostrata	2296	993	1518
Amblyraja radiata	1026	77	1347
Anarhichas minor	651	81	1388
Lycodes sp.	605	56	869
Sebastes marinus	491	83	993
Amblyraja hyperborea	365	81	1468
Brosme brosme	312	83	1025
Gaidropsarus argentatus	231	81	1400
Sebastes mentella	178	83	1404
Anarhichas denticulatus	147	83	1518
Synaphobranchus kaupii	121	993	1518
Molva dypterygia	98	122	1025
Bathyraja spinicauda	78	83	1518
Hippoglossoides platessoides	73	76	862
Hydrolagus affinis	65	980	1518
Somniosus microcephalus	53	56	1329
Gadus morhua	51	81	829
Trachyrincus murrayi	30	993	1516
Dipturus linteus	29	85	1486
Hippoglossus hippoglossus	27	281	1424
Gaidropsarus ensis	25	85	1400
Histiobranchus bathybius	22	1191	1358
Amblyraja jenseni	21	81	1516
Anarhichas lupus	12	81	710
Raja montagui	9	500	710
Myoxocephalus scorpius	7	83	544
Cottunculus microps	5	710	1325
Rajella fyllae	4	380	750
Chimaera monstrosa	5	1186	1370
Lepidion eques	3	1025	1025
Leptoclinus maculatus	3	1400	1400
Gadus ogac	2	262	710
Squalus acanthias	2	697	750
Centroscymnus coelolepis	2	1370	1370
Centrophorus squamosus	2	1217	1316
Dipturus batis	1	1516	1516
Hydrolagus pallidus	1	1217	1217
Coryphaenoides carapinus	1	1325	1325
Raniceps raninus	1	1233	1233
Unidentified shark	2	1217	1423
Unidentified skate	34	1190	1518

Table 3.2. The percentage of the bycatch made up by the three most commonly caught species and of other species at the different depth bands. (1=0-399, 2=400-799, 3=800-199 and 4= 1200-1600 m).

	Shelf			Slope		
	1	2	3	2	3	4
Macrourus berglax	3	6	20	67	80	74
Antimora rostrata	0	0	0	0	2	15
Centroscyllium fabricii	8	19	46	0	10	5
Other species	89	75	34	33	8	6

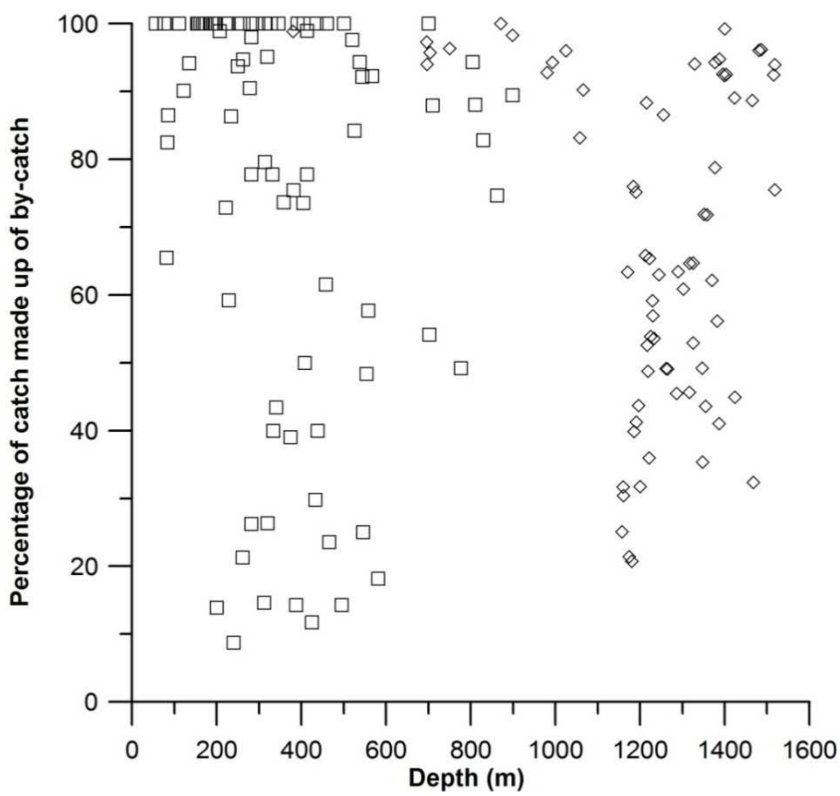

Figure 3.1. Percentage of the catch which was considered bycatch on the continental shelf (□) and continental slope (◊) versus depth in East Greenland.

