ELUCIDATING THE ROLE OF SCIENTIFIC INFORMATION IN DECISION-MAKING FOR FISHERIES MANAGEMENT

by

Suzuette S. Soomai

Submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

at

Dalhousie University
Halifax, Nova Scotia
October 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

While protocols may exist within governmental organizations for the production of scientific advice, the information pathways, i.e., how it is produced, communicated, and used in policy contexts, are not fully understood. The research addressed this knowledge gap by asking: What role(s) does fisheries scientific information fulfill in policy- and decision-making for fisheries management? Questions were asked in the context of fisheries science and management, information management, and public policy within case studies of three inter-related organizations with different jurisdictional and geographic scales of governance: Canada Department of Fisheries and Oceans (DFO), Northwest Atlantic Fisheries Organization (NAFO), and the Food and Agriculture Organization of the United Nations (FAO).

Through three internships, research was conducted using qualitative methods and included interviews of 78 key actors, e.g., scientists and managers, direct observations of 15 science and management meetings, and content analysis of scientific reports and publications. The textual data were analyzed based on coding of themes related to theoretical perspectives of the science-policy interface and information use in policy contexts.

The leading drivers in the information pathways in the organizations include: the demand for scientific advice; policy development and organizational collaboration and networking; and trade aspects. The common enablers to information flow include the attributes of information and organizational structures that facilitate iterative communication – reinforced by trust relationships and respect – among actors. The barriers include dispersed organizational structures, inadequate communication processes, austerity measures, political and trade aspects related to the fishing industry; and scientific uncertainty associated with ecosystem approaches to fisheries management (EAF).

A well-defined process for producing scientific and management advice – in DFO and NAFO – ensures transparency and creates credible, relevant, and legitimate information for operational decision-making. FAO functions as a boundary organization to bridge science and policy-making communities in its member countries. Trade-offs in the attributes of information facilitate information flow at the interface to meet the organizations' objectives. Non-governmental organizations, the fishing industry, and civil society are increasingly important actors in the information pathways. EAF requires collaborative models of decision-making and information use. A new model of information use in operational decision-making by governmental organizations for fisheries management is presented.

LIST OF ABBREVIATIONS USED

ACCASP	Aquatic Climate Change Adaptation Services Program
ACZISC	Atlantic Coastal Zone Information Steering Committee
ABNJ	Areas beyond national jurisdiction
ADG	Assistant Director General (FAO)
ASFA	Aquatic Sciences and Fisheries Abstracts
BGI	FAO global initiative on blue growth
BIO	Bedford Institute of Oceanography
CAFSAC	Canadian Atlantic Fisheries Scientific Advisory Committee
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CFS	World Committee on Food Security
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLA	Canadian Library Association
COFI	Committee on Fisheries (FAO)
CPRS	Conservation Plan and Rebuilding Strategy
CSAS	Canadian Science Advisory Secretariat
CWP	Coordinating Working Party on Fisheries Statistics
DFO	Canada Department of Fisheries and Oceans
DFO-MR	DFO-Maritime Region
DFO-NCR	DFO-National Capital Region
DFO-NLR	DFO-Newfoundland and Labrador
EAF	Ecosystem approach to fisheries management

EBSA	Ecologically and biologically significant area
EEZ	Exclusive economic zone
ESSSAC	Eastern Scotian Shelf Shrimp Advisory Committee
EU	European Union
FAO	Food and Agriculture Organization
FC	Fisheries Commission (NAFO)
FIGIS	Fisheries Global Information System
FIRMS	Fisheries and Resources Monitoring System
GC	General Council (NAFO)
GEF	Global Environment Facility
GOMC	Gulf of Maine Council on the Marine Environment
HLPE	High Level Panel of Experts on Food Security and Nutrition
IAMSLIC	International Association of Aquatic and Marine Science Libraries and Information Centers
IBSFC	International Baltic Sea Fishery Commission
ICES	International Council on the Exploration of the Seas
ICOM	Integrated coastal and ocean management
ICP	Informal Consultative Process on Oceans and the Law of the Sea
IFMP	Integrated fisheries management plan
ILC	Information life cycle
IPBES	Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported, and unregulated
JNAF	Journal of the Northwest Atlantic Fishery Science

LOMA	Large ocean management area
MPA	Marine protected area
MSC	Marine Stewardship Council
MSY	Maximum sustainable yield
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	North East Atlantic Fisheries Commission
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OSPAR	Commission based on the Oslo and Paris Conventions
RAP	Regional Advisory Process (DFO)
RDG	Regional Director General (DFO)
RFB	Regional fishery body
RFMO	Regional fisheries management organization
RSN	Regional Fishery Body Secretariats Network
SAR	Science Advisory Report (DFO)
SC	Scientific Council (NAFO)
SCR	Scientific Council Report (NAFO)
SOFIA	The state of world fisheries and aquaculture report
STACFEN	Standing Committee on Fisheries Environment (NAFO)
STACFIS	Standing Committee on Fisheries Science (NAFO)
STACPUB	Standing Committee on Publications (NAFO)
STACREC	Standing Committee on Research Coordination (NAFO)
STACTIC	Standing Committee on International Control (NAFO)
TAC	Total allowable catch

UN	United Nations
UNCED	UN Conference on Environment and Development
UNCLOS	UN Convention on the Law of the Sea
UNGA	United Nations General Assembly
UN DESA	UN Department of Economic and Social Affairs
UN DOALOS	UN Division for Ocean Affairs and the Law of the Sea
UNEP	United Nations Environment Programme
US	United States
VME	Vulnerable marine ecosystem
WECAFC	Western Central Atlantic Fisheries Commission
WGEAFFM	Working Group on the Ecosystem Approach Framework to Fisheries Management (NAFO)
WGESA	Working Group on Ecosystem Assessments and Science (NAFO)
WGNARS	Working Group on the North Atlantic Regional Sea (ICES)
WGRBMS	Working Group on Risk-based Management Strategies
WWF	World Wide Fund for Nature (also known as the World Wildlife Fund)

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Professor Bertrum MacDonald (School of Information Management) for his dedicated guidance over the four years of my doctoral studies. The quality of my research was considerably enhanced by his emphasis on the need for clarity in my interdisciplinary research and from his keen attention to detail. I also wish to acknowledge and thank the members of my Supervisory Committee – Dr. Peter Wells (Marine Affairs Program and the International Oceans Institute-Canada), Dr. Boris Worm (Department of Biology), and Dr. Elizabeth De Santo (Franklin and Marshall College, USA) – for their encouragement and for sharing perspectives from their various disciplines.

I am extremely grateful to the Social Sciences and Humanities Research Council of Canada (SSHRC) for awarding me a three-year Joseph-Armand Bombardier Canada Graduate Scholarship and a Michael Smith Foreign Study Supplement. I am also grateful to the Faculty of Graduate Studies, Dalhousie University for additional funding during my studies. My appreciation is also extended to the School of Information Management for providing office accommodation.

I would like to express special thanks to the Canada Department of Fisheries and Oceans (DFO), the Northwest Atlantic Fisheries Organization (NAFO), and the Food and Agriculture Organization of the United Nations (FAO) for hosting my internships which facilitated data collection. Finally, I thank all of the individuals in DFO, NAFO, and FAO who agreed to be interviewed for the research.

CHAPTER 1. INTRODUCTION

1.1. Why There is an Urgent Need for This Research

With the emergence of international voluntary instruments and binding multilateral environmental agreements driven primarily by the United Nations (UN), such as Agenda 21 and the UN Law of the Sea Convention, global attention on the declining health of the oceans has increased, resulting in the production of vast quantities of scientific information (Chasek, Downie, & Brown, 2014; United Nations [UN], 1992). Overfishing has been identified as one of the major threats to marine systems with regard to declining fish populations, altered food webs, and the increasing degradation of marine habitats (e.g., Pauly, Christensen, Dalsgaard, Froese, & Torres, 1998; Worm et al., 2006; Ye et al., 2013). Global marine fisheries statistics indicate overfishing of commercial fish stocks while other man-made activities and the effects of climate change are also impacting fish populations (FAO, 2014u). The apparent social and economic impacts of the declining health of marine fisheries and ecosystems are contributing to increasing poverty and social instability in fishing communities in many countries (HLPE, 2014b; Schwach et al., 2007; World Bank & FAO, 2009).

Governmental, intergovernmental, and non-governmental organizations have produced very large numbers of scientific publications containing advice to address such issues (MacDonald, Cordes, & Wells, 2004; MacDonald, Ross, Soomai, & Wells, 2015). Fisheries information is by nature broad and multidisciplinary, and with a global trend towards the ecosystem approach to fisheries management (EAF) to balance diverse societal objectives with conventional fisheries management, related publications have become even more prolific and more interdisciplinary (Garcia, Zerbi, Aliaume, Do Chi, & Lassere, 2003). The publications include scientific assessments, reviews, and other technical reports on the status of commercial fisheries and ecosystems and are largely produced and published by governmental organizations, not by commercial publishers, and are known as grey literature (GreyNet, 2015; Lawrence, Houghton, Thomas, & Weldon, 2014).

The information contained in fisheries scientific publications is often intended to inform policy decisions about sustainable development, including sustainable use of fisheries resources. It is believed that there is sufficient information on the impacts of human activities, generated in the last forty years – at the least – since the 1972 United Nations Conference on the Human Environment (Stockholm Declaration), to make the decisions to mitigate environmental problems and to reverse the declines in fish populations and catches, biodiversity, and associated livelihoods (e.g., Bundy, Chuenpagdee, Jentoft, & Mahon, 2008; UN, 1972). Syntheses of global fisheries with formal assessments revealed that well-assessed fisheries in developed countries are moving toward sustainability (Costello et al., 2012; Worm et al., 2009). This indicates that scientific information, in some jurisdictions, is assimilated into fisheries management decisions. Researchers also envision fisheries rebuilding, conservation, and sustainable use of marine resources as unifying science, management, and society (Worm et al., 2009). However, a general lack of understanding still exists on how the relevant information from wide-ranging scientific research and synthesis, available in various sources and various formats, is used in decision-making.

Overall, fisheries information is considered to be implicit in policy-making and decision-making processes and it is often not recognised in its own right as playing a critical and unequivocal role in these processes (Soomai, Wells, & MacDonald, 2011). The limited visibility profile of scientific information within policy and decision-making communities and the lack of understanding of such information use are not unique to fisheries information. Researchers have attributed the limited use of environmental information in general to challenges with information flow at the science-policy interface (e.g., Mitchell, 2010; Mitchell, Clark, Cash, & Dickson, 2006). While the role that information plays in the policy-making process is rarely described, some studies suggest limited use of scientific information by governments in policy- and decision-making and furthermore, the use or influence of this information is not fully understood (e.g., Cossarini, MacDonald, & Wells, 2014; Dicks, Walsh, & Sutherland, 2014; Holmes & Clark, 2008; Holmes & Savgard, 2008; McNie, 2007; Soomai, MacDonald, & Wells, 2013; Wells, 2003).

Modern governance espouses evidence-based policy-making wherein decisions are expected to be made based on the best available information (Lalor & Hickey, 2013; Nutley, Walter, & Davies, 2007). The role of scientific information in policy-making (or more broadly, "decision-making"), i.e., the role of information at the science-policy interface, is increasingly being questioned and examined (Gluckman, 2013, Nursey-Bray et al., 2014). Policy-making is a complex process with multiple internal and external influences on governments' use of research information which is often grounded in a range of factors related to institutional and organizational aspects, the characteristics of the actors involved in policy processes, or embedded in the characteristics of the information itself, among other factors (Healy & Ascher, 1995; Keller, 2009; Mitchell, 2010; Mitchell et al., 2006; Mol, 2008). For instance, the uptake of fisheries information into management advice by governmental organizations may be influenced by factors such as governance models, political regimes, the geographic region, information management cultures, as well as personal and institutional interests and values of multiple stakeholders (Ascher, Steelman, & Healey, 2010; Cochrane, 2002b; Liverani, Hawkins, & Parkhurst, 2013; Pal, 2009; Wilson, 2009). The level of technical details in scientific information provided as advice and the degree of scientific uncertainty also can be issues in government decision-making and in engaging the public in policy-making (Kahan, 2010; Keller, 2009; Rosenberg, 2007).

Decision-making extends beyond the interaction of government scientists and policy-makers and involves other stakeholders including resource users, non-governmental organizations, and the public (Garcia, 2008; Irvine, 2009; McNie, 2007; Soomai et al., 2011). Strategies to promote awareness of governmental publications are more likely to reach the interested public than the general public in public policy formulation activities (Soomai et al., 2013). Additionally, scientific knowledge interacts with other types of knowledge, e.g., local knowledge, and may compete with other kinds of information, including economic and social science, in decision processes. Political agendas and attempts to maintain the neutrality of science can also affect information flowing at the science-policy interface (Jasanoff, 2010; Pielke, 2007; Sarewitz, 2014). Such factors can create opportunities or challenges for the communication of scientific information to policy-makers (Likens, 2010; Mitchell et al., 2006; Tribbia & Moser, 2008).

International commitment to study the science-policy interface intensified at the 2012 UN Conference on Sustainable Development (Rio +20) which included a decision to establish a universal, intergovernmental high-level political forum to follow up on the implementation of sustainable development and thereby strengthen the science-policy interface and enhance evidence-based decision-making at all jurisdictional levels (UN, 2012; UN Department of Economic and Social Affairs [UN DESA], 2013a; UN General Assembly [UNGA], 2012). Improved access to information; the need for timely, accurate, and transparent scientific information; the exchange of information and knowledge; and more effective use of information and communication technologies are considered priorities for addressing problems at the science-policy interface (UN Environment Programme [UNEP], 2012; UNGA, 2012; UN DESA, 2013b). Support to address challenges to information use at this interface was also seen at the regional level. For example, scientists with the International Council for the Exploration of the Sea (ICES) acknowledged the importance of "building relationships and communication across science-policy boundaries" and the need for studies that specifically examine the role of scientific information such as Soomai, MacDonald, and Wells (2011a, 2011b) and Soomai et al., (2013), to support enhanced "understanding of effective strategies and gaps for linking science advice to management decisions" through "analysis of how information flows among scientists, managers, and stakeholders" (ICES, 2013, p. 54).

The need for scientific advice for decision-making is evident, given the complexity of interactions among the environment, resource users, economies, and social well-being of communities. Given the apparent disconnect between the growing volume of scientific information produced by scientists and the limited use of information by policy-makers, it is important to understand the impacts of the aforementioned factors on pathway(s) of information from production through dissemination and communication to decision-making. Recognition of the need for studies on the role of information at the science-policy interface is growing, given the increasing public demand for information and the involvement of multiple actors in policy-making. Some governmental organizations producing marine environmental information have acknowledged that information management is important and are becoming open to the idea that they need to adopt methods to ensure the use of their information by diverse stakeholder groups in practical and social applications (e.g., Cossarini, 2010; FAO, 2009b; Soomai et al., 2011a, 2011b). Studies on the role of information are increasingly important to organizations where funding for research is limited and accountability for information production is needed. A few studies have provided insights on the role of fisheries scientific information in policy and decision-making (e.g., Holmes & Lock, 2010; Soomai, 2009; Soomai et al., 2011; Wilson, 2009). In-depth studies, however, are needed to reveal the multidimensional processes at the science-policy interface by which scientific information is incorporated into policy decisions and to elucidate the enablers and barriers to this activity.

1.2. Using Interdisciplinary Case Studies to Understand the Role of Fisheries Scientific Information in Decision-Making

This research is based on detailed queries, data collection, and analyses within three interrelated fisheries management organizations – the Canada Department of Fisheries and Oceans (DFO), a national fisheries management authority; the Northwest Atlantic Fisheries Organization (NAFO), a regional fisheries management body; and the Food and Agriculture Organization of the UN (FAO), an international, intergovernmental fisheries organization. DFO (Maritime Region), NAFO, and FAO have highlighted the need to improve communication of scientific advice and are participating in a research partnership aimed at understanding awareness, use, and influence of scientific information in policy-making (EIUI, 2015). The rationale for the selection of these three organizations as case studies is discussed further in Section 1.3.

The principal research question asked: **What role(s) does scientific information play in decision-making for fisheries management?** The research used mixed-methods, mainly qualitative methods, to develop detailed understanding of the production and use of fisheries scientific information by various actors within these organizations. Interviews of key actors in the three governmental organizations were conducted using a semi-structured questionnaire, direct observations were made at relevant science and advisory meetings, and content analysis of numerous scientific documents and publications was undertaken. One goal of the research was to determine how scientific information produced by governmental organizations influences policy- and decision-making by closely examining instances where information produced by the case study organizations is used in fisheries policy development and management decisions.

Understanding the multidimensional interplay of the many factors (see Section 1.1) in the information pathway(s) from production through dissemination and communication to decision-making requires an interdisciplinary approach. This case study research draws on the disciplines of fisheries science and management, information management, and public policy, to address the research questions aimed at understanding activities at the science-policy interface. While fisheries science and management form the context for the research, the theoretical perspectives of information management are needed to understand the production of information, its communication to stakeholders, and its use by decision-makers. Within the context of public policy, knowledge and insights about different organizational types, structures, and cultures, for instance, are critical to understand the roles of multiple stakeholders and how decisions are reached. The conceptual diagram in Figure 1 highlights the inherent complexity of the processes in the production, communication, and use of fisheries information in decision-making by showing the general structure and interaction among the information, fisheries management, and the policy life cycles (FAO, 2003; Hallsworth, Parker, & Rutter, 2011).

In evidence-based policy-making, decision-making and production of fisheries policy are expected to be guided by fisheries management advice. In a fisheries governance system, policy-making is a dynamic process with expected overlaps of the stages, processes, and actors involved in each of the three cycles (Figure 1). For instance, elements of the information cycle (ILC), i.e., production of new information through to use and influence, operate at all stages of the fisheries management cycle. Research produced in the fisheries management cycle is expected to enter the policy life cycle which may then drive the production of further data and information (Figure 1).

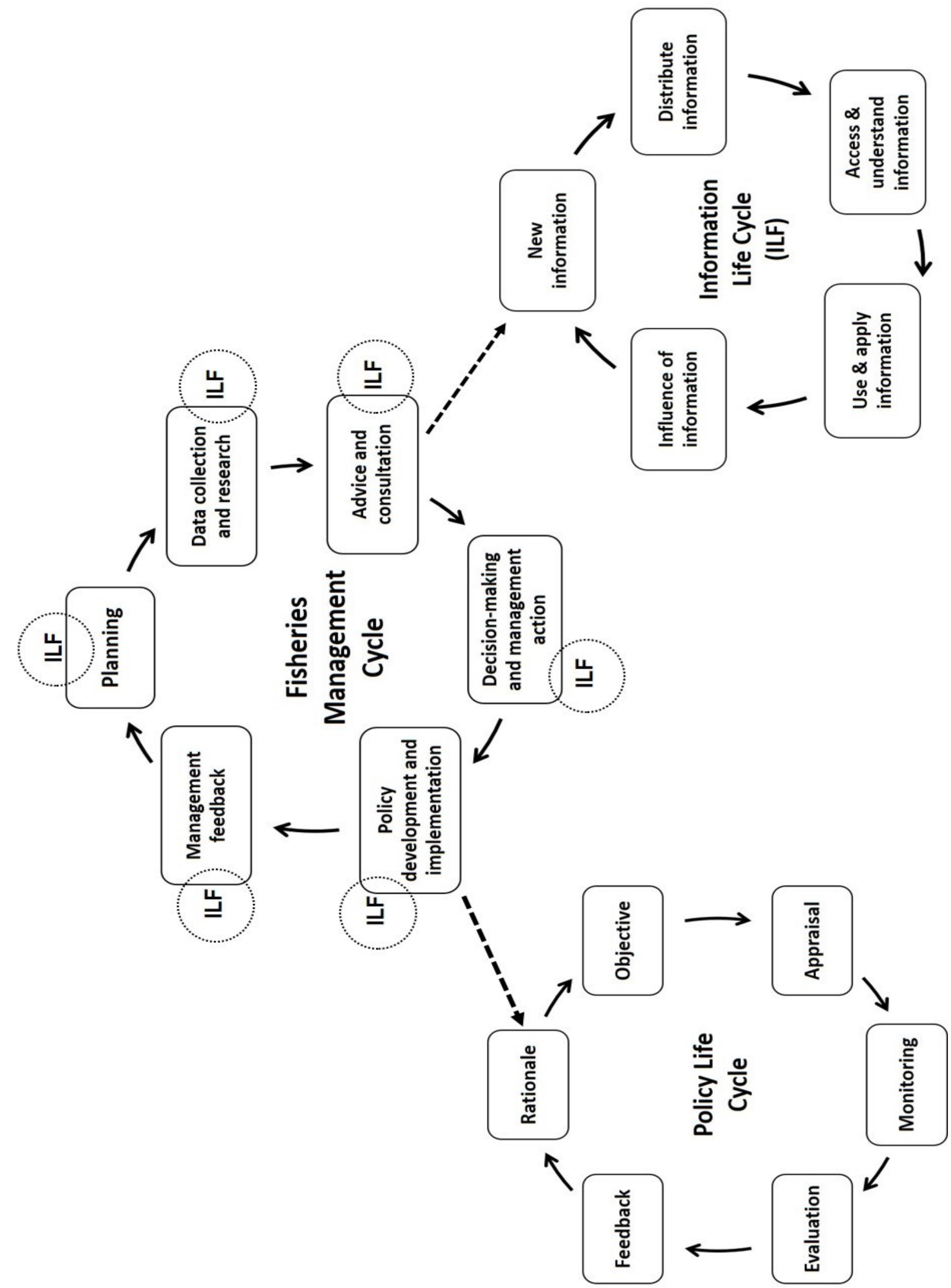

Figure 1. An idealised representation of the interactions among the fisheries management cycle, the information life cycle (ILC), and the policy life cycle.

1.3. Rationale for the Selection of the Case-Study Organizations

Information use in policy and decision-making contexts is a complex phenomenon which operates at various levels of scale: geographic, institutional, political, and temporal (Nutley et al., 2007). The doctoral research design was noteworthy as it opened up governmental decision-making processes for direct study. DFO, NAFO, and FAO are three different organizations with different but related mandates, different organizational structures and cultures, different but similar decision-making processes, and different levels of jurisdiction. The three organizations operate at different scales and the mechanisms and the actors involved are expected to be unique to each organization.

DFO is the lead federal agency responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social, and economic interests in its oceans and fresh waters (DFO, 2014k). DFO was selected as an example of a national fisheries management organization. NAFO is an intergovernmental fisheries science and management body focused on the management and conservation of most fishery resources in the Northwest Atlantic region (NAFO, 2014a). NAFO was selected as an example of a regional fishery body. FAO is an intergovernmental organization and a specialized agency of the UN (FAO, 2014a). FAO was selected as it is the foremost global fisheries management organization. FAO recommends national and international action related to fisheries, provides neutral advice to its members, and acts as a neutral forum where member countries can negotiate agreements and debate policy.

The activities of these organizations are also inter-related. Canada as a Contracting Party to NAFO is represented by its Department of Fisheries and Oceans. Similarly, DFO is the official contact organization for Canada as a member country of FAO. DFO and NAFO were also selected since the research was conducted within a Canadian context.

The three organizations are prolific producers of fisheries scientific information that is published primarily as grey literature, i.e., published by the organizations themselves and not by a commercial publisher. Production of scientific information requires dedicated resources, such as personnel, time, and public funds. In the current climate of economic constraints, accountability of resources for producing and distributing publications has increased. Moreover, the capacity of the organizations may be reduced as a consequence of austerity measures, resulting in additional constraints on the use of fisheries scientific information in decision-making.

This research examined the different levels of decision-making occurring in governmental organizations. Public policy texts refer to policy-making by political decision-makers as a high-level of decision-making (e.g., Pal, 2009). The research primarily involved government scientists and managers, including senior managers or science advisors who interacted with the policy-making communities. In this research, decision-making refers to activities such as management decisions for operational fisheries management, for instance, the setting of total allowable catches (TACs) advice in DFO and NAFO. Higher level decision-making, or policy-making, was evident in the FAO case study.

Definitions or interpretations of "information," "scientific information," "science," and knowledge can differ based on the producer and the audience. This research did not focus on data per se, e.g., fisheries statistics or data used in fish stock assessments; instead it explicitly examined how scientific advice based upon natural science research information, e.g., technical reports, syntheses, and summary reports, is used in policy- and decision-making for fisheries management. This form of scientific advice is referred to as "scientific information" in this study.

1.4. Outline and Overview of the Study

This research is unique since no known empirical studies have investigated information pathways in the three governmental organizations. This research is the first comprehensive study of the role of information in the science-policy interface in fisheries management. A passionate statement, made by a senior DFO manager participating in NAFO, illustrates the complexity of the pathways of scientific information in governmental decision-making.

> I think it is a myth to say that science is not being followed. That is not my personal experience and it is an oversimplification of something that is far more complex with numerous social and economic factors built in, more than the scientific component. (NAFO 13).

Furthermore, a statement by an FAO staff member emphasizes another critical aspect that was core to this research:

> The role of information I think is changing, maybe not so much the content, but the way that it is delivered, the way that it is packaged, and the way that it is distributed to the users. And the means of communication of course are changing very quickly. (FAO 12)

Substantial new data was gathered in three-month internships in each of these organizations between September 2013 and July 2014. Seventy-eight interviews of scientists and managers were conducted, including 26 in DFO, 19 in NAFO, and 33 in FAO. In addition, direct observations were conducted at 15 science and management meetings (eight in DFO, three in NAFO, and four in FAO). Questions were asked within the context of fisheries science and management, information management, and public policy to understand how scientific information is produced, communicated, and used primarily in operational decision-making for fisheries management.

Chapter 2 presents the theoretical framework for this research. The main characteristics of the science-policy interface are described based on a systematic review of the literature on the use of marine environmental information in decision-making contexts. Characteristics of the attributes of information, i.e., credibility, relevance, and legitimacy, operating at the science-policy interface are described. Four important challenges and enablers to information flow at the interface are discussed: organizational aspects; the paradox of science and politics; scientific uncertainty, including attributes of information; and the different motivations of scientists and managers to act in policy-making contexts. The chapter includes theoretical perspectives and models of the science-policy interface and information use.

Chapter 3 describes the qualitative research methods used in the studies of the three organizations, namely interviews, direct observations, and content analysis of documents. Chapter 3 also presents the guiding framework of the case study research that was developed based on the theoretical perspectives and models described in Chapter 2.

The results of the three case studies, i.e., of DFO, NAFO, and FAO, are presented in Chapters 4 through 6 respectively. Each chapter contains a brief background description of the organization that is needed to understand the interview responses of scientists and managers and the direct observations conducted at scientific and management meetings. As each case study used the same methodology (the details are described in Chapter 3), only aspects unique to each case study are outlined in the respective chapters. The information pathways (also referred to as information flow) – production, communication, and use of information by each organization – are described based on detailed coding of the data obtained from interviews, direct observations, and content analysis of documents. The coding was guided by themes developed in Chapter 2.

The case studies revealed the information pathways in each organization, the drivers to information production, the institutional and social enablers and barriers to communication and use of information in decision-making, and key actors in the information pathways. The studies also identified important trade-offs regarding the attributes of information, i.e., credibility, relevance (salience), and legitimacy, flowing at the science-policy interface.

Chapter 7 presents a synthesis of the findings of the three case studies and includes a comparison of the drivers, enablers, and barriers to the uptake of information in decision-making; and the trade-offs among the attributes of information. This chapter revisits the primary research question and guiding research framework of Chapter 3 and it addresses the specific questions asked in the research. The chapter also draws attention to instances where the case study findings support or diverge from the theoretical perspectives on information use and communication at the science-policy interface as described in Chapter 2. A typology of use containing 12 characteristics to describe the science-policy interface is proposed. These characteristics can be regarded as metrics and can be used as a guide for future studies on measuring information use in decision-making. The results also have practical applications in the three organizations as they identify areas where the organizations can maximize their information's value to diverse audiences and encourage participation of these groups in policy- and decision-making.

The research provides a substantially greater understanding of the role of scientific information at the science-policy interface. The research also contributes to the knowledge and theoretical frameworks on information use in policy contexts. Chapter 8 provides the main conclusions of the research and describes the organizational aspects that lead to credible, relevant, and legitimate information at the science-policy interface. The conclusions also highlight the differences in the interface with regard to traditional fisheries management and EAF. Many organizations rely on their own publications (grey literature) as a primary means to communicate the results of research and related activities. A new model of information use in operational decision-making by governmental organizations for fisheries management is presented. Recommendations for future work are provided.

CHAPTER 2. CHARACTERISTICS OF THE SCIENCE-POLICY INTERFACE AND INFORMATION USE IN POLICY-MAKING

2.1. Introduction

The science-policy interface is a complex phenomenon but in its most simple form it can be characterized by communication between information production (science) and information use (policy) (Ascher et al., 2010; Liverani et al., 2013). The interface encompasses many social processes related to decision-making and understanding the role of scientific information is particularly challenging given the complexities of modern societal and environmental issues. For example, the effects of climate change, overfishing, and pollution often operate at global levels where policy development and decision-making involve multiple considerations, such as different and often conflicting stakeholder needs and interests (Mitchell et al., 2006; Mol, 2008; Sutherland et al., 2012).

The models and perspectives on the science-policy interface and information use are primarily based on modern policy-making which espouses rational approaches, e.g., evidence-based policy-making. This approach assumes that policy-makers identify problems, gather and review all the data about alternative possible solutions and their consequences, and then select the solution that best matches their goals (Pal, 2009). Actors or individuals at the interface comprise both the "science" and "policy" realms. Research in evidence-based policy-making considers scientists (or researchers) and policy-makers (or decision-makers) as the two major "communities" involved and are the major stakeholders (National Research Council [NRC], 2012). The primary actors in the production of scientific information are scientists working in a range of bodies including: national governmental, regional, and intergovernmental organizations; academic institutions; public and private research institutes; industry; and non-governmental organizations (NGOs). The primary actors in decision-making in governmental organizations are: policy-makers, often the political or high level decision-makers; policy-analysts, and managers. Bridging the science and policy realms are a suite of additional actors serving in various communication roles (MacDonald et al., 2015). Policy-making communities have expanded to include a wide range of external influences, including the media, NGOs, and the fishing industry. In addition, a variety of drivers, enablers, and barriers to communication can influence information flow at the interface.

This chapter is a systematic review of the literature on the science-policy interface and on knowledge utilization, which describes the characteristics of the science-policy interface and scientific information use in public policy settings.

2.2. Science-Policy Interface Models

In global environmental policy, the science-policy interface is often given the characteristics of an institution, i.e., with normative structures, rights, rules and procedures, and it defines a social practice of linking scientific and policymaking processes (Koetz, Farell, & Bridgewater, 2011; Oberthur & Gehring, 2004; van den Hove 2007; Vatn, 2005; Young, 2008). The interface is often described as either a linear or a collaborative model and this dichotomy can be loosely described respectively as either a focus on collecting new knowledge or a focus on using information that already exists to support decision-making. In the linear model, science is considered to be credible over other forms of knowledge, e.g., local knowledge, and it flows directly from basic and applied research to produce societal benefits as the different institutional and organizational levels of governance complement each other (Bulkeley, 2005; Pielke, 2002, 2007; Young, 2004). In the collaborative approach, all forms of knowledge are relevant as sources of information for policy-making as policy-makers frequently consider alternative options rather than additional science alone, and decision-making is often achieved through an interactive process between scientists and decision-makers (Pielke, 2007).

Similar interpretations of the linear and collaborative models are noted in governance settings in integrated coastal management and describe a science-based interface and a participatory-based interface (e.g., Bremer & Glavovic, 2013). In the science-based interface, the inherent uncertainty in science is perceived as being a lack of available information, warranting the undertaking of new research to fill gaps in the information delivered to decision-makers (De Santo, 2010; Knol, 2010). Alternatively, the participatory approach views uncertainty as inevitable, necessitating the integration of knowledge, including scientific knowledge and local knowledge, among others, in an interdisciplinary approach (Cicin-Sain & Knecht 1998; Stojanovic, Ball, Ballinger, Lymbery, & Dodds, 2009). The science-policy interface is also considered as a dynamic phenomenon or an “interactive science-policy practice,” as it can fluctuate between the linear and collaborative models based on the involvement of different groups (Runhaar & van Nieuwaal, 2010; Van de Riet, 2003). For instance, decision-making can be initiated through request and provision of scientific advice to political decision-makers in a period of “science-dominated science-policy practice,” e.g., the provision of scientific information in response to extreme pressure from environmental groups to manage a fishery. This period is then followed by a phase of direct involvement of a wide range of stakeholders in the policy debate on the same issue (Runhaar & van Nieuwaal, 2010; Van de Riet, 2003). Taking such a broad perspective on the interface also reveals the role of diverse, and often overlooked, actors in the complex social interactions in marine management (Van de Riet, 2003; Weiss, Hamann, Kinney, & Marsh, 2011).

Knowledge utilization and knowledge mobilization are dependent on the characteristics of each science-policy interface. The linear model is applicable in the simplest of decision contexts and not to international environmental policy-making while the collaborative model is well suited for modern strategic policy-making (Pielke, 2007). The collaborative model applies to international environmental governance with complex and competing interests and values as it acknowledges that advocacy or politicising of scientific results is at times inevitable (Funtowicz & Ravetz, 1993). Nevertheless, many of the existing environmental and resource management organizations follow a linear model, where it is presumed that scientific facts and values can be separated from political influences. For instance, the communication of fish stock assessments in the International Council on the Exploration of the Seas (ICES) is a linear approach to the science-policy interface, as is also the case in many other fisheries advisory or management organizations, even though a more participatory or collaborative science-policy interface model is better suited to facilitate communication among governments and stakeholders such as the fishing industry and non-governmental organizations (Aps, Fetissov, Holmgren, Norrstrom, & Kuikka, 2012).

Framing the science-policy interface from a governance perspective, i.e., in a collaborative or participatory approach, can facilitate mobilization of information and knowledge through increased dialogue across a wide range of disciplines and stakeholders. Similarly, adaptive management, e.g., in fisheries and ecosystem management, where knowledge, policy, and practice are integrated and continuously revised and adapted to new conditions, can be viewed as a collaborative or participatory interface as the iterative relationships between producers and users of information may increase usability of information (Cochrane, 2002a; Dilling & Lemos, 2011; Levin, Fogarty, Murawski, & Fluharty, 2009; Sarewitz & Pielke, 2007). Two-way communication between scientists and users of information allows scientists to understand decision-making contexts better and they can customize information to meet specific decision-making needs. The science-policy interface is then conceptualized as a process of "reconciling" the dynamic relationship between the "demand," i.e., research is requested and funded to achieve specific societal goals, and the "supply," i.e., information is available in the form of various scientific reports for decision-making (Sarewitz & Pielke, 2007).

The key attributes of information, i.e., credibility, relevance (or salience), and legitimacy, have been used to characterize the science-policy interface models (Cash et al., 2003; Koetz et al., 2011; Mitchell et al., 2006). Given the environmental issue at hand, credibility refers to the perceived validity or scientific adequacy of the information used in the eyes of the stakeholders; relevance (salience) reflects the extent to which work carried out within a science-policy interface is related to the context of the policy process, i.e., to the needs of decision-makers; and legitimacy reflects the unbiased, and political acceptability of the outputs, e.g., it includes the views and values of multiple stakeholders. The credibility, relevance, and legitimacy of the science-policy interface in the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES), which implicitly refers to information, is the subject of study by some researchers (e.g., Young et al., 2013). The group also describes "iterativity" – the two-way communication among actors in the interface – as an important factor that influences the function of the interface (Sarkki et al., 2015). Sarkki et al. (2014) described common trade-offs among the attributes of information, e.g., a “clarity–complexity” trade-off between relevance and credibility when scientists consider the production of simple messages versus communicating uncertainty. Trade-offs are also dynamic and can be influenced by a range of aspects, e.g., the policy problem or the stage in the policy cycle, among others.

The “post-normal science” perspective can also be used to structure the science-policy interface, where knowledge “quality” becomes the guiding imperative rather than scientific “truth,” and stakeholders become participants in an “extended peer community” (Bremer & Glavovic, 2013; Funtowicz & Ravetz, 1993). The “post-normal science” approach has been promoted primarily to address concerns with scientific uncertainty in decision-making (Funtowicz & Ravetz, 1993; Petersen, Cath, Hage, Kunseler, & van der Sluijs, 2011; van der Sluijs, Petersen, Janssen, Risbey, & Ravetz, 2008). For instance, making policy decisions in circumstances that require the scientific “truth,” e.g., the exact size of a fish stock, is a challenge as this information may never be known, yet a policy decision needs to be made. The “post-normal science” perspective complements “normal science,” e.g., traditional statistical and biological analyses, by quantifying uncertainty and risk in the information available for decision-making. Scientific uncertainty is discussed in further detail in Section 2.6.1. The cornerstone of “post-normal science” is an extended peer community, where stakeholders with different expertise acknowledge, analyse, and communicate uncertainty in science for policy-makers (Peterman, 2004; van Densen & McCay, 2007). Participation of multiple stakeholders in knowledge production can increase the quality of advice and improve its use in decision-making. The extended peer community becomes the foundation for credible, legitimate, and salient scientific information for policy advice (Cash et al., 2003; Dankel et al., 2012).

2.3. Models of Information Use in Policy Contexts

Early studies on information use in policy-making described an “ideal model” where the research process is logical or linear in which researchers ask the right questions, plan and conduct research, and then disseminate the findings as scientific advice directly to the policy-maker (e.g., Caplan, 1979; Glasziou & Haynes, 2005; Knott & Wildavsky, 1980; Landry, Amara, & Lamari, 2001; Weiss, 1979). An alternative approach is the "enlightenment model," where the links between research and policy are less direct, and no single piece of research is likely to influence policy change directly (e.g., Weiss, 1977). Rather, information from research accumulates over time and permeates gradually into the policy process through a number of information channels, e.g., through the involvement of interest groups and the media, and leads to a gradual change in the thinking of policy-makers. In more modern policy contexts, "interactive models" apply where policy-makers seek additional knowledge from scientists and other actors in an iterative process and the scientific knowledge of policy-makers improves over time such that research is used to shape problem-framing and problem-solving and leads to changes in the policy-making process (Nutley et al., 2007). The interactive model of information use is analogous to a systems approach where the production of knowledge is connected to the community in which it develops and it is a continuous process, rather than a single event, and is best represented by the "continuum model" as seen in Figure 2 (Nutley et al., 2007, p. 51).

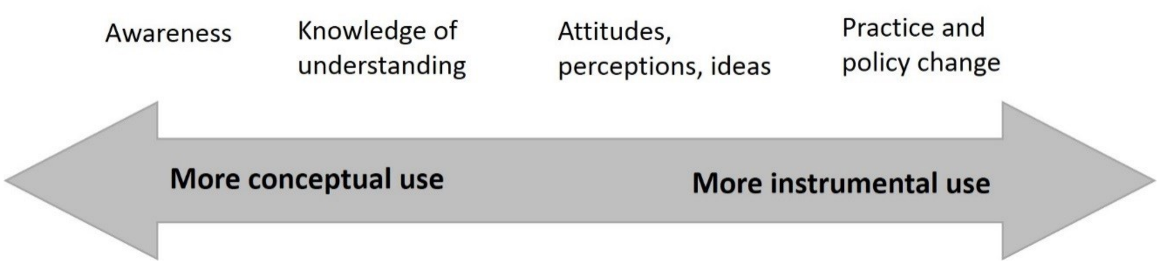

Figure 2. Continuum model of information use. (Adapted from Nutley, Walter, & Davies, 2007, p. 51)

Broad categorizations describe two main types of information use (or research evidence) in policy contexts, e.g., direct or instrumental use and indirect or conceptual use (Nutley et al., 2007). Direct use describes instances where scientific evidence is used for direct problem-solving, e.g., developing policy to manage fisheries. Such direct use can involve an interactive process where policy-makers actively seek knowledge and develop a dynamic relationship between scientists, policy-makers, and other actors in the policy process. Selective or strategic use, where particular information is used to legitimize predetermined positions, can be viewed as a sub-set of direct or instrumental use. Alternatively, conceptual use describes a more indirect way of using evidence where it often serves an “enlightenment” purpose, e.g., it influences the overall understanding of the complexity of problems leading to increased awareness and change in attitudes of policy-makers and practitioners on environmental issues (Caplan, 1979, Weiss, 1979). The degree to which evidence is used directly, indirectly, or selectively, may vary in relation to several factors, e.g., the management level at which the decision-makers operate in the policy-process in an organization; how evidence is framed, i.e., vague versus complex; or the issue itself (Hallsworth et al., 2011).

A number of typologies describe the reasons for information use in policy-making (Landry et al., 2001; Weiss, 1979). Commonly, use can be “knowledge-driven,” where the product serves an educational purpose for the intended audience, or use can be seen as “problem solving,” where information provides advice to policy-makers and is intended to guide the selection of management solutions. In a “political” typology, political ideas are fixed and research is not expected to guide policy-making; however, research can be used to support a particular political agenda. The literature on knowledge utilization also provides models that explain information use in research settings, i.e., in the science community (Landry et al., 2001; Weiss, 1979). Similar to the “supply and demand” models described for the science-policy interface (see Section 2.2), there is a technological or “science push” model where the supply of research is the major determinant of knowledge utilization and an economic model or “demand pull” model where knowledge utilization is explained by the needs and the context of the users (Landry et al., 2001; OECD, 2000; Oh, 1997; Sarewitz & Pielke, 2007). A “social interaction” model integrates the “science push” and the “demand pull” models and posits that more sustained interaction between information producers and users will likely increase knowledge utilization (Landry et al., 2001).

The “two communities” perspective, i.e., scientists and policy-makers as the main actors in information production and use respectively, formed the basis of five models of knowledge utilization that highlight information seeking behaviour by policy-makers (Dunn, 1980). In the “product-contingent model,” the characteristics of information products, i.e., format, content, language, length, reliability, validity, and timeliness, determine the scope of knowledge use by policy-makers. In the “inquiry-contingent model," differences in modes of inquiry used to acquire, process, and interpret information, i.e., research design and analytic techniques are important. In the "problem-contingent" model, the characteristics of policy problems, i.e., levels of conflict, uncertainty, and risk are relevant. In the "structure-contingent" model, variations in the structure of organizations, i.e., authority, responsibility, power, and incentive systems, are considered. In the "process-contingent" model, the nature of interaction, e.g., authoritarian versus collaborative, among producers and potential users of knowledge determines the scope of knowledge use by a policy-maker (Dunn, 1980). Actors in the science-policy interface can be further categorised by how they use information overall, e.g., as a "research-based-practitioner" to articulate research needs to the scientist and to search the available knowledge for answers to inform policy-making (Walter, Nutley, Percy-Smith, McNeish, & Frost, 2004). In the "organizational excellence" model, emphasis is placed on continuous improvement of an organization, by drawing on the expertise of the research and the practitioner communities (Walter et al., 2004). Furthermore, practitioners may respond to external stakeholders based on the legitimacy of the stakeholder and its relationship with the organization (Mitchell et al., 1997).

Scientific advice is used as evidence in developing different arguments for policy choices (NRC, 2012). However, these arguments not only involve scientific advice, but they also include value judgments and political considerations, for instance, regarding the desirability of a proposed action. Knowledge seeking and use, therefore, depend upon the characteristics of the individual policy-maker as well as those of the organization (Elsbach, Barr, & Hargadon, 2005; Greeno, 1998; Moynihan & Landuyt, 2009; Spillane, Reiser, & Reimer, 2002). Understanding how science is used in policy requires an investigation into what makes for reliable, valid, and compelling policy arguments from the perspective of policy-makers. Characteristics of policy-makers and organizations can provide further insights on the "human" aspects of decision-making, e.g., how people make judgments, decisions, and choices, but these were not included in this literature review.

Ascher et al. (2010, p. 12) developed a conceptual model that illustrates the complexities of the generation, transmission, and use of environmental information in policy-making

(Figure 3). Information from different sources – including non-governmental organizations, government, and local knowledge – is aggregated and filtered according to institutional constraints, uncertainty, and personal and professional biases of numerous actors, e.g., practitioners and policy-makers. The competing needs of the multiple stakeholders can complicate the policy-making process. The filtered information then enters the realm of policy- and decision-making which generates new knowledge and drives information production by the various groups.

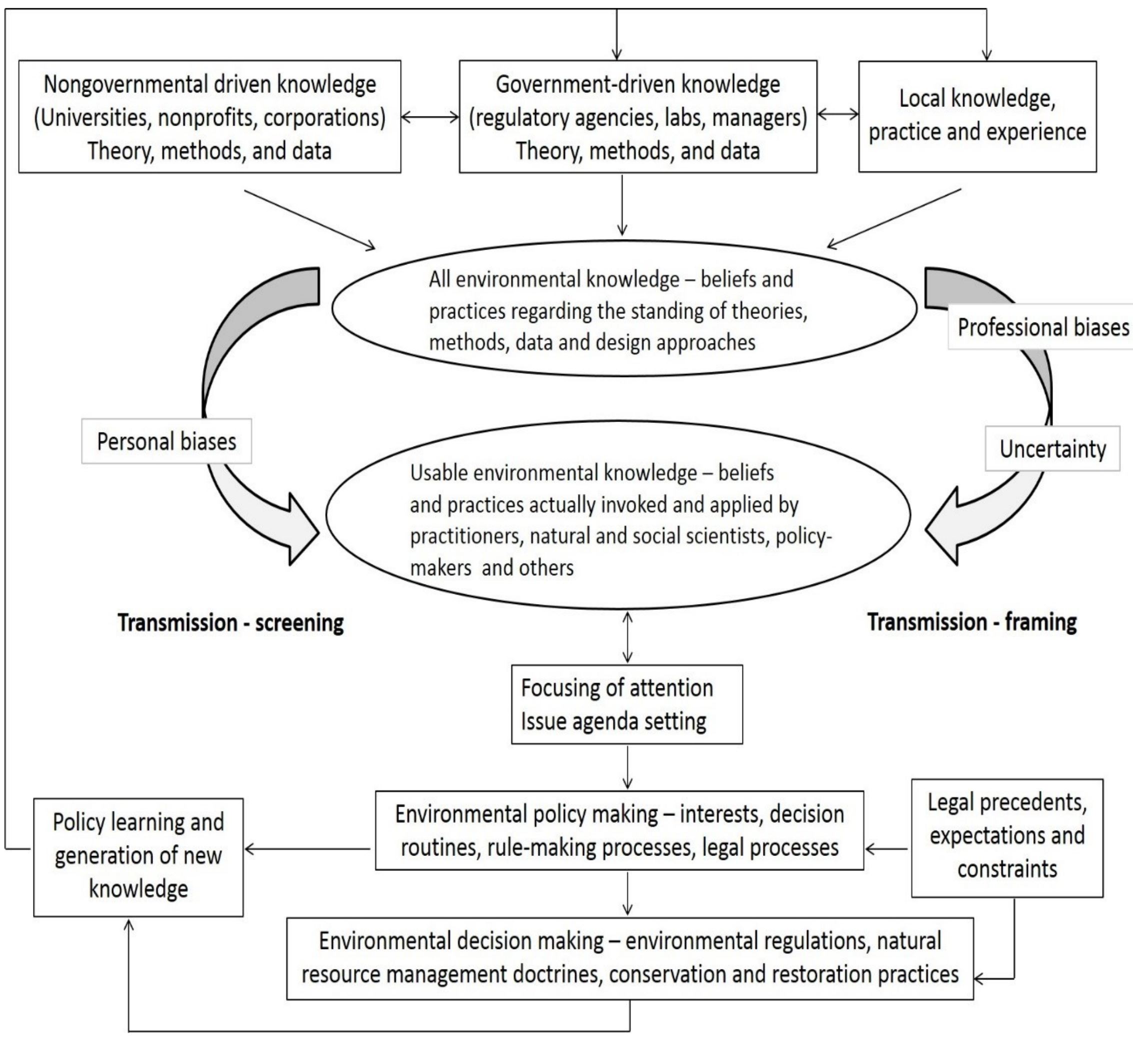

Figure 3. Model of the generation, transmission, and use of environmental information. (Adapted from Ascher, Steelman, & Healy, 2010, p. 12)

2.4. Measuring Information Use in Policy-Making

In the models of information use described in Section 2.2, research use by policy-makers can be fluid and iterative or it can proceed in stages after the information is produced, e.g., in a "chain of utilisation" or "pipeline model" (Glasziou & Haynes, 2005; Knott & Wildavsky, 1980; Landry et al., 2001). Generally, research is delivered to the policy-makers but there is no guarantee that it will be read or otherwise considered. If the publications are read and the information contained in them is understood by the policy-makers, they are subsequently cited in other reports. Efforts are taken to adopt the research into management which lead to the direct use of the information in policy-making, e.g., a policy is produced, which is later implemented or translated into practice. The last stage is considered as the "impact" where research used in policy, that had been adopted and implemented, now has societal benefits. The stage models described in some of the literature appear to be linear and suggest that research use must proceed in a logical order from one stage to the next (Glasziou & Haynes, 2005; Knott & Wildavsky, 1980; Landry et al., 2001).

Measuring use in more iterative models of information use is particularly complex. For example, in the continuum model of research, both indirect and direct use of information are linked as the spectrum of use ranges from raising awareness, to enhanced knowledge and understanding causing a shift in policy-making attitudes, to direct use of information and change in policy practice (see Figure 2) (Nutley et al., 2007). The continuum is seen as a two-way rather than a linear flow between indirect and direct use of information. The continuum model of information use also complicates the "two communities" concept, i.e., scientists and policy-makers, as the frequent exchanges between the two groups can change the characteristics of each group and relationships may be expanded to additional stakeholder groups (Bogenschneider, Olson, Linney, & Mills, 2000; Contandriopoulos et al., 2010; Greenhalgh et al., 2004; Huberman, 1994; Landry et al., 2001).

The attributes of information are important in policy and decision-making, as "useful" information satisfies a demand of the decision-makers and is salient, credible, and legitimate to the audience to which the publications are directed (see Section 2.2) (McNie, 2007; Mitchell et al., 2006). In the eyes of multiple stakeholders, information is useful if it meets the thresholds of relevance (salience), credibility, and legitimacy required for each stakeholder group. Similarly, for information to positively influence policy-making, it must establish a balance in trade-offs for the same attributes (Sarkki et al., 2014).

The terms "use" and "influence" are often used interchangeably, and the word "influence" is often not explicitly mentioned in the models on information use or the literature on knowledge utilization. With regard to global assessments, such as the state of the environment reports, influence is often understood as the "ability to affect decisions on policy or behavior ... an assessment must help to shape the perceptions of those making decisions – their understanding, beliefs, interests and goals" (UNEP & IOC-UNESCO, 2009a, p. 40). How influence is defined can depend on the context of the organization producing the information and the actors involved in policy-making (Hartley, 2010; Hartley & Glass, 2010). For instance, output such as policies, peer-reviewed papers, and reports by an organization can be considered as indicators of both use and influence.

Scientific knowledge use in public policy often follows the conceptual or indirect use typology. Evidence of conceptual utilization often goes unnoticed or is not fully realized because of an emphasis on measurements of direct or instrumental use, e.g., practical aspects, such as policies (Caplan, 1979). For instance, government bodies often establish performance indicators to determine how well environmental policies are performing, e.g., how well a fishery is managed. Performance indicators are often linked to implementation of policy, e.g., management actions taken, and not to the use of information in developing the policy. The use of information is typically not explicitly articulated as an indicator and therefore it is not measured. The UN regular process for global reporting and assessment of the state of the marine environment also describes the common absence of a "regular cycle linking monitoring and assessment to measures previously adopted in order to evaluate progress and the need for further action" (UNEP & IOC-UNESCO, 2009b, p. 25).

2.5. Review of Existing Knowledge on Information Use in Fisheries Management

Fisheries information is by nature broad and multidisciplinary, and with a global trend towards the ecosystem approach to fisheries management (EAF), the publications have become more prolific and more interdisciplinary (Bianchi, 2008; FAO, 2009a; Webster & Collins, 2005). In EAF, information that is interdisciplinary, i.e., considers social, environmental, and economic impacts, is now a critical requirement for policy-making (Garcia et al., 2003). Scientific uncertainty – a characteristic of fisheries science and consequently management advice – is associated with the inherent variability of natural systems, data collection, data used in the assessment model, the assessment method itself, and the ambiguous or technical language used to communicate results (Rice, 2005).

Studies on the use of fisheries information in policy-making from an information management perspective are few; however, they indicate that fisheries scientific publications (grey literature) prepared by government departments play a critical role in policy-making (Holmes & Lock, 2010; Holmes & Clark, 2008; Irvine, 2009; Soomai et al., 2011; Wilson, 2009). Reports commissioned by government departments and agencies are generally more useful to policy-makers as the information contained in these reports is more likely to be policy-relevant than that found in pure academic research papers and books (Clark & Holmes, 2010; Hemsley-Brown, 2004; Davies, Nutley, & Smith, 2000). The main forms of published material used by policy-makers and advisors are reviews and updates that summarize the available scientific information in less technical language. Summaries, often called briefs or briefing notes, are typically no more than two pages, including recommendations and directions for action. Often outside of the formal communication channels in organizations, policy-makers and their advisors rely on people they know for advice and they commonly seek information from their peers, scientists, and other contacts, as opposed to obtaining information directly from published material (Clark & Holmes, 2010; Nutley et al., 2007). Some of these personal sources belong to boundary organizations which bridge the science and policy communities (see Section 2.6.4 for details). Information seeking is also facilitated by scientists who are personally motivated to communicate with policy advisors, or are in positions to facilitate that role.

When fisheries policy-makers receive scientific reports, the information contained in them, including the management advice summary, is "translated" for use in policy reports. The scientific reports are first simplified, the information undergoes a valuation against other sources of knowledge, and then it is filtered by technical, administrative, legal, and political criteria to develop policy preferences (Asher et al., 2010). The filtering process also involves other stakeholders, e.g., industry and NGOs, as often scientific information, e.g., state of environment reports, is released and public opinion is then considered in policy-making (Soomai et al., 2011a, 2011b; Wilson & Pascoe, 2006).

The views and roles of scientists are often influenced by the type of organization in which they are employed. For instance, academic fisheries scientists employed in research institutes often see their primary job as contributing to the body of scientific knowledge, while producing information that is directly useful in decision-making is regarded as less important (van der Sluijs et al., 2008). The converse is often true for public service fisheries scientists whose work most often centres on the provision of advice for government decision-making. Given the policy context, "useful" information must satisfy a demand of the decision-maker and must be credible, relevant, and legitimate to the intended audience (as described in Section 2.2) (Clark, Mitchell, & Cash, 2006; Delaney & Hastie, 2007; McNie, 2007). For instance, a study of the uptake of fisheries research produced by governmental ministries, research councils, and institutes in the European Union, found that fisheries information may not be used in policy-making if the findings are not considered to be relevant to the policy process (Holmes & Lock, 2010). In some cases, fisheries managers are not interested in research per se but support the knowledge and expertise of the scientists so that they can provide advice when called upon in the future (Holmes & Lock, 2010). In other instances, what matters in the policy process is that research is being done and policy-makers can avoid taking action while still appearing to address the problem (Nutley et al., 2007). An earlier study on the effectiveness of fisheries management in selected regional fishery bodies – the Northwest Atlantic Fisheries Organization (NAFO), International Baltic Sea Fishery Commission (IBSFC), North East Atlantic Fisheries Commission (NEAFC), and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) – showed that the extent to which scientific advice is used in decision-making in the 1990s was influenced by institutional, economic, and political factors (Hastie, 2008). As an example, scientists working in governmental organizations have voiced concerns that fisheries and ecosystem science is often incompatible with other information sources in governmental policy-making on fisheries, which is still based on economics (e.g., Hutchings, Walters, & Haedrich, 1997).

