

Improving Shark Conservation and Management in Canada:
Recommendations for the National Plan of Action for Sharks

By

Brendal Alice Davis

Submitted in partial fulfillment of the requirements for the degree

of

Master of Marine Management

at

Dalhousie University

Halifax, Nova Scotia

August 2011

© *Brendal Alice Davis, 2011*

Dalhousie University,
Marine Affairs Program
Halifax, Nova Scotia Canada

The undersigned hereby certify that they have read and recommend to Marine Affairs Program for acceptance a graduate research project titled "*Improving Shark Conservation and Management in Canada: Recommendations for the National Plan of Action for Sharks*" by author in partial fulfillment of the requirements for the degree of Master of Marine Management.

Supervisor: Boris Worm, Department of Biology, Dalhousie University

Signature: _____ dated: _____

Dalhousie University

Date: August 17th, 2011

Author: Brendal Alice Davis

Title: *Improving Shark Conservation and Management in Canada: Recommendations for the National Plan of Action for Sharks*

School: Marine Affairs Program, Faculty of Management

Degree: Master of Marine Management

Convocation: October

Year: 2011

Signature of Author

The author reserves other publication rights, and neither the graduate project nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

The author attests that permission has been obtained for the use of any copyrighted material appearing in the thesis (other than the brief excerpts requiring only proper acknowledgment in scholarly writing), and that all such use is clearly acknowledged.

DEDICATION PAGE

*“Continuous effort-not strength or intelligence-is the key to unlocking our potential”-
Liane Cordes*

Perseverance is the plus that assures us of goal completion. Unquestionably, every one of us is capable of achievement. All that is required is that we commit ourselves with determination to the task before us, one moment at a time, one day at a time. Our rewards will be many. Among them will be accomplished goals, high self-esteem, and a secure sense of well-being. It's probable that we sometimes fail to recognize our worth or understand the real value of our talents. It is likely too, that on occasion we shut out of our consciousness the knowledge that our very existence validates our necessity to the whole of creation. Self-reminders are important. They are like vitamins; they contribute to our nourishment.

When we have lost sight of our ability to make valuable contributions to society and to the planet, we slow down our efforts. We close ourselves off from others and our potential is stifled. To move forward once again, requires only our attention to the moment engulfing us. We can handle what lies before us.

Today my efforts are needed, in the here and now. That's all.

The above was taken from the book “Daily Meditations” by Karen Casey and Martha Vanceburg

TABLE OF CONTENTS

ABSTRACT.....	IX
LIST OF ABBREVIATIONS AND GLOSSARY.....	X
ACKNOWLEDGEMENTS.....	XIII
CHAPTER 1: INTRODUCTION.....	1
1.1. RESEARCH SCOPE AND PURPOSE.....	1
CHAPTER 2: INTERNATIONAL AND NATIONAL PLANS OF ACTIONS FOR SHARKS.....	5
2.1. A REVIEW OF THE IPOA AND ITS PURPOSE.....	5
2.2. CANADA’S NPOA-SHARKS: INTENT AND IMPLEMENTATION	11
2.3. AUSTRALIA’S NPOA: A COMPARISON TO CANADA.....	43
CHAPTER 3: OTHER APPROACHES TO MANAGE AND CONSERVE ELASMOBRANCHS	49
3.1. SPATIAL MANAGEMENT.....	50
3.1.1. <i>Closed and Protected Areas</i>	50
3.2. BYCATCH MANAGEMENT.....	54
3.2.1. <i>Comprehensive Bycatch Management Plans in Australia and the US</i>	56
3.2.2. <i>Economic Incentives for Bycatch and Discard Reduction</i>	60
3.3. EDUCATION AND RESEARCH.....	68
3.3.1. <i>Safe Release Practices</i>	69
3.3.2. <i>Cooperative Research Programs</i>	71

CHAPTER 4: STAKEHOLDER FEEDBACK: THE FIRST ATLANTIC CANADA SHARK FORUM.....	77
CHAPTER 5: SYNTHESIS AND RECOMMENDATIONS	85
5.1. REVISING THE NPOA.....	87
5.2. DEVELOPING A PRELIMINARY RPOA: ATLANTIC CANADA/EASTERN ARCTIC.....	96
REFERENCES	101
APPENDIX 1: SHARK DISCARDS FROM CANADIAN COMMERCIAL FISHERIES	112
APPENDIX 2: AUSTRALIA’S NPOA-18 ISSUES DEFINED IN SHARK PLAN 1 .	117

LIST OF TABLES AND FIGURES

Table 1: IPOA Overarching Goal and Principles	9
Table 2: IPOA Guidelines of Implementation and Recommended Objectives	10
Table 3: NPOA Action 1, Data Collection and Research.....	15
Table 4: NPOA Action 2, Adoption of the Ecosystem and Precautionary Approach	19
Table 5: NPOA Action 3, Standardized Reporting and the Management Plan Proces	22
Table 6: NPOA Action 4, Bycatch Reduction and Reporting of Discard Mortality	27
Table 7: NPOA Action 5, Extend Conservation and Management Measures to the Arctic Coast	30
Table 8: NPOA Action 6, Enhance Outreach and Education Efforts.....	33
Table 9: NPOA Action 7, National Plan of Action Review	35
Table 10: NPOA Action 8, Cooperate Within RFMOs to Improve the Conservation and Management of Sharks	38
Table 11: NPOA Action 9, Enhance Outreach and Education Efforts Internationally	40
Table 12: WWF-ACSF, First Session Top Priority List.....	82
Table 13: WWF Cross-Cutting Priorities	83
Table 14: IPOA Objectives to WWF-Cross Cutting Priorities.....	84

Table 15: Implementation of Actions: Connecting Themes, Issues, Actions, and IPOA Objectives (Example Only).....	93
Table 16: Example of Performance Indicators Used to Assess the NPOA's Effectiveness	94
Table 17: Recommended Content for a NPOA- <i>sharks</i> in Canada	95
Table 18: Recommended Content for a RPOA- <i>sharks</i> in Atlantic Canada/Eastern Arctic	99
Figure 1: NAFO Convention Area	9
Figure 2: Summary Process, A Guide to NPOA Development, Implementation, and Review	88

Davis, B. 2011. Improving Shark Conservation and Management in Canada: Recommendations for the National Plan of Action for Sharks [graduate project]. Halifax, NS: Dalhousie University

ABSTRACT

The International Plan of Action for the Conservation and Management of Sharks (IPOA-*sharks*) is a voluntary instrument developed by the Food and Agricultural Organization (FAO). Its implementation on a national scale has been slow for most States, including Canada. Although Canada is often considered a leading country in shark management, their 2007 National Plan of Action (NPOA) is vague and unspecific, with no set timelines, priorities, or action plans to mitigate threats to sharks. There is a widely recognized need to improve upon the existing NPOA in 2012 and also an opportunity to develop Regional Plans of Action (RPOAs) to address region-specific issues. This thesis reviews and compares the existing NPOAs for Canada and Australia, highlights cutting-edge policies and management measures applicable to sharks, and considers the multi-stakeholder input from the first Atlantic Canada Shark Forum (ACSF). From this research it is proposed that Canada adopt six steps when revising their NPOA and developing an RPOA, including in this order: (1) engage stakeholders and conduct a shark assessment report (SAR), (2) include and address all ten IPOA objectives, (3) prioritize national and regional shark conservation and management issues, (4) create actions with firm timelines and identify the responsible agencies, (5) build research capacity, and (6) review the NPOA every four years for its effectiveness towards the conservation of sharks. Finally, recommended actions are provided as the minimum NPOA/RPOA shark plan content for data collection/scientific research, management/conservation, education, and coordination.

Keywords: shark, elasmobranch, IPOA, NPOA, marine species, fisheries management

LIST OF ABBREVIATIONS AND GLOSSARY

*Terms are taken from **Lack and Sant, 2011; Camhi et al., 2009; WWF, 2011, DFO, 2007a and DAFF, 2004**

ACSF- Atlantic Canada Shark Forum.

ALPAC- Atlantic Large Pelagics Advisory Committee.

Bycatch- the part of a catch taken incidentally in addition to the target species. In broad context this includes all non-targeted catch including byproduct and discards.

BAP- Bycatch Action Plan.

Byproduct- the part of the catch which is retained due to its commercial value, but which is not the primary target.

CBD- Convention on Biological Diversity (www.cbd.int).

Chimaera- a species of the order Chimaeriformes within the subclass Holocephali.

Chondrichthyes- the class Chondrichthyes: the cartilaginous fishes, which include the elasmobranchs and the holocephalans.

CITES- Convention on the International Trade in Endangered Species of Fauna and Flora. An international conservation agreement, which aims to ensure that international trade in specimens of wild fauna and flora, does not threaten the survival of species.

COSEWIC- The Committee on the Status of Endangered Wildlife in Canada.

Commercial fishery- a fishing operation that targets species for sale.

CMMB- Compensatory Mitigation for Marine Bycatch.

Critical habitat- habitat deemed to be crucial at some phase of the life history of a particular species.

DAFF- Australian Government Department of Agriculture, Fisheries and Forestry.

Demersal- occurring or living near the bottom of the ocean.

DFO- Department of Fisheries and Oceans Canada.

Discards- the component of a catch returned to the sea, either dead or alive. Primarily made up of non-target, unwanted species, but can include juveniles and damaged or unsuitable individuals of the target species.

Discards/release mortality- the proportions of fish that die as a result of being discarded after capture.

EBMF- Ecosystem-based management for fisheries.

EEZ- Exclusive Economic Zone. A zone under national jurisdiction up to 200-nautical miles wide.

Elasmobranch- Refers to Elasmobranchii.

Elasmobranchii- the subclass Elasmobranchii, a major subdivision of the Class Chondrichthyes, encompassing the living sharks, batoids, and their living fossil relatives.

FAO- Food and Agricultural Organization www.fao.org.

Finning- the practice of slicing off a shark's fins and discarding the body at sea.

Gillnet- a type of fishing net designed to entangle or ensnare a fish.

IATTC- Inter-American Tropical Tuna Commission. RFMO responsible for the management of fisheries for tunas and other species taken by tuna-fishing vessels in the eastern Pacific Ocean.

ICCAT- International Commission for the Conservation of Atlantic Tunas. RFMO responsible for the management of fisheries for tuna and tuna-like species in the Atlantic Ocean.

IFMP- Integrated Fisheries Management Plan.

IHQ- Individual Habitat Quota.

Incidental Catch- See Bycatch.

IPOA-sharks- The UN FAO International Plan of Action for the Conservation and Management of Sharks.

IUCN- International Union for the Conservation of Nature.

K-selected species- a species selected for its superiority in a stable environment; a species typified by slow growth, relatively large size, low natural mortality and low fecundity.

Longline fishing- a fishing method using short lines bearing hooks attached at regular intervals to a longer main line.

NAFO- Northwest Atlantic Fisheries Organization. RFMO responsible for the management of fisheries in the Northwest Atlantic.

NGO- Non-Governmental Organization.

NMFS- National Marine Fisheries Service.

Non-target species- a species which are not the subject of directed fishing effort, including bycatch and byproduct.

NPOA-sharks- National Plan of Action for the Conservation and Management of Sharks in fulfillment of the IPOA-sharks.

Pelagic- occurring or living in open waters or near the water's surface with little contact with or dependency on the sea floor.

Precautionary approach- a strategy that acts to ensure the well-being of a species, population, or habitat even when full scientific certainty is lacking.

Recreational fishing- where the fish captured is not for sale or for monetary gain. Predominately a leisure activity for sport.

RFMOs- Regional Fisheries Management Organizations.

RPA- Recovery Potential Assessment.

RPOA-*sharks*- Regional Plan of Action for the Conservation and Management of Sharks.

RSAR- Regional Shark Assessment Report.

SAG- Shark Advisory Group.

SAR- Shark Assessment Report.

SFLPAC- Scotia-Fundy Large Pelagics Advisory Committee.

TAC- Total Allowable Catch.

Target catch- the catch which is the subject of directed fishing effort within a fishery; the catch consisting of the species primarily sought by fishers.

UNCLOS- United Nations Convention on the Law of the Sea.

WWF- World Wildlife Fund.

ACKNOWLEDGEMENTS

My list of acknowledgements is undoubtedly exhaustive, however, I must mention a few key people who have aided me in life, on this journey, and many others.

-To my parents, who tell me I can do anything and who have supported me every step of the way. My dad continuously reminds me that life is short, yet sweet and full of adventure. To enjoy each moment, even the bad ones, can only mean life is being lived to its fullest. My mom, a strong willed and beautiful woman who gave me the passion for travel, patience, honesty, and the conscious thought to always be positive. I thank you both.

-To my dear friends Aurelie and Jarrett, thank you for not only being patient with my questions, but with your advice and guidance in seeing me to the end. Without you both, this would have been a much more grueling process.

-To my advisor, Boris Worm, your guidance has been invaluable. You always put everything so simply, with such great meaning, and that makes all the difference to a student and an individual who aspires to follow in your footsteps. Thank you for taking me on as a student and giving me a chance.

-To all of the World Wildlife Fund staff, thank you for your support, comments, and putting up with my varying mood at the office. I thoroughly enjoyed not only working with you for the summer, but also becoming your friend. Special thanks to Tonya Wimmer, Bettina Saier, Robert Rangely, and Jarret Corke.

-To the Marine Affairs Program and to all my wonderful colleagues in the MMM program. Your support unquestionably carried me through this year. I walked away from this program with a degree, but most importantly, with fourteen amazing friends. Thank you.

-Last and certainly not least, to my best friend and boyfriend Scott Townsend. I met you during this one-year intense program, and from the beginning, your patience has literally been a virtue. You not only became my best friend, you put things into perspective for me, opened my eyes to beautiful Nova Scotia, and reminded me that this is just a small journey to a much larger one. I could not have done this without you. Thank you.

To all my other friends and family, thank you.

CHAPTER 1: INTRODUCTION

1.1. Research Scope and Purpose

Despite increasing conservation concerns, many species of sharks, skates, and rays, collectively referred to as chondrichthyes, continue to decline in abundance (Baum et al., 2003; Camhi et al., 2009; Ferretti et al., 2010). Displaying k-selected life history characteristics of slow growth, late maturation, long life, and low fecundity, chondrichthyan species are extremely sensitive to overfishing (Camhi et al., 2009; Dulvy et al., 2008; Ferretti et al., 2010). Due to their vulnerability, indirect and direct threats from fishing, climate change, and pollution can greatly affect the species ability to recover from population depletion or other anthropogenic threats (Camhi et al., 2009). In response to the growing concern for depleted shark stocks, the Food and Agriculture Organization (FAO) developed a regulatory framework for the long-term conservation and management of sharks in 1999. The International Plan of Action for the Conservation and Management of Sharks or IPOA-*sharks* is a voluntary instrument from which shark fishing States can develop their own conservation plan and address the ten recommended IPOA objectives (FAO, 1999). However, the adoption and implementation of this framework at the national level has been slow for most regions (Lack and Sant, 2006). Canada, which is often considered one of the leading countries in shark management, adopted a National Plan of Action (NPOA) for sharks in 2007, which covers the Pacific, Atlantic, and Arctic Ocean regions. However, the plan is vague and unspecific, with no set timelines, priorities, or action plans to mitigate threats to sharks. There is a widely

recognized need to improve upon the existing plan and further consider a regionally developed plan to address regional perspectives and issues (Godin and Worm, 2010).

Among several environmental organizations, World Wildlife Fund (WWF)-Canada recognized the inadequacies of the existing NPOA, but specifically acknowledged the need for stakeholder input into a revised NPOA. In accordance with that vision, in 2011, WWF held the first Atlantic Canada Shark Forum (ACSF), inviting a variety of stakeholders, including the fisheries industry, policy and management (both government and non-governmental organizations), and representatives from the scientific community, to discuss and identify top priorities for shark conservation and management in Atlantic Canada (WWF, 2011).

The purpose of this research is to examine the existing NPOA for Canada and determine the plans effectiveness against its stated actions and compare this progress to the FAO's request and guidelines for a national plan (FAO, 1999). For comparison, Australia's NPOA is also reviewed to indicate the success and progress in the development of their plan of action. Australia is seen as one of the leaders in shark conservation and management (Lack and Sant, 2011) and is used as a template for the NPOA revision. Based on the WWF-ACSF stakeholder consultations and a review of the literature, the priorities for shark conservation and management in Atlantic Canada, including the Eastern Arctic, fall under three broad categories of spatial and bycatch management and education/research. Based on these broad categories, the scope of this research looks at what other countries have done to advance marine species conservation and management. This includes, *inter alia*, bycatch mitigation policies; economic incentives for sustainable fishing, improved catch and release practices, and educational initiatives to increase

awareness on species identification. From this research, six steps are recommended as the minimal process needed in the development of a revised NPOA for 2012 and a Regional Plan of Action for Sharks (RPOA-*sharks*) in Atlantic Canada and the Eastern Arctic (RPOA). Information used to support this work comes from the WWF-ACSF, the FAO, published and grey literature, government reports, policies, and fisheries plans, with an aim to:

1. Review the IPOA guidelines, the IPOA's primary purpose, and its procedures for implementation.
2. Review the Canadian NPOA for its effectiveness against its stated objectives and actions and determine its adherence to the IPOA guidelines, and compare the plan to Australia's NPOA.
3. Identify from the available literature what other measures have been taken to address marine conservation and management issues, and determine their overall effectiveness and applicability towards sharks.
4. Develop a set of recommendations on how to revise Canada's NPOA for 2012, and the development of a RPOA-*sharks* for Atlantic Canada/Eastern Arctic, based on the IPOA recommendations, stakeholder input, and the reviewed literature.

If regulatory measures are to be effective in protecting sharks in Canada, having a NPOA that closely follows the IPOA guidelines and its ten objectives is essential. Furthermore, having a broadly defined NPOA, from which a regional plan can be based is critical to strengthening shark conservation and management in Atlantic Canada/Eastern Arctic.

This thesis is divided into five chapters. The present chapter introduces the research purpose and scope. The second chapter reviews the IPOA, NPOA, and Australia's NPOA, addressing their history, purpose, and effectiveness. Chapter three provides an in-depth review of other approaches that manage and conserve species, specifically looking at the three broad categories of spatial management, bycatch management, and education/research. Chapter four reviews the purpose and intent of WWF's ACSF and its contribution to engaging stakeholders and to developing a regional plan of action. Finally, chapter five provides a synthesis and recommendations for revising the Canadian NPOA, as well as recommendations for developing a preliminary RPOA for Atlantic Canada and the Eastern Arctic.

CHAPTER 2: INTERNATIONAL AND NATIONAL PLANS OF ACTIONS FOR SHARKS

2.1. A Review of the IPOA and its Purpose

Many countries interact with “sharks” (herein collectively referred to as sharks, skates and rays or elasmobranchs, unless otherwise stated) either directly or indirectly, yet the current state of knowledge for catches, effort, landings, trade data, and practices employed by fisheries, are limited for this species group (Dulvy et al., 2008; FAO, 1999). In the face of management deficiencies and declining shark populations, the FAO recognized the need for an international framework for sharks, of their conservation and management, through the development of the IPOA-*sharks* (FAO, 1999). The purpose of the IPOA is to facilitate the identification of these gaps through a comprehensive framework and shark assessment report (SAR) that collects the necessary information for improving the conservation and management of elasmobranchs (FAO, 1999). The IPOA is circumscribed by a set of principles, an overarching goal (Table 1), and procedures for implementation with a set of ten objectives (Table 2), from which all States and RFMOs are encouraged to adopt (FAO, 1999). Within the nature and scope of the IPOA, it explicitly describes the term “shark” to include all species of sharks, skates, rays, and chimeras. 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 catches (FAO, 1999). Through the IPOA, the FAO recommends 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, voluntarily develop a National Plan of Action for the Conservation and Management of Sharks or NPOA-*sharks* (FAO,

1999). Although the FAO requested that all States submit a shark plan by 2001, to date, only 13 of the 134 shark-fishing States, including Canada, have developed an NPOA (Lack and Sant, 2011). In addition, 22 other States are reported to be currently working on an NPOA, but the status of these reports is largely unknown (Camhi et al., 2009). The content of these shark plans differ in their scope, objectives, procedures for implementation, and the extent to which they meet the IPOA objectives (FAO, 2009). Most of the plans do not contain specific actions or associated timelines, and a majority of the plans, including Canada's (Godin and Worm, 2010), neglect to address all ten IPOA objectives and the underlying principles (Lack and Sant, 2011).

Canada's NPOA follows the IPOA principles, but with a narrow focus on commercial species. While the NPOA addresses the mortality of porbeagles (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), and blue sharks (*Prionace glauca*), it does not contribute any action plans to manage other shark or skate declines, even though these species incur high levels of bycatch and discards in commercial fisheries (Gavaris et al. 2010). Nor does the plan list any actions or strategies to keep total fishing mortality down for skates. Except for the porbeagle shark, no precautionary management measures are in place to mitigate shark decline, bycatch, or discards (Godin, 2009).

Recognizing the consequences of shark population decline, their mismanagement, and the limited adoption of these voluntary plans, the FAO organized an expert consultation in 2005 to evaluate the progress of IPOA implementation (FAO, 2009). In review, the FAO found very few countries had successfully developed and implemented an NPOA and identified possible reasons why such a slow progression exists for IPOA implementation

(Box 1). Although Canada was not in the evaluation, as they had not developed a plan yet, Godin (2009) found similar problems with Canada’s NPOA. The NPOA was found

<p>BOX 1</p> <p><u>Problems found with IPOA implementation:</u></p> <ol style="list-style-type: none">1. Low economic value importance of shark fisheries and low priority for receiving allocations of funds and experts.2. Weak or lacking political will to address problems with elasmobranch populations within jurisdictions.3. Lack of expertise to determine which management actions are required to expedite implementation.4. Insufficient funding and expertise to address the problems posed by management requirements. <p><u>Other Concerns:</u></p> <ol style="list-style-type: none">1. Lack of taxonomic guides to identify species.2. Lack or insufficient amount of information on population biology of elasmobranch species, both target and bycatch.3. Scarce or lacking data for catch and fishing effort. <p>FAO, 2009</p>
--

to be “vague and unspecific”, with “no set timelines, priority actions or deliverables” (Godin and Worm, 2010). After identifying concerns with IPOA implementation, the FAO recommended all Parties improve cooperation with fisheries management bodies, establish systems to provide verification of catch, and adopt the IPOA framework, where they have not done so (FAO, 2009). From the 2005 consultation, there is a clear need for countries to improve the monitoring of shark fisheries at the regional, national, and international level, including Canada. In response to this need, in 2008, the FAO held a Technical Workshop on Status, Limitations, and Opportunities for Improving the Monitoring of Shark Fisheries and Trade (FAO, 2009). Informed by the results of the 2005 consultation, this workshop was designed to identify opportunities and

make recommendations for the improvement of existing and newly developed NPOAs (Box 2) (FAO, 2009).