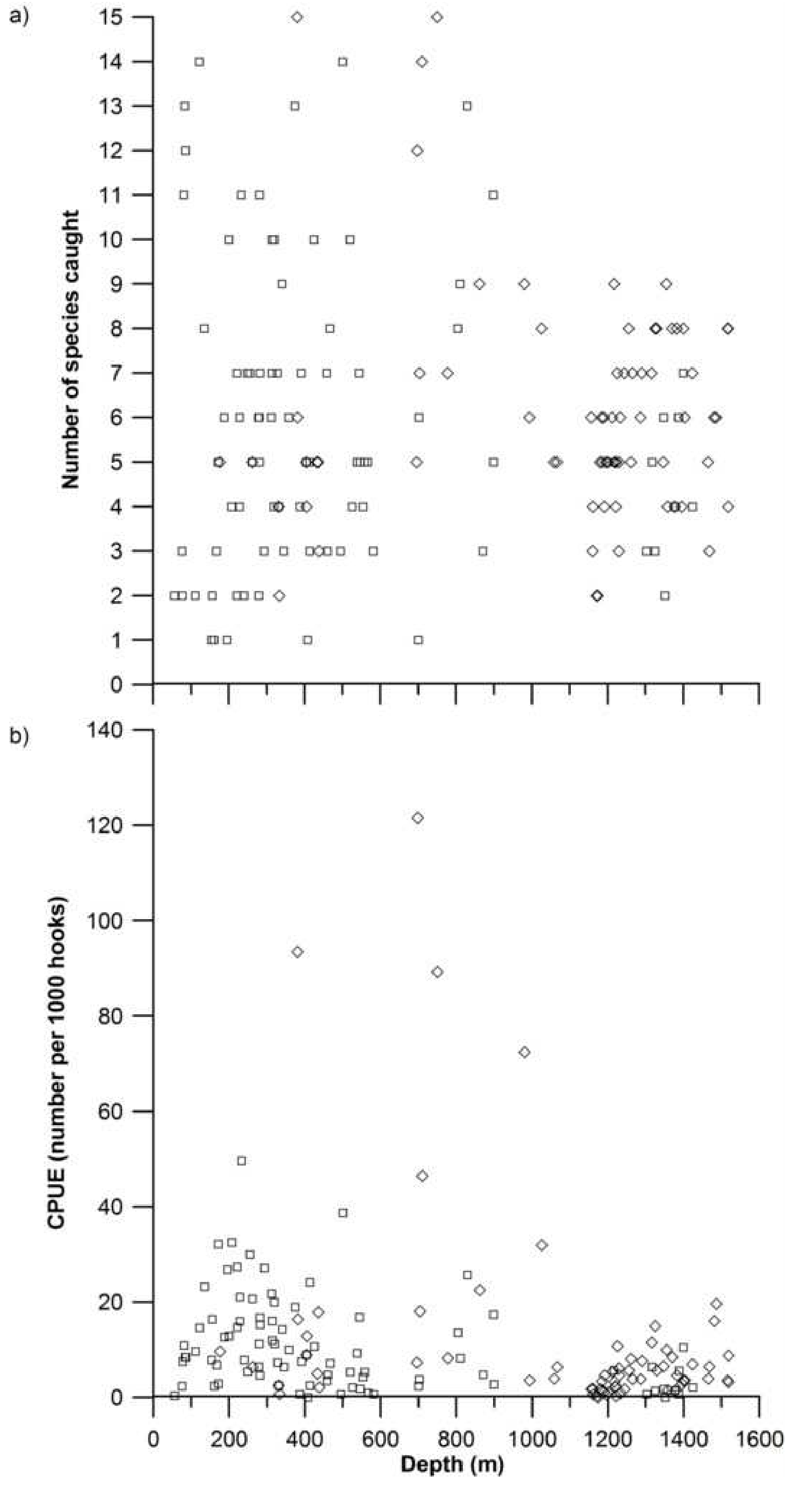

Figure 3.2. The number of species caught at each station (a) and the CPUE (catch per unit effort) for bycatch excluding catches of *Macrourus berglax*, *Centroscyllium fabricii* and *Antimora rostrata* (b) versus depth on the continental shelf and continental slope in East Greenland.

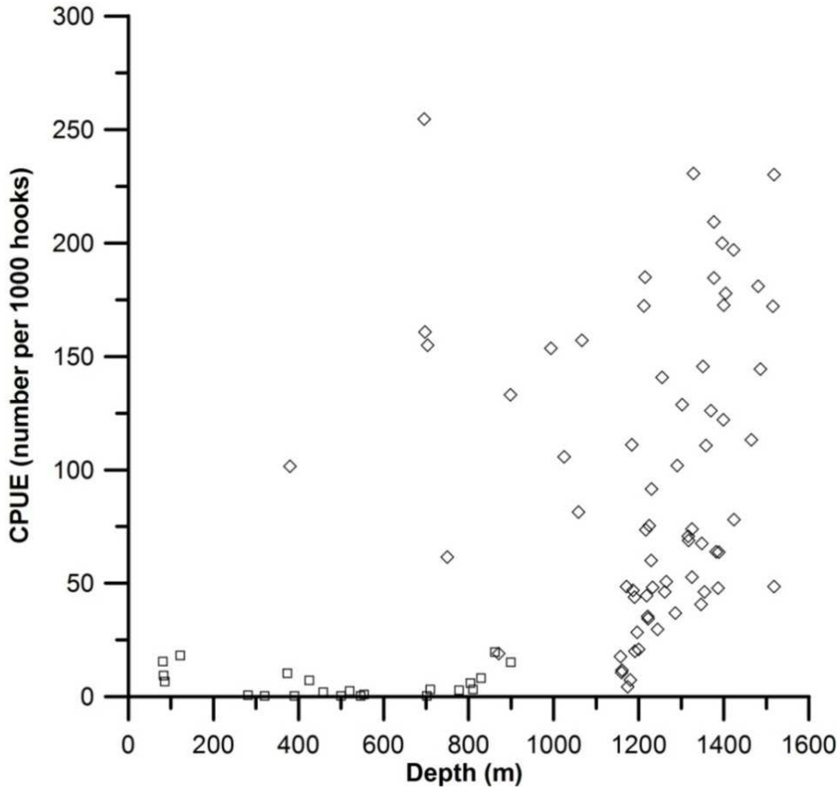

Fig. 3.3. Catch per unit effort (CPUE) versus depth for *Macrourus berglax* on the continental shelf (□) and continental (◊) slope in East Greenland.

