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Greenland shark (*Somniosus microcephalus*) catches off the U.S. East Coast based on data from data from research surveys, fishery observer programs, logbooks and tagging programs conducted by the U.S. National Marine Fisheries Service

by
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Abstract

The Greenland shark (*Somniosus microcephalus*), a large, benthopelagic shark, has been listed as “Near Threatened” on the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List since 2006. The IUCN-recommended conservation actions include the documentation of catches in North Atlantic and Arctic fisheries and determination of any fisheries-related population declines. This report was prepared as a response, in part, to a request of the Scientific Council (SC) of the Northwest Atlantic Fisheries Organization (NAFO), by the Fisheries Commission, to document Greenland shark bycatch in NAFO fisheries and to summarize existing data about the species for use in assessing the status of the population inhabiting areas under NAFO jurisdiction. The Greenland shark catch data summarized in this report were obtained from databases maintained by the National Marine Fisheries Service (NMFS) and included research bottom surveys, shark longline surveys, longline fishery logbooks, fishery observer programs and shark tagging programs. A total of 13 Greenland sharks were caught off the U.S. East Coast during 1962-2017. However, most fisheries in this area only occur at depths of up to approximately 400 m. The measured total length range for five of the females was 183-427 cm. All but one individual was caught in a bottom trawl fishery and seven fish were caught at depths between 206 m and 313 m where the surface water temperatures were very warm, 25.6-26.7, due to the influence of the Gulf Stream. Previous studies suggested that higher numbers of Greenland sharks may be present in deeper water off the U.S. East Coast but most U.S. research surveys and fisheries do not occur in these areas.



1.0 Introduction

The Greenland shark (*Somniosus microcephalus*) is a large, benthopelagic shark that inhabits the Arctic and North Atlantic Oceans at depths of 0-2,200 m (MacNeil et al. 2012). The species' geographic range (Figure 1) has been documented primarily from fisheries catches (MacNeil et al. (2012) and the southernmost limit in the Northwest Atlantic Ocean is unknown.

S. microcephalus has been listed as “Near Threatened” on the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List since 2006 (Kyne et al. 2006). The IUCN-recommended conservation actions for the species are the documentation of catches in North Atlantic and Arctic fisheries and determination of any fisheries-related population declines.

This report was prepared (in part) in response to a request, by the Fisheries Commission of the Northwest Atlantic Fisheries Organization (NAFO), for the Scientific Council to document Greenland shark bycatch in NAFO fisheries. In addition, the request included a summarization of existing data about the species in order to assess the current fishing mortality and determine the status of the population inhabiting waters under NAFO jurisdiction. The purpose of the request was noted as development of management advice, in line with the NAFO Precautionary Approach, for consideration of the Fisheries Commission.

The objective of this report is to characterize Greenland shark bycatch in fisheries that operated off the U.S. East Coast and catches from research surveys by using data from the databases maintained by the National Marine Fisheries Service and previously published data summaries.

2.0 Material and Methods

Document and summarize all data pertaining to for Greenland shark catches in the Northwest Atlantic Ocean off recorded in databases maintained by the East U.S. National Marine Fisheries Service. The following databases were queried to document and characterize catches of Greenland sharks off the U.S. East Coast. All of the databases are maintained by the Northeast and Southeast Fisheries Science Centers of the U.S. National Marine Fisheries Service, the primary government body responsible for data collection of marine species in the U.S.

Northeast Fisheries Observer Program

Since 1989, most of the fishing fleets that operate in U.S. East Coast waters between Cape Hatteras, North Carolina and the Gulf of Maine are sampled by observers from the Northeast Fisheries Observer Program (NEFOP). The NEFOP observers receive extensive training on sampling protocols and species identification. Effort coverage by fleet varies by year and seadays have been allocated annually since 2003 based on effort for each fleet during the previous year. During 1989-2002, vessels were selected randomly from a master vessel list.

The data collected by fishery observers are audited and entered in the NEFOP Database. Shark catches are identified to the species level. The following biological data are collected for shark bycatch: total length and fork length (measured to the nearest cm (some lengths were estimated due to limited catch processing time), total weight (estimated, in pounds) and sex. Disposition is also recorded (released dead or alive), along with haul depth, surface temperature and location at the start and end of each haul. Detailed gear characteristics are also recorded.

