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The Conservation of the Greenland Shark (*Somniosus microcephalus*): Setting Scientific, Law, and Policy Coordinates for Avoiding a Species at Risk

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1. INTRODUCTION

Sharks are among the most ancient predators on Earth, having roamed the oceans for more than 400 million years. Previously abundant and widespread, many populations have dwindled to a small fraction of their former abundance[1]

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[1] Nicholas K. Dulvy et al., *You Can Swim but You Can't Hide: The Global Status and Conservation of Oceanic Pelagic Sharks and Rays*, 18 AQUAT. CONSERV.: MAR. FRESHWAT. ECOSYST. 459–482 (2008).

and about one in four species that has enough data available to be assessed is threatened by extinction according to the International Union for the Conservation of Nature (IUCN).[2] Both directed fishing and its unintended bycatch have been mainly responsible for the observed decline in shark populations. In response, a number of policy and management initiatives have been aimed at mitigating these threats, so far with limited success.[3]

In this context, the Arctic is an interesting case because it has largely been spared from intensive industrialized fishing due to unfavourable weather conditions and sea-ice cover. Consequently, shark populations are still thought to be relatively abundant, although comprehensive survey data are lacking to confirm this. Recently, retreating sea-ice cover due to climate change and the requirement for development in indigenous Inuit communities are driving the expansion of Arctic fisheries. These newly developing Arctic fisheries are reportedly catching large numbers of elasmobranchs (sharks, skates, and rays), most frequently the Greenland shark (*Somniosis microcephalus*), the only large shark thought to commonly occur in the eastern Arctic Ocean (see Section 2.3. below). This common bycatch of Greenland shark in some Greenland fisheries has led to their proposed use as a biofuel resource.[4]

Compounding the effects of fisheries bycatch of Greenland shark are their inherent biological vulnerability due to suspected slow growth, late maturity, and limited reproduction. Most large sharks are exceptionally vulnerable to fishing pressure,[5] and are typically slow to recover from overfishing.[6] As scientists are lacking detailed information on Greenland shark life history, ecology, stock structure, and other vital data,[7] it is not possible to accurately predict at which fishing pressure the species will decline and eventually become threatened. The purpose of this article is to highlight recent scientific advancements on the biology of the Greenland shark and indicate how a proactive policy framework could help to avoid sending Greenland sharks on the same trajectory of decline and extinction risk of many of their southern counterparts.

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[2] Boris Worm et al., *Global Catches, Exploitation Rates, and Rebuilding Options for Sharks*, 40 MARINE POL'Y 194–204 (2013).

[3] Brendal Davis & Boris Worm, *The International Plan of Action for Sharks: How Does National Implementation Measure Up*, 38 MARINE POL'Y 312–320 (2013); MARY LACK & GARY SANT, THE FUTURE OF SHARKS: A REVIEW OF ACTION AND INACTION (2011),*at* http://www.pewtrusts.org/our_work_report_detail.aspx?id=327611 (visited 4 January 2013).

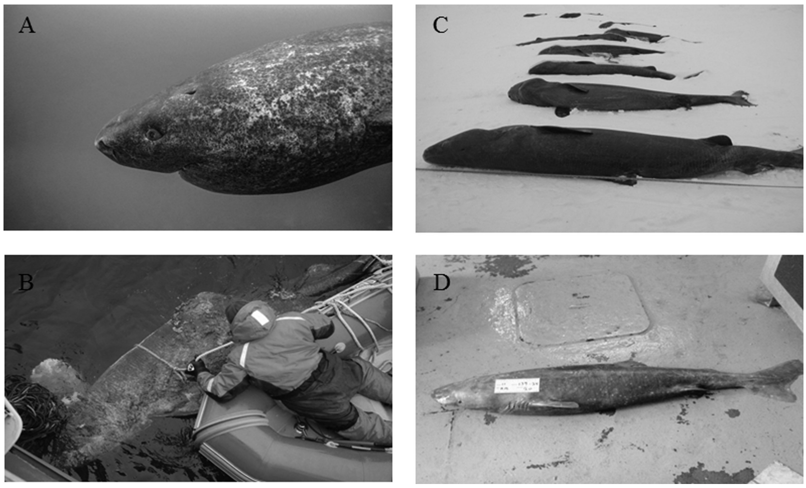
[4] S. Allagui, Press Release, Agence France Presse, *Greenland Shark May Become New Source of Biofuel* (19 July 2009).

[5] J.A. Musick et al., *Management of Sharks and Their Relatives (Elasmobranchii)*, 25 FISHERIES 9–13 (2000).

[6] C.A. Ward-Paige et al., *Recovery Potential and Conservation Options for Elasmobranchs*, 80 J. FISH BIOL. 1844–1869 (2012).

[7] M.A. MacNeil et al., *Biology of the Greenland Shark Somniosus microcephalus*, 80 J. FISH BIOL. 991–1018 (2012).

FIGURE 1. The Greenland shark (*Somniosis microcephalus*). A. A free-swimming Greenland shark; B. Satellite tagging of Greenland shark; C. Greenland shark bycatch; D. Small 20 kg Greenland shark caught in a Canadian Greenland halibut gillnet fishery in 2011 in Baffin Bay (Figure 1D Source: Fisheries and Oceans Canada, Newfoundland and Labrador Region).



2. SCIENTIFIC ADVANCEMENTS OF THE GREENLAND SHARK

2.1 Biology and Ecology

The Greenland shark continues to be an enigmatic species. The harsh Arctic environment, and the absence of commercial fisheries since the 1960s, has limited the ability to collect extensive biological information on the species.[8] The morphology of Greenland sharks is distinct from other elasmobranchs (Figure 1) with a short rounded snout, a heavy body that tapers towards the tail, small rounded pectoral fins, and a small first dorsal fin; caudal fins show variability in shape and size but are generally small relative to body length.[9] Their coloration varies from light brown to near black,[10] with white spots on some individuals.[11] Most commonly individuals are light brown with dark brown mottling.[12] The Greenland shark is similar in morphology to the closely related Pacific sleeper shark (*Sominiosus pacificus*), which may partly overlap in their geographic distribution.[13] Arguably the most notorious characteristic of the Greenland shark is the regular occurrence of the parasite *Ommatokoita*

[8] *Id*. at 992.
[9] *Id*.
[10] MacNeil et al., *supra note* 7.
[11] JOSE I. CASTRO, THE SHARKS OF NORTH AMERICAN WATERS (2011).
[12] MacNeil et al., *supra note* 7.
[13] *Id*.

elongate, which is attached externally and visibly to the sharks' cornea.[14] This parasite may damage or even blind the host.[15]

The reproductive biology of Greenland sharks is poorly understood due to the scarcity of pregnant females and young pups available for fisheries research. Only a few captured females have been found to contain a large number of fertilized eggs (from 1,800–2,931[16]) and are therefore considered to produce yolk-dependent offspring.[17] Based on the few records of small juveniles, it is estimated that size at birth is variable between 40 and 100 cm.[18] To date there is limited knowledge on pupping locations[19] and very few published accounts of size at maturity. MacNeil et al. suggested males mature at a total length (*L*T) of ~260 cm,[20] and Yano et al. indicated the size at maturity of females is *L*T > 400 cm,[21] but these estimates carry large uncertainties.[22] The largest confirmed specimen was *L*T 640 cm and total mass (*M*T) 1,023 kg, placing the Greenland shark as one of the largest of all shark species. The majority of recorded specimens have ranged between *L*T 288 and 504 cm,[23] with females larger than males on average.[24] Due to minimal vertebral calcification, it has not been possible to calculate ages for this species using conventional methods.[25] Based on the tag recapture of a single fish,

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[14] R. Grant, *On the Structure and Characters of the Lernæa elongata, Gr. a New Species from the Arctic Seas*, 7 EDINB. J. SCI. 147–154 (1827).

[15] George W. Benz et al., *Ocular Lesions Associated with Attachment of the Copepod Ommatokoita elongata (Lernaeopodidae: Siphonostomatoida) to Corneas of Pacific Sleeper Sharks Somniosus pacificus Captured off Alaska in Prince William Sound*, 88 J. PARASITOL. 474–481 (2002); J.D. Borucinska, G.W. Benz, & H.E. Whiteley, *Ocular Lesions Associated with Attachment of the Parasitic Copepod Ommatokoita elongata (Grant) to Corneas of Greenland Sharks, Somniosus microcephalus (Bloch & Schneider)*, 21 J. FISH DIS. 415–422 (1998).

[16] MacNeil et al., *supra* note 7; K. Yano, J.D. Stevens & L.J.V. Compagno, *Distribution, Reproduction and Feeding of the Greenland Shark Somniosus (Somniosus) microcephalus, with Notes on Two Other Sleeper Sharks, Somniosus (Somniosus) pacificus and Somniosus (Somniosus) antarcticus*, 70 J. FISH BIOL. 374–390 (2007).

[17] MacNeil et al., *supra* note 7; J.C. CARRIER, H.L. PRATT & J.I. CASTRO, REPRODUCTIVE BIOLOGY OF ELASMOBRANCHS (2004).

[18] MacNeil et al., *supra* note 7; Yano, Stevens, & Compagno, *supra* note 16; V. Kondyurin & N. Myagkov, *Catches of Newborn Greenland Shark, Somniosus microcephalus (Bloch and Schneider)(Dalatiidae)*, 23 J. ICHTHYOL. 140–141 (1983); E. Kukuev & I. Trunov, *The Composition of Ichthyofauna of the Meso-and Bathypelagic Zones of the Irminger Current and of Adjacent Waters*, 42 J. ICHTHYOL 377–384 (2002).

[19] Michelle R. Heupel, John K. Carlson, & Colin A. Simpfendorfer, *Shark Nursery Areas: Concepts, Definition, Characterization and Assumptions*, 337 MAR. ECOL. PROG. SER. 287–297 (2007).

[20] MacNeil et al., *supra* note 7.

[21] Yano, Stevens, & Compagno, *supra* note 16.

[22] MacNeil et al., *supra* note 7.

[23] *Id.*; H.B. Bigelow & W.C. Schroeder, *Sharks*, in FISHES OF THE WESTERN NORTH ATLANTIC, PART 1 (J. Tee-Van ed., 1948); Aaron T. Fisk, Christian Lydersen, & Kit M. Kovacs, *Archival Pop-off Tag Tracking of Greenland Sharks Somniosus microcephalus in the High Arctic Waters of Svalbard, Norway*, 468 MAR. ECOL. PROG. SER. 255–265 (2012).