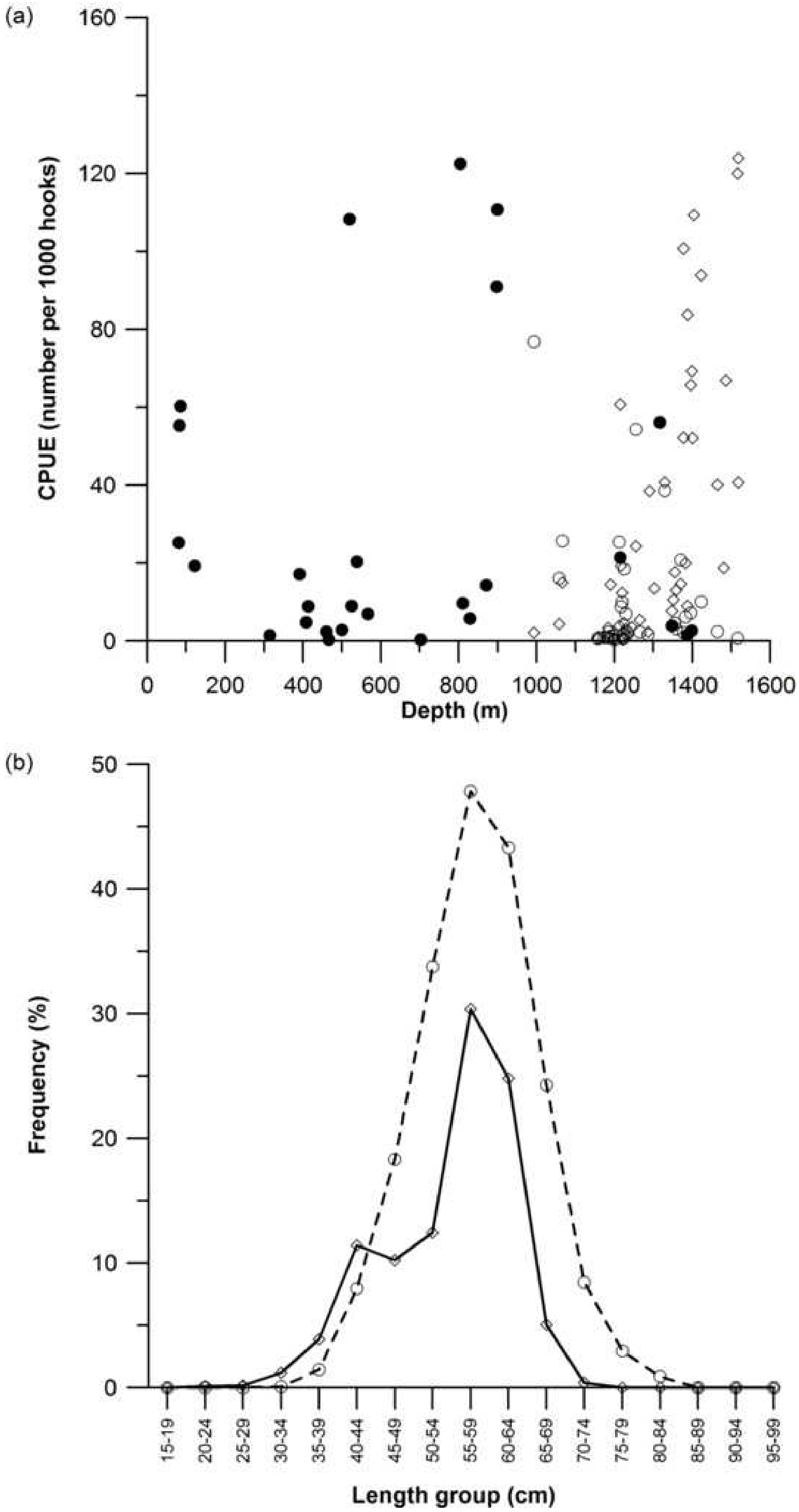

Figure 3.4. Catch per unit effort (CPUE) versus depth for *Centroscyllium fabricii*, on the continental shelf (?) and continental slope (?), and *Antimora rostrata* (◊) (a) and size distribution of *Centroscyllium fabricii* (?) (from slope and shelf combined) and *Antimora rostrata* (◊) (b) caught by longline in East Greenland.