NMFS Cooperative Shark Tagging Program

The NMFS Cooperative Shark Tagging Program has been operational since 1962. The data are stored in the Cooperative Shark Mark-Recapture Database (CSMRD) which is maintained by the Apex Predators Program of the Northeast Fisheries Science Center. More than 290,000 fish of 52 species have been tagged and more than 17,000 fish of 33 species have been recaptured (<https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html>). Details about the Program and a summary of the data for 1962-1993 are described in Kohler et al. (1998). As noted on the Program's website, most sharks were tagged by anglers, but scientists, NMFS fisheries observers, and commercial fishermen using primarily longlines, handlines, gillnets and trawls account for the remainder. Commercial fishermen report most of the recaptures. In recent years, the Program has expanded to include sharks tagged by thousands of volunteers distributed along the Atlantic and Gulf Coasts of North America and Europe. Data pertaining to the 22 Greenland sharks tagged and recaptured during 1962-1993 were previously summarized in Kohler et al. (1998), but are also discussed here, along with additional data from the CSMRD for 1994-2017.

Apex Predators Program Large Coastal Shark Survey and Shark Tournaments

Since 1986, bottom longline surveys for large coastal sharks have been conducted during mid-April-May, every two to three years, by scientists from the NEFSC's Apex Predators Program (<https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/survey.html>). This survey is the longest fishery-independent survey of sharks in the U.S. Atlantic Ocean. The surveys were conducted from Florida to Delaware at depths of 9-73 m for the purposes of tagging and collecting biological and other stock assessment-related data. As a result of the survey's shallow depth range, catches of Greenland sharks, a deepwater species, were not expected (Lisa Natanson, pers. comm., May 30, 2017). However, for thoroughness, the database was queried for catches of this species.

The Apex Predators Program staffs also collected data on species, sex and size composition of pelagic and coastal sharks caught in recreational shark tournaments held off the U.S. East Coast during 1961-2009. This database was also queried for catches of Greenland sharks (Lisa Natanson, pers. comm., May 30, 2017).

NEFSC Bottom Trawl Survey

The NEFSC Bottom Trawl Survey Database was queried for Greenland shark catches during 1963-2017. Surveys included in the database have been conducted between the Gulf of

Maine and Cape Hatteras, North Carolina, at depths of 6-366 m, during spring (mainly March-April) and fall (mainly September-October) since 1968 and 1963, respectively. The database also included surveys conducted during winter (February) and summer (June or July), but the time series were shorter and sometimes sampling areas were more limited. The surveys consisted of a stratified, random design and sampling occurred round-the-clock. Data from all surveys were included in the query.

Southeast Pelagic Fishery Observer Program

Since 1992, the Southeast Fisheries Science Center of NOAA Fisheries has operated a Pelagic Observer Program (POP) that utilizes specially trained scientists to document the catches and gear characteristics of the pelagic longline fleets that operate within the US EEZ (Figure 2). Details about the Program can be found in Keene (2016). The POP database was queried for Greenland shark bycatch during 1992-2017 (Sascha Cushner, pers. comm, May 25, 2018).

Southeast Shark Bottom Longline Fishery Observer Program

Fishery observers have sampled the directed bottom longline fishery for sharks in the Atlantic Ocean and Gulf of Mexico since 1994 (Mathers et al. 2017). A map of fishing effort (Figure 3) indicates the geographic coverage of this Program (Carlson et al. 2012). The database was queried for Greenland shark bycatch during 1994-2017.

Southeast Gillnet Fishery Observer Program

The Southeast Gillnet Observer Program (SGOP) covers anchored (sink and stab), strike, or drift gillnet fishing, regardless of target, by vessels that fish year-round from Florida to North Carolina and the Gulf of Mexico (Mathers et al. 2017). The Gulf of Mexico is not considered here because it does not constitute Greenland shark habitat. Previously, there was a much larger directed drift gillnet fishery for small and large coastal sharks which was also sampled by the SGOP observers and these data were also contained in the subject database.

Highly Migratory Species Catch Logbooks

Since 1986, all permitted domestic longline vessels have been required to report effort and catch data by set. Beginning in 2015, several databases were combined into a single database, the Unified Data Processing System (UDP), which contains the Highly Migratory Species (HMS) logbook data. The UDP contains data from the former Fisheries Logbook System (FLS) and Domestic Longline System (DLS), as well as the SE Coastal logbook data. The latitudinal range of the trips contained in the UDP is from about 50° N to about 0° N and database was queried for trips from 1986 to 2017 (Matt Maiello, pers. comm., May 29, 2018).