The role of the fishing industry, NGOs, and other stakeholders in fisheries management and policy-making is increasing and communication methods to reach such groups are developing in new directions (FAO, 2009a). Evolving information technologies, such as digital networks, including social media, may be influencing the changing roles of the public and interest groups (Cossins, 2014). With the modernization of public administration, governments are producing public sector guidelines for the use of social media to communicate information to the general public and key stakeholders with the intention of increasing awareness and encouraging public participation in policy-making (e.g., Central Office of Information, 2012; Department of Internal Affairs, 2012; Government of Canada, 2011). However, governments at this time still experience challenges in wide implementation of such digital technologies.

Evidence-based policy-making represents a major paradigm shift in some governments' approaches to policy-making, but collaboration between scientists and policy-advisors is essential, particularly in the formulation of policy alternatives (Brodhag & Talière, 2006; Davies et al., 2000; Head, 2008; Nutley et al., 2007). Critics of modern policy-making claim that the alternative incremental model is still a valid approach where there is often no clear movement toward predetermined goals but rather a series of small steps in a process of "muddling through" (Lindblom, 1959).

2.6. Challenges to Information Use in Policy-Making

Four main challenges to information use and influence at the science-policy interface were revealed from this systematic literature review: scientific uncertainty, including the format of advice; issues related to the often paradoxical relationship between science and politics; different roles of scientists and policy-makers to fulfill at the interface; and the influence of governance structures. These challenges to information use are described in Sections 2.6.1 through 2.6.4. A summary of the four challenges is presented in Table 1.

Table 1. Summary of the challenges to information use at the science-policy interface.

CHALLENGE	INFORMATION USE
Scientific uncertainty	Scientific advice in assessment reports contains extensive technical detail as scientists use statistics in their presentation of data and results
	The legitimacy and credibility of assessments to policy-makers are reduced due to the uncertainties around the data and information
	The "post normal science" perspective facilitates credibility by applying tools to measure uncertainty in scientific advice and increase policy-maker confidence in situations where scientific uncertainty is inevitable
	Participation of diverse stakeholders and the public can increase the credibility, relevance (salience), and legitimacy of knowledge produced
Paradox of science and politics	Scientists can lose credibility by engaging in advocacy; biased advice can be produced to accommodate the viewpoint of the policy-maker
	Policy-makers often receive scientific advice yet they make decisions that may not be the "right" decision for sustainable fishing, but explanations are generally not provided
	Framing of advice can be "value-laden" and can influence decision-making
Different roles of scientists and decision-makers (policy-makers, managers)	Scientists approach problem solving through the use of testable hypotheses, highly technical analysis, and long time-series of data; knowledge production involves rigorous peer review
	Policy-makers often need to make immediate decisions; they may have a limited understanding of science, are overwhelmed by the complexities of scientific uncertainty, and are risk averse
	Research may not be appropriate for policy-making; reports are often not produced in a timely format for policy-making and follow-up decisions
Governance structures – Institutions, organizations, and related cultures	Scientific advice competes with other factors shaping decision-making within organizations
	Embedding the assessment and policy-making process within an organization increases its credibility and relevance to policy-makers
	Boundary work or organizations can create networks of producers and users of information to increase trust and reframe scientific uncertainties
	Adaptive management increases interaction between producers and users of information and facilitates two-way communication

2.6.1. Scientific Uncertainty

The literature identifies scientific uncertainty as a substantial challenge in providing management advice as typically a mismatch exists between the degree of certainty that fisheries science can deliver and what policy-makers expect fisheries science to provide (Dankel et al. 2012; Hoydal, 2007; Wardekker et al., 2008; Wilson, 2009). Scientists maintain that providing scientific advice that is credible, relevant, and legitimate to policy-making and effective management, inevitably involves high levels of technical details, in the form of complex statistics, due to the inherent uncertainties associated with natural ecosystems and fisheries (Rice, 2005). Fisheries managers and policy-makers often want fisheries advice without probabilities or the likelihood of events occurring and the presence of such uncertainty can limit the uptake of the information (Funtowicz & Ravetz, 1993). In addition, management or policy decisions are often needed before relevant evidence becomes available or questions posed to scientists cannot be completely answered within a short time-frame due the unavailability of data. Given the presence of scientific uncertainty, the "precautionary principle" is often used by many managers and policy-makers to apply foresight in decision-making, e.g., in the selection of policy instruments and preferences, while taking into account the scientific uncertainties in fisheries systems (FAO, 1996; Garcia & Cochrane, 2005).

Uncertainty can be deliberately exaggerated, under-emphasized, or even ignored (Dankel et al., 2012; Rosenberg, 2007; Sarewitz, 2004; van der Sluijs et al., 2008; Wardekker et al., 2008; Wilson, 2009). Decision-makers may use scientific uncertainty in management advice to avoid making a management decision or they can demand more knowledge to address uncertainty to delay making policy decisions (Rosenberg, 2007; Wardekker et al., 2008). Emphasising uncertainty in reports for policy-makers and stakeholders can undermine political will in environmental decision-making if uncertainty in scientific advice is belaboured (Rosenberg, 2007). Uncertainty can be used as an "excuse" for not taking precautionary actions in fisheries management (Cochrane, 2002b). On the other hand, underemphasizing uncertainty or exaggerating certainty creates a false confidence in the credibility and legitimacy of scientific advice and can do lasting damage to the credibility of the science (Wilson, 2009).

Uncertainty is not unique to fisheries science as it "is a feature of all advice, but it is typically only acknowledged by the scientific advisor" (Rosenberg, 2007, p. 989). Scientists often openly draw attention to uncertainty to safeguard their professional integrity and to be accountable and open towards the general public (Wardekker et al., 2008). In complex systems, quite often a single scientific answer in insufficient and more research will not lead to less uncertainty but instead identify further complexities (Sarewitz, 2004; van der Sluijs, 2005). Full understanding of a fishery is often out of reach and from a "post-normal science" perspective (as described in Section 2.2), attempts can be made to quantify uncertainty to increase the credibility of scientific results (Dankel et al., 2012; Jentoft, 2004; Maxim & van der Sluijs, 2011).

2.6.2. The Paradox of Science and Politics

In a study of fisheries management by ICES, Wilson (2009) stated that "fisheries management in a democracy is fundamentally a political activity rather than a technical one" (p. 29). This point of view, while not shared universally, is not surprising as science is a social construct, i.e., it is practiced by humans who are imperfect in adhering to principles; therefore, science is value driven and normative, and can be influenced by policy preferences (Wilson, 2009). Guston (2001) provided a broader perspective by stating that "science is not devoid of values prior to some politicization, nor politics of rationality, prior to any scientification" (p. 399). Scientific advice, however, is expected to be policy-neutral (value-neutral), i.e., to be unbiased, objective, and impartial (Rice, 2011). This neutrality is characteristic of the "best available scientific advice" for evidence-based policy-making (Nutley et al., 2007). However, science and politics often do not exist as independent entities and can be inseparable, e.g., in the blurred boundary between advocacy and science where scientific advice can carry a political bias even if it is not intentional (Lackey, 2006; Rice, 2011; Sarewitz, 2013). Advocacy by scientists is an example of the politicization of science where society benefits from experts participating in the public discourse, but these experts can place their desired policy outcomes ahead of the basic principles of sound, objective science (Singh et al., 2014; Somers, 2008). Evidence for the politicisation of science may also be seen when scientific experts are recruited into advisory roles that link their scientific authority with their support for policies or when scientific advice is considered to be influenced by the views of the funding sources (Heazle, 2004; Roqueplo, 1995).

Framing of an issue can determine how important it becomes and how worthy of attention it should be (Funtowicz & Ravetz, 1993; Kahan, 2010; Morton, Rabinovich, & Bretschneider, 2011; Renn, Klinke, & van Asselt, 2011; Weingart, 1999). However, framing of a policy problem can be value-laden as the words used in scientific advice can convey a policy preference or support a certain political agenda (Lackey, 2006). Evidence of the "scientification of politics" is seen when scientists present information to policy-makers to increase attention to the problems but then indirectly influence the political agenda by the manner in which the scientific advice is presented (Hellstrom & Jacob, 2000; Weingart, 1999). This often unintentional bias by a scientist enters the policy discourse to favour studies reporting a particular outcome (Rice, 2011).

In an attempt to be value-neutral, scientists and policy-makers often use the conservative language of the precautionary approach to determine and influence policy options for fisheries management. However, the precautionary approach conveys a vague and ambiguous message with no clear action recommended and may in effect influence a policy option to do nothing (Rosenberg, 2007). Scientists may also present contrasting advice on the same issue which leads policy-makers to focus on the conflicting elements and not on the decision-making process itself (Lackey, 2006, Sandstrom, 2010). Furthermore, scientists, as part of the modern wide policy-making community, may also be interested in the advisory process and they often do not see their roles as ending with the production of information (Jasanoff, 1994; Pielke, 2007; Scott, Rachlow, & Lackey, 2008).

Government scientists working at the science–policy interface, e.g., within ICES, on the North Atlantic fisheries observed that their science was politics-bound even without direct involvement from politics and policy-making (Pihlajamaki & Tynkkynen, 2011; Rice, 2011; Schwach et al., 2007; Wilson, 2009; Wilson & Delaney, 2005). ICES scientists inform managers about the status and consequences of management decisions, then managers choose options that best meet their preferences within limits set by scientific advice (Dankel et al., 2012; Hauge, 2011; Rice, 2011). A divide exists between science and policy-making where management does not impose its values on science; science is considered to be complete in the sense that it tells the policy-maker everything that is relevant for making a decision (Hauge, 2011). However, the rationality of this approach is questioned since fisheries management is characterized by conflicting interests, complexity, and uncertainty, and therefore challenges the policy-makers' view that science is complete. In other circumstances, scientists in professional societies often engage in aggressive efforts to bring the results of their work and the policy and management implications of results to the attention of decision-makers and to those who lobby decision-makers on the issues (Pielke, 2007).

2.6.3. Different Roles of Scientists and Policy-Makers

The divergent professional roles and different time scales of the output associated with science and policy-maker communities, present challenges for information flow across the interface (Raadgever, 2009; Tribbia & Moser, 2008). Characterizations have been assigned to the two general "sub-cultures" involved in resource management: decision-makers are action- and interest-oriented, indifferent to evidence and new ideas; while scientists are rational, objective, and open to new ideas (Caplan, 1979; Raadgever, 2009). For example, fisheries scientists are concerned with problem solving using scientific procedures that often require an extensive time series of data and publications undergo rigorous technical peer review. In contrast, policy-makers and managers need solutions to immediate problems and advice must be politically and socially acceptable. Furthermore, government-funded programs and evaluations are often based on the fiscal year or five-year planning horizons; scientific research and related reports for policy-making often cannot be completed within similar timeframes (Pal, 2009).

Communication between scientists and policy-makers, however, does not guarantee the uptake of research results into policy (Department of International Development, 2008; Dutra et al., 2011; NRC, 2002; Sullivan et al, 2006; Williams, Eiseman, Landree, & Adamson, 2009). Schwach et al. (2007) described fisheries management as "a political system with technical components operating within political constraints" (p. 802). Policy-makers have to appear to make decisions that are fair to all stakeholders, but policy choices often favour some interests more than others. Reasons are not generally provided if the political decisions deviate from the scientific advice, and such decisions are likely based on economic and social factors (Delaney, McLay, & van Densen, 2007; Rosenberg, 2007; Wilson, 2009). A former Chief Scientific Advisor to the European Commission added that even when heads of state make policies that deviate from the available scientific evidence, they should indicate their reasons, e.g., whether their decisions were based on political, social, or economic reasons ("European Science Policy on the Move," 2013).

Studies conducted by the main governmental funders of environmental research in the United Kingdom showed that scientists in agencies responsible for environmental policy and regulation needed to take a broader view of the issue at hand and be able to see the viewpoint of the policy-maker by integrating high priority constituent or client needs into their research in order to improve the likelihood that the research would be useful for making policy (Holmes & Clark, 2008). Policy-makers responded more readily to research that affects their constituents' or clients' needs and they need to be more receptive to science and provide more policy pull. Policy-makers also need to overcome being overwhelmed by the technical complexities and uncertainty of science, to avoid being unduly confident in the answer received from the scientists, and to consider all scientific and other advice and not favour results and opinions that support a preferred policy line (Holmes & Clark, 2008). Even as scientists and policy-makers attempt new communication strategies, social and economic factors can maintain the disconnect between science and policy-making.

2.6.4. Governance Structures: Institutions, Organizations, and Related Cultures

Government bureaucracy and organizational structure and culture define a patterned and persistent way for organizations to carry out tasks and maintain relationships (Gluckman, 2013, 2014; Nutley et al., 2007; Yang & Maxwell, 2011). The formal hierarchical structure of bureaucracies creates departmentalisation and centralisation which can create barriers to communication and information transfer between departments. Departmentalization promotes fragmentation in the policy-making process wherein multiple departments have responsibility for aspects of environmental policy, each with a different functional mandate. This happened in Canada after 1979 when the environment and fisheries portfolios were split into two departments and subsequently ocean policies and programs became uncoordinated and competitive (Doern & Reed, 2000). In centralization, power and authority are located at the higher management level, i.e., the “top-down” approach, which can impede knowledge sharing in a multiunit organization as evident in the various DFO administrative regions (see Chapter 4). Information use can vary at different levels of government based on jurisdictional concerns, e.g., federal and provincial interests or value systems related to economic, social, and biological aspects of fisheries management (Sandstrom, 2010).

The degree to which the fishery stock assessment process is embedded within an organization can influence the perception of scientists, policy-makers, and the fishing industry, with regard to credibility, relevance, and legitimacy of scientific advice (Alcock, 2004). Moderate levels of embeddedness may be more effective in policy-making as the processes are seen to be more transparent (Alcock, 2004). Decision-makers generally do not question the relevance or the credibility of the advice coming from assessments produced within their organizations as the advice is tailored to inform their specific policy objectives. Given the reliance on information in evidence-based policy-making, embedding more scientists within policy-making communities, for instance, those working at senior levels of government, presents opportunities to increase the communication of scientific information in the policy-making process (Jasanoff, 1994).

In governmental organizations responsible for fisheries management, the fisheries manager is often seen as the operational decision-maker who communicates information produced by scientists to the policy-analysts who are primarily responsible for providing informational inputs and policy advice to the policy-makers. Policy-makers are generally senior civil servants and politicians (Bardach, 2004; Ouimet et al., 2010). Policy-making communities are expanding to include a wide range of stakeholders groups, including civil society, and fisheries management networks can be extensive (Hartley, 2010; Hartley & Glass, 2010; Weiss et al., 2011; Runhaar & van Niewaal, 2010). Networks in policy-making consist of formal or informal links within and across government departments and external agencies; these networks enhance information generation, transmission, and use (Newman & Tanquay, 2002; Yang & Maxwell, 2011).

Boundary work or organizations seek to bridge the divide between science and policy-making and connect scientists and non-scientists, allowing the policy networks to share information efficiently and quickly (scale and time), and lead to more productive policy-making (Guston, 2001; Guston et al., 2000). The discourse and theory about boundary organizations have focused on features that facilitate the stabilizing and translating roles. For instance, boundary organizations adapt as needed to organizational norms and cultures or they can guide and shape the context of a problem and bring partners together (Clark et al., 2011). Boundary organizations are particularly beneficial because they can define the interactions between science and policy communities to facilitate co-production of science and policy (Lemos & Morehouse, 2005). Boundary organizations employ specialists, known as "interpreters," "bridgers," or "mediators" from both sides of the boundary, to broker links between advisors or policy-makers and scientists and influence salience in decision matching (Huitema & Turnhout, 2009; Petersen et al., 2005). Scientists as part of a boundary organization can play the role of science arbiter, issue advocate, or honest broker. In science arbiter discourse, scientists steer clear of political considerations but try to meet policymakers' demands for assessment and information. In the issue advocate case, science is used to steer policy in a certain direction. The honest broker role acknowledges scientific uncertainties and recognizes a broad spectrum of values, including groups with diverging values (Pielke, 2007). According to Clark et al. (2011), "boundary work may be most generally conceived of as a negotiation support process engaged in creating usable knowledge and the social order that creates and uses that knowledge" (p. 7).

2.7. Discussion and Conclusions

The literature revealed models of decision-making and information use, including four main challenges to information use at the science-policy interface. Environmental decision-making processes are defined as linear when the focus is on the use of scientific information and other information sources are not included, e.g., local knowledge. A collaborative process is characterised by the involvement of multiple actors and interactions among diverse groups and information sources. Models of information use include an ideal or linear model where information flows through defined stages towards decision-making, and a continuum model where information cycles between indirect and direct use involving two-way communication among actors.

Evidence-based policy-making provides a framework for information production, communication, and use in decision-making. The review highlighted the important role of grey literature in public policy contexts of governmental organizations. The challenges that information faces in the information pathways include: scientific uncertainty, issues related to the often paradoxical relationship between science and politics, different motivations of scientists and policy-makers to act at the interface, and the influence of organizational culture and structure. In the description of these challenges, methods were identified that may improve the use and influence of scientific information at the science-policy interface: the use of boundary work, the paradigm of "post-normal" science and new tools for measuring uncertainty, the formation of extended peer communities, adaptive management, and increased public participation. The review also highlighted the potential for the implementation of EAF to enhance communication of information at the science-policy interface, e.g., through the production of interdisciplinary information and the formation of wide peer review communities. Nevertheless, a fundamental and significant challenge facing fisheries organizations is the actual articulation of how to implement ecosystem-based approaches to fisheries management (FAO, 2012; Levin et al., 2009).

Modern policy-making involves multiple stakeholder groups and there is a need for studies to expand beyond the "two communities" perspective described in earlier models of information use (e.g., Dunn, 1980) to understand the roles and interactions of actors, i.e., individuals or organizations, other than policy-makers and scientists, e.g., industry and NGOs. A major drawback of the strategic or evidence-based approach to policy-making is its frequent inability to make timely decisions or the "right" decisions, given the technical details and inherent uncertainties in science, the implementation of EAF, and multiple stakeholder interest. Decision-makers knowingly take political risks when a decision is made, regardless of whether the decision is consistent with scientific advice or not. Consequently, there is need for further understanding of whether scientific information is comprehended by policy-makers, to further explore the reasons why scientific information may or may not be acted upon. Alternatively, there is a need to further understand how scientists are maximizing the opportunities available to them to communicate the best available scientific advice to policy-makers while minimizing or preventing science advocacy.

A need exists for more empirical evidence on the role of scientific information in policy- and decision-making, e.g., gathered through focused studies on the use of information in public policy contexts. This finding was supported by an earlier review by McNie (2007) who concluded that more research into determining the drivers for producing scientific information is needed. Case studies are needed to understand the role of information in the overall policy processes. Reiterating this point – case studies can enhance understanding of the complexities of the policy-making processes from an information use perspective. Case studies of fisheries governmental organizations producing relevant management advice may identify where and how the challenges in the information pathways influence information production and dissemination or communication, and its use by policy- and decision-makers. Information pathways can be determined from such research.

Case studies focusing on the role of scientific information in policy- and decision-making may identify the enablers and barriers to information flow at the science-policy interface, in the context of implementing the EAF. Case studies can provide evidence to confirm or modify the science-policy interface models and information use models. Associations between the types of science-policy interface model and the models of information use can also be assessed and potentially integrated. Specifically, case studies can reveal data that are relevant to the Nutley et al. (2007) and the Ascher et al. (2007) models (see Figures 2 and 3 respectively). Evidence-based policy-making is expected to display a collaborative science-policy interface (see Section 2.2) and a "continuum" model of information use (see Figure 2, p. 18). In this case, multiple actors are involved in an iterative relationship and information continuously cycles though stages of indirect use, e.g., information increases awareness on issues, to direct use, e.g., policy decisions are made. Case studies can also provide insights on information pathways, for instance, the enablers and barriers to information flow, and how information is filtered according to the needs of different groups as demonstrated in the Ascher et al. (2007) model (see Figure 3, p. 21).

The findings of this literature review guided the development of the research framework described in Chapter 3. The case studies of the Canada Department of Fisheries and Oceans (DFO), the Northwest Atlantic Fisheries Organization (NAFO), and the Food and Agriculture Organization of the United Nations (FAO) addressed some of the gaps in the knowledge identified in the literature review. The analysis of data collected in the case studies of DFO, NAFO, and FAO, presented in Chapters 4 through 6, was also guided by the current theory on the science-policy interface and information use.

CHAPTER 3. RESEARCH METHODOLOGY

3.1. Research Questions

The research sought to gain a better understanding of information use at the science-policy interface in the field of fisheries management. While the literature identified general characteristics of the science-policy interface and information use, as seen in Chapter 2, it was expected that additional components would be revealed through focused studies on the use of information. Consequently, the principal research question was deliberately broad in scope and asked: **What is the role of scientific information in policy and decision-making for fisheries management?** One goal of the research was to determine how scientific information, produced by governmental and intergovernmental organizations, does or can influence fisheries policy decisions, policy development, and management decisions. Another goal was to develop a methodology for measuring information use at the science-policy interface.

Understanding the role of information in decision-making requires an interdisciplinary approach. The research questions were addressed within the context of fisheries science and management, information management, and public policy. To address the principal research question (above), specific questions were asked within case studies of three inter-related organizations – the Canada Department of Fisheries and Oceans (DFO), the Northwest Atlantic Fisheries Organization (NAFO), and the Food and Agriculture Organization of the United Nations (FAO).

The specific questions, which were core to the research, included:

1) What are the drivers in producing, communicating, and using marine fisheries information in the organizations?
2) What are the information management strategies of the organizations, particularly with regard to production and dissemination of scientific information?
3) What are the institutional/social enablers and barriers in the organizations to scientific information use at the science/policy interface?

4) Who are the actors involved in decision-making? What are the information behaviours (e.g., information seeking, information sharing) of the various actors engaged in each organization.

3.2. Research Framework

Chapter 2 reviewed the models of the science-policy interface and information use, the key groups of actors in policy-making, and highlighted four main characteristics related to information use and influence at the interface: scientific uncertainty, issues related to the often paradoxical relationship between science and politics, different motivations of scientists and policy-makers for their action at the interface, and the influence of governance structures. Based on this review, Figure 4 presents a framework or model of the flow of information produced by fisheries governmental organizations for use in policy-making. This framework guided the research on the role of fisheries information in the three selected organizations – DFO, NAFO, and FAO.

The research framework identifies the major stakeholders involved and the potential influences in the information pathway(s) of a fisheries management organization. Data from the fishing industry enters the stock assessment process which is embedded within each government organization. Fisheries organizations operate under many external pressures and influences that affect the production of information including: policy-makers, e.g., from other ministries or organizations; multiple stakeholders, e.g., scientists from other disciplines and the public, among others; international influences, e.g., global environmental policy; media influences; and advocacy. The influence of these factors, or their "filtering" function, is seen in responses to scientific uncertainty, advocacy (used to represent the paradoxical relationship between science and politics), motivations of stakeholders (primarily scientists and policy-makers), and organizational cultures. The "filtered" information is available for decision-making and events in the decision-making process guide the production of more information. Figure 4, which is hypothetical and simply a guide, may indicate a simple, linear flow of information; however, more complex processes are expected to be involved in the policy-process.

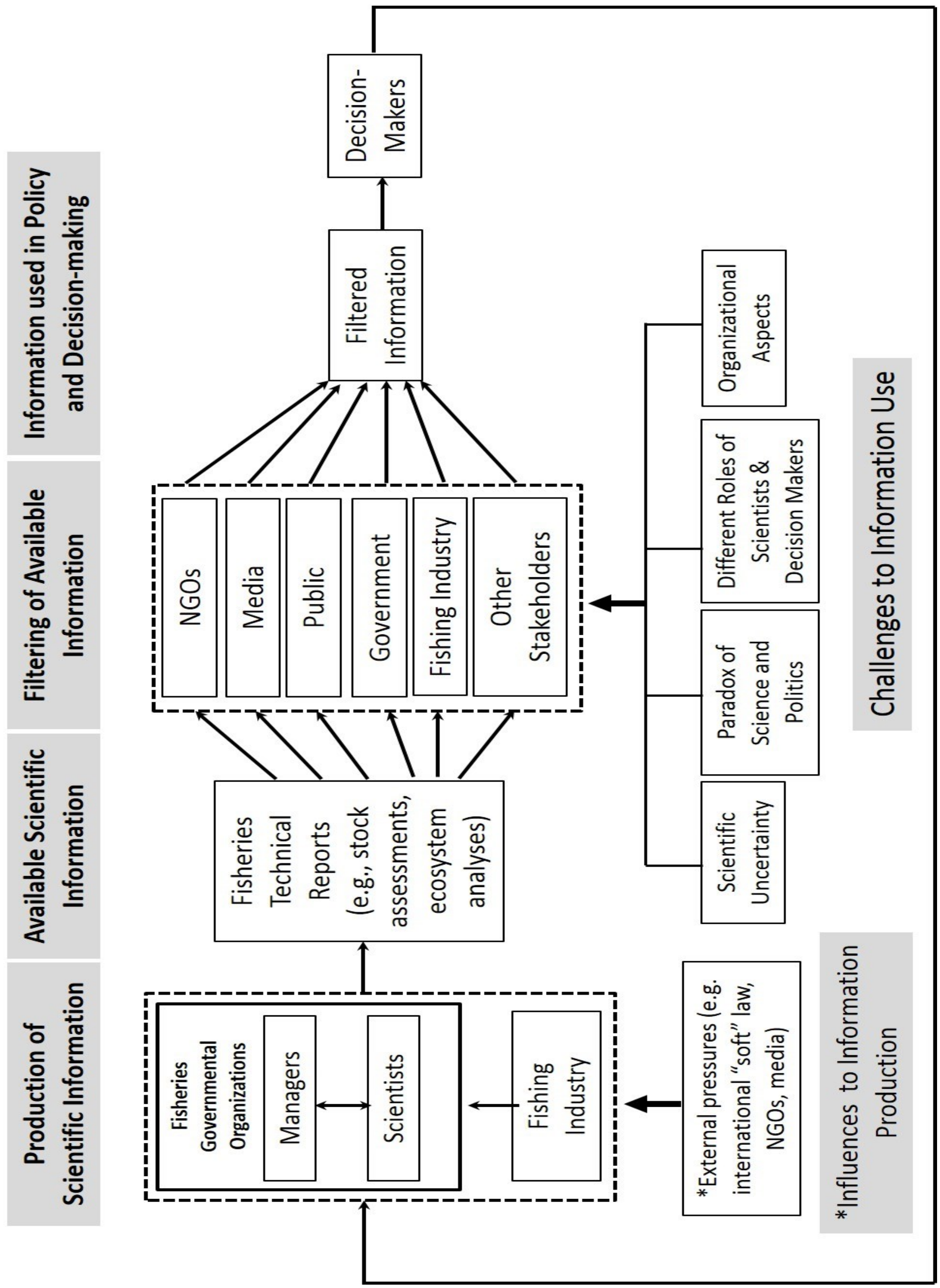

Figure 4. Guiding framework for the case study research.

3.3. Research Design

3.3.1. Case Studies and the Interdisciplinary Approach

The research studied information production, communication, and decision-making for fisheries management at three jurisdictional scales: the Canada Department of Fisheries and Oceans is a national fisheries management authority, the Northwest Atlantic Fisheries Organization is a regional, intergovernmental fisheries management body, and the Food and Agriculture Organization is a specialized agency of the United Nations (UN) with a global mandate for providing advice and policy directions for fisheries management in the UN member states, with an emphasis on developing countries. Each organization formed a unique case study based on the geographic coverage, organizational type, and historical events governing each organization. Moreover, the three organizations are interlinked in aspects of their work and the interplay among fisheries management, policy-making, and information management within DFO, NAFO and FAO was studied. The multiple case study approach facilitated comparisons and generalizations on aspects of information use across the three organizations.

The research was designed to gain an understanding of communication of information at the science-policy interface in fisheries management, taking a comparative case study approach, and using mixed, largely qualitative methods, i.e., interviews, direct observations, and content analysis (Anastas & MacDonald, 1994; Jackson, 2003; Leedy & Ormrod, 2013; Teddie & Tashakkori, 2009). The case study research design enabled the study of fisheries information use in policy-making within DFO, NAFO, and FAO for specific periods of time. The study was guided by the conceptual framework of information production and use in fisheries management (Figure 4). Mixed methods research was useful for triangulation as it provided a basis for verifying data, and supplemented data collected from the different methods; each method was selected to complement or fill in the gaps or shortcomings of another (Anastas & MacDonald, 1994; Jackson, 2003; Leedy & Ormrod, 2013). Using mixed methods for studying the science-policy interface in fisheries management was beneficial as the research questions were broad in scope.

The case studies traced information use through two lines of inquiry. In one, the focus was on process, i.e., understanding information pathways in regard to how scientific information, such as technical reports, was produced and how such information was communicated to user communities, e.g., practitioners such as managers, or policy-makers, to produce a decision or a policy output. The second approach focused on the actors and information-related behaviours, i.e., understanding how scientific information was produced and used by different actors, and how the information contained in scientific reports influenced different actors in decision-making. In this multiple case study approach, the role of information in developing policy was examined for each case study organization and then the results were integrated.

The interdisciplinary approach that was used allowed for thorough exploration of the nuances in information use in policy- and decision-making in governmental and intergovernmental organizations. For instance, with a fisheries management understanding, it was possible to follow events at technical science meetings for optimal data collection. Traditional fisheries management and the implementation of EAF involve complex technical issues that were discussed within the organizations. Within the context of public policy, insights on organizational cultures at different levels of government and within different types of organizations were critical in studying the roles of multiple stakeholders and determining how policies and other decisions are reached. An information management perspective was needed to understand the production, use, and influence of information, to examine and understand how information is produced by scientists and used by decision-makers, and how it reaches stakeholders.

3.4. Data Collection

Data collection was conducted in 2013 and 2014, using three qualitative methods: interviews using a semi-structured questionnaire, largely consisting of open-ended questions; direct observations at scientific and advisory meetings in the organizations; and content analysis of key publications, e.g., scientific and management reports and policies. The data collection occurred during separate three-month internships with DFO, NAFO, and FAO. The scheduling of the internships and selection of data collection events were largely opportunistic and were generally based on the timing of meetings and other scheduled events in the three organizations (Teddie & Tashakkori, 2009). These internships were formalised with assistance from a key contact person within each organization. Research ethics approval was granted by Dalhousie University's Social Sciences & Humanities Research Ethics Board before conducting interviews and direct observations of scientists, managers, and policy-makers (Appendix 1). Participation in the research was voluntary and potential respondents were invited to participate in the research through informed consent, while being assured that their responses would be used only for this research (Appendix 2).

The fisheries management units in the three organizations are small so to ensure a rich body of data for analysis, the case studies examined the role of general marine fisheries information and assessment reports of fish stocks and marine ecosystems. Details of the data collection within each organization are provided in the relevant chapters. Table 2 summarises the methods employed for the research (see p. 48).

3.4.1. Interviews

Semi-structured interviews of fisheries scientists and decision-makers consisted of a series of open-ended questions to obtain information in four areas: the pathways that technical reports take; drivers in the production of scientific information; enablers and barriers to information uptake in policy-making; and the information management strategies or practices used to increase awareness and use of technical reports in policy-making. The questions asked of scientists and decision-making groups, including program managers, advisors, and policy-makers in DFO, NAFO, and FAO, are given in Appendices 3 and 4 respectively.

Invitations were sent by email to key persons involved in the production of science advice and management decisions and identified from the respective organizational staff mailing lists and from content analysis of meeting reports. Snowball sampling was also utilised where some participants identified other individuals in the three organizations who were then included in the study. Snowballing also identified individuals who worked in the area of interest within the organization and staff who had recently retired. The focal point contact within each organization facilitated the identification of some contacts in some instances and introductions to them.

Interview respondents represented the key actors in the information production and the policy-making processes within each organization, i.e., scientists, program managers, advisors, and senior decision-makers or policy-makers. Apart from these respondents, conversations were held with other staff, including the retired staff producing data not included in the detailed analysis, although in some instances it guided the interpretation of results. The key respondents were interviewed within the three-month period of each internship and only by the researcher to ensure their anonymity.

Open-ended questions provided the opportunity to probe or ask follow-up questions to yield additional information. The questionnaire for each group, e.g., scientists and decision-makers, contained common core questions for comparison across the groups, as well as questions based on issues unique to each group. Each interview was scheduled to run for 45 minutes but due to the schedules of the respondents, they ranged from 20 to 90 minutes (average = 46 minutes). Interviews were either audio recorded or notes were taken and responses were later transcribed and coded for analysis.

3.4.2. Direct Observations

Direct observations were made at meetings of policy-makers, fisheries managers, and scientists of the fisheries organizations and other planned events where there was interaction between decision-makers and the science community. At such meetings, the interaction among the groups was observed with regard to communication related to information sources used by each group. This included which group(s) consulted each other during the deliberations, concerns with the content of scientific publications, participants’ perceptions regarding their role and the role of other participating groups in fisheries management and information use, and other relevant events that developed during the meetings.

Within most fisheries management organizations, scientific meetings and policy meetings were often scheduled as separate events. At scientific meetings, discussions during technical presentations provided insights on: (1) challenges to communicating science among other science groups as well as policy-making groups; (2) participants' perceptions regarding their role and the role of other participating groups in fisheries management and information use; and (3) the quality of the information, i.e., confidence in the data/information and advice. At meetings that involved management and policy groups, insights were obtained on: (1) information needs of managers and the management priorities; (2) managers' and decision-makers' perceptions of scientific information; and (3) the key contacts and the information sources for decision-making communities.

A protocol for the direct observations was developed (Appendix 5). While the protocol covered aspects of the events that were observed, the observational research was generally opportunistic, i.e., the focus of observations was adapted according to the event (Anastas & MacDonald, 1994). Direct observations complemented the data collected in the interviews of scientists and managers and also corroborated some of the responses obtained in the interviews. Detailed notes of observations were made during the organizational meetings and these were later transcribed and coded for content analysis.

3.4.3. Content Analysis

In the content analysis, key publications by scientists and decision-making communities within each organization were read for the appearance of particular words or content that indicated information production, communication, and use. For instance, the content of management plans was examined for direct reference to the particular scientific reports or inferred references to the use of science. For inferred references, the occurrence of related words such as "advice," "evidence," "research," or "decision-making" were noted. Most of the publications were available on the organizations' websites and additional internal documents were provided by some respondents and other staff of the case study organizations. Content analysis of attendance records of meetings held by each organization identified the actors involved in the policy process. Content analysis was also performed on the textual data collected from interviews and direct observations.

3.4.4. Internships

The three-month internships within each organization ensured a physical presence and facilitated the scheduling of interviews and attendance at relevant meetings. The internships also facilitated access to publications that were not posted on the institutional websites or were available in the library databases of the organizations, and were used for content analysis. In the internships, considerable time and effort was invested in increasing awareness of the research to gain the trust of the staff of each organization. As the level of trust increased, the staff became more willing to agree to be interviewed and to provide access to meetings. Gaining the trust of the staff resulted in "snowballing" or opening up of opportunities for additional data collection within the organizations. For instance, invitations to attend internal meetings or social events resulted in introductions to individuals from the science and management communities.

The arrangement of the internships was opportunistic and was related to the scheduling of the main organizational meetings at which direct observations were conducted. A summary of the data collection in the internships in DFO, NAFO, and FAO is provided here and details are available in the corresponding chapters (Chapters 4 through 6). Overall, 78 interviews of key actors in information production and decision-making were completed, and observations were made at 15 science and management meetings. These meetings included events with formal agendas and ranged from two hours or one day, to events that were scheduled for one to two weeks.

While the staff in each organization was informed of the subject of the research in the consent letter that invited their participation, in general, they still did not recognize the role of information in their activities. The respondents usually did not describe their work in terms of the production, communication, and use of information. Instead, they spoke in detail about their activities, which implicitly described their roles in the information pathways. This perspective with regard to their work was illustrated by one respondent who said: "I don't think at all from the information point of view" (FAO 15). Use of semi-structured and open-ended questions overcame this limitation as the interviewees were asked to focus their responses on specific publications or information that they worked with or they were asked to speak freely about their role in fisheries management.

While the analysis in this research focused on data obtained from the recorded interviews and direct observations, informal discussions with numerous staff members and daily observations of routine operations provided guidance for the data collection and analysis, and offered insights on the organizational cultures. These insights included: administrative details such as the scientists' and managers' agendas that assisted with the scheduling of interviews and direct observations, details on the social milieu in the organization that were informative for analysis, and the data collected.

An internship with NAFO progressed from September to December 2013 during which time data was collected while based in the NAFO Secretariat in Dartmouth, Nova Scotia. Official Observer status at NAFO was obtained in September 2013, allowing attendance at meetings of the Scientific Council and the Fisheries Commission for direct observation (EIUI, 2015). Nineteen interviews of DFO scientists and managers participating in NAFO events were conducted and three science and management meetings were observed, including the 35th NAFO annual meeting, the 6th Meeting of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WGESA), and the 1st NAFO Scientific Council-Fisheries Commission Working Group on Risk-based Management Strategies (WGRBMS).

An internship with DFO occurred from January through April 2014 while based in Marine House, DFO-Maritimes Region (DFO-MR). Direct observations were conducted at eight meetings and included the Canadian Science Advisory Secretariat Regional Peer Review meetings, fisheries advisory committee annual meetings, and interdepartmental meetings. Twenty-six interviews were conducted and included scientists, fisheries managers, and policy advisors working in the DFO-MR and selected policy-makers and senior policy advisors based in DFO-National Capital Region (DFO-NCR) in Ottawa.

An internship at FAO headquarters in Rome was completed from May to July 2014. Thirty-three interviews of staff of the Fisheries and Aquaculture Department were conducted and included technical experts in fisheries science, policy, and economics acting as advisors. Direct observations at four meetings of the Department were completed and included the 31st session of the Committee on Fisheries; a workshop on the development of a global Vulnerable Marine Ecosystems (VME) database; a planning workshop for partners of a global fisheries project (ABNJ Deep Seas Project), and an internal meeting to discuss the global implementation of the small-scale fisheries guidelines (FAO, 2014w).

Table 2. Summary of methods used to measure awareness and use of an organization's publications.

METHOD	INFORMATION PATHWAYS AND USE
Interviews using semi-structured questionnaires	Semi-structured interviews used questionnaires and follow-up questions to analyse the production, communication, and use of scientific information in policy-making (see Appendices 3 and 4 for the interview protocol for scientists and decision-makers)
	Identifies the associated activities and collaboration of different groups of actors, e.g., managers, policy- makers, and scientists, including other stakeholders, in the stages of information use, e.g., in the "chain of utilisation" and "pipeline model" of research use
	Provides examples of indirect and direct use of scientific information, e.g., publications read, understood, and decisions based on research
	Reveals how the characteristics of the science-policy-interface and the models of information use (see Chapter 2) are relevant in the case study organizations
	Highlights the information-seeking behaviours of various actors and relationships in knowledge networks
Direct observations at meetings of the science and decision-making communities	Reveals the actors at various stages of research utilization, the preferred information sources used in decision-making, why relevant information sources are not used in decision-making
	Provides evidence of scientists' understanding of policy-making processes; and how scientists communicate with managers.
	Reveals how policy-makers regard scientific information and their information needs, and how information is used in decision-making
	Reveals perceptions of "use" of information by different groups
Content analysis of organizational publications	Identifies information pathways, i.e., production, communication, and use of information, and actors
	Reveals indirect use, e.g., advice changed an actor's "frame of reference"; and direct influence, e.g., research findings were used in decisions

3.5. Data Analysis and Presentation of Results

All of the qualitative data from the interviews and direct observations of science and decision-making meetings were manually coded in Microsoft Word files. Coding was used to prepare the qualitative data for analysis; attaching codes to textual data enabled a rigorous review of the data (Coffey & Atkinson, 1996; Kondracki, Wellman, & Amundson, 2002). A framework was applied in the coding of the data to focus on broad themes under the four core characteristics of the science-policy interface, namely, organizational structure and culture, science and politics (advocacy), scientific uncertainty, and the role of scientists and policy-makers (see Chapter 2). Codes or themes based on the characteristics of the interface and information use were assigned to the textual data collected from the interviews and direct observations. The data obtained from content analysis of the organizations' publications were used primarily to verify or supplement data obtained from the interviews and direct observations, e.g., the descriptions of the processes involved in information production, communication, and use.

The data analysis of interviews began by reading the text of each interview repeatedly to obtain a sense of the whole, bearing in mind the main characteristics of the science-policy interface and models of information use, to capture additional themes or concepts. With each reading of the text, themes became more defined and exact words and phrases from the text were highlighted in the Word files to support the defined themes. Labels or codes were assigned to the identified themes and came directly from the textual data or from the theory on the science policy interface and information use. The coding was revised up to three times, going back and forth between the textual data and the codes, to produce a complete and concise scheme. The coding of the anonymized interview transcripts was validated by an independent qualitative researcher to reduce any biases in the data analysis.

The themes or codes were then sorted and grouped to develop broad coding categories and sub-categories. The codes or themes were further categorised into the main drivers and barriers to information production, communication, and use. The codes or themes are presented for each organization as tables describing the information pathway(s), and the drivers, enablers, and barriers in the pathway(s). The main themes that emerged from the coding were ranked based on the number of interviewees who identified a theme.

Figure 5 illustrates the work flow for this case study research: the use of the interview and direct observation protocols in three case study organization with different organizational structure; different levels of decision-making, i.e., national, regional, and international; and different mandates provided an opportunity to compare the information pathways in the three organizations. The use of this standard methodology in each organization provided robustness to the research methodology.

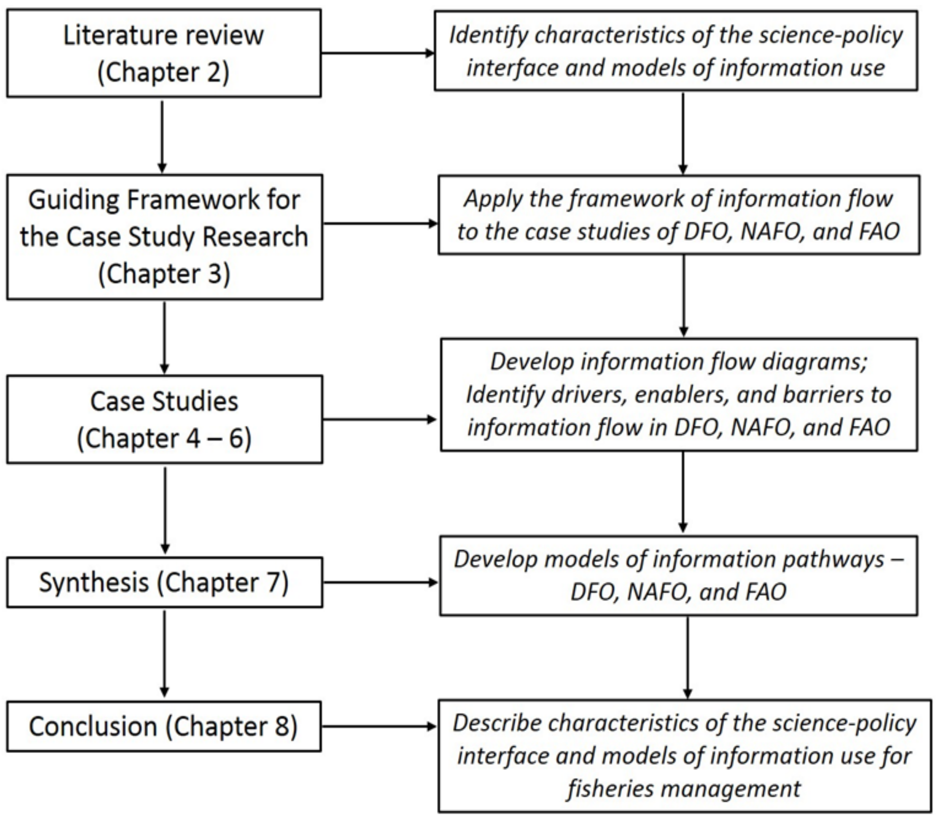

Figure 5. Work flow of the case study research on understanding the information pathways – production, communication, and use – in fisheries management organizations.

The results of the case studies of DFO, NAFO, and FAO are presented in Chapters 4 to 6 respectively. Each chapter contains a brief description of the respective organizational structure and mandate as well as the social and political milieu in the organization at the time of the study (September 2013 – July 2014). This background provided the context needed to understand, interpret, and analyse the data collected from the interviews and direct observations. Using a semi-structured questionnaire allowed the interviewees to speak freely about the information pathways. Consequently, interviewees described a range of activities and events that were specific to their role in their organization. Similarly, the protocol used for the direct observations was semi-structured. Different subjects were discussed at each meeting at which direct observations were conducted.

A description of the information pathway(s) in each organization is provided and includes details on how information is produced by the organization, e.g., the request and provision of advice, the information products, how these products are communicated, and how they are used by different audiences. A schematic diagram of the information pathway(s) for the case study organizations was developed. The main drivers, enablers, and barriers to information production, communication, and use, identified from the coding, are described for each case.

Descriptive statistics were used to analyse the case study results. In each organization, the main enablers and barriers were ranked based on the number of interviewees who identified specific drivers, enablers, and barriers in their descriptions of information production, communication, and use. Summary tables of the main drivers, enablers, and barriers in the communication pathways in each organization are included for each case study. These summary tables include details on the sub-themes that comprise the main themes. These sub-themes are not ranked.

A synthesis of the results of the three case studies of fisheries organizations is presented in Chapter 7. The results are compared and discussed in the context of the literature review on the science-policy interface and information use (see Chapter 2). Trade-offs in the attributes of information, i.e., credibility, relevance, and legitimacy, at the science-policy interface for fisheries management are also described. Characteristics of the interface and a typology of use were developed. Chapter 8 presents the main conclusions with regard to the role of information in decision-making and general recommendations for future work.

CHAPTER 4. CASE STUDY OF THE CANADA DEPARTMENT OF FISHERIES AND OCEANS (DFO)

4.1. Background

4.1.1. Organizational Context and Mandate

The Canada Department of Fisheries and Oceans (DFO) is the lead federal agency responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social, and economic interests in its oceans and fresh waters (DFO, 2014k). The department's headquarters, DFO-National Capital Region (DFO-NCR), is located in Ottawa. The case study focused on the DFO-Maritimes Region (DFO-MR), headquartered in Dartmouth, Nova Scotia, and the largest and most diverse of DFO's six administrative regions. DFO-MR is responsible for the Atlantic area extending from the northern tip of Cape Breton to the New Brunswick-Maine border (DFO, 2014e). In 2012, fisheries in the DFO-MR accounted for 39% of the total Canadian landed value estimated at $757 million (DFO, 2014e).

The department fulfills its mandate through production of scientific advice and management streamlined under four main Branches or Sectors: Ecosystem Management, Fisheries Management, Policy and Economics, and Science. The Regional Director-General in the DFO-Maritimes Region oversees the regional science and management programs carried out by scientists and managers respectively working at different sites including field and area offices throughout the Maritimes Region. The Regional Director General (Maritimes Region) reports to the Deputy Minister's Office in the DFO-NCR. As a federal department, following the Westminster-based system of government, the political representative in Parliament is the Minister of Fisheries and Oceans (Aucoin, Smith, & Dinsdale, 2004).

4.1.2. Provision of Scientific Advice for Fisheries and Ocean Management

The DFO Science sector is responsible for the provision of advice in broad areas of science, engineering, and technology to inform policy, regulatory, and management decision-making (Government of Canada, 2000). The Canadian Science Advisory Secretariat (CSAS), through its regional offices, administers and coordinates the internal science reviews and provision of scientific advice to management on behalf of the DFO Science sector (DFO, 2014c, 2014l). On an annual basis, CSAS requests scientific advice from the various program areas of DFO, e.g., fisheries, fish habitat, species at risk, and oceans. The Departmental Senior Management Committee reviews the CSAS schedule prior to the start of each fiscal year and requests for advice are prioritized according to issues of national, zonal, and regional interest. The annual requests for scientific advice from the management sectors inform the work planning of the Science sector (Curran et al., 2012).

The CSAS Regional Advisory Process (RAP) includes a regional review process of scientific advice involving DFO scientists and managers; industry and non-government organizations are invited to participate (Canadian Science Advisory Secretariat [CSAS], 2014). Four types of publications are produced from this internal review process and are referred to as "peer-reviewed" information in DFO: a Science Advisory Report (SAR) containing scientific advice achieved through consensus at a review meeting; a Research Document, e.g., detailed scientific studies and analyses on stocks, ecosystems, and habitats; a Science Response with scientific advice for urgent and unforeseen meetings; and Proceedings of meetings (DFO, 2014c). Periodically, the fish stock assessment model being used and the assessment process are internally reviewed and modified in framework meetings.

The DFO Management sector includes the Fisheries Management Branch and the Ecosystem Management Branch. The Fisheries Management Branch is composed of sub-units and provides advice on the allocation of fisheries resources; develops regulations and licensing of fisheries operations; provides conservation, protection, and enforcement of fishing activities; develops regional Aboriginal fisheries agreements, and provides assessment and experimental harvesting of potential underutilized commercial species (DFO, 2014i). DFO's Ecosystem Management Branch fulfills the Department mandate in leading initiatives in integrated management of ocean resources, including the development of management plans, designation of marine protected areas, and the establishment of marine environmental quality standards, including monitoring aquatic species at risk and fish habitat (DFO, 2014d, 2014g, 2014n).

4.1.3. Policy Framework for Decision-Making

DFO was established by an Act of Parliament in 1979. The department is guided by five key pieces of legislation for management of marine resources – chief among these are the Fisheries Act of 1867 and the 1997 Oceans Act (DFO, 2014e). The Fisheries Act provides the legislative framework governing fisheries management and conservation and it was last revised in 1991. The Oceans Act is the basis for marine ecosystem considerations including the impacts of human activities in ocean management and it was enacted in response to numerous international initiatives, e.g., the 1992 UNCED Agenda 21 and the 1995 FAO Code of Conduct (Curran et al., 2012; FAO, 1995; UN, 1992). Since, the release of the Oceans Act, DFO has focused on operationalizing the ecosystem approach to fisheries management (Curran et al., 2012; O'Boyle & Jamieson, 2006).

Developed under the Oceans Act, the 2009 Sustainable Fisheries Framework established the policy basis for implementing the EAF (DFO, 2009b). The DFO-NCR is responsible for the continued elaboration of policies under the Sustainable Fisheries Framework and encourages their implementation by the various DFO regions. Several key habitat-related policies have been developed under the Sustainable Fisheries Framework including: a Fishery Decision-Making Framework Incorporating the Precautionary Approach (the Precautionary Approach policy), the Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas (covering bycatch of benthic organisms, e.g., corals, sponges, and marine plants), and the policy on Forage Species (DFO, 2009a, 2009b). Under this Framework, attention has also been given to the use of more ecologically-friendly fishing practices leading to the release of a National Policy on Managing Bycatch in April 2013 for the management of retained and targeted catch (DFO, 2013b, 2013c).

DFO defines a decision-maker as anyone with the authority to make decisions in the federal government and typically involves ministers and deputy ministers, but may also include assistant deputy ministers, directors general, and other senior officials (Government of Canada, 2000). A policy advisor engages in the formulation and provision of policy advice and includes policy analysts/advisors who work at the interface between those who contribute advice, and senior managers or decision-makers (Government of Canada, 2000). DFO defines a scientist as an employee having expert knowledge of, and typically engaged in the conduct of, science on behalf of the federal government (Government of Canada, 2000). A science advisor engages in the formulation and provision of scientific advice and is often a scientist. More specifically, the role of the DFO fisheries scientist is to provide fisheries advice to fisheries managers and decision-makers to inform decisions on sustainable harvest levels and relevant international negotiations. The ecosystem scientist provides comprehensive ecosystem advice about how human activities may interact with other activities in aquatic ecosystems, taking into account major environmental drivers such as climate change (Curran et al., 2012).

4.1.4. Social and Political Milieu in DFO in 2014

Historically, DFO in this region has made significant contributions to increased awareness and understanding of the Atlantic and Arctic Oceans over 36 years and has advanced knowledge of the field of oceanography through work conducted at the Bedford Institute of Oceanography (BIO), Canada's premier marine research facility (Nettleship, Gordon, Lewis, & Latremouille, 2014). In the 1990s and early 2000s, DFO's focus moved from exploratory research to research about environmental regime shifts evident from patterns in historical environmental data (Nettleship et al., 2014). Now, the focus is on the ecological implications of the patterns in observed regime shifts, e.g., the impacts of ocean acidification (DFO staff personal communication, February 2014). Like other governmental organizations, DFO's attention was drawn to areas where resources were available, i.e., research money, time, and personnel, including a rich field of scientific knowledge and theory. Austerity measures, both recent and historical, have likely affected the conduct of work in the DFO Science sector. The changing focus over time, including departmental centralization and reduction in funds and staff, have resulted in significant changes in the production of scientific information in DFO.

Austerity measures as a typical government response to financial pressures are a global phenomenon and not unique to Canada. However, Canadian scientists, in particular, claim that the government funding constraints are an extension of positions taken by the Conservative federal government since 2006 that threaten the freedom of expression by government-based Canadian scientists as well as the capacity to conduct public service science (Pedwell, 2012; Turner, 2014; Wells, 2013a). Following the 2012 federal government budget that outlined plans to save $5.2 billion in departmental spending over three years, DFO saw the loss of public service jobs and cutbacks of key components of the government's marine science and ocean information resources (DFO, 2014f, 2014m). Within DFO, seven of its eleven libraries were closed based on claims that few people from outside the department used the libraries and the majority of users preferred to access the electronic collections (Canadian Library Association [CLA], 2014; Government of Canada, 2012; Sharp, 2014; Wells, 2014, 2013a, 2013b). Public concern and protest over the significant reduction of DFO's library collections including historical information that are mainly in grey literature as internal reports was high (e.g., Hoag, 2012; Owens, 2014). More difficult access is also anticipated by scientists, program managers, policy-makers, the Canadian public, and other users to the remaining materials (Wells, 2014). Another significant recent development was the transfer of and management of the department's Experimental Lakes Area research station, responsible for long-term environmental monitoring, to a non-governmental operator.

While the events in DFO (described above), among others, attracted considerable national attention, the implications related to communication of information were particularly concerning to science communities and the general public leading to claims of a "war on science" regarding the government's seeming disregard for science under the guise of reducing the national deficit (Turner, 2014). The debate on the role of government scientists as researchers and advisors has also been ongoing (Rennie & Leach, 2015). The government's position is that scientists, as public servants, must limit their communication to their role as advisors on policy; however, others argue that the public interest is best served if scientists can also speak freely about their research.

The 2012 strategic and budget review also saw the federal government change legislation and programs within DFO, purportedly to optimize operations (DFO, 2014f). The Fisheries Act was amended and changes were made to the habitat protection provisions of the Act resulting in the restructuring of the DFO Habitat Division to form the Fish Protection Program. All habitat biologist positions were eliminated in this process. These changes were viewed as having potential negative consequences on the implementation of the EAF and in conservation of biodiversity (Hutchings & Post, 2013). In another cost reduction activity, plans are in place to consolidate the Science and Management sectors of DFO-MR in one physical location – the Bedford Institute of Oceanography. The Science Branch and the Ecosystem Management Branch are based at the BIO, the Regional Director of Science being its Director. The DFO-MR headquarters of the Fisheries and Aquaculture Management Branch and the Policy and Economics Branch are located at Marine House, Dartmouth (circa April 2014).

The core structure of DFO's scientific advice mechanism has evolved over the years. The precursor to the current CSAS process was the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), formed with the extension of Canada's marine jurisdiction in 1978 and disbanded in 1992 after the collapse of the cod fishery (DFO staff, personal communication, February 2014). CAFSAC focused on single species fish stock assessments and comprised DFO experts only. The accepted stock assessments were passed to the CAFSAC Steering Committee which prepared the advice and delivered it to the minister (DFO staff, personal communication, February 2014). The CSAS is responsible for all of DFO's peer review provision of scientific advice and the process is more inclusive, being comprised of DFO experts and non-government experts from the fishing industry, academic institutions, aboriginal groups, and environmental non-governmental organizations (NGOs).