BOX 2**FAO Recommendations for Improvement:**

1. Improve communication among different agencies, especially those in species conservation and fisheries management.
2. Ensure key stakeholders are well sensitized on the importance of shark management through improved communication.
3. Utilize a participatory approach with the involvement of all stakeholders, as broad as practical.
4. Make plans as realistic and achievable as possible, including taking a step-by-step approach towards implementation.

FAO, 2009

Equally, these recommendations should be applied to a revised NPOA for Canada. Godin (2009) broadly reviewed the Canadian NPOA to evaluate how complete the plan was compared to the IPOA and found *inter alia* that it largely lacked stakeholder engagement prior and post to its development (Godin, 2009).

In this section I assess whether the existing Canadian NPOA delivered any improvements to shark conservation or management since its implementation in 2007. Since the Canadian NPOA sets no priorities, timelines, or deliverables, and is not closely linked with the IPOA principles and objectives, a full assessment on its

effectiveness is difficult. However, by reviewing each proposed action and determining current implementation and future plan of action, it is easier to assess the extent to which the principles of the IPOA have been applied, either through the NPOA or other management measures.

Table 1: IPOA Overarching Goal and Principles

IPOA Goal and Principles	
Goal: to ensure the conservation and management of sharks and their long-term sustainable use	
Principles	
1. Participation	Any State that contributes to fishing mortality on a species or stock should participate in its management
2. Sustaining stocks	Management and conservation strategies should aim to keep total fishing mortality for each stock within sustainable levels by applying the precautionary approach
3. Nutritional and socio-economic considerations	Management and conservation strategies should recognize that in some low-income food-deficit regions are/or countries, shark catches are a traditional and important source of food, employment and/or income. Such catches should be managed on a sustainable basis to provide a continued source of food, employment, and income to local communities FAO, (1999)

Table 2: IPOA Guidelines of Implementation and Recommended Objectives

IPOA Guidelines of Implementation and Recommended Objectives		Addressed by Canada's NPOA	
A.) IPOA Guidelines	B.) Ten Recommended Objectives	A	B
1. States should adopt, develop, implement, and monitor an NPOA for sharks by 2001	1. Ensure shark catches from directed and non-directed fisheries are sustainable	No- Canada developed their NPOA in 2007	Yes- addressed in action 1
2. States should consistently assess the status of shark stocks subject to fishing and data should be made available to FAO and relevant fisheries organizations	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	No- Canada's NPOA mostly addresses commercially important species and does not address non-commercial species	Yes- addressed in actions 2,4,7
3. States should regularly (every 4 years) assess the plan for its purpose and cost-effectiveness	3. Identify and provide special attention, in particular to vulnerable or threatened shark stocks	No- Canada missed the 4 year revision, but instead will assess the plan by 2012	Yes- addressed in action 6
4. States should strive to cooperate with regional and sub regional fisheries organizations or arrangements with a view to ensuring shark sustainability and when appropriate, develop regional shark plans	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- Canada has not developed a regional plan	Yes- addressed in action 3
5. Where transboundary, straddling, highly migratory and high seas stocks of sharks are exploited by two or more States, the States concerned should strive to ensure effective conservation and management of the stocks	5. Minimize unutilized incidental catches of sharks	Yes- Canada and the USA created a bi-lateral plan for spiny dogfish. However, other transboundary species are not addressed	Yes- addressed in action 4
6. States should strive to collaborate through FAO and through international arrangements in research, training, and the production of information and education material	6. Contribute to the protection of biodiversity and ecosystem structure and function	No- As of current, there are no known arrangements for collaboration	Yes-addressed in actions 5, 8, 9
7. States should report on the progress of the assessment, development, and implementation of their <i>Shark-plans</i>	7. Minimize waste and discards from shark catches	No- Canada has not reported their progress to the FAO	Not addressed
8. States should carry out a regular assessment of the status of shark stocks subject to fishing so as to determine if there is a need for a <i>shark-plan</i> . The assessment should be reported as part of the Shark Assessment Report (SAR)	8. Encourage full use of dead sharks	No- Canada has not developed a SAR	Not addressed
	9. Facilitate improved species-specific catch and landings data and monitoring of shark catches		Yes- addressed in actions 4,6,8
	10. Facilitate the identification and reporting of species-specific biological and trade data		Yes- addressed in action 6
<ul style="list-style-type: none"> • Column (A) on the left represents the IPOA guidelines and on the right, Canada's adherence to these guidelines. • Column (B) on the left represents the ten IPOA Objectives and on the right, Canada's compliance with these objectives in their NPOA Actions. <p>IPOA Guidelines and Recommendations according to FAO (1999)</p>			

2.2. Canada's NPOA-sharks: Intent and Implementation

Canada developed their NPOA for sharks in 2007 (DFO, 2007a), which provides a brief overview of commercial shark stocks and non-commercial species, existing management measures for sharks, and attempts to address eight out of the ten objectives recommended by the FAO. However, the NPOA neglects to provide any information on issues or threats currently facing sharks, priorities and responsible agencies for implementation of actions, nor does it address the recreational shark fishery. Furthermore, the NPOA fails to provide any firm actions with timelines to mitigate threats to sharks, and still has yet to complete a shark assessment report (SAR). The SAR, strongly recommended by the FAO, should quantify elasmobranch stock status, fishing effort for directed and non-directed fisheries, outline existing management and mitigation efforts, and suggest possible modifications to management measures (FAO, 1999). In addition, it still remains unclear how the nine NPOA actions (Tables 3-11) were developed, as there was no documented stakeholder consultation prior or post to the development of the NPOA (Godin, 2009). This present research focuses on and examines in detail, the nine proposed actions for Atlantic Canada and the Eastern Arctic, but also reviews some actions for the Pacific, as the NPOA should encompass Canada's three oceans. This review evaluates the effectiveness of the NPOA against its stated actions and objectives, including an evaluation of the priority to which these activities should occur, as none were given in the existing plan (Box 3).

Box 3

Evaluation of Priorities

High Priority- the likelihood of this action contributing to shark conservation and management is significant, in that it may greatly lower the degree of exploitation or harvest, greatly improve the knowledge of the species population status, distribution, and trend; addresses a species of high concern, may significantly improve education and awareness on elasmobranchs, and can greatly improve stakeholder consultation.

Med Priority-the likelihood of this action contributing to shark conservation and management is notable, in that it moderately lowers the degree of exploitation or harvest, moderately improves the knowledge of the species population status, distribution, and trend; addresses a species of medium concern; moderately improves education and awareness on elasmobranchs, and can moderately improve stakeholder consultation.

Low Priority-the likelihood of this action contributing to shark conservation and management is poor, in that it is unlikely to lower the degree of exploitation or harvest, unlikely to improve the knowledge of the species population status, distribution, and trend; unlikely to address a species of low concern; only slightly improves education and awareness on elasmobranchs, and is unlikely to improve stakeholder consultation.

The intention is to use the findings towards the development of a more comprehensive NPOA and a further defined RPOA-sharks, for the Atlantic and Arctic region. While the Pacific region is equally important, it is only briefly covered in this research due to time constraints, but should be considered for future research and development.

Proposed actions in Canada's NPOA

NPOA Action 1: Data Collection and Research

The NPOA Action one, aims to improve data collection and sharing among fishers, aboriginal groups, conservation organizations, academics, and other interested parties. Although this can be seen as a broad objective, it addresses IPOA objectives one, two, and three, and highlights primary areas of research (Table 3). The listed actions for data collection and research encompass four of the IPOA objectives and address both target and non-target species, but do not address the need for data collection in the recreational sector. Of the eight specific data collection actions listed for the Atlantic (7) and Pacific (1), all have been completed as of 2011. Species assessed included porbeagle, blue, basking (*Cetorhinus maximus*), shortfin mako, spiny dogfish (*Squalus acanthia*), black dogfish (*Centroscyllium fabricii*), and several species of skates (DFO, 2007a). Although the NPOA lists shark and skate catch and landings on the Pacific coast as a result of bycatch, only one action was listed for Pacific species, namely, big skate (*Raja binoculata*). However, for future actions, DFO-Pacific is currently undertaking studies on longnose (*Raja rhina*), big, and sandpaper skate (*Bathyraja interrupt*), and basking, blue, salmon (*Lamna ditropis*), thresher (*Alopias vulpinus*), and sixgill sharks (*Hexanchus griseus*) (personal comm, Jackie King DFO, 2011). DFO-Maritimes plans to continue studying discard mortality for porbeagles and conduct a preliminary stock abundance study for shortfin makos. Due to limited funding and staff, they do not have plans to quantify bycatch or conduct studies of estimated post-release mortality of other

shark species (personal comm, Steven Campana, DFO, 2011). Revisiting the objective under NPOA Action one, it is unclear whether any improvements were made in building upon collaborative knowledge sharing and consultation with fishers, Aboriginal groups, conservation organizations, academics, and other interests, as no activities were listed to address this, nor could be traced through the DFO website or DFO personnel.

Table 3: NPOA Action 1, Data Collection and Research

ACTION	1. DATA COLLECTION AND RESEARCH					
Objective	Enhance current research efforts on sharks, and build upon collaborative knowledge sharing and consultation with fishers, Aboriginal groups, conservation organizations, academics, and other interests					
Mean (Atlantic + Arctic)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA Objective
1.1.Recovery potential assessment (RPA) for porbeagle shark with implications for the future of directed shark fishery and identification of pupping grounds	-RPA completed in 2010 -Identification of pupping grounds completed in 2010	Campana et al. 2010 Campana et al., 2010	-DFO recently received funding to study discard mortality for porbeagles	High	DFO-Science	1,2,3
1.2. Population dynamics of blue sharks, including assessment of mortality due to commercial discarding	-Canadian population dynamics assessment completed in 2009 -ICCAT assesses whole stock assessment -Bycatch and discard mortality in commercially caught blue sharks completed in 2009	Campana et al. 2009 ICCAT, 2010 Campana et al. 2009	-Stock assessments done every few years by DFO -DFO will continue to monitor the population through shark derbies and commercial bycatch information	High	DFO-Science	1,2
1.3. Recovery potential assessment (RPA) for shortfin mako and basking sharks	-Basking shark has been listed as species of concern and therefore does not require a RPA. -Basking shark assessment completed for Atlantic region. -Shortfin mako RPA completed in	Campana et al. 2009 Campana et al. 2009 Fowler and Campana, 2009	-DFO recently received funding to put satellite tags on mako sharks to determine migration patterns and stock abundance.	High	DFO-Science	1,2,3
1.4. Completion of a five year-study on the shared population of spiny dogfish in Atlantic Canada and the US	-The five-year cooperative study completed in 2009	(personal comm., Steven Campana, 2011) (personal comm., Mike Eagles, DFO, 2011)	-A 2010 Canada/US framework assessment did not reach an agreement. Using both countries data, the US completed their own assessment and Canada's assessment will be completed by September 2011.	High	DFO-science, USA	2,4

Table 3 (continued)

ACTION		1. DATA COLLECTION AND RESEARCH				
Objective	Enhance current research efforts on sharks, and build upon collaborative knowledge sharing and consultation with fishers, Aboriginal groups, conservation organizations, academics, and other interests					
Mean (Atlantic + Arctic)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA Objective
1.5. Assessment of potential pupping ground for black dogfish in the Laurentian Channel	-Identified pupping grounds for black dogfish in 2006	Kulka, 2006	-The Laurentian Channel was selected as a candidate site for an <i>Oceans Act</i> MPA	Medium	DFO-Science	2
1.6. Ongoing research on the skate complex (14 species) off Newfoundland and Labrador	-Research conducted on stock structure, age and maturity, distribution and abundance of 14 species of skates	(personal comm, Mark Simpson, DFO, 2011)	-Ongoing research for skates to continue: diet; commercial mortality. Two sample surveys a year	High	DFO-Science	2
1.7. Growth and reproductive potential of winter, little and thorny skates on the Scotian Shelf	-Study completed in 2009	Mcphe and Campana, 2009	-No work currently being done on these species	High	DFO-Science	2,3
Mean (Pacific)	Progress	Evidence	-Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
1.1. Completion of tagging research on big skate, which will quantify seasonal migration patterns and provide information on species and age composition	-Study completed in 2010	King and McFarlane, 2010	-Bomb radiocarbon study to validate age for big and longnose skate -Surplus production model on big skate to provide advice on new TAC -Ageing methodology for sandpaper skate -Ariel surveys, satellite tags, and DNA analysis for basking sharks: Canada, Mexico, and USA - Canada, USA, Mexico, and Japan working on blue and salmon shark population genetics - 8 satellite tags for sixgill sharks -2 sat tags for tope sharks -Ageing methodology for thresher sharks	High	DFO-Science DFO DFO and SWFS	2

NPOA Action 2: Adoption of an Ecosystem Approach and the Precautionary Approach as Key Elements of Fisheries Management Renewal

Action two explicitly calls for an ecosystem approach and precautionary principle to be

BOX 4

IFMPs Applicable to Sharks

1. Canadian Atlantic Pelagic Shark Integrated Fisheries Management Plan
2. IFMP- Atlantic Mackerel
3. IFMP- Atlantic Bluefin Tuna
4. IFMP- Atlantic Swordfish and Other Tunas
5. Groundfish Management Plan Scotia-Fundy Fisheries Maritimes Region
6. Integrated Groundfish Management Plan for Gulf of St-Lawrence
7. IFMP- Greenland Halibut

DFO, 2007

incorporated into DFO fisheries management plans, as mandated by the *Oceans Act*, and includes IPOA objectives six and seven (DFO, 2007a). As defined by DFO, a fisheries plan encompassed by the ecosystem approach should take account of (among other things) **1.** All interactions the target fish stock has with predators, competitors, and prey species **2.** The effects of weather and climate and **3.** The interactions between fish and habitat, and the effects of fishing on species and habitat (DFO, 2007a). The existing Atlantic Pelagic Shark Integrated Fisheries Management Plan (IFMP) partly

considers fish and their habitat, but neglects to address fisheries interactions with skates and rays, such as barndoor (*Dipturus laevis*) and winter skate (*Amblyraja radiata*) (DFO, 2007c), which are caught as bycatch in the porbeagle fishery (Gavaris et al., 2010). Nor does the plan include the effects of weather or climate on target or bycatch species. A new IFMP for Atlantic Pelagic Sharks is currently under revision and projected to be updated in 2012 (personal comm, Michael Eagles, DFO, 2011). Although not legally binding, this plan should incorporate new management measures for shark bycatch in the pelagic longline fishery and include an ecosystem and precautionary approach to management (DFO, 2011). Since the adoption of the NPOA, the IFMPs applicable to

sharks (Box 4), except for the IFMP for swordfish (*Xiphias gladius*), have not been revised to include the ecosystem approach as defined by DFO (personal comm, Sara Quigley, DFO, 2011). To date, with the exception of shortfin mako in the swordfish fishery and dogfish in the fixed gear groundfish fleet, there are no species-specific bycatch and discard restrictions in any other fishery (Benjamins et al., 2010). For example, the mackerel (*Scomber scombrus*) mid-water trawl fishery can catch large quantities of porbeagle shark and spiny dogfish, yet the only species that can be retained is herring (*Clupea harengus*), therefore; any other species caught as bycatch must be discarded and is not counted against commercial quota (DFO, 2007b). In addition, although a vessel fishing for swordfish and tuna (*Thunnus albacares*) cannot concurrently fish for sharks, there are still no species-specific restrictions on discards or bycatch in the swordfish and tuna fishery, except for adhering to the 50 tonne bycatch limit for porbeagles (DFO, 2011). Notwithstanding the swordfish draft IFMP which has proposed to set precautionary (non-restrictive) total allowable catch (TAC) limits at 250 tonnes per year for blue and shortfin mako sharks. However, as the action in (Table 4) indicates, DFO plans to incorporate a Maritimes region framework for an ecosystem-based approach (EBM) to management, including for the Atlantic Pelagic Sharks. The Maritimes EBM approach covers the eastern Scotian Shelf, southwest Scotian Shelf/Bay of Fundy and Georges Bank/Gulf of Maine with an aim to: list fishing activities in a given area, identify priorities and key pressures on the target species, monitoring key pressures, establish operational reference points for pressures, identify suitable tactics to address pressure, and conduct ongoing performance evaluations against management measures (personal comm, Sara Quigley, DFO, 2011).

Table 4: NPOA Action 2, Adoption of the Ecosystem and Precautionary Approach

ACTION	2. ADOPTION OF AN ECOSYSTEM APPROACH AND THE PRECAUTIONARY APPROACH AS KEY ELEMENTS OF FISHERIES MANAGEMENT RENEWAL					
Objective	Incorporate management tools that reflect modern conservation objectives of DFO, in particular, through the delivery of Fisheries Management Renewal and the adoption of an ecosystem approach and precautionary approach					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
2.1. Existing or newly developed IFMPs to be encompassed by the precautionary and ecosystem approach	-Draft IFMP being prepared using the Ecosystem approach and general Precautionary approach, but specific limit reference points are not expected to be available	(personal comm, Sara Quigley, DFO-Resource)	-Development of a revised Atlantic Pelagic Shark IFMP, to be completed in the fall of 2011 -Development of limit reference points	High	DFO- Resource	2,4,7

NPAO Action 3: Standardized Reporting and the Management Plan Process

Action three aims to develop a nationally consistent approach to the management of shark and shark-like species through the consultation of shark industry representatives, to review, develop, and revise policy and management plans (DFO, 2007a). This action addresses IPOA objective four, to improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders (FAO, 1999). Although the FAO recognized stakeholder consultation as a priority for NPOAs (FAO, 2009), Atlantic Canada has only partly satisfied this objective (Table 5) (DFO, 2007a). In Canada's Pacific region, stakeholder consultations are moderately ahead. As a result of the recommendations to list the bluntnose and tope shark under the *Species at Risk Act* (SARA), DFO-Pacific held technical workshops that included consultation sessions between fishers, managers, NGOs, and DFO. As a result, in 2009, both species were listed under SARA as special concern (personal comm, Jackie King, DFO, 2011). To date, there are no direct outlets, such as forums and workshops initiated by DFO-Maritimes that consult stakeholders towards the development or review of a fisheries plan for elasmobranchs. However, there are two main advisory bodies in the DFO Maritimes region that encourage stewardship for large pelagics developed prior to the NPOA, and these could be used to foster discussions and find solutions to conservation and management of pelagic species. These include the Atlantic Large Pelagics Advisory Committee (ALPAC) and the Scotia-Fundy Large Pelagics Advisory Committee (SFLPAC) (DFO, 2007c). ALPAC is considered a collaborative body between industry

and DFO that work on the management of large pelagics (e.g. swordfish, tuna, porbeagle shark). The body is encompassed by federal and provincial government, NGOs, fishers and processors and discusses concerns or issues surrounding the management of the domestic fishery and adoption of positions in the International Commission for the Conservation of Atlantic Tunas (ICCAT) (DFO, 2007c). The SFLPAC body is a “second tier government-industry consultative group” that meets at least once a year to discuss fisheries issues at depth and provide guidance and information on the “conservation, protection, and utilization of the Canadian east coast fisheries resources of tunas, swordfish, and shark, and on the management of these fisheries”. Discussion topics can include *inter alia* regulatory measures, bycatch provisions, and gear restrictions (DFO, 2011). Similar advisory bodies should be developed for skates, rays, and chimeras in the groundfish fisheries.

Post the development of the NPOA, in 2010, an “Ecosystem Working Group” was created to advise ALPAC and DFO on the EAM and its incorporation into fisheries plans (DFO, 2011). However, since the NPOAs implementation in 2007, no outlets for stewardship exist specifically for sharks, skates, or rays. Instead, they are lumped into “large pelagics”. The only known outlet to exist for shark conservation and management in Atlantic Canada was held by an external agency, WWF-Canada in 2011, of which DFO was a participant (WWF, 2011). Details on the forum are discussed in chapter four.

Table 5: NPOA Action 3, Standardized Reporting and the Management Plan Process

ACTION	3. STANDARDIZED REPORTING AND THE MANAGEMENT PLAN PROCESS					
Objective	To develop a nationally consistent approach to the management of shark and shark-like species					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
3.1. Consultations with shark industry representatives to review and plan for policy and management of related fisheries	<p><u>ATLANTIC</u></p> <p>-Ongoing consultations between DFO, industry, fishers, and processors, through ALPAC and SFLPAC advisory bodies.</p> <p>-New “Ecosystem Working Group” developed in 2010 to advise ALPAC and DFO on the EAM for fisheries plans.</p> <p>-Once draft IFMP (Table 4) is completed, it will be provided to industry for <u>comment</u></p> <p><u>PACIFIC</u></p> <p>-A technical workshop was developed for bluntnose and tope shark, which included fishers, NGOs, DFO, and managers.</p>	<p>(DFO, 2011)</p> <p>(DFO, 2011)</p> <p>(personal comm., Mike Eagles, DFO 2011)</p> <p>(personal comm, Jackie King, DFO, 2011)</p>	<p>-No specific consultation actions for elasmobranchs</p> <p>- With only one directed fishery and only one active fisher in 2010, industry interest is limited for developing new management measures.</p>	High	DFO-Resource	4

NPOA Action 4: Bycatch Reduction and Reporting of Discard Mortality

Action four addresses bycatch reduction and reporting of discard mortality within other

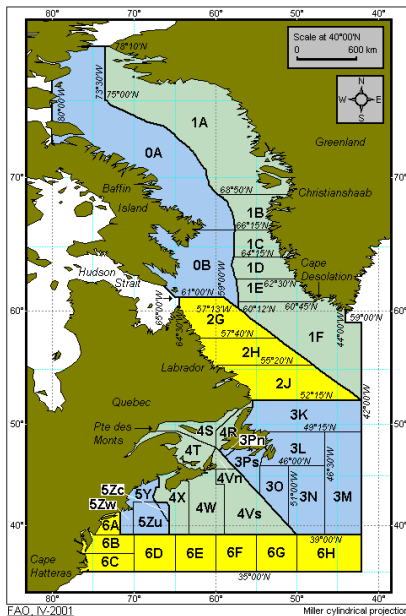


Figure 1: NAFO Convention Area (FAO, 2001)

fishing industries through several means, which are listed in Table 6. This action addresses IPOA objectives one, four, six, seven, nine, and ten. To fully assess this action, it is necessary to provide a brief background into the bycatch and discard situation in Canadian commercial fisheries. Gavaris et al. (2010), in their assessment and overview of discards in Canadian commercial fisheries (App 1, p.108), operating in Northwest Atlantic Fisheries Organization (NAFO) division’s 4V, 4W, 4X, 5Y, and 5Z

(See Fig. 1), found a general pattern for discards. The

authors’ analysis was sufficient enough to show fisheries in the above divisions largely lacked the capacity to monitor discards and that the current level of at-sea-observer coverage for principle fisheries was very low. Hence, the authors lack confidence in the reliability of discard estimates and recommend the reader view the results with caution.

