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Summary of Greenland Shark (*Somniosus microcephalus*) catch in Greenland Halibut (*Reinhardtius hippoglossoides*) fisheries and scientific surveys conducted in NAFO Subarea 0

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Abstract

Understanding the impacts that fisheries have on the Greenland Shark, as a bycatch species, is important given the species is long-lived, slow growing and slow reproducing. These life history traits as well as its high trophic position make the Greenland Shark particularly vulnerable to exploitation. This report examines Greenland Shark catch data from Fisheries and Oceans Canada multi-species surveys conducted in NAFO Subarea 0 from 2004-2017, Northern Shrimp Research Foundation surveys conducted southeast of Baffin Island from 2005-2017, and at-sea commercial fishery observer data from the Subarea 0 Greenland Halibut fishery. The percent of sets with Greenland Shark in the offshore survey dataset ranged from 0% to 3.67% (comprised of 92 individuals). Length and weight data were available for most of the sharks caught with length ranging from 81 cm to 364 cm and weight from 5 kg to 600 kg. The percent of sets with Greenland Shark in the inshore surveys ranged from 0% to 276% (comprised of 127 individuals). Lengths varied from 100 cm to 400 cm. Greenland Shark bycatch occurs throughout the range of inshore and offshore commercial fisheries off the coast of Baffin Island. Mean bycatch in the Greenland halibut Cumberland Sound winter long-line fishery was estimated at 1.1/1,000 hooks for 1989-2006 and 6.3 sharks per 1,000 hooks during an open water fishery conducted in 2009. In the Subarea 0 Greenland halibut fishery there was no apparent trends in the Greenland shark bycatch based on the available at-sea observer data. The proportion of sets with Greenland Shark bycatch ranged from 0% to 32.8% for trawl; 0% to 18.3% for gillnet and 0% to 34.4% for longline. A positive relationship between fishing effort and the bycatch of Greenland Shark was observed for data from the trawl fishery. The proportion of sharks that were dead upon release was notably higher with bottom trawls (~36%) compared to longlines (~16%). The biomass of Greenland Shark caught in bottom trawl sets increases with set duration and the percentage of Greenland Sharks that are alive when released decreases with both set duration and total catch weight suggesting that the longer a Greenland Shark is subjected to the stress of being in an active trawl, the less likely it is to survive when brought to the surface and released, suggesting that trawling set duration

could be manipulated to reduce the impact of trawling on Greenland Shark. Similarly, modifications to longline structure and fishing practices need to be further explored to determine if Greenland Shark mortality can be reduced in that fleet as well.

Introduction

As concern surrounding overfishing grows worldwide, fisheries bycatch species are receiving greater attention. Bycatch refers to any species caught during fishing activities that are not the direct legal targets of the fishery (Cosandey-Godin et al 2015). A common bycatch species in many Arctic fisheries is the Greenland Shark *(Somniosus microcephalus).* It is the only shark species known to reside in the ice-covered seas of the North Atlantic and is the largest fish that inhabits Arctic waters (MacNeil et al 2012; McMeans et al 2013). While they are found from the temperate North Atlantic to Arctic Oceans, their range is believed to be limitless throughout deep water (Figure 1) (MacNeil et al 2012).

Commercial fisheries in the Northwest Atlantic Ocean pose a potential threat to Greenland Shark populations as it is a common bycatch species in Greenland Halibut (*Reinhardtius hippoglossoides)* and northern and striped shrimp *(Pandalus borealis, P. montagui)* fisheries. These fisheries use gillnet, longline and benthic trawl, all of which are efficient at obtaining their target species but also unintentionally catch Greenland Sharks. A single longline vessel, for example, can inadvertently catch as many as 8 sharks per set and catch rates are usually highest during summer months when fishing ranges expand northward with the seasonally receding sea ice (MacNeil et al 2012; Barkley et al 2017).

Due to the thermal extreme and low variability in seasonal temperature, the Arctic ecosystem is likely to be more vulnerable to climate change than temperate ecosystems (MacNeil et al 2010). As sea ice continues to recede, we can expect to see expansions of commercial fisheries as areas become ice free for longer periods of time and target species move poleward. These fishery changes will result in increased impacts on bycatch species (Christiansen et al 2014; Barkley et al 2017). For this reason, understanding the impacts that fisheries have on the Greenland Shark, as a bycatch species, is becoming increasingly important, especially given the species is long-lived, slow growing and slow reproducing (MacNeil et al 2012; Neilsen et al 2016; Barkley et al 2017). These life history traits as well as its high trophic position make the Greenland Shark particularly vulnerable to exploitation and declines in Greenland Shark populations could threaten the top-down structuring of Arctic ecosystems due to the potentially crucial role that they play (Fisk et al 2002; MacNeil et al 2012; McMeans et al 2010; McMeans et al 2013).

This report examines Greenland Shark catch data from Fisheries and Oceans Canada (DFO) science surveys conducted in NAFO Subarea 0 from 2004-2017, Northern Shrimp Research Foundation surveys conducted from 2005-2017 and at-sea commercial fishery observer data from the Subarea 0 Greenland Halibut fishery.

Materials and Methods

Collection and analysis of at-sea fisheries observer data

DFO maintains an at-sea observer program to collect more detailed data on catch composition, including bycatch species and demographic data, than is available from daily hails or fishers' logbooks. Individual fisheries have target at-sea observer coverage rates that differ depending on the management concerns for a particular fishery. Fisheries that have a higher risk of impacting supporting ecosystems or for which conservation concerns exist (e.g. there is potential for regular bycatch of species at risk) have higher target coverage rates. The resulting data can be used to manage fisheries within specified bycatch limits, in enforcement investigations and for monitoring of biodiversity and ecosystem impacts of fisheries by DFO Science. Certified observer companies are hired to collect data during fishing trips and provide the data to DFO upon completion of a fishing trip.

Data collected by at-sea observers for Greenland Halibut directed fisheries in Subarea 0 during years 1995 to 2017 were compiled into a master file. There is inconsistency in the codes used to record species identities among observer companies that are based in different DFO regions. All Maritime region species codes (i.e. 31 for Greenland Halibut and 237 for Greenland shark) were converted to Quebec species codes (i.e. 892 for Greenland Halibut and 20 for Greenland Shark) for consistency. Species caught during each set were available in the database. For analysis, the data were cleaned, first by filtering for only sets that contained entries for Greenland Halibut and Greenland Sharks. Entries containing Greenland Halibut information were used to determine the fishing effort. Due to high uncertainty with the estimated weight data records of Greenland Shark catch were converted from estimated weights to binary entries to show Greenland Shark presence or absence (Figure 3A).