4.2. Methodology

4.2.1. Data Collection and Analysis

Data for the case study were collected from January to April 2014 while based in the Resource Management Division of the Fisheries Management Branch of DFO-MR. Fisheries managers in the Fisheries Management Branch (including managers, directors, and senior advisors), ocean and coastal managers in the Ecosystem Management Branch (including biologists), and scientists in the Science Branch (including fisheries, ecosystem, and ocean scientists) were invited to participate in the research and to be interviewed. Managers and scientists in the region communicated with their counterparts in the DFO-NCR who were also invited to participate. Table 3 shows the branches and sectors in the DFO that participated in the research. Conversations with DFO staff in the various branches or sectors highlighted some of the general issues described in the social and political milieu in the organization (Section 4.1.4) and guided the interpretation of the direct observations. These conversations were not recorded as formal interviews.

Table 3. Data collection in the Canada Department of Fisheries and Oceans (DFO).

DEPARTMENT OF FISHERIES AND OCEANS (DFO)	**INTERVIEWS**	
	Scientists	**Managers**
MARITIMES REGION (DFO-MR)		
Regional Director General's Office		1
Science Branch	6	
Fisheries Management Branch		11
Ecosystem Management Branch		6
Policy and Economics Branch, Communications Branch; and Cooperative Services	Informal conversations	
NATIONAL CAPITAL REGION (DFO-NCR)		
Office of the Assistant Deputy Minister, Ecosystems and Oceans Science Sector	1	
Office of the Assistant Deputy Minister, Ecosystems and Fisheries Management Sector		1
Total	**7**	**19**

As described in Chapter 3, the aim of the interviews and direct observations of meetings was to gain an understanding of:

- How scientific advice related to fisheries and their management is produced (including processes and actors);
- How this available scientific advice is being used in DFO for decision-making; and
- The drivers, enablers, and the barriers to information flows, i.e., in production, communication, and use of scientific information in decision-making.

4.2.1.1. Interviews

Twenty-six interviews were conducted with twenty-four respondents from the DFO-MR and two from DFO-NCR (Table 3). Seven respondents were scientists of which six work in the DFO-MR Science Branch (Population Ecology, Ecosystem Research, and Ocean and Ecosystem Sciences Divisions) and were based at the Bedford Institute of Oceanography and one scientist was based in the DFO-NCR (Ecosystems and Ocean Sciences Sector). Nineteen respondents were managers including eleven fisheries managers (managers, directors, senior advisors) with the Fisheries Management Branch (Resource Management, Aboriginal Affairs Division) and seven ocean and coastal managers with Ecosystem Management Branch (Ocean and Coastal Management Division and the Fisheries Protection Program).

Face-to-face interviews were conducted for respondents based in the Maritimes Region and by telephone for the respondents in the DFO-NCR. Interviews were scheduled for forty-five minutes, however, they ranged from 20 to 90 minutes (average = 49 minutes). Interviews were audio-recorded when permitted; otherwise, notes were taken, and all the responses were treated with strict confidentiality. The protocols used for the interviews of scientists and managers are given in Appendix 3 and Appendix 4.

4.2.1.2. Direct Observations

Direct observations were conducted at eight meetings in the DFO-MR and included three CSAS Regional Peer Review meetings, two fisheries advisory committees annual meetings, and three inter-departmental meetings as follows:

1. Assessment of the Nova Scotia (4VWX) Snow Crab Fishery (DFO Direct Observation 1; DFO, 2014b);
2. Assessment of Scallop Fishing Area (SFA) 29 (Direct Observation 2; DFO, 2013a);
3. Science Peer Review Process to update the offshore Ecologically and Biologically Significant Areas (EBSAs) in the Scotian Shelf Bioregion (DFO Direct Observation 3; DFO, 2014j);
4. Hagfish Fisheries Advisory Committee (DFO Direct Observation 4);
5. Eastern Scotian Shelf Shrimp Advisory Committee (ESSSAC) (DFO Direct Observation 5);

6. A meeting between the Population Ecology Division of Science and the Resource Management Division to discuss data requirements for managing the hagfish fishery (DFO Direct Observation 6);
7. A meeting of the Science, Fisheries and Aquaculture, Policy and Economics branches to discuss climate change considerations in fisheries management (DFO Direct Observation 7);
8. A meeting between the Policy and Economics, and the Oceans and Coastal Management branches to discuss data sharing related to climate change adaptation initiatives (DFO Direct Observation 8).

For direct observations, active participation in the meeting discussions did not occur and only notes were taken of presentations, discussions, and interactions among groups at the meetings. The protocols used for direct observations at science and management meetings are given in Appendix 5.

The scientific review of the annual assessment and harvest level projections in support of the 2014 snow crab and the scallop fisheries and the preparation of the text of the Science Advisory Reports were observed in the two one-day CSAS meetings (DFO Direct Observation 1 and 2). The four-day CSAS meeting on EBSAs reviewed a research document containing scientific advice to identify potential EBSAs to inform broader marine planning and management initiatives (DFO Direct Observation 3). The peer review meetings (DFO Direct Observation 1, 2, and 3) were attended by scientists and managers from the Science, Fisheries Management, and Ecosystem Management branches and policy analysts from the Policy and Economics Branch, along with provincial government, industry and aboriginal groups, and other invited reviewers. At the respective half-day fisheries advisory committee meetings (DFO Direct Observation 4 and 5), observations were based on how the scientific advice developed in the CSAS process and how the management response were communicated to DFO Science and Resource Management, and the fishing industry. Attendance at the three two-hour internal meetings (DFO Direct Observation 6, 7, and 8) provided an opportunity to observe the interactions among the different sectors in the DFO-MR.

4.2.1.3. Data Analysis

The interview responses and notes of direct observations were transcribed into Microsoft Word files for data analysis. Interview responses and direct observations were coded using themes based on characteristics of the science-policy interface identified from the literature presented in Chapter 2. Details of the methodology for coding are described in Chapter 3.

The results based on the interview responses, direct observations, and content analysis of DFO's publications are presented in the following section. These results include description of information pathways to explain the process of producing, communicating, and using scientific information; drivers for producing information; enablers for promoting information flow; and the barriers to information flow and information use in decision-making. Direct quotations from the interviews were used to illustrate the research findings and are referenced as DFO 1 through 26. The direct observations are referenced according to the numbering of the events listed above, i.e., DFO Direct Observation 1 through 8.

4.3. Results

4.3.1. Information Flow – Production, Communication, and Use of Scientific Advice

The flow of information in DFO, primarily from the perspective of the information produced in the CSAS peer review process is shown in Figure 6. Details on the characteristics of the requests for scientific advice, how that advice is prepared and communicated, and how it is used are provided in this section. The actors involved in the process, including their motivations, are also described. Table 4 contains a summary of the characteristics of the information pathways in DFO (see p. 74).

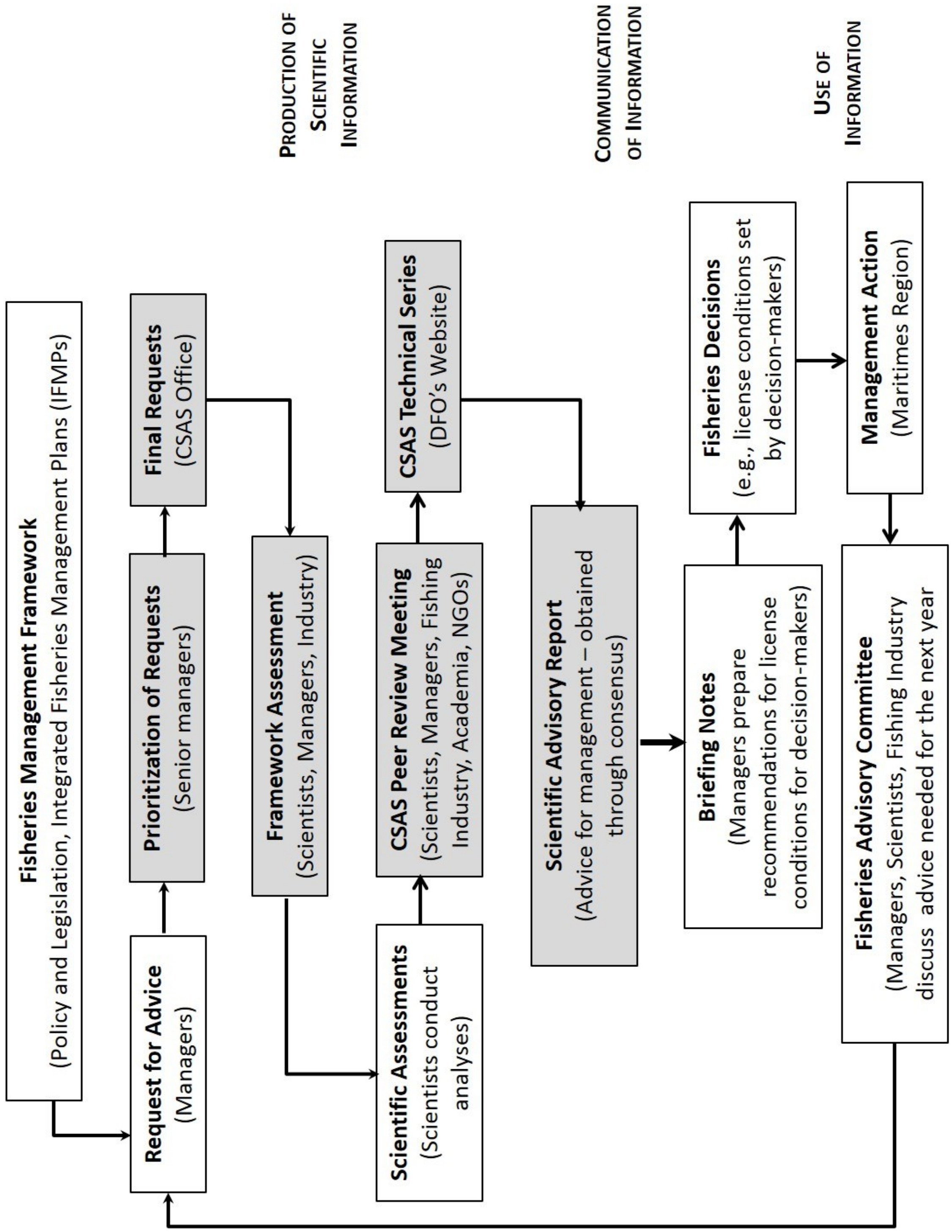

Figure 6. Scientific information flow in the Canada Department of Fisheries and Oceans related to the Canadian Science Advisory Secretariat (CSAS).
(The shaded boxes indicate the formal stages coordinated by CSAS.)

4.3.1.1. Actors

DFO "managers" include fisheries managers and ocean managers who work at different management levels and different decision-making levels. In the Resource Management Division, fisheries managers, known as senior advisors, receive scientific advice from the CSAS process and prepare the management advice which is communicated in a briefing note forwarded to three senior management levels including a division Manager, Director, and a Regional Director, before reaching the Regional Director General for approval of the management strategy for the fishery. In the Ecosystem Management Branch, ocean managers typically are educated in science and are appointed as "Biologists" and integrate science and fisheries management in their provision of management advice on ocean management. DFO refers to personnel classified as senior and junior biologists, and research scientists in the Science Branch as "scientists" as they conduct fisheries assessments, ecosystem research, or are involved in ongoing, related physical and oceanographic monitoring programs. The participants in this study had worked at DFO between 10 and 39 years.

The provision of scientific information, while primarily the responsibility of the scientists, involved a wider group of individuals, including DFO science and management sectors, the fishing industry, academic institutions, and NGOs as seen at the CSAS science peer review meetings (DFO Direct Observation 1 through 3). DFO scientists stated that faculty at universities now play an important role as reviewers for the DFO-MR, given easy access to academics at the many universities in the region (DFO 2). The fishing industry also played a role in data collection as commercial vessels are contracted to DFO for the sampling surveys and the industry worked closely with the DFO Science sector in this regard.

DFO policy-makers and managers play different roles in decision-making. Strategic decision-making is carried out in Ottawa while more tactical or operational decision-making is conducted in the regions. One manager stated that "probably 90% of strategy is done in national headquarters and about 80% of tactics gets done in the regions" (DFO 12). This manager also stated that policy-makers decide on the strategy used to manage a resource; for instance, they may decide on the biomass levels or limit reference points of fishing effort (F) in relation to the maximum sustainable yield (MSY) at which a fishery should be managed, e.g., fish at F_{MSY} or F0.1 for a single species or using ecosystem interactions, fish at 0.75 of F_{MSY} of one species and at 0.9 of F_{MSY} on another species (DFO 12). Such deliberations on levels of fishing effort are considered a policy decision as it takes into account the social and economic consequences as well as the impacts on the resource (DFO 12). Then managers in the DFO-MR make tactical decisions to implement the strategy that was decided by the policy-makers. Tactical decisions have to be made every year and include decisions on the quota and the opening and closing dates for a fishery, for example. The development of national policies is led by a policy group in the DFO-NCR which engages science, the regions, and consults with the public (DFO 25).

Managers stated that scientists "have a fair degree of flexibility to work on things of which they choose – but they must be within the governmental or departmental mandate" (DFO 10). Research scientists publish in the primary journal literature and biologists are usually involved in preparation of the CSAS assessment reports regarded as grey literature. In addition to the scientific information in the CSAS reports, managers must include information from "multiple sources," e.g., on social and economic issues, and other sources to back up recommendations to the Minister. A manager explained: "If I don't have the background and the support to tell the minister this is required, I'm not going to get it through, so I'm not going to do it. And that is one of the biggest balancing acts of an advisor … it is the rationale of what makes an advisor" (DFO 6).

4.3.1.2. Request for and Provision of Scientific Advice

CSAS coordinates a well-defined process for requesting advice annually from scientists on the status of stocks. The majority of requests come from the Resource Management Division particularly about stock assessments and advice on total allowable catch (TAC) levels to be used to develop harvest strategies for particular species. Managers use the scientific advice to establish the license conditions and then discuss the management of a fishery with the industry in fishery advisory meetings. Most fisheries are assessed every five years and DFO has a protocol for setting priority for fishery assessments and management for primary and secondary stocks in the Maritimes Region (DFO 1). Stock assessment advice is a critical output of science for the management sectors. Requests for advice received during the fiscal year bear on the work program for the scientists and the CSAS process is described as “responsive” as it needs “questions to be asked that then get worked into work-planning and then a product is provided” (DFO 10). Senior managers representing the various DFO sectors consider the workload of scientists and available funding in their prioritization of assigning the requests for advice and they consult with the scientists to ensure that the latter have the capacity to complete the work in the upcoming year, with regard to the timelines and feasibility of providing the answers (DFO 2).

Only managers request advice and only when it is needed, given the full workloads of scientists and the limited available resources, both financial and staff. As one manager stressed, “you shouldn’t ask for something if you are not going to use it ... if we are requesting advice on something it is better to get [the senior managers’] approval to do something with it, otherwise it’s better to spend the money on something else” (DFO 1). Scientists do not decide what advice is to be requested; however, they may be involved in discussions with managers when the management questions are being developed. The scientific work is only carried out to meet DFO’s mandate for management largely due to the limited financial resources to pursue research outside of this context. As a manager described, “there is not a lot of money to just go out and do interesting science just for the sake of science any more” (DFO 22). The Secretariat in collaboration with the managers develops the terms of reference for the required scientific advice. The scientists cannot respond to external requests for research as this would require “re-tuning” their work plan and a scientist stated: “We are not set up to respond directly to an outside query ... because really our mandate within DFO Science is to provide science to inform the Minister” (DFO 10). Questions asked in the CSAS process relate to making management decisions and not policy decisions.

There is a clear separation of scientific advice and management decisions in the CSAS peer review process. At review meetings, the discussions between the Science Branch and the industry focused on the science findings only; the meeting Chair stressed that “no decisions about the management of the fishery are being made ... just the advice that will be going forward for future management" (DFO Direct Observation 1 through 3). Scientists recognize that management decisions draw on other sources of information, e.g., socio-economics, in addition to the scientific advice that they provided to managers. Any industry questions related to the management aspects were referred to the managers attending the meeting. The Chair of these meetings strictly advised that participants do not represent the views on any one group and were "not to advocate an agenda but to contribute your knowledge of the fishery" (DFO Direct Observation 1 through 3). As one scientist stated:

> Often it is challenging to stay on the side of provision of advice and not make management decisions … and it's a very difficult line to follow sometimes, but in our meetings and in the documents that we are producing we are not making management decisions. We can make clear "recommendations" for example, at this specific TAC the population will continue to increase, if you go to this one lower it will stay stable, if you go above that it will decrease. But at no point do we say which one of the three they should choose because that is a management decision that gets made with input from policy, industry, and consultations ... so for our position in Science [the sector] we have to keep a very firm line with what is the advice and what does the science say versus what are we going to do with that. (DFO 2)

The provision of advice begins with a framework assessment that establishes the methodology for the assessment, e.g., how fishing mortality and population biomass will be estimated and what factors are included. The framework meetings are coordinated by the CSAS office and may engage external bodies, e.g., universities or other fisheries agencies such as the US National Marine Fisheries Service, to review the assessment model being used by the DFO scientists. Production of the assessment takes the current data and applies it to the method agreed to in the framework to generate advice on the stock status. Projections are generally made for up to three years and fisheries scientists produce interim reports for managers to make adjustments, e.g., in the quota or regulations to control fishing mortality, in the period between assessments (DFO 9).

The scientific advice provided by the scientists is considered to be the response to the request for information from the managers. The advice is generated at the formal CSAS meeting to “peer review” the completed assessment. The scientific advice is developed through consensus, that is, “basically a lack of opposition” where “we work through the science and there is discussion and questions … and we basically work towards coming to a consensus on what this information is telling us” (DFO 2). Advisors from Resource Management attend these CSAS meetings “to ensure that the scientific advice on various TAC levels being developed will still address their needs,” then they “can take that and decide what risk they are willing to take … but the science just lays out the advice for them so they can make their decisions” (DFO 2). After the formal presentation of scientific advice and discussions, stakeholder groups at the CSAS meetings collaborate to write the final science advisory report during the meetings. DFO science and management sectors, industry, and NGOs give their input and “everyone is working on it together to come to a piece of advice that works for everybody, that answers the question and moves it forward” (DFO 2). Careful wording of the text is essential – generating considerable debate – and the groups also discuss whether the advisory report addresses the specific management questions being asked (DFO, 2; DFO Direct Observation 1 through 3).

4.3.1.3. Communicating Scientific Advice within DFO

CSAS publications, i.e., the detailed Resource Document, the Scientific Advisory Reports, a briefer document with a summary of results, and the Proceedings, as well as the Special Science Response, are available to the public, in electronic format only, on the DFO website. CSAS clients can also be informed of the release of new CSAS publications by email upon request to the CSAS Secretariat. The primary target audiences for CSAS documents are the DFO managers and scientists. Scientists can also publish in the primary literature as well as the CSAS series if they wish. However, the CSAS process is set up to meet the internal demands for advice, and depending on the research program some scientists may “get stuck more in the CSAS process because of the work that they are doing” and do not publish in other fora (DFO 2). As well, ocean and coastal managers publish awareness materials, e.g., brochures and fact sheets, on the state of the coast or of a specific marine area and marine protected areas meant for the general public. While the reports are still relatively detailed, they can be understood by non-specialists as these managers aim to “translate the information in the scientific reports to something that was easily understood" (DFO 12). These managers stated that they focus on showing biological trends in spatial terms which was not common practice in scientific reports.

The CSAS office also acts as a translator of science by ensuring that the documents are understandable to all DFO sectors. A scientist in the CSAS office stated:

> I often joke that my job at DFO is a science translator job because I'm not a research scientist – I can't write a model to save my life – but I understand the science and I can explain it very well. And I think that is a lot of the role of this office … to make sure that while we are writing up these documents they are understandable and [the writing] is at a level of detail that it answers the question. (DFO 2)

Communication between managers and scientists is ongoing outside of the formal CSAS meetings as managers communicate informally with scientists on a daily basis through email or telephone conversation to seek clarification on aspects of the advice (DFO 1). These internal communications within DFO are also essential to ensure a single view is presented in interactions with external stakeholders such as the industry. Managers emphasized the need for clarity in the scientific information that they present, given the industry's investment in fisheries. One manager stated:

> When we talk about marine resource management, first of all it is a very emotional subject in this neck of the woods. So when we are generating information to operate in this environment it has to be such that all the drum work that goes into producing the thing has to be clear, has to be simple, has to be easily understood ... it is very important that we try to keep each other and ourselves in a "no surprise" environment ... it doesn't look good when we are in a meeting with the industry and both sides of the department have different opinions, it looks like we haven't closed the loop ... in terms of strategies we always make sure that our colleagues are aware. (DFO 5)

Managers generally take scientific information and prepare versions that can be used by the policy-makers and the public. Managers prepare briefing notes, their typical reporting tool to decision-makers, where they "take the scientific information and turn it into a slightly more generic or basic knowledge that is more readily understood in the public domain" (DFO 5). Managers commented on the increasing use of email among themselves and the Regional Director General for operational exchange of information to ensure that the key actors are informed. This pattern has reduced the need for briefing notes or made it more admissible to have less formal notes. However, information communicated beyond the Maritimes, e.g., to the DFO-NCR, is still placed in formal briefing notes (DFO 21).

Scientific advice is also communicated by managers to the fishing industry in informal settings as well as in formal fisheries advisory meetings. This communication practice means that the advice must be understood by the fisheries managers for them to be able to communicate it to the industry. In the fisheries advisory meetings, managers lead the discussions and scientists are present for technical support only and do not actively engage in discussing the management aspects (DFO Direct Observation 4 through 6). Managers incorporate the scientific advice, management measures, and policy directions in their presentations to industry. Managers also deal directly with industry on a daily basis and this direct communication with stakeholders can be either amicable or adversarial (DFO 1). As one manager stated:

> Advisors are always the cold face dealing with the stakeholders, the license holders, there is no intermediary. So the communication is point to point and there is no deviation from the track. So if the emphasis is on production, you have to be able to explain the highly complex, the highly scientific, to the average person so that they understand why you are making the decisions that you make. (DFO 5)

Fisheries managers in the Resource Management Division also produce Integrated Fisheries Management Plans (IFMPs) to guide the conservation and sustainable use of specific marine resources in a given geographic area. An IFMP combines the best available science on a species with industry data on capacity and methods for harvesting that species. An IFMP is not a legally binding instrument but it can form the basis of a legal challenge (DFO, 2014g). Fisheries managers stressed that they lead the production of IFMPs by integrating the advice from the Science branch, the management advice from the Fisheries and Aquaculture Management Branch and the Ecosystem Management Branch, and input from the Policy and Economics Branch. Managers also rely on their work experience in various sectors in DFO and externally prior to their current positions.

As one fisheries manager said "the department has people with different expertise that feed into that process and we're kind of like the glue that brings everybody together" (DFO 1).

There are specific protocols for communicating with the media and social media are not used by DFO to communicate scientific advice. However, social media are used by the industry, for instance, and DFO tweets out fishing advisories to the younger industry members. The Ocean and Coastal Management Division uses social media in an ad hoc manner to promote awareness of conservation and management of marine resources; for example, it produced a YouTube video on whales of the Gully, a sub-marine canyon on the Scotian Shelf and a marine protected area (MPA), and the Division managed and administered a Facebook page for the annual World Oceans Day. DFO staff do not use the media to obtain scientific information on a topic as media reports are at a "high level," meaning that the reports are summarized and they do not contain the level of detail needed for technical discussions on an issue (DFO 25). New and younger staff are now occupying science and management positions and they are more familiar with using digital technologies and online databases, so these policies may evolve (DFO 24).

4.3.1.4. Use of Scientific Advice for Fisheries Management

Fisheries managers or advisors use the scientific advice from the CSAS process for operational decision-making, such as, the harvest levels for regional stocks (DFO 25). The managers make recommendations, e.g., to extend the fishing season, "because it is fairly transactional and the guidance is quite clear" (DFO 4). Management recommendations are based on the CSAS scientific advice and as a manager emphatically stated, the information from the Science Branch is "used 100% in management recommendations" (DFO 20). The recommendations made by the fisheries advisors are passed to the senior managers in the Maritimes Region and one manager stated, "obviously scientific information informs our decisions … the advice that comes out of the science review process, we will take that advice and turn it into recommendations going forth into management" (DFO 5).

The respondents relied on reports in the CSAS series or other DFO information products for their general work. The volume of DFO publications was reiterated by another manager, “because we have so much science capacity I just use internal stuff” (DFO 23). Managers interpret and place a value on the scientific advice in order to translate it into a management response. Managers stated that they place a “management lens” on the “facts” as the information provided “is strict science” and they then look at several factors, for example, who is fishing in the area, what is the sensitivity to the activity, what are the mitigation factors that they can apply to minimise the risk. One manager stated:

> Science [the sector] will give us just the blanket, e.g., this is the impact or what will happen with this industry without consideration of the mitigation measures, which is fine because it is not their job. So there is a lot of interpretation and valuation of the scientific advice in order to translate it into a management response. (DFO 16)

Managers would use the detailed reports in addition to the summaries to communicate the scientific advice and their management recommendations to their senior managers. The latter read the summaries and one senior manager commented:

> I am looking for the end conclusions ... I look at the executive summary and generally decide if the findings logically lead to something that I would conclude as well. I just don’t have the time to go through those reports in the granular detail that some other people would. (DFO 5)

Within the managers group, ocean managers, in particular, ensure that the management recommendations that they prepare to submit to senior decision-makers have considered all the available information and consulted with all stakeholders in what managers term as doing their “due diligence.” The objective of the manager is to ensure that the decision-maker has no reason to question the management recommendations or advice that managers are providing, particularly in the case of complex issues [or subjects] such as the designation of a marine protected area, “because there is no point in spending two or three years of work if we know the Minster is not going to approve it” (DFO 11). A memorandum from an ocean manager for the minister contains supporting background analysis and justification to show that:

> We've done due diligence and consultation and research. We have to make the case that "this is a good thing Madam Minister, it will benefit Canadians, and it is based on the best available science … at the end of the day, all things considered, this is what we think you should do." … Ultimately, the minister will give approval if you do your due diligence and homework. (DFO 11)

Fisheries managers consider the political, social, and economic implications when preparing memoranda for the minister. Managers, however, consider the political implications more carefully since the fishing industry may go directly to the minister to contest any recommendations that are not in the industry's favour. Managers emphasized that their knowledge of the industry adds credibility to their recommendations. As one manager stated, "80% of my recommendations are accepted ... I'm the guy on the ground, I have the most dealings with the individuals. If I'm making a recommendation to support something, it usually means that it's the right thing to do" (DFO 6).

A senior manager (decision-maker) confirmed receiving scientific reports, reading them, understanding them, and using the advice to make a decision:

> Typically when I receive the briefing note, the science document is included in the package and I always read it. Often I will have questions about it. But the CSAS document is always with the briefing note. For a decision on a fishery, like a harvest level or a season adjustment … I rely on that CSAS document because we have gone through that peer review process to look at the issue at hand. So I've got to have some degree of confidence that that process is giving me the best science on that particular issue or subject. (DFO 25)

Senior managers describe themselves as being generalists with a broader world view and approach resource management more from a management perspective than from a technical expertise point of view. Senior managers describe the science as "low level stuff" needed to draw conclusions, and one senior manager described how lower level fisheries managers or advisors act as intermediaries between policy and science as:

> Largely it is the advisors who do the translation work for me – for us. Almost all of them have a master's degree but they also have more exposure on the policy side. So

> they know the data side and on the policy side they know what it could mean for management measures going forward. They go down to the science-oriented stuff and bring it back out to the more policy-oriented stuff. (DFO 5)

Interviewees described how separating the roles of science and management maintains the credibility of the information and strengthens the perception that the science process is providing objective information that can support different management options. A manager described the fisheries management "system" as having three distinct parts: (a) science, (b) "the management advice process," and (c) decision-making, each having clearly defined roles (DFO 19). This manager stressed that separate roles of scientists and managers and the importance of being "disciplined" in what the three parts mean:

> If you confuse those three or if you mix them up together then you devalue the process. If you have the science side making management recommendations then you devalue the objectivity of the science. Making recommendations and how to deal with uncertainty is a reflection of social values. That is not a scientific process. Scientific process is about knowing what information is out there to support an understanding of different risks. How you actually decide what to do with it is the management process. There is no way in a scientific process that you can come up with one single solution ... if it were that simple there would be no need for managers. Science has been willing to cede that level of control because they begin to trust what management is going to do. (DFO 19)

Managers consider how risk adverse decision-makers want to be and develop the management options for the decision-makers, highlighting how to balance different considerations. Managers provide the decision-makers with a series of choices on how to deal with the uncertainty. However, managers do not make decisions on how to balance uncertainty, risks, or objectives, e.g., utilization on one side, sustainability on the other, since these are "tensions that are resolved by the decision-maker who is separate from the management advice process, and which is why it is usually invested in a minister because he or she is responsible to the citizenry more broadly as we're dealing with public resources" (DFO 19).

Table 4. Summary of the information pathways – production, communication, and use of scientific advice – in the Canada Department of Fisheries and Oceans (DFO).

INFORMATION PATHWAYS	
ACTORS	**CHARACTERISTICS**
Decision-makers (senior managers) Fisheries managers (senior advisors) Ocean managers (biologists) Scientists	Lower level managers can act as intermediaries between scientists and upper management
	Managers have understanding of science due to lengthy employment in DFO or general science backgrounds
	Scientists and managers are part of the management advice process
	Senior managers hold broad world views and are risk-adverse
	The decision-maker is separate from the management advice process
PRODUCTION	**CHARACTERISTICS**
The Canadian Science Advisory Secretariat (CSAS) process	Advice is used for management decisions in the CSAS process; the CSAS process does not typically involve policy decisions
	Careful wording of advice is common to ensure clarity
	Four information products – full technical reports, summary of advice, meeting reports, and special science responses
	Credibility – peer review by DFO
	Legitimacy – wide peer review community including the fishing industry, academia, NGOs; Participants do not advocate for any group but speak as individual experts in their field; Advice is developed through consensus
	Managers pose questions to science; Requests for advice come mainly from fisheries managers
	Relevance or salience – the science produced is directly in response to requests for advice and described as "science and management matching up" by respondents
	Reports are produced in digital format only and are available on the DFO website
	Request for and provision of scientific advice is coordinated through the CSAS process which is embedded in the DFO structure
	Separation of science and management – scientists provide facts only
	Scientists provide advice only for DFO managers' requests
	Scientific work that is funded is needed directly by management; Austerity measures influence the nature and extent of science to be completed
	Transparency – record of events in CSAS reports

INFORMATION PATHWAYS	
COMMUNICATION	**CHARACTERISTICS**
Communicating scientific advice within DFO	DFO website is the main communication tool
	Email is increasingly used for internal communication and fewer briefing notes are being used
	Fisheries scientists publish mainly in the CSAS technical series, i.e., grey literature, due to time constraints. Research scientists are evaluated by their primary publications.
	Managers prepare briefing notes to present management recommendations, based on the scientific advice, to senior managers and decision-makers; Recommendations are based on due diligence, i.e., considers other factors, e.g., political feasibility
	Managers prepare IFMPs to integrate knowledge from DFO sectors and to make the knowledge more accessible to decision-makers
	Managers share information with each other to have a consistent voice for the fishing industry; Daily interaction with the industry occurs
	News media are not used as a method to communicate information as they do not operate at high levels of detail necessary to understand the science and management process
	Ongoing communication between managers and scientists occurs outside of the formal CSAS process
	Social media is not formally used to reach the public
	Summaries are prepared by managers
USE	**CHARACTERISTICS**
Fisheries management	Advice is understood by managers in order to be able to communicate to decision-makers and the fishing industry
	Direct use – scientific advice is used to develop management recommendations, e.g., on harvest levels and for setting fishing license conditions
	Managers produce recommendations and submit management advice to decision-makers
	The CSAS technical series is used in the three main areas of fisheries management: as background for science reports, management advice, and decision-making
Types of decision-making	Austerity measures make decision-makers more risk-adverse
	Operational decision-making occurs in the DFO-MR
	Strategic decision-making occurs in the DFO-NCR

4.3.2. Drivers to Information Flow into Decision-Making

Three main drivers of information production, communication, and use in DFO were identified: (a) the demand for scientific advice in the CSAS process; (b) international, regional, and national policy-development related to the implementation of the EAF; and (c) trade aspects of fisheries. Table 5 summarises the role of these three drivers in the information pathways in DFO (see p. 80).

4.3.2.1. The Demand for Scientific Advice – the CSAS Process

Seventy-seven percent of interviewees (77% - 20 out of 26) mentioned the CSAS process as the primary means for driving information production, communication, and use. A well-defined process for requesting and providing scientific advice ensures the credibility, relevance, and legitimacy of the information, thereby promoting its uptake into operational decision-making. The CSAS process was the largest driver in the information pathways and the characteristics of the process are presented in Section 4.3.1.

4.3.2.2. International, Regional, and National Policy-Development

Fifty-four percent of interviewees (54% - 14 out of 26) described external influences such as national, regional, or international policy-making in the production and communication of information. The DFO-NCR staff spoke primarily about international policy-making related to the implementation of the EAF that has directly or indirectly led to national policy-making, information production, and communication among DFO sectors. The DFO-MR staff spoke about the influence of national policy-making, e.g., the Oceans Act was described as "the most influential thing on Canada's national policy and decision-making … it really pushed us in our thinking on what the ecosystem approach to fisheries management means" (DFO 25). International policy and the global discussions, related to implementation of the ecosystem approach, at the UN level have promoted information flows in DFO by encouraging overlapping organizational memberships aimed at collaboration and by influencing how Canada moves forward on some national policies. The overlapping membership in regional and international marine fisheries management and related agencies also enables national policy-making, e.g., under the Sustainable Fisheries Framework (see Section 4.1.3).

The impetus for national research and policies, e.g., in areas such as bycatch, VMEs, and use of the precautionary approach, was reported to be driven by global guidelines and policies related to the EAF that were promoted by the UN. For example, the FAO international bycatch guidelines were released in 2012 and shortly after Canada released its first national bycatch policy. As a DFO decision-maker stated: "to make sure that we can implement that in domestic waters we came out with our national policy … it mirrors to a large extent that international policy" (DFO 1). Similarly, the 2006 UNGA resolution 61/105, calling on states to take action to eliminate fishery impacts on VMEs, influenced the national policy on Managing Fisheries Impacts on Sensitive Benthic Area where Canada "took that term [VMEs] and called it sensitive benthic areas to address corals and sponges and other benthic features that are vulnerable to bottom fishing gear" (DFO 8).

While the development of international policy can act as an external driver for creating national policy, often the national attention and discussion on an issue is already ongoing and the external drivers simply provide added incentive and relevance to the development of national policy. As a manager described Canada's national bycatch policy: "One of the drivers was the FAO policy but we were thinking of a national policy before the FAO document was public. It certainly helped because the timing of our work coincided with what they were doing" (DFO 8). DFO scientists and managers were members of the FAO expert and technical consultations and "the timing was very good because we had the technical document to refer to as we were developing our policy and it certainly helped us in writing our policy and we wanted to say that our policy was consistent with the international guidelines" (DFO 8). Similarly, a senior manager stated:

> What the external influence will cause us to do is if we are looking at something in the Canadian context but it is coming up in this international forum and that forum, like we are discussing it at FAO. What happens is that when we come back home we say "well we have been moving this at 20 miles an hour but we should move at 30 miles an hour … and the discussions happen. (DFO 25)

Another instance is seen where national action is influenced by pressure to meet national obligations to international agreements made as members of regional fisheries management bodies such as "when NAFO [Northwest Atlantic Fisheries Organization] agrees to do something it trickles down to our groundfish fisheries; because if it's agreed to at NAFO then we have to do it here to make sure that we are meeting our national obligations to NAFO" (DFO 2). As a member of NAFO and FAO, Canada attempts to ensure that its national policy is consistent with management measures recommended within the regional and international frameworks set by NAFO and FAO.

Overlapping membership of experts is often the result of Canadians participating in international fora and contributing to the discourse on international fisheries issues and concerns which in turn drives the work in DFO, e.g., related to the identification of EBSAs and VMEs (DFO Direct Observations 3). Involved scientists spoke about their participation in NAFO and FAO activities related to identification of VMEs and in the Convention on Biological Diversity (CBD) meetings to develop criteria and definitions for EBSAs. FAO and CBD have developed definitions and criteria for VMEs and EBSAs, respectively, and DFO has also established its own criteria based on participation in these two international fora. DFO scientists also considered definitions of VME developed within regional bodies such as NAFO and OSPAR (so named because of the Oslo and Paris Conventions), in addition to the CBD, to highlight the "legitimacy and relevancy" of the issue even outside of Canada. DFO scientists participating in the CSAS meeting mentioned their work completed in NAFO scientific working groups which drives their research in DFO, e.g., with regard to VMEs and indicator species. Scientists and managers also attributed the identification of EBSA to UNGA resolutions and the 2009 FAO guidelines for identification of VME in deep seas management. Overlapping membership in various organizations and what it means is described in detail in the case study of FAO which is involved in global work on VME protection (see Chapter 6).

New strategies or initiatives of scientists to provide advice for managers to incorporate climate change research into their decision-making were being discussed in DFO (DFO Direct Observation 7 and 8). Government initiatives such as the Aquatic Climate Change Adaptation Services Program (ACCASP), aimed at developing knowledge about climate change to integrate it into the delivery of departmental programs, are driving internal discussions among branches and divisions on how the research will be relevant to the management sector, how it can be applied, and how climate change information will be incorporated into scientific advice for management (DFO, 2014a; DFO Direct Observation 8). The critical need for the department to understand how it will adapt its services and functions in light of climate change is driving these discussions on new communication patterns and use of climate change data in fisheries management. Managers claim that they are "still confused about the ecosystem research going on in the department," but they have a policy expectation that they will need to use this new information in their management advice (DFO Direct Observation 8). Scientists often talk to managers about their new climate change research and ask for support, but managers are not clear on how it can be used in a decision, e.g., for a harvest strategy, since the typical questions in the CSAS process are still centred around the status of a stock being harvested and the consequences of various harvest levels. While it will be challenging to routinely incorporate indicators that measure climate change into the stock assessments, discussions are occurring among the science and management sectors regarding possible changes to the CSAS process to accommodate climate change concerns.

4.3.2.3. Trade Aspects of Fisheries

Fifty percent of interviewees (50% - 13 out of 26) highlighted trade aspects, including market factors, as an increasingly important driver for information production for use by the fishing industry. Consequently, the industry is increasingly being involved with DFO in the co-production of such scientific information for managing fisheries. For instance, the trend for environmental certification (or, commonly, eco-labelling) applied to products certified under specific standards, now requires the industry to show that fishing practices are conducted sustainably. In some ways this hastened DFO's development of its national bycatch policy "especially because the fishermen need to now show that they are sustainable and they are not having an impact" (DFO 2). Facilitating the industry to meet the requirements of the Marine Stewardship Council (MSC) requires the dedication of significant levels of resources within the department, e.g., to ensure that the relevant assessments and CSAS peer reviews are completed and that the CSAS science advisory reports are available to the industry to assist it to obtain and maintain certification.

Table 5. Summary of the drivers in the information pathways – production, communication, and use – in the Canada Department of Fisheries and Oceans (DFO).

DRIVERS IN THE INFORMATION PATHWAYS	
1. THE DEMAND FOR SCIENTIFIC ADVICE – THE CSAS PROCESS	
Production	Scientific advice is produced in response to requests for advice and is described as "science and management matching up" by respondents
	The CSAS process is embedded in the DFO structure; scientific work that is funded is needed directly by management; the primary actors are government scientists and managers (see Table 4 for details)
Communication	Fisheries scientists publish mainly in the CSAS technical series
	Ongoing communication occurs among managers, scientists, and the fishing industry inside and outside of the formal CSAS process
	CSAS translates the scientific reports for general audiences
Use	Advice is used for fisheries management decisions – operational and strategic decision-making; Used as background for science reports
	Managers prepare summaries and briefing notes containing recommendations for senior managers and decision-makers; IFMPs
2. NATIONAL, REGIONAL, AND INTERNATIONAL POLICY-DEVELOPMENT	
Production	Awareness of international advances increases the speed of the development of national policy; International guidelines and policy, e.g., in the UN system, are used as a reference in national policy to gain support and to ensure compatibility with international agendas
	Changing priorities in management – science is driven by patterns of advice needed, e.g., implementing EAF, addressing climate change
	National fisheries policy drives production of implementation of other national policy, e.g., the precautionary approach, bycatch
	National obligations at meetings of RFBs and commitments made by members, i.e., Canada, have to be taken up in national policy-making
Communication	Overlapping membership with RFBs, e.g., NAFO and ICES, promotes Canada's point of view at regional and international fora and greater legitimacy and relevance of issues on the national agenda
3. TRADE ASPECTS OF FISHERIES	
Production	Trade issues, e.g., ecolabelling, drive the production of scientific advice in the CSAS process and the involvement of the fishing industry in co-production of scientific information
Use	Ecolabelling – CSAS reports are used by the fishing industry to obtain and maintain MSC certification

4.3.3. Enablers to Information Flow into Decision-Making

Four enablers to the drivers in the information pathways in DFO were identified: (a) the attributes of the scientific information; (b) the roles of scientists and managers in motivating communication; (c) organizational structure and culture related to DFO's mandate; and (d) the involvement of the fishing industry in co-production of information. The enablers represent factors that facilitate information production, communication, and use. Figure 7 presents the four enablers and shows the percentage of interview respondents who described aspects under each of them. A detailed description of each enabler is given in the following section. Table 6 provides a summary of the characteristics of the enablers in the information pathways (see p. 92).

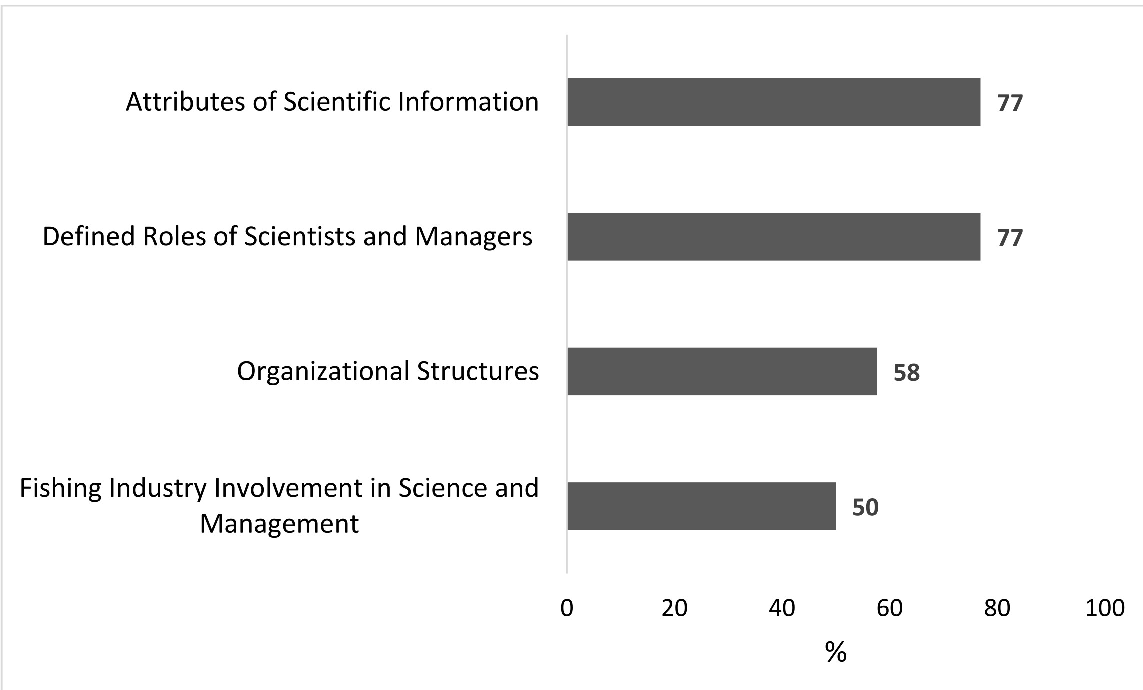

Figure 7. Enablers in the information pathways – production, communication, and use – in the Canada Department of Fisheries and Oceans (DFO).
(Percentage of interview responses; Number of interviewees, N = 26)

4.3.3.1. Attributes of Scientific Information

Seventy-seven percent of interviewees (77% - 20 out of 26), or all of the scientists and managers who supported the CSAS process of production and communication of scientific advice (see Section 4.3.2.1), spoke about the credibility, relevance, and legitimacy of the information and the process. The CSAS process is considered as relevant or salient because the scientific advice that is produced is directly in response to the requests for advice. Respondents described this feature as "science and management matching up." The CSAS documents are considered to be credible sources of scientific information as they have been produced by DFO scientists and internally peer-reviewed. As one scientist said, "I'm a big fan of it. I think most people in DFO Science [the sector] are – because it instills the concepts of peer review and it is a formalised process that hands information over to the operational sectors so that they can form their decisions" (DFO 10). Ocean and coastal managers describe how they use the advice in CSAS documents to support recommendations for developing marine protected areas because it "is a departmental publication … and the more credibility we have within the department and with our partners, the better off we are if you want to establish [them]" (DFO 11). Managers regard the CSAS reports "as DFO authoritative advice" and use that as the basis for their decision-making. Ocean managers added that they use reports like the state of the oceans reports which are "generic reports meant for broader audiences," and will not ask scientists to "filter down" their technical reports (DFO 21). Managers and scientists described the production of information in the CSAS process as a "a self-perpetuating exercise" where CSAS publications are used as an information source to prepare other CSAS reports, for instance, in the case of a CSAS Special Science Response where an immediate response is needed, e.g., for an oil and gas company, a terminal construction venture, or to meet immediate internal needs (DFO 12).

The CSAS process also addresses the need for transparency in decision-making. Staff described the levels of precaution now operating within the department so:

> You need to have this [record of advice] to back you up as the things that you considered beforehand. This is a primary driver for us not only to produce information but to gather information to be able to defend decisions. Our collection of information is based on the need to clearly articulate the basis of our decisions and to show that our decisions are based on the best scientific understanding. (DFO 16)

The current structure of the CSAS process was considered to be a marked improvement with regard to transparency in decision-making over previous mechanisms for requesting and providing scientific advice. Scientists described previous situations especially those related to the collapse of the cod fishery where:

> This type of a process was not in place; therefore, it is a lot harder to go back and figure out where the information came from, who said what … [but now] there is a scientific advice depository so you can go back and see what science was saying at the time and you can track management decisions through time as well. (DFO 2)

The advice that is provided by scientist in the CSAS process is in response to specific questions that are asked by the managers and it is considered to be relevant to the needs of managers for fisheries management in the Maritimes Region. Management issues are becoming more complex since management now attempts to include ecosystem considerations. Managers described the need for new knowledge to address more complex management questions and managers stated that they want to "make sure that we are getting it right ... the more we understand, the more we realise the less we knew the implications of decisions" (DFO 16). To this end, managers pose a very comprehensive set of questions to scientists to obtain advice through the CSAS process. Given their heavy workloads, scientists plan their research activities around the government's current priorities in anticipation of the managers' requests for advice (DFO 6). Managers agree that providing advice is time-consuming, and they do not wish to waste the time of scientists (DFO 10). The CSAS process ensures that questions are relevant for decisions that need to be made (DFO 2). A request for information by managers, even without receiving an immediate response from scientists, increases attention to an issue and it becomes a departmental priority. Eventually the question will be answered, after being asked year after year for a few years. But if a question is not asked, then the perception is that it cannot be an important one (DFO 6).

The legitimacy of the information produced in the CSAS process was described in the context of scientific uncertainty and the involvement of stakeholder groups, such as the fishing industry and non-governmental organizations. The inherent uncertainty in scientific data and scientific information published by DFO scientists in the CSAS process does not prevent its use by managers. Managers stated that they acknowledge that this output is often the only available information and: “Whatever you [the scientist] gave me, that’s what it is. You can tell me that there are a lot of uncertainties … if there were too many uncertainties, you wouldn’t publish it. Once you’ve published it, it’s the number that I can take” (DFO 6).

The fishing industry also recognises that the advice of the scientists does not contain exact numbers and fisheries stock assessment results are estimates based on the best available data. At CSAS meetings, DFO Science staff had very open discussion with industry and managers with regard to uncertainty, with input from each party being considered (DFO Direct Observation 1 through 3). The industry was also looking for assurance that the scientists had confidence in the assessments since the results, i.e., the recommended catch limits, were often not economically favourable for the fishing industry (DFO Direct Observation 1). The involvement of the industry in the peer review and the co-production of information in the CSAS process increases the legitimacy of the advice (see Section 4.3.3.4).

Other information products, such as IFMPs, are a means of making the science more understandable to non-science groups. As one manager stated:

> Making science palatable – that is a major thing that we are involved in ... I think what the average person does not understand is that the average science report is written by an expert usually for other persons who are conversant in the field. Which are almost useless for dealing with lay people who are not scientists; they may be experts in the industry, but they are not scientists. (DFO 5)

The legitimacy of DFO’s information is also enhanced by the framing of advice. When issues are framed as conservation priorities, rather than fisheries management, there is potential for greater collaboration from NGOs and the public is “more forgiving” to DFO when decisions are made that may appear to not favour conservation (DFO 1). The work of some divisions such as the Ocean and Coastal Management Division on Marine Protected Areas is aligned with the conservation objectives of NGOs (DFO 11).

Legitimacy of the information is also enhanced and the involvement of other stakeholder groups, such as non-governmental organizations. DFO meets with NGOs to develop the management advice which is then included in the recommendations for management considerations submitted to senior management in the DFO-MR and DFO-NCR: "We are the intermediaries between the frontline NGOs and senior management" (DFO 11).

4.3.3.2. Defined Roles of Scientists and Managers

The roles of scientists and managers, the key actors in information production and use, were the second most important enabler to information flow (see Figure 7). Seventy-seven percent of interviewees (77% - 20 out of 26) described aspects of each group as well as the interactions between the two groups that enabled the information flow. Fisheries scientists believe that in the last three to four years more interactions between fisheries scientists and fisheries managers occurred within and outside of the formal CSAS advisory process than previously to discuss how the science fits into the decision-making. This stronger relationship between DFO scientists and managers is a new development and a significant improvement as a generally antagonistic relationship between the two groups had existed in past years which often resulted in the provision of "sparse" advice in the view of one scientist (DFO 24). Another scientist stated "now that we are clear what the question is, how the advice will be used, and how it will be interpreted … our answer can be more tailored to the question" (DFO 9). Communication between managers and scientists results in questions being asked that can be answered as "scientists better understand what managers need and managers understand what scientists can and cannot provide. That is a big change … I think the philosophy that underlies all of this is really doing the science that matches the management strategy" (DFO 9). All of the scientists who were interviewed commented on this new era of the science and the management "matching up" and described it as a unique feature to the DFO-Maritimes Region, which is largely dependent on personalities:

> We're very fortunate here to have managers who have that philosophy because it is not a given and … there is nothing institutionalised about why this works. It works because you have people in levels who think this is the way that it should work. And it could just as easily not work. (DFO 9)

Science backgrounds of managers facilitate the communication of the CSAS documents. Scientists in the CSAS meetings found that managers with science education understand the advice and they have “the most effective relationships when managers understand the science … so you don’t need to go into it” (DFO 3). Of the nineteen managers who were interviewed, three did not have fisheries science or biology degrees. The longevity of scientists and managers in their respective roles also contributed to ongoing dialogue and understanding of science and management objectives and particularly for managers who “have been around so long and have worked with Science [the Branch] so long that they have a clear understanding. They have such a long history with the files that they are more than capable of understanding the science that is going into it” (DFO 3). Managers consider the DFO scientists as the experts in the local fisheries context and managers interact with one or two scientists who they consider to be “the be all and end all for the science” (DFO 6).

Good relations among the groups within DFO are critical to ensure the provision of good quality scientific information. Implementation of the EAF, sustainable fisheries, and the precautionary approach necessitate increased communication between science and management. Managers and scientists firmly believe that personalities greatly influence the increasing communication. The improved communication appears to have enhanced the trust between the two groups to the extent that managers are very open with scientists and ask for explanations when they do not understand the science. Debates between scientists and managers still occur but are considered part of the communication process. One manager said: “I get along with Science [the sector] because I go out of my way to form a solid relationship …. when I don’t understand, I ask, and I make them make me understand. They are always patient and explain” (DFO 24). Another manager stated that:

> There is no substitute for a strong personal relationship with the science community. If you don’t get along with them or see their role as antagonistic, it’s not going to work very well, you won’t get good advice. It’s not that they withhold advice; it’s just that you will not be able to articulate what you need in a way that they can actually deal with and help you. So they need your help in order for them to help you … fisheries management is about managing uncertainty ... so as much as possible if

> you can say how you can deal with uncertainty and risk, then science can help you with that. (DFO 19)

Fisheries scientists also believe that managers in the Maritimes Region have become more transparent in their decision-making and one scientist recounted working with a "good" manager who:

> Ensured that the science was well aligned; the scientific information was not the impediment to making the decision. So he was very good at saying, "this is what we know about the science, I am going to make this decision, and I'm either making it in spite of the science or I'm making it because of the science," but he was very clear about what his decision-making process was and where the science fit in (DFO 9)

Managers described themselves as being adaptable to changing situations as regards to information need and addressing management issues and that this flexibility is a critical requirement to being a good fisheries manager. Having a science background may also enhance this characteristic. One manager described the job as needing to: "understand the nuances of what you need to do versus what you are capable of doing. We have to understand what's important, what can be done, and what should be done, and none of those might be the same thing" (DFO 6). Managers and policy-makers must also be able to adapt to changing priorities in government and as a manager stated: "In this risk adverse climate in the public service, a senior level public servant needs to be able to sway according to how things are going but still speak truth to power" (DFO 10).

Scientists who are now holding administrative posts, e.g., a manager or director of a science unit, described the benefits of working as a scientist before attaining such a leadership position. As one such individual stated: "There is value of senior management of science being drawn from the research ranks, rather than bringing people on from other sectors. It changes your perspective on research" (DFO 10). Based on their experience as scientists, these individuals can now influence the direction of science programs, the research priorities, and the allocation of staff to "relevant" priority areas (DFO 10). Similarly, the staff of the Ocean and Coastal Management Division and the Fish Protection Program have backgrounds in science that is much more applied in contrast to the research of the Science Branch. This arrangement allows managers to act efficiently as "they understand the scientific process, they understand the value of research, they understand the value of science, and they can then incorporate that into their recommendations and decisions" (DFO 11). Some general features of the staffing of DFO were also noted as enablers to information pathways. Given competing demands on time and resources, persons who champion certain projects or agendas can guarantee that these move forward, e.g., actions in relation to ecosystem-based management (DFO 14).

4.3.3.3. Organizational Structures

Fifty-eight percent of interviewees (58% - 15 out of 26) described organizational aspects of DFO that were driven by national policy to implement EAF and act as enablers to information flow. For instance, the Oceans Act, viewed as a catalyst for implementing EAF, led to structural changes within DFO. Chief among these changes was the creation of the Ocean and Coastal Management Division, which "was instrumental" in working as an "integrator" with Science and Resource Management in the earlier days of the application of the Oceans Act to ensure that ecosystem considerations were incorporated into fisheries management (DFO 25). Ocean managers described the role of the new division as "filling a gap that the Science sector and Fisheries Management sector are not able to fill" (DFO 11). The new division, formed under the Ecosystem Management Branch, works with the Science and the Fisheries Management branches, and various stakeholders to designate and establish marine protected areas, and to examine potential interactions that overlap and cannot be captured in a single approach, e.g., fisheries and oil and gas activities, and fisheries and coastal communities (DFO 11).