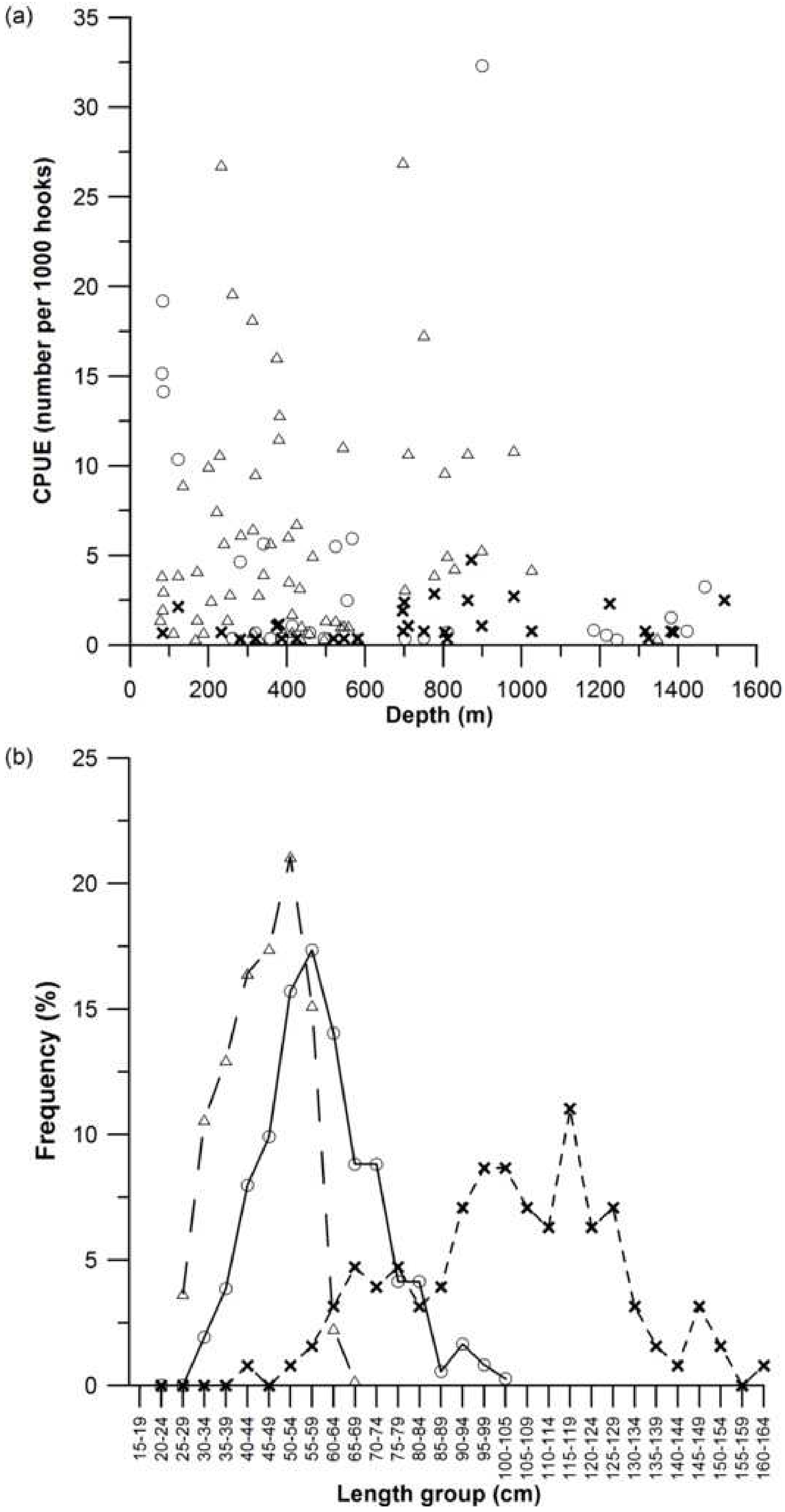

Figure 3.5. CPUE (catch per unit effort) versus depth (a) and size distribution (b) for *Amblyraja radiata* (△), *Amblyraja hyperborea* (○) and *Bathyraja spinicauda* (X) in East Greenland.

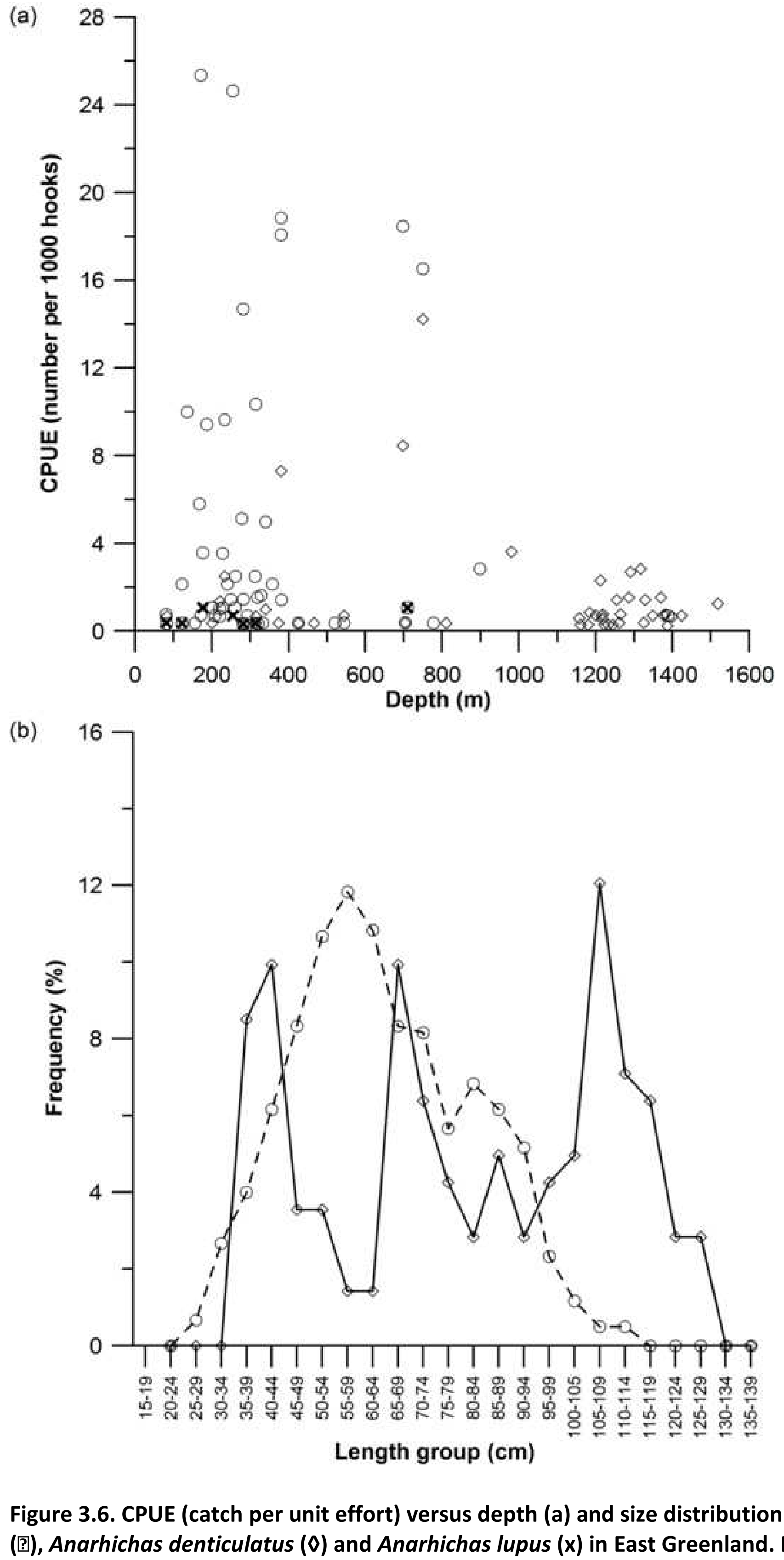

Figure 3.6. CPUE (catch per unit effort) versus depth (a) and size distribution (b) for *Anarhichas minor* (○), *Anarhichas denticulatus* (◊) and *Anarhichas lupus* (x) in East Greenland. No size distribution is shown for *Anarhichas lupus* due to low number of samples.