Hard copies of at-sea observer set and large pelagic data sheets were reviewed and entries pertaining to Greenland Shark bycatch were entered into an Excel spreadsheet. These entries included information on the sex, weight, length and condition of individual sharks when released (i.e. dead or alive). In most cases at-sea observers are not able to weigh captured Greenland Sharks and they may not even be able to take accurate measurements of shark length. To avoid having observers make their best guess at the weight of a Greenland Shark (i.e. mentally extrapolate from a measured or estimated length to weight based on an assumed length-weight relationship or tissue density), at-sea observers assigned to DFO Central and Arctic Region were provided with a length-weight conversion formula based on Greenland Sharks caught and accurately measured during DFO surveys or other research programs. Figure 4 shows the length-weight relationship for Greenland Sharks caught in DFO surveys and data from at-sea observers, most of which involves weights calculated based on length. All data were analysed to examine various relationships, including temporal and spatial patterns in bycatch biomass and differences in Greenland Shark bycatch among different types of gear. Greenland Shark bycatch occurs throughout the range of the commercial fishery. Changes in Greenland Shark bycatch through time were not apparent in the available at-sea observer data (Table 1, Figure 4). The proportion of trawl sets with Greenland Shark bycatch ranged from 0% to 32.8%; gillnet from 0% to 18.3% and longline from 0% to 34.4%).

A potential source of error in the observer data that needs to be recognized is the misidentification of Spiny Dogfish *(Squalus acanthias)* as small Greenland Sharks. This misidentification would skew the Greenland Shark results by inflating the number of smaller individuals. These misidentifications are known to occur occasionally but this would primarily be limited to the southern portion of NAFO Division 0B.

Collection and analysis of DFO in-shore and off-shore survey data

DFO has conducted depth-stratified random bottom trawl surveys in NAFO Subarea 0 since 1999. The survey originally alternated between areas within Divisions 0A and 0B, then in 2014 the survey was revised in order to survey Division 0A-South (to 72° N) and 0B each year. Details of the survey design can be found in annual survey reports (see Treble 2017 for the most recent report). At each survey station an otter trawl is fished for 30 min, all species caught are identified and those of commercial importance are measured for length and weight. Age structures are collected for Greenland Halibut and additional biological samples may be collected on an opportunistic basis. Following post-survey data quality assurance and auditing, catch data are made publicly available by uploading to the Ocean Biogeographic Information System (OBIS, www.iobis.org).

Benthic fish and invertebrate communities in nearshore waters near Nunavut communities have also been surveyed by DFO Science. A longline survey was established in Cumberland Sound in 2011 to provide fishery-independent data to support stock assessments of Greenland Halibut in the Cumberland Sound Turbot Management Area. Otter trawl and longline surveys have also been conducted at Scott Inlet (2011-2015), Broughton Island (2011 and 2017, ongoing), Resolution Island (2017), and Pond Inlet (2017, ongoing). All fishes and invertebrates are enumerated and demographic data and tissue samples are taken during these surveys.

Spatial analysis

ArcGIS 10.4 was used to map the presence and absence of Greenland Sharks based on the at-sea fisheries observer and DFO survey data. Figure 3A depicts Greenland shark presence and absence in fishing sets in the at-sea observer data and Figure 3B depicts Greenland Shark presence and absence in DFO survey sets. Errors were identified in some at-sea observer records in the latitude and/or longitude values; sets with coordinates that fell on land or outside the range of the fishery were removed. The fisheries data were then binned into 5 year intervals and kernel density analysis was used to create a series of Greenland Shark catch distribution maps through time (Figure 5).

Results

Greenland sharks caught in DFO surveys

Greenland Shark are caught during the multi-species bottom trawl surveys conducted in Subarea 0 by DFO as well as the Northern Shrimp Research Foundation (NSRF) surveys conducted in Canadian shrimp fishing areas southeast of Baffin Island (Table 2, Figure 3B). It is important to note the duration of survey trawl sets is much lower (~30 min for the deep-water DFO surveys and 15 min for the NSRF survey) compared to typical commercial trawl sets (up to 13 hours). The percent of sets with Greenland Shark ranged from 0% to 3.67% (comprised of 92 individuals). Length and weight data were available for most of the sharks caught with length ranging from 81 cm to 364 cm and weight from 5 kg to 600 kg.

Inshore surveys took place in various locations along the Baffin Island coast with repeated surveys in Cumberland Sound (2010-2014) and Scott Inlet (2012-2015) (Table 3, Fig. 3B). The percent of sets with Greenland Shark catch ranged from 0% to 276% (comprised of 127 individuals). Lengths varied from 100 cm to 400 cm.

Greenland shark bycatch in the inshore Cumberland Sound Greenland halibut fishery
Greenland shark is a bycatch in the Cumberland Sound winter longline fishery directed to Greenland halibut. Greenland shark are all discarded, either alive or dead depending on the extent of entanglement with the gear (Idrobo 2008). Some fishermen participate in a voluntary logbook program and from1987 to 2006, reported catches of Greenland shark in the winter Greenland halibut fishery ranged from 0.4 to 2.9 sharks per 1,000 hooks (mean, 1.1/1,000 hooks) (Fisheries and Oceans Canada 2008). The bycatch of Greenland shark during an open water longline fishery for Greenland halibut in Cumberland Sound in 2009 was 6.3 sharks per 1,000 (570 in total) (Young, 2010). About 50% of these sharks were released alive.

Greenland sharks as a bycatch species in the offshore Greenland Halibut fishery
Greenland Shark bycatch occurs throughout the range of the commercial fishery (Figure 3A). The main gear in the fishery is bottom trawls and gillnets with bottom set long lines used occasionally. Changes in Greenland Shark bycatch through time were not apparent in the available at-sea observer data (Table 1, Figure 4). The proportion of trawl sets with Greenland Shark bycatch ranged from 0% to 32.8%; gillnet from 0% to 18.3% and longline from 0% to 34.4%).

Distribution of Greenland Shark bycatch followed the expansion of the Subarea 0 fishery. In the early years the fishery was concentrated in southern Div. 0A, then expanded north in the early 2000's and east to the slopes of the West Greenland shelves that extend into Canadian waters in the late 2000's early 2010's (Figure 6). A positive relationship between fishing effort and the bycatch of Greenland Shark was observed for data from the trawl fishery (Figure 7).

State of Greenland sharks upon release by gear type
One factor that could affect the mortality of bycaught Greenland Sharks is gear type. The state of Greenland Sharks at release differs among the three commercial fishing gears used in Subarea 0 (Figure 8). The proportion of sharks that were dead upon release was notably higher with bottom trawls (~36%) compared to longlines (~16%). We had data on post-release status for only one Greenland Shark caught in gillnets, Differences in mortality rates among gear types are expected given that Greenland Sharks will experience very different conditions while captured in the various fishing gears.