[24] Yano, Stevens, & Compagno, *supra* note 16; Bigelow & Schroeder, *supra* note 23.

[25] MacNeil et al., *supra* note 7.

Hansen[26] suggested an average growth rate of 0.5 cm year^{-1}, which would make a *L*T 600 cm specimen in excess of 100 years old and among the oldest of any fish species.[27] Though many aspects of the Greenland shark life history are uncertain, all known information indicates that this species may be highly vulnerable to overfishing.

Greenland sharks typically inhabit deep and extremely cold waters, thus they could conceivably colonize much of the world's deep seas.[28] However, their global range is currently not well known.[29] To date, Greenland sharks have been documented between 42–82°N and 41°E–105°W.[30] Tagging information (see Section 2.2 below) indicates both localised movements and large-scale migrations,[31] but very little is known of their spatial ecology.

Greenland sharks are considered to be generalist feeders of both benthic (bottom-living) and pelagic (open-water) organisms, most of them fishes.[32] They also consume a range of invertebrates and marine mammals (most commonly seals).[33] Greenland sharks are known to scavenge on dead marine mammals,[34] and it is unclear yet as to how much they actively prey on these animals.[35] Circular scars believed to be from Greenland shark bites have been documented on living marine mammals.[36] Recent accelerometer results indicate that they cannot achieve the necessary locomotion required for the capture of free swimming marine mammals,[37] but they may employ ambush predation, most probably around breathing holes of marine mammals trapped under sea ice[38], or predate on sleeping seals in the water column.[39] Furthermore,

[26] P. Hansen, *Tagging Experiments with the Greenland Shark (Somniosus microcephalus (Bloch and Schneider)) in Subarea* 1*,* 4 SPEC. PUBL. INT. COMM. NW ATL. FISH. 172–175 (1963).

[27] MacNeil et al., *supra note* 7.

[28] *Id.*

[29] *Id.*

[30] Fisk, Lydersen, & Kovacs, *supra* note 23.

[31] MacNeil et al., *supra* note 7; Hansen, *supra* note 26; Fisk, Lydersen, & Kovacs, *supra* note 23.

[32] MacNeil et al., *supra* note 7; Bailey C. McMeans et al., *Diet and Resource Use among Greenland Sharks (Somniosus microcephalus) and Teleosts Sampled in Icelandic Waters, Using δ13 C, δ15N, and Mercury*, 67 CAN. J. FISH. AQUAT. SCI. 1428–1438 (2010); Lisa-Marie E. Leclerc et al., *A Missing Piece in the Arctic Food Web Puzzle? Stomach Contents of Greenland Sharks Sampled in Svalbard, Norway*, 35 POLAR BIOL 1197–1208 (2012); Bigelow & Schroeder, *supra* note 23; Fisk, Lydersen, & Kovacs, *supra* note 23.

[33] MacNeil et al., *supra* note 7; Leclerc, et al., *id*; Fisk, Lydersen, & Kovacs, *supra* note 23.

[34] Lisa-Marie Leclerc et al., *Greenland Sharks (Somniosus microcephalus) Scavenge Offal from Minke (Balaenoptera acutorostrata) Whaling Operations in Svalbard (Norway)*, 30 POLAR RES. (2011), *at* http://www.polarresearch.net/index.php/polar/article/view/7342 (visited 13 December 2012).

[35] MacNeil et al., *supra* note 7.

[36] *Id.*

[37] Yuuki Y. Watanabe et al., *The Slowest Fish: Swim Speed and Tail-beat Frequency of Greenland Sharks*, 426–427 J. EXP. MAR. BIOL. ECOL. 5–11 (2012).

[38] MacNeil et al., *supra* note 7; Watanabe et al., *id*.

[39] Bailey C. McMeans et al., *The Role of Greenland Sharks (Somniosus microcephalus) in an Arctic Ecosystem: Assessed via Stable Isotopes and Fatty Acids*, MAR. BIOL. (2 April 2013), *at* http://link.springer.com/10.1007/s00227–013–2174-z (visited 8 December 2012).

recent studies by Leclerc et al.[40] and McMeans et al.[41] confirm that Greenland sharks do actively feed on live seals, as they observed, consistently, non-scavenged seal tissue in their stomachs.

2.2 Tracking Information

Movement and migration patterns of the Greenland shark largely remain unknown due to the logistical difficulties of studying fish in the Arctic environment. Typically the Greenland shark was considered a cold and deep water benthic species confined to Arctic and North Atlantic waters, but recent tracking data have indicated wider movements, and raised questions on whether it can be considered a true Arctic species. To date, conventional marker tags, active or passive acoustic tracking, and pop-up satellite archival tags (PSATs) have all been used to examine residency and movement patterns and to derive data on habitat and temperature preferences. These data indicate the Greenland shark is a large mobile species that crosses national and international boundaries.

The first tagging of Greenland sharks was undertaken in coastal waters and fjords off Greenland by Hansen.[42] Between 1936 and 1949 a total of 411 sharks were tagged and released, with 28 individuals later recaptured. Some sharks were re-caught less than 60 miles from the tagging location following up to 14 years at liberty, while two individuals moved approximately 700 miles over seven and eight years, respectively. These preliminary data indicated that Greenland sharks have variable movement patterns with no obvious trend in distance travelled. Much later, Skomal and Benz[43] undertook the first acoustic tracking of six Greenland sharks through ice holes off North Baffin Island in the Arctic Archipelago. All recorded movements were local, largely due to the short-term nature of the acoustic tracks (6 to 73 hours). Importantly, these data revealed that Greenland sharks were not strictly a deep-water benthic species with two individuals undertaking vertical movements close to the ice surface. The authors suggested that these shallow-water movements likely related to the sharks interacting with seals, a common prey item. Although the sharks did not show consistent depth or temperature preferences, there was a tendency for sharks to remain deeper in the morning, moving into shallow waters during the afternoon and night. Stokesbury et al. reported further evidence questioning the benthic character of the Greenland shark and documenting

[40] Leclerc et al., *supra note* 32.

[41] McMeans et al., *supra note* 39.

[42] Hansen, *supra* note 26.

[43] G.B. Skomal & G.W. Benz, *Ultrasonic Tracking of Greenland Sharks, Somniosus microcephalus, under Arctic Ice*, 145 MAR. BIOL. 489–498 (2004).

pelagic movements in the water column.[44] Through a combination of acoustic and satellite telemetry in the comparatively shallow waters of the St. Lawrence Estuary, these authors found that Greenland sharks increased vertical activity at night with some evidence for diel differences in depth and temperature preferences.

More recently Fisk et al.[45] and Campana et al.[46] attached satellite tags to a larger number of Greenland sharks off Svalbard, Norway (n = 20) and in the Canadian Arctic and Northwest Atlantic (n = 15), respectively (Figure 1B). Greenland sharks tagged off Svalbard generally moved north and travelled a distance <500 km from the tagging location, with the exception of two sharks that moved up to 900 km, without a defined migration pathway. In contrast, the movements of sharks tagged in Canada were highly directional. In the Canadian Arctic all sharks exited Cumberland Sound and undertook northerly movements between 315 and 1,615 km. These sharks ranged in size between 243 and 325 cm FL (fork length) and were reported as immature. In contrast, three large Greenland sharks (376–516 cm FL; estimated to be mature) tagged off the east coast of Canada travelled minimum distances between 735 and 1,505 km, all in a southerly direction. These movements were off the continental shelf into abyssal waters and included the deepest recorded dive for this species, to 1,816 m depth.[47] Interestingly these sharks also encountered temperature ranges of 2.6–17.2°C, which is a larger range than those previously reported. These temperature profiles and habitat preferences may suggest that Greenland sharks could be more wide-ranging than previously assumed and that northern movements of tagged juvenile sharks may be a result of the sharks seeking protection from larger predators.

To build on and improve our understanding of the long-term movement patterns of Greenland sharks, the Ocean Tracking Network (OTN) has deployed acoustic monitors at several Arctic regions (Resolute Bay, Maxwell Bay, Clyde River, and Cumberland Sound) (Figure 2). These acoustic monitor arrays complement other OTN deployments in the North Atlantic. A total of 43 acoustic tags (VEMCO V16–6H; life span of 3,650 days) have so far been surgically implanted in Greenland sharks between 2010 and 2012, and 12 high resolution time series PSATs have been deployed for periods ranging between 42 and 300 days (Figure 2).

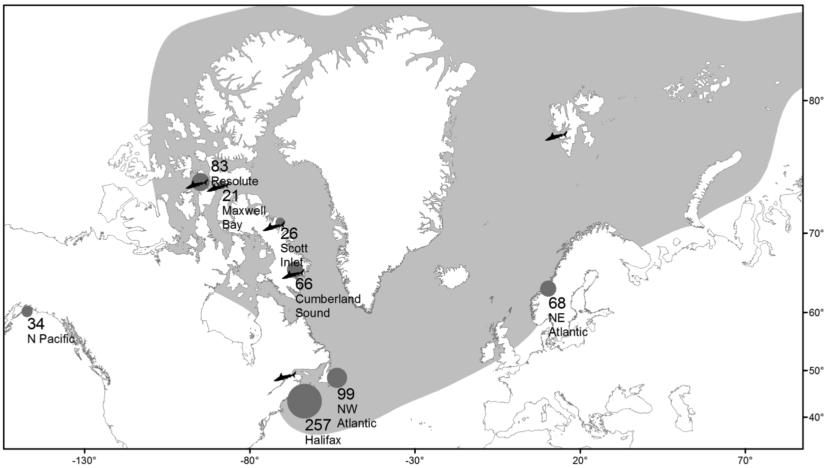
[44] Michael J.W. Stokesbury et al., *Movement and Environmental Preferences of Greenland Sharks (Somniosus microcephalus) Electronically Tagged in the St. Lawrence Estuary, Canada*, 148 MAR. BIOL. 159–165 (2005).

[45] Fisk, Lydersen, & Kovacs, *supra* note 23.

[46] S. Campana, *Pelagic and Benthic Migrations of Arctic and Northwest Atlantic Greenland Sharks (Somniosus microcephalus) as Monitored with Archival Satellite Popup Tags*, DEEP-SEA RES. in review .

[47] *Id.*

FIGURE 2. Greenland shark distribution and tagging efforts. The infrastructure for current Greenland shark tracking efforts is indicated. Black dots represent the location and numbers of Ocean Tracking Network (OTN) acoustic monitors; shark symbols represent tagging locations of Greenland sharks equipped with acoustic or satellite tags; and shaded grey area represents the assumed Greenland shark distribution.