3.0 Results

Northeast Fisheries Observer Program

During 1989-2017, incidental catches of seven Greenland sharks were documented by NEFOP observers in U.S. commercial fisheries. All individuals were caught by bottom trawlers fishing offshore, along the upper slope of the U.S. As described in Moore et al. (2013), an individual estimated at 500 kg was caught on September 10, 1979 (and photographed), just south of Tom's Canyon, at a depth range of 246-380 m. A female 4.5 m long, also estimated at 500 kg, was described by another observer and was caught in nearly the same vicinity, but at a depth range of 197-215 m. This female had consumed 75 fresh *Illex* and two deep sea red crabs, *Chaceon quinque-dens*. The NEFOP database indicated that incidental catches of Greenland sharks occurred in offshore bottom trawl fisheries during 1979, 2008 and 2012 (Table 1). All of the catches were verified by shark identification experts based on photos and written observer descriptions and drawings. A single individual was caught during August of 2008 (individual A in Figure 4) and four individuals were caught during September of 2012 (individuals B-E in Figure 4). Individuals B-E were caught during the same trip during each of two hauls. All five individuals were returned alive.

Southeast Pelagic Fishery Observer Program

During 1992-2017, there were no records of Greenland shark catches for trips sampled by observers from the Southeast Pelagic Fishery Observer Program (Sascha Cushner, pers. comm., May 25, 2018).

NMFS Cooperative Shark Tagging Program

During 1962-2016, over 290,000 fish of 52 species have been tagged and more than 17,000 fish of 33 species have been recaptured (<https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html>).

Of this large number of tagged sharks, only 22 were Greenland sharks tagged during 1962-1993 (Kohler et al. 1998). One of the sharks was recaptured off the west coast of Norway after one year at-large. An additional 67 individuals were tagged between 1994 and 2017. During 1962-2017, a total of 89 Greenland sharks were tagged and one was recaptured. However, only six of these individuals were caught off the U.S. East Coast (Figure 5). The northernmost catch occurred about 50 km east of Gloucester, MA in the Gulf of Maine. The fish was caught on longline gear and was tagged by a NEFOP observer on June of 1982 (Table 2). The other five individuals were also tagged by NEFOP observers and the data collected are also presented in Table 2.

Apex Predators Program Large Coastal Shark Survey and Shark Tournaments

As expected, there were no records of Greenland shark catches in the Apex Predators Program Large Coastal Shark Survey during 1989-2015 or in the database containing shark catches in recreational shark tournaments conducted along the U.S. East coast during 1961-2009 (pers. comm., Lisa Natanson, May 30, 2017).

Southeast Gillnet Fishery Observer Program

During 1998-2017, a Greenland shark has never been encountered in trips sampled by observers from the Southeast Gillnet Fishery Observer Program and the Southeast Bottom Longline Fishery Observer Program (John Carlson, pers. comm., May 25, 2018).

NMFS Highly Migratory Species Logbooks

During 1986-2017, no Greenland shark catches were recorded on trips contained in the Highly Migratory Species logbook database, which covers the entire U.S. East Coast, from Maine to Florida.

4.0 Discussion

Most of the databases queried for Greenland shark catches off the U.S. East Coast did not contain any records of this species. Only the NMFS Cooperative Shark Tagging Program (N=90 during 1962-2017, but only six individuals were caught off the U.S. East Coast) and the Northeast Fisheries Observer Program (N=7 individuals during 1989-2017) documented catches of Greenland sharks, for a total of 13 individuals caught off the U.S. East Coast during 1962-2017. However, most fisheries in this area only occur at depths of up to approximately 400 m. The measured total length range for females was 183-427 cm. All but one individual was caught in a bottom trawl fishery and seven fish were caught at depths between 206 and 313 m where the surface water temperatures for some catch locations were very warm, 25.6-26.7, due to the influence of the Gulf Stream.

A tagging study conducted by Campana et al. (2015) showed that Greenland sharks that inhabit the Northwest Atlantic and Arctic Oceans are capable of long distance migrations. Two individuals tagged near the edge of the upper slope of the Scotian Shelf traveled in a southwest direction as far as Cape Hatteras, North Carolina (Figure 6). This suggests that greater numbers of Greenland sharks may be found in deeper waters off the U.S. East Coast.

The subject study documented Greenland shark catches as far south as 38.2500° latitude, which extends the southern limit of the species' geographic range. A Greenland shark was previously documented south of this catch location, but it was found in much deeper water and the sighting may have been due to the fact that bait was used to lure fish to the site. It was observed in 1988 when an unmanned research submersible filmed a male that was reportedly 6 m long at a depth of 2,200 m about 370 km east of Savannah, Georgia (Herdendorf and Barra 1995). The northernmost limit of a Greenland shark catch off the U.S. East Coast occurred in the Gulf of Maine at 42.6333° latitude.

The U.S. has regulated shark fisheries since 1993 and manages 39 species. In 1999, a Fishery Management Plan (FMP) that includes sharks, swordfish, and tunas went into effect and the FMP's shark management measures included catch limits and quotas. Greenland sharks are not included in the FMP, probably because, as indicated here, few individuals have been caught in East Coast fisheries. However, the results of other studies suggest that Greenland

sharks may exist in greater numbers in deeper water beyond the U.S. slope and if fisheries move into deeper water in the future, the species may be caught more frequently.