Greenland Sharks caught in gillnets typically become rolled up in the net and have restricted movement. Greenland Sharks caught on longlines are found in two states, they are brought to the surface either caught by a hook in the mouth, which makes release relatively simple, or they have become entangled in the longline and have loops of the mainline around their bodies, restricting their movements and complicating their release. The survival of entangled sharks will depend on how and how quickly they are disentangled from the longlines. While testing the efficacy of SMART hooks for reducing Greenland Shark catch rates on longlines, Grant et al. (2018) required 2-20 minutes to disentangle Greenland Sharks caught on longlines, depending on the degree of entanglement. Despite the large range in longline set duration (1-45 h) in the at-sea observer and DFO survey data, the percentage of Greenland Sharks that were alive at release showed no relationship with set duration (Figure 8). Post-release survival in longline caught Greenland Sharks is likely most strongly affected by their degree of entanglement in the fishing gear instead of the length of time caught by the gear.

Greenland Sharks caught in commercial bottom trawls could spend hours in the net, depending on when they were caught during a fishing set, suffering damage from impacts with or pressure from the accumulated catch biomass and rocks in the net, and be out of water for several minutes before being separated from the catch and returned to the sea. The biomass of Greenland Shark caught in bottom trawl sets increases with set duration (Figure 10) and the percentage of Greenland Sharks that are alive when released decreases with both set duration (Figure 11) and total catch weight (Figure 12), although there is clear autocorrelation between these figures. Together, Figures 10, 11 and 12 suggest that the longer a Greenland Shark is subjected to the stress and violent nature of being in an active trawl, the less likely it is to survive when brought to the surface and released.

Discussion

Greenland Shark are caught as bycatch throughout Subarea 0 by all commercial fishing fleets, including gillnet, longline and bottom trawl vessels. Post-release survival varies among fisheries. Limited data are available for gillnet post-release survival, but survival from longlines is affected by the degree to which Greenland Sharks become entangled in the mainline, which can cause constriction of blood flow, limits movement and complicates release from the fishing gear.Survival from bottom trawls is related to set duration and total weight of catch (all species) in the trawl. The percentages of sharks that were alive at the time of release represent survival through the fishing event but do not reflect long term survival post-release. Hussey et al (2018) captured Greenland Shark on longlines set for 12-24 h in Steiness Fjord, tagged each with a series of satellite tags that were programmed to release at intervals from the shark and tracked the animals' movements over the following 36-45 days at liberty. The five tagged Greenland Sharks showed significant movement during the period of tracking, moving from southern Ellesmere Island to northwest Greenland, demonstrating strong resilience to capture on and release from longlines.

Greenland Shark bycatch levels have shown strong correlations with Greenland Halibut fishing effort, possibly due to their reliance on Greenland Halibut as a food source (McMeans et al 2013). Changes in Greenland Shark bycatch through time might be expected given the expansion in the Greenland Halibut fishery in Subarea 0 since the early 2000s. However, a trend was not apparent in the at-sea observer data that was available for this study. Greenland Shark are caught in all fishing areas. Comparing between the at-sea observer and DFO survey data (Figure 3), Greenland Sharks are caught more sporadically during the surveys despite the use of comparable fishing gear. The lower representation of Greenland Shark in the survey sets could be an effect of the significantly shorter set time (30 min in the survey compared to up to 13 hours in commercial sets), the timing of the survey, which typically occurs towards the end of the commercial fishery, or simply an artefact of the smaller number of survey sets compared to commercial fishing sets.

Given the growing attention that is being given to bycatch species in general and Greenland Shark bycatch in particular, modifications to fishing gear or fishing practices that reduce Greenland Shark mortality warrant exploration. The observed relationship between bottom trawl set duration and Greenland Shark mortality and the difference in Greenland Shark catches between commercial and survey trawling sets suggest that trawling set duration could be manipulated to reduce the impact of trawling on Greenland Shark. Similarly, modifications to longline structure and fishing practices need to be further explored to determine if Greenland Shark mortality can be reduced in that fleet as well (e.g. Grant et al 2018). Efforts to minimize Greenland Shark mortality on longlines will be particularly timely as several Nunavut communities are actively working to develop new community-based Greenland Halibut longline fisheries.

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Table 1. Total number of sets, number of sets in which Greenland Shark were caught and the percentage of sets in which Greenland Shark were caught for each gear type per year for at-sea observer data. GNS = stationary gillnets, LLS = stationary longlines, OTB2 = trawl towed from stern, TT = double trawl.

Year	Gear Type	Total Tows	Tows Caught	%	Year	Gear Type	Total Tows	Tows Caught	%
1995	GNS	40	0	0	2007	GNS	811	46	5.7
	LLS	252	5	2		LLS	0	0	0
	OTB2/TT	825	113	13.7		OTB2/TT	2154	698	32.4
1996	GNS	58	7	12.1	2008	GNS	619	53	8.6
	LLS	0	0	0		LLS	0	0	0
	OTB2/TT	892	149	16.7		OTB2/TT	1586	441	27.8
1997	GNS	0	0	0	2009	GNS	520	39	7.5
	LLS	0	0	0		LLS	0	0	0
	OTB2/TT	992	137	13.8		OTB2/TT	1626	246	15.1
1998	GNS	44	0	0	2010	GNS	578	31	5.4
	LLS	0	0	0		LLS	0	0	0
	OTB2/TT	510	31	6.1		OTB2/TT	2167	228	10.5
1999	GNS	76	7	9.2	2011	GNS	668	53	7.9
	LLS	0	0	0		LLS	0	0	0
	OTB2/TT	714	184	25.8		OTB2/TT	1272	180	14.2
2000	GNS	71	13	18.3	2012	GNS	468	15	3.2
	LLS	56	0	0		LLS	0	0	0
	OTB2/TT	786	84	10.7		OTB2/TT	858	130	15.2
2001	GNS	29	0	0	2013	GNS	729	23	3.2
	LLS	0	0	0		LLS	32	11	34.4
	OTB2/TT	1343	277	20.6		OTB2/TT	811	192	23.7
2002	GNS	71	7	9.9	2014	GNS	391	2	0.5
	LLS	677	47	6.9		LLS	0	0	0
	OTB2/TT	998	327	32.8		OTB2/TT	676	112	16.6
2003	GNS	0	0	0	2015	GNS	776	33	4.3
	LLS	675	95	14.1		LLS	13	1	7.7
	OTB2/TT	1210	324	26.8		OTB2/TT	614	181	29.5
2004	GNS	9	1	11.1	2016	GNS	578	41	7.1
	LLS	0	0	0		LLS	0	0	0
	OTB2/TT	1550	335	21.6		OTB2/TT	718	215	29.9
2005	GNS	443	80	18.1	2017	GNS	451	13	2.9
	LLS	0	0	0		LLS	0	0	0
	OTB2/TT	1301	213	16.4		OTB2/TT	714	189	26.5
2006	GNS	1142	111	9.7					
	LLS	0	0	0					
	OTB2/TT	1294	268	20.7					

Table 2. Summary of Greenland Shark caught during DFO multi-species surveys.