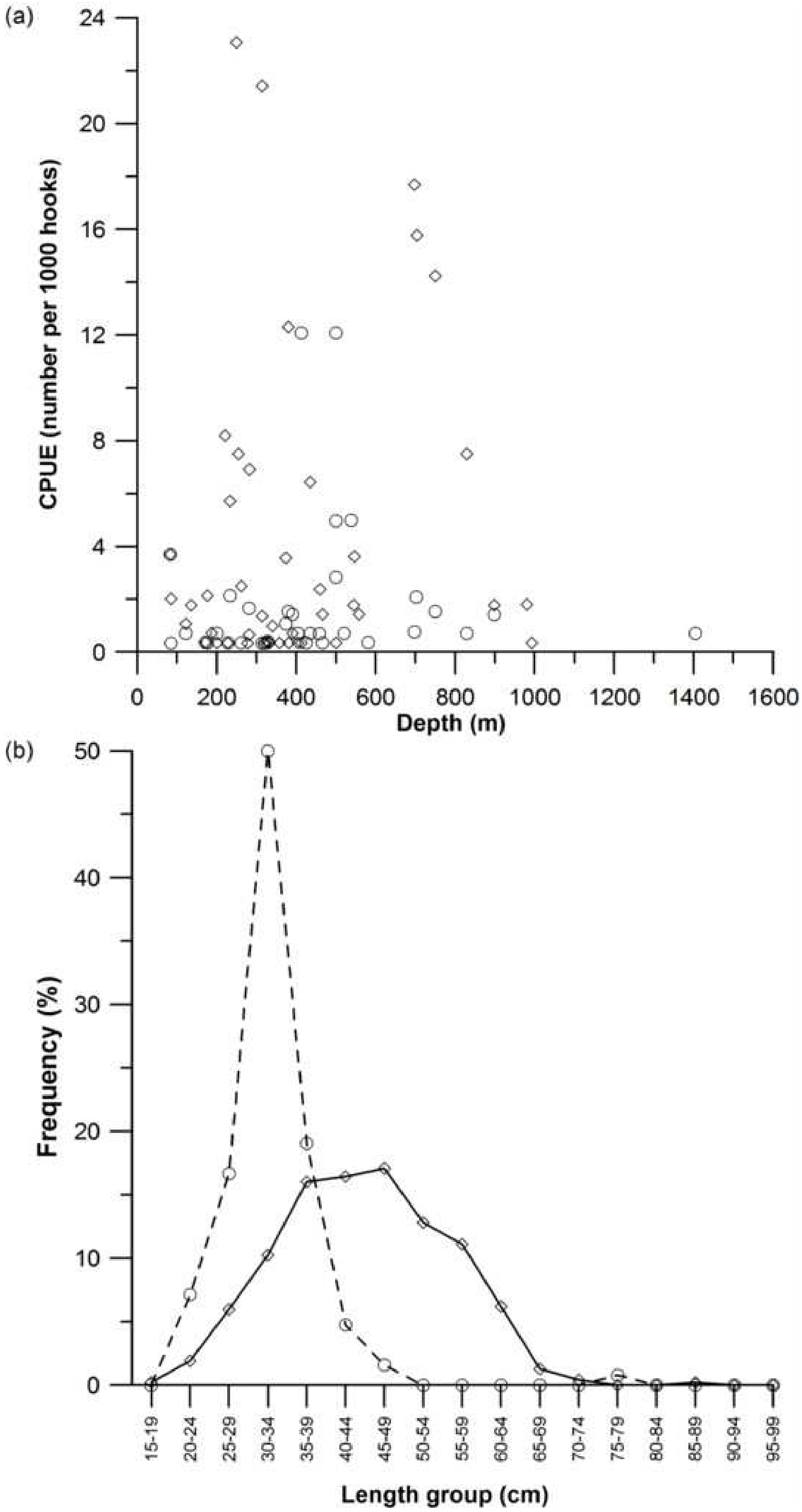

Figure 3.7. CPUE (catch per unit effort) versus depth (a) and size distribution (b) for *Sebastes marinus* (◊) and *Sebastes mentella* (?) in East Greenland.