The Ocean and Coastal Management Division envisions itself as the formal entry point to the department for information about the different sectors. The Division plays an important role in drawing on information from the science and fisheries management sectors and coordinating it to support key management issues outside of fisheries management. This division is often asked by external clients for information from the other sectors, "so we are not a piece of the puzzle, we are like the integrator" (DFO 21). There is still scepticism about ecosystem approaches within the organization as guidance is still traditionally directed at fisheries management. Ocean and coastal managers collaborate with local and regional ecosystem or integrated coastal and ocean management (ICOM) initiatives as a way of endorsing the EAF and they seek out opportunities to promote the principles of the Oceans Act, such as participation in ICOM conferences "while other parts of the department are quite leery of doing that and are not quite as open" (DFO 11; DFO 22). Ocean managers describe themselves as being "somewhere in the middle … we have some management responsibilities for MPAs ... but most of what we do is planning and facilitating" (DFO 11).

Other recent organizational restructuring within DFO, largely due to austerity measures and linked to modified legislation, have aligned the goals and activities of different parts of the department. For instance, the Fish Protection Program – previously the Habitat Division – under the Ecosystem Management Branch has expanded its mandate beyond "just physically looking at how much habitat is lost … to … managing for the sustainability and ongoing productivity of fisheries. So now we are more incorporated with fisheries management [the Branch]" (DFO 16). Depending on the project, the Fish Protection Program interacts formally with the DFO scientists through the CSAS process or informally by discussing stock assessments and sensitivities around different projects. Through CSAS, the new program requests Special Science Responses where specific questions, unique to a project, are asked, e.g., the impact of electromagnetic fields on the habitat and the movement of the stocks in an area where marine electric cables are being laid down. The reports are reviewed internally and then posted on the CSAS website.

Departmental downsizing (2012 onwards) aimed at reducing operating costs resulted in increased production of information to communicate to the public. In the transformation of the Habitat Division into the Fish Protection Program (linked to changes in the Fisheries Act), the field offices were closed and it was estimated that the program lost one third of its staff. DFO then produced documents to replace the interactions of the field staff with the public. The rationale given was:

> We acted as consultants for the public to make sure that things were done right. The department then said "we spend a lot of resources trying to tell people how to do things right, here's a set of standards and guidelines on how to do it, as long as you follow those you don't need to come see us." (DFO 16)

The overlapping membership in regional and international fora encourages the national research agenda and policy-making to keep up with modern developments in fisheries and ecosystem management. For example, to implement EAF, staff of the DFO-MR Science Branch are members of the International Council on the Exploration of the Seas (ICES) and NAFO ecosystem working groups, they participate in the work of the Gulf of Maine Council on the Marine Environment (GOMC), and collaborate with national organizations like the National Oceanic and Atmospheric Administration (NOAA) in the United States that engage in similar work at a federal level. Often the same scientist, or group of scientists, is the designated member for each external organization, e.g., membership in the ICES Working Group on the North Atlantic Regional Sea (WGNARS), so as to develop guidance on how to create more effective linkages between scientific knowledge and management to support ecosystem approaches (ICES, 2013). Advice generated through Canada's participation in external working groups does not necessarily enter the CSAS process, but as one scientist stated, it is "one of the avenues that we have for collaborating and obtaining information from external sources" (DFO 2). Interacting with working groups, e.g., in ICES or FAO, also "provides a Canadian presence and, to some degree, promotes the Canadian point of view" (DFO 10).

4.3.3.4. Fishing Industry Involvement in Science and Management

Fifty percent (50% - 13 out of 26) respondents described the role of the fishing industry in science and management as an enabler to information flow. DFO managers described advances in the organization of the industry and the education level of its members which make it necessary to produce more information and to collaborate in the science and management process. One manager stated:

> Industry is more professional now than they were in the earlier days. They are more educated, and have invested more money in vessels and gear. They are a huge driver in managing the fishery as they have a greater investment in it now. They hire people to advocate for them for more precautionary measures. (DFO 4)

In the last five years, the fishing industry has contributed more than previously to the science of many fisheries, e.g., through chartering of commercial fishing vessels for sampling surveys. The industry members work closely with DFO Science Branch during these surveys. The fishing industry representatives were fully engaged in the discussions in the CSAS science peer review meetings (DFO Direct Observation 1 through 3). They asked technical questions about the stock assessment models, added to descriptions of the sampling protocols at sea, and included observations based on their fishing experience. The industry members were generally in agreement with the presentations of the sampling and research protocols since they had participated in the earlier framework meeting where the research methodology was developed. A science-industry liaison was apparent and the more industry representatives can understand the science, the better they can communicate the science to their peers (DFO Direct Observation 1 and 2; DFO 1). The clarity of the text of the CSAS advice is also important to members of the industry wishing to use the advice contained in the Science Advisory Report in their attempts to maintain and gain MSC certification and hence the industry involvement in writing the CSAS advisory reports (DFO Direct Observation 3 and see Section 4.3.1.2).

The fishing industry is driving internal communication within DFO, e.g., between scientists and managers, in response to demands for information from the industry as a result of opportunities to exploit emerging fisheries. The industry is reactive to changes in fisheries, particularly with regard to emerging fisheries and international markets for new species. However, DFO generally cannot dedicate resources to assess species apart from the primary species that it is required to assess through the CSAS process. In response, the industry is being asked to collect data and perform the scientific assessments needed since DFO cannot act quickly enough to enable the industry to take advantage of opportunities to explore and harvest new species. DFO, however, provides the benchmarks or guidelines for the industry-led research in order for the results to be credible and acceptable to DFO (DFO Direct Observation 5 and 6). The management sector views the process as a means of being proactive in initiating a scientific study to determine the status of the fishery (DFO Direct Observation 6). Regarding the industry conducting assessments for secondary species, e.g., hagfish, DFO scientists are concerned that the interpretation of data produced by scientists outside of DFO and the DFO CSAS process “will be perilous.” The DFO Science sector must peer review the analysis completed by the industry before DFO can make decisions based on the industry input.

Table 6. Summary of the enablers in the information pathways – production, communication, and use – in the Canada Department of Fisheries and Oceans (DFO).

CHARACTERISTICS OF THE ENABLERS	DETAILS
1. ATTRIBUTES OF SCIENTIFIC INFORMATION (in the Canadian Science Advisory Secretariat (CSAS) process)	
Credibility	Careful wording of advice is common to ensure clarity
	Interpretation of science only occurs within the CSAS process
	Production of scientific information by DFO as an authority
	Separation of science and management
	Transparency – CSAS reports provide a record of the basis of recommendations
Legitimacy	Advice is developed through consensus
	Participants speak as individual experts in their field
	Wide peer review community – fishing industry, academia, NGOs
Relevance (salience)	Managers request advice and the need for new knowledge to answer complex management questions
	Science and management "match up" as questions are developed in discussions with scientists
	Scientists and managers engage in more dialogue with each other and have better trust relationships than in previous years
	Summaries like IFMPs make science understandable for the public
Framing issues in various contexts	Framing issues as conservation priorities promotes greater collaboration from NGOs and increases public trust in the department
Risk and Uncertainty	Annual questions from managers start the process to obtain advice from scientists when the advice may not be available until years later; Ongoing work guides the development of questions
	Requests for advice – questions from managers are becoming more complex relevant to the issue
	Uncertainty is accepted as part of science by managers and the industry
2. DEFINED ROLES OF SCIENTISTS AND MANAGERS	
Increased communication between science and management	Advice is understood by managers in order to be able to communicate to decision-makers and the industry
	Necessary for implementing EAF; Some managers and scientists are "champions" for EAF
Managers have a better understanding	Better understanding ensures communication of advice to other groups, e.g., fishing industry, senior managers, and decision-makers

CHARACTERISTICS OF THE ENABLERS	DETAILS
of science	Lower level managers can act as intermediaries between scientists and upper management
	Managers came from the science ranks, have science backgrounds, lengthy employment in DFO, or have worked in several DFO sectors
	Senior managers hold broad world views; Managers are adaptable with regard to information needs and addressing management
Scientists understand management needs	Iterative communication between scientists and managers ensures quality advice is produced and communicated
3. ORGANIZATIONAL STRUCTURES	
Legislation – Oceans Act	Formation of a new division - Ocean and Coastal Management (OCMD)
Legislation – amendments to the Fisheries Act	More publications produced for the public as field offices were closed
	Restructuring of the Habitat Division to form the Fish Protection Program (FPP); FPP work is integrated with management and science
Ocean and Coastal Management Division (OCMD)	Acts as a boundary agent, and integrator of the science and management sectors; Performs outreach to increase the department's and public awareness of EAF
Overlapping membership	Increases the networking opportunities of experts, facilitates collaboration, and increases dialogue and access to external sources of information
4. FISHING INDUSTRY INVOLVEMENT IN SCIENCE AND MANAGEMENT	
More professional; more financially invested in the fisheries	Co-production of information in the CSAS process
	Conducts science for emerging fisheries as DFO only provides advice for primary species
	Encourages dialogue between science and management on secondary species
	Involved in science surveys for data collection

4.3.4. Barriers to Information Flow into Decision-Making

Four main barriers to scientific information flow were identified: (a) aspects of the organizational structure and culture of the organization related to its decentralised or "dispersed" structure and its traditional focus on fisheries management; (b) political influences of the fishing industry often seen when they do not favour management decisions; (c) limited communication tools; and (d) aspects of the peer review component of the CSAS process. Figure 8 presents the main barriers and the percentage of interviewees who described aspects under each of these categories. Table 7 provides a summary of the barriers in the information pathway (see p. 110). A detailed description of each barrier is given below.

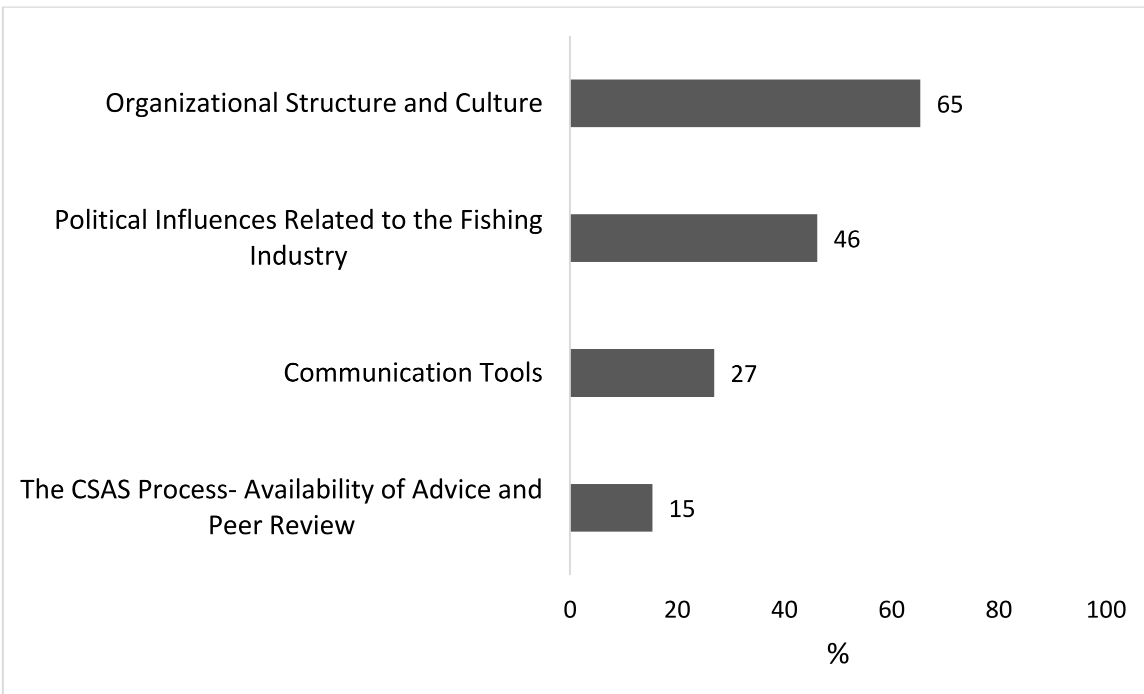

Figure 8. Barriers to the information flow – production, communication, and use of scientific advice – in the Canada Department of Fisheries and Oceans (DFO). (Percentage of interview responses; Number of interviewees, N = 26)

4.3.4.1. Organizational Structure and Culture

Sixty-five percent of interviewees (65% - 17 out of 26) highlighted the characteristics and culture of DFO, related to its de-centralization, as a main challenge to information flow. Aspects of the physical structure where staff are dispersed across regions and the department's traditional focus on fisheries management were described as barriers to communicating information among sectors and regions, implementing fisheries policy and EAF, and incorporating scientists more closely in high-level decision-making. A scientist described DFO as the most dispersed department within the Canadian government where "80% of our staff sit out in the regions so we are very much a water-faced department than a minister-faced department ... this matrix management and highly regionalised structure may also play a role in the stickiness of information flow" (DFO 10). As a federal government department, high level policy is developed in the national region and implemented in the regions. Managers in the region describe two levels of guidance where for "the high level long-term approaches we get direction from above but for the day-to-day work we don't get a lot of direction ... the day-to-day stuff that are going to impact the fishers and the fishery, those are ours" (DFO 6).

Managers and scientists in the National Capital Region were involved in policy-making while managers in the Maritime Region were involved in policy implementation. Managers in the DFO-MR struggle to interpret or use policies that are relevant to their regions and they believe that managers in the DFO-NCR develop policy and assume that it could be applied in different situations across the country (DFO 8). Scientists and managers in DFO-MR commented on not being involved in the higher-level decision-making because policy is made "remotely and regions are not involved" which creates a "challenge for regions to implement policy with little context" (DFO 10). These respondents said that they usually receive policy that they "didn't flesh out" and described the next level of management as being "very opaque" as they were not sure how policy was developed. One scientist described the pattern as:

> We get direction but very little context coming down. So you get some cryptic policy and it goes up and comes down, and you try to work with it, because you have to respond to the government of the day of course. That is what you do in the public service, operationalise their directions. But not a lot of communication. (DFO 10)

Managers and scientists in the DFO-MR identified problems with the formal communication pathways with the DFO-NCR with regard to the general understanding of management issues and subsequent positions taken by policy-makers positions. For example, within the Science Branch, different reporting structures in the National and Maritimes regions make communications "'clunky' as program mandates go through different pipelines up to Ottawa [headquarters]" (DFO 10). Communication across DFO sectors, however, can often be ad hoc and not formalised as it is operated on a "by file or as needed" basis, which can pose challenges for moving various sources of information into operational policy. Managers think that this situation is partly due to the high turnover of files and partly due to the lack of a formal or specific manner in which the information is communicated.

Managers and scientists think that the communication gaps between regions and sectors may also be related to lack of understanding of how other sectors work or what their unique day-to-day considerations may be. Scientists said that they understood how the fisheries management sector worked in general, particularly since they communicate frequently in the CSAS process, but some scientists also believe that spending time, e.g., up to six months, in other sectors, particularly the policy sector, will be beneficial to improving communication and understanding between the sectors Not all scientists see this idea as a priority or have any interest in pursuing it, which was a concern for other scientists wishing to bridge the gap between science and policy who were distressed that some scientists are still "quite happy to keep their heads down" (DFO 10).

Scientists commented on the lack of transparency in decision-making as a result of the limited communication among some sectors. For instance information from the Science Branch is always available to the public but not all management decisions are open to public knowledge. As one scientist stated: "I am unaware of any case where science was involved in a project that cannot be communicated outward. Now you will find that in policy and in fisheries management because they are providing advice to the minister's office" (DFO 10). Members of the Science Branch interact more with management in the CSAS process than with the policy sector and scientists and managers would like to have more interaction particularly with the Policy and Economics Branch as they feel that this practice would make them understand how policy is disseminated and how it gets into management. Scientists feel that because they mainly communicate with the management sectors and not with the policy sector, they have difficulties in interpreting many of the key DFO policies, which they describe as being generally broad and "vague," e.g., the new emerging fishery policy and the precautionary principle policy (DFO 13).

Ocean managers and ecosystem scientists pointed out that fisheries management has been a traditional priority area of work for DFO and the current structures favour fisheries management, making it a challenge to move ahead with more integrated management approaches like ecosystem management. For instance, Resource Management is the only division with two executive levels, i.e., a Regional Manager and a Director, reporting to the Regional Director of the Fisheries Management Branch. Fisheries Management encompasses different major sections such as Resource Management, Enforcement, and Aboriginal fishing, and:

> Because of the political implications and the importance of fisheries management to the department it was necessary to have somebody at the executive level dedicated just to the resource management decisions … fisheries management has been the focus of this department to the bane of us in Oceans Management, we feel that it is a challenge getting any air time or face time for oceans management issues. (DFO 11)

Advice on ecosystems or environmental data is perhaps even further removed as some sectors in DFO involved in physical and oceanographic data collection feel that they are "one step away from the direct provision of specific advice on a question" because their data is not linked directly to the request for fisheries advice and that information "isn't getting through to decision-makers in an effective way" (DFO 10). For instance, the Ecosystem Science branch is not as directly linked as the Population Ecology Division is with the Fisheries Management sector. The Oceans and Coastal Management Division recognize and attempt to integrate these different information sources as seen in its lead role in projects like the identification of EBSAs (DFO Direct Observation 3).

The CSAS process for the identification of EBSAs, however, differed from the typical process for provision of fisheries scientific advice (DFO Direct Observation 3). The credibility of the EBSA review was questioned by scientists since the input data came largely from digital maps that layered environmental, biological, and fisheries data and the setting of boundaries around the EBSAs were considered to be subjective and the process was described as “arbitrary” with “no scientific basis” (DFO Direct Observation 7). Reports from the Science Branch and CSAS reports are considered to have more credibility and as an ocean manager stated, “it is very important to us that the information is published and endorsed by Science [the Branch] as this provides a foundation for MPA network planning ... it is also part of implementing the whole EAF process” (DFO 18). Advice required for identifying EBSAs is, however, considered to be more of a policy request as DFO is considering how to move forward, e.g., in developing a program to identify marine protected area networks. DFO recognises that collecting baseline information through the CSAS process is critical to identifying EBSAs (DFO 2).

Managers described the bureaucracy developed around the administration of fisheries based on single-species licenses as making it particularly challenging for DFO to shift its management regime to incorporate ecosystem advice or the ecosystem approach (e.g., DFO 6; DFO 25). Fishermen obtain licenses to fish specific species; they cannot easily switch to fish another species based on ecological evidence unless they obtain another license that specifies the harvesting conditions for that species and they may require different gear. Furthermore, since the industry currently plays an important role in funding data collection for species though fisheries surveys, “why should a fisherman with a snow crab license for example, care about protecting another fishery or about ecosystem based management” (DFO 6)? This manager proposed a paradigm shift and a new format of fishing license to facilitate the EAF where a single license outlined the conditions for different species of fish and fishermen were allowed to fish year round and not part-time (DFO 6). These changes will clearly warrant a major change in DFO’s operations. Furthermore, the fishing industry will have to be educated as to why these changes are necessary and to be convinced that they can benefit.

The prevailing culture characterized by slow rates of change in the organization and in the fishing industry negatively affects information production and the uptake of available information. Managers lamented the “churning of government bureaucracy” which prevented any noticeable change in operations, and “paralyzes” employees in any action (DFO 6). When pressured by external agents, such as NGOs, to act in a timely manner in response to shark conservation, for example, managers and scientists are often willing to act but “they don’t have the mandate, the authority, or the ability to do things” which then becomes an issue in itself (DFO 6). This manager summarized this view:

> DFO is a very slow machine but it does work given an opportunity and given enough time ... we’re not only educating the fishermen and changing the fishermen we’re also doing it for DFO management ... it takes a long time ... DFO’s got to modernise just as industry has to. Just don’t hold your breath for it …we are definitely talking about cold molasses flowing uphill in the middle of winter. It’s a slow process … baby steps. (DFO 6)

While scientists were clear about their role in the CSAS process, i.e., “scientists don’t make decisions, we might provide advice so that decisions can be made and are informed as possible,” they were not certain whether additional communication pathways were needed apart from addressing specific questions from managers (DFO 10). This real or perceived gap in communication comes to light in instances when policy-makers in the DFO-NCR are not aware of the work progressing in the regions outside of the CSAS process, e.g., the long-term environmental monitoring programs. One scientist stated:

> I don’t know if there are actual barriers to information flow, or if the pipelines that we have built other than CSAS are sufficient. Sometimes I am mind boggled by the lack of understanding from some of the headquarters staff on major issues and how unaware they are on what is actually occurring, what kind of science is happening, and what has already been done, and what it means. So that state of ignorance is I don’t think a reflection of an individual’s ability to understand, obviously the information isn’t flowing … We like the model of CSAS. But CSAS is very much about dealing with a specific question. (DFO 10)

Other government policies, priorities, and traditional practices aimed at socio-economic well-being, often administered by other government sectors, can affect information flows related to DFO fisheries management policies. One manager described the case in which historically DFO managed fisheries based on the Employment Insurance (EI) program (formerly Unemployment Insurance) where the time period for a fishery matched the time needed “to ensure that fishermen paid into the program to be able to have [i.e., benefit from] unemployment insurance" (DFO 6). While DFO no longer manages fisheries in this manner, fishermen are still eligible for EI outside of the fishing periods stated on their fishing licenses. The disconnect between the regions was highlighted as this manager stated:

> It wouldn't surprise me if people in Ottawa, politicians, still think about it. We on the ground here don't think about it. We've been managing the fishery this way for twenty years, unless there is a legitimate reason to change it, we're going to continue to manage it in the same way that was developed by the UI thoughts. (DFO 6)

Canada's participation on a global level, e.g., the development of the international bycatch guidelines, was described as a key driver in national policy development (Section 4.3.2.2). However, less attention was given to the policy implementation, i.e., allocating time and resources for DFO Science to provide evidence to support the policy action and for the management sector to implement new management actions (DFO 1). This situation illustrates a larger issue where the policy has preceded the capability of the scientists to include information related to bycatch and discards in assessments conducted in the CSAS process and the ability of the managers to incorporate the relevant management advice into the licenses. One manager stated:

> It doesn't change really what we do except for putting it in writing. Now anybody can pick it up and say, "well DFO this is your bycatch policy and you are going to manage so that impacts on bycatch species are sustainable, show me how you doing that, show me the proof that they are sustainable" ... it puts us a lot of pressure on us to do our job. (DFO 1)

In the case of bycatch management, fisheries managers stated that it is important that the policy be consistent with global practice but having a national policy does not necessarily change national management practices. Bycatch management was a long standing consideration in Canadian fisheries and methods to deal with bycatch were generally included in fisheries management plans prior to the development of the national bycatch policy. The development of the national bycatch policy "simply sends a much stronger message about how serious the department" considers the issue, but actions are not necessarily changing (DFO 8).

Austerity measures implemented by the federal government (since 2011-2012) have curtailed professional networking as more and more scientists are unable to attend national, regional, and international meetings and conferences due to the unavailability of funds for travel. One scientist stated "we pick and choose and try to be strategic about representation at meetings, but also give other scientists the ability to participate in those things because it is also important for their career development" (DFO 10).

Austerity measures have also negatively affected the sustainability of some research areas resulting in scientists and managers integrating objectives and activities among divisions to ensure that funding for some aspects of research are allocated to the lead branches. For example, Oceans and Coastal Management, Species at Risk, and Fish Protection divisions are asking for scientific information to increase knowledge on particular issues which result in the Science Branch receiving funds to do the research necessary to answer the request for advice (DFO Direct Observation 6 and 7). One senior scientist stated: "Nowadays, there are not enough resources to do a credible job now with more work. It comes down to whose core work is more important than someone else's" (DFO 14).

Scientists describe the environment in DFO as "incredibly risk adverse" resulting from recent (since 2012) rounds of job cuts and budget measures, freezing the size of the public service (DFO 10). A manager stated:

> Because of this risk aversion, much more of the decision-making has now been bumped up to higher levels. So I like to facetiously state that I am no longer a manager, I am a recommender. It has created a lot of bureaucratic work for the director level staff and I just don't know how they keep up with it. (DFO 10)

4.3.4.2. Political Influences Related to the Fishing Industry

Forty-six percent of interviewees (46% - 12 out of 26) highlighted that politics related to the fishing industry can be a challenge to operational decision-making. Industry speaks directly to managers (fisheries advisors) and scientists seeking information but the managers are the primary group to face the industry's hostility when it is not in favour with management actions. Advisors, who understand the workings of the industry, stated that industry is not an ally of DFO when management decisions negatively affect their business. The industry can resort to pressuring government; as a consequence managers "don't ever underestimate the influence of the fishing industry … there is a lot of political influence – small p politics" (DFO 22). Managers described numerous occasions where fishing issues become political and decision-making was largely influenced by the fishing industry. Industry members often had direct contact information for their local politician, Member of Parliament, or the Minister's office, and they would use these public privileges while out at sea or any opportune time to present their views especially when they were in disagreement with the managers. A manager lamented that:

> My recommendations should be based on logic and if the decision is going to be a political decision then logic has nothing to do with it … you have to remember that industry always has the ability to go the political route … you have to really understand, at least within Canada, politics does work at times. (DFO 6)

One manager described an incident after the collapse of the northern cod fishery in the 1990s when affected fishers became temporary license owners for a particular fishery but could not agree on catch allocations with the permanent license holders. Fisheries managers advised the Minister on a catch allocation in favour of the permanent licence holders who were funding some of the science and had developed the fishery. However, the temporary license holders met with staff of the Minister's office in Ottawa to lobby for an equal allocation. The Minister, being advised by staff in the Minister's Office, was prepared to act in favour of the temporary license holders and thus contrary to the advice of the fisheries managers (DFO 24). This incident demonstrates the power of the industry to block information flowing between managers and senior decision-makers. The permanent license holders, which included aboriginal communities, then wrote to the fisheries managers voicing their concerns because they were funding DFO science and assisting with managing the fishery and had an influence on who entered the fishery. The incident also showed the important role of briefing notes prepared by fisheries managers to inform the Minister of the facts. The temporary licenses holders used the *Access to Information Act* to receive copies of the briefing notes and email messages written by fisheries managers on how the recommendation was made. This manager stressed the important role of briefing notes: "For one year I wrote briefing note after briefing note to the Minister to convince her" (DFO 24). Lastly, the incident showed that while managers are expected to adhere to transparency in their "decision-making" regarding the management advice provided to the Minister, the Minister's staff can also present advice that may override the managers' recommendations. While the ultimate decision rests with the Minister, the communication gap was evident as the Minister's staff did not consult DFO-MR before advising the Minister (DFO 24). Events like these lead to low morale among the fisheries managers: "If people [managers] are doing this for years, then they are probably doing a good job. You are getting briefing notes from them, they are giving you options, they are giving you pros and cons of each option" (DFO 24).

4.3.4.3. Communication Tools

Twenty-seven percent (27% - 7 out of 26) described challenges associated with the communication tools used by DFO. While DFO produces considerable volumes of information meant for management and for public education and awareness purposes, managers think they can still improve information sharing across the different sectors. The departmental website and news media are two main methods used for disseminating information; however, concerns regarding these communication tools are described below.

As regards the DFO website, scientists and managers claim that it is not dynamic or interactive on a timely basis. As a Government of Canada website, the Communications Branch manages the DFO website and it is a good source of general information; however, it is not appropriate for ongoing communications or as an engagement tool, as it is "too slow, it's cumbersome, it's restrictive" (DFO 11). The information available of the DFO website is also limited to documents produced and peer-reviewed by DFO staff due to a concern related to ensuring the credibility of the information. For instance, *The State of the Scotian Shelf Report* was anticipated to be a part of the ocean management mandate for reporting on the state of the ocean environment. But the Ocean and Coastal Management Division outsourced production of the report to contributors to themes that are presented in modular format. The final report was not posted on the Government of

Canada website because of issues related to translation and, more importantly, "the theme papers were written by a third party and they do not necessarily reflect the opinions of the Government of Canada" (DFO 11). This outcome led to a partnership with two bodies, the Atlantic Coastal Zone Information Steering Committee (ACZISC) and the GOMC to ensure that the project moved forward. *The State of the Scotian Shelf Report* was then posted on the ACZISC website. The communication of the reports was uncertain because they were "still in some way seen as DFO products …we are [still] getting questioned from our management … and [getting] comments that they were not peer-reviewed by DFO. But the reports went through a rigorous peer review system with our partners under the banner of the GOMC and the ACZISC" (DFO 11).

DFO's use of the news media, the national media, and DFO's communications department has been criticised by managers and scientists as well. The interviewees expressed concern about the extent of skewed media reporting that science input was lacking in the process of developing the new policy and changes to the Fisheries Act that led the formation of the Fish Protection Program. On the contrary, the interviewees noted that the science input was critical in the development of policy: "we went through a whole bunch of CSAS processes just to get to there. So we had scientific advice in support of fisheries protection policy for Canada in the last year to two years" (DFO 16). Furthermore, DFO did not educate the public on the changes and consultation process and this resulted in the media biases:

> For any policy that I have been involved with, this scale of consultation both internally and externally was the most that I have seen in my career in government … communications has not been a strong side of this so maybe that is why there is all the public speculation and concern ... we don't do a very good job in explaining what we are doing. Part of that is just the structure of the organization and part is that we are so focused on trying to get things done and there hasn't been a lot of focus on communication of the changes around the Fisheries Act. (DFO 16)

Managers and scientists spoke about the challenges of communicating to the public and the strict communication protocols. Managers and scientists are coached on responses to the media by communication specialists from the Communication Branch. The interviewees believed that it is always difficult to speak about subjects that are still developing and "when you don't know what the end product is going to look like" (DFO 16). Overall, managers and scientists spoke of the communication restrictions both as a necessary action to ensure accurate communication with the public and as a restriction to their freedom to connect with the public. One manager stated, "there's talk all the time about scientists, about the scientists being muzzled, but it's all of us … actually it is not just the scientists that have muzzles, we all do" (DFO 24).

DFO reporting has traditionally been largely the realm of the Science Branch. DFO management lacks social science expertise to generate and incorporate information on human elements and anthropogenic activities in state of the ecosystem reporting (DFO 11). DFO partnerships with universities to outsource social science expertise are becoming more common. For example, the Department collaborated with the Environmental Information: Use and Influence research program at Dalhousie University which has conducted studies on the use of *The State of the Scotian Shelf* and *The State of the Gulf of Maine Report* (Ross, 2015; Ross and Breeze, in press; Soomai, MacDonald, & Wells, 2013).

Some respondents believed that focusing on output and not operational aspects was not always favourable. An ocean manager stated that the DFO-NCR from which DFO-MR receives its guidance, is interested in output, e.g., databases and mapping tools, and:

> I am always wary about the shiny outputs – sometimes it's not what we need at the end of the day. We need to focus on the operational aspects and what we need to do in DFO and what we need to have in place to do it ... we need to go there but we also need to do what we have to inside – that is the important message. (DFO 21)

4.3.4.4. The CSAS Process- Availability of Advice and Peer Review

While the CSAS process received praises by scientists and managers, 15% of interviewees (4 out of 26) described challenges related to the provision of scientific advice and peer review.

Although scientists working on traditional stock assessments may strongly support the CSAS process, others working in research areas that include wide stakeholder involvement feel that they can contribute more to the direction of management. For instance, scientists may be able to define the information that they think is relevant to a decision more broadly than an operational manager or a policy-maker is capable of doing. However scientists are not involved in deciding what advice is to be requested in the CSAS process. With increasing commitments to address large numbers of management requests for advice, the CSAS office only schedules meetings on a regional or national scale to answer specific requests from a client. This means that "science can't think more broadly than the operational or policy client defines how they want the problem to be solved" (DFO 10), One scientist stated:

> We have given up the ability to say this is the scope of advice that you really need with regard to that question. We let the operational sectors and the policy sectors decide the breadth that they want science to consider and we are supposed to stop with their definition. To me, we have lost something of the potential value of science if we constrain the range of questions that it could consider to only those questions that the policy and management want them to consider. That can be a bigger or smaller problem in different categories of work depending on how broad minded the operational and policy sides are. (DFO 14)

DFO funds and sets priorities about what data are collected, who collects the data, and what assessments are completed. There is a list of primary species that DFO has considered its role to manage. A list of secondary species exists, but DFO has no resources – staff and money – to fund the work. A secondary species is hagfish, for example, for which a fishery exists; however, "DFO's role will not be one of the analyst but will be the one providing the standards for the analysis, the scientific protocols for data collection, and then someone else funds that work. Ideally they would still go through the same process of a framework and an interim reporting, but where the money [to support this work] comes from differs" (DFO 9). Concerns are growing with regard to the CSAS process for developing scientific advice for these secondary species that have been assessed by scientists external to DFO and in collaboration with the fishing industry (DFO Direct Observation 4 and 6).

Like many national fisheries management organizations, DFO's current ability to implement an ecosystem science approach is limited as data do not exist for many aquatic ecosystems and populations of importance, and, in some instances, existing information may not be efficiently managed for ease of access (Curran et al., 2012). In 2010 - 2012, DFO scientists and managers began an ecosystem initiative to integrate stock assessments and EAF assessments to determine whether it worked in some specific geographic areas. It was not clear how and which management sector would use such a new format that would incorporate climate change and EAF to make decisions. One scientist stated: "You kind of respond to management pressure and there was not enough management pressure to do this. So the ecosystem approach sort of drifted into marine protected area designation … our survey data is a big player there" (DFO 9). A barrier in information flow, given the new EAF approaches, is the need for more dialogue within the science sector "to discuss what the role of every division is in providing advice and taking a science-centric look at it … part of why we had the success with fisheries management is because we [fisheries science] had discussions with them about what we need from them and what they need from us. And we haven't had those discussions with other sectors [within DFO]" (DFO 9).

While more dialogue with the Science Branch is seen as a way forward, evidence from direct observations showed that such discussions are starting to take place (e.g., DFO Direct Observation 6). Furthermore, decision-makers stated that they were very aware of the science sector's reporting on changes in the ecosystem due to climate change and the potential impacts of these changes on fisheries. But the main challenge is not knowing how to proceed and how to initiate dialogue with members of the fishing industry on climate change adaptation related to their fishing activities. A senior manager stated:

> I think a lot about climate change. With DFO as a regulator, the question is how we get the conversation going with the industry about the impacts and get them to become involved in a proactive fashion. It will be difficult because we will not be able to get Science to give us precise predictions but we know that environmental conditions are changing and species distributions are changing. We have not set up fisheries on the basis of biological or ecological areas. There is perhaps a

> hodgepodge of reasons for setting boundaries. So what do we do when things start to change? DFO is not set up to have the flexibility to adapt to that change. I don't have an answer but I think about it a lot. (DFO 27)

The format for stock assessments does not allow for EAF considerations, e.g., climate change. "In our stock assessments we don't have a way of putting that in partly because the advice that we provide is on an annual basis and effects from climate change will occur after a five-year period for the soonest … I don't think there is anything in the annual fisheries management cycle that will accommodate climate change. It would come in more if you were doing more strategic type of thinking, like where do you want the snow crab fishery to be in 30 years" (DFO 9).

Scientists were concerned that other branches in the department were not required to operate under the same strict guidelines of peer review like the Science Branch; therefore, transparency in the decision-making process is questioned. There is no equivalent structure to the CSAS science process for peer review of the management advice (DFO 21). For instance branches like Policy and Economics also provide information for senior decision-makers, but it is not clear how the policy-makers weigh the different sources of information, e.g., a two-page summary document condensed from a 300-page technical report and a report from the Policy and Economics Branch. Fisheries managers and scientists were also not clear about what the Policy and Economics Branch produces for the policy-makers (DFO Direct Observation 1). Such reports are not generally part of the CSAS process.

Unlike its predecessor, CAFSAC, from the outset CSAS was inclusive of non-government experts (academics, fishing industry, and NGOs), who served in an individual capacity, not as representatives of stakeholder groups. While managers and scientists in the region praised the process, a senior scientist described grave concern that DFO no longer produces scientific advice based on rigorous peer review but instead follows the current CSAS process, which "is more a consultative process than a review process" (DFO 14). The "challenge-format peer review" of the CAFSAC meetings and early CSAS meetings where scientists were asked "very tough technical questions" no longer applies (DFO 14). This senior scientist stated:

> This culture has been lost more so in the Maritime region than in any other part of the country. There is almost no rigorous technical content to the review anymore ... the CSAS process is almost more a step in the consultation process than a rigorous quality control of scientific and technical content. Expansion of the peer review to include academics, industry, and NGOs in the CSAS process is a watered down version of peer review. Multi-stakeholder participation in CSAS meetings does not allow for addition of any technical details and more in depth discussions. (DFO 14)

This "watering down" of the peer review was also observed during the CSAS meetings (DFO Direct Observation 1 through 3). Each meeting involved largely a discussion between the managers, considered as the clients of the science reports, and the scientists – with scientists asking managers if the advice provided was what they wanted and were they going to be "happy with it." Managers would say if they "liked" it or not and other invited participants, e.g., the industry and NGOs would weigh in on whether they "liked" the analysis or not (DFO Direct Observations 1 through 3). When attempts are made to discuss the technical content, "most of the people in the room cannot be engaged and the discussion cannot continue" (DFO 14).

Grey literature is often the main source of information as the topics are emerging and not yet covered in the primary literature. For example, "for some of the species at risks problems that we are working on, we're trying to look forward to things that will come up as challenges that we aren't addressing yet ... it's hard to find anything in the primary literature because no one's doing anything yet" (DFO 2). Personal communication is the next alternative when the grey and primary literature does not provide information on a topic. One manager pointed out the limitation of the reliance on CSAS publications:

> Both on the science and management side, the stuff that we use directly tend[s] to be internal, but there is a lot that we can draw on ... this place is way too insular in that people assume that there is nothing of value to be learned, particularly on the management side, by going outside the department. (DFO 19)

Table 7. Summary of the barriers in the information pathways – production, communication, and use of scientific advice – in the Canada Department of Fisheries and Oceans (DFO).

CHARACTERISTICS OF THE BARRIERS	DETAILS
1. ORGANIZATIONAL STRUCTURE AND CULTURE	
Austerity measures and risk adversity	Austerity measures increase the risk adverse nature of managers seen in the consensus focus of the CSAS process
Dispersed structure of DFO - Disconnect between the National Capital Region (HQ) and the Maritimes Region	Fragmentation leads to lack of awareness of how different sectors work
	HQ has limited awareness of research outside of the CSAS requests in the Maritimes as requests for other sources of information are few
	Managers and scientists in the Maritimes implement policy almost in a vacuum as they were not involved/consulted in the policy production
	Policy is made in HQ and implemented in the Maritimes
	Weak links with some sectors, e.g., Policy and Economics was not commonly engaged in dialogue with management and science sectors
Fisheries is the traditional priority of DFO	Bureaucracy around fisheries administration prevents EAF implementation – single species approach to multispecies licenses
	Fisheries decision-making has shifted to higher executive levels
	Other science areas outside of the Population Ecology Division (which provide fisheries assessments), e.g., environmental data collection, are not directly considered in the CSAS process
National policy ahead of the science	EAF policy, e.g., the Precautionary Approach and bycatch policies were developed ahead of DFO sectors developing the capability to provide science and management advice through the CSAS process
Other government policies	Social services, e.g., Employment Insurance, was linked to fisheries management
Slow rate of change	DFO cannot keep up with requests from the industry and NGOs and is often "paralyzed" to act
2. POLITICAL INFLUENCES RELATED TO THE FISHING INDUSTRY	
Communication gaps between the Minister's office and regional managers	Through the use of briefing notes to bring facts to the Minister, managers have to maintain firm positions with the Minister to prevent political decision-making that overrides advice
Industry consults political figures	Industry consults political figures when it does not favour the scientific advice; Political decision-makers can override management

CHARACTERISTICS OF THE BARRIERS	DETAILS
	advice which is based on the best available scientific advice.
3. COMMUNICATION TOOLS	
DFO communications protocols	Strict protocols exist for internal and external communication
	No formal use of news and social media to disseminate information
	Only DFO reviewed material is considered to be credible; In spite of this view, DFO partners with other agencies
Inadequate information dissemination	Inadequate information dissemination by the DFO Communications Branch increases public mistrust as a result of misconceptions about fisheries legislation and restructuring in DFO
Static website	The DFO website is not dynamic enough for social media
4. THE CSAS PROCESS – AVAILABILITY OF ADVICE AND PEER REVIEW	
Consensus versus rigorous peer review	Consensus versus rigorous peer review – multi-stakeholder participation prevents stricter peer review as groups are incapable of discussing the technical details of the science
Lack of transparency in decision-making	Reports from other sectors, such as Policy and Economics, are not part of CSAS, yet are considered in decision-making
Limited available resources and inflexibility of the CSAS schedule to deal with complex issues, e.g., climate change	Availability of scientific advice – research on species that are not considered as priority for management is not funded
	Complex issues like climate change and EAF – data not available or just emerging for some topics but the effects are anticipated. DFO is seeking ways to bring the industry into the discussions with managers
	DFO lacks social science expertise in the CSAS process
	The process is geared towards annual stock assessment advice; Climate change consideration has to be made over a longer time interval
Scientists play a limited role in requests for advice	Scientist do not ask or suggest questions they perceive as important; scientists may be able to define the information relevant to a decision more broadly than an operational manager or a policy-maker can

4.4. Discussion and Conclusions

The DFO case study examined the information pathways in a national fisheries management context involving the DFO science and management sectors. The findings primarily related to the use of scientific information in operational decision-making in fisheries management in the DFO-MR and not in fisheries policy-making. DFO managers and scientists relied on the organization's publications, primarily those produced through the CSAS process. Managers depended on the CSAS science advisory reports to guide their fisheries management decisions while scientists used the more detailed CSAS reports as background materials to guide assessments. Overall, the observations at science and management meetings supported and complemented what was said in interviews. The models of information use and the characteristics of the science-policy interface in national fisheries management are discussed below. The discussion also highlights activities that seek to remove some of the barriers in the information pathways in DFO.

The key enablers in the information pathways include the attributes of the scientific advice, the roles of scientists and managers, and organizational structures that support information flow at the interface (Figure 7). Conversely, some organizational structures also featured as major barriers in the information pathway (Figure 8). The provision of scientific advice is embedded in the organisation as the CSAS process plays a central role in setting the work schedules for scientists in regard to stock assessments and other research to be completed on an annual cycle. Because the CSAS process is embedded in DFO, the information produced embodies the attributes of quality scientific advice, i.e., the reports are credible, relevant (salient), and legitimate. The credibility of the information was attributed to its production by DFO, the authority for fisheries management. The CSAS process also adds transparency to fisheries management. Relevance of the information was primarily based on the fact that advice was provided only in response to the questions asked. Legitimacy was attributed to the wide-peer review community that expanded beyond the main actors, i.e., the scientists and managers. Production of scientific advice in DFO is driven by an annual need for the information for fisheries management decision-making, e.g., in setting the fishing license conditions. Overall, the scientific advice is produced in direct response to requests from managers which interviewees openly described as science and management “matching up.”

The “matching up” of scientific advice and management needs can be interpreted as a trade-off in the science-policy interface. Trade-offs seek to balance the complex two-way interactions at the interface (Sarkki et al., 2014). The “matching up” trade-off of the scientific advice and management is an inherent characteristic of the CSAS process starting from the initial requests from managers who don’t ask questions if they know scientists cannot answer them, the senior managers’ review committee that considers the workload of scientists in their prioritization of the requests, and the managers who may work with the scientists to ensure that they have the capacity to complete the work in the year. All managers and scientists who were interviewed were very clear about this process and appeared to be in favour of this “matching up” as it provided unambiguous guidance and direction, thereby making their respective work schedules relevant to decision-making needs. While this practice drives the production, communication, and use of scientific information, scientists felt that they should be allowed to propose questions to be asked as they can interpret a problem in a much broader context than a manager is expected to and this may be beneficial in regard to the extent and quality of advice that can be produced. The strong focus on producing advice to meet management needs also poses the risk of excluding important sources of information or “watering down” the scientific advice.

Information flow in the CSAS process fits a linear science-policy interface model where science, in the form of fisheries and ecosystem science, is the principal input in the development of advice as described by Koetz et al. (2011). The “matching up” of science and management is a trade off in the legitimacy of the information to ensure that credible and relevant information is available for decision-making. The use of fisheries scientific advice in the CSAS process is based on an annual cycle with a definite beginning and end. Information use in DFO’s CSAS process followed a direct use model where questions were asked by managers, advice was provided, and management recommendations for fisheries management were made. These stages in the CSAS process are akin to the stage models of information use described by Nutley et al. (2007)

where information is received by managers; it is read, understood, and communicated to senior managers; used in briefing notes; and then employed in setting the conditions for the fishing licenses, e.g., the harvest levels. While the entire CSAS process appeared to be linear in terms of the reliance on scientific information and the involvement of DFO scientists and managers in the information pathway (see Figure 6), considerable interaction occurs at the beginning of the process among scientists and managers, making the process iterative with regard to the framing of questions to be asked by managers in light of the scientists' capabilities. To ensure understanding of the scientific advice, managers also interact considerably with scientists.

Fisheries management issues are becoming more complex and while international policy related to the implementation of the EAF is a driver in the production of national legislation, the CSAS system, the primary process for producing scientific information and advice, is not equipped to include ecological data and climate change considerations. Decisions on stock status are made on an annual basis; however, this new paradigm for ecosystem predictions needs a long time series of data for ecosystem effects to be noticeable, e.g., about 20 years. Climate change effects require long term frameworks for validation of the role of climate change and framing research questions accordingly in CSAS assessments and reviews will be critical. For this important issue, managers and scientists are engaging in an ongoing dialogue to determine the types of questions that have to be posed to the science sector to provide advice on the impacts of climate change. It is anticipated that management will need to guide the science sector in this regard. The impetus for the EAF relates to lessons learnt after the decline in cod stocks and scientific uncertainty and the research models are discussed openly. DFO is progressing toward the inclusion of environmental indicators in the stock assessment advice so the advice takes a more ecosystem approach. It is expected that information pathways for new research and questions related to the EAF and climate change will likely change – from the current format of the CSAS process – and will not travel directly to the Resource Management Division (management sector) from the Population Ecology Division (science sector) as is currently the practice with the stock assessment advice about harvest levels (see Figure 6). Consequently, the use of scientific information to implement EAF is progressing towards a continuum model of information use where communication between managers and scientists is an iterative process as described by Nutley et al., (2007) and Sarkki et al. (2015).

The participation of multiple groups in the CSAS process acts both as a driver and as a barrier to communication and was a paradox in itself. While most managers and scientists praised the inclusive nature of CSAS, which ensured that the peer review process was transparent, one senior scientist with policy experience raised concerns that “the reason for peer review should not be to discuss how palatable the advice is to different groups but to do rigorous quality assurance” (DFO 14). The reason for this difference in rationale regarding the role of science was not explored in depth in this study; nonetheless, some suggestions can be offered. The relative seniority of the scientists interviewed can be a factor since more junior scientists may not see the participation of multiple groups as compromising the peer review. The difference also could simply have been a case where this compromise is noted but accepted by scientists but not discussed in the responses to questions posed to interviewees in the study. The senior scientist provided an explanation for the CSAS dilemma, which is also a paradox, as it is rooted in the movement towards integrated ocean management which began when the concept of large ocean management areas (LOMAs) was introduced to facilitate integrated planning (DFO, 2014h). Subsequently, integrated planning activities, such as consultations, began to overlap with science activities, and:

> Once they started being consultative on ocean issues, they quickly became consultative on everything. Science advice and consultation are two separate entities and there should be an impenetrable boundary between a science process that leads to a science conclusion and advice and a consultation process that gets into how palatable the conclusions are … and what management can do and what policy should do given the results. It is the job of operations to do all of the consultations. And they do it starting with the results of a science process that has no consultative component to it. (DFO 14)

This movement towards consultation may represent a “consultation-peer review” trade-off in the science-policy interface. This trade-off describes the involvement of multiple stakeholder groups in the CSAS review process, i.e., extending the peer review community, thereby espousing the principles of modern fisheries management; however, rigorous science review is now limited since many of the groups are not capable of asking technical questions. The result is a consensus process where there is agreement on the advice by the different stakeholder groups as opposed to challenging the validity of the advice. The consultation-peer-review trade-off in the credibility of information in the science-policy interface favours legitimacy and relevance of the information to multiple stakeholder groups. The scientific assessment is still considered to be credible because it is produced by DFO scientists and managers. The acceptance of the scientific advice through consensus among groups was stated by the chairperson at the start of CSAS review meetings (DFO Direct Observation 1, 2, 3, and 7). The consensus approach to developing scientific advice in the CSAS process can be a means of addressing scientific uncertainty at the science-policy interface. Accepting the scientific advice through consensus appears to appeal to the risk adverse characteristic of decision-makers, particularly in the face of increasing austerity measures.

The "consultation-peer review" trade-off also indicates a shift from a linear model of the science-policy interface, seen in the robust science review process in CAFSAC and in the earlier years of CSAS, to a collaborative model in the current process involving consensus within a wide peer review community, i.e., apart from DFO scientists and managers. The somewhat limiting role of an extensive peer community in a fisheries management context diverges from the literature on collaborative science-policy interface models that espouses the benefits of such communities in integrated coastal zone management settings (see Chapter 2, e.g., Bremer & Glavovic, 2013). In the DFO CSAS process, expert groups, apart from fisheries and ecosystem scientists and other researchers, may not be capable of asking detailed technical questions, e.g., on a stock assessment model. However, non-expert groups are becoming more knowledgeable of fisheries science and industry members are more engaged in the technical discussions at CSAS meetings than expected (DFO Direct Observations 1 through 3). DFO staff commented on the increased capability of the fishing industry to understand the scientific process since industry members participated in fisheries data collection and in some of the framework meetings to discuss the assessment methodology.

The view that the DFO CSAS peer review process has been compromised by moving from a strict science peer review meeting to a "consultation" type meeting involving a wide range of stakeholders may be an illustration of a "post-normal science" perspective on the science policy interface (e.g., Funtowicz & Ravetz, 1993, van der Sluijs et al., 2008). Extensive peer-communities have been purported to be the cornerstone of "post-normal science" where inclusion of multiple stakeholder groups can address concerns with scientific uncertainty. Direct observations at CSAS meetings also revealed discussions to ensure that the scientific analyses were understood, validated, and trusted by the members of the fishing industry, and other participants representing, e.g. the provincial government, NGOs, and academic institutions. As a consequence, uncertainty was not considered an issue and it was accepted in the scientific advice. However, in areas where the science is new, e.g., ecological science, dealing with uncertainty is much more challenging to managers who need to translate scientific uncertainty and precaution into "fairly expensive management decisions" and the science is not always available to address some of the management issues (DFO 22). The extended peer community in the DFO CSAS process became the foundation for credible, relevant (salient), and legitimate science and management advice.

The roles of scientist and manager communities and characteristics of the organizational structure and culture in DFO appear to be the chief enablers in the information pathway. At the same time, aspects of the dispersed organization's structure of DFO and the traditional focus on fisheries management posed the major barriers to information movement in light of the growing need to adopt the EAF. The asynchronous character of the science-policy interface in DFO, where national policy precedes the available science needed to implement the policy, as seen with the release of the national bycatch policy (see Section 4.3.4.4), is a phenomenon that has also been described by Rice (2005). Politics related to the fishing industry was listed as a barrier but only became an issue when management decisions were not in the industry's favour. With the inclusion of the industry in the CSAS process, the incidence of grievances reaching the level of the Minister is expected to be lower.

An unexpected finding from the research was that only the senior managers in the Maritimes Region spoke about the policy implementing role of DFO as a driver in the information pathways. All of the interviewees in the National Capital Region spoke about Canada's role in supporting and implementing regional and international policy and national legislation as a driver in the information pathways. To be expected, such individuals are more closely involved with policy- and decision-making circles. DFO-NCR staff also referred to international policies and guidelines, particularly those by the FAO, e.g., the *FAO Code of Conduct for Responsible Fisheries* and the FAO's deep sea fishery guidelines. In the interviews and the direct observations, DFO-MR staff did not mention sources of scientific information outside of DFO, nor did they place their work in the context of international policy, for instance policies produced by the FAO. Staff of the DFO-NLR participating in NAFO were aware of UN and FAO-led policies. DFO-MR staff appeared to be generally unaware of many of the developments in international policy-making. The observations support the view that was common among respondents based in the Maritimes Region that they were physically removed from policy-making and play the role of implementing policy without much context for how it was developed.

Interviewees also spoke about the communication challenges due to the decentralized structure of DFO and policy-making being based primarily in the DFO-NCR. The role of NGOs in filling this gap in knowledge of the international discourse on fisheries management issues in the Maritime Region was seen, for instance, in the CSAS peer review meeting to identify EBSAs (DFO Direct observation 3). At this meeting, NGOs, such as the World Wildlife Fund (WWF)-Canada, were able to update the participants on events at recent meetings of the Convention on Biological Diversity where the EBSA issue was discussed.

Aspects of the innate organizational structure of DFO pose many challenges to internal information flow. Communication between the DFO management and the DFO science sectors was observed to be direct and frequent and less so with the DFO policy sector. The findings support Curran et al. (2012, p. 3) who stated that "institutional structure and functioning (and not scientific knowledge) may be the culprit behind slowed implementation of the ecosystem approach in government." Curran et al. (2012)

recommended the use of CSAS and the Policy and Economics or the Oceans sectors as the collaborative means by which management sectors can confer and bring information together. This study showed that CSAS and the Oceans and Coastal Management Division were acting in this role but the Policy and Economics Branch was not commonly involved in the routine fisheries or ocean management aspects. Of note, staff of the Policy and Economics sector participation in this research was limited, unfortunately.

Some managers in DFO shared the vision of the need to develop a new type of publication that compiles relevant information from each branch for use by decision-makers requiring departmental information, e.g., when an environmental assessment report is being prepared (DFO 17). The major benefit of such a report is that all the information will be assembled in a single document, ensuring that a single and credible source of information is readily available to decision-makers. The report would also be available to meet requests for information outside of CSAS, which is not often given priority because of already large workloads or the unavailability of staff.

Little mention was made about the use of primary literature and respondents, focusing on the CSAS process, had little time or interest in publishing outside the Department. Only scientists holding formal “Research Scientist” posts in the public sector may be so inclined to publish in the primary literature because communication of scientific results is a performance measure of the posts. CSAS publications are not considered in this measurement. The reasons for the reliance on DFO’s own publications included the relevance of the content related to the species and geographic area and the credibility of the information since DFO is considered the management authority. The results show the critically important role of grey literature produced in the CSAS process in decision-making in DFO.

The negative impacts of continuing austerity measures (circa 2012 onwards) are expected and DFO staff spoke about the changing management and research priorities that drive information production and use (see Section 4.3.4.1). Nonetheless, it is anticipated that a demand for information for fisheries management through the CSAS process will remain. Austerity measures, however, can have some positive outcomes as seen in the organizational restructuring that integrated the Department’s fisheries management mandate into fisheries protection (see Section 4.3.3.3). Questions from managers are becoming more complex, given the fisheries issues at hand. There is limited information on the anticipated effects of complex issues like climate change. Managers and scientists acknowledged that changes must be made to facilitate the production of scientific information for future decision-making. With a growing demand for fisheries science and management that incorporates climate change considerations, DFO will need to urgently review its organizational structures, e.g., the CSAS process, to facilitate the supply of the relevant scientific advice. The CSAS process may also provide the framework for engaging with the industry to initiate discussions on management adaptations in the face of climate change.

The main conclusions of this case study are:

1. The credibility, relevance, and legitimacy of scientific information and advice in DFO are assured by having a formal process for information production, communication, and use, i.e., the CSAS process. Having a well-defined process for requesting advice by managers, producing and providing advice by scientists, and the internal peer review by DFO staff and invited stakeholders ensures that the "best" scientific information is available for decision-making. DFO staff believe that the "best" information for fisheries management by DFO is the information produced by processes embedded in the organization itself. Therefore, DFO's grey literature is a critically important source of information for decision-making in DFO.

2. Although a formal process for production of scientific advice is established, its success is facilitated by trust relationships between the main actors, e.g., scientists and managers, and other main stakeholder groups, such as the fishing industry. Trust relationships contribute to the perception of credibility of the information produced. Such relationships are enabled through ongoing formal and informal dialogue among groups of actors and the number of years that individuals have been working together. The iterative communication between the two main groups of actors facilitates the managers' understanding of the science and the scientists' understanding of the management needs. Having a science background also enhances managers' understanding of the scientific information.