Year	Surveys	# of Sets	# Sharks Caught	%	Length Range (cm)	Weight Range (kg)
2004	0A-North	38	0	0	-	-
2005	NSRF	240	2	0.83	n/a	25-500
2006	0A-South	435	7	1.61	139-310 (6 sharks)	16-560
2007	0A + 0B	350	6	1.71	295-350 (2 sharks)	5-290
2008	0A-South	436	16	3.67	124-364 (10 sharks)	6-538
2009	0B	418	9	2.15	298 (1 shark)	10-375
2010	0A-South + NSRF	449	8	1.78	298-340 (5 sharks)	5-500
2011	0B	435	7	1.61	90-210 (4 sharks)	10-205
2012	0A + NSRF	471	8	1.70	n/a	6-400
2013	0B+NSRF	443	7	1.58	81-308	7-114
2014	0A-South +0B+NSRF	498	7	1.41	n/a	50-600
2015-17	0A-South +0B+NSRF	na	15	na	102-300	5-784

Table 3. Summary of Greenland Shark caught during DFO inshore surveys.

Year	Location	# of Sets	# Sharks Caught	%	Length Range (cm)	Sex
2010	Cumberland Sound	5	3	60	n/a	n/a
2011	Cumberland Sound Clyde River Merchant's Bay	29	27	93	100 - 350	M – 9 F – 16 U - 2
2012	Cumberland Sound Scott Inlet	17	47	276	117 – 450 (42 sharks)	M – 21 F – 17 U - 9
2013	Cumberland Sound Scott Inlet	43	0	0	n/a	n/a
2014	Cumberland Sound Scott Inlet	36	11	31	200 – 400	M – 1 F – 5 U - 5
2015	Scott Inlet	20	33	165	178 – 400 (14 sharks)	M – 9 F – 5 U - 19
2016	n/a	n/a	n/a	n/a	n/a	n/a
2017	Pond Inlet Qikiqtarjuaq Pangnirtung	36	6	17	135 - 400	M – 0 F – 1 U - 5

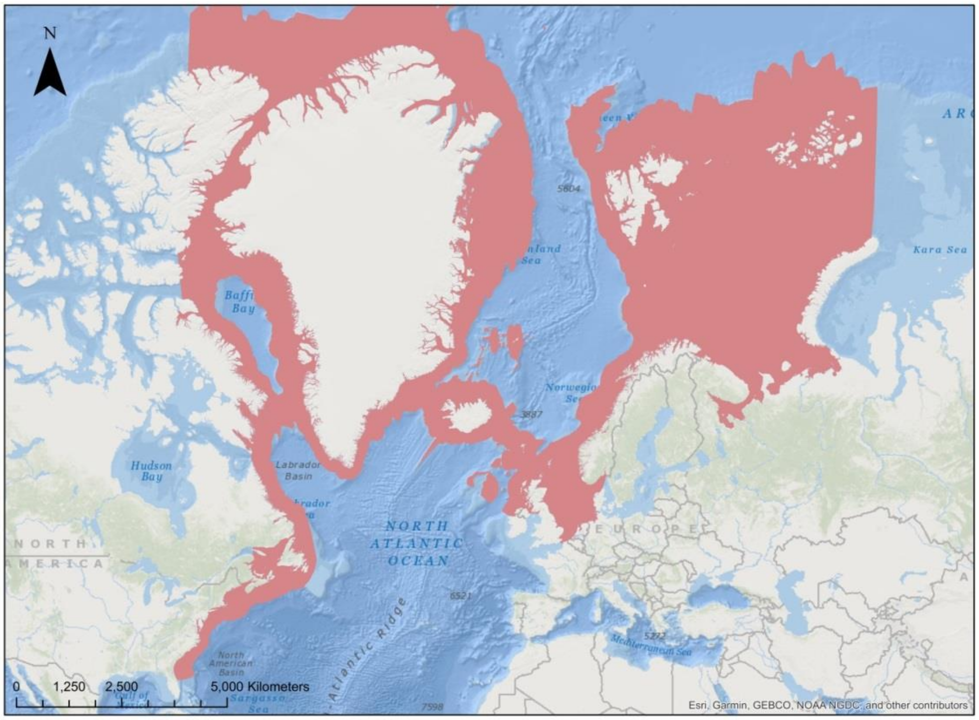

Fig. 1. Global distribution of Greenland Sharks. (Basemap: ESRI 2012; Distribution: IUCN 2012).

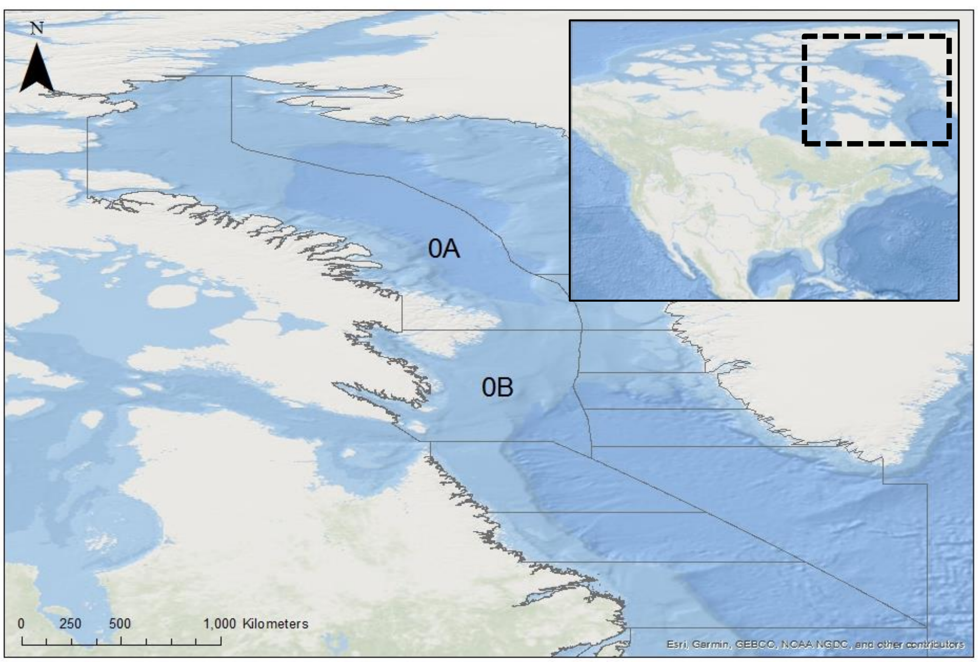

Fig. 2. Map of Northwest Atlantic Fisheries Organization Divisions 0A and 0B off the coast of Baffin Island. These two Divisions comprise NAFO Subarea 0 (Basemap: ESRI 2012; Divisions: NAFO 2011).