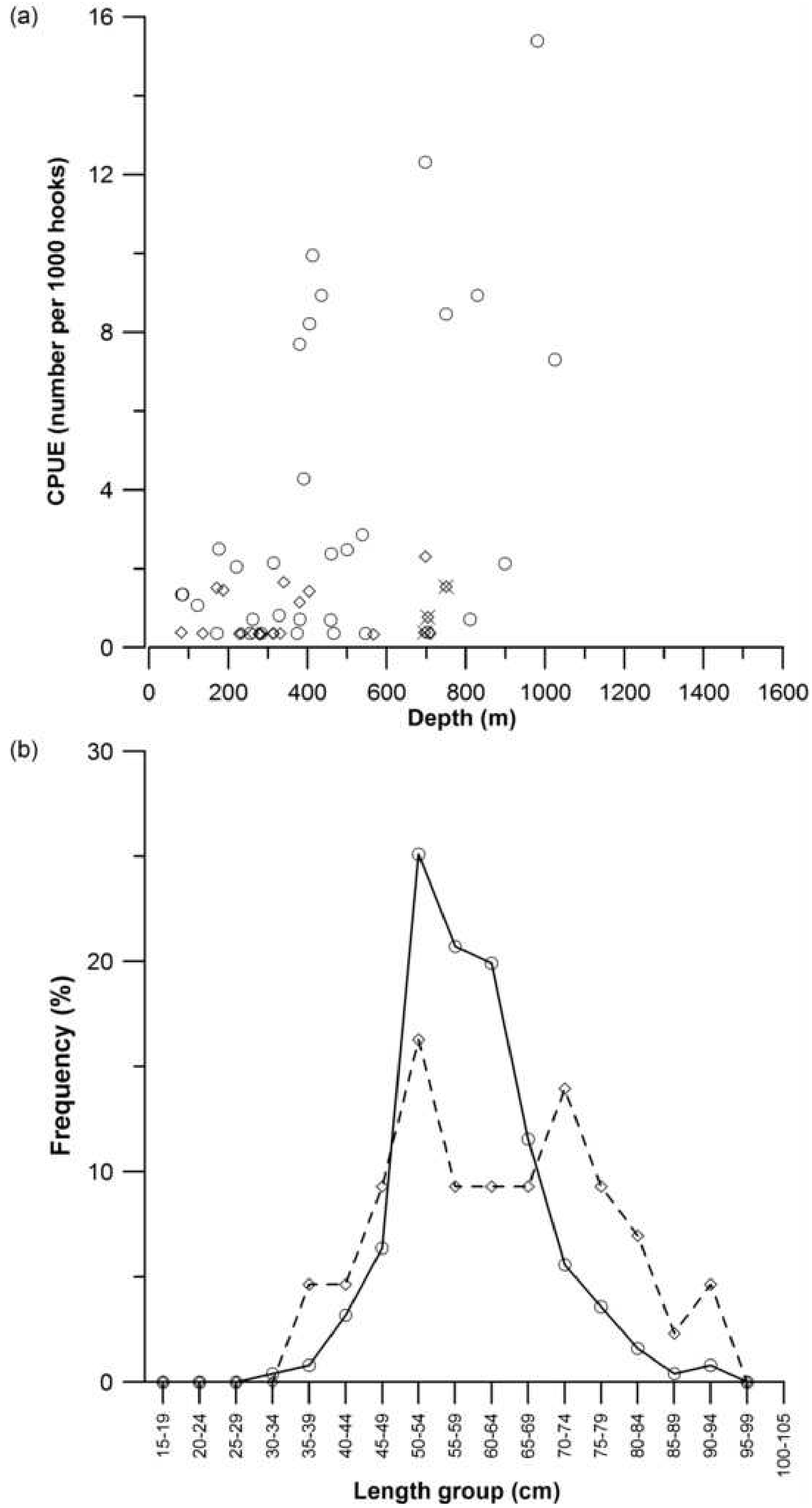

Figure 3.8. Catch per unit effort (CPUE) versus depth (a) and size distribution (b) for *Brosme brosme* (◯) and *Gadus morhua* (◊) in East Greenland.

4 DISCUSSION

It must be noted that the results of the bycatch within this study do not necessarily reflect the rates of bycatch within the fishery. The data from which these surveys were taken were primarily exploratory surveys with the target species being Greenland halibut. Some of these surveys were carried out over a wider area and also a greater range of depths than would normally be covered by the commercial fishery. The data presented is thus regarded as a rough guide to the species caught by the commercial fishery and their catch rates in relation to depth.

There are very few reports of the bycatch in the Greenland halibut fishery. A report for the Spanish trawler fishery in NAFO division 3LMNO documented fewer species in the bycatch; 17 compared to 40 in the present study. The Spanish trawl fishery takes place mainly at depths between 800 and 1500 m (Durán *et al.*, 1997), a depth range which is less than in the present study. At this depth range, the present study registered a total of 32 species. However, comparison of the number of species between the two studies is difficult as Durán *et al.*, (1997) did not separate the *Anarhichas, Chimera, Sebastes*, or *Raja* genus by species so they are likely to have underestimated the number of species. There are many NAFO reports (available at http://www.nafo.int) which document the species caught during trawl surveys targeting Greenland halibut. The numbers of species caught during these surveys are much greater than caught during the longline surveys and there are several species where catches in terms of numbers make up a substantial part of the catch, however these are generally smaller species and make up only a small percentage of the weight of the catch.

The longline fishery in East Greenland for Greenland halibut takes place mostly at depths greater than 1000 m due to the higher catches and larger fish; the CPUE of Greenland halibut in the surveys from this study peaked between 1200 and 1400 m (Gundersen *et al.*, 1997). The average ratio of bycatch to Greenland halibut at depths greater than 1200 m, in terms of the number of individuals was 6:1. Assuming all bycatch is discarded, then this ratio places the fishery for Greenland halibut among ones with elevated discard ratios (ratios ranging from 12.3 to 0.39) (Alverson *et al.*, 1994). However, it is doubtful that all of the bycatch is discarded. There is very little data available for discard rates in the Greenland halibut fishery in East Greenland, however in the Spanish Greenland halibut trawl fishery the discard rate for M. berglax in NAFO divisions was about 50 % of the numbers caught (Durán *et al.*, 1997).

It can be seen that the composition of the catch was affected by fishing depth. The fishery for Greenland halibut occurs mostly at depths greater than 1000m this means that the main bycatch of this fishery will consist of mostly of M. berglax, A. rostrata and *C. fabricii*. *M. berglax* are characterised by having late maturity, low fecundity and slow growth (Murua & Motos, 2000). *C. fabricii* also have a low fecundity (Yano, 1995) and presumably have slow growth. *A. rostrata* has been described as having slow (Magnússon, 2001) and intermediate growth (Fossen and Bergstad, 2006) and has been aged up to 25 years. Due to the mentioned aspects of the biology of these three species, their populations are likely to be only able to sustain a limited fishing mortality. However, the fishing mortality on *M. berglax* is likely to be high due to its high CPUE at depths where the CPUE of Greenland halibut is highest. Knowledge on these three species is extremely limited so the effects on the population or how a decrease in the population level can affect the ecosystem are unknown.