This work has discovered a potential shark nursery in Scott Inlet, Baffin Island, Canada. Here, juvenile Greenland sharks have been caught over two consecutive years, and the smallest Greenland shark tagged to date (117 cm FL) was released in September 2012. Initial acoustic telemetry data from nearby Cumberland Sound demonstrate that some individuals remain in the Sound for short periods, up to approximately 50 days, but that most animals exit following tagging (Hussey and Fisk, unpublished data), in agreement with Campana et al.[48] The high resolution time series PSATs show that Greenland sharks undertake oscillating vertical movements similar to many pelagic fishes,[49] with uniform oscillatory diving patterns interspersed with occasional deeper dives (Hussey and Fisk, unpublished data). It is anticipated that data generated from OTN will provide the first long-term information on individual shark movements and will begin to discern population-level movement patterns required for species-specific management plans. Long-term tracking is required given the Greenland sharks' large size and potential longevity and very slow swimming speeds.[50]

[48] *Id.*

[49] Barbara A. Block et al., *Migratory Movements, Depth Preferences, and Thermal Biology of Atlantic Bluefin Tuna*, 293 SCIENCE 1310–1314 (2001); I. Nakamura et al., *Yo-Yo Vertical Movements Suggest a Foraging Strategy for Tiger Sharks Galeocerdo cuvier*, 424 MAR. ECOL. PROG. SER. 237–246 (2011).

[50] Watanabe et al., *supra* note 37.

2.3 Catch and Bycatch Information

Accounts of directed fishing for Greenland sharks date back to the 16th century in Iceland.[51] However, it was not before the 1950s that the Food and Agriculture Organization of the United Nations (FAO) reported landings for the species.[52] Historically, the species has been heavily fished for its liver oil by Norway, Iceland, and Greenland, particularly during the 17th and 18th centuries with an increased market demand in Europe. Estimated catches grew from 2,000 to 3,000 sharks per year to 11,500 to 15,000 sharks per year at the end of the 18th century and peaked at 32,000 sharks in 1910 in Greenland alone.[53] These directed fisheries ceased in the early to mid-1990s due to a decrease in demand for oil. The impact of these fisheries on Greenland shark populations remains unknown. Since the 1970s, Iceland accounts for most of the reported catch to the FAO, which has remained below 100 tonnes annually.[54] The sharks are currently used for human and sled-dog food. Greenland sharks are a common bycatch species in Arctic and subarctic demersal fisheries (Figure 1C, D; Figure 3; Table 1).[55] It is probable that a significant number of sharks are discarded dead every year in these fisheries. However, these incidental catches and discards are poorly quantified and not reported to FAO.

TABLE 1. Greenland shark bycatch in Arctic Canadian fisheries from 2003 and 2011.

Fishery	Gear	Total number of fishing sets observed	Mean depth of fishing (m) ± SD	Percent sets with bycatch	Total catch (kg)	CPUE
Greenland	twin trawl	4942	990 ± 129	23.4	528470	106.93
Halibut	otter trawl	3692	1001 ± 136	16.1	243760	66.02
	bottom longline	645	1056 ± 98	12.4	33525	51.98
	gillnet	4492	1041 ± 136	9.1	151390	33.70
Shrimp	shrimptrawl (with Nordmore grid)	11280	335 ± 51	0.07	4940	0.44
	triple trawls	286	303 ± 44	0	0	0
	twin trawl	4737	320 ± 50	0	0	0

Note: all fixed gears (i.e., gillnet and bottom longlines) have not received 100 per cent observer coverage; the numbers in this table represent an unknown fraction of the total amount captured by these fisheries over the time period. CPUE: catch-per-unit-of-effort (kg per fishing event).

[51] MacNeil et al., *supra note* 7.

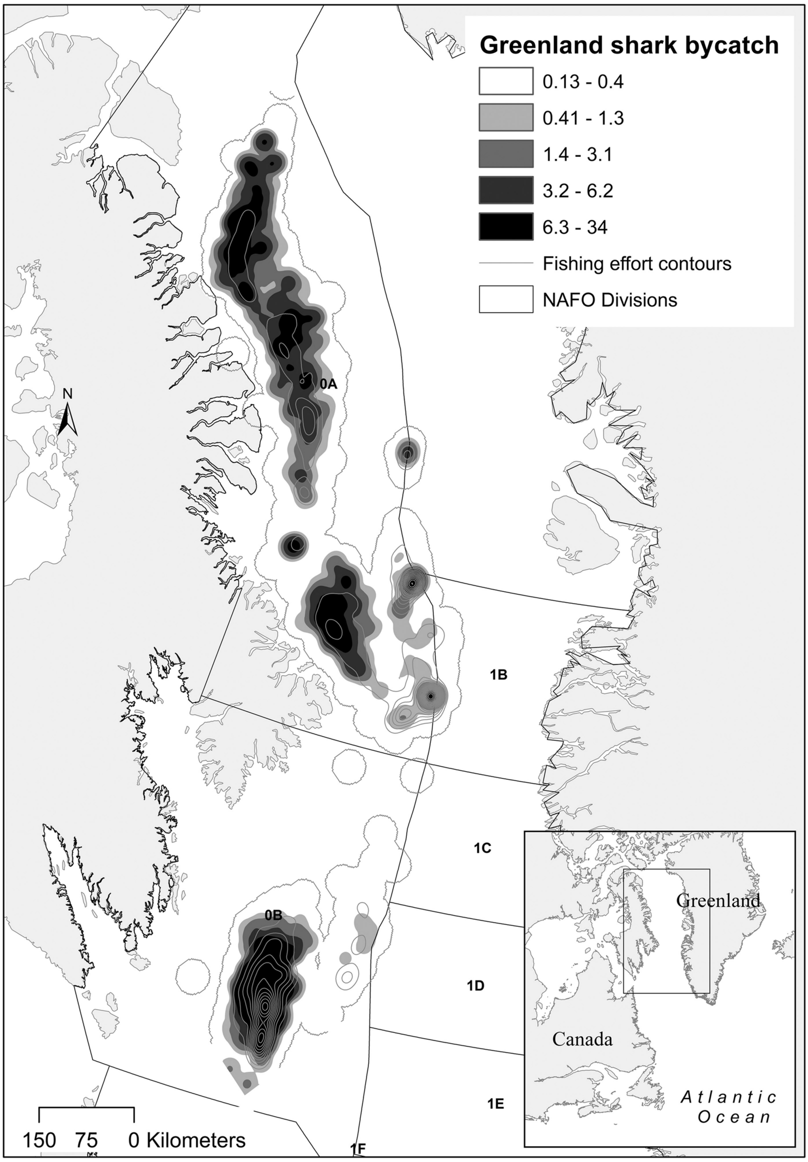
[52] Food and Agricultural Organization of the United Nations, *Global Capture Production, Global Statistical Collection* (2012), *at* http://www.fao.org/fishery/statistics/global-capture-production/en [hereinafter FAO] (visited 12 February 2013).

[53] ADOLF SEVERIN JENSEN, THE SELACHIANS OF GREENLAND (1914), *at* http://archive.org/details/selachiansofgree00jens (visited 11 January 2013).

[54] FAO, *supra* note 52.

[55] MacNeil et al., *supra* note 7.

FIGURE 3. Greenland shark bycatch in Arctic fisheries for Greenland halibut (trawls and gillnets) with Northwest Atlantic Fisheries Organization (NAFO) Divisions. Kernel density analysis shows fishing location overlaid with Greenland shark bycatch (kg) on 2 km × 2 km grid cells. For simplicity, contour lines and quantiles are displayed for fishing locations and Greenland shark bycatch, respectively. Areas of black shades highlight the areas of highest shark bycatch.



Canadian fleets have been fishing eastern Arctic waters since the 1970s, but have greatly expanded their geographic effort following the cod moratorium in 1992. Since 2003, nearly all offshore fisheries conducted in Baffin Bay and Davis Strait have received observer monitoring, recording bycatch of Greenland sharks at a very fine scale. This has presented a unique opportunity to study the spatial and temporal catch patterns of this species (Figure 3). Canadian Arctic fisheries target Greenland halibut (*Reinhardtius hippoglossoides*) and northern shrimp (*Pandalus species*), and, most recently, crab species. The majority of Greenland shark bycatch is associated with Greenland halibut trawling activities (Table 1). The Greenland halibut fishing season is limited by the extent of seasonal sea-ice formation and primarily occurs May through December in deep waters (800–1200 m) along the shelf slopes. Greenland shark bycatch appears to follow patterns of fishing effort and target catch; areas of high fishing effort and catch are associated with large bycatch of Greenland sharks (Figure 3).

For fisheries monitoring, Canadian at-sea observer programmes do not provide the number of sharks captured but rather a total weight (kg) per fishing set. This significantly limits the ability of scientists and managers to estimate the impact of these fisheries on the Greenland shark population or to infer any changes in age and size structure for that population. Communication with fisheries observers and recent count information collected from Newfoundland and Labrador suggest that many small sharks (<50 kg) are also caught. These are likely young-of-the-year or juvenile sharks, most of which are caught in gillnet fisheries in Baffin Bay, with up to 40 sharks caught per set. Although some of these records could be misidentified black dogfish (*Centroscyllium fabricii*), photographic records indicates otherwise (Figure 1D). These observer results combined with recent tracking data of juvenile sharks (see Section 2.2.) confirms the assertion that pupping grounds for Greenland sharks are likely located in and around northeastern Arctic Canadian waters, warranting further investigation.

2.4 Inuit Knowledge and Interactions

The Greenland shark is historically not considered an important species for Inuit culture due to its occurrence in deep waters and the consequent lack of interactions. However, since the development of Greenland halibut fisheries through ice holes in the 1980s, and associated bycatch of Greenland sharks, there has been a marked increase in direct interactions. Greenland sharks caught as bycatch on longlines typically roll upon capture, resulting in the base longline wrapping around the entire animal, in particular the caudal fin. This behaviour results in excessive snarling of the lines and damage or loss of fishing gear. To remove Greenland sharks caught in this manner, the tail is often removed and the remaining animal carcass discarded through the ice hole. Although shark finning, the practice of removing fins while disposing the carcass at sea, has been illegal in Canada since 1994,[56] this practice exists in Inuit communities (Hussey and Fisk personal observation). As a result of these negative interactions, the Greenland shark is commonly viewed as a "nuisance species" rather than a species of cultural significance. Given the recent increase in interactions, Idrobo suggested that the Inuit now possess basic knowledge on the Greenland shark in terms of anatomy, food, and behavioural ecology, habitat use as well as their role in Arctic ecosystems.[57] Unfortunately, even with this recent addition to Inuit traditional knowledge, the Greenland shark does not provide any direct social or economic advantage to Inuit communities and consequently its cultural importance remains limited.[58]

The continued development of Greenland halibut fisheries, the increasing potential for shark-human interactions, and the perceived lack of importance of the species to Indigenous peoples presents problems for implementing regional management measures for the Greenland shark throughout the Arctic region. The success of these measures will rest on Inuit communities accepting the important role of this large apex predator within the Arctic ecosystem, much like the marine mammals and commercial fish species that their communities currently depend on. Through education and development of safe handling practices, Greenland sharks could be released successfully from longlines, but post-release mortality would still need to be assessed.