5.0 Acknowledgements

I am very grateful to the following individuals who provided me with background documents and other information about the programs they either administer or are associated with and either sent me data or queried their databases for Greenland shark catches: John Carlson, Sascha Cushner, John Galbraith, Ken Keene, Nancy Kohler, Matt Maiello, Joe Mello and Lisa Natanson.

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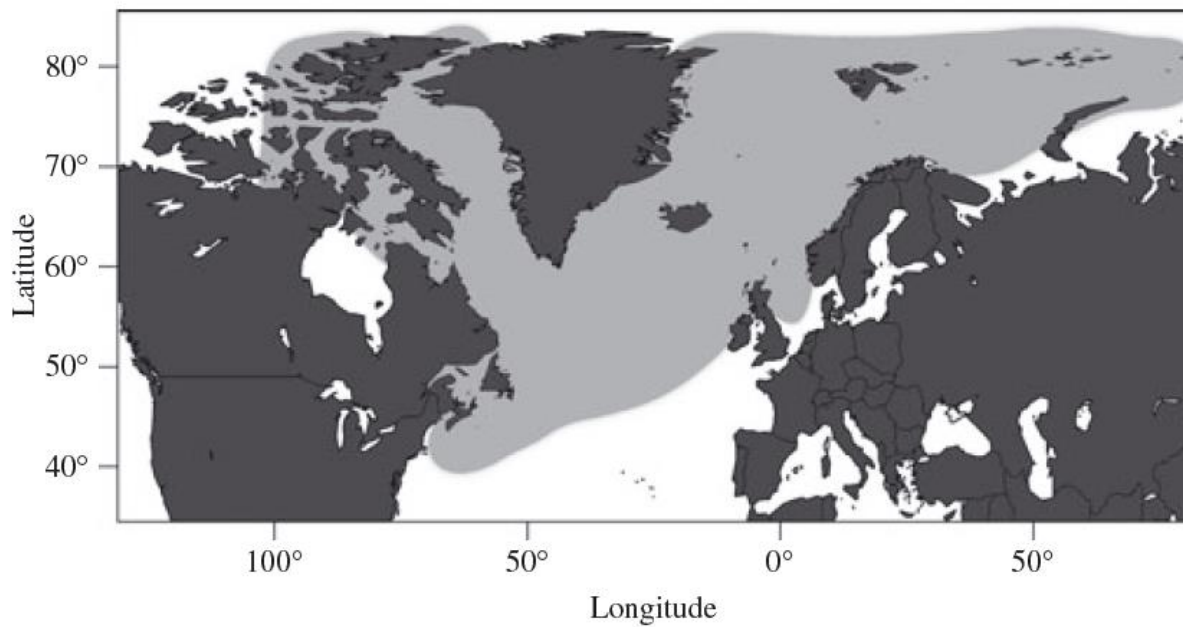


Fig. 1. The geographic range of Greenland shark, *Somniosus microcephalus* (from MacNeill et al. 2012).

