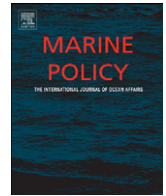


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The International Plan of Action for Sharks: How does national implementation measure up?

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ABSTRACT

Various species of sharks, skates, and rays continue to decline globally, demonstrating a greater need for effective conservation measures. In 1999 the Food and Agriculture Organization (FAO) developed comprehensive guidelines in its International Plan of Action for the Conservation and Management of Sharks (IPOA-sharks), which was followed by corresponding national plans in some nations. A case study of national implementation is presented here. Specifically, progress under Canada's National Plan of Action for Sharks (NPOA-sharks) is reviewed, against its stated goals, against Australia's NPOA, and against the original FAO guidelines. For comprehensiveness, additional management and conservation measures for sharks, as well as stakeholder input from the first Atlantic Shark Forum is provided. Although Canada is recognized as a leader in shark management, as it was one of the first countries to develop an NPOA, it has not effectively adopted the FAO's principles and guidelines. The plan lacks set timelines, priorities, and action plans to mitigate threats to sharks, and contains no performance indicators. Additionally, the plan neglects to identify priority species and engage stakeholders, and cannot be directly linked to management measures. To advance the revision of this plan (as well as other NPOAs), a stepwise process is recommended that includes (i) stakeholder engagement and development of a shark assessment report (SAR) (ii) addressing all IPOA objectives, while prioritizing issues arising from the SAR, and (iii) implementations of actions, targets, and timelines that are reviewed every four years. Key policy items to advance Canada's role in shark conservation and management are also presented. These include actions to improve data collection and research, management, and education, as well as coordination with stakeholders. In conclusion, major changes are needed to the existing NPOA to be fully effective and accountable. Likewise, the abovementioned measures may help guide more proactive plans in nations that have not yet established an NPOA.

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1. Introduction

Sharks, skates, and rays, collectively referred to as elasmobranchs and often referred to as 'sharks' in academic literature, have roamed the oceans for over 400 million years [1,2]. However, a rising demand for shark products such as fins and meat has fueled new types of fisheries, jeopardizing the survival of many populations [3]. Sharks are believed to be globally under threat and are poorly represented in most fisheries management plans. In addition, due to a lack of or poor-quality data, stock assessments are rarely available and total mortality estimates are difficult to obtain, as they should include estimates of shark bycatch, discards, and landings [4]. Lack of effective management

and stock assessments, unreliable catch and trade data, and lack of political will and resources to manage and protect these animals, have contributed to the demise of shark populations worldwide [5]. In Atlantic Canada, 42 elasmobranch species have been reported, and over half, mostly sharks and skates, are globally considered near threatened, vulnerable, or endangered by the International Union for the Conservation of Nature (IUCN), and face varying risks of extinction [6]. Approximately 19 species of sharks have been reported in Atlantic Canada, of which half are considered vulnerable to extinction by the IUCN, and of the 14 species of skates listed, 4 are considered endangered, implying that these species face a very high risk of extinction in the wild [6].

To understand the issues surrounding sharks in Canada, Godin and Worm [7] examined the overall state of knowledge of sharks across Canada and identified several best practices and management measures, related to shark finning, bycatch and discarding of sharks, as well as legislation to list priority species for

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conservation. Yet they do not assess in depth Canada's adoption of the International Plan of Action (IPOA-*sharks*), which represents the only international framework for conserving and managing sharks. Here, Canadian policy is used as a case study to focus specifically on the success of the IPOA to improve the assessments and management of sharks. As this plan is up for review in Canada in 2012, this research is also intended to support the Department of Fisheries and Oceans (DFO) in the upcoming revision process.

Recognizing the urgency of collecting and improving data on sharks, the Food and Agricultural Organization (FAO) developed and implemented the IPOA-*sharks* in 1999 [8]. The plan aims to ensure the long-term conservation and management of chondrichthyan fish (sharks, skates, rays, and chimaeras, herein referred to as 'sharks' unless otherwise stated), across all shark-fishing states, foreign vessels fishing within a States Exclusive Economic Zone (EEZ), or states whose vessels fish for sharks on the high seas. The plan aims to safeguard sharks through improved data collection and research; implementation of action plans to mitigate threats to sharks, identification of priority species for conservation, and development and implementation of education and collaborative consultation initiatives [8]. Although voluntary, the IPOA-*sharks* acts as a guideline from which states can design, implement, and monitor a National Plan of Action for Sharks (NPOA-*sharks*), and any subsequent Regional Plans of Action (RPOA) [8]. Likely due to its non-binding nature, the development of NPOAs has been slow [9,10]. A compounding problem is the lack of proper monitoring to identify progress and directions for improvement of these plans, which should be assessed every four years. The FAO indicates that approximately 136 shark-fishing states voluntarily develop a plan. Of the 136 states, 26 account for more than 1% of the global shark catch. Of these 26 states, 88% are said to have adopted or drafted a NPOA, including Canada, while the remaining 12% are described as 'of concern', which indicates that the country has taken no action, nor has communicated intent to develop a plan (Shark working group at the CITES animals committee meeting; 2012, Switzerland, pers. comm.). Only two of the twenty-six countries, Japan and Australia, have reviewed and revised their plans since they were implemented [10–12]. In light of limited adoption, review, and revision of NPOAs, the goal of this research was to

evaluate Canada's 2007 NPOA against its own stated objectives and actions, against the recommended process and content provided by the IPOA and against Australia's NPOA. It was found that the development and content of Canada's NPOA was predominately focused on Atlantic Canada and the eastern Arctic region, and as such this region forms the focal point of this research; however, the Pacific region is also discussed where appropriate.