3. MAKING A CASE FOR CONSERVATION

3.1. Developing Arctic Fisheries and the Threat of Overexploitation

Until recently, most Arctic waters were only accessible for a few weeks of the year. Now, with the Arctic warming two-times as fast as any other region on Earth, the Arctic seas are projected to be ice-free in summer as early as 2030.[59] The Arctic marine ecosystem is considered to be extremely sensitive to temperature change, and the effects of climate change are already visible to scientists and Indigenous peoples. Rising temperatures have generated distributional shifts in species as southern species head northward, and significant changes in flora and fauna have occurred.[60]

A number of countries are vocalizing their interests in Arctic resources. Shipping, fishing, and gas and oil exploration are likely to increase as

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[56] Fisheries and Oceans Canada (DFO), National Plan of Action for the Conservation and Management of Sharks (2007), *at* http://www.dfo-mpo.gc.ca/npoa-pan/npoa-pan/npoa-sharks-eng.htm [hereinafter NPOA Sharks] (visited 11 January 2013).

[57] C. J. Idrobo & F. Berkes, *Pangnirtung Inuit and the Greenland Shark: Co-producing Knowledge of a Little Discussed Species*, Hum Ecol 1–10 (2012).

[58] *Id*.

[59] Jennifer Jeffers, *Climate Change and the Arctic: Adapting the Changes in Fisheries Stocks and Governance Regimes*, 37 Ecology L. Q. 917 (2010).

[60] Aevar Petersen, *Emerging Issues and Challenges*, Arctic Biodivers. Trends, 15–16 (2010).

sea-ice cover continues to decrease. Climate change is facilitating access to new fish stocks, and although most fishing today occurs along the Arctic coast by subsistence fishers;[61] industrialized fisheries for northern shrimp, Greenland halibut, and Arctic char (*Salvelinus alpinus*), among other species, are moving northwards. Projected ice-free summers may facilitate an intensification and expansion of maritime activities, including fishing, into areas currently considered pristine. This poses new challenges for existing regional fisheries management agreements.

3.2 The Ecosystem Role of an Arctic Predator

It is unknown how the Greenland shark affects the structure of the Arctic marine ecosystem or the energy flow through marine food webs. However, through studying the sharks' feeding ecology, scientists now have a reasonable understanding of their trophic position.[62] Until recently, the species had been described as an opportunistic scavenger, specializing in the consumption of carrion. New studies have revealed a diverse range of consumed prey (see Section 2.1.).[63] Regionally the sharks' diet varies, but primarily consists of fish and seals. Fisk et al. proposed that the sharks feed in the pelagic zone, at the same trophic level as turbot and ringed seals, and at a higher level than harp seals, thus utilizing the whole water column for foraging. Additional studies on stable isotopes, contaminant metabolites, and fatty acids place the shark at the top of Arctic marine food webs.[64] Other studies that have looked at levels of contaminant accumulation, such as dioxins and polychlorinated biphenyls (PCBs), suggest the species can be used to monitor levels of marine pollution in the Arctic[65] due to the high cumulative concentrations found in the sharks. Collectively, this evidence suggests a generalist feeding strategy consistent with an effect of Greenland sharks on a large number of prey species.

How the "top-down" effects of Greenland sharks propagate through the Arctic ecosystem is unknown. From studies of other species, large sharks generally maintain a high trophic position, and can affect the populations of their prey species when there is little diet overlap between sharks and other predators.[66] They can induce changes in the food web through the release of smaller predators and by inducing anti-predator avoidance behaviours (risk

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[61] A. Lynghammar et al., *Species Richness and Distribution of Chondrichthyan Fishes in the Arctic Ocean and Adjacent Seas*, BIODIVERS. 1–10 (2012).

[62] A.T. Fisk et al., *Using Anthropogenic Contaminants and Stable Isotopes to Assess the Feeding Ecology of Greenland Sharks*, 83 ECOLOGY 2162–2172 (2002); M. J. Vander Zanden, *Trophic Position in Aquatic Food Webs* (August 1999) (unpublished Ph.D. dissertation, McGill University).

[63] Yano, Stevens, & Compagno, *supra* note 16; McMeans et al., *supra note* 39.

[64] Fisk et al., *supra* note 62; 34; McMeans et al., *supra note* 39.

[65] Anna Strid et al., *Dioxins and PCBs in Greenland Shark (Somniosus microcephalus) from the North-East Atlantic*, 54 MAR. POLLUT. BULL. 1514–1522 (2007).

[66] McMeans et al., *supra note* 39.

effects) among mesoconsumers (prey species) and lower-trophic resource species.[67] New research confirms the limited diet overlap of Greenland sharks and other predators, but the extent to which these large-bodied predators induce risk effects on Arctic marine species is unknown.[68]

Change in abundance of apex predators can alter the community structure and function of their associated ecosystems.[69] Well-documented studies indicate that declines in large sharks over time are linked to changes in abundance of prey species. Both species of the family *Somniosidae*, which includes the Greenland and Pacific sleeper shark, are suggested to exert top-down control on marine mammal populations, which indirectly affects lower trophic species. Frid et al. predicted that harbour seals (*Phoca vitulina*) and stellar sea lions *(Eumetopias jubatus*) in Prince William Sound, Alaska, may alter their deep-water foraging behaviour to lessen the risk of Pacific sleeper shark predation. Similarly, in the northwest Atlantic Ocean, off Sable Island, Greenland shark predation is assumed to have reduced the harbour seal pup population by 50 per cent, likely generating similar anti-predator behaviour responses in the affected colonies.[70]

Although the effects of changes in Greenland shark abundance are unknown, a new stable-isotope analysis of the Pacific sleeper shark suggests a change in abundance of this species could have direct effects on the North Pacific Ocean ecosystem.[71] A similar forecast could be made for the Greenland shark and the Arctic Ocean as it is almost identical in habitat and prey preference to the Pacific sleeper shark; both species share similar known life history characteristics of long life and slow growth. As such, detailed studies on Greenland shark diet, distribution, movement, behaviour, habitat preference, and species interactions are essential for understanding its role in the structuring of Arctic marine ecosystems.

3.3 A Case for Proactive Management

Despite the severely limited biological and catch data, the Greenland shark is reported to be abundant throughout its range and is presumed to be under little threat.[72] However, the developing fisheries in the Arctic, the reported

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[67] M.R. Heithaus et al., *Predicting Ecological Consequences of Marine Top Predator Declines*, 23 TRENDS ECOL. EVOL. 202–210 (2008).

[68] McMeans et al., *supra note* 39.

[69] E.G. Ritchie & C.N. Johnson, *Predator Interactions, Mesopredator Release and Biodiversity Conservation*, 12 ECOL. LETT. 982–998 (2009).

[70] M.R. Heithaus et al., *Unraveling the Ecological Importance of Elasmobranchs*, in SHARKS AND THEIR RELATIVES II: BIODIVERSITY, ADAPTIVE PHYSIOLOGY AND CONSERVATION, 611–637 (J.C. Carrier, J.A. Musick, & M.R. Heithaus, eds., 2010).

[71] D.L. Courtney & R. Foy, *Pacific Sleeper Shark Somniosus pacificus Trophic Ecology in the Eastern North Pacific Ocean Inferred from Nitrogen and Carbon Stable-isotope Ratios and Diet*, 80 J. FISH BIOL. 1508–1545 (2012).

[72] MacNeil et al., *supra* note 17.

increase in shark catches, and the shark's assumed role as an Arctic apex predator are factors that call for enacting precautionary measures and proactive approaches to the management and conservation of this species. No such measures have been applied to Eastern and Central Arctic fisheries management in general, or to the Greenland shark in particular. This situation provides the management community with a unique opportunity to apply the precautionary approach to Arctic fisheries governance so as to minimize the combined negative effects of climate change and developing fisheries on sharks and other Arctic wildlife.

4. NASCENT GOVERNANCE ARRANGEMENTS

4.1 The Global Legal Framework

A fragmented array of international agreements and documents, not specifically targeting sharks, is relevant to the conservation of the Greenland shark and other elasmobranch fishes. The United Nations Convention on the Law of the Sea (LOSC)[73] provides an overall framework for managing living marine resources by calling upon states to sustainably manage fish stocks within their exclusive economic zones,[74] urging international cooperation to conserve high seas fish stocks[75] and those of a transboundary nature (shared, straddling, and highly migratory), and encouraging the protection of marine habitats and rare or fragile ecosystems.[76] The UN Agreement on Straddling and Highly Migratory Fish Stocks (UNFA)[77] outlines the general cooperation responsibilities under the LOSC by requiring precautionary and biodiversity protective approaches, encouraging the strengthening of existing subregional and regional fisheries management organizations and arrangements, and calling for the establishment of new subregional or regional arrangements where they do not exist.[78]

The Convention on Biological Diversity (CBD),[79] setting out a wide range of responsibilities to sustainably use and conserve natural resources,[80] requires states to establish systems of protected areas, including marine pro-

[73] United Nations Convention on the Law of the Sea, 10 December 1982, 1833 U.N.T.S. 396 [hereinafter LOSC].

[74] *Id.* at Art. 61.

[75] *Id.* at Art. 118.

[76] *Id.* at Art. 194(5).

[77] United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 4 August 1995, 2167 U.N.T.S. 3.

[78] *Id.*

[79] Convention on Biological Diversity, 5 June 1992, 1760 U.N.T.S. 79 [hereinafter CBD].