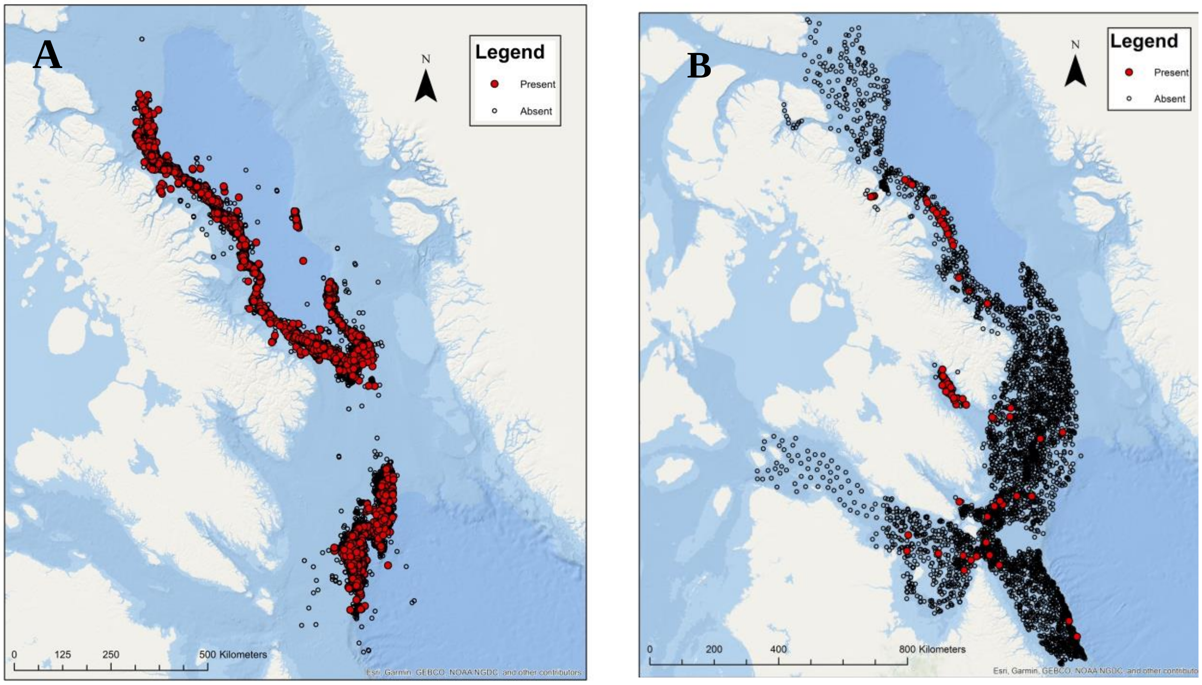

Fig. 3. Presence and absence of Greenland Sharks in trawl catches throughout Baffin Bay, Davis Strait and Hudson Strait. (A) At-sea fisheries observer data, mixture of trawls, longlines and gillnets from years 1995-2017. (B) DFO inshore (2010-2017) and offshore (2004-2014) survey data (Basemap: ESRI 2012). Red circles indicate Greenland Shark catches, open circles indicate fishing sets that did not capture Greenland Sharks.

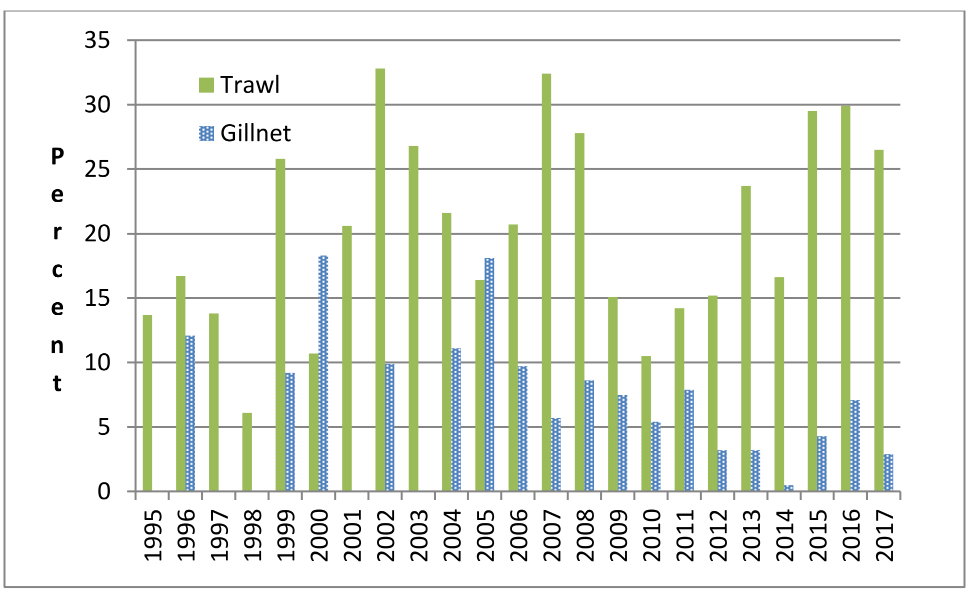

Fig. 4. Percent of Greenland Shark bycatch in the Subarea 0 commercial fishery bottom trawl sets. Data from Table 1.

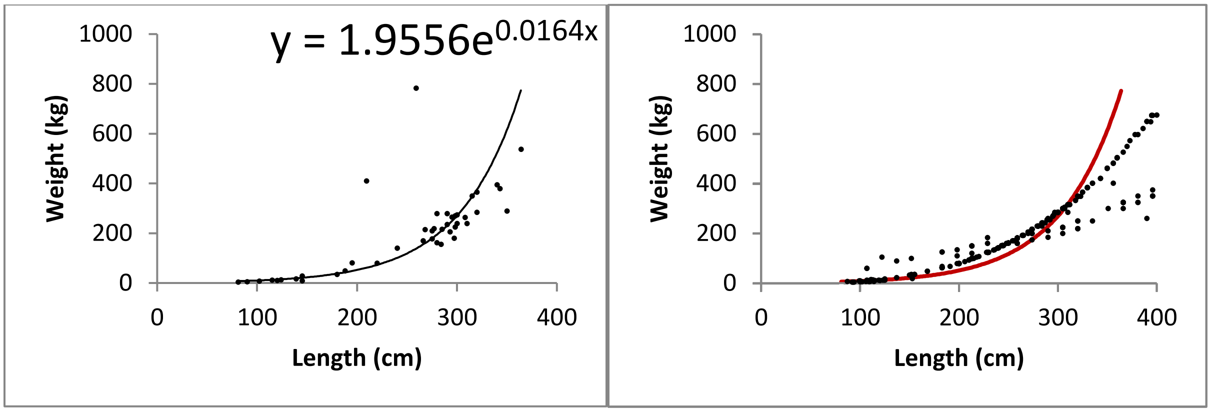

Fig. 5. Length-Weight relationship for Greenland Sharks caught during DFO surveys (left) and in at-sea observer data (right). The red curve on the right is the length-weight curve from the DFO survey data, for comparison.

