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Overview of sources of uncertainty in reported catches of Greenland shark *Somniosus microcephalus* within the NAFO Convention Area

by

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Abstract

Greenland shark *Somniosus microcephalus* are encountered as incidental bycatch in commercial fisheries within the NAFO Convention Area. Bycatch records are typically from At-Sea Observer records or fishery logbooks. Variability in observer coverage, logbook returns, and reporting rates and requirements have resulted in incomplete records of Greenland shark bycatch. In addition, catch weights are visually estimated, not weighed, and in most jurisdictions catch numbers have not historically been recorded. Total fishery removals of this species are currently unknown.

Introduction

There is significant uncertainty in the amount of Greenland shark bycatch within the NAFO Convention area. This is an identified barrier to quantifying fishing mortality for this species, or undertaking a quantitative assessment of population status. There have been no directed fisheries for Greenland shark in the NAFO Regulatory Area (NRA), Canada, or the USA, and incidental catches are released at the site of capture, not landed. Historically there was an important commercial fishery for this species in Greenland, though since 1966 Greenland sharks have been limited to unwanted bycatch and a small directed subsistence fishery in inshore areas (Hedeholm et al. 2018).

Reporting requirements for bycatch of Greenland shark differ throughout the NAFO Convention Area, with different requirements for domestic fisheries by Canada, the United States of America, and Greenland (Denmark) and for fisheries beyond national jurisdictions within the NAFO Regulatory Area (NRA) are outlined below.

Materials and Methods

Here we summarize sources and uncertainties in collected data on catches for the NRA and domestic fisheries within the NAFO Convention area. Analysis of catches have been previously reported for the NRA (Hendrickson et al. 2018), Canada (Bryk et al. 2018; Simpson et al. 2018), Greenland (Hedeholm et al. 2018), and EU-Spain (González-Costas and Ramilo 2017, 2019).

Results

NAFO Catch Statistics - STATLANT

In 2002 the NAFO Conservation and Enforcement Measures (CEM) were updated to include mandatory reporting of shark catches from all Contracting Parties, including available historical data (Table 1). These data are held within the STALANT 21 database, and are presented for Greenland shark in Figure 1. However, there have been instances noted of duplicate records within this database that have yet to be corrected. Presented totals may therefore not reflect actual reports. As there are no commercial fisheries for this species in the NAFO Convention Area, catch records of Greenland shark within the STATLANT 21A database are of discards from incidental bycatch, not landings. The sharp increase in Greenland shark catches within the STATLANT 21A database starting in 2017 is thought to be a result of increased reporting requirements within Greenland (see below), rather than a change in amounts caught.

Data are also available in the STATLANT 21B database. Though these are not examined here, it may be assumed that the issues identified for STATLANT 21A are also applicable to 21B. The U.S. has not reported to 21B since 1994 (Hendrickson et al. 2018).

NAFO Regulatory Area

The NAFO Regulatory Area is defined as "that part of the Convention Area which lies beyond the areas in which Costal States exercise fisheries jurisdiction (outside of the Exclusive Economic Zones)."

Reporting of shark bycatch from Flag States was not mandatory prior to 2002, while specific measures on the Conservation and Management of Sharks were introduced in 2006. Table 1 presents a summary of Conservation and Enforcement Measures relevant to Greenland shark from 2005-2018. These measure area outlined by the NAFO Commission in accordance with provisions of Articles VI and XIV of the Convention on Cooperation in the Northwest Atlantic Fisheries.

Bycatch within the NAFO Regulatory Area is monitored through At-Sea Observers (ASOs). Until 2019, NAFO Conservation and Enforcement Measures (CEM) dictated that "every fishing vessel shall at all times in the Regulatory Area carry at least one independent and impartial observer." (NAFO/COM 2018-01). However, coverage (defined based on the percentage of sampled trips in available data) within available NAFO ASO reports from 2014-2017 varied from 60 to 88% coverage of trips annually (Hendrickson et al. 2018). Exceptions were added in 2019 (NAFO/COM 2019-01) allowing coverage "less than 100% but not less than 25%" in areas where bycatch is expected to be negligible. Issues with species identification and discrepancies between scientific and NAFO observers when both have been onboard a fishing vessel have also been identified (González-Costas and Ramilo, 2019).