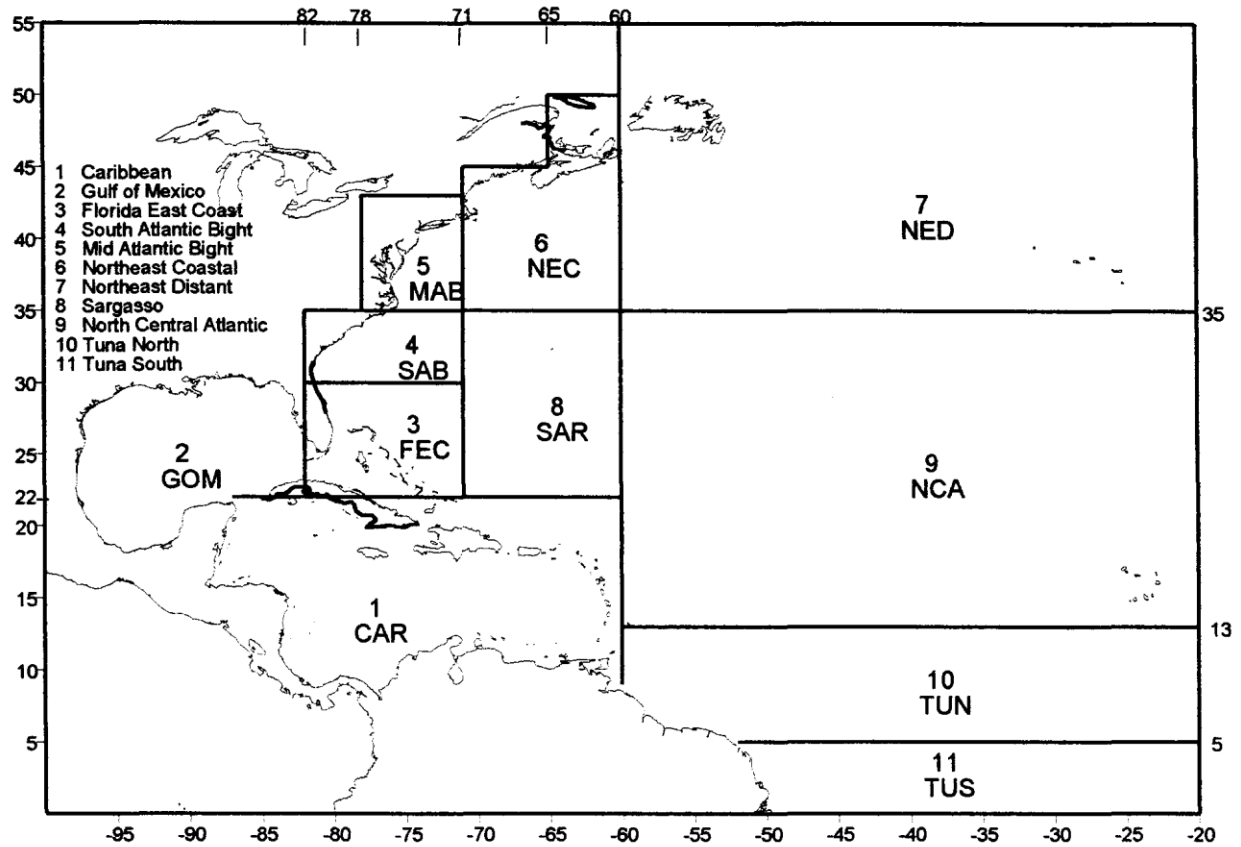


Fig. 2. Catch and effort reporting areas for U.S. pelagic longline fisheries that are sampled by the Pelagic Observer Program (from Lee and Brown 1998).

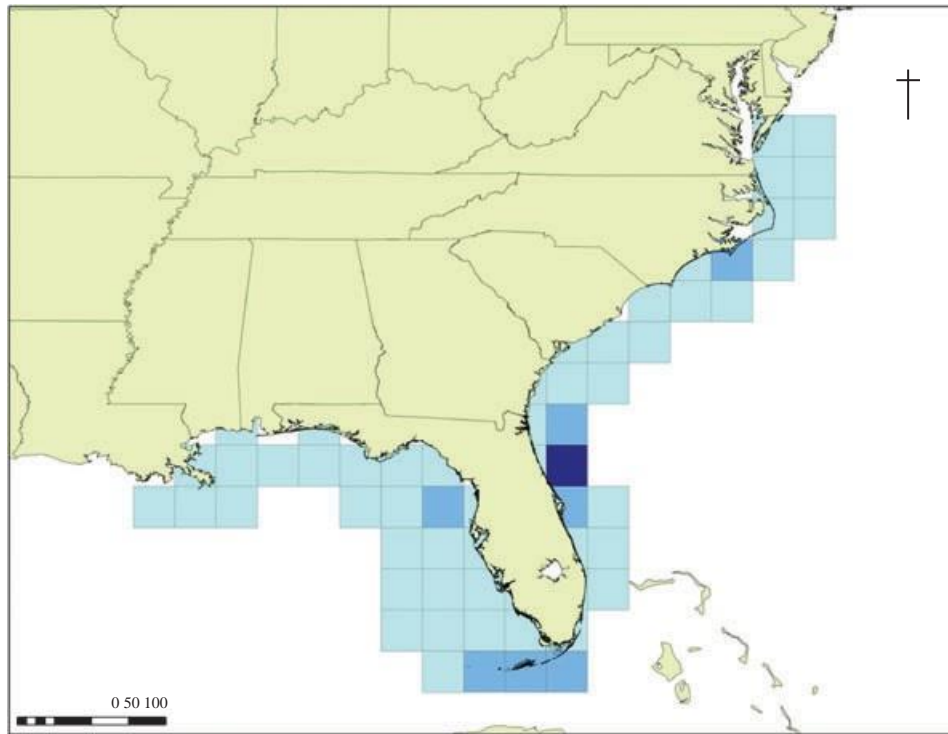


Fig. 3. Distribution of observed fishing effort in the directed U.S. coastal shark longline fishery, during 1994 – 2009 (number of sets: 1-50, 51-100, 101-150, 151-200, 201-300). This fishery is sampled by the Observer Program (from Carlson et al. 2012).