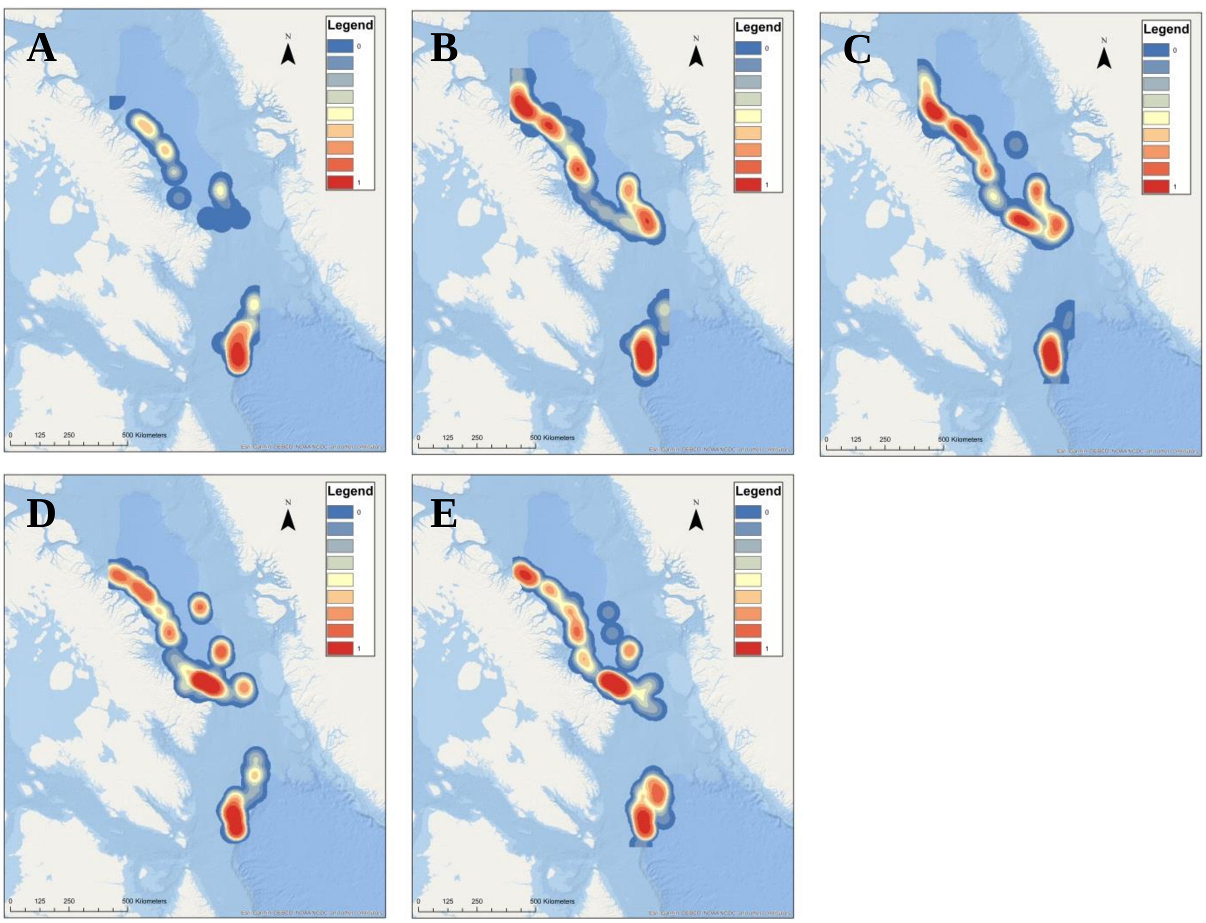

Fig. 6. Kernel density maps of instances of Greenland Shark bycatch based on presence and absence values obtained from at-sea observer data. The figures are binned at five year intervals (A 1995-1999, B 2000-2004, C 2005-2009, D 2010-2014, E 2015-2017) and represent all gear types and data within NAFO Subarea 0 (Basemap: ESRI 2012).

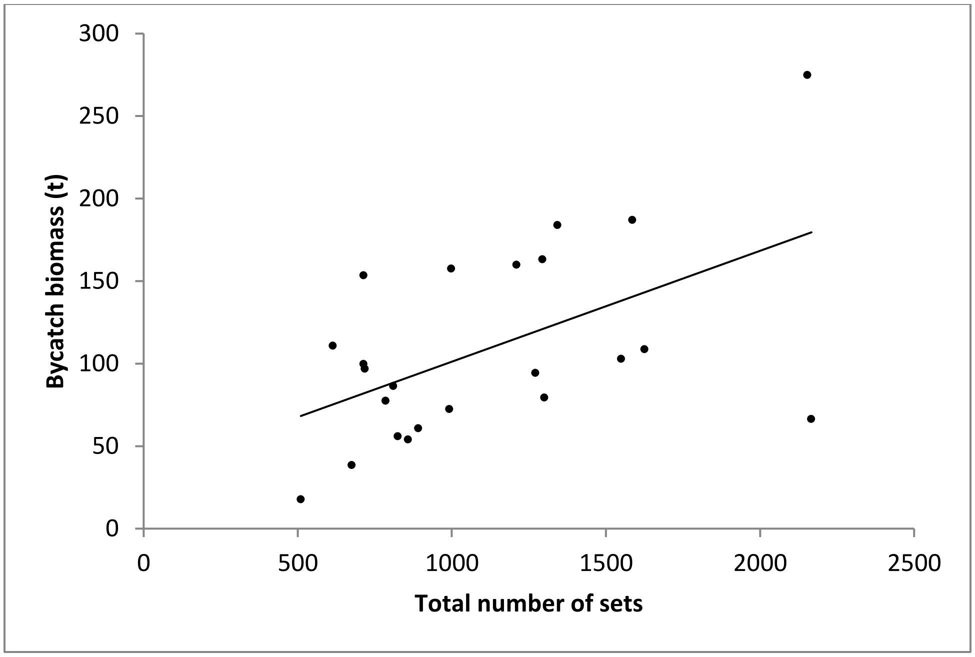

Fig. 7. Greenland Shark bycatch biomass (t) by the total number of sets in a given year. The data are from the at-sea observer program and are from years 1995–2017. Only trawl and double trawl data were used due to a lack of data for gillnet and longline gear types.