2. National Plans of Actions for Sharks

The purpose of the IPOA-*sharks* is to facilitate the identification of data gaps through its comprehensive framework and shark assessment report (SAR) at the national level. The framework is circumscribed by an overarching goal, a set of principles, and procedures for implementation with a set of ten objectives, which all states are encouraged to adopt in their NPOAs (see Table 1) [8]. Table 1 summarizes the IPOA recommendations on process and the minimum objectives needed for developing content in a plan of action, and can be used as a checklist in following a standardized method to protect and manage sharks.

The purpose of conducting a SAR is to ensure a comprehensive report, which aims to quantify elasmobranch stock status, fishing effort for directed and non-directed fisheries, outline existing management and mitigation measures, identify threats, and suggest possible modifications to these management measures. Within the nature and scope of the IPOA, it explicitly describes the term "shark" as including all chondrichthyan fishes [8]. Equally inclusive, the IPOA defines shark "catch" as directed, bycatch, commercial, recreational, or other forms of taking sharks and incorporates both target and non-target species. In addition, the FAO recommends that states engage stakeholders in the development of the plan, review the plan at least every four years, and report their progress to the FAO [8]. In theory, all NPOAs should work towards incorporating FAO guidelines on process and content (Table 1). However, most NPOAs, including Canada's, fall short in adopting these recommendations, and neglect, for example, addressing all chondrichthyans, developing

Table 1
Summary of recommendations on International Plan of Action (IPOA) process and content. National Plans of Action (NPOA) of Canada and Australia are compared.

IPOA-process	Countries adherence		Minimum content-IPOA objectives	Addressed in NPOA	
	Canada	Australia		Canada	Australia
1. Engage stakeholders in the development, implementation, and review of the plan	No	Yes	1. Ensure shark catches from directed and non-directed fisheries are sustainable	In-part	Yes
2. Conduct a Shark assessment report (SAR)	No	Yes	2. Assess threats to shark populations, determine and protect critical habitats and implement harvesting strategies consistent with principles of biological sustainability and rational long-term economic use	In-part	Yes
3. Identify and address all ten IPOA objectives	No	Yes	3. Identify and provide special attention, in particular to vulnerable or threatened shark stocks	Yes	Yes
4. Prioritize shark conservation and management issues arising from the SAR	No	Yes	4. Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management, and educational initiatives within and between States	No	In-part
5. Create actions, targets, and timelines to respond to issues identified in the SAR	No	Yes	5. Minimize unutilized incidental catches of sharks	No	Yes
6. Identify responsible agencies for implementation	No	Yes	6. Contribute to the protection of biodiversity and ecosystem structure and function	In-part	Yes
7. Develop performance indicators to assess and monitor the plan for effectiveness	No	Yes	7. Minimize waste and discards from shark catches	No	Yes
8. Identify and build capacity to implement actions	No	Yes	8. Encourage full use of dead sharks	No	In-part
9. Review and revise the plan at least every four years	No	Yes	9. Facilitate improved species-specific catch and landings data and monitoring of shark catches	Yes	Yes
10. Develop regional plans that complement the national plan	No	No	10. Facilitate the identification and reporting of species-specific biological and trade data	In-part	Yes
11. Report progress of plan to FAO	No	Unknown	–	–	–

a SAR, and mitigating both direct and indirect impacts to these species.

2.1. Canada's NPOA, intent and implementation

Canada developed and implemented its NPOA in 2007 through a series of nine action categories (Table 2), followed by an overarching objective for each action, and identified some means to achieve these objectives (Table 2). Table 2 identifies the number of means allocated to an action category, the completion status of each mean, whether these means comply with any IPOA objectives, and an assessment of the overall progress towards each action category. The overarching objective for each category is not listed in Table 2, but can be found in Canada's NPOA [13]. To assess progress made by the government of Canada, specifically by the DFO, each proposed action was reviewed to determine its current implementation and the extent to which Canada adopted the FAO's guidelines. This process was achieved by contacting a number of government officials, including scientists at the DFO, as well as academic researchers. It was found that Canada listed 23 means under the 9 action categories, of which 14 had been completed by 2011. This implies Canada has achieved 61% of its proposed means (see Table 2).