3. The information pathways in the DFO CSAS process are characterised as a linear science-policy interface model. There are no information inputs from other sources apart from the fisheries and marine scientists employed by the organization. However, this overall linear model contains some collaborative aspects, i.e., the iterative relationship between scientists and managers in the production of advice and the development of management decisions.

4. The "matching-up" trade-off, where questions are posed by managers to the scientists, advice is provided by the scientists, and management decisions are made by mangers based on the scientific advice, ensures that advice is available to meet the management needs. This is a trade-off in the attribute of legitimacy of information in the science-policy interface.

5. The "consultation-peer review" trade-off favours the attribute of legitimacy of information in the science-policy interface where the agreement of the scientific advice by multiple stakeholder groups is attained by consensus. This consensus among a wide peer review community may indicate a philosophical shift in the organization's approach to the production of advice. Foremost, an extended peer community espouses the principles of modern fisheries management. The risk adverse characteristic of decision-makers, in the face of increasing austerity measures, may be the basis of the consensus approach to developing scientific advice in the CSAS process. The consensus approach to developing scientific advice in the CSAS process may be a method of accepting scientific uncertainty at the science-policy interface.

6. In addition to the three attributes of information – credibility, relevance, and legitimacy – of the information, transparency was specifically identified as a critical attribute and is now given more consideration in the current CSAS process, compared with its predecessor, CAFSAC.

7. Contemporary communication tools, e.g., social media, continue to be used on an ad hoc basis and national governmental organizations, such as DFO, prefer to use their websites as a primary means for communicating with the fishing industry, the public, and staff.

8. Organizational structures, related to decentralization, are a major barrier to information flow. While this may be unavoidable in a country the size of Canada with five large ocean management areas under its jurisdiction, efforts could be made to decrease the gap in communication between the DFO-NCR and the administrative regions, such as the Maritimes. Within the DFO-MR, efforts could be made to increase the communication between the Policy and Economics sector and other sectors. The science and management sectors have a well-defined association through the CSAS process. However, the scientists and managers believe that more interaction from the Policy and Economics sector will improve their understanding of policy and may assist scientists and managers in the Maritimes Region to understand the policy actions in the DFO-NCR.

9. Understanding the role of scientific information in policy-making in the organization necessitates a similar case study being conducted in the DFO-NCR. While it is anticipated that senior managers and policy-makers may not be willing to answer questions on information use, direct observations of science and policy discussions, e.g., at House of Commons and Senate committee meetings, could reveal the role of science in these decision-making groups.

The relevance of the results of the case study of DFO is discussed in further detail in Chapter 7, including the influence of international policy-making and Canada's role in regional and international policy-making.

CHAPTER 5. CASE STUDY OF THE NORTHWEST ATLANTIC FISHERIES ORGANIZATION (NAFO)

5.1. Background

5.1.1. Organizational Structure and Mandate

The Northwest Atlantic Fisheries Organization (NAFO) is an intergovernmental fisheries science and management body focused on the management and conservation of most fishery resources in the Northwest Atlantic region (NAFO, 2014a). NAFO was founded in 1979 as a successor to the International Commission of the Northwest Atlantic Fisheries (ICNAF) (1949-1978). The organization consists of 12 members or Contracting Parties from North America, Europe, Asia, and the Caribbean; four members are referred to as coastal states as they border the NAFO Convention Area, i.e., Canada, USA, France (in respect of St. Pierre and Miquelon), and Denmark (in respect of the Faroe Islands and Greenland) (NAFO, 2014a). NAFO facilitates consultation and cooperation among the members for utilization, management, and conservation of designated fishery resources of the marine areas outside of their exclusive economic zones (EEZs) and within the NAFO Regulatory Area (NAFO 2004a). The organization is composed of four constituent bodies: a General Council (GC), a Fisheries Commission (FC), a Scientific Council (SC), and a Secretariat (NAFO, 2014a). The Secretariat is located in Dartmouth, Nova Scotia and provides support services for the organization. Canada as a Contracting Party to NAFO is represented by its Department of Fisheries and Oceans (DFO).

5.1.2. Relevant Fisheries Management Policy Frameworks

NAFO is a regional fisheries management organization (RFMO) established outside of the UN Food and Agriculture Organization's (FAO) main framework of RFMOs. However, FAO follows NAFO's activities in the NAFO Convention Area or FAO statistical area 21, given its relevance to global and regional fisheries governance (FAO, 2014h, 2014i; NAFO, 2004a). The 2007 NAFO amended Convention has not yet been ratified by enough members to come into force but it nonetheless is an improvement to the original 1978 *Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries* related to implementation of international fisheries instruments and initiatives for conservation and management of straddling fish stocks, such as the UN Fish Stock Agreement (UNFSA), and other binding and non-binding instruments for sustainable use and protection of marine biodiversity (NAFO, 2004a; UN, 1995). Guided by the *1995 FAO Code of Conduct for Responsible Fisheries*, NAFO's 2007 amended Convention aims to achieve consistency and compatibility of conservation and management measures adopted by coastal states and the NAFO FC. To this end, the amended Convention has incorporated relevant provisions, e.g., for cooperative and integrated monitoring, control, and surveillance (MCS), flag State duties as set out in the UN Convention on the Law of the Sea (UNCLOS), the FAO Compliance Agreement, and other international instruments (FAO, 1993, 1995; UN, 1982). As an RFMO, NAFO also facilitates opportunities to ensure that these principles and provisions permeate national and regional fisheries management frameworks. When the amended Convention comes into force, the FC and the GC will become one body – the Commission (NAFO, 2004a).

Upon the recommendation of the SC, the FC adopted a NAFO "Precautionary Approach Framework" (PAF) in 2004 to guide fisheries management decision-making (NAFO, 2004b; 2014d). The precautionary approach is used for improved protection of the resources and to determine appropriate resource management measures in the absence of sufficient scientific data. In keeping with global trends, NAFO also began the implementation of the EAF, but specifically within the context of deep sea fisheries following the publication of the FAO Guidelines on Deep Sea Fisheries (FAO, 2009b).

5.1.3. Provision of Scientific and Fisheries Management Advice

NAFO is a prolific producer of fisheries scientific information published largely as grey literature which is available on the NAFO website. The NAFO SC, made up of scientists from the responsible national fisheries management authorities or agencies within each member state or Contracting Party, provides scientific advice for the management of specific fish stocks within the NAFO Regulatory Area (NAFO, 2014a). The organization now produces scientific advice regarding marine habitats and vulnerable species in addition to the traditional stock assessments of commercial fish species. Formulation of scientific advice is based on the work of the SC's four standing committees, each with working groups, comprised of representatives and designated experts from the member states. Scientific meetings under each standing committee are held throughout the year. Of relevance to this study on information use, fish stock assessments are completed in the Standing Committee on Fisheries (STACFIS) and state of the ocean reports are completed by the Standing Committee on Fisheries and the Environment (STACFEN). Likewise, ecosystem research is completed in the Working Group on Ecosystem Science and Assessment (WGESA) (formerly known as the Working Group on the Ecosystem Approach to Fisheries Management (WGEAFM)) that was created in 2007 in response to the new NAFO Convention and efforts to adopt an ecosystem approach.

At the NAFO annual meeting, usually held in September, the FC made up of fisheries managers and decision-makers from the Contracting Parties requests advice on catch limits from the SC to be able to develop fisheries management measures (NAFO, 2014c). Specific requests may also come from coastal states, e.g., Canada, needing information on fish stocks within their exclusive economic zone or on stocks that straddle the jurisdictional areas of member states. The scientific advice for the FC is prepared at the SC meeting usually held in June. Scientific advice is generated through a joint effort by NAFO members and relies on fisheries and environmental statistics obtained from the data sampling programs carried out by the national fisheries agencies of the member states. The advice generally provides the limit (precautionary) reference points for fishing mortality and spawning stock biomass for each stock. The FC then determines the risk it is willing to accept that a stock is below recommended limit reference levels for biomass for the commercially important species. The FC decides annually on the NAFO Conservation and Enforcement Measures including fisheries regulations, total allowable catches (TACs), and quotas, which are reported in the Conservation and Enforcement Measures handbook published after each annual meeting. The General Council has overall administrative function for the organization and meets yearly with the FC (NAFO, 2013a).

The organization publishes a range of reports generated by its constituent bodies including: the main SC Report which is prepared as an annual compilation of reports of standing committee meetings and contains the stock assessment advice to the FC and coastal states; the SC research (SCR) documents, such as, stock assessments and summary reports; and ad hoc reports or studies aimed at the scientific community on topical interest and importance, e.g., the 2009 *Coral Identification Guide* and the 2010 *Sponge Identification Guide* (NAFO 2009, 2010). The SC also publishes the NAFO *Journal of Northwest Atlantic Fishery Science* (JNAF), a source of peer reviewed scientific papers (NAFO, 2014e). The SC produces the NAFO Annual Report in collaboration with the Secretariat (NAFO, 2014b). A new series of documents was created in 2014 to report on the work of the joint Fisheries Commission-Scientific Council working groups. The annual proceedings of the GC and of the FC contain reports of all meetings of these two bodies and provides a consolidated text of all NAFO discussions during the year.

5.1.4. Social and Political Milieu in the Organization

NAFO established new working groups in 2013 and 2014 to address important issues with regard to fisheries management and the provision of ecosystem advice. For instance, NAFO is continuing its efforts to rebuild fish stocks in the region but some of the 20 stocks that are managed by the organization remain at low levels. To address this issue, NAFO moved towards risk-based management "to strike the right balance between the biological risk and the stability of harvest over time" (NAFO, 2013b, p. 18). A general framework on risk-based management strategies to reinforce cooperation between fisheries managers and scientists to achieve these objectives was adopted at the 35th NAFO annual meeting (NAFO, 2013b). A joint FC and SC Working Group met for the first time in 2014 to discuss the issue (NAFO, 2014f).

Similarly, in 2008 the creation of a working group devoted to ecosystem considerations was considered critical to providing advice to implement the ecosystem approach to fisheries. NAFO's cadre of scientists are primarily fisheries assessment biologists rather than ecosystem scientists given the organization's traditional scientific and management needs in respect to stock assessments. With the broadening of its advice capabilities, the new SC working group was tasked to develop a "roadmap for an ecosystem approach" specific to the NAFO Regulatory Area, the fisheries, and the unique governance aspects of the region (NAFO, 2011b). The group built on joint work with other management bodies, e.g., the International Council on the Exploration of the Seas (ICES), resulting in a change to the NAFO Conservation and Enforcement Measures to prohibit bottom fishing in a number of areas where Vulnerable Marine Ecosystem (VME) indicator species were known to occur in high densities in order to protect the biodiversity. NAFO is now leading the protection of VMEs in the region and is considered to be a leading RFMO in deep sea fisheries management (NAFO, 2014c).

NAFO has been addressing recommendations from a 2011 performance review that assessed the organization's performance since its inception in 1979 (NAFO, 2011a). The review highlighted aspects of the flow of information among NAFO's constituent bodies and noted a separation of science and management aimed at ensuring that scientific debate is not "'contaminated' by political considerations which may lead to 'overly formal' dialogue between the FC and the SC and delay management or science responses" (NAFO, 2011a, p. xiv). The panel recommended consideration of how the dialogue between the two bodies could be strengthened, while still maintaining the intended "philosophical" separation between them. The review also highlighted the comprehensive and high standard of scientific advice provided by the SC; however, its use may be limited given the "scientifically complex manner" in which the advice is presented which assumes considerable understanding of the scientific methods and prevents broader scientific debate on the work (NAFO, 2011a, p. xx). The review also highlighted the need for improvements to the NAFO website, e.g., as regards clear linkages to increase the potential use of information on the site.

Austerity measures continue in NAFO with a growing focus on a zero-increase budget as seen in the Secretariat where the office is close to a critical point in terms of its workload and the availability of personnel to meet daily work needs (NAFO staff, personal communication, February 2014). The organization is considering more cost-effective approaches to publishing as more online versions of reports are now available. Since 2006 NAFO attends annual meetings of partners and provides input into the Aquatic Sciences and Fisheries Abstracts (ASFA) database which is coordinated by FAO and published by Proquest (FAO, 2014b). Before 2006, DFO-National Capital region (DFO-NCR), Ottawa entered data into ASFA for NAFO. Submissions to the NAFO journal are decreasing yearly and its future is being considered by the SC Standing Committee on Publications

(STACPUB). The journal does not have an ISI Thomson impact factor like other peer reviewed journals so it is “off the radar,” for academics needing to publish in peer reviewed journals (NAFO staff, personal communication, October 2013).

Relations among the Contracting Parties in NAFO were not always amicable in contrast to the study period. Over the period 1978 – 1995, major differences of view between NAFO Contracting Parties on the appropriate management strategies to be followed for groundfish stocks were reported (Barry, Applebaum, & Wiseman, 2014; NAFO, 2011a). These differences also happened during the period when overfishing and the final collapse of the northern cod fishery occurred. Decisions were largely taken by a simple majority, in accordance with the decision-making process outlined in the NAFO Convention, but were often reached “only after divisive and acrimonious debates among Contracting Parties” (NAFO, 2011a, p. x). During this period, the Contracting Parties generally disagreed with the decisions and a significant number of objections were made to the Fisheries Commission quota decisions. Since 1995, more constructive relations developed between the Contracting Parties largely through the FC’s use of consensus-based decision-making. The Contracting Parties now operate in a “more collegial and transparent spirit,” and recognize international instruments such as the precautionary approach and ecosystem-based management, to reach consensus on management decisions on fishery resources and marine ecosystems (NAFO, 2011a, p. xi).

NAFO is addressing claims of discrepancies among the different datasets used in its fish stock assessments. Since 2011, the SC has been questioning the data sources resulting in more uncertainty associated with the annual scientific assessments completed in June. Fisheries catch and effort data come from various sources including the coastal states, which submit statistics from their vessels to the NAFO Secretariat; the Eurostat database, developed by DG MARE (Directorate-General for Maritime Affairs and Fisheries) in Brussels for statistics from the EU member states; the STATLANT 21 database compiled by FAO from data submitted by countries for fishing activity in FAO statistical area 21; and survey data from fisheries research laboratories. Data submitted from these sources are often submitted in a different format and have to be standardized. The authority to solve this situation lies with the Contracting Parties and discussions are ongoing.

5.2. Methodology

5.2.1. Data Collection and Analysis

Data collection in NAFO progressed from September to December 2013 while based at the NAFO Secretariat in Dartmouth, Nova Scotia, and for one week in February 2014. As noted in Chapter 3, the Environmental Information: Use and Influence research program obtained Official Observer status at NAFO in September 2013. As an Observer, attendance at relevant NAFO meetings in Halifax, Nova Scotia was facilitated. Direct observations at meetings and interviews of DFO scientists and managers participating in NAFO were conducted during this time. DFO scientists and managers participating in NAFO were mainly from the DFO-Newfoundland and Labrador Region (DFO-NLR) since its fisheries management responsibilities include the NAFO Regulatory Area. The headquarters for the DFO-NLR is located in St. John's, Newfoundland. Scientists and managers from other Contracting Parties were not interviewed as the research was designed in part to investigate the interactions among the three organizations: DFO, NAFO, and FAO. See Appendices 3 through 5 for the protocols for interviews of scientists and policy-makers, and direct observations respectively. Content analysis of relevant NAFO reports was also completed with regard to the provision of scientific advice and decision-making.

Direct observations were made at three meetings:

1. The 35th NAFO annual meeting, 23-27 September 2013 (NAFO Direct Observation 1; NAFO, 2013a, 2013b).
   Direct observations were made at the GC, FC, and SC meetings held within the five-day annual meeting primarily on how scientific advice on fisheries and ecosystem status was communicated by scientists in the SC to managers and policy-makers in the FC; how requests for clarification of the science advice was formulated; how fisheries management advice and decisions were made by the Contracting Parties; and how the FC formulated its annual requests science advice. Observations were made of the interactions among DFO scientists and managers from the DFO-NLR and the policy-makers from the DFO-NCR.

2. The sixth meeting of the Working Group on Ecosystem Science and Assessment (WGESA), 19-29 November 2013 (NAFO Direct Observations 2; NAFO, 2013c). This group is comprised of scientists from the DFO-NLR and the DFO Maritimes Region (DFO-MR) including fisheries scientists, ecosystem modellers, benthic ecologists, and oceanographers. The topics in the two-week agenda involved defining VMEs and providing reports of related bycatch for use in fish stock assessments and Significant Adverse Impact assessments of VMEs (NAFO, 2013c). Direct observations focused on who were the actors, the drivers for the work, how requests from the FC for ecosystem advice were addressed, how ecosystem science was discussed and communicated, and challenges in communicating the advice.
3. The 1st NAFO Scientific Council-Fisheries Commission Working Group on Risk-based Management Strategies (WGRBMS), 5-7 February 2014 (NAFO Direct Observation 3; NAFO, 2014f).

   The proposal to establish this group was adopted at the 35th NAFO annual meeting and the group reports to both the FC and SC. The Working Group considers the advice of the SC and provides recommendations to the FC on the development and implementation of management strategies based on the application of the NAFO Precautionary Approach Framework (NAFO, 2014d). Direct observations were made in this three-day meeting and included the information sources used by the SC and FC, the actors involved, how science was communicated, and how management aspects were discussed between scientists and managers.

Direct observations were made at the SC ecosystem working group meetings and not of fisheries assessments, due to the timing of the internship with NAFO. However, sessions of the 2015 meeting of the SC and its standing committees were attended and this provided an opportunity to verify some responses made in the 2013 WGESA meeting. Members of the working groups were invited to participate in the research from the Canadian delegation belonging to DFO and attending the NAFO meetings where direct observations were made. Members of the NAFO Secretariat were also invited to participate. Table 8 shows the composition of the research participants. Nineteen interviews were conducted with DFO scientists and managers participating in NAFO SC working groups and the FC. Of the nineteen interviewees, eleven were scientists and eight were managers. Of the eleven scientists, five were fisheries scientists involved in fish stock assessments and ecosystem analyses while four were ecosystem modellers, oceanographers, and benthic ecologists. Interviews lasted 20 to 80 minutes (average = 40 minutes) and were digitally recorded and later transcribed into Word files. Since digital recording of official NAFO meetings was not allowed, detailed notes were made at these events.

Table 8. Number of participants in the case study of the Northwest Atlantic Fisheries Organization.

PARTICIPANTS	**INTERVIEWS**	
	Scientists	**Managers**
DEPARTMENT OF FISHERIES AND OCEANS (DFO)		
DFO-NEWFOUNDLAND AND LABRADOR REGION (DFO-NLR)		
Science Branch (Aquatic Resources; Environmental Sciences Divisions)	7	
Fisheries Management Branch		2
DFO-MARITIMES REGION (DFO-MR)		
Science Branch (Marine Ecosystems; Oceanography and Climate Change)	2	
DFO-NATIONAL CAPITAL REGION (DFO-NCR)		
Office of the Assistant Deputy Minister, Ecosystems and Oceans Science Sector	1	
Office of the Senior Assistant Deputy Minister, Strategic Policy		2
NAFO SECRETARIAT		
NAFO staff	1	2
NAFO OBSERVERS		
Working group members (Non-governmental organizations)		2
Total	**11**	**8**

Data analysis involving coding of interview responses and direct observations to extract themes as described in more detail in Chapter 3. The results are presented in the following section and direct quotations are used to illustrate the drivers for producing information and the enablers and barriers to information use in decision-making. Interview responses are cited as NAFO 1 through 19. Direct Observations are cited as NAFO Direct Observations 1 through 3.

5.3. Results

5.3.1. Information Flow in the Production and Use of Scientific Advice

The information pathways in NAFO are summarised in Figures 9 and 10 related to the NAFO constituent bodies and the annual flow of science advice into decision-making respectively. Information flow, including the request for scientific advice, the production of fisheries and ecosystem advice, its communication to managers, the range of information products and how it is shared, and the use of the advice are described in this section. Table 9 contains a summary of the characteristics of the information pathways in NAFO (see p. 140).

5.3.1.1. Request for Scientific Advice

The FC and the coastal states, usually Canada and Greenland, provide clearly outlined instructions for scientific advice in the "Request for Scientific Advice" statement prepared by the FC at the annual meeting in September (NAFO Direct Observation 1; NAFO 17) (Figure 10). The FC request for advice follows a standard format where the first three items request advice on the status of fish stocks and guide the greater part of the agenda for the SC meeting in June. Stock assessments are presented for the same list of species conducted every year and stock advice is requested for 2-year or 3-year periods for different species. Requests for advice on VMEs are included, which are addressed in the WGESA that meets in November of the same year and before the SC meeting in June.

The FC request for advice is included in the FC adopted report and "becomes an official record of the work of the SC for the coming year" (NAFO 17). The FC request is not presented to the SC during the annual meeting. Instead, the request becomes official when the agenda for the June SC Meeting is prepared in the spring by the SC and the Secretariat. A manager described its preparation as a liaison between the FC and SC:

> The scientists know what they can and cannot do and they know what their limitations are. The FC cannot ask outrageous questions and deliver it to the scientists; the scientists might say we do not have the expertise … from the start, there is the coordination between the FC and SC ... It is an FC document but it is the scientists who draft the text of the request (NAFO, 17).

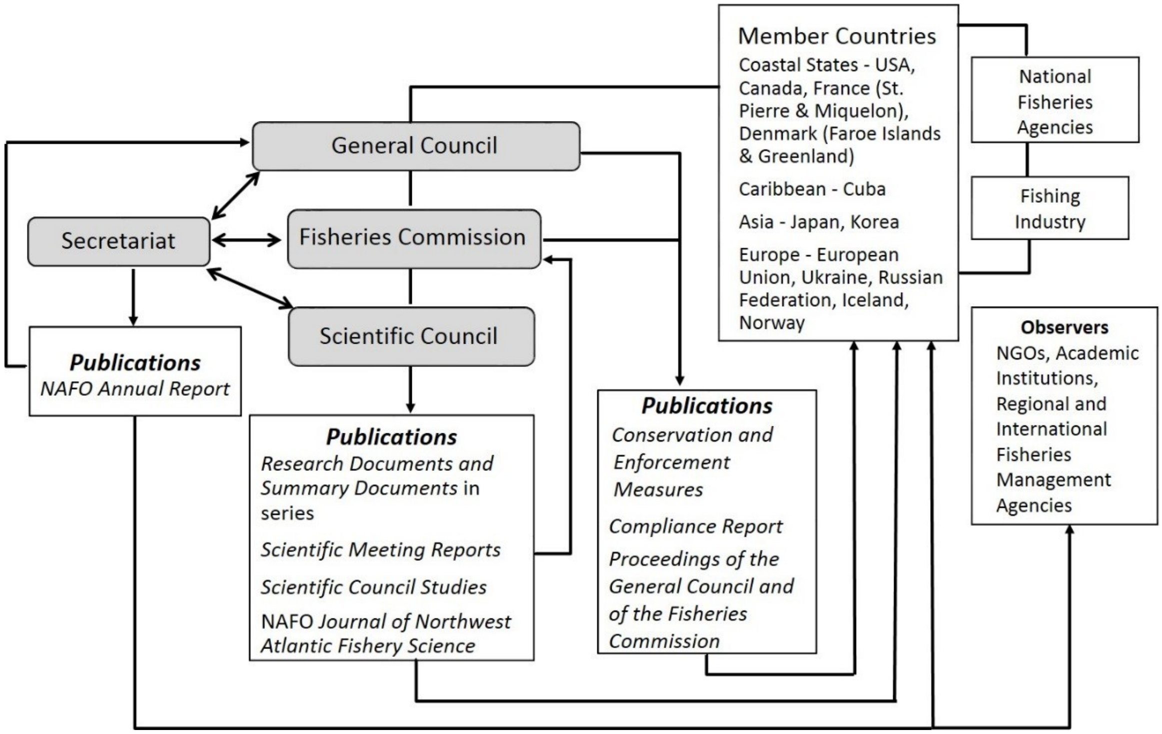

Figure 9. Organizational chart of the Northwest Atlantic Fisheries Organization (NAFO) showing the constituent bodies and the overall publication pathway.

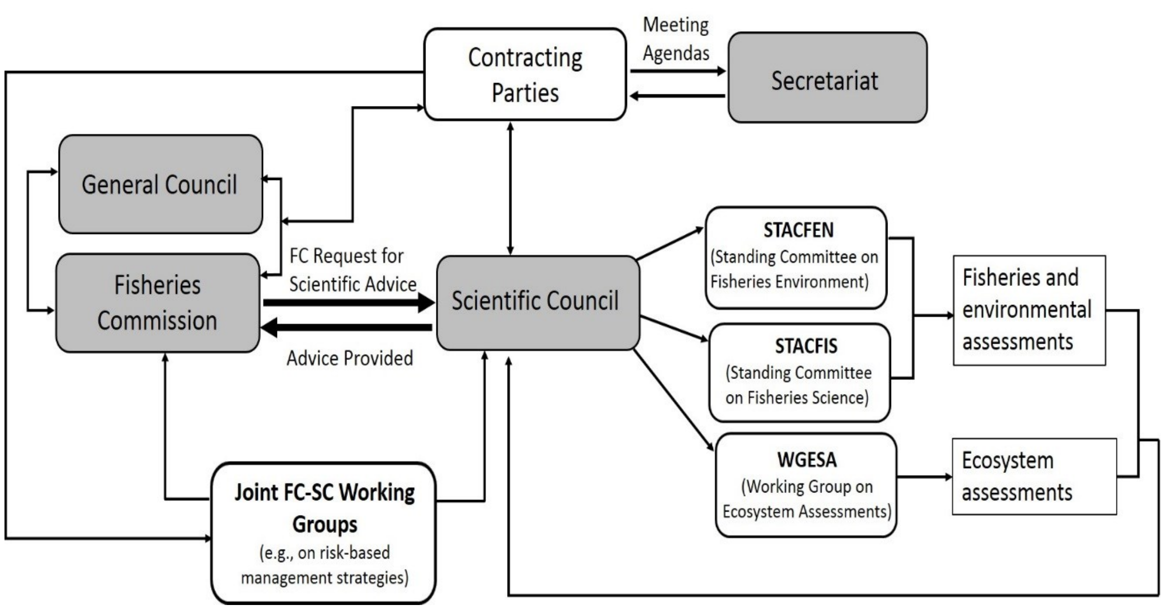

Figure 10. Information flow – production of science advice, communication, and use – in fisheries management in the Northwest Atlantic Fisheries Organization (NAFO).

5.3.1.2. Production of Fisheries Scientific Advice and Ecosystem Advice

Stock assessments are completed in the Standing Committee on Fisheries Science (STACFIS), primarily during the SC annual meeting in June – the main meeting of this body, held over two weeks – where the advice is generated, and responses to requests from the FC are discussed. Overlapping membership of the SC committees is common as they "comprise the same group of people, sitting in the same meeting room, but with slightly different responsibilities and a different chairperson" (NAFO 17). The FC request for advice is also not new to some scientists as they were present at the annual meeting when the request was drafted (NAFO Direct Observation 1 through 3; NAFO 17).

The SC meeting in June provides the forum for peer review of the scientific assessments completed by STACFIS. Scientists typically work as a team with a leader for each stock assessment and produce multi-authored reports of about 50 pages containing the technical details on the methodology and data, the results of analyses and options for management actions, background on each fishery, and references to previous studies often available as Scientific Council Studies (SCS) documents. The detailed reports describing the stock assessment methods used by the scientists in STACFIS are presented during the June SC meeting (NAFO 1). The SC Report is considered peer reviewed when it has passed through the SC plenary meeting. Fisheries managers who may be in attendance have the opportunity to seek additional clarification regarding the scientific assessments and "typically, these types of exchanges between science and policy during the working meeting are useful in order to address the strengths and weakness of the information and to highlight the uncertainties of the data" (NAFO 6).

The Working Group on Ecosystem Science and Assessments (WGESA) meets in November and comprises mainly ecosystem scientists. This working group then presents its report to the fisheries scientists at the June SC meeting. Ecosystem scientists described the communication of ecosystem science and the development of ecosystem advice as challenging overall and more so within the SC meeting where their work is reviewed in order to present the ecosystem advice to FC at the annual meeting. Ecosystem scientists stressed that they make extra efforts to communicate to the fisheries scientists only the results that answer the questions from the FC and usually provide more details to:

> Make sure that Scientific Council understands what we have done because they need to understand it, they need to review it, they need to believe in the conclusions before they are confident that they can use what we have produced as a basis for their response to the Fisheries Commission. (NAFO 4)

Before the annual meeting, the SC prepares the responses to the FC request for advice as an FC working paper. Scientific Council develops primarily stock assessment advice and advice on management issues such as catches, TACs, mesh sizes, closed areas, and ecosystem considerations that it is asked to address. A section on environmental considerations is now placed within the main text of the summary of advice presented to the FC. There is some duplication as the information contained in the SC report becomes an FC document which "makes the information easily traceable from SC to FC and easier to retrieve as well by anyone looking for the answers to the FC requests" (NAFO 17).

5.3.1.3. Communicating Science Advice to Managers

From the perspective of Canada as a Contracting Party to NAFO, part of the work of the DFO scientists after the June SC meeting is to brief the Canadian managers who will be attending the FC meeting three months later in September. These briefings are typically with managers from DFO-NCR and DFO-NLR, including the fishing industry. These "internal briefings" entail lengthy PowerPoint presentations of scientific information for each species and related issues are extracted from the Scientific Council Report (SCR) (NAFO 1). The SCR is a comprehensive technical document containing details of the completed assessments, such as the methodology or data sources, and contains clearly articulated messages as to "why the analysis was done, what the methods were to address the question, what the results were, and what is the conclusion" (NAFO 4).

The science advice on fisheries and ecosystems is formally presented to the FC at the NAFO annual meeting in September. In general, only science advice developed in response to requests by FC is presented at the FC meeting (NAFO 19). The Contracting Parties are prepared to discuss the scientific advice at the annual meeting having been involved in the development of the agenda as early as 90 days before the meeting when the NAFO Secretariat circulated the draft provisional agendas including the review of recommendations from the SC standing committees. As a manager stated:

> Contracting Parties already have their minds made up prior to the September annual meeting. Nobody is hearing anything new when the SC chair gives his presentation of assessments and advice to the FC … When the June SC meeting is over … the report is available and goes to all the Contracting Parties and their advisors are consulted on the advice to explain what they mean and there may be some bilateral discussions. By the time they come to the annual meeting, the Contracting Parties already know what outcomes they want, nothing is a surprise. (NAFO 17)

The SC reports briefly to the FC on ecosystem work. In recent years, the time allocated to ecosystem work has been increasing as more and more questions on ecosystems are being asked, in addition to the extensive list of questions on the status of stocks (NAFO 4).

5.3.1.4. NAFO Information Products and Information Sharing

National scientists rely on their individual articles in NAFO documents as well as documents of their national fisheries organization, e.g., reports in the DFO Canadian Scientific Advisory Secretariat series (CSAS), as information sources. Supplemental sources of advice may be considered, e.g., advice generated from other RFMOs such as ICES which works on species that straddle the northwest and northeast region managed by NAFO. DFO does not maintain a central repository for NAFO publications and these are generally not used at the national level as DFO scientists would use their CSAS documents which they liken to the NAFO reports. During NAFO SC meetings, technical documents are communicated in a SharePoint site which facilitates collaborative writing of draft meeting reports. Managers prefer the summary reports over the full technical reports and will refer to the detailed SCR reports for clarification if needed (NAFO 14).

Each Contracting Party representation is estimated at 35 persons and after the annual meeting the Secretariat sends printed copies of the FC and GC reports to the 12 Contracting Parties; this distribution includes the head of delegations and others, e.g., the designated scientific experts for each fish stock. Print copies of the FC reports and the SC technical reports are also sent from NAFO to libraries or document repositories of its members; the digital versions are now sent by email. More of the technical reports are now placed on the NAFO website and the digital versions are preferred given the length, although printed copies are still used as a reference resource at meetings (NAFO Direct Observation 1 through 3; NAFO 18). With the closure of libraries in some of the member states, such as the DFO libraries in Canada, the number of distributed print copies is fewer and NAFO no longer prints the SC, GC, and FC reports unless otherwise requested. The public pages of the NAFO website now contain all reports, once adopted.

NAFO uses its website as the primary communication tool as a manager stated (NAFO 17). The Secretariat receives fewer direct requests from the public, students, and consultants, e.g., on issues regarding the basis of fishing area closures, as NAFO's publications are all on its website (NAFO 19). The utility of the NAFO website was, however, critiqued because, except for the journal, there is no "Search" function or a current index of meeting documents. This "Search" function is a priority as NAFO is moving towards fewer printed reports and towards providing more digital documents (NAFO 19). Furthermore, in the last 3-5 years, all of the earlier NAFO and ICNAF documents have been digitised. Traffic on the website is not currently tracked.

The audience of the online NAFO *Journal of Northwest Atlantic Fishery Science* (JNAF) is considered narrow, comprised mainly of scientists working on the Northwest Atlantic region and members of the SC (NAFO 18). Contributing authors to the journal include scientists who are members of the SC and scientists who regularly submit papers for publication in the journal. Some of the papers are SCR documents that have been reformatted. Other SC scientists writing on general topics often publish in other journals more likely to be read by scientists outside of the region. Members of the FC are more inclined to read the SCR reports than to read the NAFO journal (NAFO 18).

NAFO sees the online availability of adopted papers and reports as a demonstration of its transparency in regard to fishing operations. For instance, the compliance report completed by the FC Standing Committee on International Control (STACTIC) is the only source of information on the fishery, e.g., who is fishing, what kinds of fish are being caught, and how many vessels are fishing. This information is summarized in the compliance review so "we are a very open organization, not a secretive one" (NAFO 17).

Through its SC, NAFO exchanges information and cooperates with external bodies, such as the FAO's Fisheries and Resources Monitoring System (FIRMS) and ICES.

NAFO uses the news media mainly for an annual press release. NAFO is not using social media as there are insufficient activities in NAFO to warrant using Twitter. DFO scientists participating in NAFO described conflicting views on communication within their national organization regarding work conducted at NAFO. One school believes that it is not the role of scientists to publicize their work as this is seen as advocacy to further the scientist's work or for recognition to do more work. As one scientist added: "In science, when you do something good the whole world [meaning DFO] knows about it, you don't have to pursue publicizing it … I don't think that this falls within the scientific framework" (NAFO 5). Another school believes that scientists are "muzzled" as they can only speak through directives from their organization's Communication Branch and are given media lines to use, so much so that the belief is that:

> Communication today in DFO is extremely heavily managed … the word "managed" is a big understatement because it is being crafted and molded into media bytes that favour specific perspectives. It's extremely difficult … it's sad ... it's concerning ... because we really do not have the freedom to reach out to the public to tell them what we think. And if we do, we will get fired. (NAFO 4)

5.3.1.5. Use of Science Advice for Fisheries Management

The FC makes final decisions on management and conservation measures regarding TACs based on advice from the SC; however, other information has been known to take precedence in the decision-making process. As a scientist stated, "sometimes they deviate on what they base their decisions on and it's more socio-economic considerations rather than strictly on the science information" (NAFO 1). A manager explained:

> You are trying to balance out three objectives: the conservation objective in the long term, and in the short term, the social and economic which at times are in conflict … the economic is obviously a good measure of the biological because if you push a stock to collapse then there is not much economic value … so your big debate then is social in the short term versus the economic in the short to long term. (NAFO 14)

Advice provided by the SC is considered to be credible but the FC has the prerogative to ask for clarification of the advice. As a manager stated:

> The FC does not question the veracity or credibility of the scientific information, they just want further clarification. When they question, it is engendering a request for more discussions. Science is not about truth, it is about debate; if you say that it is scientific information with evidence, it is not necessarily gospel … if the SC advises no directed fisheries and if I am fishing over there which is worth millions and jobs, I just have to look at the scientific advice more closely. (NAFO 17)

Given the social and economic consequences of a decision, a manager stressed the thorough and collaborative nature of the decision-making process where the risk of adhering to the SC advice is considered by the FC and “there is an extensive process of digestion, absorption, understanding, and discussion on the advice. And equally, reaching out to advisors and environmental groups and other partners and Contracting parties on how they are seeing the advice” (NAFO 14). Informal networks were considered to be more effective in achieving dialogue than the use of formal networks, e.g., between Contracting Parties like Canada and the EU where a Canadian manager stated:

> There is no formal arrangement – we work extensively with them, we exchange emails, we pick up the phone. We have a more formal bilateral arrangement with them and we have a formal meeting once a year. We are in regular contact with them through email…We would have separate meetings with industry, NGOs, and academia, to get their ideas on particular issues and concerns, and issues that they would be advocating for. (NAFO 14)

The FC report containing the decisions goes to the heads of delegation and advisors of each Contracting Party before being approved and it is an “almost negotiated” text (NAFO 17). The Secretariat then prepares the handbook on conservation measures containing the quota tables as the primary method for disseminating information to the public on NAFO management measures that were adopted at the annual meeting (NAFO, 2014c). This handbook is the chief fisheries management information product produced and updated every year after the annual meeting and is used by all Contracting Parties.

Table 9. Summary of the characteristics of the information pathways – production, communication, and use of scientific advice – in the Northwest Atlantic Fisheries Organization.

INFORMATION FLOW	CHARACTERISTICS
ACTORS IN NAFO	
NAFO Constituent Bodies	General Council (GC); Fisheries Commission (FC); Scientific Council (SC) and its standing committees and working groups; Secretariat
	Joint working groups – Managers and scientists answering to FC and SC
Contracting Parties	Twelve member countries represented by managers and scientists of the respective national fisheries authority
	Managers. Fisheries Scientists, Ecosystem Scientists – Representatives of the national fisheries authority of the Contracting Party in the FC
Observers	External groups - NGOs and industry are important at NAFO
REQUESTS FOR ADVICE	
Fisheries Commission – well-defined process of requesting advice	Main request for advice is from the FC at the September annual meeting; Two coastal states, Canada and Greenland, generally request advice
	Standard format for the "Request for Science Advice" document from the FC; SC receives the FC request when the Secretariat prepares the agenda for the SC meeting in June
Fisheries and ecosystem advice is requested	SC formalizes the FC request at the SC meeting
	Requests are mainly for fish stock advice; Requests for ecosystem advice are increasing
Iterative process for developing advice	Within a member country, managers and scientists, i.e., FC and SC members, engage in dialogue between official NAFO meetings
	Dialogue between FC and SC in joint working groups
PRODUCTION OF SCIENCE ADVICE	
Scientific Council Meetings – Standing Committees and Working Groups	Fisheries assessments are completed in Working Groups under the Standing Committee on Fisheries (STACFIS); STACFEN contributes a section on environmental considerations in the SC summary of advice
	Ecosystem assessments are completed in the Working Group on Ecosystem Approaches (WGESA) which is not under a standing committee; WGESA may be transformed to a Standing Committee
	Information pathways are different for fisheries and ecosystem advice
	Overlapping membership of working groups and standing committees
	SC hears the request for advice at the Annual Meeting but the FC requests are formalized in the SC meeting in June

INFORMATION FLOW	**CHARACTERISTICS**
	Collaboration among the Contracting Parties – Stock assessments are completed as teams; Technical work is often based on work mandated in the national fisheries organization; Advice generated in other RFMOs, e.g., ICES, may be incorporated
	Peer review of fisheries and ecosystem assessments in the SC plenary
COMMUNICATION	
Protocols for internal communication	FC does not pose questions directly to scientists in SC; Advice is presented only to answer FC requests; The science advice is not new to FC at the Annual Meeting
Scientific Council documents	Scientific Council Reports (SCR) contain stock assessment details and summary of advice, and a record of all SC meetings in the year
	Annual state of the oceans report is prepared in STACFEN
	SC Research Documents or Studies (SCS) contain details of all the methods used in the assessment and ad hoc studies
Fisheries Commission	FC Requests for advice; Duplication of the content of SC and FC documents ensure transparency
Communication in the Contracting Parties	Contracting Parties – scientists brief managers and head of delegations on science advice in preparation for the NAFO annual meeting
	Internal briefings include the fishing industry
Communication among Contracting Parties	International networks facilitate work of the managers and scientists
	Bilateral talks are often scheduled in the intercessional period, i.e., between annual meetings
Challenge of communicating ecosystem advice	SC meeting is made up mainly of fisheries scientists
	Ecosystem scientists make special efforts to help fisheries scientists understand the results; Fisheries scientists present the fisheries and ecosystem advice to FC; Ecosystem advice is minimal in the SC presentation of advice to FC
Conflicting views on communicating with the public	Scientists must only speak through directives from their organization's Communication Branch
	It is not the role of scientists to publicize their work – this is "advocacy" – to further the scientist's work or for recognition to do more work
COMMUNICATION TOOLS	
Website	All SC documents and all adopted FC reports are available online
	Less requests for information as the website contains more of NAFO reports; Posting reports on the website is a main communication strategy

INFORMATION FLOW	CHARACTERISTICS
	No search function to locate documents
NAFO Journal	Peer reviewed; specific to NW Atlantic area; mainly SC scientists contribute to the journal; articles are reworked versions of SCRs
Sharepoint	Used by SC working groups and in all meetings for collaborative writing and to share technical reports
Print copies	Print copies are sent to libraries of the Contracting Parties – Summary reports contain advice; technical report contains details
	Fewer hardcopies due to austerity measures in NAFO and less demand due to the loss of libraries in many of the Contracting Parties
Digital versions and email	Digital versions and email – Main mode of communication with Contracting Parties
Media	Annual press release describing NAFO's management decisions at the annual meeting in September
	No social media, e.g., insufficient activity for use of Twitter; No communication with the public, e.g., use of blogs during meetings
Summaries for briefings	200-300 page SC report summarized in a series of Powerpoint presentations by species and issues for delegations
Face-to-face communication	Best tool for managers and scientists given the complex and dynamic issues to be discussed in NAFO
USE OF SCIENCE ADVICE	
Fisheries Commission decides on management measures	FC decides on management measures, e.g., quotas, TACs
	SC advice is considered credible and is not questioned by the FC
	FC only seeks clarification on advice because the impacts of decisions are economically significant to the fishing industry
	Social and economic considerations are priority while the biological status is a function of the two
Conservation measures	The NAFO handbook is produced as a primary tool for disseminating information to the public on NAFO management measures
Reports by the Contracting Parties	For the national fisheries authority, e.g., DFO in Canada, the DFO scientists use their NAFO SCR documents as input into the DFO CSAS reports
Marine Stewardship Certification	Scientists relate information from the SC stock assessments and the decisions to the industry groups relevant to Marine Stewardship Certification (MSC) applications
Observers	NGOs prepare educational and promotional material on NAFO science advice and management decisions for the industry and the public

5.3.2. Drivers to Information Flow into Decision-Making

Three main drivers to the flow of scientific information into decision-making were identified: the demand for scientific advice for management; international fisheries management policy, primarily the UN resolutions related to deep sea fishing; and national mandates and policy-making for fisheries and ecosystem research and management in the Contracting Parties. Table 10 contains a summary of the characteristics of these drivers (see p. 149).

5.3.2.1. The Demand for Scientific Advice for Fisheries Management

Sixty-eight percent of interviewees (68% - 13 out of 19) spoke about the information pathways in NAFO when asked to describe how they produced and used scientific information. NAFO's mandate to make fisheries management decisions is an important driver of information production and is evident by the FC requests for scientific advice prepared at the September NAFO annual meeting. The SC then completes assessments and prepares the advice in its annual June meeting. The scientific advice is presented to FC in September – a year after the initial request. The FC makes management decisions drawing on the advice from the SC, requests are made for the following year, and the cycle continues (as described in Section 5.3.1). As one manager stated, "there is a need for decision-making and this is fundamental in the FC where you are making a decision on the level of fishing that will be allowed to occur and what the impacts are of fishing" (NAFO 14). Similarly, a scientist stated that "basically, it's the job that drives the process. You are told that you have to assess a particular species or a particular process in the marine environment. This is a more directed and predestined process" (NAFO 5). The annual list of requests prepared by the FC largely determines the workload and the work flow of the SC and the influence of these requests extends to the work commitments within the national fisheries management agencies.

The organizational structure of NAFO as seen by its constituent bodies, i.e., both a scientific and a management component – one of the few RFMOs created in this fashion – drives information pathways and flow as the work of the SC is conducted primarily to respond to direct requests from the FC. Obvious pathways for information related to the requests and provision of advice exist (See Section 5.3.1). Established roles of managers and scientists also exist where facts and recommendations are kept separate; the scientific advice to FC only contains facts. The NAFO Secretariat also plays a critical role in steering the development of the agenda at the annual meeting. While the FC ultimately approves the agenda, the Secretariat must be aware of the issues, concerns, and needs of Contracting Parties when preparing the provisional agenda (NAFO 17, 18). One interviewee stated:

> If you think this [subject] is going to be a big issue, put it there. If you don't think that they have the political will to talk about it, you might not have to put it there ... but you cannot put something in the agenda if you don't know what the Contracting Parties are currently talking about. (NAFO 17)

For instance, the bycatch issue was placed on the agenda for meetings of the SC and FC in 2011, and over time an ad hoc working group on bycatch was formed which led to the establishment of a joint FC-SC working group with direct responsibility to examine this matter (NAFO 18). This issue is also being discussed in many of the standing committees under the Scientific Council. Proposals, however, must come from the Contracting Parties; therefore, if the Secretariat has a strong suggestion for a proposal, it must look for a Contracting Party who can sponsor it (NAFO 17). The Contracting Parties also are provided with an opportunity to decide what issues are placed on the agenda as it is prepared in stages (90-day, 60-day stage) according to the NAFO Rules of Procedure.

5.3.2.2. International Fisheries Management

Sixty-three percent of interviewees (63% - 12 out of 19) described a range of international policies that are relevant to their work and are likely driving information production in NAFO. As stated in the DFO case study (Chapter 4), fisheries management has become more complex and as an intergovernmental organization, NAFO is striving to be proactive as an RFMO and to stay abreast of contemporary fisheries management issues and global policy, e.g., 1982 UNCLOS, Precautionary Approach, UN General Assembly (UNGA) resolutions, FAO International Plans of Action, among others. Given this range of international drivers, the information pathways have become more complex and more dialogue between the FC and the SC ensures that advice is communicated for decision-making. Important changes within the organizational structure of NAFO facilitate this communication, e.g., the formation of the SC and joint FC-SC working groups. NAFO's response to the international drivers is seen in activities of the SC Working Group on Ecosystem Science and Assessments (WGESA), which was primarily established to advance the *Roadmap for Developing an Ecosystem Approach to Fisheries for NAFO* (NAFO, 2011b). This work was driven by the UNGA resolution (UNGA 61/105) for protection of VMEs (NAFO 4). Because of the UN Fish Stocks Agreement (UNFSA) and UNGA 61/105, the VME issue became a critical component of ecosystem management due to the "pressure" to comply with the UNGA resolution. NAFO's area of responsibility has now expanded to protect VMEs. These resolutions state timelines and deadlines that RFMOs need to fulfill, hence placing pressure on NAFO to deliver on those issues. As a scientist stated, "when you start bringing that complexity [of the work] to the decision-making process is when managers get their teeth into it and they start asking more and more questions like: is this practical, is this useful, and is this something that we can actually implement?" (NAFO 4).

The complexity of issues involved in decision-making on deep seas issues, for instance, has influenced the types of organizations interacting with NAFO, e.g., universities, non-governmental organizations, and industry, which now also play a role in driving information production within NAFO. For example, a university picked up the coral and sponge issue instead of DFO and drove the research in the area (NAFO 9). In this instance, DFO partnered with the university in the research and published papers in the primary literature (NAFO 9). Scientists who worked closely with industry on their vessels were able to communicate aspects of coral and sponge conservation to scientists and the fishing industry alike as "hands on experience is important and not necessarily published [information]" in this instance (NAFO 9).

Local and international NGOs such as the World Wildlife Fund (WWF) and Ecology Action Centre (EAF) participate as Observers in NAFO meetings and bring their perspective on deep sea fisheries, among other expertise, to the Scientific Council working groups (NAFO Direct Observation 2, 3). NGOs are able to lobby key delegations, e.g., Canada, the EU, and the US, at NAFO meetings as they strive to understand what will be recommended, the political difficulties related to the implications, and the feasibility of implementing various recommendations (NAFO 11). It is believed that the VME issue that is now a priority for work in NAFO was prompted by the UNGA resolution that was adopted because of the pressure from NGOs to ban bottom trawling on the high seas. This resolution triggered the chain of activities in NAFO and also globally (NAFO 11). One scientist described NGOs as "watchdogs" for the international and contemporary fisheries management initiatives (NAFO 9). A manager noted:

> Many of our objectives are very well aligned. I think they would echo the same things. Maybe we are not able to get there as quickly as they would like. But even though they are Observers their views are very important and they bring good perspectives and help to shape our priorities and management objectives. (NAFO 12)

While the international element brings focus to some issues, society more generally also influences information production and policy-making. Managers stated that the demand for action from stakeholders and the public drives information production and flow, e.g., related to economics and market dynamics seen in the emergence of eco-labeled products. Canadian stakeholders demand information from government that will help the fishing industry, for example, to obtain and maintain Marine Stewardship Certification (MSC). In response to the industry's demands, DFO scientists would present information from NAFO stock assessment and relevant decisions made in the organization to industry groups (NAFO 16). A scientist stated that society drives information production largely as a result of public concerns that are highlighted in the news media; these news items then get the attention of politicians (NAFO 10). For instance, information produced by NGOs which may overstate the threats to ecosystems, e.g., related to deep sea biodiversity, is picked up by the popular press and then politicians respond (NAFO 10).

5.3.2.3. National Mandates and Policy-Making in Contracting Party Jurisdictions

Sixty-three percent of interviewees (63% - 12 out of 19) described national activities of a Contracting Party that drive aspects of the information pathway in NAFO. For instance, national activities in DFO support the need for communication between the NAFO constituent bodies and drive the formation of joint working groups. An example is the Joint Fisheries Commission-Scientific Council ad hoc Working Group on Catch Reporting which was established as a result of the need for a collaborative approach and dialogue to validate NAFO catch estimates in light of multiple catch data sources and claims of data discrepancies. A manager from Canada stated:

> We brought together scientists, the managers, and enforcement internal to DFO and tried to discuss and resolve this internally. This led to the working group … to joint FC-SC dialogue to have better understanding and exchange of information between two groups that can become very siloed and perhaps antagonistic groups. Scientists didn't understand the managers and managers didn't understand where the scientists were coming from and they go off in different directions (NAFO 14).

NAFO provides a forum where scientists in national fisheries management organizations can apply their findings and research to expand on their work. For example, ecosystem scientists involved in programs like DFO's Atlantic Zone Monitoring Program incorporate the environmental information collected in such programs into the ecosystem initiatives in NAFO, e.g., to produce evidence of large scale patterns and ecoregions that can be applied to develop an ecosystem approach. Conducting this ocean monitoring program is a core mandate of DFO. NAFO is typically the first forum in which the information is presented before being incorporated later into the CSAS process for the DFO-NLR (NAFO 6). DFO scientists can provide environmental explanations for stocks of interest which are incorporated in the report of the NAFO Standing Committee on Fisheries and Environment prepared for the June Scientific Council meeting.

Drivers for information use and policy-making in the national fisheries organizations also affect the information flow patterns within NAFO. For instance, the fishing industry lobbied strongly to reopen the cod fishery in Newfoundland – contrary to the scientific advice; the fishery was subsequently reopened in a very limited way. As one scientist stated:

> But it [the fishery] was still reopened … that doesn't produce a good working relationship [with scientists] … Industry lobbies long and hard for certain things. It

> happens all the time in the background and nobody ever really sees it except for the managers because they are dealing with it. The industry also comes to these meetings. So they are there from step one these days and they interact with the managers and if need be some go directly to the minister to get certain decisions changed. (NAFO 5)

A well-defined process exists for the development of country positions for NAFO negotiations involving collaboration between managers and scientists, including stakeholders like the fishing industry. As an interviewee stated, "if you broke it down to basics, clearly someone that is the head of the delegation is going to finalize decisions … the fact that we have four to five stakeholder meetings, because there are observers in the meetings that are aware of our positions, because of the advanced discussions – positions develop, there's no one person who makes decisions" (NAFO 16).

Within NAFO, different levels of decision-making prevail that follow much the same levels as in the national fisheries agencies. An interviewee noted:

> In NAFO you have individual stocks that my fisheries management colleagues will be involved in … identifying specific positions for. But you also have to have the development of relatively broad concepts like the ecosystem approach and the precautionary approach and bigger policy ideals. So you do both in an arena like NAFO" (NAFO 16).

National policies can precede or feed into international policy. One interviewee outlined how national policy is often developed independently and then the relevant international policy is subsequently developed (NAFO 16). For example, the UN can develop a provision or a requirement to drive the development of policy. Meanwhile, member states work to implement the requirements and accumulate information and experience on what works and what doesn't work. This knowledge produced by members may feed back into the international policy or agreement or resolution. In such cases, policies are developed prior to the international action "because frankly these international resolutions to my understanding are still countries sitting together and trying to figure out what should be done" (NAFO 16).

Table 10. Summary of the drivers in the information pathways – production, communication, and use of scientific advice – in the Northwest Atlantic Fisheries Organization (NAFO).

DRIVERS	
1. THE DEMAND FOR SCIENTIFIC ADVICE FOR FISHERIES MANAGEMENT (see Table 9)	
Production	Fisheries Commission – Managers request fisheries and ecosystem advice at the September meeting in the "Request for Science Advice" document
	Scientific Council – Scientists formalize the FC requests in the SC meeting in June; Requests are mainly for fisheries and include ecosystem advice
Communication	Communication among Contracting Parties – International networks of managers and scientists; Bilateral talks between annual meetings
	Contracting Parties – Scientists brief managers, head of delegations, and the fishing industry on advice in preparation for the annual meeting
	Reports contain stock assessment details, summary of advice, and a record of all SC meetings in the year; Documents are available on the website
Use	Marine Stewardship process (MSC) – Industry groups use information from the SC stock assessments and the decisions relevant to MSC
	Observers – NGOs prepare educational material on NAFO science advice and management decisions for the industry and the public.
	The FC decides on management measures, e.g., quotas, TACs; NAFO handbook on conservation measures is produced
2. INTERNATIONAL FISHERIES MANAGEMENT	
Production	Market dynamics and eco-labeling – Industry needs scientific evidence of management to maintain Marine Stewardship Council (MSC) certification
	Society – Media reports are picked up by the politicians who approach managers and scientists for a response; NGOs attend meetings as Observers
	UN system – FC requests are embedded in UN resolutions and timelines, e.g., UN 61/105 Resolution drove high seas fisheries management
3. NATIONAL MANDATES AND POLICY-MAKING IN CONTRACTING PARTY JURISDICTIONS	
Production	Funding for international governance activities drives the work completed, e.g., DFO has funds allocated for participation in NAFO; Industry lobby
	The mandate of the organization to manage fisheries – The need for fisheries management drives production of science for advice
	Well-defined process for developing country positions for NAFO negotiations – Internal briefing sessions and collaborative decision-making
	Work completed in NAFO is often based on work mandated in the national organization, e.g., DFO work overlap with NAFO's activities

5.3.3. Enablers to Information Flow into Decision-Making

Four main enablers in the information pathways include: (a) the format of advice documents and reports such as the importance of summaries and grey literature; (b) organizational aspects related to joint FC and SC working groups; (c) different roles of scientists and managers in communicating information; and (d) overlapping membership of science and management groups within NAFO, other regional agencies, and agencies in the member states. Figure 11 shows the number of respondents out of 19 who described these four drivers in their interview responses. The following sections describe these enablers to information flow. Table 11 contains a detailed summary (see p. 159).