[80] *See* A. Charlotte Le Fonteubert, David R. Downes, & Tandi S. Agardy, *Biodiversity in the Seas: Implementing the Convention on Biological Diversity in Marine and Coastal Habitats*, 10 GEO. INT'L ENVTL. L. REV. 753 (1998).

tected areas (MPAs).[81] The Conference of the Parties has set 2020 as a target for ensuring ten per cent of the world's coastal and marine areas are covered by MPAs.[82]

The Food and Agricultural Organization of the United Nations (FAO) has issued numerous non-legally binding documents of relevance to shark conservation.[83] For example, the FAO Code of Conduct for Responsible Fisheries[84] provides guidance for managing all fisheries in a precautionary and integrated manner.[85] Over 20 technical guidelines have been issued pursuant to the Code offering advice on such topics as the ecosystem approach,[86] the precautionary approach,[87] and the reduction of bycatch.[88]

Shark-specific law and policy developments at the global level have emerged on four main fronts and are described below. Two convention regimes have sought to protect some shark species, namely, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)[89] and the Convention on Migratory Species of Wild Animals (CMS).[90] The FAO's International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks)[91] calls for various national and regional actions to conserve sharks, while UN General Assembly sustainable fisheries resolutions continue to pressure states and regional fisheries management organizations (RFMOs) to better protect sharks.

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[81] CBD, *supra* note 79, at Art. 8(a).

[82] CBD, *COP 10 Decision X/2, The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets* (2010), Target 11.

[83] *See generally*, Dawn A. Russell & David L. VanderZwaag, *The International Law and Policy Seascape Governing Transboundary Fisheries*, *in* RECASTING TRANSBOUNDARY FISHERIES MANAGEMENT ARRANGEMENTS IN LIGHT OF SUSTAINABILITY PRINCIPLES: CANADIAN AND INTERNATIONAL PERSPECTIVES 9, 16–19 (D.A. Russell & D.L. VanderZwaag eds., 2010).

[84] FAO, CODE OF CONDUCT (31 October 1995), *at* http://www.fao.org/docrep/005/v9878e/v9878eOO.htm (visited 12 January 2013).

[85] *See* G. Moore, *The Code of Conduct for Responsible Fisheries*, *in* DEVELOPMENTS IN INTERNATIONAL FISHERIES LAW 85 (E. Hey ed., 1999).

[86] FAO, *The Ecosystem Approach to Fisheries,* FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES No. 4, Suppl. 2 (2003).

[87] FAO, *Precautionary Approach to Capture Fisheries and Species Introductions*, FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES NO. 2 (1996).

[88] Among other things, states are urged to establish national policies and legal frameworks for the effective management of bycatch and the reduction of discards. FAO, *Report of the Technical Consultation to Develop International Guidelines on Bycatch Management and Reduction of Discards, Rome, 6–10 December 2010*, FAO FISHERIES AND AQUACULTURE REPORT, No. 957 (2011) at Appendix E, para. 3.1.2.

[89] Convention on International Trade in Endangered Species of Wild Fauna and Flora, 3 March 1973, 993 U.N.T.S. 243 [hereinafter CITES].

[90] Convention on Migratory Species of Wild Animals, 23 June 1979, 1651 U.N.T.S. 356 [hereinafter CMS].

[91] FAO, INTERNATIONAL PLAN OF ACTION FOR THE CONSERVATION AND MANAGEMENT OF SHARKS (1999), *at* http://www.fao.org/fishery/ipoa-sharks/en [hereinafter IPOA-Sharks] (visited 14 December 2012).

4.1.1 Convention on International Trade in Endangered Species

Since CITES aims at protecting listed threatened and endangered species that are subject to international trade, the Convention is not directly applicable to the Greenland shark. However, a brief description of CITES is provided to show the limited management measures taken to date even for threatened/endangered shark species.[92] CITES may have indirect relevance as it has become a limited forum for reviewing national and regional plans of action for the conservation and management of sharks.

Relatively few shark species have been listed under the Agreement's Appendices for trading restrictions. Only various species of sawfish are included in Appendix I[93] where trade for species threatened with extinction is only permitted under exceptional circumstances, mostly for scientific purposes, and would require both export and import permits.[94] Just eight shark species, basking (*Cetorhinus maximus*), great white (*Carcharodon carcharias*), whale shark (*Rhincodon typus*), porbeagle shark (*Lamna nasus*), oceanic whitetip shark (*Carcharhinus longimanus*), and three species of hammerhead shark; scalloped (*Sphyrna lewini*), great (*Sphyrna mokarran*), and smooth (*Sphyrna zygaena*) are listed under Appendix II[95] where commercial trade is allowed subject to export permitting requirements which must include a finding that the trade will not be detrimental to the species' survival.[96]

Parties to CITES through various resolutions and decisions have addressed shark issues with the central resolution on the Conservation and Management of Sharks adopted in 2002.[97] The Resolution encourages parties to improve data collection and enhance management and conservation measures for shark species at the national, bilateral, and regional levels. Parties are urged to continue reporting to the CITES Secretariat and the Animals Committee on progress in implementing national or regional action plans.

4.1.2 Convention on Migratory Species

The CMS also offers a limited protective net for sharks. For migratory sharks listed on Appendix I of the Convention because they are threatened with extinction, Range State parties are required to conserve, and where

[92] For further critiques, *see* Holly Edwards, *When Predators Become Prey: The Need for International Shark Conservation*, 12(2) OCEAN & COASTAL L. J. 305–354 (2007); Erika J. Techera & Natalie Klein, *Fragmented Governance: Reconciling Legal Strategies for Shark Conservation and Management*, 35 MARINE POL'Y 73–78 (2011).

[93] CITES, APPENDICES I, II, III, *at* http://www.cites.org/eng/app/appendices.php (visited 21 January 2013).

[94] A scientific authority of both the state of export and import must advise that the trade will not be detrimental to the survival of the species involved. CITES, *supra* note 89, at Art. III.

[95] CITES Appendices, *supra* note 93.

[96] CITES, *supra* note 89, at Art. IV.

[97] CITES, *Conservation and Management of Sharks (Class Chondrichthyes)*, Conf. 12.6 (Rev. COP 15) (2002).

possible restore, the habitats of listed endangered species and to prohibit their taking with limited exceptions, such as for scientific purposes and subsistence hunting.[98] For sharks listed under Appendix II, which have an unfavourable conservation status or could significantly benefit from international cooperation, Range State parties are encouraged to conclude further agreements[99] with various provisions suggested including the development of coordinated management plans, maintenance of a network of suitable habitats, and cooperation in scientific research and dispute settlements.[100] A migratory species may be listed both in Appendix I and Appendix II.[101]

Actual listing of shark species has lagged. The great white and basking shark are listed on both Appendices. Those just listed on Appendix II include the shortfin mako (*Isurus oxyrinchus*), longfin mako (*Isurus paucus*), porbeagle, whale shark, and spiny dogfish.[102]

A Memorandum of Understanding (MOU) on the Conservation of Migratory Sharks,[103] adopted on 12 February 2010, also stands out for its limitations. The MOU only covers an initial list of seven shark species included in Annex I of the MOU.[104] Commitments by signatories are quite general—for example, they are encouraged to improve research, monitoring, and information exchange on migratory shark populations; to ensure directed and non-directed shark fisheries are sustainable; to ensure to the extent practicable the protection of critical habitats and migratory corridors; and to enhance national, regional, and international cooperation.[105] Signatories pledged to develop at their first meeting a conservation plan to be incorporated as an annex to the MOU.[106] Implementation funding is left voluntary.[107] Relatively few states have accepted the MOU.[108]

The Conservation Plan, adopted by the first meeting of MOU signatories in September 2012 and becoming Annex 3 to the MOU, further highlights what conservation actions need to be undertaken, but implementation details

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[98] CMS, *supra* note 90, at Art. III.

[99] *Id*. at Art. IV.

[100] *Id*. at Art. V.

[101] *Id*. at Art. IV(2).

[102] CMS, LIST OF COMMON NAMES, CMS APPENDICES I AND II - FEBRUARY 2012, *at* http://www.cms.int/pdf/en/cms-species_6lng.pdf (visited 17 February 2013).

[103] CMS, MEMORANDUM OF UNDERSTANDING ON THE CONSERVATION OF MIGRATORY SHARKS (2010), *at* http://www.cms.int/species/sharks/sharks_mou.htm [hereinafter Sharks MOU] (visited 17 February 2013).

[104] Whale shark, basking shark, great white shark, shortfin mako, longfin mako, porbeagle, and the spiny dogfish (northern hemisphere populations).

[105] Sharks MOU, *supra* note 103, at s. 4(12).

[106] *Id*. at s. 4(11).

[107] *Id*. at s. 5.

[108] Only 24 states and the EU are listed as signatories. CMS, SUMMARY SHEET ON THE MOU ON THE CONSERVATION OF MIGRATORY SHARKS, *at* http://www.cms.int/pdf/en/summary_sheets/sharks.pdf (visited 17 February 2013).

remain to be completed.[109] The MOU Advisory Committee has been tasked with setting priorities, time frames, and responsible entities for implementing the Plan.

4.1.3 International Plan of Action for Sharks

The IPOA-Sharks, an international instrument that urges the application of the precautionary approach to keep total fishing mortality for each stock within sustainable levels,[110] bestows broad discretion on states to develop and implement shark plans. States are urged to adopt national plans of action (NPOA) for the conservation and management of sharks if their vessels conduct direct shark fishing or if their vessels regularly catch sharks as bycatch.[111] The IPOA provides general guidance on what national plans should contain, including a description of shark stocks status, associated fisheries, and a management framework.[112] At least every four years states are urged to assess plan implementation and to identify strategies for increasing effectiveness.[113] States are also encouraged to develop subregional or regional shark plans.[114]

Implementation progress has been slow and varied. In 2010, only 65 per cent of FAO members indicated that they had shark plans in place,[115] while 63 per cent of members reported that they monitored shark bycatch and discards on a regular basis.[116]

4.1.4 UN General Assembly Sustainable Fisheries Resolutions

Since 2003 the UN General Assembly has adopted on an annual basis sustainable fisheries resolutions[117] seeking to promote the strengthening of fishery management arrangements both generally and specifically for sharks. For example, the Sustainable Fisheries Resolution, adopted on 6 December 2011, calls upon all states, directly and through regional fisheries management organizations and arrangements, to apply precautionary and ecosystem approaches in fisheries management[118] and to establish stock-specific precautionary