Differences in the catch rate of *M. Berglax* by area have been documented by Fossen *et al.* (2003). Catch rates were higher in area C compared to area D (Fig. 1), this is the opposite to that found for the catch rates of Greenland halibut (data not shown). The commercial fishery is much more intensive in area D than area C, however, the significance of this is not clear as there are many unconsidered factors including habitat type, food availability etc. which may also play a part in the observed distribution pattern of the two species.

The results for this study aises important considerations for the cod (*Gadus morhua*) fishery in East Greenland. With a rise in the cod population in East Greenland there has been a resumption of the cod fishery (ICES, 2009a). This fishery takes place down to 700-800 m. At this depth the species diversity of the bycatch was higher than in deeper water, there was also a peak in the CPUE of several of the bycatch species at this depth. There also some high catches of *M. berglax* and *C. fabricii* around 700 m. There is a possibility that these catches are due to area rather than depth as most of the stations at this depth were at Heimland ridge, there were only 3 stations at a similar depth in a different area. Further work is thus needed to examine the bycatch at this depth in other areas around East Greenland.

The bycatch of skates in the longline fishery for Greenland halibut and redfish in the Barents Sea has been documented by Dolgove *et al.* (2005). In comparison with the results from the present study the length distribution of the A. radiata was wider in East Greenland than in the Barents Sea with both larger and smaller individuals being caught in East Greenland. The peak in distribution was also slightly different with a peak at 46-50 and 50-54 cm in the Barents Sea and East Greenland respectively. In the Barents Sea A. radiata was common down to about 600 m, and rarely caught deeper than 700m, whereas in East Greenland it was commonly caught down to about 1000 m. The catches of *A. hyperborea* was much lower in East Greenland in comparison to the Barents Sea with the CPUE rarely exceeding 6 individuals per 1000 hooks whereas in the Barents sea it average around 10-25 fish per 1000 hooks. The *A. hyperborea* caught in East Greenland were generally smaller than those caught in the Barents Sea with males and females being about 15 and 20 cm smaller respectively. The size difference between the males and females seen in the Barents Sea was also seen in those caught in East Greenland. The *R. fyllae* and *D. linteus* were also caught in the Barents Sea in low numbers; the occurrence of these was also low in East Greenland. A significant number of *B. spinicauda* were caught in East Greenland, these are however, not mentioned in Dolgov *et al.* (2005) which suggests they are not available to the fishery due their distribution or they are not present in the Barents Sea.

The catch of elasmobranches in East Greenland differed greatly to that of the caught in the Rockall trough and Porcupine bank. The catches in these areas were dominated by sharks, particularly *Centroscymnus coelolepis*, *Centrophorus squamosus* and *Deania calceus* with very little catch of the *C. fabricii* (Clarke *et al.*, 2005). However, in East Greenland, the *C. fabricii* dominated the catch of elasmobranches' with only a low number of *C. coelolepis* and *C. squamosus* being caught and the *D. calceus* was completely absent from East Greenland. It is also noted that the catches skates were higher in East Greenland compared to the Rockall trough and Porcupine Bank, but it is not clear if this is a difference due fishing gear or a true area difference. Apart from *C. Fabricii*, the catch of Elasmobranches' in the main fishing depth for Greenland halibut was low, however little is known about the population dynamics of these species or how much mortality from fishing their populations can withstand.

Size at maturity is unknown for many of the species caught during the surveys or there are estimations for the population of the species in other areas so it is difficult to estimate the catch of non-mature versus mature fish. There are estimates of maturity for *M. Berglax* for East Greenland (Fossen *et al.*, 2003) which is 16 and 29.5 cm for males and females respectively. The modal peak of the length distribution caught in East Greenland by longlines for *M. Berglax* is around 20 cm suggesting the fishery will capture a large number of immature females. Yano *et al.* (1995) estimated the length at maturity for *C. Fabricii* in west Greenland to be about 55 and 65 cm for males and females respectively. Assuming this species in East Greenland matures at a similar size then the catch of *C. Fabricii* in East Greenland will consist mainly of immature individuals due to the modal peak in length of the catch being 55-59 cm. Magnússon (2001) estimated the L50 of A. Rostrata to be 45 and 42 cm for males and females respectively, thus the catch of this species will consist of mostly mature specimens.

The fishery for Greenland halibut is mainly a trawl fishery but a number of longliners also operate in the area (Gordon *et al.*, 2003). Information from bycatch studies in the Rockall trough showed that trawling led to a more teleost dominated catch with a greater diversity of species in comparison to longlining which leads to a more elasmobranch dominated catch (Clarke *et al.*, 2005). An important consideration is that trawling may also lead to higher un-accounted for mortality; the skin of deep sea fish is not coated with mucus thus a high proportion of fish entering trawls but escaping through the meshes probably die (Connolly & Kelly, 1996, Koslow *et al.*, 2000). The trawl fishery for Greenland halibut is described as a 'clean fishery' with very little bycatch (ICES, 2009a) however there are no published reports to back up this claim. With the large amount of bycatch caught when fishing with longlines and that documented in trawl surveys (www.nafo.int) and in the Spanish trawl fishery (Durán *et al.*, 1997) makes this claim unlikely to be true. There are currently no reports on bycatch from the commercial trawl fishery in East Greenland, thus it is difficult to discern any possible effects the fishery has on non-target fish populations in this area.

This study shows that the longline fishery for Greenland halibut has elevated levels of bycatch, however data on discard levels are currently lacking. Many of the species which were caught are slow growing, with low fecundity and their populations are likely to be sensitive to the effects of fishing mortality. Also any discarded fish are very unlikely to survive. There is a clear need for increased knowledge on the species caught in this fishery to provide understanding on the effects this fishing mortality will have on the population.