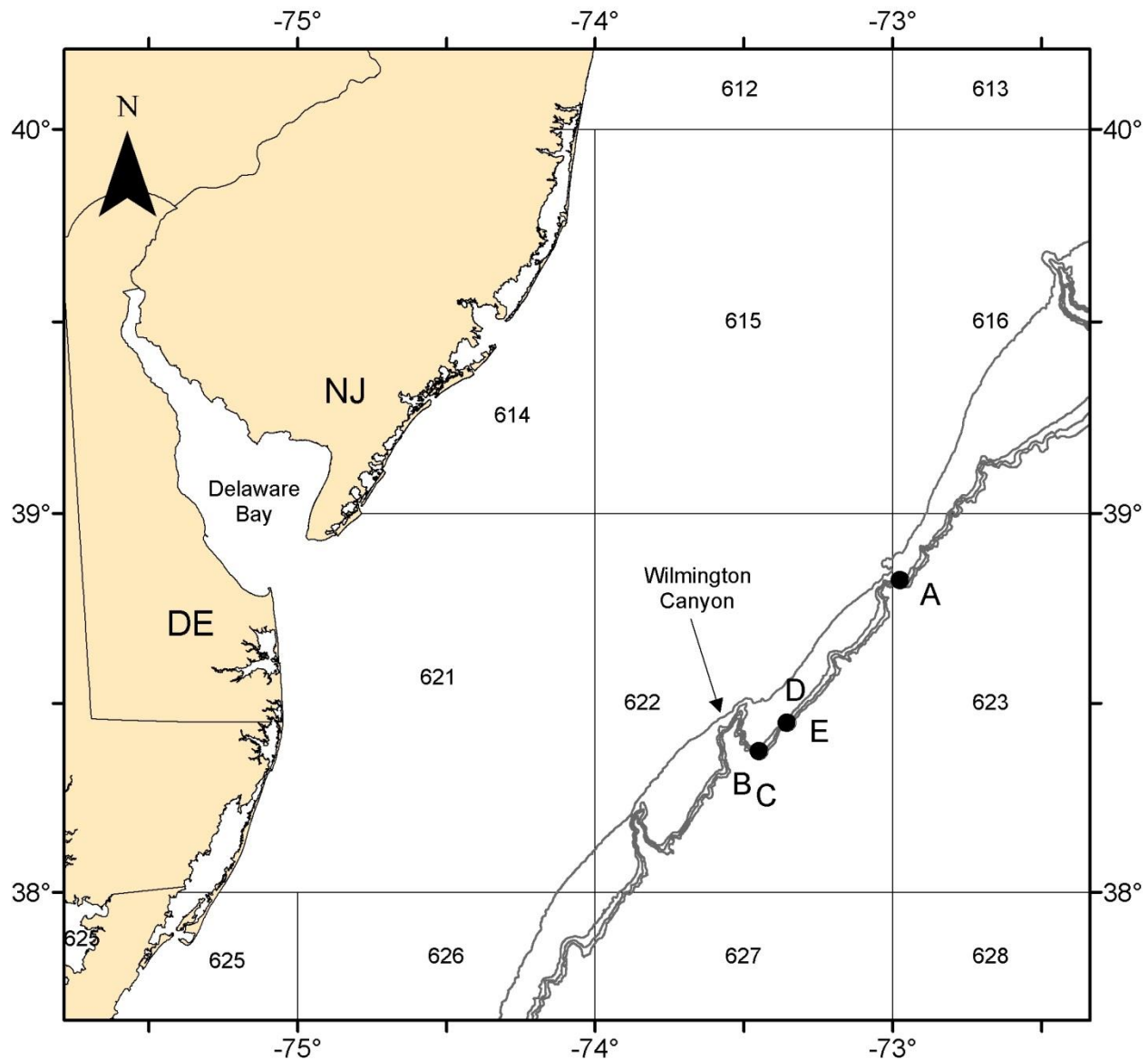


Fig.4. Locations of the five Greenland sharks recorded as bycatch in U.S. East Coast fisheries that operated between the Gulf of Maine and Cape Hatteras, North Carolina during 1989-2017. A single individual was caught in a bottom trawl fishery at location “A”, near Toms Canyon, during 2008 and four individuals (two in each tow) were caught in a bottom trawl fishery at locations “B” – “E” during 2014. The 100, 200, 300 and 400 m isobaths and Statistical Areas used for fishery catch reporting are shown. Data source: Northeast Fisheries Observer Program Database, 1989-2017.