[109] CMS, ANNEX 3 TO THE MOU: CONSERVATION PLAN, *at* http://www.cms.int/species/sharks/pdf/CP_Conservation_Plan_Final_Eng.pdf (visited 18 February 2013).
[110] IPOA-Sharks, *supra* note 91, at para. 14.
[111] *Id*. at para. 18.
[112] *Id*. at Appendix A.
[113] *Id*. at para. 23.
[114] *Id*. at para. 25.
[115] FAO, *Committee on Fisheries, Progress in the Implementation of the Code of Conduct for Responsible Fisheries and Related Instruments, Including International Plans of Action and Strategies, and Other Matters*, COFI/2011/2, (29th Session, Rome, 31 January–4 February 2011), at para. 38.
[116] *Id*. at para. 36.
[117] The resolutions are available online at http://www.un.org/Depts/los/general_assembly/general-assembly_resolutions.
[118] Sustainable Fisheries, G.A. Res. 66/68, U.N. Doc. A/RES/66/68 (28 March 2012), at para. 7.

reference points.[119] Specific to sharks, states are urged to fully implement the IPOA-Sharks through various measures including: setting limits on catch or fishing effort; requiring regular reporting of shark catches (species-specific data, discards and landings); reducing shark bycatch and bycatch mortality; and where scientific information is uncertain or inadequate, not increasing directed shark fishing effort.[120] States are encouraged to further strengthen the control of shark fin harvesting and to consider requiring all sharks to be landed with each fin naturally attached.[121] RFMOs are urged to strengthen and establish precautionary, science-based commitments and management measures for sharks.[122]

4.1.5 Regional Law and Policy Approaches to Shark Conservation

Three North Atlantic regional fisheries management organizations have addressed shark conservation but in quite limited ways.[123] The Northwest Atlantic Fisheries Organization (NAFO), the International Commission for the Conservation of Atlantic Tunas (ICCAT), and the North-East Atlantic Fisheries Commission (NEAFC) have made minimal strides to manage the taking of sharks with ecosystem and precautionary approaches still at the nascent stage.

4.1.6 NAFO

While the convention area covered by NAFO was historically extended to cover the waters off northwest Greenland because of concerns by Denmark over developing fisheries in the region, particularly for Greenland sharks,[124] NAFO has only adopted general conservation and enforcement measures for sharks, such as banning shark finning.[125] Contracting parties are encouraged to require their flagged vessels to release live sharks caught in non-directed fisheries.[126] Parties are urged to undertake research to identify more selective fishing gear for the protection of sharks and to locate shark nursery areas.[127] Reporting of shark catches is required at the species level to the extent possible.[128]

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[119] *Id*. at para. 9.
[120] *Id*. at para. 14.
[121] *Id*. at para. 15.
[122] *Id*. at para. 16.
[123] For an overview of sharks conservation measures commonly taken by RFMOs, *see* CITES Secretariat, *The Future of Sharks: A Review of Action and Inaction*, AC 25 Inf. 6 (2011), at 11.
[124] R.G. Halliday & A.T. Pinton, *The Delimitation of Fishing Areas in the Northwest Atlantic*, 10 J. NORTHW. ATL. FISH. SCI. 1, 7–8 (1990).
[125] Parties must require their vessels not to have on board shark fins that total more than five per cent of the weight on board, up to the first point of landing. Northwest Atlantic Fisheries Organization, *Conservation and Enforcement Measures*, NAFO/FC Doc. 12/1 (2012), at Art. 12(3).
[126] *Id*. at Art. 12(5).
[127] *Id*. at Art. 12(6)(7).
[128] *Id*. at Art. 12(1) and 25(2)(g).

4.1.7 ICCAT

Since ICCAT's Convention area covers all waters of the Atlantic Ocean, ICCAT is potentially relevant to the Greenland shark, although bycatch in tuna fisheries does not presently appear to be a major issue. The Greenland shark is listed on ICCAT's list of bycatch species.[129]

ICCAT, the first RFMO to impose a shark finning ban in 2004,[130] has moved incrementally to restrict directed fishing and bycatch for a limited number of shark species. While more than 350 shark species inhabit pelagic and coastal areas of the Atlantic Ocean covered by ICCAT,[131] prohibitions on retaining sharks or their parts have only been imposed for four species, bigeye thresher sharks (*Alopias superciliosus*),[132] oceanic whitetip,[133] hammerhead sharks (*Sphyrna* spp.),[134] and silky sharks (*Carchahinus falciformis*).[135] Reduction of fishing mortality in fisheries targeting porbeagle and North Atlantic shortfin mako sharks is required until sustainable levels of harvest can be determined.[136] ICCAT parties and fishing entities have been urged to enhance research on pelagic shark species caught within the Convention area in order to identify potential nursery areas and to build the case for time and area closures.[137] Release of live sharks incidentally caught in fisheries is also encouraged.[138]

4.1.8 NEAFC

The North-East Atlantic Fisheries Commission, besides closing large areas to bottom fisheries on the Mid-Atlantic Ridge to protect vulnerable

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[129] Available at Standing Committee on Research and Statistics (SCRS), ICCAT (2012), *at* http://www.iccat.int/en/SCRS.htm (visited 18 January 2013).

[130] Contracting parties and fishing entities must ensure their vessels do not have on board fins that total more than five per cent of the weight of sharks on board, up to the first point of landing. ICCAT, *Recommendation 04–10 by ICCAT Covering the Conservation of Sharks Caught in Association with Fisheries Managed by ICCAT* (in force 13 June 2005).

[131] ICCAT, *Resolution 95–02 by ICCAT on Cooperation with the Food and Agriculture Organization of the United Nations (FAO) with Regard to Study of the Status of Stock and By-Catches of Shark Species* (21 December 1995).

[132] With the exception of a Mexican small-scale coastal fishery with a catch of less than 110 fish. ICCAT, *Recommendation 09–07 by ICCAT on the Conservation of Thresher Sharks Caught in Association with Fisheries in the ICCAT Convention Area* (in force 1 June 2010).

[133] ICCAT, *Recommendation 10–07 by ICCAT on the Conservation of Oceanic Whitetip Shark Caught in Association with Fisheries in the ICCAT Convention Area* (in force 14 June 2011).

[134] Except for the bonnethead (*Sphyrna tiburo*) and hammerhead sharks caught by developing coastal countries for local consumption. ICCAT, *Recommendation 10–08 (Family Sphynidae) Caught in Association with Fisheries Management by ICCAT* (in force 14 June 2011).

[135] With an exception for silky sharks caught by developing coastal countries for local consumption. ICCAT, *Recommendation 11–08 by ICCAT on the Conservation of Silky Sharks Caught in Association with ICCAT Fisheries* (in force 7 June 2012).

[136] ICCAT, *Supplemental Recommendation 07–06 by ICCAT Concerning Sharks* (in force 4 June 2008).

[137] *Id*.

[138] ICCAT Recommendation 04–10, *supra* note 130.

marine ecosystems,[139] has taken a number of measures to conserve sharks. Directed fisheries for porbeagle,[140] spiny dogfish,[141] and basking shark[142] are prohibited from 2012–2014. Each contracting party of NEAFC is required for 2013 to prohibit vessels flying its flag in the Regulatory Area from directed fishing for deep sea sharks which include the Greenland shark.[143] Parties must submit all data on deep-sea sharks to the International Council for Exploration of the Sea (ICES) and are encouraged to prohibit directed fishing for deep-sea sharks within waters under their national jurisdiction.[144]

4.1.9 Bilateral (Canada-Greenland) Cooperation

Bilateral cooperative arrangements in the Davis Strait-Baffin Bay region remain limited and do not specifically address shark conservation.[145] An Agreement for Cooperation Relating to the Marine Environment, concluded in 1983,[146] focuses on preventing and responding to pollution incidents with contingency planning details set out for both offshore hydrocarbon incidents[147] and shipping accidents.[148] A Canada-Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB) provides scientific and management advice for shared populations of narwhal (*Monodon monoceros*) and beluga (*Delphinapterus leucas*) in the sea between Greenland and Canada.[149] Canada and Denmark (Greenland) cooperate in seeking scientific advice from NAFO on appropriate total allowable catch levels of shared Greenland halibut and northern shrimp stocks and setting annual national quotas,[150] but the focus has been on single species management, not on broader ecosystem conservation or the issue of Greenland shark bycatch.

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[139] NEAFC, *Map of Vulnerable Marine Ecosystem Closures*, *at* http://www.neafc.org/page/32397 (visited 3 December 2012).

[140] NEAFC, *Recommendation 6:2012 for Conservation and Management Measures for Porbeagle (Lamna Nasus) in the NEAFC Regulation Area from 2012 to 2014* (November 2011).

[141] NEAFC, *Recommendation 5:2012 for Conservation and Management Measures for Spurdog (Squalus Acanthias) in the NEAFC Regulation Area from 2012 to 2014* (November 2011).

[142] NEAFC, *Recommendation 4:201 for Conservation and Management Measures for Basking Shark (Cetorhinus maximus) in the NEAFC Convention Area from 2012 to 2014* (November 2011).

[143] NEAFC, *Recommendation 7:2013 for Conservation and Management Measures for Deep Sea Sharks in the NEAFC Regulation Area from 2013* (November 2012).

[144] *Id*.

[145] *See* Robert Siron, David VanderZwaag, & Helen Fast, *Ecosystem-based Ocean Management in the Canadian Arctic*, *in* BEST PRACTICES IN ECOSYSTEM-BASED OCEANS MANAGEMENT IN THE ARCTIC 81, 89–90 (Alf Håkon Hoel ed., 2009), *at* http://www.sdwg.org/media.php?mid=1017 (visited 2 March 2013).

[146] Agreement for Cooperation Relating to the Marine Environment, 26 August 1983, C.T.S. 1983, No. 19.

[147] *Id*. at Annex A.

[148] *Id*. at Annex B, as amended by C.T.S. 1991, No. 35.

[149] Siron et al., *supra* note 145, at 90.

[150] *See, for example*, NAFO, *Canadian Request for Scientific Advice on Management in 2013 of Certain Stocks in Subareas 0 to 4*, NAFO SCS Doc. 12/04 (2012) and NAFO, *Denmark (Greenland) Request for Scientific Advice on Management in 2013 of Certain Stocks in Subarea 0 to 1*, NAFO SCS Doc. 12/03 (Revised) (2012).

4.2 Domestic Law and Policy: Canada as a Case Study

Here we use Canada as a case study to showcase available national laws and policies that could be used to manage and conserve the Greenland shark. Canada's legislative framework and management approaches for sharks largely stems from the mandate of international policies and commitment's as discussed above.