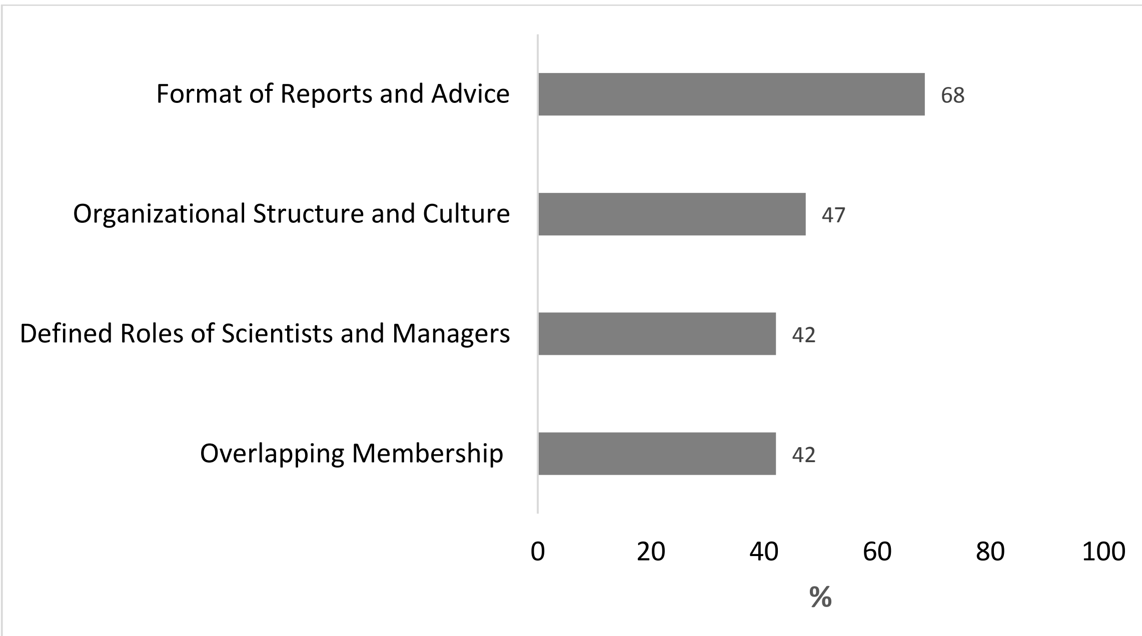

Figure 11. Enablers in the information pathways – production, communication, and use of scientific information – in decision-making in the Northwest Atlantic Fisheries Organization (NAFO).
(The percentage of respondents who spoke about each enabler is noted; N=19)

5.3.3.1. Format of Reports and Advice Documents

Sixty-eight percent of interviewees (68% - 13 out of 19) talked about the perception of the format of NAFO's reports with regard to their value as grey literature and in communicating risk. Grey literature is a fundamental form of information used in NAFO's activities, including its own publications, e.g., the SCRs, and the publications from the national fisheries organizations, e.g., the DFO CSAS publications. NAFO scientists say that theoretical information is generally published in the primary literature and more applied research on fisheries issues and studies relevant to specific geographic areas is presented in the secondary literature, e.g., as the organizations' publications, to become immediately available for use. Ecosystem scientists stated that the primary literature is being published too slowly to communicate findings in such new fields of research (NAFO 9). Some scientists believe that the grey literature is often the main information source for use in primary and other grey publications, as stated:

> There were no primary publications really … and everyone in the assessment community uses the [NAFO or national] assessments. It is a circular thing. They cite it as well in their primary publications, e.g., if you look at the citations you will see the grey literature … If you want to know the biology of a particular species the only place you can find it is in the secondary literature, the grey literature, because it was never made primary. (NAFO 5)

Some scientists accept the public perception that grey literature prepared by NAFO, in spite of it being rigorously peer reviewed internally, is not as "credible" as publications in the primary peer-reviewed journals. Some scientists believe that this public perception limits the use of NAFO's documents outside of the organization's management functions. Some ecosystem scientists also decide to publish in the primary literature as the NAFO SCRs are not seen as providing a high profile in contrast to primary publications. Furthermore, these scientists believe that when their ecosystem research is published in the primary literature, it is considered more credible by other fisheries scientists and managers (NAFO 3). Open access journals, like PLOS ONE, are being used more frequently as scientists want to publish their work in peer reviewed journals and become widely available soon after the science meetings.

Communicating risk is improving in the SC meetings as scientists understand the needs of managers and present advice with a risk management context. A new standardized method of presenting scientific advice was adopted by the SC in 2013 (NAFO Direct Observation 1; NAFO 14). Tabular presentation of key management decisions provided more risk-based, or risk-determined scientific advice to be clearly presented rather than being obscured in other documentation in the scientific advice report. In addition, consolidated descriptions of the scientific approaches, models, and underlying assumptions used by the Scientific Council were developed and presented. These changes in reporting format were implemented in response to recommendations in the 2011 NAFO Performance Review and were well received by the managers in the FC at the 2013 NAFO annual meeting (NAFO Direct Observation 1; NAFO, 2011a, p. xviii).

5.3.3.2. Organizational Structure and Culture – Constituent Bodies and Working Groups

Forty-seven percent of interviewees (47% - 9 out of 19) spoke about the benefits of the new formal FC-SC working groups that are co-chaired by representatives from each constituent body. These groups provide recommendations to the FC and consider the advice of the SC. The establishment of the joint working groups, such as the WGRBMS, facilitate increased and ongoing communication between managers and scientists and enhances the attributes of the scientific advice, i.e., its credibility, relevance, and legitimacy (NAFO Direct Observation 1, 2). The credibility and relevance of the information is enhanced since the role of the scientists in these joint groups is "not to deliver or talk about science, but to help the managers understand … issues are fairly technical and the ecosystem and benthic research is new, and not one that managers have a full understanding of" (NAFO 1). Since the establishment of groups, such as the FC-SC Working Group on the Ecosystem Approach Framework to Fisheries Management (WGEAFFM), communication between the FC and SC has improved as "scientists get a better idea of what managers need and managers get more opportunity for ongoing dialogue with science in meeting those management goals" (NAFO 12). Furthermore, joint groups such as the WGRBMS, established in 2013, ensure formal discussions between fisheries managers and scientists compared to arrangements in past years where the two groups met under a FC working group which was "not truly joint … as it was still a FC group and the scientists were just there to make inputs" (NAFO 17).

The formation of joint working groups not only increases dialogue in a formal NAFO setting but also necessitates communication between managers and scientists in the intersessional period. For example, the meeting agenda is decided though ongoing consultations between the two groups. This communication is typically channeled through the NAFO FC and SC coordinators based in the Secretariat and who now need to collaborate more in steering the development of draft agendas to guide discussions and in order for the NAFO mandate to be filled (NAFO 17). With the expansion of the Precautionary Approach, more stocks will be considered under the NAFO Conservation Plan and Rebuilding Strategy (CPRS), more work on VMEs is expected, and it is now recognised that there is greater need for increased dialogue between the FC and SC (NAFO 17). Moreover, the mixed expertise of fisheries and ecosystem scientists and managers participating in such joint working groups creates extended peer communities that are expected to facilitate new interpretations of each other's discipline (NAFO 8). Expanding the peer community will likely increase the legitimacy of the advice.

5.3.3.3. Defined Roles of Scientists and Managers

Forty-two percent of interviewees (42% - 8 out of 19) mentioned the roles and characteristics of managers and scientists that are important enablers of communication patterns both in NAFO and the national fisheries management agencies of the Contracting Parties. Interviewees highlighted aspects, e.g., longevity in their roles as managers and scientists, their position within the national agency, and their information seeking behaviour, as enablers to communication of information and decision-making.

Within a national delegation, scientists and managers participate at different levels. In the Canadian delegation, for example, managers or "advisors" from the DFO-NCR said that they attend meetings to engage at a policy level, "a higher level", e.g., to discuss the Precautionary Approach, compared to scientists engaging at a "technical level" (NAFO 15). Managers from the DFO-NCR say that "working at headquarters gives a different perspective on management compared to intermediaries working in the regions" (NAFO 15). Their NAFO responsibilities also overlap with national responsibilities and the role of an advisor was to maintain the networks of different stakeholders in the NAFO context.

Personal aspects of communication were also highlighted, e.g., discussing matters in informal settings often resolved differences aired when delegates meet in formal meetings. As a scientist stated, “they [managers] can understand your way of thinking a lot better and developing those personal relationships is often as important in the process as doing the work itself” (NAFO 8). DFO managers are fully engaged in their internal briefing sessions to prepare for the NAFO annual meeting and they not only actively seek the scientific information but they strive to understand it too. A manager stated:

> We have a lot of dialogue with our scientists on understanding the advice and what are the implications of various scenarios depending on what policy or how we will shape decisions. These are the most important meetings for us. And this is a new trend in DFO … we are interested in understanding the scientific advice. (NAFO 12)

Managers seek out information from individuals in national and international networks to achieve an expected outcome. One manager described the difference between information and knowledge where:

> I would make the distinction that the SC reports are information. The knowledge comes … only when you understand the report and that comes from when you talk to people. So there is a three-step process: production of information, conversion of information to knowledge, and with knowledge comes decision-making. (NAFO 14)

DFO managers also see their role as bridging the gaps in communication at the operational level; as a respondent stated, “I am the liaison between science and industry so I have to bring together things in a cohesive way and it is really about having those relationships” (NAFO 12). Managers consider the briefing sessions with scientists and the industry to be extremely important in arriving at a common position for Canada:

> We’ve had a lot of compliments over the years on the fact that we bring scientists and stakeholders together. It’s still a lot to absorb for people who are not thinking from a scientific perspective on a regular basis. In general, the stakeholders do their homework and they are prepared – they value that presentation a huge amount. We use that meeting to start developing a position for the Government of Canada based on feedback from stakeholders based on advice. (NAFO 15).

At such delegation briefings, managers stated that they coordinate with others in examining policies to establish uniformity between DFO and NAFO, e.g., to create consistent messaging on an ecosystem approach to stakeholders; and to ensure that national policies are reflected in their NAFO positions as well (NAFO 16). DFO scientists also stated that in the delegation briefing meetings there is a discussion on what the Contracting Parties respective positions will be and they can see whether their scientific advice was accepted by the managers at this forum.

The relations among NAFO members have improved and a manager described the 2013 NAFO annual meeting as "remarkably different from previous years … it was very calm compared to earlier meetings, e.g., around 2006-2008, when there was a great deal of confrontation among the Contracting Parties and heads of delegation used to insult each other … this year there was a spirit of negotiation" (NAFO 17). This manager also alluded to the influence of gender in the current climate in NAFO which is characterised by less aggression and more progress as "women are now the main voice in FC plenary." The manager (male) pointed out that the GC and FC chairs as well as the European Union and Canada heads of delegation were women. The EU and Canada are generally the most vocal Contracting Parties at the annual meeting and at the FC plenary (NAFO Direct Observation 1). Politics is "always a major influence on decision-making," for instance, political agendas and directions taken by Canada involving NAFO in the past. For example, the earlier fish wars, were confrontational, but "now the politics of the EU and Canada has changed how NAFO operates. Now there is more agreement and negotiations at the annual meetings instead of conflict" (NAFO 17).

Scientists spoke about the value of a champion in taking on an issue and ensuring that it is discussed in NAFO. It is believed that this "champion" can be viewed with more credibility and managers can readily develop a trust relationship with these individuals compared with the leading scientists in NAFO. This responsibility can lead to extensive work occurring outside of the plenary sessions at an annual meeting. A scientist who was a member of a working group stated:

> An individual, not the chair, is a better person to ensure communication upwards ... having somebody who is willing to press their point of view and provide it in a valid

> way and discuss it with decision-makers can be a little more influential than the chair of the group presenting the information … the value is in having someone who is knowledgeable about the fisheries issue but is not necessarily the "expert" making the presentation. (NAFO 8)

In order to influence policy, scientists must also become the advocate for the information that they put forward, as one scientist stated:

> If all you do is you come to a meeting like this and you put it down on the table and say "this is my information, thank you very much" and it goes into the report, it might influence things a little bit. But the reality is that you are the one who is going to push it and move it through, you are the one. (NAFO 8)

In the case of DFO, the importance of relationships developed between managers and scientists over time, based on the personal characteristics of each group, was highlighted as a critical factor in encouraging increased dialogue among NAFO constituent bodies. Scientists stated that informally they deal quite frequently with managers and colleagues in DFO-NLR and DFO-NCR, on NAFO issues. The managers and scientists were senior staff members, holding positions on average for over ten years. These lengthy appointments helped to cement relationships and build trust among the stakeholder groups. Managers encourage these communication channels with scientists as follows:

> Upper managers value building relationships with science in other branches in the department related to NAFO. These are extremely important and very complex because people speak different languages – the science language and a management language. There's a lot of interaction between specific individuals leading up to the meeting and as you get closer, you bring everybody in the same room. (NAFO 16)

Managers holding positions for such long periods were knowledgeable about fisheries science concepts even though they were not scientists. Scientists stated that "we would translate scientific advice … it could be challenging but many of the people in the delegation have considerable experience or are used to these types of things" (NAFO 9). This knowledge of fisheries by managers and the relationships between the two groups facilitate discussions and managers rely on support from scientists, e.g., during the annual meeting or joint FC-SC working group meetings when decisions are being made. As one manager stated, "there will be elements that inevitably you won't be able to capture as a manager and that is why this kind of forum is very helpful as sometimes you have a point and it's hard to get across and you need that person next to you from the Science branch to fill in all of the details" (NAFO 15). At such meetings, scientists are called on periodically outside of the FC plenary sessions to answer questions by managers, e.g., "what if we ask that question, what type of answer are we likely to get back" (NAFO 1). In this regard, scientists assist the managers in understanding the science in order to be able to guide the discussions in plenary sessions.

5.3.3.4. Overlapping Membership of Science and Management Groups

Forty-two percent of interviewees (42% - 8 out of 19) spoke about their involvement in various working groups inside and outside of NAFO. The overlapping membership of managers and scientists in the constituent bodies and working groups in NAFO, with other regional science and management organizations, and the national fisheries management agencies enables the production of information, its communication, and its uptake into decision-making. Overlaps within NAFO, e.g., scientists working in specific areas in NAFO standing committees and working groups ensure communication of the science to other scientists in other fields and to managers. Examples include the fisheries and ecosystem scientists in STACFIS and the Working Group on Ecosystem Science and Assessments (WGESA) respectively. Many scientists are also involved in external working groups, for example, within ICES groups on stock assessment methods, the precautionary approach, among others, and this arrangement can be a means of staying informed about the fisheries and new developments in research. Information is often brought back to the NAFO SC where it can be considered in the NAFO context. A DFO scientist participating in the NAFO WGESA and the ICES Working Group on the North Atlantic Regional Sea (WGNARS) stated that "basically we have the same objectives but the jurisdictions and locations are different. Any methodology that is developed for one group can be used by the other group; so we try not to reinvent the wheel over and over again" (NAFO 2). In some instances, the chairs of the NAFO and ICES working groups play reciprocating roles, e.g., the chairs attend each other's meetings to keep abreast of each other's work and to prevent duplication of activities and ensure consistency of methods. In the NAFO-ICES setting, a precedent has also been set where future chairs of each working group will continue to attend each organization's meetings (NAFO 2).

The representatives of the NAFO constituent bodies and working groups typically belong to the same national organizations. For example, DFO, in the case of the Canadian delegation, facilitates information flow within the national fisheries agency in preparation of positions taken at NAFO. For instance, this practice involves collaboration among DFO branches, e.g., between DFO-NCR and DFO-NLR. Domestic issues discussed in Canada can be relevant to some of the issues discussed in NAFO working groups, e.g., the potential impacts of oil and gas exploration in the NAFO Regulatory Area are discussed in the NAFO WGESA. Similarly, scientists who are working on particular national projects and stock assessments often have information that can be brought to bear on a particular question posed in NAFO meetings. Overlapping membership also promotes networking opportunities as national scientists participating in NAFO working groups can attend scientific meetings of other organizations to advance research, e.g., samples of deep sea corals and sponges are exchanged at international meetings. Through these networks, scientists can also learn about new research in a timely manner instead of "learning much later through a published paper" (NAFO 9).

NAFO is a member of the Regional Fishery Body Secretariats Network (RSN) coordinated by the FAO. The RSN meets formally before the biennial FAO Committee on Fisheries (COFI) meetings to discuss common interests related to the Contracting Parties. The NAFO Secretariat is represented at the RSN meeting which offers an opportunity to exchange general information with other regional fishery bodies (RFBs), e.g., to share lists of illegal, unregulated, and unreported (IUU) vessels. This meeting also presents an opportunity to discuss collaboration on issues such as data management with other RFMOs, e.g. NEAFC. The network also provides a forum for information exchange on global governance initiatives led by FAO that involve the RFBs, e.g., the development of a global VME database, the Areas Beyond National Jurisdiction (ABNJ) project, and vessel registry initiatives. Given the important role of the Secretariat in steering discussions and the agenda in NAFO, participation in this network is critically important.

Table 11. Enablers in the information pathways – production, communication, and use of scientific information – in decision-making in the Northwest Atlantic Fisheries Organization (NAFO).

CHARACTERISTIC	DETAILS
1. FORMAT OF REPORTS AND ADVICE	
Communicating risk	Scientists present advice in a risk management context; A standardized method of presenting advice was adopted in 2013
Grey literature is a fundamental source of information	Information becomes immediately available for use when published as grey literature, i.e., as NAFO or DFO publications
	International fisheries policy, e.g., FAO guidelines, other UN documents on the precautionary approach are key references
	National scientists produce peer-reviewed papers and grey literature, e.g., state of the environment reports and DFO CSAS documents which feed into their contribution at NAFO
	Theoretical information is published in the primary literature and applied studies are published in the grey literature
Primary literature as a validation	Scientists use open access journals like PLOS to make their work publicly available in a peer reviewed journal; Ecosystem scientists prefer this source as it gives credibility to ecosystem studies
2. ORGANIZATIONAL STRUCTURE AND CULTURE	
Joint Fisheries Commission and Scientific Council Working Groups	Provides more opportunities for formal discussions on specific issues and is co-chaired by representatives from each side
	The scientists' role in joint working groups is to help the managers understand the science; They get a better idea of managers' needs
NAFO as an RFMO	NAFO is unique as an RFMO – Has a scientific and management component which can influence information flow at the interface
	Mandate of RFMOs and high seas fisheries – NAFO is a leader and drives the participation of experts from national organizations
Role of NAFO Constituent Bodies (pathways for information flow)	Decision-making is by consensus based on the science advice
	Defined roles of scientists and managers – Separation of facts and recommendations; scientists' "advice" contains only the facts
	Extended peer community – Working groups with mixed expertise
	The Secretariat keeps abreast of discussions in the bodies and steering discussions through preparation of the meeting agendas
	Well-defined pathways for information flow – Fisheries Commission requesting advice; Scientific Council providing advice

Characteristic	**Details**
Transparency in decision-making (to a point)	Advice is available to Contracting Parties to inform their decisions; Consensus on the outcome forms the management measures
	Managers pose questions to scientists or ask for additional information during critical decision-making times at meetings
	NGO and industry are NAFO's most important network groups
3. Defined Roles and Characteristics of Scientists and Managers	
Longevity and seniority of membership in NAFO	Increased understanding of science by managers; High frequency of attendance at FC and SC meetings; Trust relationships between FC and SC members; Scientists understand the needs of managers and present advice with a risk management context
Managers	Role of a manager is to ensure flow of information; Managers are interested in understanding the scientific advice and have a "smaller scale" vision than advisors; National advisors, e.g., from DFO headquarters, attend meetings to understand how information will be used to implement policy
Personal aspects of communication	Discussing matters in informal settings often resolves disagreements; Developing personal relationships is as important as the work itself
	Gender may play a factor in the improved relations at NAFO as females are currently in lead positions in the FC and GC
Scientists	Increased communication between ecosystem and fisheries scientists; Act as advocates or champions to move their work ahead
4. Overlapping Membership of Science and Management Groups	
Overlaps between NAFO Standing Committees and working groups	Communication of the science to scientists in other fields and to managers, e.g., fisheries and ecosystem scientists participating in the Standing Committee on Fisheries Science (STACFIS) and the Working Group on Ecosystem Assessments (WGESA)
Overlaps with NAFO and other RFBs	Memberships in groups, e.g., NAFO-ICES, keep scientists abreast of related research, ensure consistency of methods and output, and prevents duplication of work; Proactive methods by NAFO keep the groups connected; networks facilitate work
Overlaps with NAFO and the national agency	National scientists provide a substantial amount of information for the NAFO assessments; Information on domestic issues in Canada can be brought to bear on questions being asked in NAFO

5.3.3. Barriers to Information Flow into Decision-Making

Barriers to the flow of scientific information at the science-policy interface include: (a) aspects of the organizational structure and culture of NAFO particularly related to the Contracting Parties, (b) the format of the scientific advice, (c) the challenges of communicating ecosystem advice not only to managers but also to fisheries scientists, and (d) the different roles of scientists and managers in communicating information. Fewer interviewees – between 26 and 32%, described barriers to information flow. Figure 12 shows the percentage of interviewees who generally perceived these areas as barriers for information flowing into decision-making and ultimately being used by managers. Table 12 gives a summary of the characteristics of the main barriers (see p. 169).

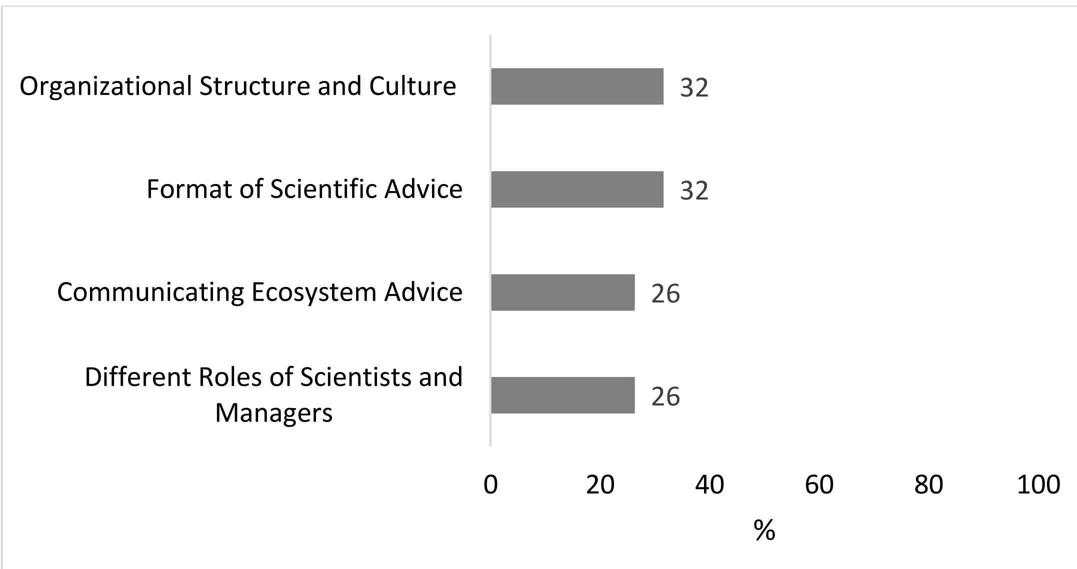

Figure 12. Barriers in the information pathway – production, communication, and use of scientific information – in decision-making in the Northwest Atlantic Fisheries Organization (NAFO).
(The percentage of respondents who spoke about each barrier is noted; N=19)

5.3.3.1. Organizational Structure and Culture – NAFO and the Contracting Parties

Thirty-two percent of interviewees (32% - 6 out of 19) spoke about organizational aspects within the national fisheries organization related to information production that can hamper the progress of work and the extent to which NAFO-generated information can be used at the regional level. Interviewees raised concerns with regard to the implementation by the national fisheries agency of decisions made at NAFO. These factors are related to austerity measures applied by the Contracting Party. DFO staff spoke about their participation in NAFO as happenstance.

The level of support that DFO scientists receive within their national organization influences the quantity and quality of information that they can contribute to NAFO working groups. DFO scientists spoke of the lack of adequate guidance and direction from the DFO-NCR (Headquarters) regarding priorities and an overall strategic direction for DFO for ecosystem research (NAFO 2). DFO scientists also spoke about funding constraints that negatively influence the breadth of the ecosystem research questions and the scientists' ability to provide advice. These challenges within the national agency affects the progress of work, e.g., in the Working Group on Ecosystem Science and Assessments (WGESA). National policies within the Contracting Parties can also conflict with progress within the NAFO SC working groups by preventing the completion of more robust analyses. One scientist described how some fisheries resources that should be treated as transboundary, i.e., shared by Canada and the US in the Gulf of Maine area, are managed as single stock populations by each party (NAFO 2).

Decisions and policies made at NAFO can be ahead of the capability in the national fisheries management authority to implement them, e.g., in the DFO administrative regions, to undertake scientific research to support the decisions. This situation is referred to as the policy-making coming before the science. A DFO manager pointed out that:

> After the policy is created, the national region is now looking at the regions for the science to understand how to implement the policy or what is practical for fisheries management. We produced something that was so complicated and it's only now when you get a chance to do the science, you know what is practical in relation to fisheries management, what's possible when it comes to the research you need to develop the basis for the implementation of these policies. (NAFO 16)

Scientists on the receiving end of such decision-making support this claim and believe that they continue to receive limited direction from their national fisheries management authority and for the policy decisions to now move forward in the regions. Often, action depends on the personal motivations or scientific interests of individuals to drive the direction of research. Scientists state that the lack of engagement of stakeholders including managers at the start is a barrier to uptake of information. As one scientist stated:

> The scientists are not really involved in the high level discussion. It's more like we get the bottom end of it where they are saying 'here is the stuff that we want' ... so people [scientists] take their interests and try to work it through ... if we had a higher level discussion, the projects that get done will be a little bit different. (NAFO 2)

Scientists participating in NAFO described the typically ad hoc or serendipitous manner in which they became members of scientific working groups. The lack of formal designations to specific work areas means that the composition of groups can change in a similarly ad hoc manner as they were formed, thereby threatening the sustainability of some working groups, specifically the expertise and related knowledge created with each meeting. As one scientist stated:

> I went the first time to a NAFO Scientific Council Meeting not because I was told by my department to go to NAFO, but because I was invited to participate in a conference or presentation ... the work that I was already doing for DFO was also useful in the NAFO context. So I got deeper and deeper involved in this work and the work of NAFO through the working group but at no point [did] I … [have] an official mandate from DFO to do it ... eventually DFO and Canada appointed me advisor for some of the meetings ... not because I was doing that work on the mandate from my DFO managers, on the contrary. (NAFO 4)

Limiting travel to meetings is one of the fiscal restraints that governments are imposing in response to the current economic environment. Canadian scientists stated that their travel to meetings was limited to where Canada was obligated to participate and provide advice in NAFO and they were unable to attend other related conferences to maintain and expand their networks and to remain up to date in their field of research. One scientist stated:

> Much of the networking work that was extremely valuable in the past has been lost. Now you just cannot connect to people … Every time I apply to go to a regular scientific conference, not NAFO this or DFO that, I systematically get denied. So, I haven't attended a formal science conference, for the pleasure of attending a science conference, for at least seven years now. (NAFO 4)

Much of the research and assessments completed under NAFO relies on collaborative work, yet travel to facilitate networking and collaboration among Contracting Parties is not supported, thereby compromising the quality and quantity of work that can be completed. A scientist spoke about the irony of this current situation where "even though that's the work that many of our policies today use … it is severely affected by this perception that travel is unnecessary and is a waste of money" (NAFO 4). Scientists strongly believe that the benefits of physical meetings when brainstorming on such complex issues as ecosystem assessments are being discussed cannot be replaced by conference calls and email. Managers are also similarly affected by these travel restrictions, and since the management issues are dynamic, the limited direct interaction severely affects decision-making. A manager stated: "To me, face-to-face interaction is the best tool for communication" (NAFO 12).

While the benefits of the creation of joint FC-SC working groups were discussed in Section 5.3.2, these groups have been given very specific terms of reference. For example, the FC-SC WGEAFFM discusses ecosystem management, closed areas, and VMEs, while technical fisheries management issues such as rebuilding plans and the precautionary approach are discussed in the FC-SC WGRBMS. Although attempts to increase dialogue within the new joint FC-SC working groups may have been made, these groups are not communicating with each other as they are tasked with addressing specific issues as opposed to the general delivery of fisheries management advice (NAFO 1). Scientists believe that, outside of these formal groups, they have little or no time to engage in communication or to strongly support general research agendas.

5.3.3.2. Format of the Scientific Advice

Thirty-two percent of interviewees (32% - 6 out of 19) described aspects of the format of the advice generated by NAFO that they perceive to be challenges to communication and use of the information.

Scientists debate how the SC should structure its options and recommendations. One school of thought suggests that information should be provided in a way that managers can choose from a range of options. Another school of thought argues that the role of the SC is to point out which option it thinks is best from a scientific perspective (NAFO 1). For instance, the SC should "simply present options A, B, C, and D as asked for and present nothing further" or "present options A, B, C, and D and say option C is the one to go with" (NAFO 1). "The Scientific Council, as the word 'council' implies, means that … [its] role is recommendatory" (NAFO 17). This situation resulted in lengthy periods of discussion in meetings during which scientists meticulously drafted text to communicate with other scientists and with the FC (NAFO Direct Observation 1 through 3). The way in which the text was written by scientists was critically important to prevent any ambiguities in the interpretation by non-scientists, e.g., the FC, or by fisheries scientists in the case of ecosystem assessments prepared by ecosystem scientists. One scientist stressed: "I think we are getting to the point where the level of frustration is such that the advice that we are willing to provide is going to be much more strongly worded simply because management seems less willing to act, if presented otherwise" (NAFO 8).

The perception that grey literature is not peer reviewed is seen as limiting the extent of use of NAFO documents outside of the organization's management functions. Questions about the credibility of grey literature were lamented by scientists who believe that the criticism is not often related to the information itself. As one scientist stated:

> They [the criticisms] really have nothing to do with the information. It's more a problem with academia seeing the issue as credible, probably because they do not publish in the grey literature, and their aim is to publish in the primary literature. It's just a different way of doing business really and it doesn't mean that the grey literature is any less useful or citable. (NAFO 5)

5.3.3.3. Challenge of Communicating Ecosystem Advice

Twenty-six percent of interviewees (26% - 5 out of 19) highlighted the continuing challenge of communicating ecosystem advice. Ecosystem research is not yet as fully understood as fisheries assessments and while fisheries carries its own levels of scientific uncertainty, in NAFO, scientific uncertainty was highlighted within the context of ecosystem science and assessments such as the work on VMEs. National scientists who work on NAFO subjects are still mainly fisheries experts and managers are more experienced in interpreting fisheries issues given their long relationships with fisheries scientists and practice in this field. As an ecosystem scientist stated, "some of these questions are not simple questions and many of the managers don't have any experience whatsoever in thinking about ecosystems" (NAFO 4). Ecosystem scientists subsequently believe that the information they provide is not being incorporated into the management process; instead, its use is merely contextual, i.e., it is used solely as background information when ecosystem data is needed to describe a process in a stock assessment but is not used in its own right as a piece of standalone information. The perception persists that ecosystem science is "not valid compared with stock assessment science" (NAFO 2). DFO scientists participating in NAFO SC working groups often refer to publications in the DFO CSAS process on stock assessments, which also do not generally include ecosystem or environmental information (NAFO 2). Ecosystem scientists believe that the uptake of ecosystem information in fisheries management depends on who is the responsible fisheries scientist. One ecosystem scientist stated:

> I think it is haphazard how you are invited to participate in those processes ... to me the most influential factor in determining how environmental information is incorporated in management decisions is the scientific training of and interests of the stock assessment scientist. (NAFO 2)

The formation of the Working Group on Ecosystem Science and Assessment (WGESA) was considered an approach to address the uncertainty of ecosystem science in the provision of advice for ecosystem management. The WGESA, however, is not a standing committee under the Scientific Council, which gives it less leverage or "credibility" for providing advice in NAFO compared with SC working groups conducting fisheries assessments under the Standing Committee on Fisheries (STACFIS). This fragmented organizational structure where fisheries scientists or stock assessment biologists and ecosystem scientists work at different levels may also be facilitating these communication challenges. It is anticipated that WEGESA will become a standing committee under the SC given the increasing demand for ecosystem advice within NAFO (NAFO 19). Scientists used the example of the Standing Committee on Fisheries and the Environment (STACFEN) which operated in the 1990s as a working group on the environment until it was designated as an SC standing committee, almost ten years later after it was recognised that the committee produced valuable input to advice produced by the SC.

While more ecosystem considerations are being incorporated into advice provided to the FC, care should be taken that the advice does not become too "narrow-focused." For instance, ecosystem advice from benthic scientists can be narrow-focused if the scientists do not understand the many other realms of the marine system. Similarly, ecosystem advice may be narrowly stated if it comes from a fisheries scientist (NAFO 8). The ecosystem perspective should be provided by the decision-makers, who are more likely to ensure that the ecosystem science is balanced (NAFO 8). While these two bodies report to the SC, the challenge of communicating ecosystem science in NAFO decision-making processes is expected to continue. National scientists also stated that communicating ecosystem information outside of NAFO was a further challenge with regard to the inability to get the right stakeholder groups involved due to the ad hoc processes involved in most of the ecosystem work (NAFO 2).

5.3.3.4. Different Roles of Scientists and Managers

Perceptions within the organization persist with regard to communication gaps between the FC and the SC. Staff working in the Secretariat stated that they "see both sides of the science-policy divide" with regard to technical aspects and communication, and the general opinion is expressed that a real divide in the relationship between the FC and the SC has existed for years (NAFO 19). This division was often exacerbated by the personalities and characteristics of managers and scientists alike; for instance, in the 1990s scientists provided overly technical presentations at the annual meetings and were "adamant that they were not going to dumb down the work" (NAFO 19). Physical appearances are also considered important. For example, a member of the Secretariat observed that:

> If you are a scientist going into a meeting with fifty men wearing black suits, I think you should wear a black suit too. But the scientist would say, “No, I’m wearing a Hawaiian shirt and shorts.” I don’t really get that, you get mad when you don’t get invited … when you are invited you make a spectacle of yourself. (NAFO 19)

A common quality trait that scientists observed was that managers do not pressure governments to act. The managers simply move to other activities when they cannot solve a complex issue, e.g., the impacts of climate change. As a result, not enough pressure is applied within governments on such complex issues. This state of affairs prompts external pressure from NGOs, for example, which often override any attempts at internal pressure arising within the national fisheries organization. The credibility of the external pressure is questioned as the government is not entirely convinced that a problem exists because the pressure did not come from within the national organization, simply because the message was never transmitted through the hierarchy to the top of the department.

Managers communicate with scientists but their personal or individual characteristics influence this process. Scientists and managers exhibit different cultural characteristics. “Managers don’t look at the detailed information, only the summary in terms of setting quotas or whatever their management objectives are” (NAFO 5). Furthermore, a mismatch in the time scales for providing advice may exist. One scientist claimed that in most instances a mismatch occurs “between what managers want in terms of concrete evidence and where scientists are in terms of providing the robust science to support a decision, one way or the other” (NAFO 10).

Table 12. Barriers in the information pathways – production, communication, and use of scientific information – in decision-making in the Northwest Atlantic Fisheries Organization (NAFO).

CHARACTERISTIC OF THE BARRIER	DETAILS
1. ORGANIZATIONAL STRUCTURE AND CULTURE – CONTRACTING PARTIES AND NAFO	
Communication	Scientists publish to meet their job performance criteria and focus less on communication or to champion research agenda.
	The need for a dedicated person to act as "champion" for research agendas in DFO and to liaise with Ottawa; Vague boundary roles
Joint Fisheries Commission and Scientific Council Working Groups	Working groups are focused on specific areas (ecosystem management including closed areas and VMEs; rebuilding plans and the precautionary approach) as opposed to the general delivery of fisheries management advice
National organizational aspects	DFO scientists in the Canadian delegation describe limited direction from DFO Headquarters in Ottawa; Limited strategic direction on ecosystem science; DFO funding determines research priorities
Work within NAFO and the contracting party can be conflictual	Ecosystem management and fisheries management can conflict with each other in national policy, e.g., scallop stocks on Georges Bank are shared between Canada and US but managed as two separate stocks and not as a transboundary stock
Travel restrictions	Loss of networking opportunities constrains bilateral collaboration and scientists staying abreast of research; Policies relying on collaborative work are strained; Brainstorming on complex issues is challenging without physical meetings
Decision-making in NAFO may not be completely transparent	Managers actively seek out scientific opinion in negotiations but make the final decision after considering other factors; Scientists are not privy to these other considerations; Observers can only attend open meetings of FC and SC
Policy is ahead of the science	After the policy is created, DFO Headquarters looks to the other regions for the science to understand how to implement the policy
2. CHALLENGE OF COMMUNICATING ECOSYSTEM ADVICE	
Communicating within the Scientific Council is challenging	Ecosystem information use is contextual – It is used as background information when data are needed to describe a process in a stock assessment; It is not used as standalone information
	Ecosystem scientists focus on giving Scientific Council details to understand the results to be able to present it to FC
	Fisheries advice from a benthic scientist or ecosystem advice from a fisheries scientist can be skewed

Characteristic of the barrier	**Details**
	The uptake of ecosystem information in fisheries management depends on interest of fisheries scientist
3. Format of advice	
Format of the presentation of advice	Debate on whether the Scientific Council should present options for managers, or to suggest the best option from a scientific perspective
Grey versus primary literature	SCRs (grey literature) are not regarded as high profile compared to primary publications; Perception that grey literature is not peer reviewed; Ecosystem science is published in the primary literature so it will be considered more credible
Managers do not understand what is needed	Scientists are frustrated so the advice provided is going to be more strongly worded for management act
Media	Social media is not formally used
Policy before science	Scientists are not involved in higher level decision-making in DFO
4. Different Roles of Scientists and Managers	
Managers	Managers communicate with scientists but their personal or individual characteristics influence the effectiveness of the process
	Managers do not address problems that they cannot solve, e.g., large scale and complex issues like climate change impacts
	Managers focus on short-term problem-solving and put little into long term vision of things
	Not enough pressure from managers within government on complex issues leading to external pressures, e.g., from NGOs, override internal pressures
	Government per se is not entirely convinced that there is a problem because the message never moves through the hierarchy, i.e., from managers to decision-makers
Scientists	Scientists tend to focus on the long term for problem-solving
	Scientists don't want to "dumb" down their work – their perception is that managers should understand science
Time scales	In most instances a mismatch exists between what managers want in terms of concrete evidence and where scientists are in terms of providing the robust science to support a decision

5.4. Discussion and Conclusions

Scientists and managers described decision-making in NAFO as primarily based on “hard science” available as stock assessments while “soft science,” available as ecosystem reports, is being increasingly generated and used. The formal process of requesting scientific advice, i.e., the FC annual request for advice, is primarily based on questions seeking fish stock advice. Overall, the information pathways in NAFO follow a linear science-policy interface model since decision-making is based solely on science; other information sources, e.g., local knowledge, are not used (Bremer & Glavovic, 2013; Pielke, 2007). In addition, the advice flows through defined stages to reach the managers and decision-makers in an “ideal model” that appears to be logical and linear in which managers ask the questions, scientists plan and conduct research, and scientists disseminate the findings as scientific advice directly to the managers (Knott & Wildavsky, 1980; Weiss, 1979). Iterative communication, i.e., ongoing two-way dialogue between managers and scientists is an outstanding feature of the information pathways. Information use in NAFO is direct or instrumental, based on the Nutley et al. (2007) categorization of information use – the science advice leads to NAFO management measures.

The publications produced by NAFO play an important role in decision-making in the organization. The scientific advice provided by the Scientific Council in response to the annual request for advice from the Fisheries Commission is similar to the well-defined process seen in the DFO CSAS process. DFO staff described the process as science and management “matching up” (see Section 4.3.3.1). This “matching up” characteristic was evident in NAFO in the well-defined process whereby the FC requests scientific advice and the scientists provide advice only for the questions asked by managers. Aspects of the “matching-up” trade-off in the science-policy interface in NAFO were similar to those observed in DFO (see Chapter 4, p. 113).

Information generated in the formal process for requesting advice in NAFO attains the attributes of credibility, relevance, and legitimacy. The advice is credible as it is produced by the scientists of the Contracting Parties, the technical reports and advice are relevant to the management needs in the NAFO convention area, and the advice is legitimate as it was developed through collaboration among NAFO members. The credibility of the scientific advice is enhanced by the separation of science and management decision-making in NAFO. The attributes of the information were also enhanced through the increased dialogue as a result of the new joint FC-SC working groups. An additional attribute was highlighted – transparency – where publications available on the NAFO website were considered as evidence of the openness of the organization. Scientific uncertainty in decision-making in NAFO was highlighted more for ecosystem science than for fisheries science. The characteristics of the FC annual request for science advice and the attributes of the advice are similar to the DFO CSAS process seen in the case study of the Canada Department of Fisheries and Oceans (see Chapter 4) and are compared and discussed in Chapter 7.

The interface between NAFO and each national fisheries management authority was a major factor affecting information flow. As seen in Canada as a Contracting Party, scientists who participated in the case study often did not separate their role in DFO from that in NAFO as they saw the latter as a natural extension of their positions within their national organization or saw the two as complementary roles. The interface between NAFO and the national fisheries agency of the Contracting Party influences the work agendas in NAFO, the science that is undertaken, and the decisions that are made. Similarly, the decisions made by managers from the DFO-NCR participating in NAFO influences the work program in DFO. Often these decisions may be ahead of the ability of scientists to provide the necessary science advice to implement policies in the national organization. The enablers and barriers in the information pathways in the national agency can influence the quality and quantity of work that national scientists can contribute to NAFO's activities. For instance, DFO allocates funds for international governance activities which support its scientists' participation in NAFO. On the other hand, current austerity measures have reduced the frequency that DFO scientists can travel, thereby making collaboration on assessments between the Contracting Parties more challenging, e.g., brainstorming of scientists from DFO-NLR and DFO-MR. Despite the national commitment by Contracting Parties to support NAFO's work, NAFO appears to be driving the participation of experts from national organizations and not vice-versa. For instance, DFO scientists generally joined the NAFO working groups in an ad hoc manner and could not recall being officially mandated by their national organization to undertake this work. Because of their participation in NAFO, they were eventually appointed by DFO as advisors for some of the NAFO meetings.

Participation by national scientists, managers, and policy-makers of the respective Contracting Parties at NAFO FC-SC meetings enables information flow within the national fisheries management authority as well as within NAFO. For instance, participation of the Canadian delegation, comprising advisors from the DFO-NCR, and managers and scientists from the DFO-NLR, ensures dialogue within the national organization. Furthermore, in matters related to NAFO, managers based in the DFO-NCR see their roles as advisors where they act as an intermediary between scientists and managers from DFO-NLR. As a manager stated: "Scientists have different ways of doing things and managers see it differently and [as an advisor] I act as the middle man – let's say. There are some other people who do that but I have a different perspective being from the headquarters office" (NAFO 15).

The organizational structure of NAFO is being revised to keep pace with the growing complexity of fisheries management. Based on the information pathway diagram (see Figure 10, p. 133), information flows between the SC and the FC are currently more iterative and formalized in many ways than in the early decades of NAFO and ICNAF. Traditionally decision-making in NAFO centred on fish stocks where the SC provided advice which the FC took and made decisions, e.g., on TACs for the next year, and the cycle continued. Now, the FC is asking questions on more complex topics related to ecosystems, e.g., risk-based management strategies and VMEs. The creation of mechanisms to facilitate increased dialogue at NAFO meetings, e.g., joint Fisheries Commission and Scientific Commission working groups has resulted in decision-making now occurring within more iterative contexts. Overlapping membership of working groups also facilitates greater dialogue in decision-making. The NAFO Secretariat plays an important role as a "bridger" to ensure communication between the Contracting Parties and NAFO in general and also between the constituent bodies of NAFO. As described in the DFO case study (see Chapter 4), "bridgers" can be individuals or organizational structures that connect two groups that often operate independently. The new FC and the

SC working groups created in September 2013 serve as communication bridges between the two constituent bodies. Within the NAFO Secretariat, the FC and the SC co-ordinators are also expected to be more engaged in ensuring the success of the joint working groups. DFO managers may play a bridging role between the scientists and the senior decision-makers, but this is not a formal role.

Scientists of the DFO-NLR who participate in NAFO were more open with regard to communication restrictions within DFO (see Chapter 4, Section 4.1.4) compared with the scientists and managers from the DFO-MR who were interviewed in the case study of DFO. The reasons for this difference are not evident; it is likely that participation of DFO scientists in a regional fishery body like NAFO allowed the scientist to speak more freely than they would in the setting of their national organization.

The separation of the science and management communities in NAFO was evident from direct observation and the interview responses. This observation supports the conclusion in the organization's 2011 performance review described in Section 5.1.4 (NAFO, 2011a). However, the subsequent creation of joint FC and SC working groups seeks to overcome this disconnect between the two constituent bodies. This case study revealed how an enabler for communication of information can also pose as a barrier. For instance, the joint FC-SC working groups were created to facilitate discussions between the FC and the SC, yet some interviewees stated that these groups do not necessarily communicate with other groups on additional priority issues. NAFO has inadvertently created another organizational level that can act as a barrier to communication. However, considerable overlap of memberships among standing committees in the Scientific Council may balance the advantages and disadvantages of having joint FC-SC working groups.

Informal networks were considered to be more effective in achieving dialogue than the use of formal networks. For instance, managers based in the DFO-NCR described email and telephone conversations between Contracting Parties like Canada and the EU. Similarly, within the Contracting Party, DFO managers had frequent communication with scientists since they worked in the same building. The preference for informal networks between policy-makers or senior-decision-makers in the Contracting Parties indicates that decision-making in NAFO may not be completely transparent. Managers actively seek out scientific opinion in the formal negotiations but often the final decisions are made after considering other factors and scientists are often not privy to these other considerations. The issue of transparency was also observed at the annual meeting where Observers were allowed to attend the plenary sessions of the FC meeting but not the break-out meetings that included members of the SC and FC.

The main conclusions include:

1. Credibility and relevance of the NAFO-generated scientific advice is guaranteed through the formal process for producing, communicating, and using scientific information, evident in the NAFO FC annual request for advice, the formal SC meetings where assessments are completed and advice is generated, and the presentation and use of the advice for management measures that are negotiated at the annual meeting. The scientific advice produced within NAFO is credible since the organization is regarded as an authority for decision-making for joint fisheries management in the Northwest Atlantic region. The scientific information is relevant since it meets the needs of the managers for managing fisheries in the region. The FC annual request for advice acts as the filter for information use in decision-making in NAFO, i.e., it ensures that only credible and reliable information is available for decision-making. The provision of science advice by scientists from the national fisheries management authority of the Contracting Party is separate from decision-making within NAFO and is a trade-off in legitimacy in the science-policy interface. This trade-off is similar to the "matching-up" trade-off described in the case study of the Canada DFO (see Chapter 4).

2. In spite of the separation of science and management in the process involving the FC request for scientific advice, "scientification" of politics is evident in NAFO whereby the Contracting Parties negotiate and reach consensus on management decisions that are based on the scientific advice on fishery resources and marine ecosystems. Scientists are also able to promote the management option that they think is the best by careful wording of the advice. Evidence of the "scientification" of politics is seen when scientists present information to policy-makers to increase attention to the problems but then indirectly influence the political agenda by the manner in which the scientific advice is presented (Hellstrom & Jacob, 2000; Weingart, 1999). The current situation developed after the

1990s when the NAFO Fisheries Commission introduced consensus-based decision-making. Management decisions are grounded in the scientific advice in support of implementing international instruments such as the precautionary approach and EAF. NAFO has produced its precautionary approach framework which is guided by limit reference points that are agreed to by the managers and the scientists.

3. Managers have become more science literate over time. This is due to their long working relationships with the scientists, the frequency of NAFO meetings and their attendance, and they may also have experience working in science sectors. Iterative communication between scientists and managers is characteristic of the communication phase of the FC request for advice process, particularly in the national briefing sessions of the Contracting Party in preparation for the annual meeting that is held in September.

4. The interface between NAFO and the national fisheries agency of the Contracting Party is a critical factor that influences the work agendas in NAFO, the science that is generated, and the decisions that are made. Factors influencing policy-making and science in the Contracting Parties can have a direct impact on the success of NAFO in maintaining its mandate. For example, for Canada, austerity measures being faced by DFO, e.g., limited resources for research and travel for collaboration on joint assessments, can weaken the contribution of scientific information by Canada as a Contracting Party to NAFO.

5. Communicating ecosystem advice is challenging because the demand for scientific information in NAFO is driven by the need to manage fisheries and not ecosystems. Scientific uncertainty in ecosystem science is considered to be greater than the uncertainty associated with fisheries science. Ecosystem science and advice will be given more weight in the advice to FC if the current Working Group on Ecosystem Assessments (WGESA) is transformed to a Standing Committee like STACFEN that deals with environmental data. Communicating risk and uncertainty was a greater concern for ecosystem advice.

6. Stakeholder groups, such as NGOs acting as Observers, play a critically important role in NAFO and the national fisheries agencies of Contracting Parties by increasing attention

given to complex issues, such as climate change impacts, at senior-decision-making levels. Managers in the national fisheries authorities often do not address such large scale problems because the issues cannot be solved in a short time. Managers also do not transmit such concerns through the hierarchy to the top of the department. Overall, the government may not be entirely convinced that a problem exists because the pressure did not come from within the national organization.

CHAPTER 6. CASE STUDY OF THE FOOD AND AGRICULTURE ORGANIZATION (FAO) OF THE UNITED NATIONS

6.1. Background

6.1.1. Organizational Structure and Mandate

The Food and Agriculture Organization (FAO) is an intergovernmental organization and a specialized agency of the United Nations (UN) with 191 member countries, two associate members and one member organization, the European Union (FAO, 2014a). Its mandate is to achieve food security, promote social stability, and to contribute to the growth of the global economy through its work in the fields of agriculture, forestry, and fisheries. The organization is described as a "knowledge network," using the expertise of its staff to collect and analyze agriculture and natural resources data, and to disseminate this new knowledge to aid development (FAO, 2013). Knowledge production has been a central activity of FAO since its establishment in 1945, and this knowledge supports FAO's global programs for promoting sustainable use of natural resources, environmental protection, as well as economic and social equity primarily in developing countries (FAO, 2013). FAO recommends national and international action related to agriculture, forestry, and fisheries; provides neutral advice to its members; and acts as a neutral forum where countries can negotiate agreements and debate policy.

With its headquarters in Rome, Italy, FAO has a decentralized network of regional, sub-regional, and country offices spread over 130 countries; approximately 58 percent of its staff is based at FAO headquarters (FAO, 2014a). The organization is headed by the Director-General and is composed of seven departments. This case study focused on the Fisheries and Aquaculture Department. This Department is headed by an Assistant Director-General and is composed of six branches, each headed by a Director or Chief, namely, Statistics and Information; Marine and Inland Fisheries; Policy, Economics, and Institutions; Products, Trade and Marketing; Fishing Operations and Technology; and Aquaculture. The role of the Department is to strengthen global governance and the capacities of FAO member countries to implement national programs on conservation and sustainable utilization of resources aimed at improving human well-being, food security, and poverty alleviation (FAO, 2014k).

The Committee on Fisheries (COFI) is a governing body within FAO; specifically, it is a technical committee and a subsidiary body of the FAO Council (FAO, 2014m). COFI is the only global inter-governmental forum where major international fisheries and aquaculture problems and issues are deliberated by member countries. COFI meets biennially and also reviews FAO's fisheries and aquaculture programs and specific matters referred to it by the Council, the Director-General of FAO, member countries, or the UN General Assembly (UNGA). While only the member countries have a right to vote at COFI meetings, recommendations approved by COFI are addressed to governments and regional fishery bodies (RFBs), non-governmental organizations (NGOs), fish workers, FAO, and the international community and civil society alike (FAO, 2014e). Membership in COFI is open to any FAO member country and to eligible non-members as Observers.

6.1.2. Scientific Advice and Global Policy Development

FAO supports member countries and RFBs through the production of a wide range of technical and policy guidelines, and management tools grounded in the 1982 UN Convention on the Law of the Sea (UNCLOS), which provides the legal basis for fisheries management. Two key legal extensions to UNCLOS, the 1993 FAO "Compliance Agreement" and the 1995 UN "Fish Stocks Agreement," were developed to assist member countries in building good management practices related to high seas fishing and reflagging of fishing vessels, and in fostering international coordination and cooperation for the management of straddling and highly migratory fish stocks both within and beyond their exclusive economic zones respectively (FAO, 1993; UNGA, 2007). Overall, FAO has played a critically important role in shaping and steering global fisheries management through the development of voluntary international instruments to address overfishing, e.g., through the 2001 Reykjavik Declaration on Responsible Fisheries which introduced the concept of an ecosystem approach for fisheries management (EAF) (FAO, 2001; Garcia & Cochrane, 2005). The Johannesburg Plan of Implementation at the 2002 World Summit on Sustainable Development subsequently set time-bound objectives for fisheries management, e.g., the implementation of EAF by 2010, and action to restore all overexploited fish stocks to the level that produced the maximum sustainable yield by 2015 (Doulman & Swan, 2012; UN, 2002).

FAO developed several non-binding fisheries management guides such as the 1995 *FAO Code of Conduct for Responsible Fisheries* which is central to FAO's global programs (FAO, 1995). The *Code of Conduct* promotes movement away from a single country, single species approach to the EAF that seeks to balance social, biological, and economic values and goals, with fisheries management. The precautionary approach to fisheries management, a guiding principle of modern fisheries management, is reinforced in the *Code* and recognizes that scientific uncertainty characterizes fisheries management and complicates informed decision-making (Cochrane, 2002a). FAO's *Technical Guidelines for Responsible Fisheries* information series are intended to assist national fisheries management and policy-making and implementation of the *Code of Conduct* (e.g., FAO, 2003). Concerns for the long-term sustainability of fisheries have also led to the development of international policies and management guidelines for specific issues, e.g., deep sea fisheries in the high seas, and bycatch and discards (FAO, 2009b; FAO, 2011a).

In spite of being a voluntary instrument, the *Code of Conduct* has been endorsed by all FAO members; it is widely recognised as the global standard for fisheries management and as a basis for reviewing and adopting national fisheries legislation (FAO, 2009d). Regional fishery bodies, e.g., the Northwest Atlantic Fisheries Organization (NAFO), are a primary driving force in the implementation of international guidelines while national fisheries authorities, e.g., the Canada Department of Fisheries and Oceans (DFO), are responsible for implementing the global guidelines and taking steps, e.g., through the development of national policy, to manage fisheries in a manner consistent with the *Code's* principles and objectives.

The FAO Fisheries and Aquaculture Department produces a range of technical reports, statistical databases, and policy guidelines for fisheries management (See Section 6.3). Much of the technical work of the department is completed through its subsidiary bodies for Asia and the Pacific, Europe, Latin America and the Caribbean, and the Near East. The FAO headquarters provide overall supervision and technical backstopping to member countries for global projects coordinated by the subsidiary bodies and regional fishery bodies, e.g., the Coordinating Working Party on Fisheries Statistics (CWP) and the Western Central Atlantic Fisheries Commission (WECAFC) (FAO, 2014f; 2014r). FAO has a formal system for producing international guidelines on fisheries management issues that includes expert and technical consultations where member countries can lead the finalization of international instruments, e.g., the *Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported, and Unregulated (IUU) Fishing*.

6.1.3. Social and Political Milieu in the Organization at the Time of the Internship

FAO is increasingly partnering with global initiatives and civil society to advance the global oceans agenda which has its roots in the 1992 UN Conference on Environment and Development (UNCED) and Agenda 21 when the global community recognized the central role that coastal and marine areas play in sustainable development (UN, 1992). With ongoing support for this global agenda, the "blue economy" concept was introduced in the Rio+20 Declaration in which conservation and sustainable management are now considered to be critical to ensure sustainable ocean-based economies (UNGA, 2012). Continuing to position ocean health on the international development agenda, FAO developed a sustainability concept, the FAO Global Initiative on Blue Growth (BGI), framed around the "blue economy" and its potential to support achievement of the "Sustainable Development Goals" that are expected to build on the "Millennium Development Goals" which end in 2015 (FAO, 2014c; International Institute for Sustainable Development [IISD], 2014). The "Blue Growth Initiative" provides a framework through which FAO will assist countries to develop and implement blue economy and growth agendas, i.e., sustainable use and conservation or resources in an economically, socially, and environmentally responsible manner; and to contribute to the global debate and decision-making process (FAO, 2014c; IISD, 2014). The initiative is also promoted as a vehicle for mobilizing resources and advocacy in international fora and it enables FAO to align with other major global initiatives and partnerships related to the "green economy" (e.g., Global Partnership for Oceans [GPO], 2014; UNEP et al., 2012). FAO's "Blue Growth Initiative" was described as a new interpretation of the EAF as the principles are largely the same (FAO staff, personal communication, June 2014).