Canada's plan provides a general overview of commercial shark stocks and few non-commercial species, outlines existing management measures for commercial sharks, attempts to address eight out of the ten IPOA objectives, and provides some means to assess identified threats or data gaps. However, no timelines for completion are provided. The NPOA recognizes that there are 27 species of sharks, 29 species of skates and rays, and 4 species of chimaeras across Canada's 3 ocean regions. For Atlantic Canada, the plan acknowledges that very few of these species are subject to commercial fishing, but are often caught as bycatch and discarded [7,13]. A detailed overview of the management, usage, and status of commercial species is given. However, non-commercial species commonly caught and discarded as bycatch, such as several species of skates and sharks, are disregarded. Larger shark species, such as the basking (*Cetorhinus maximus*) and Greenland shark (*Somniosus microcephalus*) are briefly mentioned in the Annex as rarely-caught bycatch species, yet both species are frequently captured in several groundfish and bottom longline fisheries throughout Atlantic Canada and the eastern Arctic [14,15]. Threats to these species are not addressed in the plan. In addition, the salmon shark (*Lamna ditropis*), a pelagic species found in the North Pacific, is caught in gillnets and purse seines targeting salmon in Canada and the United States, and is frequently taken in recreational fisheries in the United States [16]. Yet Canada's plan does not address threats or opportunities for improving the management of this species. In contrast, the NPOA does address the threats and available data for

commercially exploited spiny dogfish, pointing towards an ongoing study on the shared population in Atlantic Canada and the United States [13].

The NPOA scarcely addresses the issues of bycatch and has identified limited means and no timelines to include discard mortality into stock assessments and to collect biological data on sensitive species. It also omits Canada's role in the shark fin trade or the indigenous use of elasmobranchs. The growing demand for shark fins internationally provides an incentive for countries to harvest sharks for the lucrative Asian fin market. In 2008, 10 million kg of shark fins were imported to Hong Kong, the largest known market for fins [17]. Out of the 87 countries that exported fins to Hong Kong, Canada ranks 27th, exporting 57,828 kg of dried and frozen shark's fin in 2008 [17]. There is a need to address both the import and export of shark fins in Canada, and to accurately assess Canada's contribution in the trade of shark products, particularly those from threatened populations. This issue is currently not addressed in the NPOA. Although the NPOA endorses a precautionary approach for the management and conservation of elasmobranchs, except for the porbeagle shark (*Lamna nasus*) and thorny skate (*Amblyraja radiata*), no species-specific restrictions exist to minimize the bycatch and discarding of commonly caught species, such as the Greenland, basking, blue (*Prionace glauca*), and shortfin mako (*Isurus oxyrinchus*) sharks, several species of skates, and deep-water species.

Within the context of what the FAO recommends on process and content (Table 1), Canada's plan does not address and designate means regarding two of the ten IPOA recommended objectives, namely objectives five and eight (Table 2). Where means are listed, the plan neglects to designate timelines and has yet to complete a shark assessment report (SAR), as is strongly advised by the FAO. Furthermore, the plan has yet to be reviewed for its effectiveness (this is scheduled for 2012). The FAO also requests that states address the threats, management, and stock status of any elasmobranchs that occur in their waters, whether target or non-target species [8]. Canada has fallen short in this, likely due to the absent SAR, as many species are missing or are only briefly mentioned in the plan, with no actions to alleviate existing threats. Like most other fishing nations, Canada maintains a priority focus on commercial species, possibly due to data gaps. However, these data gaps are not clearly identified nor addressed in the NPOA.

On the positive side, all of the eight action items for data collection and research have been completed as of 2011. Some studies included principal findings on population dynamics and assessment mortality of blue sharks, recovery potential assessment (RPA) for shortfin mako and basking sharks, and assessment of black dogfish pupping grounds in the Laurentian Channel [13]. Similarly, outlined research goals for sharks on the Arctic coast

Table 2
Canada's NPOA action categories. It also indicated to which IPOA objectives each action item complies.

Canada's NPOA action categories	No. of means listed	No. of means completed	Complies with IPOA objective (s)	Overall progress
Improve data collection and research	8	8	1,2,3,4	Excellent
Adopt ecosystem and precautionary approach	0	0	2,4,7	Poor
Improve standardized reporting and the management plan process	0	0	4	Poor
Reduce bycatch and report discard mortality	4	2	1,4,6,7,9,10	Good
Extend conservation and management measures to the Arctic	2	2	2,3,6	Excellent
Enhance education/outreach in Canada	4	1	4,6,9,10	Poor
Review and progress the NPOA	1	0	Complies with FAO guideline	Poor
Cooperate with RFMOs	4	1	2,4,6	Poor
Enhance education/outreach internationally	0	0	Complies with FAO guideline	Poor
Overall	23	14	Missing objectives 5 and 8	61% of actions completed

had been completed as of 2011; these entailed increasing knowledge of the life history, abundance, and changing conditions for sharks in the Arctic. For example, several pop-off archival tags were deployed on Arctic skates and Greenland sharks to help determine species' distribution (A. Fisk, University of Windsor, pers. comm.). However, the available knowledge base is still very scant, for example for the Greenland shark, and many species have yet to be addressed.