4.2.1 Code of Conduct for Responsible Fisheries: NPOA-Sharks

Through the FAO's Code of Conduct for Responsible Fisheries framework, an international non-binding instrument (IPOA-Sharks) (see Section 4.1.3) for *Chondrichthyes* (sharks, skates, rays, chimeras) was developed in 1999 to guide shark-catching countries in developing their own national plan (NPOA-Sharks). Through this plan, countries can facilitate the adoption of precautionary- and ecosystem-based measures, with an ultimate goal of sustainably managing target and non-target *Chondrichthyan* species. Canada, one of the first countries to manage shark stocks, adopted a NPOA in 2007.[151] Ideally, the plan should comply with the FAO's outlined principles and guidelines and address threats (natural and anthropogenic) for all *Chondrichthyan* species. However, a recent review of the plans effectiveness and compliance with FAO guidelines[152] found the plan focused mostly on threats to commercial species (i.e., porbeagle, blue (*Prionace glauca*), shortfin mako, and spiny dogfish), and lacked robust management measures for species commonly caught as bycatch, such as the Greenland shark.

Canada's NPOA-Sharks also states that the inclusion of precautionary- and ecosystem-based approaches to fisheries is essential, specifically where science is limited. Partly due to these concerns, actions have been taken to investigate the ecological importance of Greenland sharks and to determine the species movements and migration patterns.[153] Yet, there is a lack of suitable data to assess the effects of increased bycatch of Greenland shark in developing fisheries and neither abundance nor mortality rates have been estimated. These data would be essential for assessing the species vulnerability to extirpation. The NPOA-Sharks could become an effective management tool if firm commitments were made to collect biological data where needed, precautionary measures were applied for data-deficient and threatened species, and long-term monitoring mechanisms were put in place for identifying threats that may arise from a changing environment.

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[151] DFO, *supra* note 56.
[152] Davis and Worm, *supra* note 3.
[153] DFO, *supra* note 56.

4.2.2 Canadian Law and Policy

Canada has a number of domestic legislative instruments that can be used to manage Arctic fisheries. The Fisheries Act[154] and Oceans Act[155] give the Department of Fisheries and Oceans (DFO) the authority to manage target and non-target species, to facilitate marine science, and to protect species habitats through oceans and sustainable integrated management activities and management plans. Examples of integrated sustainable oceans management could include marine protected areas (MPAs), Integrated Fisheries Management Plans (IFMPs), or Marine Managed Areas (MMAs). These tools can be used to reduce fishing effort, protect species from exploitation, and manage multi-use ocean environments.[156]

Canada's first IFMP for sharks was developed in 1995 and primarily focuses on the management of commercial species. As only two species of sharks in Canada, the spiny dogfish (Pacific coast) and porbeagle shark (Atlantic coast), are considered economically viable for fisheries,[157] most bycatch species, like the Greenland shark, are neglected in fisheries management plans. However, bycatch species can be indirectly managed through IFMPs. This is the case for spiny dogfish, a commonly caught bycatch species in groundfish fisheries. Under the IFMP for groundfish, spiny dogfish catch can be reduced through effort control, quota allocations, and imposing gear restrictions on the target species.[158] In contrast, the IFMP for Greenland halibut, the fishery considered to have the highest Greenland shark bycatch, indicates minimal shark catch in the fishery, and has no bycatch limits or conservation strategies in place to mitigate bycatch or to collect fisheries data for stock assessments.[159]

Following Canada's adoption of a Sustainable Fisheries Framework in 2009, several policies have been developed to ensure fisheries sustainability and conservation. Policies which can be used to manage the Greenland shark include the Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas[160] and Canada's Policy on Managing Bycatch.[161] The former policy was developed to manage those fisheries which may impact sensitive benthic areas, or those fisheries that may cause irreversible harm to sensitive marine

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[154] Fisheries Act, R.S.C. 1985, c. F-14.
[155] Oceans Act, S.C. 1996, c. 31.
[156] DFO, *supra* note 56.
[157] *Id.*
[158] *Id.*
[159] DFO, FISHERY MANAGEMENT PLAN GREENLAND HALIBUT NAFO SUBAREA 0, 2006–2008 (2006), *at* http://www.dfo-mpo.gc.ca/Library/333912.pdf (visited 22 April 2013).
[160] DFO, POLICY FOR MANAGING THE IMPACTS OF FISHING ON SENSITIVE BENTHIC AREAS (2009), *at* http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/benthi-eng.htm (visited Jan 16, 2013).
[161] DFO, POLICY ON MANAGING BYCATCH (2013), *at* http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/bycatch-policy-prise-access-eng.htm (visited 22 April 2013).

habitats, communities, or species. Benthic habitats and species are defined as being found on the seafloor, including on the slope of the continental shelf.[162] This policy considers "frontier areas," defined as those areas that have not yet been exposed to fishing activity, areas that are deeper than 2,000 m, and areas in the Arctic where there is no history of fishing and little to no information is available on species and habitats.[163] These areas are to receive priority management consideration with the granting of licenses for small-scale exploratory fisheries. However, implementation of this policy depends on the risks and priorities identified through an Ecological Risk Analysis Framework (ERAF). This tool was developed to outline a comprehensive process to identify the impacts of fishing on habitats or species,[164] and to use the information to make informed management decisions. Since developing Arctic fisheries are catching large numbers of Greenland sharks, the Fishing in Sensitive Benthic Areas Policy could be an effective management tool for identifying the ecological risks and impacts of these fishing activities.

Canada's recently released Policy on Managing Bycatch seeks to minimize adverse effects of bycatch and discarded species in commercial, recreational, and Aboriginal fisheries. Under the Sustainable Fisheries Framework, fisheries managers are encouraged to account for total mortality in fisheries, including retained bycatch and discarded species.[165] The Bycatch Policy acts as a reference tool that allows fisheries managers to better manage bycatch at sustainable levels and to improve upon existing fishery-specific bycatch policies. Key objectives of the policy include evaluating risks to bycatch species; ensuring adequate monitoring and reporting; minimizing capture of non-target species and supporting live-release; and implementing measures to manage bycatch and discards where appropriate. The policy will be implemented over time through integrated management plans and recognizes that other existing management plans, for example, Canada's NPOA Sharks,[166] may address the threats facing particular species.

As noted in Section 2.3., fisheries catch data indicate high bycatch of Greenland sharks in Arctic fisheries, with no restrictions or management strategies. Thus the Bycatch Policy is a starting point for managing the incidental capture of this species. DFO has indicated a phase-in process of the Bycatch Policy based upon national, regional, and fishery priorities with no timeline. These sustainable fisheries policies could be used to manage Greenland sharks by determining safe biological extraction limits, managing

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[162] DFO, *supra* note 160.
[163] *Id.*
[164] *Id.*
[165] DFO, SUSTAINABLE FISHERIES FRAMEWORK (2012), *at* http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/overview-cadre-eng.htm (visited 27 April 2013).
[166] NPOA Sharks, *supra* note 56, at s. 2.4.

fisheries bycatch and discards, and enacting precautionary measures where science is uncertain, unreliable, or inadequate.

Other means for managing the Greenland shark include the application of the Species at Risk Act (SARA).[167] This Act was created to protect Canadian wildlife at risk, to prevent populations from extirpation, to rebuild those populations considered depleted, and to prevent species of special concern from becoming threatened or endangered. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is the scientific advisory body that assesses the conservation status of individual species and recommends species listing to SARA.[168] As of yet the Greenland shark has not been assessed by COSEWIC, but is considered a mid-priority species.[169] No date for assessment is listed, likely due to the paucity of biological and management information available for this species.

5. CONSERVING THE GREENLAND SHARK—FUTURE DIRECTIONS FOR AVOIDING A SPECIES AT RISK

Charting precise coordinates for future conservation of the Greenland shark is not easy. A fragmented array of global and regional agreements holds the potential to address the conservation of the Greenland shark, particularly if its threatened status rises.[170] International debates continue over the need for strengthening the governance regime for marine biodiversity in areas beyond national jurisdiction and whether a further implementation agreement to LOSC on high seas biodiversity should be negotiated.[171] Suggestions for creating a new global institutional framework for conserving sharks, specifically an International Shark Fishing Commission[172] or an International Commission

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[167] Species at Risk Act, S.C. 2002, c. 29. For a critical review, *see* David L. VanderZwaag et al., *Canada's Species at Risk Act and Atlantic Salmon: Cascade of Promises, Trickles of Protection, Sea of Challenges*, 22 J. ENVT'L L. & PRAC. 267 (2011).

[168] NPOA Sharks, *supra* note 56, at s. 2.1.2.

[169] COSEWIC, COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA (1977), http://www.cosewic.gc.ca/eng/sct6/sct6_6_e.cfm.

[170] This species is presently considered near threatened on IUCN's Red List because of its possible population declines and limiting life history characteristics. PETER KYNE ET AL., THE CONSERVATION STATUS OF NORTH AMERICAN, CENTRAL AMERICAN, AND CARIBBEAN CHONDRICHTHYANS (2012), *at* https://www.iucn.org/knowledge/publications_doc/publications/?uPubsID=4701 (visited 27 April 2013).

[171] Debates have occurred primarily under the auspices of the Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction which held its fifth meeting 7–11 May 2012, *see* United Nations, Division of Ocean Affairs and the Law of the Sea, *at* http://www.un.org/Depts/los/biodiversityworkinggroup/biodiversityworkinggroup.htm (visited 27 April 2013).

[172] Ingrid M. Anderson, *Jaws of Life: Developing International Shark Finning Regulations through Lessons Learned from the International Whaling Commission*, 20 TRANSNATIONAL & CONTEMP. PROB. 51 (2011).

for the Conservation and Management of Sharks,[173] have not received political attention or support. However, general law and policy directions may be garnered from two of the fundamental marine management principles being advocated through various international agreements and documents. Implications of taking precautionary and ecosystem approaches, as repeatedly urged through UN General Assembly resolutions,[174] are discussed below in relation to the Greenland shark.

5.1 Implementing the Precautionary Approach

While the precautionary approach has been subject to substantial confusion and even controversy in relation to its practical implications,[175] a major thrust in resource management has been the adoption of a precautionary moratorium on certain activities. Under such a regime further development is halted until scientific information is available regarding the environmental risks and impacts, and until effective management measures are in place. Precautionary prohibitions on fishing with pelagic driftnets and for bottom trawling on the high seas stand out as prime international examples.[176] The imposition of a precautionary moratorium on development of commercial fisheries in U.S. Arctic waters in light of limited ecosystem understanding provides a relevant national example.[177]

Protecting the central Arctic Ocean beyond national jurisdiction with a precautionary fisheries moratorium has already been advocated[178] and might be imposed through various means. Establishment of a new RFMO to facilitate cooperative scientific research and to consider the opening of future fisheries has been suggested.[179] The NEAFC could call for a precautionary moratorium in the wedge of Arctic high seas under its jurisdiction as the Arctic ice habitat has already been identified as an ecologically or biologically significant and

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[173] Andrew N. Porter, *Unraveling the Ocean from the Apex Down: The Role of the United States in Overcoming Obstacles to an International Shark Finning Moratorium*, 35 ENVT'L L. & POL'Y J. 231 (2012).