Nevertheless, they feel their analysis still provides the first glance into discard estimates by fishery, region, and species (Gavaris et al. 2010). For elasmobranch species the authors found several species of potential concern based on discard estimates by region.

For the 4VW region (See Fig.1), the porbeagle shark (App 1, p.111) and thorny (*Amblyraja radiata*) skate constitute a significant amount of discards in the swordfish and

tuna longline fishery. In the 4X5Y region (See Fig. 1), the thorny and winter skate account for large amounts of discards in the groundfish bottom longline and bottom trawl fisheries, and the barndoor skate in the groundfish longline fishery. Finally, in the 5Z region (See Fig. 1), skates (winter, thorny, smooth (*Malacoraja sent*), and barndoor) show the highest rate of discards across several fisheries (App 1, p.109) (Gavaris et al. 2010). The authors recommend that any future management plans to address bycatch and discards in commercial fisheries be given to several priority region, fishery, and species groups (App. p.112). To date, Gavaris et al. (2010) offer the only study that characterizes discards by weight, region, fishery, and species from Canadian commercial fisheries in the specified NAFO divisions.

In addition, data gathered by Benjamins et al. (2010) from 2001-2003, provides additional input on shark and skate bycatch in gillnet fisheries off Newfoundland and Labrador. These authors also collected data from at-sea-observers and provide a description on incidental shark catch for several fisheries. The basking shark was found regularly as incidental bycatch in fish traps targeting cod (*Gadus morhua*), and in gillnets fisheries targeting cod, halibut (*Hippoglossus hippoglossus*), and herring (Benjamins et al., 2010). The Greenland shark (*Somniosus microcephalus*) and black dogfish were reported as incidental catch in a number of offshore fisheries, specifically those targeting Greenland halibut (*Reinhardtius hippoglossoides*). A majority of these catches are discarded at sea, due to poor markets, and are not counted against commercial quota of target species, and the effects of these discards on species populations is unknown (Benjamins et al. 2010). In addition, the authors also found high incidental catch estimates for black and spiny dogfish, also caught in the Greenland halibut “turbot”

fishery. Although large sharks (e.g. blue, shortfin mako, and porbeagle) were not determined as frequent discards, the observer results indicated that several tens to hundreds of porbeagle, blue, shortfin mako, and basking were caught per year between 2001-2003 (Benjamins et al. 2010). The discard estimates from that study are not included in Gavaris et al. (2010) analysis and should be taken into consideration when looking at total discard mortality across regions, fisheries, and species. Neither the Greenland or basking shark, nor black or spiny dogfish, are addressed in the NPOA with respect to mitigating or monitoring discard mortality, yet these species are commonly caught and discarded across many fisheries (Benjamins et al. 2010).

Data collection has resulted in fair improvements to elasmobranch conservation and management. As a result of the Gavaris et al. 2010 report, DFO provided extra observer coverage in several fisheries: inshore scallop (*Placopecten magellanicus*), inshore lobster (*Homarus americanus*), swordfish/tuna, and groundfish. The results are currently being analyzed and should be available for review by end of 2011 (personal comm, Sara Quigley, DFO, 2011). In addition, DFO is currently developing a comprehensive work plan to address the incidental catch of large pelagics in Atlantic Canada. This plan will focus its efforts on six species: bluefin tuna, porbeagle, shortfin mako, and blue shark, and leatherback (*Dermochelys coriacea*) and loggerhead sea turtles (*Caretta caretta*). This plan aims to examine appropriate levels of observer coverage, manage discards for all target species, and manage bycatch of non-target species (DFO, 2011). However, few improvements have been made to effectively monitor discarded bycatch in any fisheries or enhance species identification for better data collection, specifically for skates. For awareness-raising efforts among commercial and recreational fishers and other resource

users about the risks facing sharks and shark like species and the promotion of best release practices to reduce discard mortality (Table 6), some improvements have been made. For example, recreational shark license conditions now require submission of logbook data to a Dockside Monitoring Company (DMC), and new monitoring documents have been developed that require species identification of both released and kept fish in the recreational sector. Finally, little progress has been made to encourage proper catch and release techniques for shark bycatch species amongst relevant regional fisheries management organizations (RFMOs) or to improve the identification and reporting of bycatch and associated mortality. These areas remain a high priority, as the reporting of shark bycatch species and discards can better inform fishery managers of total catch mortality and can allow them to incorporate these estimates into realistic TACs or appropriate bycatch quotas. In addition, encouraging best catch and a release practice in all fisheries maximizes the survival of the species. These actions need to be addressed with action timelines, strategies, and firm deliverables in a revised NPOA.

Table 6: NPOA Action 4, Bycatch Reduction and Reporting of Discard Mortality

ACTION	4. BYCATCH REDUCTION AND REPORTING OF DISCARD MORTALITY					
Objective	To reduce levels of bycatch and increase reporting of discard mortality within other fishing industries					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
4.1. Improve the reporting of discarded bycatch and the associated mortality rates in domestic fisheries through better data collection and species identification by at-sea fisheries observation, mandatory reporting of all bycatch for commercial and recreational sectors.	<p>-Extra observer coverage was added for several fisheries:</p> <ol style="list-style-type: none"> 1. 2008/2009 inshore scallop 2. 2009/2010 inshore lobster and swordfish/tuna 3. 2010/2011 swordfish/tuna and 4x groundfish <p>-Development of Work Plan to address Incidental Catch in Canadian Large Pelagic Fisheries. The work plan includes: reviewing level of observer coverage; managing discards for all targeted species including estimation of amount and survival of discards and potential incorporation into stock assessments; control for non-targeted species</p>	<p>(personal comm, Sara Quigley, DFO 2011)</p> <p>(personal comm, Mike Eagles, DFO, 2011)</p>	<p>-DFO is in the process of analyzing the results of added observer coverage, to be completed by December 2011.</p> <p>-DFO is developing a research program to examine the impacts of bycatch in the pelagic longline fishery towards mitigating catch of sensitive species and to understand the impacts of discards on sharks.</p>	High	DFO	1,6,7,9,10

Table 6 (continued)

ACTION	4. BYCATCH REDUCTION AND REPORTING OF DISCARD MORTALITY					
Objective	To reduce levels of bycatch and increase reporting of discard mortality within other fishing industries					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
4.2. Continue awareness-raising efforts among commercial and recreational fishers and other resource users about the risks facing sharks and shark like species and promote conservation based release practices to reduce discard mortality	<ul style="list-style-type: none"> -Recreational shark license conditions now require submission of logbook to Dockside Monitoring Company (DMC) -New monitoring documents developed for recreational shark fishery requiring identification of both released and kept fish -Letters sent to charter vessel owners, and derby organizers identifying requirements for licenses conditions. 	(personal comm, Mike Eagles, DFO 2011)	<ul style="list-style-type: none"> -Once incidental work plan in Canadian Large Pelagic Fisheries is in place, it will improve data collection for this sector. -Similar letters to be provided to the recreational sector 	High	DFO	4,6
4.3. Encourage the strengthening of regulations of relevant RFMOs with regard to both the handling and release of shark bycatch species and to improve the identification and reporting of bycatch and associated mortality	No evidence	No evidence	No evidence	High	DFO	4
4.4. Review the current practices in all commercial and recreational fisheries and implement, where feasible, new rules or technologies with the potential to reduce both bycatch of sharks and associated mortality	<ul style="list-style-type: none"> -DFO initiated a study to characterize discards across all commercial fisheries in Atlantic Canada -Development of Work Plan to address Incidental Catch in Canadian Large Pelagic Fisheries 	Gavaris et al. 2010 (personal comm, Mike Eagles, DFO, 2011)	<ul style="list-style-type: none"> -Regional advisory meeting to discuss and develop a bycatch policy for all pelagic species (2011) 	High	DFO	4

NPOA Action 5: Extend Conservation and Management Measures to the Arctic Coast

For the Eastern Arctic, action five aims to enhance information on northern species, such as the Greenland shark and Arctic skate (*Amblyraja hyperborean*), on their life history, abundance, and the possible effects of climate change on species population. This follows IPOA objectives two, three, and six (Table 7). For this action, DFO worked with academics from the University of Windsor to study the life history of Greenland sharks and conduct preliminary studies on their feeding ecology (personal comm, Aaron Fisk, 2011). In addition, 15 pop-off archival satellite tags have been deployed on Greenland sharks and three on Arctic skates in 2010 in Cumberland Sound, with results unpublished. Furthermore, three acoustic tags were deployed in Greenland sharks; each tag is expected to last a total of ten years. Future studies include using three satellite tags on Greenland sharks to aid in determining migration patterns, 15 satellite tags to look at turbot and skate distribution, and 40-80 acoustic tags are to be deployed in Greenland sharks (tags lasting ten years) and Arctic skates (lasting four years) (personal comm, Aaron Fisk, University of Windsor 2011). Greenland sharks are commonly caught as bycatch in halibut fisheries (Benjamins et al., 2010), yet little is known of their life history, the role they play as a predator in the Arctic ecosystem, and how bycatch and discard mortality affects their population or other species (Harvey-Clark et al., 2010). Further studies are warranted for this species and the Arctic skate, and should be included as primary research into a revised NPOA.

Table 7: NPOA Action 5, Extend Conservation and Management Measures to the Arctic Coast

ACTION	5. EXTEND CONSERVATION AND MANAGEMENT MEASURES TO THE ARCTIC COAST					
Objective	To enhance information about northern species of sharks by evaluating the potential impacts of changing conditions on shark species in the Arctic					
Mean (Atlantic + Arctic)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
5.1. Increase knowledge about the life history and abundance of shark species in the Arctic (e.g. Greenland shark and Arctic skate)	<ul style="list-style-type: none"> -Studies on stable isotopes of Greenland sharks have been completed. -3 pop-off archival tags have been deployed on Arctic skate in the Cumberland Sound in 2010; manuscript in preparation. -15 pop-off archival tags have been deployed on Greenland sharks in Cumberland Sound and off coast of Nova Scotia; manuscript in preparation. -3 acoustic tags have been deployed in Greenland sharks (will last 10 years). 	<ul style="list-style-type: none"> Papers to be reviewed and published soon (personal comm, Aaron Fisk, DFO) Results to be published soon (personal communication Aaron Fisk, DFO) 	<ul style="list-style-type: none"> -Additional satellite tags to be deployed on skates and sharks in Cumberland Sound in 2011 and 2012. -Pilot projects underway to study mitigation measures for Greenland bycatch in the Arctic. -40-80 acoustic tags to be deployed in Greenland sharks (10 yrs of life) and Arctic skate (4 yrs of life). 	High	<ul style="list-style-type: none"> -DFO -University of Windsor 	2,3
5.2. Evaluate how changing conditions in the Arctic may be affecting shark species	<ul style="list-style-type: none"> -Movement and depth and temperature preference of Greenland sharks and Arctic skates. -Feeding ecology study for Greenland sharks completed in 2010 (this study looked at potential effects of climate on Greenland sharks; studied fatty acids) 	<ul style="list-style-type: none"> Results to be published soon (personal comm, Aaron Fisk, DFO) 	<ul style="list-style-type: none"> -No defined projects at this time. 	High	<ul style="list-style-type: none"> -Collaboration between DFO and University of Windsor 	2,6

NPOA Action 6: Enhance Outreach and Education Efforts

Action six was intended to enhance education and outreach on sharks and shark-like

BOX 5

Australia's NPOA: Education and Awareness

1. Introduce a community education strategy aimed at the general public, commercial, recreational, indigenous and game fisher. Action to be initiated within 12 months and completed within two years.

Examples of strategies include inter alia to:

-Raise national awareness of the vulnerability of particular shark species, their role in the ecosystem, current threats and status, impact of shark bycatch, and the need to return sharks to the sea alive to maximize survival.

-Educate resource users about the rationale for and use of recorded shark data

2. Develop a coordinated approach to production of region specific, waterproof species ID guides and develop measures to monitor the effectiveness of these guides. Action must be initiated within 12 months and completed within two years.

***For full report, see Australia's 2004 NPOA (SAG and Lack, 2004)**

species in Canada, understand their importance within the ecosystem, explain why a NPOA for sharks exists, and inform the public on current efforts underway to progress their conservation and management. This action complies with IPOA objectives four, six, nine, and ten. To date, few actions have been taken to address this objective (Table 8). DFO Pacific incorporated an observer-training program with shark ID cards to aid in species identification. Currently, efforts are underway to create skate ID cards, which will be distributed to all commercial and recreational fishermen to advance species ID (personal comm, Jackie King, DFO 2011). For the Atlantic and Eastern Arctic, the only form of outreach is through annual lethal shark derbies, which is seen as an opportunity to raise awareness on the biology of shark species (DFO, 2007a). However, future actions for the Atlantic include developing new species ID sheets for commercial fisheries at-sea-observers and participants at the shark derbies (personal comm, Mike Eagles, DFO,

2011). Compared to other NPOAs, namely Australia's, Canada falls far behind on education, outreach, and awareness for elasmobranchs. For example, Australia's NPOA lists specific actions with associated agencies and timelines that address species ID and community education strategies aimed at the public, commercial, recreational, game fisher, and indigenous sector (Box 5).

Table 8: NPOA Action 6, Enhance Outreach and Education Efforts

ACTION	6. ENHANCE OUTREACH AND EDUCATION EFFORTS					
Objective	To enhance public knowledge about the presence and types of shark species within Canadian fisheries waters, the importance of shark species to sustainable ecosystems, the reasons why Canada has developed a national plan of action for the conservation of sharks, and the efforts that are being taken to assess, understand, and manage these species					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
6.1. Increase public awareness in Canada about shark species, risk to their survival, their importance within the ecosystem, and the fact they are often a global resource requiring international research and conservation efforts	-No specific actions taken by DFO Atlantic -Education has been initiated by external agencies (NGOS)	WWF, 2011	-No evidence	Medium	DFO, external agencies	4,6
6.2. Encourage commercial and recreational fishers, and other industries to be more aware of the shark species present in Canadian fisheries waters, their biology, risks these species face, and catch-and-release practices through the advisory committee processes	-No evidence	No evidence	-No evidence	Medium - High	DFO, external agencies	4
6.3. Enhance efforts to classify and record rare species of sharks and skates by promoting better identification in existing observers programs and through enhanced reporting by fishers	-DFO Pacific incorporated a protocol for observer training	(personal comm, Heather Breke, DFO, 2011)	-Pacific- Skate ID keys to be developed for commercial and recreational fishermen -Atlantic-New ID sheets are being prepared for commercial fisheries at-sea observers and participants at shark derbies	High	DFO	9,10
6.4 Continue annual shark derbies as opportunities to raise public awareness about shark species, their biology, and identification criteria	-Yearly shark derbies take place (Atlantic) -Monthly presentations to schools about sharks (Atlantic)	(personal comm, Steven Campana, DFO, 2011)	-Continue collecting data from shark derbies	Low	DFO	6

NPOA Action 7: National Plan of Action Review

Action seven follows the FAO recommended guidelines for implementation (Table 9). The FAO strongly recommends that States assess their NPOA every four years and provide updates to FAO on the current status of elasmobranch stocks, new initiatives underway, current research and development, and changes to existing management measures (FAO, 1999). To date, Canada has not reported its progress to the FAO, nor has it identified and considered measures to improve the NPOA. Simultaneous to this report, DFO is looking at the status of the NPOA and progress made to date, and intends to revise the NPOA in the summer of 2012 (personal comm, Brian Lester, DFO, 2011). To date, no stakeholders external to DFO have been included into the revision process.

Table 9: NPOA Action 7, National Plan of Action Review

ACTION	7. NATIONAL PLAN OF ACTION REVIEW					
Objective	To report progress on Canada's NPOA-sharks as required under the IPOA-sharks, and to ensure that the NPOA remains a living document that can be updated as new measures are developed and endorsed					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
7.1. Report every four years on the progress, lessons learned, and effective strategies implemented	-The review has been moved to 2012, putting the timeframe at 5 years	(personal comm, Brian Lester, DFO, 2011)	-To be revised in 2012	High	DFO	Does not address a direct objective, but is considered a guideline
7.2. Provide updates on the current status of stocks, new initiatives in management and research, and any substantial changes to existing management measures and practices	-There are no known updates on status of stocks, new initiatives, or changes to management by DFO	No evidence	-No evidence	High	DFO	Does not address a direct objective, but is considered a guideline
7.3. Provide an updated assessment of the conservation and management efforts for sharks	-Currently under review for 2012	(personal comm, Brian Lester, DFO, 2011)	-To be revised in 2012	Med	DFO	Does not address an objective, but is considered a guideline
7.4. Identify and consider measures for improving the NPOA in Canada	-Currently under review for 2012	(personal comm, Brian Lester, DFO, 2011)	-To be revised in 2012	High	DFO	Does not address an objective, but is considered a guideline

Action 8: Cooperate within RFMOs to Improve the Conservation and Management of Sharks

While Canada is party to a number of RFMOs, only four of those deal directly to shark conservation and management (Godin, 2009). These include the Inter-American-Tropical-Tuna-Commission (IATTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Northwest Fisheries Organization (NAFO), and the Western and Central Pacific Fisheries Commission (WCPFC). Action eight aims to improve the conservation and enforcement measures for sharks within these RFMOs through several means (Table 10), and narrowly addresses IPOA objectives two, four, and six. Some improvements have been made since the NPOA was drafted in 2007. The FAO encourages States within their framework to cooperate with RFMOs and other sub-regional fishery organizations to ensure sustainability of elasmobranch populations (FAO, 1999). This includes data collection and monitoring of shark stocks, development of subregional or regional shark plans, and participating in international arrangements that advance research, training, and production of educational materials (FAO, 1999). For example, ICCAT asks all members to use precautionary management measures for stocks for which there is little data (e.g. shortfin mako), and when possible, implement species-specific management measures (ICCAT, 2010). Except for the porbeagle shark, Atlantic Canada has not set any restrictive catch limits or species-specific measures for species caught in ICCAT fisheries, such as the blue and shortfin mako shark. However, live-release is recommended for all sharks, and mandatory release is required for oceanic whitetip (*Carcharhinus longimanus*), thresher, and hammerhead sharks (*Sphyrnidae*)

(DFO, 2011). ICCAT also recommends that countries develop and implement research projects that have the potential to minimize bycatch and discard mortality of sharks in their fisheries (ICCAT, 2010). Under the draft swordfish IFMP, a research project is being developed to study the impact of bycatch in the pelagic longline fishery and will undertake additional studies to understand the impacts of discards on sharks (DFO, 2011). Another RFMO, NAFO, manages a number of fisheries (mainly bottom trawl for groundfish) in the Northwest Atlantic (NAFO, 2011). These include Greenland halibut, redfish (*Sebastes spp*), and silver hake (*Merluccius bilinearis*). As Gavaris et al. (2010) point out; these offshore bottom trawl fisheries catch a variety of sharks and skates, yet neither Atlantic Canada nor NAFO has any management measures in place to effectively mitigate bycatch and discarding of chondrichthyan species. From this review, it is recommended that Canada update this NPOA action and encourage the application of the precautionary approach into Canada fisheries and relevant RFMOs through: implementing maximum or minimum size limits to protect juvenile sharks, apply spatial-temporal restrictions, and technical measures to mitigate shark bycatch.

Table 10: NPOA Action 8, Cooperate Within RFMOs to Improve the Conservation and Management of Sharks

ACTION	8. COOPERATE WITHIN RFMOs TO IMPROVE THE CONSERVATION AND MANAGEMENT OF SHARKS					
Objective	To improve the conservation and enforcement measures for sharks in regional fisheries management organizations of which Canada is a member					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
8.1. Encourage contracting Parties that have not done so to implement the FAO IPOA-sharks through national plans of actions	-No evidence	No evidence	-No evidence	Unknown	Unknown	Does not address a direct objective, but is considered a guideline
8.2. Promote the adoption of an ecosystem approach and the precautionary approach to fisheries management within RFMOs	-No evidence	No evidence	-No evidence	Unknown	Unknown	6
8.3. Encourage improved data collection and information sharing within and among RFMOs regarding commercial catches and incidental bycatch of sharks	-In 2010, Canada held a workshop with several Caribbean states to stress importance of good data collection and provided examples on how they can ensure better data collection within their own fisheries.	(personal comm, Brian Lester, DFO, 2011) (personal comm, Ricardo Federizon, NAFO, 2011)	-The fisheries commission of NAFO is reviewing and revising Article 17: Conservation and Management of Sharks. To be completed in September 2011	Medium to High	-The USA is drafting the proposal for a newly revised Article 17	4
8.4. Promote the review and implementation of measures to reduce shark bycatch in directed fisheries managed by the RFMOs	-No evidence	No evidence	-No evidence	Unknown	Unknown	2,4,6

NPOA Action 9: Enhance Outreach and Education Efforts Internationally

Action nine follows IPOA objective four, “to improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management, and educational initiatives within and between States” (Table 11) (FAO, 1999). However, Canada has not made any visible progress in encouraging other States to develop action plans, nor has Canada taken any known steps to work with other countries and RFMOs to raise awareness on the importance of the IPOA framework for sharks.