Successful shark management requires on-going collaboration between all agencies and stakeholders that interact with elasmobranchs. In Atlantic Canada, there are few opportunities where such collaboration can take place with respect to fisheries management plans for elasmobranchs. Without the support from stakeholders, the incentive to establish effective management measures for sharks is limited. If FAO regulatory measures are to be effective in protecting sharks in Canada and internationally, having a NPOA that closely follows the IPOA guidelines on process and content is essential for harmonizing global conservation strategies and identifying the cumulative impacts on chondrichthyans. Furthermore, having a broadly defined but comprehensive NPOA, from which more detailed regional plans can be derived, is critical to strengthening shark conservation and management across the Atlantic, Pacific, and Arctic regions.

2.2. Australia's NPOA: A comparison to Canada's NPOA

Australia is not a major shark-fishing state and, similar to Canada, the majority of the sharks, skates, and rays are caught as bycatch or discarded at sea. For comparison, Australia's NPOA is examined here.

Like Canada, Australia defines "shark" as including all chondrichthyes and refers to "catch" as any target, byproduct, bycatch, or discard by any Australian fishery [18]. Conservation and management issues facing elasmobranchs in Australia are comparable to those in Canada. These include, but are not limited to, poor use of the precautionary approach, poor data collection and information exchange, limited education and awareness, and few collaborative research programs. In response to these issues, Australia developed a NPOA in 2004. In the review of Australia's plan, it was found that it followed most of the FAO guidelines on process and content, (see Table 1), and had addressed all ten IPOA objectives, engaged stakeholders, and developed a SAR from which strategies and actions were formed. These included timelines and performance indicators. Australia's plan yielded a number of improvements including better stock assessments for shared stocks, refined observer and monitoring programs, designated areas to protect shark nursery grounds, and the adoption of bycatch mitigation measures in a number of fisheries [10,18]. In addition, Australia recently reviewed and revised its 2004 plan, and is now in the process of finalizing its 2011 draft NPOA.

When comparing the development of a NPOA between Australia and Canada, several weaknesses became apparent. Unlike Australia, Canada did not develop a stakeholder advisory group (SAG) or a Shark assessment report (SAR) to guide the development of the plan. The existing plan was developed without stakeholder consultation, contrary to FAO guidelines [19]. Furthermore, Canada's NPOA scarcely addresses the issues of bycatch and discarding, and neglects to mention the import and export of shark fins and indigenous use of elasmobranchs. Thus it is concluded Canada's plan is lagging behind, relative to both stated IPOA goals, and the Australian implementation (Table 1).

Regardless of the state in question, an NPOA should be designed to facilitate and complement regional and national management initiatives that are underway (e.g., bycatch policy, conservation and fishery management plans), coordinate shark research at the regional and national level, improve data and

information sharing among all stakeholders, and use the NPOA to guide and prioritize regional and national strategies for elasmobranch conservation and management.

3. Other approaches for the management and conservation of elasmobranchs

Although the FAO intends to use the IPOA to guide states in developing management strategies to conserve and manage chondrichthyes, there are a number of additional approaches to aid in the conservation and management of sharks. In Atlantic Canada and the eastern Arctic, bycatch and discarding of shark species remains the primary threat. Therefore, this research attempts to address additional approaches to mitigate these specific threats (see Table 3). These approaches could provide additional measures as content to be considered when revising the Canadian NPOA in 2012.

3.1. Spatial and temporal management

Increasingly, spatial management tools, such as reserves, closures and multi-use areas, are being employed to protect marine species, restore communities, and enhance fish stocks [20,21]. In Atlantic Canada, there is one area closure that has been established to protect sharks. A porbeagle mating area off southern Newfoundland and the Gulf of St. Lawrence is closed to directed shark fishing annually from September 1 to December 31 (S. Campana, pers. comm.). This closure does not apply to other types of fishing. Additional closures for the porbeagle shark are likely warranted. Currently listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada [22], this species is frequently caught in the Emerald Basin, a 250-m deep depression located on the continental shelf off Nova Scotia. This appears to be a nursery area, as the majority of the porbeagle sharks caught, as bycatch are juveniles and many are believed to be dead when discarded (S. Campana, pers. comm.). Since longline fishing pressure here peaks in the fall, a temporal closure would likely be most effective during the fall season. Another area of interest for porbeagle sharks is the Grand Banks, off Newfoundland. This area is heavily fished by numerous fleets. During the summer months when porbeagle sharks are known to mate, this area could be considered a no-shark fishing zone for directed and bycatch-intensive fisheries catching porbeagle sharks. Currently, only limited information on most other shark species relating to the designation of possible spatial or temporal closures is available.

Table 3
Additional approaches to manage and conserve elasmobranchs.