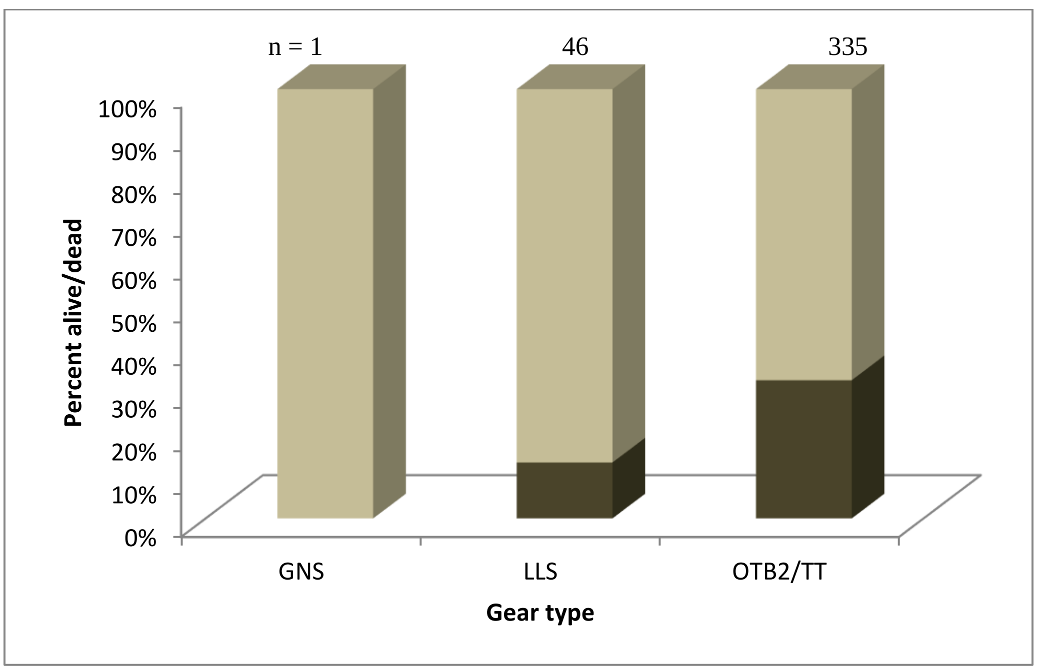

Fig. 8. Percentage of Greenland Shark bycatch that was alive (tan) and dead (dark brown) when discarded as it relates to gear type. Data were obtained from at-sea observer data sheets as well as large pelagic data forms. Only years 2015–2016 are represented. GNS = stationary gillnets, LLS = stationary longlines, OTB2 = trawl towed from stern and TT = double trawl.

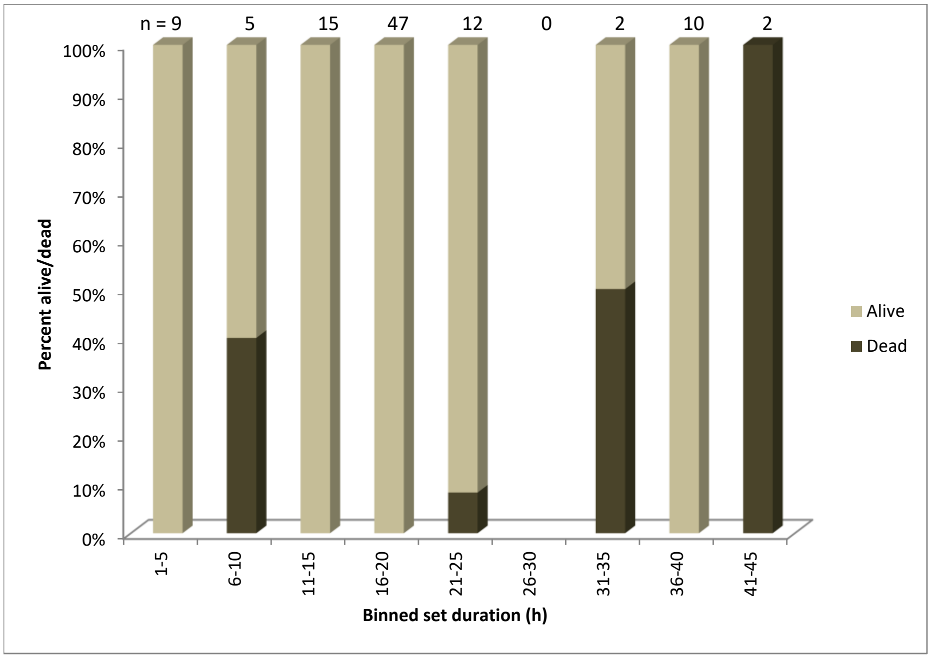

Fig. 9. Percentage of Greenland Shark bycatch that was alive (tan) and dead (dark brown) when discarded as it relates to set duration (hours) for longlines. Data were obtained from at-sea fisheries observer data sheets and DFO nearshore surveys (2011-2017).