Table 11: NPOA Action 9, Enhance Outreach and Education Efforts Internationally

ACTION	9. ENHANCE OUTREACH AND EDUCATION EFFORTS INTERNATIONALLY					
Objective	To enhance international and regional awareness about the purpose and principles of IPOA-sharks					
Mean (Atlantic + Arctic + Pacific)	Progress	Evidence	Future Actions	Priority Level	Responsible Agency	Meets IPOA objective?
9.1. Support and encourage other States in developing plans of actions for sharks	-In 2010, Canada offered assistance to Caribbean States in developing their data collection process.	(personal comm, Brian Lester, DFO, 2011)	-While not specifically identified as an area where Canada could assist these States, Canada is open to assist other countries in the development of their NPOA-sharks.	Medium	Unknown	Does not address a direct objective, but is considered an IPOA guidelines
9.2. Canada will work with other countries and RFMOs to raise awareness of the importance of the IPOA/NPOA sharks, and to promote practical skills and knowledge transfer between countries	-Canada has met with several Caribbean States to provide knowledge transfer on fisheries management, data collection, and enforcement of regulations.	(personal comm, Brian Lester, DFO, 2011)	-Canada will continue to express the importance of countries preparing an NPOA on sharks.	Medium	Unknown	Does not address a direct objective, but is considered an IPOA guidelines

Issues Identified in Canada's NPOA

The NPOA in its overview of sharks recognizes that there are 27 species of sharks, 29 skates, and four chimaeras across Canada's Atlantic, Arctic, and Pacific waters. For Atlantic Canada, the plan acknowledges that very few of these species are subject to commercial fishing, but instead are caught as bycatch and are often discarded in commercial fisheries (DFO, 2007a). Yet, as it stands, the existing NPOA scarcely addresses the issues of bycatch and has set no actions nor timelines to include discard mortality into stock assessments, or collect biological data on sensitive species, such as skates. Although the NPOA warrants the precautionary approach into the management and conservation of these species, except for the porbeagle, no species-specific regulations exist to prevent bycatch or discarding. Furthermore, no measures are taken to protect species with highly uncertain stock status, such as the Greenland and basking shark, black dogfish, and many species of skates. Most sharks can be caught and discarded with no consequences for an individual vessel or fleet.

Furthermore, shark management requires on-going collaboration with all stakeholders between all agencies that interact with elasmobranchs (FAO, 2009). However, the NPOA shows little to no progress in improving coordination among stakeholders or RFMOs. This includes both primary (fishery managers, industry, scientists, NGOs) and secondary (public, recreational fisher, and tourism) stakeholders. Without buy in from these sectors, the incentive to establish effective management and conservation measures for sharks is limited. In addition, no priority species are identified in the NPOA; which is in conflict with FAO recommendations (FAO, 2009). With no measures to confidently

monitor, record, and measure changes in elasmobranch populations impacted by bycatch and discarding, stock status remains unknown and cannot be considered into revised IFMPs or other management plans. Finally, the NPOA should be reviewed every four years for its effectiveness and lessons learned, so that new measures can be considered into a working national framework. Canada missed the four-year revision, but plans to revise their NPOA in 2012.

2.3. Australia's NPOA: A Comparison to Canada

Australia is not a major shark-fishing State and, similar to the situation in Canada, the majority of the sharks, skates, and rays are caught as bycatch and /or are discarded at sea (DAFF, 2004). In response to the FAOs request to develop a NPOA and the concern over the increase of shark catches in Australian fisheries, in 2000, Australia developed a Shark Advisory Group (SAG) to oversee the development of a shark assessment report (SAR). The report provides a comprehensive overview of shark catch, including bycatch and byproducts associated with target shark fisheries for each territory/state, recreational catch in Australia, and catch for non-target species in commonwealth fisheries (DAFF, 2001). The report also discusses the distribution of target and non-target shark species, stock assessments and fisheries statistics, overview of market uses, and the problems associated with bycatch and byproducts of elasmobranchs. While not every detail of the SAR is provided, in summary, it goes significantly beyond what the FAO requests for a State to include in a SAR (DAFF, 2001). From the report, 24 conservation and management issues were defined and a consensus was reached that the development of an NPOA-*sharks* in Australia was considered necessary (DAFF, 2004). The report led to the development of Australia's first NPOA for shark's known as, "Shark-Plan 1" in 2004, and was developed by the SAG in consultation with a variety of stakeholders. Representatives included all resource users (commercial, indigenous, and recreational), indigenous research and scientific agencies within their jurisdictions, government, and non-governmental agencies (DAFF, 2004).

Furthermore, Australia’s NPOA closely follows the FAO’s technical guidelines for the conservation and management of sharks, which incorporates four overarching elements of species conservation, biodiversity maintenance, habitat protection, and management for sustainable use (FAO, 2000). Like Canada, Australia defines “shark” to include shark, skates, rays, and chimeras and refers to “catch” as all target, byproduct, bycatch, or discard, by any Australian fishery (DAFF, 2004). As well as incorporating all ten IPOA objectives into shark-plan 1, Australia identified 18 issues with respect to the conservation and management of sharks, taken from the SAR in 2001, and forms the basis on which the plan was created. Responding to the 18 issues (See Annex 2), six themes (Box 5) were developed to cover both the issues and the IPOA objectives, under which 43 actions were identified with priority rankings and responsible agencies for implementation (DAFF, 2004). The plan was developed to link the IPOA objectives to one or more of the 18 issues and designated actions.

BOX 5
<u>Six Broad Themes in Australia’s NPOA</u>
<ol style="list-style-type: none">1. Review existing conservation and management measures2. Improve existing conservation and management measures3. Improve data collection and handling4. Undertake targeted research and development5. Initiate focused education/awareness raising programs6. Improve coordination and consultation
DAFF, 2004

In addition, a priority system was created to rank each action in terms of its feasibility and available funding. The interpretation of priorities is provided in Box 6. To effectively monitor and review the 43 actions and their contribution to shark conservation

and management, a set of performance indicators were created to assess the extent to which shark-plan 1 achieved its objectives (DAFF, 2004).

As requested by the FAO, States that have developed a NPOA should assess the plan every four years for its effectiveness. Five years after its implementation, the Australian Shark-Plan Implementation and Review Committee (SIRC) and a steering committee from the Australian Government’s Department of Agriculture, Fisheries, and Forestry (DAFF) reviewed shark-plan 1 for its effectiveness.

BOX 6: Interpretation of Priorities (DAFF, 2004)				
Priority	Action Initiated	Action Completed	Management Funding	Research Funding
1A	Within 12 months	Within two years, if not sooner	Funding identified immediately	Submit funding proposals as a priority
1B	Within 12 months	In shortest timeframe possible	Funding identified immediately	Submit funding proposals as a priority
1C	Within 12 months of pre-requisite work completed	In shortest timeframe possible	Need for funding foreshadowed in management budgets	Submit funding proposals based on expected timing and completion of pre-requisite work
2	Within three years	Within three years	Need for funding in next management budget following adoption of shark-plan 1	Submit funding proposals in the next round, following the adoption of shark-plan 1
3	Within four years, if not sooner	As soon as possible	Not applicable	Advise funding bodies of reasons for the priority of the research required

While the plan had been found to not be a major driver to improved shark conservation and management, likely due to its non-binding management framework, the plan was

noted to have well-rounded objectives, strategies, actions, and issues (Bodsworth et al., 2010). Similar to Canada, Australia's NPOA lacked a stakeholder communication and engagement strategy, poor incorporation of the precautionary approach, and a lack robust management measures. However, the plan also yielded a number of improvements including, better stock assessments for shared stocks, refined observer and monitoring programs, commitments from the shark research community, and the adoption of bycatch mitigation measures in a number of fisheries (Bodsworth et al., 2010). In response to the strengths and weaknesses of shark-plan 1, Australia developed a second SAR, to support the review process and identified gaps to be addressed in a revised NPOA (Bensley et al., 2010). Recognizing the need to improve the NPOA, in 2011, a draft NPOA for sharks "shark-plan 2" was developed, building on lessons learned from shark-plan 1 (DAFF, 2011). Shark-plan 2 provides an updated assessment on the 18 issues previously identified in plan 1, and continues to use these issues as the primary focus. However 2 focuses more on active engagement by all jurisdictions, with an aim to link the NPOA plan to existing management strategies and develop upon initiatives already underway (DAFF, 2011). While a full list of recommendations, actions, strategies, and timelines to be incorporated in the 2011 Australian NPOA can be found in the draft, several key items are provided as examples as they are equally applicable to the revision of Canada's NPOA (Box 7).

When comparing the development of a NPOA between Australia and Canada, several weaknesses become apparent in the Canadian process. Canada did not develop a SAG to oversee development of their plan, nor did they consult with stakeholders external to

DFO or develop a SAR to guide the content of the NPOA, all of which are strongly recommend by the FAO through the IPOA (Bodsworth et al., 2010).

BOX 7

Key Items to be Included Into the 2011 Australian NPOA

1. Understand how timeliness and extension of shark related data/information to managers, researchers, and other key stakeholders like the public and environment NGOs, might be improved.
2. Great adoption of carefully designed and targeted observer programs to enable higher quality information on shark catch and the nature of fishing operations and impacts on sharks.
3. Develop collaborative/joint management research initiatives, and/or policy instruments.
4. Review the need for, and where necessary, methods to obtain accurate market and trade data.
5. Assess the sustainability of imported shark products (e.g. shark fins)
6. Develop more effective shark bycatch mitigation methods.
7. Use the NPOA as a guide to prioritize national and regional approaches to shark management (e.g. develop a regional plan of action for elasmobranchs), through the development of an engagement strategy.
8. Improve id of shark species caught, shark handling procedures, and coordination of information sharing across fleets.

* Not all key items and recommendations are listed. Only those also seen as recommendations for Canada's revised NPOA are provided.

DAFF, 2011

Furthermore, Canada's NPOA scarcely addresses the issues of bycatch, discarding, and completely neglects to mention the import of shark fins and indigenous use of elasmobranchs, all of which are discussed in the SAR for Australia. To date, Canada has not addressed all ten IPOA objectives in their NPOA, nor created a priority ranking system with designated responsible agencies, nor developed a set of performance indicators from which to assess the success of their plan.

Conservation and management issues facing elasmobranchs in Australia are comparable to those in Canada. These include, but are not limited too, the poor use of the precautionary approach into the management of elasmobranchs, poor data collection and information exchange, limited education and awareness engagement strategies, and few

collaborative research programs (DFO, 2007a). Regardless of the State in question, an NPOA should be designed to facilitate and compliment 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 (DAFF, 2011). As Canada reviews and revises the NPOA in 2012, careful consideration should be given to: addressing all ten IPOA objectives, identifying shark conservation and management issues across a regional and national scale (i.e. Atlantic, Pacific, and Arctic), developing firm actions with priority rankings and timelines, indicating responsible agencies for implementation, developing a set of performance indicators from which to assess the plan, consult stakeholders, and forming a SAG to provide detailed technical guidance on NPOA content.

CHAPTER 3: OTHER APPROACHES TO MANAGE AND CONSERVE ELASMOBRANCHS

The dual objectives to protect marine species, and to maximize sustainable yield of fisheries present a management challenge for fisheries scientists and conservationists (Salomon et al. 2009). Clearly, the integration of different perspectives from a variety of disciplines is crucial to fully understanding and solving issues of marine conservation and management (Worm et al. 2009). Whilst differing viewpoints persist, more often than not, the overarching goals of conservation and sustainable yield can be reconciled (Salomon et al. 2009, Worm et al. 2009). An integrated approach would include mitigating bycatch and discards, combating overfishing, recovering depleted species and improving the long-term sustainability of fisheries (Salomon et al. 2009, Worm et al. 2009). For sharks, one such integrated approach was forwarded by the FAO, in their development of the IPOA-*sharks*. Due to the growing concern of increased levels of fishing mortality as a result of directed fishing, bycatch and discarding, the FAO intended to use the IPOA to guide States in developing *inter alia* alternative management strategies to conserve and manage sharks (and other elasmobranchs) more effectively; yet, high levels of bycatch and discarding still remain in many fisheries, and hence the FAO developed international guidelines on bycatch management and reduction of discards through the process of an expert consultation (FAO, 2010). While these guidelines are intended to be complimentary to the objectives addressed in the IPOA-*sharks* and cover a variety of topics, such as improving research and development, data collection and management, monitoring and control, the “measures to manage bycatch and reduce discards” (FAO, 2010) remain the focus of this present Chapter, as shark

bycatch and discarding is largely the dominant issue for sharks in Atlantic Canada fisheries (Godin and Worm, 2010). FAO (2010) recommends several measures be implemented to manage bycatch and reduce discards, these include, among others: (1) spatial and temporal restrictions on fisheries (2) limits and/or quotas on bycatch and discards (3) economic incentives for managing bycatch and reducing discards and (4) awareness, communication, and capacity building (FAO, 2010).

Therefore, this chapter discusses several topics (i.e. spatial management, bycatch management, and education/research), which may prove beneficial in bridging the gap between fisheries science and conservation, thus providing additional measures which could be applied to a revised NPOA in 2012.

3.1. Spatial Management

3.1.1. Closed and Protected Areas

Increasingly, spatial management tools, such as spatial closures and multi-use areas, are being used to protect marine populations, restore functioning communities, and enhance fish stocks (Salomon et al., 2009). The term Marine Protected Area can be used interchangeably with conservation areas, sanctuaries, and marine reserves; all of which provide some sort of protection against increasing anthropogenic and naturally occurring threats to the marine environment (Pauly et al., 2002). Although MPAs are not seen as a panacea by themselves, they can be used to complement other forms of fisheries management.

Article 8 of the Convention of Biological Diversity (CBD) and the Food and Agricultural Organization (FAO) help reinforce the establishment of MPAs. The CBD, of which Canada is a signatory, calls upon States to “establish marine protected areas for conservation and sustainable use of threatened species, habitats, living marine resources and ecological processes” (CBD, 2007). In addition to the CBD, through the IPOA, the FAO strongly recommends that States “contribute to the protection of biodiversity and ecosystem structure and function” (FAO, 1999).

In Atlantic Canada, several conservation areas and spatial closures have been designated for particular marine species or groups of species; two conservation areas for Atlantic cod and deep-sea corals and one spatial closure for porbeagle sharks (DFO 2002; DFO, 2003). Due to an extremely low abundance of cod stocks off Newfoundland and Labrador, no-trawling zones were implemented in 2003 to protect spawning and juvenile concentrations of cod to facilitate the recovery of the species (DFO, 2003). In 2002, DFO established a 424-square kilometer coral conservation area off southwestern Nova Scotia, where 90 percent of the protected area restricts bottom fisheries (e.g. longline, otter trawl, and gillnet), whilst developing a broader coral conservation plan to protect key coral habitats and outline ongoing commitments for these areas (DFO, 2002). The above examples show Canada’s use in MPAs as a fisheries management tool to protect and conserve species from exploitation and habitat degradation. The same concept is applicable for elasmobranch species, however this is still a novel conservation measure, and has not been readily applied in Canadian fisheries. The only area known to be closed to shark fishing is off of southern Newfoundland and the Gulf of St. Lawrence annually between September 1st and December 31st. During this time, “no directed shark fishing

is allowed”, due to the porbeagle mating season (personal comm, Steven Campana, DFO 2011). Although few examples exist, it can be assumed that MPAs or closed areas provide similar benefits to sharks as they do for other migratory species, such as whales and dolphins. Benefits include the protection of vulnerable life stages of these species from exploitation, promotion and enhancement of fishery yields in nearby bioregions, and further improve the health of the marine ecosystem (Bonfil, 1999).

For Atlantic Canada, developing a conservation area for vulnerable, threatened, or endangered elasmobranch species (e.g. porbeagle shark and winter and thorny skates) could be considered as a management action in a revised NPOA or regionally developed plan. For porbeagle sharks, currently listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC, 2009), a few areas of interest already exist. The Emerald Basin, a 250m deep depression on the continental shelf off Nova Scotia (Keigwin et al., 2003), is consistently fished by the swordfish and tuna longline fleet. Although limited information is available for this region, at-sea-observers have consistently recorded high discards of juvenile porbeagle sharks from the fishery (personal comm, Steven Campana, DFO 2011). The data collected by observers indicate that catch of juvenile porbeagles is at least four times higher in the Emerald Basin compared to all other fishing areas for the tuna and swordfish fleet. Most sharks caught in the basin are one and two years old while they are around age eight elsewhere (personal comm, Steve Campana, DFO 2011). It is believed that many of these sharks are dead when discarded. To date, no discard mortality estimates have been published for porbeagle sharks in this fishery, however; DFO has recently received funding to study discard mortality in the Emerald Basin within two years time (personal comm, Steve

Campana, DFO 2011). The consistent catch of age of one and two sharks, if dead when discarded, could potentially prevent the porbeagle population from recovering. Jensen et al. (2002) determined that 50 percent of porbeagle males reach sexual maturity at 174 cm in length or age eight, while females reach sexual maturity at 217 cm in length or 13 years of age. Observer data indicates a 50/50 split in catch between the amounts of females and males being caught in this fishery (personal comm, Steve Campana, DFO 2011). In addition, DFO scientist, Dr. Steven Campana, also believes this area to be another nursery ground for porbeagle sharks (personal comm, Steve Campana, DFO 2011), warranting further measures for its conservation and management. Therefore, it can be assumed that most porbeagle sharks caught in the Emerald Basin have not reached sexual maturity and could benefit from a conservation area. Since porbeagles undergo the strongest fishing pressure in the fall by the swordfish and tuna longline fleet, a possible closure would likely be most effective in the fall season.

Another potential location for a conservation area that would benefit porbeagle sharks is the Grand Banks, off Newfoundland. This area is heavily fished by numerous fisheries (e.g. groundfish and longline) (DFO, 2009), and is known as a porbeagle mating ground (personal comm, Steve Campana, DFO 2011). It would not be realistic or feasible to make this area a no-take, however; during the summer months when porbeagle sharks are known to mate, this area could be considered a “no directed shark fishing zone”.

3.2. Bycatch Management

Fishing inevitably catches target as well as non-target species, due to the unselective nature of most types of gear (Bellido et al., 2011; Huang, 2011). While some species are retained as target catch against quota, other species that are not discarded, which can be dead, dying, or alive, may be retained as bycatch species. This problem is an integral part of most fishing operations and remains a constant challenge for fishery managers (Bellido et al., 2011; Campbell and Cornwell, 2008). Although discarding requires a conscious decision on the part of a fisher, several reasons exist that may influence their decision including, but not limited to, fisheries regulations (e.g. size limits, over quota, etc.), lack of storage space, damage to gear and market prices (Carruthers and Neis, 2011). In some cases, bycatch may offer some economic benefit to the fisher depending on the species, government regulations, and available market price for the fish. Alternatively, no benefits are derived from discards. In addition, the act of discarding is largely seen as contributing to unnecessary mortality and wastage of potential fishery profit (Bellido et al., 2011). 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; a management measure that should be developed congruently with the NPOA.

Through the United Nations Convention on the Law of the Sea (UNCLOS), all States are required to manage their marine resources, including species taken as bycatch within the Exclusive Economic Zone (EEZ) (UNCLOS, 1982). In addition, the FAO Code of Conduct for Responsible Fisheries calls on all States to, “minimize waste, catch of non-

target species, both fish and non-fish species, and impacts on associated or dependent species” (FAO, 1995). Canada is required to do all of the above; however, they fall short in managing bycatch of elasmobranch species and minimizing the waste of sensitive species, particularly with regards to skate species. As of 2010, the FAO developed International Guidelines on Bycatch Management and Reduction, calling on States and RFMOs, including Canada, to “where appropriate, map seabed habitats, distribution and range of species taken as bycatch, in particular rare, endangered, threatened, or protected species, to ascertain where species taken as bycatch might overlap with fishing effort” (FAO, 2010). The IUCN has listed several elasmobranch species that have been reported in Canadian waters as endangered and are therefore considered to be facing a very high risk of extinction (IUCN, 2001). These species include winter, barndoor, and smooth skate (COSEWIC, 2009; Dulvy, 2003; Kulka, 2004). Following FAO recommendations, the above species should be considered a priority when developing bycatch management plans, mitigating the waste of these sensitive species wherever possible.

Since many marine species interact with multiple fisheries, gear types, and across several ocean regions, it seems logical to construct firm policies that understand the demographic impact of cumulative catch and its consequences on the ecosystem (Moore et al., 2009). Similarly, for bycatch and discards, addressing the impacts of multi-species bycatch across fisheries, gear types, and regions allows fishery managers to implement appropriate measures to benefit multiple species (Moore et al., 2009). Species-specific approaches allow managers to study the impacts of fishing on one particular population (Lewison et al., 2009); however, focusing on mitigation measures for one species may indirectly shift bycatch onto another species in another location. Moore et al. (2009)

argue that management measures implemented for once species, does not necessarily translate into multi-species management. A multi-species perspective can better evaluate which fisheries, gear types, and/or regions are the most problematic, and by doing so create priority conservation actions that may benefit multiple species over a larger spatial scale (Lewison et al., 2009; Moore et al., 2009).

Although Canada is currently developing a National Bycatch Policy, there is no firm national definition of bycatch and discards, their draft objectives are vague and non-binding, it lists no priority species or action plans, and it is not being developed alongside the NPOA-*sharks* (personal comm, Michael Eagles, DFO, 2011). For example, one objective states to, “work towards accounting for all catch and related mortality, where the catch is retained for use or discarded”, which does not translate into a firm commitment to account for all sources of mortality. The draft policy is in its preliminary stage and may become more comprehensive over time as stakeholders provide feedback. Nevertheless, examples of existing bycatch policy plans from Australia and the USA are provided as case studies.

3.2.1. Comprehensive Bycatch Management Plans in Australia and the US

Australia’s Commonwealth Policy on Fisheries Bycatch:

Similar to Canada, Australia is required to manage and mitigate bycatch through a number of national and international policy and management measures (e.g. UNCLOS, FAO, *Fisheries and Oceans Act*). Recognizing the need to manage the broader environmental impacts of fishing in 2000, Australia developed the *Commonwealth Policy on Fisheries Bycatch* (Bensley et al., 2010). The policy specifically focuses on bycatch

species that are not currently subject to commercial management plans and that are returned to the sea dead or alive. By definition, this includes, “1) that part of a fisher’s catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained, and 2) that part of the ‘catch’ that does not reach the deck of the fishing vessel but is affected by interaction with the fishing gear” (AFMA, 2000). To address fishery-specific bycatch issues, Australia developed Bycatch Action Plans (BAPs) and overarching core objectives (Box 5). These plans identify bycatch issues, data requirements, options, and possible solutions for individual fisheries to reduce bycatch. Examples of BAPs include: South East Non-Trawl and Southern Shark Fisheries, Tuna Fisheries, and Sub-Antarctic Fisheries (AFMA, 2000).

Box 5

Australia’s Commonwealth Bycatch Policy Core Objectives

1. To reduce bycatch, this could be by *inter alia*:
 - Incentive programs for fisheries, applying target species management arrangements and other measures to bycatch species where deemed necessary
2. Improve protection of vulnerable species by *inter alia*:
 - Gathering data on the impact of fishing on populations, which may be vulnerable to fishing or other pressures.
 - Education/and awareness programs
3. To arrive at decision on the acceptable extent of ecological impacts by *inter alia*:
 - Using biological reference points or the precautionary principle for management of bycatch species.
 - Emphasizing the need for appropriate solutions (e.g. educational, economic incentives, and engineering solutions) to the bycatch issue.