[174] *See, for example*, Sustainable Fisheries Resolution, *supra* note 118, at para. 7.

[175] Dawn A. Russell & David L. VanderZwaag, *Ecosystem and Precautionary Approaches to International Fisheries Governance: Beacons of Hope, Seas of Confusion and Illusion*, *in* Russell & VanderZwaag, *supra* note 83, at 58–61.

[176] *Id*. at 57–58.

[177] Pursuant to the North Pacific Fishery Management Council's Arctic Fisheries Management Plan, adopted in 2009, which covers federal waters of the U.S. Arctic. NPFMC, FISHERY MANAGEMENT PLAN FOR FISH RESOURCES OF THE ARCTIC MANAGEMENT AREA (2009), *at* http://www.fakr.noaa.gov/npfmc/PDFdocuments/fmp/Arctic/ArcticFMP.pdf (visited 28 April 2013).

[178] More than 2,000 scientists, in an open letter issued by the Pew Environment Group in April 2012, have called for negotiation of a regional fisheries agreement prohibiting the start of commercial fishing until research-based management measures are put in place. *at* http://www.oceansnorth.org/arctic-fisheries-letter (visited 17 December 2012).

[179] *See, for example*, Jeffers, *supra* note 59.

sensitive area.[180] A precautionary closure might also be accomplished in less formal ways, for example, through recommendatory language in an Arctic Council ministerial declaration or a UN Sustainable Fisheries resolution.

The Arctic Council's Arctic Ocean Review (AOR) project, aimed at developing recommendations for enhancing global and regional measures to protect the Arctic marine environment,[181] is expected to deliver a final report to the Ministerial meeting in May 2013. The report will contain a chapter on living marine resource management[182] and may provide further guidance on future directions for managing the central Arctic Ocean beyond national jurisdiction.[183]

5.2 Implementing the Ecosystem-based Approach

The marine ecosystem provides goods and services to society, some of which are relevant to fisheries, others which are relevant to the productivity of the ecosystem at large. Because fisheries have a direct impact on the ecosystem, which is also impacted by other human activities, they need to be managed as a unified system. Thus the ecosystem approach to fisheries explicitly recognizes the effect that a fishery has both on the target species and on the ecosystem that is being impacted. Two primary concerns stand out: impacts on bycatch species and impacts on bottom habitats from fishing activities. With respect to the Greenland shark, the concern for increasing fishing effort and high bycatch rates is paramount. Figure 3 shows that bycatch is high wherever fishing effort and target catch is high. Limiting the amount of bycatch to sustainable levels will require either some form of spatial management, where bycatch hotspots (either spatial or seasonal) are avoided, or alternatively, a form of gear modification that minimizes the incidental capture of Greenland sharks. The incentive for this is two-fold. First, it would ensure that Greenland sharks continue to play their ecological role as a top predator in the Arctic ecosystem. Second, it would prevent gear damage and gear loss for fishermen, and conceivably make fisheries operations more safe and efficient. Similar concerns about unsustainable bycatch rates led to the development of turtle

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[180] *See* CBD, *Report of Joint OSPAR/NEAFC/CBD Scientific Workshop on EBSAs*, UNEP/CBD/SBSTTA/16/INF/5 (2012).

[181] Arctic Ocean Review documentation, including a Phase I overview report on global and regional agreements/arrangements relevant to Arctic marine environmental protection, is available at http://www.aor.is (visited 17 December 2012).

[182] *See* AOR, *Arctic Ocean Review (AOR) Phase II Project Plan*, *at* http://www.aor.is/images/stories/AOR_ii_/AOR_Phase_II_Project_Plan_and_Timeline1.pdf (visited 2 March 2013).

[183] A draft AOR report, subject to review at an AOR Workshop convened by the Council's Protection of the Arctic Marine Environmental Working Group (PAME) and held in Halifax, Nova Scotia, 17–18 September 2012, suggested various options for implementing a precautionary moratorium but actual recommendations were yet to be negotiated. Professor VanderZwaag, one of the authors of this article, was a workshop participant.

excluder devices and Nordmore grates for tropical and cold-water shrimp fisheries, respectively.

An ecosystem approach to fisheries would likely include similar measures for those fisheries that interact regularly with Greenland sharks. Another important aspect would be the continued research into the habitat use and ecological role of Greenland sharks, ideally in close cooperation with Aboriginal peoples, and including the knowledge base that is accumulating in these communities. Our emerging knowledge of Greenland shark movements, potential nursery areas, and other habitats helps to predict the scale of shark-fisheries interactions and to foresee any negative impacts that could arise from expanding Arctic fisheries in the wake of retreating sea-ice cover.

The legal and institutional frameworks for implementing the ecosystem approach in the Arctic might be described as rudimentary.[184] The Arctic Council is still at the first stages of working through the practical implications of the ecosystem approach with an Arctic Council Ecosystem-based Management Experts Group tasked with developing recommendations on further activities before the end of the Swedish chairmanship in May 2013.[185] The AOR report will have a chapter on ecosystem-based management in the Arctic but it remains to be seen what EBM recommendations will be included in the final report expected to be endorsed by Ministers in May 2013.

The Council's project on best practices on ecosystem-based oceans management in the Arctic highlighted the lack of bilateral and subregional integrated management planning arrangements in the Arctic.[186] A summary document on Observed Best Practices in Ecosystem-based Oceans Management in the Arctic Countries[187] has simply defined core elements of the EBM approach and has identified a number of key practices, including increased international cooperation in studying and managing shared ecosystems.[188] The Council's Working Group on the Conservation of Arctic Flora and Fauna (CAFF), while making substantial strides in monitoring and assessing the status of marine biodiversity in the Arctic,[189] has yet to move countries forward in developing a network of Arctic marine protected areas.[190] How marine

[184] For a recent critique of Arctic Council initiatives, *see* David L. VanderZwaag, *The Arctic Council at 15 Years: Edging Forward in a Sea of Governance Challenges*, 54 GERMAN Y.B. INT'L L. 281 (2011).

[185] EBM Experts Group reports are available at http://www.arctic-council.org/index.php/2n/about-us/expert-groups/275-expert-groups (visited 18 January 2013).

[186] Hoel, *supra* note 145.

[187] *Id*. at 110–112.

[188] *Id*.

[189] For example, a full scientific Arctic Biodiversity Assessment is scheduled for release in the spring of 2013, while a first phase of the assessment, *Arctic Biodiversity Trends 2010: Selected Indicators of Change*, was published in May 2010, *at* http://www.caff.is/aba (visited).

[190] For a critique, *see* David L. VanderZwaag and Hai Dang Vu, *Regional Cooperation in the South China Sea and the Arctic: Lessons to Be Learned?*, in THE REGULATION OF INTERNATIONAL SHIPPING: INTERNATIONAL AND COMPARATIVE PERSPECTIVES ESSAYS IN HONOR OF EDGAR GOLD 171, 196 (Aldo Chircop et al. eds., 2012).

scientific research cooperation might be strengthened across the Arctic region remains an on-going issue.[191]

Subregional approaches to implementing the ecosystem approach might also be enhanced. For example, Canada and Denmark/Greenland might move beyond the present sectorial management approach in Baffin Bay and Davis Strait to develop an integrated planning arrangement for their shared waters.[192] Development of a plan of action for the conservation and management of sharks in the region might also be considered.

6. CONCLUSION

The Greenland shark is the largest fish species in the Arctic Ocean and likely plays an important ecological role as an apex predator. There are concerns arising from the increasing development of commercial fisheries in the Arctic, which is projected to accelerate as sea ice cover is lost. Greenland sharks are frequently caught as bycatch in shrimp and halibut fisheries, and are likely suffering from high mortality rates. The life history of Greenland sharks is poorly understood but all indications point towards slow growth, long life span, and low reproductive rates. As such, there is a pressing concern that this species could be severely impacted by unsustainable fishing practices. A number of national and international policy instruments are available to take precautionary action for avoiding putting this species at further risk. In addition, continuing tracking studies provides new information about cross-border movements, and habitat use beyond Arctic waters, that can inform further management actions. As of 2013, this species is virtually unprotected. Spatial management, modifications to fishing gear, and increased research and education efforts are required to effectively protect this large predator in a rapidly changing environment. Whether future evolution in national and international ocean governance arrangements will be able to prevent the Greenland shark from becoming endangered remains to be seen.

7. POSTSCRIPT

The Arctic Council's Arctic Ocean Review (AOR) report, released in May 2013, offered only a very general recommendation on fisheries resources in areas beyond national jurisdiction. Recommendation 10 urged that such resources "should be managed based on cooperation in accordance with

[191] The draft AOR report raised various possible options including the negotiation of a new Arctic marine scientific research instrument. *See supra* note 183.

[192] Siron et al., *supra* note 145.

international law to ensure long term sustainability of fish stocks and ecosystems."[193]

At a meeting of officials in Washington, DC (29 April–1 May 2013) from the five Arctic coastal states to discuss possible future fisheries in the central Arctic Ocean (CAO), it was generally agreed that commercial fishing in the high seas of the CAO is unlikely to occur in the near future and that at present there is no need to establish any additional RFMO or RFMO(s) for this area. Nevertheless, officials recognized the desirability of developing interim measures until such time when it *may* become necessary to establish an additional RFMO or RFMO(s). Such interim measures should ensure that commercial fishing in the high seas area of the CAO does not take place until one or more regional or subregional fisheries management organizations or arrangements are in place to manage such fisheries in accordance with modem international standards. Denmark offered to host a further meeting of officials for policy discussions before the end of 2013.[194]

The Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction held its sixth meeting, 19–23 August 2013, and recommended that the General Assembly approve the holding of at least three additional meetings. Such meetings would discuss the scope, parameters and feasibility of an international instrument under the Law of the Sea Convention and lead to recommendations to the General Assembly.

[193] PAME, *The Arctic Ocean Review Project, Final Report (Phase II 2011-2013)*, Kiruna, May 2013, at 96.

[194] Meeting on Future Arctic Fisheries, Washington, DC, April 29-May 1, 2013, Chairman's Statement (on file with the authors).