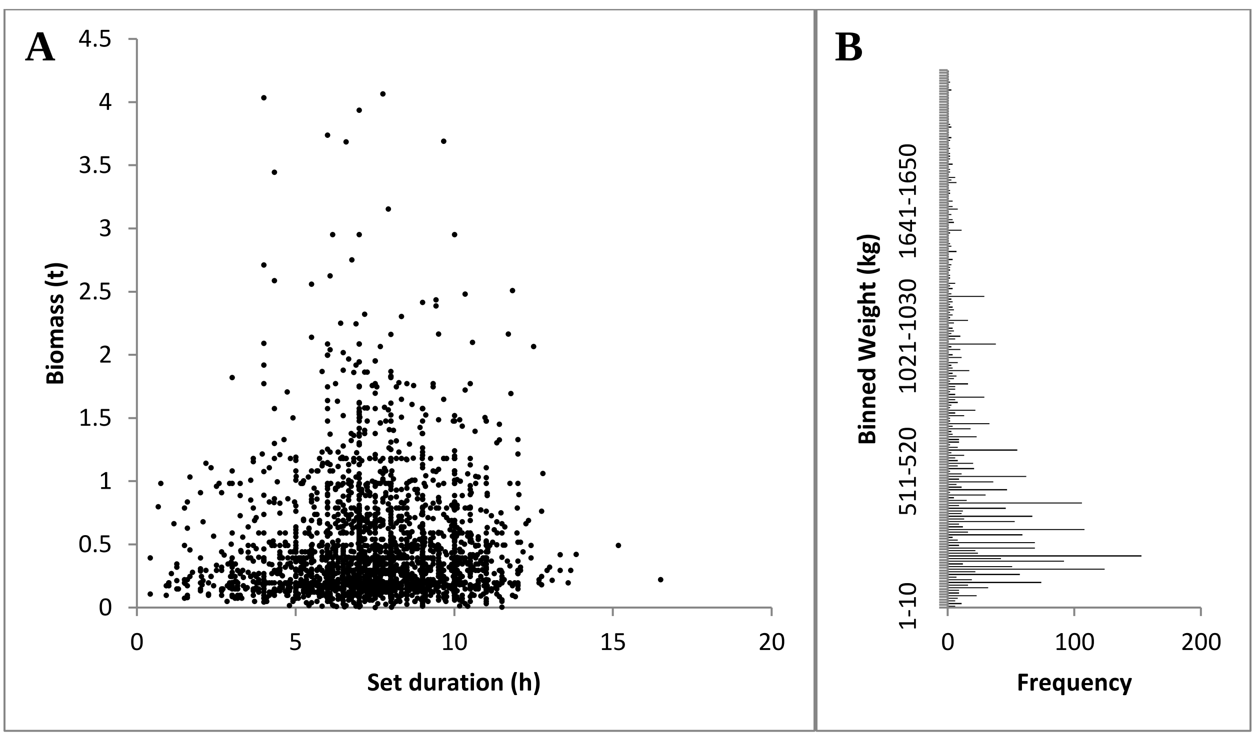

Fig. 10. Total Greenland Shark biomass (t) based on the duration of trawl and double trawl sets (h) (A) and frequency histogram of catch weights (kg) (B).

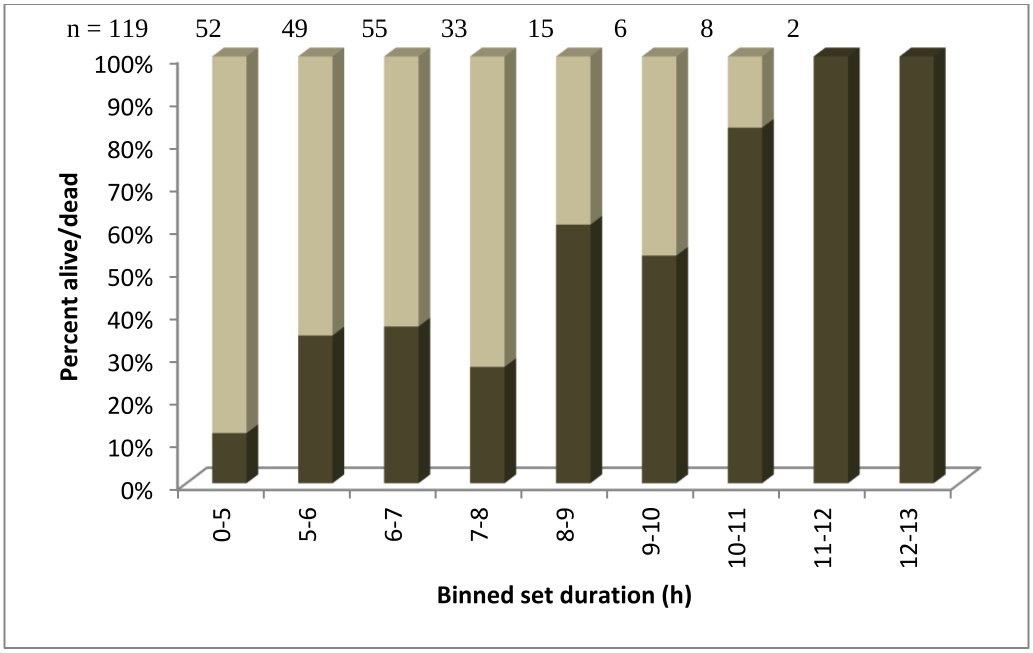

Fig. 11. Percentage of Greenland Shark bycatch that was alive (tan) and dead (dark brown) when discarded as it relates to set duration (hours) of trawling. Data were obtained from at-sea fisheries observer data sheets, large pelagic data forms (2015-2016) and DFO survey data (2005-2016).

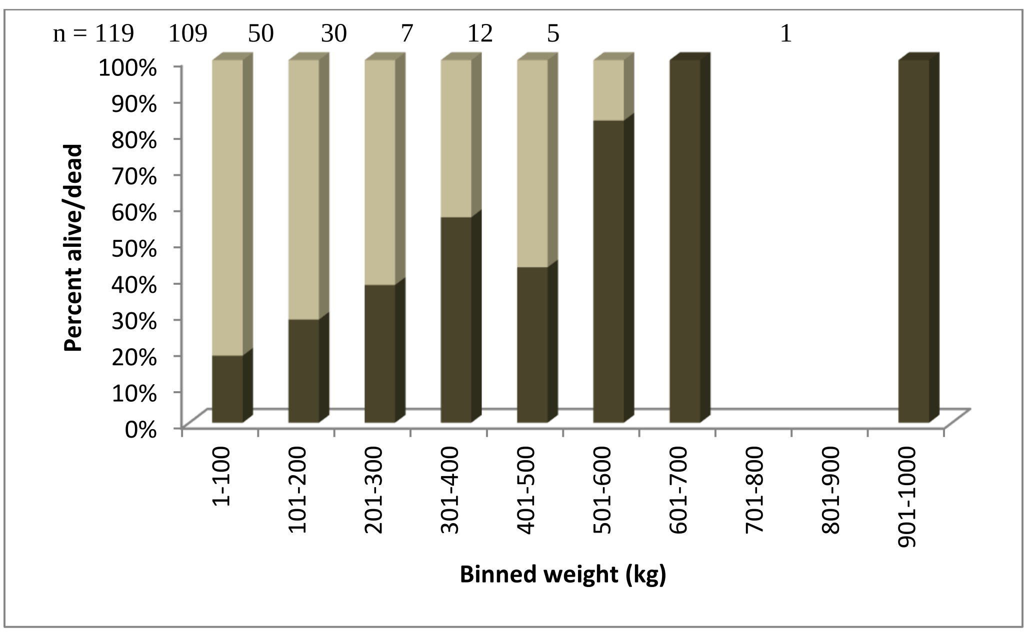

Fig. 12. Percentage of Greenland Shark bycatch that was alive (tan) and dead (dark brown) when discarded as it relates to total catch weight (kg) for all species caught in trawling sets. Data were obtained from at-sea observer data sheets, large pelagic data forms (2015-2016) and DFO survey data (2005–2016).