*Not all core actions within each objective are listed. See the AFMA policy for a comprehensive overview.

AFMA, 2000

This policy, in contrast to Canada’s draft bycatch policy, promotes cooperative and transparent approaches that include all stakeholders, aims to create economic incentive programs for fishers to reduce bycatch and discards, aims to create education and

awareness programs, and develops specific Bycatch Action Plans (BAP) for different fisheries (AFMA, 2000). Since the policy's implementation, significant changes have been made to the way Australia manages their bycatch. Although the policy has never been reviewed for its effectiveness, it clearly takes proactive measures to identify fishery-specific issues, involve and list all stakeholders in the development and review of BAPs, creates education and awareness programs, and has developed a legally binding policy (Bensley et al., 2010).

United States National Bycatch Management: Plan, Strategy, and Reporting:

In response to increased bycatch and discarding problems in US fisheries, as well as in response to recent regulatory requirements to mitigate bycatch, to increase bycatch/discards data collection, and to protect vulnerable species, the US commercial fishing industry initiated a series of bycatch workshops in the 1990s (Benaka and Dobrzynski, 2008). The recommendations of the workshop series indicated a clear necessity to address bycatch at the national and regional level. Consequentially, recreational and commercial fishermen, the public, and NGOs urged the National Marine Fisheries Service (NMFS) to develop a national bycatch plan with clear objectives, priorities, and strategies at the national and regional levels (NMFS, 2004). As a result, in 1998, NMFS developed a National Bycatch Plan that aims to “implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided” (NMFS, 2004). The plan is a strategic document that acts as a set of management guidelines for fishery management councils, states, commissions, fishing industry, conservation community, and other stakeholder groups to reduce bycatch and bycatch mortality. The plan covers a

number of US bycatch mandated legislation, such as the Endangered Species Act (ESA), MMPA, and the Magnuson-Stevens Act (MSA). The plan consists of seven primary objectives (Box 6) and includes national and regional bycatch objectives: data collection, evaluation of management actions needed to obtain the seven objectives, and an assessment of the state of knowledge about bycatch in US fisheries (Benaka and Dobrzynski, 2008). Emphasizing the need for a more regional approach to bycatch and discard management, in 2003, NMFS updated their bycatch plan through the development of a National Bycatch Strategy (NBS). Through the strategy plan, bycatch is defined as, “the discarded catch of any living marine resource due to a direct encounter with fishing gear” (NMFS, 2004). The strategy outlines a number of recommendations to advance research and management of bycatch and developed seven bycatch implementation plans. Some of these plans include: reduce fishing capacity in the Gulf of Mexico shrimp fishery and to promote the use of electronic logbooks in the state of Alaska (Benaka and Dobrzynski, 2008). Among other things, both aspects of the plan and strategy include the continuation and development of vessel observer programs, development and implementation of bycatch mitigation techniques, legislative frameworks, and the distribution of funding for marine research and conservation initiatives (Moore et al., 2009). In addition to the strategy plan, NMFS formed six regional bycatch teams to report on implementation, created a bycatch website (<http://www.nmfs.noaa.gov/bycatch.htm>), formed a national working group on bycatch, and sponsored a three-day symposium to discuss bycatch management of longline fisheries and bycatch data collection (Benaka and Dobrzynski, 2008).

In summary, the case studies discussed above provide examples of comprehensive bycatch policies that could be used to inform Canada’s bycatch policy. It is desirable that the Canadian draft policy shall contain and reflect similar objectives and strategies as seen in the Australia and US plans, which include *inter alia* stakeholder engagement, economic incentives for bycatch reduction, fishery-specific bycatch plans, and education and awareness programs.

Box 6
<u>US National Bycatch Plan Seven Objectives</u>
<ol style="list-style-type: none">1. Determine the magnitude of bycatch and bycatch mortality.2. Determine the population, ecosystem, and socio-economic impacts of bycatch and bycatch mortality.3. Determine whether current conservation and management measures minimize bycatch to the extent practicable, and if they do not, select measures that will.4. Implement and monitor selected bycatch management measures.5. Improve communications with all stakeholders on bycatch issues.6. Improve the effectiveness of external partnerships.7. Coordinate NMFS activities to effectively implement the plan.
NMFS, 1998

3.2.2. Economic Incentives for Bycatch and Discard Reduction

The discarding of unwanted fish is a common problem found in most fisheries. Understanding the ecological and economic costs of discarding is an area of study that is gaining momentum and is critical to the analysis of appropriate tradeoffs (e.g. where to reduce fishing effort, how to approach spatial management, the siting of marine reserves) (Holland, 2010). Within the last 30 years, a number of policy and management measures have been adopted in attempt to mitigate these “unknown” costs. No-discard policies, marketing of incidental catch, development of bycatch pilot projects, and the placement of video surveillance and observers on vessels to monitor and record catch, are just a few

examples (Catchpole and Gray, 2010). Whether discarding occurs because of management measures, such as minimum size limit and ITQs, or because the current market price is too low to offset the cost of landing the fish, the problem of discarding remains. Strategically placed economic incentives may alter the behavior of the industry and help promote long-term fisheries sustainability. Therefore, this section highlights alternative solutions to managing bycatch and discard management through a variety of economic incentives.

Bycatch and Habitat Quotas

Bycatch Quotas:

Limiting the amount of fish that can be caught and retained are common management controls used to maintain fishing mortality (F) at or below the mortality that provides maximum sustainable yield (F_{MSY}). However, in order to estimate total fishing mortality, one needs to include both landed and discarded catch. Such estimates are needed to design realistic management programs that include bycatch, discards, and catch into fishery quotas to account for a total biomass loss (Punt et al., 2006). To help circumvent bycatch and excessive discarding, management instruments, such as bycatch quotas have been introduced. Bycatch quotas can be used at the fleet (aggregate bycatch quotas) or individual level; however, only fleet quotas are discussed here due to time constraints. As implied, fleet bycatch quotas are used to limit the permissible amount of bycatch over time, similar to commercial TACs. Once the bycatch limit has been reached, the fishery may be closed for the season. Again, like TACs, bycatch quotas can be adjusted over time, depending the fleet's response to mitigation measures (Hutton et al., 2010). However, determining an appropriate bycatch quota requires ongoing monitoring of

fishery discards and bycatch and should reflect scientific assessments and fishermen's knowledge, rather than based solely on historical catch. This option must be accompanied by high observer coverage or video surveillance to accurately record the amount of bycatch (Hutton et al., 2010).

Bycatch limits for non-target species have been implemented for marine mammals and reptiles. A few examples are provided. (1) For the US shallow set pelagic longline swordfish fishery in the western Pacific, annual binding bycatch limits have been set for leatherback (16 allotted) and loggerhead (17 allotted) turtles. Catch includes turtles that have been hooked and released alive as well morbid turtles. Observers are required to be on every longline trip to record turtle catch (NOAA, 2011a). Due to the cap being reached in 2006, the fishery was shut down three months into the fishing year (Holland, 2010). Since 2006, the fishery has managed to avoid closure; however, it is not known if this is due to increased mitigation measures and/or avoidance techniques (NOAA, 2011a). (2) In New Zealand, bycatch limits are used to manage the bycatch of Hooker sea lions in the squid fishery. Similar to the above example, observers are placed on some but not all vessels, and when the sea lion mortality limit is reached, based on comprehensive observer data, the fishery is shut down (Hutton et al., 2010). In addition, a maximum level of fisheries related mortality (MALFIRM) is used in this fishery to reduce marine mammal bycatch and enhance stocks. However, due to New Zealand's incomplete observer coverage, they developed a system to help calculate the permissible level of bycatch by using a "strike rate" (Hutton et al., 2010). A strike rate is the likelihood of catching a sea lion on any given tow. This data was gathered from existing observer coverage to determine the maximum number of tows a vessel may have in a season.

Therefore, fishers who reduce their sea lion bycatch are allowed higher tows to catch more squid and fishers who have high strike rates, are allocated lower tows, thus creating an incentive to lower the strike rate (Hutton et al., 2010). In response to this system, between 1996-2007, the squid fishery had to be closed early six times. Consequentially, the fishery invested into alternative methods to reduce sea lion bycatch and invented the sea lion excluder device (SLED). To further encourage the adoption of this measure, discount rates are given to for the purchase of this device (Hutton et al., 2010).

Management measures, such as placing a cap on bycatch, encourage fishers to find alternative methods to fish. These measures must be coupled with increased observer coverage or video surveillance to accurately record the level of bycatch and discards, otherwise misreporting may occur. In Atlantic Canada, observer coverage is known to be comparatively low (Gavaris et al., 2010) and would need to be addressed prior to adoption of this measure. Nevertheless, developing restrictive bycatch quotas for Atlantic Canada fisheries that yield high bycatch levels, such as the swordfish and tuna longline fleet is recommended (Gavaris et al., 2010; Godin and Worm, 2010). Currently, no incentive exists to reduce bycatch in this fishery, as there are only non-restrictive measures for catching and discarding sharks. Although catch and release and the use of circle hooks are practiced in this fishery, the development of workable mitigation measures has been slow.

Habitat Quotas:

Another possibility for reducing bycatch is through individual habitat quotas (IHQs), also referred to as Habitat Impact Units (HIUs) (Grafton et al., 2006). Through particular

harvesting measures, such as bottom trawling, sensitive marine habitats can be damaged. To mitigate habitat degradation, transferable habitat quotas could be allocated and penalties given if vessels were found to be fishing in a designated no-fishing zone. The level of damage incurred to a habitat from fishing determines the no-fishing zone, or areas that remain off limits to specified fisheries. Fishers use their quota based on when and where they decide to fish and can be monitored through a vessel monitoring system (VMS) (Hutton et al., 2010). Although this method is seen as a spatial management measure for protecting sensitive habitats, the same idea can be used for avoiding known “bycatch hotspots” (Hutton et al., 2010). For example, the aforementioned Emerald Basin is known to hold large numbers of juvenile porbeagle sharks during the fall season. If IHQs were allocated to the swordfish and tuna fishery, they could decide when and where to use the quota, but would be monitored year round for compliance. In addition, although this system is not readily applied into fisheries management, it has been used as a bycatch management system in the Australian Eastern tuna and billfish fishery since 2009 (Hutton et al., 2010). This fishery devised an incentive based approach to reducing bycatch through spatial distribution of effort, namely, a “hook decrementation system”. This system 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 (Pascoe et al., 2010). 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, penalties are given and a reduction of hooks is required, therefore reducing the value of fish per hook. Similar to the habitat quota, the rate at which these hooks are used and where the fishing

occurs is entirely up to the fishermen. Through this type of measure there is an incentive to avoid bycatch hotspots and find alternative ways to fish, thus increasing target catch per hook allowed (Pascoe et al., 2010). However, bycatch hotspots and catch per value of hook (VPH) must be determined prior to the implementation of this measure. Whilst careful measures must be taken to ensure bycatch effort is not transferred to another location.

In summary, bycatch quotas with restrictive measures are often not favoured by the industry, but are considered an effective management tool to reduce bycatch (Hutton et al., 2010). However, in order for this economic incentive to be successful in Atlantic Canada, observer coverage, video surveillance, or a combination of the two must be used broadly in fisheries that catch and discard elasmobranchs (e.g. longline and groundfish fisheries). Habitat quotas are considered a softer measure and also have the potential to reduce elasmobranch bycatch. Prior to the implementation of this measure, collaborative efforts between managers, scientists, and fishermen should be utilized to determine bycatch hotspots. Regardless of the incentive, further research is required to understand the tradeoff between maximizing elasmobranch conservation and minimizing the negative economic impact on Canadian fisheries that interact with elasmobranch species.

Performance Bonds

The use of financial mechanisms to enhance marine stewardship is a relatively new concept. While this incentive is more commonly used on land, it can equally be applied to maintain marine ecosystems through performance bonds. Performance bonds are pre-determined amounts of money set-aside in escrow (funds held in a trust account) that are

subject to penalty (Anderson, 2002; Kahn, 2004). The funds should be equal to the estimated amount of damage that is likely to occur from an activity, such as fishing, and are set aside by the individual fisher or fleet (Bagstad et al., 2007; Hutton et al., 2010). In the case of Atlantic Canada pelagic longline fishing, a precautionary limit (total amount of funds) should reflect total catch, including discards, as this type of fishing catches many non-target charismatic species, such as turtles and sharks (DFO, 2007c). High discarding in one fishery can be seen as potential damage to another fishery or to the marine ecosystem itself. Hutton et al. (2010) highlight, “the funds would be returned provided the industry achieved a pre-determined performance target in terms of bycatch reduction against some base level”. This type of financial mechanism can be allocated at the individual fleet or industry level. Again using the Canadian swordfish and tuna longline fishery as an example, if the bond was operating at the fleet level, all vessels are responsible for the liability of the bond, encouraging self-reporting and information exchange to avoid bycatch hotspots. However, if some fishers believe the other participants will reduce bycatch first, then “free-riding” may occur and a disincentive to reduce their own bycatch exists (Hutton et al., 2010). Like many of the above recommendations, increased observer coverage and/or video surveillance are necessary for acknowledging the level of fishery performance in meeting the bond’s requirements.

This economic incentive is most likely to be effective in fisheries with low bycatch, as fisher’s communication and self-reporting is more feasible and where available higher observer coverage is realistic. As the bond is tied to a contractual set of fishing lease agreements, not complying with the performance standards can close the fishery.

Therefore, an incentive to mitigate bycatch and fish sustainably exists, and could be applicable towards incidental catch of elasmobranchs.

Bycatch Tax System

An alternative to spatial management and fishery closure is through implementing a levy on fisheries bycatch and discards, namely, a bycatch tax system. Placing an economic value on bycatch provides an incentive for fishers to adjust their fishing techniques and avoid bycatch and adopt alternative fishing methods (Hutton et al., 2010). Similar to a carbon tax that regulates greenhouse emissions, fishers could be charged a fee for landing or discarding incidental catch, which is then placed into a fisheries fund to finance pilot projects aimed to reduce bycatch (Chang, 2009). This method is called compensatory mitigation for marine bycatch (CMMB). In theory, this fund compensates for environmentally damaging activities, such as longlining, 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 that fishers be charged graded scales of taxes per weight of bycatch to fund compensatory mitigation measures (Finkelstein et al., 2008). A tax system can appropriate different levels of fees based on the bycatch species, affording maximum protection to vulnerable, threatened, and endangered species (Hutton et al., 2010). However, minimizing financial strain to fishers is also important and should be considered if using this economic incentive. This could be achieved by delaying implementation for a few years, allowing fishers to adopt the necessary mitigation measures (Chang, 2009).

Although this system is not currently used in any fishery as a bycatch and discard management measure, it is assumed that the system prompts a disincentive to report bycatch, and that it is hard to enforce without extensive observer coverage (Hutton et al., 2010). Nevertheless, several authors have confirmed the 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 (Diamond, 2004; Herrera, 2005; Hutton et al., 2010; Sanchirico, 2003). If a bycatch tax system is a workable solution for the above-mentioned species, it might also be applied to the incidental catch of elasmobranchs.

3.3. Education and Research

Through the IPOA, States are strongly encouraged to establish systems that provide verification of catch and coordinate with RFMOs and other agencies to improve the monitoring and reporting of bycatch and discards at the species level (FAO, 2009). The IPOA further prompts States through their NPOAs to improve communication among all stakeholders and develop frameworks that establish and promote effective consultation with regards to research, education, and management initiatives (FAO, 1999). While Canada's NPOA addresses the need for increased communication and monitoring efforts to reduce bycatch, few steps have been taken to improve education and awareness on bycatch and discarding, information sharing across fleets, or improved species identification. Nor does the plan take any actions to encourage safe handling and release of elasmobranch bycatch species (DFO, 2007a). Therefore, this section provides an overview of selected measures that could be included into a revised NPOA and that fall within IPOA objectives one, four, six, nine, and ten, including safe catch and release

practices and collaborative research programs, such as fleet communication and study fleet pilot programs.

3.3.1. Safe Release Practices

Sharks face a number of human created pressures including habitat degradation, fisheries interactions, and pollution. Stress and injury from being caught and then released is another pressure that is often overlooked. The diversity of shark species and their life history patterns indicates that there is not a “typical” response in sharks to these pressures, but species-specific responses (Skomal, 2007). Stressors can come in acute and chronic forms, depending on the intensity and type of fishing activity. Acute stress involves rapid short-term response (minutes to hours) of fishing (Skomal, 2007). This could include stress as a result from prolonged recreational shark fishing or sharks being left on a longline for hours (Skomal, 2007). Chronic stress results from long-term sub lethal effects caused by a drawn out duration of stressors over a period of time (inability to feed, infection, wounds, etc.). Improper catch and release techniques, gaffing, rough handling, or ripping hooks out of the jaw can cause these types of stressors, as a result of injury(s). In addition, chronic stress can negatively alter reproduction, growth, and resistance to disease, creating compound effects that accumulate at multiple levels (Carrier et al., 2010). As a result, many scientists think there should be species-specific guidelines and codes of conduct to increase post-release survival of marine species (Cook and Suski, 2005). Two examples are provided to demonstrate some existing species-specific guidelines. (1) The Southwest Fisheries Science Center in the US developed a “best fishing practices for safe handling” of the common thresher shark (*Alopias vulpinus*) for recreational fishing. While the overarching guidelines are similar to other

catch-and-release best-practices (e.g. minimize fight time, use of circle hooks, and reviving the fish), this particular example addresses tail-hooked threshers, and recommends special handling practices (NOAA, 2011b). This recognizes that threshers require different handling methods than other large pelagic sharks, due to its large tail, which frequently gets hooked. (2) In 2006, the Southern and Eastern Scalefish and Shark Fishery (SESSF) in Australia, developed a code of practice for auto longline operators who encounter gulper sharks (*Centrophorus granulosus*), a common deep-water dogfish that is vulnerable to overfishing (AFMA, 2006). Every longline operator that interacts with these sharks is required to adopt the best practices. Within the code, operators are provided with information on species biology and distribution, how to reduce incidental mortality, species id charts for a range of gulper species, and procedures on how to properly catch-and-release a gulper shark (AFMA, 2006). In addition to the aforementioned practices, the code also recommends that all operators be trained (Gulper Shark Handler) in species id and assess the sharks life stage as alive/good condition (AGC), alive/sluggish (AS), or dead (D). If the gulper shark is AGC, specifically trained operators may tag, record biological information, identify position, and identify condition of release (AFMA, 2006).

For Atlantic Canada, the swordfish and tuna longline fishery practices live release of sharks when possible, and uses circle hooks to reduce mortality of non-target species, such as turtles (DFO, 2011). In addition, this fishery must also adhere to a code of conduct for the handling and release of turtles and fishers are equipped with a customized de-hooking kit (DFO, 2010). However, there is no code of conduct or safe handling practices for sharks, either in the commercial or recreational sector. The knowledge on

the survival of released sharks in Atlantic Canada fisheries is limited, yet essential for assessing the validity of current handling practices and associated mortality rates (Hoolihan et al., 2011). The overall effects on catch and release fish depend on factors such as on fight time and gear used, so it is vital to conduct more studies on post-release survival in both recreational and commercial fisheries, to determine if current methods used are optimal (Hoolihan et al., 2011). Studying post-release survivorship of elasmobranchs and assessment of proper handling methods falls well within IPOA objectives one, four, and six. Furthermore, while each State can develop and implement the NPOA independently of the IPOA objectives and recommended guidelines as Canada did, it is important to reduce stress and minimize injury to the fish, ensuring post-release survival. Although Canada's NPOA vaguely addresses the need to encourage commercial and recreational fishermen to be more aware of catch-and-release practices, DFO provides no information (e.g. workshops, posters, id charts, or brochures) to advance this action. However, through the revision of the NPOA, the development of effective catch and release strategies, through the use of videos, species id charts, and workshops, for target and non-target species, may help increase post release survival rates and promote best fishery practices (Cooke and Suski, 2005).

3.3.2. Cooperative Research Programs

The development of cooperative research programs is seen as developing a partnership between the fishing industry and other stakeholders to improve capacity building and information gathering (e.g. species-specific catch, multi-species, species abundance and distribution) (Johnson et al., 2007). Strongly recommended by the FAO through the IPOA, States should improve species-specific catch, landings, and discards, and develop

systems that promote strong stakeholder relations and information exchange (FAO, 1999). Although addressed in Canada's NPOA Action six "Enhance Outreach and Education Efforts in Canada", the *shark-plan* has neither improved species-specific catch of elasmobranchs, nor have any actions been taken to develop collaborative research programs to mitigate bycatch, improve scientific data, and improve data collection and species id by at-sea fisheries observers and fishermen (DFO, 2007a). Therefore, this section addresses two types of successful fishery-dependent cooperative research programs that could be adopted to act in accordance with IPOA objectives four, nine, and ten and included into a revised NPOA.

Fleet Communication Programs:

Gilman et al. (2006) reviewed three case studies that use fleet-wide communication programs to report real-time observations of bycatch hotspots. A full analysis of the three case studies is not provided, as Gilman et al. (2006) already did this. However, a brief overview of their strategy and effectiveness is discussed to show the likelihood of this program working in Atlantic Canada. Three case studies are discussed: (1) US North Atlantic Longline Swordfish Fishery (2) US Alaska Dermersal Longline Fisheries, and (3) US North Pacific and Alaska Trawl Fisheries.

(1) Although voluntary, from 2001-2003, the Blue Water Fishermen's Association established a fleet communication program for the US North Atlantic Swordfish Fishery, to help mitigate loggerhead and sea turtle bycatch. The fleet developed an information-sharing program that allowed them to convey information to each other on turtle encounters, sightings, hotspots, and oceanographic features. During its implementation,

reports indicated reductions in turtle bycatch rates by 50 percent, solely as a result of improved fleet communication (Gilman et al., 2006).

(2) In 1992, a private company named Fisheries Information Services (FIS) was hired by the North Pacific Longline Association (NPLA) to develop and control a voluntary fleet communication program to reduce halibut bycatch in Alaska demersal longline fisheries. Additional requests were made in 1999 to reduce seabird bycatch. Through the use of at-sea-observers, the FIS were able to upload catch data, weight of target and bycatch species, location of set and haul, and fishing effort into an online database. From this data, weekly report cards were sent out to individual vessels, managers, and to the NPLA. In addition to the reports, bycatch hotspot maps were developed and provided to the participants. Prior to the fleet communication program, seabird bycatch mortality rates had been estimated at 24,000 birds in 1998. After the development of the fleet program fewer than 500 birds were caught in 2003. For halibut, a 33 percent decline in bycatch rates was recorded from 1992-1995 (Gilman et al., 2006).