Spatial and temporal management	Country	Reference
1. Spatial/temporal closures for priority species	CA	Campana, S. pers. comm.
Bycatch management	Country	Reference
1. National bycatch policy	USA	[23,25]
2. Bycatch quotas or caps	USA, NZ	[26,27]
3. Individual habitat quotas (IHQs)	AU	[27,29]
4. Bycatch tax system	Theoretical	[27,33,34,35]
Education and research	Country	Reference
1. Safe catch and release practices	USA	[40]
2. Code of conduct for best practices	AU	[41]
3. Fleet communication program	USA	[42]
4. Study fleet program	USA	[43]

3.2. Bycatch management

Several management approaches have been developed to reduce wastage, bycatch, and discarding in fisheries. A number of these approaches, including comprehensive bycatch and discard policies and economic incentives for sustainable fishing are discussed.

Developing comprehensive bycatch and discard policies that minimize fishing impacts on target and non-target species may help to maximize the sustainability of the fishery and promote responsible fishing. Comprehensive bycatch and discard policies for the United States and Australia are briefly discussed. Australia's policy, developed in 2000, focuses on species not currently subject to commercial management plans, which are either returned to the sea dead or alive [23]. To address fishery-specific issues, Australia developed bycatch action plans (BAPs) that are circumscribed by several core objectives that promote education and awareness, the use of economic incentives, and the protection of vulnerable species. These BAPs are implemented at the regional level to mitigate regional concerns and issues [23]. The United States' bycatch policy, developed by the National Marine Fisheries Service (NMFS) in the late 1990s, promotes a strong regional approach to managing bycatch and discards. In response to a series of stakeholder bycatch workshops, seven bycatch implementation plans were developed to address fishery-specific issues [24]. In addition to the plans, NMFS formed six regional bycatch teams to report on status of implementation [25]. The outlined comprehensive bycatch policies could be used to inform Canada's national bycatch policy, which is currently being developed. It is desirable that the Canadian policy reflect similar objectives and strategies as seen in the Australian and U.S. plans, which include inter alia stakeholder engagement, economic incentives for bycatch reduction, fishery-specific bycatch plans, and education and awareness programs.

To further help reduce bycatch and excessive discarding, management instruments such as bycatch quotas or caps have been introduced in several fisheries. These quotas limit the permitted amount of bycatch and once the quota is reached, the fishery may close for the season. Similar to total allowable catches (TACs), bycatch quotas can be adjusted over time, depending on a fleet's track record and the population status of bycatch species [26]. Bycatch limits for non-target species, such as turtles and sea lions, are provided as examples. The U.S. shallow-set pelagic longline swordfish fishery in the western Pacific has annual binding bycatch limits for leatherback (*Dermochelys coriacea*; 16 allotted) and loggerhead (*Caretta caretta*; 17 allotted) turtles. These limits include turtles that are hooked and released alive, as well moribund turtles. Observers are required to be on every longline trip to record turtle catch and if the limit is reached, the fishery can be shut down, such as in 2006 [27,28]. Since 2006, the fishery has managed to avoid closure; however, it is not known if this is due to increased mitigation measures or the use of avoidance techniques [27]. In New Zealand, similar measures are used to manage the bycatch of Hooker's sea lions (*Phocarctos hookeri*) in the squid fishery. Observers are placed on some (but not all) vessels, and when the sea lion mortality limit is reached, the fishery is shut down [26]. Determining an appropriate bycatch quota requires ongoing monitoring of fishery discards and bycatch and should be based on stock assessments and fishers' knowledge, rather than solely on historical catch [26]. Management measures, such as placing a cap on bycatch, can encourage fishers to find better methods to fish. These measures must be coupled with increased observer coverage or video surveillance to accurately track bycatch and discards. In Atlantic Canada, observer coverage is known to be comparatively low, and would need to be raised prior to adoption of this measure [7,15]. Nevertheless,

developing bycatch quotas for Atlantic Canada fisheries that yield high shark bycatch is recommended.

Another possibility for reducing bycatch via economic incentives is through individual habitat quotas (IHQs), also referred to as Habitat Impact Units (HIUs). Under this system, fishers must use their quota based on when and where they decide to fish and can be monitored through a vessel monitoring system (VMS) [26,29]. This measure has been used in the Australian Eastern tuna and billfish fishery since 2009. This fishery devised an incentive based approach to reducing bycatch through spatial distribution of effort, namely, a "hook decrementation system" [26]. This allocates fishers individual transferable effort units through the use of total number of hooks employed by each vessel and total allowable number of hooks allowed in the fishery [30]. Used as a spatial management policy, hook-penalties have been devised to discourage vessels from fishing in certain areas (e.g., bycatch hotspots). If the vessel is found to be fishing in high bycatch areas through a vessel monitoring system (VMS), penalties are given and a reduction of hooks is required, therefore reducing the value of fish per hook. However, bycatch hotspots and catch per value of hook (VPH) must be determined prior to implementation; also measures must be taken to ensure the incidence of bycatch is not transferred to another location, fishery or species [30].