In 2013, FAO revised its strategic framework and established a new program structure with five strategic objectives related to the technical quality of FAO's information and knowledge, and outreach, among other factors (FAO, 2014t). The strategic objectives are: (1) help eliminate hunger, food insecurity, and malnutrition; (2) make agriculture, forestry, and fisheries more productive and sustainable; (3) reduce rural poverty; (4) enable inclusive and efficient agricultural and food systems; and (5) increase the resilience of livelihoods to disasters (FAO, 2014t). The Blue Growth Initiative is anchored in Strategic Objective 2. Internal departmental changes were made to create a "fitter, flatter, and more flexible organization" aimed at improving the institutional arrangements for knowledge dissemination work in support of the strategic objectives (FAO, 2014t). Activities in the regular and extra-budgetary programs in the Fisheries and Aquaculture Department are now expected to be clearly aligned to the new strategic objectives (FAO staff member, personal communication, June 2014).

FAO is experiencing financial constraints since contributions to the organization by its member countries and voluntary contributions received from multilateral and bilateral resource partners, including international funding institutions and other UN system organizations, have been decreasing over the years (FAO staff, personal communication, July 2014). These financial restrictions may likely be influencing FAO's regular work program in a range of areas, specifically with regard to production of information products and its dissemination.

Not unlike the situation in Canada (see Section 4.1.4), FAO downsized its library facilities and the Fisheries and Aquaculture Branch Library was closed in 2014 and its collections were merged within FAO's main library (FAO, 2014j). The main library also lost five out of 11 library staff posts (FAO staff, personal communication, May 2014). The branch library provided specialized library and information services to the Fisheries and Aquaculture Department, other FAO staff, fisheries and aquaculture bodies in member countries, and the general public, for more than 45 years (FAO, 2014j). A critical role of the branch library was to ensure that FAO fisheries field documents and other published outputs are accessible through the library and preserved in the FAO Corporate Document Repository. The changes are expected to negatively impact the extent and quality of services related to fisheries and aquaculture information. Nonetheless, FAO continues to support library and information networking, e.g., with the International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC) and the Aquatic Sciences and Fisheries Abstracts (ASFA) Secretariat (FAO, 2014b, 2014o).

The organization is becoming increasingly involved in donor-funded projects consisting of extensive partnership activities, e.g., FAO is partnering with governments, regional fishery bodies, and relevant private sectors, industries, and non-governmental organizations (NGOs) in the implementation of the FAO-GEF Global Programme on Sustainable Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction (ABNJ) (FAO, 2014s). FAO is considered to be well-placed to lead the global agenda on fisheries and aquaculture in such partnerships due to its knowledge, experience, and role in ongoing global and regional activities, including coordination of RFBs and other similar mechanisms and networks, its network of regional and country offices, and the high profile of COFI. FAO is also partnering with universities and research institutes in projects aimed at assisting countries to implement EAF, e.g., the iMarine project that is establishing an infrastructure to facilitate open access and sharing of data (FAO, 2014n).

6.2. Methodology

6.2.1 Data Collection and Analysis

A three-month research internship at FAO headquarters in Rome was pursued from May to July 2014. Interviews of staff of the Fisheries and Aquaculture Department and direct observations at internal and international meetings held at the FAO headquarters were conducted. Content analysis of key FAO publications provided insights on the organization’s role in production of information and its use by the member countries.

Interviews with 33 members of the Fisheries and Aquaculture Department were conducted using an open-ended interview guided by the protocols included in Appendices 3 and 4. Responses were obtained regarding the pathways that FAO technical reports take, the drivers in the production of this information, enablers and barriers to the uptake of information in policy-making, and the information management practices aimed at increasing awareness and use of information in technical reports and other sources in policy-making by member countries. Interviews were conducted in person and lasted from 30 to 90 minutes (average = 49 minutes). The interview transcripts were assigned an alpha-numeric code, i.e., FAO 1 through 33 to protect the identity of participants.

Direct observations supplemented the interviews and were completed at four FAO meetings. At these meetings, the interaction among groups was observed with regard to the information sources used by each group, which group(s) consult with others during the deliberations, concerns with the content of scientific publications, and perceptions regarding the roles of each group in fisheries management and information use. The protocol for the direct observations is given in Appendix 5. The meetings included:

1) A three-day workshop on the development of a global Vulnerable Marine Ecosystems (VME) database held on 7-9 May 2014 (FAO Direct Observation 1). This meeting was attended by scientists from regional fishery bodies working on deep sea fisheries issues including management of the high-seas bottom fisheries in areas beyond national jurisdiction. The objective of the meeting was to test a prototype of the VME Database and provide feedback on related issues before launching the global database (FAO, 2014p, 2014v).
2) A two-day planning workshop for partners of a global fisheries project, *Sustainable Fisheries Management and Biodiversity Conservation of Deep-sea Living Marine Resources and Ecosystems in the Areas Beyond National Jurisdiction* (ABNJ Deep Seas Project) held on 5-6 June 2014 to discuss the current status and partner arrangements for the implementation phase of the project (FAO Direct Observation 2). The workshop included representatives from regional bodies managing deep-sea fisheries, regional seas programs, the fishing industry, international NGOs, national fisheries administrations and scientific institutions, civil society, and universities, as well as representatives of the Global Environmental Fund (GEF), FAO, and UNEP (FAO, 2014g).
3) The 31st session of the Committee on Fisheries (COFI), 9-13 June 2014 (FAO Direct Observation 3). This five-day meeting was attended by delegates from 116

member countries of FAO, six specialized agencies of the UN, and observers from 65 intergovernmental organizations and international NGOs (FAO, 2014q). Direct observations were also made at side events, e.g., on the Blue Growth Initiative and the ABNJ project, scheduled outside of the plenary sessions of this meeting. The international discourse on fisheries policy, discussions on information products and their use, and how requests for scientific and policy advice are developed in the governing body were observed.

4) An internal meeting of FAO staff to prepare for a global meeting to discuss the implementation of the FAO Small-Scale Fisheries Guidelines that were adopted at the 31st session of COFI (FAO Direct Observation 4, FAO, 2014w). The three-hour meeting was attended by staff of the branches of the Fisheries and Aquaculture Department and representatives from the Forestry Department of FAO, as well as a regional fishery body.

The interview responses and notes of direct observations were transcribed into Microsoft Word text files for data analysis as described in Chapter 3. The textual data were coded using categories guided by the characteristics of the science-policy interface presented in Chapter 2. Analysis of the responses also allowed additional themes to emerge. Themes were extracted from the data to describe the drivers for producing information, and the enablers and the barriers for its communication and use in decision-making. Data obtained from the interview responses were also used to develop information pathway(s) models and to describe the process of producing information.

The results are based on the interview responses, direct observations, and content analysis of FAO's publications. The information pathway(s), i.e., the production and the communication of science and policy advice by FAO, and the intended or actual use by FAO's clients are described. The drivers to information production, communication, and use are presented. The enablers and the barriers, mainly with regard to communication and use of information in policy context, were categorized under the coded themes. Direct quotations from the interview responses are used to illustrate the themes and are referenced as FAO 1 through 33. The direct observations are referenced as FAO Direct Observation 1 through 4 as described above.

6.3. Results

6.3.1. Information Pathway(s) – Production, Communication, and Use of Fisheries Scientific Advice and Policy

The information pathways that document the production and the communication of scientific and policy advice by FAO, and its intended or actual use by FAO's clients are described in this section. Figure 13 illustrates the general information pathways involving the key actors and the main FAO information products. The complex interplay between FAO and key actors, e.g., the UN system, and other international governmental organizations; RFBs; FAO member countries; and NGOs, is underplayed in this schematic diagram. The flow of information appears to be linear in the "Expert and Technical Consultation" process and in the production of global statistics, reviews, and standards. Details about the complexities related to the actors involved, the types of information products, and how these products are used and disseminated to multiple audiences are described particularly with regard to the Fisheries and Aquaculture Department. Attempts by FAO to measure use of its information are discussed. Table 13 provides an overview of the main components of the information pathways (see p. 203).

6.3.1.1. Actors

All of the individuals in the FAO Fisheries and Aquaculture Department who were interviewed in this study play a role in production of information and its dissemination, and in the formulation of policy from their varied backgrounds in science, policy, economics, or law. The staff of the Department are mainly biologists and include gear technologists; staff involved in the policy-side of projects are mainly economists and there are a few sociologists (FAO 33). The interviewees provide a technical backstopping role for national field projects in member countries but do not consider themselves as scientists, managers, or policy-makers. One respondent stated, "we are not scientists ourselves ... but we are supposed to be in the position to absorb the science and then translate it" (FAO 4).

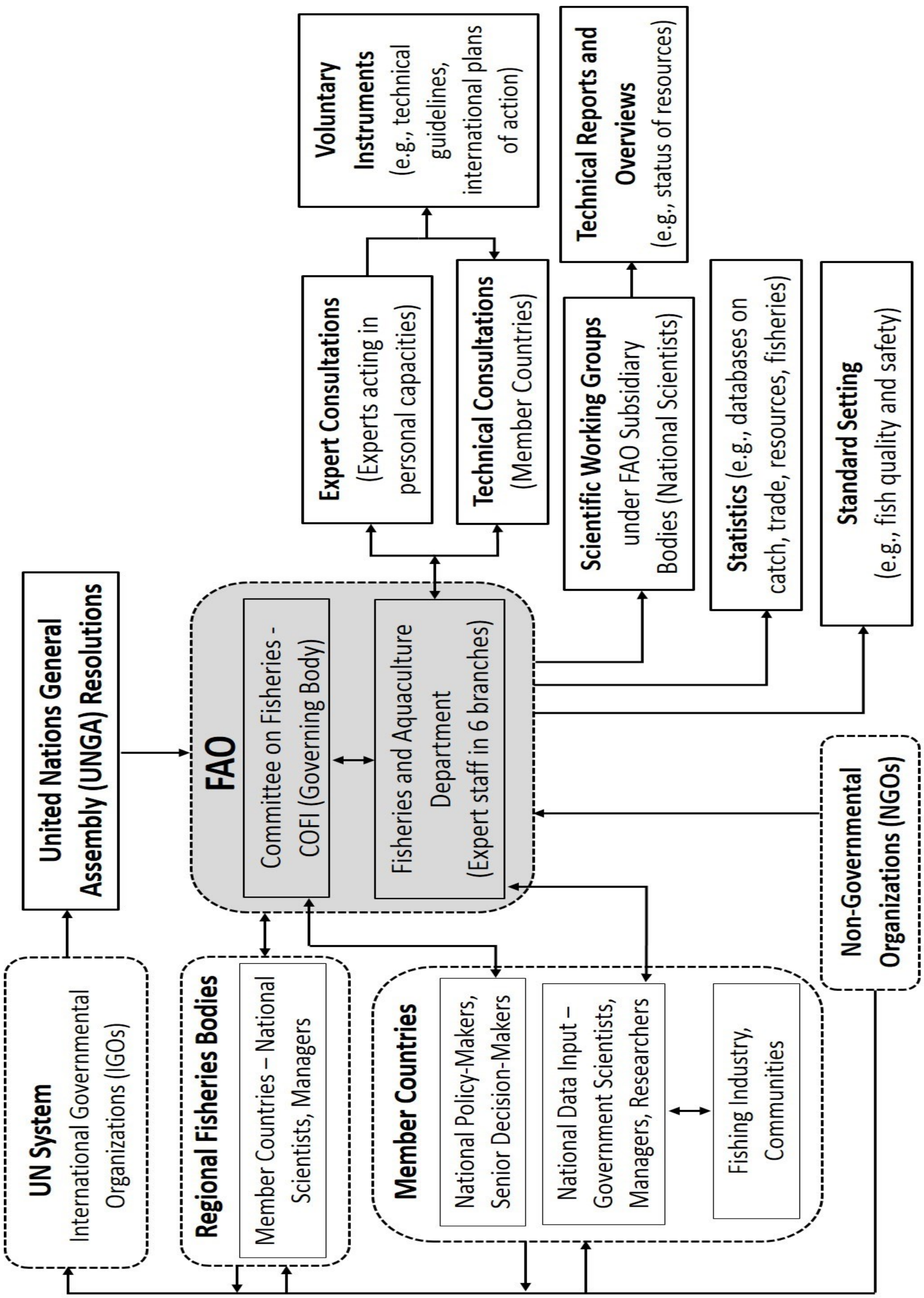

Figure 13. Information pathways – production, communication, and use – in the Food and Agriculture Organization of the United Nations (FAO).

The respondents described how information was used in their work in service to the member countries to fulfill FAO's global mandate of hunger reduction and poverty alleviation. The interviewees also interpreted the term "information" in the operation of FAO to mean data and data collection, e.g., of fisheries statistics. They defined FAO as a "knowledge organization," and described information production, its communication, and use in a "knowledge utilization" context where new "knowledge" contained in FAO's information products contributes to the organization's mandate. One staff member summarized this perspective as follows:

> The key issue is that we don't call it information that actually makes the change … we call it knowledge that we need. If you use the word information it is so wide and it does not connect with me … I don't think at all from the information point of view. I am thinking how to impact people's behavioural patterns and their motivation in their social life where they have their own motivations and hidden agendas. So I don't use the word information in my thinking at all. (FAO 15)

6.3.1.2. Production of Scientific Advice and Policy Advice

The respondents are not directly engaged in national science or policy-making; however, they facilitate the "Expert Consultation and Technical Consultation" process, e.g., to develop international guidelines which are considered to be high level policy instruments to address issues of special global concern (FAO 11). The process for developing guidelines was described as:

> A really unique mechanism in FAO is when we are requested to develop an instrument. And if that instrument is based on science … FAO asks for expert consultation ... we are supposed to provide the science, but we're not scientists. So we call this expert panel and we make sure that we select the right experts … we facilitate, and they come up with recommendations which become the FAO recommendations but it's actually the expert panel. (FAO 4)

The process of developing international guidelines generally occurs over a period of years and often starts with a request from the UN Nations General Assembly (UNGA). For example, the development of the 2011 FAO *International Guidelines for Bycatch*

Management and Reduction of Discards can be traced, at the least, from the 2006 UNGA Resolution 61/105 on sustainable fisheries which called upon all states to apply the precautionary approach and an ecosystem approach (UNGA, 2007). The 63rd UNGA session in 2009 then called on the global community for action to reduce or eliminate bycatch and discards and to support related research. The 28th session of COFI in 2009 resolved to address the issue of bycatch and discards and requested FAO to develop international guidelines through the "Expert Consultation and Technical Consultation" process (FAO, 2009d, 2010). The participants in the expert consultations work as individual experts in their respective fields and do not represent any stakeholder groups. The technical consultation is a more formal process where decision-makers from the member countries are invited to participate and the text developed by the expert consultation becomes "a negotiated instrument as countries deliberate over it word by word" (FAO 4). FAO facilitated the 2009 expert consultation on bycatch and discards to draft the guidelines with participating scientists from governmental organizations, e.g., DFO; NGOs, e.g., the World Wildlife Fund (WWF); and independent consultants (FAO, 2009b). The technical consultation for the bycatch and discards issue was held in 2010 and was attended by fisheries advisors and ministers of member countries (FAO, 2010). The subject of bycatch management remained on the COFI agenda until the FAO *International Guidelines for Bycatch Management and Reduction of Discards* were endorsed by the 29th COFI meeting and released in 2011 (FAO, 2011a; 2011c). FAO guidelines are sufficiently vague to be able to be applied in any national context (FAO 4). Through global projects, FAO is working with regional fishery bodies and member countries to facilitate the uptake of the guidelines at regional and national levels, while also focusing on changing practices at the local level in fishing communities.

With regard to technical publications, the FAO staff work with national scientists to conduct regional and national stock assessments, ecosystem research, and related work in the FAO major fishing areas (see Section 6.3.1.3 for examples). This work can be completed under FAO's regular program of work or as extra-budgetary projects receiving donor funding. The respondents stressed that the technical information that FAO generates or uses is defined as "science" as "science is everywhere and in everything, you need science to make decisions" (FAO 22). FAO acknowledged that the role of this “science” was most visible or “strongest when management measures are defined, and at the national level when it is transferred from a policy to a strategy with management measures” (FAO 11). FAO also recognises the need to include other sources of knowledge in policy and decision-making as one interviewee described:

> We say science ... however you define science ... but we want it to be integrated with other forms of knowledge like traditional and local knowledge ... there is a lot of local knowledge but it may not be documented but can still have a lot of value ... you should also give fishers a role in generating knowledge through dialogue with scientists. (FAO 11)

The Committee on Fisheries, as part of FAO’s governance mechanism, considers fisheries and aquaculture issues from a technical perspective and endorses science and management advice (FAO Direct Observation 3). The COFI working papers are not scientific research papers and are only produced to provide normative information for FAO members to guide their discussions. In addition, the documents used at COFI meetings are “as value-neutral as possible; not too pro-fisheries or pro-environment” (FAO 6). The member countries report on the progress of work for the previous two years given funds received from FAO and priority activities and funding for the next two years are discussed (FAO 15). Decisions at COFI meetings are taken up in the other bodies in FAO’s governance structure, e.g., the FAO Programme and Finance Committee, the Council, and then the Conference adopts the final recommendations (FAO 6).

6.3.1.3. FAO Information Products and Their Use

FAO produces statistical and specialized databases, field project reports, a range of meeting and conference proceedings reports, technical reports in series, and information brochures, among other information products. Each branch within the Fisheries and Aquaculture Department produces information products in their program areas and examples are discussed in this section. The focus is given here to fisheries statistical information, global statistical and resource status reports, and trade and fish quality reports.

The respondents described most of the information output produced by FAO as "secondary data" because the organization uses data and statistics provided by the national fisheries authorities, as countries are obliged under the FAO constitution to supply this data (FAO 12). Information is also submitted from the industry, including fishers, exporters, importers, and processors. FAO does not generate primary data except when producing technical or policy guidelines (FAO 12). FAO collects and analyses long time series of data, e.g., on commercially important products, species, and related fisheries for the last 50 years, and compiles these datasets into global databases made available to its member countries and the public. The accuracy of national statistics provided to FAO is sometimes questioned. FAO then uses internal verification processes through the RFBs and the Coordinating Working Party on Fishery Statistics and works with countries to improve their data collection systems (FAO, 2014f). FAO is described as an authority on fisheries statistics and the interviewees described them as their "basis for everything." One respondent boasted that:

> Anyone who talks about fish will take FAO statistics ... we understand that there are many limitations and we are not 100% accurate and perfect, but I can proudly say that no other organization has this rich, chronological database on fish. (FAO 22)

FAO is often the only organization that has assembled all of the data from particular RFBs in a single database, e.g., data from the tuna regional fisheries management organizations (RFMOs) used in the production of the open-access tuna atlas made available on the FAO website (FAO 21). FAO also uses the compiled statistics to produce other information products, as input into assessments of resources by regional working groups, for advocacy for fisheries management, and for funding purposes.

The respondents described the use of FAO's statistics in global decision-making, e.g., by "high level" decision-makers in member countries "at the G8, or G9, or G20 [meetings] … to make their decisions on how development aid will flow into fisheries and aquaculture" (FAO 29). However, some developed countries can use FAO statistics and information "out of convenience for issues on their national agenda ... they want independent support for what they are saying … they want to push a certain viewpoint that requires ... that a particular issue be sanctioned ... or for the justification for their work” (FAO 1). FAO can use the national catch statistics submitted to FAO by the governments to make a recommendation about a policy direction. Information is used by other FAO’s clients, such as the donor community and regional fishery bodies, to support proposals for research activities. Available as open-source data, FAO statistics are often used by developing countries as a primary source of information for fisheries management (FAO 1).

“Flagship” publications, such as *The State of World Fisheries and Aquaculture* (SOFIA) report, integrate the work and issues relevant to the Fisheries and Aquaculture Department (FAO, 2014u). This biennial publication provides diverse audiences with an overview of the status of global fisheries and contemporary fisheries management issues. SOFIA is informally endorsed in the COFI meeting as the committee recognises that it is “a good contribution to understanding the state of the world fisheries” (FAO 33). Member countries also provide suggestions for improvements in subsequent issues of the report. The summary of statistics and the overviews contained in SOFIA can create greater awareness of the need to act to manage fisheries, as was evident at the 2014 COFI meeting where the statistic from the 2014 edition of SOFIA that “about 30% of fish stocks are overfished” was repeatedly mentioned by member countries (FAO Direct Observation 3; FAO, 2014u). Such statistics have always had a general indirect impact on national fisheries policies as they raise awareness of issues such as the need to rebuild fisheries stocks (FAO 17). National scientists prefer to use FAO’s global databases, e.g., those compiled under the Fisheries Global Information System (FIGIS), as their source of primary data on fisheries landings for conducting assessments since the summaries in SOFIA do not account for data gaps and uncertainties. While summary statistics, such as the percentage of overfished stock, can raise awareness of the need for action, misrepresentation of the SOFIA statistics in publications by other organizations is also common, e.g., related to the interpretation of “fully fished” and “overfished” (e.g., WWF, 2014, p. 80).

The *Review of the State of the World Marine Fisheries Resources* is another “flagship” publication which presents a comprehensive global perspective of stock status on all regions every five years (FAO, 2011b). Fish stock status is reported according to biologically sustainable levels, e.g., "fully-utilized" and "under-utilized," which have been described as being "scientifically correct, politically more acceptable to the majority, and in line with COFI recommendations" (FAO 17). These statistics are summarised in the SOFIA report and stock status indicators are used in the UN Millennium Development Goals and to develop Convention on Biological Diversity (CBD) indicators (FAO 17). Most countries use the information in the report as "hands-on advice for their region" (FAO 19). Observed global and regional trends provided in the technical report, e.g., stock declines, feed into national policy-making (FAO 25).

FAO compiles fish quality and safety information and standards in the *Codex Alimentarius* and helps countries to implement these standards so the countries are able to export their products (FAO, 2014d). This information is disseminated mostly through workshops on fish and fishery products along with advocacy and awareness-building programs (FAO 12). The Globefish project provides online access to fishery commodity data including global production and trade data such as price indices and market studies on commercially important fish species (FAO, 2014l). Globefish maintains a dedicated webpage and information is distributed directly to FAO member countries and industry and directly or indirectly to fisheries and industry associations globally. Trade statistics are important for export-related activities in developing countries and these statistics are often used as supporting data for lobbying for project funds from donors. FAO also uses the data for capacity building to develop national capacity in project management, e.g., to prepare project concept notes for national financial institutes (FAO 12).

The 1995 FAO *Code of Conduct for Responsible Fisheries* (described in Section 6.3.1.2) is the globally accepted guidelines on fisheries policy. Implementation of the *Code* is voluntary but the way that it is written lends itself to be translated into binding legislative texts in the member countries and "you will find that [in] a lot of fisheries management organizations, the regional fishery bodies, the European Union as well, there is always reference to the *Code* or a specific article in the *Code* in their binding legislation ... so this is the strength of the *Code*" (FAO 7). Monitoring the implementation of the *Code* in member countries is a central activity in FAO and is an example of the organization measuring information use (and influence). Every two years, member countries complete a questionnaire based on a set of indicators and criteria for measuring success in implementing the *Code*. FAO analyses the responses to determine opportunities and constraints to implementing the *Code*. The responses submitted by member countries are considered confidential and only summarised information is reported to COFI. An independent study of the impact of the implementation of the *Code of Conduct* showed that countries that implemented the *Code* had managed sustainable fisheries (Coll, Libralato, Pitcher, Solidoro, & Tuleda, 2012). FAO, therefore, gauges implementation of the *Code* as a means of measuring the growth of sustainable fisheries management. This information has many expected uses, e.g., as an indicator for the achievement of the fifteen UN Millennium Development Goals (FAO 7). The range of stakeholders targeted to assess the implementation of the *Code* goes beyond the national fisheries agencies to include a version of the *Code of Conduct* questionnaire for RFBs and one for the NGOs (e.g., international NGOs such as the WWF). Comparison of the responses of the RFBs to the responses of the countries in the respective regions adds validity to the measurements.

6.3.1.4. Communication of FAO Information and Publications

FAO interacts with a range of audiences or its "clients," including various levels of government and professionals in different subject areas representing a range of networks, e.g., the RFBs, experts, processors, and civil society. The interviewees prefer to use traditional methods of communication, e.g., email, Skype, hardcopy, and websites to communicate with clients. The clients are often sent a link to new publications, meeting and workshop documents, or related new information in their field of interest. FAO publications are now being disseminated mainly in digital version available on the FAO website. FAO also produces multiple versions of its documents for use by diverse audiences, e.g., scientists, managers, and industry. The information products made for the public and industry aim to be "very simple, but the message is clear," e.g., video, flyers, infographics, brochures, booklets, and sometimes cartoon-type materials are used to reach fishing communities (FAO 13). Information materials are generally produced as output from technical studies and they identify priority issues of concern and provide recommendations. These materials are sent to the fisheries administrations in member countries and it is expected that the national fisheries extension services will communicate the information to the fishing industry.

FAO staff share information at meetings, conferences, and workshops, which are opportunities for two-way flow of information, i.e., "during presentations of commissioned studies, a great deal is also learnt from the audience from their questions and the discussion" (FAO 13). Attendance at national meetings and workshops on technical assistance, e.g., scientific working group meetings and training workshops hosted by the governments of member countries, are opportunities to communicate information (FAO 13). Discussions at national events have an added benefit of communicating with groups outside of the national government agencies (FAO 13). The respondents use the opportunity of the COFI meeting held at the FAO headquarters to meet country delegations between the formal sessions to follow up on project activities. FAO also uses side events at other conferences to promote its work and seek feedback from members and the wider UN community. For example, FAO hosted a side event on the implementation of the *Code of Conduct for Responsible Fisheries* at a 2013 meeting on the fish stocks agreement at the UN office in New York attended by top level representatives of governments of the member countries (FAO 7). FAO produces policy briefs based on the scientific information for countries attending the COFI meeting. An interviewee described the importance of policy briefs as "basically a succinct summary that presents the science by saying what is what, what we need, and what government, private sector, and industry need to do. We need to go back to science always; we need to convey science through briefs" (FAO 22).

References to the background sources of information were not included in policy briefs prepared for the UNGA or any other international governance fora. Input for the UN Secretary General Reports prepared by FAO, e.g., on the UNCLOS, fisheries, or ad hoc reports, are generally based on national and international government reports, and not peer-reviewed papers in research journals. One respondent explained:

> If you are writing from a governance perspective, you can have the background information in the back of your mind, but you cannot add your references and publications, because there are people's names associated with publications that can

> jeopardise the validity of the statement that you are trying to make. So you see, there is a rationale behind it, it's not that they don't care about the information. (FAO 10)

Social media as a communication tool was recently implemented at FAO and live streaming of meetings and open chat lines were introduced in the last five years (2009-2014) (FAO 26). However, while the number of people using social media is increasing, FAO has not determined how effective social media is as a communication tool (FAO 26). By-products of some of the main technical information products are communicated through social media. For example, several "by-products" based on the contents of the SOFIA report are produced, including tweets, infographics, and other presentations (FAO 26). Through the use of social media tools, such as Twitter, FAO can take advantage of events to reach audiences with whom the organization generally would have no direct contact. For instance, as one interviewee noted, FAO was able to participate by Twitter in the 2014 US State Department *Our Ocean Conference*: "we were able to interact directly with the State Department, something that we would have never done through such channels before … we would have had formal channels" (FAO 26).

6.3.2. Drivers to Information Flow into Decision-Making Contexts

Three main drivers for the production, communication, and use of marine fisheries information were identified: (a) FAO's mandate and the global demand for information; (b) the UN system; and (c) trade. Table 13 outlines the characteristics of these main drivers (see p. 203).

6.3.2.1. FAO's Mandate and the Global Demand for Information

The organizational mandate and the demand for information are main drivers of information production, communication, and use in decision-making, according to 94% of the respondents (31 out of 33). FAO's role in setting agendas at the international level that drive the production of information was emphasized: "when FAO writes a paper on something, that's pushing the agenda forward on the global discussion and dissemination of information" (FAO 5).

Information products, e.g., annual fisheries statistics produced by FAO, often drive the production of further information, e.g., flagship publications such as SOFIA, and technical guidelines for policy. As a result, scientific information and policy are inter-related: “both respond and generate, push and pull; the information drives the policy and the policy drives the production of information – it’s a circular sort of activity” (FAO 1). The information-policy push and pull phenomenon was also illustrated in instances when “information should drive policy but sometimes we gain some idea of what is going on and we recommend policy that requires that certain information … [is] collected” (FAO 14). The “supply and demand” of information was described as a dynamic and iterative process whereby the FAO staff “interact back and forth with some of the producers of information to provide feedback and overall information on the industry for users” (FAO 22). Networks formed in this information flow process, e.g., between FAO, countries, and other international bodies, facilitate data collection, communication of information, and link actors at the global level to “see to it that it [information] is read, it is perceived, and there is some follow up action and there is reporting back” (FAO 2).

Decisions made by member countries in COFI meetings and NGOs lobbying for industry can influence the prioritization of work activities in FAO, thereby driving related information production and its use. For example, with regard to ecolabelling of fish and fish products, branches in the Fisheries and Aquaculture Department have been encouraged to move forward in promoting ecolabelling guidelines and are expanding its data sets with this new information being made available to users (FAO 28). NGOs can “utilise FAO or they can influence FAO” depending on the level at which NGOs enter. At the research level, for example, NGOs can influence information production to increase awareness of issues, or at the policy-making level, they can promote actions to address global issues and encourage information uptake into policy (FAO 25).

Member countries can also drive some of the issues placed on the international agenda, with FAO playing the role of facilitator. For example, in the development of the database on VMEs, “the original trigger came from a few motivated countries” such as Canada, New Zealand, and Europe (FAO 25). These countries drove the idea at COFI meetings and then to the UNGA where there are a more international players; when FAO received the mandate from the UNGA, it was then tasked to play a facilitation role (FAO 25). Member countries can also drive the development of international guidelines. For instance, the expert consultations for the guidelines for management of bycatch and discards was driven largely by scientists from a range of countries, including Canada, although the experts participate in a personal capacity (see details in Section 6.3.1.2.)

Donor funding from a range of sources is driving FAO's work program and facilitating partnerships with external organizations. For example, the FishCode program is a major project area in the Fisheries and Aquaculture Department, which is funded primarily by the Global Environment Facility (GEF). This project involves governments, the private sector, NGOs, and RFBs, among others and is described as "a very different beast, it's not entirely FAO, it's funded by GEF…it's FAO, it's UNEP, it's World Bank, and then a lot of different partners…so we cannot give it a total FAO branding, it will be unfair" (FAO 3). The project has its own website with its own branding and logo apart from the FAO (FAO 3). Activities using regular program funds often do not receive as much support internally in FAO compared to extra-budgetary or externally funded projects, e.g., the ABNJ project (FAO 27).

The FishCode program is currently implementing a Common Oceans project to promote efficient and sustainable management of fisheries resources and biodiversity conservation in the Areas Beyond National Jurisdiction, commonly called the high seas. The "Strengthening of Global Capacity to Effectively Manage ABNJ" component of the project aims to improve the global and regional coordination and exchange of information on marine ABNJ through integrated information systems, advocacy platforms, and social networks, as well as through facilitating increased dialogue with decision-makers (FAO, 2014s). GEF is enabling the involvement of multiple stakeholders through a focus on partnerships to build on the baseline work of different organizations involved in management of deep-seas resources, including the RFBs, other UN agencies, and NGOs. The overall results in terms of production of information and networking for decision-making are strengthened (FAO 19). The iMarine project is another example of partnerships with FAO, which involves collaboration with academic and research institutions to support the EAF through development of a sustainability-driven data infrastructure governance model (FAO, 2014n). The project will ensure that "otherwise dispersed and heterogeneous data ... [are] available to all stakeholder communities through a shared virtual environment that brings together multidisciplinary data sources, supports cross-cutting scientific analysis, and assists communication" (FAO 25).

6.3.2.2. United Nations System

Fifty-eight percent of respondents (58% - 19 out of 33) spoke about aspects of the UN system that acted as a driver in the information pathway. First and foremost, implementation of binding and non-binding fisheries instruments, e.g., UNCLOS and Agenda 21 of UNCED, respectively, as well as binding non-fisheries instruments, e.g., CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and CBD conventions, drive the demand for and supply of scientific information production (FAO, 18). Furthermore, directives within the UN system, e.g., UN Headquarters and other UN agencies and intergovernmental bodies, influence the setting of priorities for research and information production in FAO. For instance, the UNGA resolutions directed the production of FAO international guidelines, e.g., for the management of deep-sea fisheries, bycatch and discards, and small-scale fisheries (FAO, 2009b; 2011a; 2014u). With regard to deep seas fisheries, the UNGA Resolution 61/105 initiated a chain of activities focused on addressing impacts on ocean bottom habitats (FAO, 2009). A respondent described this development as "following the same ancient route or cascade of events" where "high policy frameworks such as the UN General Assembly and the COFI process are driving the production of related information such as the development of the vulnerable marine ecosystem database" (FAO 25). Extensive networks of RFBs, experts, professionals, industry, and civil society, among others, have been established in the development of each of FAO's set of technical guidelines (FAO 25).

The need to complete projects arising from the 2012 Rio +20 conference has encouraged collaboration across UN agencies to address scarce staff resources, e.g., in FAO to meet the demands of additional information production. This collaboration also ensures consistency of agreements at COFI meetings and at the UNGA as "everything [fisheries issues] agreed to at the UNGA comes back to us at FAO, because nobody else under the UN system can implement what they agreed" (FAO 6). The respondents believe that an ideal practice is "to work more strategically with the regional bodies…and collaborate with UNEP and UN and GEF at the global level … FAO cannot do everything" (FAO 6).

Within the limits of available funds, FAO maintains a presence at particular meetings at the UN Headquarters to promote awareness of the role of fish and food security (FAO 10), e.g., by attending the UN Informal Consultative Process on Oceans and the Law of the Sea (ICP) (UN, 2014). Participation in conferences and recognized UN days are ideal opportunities for FAO to gain more visibility, e.g., at the World Oceans Day, which "is a gateway to reaching a range of people" (FAO 10). In the past, FAO has participated in such events in various ways, e.g., by preparing summary documents or by hosting panels at the UN Headquarters in New York where experts are invited to participate in coordination with the occasions. FAO is, however, striving towards achieving an increased presence at the UN to emphasise its role and activities and in so doing it produces summaries and policy briefs for its member countries (FAO 10). For instance, FAO's contribution to the Sustainable Goals and Sustainable Development Goals, and Millennium Development Goals related to fisheries was described as follows:

> It is different from a UNGA resolution as it is more specific and the process is driven by member countries but we provide advice. Some states like to get our opinion; so, it is good to have things prepared to brief them. We cannot push for things; it is in the hands of the states. (FAO 10)

How information is framed can lead to a different outcome in the UN system. The respondents stated that part of their job is to ensure that FAO's messages and related views of governments or regions are reflected in the UNGA resolutions (FAO 10). For instance, the issues of disaster relief and risk management were always included under discussions on climate change, but now disaster relief receives more attention since it is considered as a separate concern (FAO 10). Other priority areas of work in the UN system, such as the protection of human rights through ensuring food security, also influence how fisheries information is framed and subsequently used in policy-making. For example, the small-scale fishery guidelines that were approved at the 2014 COFI meeting were framed in terms of the human right to food security in order to promote uptake by politicians (FAO 11; FAO, 2014q). The Fisheries and Aquaculture Department drafted the small-scale fisheries guidelines based on lessons learnt from FAO's Forestry Department that drafted the land tenure guidelines which were adopted by the World Committee on Food Security (CFS). The small-scale fisheries guidelines were shaped and guided over several years by dedicated social science and economics experts in the Fisheries and Aquaculture Department and an extensive network of fisher organizations and other civil society groups.

The production of synthesis publications, e.g., by the High Level Panel of Experts on Food Security and Nutrition (HLPE), also illustrates the reframing of fisheries information in a food security context (FAO Direct Observation 3). This Panel was established in 2010 "as the science-policy interface of the UN Committee on World Food Security (CFS) and aims to improve the robustness of policy-making by providing independent, evidence-based analysis and advice at the request of CFS" (HLPE, 2014a). This Panel's report was presented at the 31st session of COFI and provided "a synthesis of existing evidence regarding the complex pathways between fisheries and aquaculture and food and nutrition security, including the environmental, economic and social dimensions, as well as issues related to governance" (HLPE, 2014b, p 11). The inclusion of a report on fisheries in the series of reports by CFS was a strategic decision to reach politicians:

> It is a good thing that they included fisheries because we talk among the converted at COFI – the fisheries communities, people involved in fisheries. We don't need to tell ourselves how good fish is for food security. But the CFS relates with agriculture ministries and other audiences that go far beyond the fisheries sector. If we can get the attention of these other agents, then we can get into things like national food strategies and national poverty alleviation strategies beyond the sector. (FAO 11)

6.3.2.3. Trade

Forty-five percent of respondents (45% - 15 out of 33) highlighted trade in fish and fish products as a driver in the production, communication, and use of marine fisheries information. Primarily, regulation of international trade in fish and fish products necessitates the production of market data and trade standards, e.g., the statistics compiled under the Globefish project. The fishing industry demands information on sustainability, such as stock status and global capture fisheries production statistics, in its need to maintain its markets. One respondent noted that:

> Exporters and importers want information on global markets and are interested in what's happening in the sourcing environment, what's happening in the supply countries … their key concern is the supply situation. The state of stocks, quotas, and outlook for quotas, that is the most important information that they are looking for ... that is what influences most the price, the cost of the product that they are dealing with. (FAO 12)

Most of FAO's work is focused on developing countries where the objective is not only food security but the ability to compete in international markets. The production of information is, therefore, demand driven as "you need to follow the markets to know what the consumer wants ... you cannot afford to invest research and technology to develop a product that is not needed" (FAO 13).

FAO's statistics and international standards related to traceability of fish and fish products, such as ecolabelling, and for food safety, such as the *Codex Alimentarius,* are often used as a reference or as background information for trade requests or to ensure consumer protection and food safety (FAO, 2014d). For instance, in trade disputes between countries, the World Trade Organization (WTO) accepts the international standards set by FAO, e.g., the requirements for ecolabelling or for illegal, unregulated, or unreported vessels (FAO 4). In spite of being voluntary, FAO's international standards are used as the baseline. The guidelines are considered the authority as "any country who wants to develop national market access will do their best to make sure that they fit with the FAO" instead of "exposing themselves to a situation where they are creating barriers to trade because they are not following the international guidelines of FAO" (FAO 4). The FAO Blue Growth Initiative is another example of how framing of fisheries issues is influencing the attention given to existing concerns; in this instance, fisheries management issues are framed in a sustainable economy context, i.e., on the consequence of increasing fisheries and aquaculture to food security (FAO, 2014c; IISD, 2014).

Table 13. The key drivers in the information pathways – production, communication, and use – in the Food and Agriculture Organization of the United Nations (FAO).

Drivers	
1 - FAO's Mandate and the Demand for Information	
Production	Capacity building, i.e., knowledge transfer to develop national skills in fisheries management; and technical backstopping to ensure that science and policy advice is available (particularly developing countries),
	Developing global norms and standards
	Donor funding influences the FAO work program and drives partnerships, e.g., to support the EAF
	FAO's mandate, i.e., sustainable resource management contributes to long term well-being, ending hunger, and poverty eradication
	Public outreach to civil society – less technical information
	Supply and demand – information-policy push and pull process, i.e., production of information can push agendas at the international level
Communication	Diverse audiences – from civil society to national, regional, and international scientists, managers, and policy-makers
	Various formats – print, digital versions; Information communicated in five languages; Various tools – website, news media, social media
Use	Publications are considered the international authority; Use ranges from awareness in society to national, regional, and international policy-making
2 - United Nations System	
Production	High policy frameworks, e.g., UNGA and the COFI process where UNGA resolutions lead to a request for an instrument for policy from COFI
	Framing FAO information for use at the UNGA – Reframing fisheries issues in a UN focus leads to different outcomes, e.g., human rights
	Implementing binding fisheries instruments, e.g., UNCLOS, 1993 Compliance Agreement, 1995 Fish Stocks Agreement, 2009 Port State Measures; Non-binding fisheries instruments, e.g., UNGA resolutions, Agenda 21 of UNCED; Binding non-fisheries instruments, e.g., 1973 CITES convention, CBD
	Including fisheries issues in publications aimed at decision-makers
	Collaboration with other agencies after Rio +20, e.g., to implement the Sustainable Development Goals and Millennium Development Goals
3 - Trade	
Production	Need for information by the fishing industry to maintain markets
	Reframing fisheries issues as trade issues, e.g., the consequence of increasing fisheries and aquaculture to food security

Drivers	
	Supply and demand of fish influences the flow of information – Production of standards related to traceability and sustainability; Agreements at COFI, e.g., to develop a system for global fish traceability
Communication	Training to enable developing countries to adhere to international standards and requirements to gain access to international standards
Use	Information on the state of stocks, quotas, and outlook for quotas are important to industry (i.e., fishers, importers and exporters, and retailers)

6.3.3. Enablers to Information Flow into Decision-Making Contexts

Four main enablers in the information pathways include: (a) the credibility of the organization and its information; (b) the organizational structure and culture of FAO; (c) external stakeholders, e.g., NGOs, industry, civil society, member countries; and (d) overlapping institutional membership. Figure 14 shows the percentage of respondents who identified these drivers in the interviews. Table 14 provides a summary of the enablers and their characteristics (see p. 211).

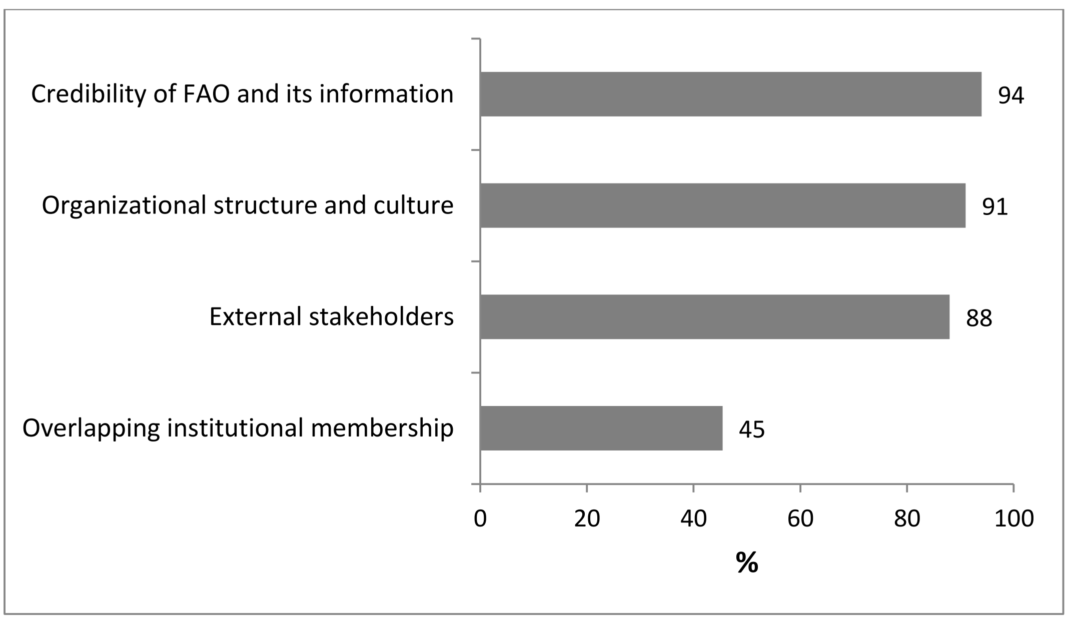

Figure 14. Enablers in the information pathway – production, communication, and use – in the Food and Agriculture Organization of the United Nations (FAO).
(The percentage of respondents is indicated; Number of respondents, N=33)

6.3.3.1. Credibility of FAO and its Information

Almost all of the respondents, 94% (31 out of 33) described a range of characteristics of FAO related to its mandate that convey credibility to the organization and its information. FAO is regarded as *the* authority on global fisheries information as its information is "considered to be impartial … the best possible information ... governments say that this is very important that they have one international body that they can trust" (FAO 15). The expertise and competence of staff was also seen as the cornerstone of the organization's credibility since "FAO's real strength is the technical expertise that it can bring in itself" (FAO 33). Given these attributes of impartiality, authority, and credibility, countries are more inclined to adopt or acknowledge international guidelines, e.g., on bycatch management and reduction of discards, even though they are voluntary (FAO, 2011a). Countries see such guidelines as credible because "FAO is still respected quite a lot" and therefore they "carry some weight because they are coming from FAO and because it was agreed to internationally it carries more weight than the national or regional stuff" (FAO 15). FAO encourages countries to use its information products instead of preparing their own national materials. For instance, using FAO materials as reports for national fisheries ministries is recommended since the information "is easy to read and easy to manage, all in one place, all comparable" (FAO 19). FAO gives approval to developing countries, in particular, to utilize or "recycle" FAO's summarized information on country websites.

FAO's mandate with regard to the production of information, provision of technical support (i.e., backstopping), and long-standing relationships with countries is intended to encourage uptake of scientific information in national policy-making. However, the ultimate decision to use scientific information, e.g., the advice from stock assessment working groups of the regional bodies, is made by the member countries. In the context of such regional scientific working groups, one respondent stated that:

> FAO's role is to ensure that the information is out there. It is up to the competent authority who has to make that weighing up and down to see how to use it best. You have the scientific advice that is very clear ... if scientific advice is always ignored we have to find some way of asking questions [why not]. In the end they have the authority to make the decision on whatever they have to put emphasis on. (FAO 19)

FAO is a knowledge-based organization and gathers information to develop databases and to produce publications. However, this information is only used to shape policy as the organization provides recommendations on policy directions (FAO 31). Fisheries information produced by the Fisheries and Aquaculture Department is used to support FAO's corporate messages on the value of fisheries and aquaculture in contributing to long term well-being and the need for sustainable management to meet the organization's long term goals of ending hunger, poverty eradication, and maintaining balance with economic growth and development (FAO 26). FAO sets standards by developing global and regional guidelines which were described as a "great strength" of the organization as other organizations, e.g., NGOs, do not have the same ability (FAO 33).

6.3.3.2. Organizational Structure and Culture

Most of the respondents, 91% (30 out of 33) identified characteristics of the organization of FAO that facilitate information production and use. Project task forces are set up across the department to oversee and implement projects. Each task force works on a particular issue and involves experts from other departments when necessary, e.g., from the agricultural sector (FAO 33). The respondents described the Fisheries and Aquaculture Department as "not very hierarchical," which promoted a level of "independence" and "flexibility," where staff in general work:

> On a variety of topics which may complement or supplement each other but not necessarily feed into one another. They have their own almost parallel streams of progression from generation and fact finding to a document that may get distributed, or information gets passed out or a meeting gets organized. (FAO 5)

Other respondents believed that an overall hierarchical structure in FAO constrained internal communication but this was typical of any organization (FAO 8). The interviewees also believed that the technical experts from different geographic regions working at FAO headquarters, as well as the global experts consulted for projects, placed the organization at an advantage with regard to the credibility of knowledge production (FAO 14). The job position and geographical representation of FAO experts influences information use in their respective home countries, as one respondent revealed: "now that

I am here [at FAO] I am influencing the directors back home to use the [FAO] databases" (FAO 14). In fulfilling FAO's role in training and capacity building, these experts and consultants are highly motivated personally to produce information so much so that they:

> Feel driven to produce things to help countries. That is why perhaps there is no real reporting back to a boss. Most of us feel that we are doing something and working extra hours not for something that our boss will see, but because you have to produce something for some country and there is someone waiting there for it. (FAO 9)

FAO keeps abreast of its client and audience needs and is continuously trying to redefine its role in line with the interests of its clients and to ensure that information remains relevant, both in terms of its content and in its delivery to multiple audiences (FAO 25). Methods and tools used to deliver FAO's messages and information are changing rapidly, e.g., the way that they are packaged and the way that they are distributed to the users. Communication methods are becoming increasingly digital and as much as 61% of the traffic on some project websites comes from social media (FAO 12). FAO acknowledges that social media is an important tool to attract users to its repository of information. Websites external to FAO's main website also provide "more flexibility" in reaching a wide range of stakeholders in the fishing industry (FAO 12). Details on the use of social media by FAO are outlined in Section 6.2.1.4.

The new strategic objectives of the organization are driving increased internal collaboration among the branches of the Fisheries and Aquaculture Department and with other FAO departments, e.g., Forestry, as project documents and work activities must indicate linkages and overlaps germane to each of the five strategic objectives. Identifying these linkages and overlaps is also beneficial to facilitating funding, e.g., for climate change projects, where resources are "easy to find when we show the multi-sectoral approach" (FAO 14). Staff from various departments and branches also collaborate to produce or update information briefs for the FAO Director-General. New organizational mechanisms to facilitate partnerships were created, e.g., the FishCode Programme in the Fisheries and Aquaculture Department, which differs in structure from other Departmental branches since it reports directly to the Assistant Director General of the Fisheries and Aquaculture Department rather than to a Branch Director.

Partnership projects, e.g., the ABNJ project described in Section 6.3.2.1, are building on the authority of the information already being provided to clients by FAO. When organizations such as RFBs and NGOs partner with FAO in such projects, they can benefit by obtaining greater credibility both in terms of the data they produce and as an authoritative body (FAO 25). For example, NAFO is one of the actors in the FAO Fisheries and Resources Monitoring System (FIRMS) partnership involving iMarine. Scientific information from NAFO is included in FAO's statistical databases and in turn FAO provides NAFO with access to FAO's enriched data set (FAO Direct Observation 1). RFBs like NAFO can then embed products such as FAO maps into their own scientific publications which are available to the public and their members on the RFB's website. More comprehensive datasets and publications can be produced in partnership projects, e.g., the global database on VMEs which was developed under the ABNJ project and released in 2014 (FAO Direct Observation 1, 2; FAO, 2014v). This VME database was developed by FAO through collaboration among the main regional bodies involved in deep-sea fisheries management. The database links to the respective websites of the RFBs, e.g., NAFO, and their relevant publications, e.g., NAFO Fisheries Commission reports which contain management decisions. The data and information linkages between FAO and partners increase access to available information as often "the general public does not know where to find this information" (FAO 25).

Projects like ABNJ and iMarine also facilitate the emergence of an "Ecosystem Approach Community of Practice," an informal network of practitioners with experience and expertise relevant to ABNJ with respect to key issues, e.g., marine protected areas and environmental impact assessments, to facilitate sustained multi-stakeholder dialogue. Through these communities of practice, consensus building is now easier to achieve from all the partners in a GEF-related program, e.g., the private sector-industry, intergovernmental organizations, and international NGOs (FAO 2). Through partnerships, scientific information is also being repackaged for use by managers, policy-makers, and the fishing industry.

6.3.3.3. External Stakeholders

A main driver of information production, communication, and use in decision-making, according to 88% of the respondents (29 out of 33), is the external stakeholders such as non-governmental organizations, industry, and member countries themselves.

FAO has growing interactions with civil society as a means of influencing information uptake in policy-making because attempts to directly influence decision-makers may be challenging due to national politics within member countries. The organization targets information production and communication with the national policy-makers in a top-down approach, but as one respondent stated: "You never reach the political level directly, they listen to you but forget directly after. But the public pressure … when a major group of people want a change, and those are the people who vote for them, they will act" (FAO 15). FAO is, therefore, increasingly targeting the "end-point," i.e., the industry, and is developing a demand for information since an "educated and empowered industry then applies pressure to the policy-maker and policy impacts on the actions of the industry" (FAO 22). Civil society in democratic countries often obtains the attention of politicians and can also place public pressure on them to act.

FAO is increasingly relying on external stakeholders such as NGOs to disseminate information on fisheries issues to the fishing industry, given the closer link that most NGOs have with the industry and communities at national and local levels. FAO is also engaging more with NGOs as a means of maintaining the credibility of the organization and its information with the industry (FAO 15). Another strength of this relationship is the ability of NGOs to interact with member countries in ways that FAO cannot act because it is a specialised UN agency that operates on the principle of neutrality. As one respondent stated: "We cannot point the finger at countries who don't follow the rules, or who don't fight against illegal fishing, who don't provide good statistics…we just can't do that" (FAO 20). Additionally, pressure from international NGOs such as the World Wildlife Fund and the International Union for Conservation of Nature (IUCN), can influence member countries to move agenda items at COFI meetings. For instance, a strong request was presented by members at the 2014 COFI meeting to facilitate ecolabelling by developing a system for global traceability of fish and fishery products (FAO Direct Observation 3).

6.3.3.4. Overlapping Institutional Membership

Forty-five percent of the respondents (45% - 15 out of 33) described examples of overlapping membership of actors in organizations that facilitated information production, communication, and use. For instance, membership of regional fishery bodies, FAO, COFI, and other UN organizations often overlapped such that member countries are able to "connect the conclusions made at different fora, e.g., UNGA resolution with the COFI document" (FAO 6). FAO member countries are also members of different RFBs. RFBs are instrumental in promoting and facilitating the uptake of FAO's information and international instruments into decision-making by the RFB member countries through their national fisheries agencies. Commonly, the members of RFBs are also members of FAO and all RFMOs are invited to send observers to FAO meetings (FAO 7).

To illustrate overlapping memberships, FAO has been actively collaborating with RFBs with a mandate to manage deep-sea fisheries in the development of the Areas Beyond National Jurisdiction Deep Seas Project. Each regional body is now a partner in this project involving networks of individuals representing national, regional, and international organizations with the objective to facilitate sharing of information and experience between regions on stock assessment methodologies, methods to identify areas likely to contain VMEs, the development of the VME database, and species identification programs, among other topics (FAO Direct Observation 1 and 2 respectively). The VME database involves mapping of the relevant regional level information on VMEs, habitats, fishing activities, and management measures linked to the advisory and management reports available on the individual RFB websites. NAFO and a key scientist from the Canadian Department of Fisheries and Oceans participating in the NAFO Scientific Council Working Group on Ecosystem Assessments and Science (WGESA) were involved. This overlap in institutional membership facilitated the flow of related information produced by DFO, NAFO, and FAO into one consolidated database that is now available to the public and managers.

Overlapping memberships are also instrumental in maintaining comprehensive datasets of national and regional statistics collected by FAO. For instance, national scientists participating in regional bodies, e.g., NAFO, use national information to generate advice for management and this information is also collated by the regional bodies and submitted to FAO. The Regional Fishery Body Secretariats Network (RSN) is a major communication mechanism for sharing information among the RFBs and for FAO to communicate with the RFBs. One simply has to “send an email though the network and people respond” (FAO 10). The regional fishery bodies are also in frequent contact with national governments and help to facilitate communication between FAO and the member countries.