(3) Lastly, in 1994, the US North Pacific and Alaska Trawl Fishery developed a real-time information exchange program to monitor and reduce bycatch of chum (*Oncorhynchus keta*) and Chinook salmon (*Oncorhynchus tshawytscha*) in pollock fisheries; halibut in flatfish and cod and scallop fisheries; crabs in flatfish, scallop, and cod fisheries; and rockfish in pollock, mackerel, and whiting fisheries. A private company named Sea State Inc. was hired to manage the fleet communication program. Since 1994, the voluntary program has been operating at 100 percent fleet participation and uses satellite systems, the Northwest Groundfish Observer Program, VMS, and phone calls to communicate between fleets. Sea State uses the observer data to produce digital charts that identify

bycatch hotspots, and send the information daily to participating fleets (Gilman et al., 2006). Due to a lack of information on the abundance of bycatch species, the success of this program at reducing bycatch is not entirely clear; however, the program has proven to be an effective tool for information exchange across this fishery, thus providing the opportunity to avoid bycatch hotspots and fish longer days at sea (Gilman et al., 2006).

The above fleet communication programs, overall, were found to be effective at reducing bycatch levels of fish, seabirds, and turtles and improving information exchange. Clearly, this is an option that could be considered to advance fleet communication, avoid bycatch hotspots, and improve knowledge on spatial and temporal distributions of elasmobranch bycatch in Atlantic Canada.

New England Groundfish Study Fleet Pilot Program:

By definition, a study fleet is, “ a sample of fishing vessels from which high quality data on catch, fishing effort, gear characteristics, area fished and biological observations are collected. These vessels fish in *normal* commercial mode, and are selected to be representative of the larger fleet over time” (Palmer et al., 2007). Study fleet programs generally employ electronic data collection to provide high resolution (temporal and spatial) self-reported data, enhancing the precision and accuracy of data collection (Palmer et al., 2007). 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, several NGOs, and NMFS conducted a series of workshops in 2000 to discuss industry’s interest in such a program. In response to the workshops, in 2002, a study fleet program was developed with two primary

objectives: “(1) assemble a study fleet of commercial New England groundfish vessels capable of providing high-resolution data on catch, effort, and environmental conditions, while working under normal fishing conditions and (2) develop and implement electronic reporting hardware and software for the collection, recording, and transferring of more accurate and timely fishery based data” (Palmer et al., 2007). A full analysis of the study fleet program is not provided, given its comprehensive nature; however, a brief summary of its success is discussed.

A summary of the fleet data collection from 2003-2005 resulted in successful development, testing, and deployment of ELB system among the New England groundfish fleet. Several observations were made: electronically entered data was available for analysis 29-76 percent faster than traditional logbook data, more accurate estimates of individual effort data were available, improved discard reporting rates, and data was more timely and had greater spatial accuracy (Palmer et al., 2007). In summary, the fleet pilot program allowed for high resolution of self-reporting data than that of the FVTRs and sometimes equals to that of observer coverage, and proved that fishermen can collect the information simultaneous to “normal” fishing activity. However, the analysis also showed the need for substantial improvements in operator use and training, which led to the misreporting of effort data, among other things (Palmer et al., 2007). Nevertheless, this program may offer improvements in self-reporting data collection in Atlantic Canada fisheries with low observer coverage and paper logbooks, such as the swordfish and tuna longline fishery. Using a study fleet program may improve or facilitate more timely species-specific catch and monitoring data, an objective that is strongly encouraged by the FAO (FAO, 1999).

Summary Recommended Actions that Could be Considered Under the NPOA

1. Determine cumulative bycatch across all fisheries, by gear, and region, and assess its impact on population dynamics.
2. Account for uncertainty in estimates using a precautionary approach.
3. Develop and implement management plans that reduce bycatch in the highest impact fisheries (e.g. swordfish and tuna longline fishery).
4. Develop a comprehensive binding National Bycatch Policy Plan.
5. Ensure the widest adoption of bycatch mitigation measures through collaboration with the fishing industry, research funding organizations, NGO agencies, fisheries management agencies, and other relevant governmental agencies.
6. Raise awareness and encourage participation of stakeholders in the management of fisheries bycatch.
7. Development of economic incentives for sustainable fishing (e.g. bycatch tax system, habitat quota, or bycatch quota).
8. Consider conservation areas for vulnerable, threatened, or endangered elasmobranch species (e.g. porbeagle sharks at Emerald Basin).
9. Conduct research on post-release conditions for elasmobranchs in commercial and recreational fisheries.
10. Develop cooperative research programs (e.g. fleet communication or study fleet pilot project) to improve species-specific effort and catch data, reduce incidental catch, and improve education and awareness among stakeholders.
11. Develop a code of conduct for elasmobranch bycatch species alongside best catch-and-release practices for both commercial and recreational fishing sectors.

*Not in any order of importance

CHAPTER 4: STAKEHOLDER FEEDBACK: THE FIRST ATLANTIC CANADA SHARK FORUM

Stakeholder participation is becoming increasingly important in the development of fishery management plans and is recognized as a key element in an ecosystem based approach to management (Berghofer et al., 2008; Wiber et al., 2009). In order to adequately manage, protect, and recover species, it is essential to involve all stakeholders with common interests to identify threats, and develop mitigation measures (Gilman and Lundin, 2008). Previously mentioned, the FAO Technical Workshop identified several recommendations to improve the conservation and management of sharks (Box 2, Ch.2) (FAO, 1999). It recognized the need to improve communication among all stakeholders, close the gap of knowledge between fisheries conservation and management sectors, and develop a step-by-step approach towards NPOA implementation (FAO, 2009). Due to the conservation and management issues surrounding sharks in Atlantic Canada and the Eastern Arctic, such as bycatch, species decline, absence of biological data, and a largely incomplete NPOA, WWF-Canada organized the first Atlantic Canada Shark Forum in March of 2011. The Atlantic Shark Forum was a first step in a collaborative process that brought together fishermen, scientists, managers and practitioners. These stakeholders either interact with shark species directly or are involved in the conservation and management of sharks in Atlantic Canadian waters. The goal of the forum was to identify top priorities that would significantly advance conservation and management of sharks and inspire collaboration between different interest groups. In attendance at the forum were representatives from several regions/departments of Fisheries and Oceans Canada,

relevant gear sectors, non-governmental organizations, tourism, and academia (WWF, 2011).

During the forum, participants were asked to develop priorities for the improved management of sharks in Atlantic Canadian waters. To help seed and focus discussions, participants' were provided with three draft priority lists that were organized by category including: on-the-water practice, science, and policy/management. During the first session, participants were organized, where possible, according to their expertise to discuss the top priorities that they felt to be most pressing (Table 12) (WWF, 2011). A summary of identified priorities is provided below.

On-the-water-practice

Industry representatives that participated in the on-the-water-practice group included representatives from pelagic longline, bottom longline, trawl/dragger, groundfish gillnet, recreational shark fishing (both charter operators and shark derby organizers), and harvest seafood processors. Most, but not all relevant industries were present. Nevertheless, the present participants consistently expressed the need for a number of improvements in shark management, particularly with regards to the following: improve information exchange across fleets (e.g. bycatch hotspots and tested shark avoidance measures), development of species-specific best practices for safe handling and release of sharks, and improvement of species identification skills for fishermen and observers (e.g. through id charts, videos, workshops) (WWF, 2011). Some of the aforementioned measures provided in chapter three, such as fleet communication or study fleet pilot programs, could be introduced to improve species id, data collection, and information exchange across fleets. In addition, species-specific handling practices, like those for the

thresher and gulper shark also discussed in chapter three, could be developed for commonly caught or sensitive bycatch species in Atlantic Canada or Eastern Arctic (e.g. Greenland, blue, and porbeagle shark).

Science

Individuals representing the science category included university researchers (e.g. Dalhousie University, University of North Carolina, University of New Brunswick, University of Windsor, and Marine Institute Memorial University), DFO-scientists, NGOs (e.g. WWF and EAC), and several research institutes. While many topics were up for discussion, general agreement centered on the following science priorities: evaluating current options for bycatch mitigation, quantifying bycatch across all fisheries and incorporating this information into robust stock assessments, determining the spatial and temporal distribution of sharks and shark bycatch, improving observer data and monitoring, and collect more biological data for non-commercial species (WWF, 2011). If insufficient funding, lack of political will, and low economic importance of sharks are reasons that inhibit improved science of elasmobranchs, new innovative methods and economic incentives need to be explored. After revisiting the examples provided in chapter three, I recommend that conservation areas be considered for research and mitigation activities. In addition, consideration should be given to a bycatch tax system and/or performance bond, that collect money from environmentally damaging activities and place the funds into a research fund to test and fund pilot projects.

Policy/Management

Policy and management officials included representatives from DFO science, oceans, resource management, fisheries management, and species at risk. Similar to the above

categories, many issues were discussed, but certain topics emerged as key priorities. These included committing to a NPOA with clear objectives, actions, timelines, and responsible agencies, using the forum as a basis to make recommendations for a revised NPOA and regional plan, developing best practices for safe handling and release of sharks, increasing observer coverage in high bycatch fisheries, and accounting for discard mortality in all fisheries (WWF, 2011).

For a second discussion session, working groups were rearranged at random, to achieve mixed-representation, and participants were tasked with the identification of cross-cutting or top priorities that apply to all stakeholders (Table 13) (WWF, 2011). Following this session, one representative from each of the three working groups was convened with the facilitator to determine a final list of top cross-cutting priorities, which then was presented to the entire group. These priorities were discussed in a plenary session and finally agreed upon by all participants as being a fair representation of the top priorities for shark management and conservation in Atlantic Canada (WWF, 2011). Cross-cutting priorities included: (1) Better understanding of shark avoidance and release practices, (2) advancement of research on bycatch mitigation techniques, (3) generation of more and better information on or changes to stock status, and (4) improvement of training and education on shark conservation (WWF, 2011). As the forum concluded, stakeholders stressed the need for continual communication, information sharing, and transparency across all sectors, and emphasized the importance of developing an action plan with real timelines and deliverables to address these priorities. These top cross-cutting priorities were identified to inform a process of implementing a shark fisheries and conservation plan at the regional level, congruent to the development of a revised NPOA in 2012.

Although the Atlantic Shark Forum priorities and those of the IPOA were developed independently from one another, they significantly overlap and address similar conservation and management needs for elasmobranches (Table 14). The forum provided an opportunity to compare regional concerns against those addressed in the NPOA, and recommended by the IPOA (Table 14). As table 14 shows, IPOA objectives overlap largely with those identified at the forum, and may as such help to develop a Regional Plan of Action for Shark Conservation and Management (RPOA-*sharks*), under the umbrella of a more comprehensive NPOA (see Chapter 5).

Table 12: WWF-ACSF, First Session Top Priority List (WWF, 2011)

Expert Group: ON-THE-WATER PRACTICE
1. More accurate scientific information is needed for some shark species (e.g. basking, blue, spiny dogfish, and Greenland sharks), to reduce uncertainties that exist for sharks
2. As the marine environment is in flux, new and/or more species of shark may inhabit our waters in the future. It is critical that fishermen and their knowledge are recognized as a vital source of information that needs to be trusted and accepted by science.
3. Determine appropriate levels of observer coverage to provide consistent and relevant data on shark species across fleets and regions.
4. Some fisheries have their own strategy or avoidance plan that is adapted and changed on-the-water. These strategies need to be collected, shared, and tested in areas of high bycatch across fleets and regions.
5. Fishery specific best practices for safe handling and release of sharks is of high importance for fleets. Workshops and forums are needed to disseminate this information and experience across fleets and regions.
6. Identification of species is a problem for some fisheries. Education and the development of educational tools are required for fishermen, as well as for observers.
7. Shark derbies represent an opportunity to educate participants and spectators alike, while at the same time gathering scientific information; however these derbies should move towards catch and release of sharks, potentially using USA tournaments as an example.
Expert Group: SCIENCE
1. Analyze existing data in order to: determine the spatial and temporal distribution of sharks and shark bycatch, develop robust stock assessments for all species, and quantify bycatch of sharks across all fisheries.
2. Evaluate current options for bycatch mitigation of sharks, including reducing harm, mortality and catch rates across all fisheries, and should include: collaborating with industry to determine possible methods of gear modifications and safe handling, establish post release mortality rates for all shark species, and integrate science and fishers knowledge for a more comprehensive understanding of shark bycatch.
3. Improve data collection for all shark species through: fisheries-independent surveys for shark population assessments (excluding spiny dogfish and porbeagle), more accurate observer data and coverage in fisheries with high bycatch, and more biological data for non-commercial species (e.g. basking, Greenland, and other deep water species).
Expert Group: POLICY/MANAGEMENT
1. Develop best practices for safe handle and release of sharks to increase survival.
2. Expand regulations requiring that shark discard mortality be accounted in all fisheries known to have bycatch.
3. Establish precautionary catch limits for discard mortality of non-commercial priority species based on available data and peer-reviewed assessments.
4. Using the shark forum as a basis for recommendations to revise the Canadian NPOA, with clear actions, priorities, timeframes, and responsible agencies.
5. Expand fisheries monitoring and enforce regulations established for conservation and management of shark species.
6. Fisheries Act renewal, to redefine a “shark”, and break up their current categorization to include all species in order to safeguard specific species that require additional protection.
7. Develop a regional plan of action (RPOA) for the conservation and management of sharks in Atlantic Canada and the Eastern Arctic.
8. Consider shifting current “finning” regulation of 5% ratio to fins attached policy.

Table 13: WWF Cross-Cutting Priorities (WWF, 2011)

Sectors	Science; Policy/Management; On-the-water Practice	
Cross-cutting Priorities	Action	Time Needed
1. Shark avoidance and release practices	<ul style="list-style-type: none"> a. Development of protocols and tools for safe release by fleet b. Information sharing of what has been done and/or could be done for avoiding shark bycatch c. Training and educational workshops to disseminate shark avoidance and release practices between fleets 	Short-term
2. Develop a better understanding on shark stock status	<ul style="list-style-type: none"> a. Determine stock status for key shark bycatch species with limited information (e.g. Greenland, blue, and basking sharks) b. Assessment of total bycatch and post-release mortality for species across fleets c. Determine reference points and bycatch limits for species across fleets d. Integration of fishers knowledge into conservation and management recommendations 	Medium-Long-term
3. Training and education	<ul style="list-style-type: none"> a. Keeping good and open communication among all stakeholders b. Sharing of information and knowledge through formal (e.g. workshops) and informal (e.g. conversation) means of communication c. Develop or make use of existing educational tools (e.g. identification cards) d. Inform the public on issues and initiatives related to participant efforts with regards to sharks through a collaborative website 	Short-Long-term
4. Research and development into mitigation measures	<ul style="list-style-type: none"> a. Better use of existing bodies of knowledge and data (e.g. logbooks) b. Identify where possible, when and where risks exist for all shark species c. Investigation by sector, of potential mitigation measures d. Conduct pilot projects to test possible options to address specific problems for shark species (e.g. shark repellent hooks, setting practices) 	Medium-Long-term
Time Needed: Short (1-5 years); Medium (5-10 years); Long (> 10 years)		

Table 14: IPOA Objectives to WWF-Cross Cutting Priorities (FAO, 1999; WWF, 2011)

IPOA Objectives	WWF-Atlantic Shark Forum Cross Cutting Priorities				Broad Category
	1	2	3	4	
1. Ensure shark catches from directed and non-directed fisheries are sustainable	x	x	x		Spatial Management/Bycatch Management/Education and Research
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		x	x	x	Spatial Management/Bycatch Management/Education and Research
3. Identify and provide special attention, in particular to vulnerable or threatened shark stocks		x	x	x	Spatial Management/Bycatch Management/Education and Research
4. Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management, and educational initiatives within and between States	x	x	x	x	Spatial Management/Bycatch Management/Education and Research
5. Minimize unutilized incidental catches of sharks				x	<i>Not a priority</i>
6. Contribute to the protection of biodiversity and ecosystem structure and function	x		x	x	Spatial Management/Bycatch Management/Education and Research
7. Minimize waste and discards from shark catches	x	x	x	x	Spatial Management/Bycatch Management/Education and Research
8. Encourage full use of dead sharks					<i>Not a priority</i>
9. Facilitate improved species-specific catch and landings data and monitoring of shark catches	x		x	x	Spatial Management/Bycatch Management/Education and Research
10. Facilitate the identification and reporting of species-specific biological and trade data	x		x	x	Spatial Management/Bycatch Management/Education and Research
<p>1. Better understanding of shark avoidance and release practices used by industry in Atlantic Canadian waters by species and fleet through: development of protocols and tools for safe release by fleet; information sharing of what has been done and/or could be done for avoiding shark bycatch; training and education workshops</p> <p>2. Advance research on and implementation of appropriate mitigation measures through: better use of existing bodies of knowledge and data; identify when and where risks exist for all shark species; investigate by sector potential mitigation measures; conduct pilot projects to test possible options</p> <p>3. Require more and/or better information on or changes in stock status through: stock assessments for key bycatch species with limited information (e.g. Greenland, blue, and basking shark); assess total bycatch and post-release mortality for species across fleets; establish reference points and bycatch limits for species across fleets; integration of fishers knowledge</p> <p>4. Training and education about shark conservation issues through: keeping open communication with stakeholders; workshop developments; identification cards; inform the public on issues and initiatives</p> <p>*The Broad Categories of Spatial Management/Bycatch Management/and Education and Research are chosen to be all encompassing research headings under which many measures can be included (e.g. bycatch mitigation, best catch and release techniques, incentives for sustainable fishing), and addressed through the IPOA objectives</p>					

CHAPTER 5: SYNTHESIS AND RECOMMENDATIONS

The decline of marine species, including many sharks, skates and rays, has urged the international community to develop international plans, initiatives, and agreements to minimize overexploitation, while attempting to ensure the conservation of marine biodiversity (FAO, 2000). Although a number of other management measures exist (Techera and Klein, 2011), the FAO has taken a lead in improving shark conservation through the development of the IPOA-*sharks*. To this day, it is the only international framework that guides States in developing comprehensive conservation measures for sharks and represents an important commitment to their long-term conservation and management (FAO, 2000; Techera and Klein, 2011). Although the IPOA is not considered a panacea for shark conservation and management (Lack and Sant, 2011), it is a tool to help States develop and implement conservation and management objectives at the national policy level (National Plans of Action – NPOAs), which in turn aides management bodies in developing focused Regional Plans of Action (RPOAs), (FAO, 2000). In theory, the NPOA is an overarching national framework that guides the State in developing strategies for achieving regionally focused objectives and management outcomes for sharks (FAO, 1999). However, if the underlying objectives, strategies, actions, and identified issues are poorly defined, or implemented, the likelihood that regional plans will complement the IPOA objectives and guidelines are limited (DAFF, 2004). While shark populations continue to decline in the face of limited management (Ferretti et al., 2010; Techera and Klein, 2011), it becomes increasingly important to not

only adopt an NPOA, but to thoroughly address all IPOA objectives and guidelines and to assess the plan for its realized contributions to shark conservation and management.

It is the responsibility of the State to develop, implement, and monitor the NPOA for its effectiveness every four years, yet few countries have done this. With the exception of Australia (Lack and Sant, 2011) and the work of this thesis, none of the existing National Plans have been assessed for their effectiveness against their stated objectives. As this review indicates, Canada's NPOA was not adequately developed and, like many others, involved no stakeholder consultations (a key component to drafting an NPOA), lacks development of a shark assessment report (SAR) which identifies primary management issues, contains no firm actions, timelines, or responsible agencies for implementation, and neglects to include performance indicators which could be used to validate progress. While some progress has indeed been made for sharks in Canada, particularly in data collection and research, failing to include the above elements leaves the existing Canadian NPOA incomplete and largely ineffective towards shark conservation and management (DFO, 2007a).

The primary purpose of this research was to identify the intent of the IPOA, review the Canadian NPOA for its effectiveness, find alternative policy measures applicable to shark conservation and management, and make recommendations for a newly revised NPOA, specifically on its process and content. In addition, considering Canada's slow progress in NPOA implementation, this research also recommends that a more pragmatic regional approach be taken to address issues on a more practical scale. This process involves *inter alia*, consulting all stakeholders in the development of a regional plan of action for sharks (RPOA).

The following sections outline a number of key issues and actions to be considered in a revised NPOA for 2012 and recommend a preliminary RPOA for Atlantic Canada and the Eastern Arctic.

5.1. Revising the NPOA

A primary goal in developing and implementing an NPOA is to ensure the conservation and management of sharks over the long-term (FAO, 1999). A review of the Canadian NPOA indicates a slow progress of implementation and minimal contribution towards shark conservation and management, particularly for non-commercial species, including most non shark- elasmobranchs (rays, skates, and chimeras). The NPOA requires a thorough revision in order to contribute decisively to the conservation of elasmobranchs in Canadian waters. This section recommends two essential components to revising the NPOA. First, to guide the revision of the NPOA, it is proposed that Canada follow the six steps discussed below. These steps are recommended as the logical process to developing an NPOA (Fig. 2). Second, a set of recommended actions are provided to show the minimum content needed in a revised NPOA. These actions are derived from the priorities identified at the ACSF, recommended actions discussed in the literature review (Ch.3), and those actions listed in the Australian NPOA. However, it is important to note that these actions are not necessarily complete, and should be considered a minimum standard to advance shark conservation and management on a national and regional scale. A majority of these recommendations reflect the process that was used for developing Australia's first Shark-Plan 1 and the Pacific Island RPOA-*sharks* (Lack et al., 2009; DAFF, 2004); however, further guidance on developing a comprehensive

NPOA can be found in the IPOA-*sharks* and the FAOs Technical Guidelines for the Conservation and Management of Sharks (FAO, 1999; FAO, 2000), as well as in the proceedings from WWF’s Atlantic Shark Forum.



Figure 2: Summary Process, A Guide to NPOA Development, Implementation, and Review

Step 1: Engage Stakeholders and Develop a Shark Assessment Report

Prior to the development of a revised NPOA, all resource users (commercial, recreational, and indigenous), management, fisheries policy, academia, government, and non-governmental organizations should be consulted, and given the opportunity to provide input throughout the development process (FAO, 2009). All stakeholders should be made aware of the importance of shark conservation and management and should be knowledgeable of the NPOA, its purpose, and its contribution to shark conservation (FAO, 2009). Similar to the Atlantic Shark Forum, a dedicated forum or series of workshops should be held to discuss the revision and content of the NPOA. Bringing together stakeholders improves communication between sectors, gathers relevant information, and helps to develop a more realistic plan that has been agreed upon by all interested parties (WWF, 2011). Without stakeholder involvement from the very beginning, the scope for collaborative research and mitigation projects may be limited and any restrictive measures will be more difficult to implement.