An alternative to spatial management and fishery closures is the implementation of a levy on fisheries bycatch and discards, such as a bycatch tax system. Placing an economic value on bycatch provides fishers with an incentive to adjust their fishing techniques, avoid bycatch, and adopt alternative fishing methods [26]. Fishers could be charged a fee for landing or discarding incidental catch, which is then placed into a fund to finance pilot projects aimed to reduce bycatch, also known as compensatory mitigation for marine bycatch (CMMB) [31]. In theory, this compensates for environmentally damaging activities, such as longlining, trawling, or gillnetting, but allows the fishery to remain open. Rather than close the fishery due to high bycatch levels, CMMB allows for current levels of fishing effort to remain in exchange for fishers being charged graded scales of taxes per weight of bycatch to fund compensatory mitigation measures [32]. Several authors have confirmed the potential benefits of a bycatch tax system in its ability to reduce incidental catch of non-commercial species, including several types of megafauna, such as turtles, seals, and seabirds [26,33–35]. Hutton et al. [26] summarize the potential impact of several incentive based management approaches, such as bycatch and habitat quotas, and found that both measures have the potential to reduce bycatch and discarding of non-target species.

3.3. Education and research

While Canada's NPOA identifies a need for increased communication and monitoring efforts to reduce bycatch, few steps have been taken to improve education and awareness, information sharing across fleets, or improved species identification, and the plan does not encourage safe handling and release of elasmobranch species that might increase post-release survival [13]. In Atlantic Canada, the swordfish and tuna longline fishery voluntarily releases live sharks, when possible, and uses circle hooks to reduce mortality of endangered sea turtles. In addition, this fishery must adhere to a code of conduct for the handling and release of turtles and fishers are equipped and trained with a customized de-hooking kit [36]. However, there is no similar code of conduct or recommended handling practices for sharks in other commercial or recreational sectors. Within the last several years, scientists have estimated pelagic shark bycatch of porbeagle sharks and associated mortality in some Atlantic Canadian

fisheries and have estimated the bycatch and discard mortality of blue sharks caught in commercial fisheries [37,38]. In addition DFO assessed the effects of recreational and commercial fishing on blue sharks in Atlantic Canada [39]. Additional studies are needed, particularly for those species considered threatened, vulnerable, or endangered.

Both the United States and Australian governments have developed species-specific handling practices or codes of conduct which could be used as guidelines when creating similar measures under Canada's NPOA. In some cases, these practices need to be species-specific. For example, the U.S. Southwest Fisheries Science Center developed specific recreational fishing practices for safe handling of the common thresher shark (*Alopias vulpinus*); these include minimizing fight time, usage of circle hooks, measures to revive the fish, and specific procedures to safely release tail-hooked threshers [40]. Similarly, the Southern and Eastern Scalefish and Shark Fishery in Australia developed a specialized code for auto longline operators who encounter gulper sharks (*Centrophorus granulosus*), a common deep-water dogfish that is vulnerable to overfishing. Every longline operator is required to adopt best practices, which include specialized information on the biology and distribution of the species, ways to reduce incidental mortality and to properly release a gulper shark [41]. The revision of Canada's NPOA, the development of effective catch and release strategies, and the use of videos, species identification charts, and workshops may help to elevate post-release survival and promote best practices.

As recommended by the IPOA, states should also improve species-specific catch, landings, and discard data, and develop systems that promote strong stakeholder relations and information exchange [8]. Two management approaches are recommended, specifically fleet communication programs and cooperative research programs. Fleet-wide communication programs can report real-time observations of bycatch hotspots, such as those found in the U.S. North Atlantic Longline Swordfish Fishery, the U.S. Alaska Dermersal Longline Fishery, and the U.S. North Pacific and Alaska Trawl Fisheries [42]. Overall, the programs used in these fisheries consisted of exchanging daily reports comprised of encounters, sightings, hotspots, and associated oceanographic features, and were found to be effective at reducing bycatch levels of endangered fish, seabirds, and turtles and improving information exchange [42]. This could be adopted to improve knowledge on the spatial and temporal distributions of elasmobranch bycatch in Atlantic Canada.

Collaborative study fleet research programs by definition are "a sample of fishing vessels from which high-quality data on catch, fishing effort, gear characteristics, area fished and biological observations are collected" [43]. These vessels fish in normal commercial mode, but are selected to be representative of the larger fleet over time. The fleet generally employs electronic data collection to provide high-resolution, temporal and spatial data that enhances the precision and accuracy of data collection on the water [43]. Due to the need to improve data collection from typical fishing vessel trip reports (FVTRs; e.g., paper logbooks) and avoid costly increases in observer coverage, the New England Groundfish Fishery developed a study fleet pilot program in 2002 to provide high resolution data on catch, effort, and environmental conditions. This was achieved via an electronic reporting system to collect, record, and transfer more accurate and timely fishery data. The electronically entered data was available for analysis 29–76% faster than traditional logbook data, provided more accurate estimates of individual effort, improved discard reporting, and had greater spatial accuracy [43]. The fleet program allowed fishers to collect accurate, timely, and high-resolution data simultaneous to normal fishing activity and could be considered under the NPOA to facilitate more timely species-specific catch and monitoring data.