Until 2019 Greenland shark bycatch was recorded by weight, with weights of sharks visually estimated, not measured. This estimation is necessary due to a combination of factors including their large size, difficulty in handling, and desire to have these fish released as quickly as possible. NAFO Conservation and Enforcement Measures were expanded in 2019 to specifically address bycatch of Greenland shark, stating that "for all observed hauls that contain Greenland shark, observers shall record the number, estimated weight and measured length (estimated length if measured length is not possible) per haul or set, the sex, and catch disposition (alive, dead, unknown) of each individual Greenland shark" (NAFO/COM Doc. 19-01).

Canada

Greenland Shark bycatch data within Canada's Exclusive Economic Zone has been recorded in the Canadian At-Sea Observer database since 1985. Canadian ASO data are maintained by Fisheries and Oceans Canada in regional databases in Newfoundland and Labrador, Maritimes, and Quebec. ASO data for Gulf region licences are held in the Quebec Region database, and for Central and Arctic Region licensed fisheries are held in the Quebec Region database. Discarding in unobserved fisheries is not recorded in any catch statistics, and is therefore unknown.

As a result of the high uncertainty in catch weights resulting from visual estimation of individual shark weight by ASOs, analyses of catch within Canadian waters have typically used observer data as a measure of presence of Greenland shark bycatch, as opposed to a value of total amount (Bryk et al. 2018; Simpson et al. 2018). Given the prevalence of reporting issues, sets within the ASO database with no documented shark catch cannot reliably be assumed as an absence of catch. In 2014 Central and Arctic Region distributed to ASOs a key for the caudal fin length to weight relationship based on length-weight relationships published in MacNeil et al. (2012) and unpublished data from that same study, in an effort to improve the reported weights for Greenland shark bycatch. There has been no follow-up on this initiative and it is not known how many of the ASOs were using the key, or if they are still using it.

Since 2008, data include set by set counts of sharks caught, though these data area not complete as there are trips/vessels that have not reported. Effort is currently underway to improve reporting of catch numbers in addition to the estimated weights, and to collect additional information on length and sex.

Reported levels of Greenland shark bycatch within the observer database will depend on the type and scale of fisheries occurring in any given year; the geographic distribution of these fisheries; and the level of ASO coverage, which varies by fishery. The majority of Greenland shark bycatch records within the ASO database are from Subarea 0. The Subarea 0 (Divisions 0A and 0B) Greenland halibut bottom trawl fishery has 100% ASO coverage and the gillnet fishery in Div. 0A also has 100% coverage. The exception is the fixed gear in Div. 0B which only requires 20% ASO coverage from May 1 to Dec. 31 (DFO 2014). ASO coverage in the offshore shrimp fisheries (SA0, 2 and 3) requires 100% for vessels >100' and Nunavut temporary license holders, while there is a 10% target for the inshore fleet (DFO 2018).

There are also concerns with species identification in the observer data, whereby Squaliformes such as the Spiny Dogfish *Squalus acanthias* may be misidentified as small Greenland sharks (Bryk et al. 2018).

Community-based commercial and exploratory fisheries within Nunavut territorial waters (within 12 nmi of shore) do not have fishery independent monitoring of catch or bycatch and logbooks for commercial fisheries are often not returned. Bycatch levels of Greenland shark are not quantified within these community-based fisheries. Exploratory commercial fisheries in these inshore areas have documented high rates of occurrence of Greenland shark on longlines targeting Greenland halibut (Wheeland and Devine 2018).

There may be additional records of Greenland shark bycatch from commercial logbooks kept by vessel captains. However, logbook returns are not consistent; some fisheries require logbooks to be returned in order for a new license to be issued, while others lack an enforcement mechanism for mandated logbook returns. In addition, there is a known lack of reporting of bycatch in some cases. Records of incidental catches of Greenland shark within logbook databases are therefore incomplete.

United States of America

There are few documented catches of Greenland shark off the U.S. East Coast, with only seven documented in the Northeast Fisheries Observer Program (NEFOP) Database during 1989-2017; 2 in 1979, 1 in 2008, and 4 in 2012 (Hendrickson et al. 2018). The NEFOP data are collected by trained scientific observers who are required, for sharks, to record numbers kept and discarded, measured individual weight (estimated for Greenland sharks), measured total length (or estimated if measurements are not possible), sex, and catch disposition (i.e., kept or discarded dead or alive) for each tow. Since 2008, observer coverage has been based on analyses conducted in accordance with the Standardized Bycatch Reporting Methodology (SBRM), which is described in NMFS (2008) and NEFMC (2007). The SBRM consists of an annual allocation of the number of observer sea days assigned to each fleet (i.e., gear type, access area, trip category, region, and mesh group combinations) in order to obtain discard estimates that have a minimum CV of 30% for 15 species groups and one sea turtle species. During 1989-2007, several different methods were used to assign fishery observers to vessels that were randomly selected from a master list of vessels.