In addition, stakeholder engagement is a crucial component to addressing the issues identified in the SAR. The FAO requests that each State prepare a SAR with an aim to identify shark conservation and management issues, and highlight gaps of knowledge that may be relevant (FAO, 1999). The primary purpose of the SAR is to present the current state of knowledge on sharks and to use this information as a basis to list issues and associated actions in the NPOA (DAFF, 2001). Suggested content for the SAR is provided in the FAOs Technical Guidelines for the Conservation and Management of Sharks (FAO, 2000).

Once the issues have been identified in the SAR, in consultation with stakeholders, the development of responses to these issues should involve input from industry, government, non-governmental organizations, and any other relevant stakeholders. Stakeholder input can maximize the likelihood that these measures are not only included in the revised NPOA, but are actually adopted by industry.

Step 2: Address All Ten IPOA Objectives and Additional Objectives as Required

The FAO's IPOA-*sharks*, Guidelines on Bycatch Management and Reduction of Discards, and the technical guidelines for sharks, consistently overlap in their objectives and advice towards conserving and managing sharks (FAO, 1999; FAO, 2000; FAO, 2010). Similarly, the priorities identified at the WWF Atlantic Shark Forum also overlap with those identified in the aforementioned guidelines, and remain consistent in their agreement on the overarching IPOA principles (WWF, 2011). In addition to including all ten IPOA objectives (Table 2, Ch.1) in the NPOA, six additional overlapping objectives or "themes" were found and could also be considered as broad categories from which identified issues and associated actions could follow. The six broad themes (Box 5, Ch. 2) reflect those identified in Australia's NPOA and are also found to be consistent throughout the above guidelines.

When Australia developed their NPOA in 2004, they not only identified all ten IPOA objectives, but also used the six themes identified above to respond to 18 specific conservation issues identified in the SAR (DAFF, 2004). The development of these themes allowed Australia to condense the 18 issues into theme headings that could then address a number of issues under one heading and also link to one or more IPOA

objectives (DAFF, 2004). It is important that the objectives or themes also reflect and/or complement those of fisheries management and conservation, and existing regional, national, and international policies and obligations (Lack et al., 2009).

Therefore, it is recommended that Canada address all ten IPOA objectives in the revised NPOA, and consider the inclusion of the six broad themes identified above.

Step 3: Prioritize Shark Conservation and Management Issues Arising From the SAR

Although Australia originally identified 25 shark conservation and management issues from the SAR, through their consultation process, they were able to condense these to 18 issues. The SAR provided Australia with a comprehensive review on the state of knowledge on sharks in their national waters and helped highlight issues, which were then prioritized and addressed by 43 concrete actions (DAFF, 2004). The broad interpretation of Australia's priority system was provided in chapter 2.3. and is an excellent example for successful NPOA implementation, and could equally be used in Canada's NPOA (DAFF, 2004).

Although a SAR has not been developed for Canada, based on grey and peer-reviewed literature, as well as the analysis of this research, the first 15 identified issues (See Annex 2) in Australia's 2004 NPOA should be considered as possible key issues for Canada when revising the NPOA. However, this does not imply a Canadian SAR is not needed. It is still recommended that Canada identify a list of shark conservation and management issues in consultation with all stakeholders, using the results of the SAR, and identify responsible agencies for implementation. These issues should then be prioritized to reflect the current state of knowledge on shark populations, national and international

species listings, levels of uncertainty in data collection and life history, economic importance of the species, and take into account Canada's capacity to address these issues at the regional and national level (Lack et al., 2009). However, until a SAR is completed, the first 15 identified issues in Australia's NPOA could be considered relevant issues to be included into a revised NPOA for Canada.

Step 4: Create Actions, Targets, and Timelines to Respond to Issues Identified in the Shark Assessment Report

Similar to Australia, Canada's NPOA should implement specific actions to address all identified issues, and assign these actions a priority level, responsible agency, and a corresponding IPOA objective(s). In order to be effective, actions must be accompanied by associated timelines and targets, to help ensure they are actually used as mechanisms to improve conservation and management of sharks. Although Canada currently lists some actions as content in their NPOA, the existing actions are not clearly motivated, limited in scope and outcomes, and have no timelines or responsible agencies for implementation. Going forward, future actions could include, but are not limited to, the examples provided in chapter three and those listed as key actions towards the end of this chapter (Table 17). For example, complying with IPOA objectives two and four, the development of a fleet communication program, implementation of mandatory safe handling and release practices, and the consideration of conservation areas for vulnerable and endangered shark species could be considered under theme (2) "Improve existing conservation and management measures or (5) "Initiate focused education and awareness programs" (DAFF, 2004). Provided below in Table 15 are examples of the linkages that illustrate a connection between the SAR issues, IPOA objective(s), action(s), designated

priorities, responsible agencies and funding, and could be used as a template when revising the NPOA.

Table 15: Implementation of Actions: Connecting Themes, Issues, Actions, and IPOA Objectives (Example Only) (DAFF, 2004)

Theme 3		Improve Data Collection and Handling		
Issue 2 (Complies with IPOA Objective iv)	Action	Priority	Responsible Agency	Funding
The need for secure, accessible, and validated data sets that record all catch, including bycatch and discards	Ensure that processes for validation of shark catch data from commercial fisheries and charter operators, using observer monitoring, fishery-independent research programs have been initiated.	1A	DFO- Science DFO- Resource Management	Funding identified immediately
Theme 5		Initiate Focused Education/Awareness Raising Programs		
Issue 10 (Complies with IPOA Objectives ii)	Action	Priority	Responsible Agency	Funding
The need for an assessment of shark handling practices for the conservation and management of sharks in commercial and recreational fisheries	Develop a safe handling and release practice for sharks	1A	-NGOs -DFO Resource Management	Funding identified immediately
Theme 6		Improve Coordination and Consultation		
Issue 7 (Complies with IPOA Objectives i and ii)	Action	Priority	Responsible Agency	Funding
The need for assessment of the adequacy of management for all shark species and more innovative approaches to dealing with identified shark management issues	Within six months of the adoption of the revised NPOA, establish a collaborative shark research program between DFO, Industry, NGOs, and Academia	1A	-DFO- Science -DFO- Resource Management -Academic/ University -Industry -NGOs	Funding identified immediately

Step 5: Identify and Build Capacity to Implement Actions

It is essential that Canada review its available resources to determine if the NPOA plan and its stated actions are feasible. Understanding the timeframe in which a management response to actions can realistically be implemented is crucial to the success of the NPOA (Lack et al., 2009). If capacity and resources are limited or unavailable, then strategies should be developed to identify additional sources of assistance or income, build capacity through workshops, conferences, and training seminars, or modify the action(s) to a level that is in fact feasible (Lack et al., 2009).

Step 6: Review the NPOA Every Four Years

Canada should include a specified time frame for reviewing the NPOA against its stated objectives. Best practices would suggest that the plan also include a set of performance indicators against which the effectiveness of the plan can be evaluated every fourth year (DAFF, 2004). See Table 16 below for an example. In addition, Figure 2 depicts the summary process and order of developing, implementing, and reviewing the NPOA.

Table 16: Example of Performance Indicators Used to Assess the NPOA's Effectiveness

IPOA Objective	Performance Indicator
i. ensure that shark catches from target and non-target fisheries are sustainable	-by 2014, require that any shark species taken in two or more fisheries within a jurisdiction or more jurisdictions have a multi-jurisdictional management plan.
vi. contribute to the protection of biodiversity and ecosystem structure and function	-by 2013, ensure that a shark research program is developed and implemented to study the loss of large pelagic sharks and its effects on the ecosystem.
vii. minimize waste and discards from shark catches	-by 2014, require that Canadian longline fisheries have reduced their shark bycatch by 30%.

Table 17: Recommended Content for a NPOA-sharks in Canada

Data Collection and Scientific Research (IPOA Objectives 1, 2, 3, 6, 9, 10)
1. Improve data collection and scientific research for sensitive species for catches, effort, and landings.
2. Quantify bycatch of all elasmobranch species, estimate post-release mortality, and incorporate these results into a true stock assessment.
3. Develop stock assessments for all elasmobranchs where they do not exist, and truly introduce the precautionary management approach in the absence of such assessments through bycatch and discard restrictions with associated penalties or rewards for behavior change.
4. Engage recreational fishermen for on-the-water data collection.
5. Implement effective mechanisms to obtain reliable catch information from observers, fishermen, and independent surveys.
6. Identify critical habitat of chondrichthyan species, identify threats to these habitats, and introduce appropriate management measures to reduce these threats.
7. Develop a list of priority species based on quantity taken in all fisheries (directed, bycatch +discards), the socio-economic importance, international and national species listings, and data deficiency.
8. Research economic incentives that foster efforts towards improving species ID, mitigating bycatch and discards, building capacity and coordination, and other measures that advance shark conservation and management.
Management and Conservation Measures (IPOA Objectives 1, 3, 4, 5, 6, 7,)
1. Review and assess the impact of recreational fishing on the sustainability of shark species.
2. Where a species is taken in two or more fisheries within a jurisdiction or in two or more jurisdictions: ensure that processes are in place to collect data in all fisheries and regions that interact with the species, that multi-jurisdictional management approaches are considered and introduced where needed, and effective communication among all stakeholders is present.
3. Control fishing mortality through: limiting fishing effort or target catch, inducing biological controls (e.g. size limit), technical solutions (e.g. gear modification), and closure of fisheries with high bycatch, until fisheries can demonstrate to have minimal incidental catch and discarding.
4. Identify species and/or stock in need of priority attention and introduce management measures to mitigate species decline (e.g. legal protection, closed or restricted areas).
5. For data deficient species (e.g. black dogfish, greenland shark, skates), reversing the burden of proof should be applied until data can be collected, taking full advantage of the precautionary approach).
Education and Awareness (IPOA Objectives 4,6,9,10)
1. Develop a communication and education strategy aimed to inform the public, commercial, recreational, game fisher, and indigenous sector on the importance of sharks, their existence in Canada, current threats facing sharks, and what management measures are in place for shark conservation and management.
2. The development of identification guides to improve species identification for all fishermen and fisheries observers.
3. The development of training resources to address: best practices for catch and release for all fisheries.
4. Improve information sharing between fisheries and regions on: bycatch hotspots, mitigation measures, and species composition.
Coordination and Consultation (IPOA Objectives 4)
1. Develop effective communication and consultation mechanisms among all stakeholders (i.e. workshops, forums, seminars).
2. Improve regional management of sharks through ongoing stakeholder workshops.
3. Ensure key stakeholders are knowledgeable on the issues and threats surrounding sharks, so that a step-by-step regional approach is feasible.

5.2. Developing a Preliminary RPOA: Atlantic Canada/Eastern Arctic

To date, no regional shark conservation plan exists in Canada or the Eastern Arctic. Instead commercially significant species such as spiny dogfish, porbeagle, blue and shortfin mako sharks are managed under different fisheries management plans, policies, or other types of measures (DFO, 2007c). Other species, such as greenland shark and arctic skate, two species known to have multi-jurisdictional movements, are not managed at all (personal observation). When collecting information for this research, it was evident that the agencies responsible for shark conservation and management are not consistently communicating across their respective regions and divisions of fisheries management and species conservation. Although skates and large sharks are often caught as bycatch in the same fisheries (Gavaris et al., 2010), and are considered vulnerable to overfishing, they are managed under separate plans. Many of these integrated fisheries management plans (IFMPs) are outdated and do not include the ecosystem-based approach to fisheries management. In addition, most of the information on shark management had to be collected through personal interviews, and was not publicly available on the DFO website, or elsewhere.

As indicated by Gavaris et al. (2010), several potential priority management issues have been identified for the Atlantic and Eastern Arctic Region, with respect to sharks caught in the swordfish/tuna, groundfish, and scallop fisheries. These fisheries maintain high bycatch rates of specific elasmobranch species, catch species with similar life history characteristics, and catch more than one species of shark, skate, or ray (Gavaris et al., 2010). Therefore, it appears logical to develop a regional plan under which all species can be included and managed appropriately.

Developing a RPOA-*sharks* for a specific region, such as Atlantic Canada, the Pacific or the Arctic, requires similar steps and actions to be taken as the national plan. In order, these steps include: consulting stakeholders, conducting a regional shark assessment report (RSAR), developing a set of objectives, identifying issues from results of the RSAR, implementing actions with firm timelines and responsible agencies, building research and management capacity, and monitoring the plan every few years for its effectiveness. Similar to the IPOA and NPOA, an RPOA should define “shark” to include all sharks, skates, and rays, include commercial and recreational fisheries, and define “catch” to include all non-target, target, discard, and by-catch (FAO, 1999). Within a regional plan, all ten IPOA objectives may not need to be addressed, 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 RSAR can allow fishery managers to more effectively assess progress and outstanding issues for all sharks.

In addition, based on the results from the ACSF, there is a lack of communication between government, industry, and other primary stakeholders, most information is not updated and consistently available on the DFO website, and capacity and funding to improve shark conservation and management within the region is limited (WWF, 2011). As a result, one of the many recommendations from the forum was to use the cross-cutting priorities (Table 12, Ch. 4) as a basis to form the content of a regional plan of action (Table 18), congruent to the development of a more defined NPOA (WWF, 2011). In effect this does provide the first step of the development of a Regional Plan: as stakeholders have been engaged and asked to identify top-priorities; now, additional steps

include developing a set of actions, targets and timelines; assign a priority level to issues and actions, and include a set of performance indicators to assess the effectiveness of the plan.

Table 18: Recommended Content for a RPOA-sharks in Atlantic Canada/Eastern Arctic

Data Collection and Scientific Research (IPOA Objectives 1, 2, 3, 6, 9, 10)
1. Conduct a preliminary basking shark bi-lateral stock assessment, to help understand the implications for future management actions for Canada and the USA.
2. Understand the impacts of incidental catch of greenland sharks in gillnet fisheries.
3. Collect biological data for greenland sharks including age at maturity, reproduction, longevity, and stock structure for the Northwest Atlantic.
4. Improve data collection and scientific research for sensitive species through: catches, effort, and landings (e.g. deep-sea catshark and portuguese shark, skates)
5. Research required for the seasonal abundance, distribution, life history, population structure of greenland shark and black dogfish.
6. Identify critical habitat of chondrichthyan species, identify threats to these habitats, and introduce appropriate management measures to reduce these threats.
7. Develop a list of priority species based on quantity taken in all fisheries (directed, bycatch and discards), the socio-economic importance, international and national species listings, and data deficiency.
8. Quantify bycatch of all elasmobranch species, estimate post-release mortality, and incorporate these results into a true stock assessment.
Management and Conservation Measures (IPOA Objectives 1, 3, 4, 5, 6, 7,)
1. Review and assess the impact of recreational fishing on the sustainability of shark species.
2. Where a species is taken in two or more fisheries within a jurisdictions or in two or more jurisdictions: ensure that processes are in place to collect data in all fisheries and regions that interact with the species, that multi-jurisdictional management approaches are considered and introduced where needed, and effective communication among all stakeholders is present.
3. Control fishing mortality through: limiting fishing effort or target catch, inducing biological controls (e.g. size limit), technical solutions (e.g. gear modification), and closure of fisheries with high bycatch, until fisheries can demonstrate to have minimal incidental catch and discarding.
4. Identify species and/or stock in need of priority attention and introduce management measures to mitigate species decline (e.g. legal protection, closed or restricted areas).
5. For data deficient species (e.g. black dogfish, greenland shark, skates), reversing the burden of proof should be applied until data can be collected, taking full advantage of the precautionary approach).
Education and Awareness (IPOA Objectives 4,6,9,10)
1. Develop a communication and education strategy aimed at informing the public; commercial, recreational, and game fishers; and indigenous sector on the importance of sharks, their existence in Canada, current threats facing sharks, and what management measures are in place for shark conservation and management.
2. The development of identification guides to improve species identification for all fishermen and fisheries observers.
3. The development of training resources to address: best practices for catch and release for all fisheries.
4. Improve information sharing between fisheries and regions on: bycatch hotspots, mitigation measures, and species composition.
Coordination and Consultation (IPOA Objectives 4)
1. Develop effective communication and consultation mechanisms among all stakeholders (i.e. workshops, forums, seminars).
2. Improve regional management of sharks through ongoing stakeholder workshops.
3. Ensure key stakeholders are knowledgeable on the issues and threats surrounding sharks, so that a step-by-step regional approach is feasible.

Conclusion

In summary, the development of a national or regional shark plan at a minimum requires the six recommended steps and suggested actions for content. The six steps and provided content address the overlapping recommendations made by the FAO, peer-reviewed and grey literature, and those priorities identified at the ACSF. Based on this research, Canada should be well-equipped to revise their NPOA in 2012, and considering the existing stakeholder input, to develop a regional shark plan for Atlantic Canada and the Eastern Arctic, that incorporates some or all of the recommended actions in (Table 18). Furthermore, there is surprising consistency among the FAO recommendations, and the priorities identified by stakeholders at the ACSF. Both aim to ensure the long-term conservation and management of sharks and there appears to be no disagreement that a national plan is needed to manage sharks, and that from this national plan, a regional plan can and should be created to address region-specific concerns. However, it remains unclear why Canada still has not translated the NPOA into action, developed a SAR, or consulted stakeholders in the NPOA process. It is evident that other countries, such as Australia, have taken more of a lead in developing and implementing an all-inclusive NPOA for sharks, and this could be used as a template when revising the NPOA or creating a RPOA in Canada. If Canada aims to demonstrate its lead in shark management and conservation, major changes are needed to the existing NPOA-*sharks*.

REFERENCES

- AFMA (2000) Australia's commonwealth policy on fisheries bycatch.
<http://www.affa.gov.au/ffid/bycatch/index.html>
- AFMA (2006) Prepared by automatic longline operators of the GHAT Fishery Endorsed by South East Fishermen's Association. http://www.afma.gov.au/wp-content/uploads/2010/07/code_of_practice.pdf
- Anderson RC (2002) Incentive-based policies for environmental management in developing countries. *Resources for the Future*.
<http://www.rff.org/rff/Documents/RFF-IB-02-07.pdf>
- Bagstad KJ, Stapleton K, D'Agostino JR (2007) Taxes, subsidies, and insurance as drivers of United States coastal development. *Ecological Economics* 63: 285-298.
- Baum JK, Myers RA, Kehler DG, Worm B, Harley SJ, Doherty PA (2003) Collapse and conservation of shark populations in the Northwest Atlantic. *Science* 299: 389-392.
- Bellido JM, Santos MB, Pennino MG, Valerias X, Pierce GJ (2011) Fishery discards and bycatch: solutions for an ecosystem approach to fisheries management? *Hydrobiologia* 670: 317-333.
- Benaka LR, Dobrynski TJ (2004) The National Marine Fisheries Service's National Bycatch Strategy. *Marine Fisheries Review* 66: 1-8.
- Benjamins S, Kulka DW, Lawson J (2010) Recent incidental catch of sharks in gillnet fisheries of Newfoundland and Labrador, Canada. *Endang Species Res* 11:133-146.
- Bensley N, Stobutzki I, Woodhams J, Mooney C (2010) Review of wildlife bycatch management in Commonwealth fisheries. BRS report prepared for the Department of Agriculture, Fisheries & Forestry, Fisheries Policy Branch, Canberra, July.

- Bensley N, Woodhams J, Patterson HM, Rodgers M, McLoughlin K, Stobutzki I, Begg GA (2010) 2009 Shark Assessment Report for the Australian National Plan of Action for the Conservation and Management of Sharks. Final Report to the Department of Agriculture, Fisheries and Forestry. Bureau of Rural Sciences, Canberra.
- Berghofer A, Wittmer H, Rauschmayer F (2008) Stakeholder participation in ecosystem-based approaches to fisheries management: A synthesis from European research projects. *Marine Policy* 32: 243-253.
- Bodsworth A, Scandol J (2010) Shark futures: An RD&E framework for sustainable shark fisheries. Fisheries Research and Development Corporation (FRDC) project 2009-008.
- Bodsworth A, Mazur N, Lack M, Knuckey I (2010) Review of Australia's 2004 National Plan of Action for the conservation and management of sharks. Final report to the Australian Government Department of Agriculture, Fisheries and Forestry. Cobalt Marine Resource.
- Bonfil R (1999) Marine protected areas as a shark fisheries management tool. Proceedings of the 5th Indo-Pacific Fish Conference, Noumea.
- Camhi MD, Valenti SV, Fordham SV, Fowler SL, Gibson C (2009) The conservation status of pelagic sharks and rays: Report of the IUCN shark specialist group pelagic shark red list workshop. IUCN Species Survival Commission Shark Specialist Group. Newbury, UK.
- Campana S E, Joyce W, Fowler M (2010) Subtropical pupping ground for a cold-water shark. *Can. J. Fish. Aquat. Sci.* 67:769-773.
- Campana S E, Gibson A J F, Fowler M, Dorey A, Joyce W (2010) Population dynamics of porbeagle in the northwest Atlantic, with an assessment of status to 2009 and projections for recovery. *Collect. Vol. Sci. Pap. ICCAT*, 65(6): 2109-2182.
- Campana S E, Joyce W, Manning M J (2009) Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags. *Mar. Ecol. Prog. Ser.* 387:241-253.

- Campana SE, Gibson J, Brazner J, Marks L, Joyce W, Gosselin JF, Kenney RD, Shelton P, Simpson M, Lawson J (2008) Status of basking sharks in Atlantic Canada. CSAS Res. Doc. 2008/004. 67 p
- Campbell LM, Cornwell ML (2008) Human dimensions of bycatch reduction technology: current assumptions and directions for future research. *Endang Species Res* 5: 325-334.
- Carrier CJ, Musick JA, Heithaus MR (2010) Sharks and their relatives II, biodiversity, adaptive physiology, and conservation. Boca Raton: CRC Press.
- Carruthers EH, Neis, B (2011) Bycatch mitigation in context: using qualitative interview data to improve assessment and mitigation in data-rich fishery. *Biol. Conserv.*
- Catchpole TL, Gray TS (2010) Reducing discards of fish at sea: a review of European pilot projects. *Journal of Environmental Management* 91: 717-723.
- Chang E (2009) Policies to enhance long-term sustainability of marine fisheries. University of California, 2009 STEP White Paper Competition.
- Cooke SJ, Suski CD (2005) Do we need species-specific guidelines for catch-and-release recreational angling to effectively conserve diverse fishery resources? *Biodiversity and Conservation* 14:1195-1209.
- Convention on Biological Diversity (CBD) (2007) Article 8. In-situ conservation. Retrieved from <http://www.cbd.int/convention/articles/?a=cbd-08>
- COSEWIC (2009) Wildlife species search. http://www.cosewic.gc.ca/eng/sct1/SearchResult_e.cfm?commonName=skate&scienceName=&Submit=Submit
- DAFF (2001) Australian shark assessment report for the National Plan of Action for the Conservation and Management of sharks. Commonwealth of Australia, Canberra.
- DAFF (2004) Australia's National Plan of Action for the Conservation and Management of Sharks (*Shark-plan*). DAFF, Canberra.