5 REFERENCES

Albert, O.T., Kvalsund, M., Vollen, T., Salberg, A-B. 2009. Towards accurate age determination of Greenland halibut. Journal of Northwest Atlantic Fishery Science, 40: 81-95.

Allain, V., Biseau, A., Kergoat, B. 2003. Preliminary estimates of French deepwater fishery discards in the Northeast Atlantic Ocean. Fisheries Research, 60(1): 185–192.

Alverson, D.L., Freeberg, M.H., Murawski, S.A., Pope, J.G. 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper, 339.

Clarke, M.W., Borges, L., Officer, R.A. 2005. Comparisons of trawl and longline catches of deepwater elasmobranchs west and north of Ireland. Journal of Northwest Atlantic Fishery Science, 37: 429-442.

Clarke, M.W., Kelly, C.J., Connolly, P.L., Molloy, J.P. 2003. A life history approach to the assessment and management of deepwater fisheries in the northeast Atlantic. Journal of Northwest Atlantic Fishery Science, 31: 401-411.

Connolly, P.L., Kelly, C.J. 1996. Catch and discards from experimental trawl and longline fishing in the deep water of the Rockall Trough. Journal of Fish Biology, 49(Supplement A): 132-144.

Davies, R.W.D., Cripps, S.J., Nickson, A., Porter, G. 2009. Defining and estimating global marine fisheries bycatch. Marine Policy, 33(4): 661-672.

Dolgov, A.V., Grekov, A.A., Shestopal, I.P., Sokolov, K.M. 2005. By-catch of skates in trawl and long-line fisheries in the Barents Sea. Journal of Northwest Atlantic Fishery Science, 35: 357–366.

Durán, P., Paz, J., Ramilo, L. 1997. By-catch in the Spanish Greenland halibut fishery (NAFO divisions 3LMNO): 1991-1994. NAFO Science Council Studies, 30: 1-20.

Fossen, I., Bergstad, O.A. 2006. Distribution and biology of blue hake, *Antimora rostrata* (Pisces: Moridae), along the mid-Atlantic Ridge and off Greenland. Fisheries Research, 82: 19-29.

Fossen, I., Jørgensen, O.A., Gundersen, A.C. 2003. Roughhead grenadier (*Macrourus berglax*) in the waters off East Greenland: distribution and biology. Journal of Northwest Atlantic Fishery Science, 31: 285-298.

Gordon, J.D.M., Bergstad, O.A., Figueiredo, I., Menezes, G. 2003. Deep-water fisheries of the Northeast Atlantic: I. Description and current trends. Journal of Northwest Atlantic Fishery Science, 31: 137-150.

Gundersen, A. C., E. Hjørleifsson, and J. Kennedy. 2009. Fecundity of Greenland Halibut (*Reinhardtius hippoglossoides* W.) in the Waters of Iceland. J. Northw. Atl. Fish. Sci., 40: 75-80. doi:10.2960/J.v39.m656

Gundersen, A.C., J.E. Rønneberg & J. Boje. 2001. Fecundity of Greenland halibut (*Reinhardtius hippoglossoides*) in East Greenland waters. Fisheries Research. 51: 229-236.

Gundersen, A.C., K.H. Nedreaas, O.S. Kjesbu and O.T. Albert. 2000. Fecundity and recruitment variability of Northeast Arctic Greenland halibut during 1980-1998, with emphasis on 1996-1998. Journal of Sea Research, 44: 45-54.

Gundersen, A.C., O. Kjesbu, A. Stene & K. H. Nedreaas. 1999. Fecundity of the northeast Arctic Greenland halibut (*Reinhardtius hippoglossoides*). Northwest Atlantic Fisheries Science 25: 29-36.

Gundersen, A.C. & A.K. Woll. 1997. Linesurvey ved Øst-Grønland, sommeren 1996. Forvaltningsrelaterte undersøkelser på blåkveite. Møreforskingsrapport nr. Å9702, 89p.

ICES. 2009a. Report of the North Western Working Group (NWWG), 29 April - 5 May 2009 ICES Headquarters, Copenhagen. Diane Lindemann. 22 pp.

ICES. 2009b. Report of the Working Group on the Biology and Assessment of Deep Sea Fisheries Resources (WGDEEP), 9–16 March 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:14. 511 pp.

Kennedy, J., Gundersen, A.C., Boje, J. 2009. When to count your eggs: Is fecundity in Greenland halibut (*Reinhardtius hippoglossoides* W.) down-regulated? Fisheries Research, 100(3): 260-265.

Koslow, J.A., Boehlert, G.W., Gordon, J.D.M., Haedrich, R.L., Lorance, P., Parin, N., 2000. Continental slope and deep-sea fisheries: implications for a fragile ecosystem. ICES Journal of Marine Science, 57(3): 548-557.

Large, P.A., Hammer, C., Bergstad, O.A., Gordon, J.D.M., Lorance, P. 2003. Deep-water fisheries of the northeast Atlantic: II. Assessment and management approaches. Journal of Northwest Atlantic Fishery Science, 31: 151-163.

Magnússon, J.V. 2001. Distribution and some other biological parameters of two morid species *Lepidion eques* (Günther, 1887) and *Antimora rostrata* (Günther, 1878) in Icelandic waters. Fisheries Research, 51(2-3): 267-281.

Murua, H., Motos, L. 2000. Reproductive biology of roughhead grenadier (*Macrourus berglax* Lacepède, 1801) (Pisces, Macrouridae), in northwest Atlantic waters. SARSIA, 85(5/6): 393-402.

Saila, S.B. 1983. Importance and assessment of discards in commercial fisheries. FAO Fisheries Circular, 765: 1-62.

Yano, K. 1995. Reproductive biology of the black dogfish, *Centroscyllium fabricii*, collected from waters off western Greenland. Journal of the Marine Biological Association of the United Kingdom, 75(2): 285–310.

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