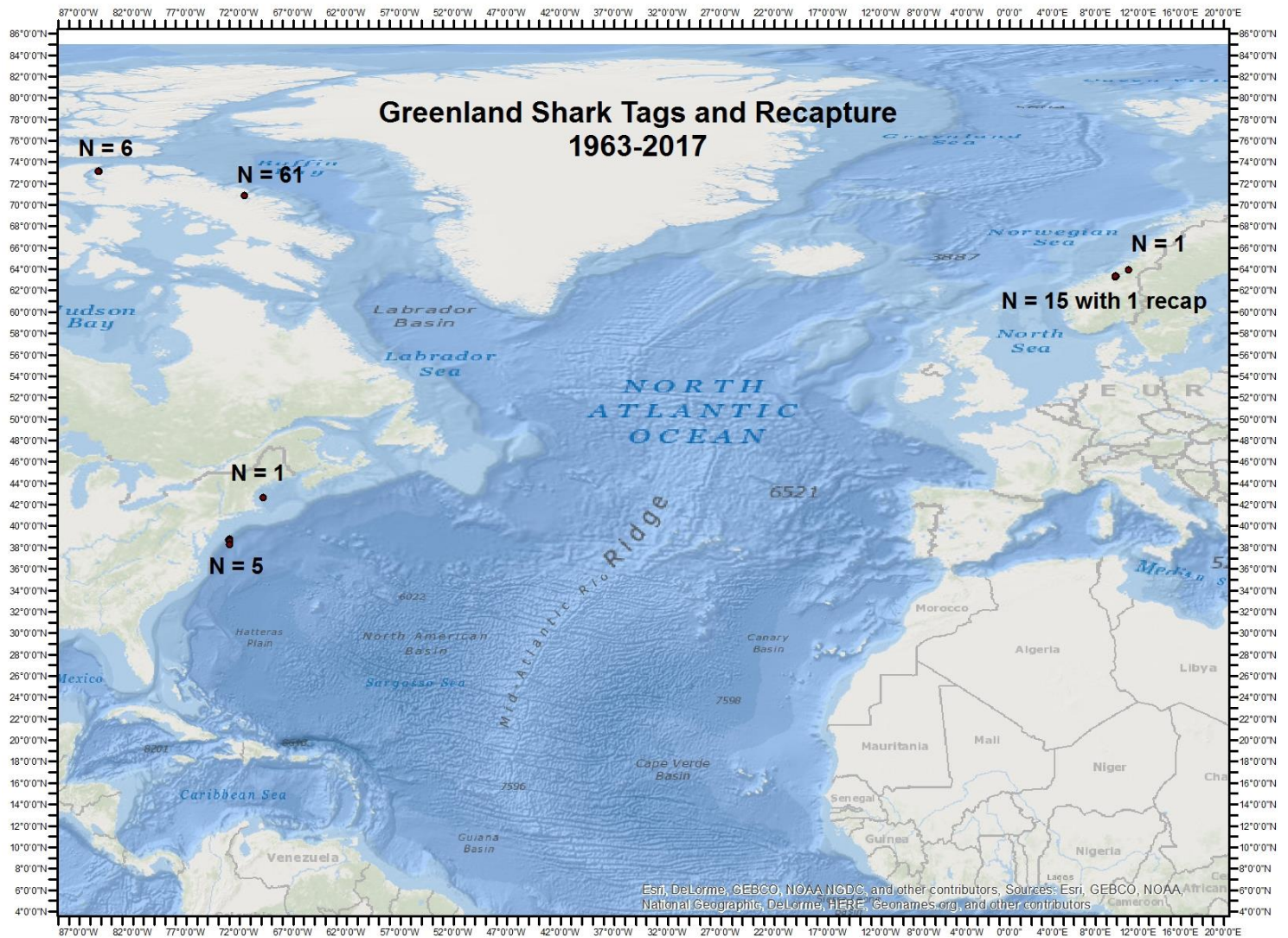


Fig. 5. Locations of 89 tagged Greenland sharks and one recapture recorded in the NMFS Cooperative Shark Tagging Program Database (map provided by Nancy Kohler).