4. Stakeholder feedback: Canada's first Atlantic Canada Shark Forum

Due to the conservation and management issues surrounding sharks in Atlantic Canada and the eastern Arctic, World Wildlife Fund Canada (WWF-Canada) organized the first Atlantic Shark Forum (ASF) in March of 2011, in Halifax, Nova Scotia [44]. The forum brought together fishers, scientists, managers and practitioners to discuss, identify, and endorse cross-cutting priorities that, if implemented, would significantly advance the conservation and management of sharks. Using a collaborative approach, participants were provided with three draft priority lists addressing on-the-water practice, science, policy and management priorities. After two days of consultations, identified priorities were discussed in a plenary session and endorsed by participants as top priorities for shark management and conservation in region. Cross-cutting priorities included: (1) better understanding of shark bycatch avoidance and release practices, (2) advancement of research on bycatch mitigation techniques, (3) improved information on changes in stock status, and (4) improvement of training and education with respect to shark conservation issues. As the forum concluded, stakeholders stressed the need for continued communication, information sharing, and transparency across all sectors, and emphasized the importance of developing a regional plan of action with real timelines and deliverables to address these priorities [44].

Although the ASF priorities and IPOA objectives were developed independently from one another, they significantly overlap and address similar conservation and management needs for elasmobranchs. These include minimizing waste and discards of elasmobranchs, improving coordination and consultation among all stakeholders, developing education and training initiatives, and improving the species-specific identification of shark landings, bycatch, and discard catches. The forum provided an opportunity to compare regional concerns against those addressed in the NPOA and those recommended by the IPOA. It was found that the IPOA objectives overlap largely with those identified at the forum, and may help to develop a Regional Plan of Action for Shark Conservation and Management (RPOA-sharks), under the umbrella of a more comprehensive NPOA.

5. Recommendations

5.1. Revision of Canada's National Plan of Action for Sharks

The FAO is the only organization to have developed an international framework that guides states in developing comprehensive conservation measures for chondrichthyes. Although the IPOA-sharks is certainly not a panacea for shark conservation and management, it can help states to develop and implement clear conservation and management objectives at the national scale through an NPOA. This in turn aids regional management bodies in developing focused Regional Plans of Action (RPOA).

Canada was one of the first shark-fishing states that have developed an NPOA, yet this review indicates deficiencies in process and content relative to the original IPOA objectives. For example, Canada's NPOA notably lacked stakeholder consultations and a shark assessment report (SAR) which would identify management and conservation issues, and neglects to include performance indicators which could be used to validate progress. Furthermore, the plan does not address all chondrichthyes and the possible threats these species face, nor does it identify actions to provide this information. While some progress has been made for commercial shark species in Canada, particularly in data collection and research, the existing Canadian NPOA is currently

incomplete. In order to contribute decisively to the conservation of elasmobranchs in Canadian waters, the NPOA requires a thorough revision.

It is recommended that the Canadian government follow a six-step process to develop effective NPOAs and RPOAs (Fig. 1; summarized from the IPOA guidelines, Table 1; [8]). These include: (1) Engage stakeholders and develop a shark assessment report; (2) Address all ten IPOA objectives; (3) Prioritize shark

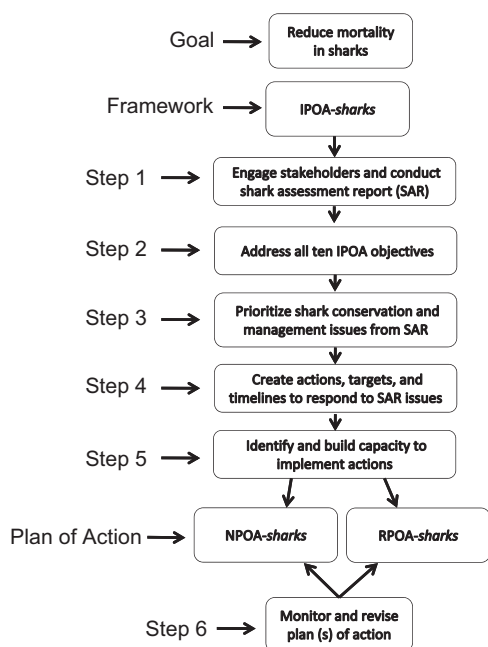


Fig. 1. Development and implementation process for National and Regional Plans of Action for Sharks (modified from the FAO IPOA guidelines).

conservation and management issues from the SAR; (4) Create actions, targets, and timelines; (5) Identify and build capacity; and (6) Monitor and revise the plan. As demonstrated by the Australian NPOA, which followed most of these steps (Table 1), such a process ensures a more comprehensive and collaborative approach to managing and protecting chondrichthyes.

To ensure the NPOA is comprehensive and results in effective and meaningful actions, a set of recommended actions are provided to show some minimum content needed in a revised NPOA for Atlantic Canada and the eastern Arctic (Table 4). The actions are derived from the priorities identified by the IPOA as well as the regional ASF, additional management measures discussed above, and actions listed in the Australian NPOA. These actions are not complete, and should only be considered a minimum standard to advance shark conservation and management on a national and regional scale.