All pertinent databases outside of the NEFOP that are maintained by the U.S. National Marine Fisheries Service were also examined to determine whether Greenland shark catches were recorded. These databases included annual shark tagging databases, commercial shark fishery logbooks, recreational shark and large pelagic fishery databases, shark survey databases and bottom trawl survey databases which covered the US East Coast from the Gulf of Maine to southern Florida. These databases contained records of six Greenland sharks over 1962-2017 (Hendrickson 2018).

Greenland (Denmark)

Greenland shark catches in Greenland waters of NAFO Subarea 1 and ICES XIV have been described in Hedeholm et al. 2018. Catches of Greenland shark are reported in logbooks, though there is known underreporting of this bycatch species until 2016. It became mandatory in 2017 to report bycatch, though only vessels larger than 30ft are required to submit logbooks. When sharks are alive they must be released, but under all circumstances, they must be recorded in the logbook as bycatch. Greenland Fishery License Control Authority (GFLK) has had an increased effort to make sure that the sharks are reported. The Greenland Insitute of Natural Resources (GINR) has suggested to GLFK that observers and fishermen should have to record individual length, and sex, and not summed biomass for the entire catch. Because weighted is not always an option, GINR has produced a conversion factor to estimate the weights, based on the length-weight relationship provided in Nielsen et al. 2014. Work is ongoing to change common practice to that of reporting sharks. In order

to gain more size (weight and length) information, in 2019 Greenland presented a protocol for bycatch reporting to the NAFO STACTIC Intersessional Meeting (STACTIC WP 19-36) in May 2019.

EU-Spain

Scientific observers on board EU-Spain vessels operating in the NRA collect fishing information (catches, positions, etc.) on a haul by haul basis and carry out length and biological sampling of the main species in the catches. These observers do not cover all Spanish fleet effort. The mean percentage of the total effort surveyed by these observers by year is around 20%. The quality of catch weight is low due to the difficulties in measuring the specimens weight. Similar to other databases described here, normally the weight is estimated visually. There are also problems of proper identification of shark species in the catch information. In some cases the species is not identified by ASOs, and resulting data is a grouping of all shark species caught.

Discussion

While information on Greenland shark bycatch is available within observer reports and fisher logbooks, there remains significant uncertainty in amounts caught. Uncertainty stems largely from the visual estimation of catch weights, variable observer coverage, and logbook returns. Increasingly effort is being made to enhance reporting requirements to include counts, length, and sex to better quantify Greenland shark bycatch within the NAFO Convention Area. Given the uncertainty in available catch data, total catches and fishery mortality have not been quantified.