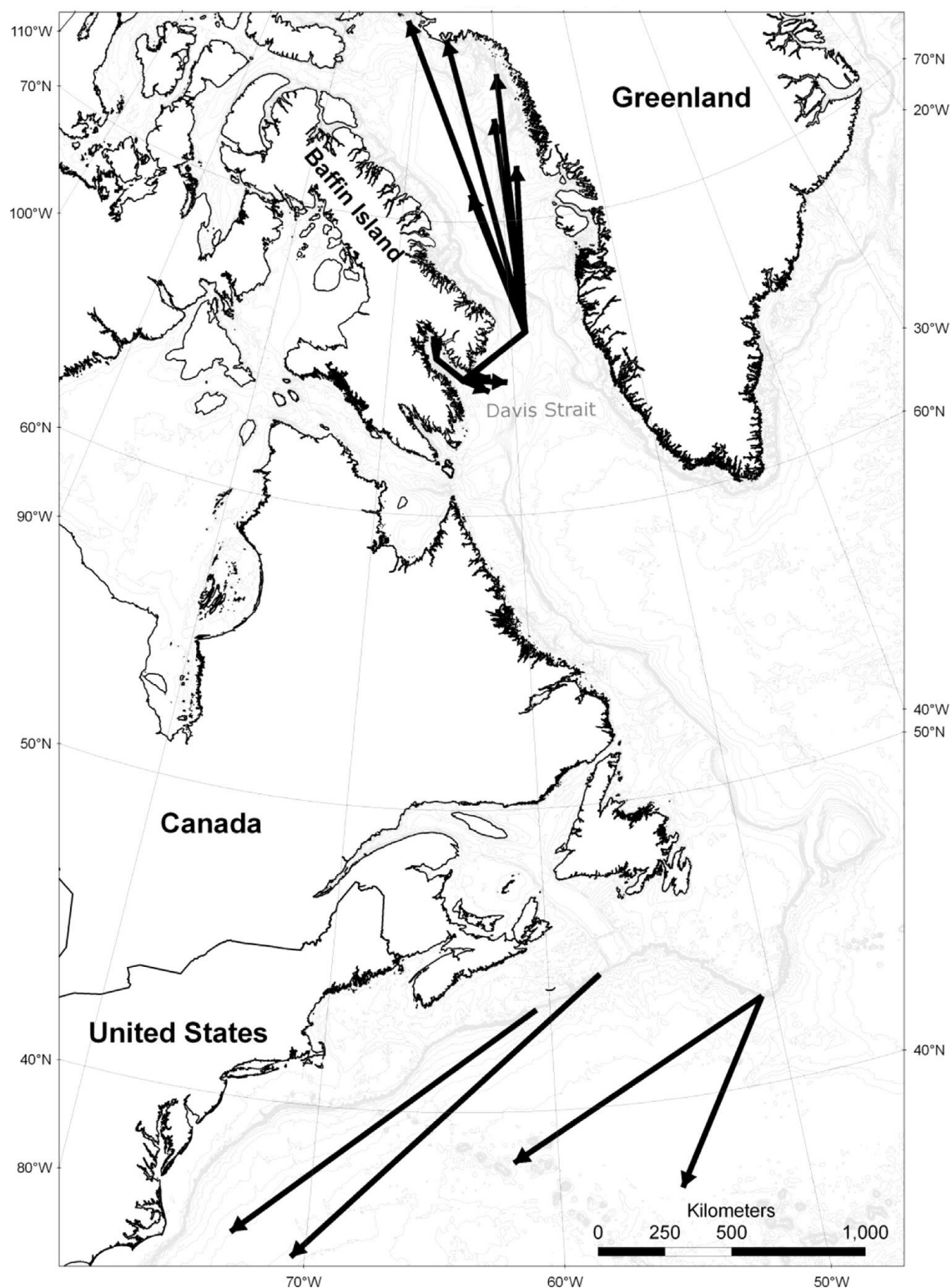


Fig. 6. Net movement of 14 Greenland sharks tagged in the Northwest Atlantic Ocean with pop-up archival transmitting tags (from Campana et al. 2015). Arrowheads indicate the tag pop-up locations.

Table 1. Capture information and biological data for Greenland shark bycatch in U.S. commercial fisheries during 1989-2017. All individuals were caught in offshore bottom trawls and were released alive. Data source: Northeast Fisheries Observer Program.

Individual Number	Catch Year	Catch Month	Catch ¹ Depth (m)	Surface Water Temperature (°C)	Estimated Body Weight (kg)	Estimated Total Length (cm)	Sex
1	1979	9	313	-	500	-	-
2	1979	8	206	-	500	450	F
3	2008	8	252	26.1	181	-	M
4	2012	9	260	25.6	907	490	F
5	2012	9	260	25.6	1,089	540	F
6	2012	9	262	26.7	726	390	F
7	2012	9	262	26.7	1,089	540	F

¹ Catch depth was computed as an average of the depths at the start and end of each haul.

Table 2. Capture information and biological data for Greenland sharks tagged off the U.S. East Coast during 1962-2017. All data were collected by observers from the Northeast Fisheries Observer Program. Data source: NMFS Cooperative Shark Tagging Program.

Individual Number	Catch Year	Catch Month	Estimated Body Weight (kg)	Measured Total Length (cm)	Sex
1	1979	9	-	396	F
2	1979	9	-	411	F
3	1980	8	500	300	F
4	1980	10	-	427	F
5	1981	7	350	366	F
6	1982	6	100	183	F

The length of individual 5 was estimated and is the fork length