5.2. Development of a RPOA-sharks for Atlantic Canada and eastern Arctic

To date, no shark conservation plans exist to address regional concerns for the Atlantic or Arctic. Instead, commercially significant species such as spiny dogfish, porbeagle, blue and shortfin mako sharks are managed under different fisheries management plans. Developing a RPOA for sharks requires similar steps and actions as for the national plan (Fig. 1). Similar to the IPOA and NPOA, an RPOA should define “shark” as including all sharks, skates, rays, and chimaeras, include commercial and recreational fisheries, and define “catch” as including all non-target, target, discard, and by-catch species. Within a regional plan, all ten IPOA objectives may not apply, but should complement those objectives identified in the NPOA. While each species may require separate management measures and actions depending on the gear type, region, and fishery, having a plan that addresses all the issues identified in a regional SAR can allow

Table 4

Suggested content for National and Regional Plans of Action for Sharks in Canada.

Broad categories	NPOA-sharks	Atlantic/Arctic RPOA-sharks
Data collection and scientific research	<ol style="list-style-type: none"> 1. Quantify bycatch of elasmobranchs, estimate post-release mortality, and incorporate into stock assessments 2. Implement effective mechanisms to obtain reliable catch and bycatch information from observers, fishermen, and independent surveys 3. List priority species based on: quantity taken in all fisheries (bycatch & discards), socio-economic importance, species listings, data deficiency 	<ol style="list-style-type: none"> 1. Understand the impacts of incidental catch of Greenland sharks across all relevant fisheries 2. Improve data collection and research for sensitive species, e.g., deep sea catshark, portuguese shark, Greenland shark, and winter skate 3. Improve research on the life history, abundance, and population structure of data-poor species, e.g., Greenland shark and black dogfish
Management and conservation	<ol style="list-style-type: none"> 1. Ensure that multi-jurisdictional management approaches are considered or introduced where warranted 2. Control fishing mortality through: appropriate controls, bycatch mitigation techniques, and economic incentives 3. Assess Canada's role in the shark fin trade: identify, monitor, and improve data on import and export of shark fins 	<ol style="list-style-type: none"> 1. For data deficient species, reverse the burden of proof until data is collected, taking full advantage of the precautionary approach 2. Identify priority species and introduce management measures to halt species decline (legal protection, closed or restricted areas) 3. Explore alternative approaches to manage and conserve sharks: economic incentives, and bycatch and spatial management measures
Education and awareness	<ol style="list-style-type: none"> 1. Cooperative research programs to improve effort and catch data, reduce incidental catch, and improve education and awareness 2. Raise awareness and encourage participation of stakeholders in the management of fisheries bycatch 3. Develop codes of conduct for handling of elasmobranch bycatch species 	<ol style="list-style-type: none"> 1. Develop a communication and education strategy aimed to inform all stakeholders on the conservation and management of sharks 2. Improve information sharing between fisheries and regions on: bycatch hotspots, mitigation measures, and species composition 3. Promote best practices for catch and release of sharks across all fisheries
Coordination and consultation	<ol style="list-style-type: none"> 1. Develop effective communication and consultation mechanisms among all stakeholders through an annual workshop for all three ocean regions 2. Conduct workshops to assess the progress of the NPOA 3. Ensure key stakeholders are knowledgeable on the issues and threats surrounding sharks on a national scale 	<ol style="list-style-type: none"> 1. Continue and improve upon the ongoing participation and collaboration of stakeholders through the Atlantic Canada Shark Forum 2. Develop a series of bycatch action workshops to determine and solve specific bycatch issues 3. Ensure key stakeholders are knowledgeable on the issues and threats surrounding sharks on a regional scale

fishery managers to more effectively assess progress and outstanding issues for all sharks within a region. Recommended content is provided in Table 4.

6. Conclusions

This case study suggests that the national implementation of the IPOA can be fraught with problems. The Canadian NPOA highlighted here needs to be revised, in order to better comply with the IPOA framework. However, Canada should be well equipped to do this (a revision is scheduled for 2012). Considering the existing stakeholder input from the ASF, a regional shark plan for Atlantic Canada and the eastern Arctic could be developed as well. The recommendations on the process for revision (Fig. 1) and the particular issues that need to be addressed (Table 4) provide a framework for this revision. There is encouraging overlap and consistency among the IPOA recommendations and those priorities independently identified by regional stakeholders at the ASF. It remains unclear why the Canadian government has so far only partly satisfied its commitment to implement and review a NPOA-sharks. In contrast, Australia has developed a more comprehensive NPOA for sharks, which could be used as a further template for other nations that are currently drafting or revising their National Plans of Action. Thirteen years into its existence, the IPOA-sharks remains an authoritative and important instrument for coordinated action to conserve and manage sharks and their relatives. Although individual nations are defined by political boundaries, sharks continually cross those lines. This simple fact necessitates the continued implementation of an integrated global strategy to conserve and manage these vulnerable species.

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