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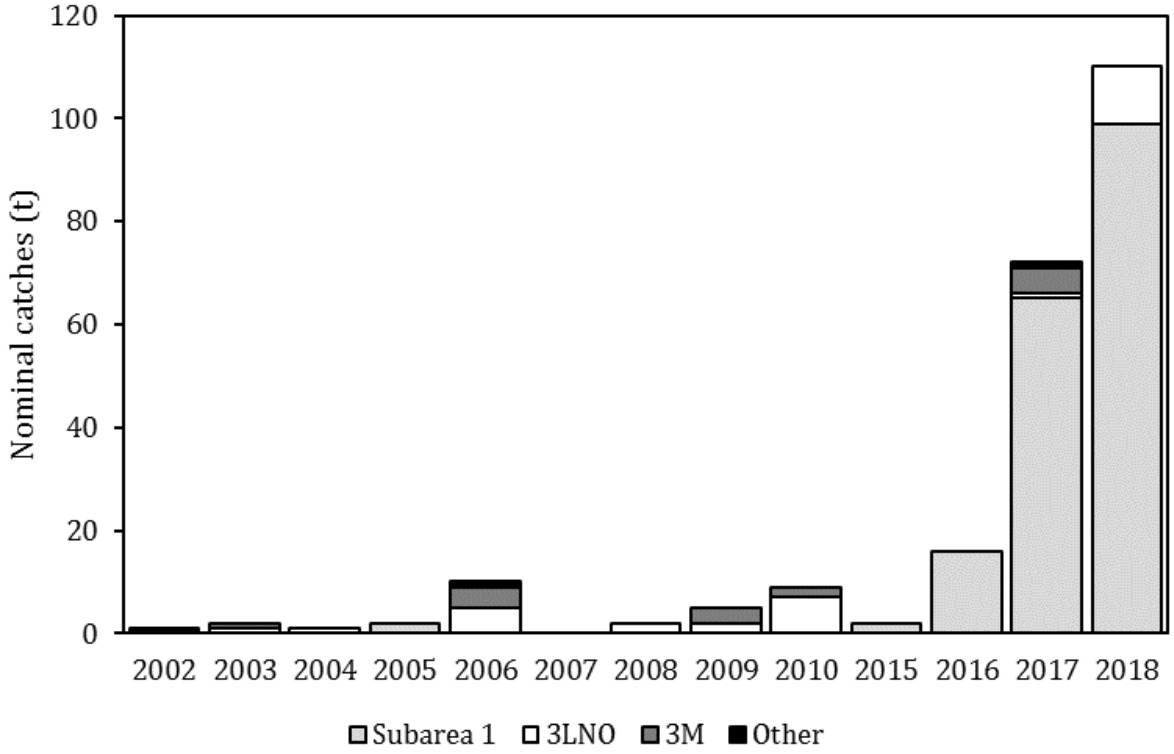

Figure 1. Catches (t) of Greenland shark reported by Flag States to the NAFO Secretariat during 1960-2017 (Source: STATLANT 21A Database). The increase in reported bycatch over 2016-2018 is associated with increased reports in NAFO Subarea 1, where reporting of Greenland shark catches became mandatory within Greenland domestic fisheries in 2017.

Table 1. Summary of NAFO Conservation and Enforcement Measures Relevant to Greenland Shark. CEM are available at https://www.nafo.int/Fisheries/Conservation

Years	Conservation and Enforcement Measures
2019 NAFO/COM Doc. 19-01	Article 12 Conservation and Management of Sharks 1. (a) report all catches of sharks, including available historical data, in accordance with the data reporting procedures set out in Article 28. (b) for all observed hauls that contain Greenland shark, observers shall record the number, estimated weight and measured length (estimated length if measured length is not possible) per haul or set, the sex, and catch disposition (alive, dead, unknown) of each individual Greenland shark. … (e) prohibit fishing vessels flying its flag from conducting a directed fishery for Greenland shark (Somniosus microcephalus) in the Regulatory Area. (f) require every vessel entitled to fly its flag to undertake all reasonable efforts to minimize incidental catch and mortality, and where alive, release Greenland sharks in a manner that causes the least possible 4. In fisheries that are not directed at sharks, each Contracting Party shall encourage every vessel entitled to fly its flag to release sharks alive, and especially juveniles, that are not intended for use as food or subsistence.
2012-2018 NAFO/COM Doc. 18-01 NAFO/FC Doc. 17-01 NAFO/FC Doc. 16/01 NAFO/FC Doc. 15/01 NAFO/FC Doc. 14/01 NAFO/FC Doc. 13/01 NAFO/FC Doc. 12/01	Article 12 Conservation and Management of Sharks 1. (a) report all catches of sharks, including available historical data, in accordance with the data reporting procedures set out in Article 28[1]. 4. In fisheries that are not directed at sharks, each Contracting Party shall encourage every vessel entitled to fly its flag to release sharks alive, and especially juveniles, that are not intended for use as food or subsistence. [1]Article 25 in 2012
2008-2011 NAFO/FC Doc. 08/01 NAFO/FC Doc. 09/01 NAFO/FC Doc. 10/01 NAFO/FC Doc. 11/01	Article 17[1] Conservation and Management of Sharks 1. Contracting Parties shall report data for all catches of sharks, in accordance with the data reporting procedures laid down in Chapter III, including available historical data. 6. In fisheries that are not directed at sharks, Contracting Parties shall encourage the release of live sharks, especially juveniles, to the extent possible, that are caught as by-catches and are not used for food and/or subsistence. [1]Article 16 in 2008, Article 13 in 2006-2007
2005 NAFO/FC Doc. 05/01	No specific shark measures outlined within the SEM