- DAFF (2011) Australia's 2011 National Plan of Action for the Conservation and Management of Sharks: Shark-plan 2. DAFF, Canberra.
- DFO (2002) Coral conservation measures in the Maritimes. <http://www.mar.dfo-mpo.gc.ca/e0010585>
- DFO (2003) DFO conservation and science measures. <http://www.dfo-mpo.gc.ca/media/back-fiche/2003/cod-4-eng.htm>
- DFO (2006) Canadian Atlantic swordfish and other tuna: 2004-2006. <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/swordfish-espardon/swordfish-2004-espardon-eng.htm>
- DFO (2007a) Canada's national plan of action for the conservation and management of sharks. Accessed 12, May. <http://www.dfo-mpo.gc.ca/npoa-pan/npoa-pan/npoa-sharks-eng.htm>
- DFO (2007b) Integrated fisheries management plan Atlantic mackerel. <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/mackerel-atl-maquereau/mac-atl-maq-2007-eng.pdf>
- DFO (2007c) Canadian Atlantic Pelagic Shark Integrated Fisheries Management Plan. http://www.dfo-mpo.gc.ca/communic/fish_man/ifmp/shark-requin/index_e.htm
- DFO (2010) Sustainable Management of Canadian Swordfish Fishery. <http://www.dfo-mpo.gc.ca/international/swordfish-espardon/swordfish-mgt-gestion-espardon-eng.htm>
- DFO (2011) Canadian Atlantic swordfish and other tunas. Draft IFMP, *unpublished information*.
- Diamond SL (2004) Bycatch quotas in the Gulf of Mexico shrimp trawl fishery: can they work? *Reviews in Fish Biology and Fisheries* 14: 207-237.
- Dulvy NK (2003) *Dipturus laevis*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org

- Dulvy NK, Baum JK, Clarke S, Compagno LJV, Cortes E, Domingo A, Fordham S, Fowler S, Francis MP, Gibson C, Martinez J...et al. (2008) You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays. *Aquatic Conserv: Mar. Freshw. Ecosyst* 18: 459-482.
- FAO (1995) FAO code of conduct for responsible fisheries.
<http://www.fao.org/docrep/005/v9878e/v9878e00.HTM>
- FAO (1997a) A study of the options for utilization of bycatch and discards from marine capture fisheries. FAO Fisheries Department No.928.
<http://www.fao.org/docrep/W6602E/w6602E00.htm>
- FAO (1997b) Bycatch management and the economics of discarding. FAO Fisheries Technical Paper 370. FAO, Rome: 1-153.
- FAO (1999) International plan of action for the conservation and management of sharks (IPOA). Accessed 12, May. <ftp://ftp.fao.org/docrep/fao/006/x3170e/X3170E00.pdf>
- FAO (2000) Fisheries management. 1. Conservation and management of sharks. FAO Technical Guidelines for Responsible Fishing. No. 4, Suppl.1. FAO, Rome.
- FAO (2001) FAO major fishing areas: Northwest Atlantic.
<http://www.fao.org/fishery/area/Area21/en>
- FAO (2009) Report of the Technical Workshop on the Status, Limitations and Opportunities for Improving the Monitoring of Shark Fisheries and Trade. Rome, 3–6 November 2008. FAO Fisheries and Aquaculture Report. No. 897. Rome, FAO. 152p.
- FAO (2010) Report of the technical consultation to develop international guidelines on bycatch management and reduction of discards. FAO Fisheries and Aquaculture Report No. 957. FAO, Rome: 32pp.
- Ferretti F, Worm B, Britten G L, Heithaus M R, Lotze, H K (2010) Patterns and ecosystem consequences of shark declines in the ocean. *Ecology Letters* 13(8): 1055-1071.

- Finkelstein, Bakker V, Doak DF, Sullivan B, Lewison R, Satterthwaite WH, McIntyre, PB, Wolf S, Priddel D, Arnold JM, Henry RW, Sievert P, Croxall J (2008) Evaluating the potential effectiveness of compensatory mitigation strategies for marine bycatch. *Plos One* 3: 1-11.
- Fowler G M, Campana S E (2009) Commercial by-catch rates of shortfin mako (*Isurus oxyrinchus*) from longline fisheries in the Canadian Atlantic. *Collect. Vol. Sci. Pap. ICCAT* 64:1650-1667.
- Gavaris S, Clark KJ, Hanke AR, Purchase CF, Gale J (2010) Overview of discards from Canadian commercial fisheries in NAFO divisions 4V, 4W, 4X, 5Y, and 5Z for 2002-2006. *Can. Tech. Rep. Fish. Aquat. Sci.* 2873: vi + 112p.
- Gilman EL, Dalzell P, Martin S (2006) Fleet communication to abate fisheries bycatch. *Marine Policy* 30:360-366.
- Gilman E, Lundin C (2008) Minimizing bycatch of sensitive species groups in marine capture fisheries: lessons from commercial tuna fisheries. *Handbook of Marine Fisheries Conservation and Management*. Oxford University Press.
- Godin AC (2009) Strengthening shark conservation in Canada: A management blueprint. (Unpublished masters thesis). Dalhousie University, Halifax, NS.
- Godin AC, Worm B (2010) Keeping the lead: How to strengthen shark conservation and management in Canada. *Marine Policy* 34: 995-1001.
- Grafton QR, Arnason R, Bjorndal T, Campbell D, Campbell HF, Clark, CW, Connor R, Dupont DP, Hannesson R, Hilborn R, Kirkley JE, Kompas T, Lane DE, Gordon RM, Pascoe S, Squires D, Steinshamn SI, Turriss BR, Weninger Q (2006) Incentive-based approaches to sustainable fisheries. *Can. J. Fish. Aquat. Sci.* 63: 699–710.
- Harvey-Clark CJ, Gallant JJ, Batt JH (2005) Vision and its relationship to novel behavior in St. Lawrence River Greenland sharks *Somniosus microcephalus*. *The Canadian Field-Naturalist* 119: 355-358.

- Herrera D, Schnier KE (2005) Stochastic bycatch, informational asymmetry, and discarding. *J. Environ. Econ. Manage* 49: 463-483.
- Holland DS (2010) Markets, pooling and insurance for managing bycatch in fisheries. *Ecological Economics* 70:121-133.
- Hoolihan J P, Luo J, Abascal F J, Campana S E, De Metrio G, Dewar, H, Domeier M L, et al. (2011) Evaluating post-release behaviour modification in large pelagic fish deployed with pop-up satellite archival tags. *ICES Journal of Marine Science* 68(5): 880-889.
- Huang Hsiang-Wen (2011) Bycatch of high sea longline fisheries and measures taken by Taiwan: actions and challenges. *Marine Policy* 35: 712-720.
- Hutton T, Thebaud O, Fulton B, Pascoe S, Innes J, Kulmala S, Tudman M (2010) Use of economic incentives to manage fisheries bycatch: An application to key sectors in Australia's southern and eastern scalefish and shark fisheries. CSIRO Marine and Atmospheric Research Final Report.
- ICCAT (2010) Executive summary sharks.
http://www.iccat.es/Documents/SCRS/ExecSum/SHK_EN.pdf
- IUCN (2001) IUCN red list categories and criteria version 3.1.
<http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria#categories>
- Jensen CF, Natanson LJ, Campana SE (2002) The reproductive biology of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. *Fish.Bull.* 100: 727-738.
- Johnson TR, Van Densen WLT (2007) Benefits and organization of cooperative research for fisheries management. *ICES Journal of Marine Science* 64: 834-840.

- Kahn JR (2004) Economic incentives, direct controls and ecosystem management of fisheries: out with the old and in with the new. Environmental Studies Program. www-heb.pac.dfo-mpo.gc.ca/.../2004/Comm/54KahnEconomic.doc
- Keigwin LD, Sachs JP, Rosenthal Y (2003) A 1600-year history of the Labrador Current off Nova Scotia. *Climate Dynamics* 21: 53-62.
- King JR, McFarlane GA (2010) Movement patterns and growth estimates of big skate (*Raja binoculata*) based on tag-recapture data. *Fisheries Research* 101:50-59.
- Kulka DW, Sulikowski J, Gedamke T (2004) *Leucoraja ocellata*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org
- Kulka DW (2006) Abundance and distribution of demersal sharks on the Grand Banks with particular reference to the NAFO Regulatory Area. Northwest Atlantic Fishery Organisation SCR Doc 06/20
- Lack M, Sant G (2011) The future of sharks: A review of action and inaction. TRAFFIC International and the PEW Environment Group
- Lack M, Sant G (2006) Confronting shark conservation head on! TRAFFIC International. Accessed 16, Feb. <http://www.traffic.org/fish/>
- Lack M, Meere F (2009) Pacific Islands regional plan of action for sharks: Guidance for Pacific Islands Countries and Territories on the Conservation and Management of sharks. Accessed 13, May. http://www.ffa.int/system/files/Pacific%20Islands%20RPOA%20Sharks%20Final%20Report%20__3_.pdf
- Lewis RL, Soykan CU, Franklin J (2009) Mapping the bycatch seascape: multispecies and multi-scale spatial patterns of fisheries bycatch. *Ecological Applications* 19: 920-930
- McPhie R P, Campana S E (2009) Reproductive characteristics and population decline of four species of skate (*Rajidae*) off the eastern coast of Canada. *J. Fish Biol.* 75:223-246.

- Moore JE, Wallace BP, Lewison RL, Zydalis R, Cox TM, Crowder LB (2009) A review of marine mammal, sea turtle and seabird bycatch in the USA fisheries and the role of policy in shaping management. *Marine Policy* 33:435-451
- NAFO (2011) NAFO fishery. <http://www.nafo.int/fisheries/frames/fishery.html>
- NMFS (1998) Managing the nation's bycatch: priorities, programs and actions for the National Marine Fisheries Service, NOAA. U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv., Silver Spring, Md., 192 p. NOAA (1998)
<http://www.seagrantfish.lsu.edu/pdfs/brds/bycatchplan.pdf>
- NMFS (2004) Evaluating bycatch: a national approach to standardized bycatch monitoring programs. U.S. Dep. Commer. NOAA, Natl. Mar. Fish. Serv., Silver Spring, Md., 108 p.
- NOAA (2011a) Sea turtle interactions: Leatherback and loggerhead in the Hawaii-based shallow-set longline fishery.
http://www.fpir.noaa.gov/SFD/SFD_turtleint.html
- NOAA (2011b) Best fishing practices for safe handling: Common thresher (*Alopias vulpinus*). http://www.pier.org/flyers/BREP_thresher_brochure.pdf
- NOAA (2011c) National cooperative research program.
<http://www.st.nmfs.noaa.gov/st4/NationalCooperativeResearchCoordination.html>
- Palmer MC, Wigley SE, Hoey JJ, Palmer JE (2007) An evaluation of the northeast region's study fleet pilot program and electronic logbook system: Phase I and II. NOAA Technical Memorandum NMFS-NE-204. Woods Hole, MA.
- Pascoe S, Wilcox C, Dowling N, Taranto T (2010) Can incentive-based spatial management work in the Eastern tuna and billfish fishery? 54th Annual AARES National Conference Adelaide, South Australia, February 10-12, 2010.

- Pauly D, Christensen V, Guenette S, Pitcher TJ, Sumaila UR, Walters CJ, Watson R, Zeller D (2002) Towards sustainability in world fisheries. *Nature* 418: 689-695.
- Punt AE, Smith DC, Tuck GN, Methot RD (2006) Including discard data in fisheries stock assessments: Two case studies from south-eastern Australia. *Fisheries Research* 79:239-250.
- SAG, Lack M (2004) National plan of action for the conservation and management of sharks. <http://www.fao.org/fishery/ipoa-sharks/npoa/en>
- Salomon AK, Gaichas S, Jensen O, Agostini VN, Sloan NA, Rice J, McClanahan T, Fujita R, Ruckelshaus M, Levin P, Dulvy NK, Babcock EA (2009) Bridging the divide between fisheries and marine conservation science. Manuscript from the: Invited Report from the 2009 International Marine Conservation Congress (IMCC) p.1-46.
- Sanchirico JN (2003) Managing marine capture fisheries with incentive based price instruments. *Public Finance and Management* 3: 67-93.
- Skomal GB (2007) Evaluating the physiological and physical consequences of capture on post-release survivorship in large pelagic fishes. *Fish Manag Ecol* 14:81-89.
- Techera EJ and Klein N (2011) Fragmented governance: reconciling legal strategies for shark conservation and management. *Marine Policy* 35: 73-78.
- UNCLOS (1982) United Nations Convention on the Law of the Sea of 10 December 1982. http://www.un.org/Depts/los/convention_agreements/texts/unclos/UNCLOS-TOC.htm
- Wiber M, Charles A, Kearny J, Berkes F (2009) Enhancing community empowerment through participatory fisheries research. *Marine Policy* 33: 172-179.
- Worm B, Hilborn R, Baum JK, Branch TA, Collie JS, Costello C, Fogarty MJ, Fulton EA, Hutchings JA, Jennings S, Jensen OP, Lotze HK, Mace PM, McClanahan TR, Minto C, Palumbi SR, Parma AM, Ricard D, Rosenberg AA, Watson R, Zeller D

(2009) Rebuilding global fisheries. *Science* 325:578-585.

WWF (2011) Top priorities for future conservation and management for sharks in Atlantic Canada: Results from the Atlantic Shark Forum April 1st. Halifax, NS.

APPENDIX 1: SHARK DISCARDS FROM CANADIAN COMMERCIAL FISHERIES

Fisheries and Descriptions of Commercial Fisheries in Atlantic Canada

Fisheries	Description	Fisheries	Description
<i>Groundfish</i>		<i>Large Pelagic</i>	
GRO-OTB	Groundfish bottom trawl	SHX-LL	Shark longline
GRO-OTB-OF	Groundfish bottom trawl offshore	SWO-LL	Swordfish/other tuna longline
GRO-OTM-OF	Groundfish midwater trawl offshore	TUN-LL	Bluefin tuna longline
GRO-LLS	Groundfish longline	BFT-LHP	Bluefin tuna tended line
GRO-GNS	Groundfish gillnet	BFT-LTL	Bluefin tuna angling
YEL-OTB	Yellowtail flounder bottom trawl	<i>Multi-license</i>	
HKS-OTB	Silver hake bottom trawl	M-GS	Groundfish/Swordfish
SKW-OTB	Winter skate bottom trawl	M-ST2	Swordfish/other tuna mix2
RED-OTB	Redfish bottom trawl	<i>Invertebrate</i>	
RED-OTB-OF	Redfish bottom trawl offshore	SCA-DR	Scallop dredge
SCU-OTB	Sculpin bottom trawl	SCA-DR-OF	Scallop dredge offshore
<i>Small Pelagic</i>		LBA-FPO-OF	Lobster/Jonah trap offshore
HM-OTM	Herring/Mackerel midwater trawl	CRQ-FPO	Snow crab trap
HER-OTM	Herring midwater trawl	PAN-OTS	Shrimp bottom trawl
HER-PS	Herring purse seine	CUK-DR	Sea cucumber dredge
*Information taken from Gavaris et al. 2010			

Skate Discards Across All NAFO Areas (2002-2006)

All NAFO Areas: 4vw, 4x5y, 5z	GRO-OTB	GRO-GNS	GRO-LLS	GRO-OTB-OF	SCA-DR-OF	M-GS	YEL-OTB	CRO-FF0	HKS-OTB	RED-OTB and OF	SKW-OTB	SCU-OTB	CUK-DR	GRO-OTM-OF	SHX-LL	LBA-FPO-OF	PAN-OTS
Species																	
4VW																	
Barndoor			X						X	X	X				X		
Spinytail			X														
Thorny	X		X	X				X	X	X	X			X	X		X
Winter	X		X	X				X	X		X			X	X		
Smooth									X	X	X						
Other	X		X	X					X	X							
4x5y																	
Barndoor	X	X	X	X	X				X	X	X						
Spinytail	X				X												
Thorny	X		X	X	X			X	X	X	X	X					
Winter	X		X	X	X				X	X	X	X					
Smooth	X		X	X	X				X	X			X			X	
Other	X	X	X	X	X				X	X		X					
5z																	
Barndoor	X	X	X	X	X		X										
Spinytail	X				X												
Thorny	X		X	X	X	X	X										
Winter	X		X	X	X	X	X										
Smooth	X		X	X	X		X										
Other	X		X	X	X		X										

*Across all three sectors, skates are commonly caught in: groundfish bottom trawl, groundfish longline, groundfish bottom trawl, scallop offshore dredge, silver hake bottom trawl, redfish bottom and offshore trawl, and winter skate bottom trawl (this fishery is no longer active)
 *Rays are only known to be caught in the swordfish and tuna longline fisheries (no separate table needed)
 Gavaris et al. 2010

Dogfish Discards Across All NAFO Regions (2002-2006)

All Areas: 4VW; 4X5Y; 5Z	HER-PS	GRO-OTB	GRO-OTB- OF	HM-OTM	RED-OTB	RED-OTB- OF	SKW-OTB	SHX-LL	TUN-LL	SWO-LL	GRO-LLS	HKS-OTB	GRO-GNS	LBA-FPO-OF	SCA-DR and OF	M-GS	YEL-OTB
Species: Dogfish																	
4vw																	
Dogfish	X	X	X	X	X	X	X	X			X	X					
Other dogfish			X		X	X					X						
4x5y																	
Dogfish	X	X	X		X		X	X			X	X	X	X	X		
Other dogfish																	
5z																	
Dogfish		X	X								X		X	X	X	X	X
Other dogfish		X	X								X						X
*Dogfish commonly caught among all three areas: groundfish bottom trawl; groundfish offshore bottom trawl; groundfish longline																	
Information taken from Gavaris et al. 2010																	

Shark Discards Across All NAFO Regions (2002-2006)

All NAFO Areas	GRO-LLS	HKS-OTB	GRO-OTB	HER-OTM	M-ST5	HM-OTM	BFT-LHP	SHX-LL	TUN-LL	SWO-LL	GRO-GNS	HER-PS	BFT-LTL	GRO-OTB-OF	RED-OTB	RED-OTB-OF	YEL-OTB
Species																	
4VW																	
Blue	X				X			X	X	X							
Basking	X	X															
Porbeagle					X	X		X	X	X							
Shortfin Mako					X				X	X							
Other Sharks		X	X						X	X							
4x5y																	
Blue	X						X	X	X	X		X	X				
Basking		X													X	X	
Porbeagle	X		X					X	X	X	X	X		X			
Shortfin Mako							X		X	X	X	X		X			
Other Sharks									X	X		X					
5z																	
Blue	X			X						X			X				
Basking	X													X			
Porbeagle	X		X							X							
Shortfin Mako	X		X							X				X			X
Other Sharks	X									X				X			
*Across all areas, sharks are caught in: groundfish longline; tuna longline, swordfish longline; groundfish offshore bottom trawl Information taken from Gavaris et al. 2010																	

Priority Shark Management Areas by Region

Priority Management Measures By Region, Fishery, and Species		
<i>Region</i>	<i>Fishery/Gear</i>	<i>Species</i>
4VW	Swordfish/Tuna Longline	Blue, Porbeagle, and Shortfin Mako
4VW	Groundfish Longline and Trawl and Silver Hake Bottom Trawl	Skates (all listed skates) and Spiny Dogfish
4VW	Silver Hake Bottom Trawl	Basking Shark
4X5Y	Scallop Dredge Fishery	Skates (all listed skates, except spinytail)
4X5Y	Swordfish/Tuna Longline	Blue, Porbeagle, and Shortfin Mako
4X5Y	Groundfish Longline and Trawl	Skates, Spiny Dogfish, Porbeagle, and Shortfin Mako
5Z	Scallop Dredge Fishery	All Skates
5Z	Groundfish Longline and Trawl	All Skates
5Z	Swordfish and Tuna Longline	Blue Shark
5Z	Groundfish Longline	Basking Shark
*Information taken from Gavaris et al. 2010		

APPENDIX 2: AUSTRALIA'S NPOA-18 ISSUES DEFINED IN SHARK PLAN 1

Australia's NPOA: 18 Issues Addressed in Shark-plan 1 and 2	Complies with IPOA Objective
1. The need to improve identification of shark species by all resource users	9, 10
2. The need for secure, accessible and validated data sets that record all catch and are consistent over time with compatible resolution between jurisdictions over the full range of each species from all resource users	9
3. The need for full utilization of dead sharks and an improved understanding of markets for and trade in shark products	7,8,10
4. The need for coordination of shark research	4,7
5. The need for continued effort to maintain and improve the standard of stock assessments for target shark species in dedicated shark fisheries	1
6. The need for reliable estimates for bycatch and byproduct shark species	1,2
7. The need for assessment of the adequacy of management for all shark species and more innovative approaches to dealing with identified shark management issues	1,2
8. The need for improved understanding of the impact of an, where required, implementation of better management for recreational fishing	4
9. The need to reduce cryptic fishing mortality of species	5,7
10. The need for an assessment of shark handling practices for the conservation and management of sharks	2
11. The need for better understanding and, where necessary, recognition in management arrangements, of shark fishing by Indigenous people	4
12. The need for risk assessments for all shark species from all impacts on those species	2,3,4
13. Where necessary, develop strategies for the recovery of shark species and populations	3
14. The need to reduce or, where necessary, eliminate shark bycatch	5, 7
15. The need for a better understanding of the effects of shark fishing, control programs for bather protection and management practices on ecosystem structure and function	6
16. The need to reduce the impact of environmental degradation on sharks	6
17. The need for more information on the impact on sharks of sound waves in the marine environment	2,6
18. The need for more information on the impact on sharks of electromagnetic fields	2, 6
* Issues 1-15 are similar to those found in Canada, and should be addressed in a revised NPOA. DAFF, 2004	