Table 14. Enablers in the information pathway – production, communication, and use – in the Food and Agriculture Organization of the United Nations (FAO).
(The percentage of respondents is indicated; Number of respondents, N=33)

Enablers	Characteristics of the Enablers
1. Credibility of FAO and its information	
Authority on global fisheries statistics and information	Governments of member countries trust FAO as an international body; International guidelines carry more weight than national or regional ones
	Provides the best available information – considered to be impartial
	Recognition by the governing body, COFI, gives publications authority
Information supply and demand	Capacity building in countries to enhance national data collection ensures that FAO receives data to produce comprehensive databases
	Implementing non-binding fisheries instruments, e.g., *Code of Conduct*
	Information-policy push and pull process, i.e., production of information in, e.g., technical series, can push agendas at the international level
	Statistics are used in scientific advice and policy-making by members
2. Organizational structure and culture	
Communication with clients	Continuously redefining of FAO’s role to ensure that information remains relevant to the interests of its clients
Departmentaliza-tion	Hierarchical structures are not pronounced – staff work independently on topics which may complement or supplement each other; FishCode, a special unit that reports to the ADG and receives the highest source of extra-budgetary funds
Experts	Technical expertise of staff to transfer knowledge; Staff are motivated to produce information to help countries

Enablers	Characteristics of the Enablers
Donor funding and partnerships	Donor funding influences the FAO work program and drives partnerships, e.g., to support the EAF; The philosophy of donors, e.g., GEF – baseline information must exist in order to receive funds
	Extra-budgetary projects are more autonomous, i.e., with their own websites, branding, and logo, e.g., the ABNJ project
	Partners benefit from FAO's authority as a "knowledge organization"; Formation of formal and informal networks of practitioners occurs
New Strategic Objectives (SOs)	Promotes integration of work across programs and departments to create an interdisciplinary approach; Fisheries and Forestry will work closer
	Resources are allocated to projects with a multi-sectoral approach
3. External Stakeholders and Politics	
Civil society	Civil society is becoming more organized into communities of interest; Public pressure on politicians to act
Industry	Supply and demand for information are driving market forces
NGOs	Interactions with NGOs to maintain credibility, e.g., shared goals
	NGOs can influence the agenda at COFI and which programs get priority in FAO, e.g., on ecolabelling and fighting against IUU
	NGOs are free to act while FAO is bound by the principle of neutrality
Member countries	Motivated to address fisheries management issues and implement EAF
Politics	Policy-making is driven by governments; Multiple considerations, e.g., science, economics, and social issues; Policy-makers see the big picture
4. Overlapping Institutional Membership	
Memberships of RFMOs and FAO	Member countries of RFMOs are members of FAO; all RFMOs are invited as observers to FAO meetings
National, regional, and international	RFMOs discuss the science produced by national scientists; FAO provides the forum to discuss global political issues; Networks; Greater credibility of data from RFMOs compared with national submissions
Participants at FAO and UNGA	Member countries can connect the conclusions made at different fora (UNGA resolutions with the COFI documents)
Sharing and linking information	FAO maintains comprehensive and credible databases, e.g., NAFO adds to FAO's databases and FAO gives NAFO access to the enriched data
	FAO VME database links management decisions to the RFMO documents giving the latter more visibility
	Overlaps among member countries, FAO, NAFO in database development (provision of data and use), e.g., FIRMS, iMarine

6.3.4. Barriers to Communication and Use of Information in Decision-making

Five main barriers to the communication of information and its use in decision-making were identified: (a) organizational aspects affecting communication of information; (b) communication gaps between FAO and its members; (c) the format of advice and access to information produced by FAO; (d) politics; and (e) a lack of harmonization with the UN system. Figure 15 shows the percentage of participants who identified these barriers in their interview responses. Table 15 provides a summary of the characteristics of these main barriers in the information pathways (see p. 228).

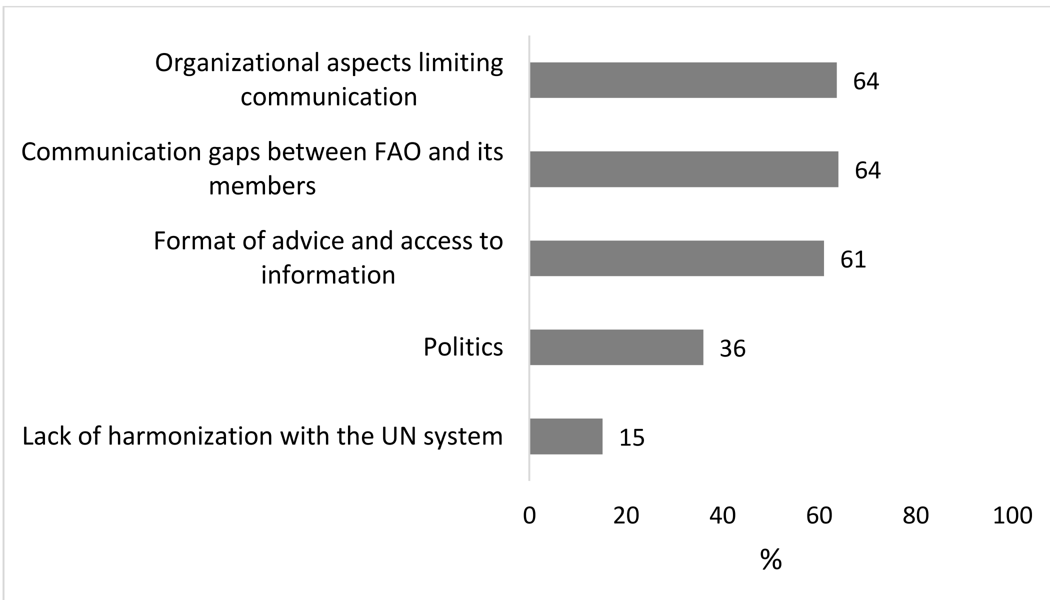

Figure 15. Barriers in the information pathways – production, communication, and use – in the Food and Agriculture Organization of the United Nations (FAO).
(The percentage of respondents is indicated; Number of respondents, N=33)

6.3.4.1. Organizational Aspects Limiting Communication and Use of Information

Although the importance of the communication of information produced by the Fisheries and Aquaculture Department was recognised, 64% of respondents (21 out of 33) considered the communication of this information to be limited. The respondents described different challenges to communication, which were largely due to aspects of the organizational structure and mandate of FAO, personal motivations of staff, and different perceptions of the value of grey and primary publications.

Since there are no dedicated fisheries communications staff in the Fisheries and Aquaculture Department, communication of project findings is mainly the responsibility of the respective project leads. Effective communication is also further hindered as individuals working in information and communication-related fields “normally are not technical experts and that is an enormous problem and vice versa” (FAO 2).

The communication challenge is increasing; respondents spoke about their heavy workloads resulting in limited time to focus on such activities. One interviewee stated:

> I don’t think that FAO does a good job at disseminating information, not that we do a bad job, but we are so busy with so many things that this is not considered a priority. We are focused on helping countries; so, sometimes we don’t get time to do full analyses as well. (FAO 23)

Heavy workloads also resulted in limited time for internal communication within FAO as one interviewee observed:

> There is so much pressure on the technical division, there is less and less time to have good technical interactions between the people here ... it’s not often that you get a chance to talk with someone else to get a different perspective on things. (FAO 19)

Heavy workloads also contributed to more informal internal communication where “directors are generally briefed through verbal meetings … it’s again part of our communication problem, nobody knows where others have been, who did what, there is no record of who said what to who and this is a big communication problem” (FAO 9).

FAO’s corporate communications office uses social media, live streaming, and open chat lines for global events. However, only a few interviewees in the Fisheries and Aquaculture Department are capable of using these digital communication technologies or even motivated to use them since it means taking on more tasks in addition to their regular work (FAO 26). While the respondents acknowledge that communications through social media and the website are becoming more important, perhaps more so than paper products, they were still unwilling to adapt and as one stated, “the truth is that I simply don't have the time. We are already overloaded with projects and activities and so on, so the first thing you let down is the communication aspect" (FAO 20).

The importance of information communication is generally not addressed because of a general perception that information production is implicit rather than explicit in project outcomes. Communication of information is still not openly considered when planning program activities within the new strategic objectives because more time is spent on defining how departments and branches will work together compared with how information dissemination and communication will be addressed (FAO 2). One respondent stated "information is a commodity and it's not seen as one by my colleagues; they see information as auxiliary to what they are doing sometimes or they don't realise the full meaning of what information can be" (FAO 26). This interviewee described the perception that communication is secondary to completion of projects and stated, "I think the bottom line is that communications is very undervalued and underappreciated and is really seen as a soft luxury rather than a key component of every project and activity that we have" (FAO 26). Furthermore, this mind-set is compounded by a "publish or perish attitude" where a publication is often seen as "the end of the road to an activity or a project, so it's a form of closure" and often the driving force is mostly the need to enhance institutional or personal bibliographies (FAO 26).

The Fisheries and Aquaculture Department is engaging in more extra-budgetary funded projects, given the reduced availability of general operational funds, and these programs have their own recruitment and reporting procedures which contribute to a disconnect between the extra-budgetary funded and regular (general funded) program areas. Consultants are generally hired to do preparatory work for extra-budgetary projects as opposed to FAO regular staff, given the current workloads as previously described. Extra-budgetary funded partnership projects provide FAO with substantial resources; however, a considerable period of time is spent by staff in gaining consensus from project partners and limited time is left for communication of results; so, "to the outside world there is absolutely nothing [no communication]" (FAO 2) and "even donors have told us they would like to see more awareness and dissemination work built into projects that they are funding (FAO 9). While extra-budgetary project activities may not be very different from the regular program of activities, they often do not complement each other and there is limited sharing of results from some projects (FAO 2). The communication challenge was described as follows:

> Projects are more or less autonomous ... this is a big, big challenge and lost opportunity [for communication]…you get a project like the EAF Nansen, which is an amazing project and they will have their own kind of project communications people and it stays very hermetic because they are looking at their project and it's not well hooked into what we're doing unfortunately ... it should fold naturally into what FAO's doing and vice-versa. (FAO 26)

Constraints to efficient dissemination of information are also linked to the geographic representation of experts at FAO, which is often related to the ability of individuals to frame project outputs in less technical formats for the respective regional audiences. As one respondent explained, there is:

> Uneven representation of nationality of staff … [and] apart from generating information we have to disseminate it and apply this to mainly developing countries in Asia, Africa, Pacific and Latin America. In doing so you need people with local experience who know how to distribute the information…in terms of country membership, it is not evenly distributed. So this will impact on how we disseminate information. (FAO 14)

Some respondents noted a growing disregard over the years for the technical expertise of staff (e.g., FAO 18, 24, 33). One interviewee added "that is where FAO's great strength lies … but recently there is not much respect for this. I sometimes think that the staff is seen as a burden rather than an asset" (FAO 33). As a result, a disconnect exists between management and technical staff in FAO where management is "reinventing" technical networks to facilitate communication and work when extensive networks of experts already exist (FAO 2; FAO 24). Consequently, efforts to "re-invent" networks slow down any advances in communication with FAO's current clients (FAO 24).

Furthermore, some respondents also believe that the role of FAO as an organization is changing from a technical focus to advocacy (FAO 24, 33). Member countries appear to be content with less technical information and perhaps this is also a conscious decision by FAO to act as an advocacy organization by reducing positions and outsourcing the technical expertise to consultants from the market place (FAO 24). As a responded described:

> FAO is moving, opportunistically, towards an advocacy organization focus and while I support that, in the meantime the contents are being lost and are being propagated by incompetent people. And that is the beginning of the end…There is less thoroughness and less political responsibility for technical content. So there is a risk of disseminating information that is shallow. (FAO 24)

Given the challenges to communication in the department, i.e., the disconnect between FAO's regular and extra-budgetary programs where activities are often not integrated, the lack of dedicated communication staff, the inability of technical staff to communicate their project findings efficiently, the use of new tools like social media, and the perceived changing role of the organization, one staff member commented:

> There is an enormous need to define where we are as an organization, where we are as a department, where we are as a unit, how we would like to communicate with the outside world. What is it we would like to communicate is one thing, but with the technical and technological developments at the same time, it might be two completely different issues, and two completely different challenges that need to be handled in two different ways or maybe more ways. We are definitely not up for this; it is just more than enough running our day-to-day business. (FAO 2)

6.3.4.2. Communication Gaps between FAO and Its Members

Sixty-four percent of respondents (64% - 21 out of 33) also highlighted challenges in communication with FAO member countries including communication problems at the national level within the member counties. Often, FAO's program activities may not have a defined plan for communication of the information to member countries which is often associated with the absence of a current program to monitor or measure the impacts of the organization's field projects as was the case in the past. While information is being communicated, the organization is not sure how information is used, who uses it, and what is being used for. A respondent stated:

> We have learned now that information and communication and dissemination is important but to really do the follow up and to really see that these techniques, these messages, the information, are systematically introduced at the various levels in the countries, there is still a long way to go … we should go further than that, we should link it up to what we know about national plans and where does this information fits in and link it together…this is not being done in a systematic way" (FAO 2).

The lack of follow up to projects in the member countries may be negatively affecting the organization's mandate for information production and communication. As one respondent noted:

> We are producing information and trying to make it available to the right people and the right time. It is frustrating. I see things being produced that are being regurgitated; the same things were produced 20 or 30 years back. We say the same messages, maybe change it up a bit, to the same target groups, or the wrong groups, we are not learning. (FAO 24)

This need to follow the pathways of the information produced in projects is also evident in statements made by other staff members who described the uncertainty in knowing whether publications are reaching decision-makers in spite of the demand for information from member countries. One stated:

> Information production in FAO is becoming more demand oriented and we talk to the governments. We assume that when we talk to the government, that person represents the interests of the government and is listening. When we go to the field we don't see that situation, as fishers don't feel represented. (FAO 23)

This disconnect is also seen in the communication of the scientific information generated by national scientists in the regional scientific working group meetings facilitated by FAO. As a respondent described:

> Sometimes you don't know exactly where it goes. You have the advice and speak to the scientists about the importance of interacting at the national level … when they come back from the working group, they go to their office … they have to submit the report through their channels. They might [send it] to the director but I don't know if it goes through the management channels in the country. (FAO 19)

The respondents believe that there is a general disconnect with the national level policy-making, and clients and audience needs. The staff also described challenges in communicating with member countries in cases where FAO research projects were not obviously relevant to the member country's or industry's needs because the research was based on the research interests of some FAO staff who "are interested in research and they have their research network. And they are not particularly interested in what is happening in the field at a more practical level" (FAO 2). This leads to a gap between the needs of the country or industry and the information produced by FAO (FAO 23). Research that is influenced by staff interests and capabilities is not considered to be part of FAO's mandate as one interviewee stressed: "in theory, at FAO we shouldn't produce original research and should be more collaborative" (FAO 10). For instance, events like COFI meetings are not being used strategically to highlight FAO's information to the high-level decision-making audience in attendance, i.e., ministers and other senior representatives from member countries (FAO, 14). One respondent remembered suggesting that a computer be made available to demonstrate the range of statistical databases so "when they [COFI attendees] see their country information, when they go home they could delegate relevant responsibilities and consult the statistics" (FAO 14).

While FAO houses comprehensive global databases and is considered an authority on global fisheries data (see Section 6.3.1.3), awareness of the importance of FAO's work is still considered by the interviewees to be low globally. FAO has to continuously encourage members to submit data for the statistical databases and often has to convince national scientists and managers to use the information as output (FAO 27). In the case of FIRMS, a global inventory of marine resources and fisheries, which includes information on socio-economic aspects and management status of fisheries, a staff member noted that "we spend a lot of time trying to explain the need to scientists, sometimes fisheries ministers and a wide range of people, the importance of having a very nice, easy, and effective way of delivering information" (FAO 27).

Different motivations of national scientists and managers related to information production and use contribute to the communication gaps between FAO and member countries. For instance, national scientists generally focus on their national data and find it less important to compile global databases (FAO 27). FAO then uses the regional fishery bodies as an intermediary in information flow as it "channels the information from the national level up to the global view, through the regional bodies as a filter" (FAO 27). FAO also recognises that national scientists are often not effectively communicating the scientific information to the managers. The respondents see tools like FIRMS as a means to bridge the science-policy gap as they provide rapid access by managers to information for decision-making.

6.3.4.3 Format of Advice and Access to Information Produced by FAO

Sixty-one percent of respondents (61% - 20 out of 33) described challenges in communicating information related to the format of the advice, e.g., the varying levels of technical detail; the limitations of communications tools, e.g., digital versions and the website; and, loss of direct access to information and information professionals, e.g., in the closure of the departmental library.

The respondents stated that they are often criticised by member countries – mainly developing countries – about the format of management advice in FAO technical reports. For instance, "quite often we hear that the advice is too vague, e.g., you need to reduce effort. And they say they need to know, e.g., which gear and by how much" (FAO 23). Member countries often need to be provided with additional details about how to interpret the advice. Conversely, the information can also be too technical or superfluous for decision-making audiences and some FAO staff members believed it was because of too much reliance on "highly" technical models and science (e.g., FAO 14, 15, 20). The respondents noted that decision-makers in some of the member countries do not read information from FAO that contains too many technical details because "they don't have the capacity, because it is complicated information and … [FAO provides] a lot of it"

(FAO 15). Often, the levels of technical detail reflect the personal interests of FAO staff and are unnecessary for providing advice in summaries and policy briefs (FAO 26). FAO staff need to carefully think about the objective of each publication and who the intended audience is (FAO 30). The objective should be to direct the audience to the detailed technical information by first attracting their attention with a concise, non-technical summary, and to refrain from providing unnecessary details – a common practice among FAO staff (FAO 26).

The levels of detail provided in FAO publications can influence whether the information is taken up in decision-making. Various types of information come from FAO, ranging from high level overviews, e.g., in *The State of World Fisheries and Aquaculture* (SOFIA), to the more detailed regional and national technical reports containing technical advice. SOFIA is communicated globally, and senior national fisheries managers and policy-makers are aware of the report (FAO Direct Observation 3). Information contained in SOFIA may raise awareness of issues but may not be sufficient to influence national policy-makers and managers. As one respondent stated, the highly summarised technical information provided in SOFIA is "at such a global level that I don't think anybody makes a decision at the national level based on what we say in SOFIA" (FAO 29). FAO member countries generally requested specific information on the status of fish stocks in SOFIA, e.g., the number of stocks above and below the limit of biomass at the maximum sustainable yield (B_{MSY}) (FAO, Direct Observation 3). Few linkages are made between SOFIA and other FAO information products containing more technical details, e.g., links in the online version of SOFIA and the *Review of the State of World Marine Fishery Resources* can be made. One respondent stressed:

> SOFIA shouldn't just become tables and figures of the state of different resources. The Fisheries Department should pay more attention to that report [*Review of the State of World Marine Fishery Resources*] because that is where all the details on the status of the stocks are … countries did not mention this document at COFI and were asking for a more detailed description on the status of stocks by species and regions … perhaps countries don't know of its existence. (FAO 33)

The closure of the departmental library and the relocation of the fisheries library staff to the main library is expected to negatively affect the extent and quality of services to the Fisheries and Aquaculture Department. This event is not unlike what has occurred in Canada (see Section 4.1.4). This act by management in reaction to austerity measures was perceived by the technical staff as an indication of the low value given to information. As one respondent stated:

> I believe that for an institution like FAO, the primary step is to really realize that we need information experts. We have suffered a major blow in the Fisheries Department in an irresponsible decision of de facto eliminating our library … the number of librarians in the main library has been cut in half. (FAO 24)

FAO's reduced spending for publications and for warehouse storage is also influencing how many printed copies of publications are produced. Printed copies are becoming less accessible as more digital versions are now available. Meeting and conference proceeding reports that were prepared in print are now being placed in digital format on the website and no print copies copy are made largely due to storage and printing costs (FAO 9). Concerns were voiced by the interviewees that awareness of these meeting reports will drop. Despite the drive to make digital versions available, developing countries still request printed publications and some people prefer print over digital versions. This preference is a further challenge for FAO as the format influences the communication language used, and contents prepared for one context cannot be easily moved to another, i.e., from print to digital, without adapting the contents to the new venue (FAO 30).

The FAO website is a major communication tool but the respondents noted that the website is not easy to navigate and external to FAO "people complain that they can't find anything. They usually have to go through Google … I don't think that people are using our website as a way to get something" (FAO 9). For instance, a Google search for deep sea fisheries should produce results for publications from NGOs that have lobbied on deep sea issues and not FAO's science and management advice on the topic (FAO 9). Furthermore, FAO does not formally collect statistics on web usage even though these are considered to be "more robust ways to assess how much and how often the information we produce is actually used" (FAO 21). In addition, it is not clear who are the audiences or users of the information products. Discussions are generally held on what is the target or who are the users for new websites or projects, "but besides the institutional users to which FAO is aimed, like the policy-makers and ministries…it was a vague kind of user" (FAO 30). Moreover, FAO has not assessed how effective the social media methods are in communicating its information products.

Producing information materials that can be useful to audiences with a range of science literacy can be a challenge. At the VME database development meeting, participants deliberated on a format that could reach a range of audiences without losing the technical soundness (FAO Direct Observation 1). An FAO participant at the workshop stated that "the database is not very technically detailed and it is challenging to reach managers, scientists, and the broad public with one level of detail" (FAO Direct Observation 1). Another FAO participant stated that "a one size fits all solution may not be possible" since the data contributors, e.g., the RFBs, may not agree with the new content of the database (FAO Direct Observation 1). FAO produces most of its information products in six officially recognised languages of its member countries. However, for some key databases with considerable technical content, for instance, the VME database, production in English only is preferred, thereby narrowing the user audience.

While the respondents noted that FAO produced large quantities of information as FAO technical reports, primarily intended for scientists, managers, and the fishing industry, they believe that academic publications "have a greater impact" since they are considered to be more credible in technical and academic communities (FAO 23, 29). As one respondent stated: "When you publish something as a FAO series, it does not have as much impact as if you published in a refereed journal. FAO series are not peer-reviewed and do not have the same impact" (FAO 23).

6.3.4.4 Politics

The role of politics in decision-making and information use was explicitly mentioned by 36% of respondents as a barrier to information use (36% - 12 out of 33). While FAO produces large quantities of information intended to increase knowledge about fisheries matters and to guide sustainable management of fisheries, decision-making is often much more political where science and other interests are considered (FAO 24). One respondent claimed that: "Science brings the deterrent, science brings reason, science brings clarity, and science brings the evidence. Sometimes the evidence base doesn't work because the politics overrides it" (FAO 22).

The role of scientific information changes at different levels in the decision-making processes up to the international level where policy on fisheries is either established at COFI meetings, which is the largest fisheries forum, or within the UN framework, i.e., in the UN General Assembly resolutions which often reflect what has been discussed in FAO and other fora around the world (FAO 7). FAO staff presented their insights into the role of politics in decision-making. After scientific information is produced by national scientists in the member countries and communicated to managers, less interest in the information can be found because:

> The higher level of decision-making like the Ministry or at the Minister level or the European Union or the Fisheries Commission wants to see the big picture...policy-making is driven by governments, it is political ... the technical information plays a role but maybe its role is minor, because so much political considerations come [in the process]. A lot of information comes to the table and this technical expertise plays a minor role; it is only utilised if it is useful for the political pedal. (FAO 15)

Even in FAO technical consultations, e.g., for the development of management guidelines on fisheries issues, member countries represented by senior decision-makers such as a Minister responsible for fisheries, can say "this is what the science says, but this is how we politicians are going to deal with it ... the scientist worked but we are going to go this way for this reason or that way for that reason" (FAO 4).

Events at the 2014 COFI meeting demonstrated how political influences can stymie discussions in an FAO technical forum (FAO Direct Observation 3). The FAO had collaborated extensively with governments, civil society organizations, and other stakeholders to develop the Voluntary Guidelines on Securing Sustainable Small-Scale Fisheries, the first international instrument dedicated to protecting and promoting small scale fisheries some of which operate in areas that are under territorial dispute (FAO, 2014w). The discussions subsequently went beyond the scope of the intention of the guidelines and the issue became the insistence of particular wording that could have prevented the adoption of the guidelines. A respondent confirmed that the issue “was one for an international political forum and not a technical committee like COFI” (FAO 11). Political influence is also evident in the historical context of the development of the small-scale fisheries guidelines which were initiated in response to the scientific evidence showing that inshore fisheries were in danger due to overexploitation. This situation was later framed with a human rights focus which gained considerable political attention (FAO 32). The final instrument was titled the “Voluntary Guidelines for Securing Sustainable Small-scale fisheries in the Context of Food Security and Poverty Alleviation” (FAO, 2014w). Political considerations are often based on information but how the information is framed is key to issues gaining attention (FAO 22).

Based on their interactions with national policy-makers, FAO staff members described their perspectives on the role of scientific information in national and regional decision-making. One respondent described how national decision-makers must consider a range of issues, including their political careers:

> In many cases they know there are too many boats, there’s overcapacity. Of course they will not act on reducing fishing capacity. There is a tremendous social cost because you are going to remove livelihoods from people. I don’t think it is lack of information or lack of willingness to act on it. There are a lot of considerations … they have to think about overall impacts – social impacts on livelihoods for example. Unless they have an alternative to offer, it will be difficult for them to act on that kind of information. Maybe, they just think that it is too difficult or it creates conflict. They would like to avoid conflict. (FAO 16)

Another staff member added:

> There isn’t necessarily an interest in the information, but they find information to support the decision that is being made. There are so many options and nothing is really black and white and there is no one right or wrong. Even if you had all the information, it may still not be clear what the decision should be. (FAO 22)

Risk assessments can determine whether information is used and decision-making may be innately political. Even though the science is clear, a decision must be made on the acceptable level of protection of a resource and “this is politics as somebody decides we will take that risk” (FAO 22). Both politics and science have roles to play in decision-making, although as a staff member pointed out

> Politics have overwritten science in many places – I don’t think we can stop that, that’s the way it is, its part and parcel of the whole system. That’s why we have politics, that’s why we need politics. Then, the science can just rule the world, it doesn’t happen that way. (FAO 22)

Recognising the challenges faced by member countries, FAO seeks to encourage the uptake of information in decision-making through the use of alternative methods to reach these decision-makers, such as, through partnerships with industry and NGOs (FAO 15). Priority setting for such work largely comes from the governing body, COFI, but it is also driven by donors providing extra-budgetary funding and this is a concern for some member countries as it appears that donors are driving FAO’s agenda (FAO 33). While public-private partnerships are being promoted, there is the danger of science being influenced by the agendas of the external groups that fund research coordinated by FAO. Similarly, NGOs are becoming more involved in disseminating FAO’s information and this communication focus could be driven by the NGO agenda (FAO 15).

6.3.4.5. Lack of Harmonization within the United Nations System

FAO, while being a specialised agency within the UN, operates on different timelines and its staff are driven by motivations based on the mandate of the organization that are unique within the UN system. Five of the respondents (15% - 5 out of 33) spoke about these factors. As one interviewee explained:

> The member countries give us the mandate to do something at the COFI meeting which is held every 2 years. However, at the UN headquarters in New York, they meet constantly. It is not really convenient if you can’t reach something [quickly because] you have to wait another two years. (FAO 10).

The asynchronous timing of decisions may not work well or it can be an advantage as FAO may have more time to prepare information. Whether one position or the other occurs is context-specific, however (FAO 10). Additionally, FAO staff are technical personnel mostly with science backgrounds complemented by others with policy backgrounds. In the other UN agencies, e.g., within the Oceans and Law of the Sea (UNDOALOS) in New York, the staff are mainly policy-makers or lawyers and because they deal with governance, they tend to be more informed on what the governments are doing (FAO 10). This difference in the staff profiles results in different information resources being produced and used by the different groups at FAO (agency) and the UN (main office). At the FAO, staff "rely on information by teams … written by different people" and information is used by technical staff, while at the UNGA information is used by "governance staff dealing with governance and political issues" (FAO10).

While overlapping membership was seen to be a driver promoting information flow (see Section 6.3.3.4), some aspects of membership can pose barriers to communication. For instance, participation of the RFBs at COFI meetings introduces redundancies as their role is not clear. There is confusion as to what the secretary of an RFB attending COFI can say when the members of the RFB are also members of COFI and can speak for themselves (FAO 6). The Regional Secretaries Network was also described earlier (see Section 6.3.3.4) as an essential mechanism to enhance collaboration and information exchange among the RFBs and FAO. The RSN meets in the days prior to the COFI meetings but the outcomes of the RSN meetings are not formally reported to COFI as the COFI agendas are often unrelated to the discussions in the RSN meetings (FAO 6). Closing this gap and encouraging networking within FAO will increase information flow. Different types of RFBs have been formed under and also outside the FAO Constitution. For example, NAFO is the most independent RFB and well established historically outside of FAO (FAO 6). The size of RFB reports is often a barrier to managers or the public seeking information. Some RFMOs, e.g., the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) "have huge working groups and their reports are often quite large and there are always confidentiality issues, so it can be challenging to obtain information" (FAO 9).

Table 15. Barriers in the information pathways – production, communication, and use – in the Food and Agriculture Organization of the United Nations (FAO).

CHALLENGE	CHARACTERISTICS OF THE CHALLENGES
1. ORGANIZATIONAL ASPECTS LIMITING COMMUNICATION AND USE OF INFORMATION	
Changing role of FAO	Need to redefine FAO's role – to determine the right audience, to maintain relevance of its information and communication tools
	The perception that the role of the organization is changing from a technical focus to advocacy
Disconnect between regular and extra-budgetary programs	Extra-budgetary projects are often autonomous; they can have their own project communications people and they stay very self-contained
	No accountability for resources dedicated to extra-budgetary projects and no sharing of results with the regular programs
	Regular program staff have limited time to be involved in extra-budgetary projects
Disconnect between management and technical experts	Loss of regard for the technical expertise of staff
	Reinventing mechanisms, e.g., technical networks to facilitate communication and work, when networks already exist among experts
Inadequate emphasis on communication	Communication and information are not explicitly considered in the new strategic objectives; Communication of information is undervalued and underappreciated
	No dedicated fisheries communications officer in the Fisheries and Aquaculture Department; No dedicated information specialists; Loss of the department's library and staff assigned to a range of activities
	The published reports are the end of the processes and there is generally no follow-through
	Work overload: limited time for internal communication; Communication is verbal; Limited time for social media
Staff capabilities	Uneven representation of nationalities: staff with local experience can distribute FAO's information more effectively to regional groups
2. COMMUNICATION GAPS BETWEEN FAO AND ITS MEMBERS	
Disconnect with national level policy-making and clients' needs	Awareness of FAO's work is still low globally despite its authority
	Development of FAO's databases and their credibility depend on cooperation and submission of data by member countries
	Different motivations of national scientists and managers related to information production, communication, and use
	FAO program activities are not often linked to national plans
	Personal interests of staff - research is not relevant to the industry needs;

CHALLENGE	CHARACTERISTICS OF THE CHALLENGES
	FAO should conduct collaborative and not original research
No measurement of information use	FAO "regurgitating" information and repeating the same communication mistakes
	Scientists may not follow up on advice produced in working groups; No follow up on field projects as in previous years
	Vague advice; too many technical details
3. FORMAT OF ADVICE AND ACCESS TO INFORMATION PRODUCED BY FAO	
Open access and confidentiality	Partnerships are now facing this issue related to trust and guaranteed confidentiality
Perceptions of grey literature and primary publications	Perception that academic publications have more impact than those in an FAO series; primary literature is more credible to the public
	Scientific journals are often too technical and not relevant to be used by staff working with non-technical audiences
Print versions are not as accessible digital versions	Developing countries request printed copies and some people prefer print versions; Few linkages between online information products; Closure of the departmental library
Too much detail in technical advice	Documents are too technical for senior decision-makers attending COFI meetings and for the average national decision-maker.
	Not clear as to the audience or user of the information product
	Personal interests related to assessments determine methods selected
	Too much reliance on technical models and science
The audience is often unknown	Information products are intended to reach multiple audiences with varying levels of understanding of science
Use of detailed and summary reports	Overviews like SOFIA with global information are widely referred to; Detailed technical reports are more visible on a regional level
Website	No internet tracking statistics; not mandatory for websites and project databases; Websites are difficult to navigate
	Print vs. website language – print versions have to be adapted to fit the new online system; Voluminous publications – cover too many topics and difficulty finding the relevant information contained in them
4. POLITICS	
Partnerships with the private sector	External stakeholders and donors drive agendas; Danger of science being influenced by the agendas of groups that fund FAO's work
Risk	Decision-makers have to decide on the acceptable level of protection of a resource; this type of decision involves politics
	Level of risk determines information use and decision-making

CHALLENGE	CHARACTERISTICS OF THE CHALLENGES
Role of politics	Limited access of scientists to policy-making communities; challenges to reach the political level directly
	Political considerations are based on various types of information relevant to maintaining the industry; Sometimes the evidence base is not used, because politics overrides the evidence
5. LACK OF HARMONIZATION WITHIN THE UNITED NATIONS SYSTEM	
Asynchronisity	COFI meets every two years; UN headquarters meet continuously
Communication gaps with RFBs	Communication gap between the RSN and COFI – RSN discussions are not reported to COFI; unclear role of RFBs at COFI
	Some RFBs network with FAO only when it is convenient to the RFB
Different groups and information sources at the FAO (agency level) and UN	FAO has mainly technical staff; UN staff are mainly policy-makers or lawyers who deal with governance and political issues
	FAO uses references to technical information; the UN uses governance sources with no cited background information to remove all prejudices
FAO not involved in drafting UNGA text	UNGA is the highest level for discussions in the UN system; it is unclear how FAO reports on COFI activities

6.4. Discussion and Conclusions

The results indicate that FAO plays the role of a boundary organization based on the characteristics outlined in Chapter 2 (e.g., Guston, 2001; Huitema & Turnhout, 2009; Petersen et al., 2005). The functions described herein describe the unique characteristics of FAO's role as a boundary organization. Scientific data and national fisheries management measures are not the focus of debates by FAO. Instead, FAO acts as a forum to discuss global fisheries issues, from which it provides recommendations for policy directions based on scientific advice. FAO is not responsible for national policy-making; instead, the organization provides technical information and international policies to guide national policy-making on fisheries in its member countries. The role of scientific information in FAO can be viewed from two perspectives: the use of FAO's information products for national policy-making in member countries and by other groups, e.g., NGOs and civil society; and the use of information in decision-making within FAO, e.g., by member countries in governing bodies such as the COFI. FAO staff spoke primarily about the use of the organization's products by the external users in relation to the FAO's mandate.

The study shows evidence of how information produced by FAO is being used globally in policy-contexts, the high regard and authority that FAO and its global fisheries information merits, how FAO uses its information to achieve its mandate with regard to technical backstopping and policy guidance, how scientific information is considered in international decision-making, and how the framing of advice influences the attention that it receives by stakeholders. The non-hierarchical structure of the organization facilitates the organization's boundary work. Being a global organization, FAO is well placed for facilitating collaborations or partnerships with other organizations. FAO is currently connected with the RFBs and NGOs, and it communicates directly with national fisheries agencies in a technical capacity and through its governing body, COFI. Increased connections with NGOs and industry were also observed. These collaborations facilitate information communication and use. Respondents highlighted overlapping institutional membership as a driver to production, communication, and use of information.

Primarily, FAO's role (see Figure 13, p. 187), is to compile and analyse information received from the member countries. FAO's information is considered to be "secondary," e.g., the statistical databases, as it is largely based on data provided by its member countries. This information becomes publications, i.e., FAO has the knowledge; the publications and databases receive the attention of policy-makers; the management issue or process is supported by these decision-makers; and relevant policies are made at upper levels, e.g., in COFI, at higher levels within the UN system, or in a national level in the member countries. Information flow from the international, to the regional, and then to the national level has been described as a linear process by FAO (FAO, 2009a). The case study results show that the flow of information is iterative at each level, i.e., there is bi-directional communication between FAO and regional bodies, between FAO and national policy- and decision-making bodies, and between FAO and other UN bodies. The wider UN system and UNGA resolutions are driving the policy advice process in FAO, i.e., the "Expert and Technical Consultations" process through which international guidelines and plans of action on critical fisheries management issues are developed. The UNGA resolutions can also be viewed as a culmination of the complex interplay of information at the international, regional, and national levels. Information production in FAO is not as well-defined with regard to the time scales as was seen in annual cycles of information production in DFO and NAFO. Nonetheless, each of FAO's multiple information products has a unique lifecycle.

The science-policy interface in FAO is described best by the participatory or collaborative interface model (see Chapter 2), where the premise is that there already exists enough knowledge to support wise decisions but that this knowledge is not aggregated, hence FAO's enormous efforts in integrating global datasets from a range of disciplines, e.g., biology, economics, and policy, into databases and reviews. The participatory or collaborative interface is also seen in the considerable initiatives towards partnerships in FAO's work programs.

FAO's mandate and its authority as a "knowledge organization" are significant drivers in the production and use of its information. The primary roles of the FAO Fisheries and Aquaculture Department related to information include: to serve as a repository of fisheries information and to transfer this knowledge to the FAO member countries; to be a policy-making and policy-developing forum for the international community using the information gathered from member countries; and to support the member countries to implement the policies that they have agreed to. FAO often facilitates the international fora in which member countries discuss policies, e.g., at COFI meetings, or in other international fora outside of FAO, e.g., the UNGA, where FAO assists member countries in their preparations. FAO coordinates projects to assist countries in developing their national data collection systems based on the countries' needs and in keeping with global standards developed by the organization.

A supply and demand of information was highlighted as a main driver to production, communication, and use of FAO's information, Technical information produced by FAO prompts the production of more technical information and policy advice. For example, based on observed trends in the statistical information, FAO proposes appropriate management approaches to be incorporated into policies developed to address the problems and aimed at national policy-makers. FAO also targets the "end-point" for fisheries management, i.e., the fishing industry, because ultimately national policy affects the industry which also drives a demand for information. Moreover, an informed industry can pressure governments to act. To facilitate this activity, FAO also produces many information materials for non-technical audiences. The study also showed that FAO is relying more on external stakeholders, such as NGOs, to communicate information at the national level and the level of the fishing communities.

This study strongly confirmed the high global regard for FAO related to its information products and its guiding role in national and regional policy development. However, while 94% of the respondents described the FAO as a "knowledge organization" where its mandate was a main driver to produce information and 94% described the credibility of FAO and its information as a main enabler to information flow, an average of 63% of the interviewees identified three main barriers to communication and use of information, i.e., organizational aspects of FAO, communication gaps between FAO and its members, and the format and access to the advice (Figure 15 and Table 15). Concern for the communication challenge faced by the organization was evident. As one respondent stated: "It is as much important as the analysis of data. You can have the best analysis of data and the best assessment in the world, but if you don't find the right way to deliver the information, it is totally un-useful" (FAO 27). The organizational structure was also geared towards information production and not information communication. Fundamental requirements such as dedicated communication staff in FAO are limited and the organization is not actively incorporating well-defined methods to communicate information. Barriers to communication negatively affect the member countries' ability to use FAO's advice in policy-contexts.

In spite of being a "knowledge organization," and playing a substantial role in the production of credible global information based on multiple data sources, FAO does not systematically follow through with communication of this information. The dichotomy in the roles of FAO can be explained though a main trade-off in the relevance of the information in the science-policy interface – a "production-communication" trade-off. The emphasis on information production and not on communication is a trade-off in the relevance of information at the science-policy interface where credibility is ensured because of the authority of the organization and legitimacy is central as the information is prepared through collaboration with a wide range of stakeholder groups. The "production-communication" trade-off was evident in the staff accounts of focusing on project output and not having time to communicate their work.

Actors, apart from science and policy experts, are becoming more involved in policy processes and the "production-communication" trade-off may facilitate the increasing involvement of NGOs and civil society in disseminating information produced by the FAO. The role(s) of knowledge networks and partnerships appear to be critical in current decision-making, given global austerity measures that limit resources available for research and for producing information. The important role of NGOs in communicating FAO's information and in lobbying for particular issues to be addressed and for policy guidelines to be developed was observed in the case study. FAO produces technical reports and a considerable number of information materials that are intended for less technical audiences. FAO staff also indicated that the organization may be adopting an advocacy role. For example, SOFIA provides an overview of the status of global fisheries and contemporary fisheries management issues and it is also viewed as an advocacy tool. Information contained in publications such as SOFIA may raise awareness of issues but may not be sufficient to influence national policy-makers and managers. The relationship with NGOs and academic institutions, e.g., in partnership projects, can facilitate the communication of firm messages to FAO member countries particularly with regard to aberrant behaviour related to fisheries management. FAO is not able to communicate with its member countries in this manner as the organization operates under the principle of political neutrality.

The absence of systematic monitoring or measuring the impact of projects by tracking the use of its publications is evident in FAO. Some attempts have been made to monitor information use in general, for example, previous studies used citation analyses to track information use (Avdic, 2013; Webster & Collins, 2005). More importantly, the organization has been successful in its attempts to measure use of its information with regard to the implementation of the *Code of Conduct for Responsible Fisheries*. The reasons for this may include the presence of dedicated staff; the global awareness building programs aimed at a range of stakeholders, including high-level decision-makers; and capacity building in member countries with regard to the implementation of the *Code of Conduct.* A questionnaire is designed to track implementation of the *Code of Conduct* by member countries and not the use of information per se, even though implementation of the *Code of Conduct* does involve uptake of information. Above all, the specific audience(s) for FAO's publications are often not known. It is, therefore, critical for FAO to determine who uses its information in the member countries and what information is most useful. The barriers to communication of the vast output of FAO's information are cause for concern and some respondents stressed the urgent need for FAO to rethink its role and then redesign its information and communication tools for reaching its goals, i.e., to achieve food security, to promote social stability, and to contribute to the growth of the global economy. To redefine itself and to be able to meet its clients' needs, FAO must first understand who the audiences of its information are.

Politics as a barrier was highlighted by 36% of respondents and may, in fact, be more influential than the number shows. However, it was not openly mentioned by many respondents, but appeared to be implicit in aspects of their responses, e.g., regarding donor funding and partnerships, and by direct observations made at COFI meetings. FAO staff referred to the evidence of political decision-making at the national level in their interactions with the member countries. An interviewee expressed the view that "scientists try to correct things with the information they have but it is not realistic, it is politically unrealistic because politicians will not make a decision that will stop activities ... politicians rely on information that tells them how to maintain the current activities of the industry" (FAO 15). As a boundary organization, FAO staff interacts with the science and policy-making communities in these countries and bridges the gap between the two communities.

COFI is a technical committee and a governing body of FAO, and at the international level, policy on fisheries is either established at COFI, the largest fisheries forum, or under the UN Framework, e.g., in the UN General Assembly resolutions. The UNGA resolutions often reflect what is being discussed in FAO and other related international fora at the time. This high level of policy-making is also driven by the governments of member countries and a few respondents described this as "naturally political." The role of technical information contained in FAO's publications at high-level fora such as COFI was evident, e.g., in the "endorsement" of SOFIA. At the COFI meeting, individual member country comments on SOFIA also indicated how FAO's members contribute to FAO's authority by "endorsing" its publications and other information products. However, global, regional, and national politics also played a noticeable role in decision-making in COFI, e.g., with regard to the adoption of the small scale fisheries guidelines, scientific information was not the only player at the table (FAO Direct Observations 3).

Aspects of the UN system acted as drivers, e.g., implementation of fisheries and non-fisheries instruments and projects arising from the Rio +20 conference, while others acted as barriers in the information pathways, e.g., asynchronous timing of events in FAO with other UN agencies. These less frequently mentioned drivers and barriers are important to note as they refer to mechanisms and actors outside of the framework of FAO. Barriers, such as the lack of harmonization with the overall UN system, may be outside of the scope of FAO to address.

The main conclusions of the FAO study are:

1. FAO is playing the role of a boundary organization by bridging decision-making at different geographic levels and bridging science and decision-making communities in member countries. The non-hierarchical structure of the organization facilitates the organization's boundary work. FAO staff are experts in the science and policy realms and interact with the range of actors involved in decision-making. Increased networking with the fishing industry and civil society facilitate information communication and use. FAO communicates directly with national fisheries agencies in a technical capacity and through its governing body, COFI. Being a global organization, FAO is well placed for facilitating collaborations or partnerships with other organizations such as RFBs and NGOs. Overlapping institutional memberships drives the production, communication, and use of information at different levels of decision-making, i.e., national, regional, and international.

2. A participatory or collaborative science-policy interface is evident in FAO. Information use is primarily indirect or conceptual where FAO's information increases awareness of issues and permeates over time into national policy-making in the member countries.

Information produced by FAO is credible and legitimate. FAO's information is considered as credible as it is regarded as the global authority. FAO operates on the principle of political neutrality, it is staffed by experts, and the organization sets global standards and guidelines. The credibility of the organization and its information is a major factor in the influence of FAO in national decision-making. FAO's information is legitimate as it is generally produced through collaboration with a wide range of stakeholder groups and information sources, e.g., fisheries science, economic, and social data.

3. A "production-communication" trade-off regarding the relevance of information in the science-policy interface allows the organization to keep abreast with the supply and demand for information but it falls short on broad communication of its products. FAO staff are driven to produce information to satisfy the demand for information but the workload of the staff provides limited time for communicating the information products. The organizational structure of FAO reflects an emphasis on production of information and an inadequate focus on communication.

4. Framing of advice can enhance the relevance of information. For instance, fisheries issues that are framed as human rights issues, e.g., the small-scale fisheries guidelines, or in an economical context, e.g., the Blue Growth Initiative, gain greater attention from diverse audiences. Reframing fisheries issues can also attract support from multiple donors.

5. FAO may be moving towards an advocacy role since the organization dedicates considerable resources to produce publications that contain simple messages aimed at different audiences, from fishing communities to policy-makers. FAO produces less technical versions of publications to assist the member countries in information use in national policy-making. FAO's efforts to communicate simplified messages are primarily directed to general audiences (non-specialists) and for use in developing countries. The considerable production of such material and the low emphasis on communication, as evident in the "production-communication" trade-off facilitate the increased involvement of NGOs and civil society in communicating information produced by FAO. The trade-

off also facilitates FAO's work as a boundary organization as less technical information is a means of communicating scientific information to policy-makers.

6. Grey literature is a source of credible background information in governance settings. Grey literature produced by governmental organizations is the preferred type of information used in the UN system as it is considered to be less biased compared with the primary literature or literature associated with individual authors.

7. FAO is increasingly relying on digital means of communication. The benefits of dedicated websites or web pages, e.g., *Globefish*, are evident with regard to awareness building and facilitating use of information. Unlike DFO and NAFO, FAO uses social media. Social media as communication tools were implemented at FAO in the last five years but their effectiveness at enhancing information use is not known. However, they allow FAO to be part of the international discourse and to join audiences that it normally would not engage with, e.g., advocacy groups in FAO member countries.

8. The definition or interpretation of "information" and "science" differ between FAO and the other case study organizations (DFO and NAFO). Within FAO, information is interpreted as data and science is interpreted as all of FAO's information products. The organization uses the word "knowledge" to describe the advice contained in the information products.

9. In spite of being an authority on global fisheries information, FAO staff perceived that publishing in the primary literature provided more credibility to their work than solely publishing in FAO technical report series, i.e., grey literature.

10. There is a need for dedicated fisheries communications staff in the Fisheries and Aquaculture Department. FAO also needs a defined plan for communication of information to member countries and a program to monitor or measure the impacts of its information on national, regional, and international policy-making.

CHAPTER 7. THE ROLE OF SCIENTIFIC INFORMATION IN DECISION-MAKING FOR FISHERIES MANAGEMENT

7.1. Introduction

This chapter integrates the key results of the case studies of the Canada Department of Fisheries and Oceans (DFO), the Northwest Atlantic Fisheries Organization (NAFO), and the Food and Agriculture Organization of the United Nations (FAO) in the context of the questions that were core to the research (see Section 3.1). The principal research question asked: **What role(s) does scientific information fulfill in policy- and decision-making for fisheries management?** Section 7.2 summaries the results of the studies while Sections 7.3 to 7.5 address the four specific research questions in detail: (1) What are the drivers in producing, communicating, and using marine fisheries information by the organizations; (2) What are the information management strategies of the organizations, particularly with regard to communication; (3) What are the institutional and social enablers and barriers in the organizations to scientific information use at the science-policy interface; (4) Who are the actors in the information pathways and what are the information behaviours (e.g., information seeking and sharing) of the various actors in each organization. Appendix 6 contains a summary of the comparison of the three organizations (see p. 338).

Section 7.6 integrates the results of the case studies in the context of the general models of decision-making and information use at the science-policy interface that were described in Chapter 2. Section 7.7 presents the key characteristics of information use at the interface that can lead to the creation of credible, relevant, and legitimate scientific information. The characteristics are presented as a typology of information use that can guide future studies on analysing information pathways in organizations producing marine fisheries information and for measuring information use in decision-making.

7.2. The Key Results of the Case Studies

Table 16 summarises the key results of the research and indicates the drivers, enablers, and barriers in the information pathways – production, communication, and use – that were identified and ranked in DFO, NAFO, and FAO (see Chapters 4 to 6).

Table 16. The key results of the case studies relating to the specific research questions.

RESEARCH QUESTION	KEY FINDINGS ACROSS THE FISHERIES ORGANIZATIONS
1. What are the drivers in producing, communicating, and using marine fisheries information?	The demand for scientific advice for operational fisheries management in DFO and NAFO
	National, regional and international policy development – national and regional mandates, UN system
	Trade – supply and demand of fish; maintaining markets; eco-labelling
2. What are the information management strategies particularly with regard to communication?	Separation of science and management: Iterative communication – regular dialogue between actors (scientists and managers); Increased understanding of science and management needs;
	Addressing uncertainty in fisheries and ecosystem scientific advice; Trust relationships between actors
	Reliance on information produced as internal grey literature; Internal peer review of advice produced by governmental bodies
	Dissemination of information: websites as a main communication tool; Limited use of social media
3a. What are the institutional and social ***enablers*** to information use at the science-policy interface?	Attributes of scientific information – credibility, relevance, and legitimacy; Production of advice for decision-making is embedded in the organization; The organization is regarded as an authority
	Donor funding; Partnerships with other organizations
	Framing fisheries and ecosystem issues, e.g., as conservation priorities, human rights, sustainable economies
	Organizational restructuring to enable integration of programs and to address the increasing complexity of fisheries management issues
	Overlapping memberships within and among the organizations that create multiple science-policy interfaces.
3b. What are the institutional and social ***barriers*** to information use at the interface?	Asynchronous national policy and science, i.e., policy ahead of science in implementing EAF
	Austerity measures, e.g., limiting networking and collaboration
	Challenge of communicating ecosystem advice to fisheries scientists and managers
	Decision-makers are not pressured by managers to address complex issues – governments are often not aware of the extent of problems
	Dispersed organizational structures – disconnect between policy-making and science
	Political influences in decision-making
4. Who are the actors in the information pathways	Government scientists and decision-makers (policy-makers, managers); Wide stakeholder involvement – fishing industry, NGOs, civil society

The leading drivers of information production, communication, and use that were identified in the organizations include: the demand for scientific advice; national, regional, and international policy development; and trade in fish and fish products. The most important information strategies include well-defined processes in the information pathways that are based on iterative communication between actors from the science and decision-making realms, and a reliance on grey literature produced by the organizations. The common enablers to information flow in the three organizations include: the attributes of the scientific information; organizational structures that facilitate communication among the managers and scientists, and with other stakeholders such as the fishing industry; and overlapping memberships of the organizations. The principal barriers in the information pathways include asynchronous policy and science related to the ecosystem approach to fisheries management (EAF), the dispersed organizational structures, austerity measures, inadequate communication tools, and political influences. Apart from government scientists and decision-makers, a wide range of actors are involved in the information pathways. The main results are discussed in Sections 7.3 through 7.5.

7.3. Drivers in the Production, Communication, and Use of Fisheries Information

This section addresses the specific research question 1 – what are the drivers in producing, communicating, and using marine fisheries information in the organizations (as presented in Table 16, p. 240).

7.3.1. The Demand for Scientific Advice for Fisheries Management

The demand for scientific information for decision-making was ranked as a major driver for information production in the three organizations. The DFO Canadian Scientific Advisory Secretariat (CSAS) process and the NAFO Fisheries Commission (FC) annual request for advice are well-defined protocols for the production, communication, and use of scientific information (see Sections 4.3.1 and 5.3.1 respectively). Production of scientific advice in DFO and NAFO is driven by an annual requirement for the information to be used in the operational management of fisheries.

The drivers in the production, communication, and use of scientific information and advice in DFO and NAFO are comparable, given the similar mandates for fisheries management and the geographic area of operation. Scientists and managers in DFO and NAFO policy-makers rely primarily on the information produced within their respective organizations for use in their activities. The authority of the producing organization is the primary standard or filter used by these actors to determine “useable” information. In DFO, NAFO, and FAO, the information produced by each organization is regarded as credible since the organizations are the recognised authority because of their mandates and their internal experts. Credibility of information in these organizations means that the information is valid, trustworthy, and dependable. Information produced in DFO and NAFO is relevant because of its geographic applicability to the management of fish stocks and ecosystems in the Northwest Atlantic. The production of scientific advice for decision-making is embedded in DFO and NAFO and this also contributes to the credibility and relevance of the information. Legitimacy of the information is gained through the involvement of stakeholder groups in aspects of the production of scientific advice, e.g., in the peer review component of the DFO CSAS process (see Section 4.3.1.2).

The legitimacy of information is also associated with transparency in the decision-making process, as highlighted in DFO and NAFO. Transparency was specifically mentioned by some respondents with regard to the availability of the scientific advice to the public. For instance, NAFO sees the online availability of all adopted papers and reports as a demonstration of its transparency with regard to fishing operations (see Section 5.3.1.4). The DFO CSAS process is transparent as the CSAS publications are a record of how decisions were made. DFO staff described the levels of precaution now operating within the department that are driving the current CSAS process to pay closer attention to transparency in decision-making by recording the requests for advice by management and the subsequent production of the scientific advice (see Section 4.3.3.1). As one DFO manager stated: “you need to have this [record of advice] to back you up, as the things that you considered beforehand” (DFO 16).

Embedding the science advisory process in the management authority ensures the credibility, relevance, and legitimacy of advice produced in DFO and NAFO. However, this finding contrasts with a previous study which ascribes moderate levels of embeddedness as more effective in policy-making (Alcock, 2004). That study found that scientific advice produced through a partnership between federal scientists, academic experts, and a broad range of industry interests in Australia was regarded as more transparent or legitimate than advice produced within a governmental organization (see Section 2.6.4).

Alcock (2004) also examined the institutional arrangements in the management of the Atlantic cod fishery where fisheries stock assessments were produced by the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) (a precursor of the current CSAS process) embedded within DFO. Decision-makers did not question the salience (relevance) or credibility of the advice coming from assessments as the advice was tailored to inform their specific policy objectives. However, the fishing industry was the main critic of the DFO science, stating that the stock was declining; the industry was proven correct when the cod fishery collapsed (Alcock, 2004). This historical account provides some context for the current participation of the fishing industry and other stakeholders, in addition to government scientists and managers, in the CSAS process (see Section 4.3.3.4). After the collapse of the cod fishery, ongoing fisheries monitoring programs received greater attention from decision-makers and adapting the assessment methodologies was facilitated by new scientists in DFO who offer new ideas on ecosystem assessments.

Information production in FAO generally occurs on an ad hoc and project-driven basis. Information production often occurs in response to the needs identified by member countries, e.g., within the Committee on Fisheries that meets biennially or to requests from within the UN system, as from the UNGA, that are motivated by the international awareness and concern for an issue. The production of information also depends on the availability of funds from FAO’s regular program or extra-budgetary programs that receive donor funding. FAO headquarters has a well-defined protocol for the production of international technical guidelines and the FAO technical report series through the expert and technical consultations (see Section 6.3.1.2). This consultation process can unfold over a period of years since it is contingent on the level of global awareness, concern, and action to resolve on an issue, including the availability of funds for FAO to coordinate the process. Production of some FAO information products is ongoing, e.g., statistical and trade databases. Structured processes for providing scientific advice are characteristic of working groups in the regional fisheries commissions managed by FAO. However, the production of scientific advice by national scientists within commissions, such as the Western Central Atlantic Fisheries Commission, is dependent on funding and occurs on an ad hoc basis (see Section 6.1.2).

External use of information produced by the three organizations is driven largely by the high public regard for the organizations. This was evident for the FAO where representatives of each member country attending the FAO Committee of Fisheries meeting referred to the organization's statistics as the "global authority" (FAO Direct Observation 3). FAO is recognized as the global authority on fisheries statistics, technical advice for policy development, and international standards, e.g., for trade related criteria including the quality of fish products and eco-labelling. The input into FAO publications comes primarily from national data sources from member countries. The countries then use the FAO information products to guide national fisheries management.

7.3.2. National, Regional and International Policy Development

FAO plays a critically important role in setting agendas at the international level related to the implementation of the EAF. For instance, the FAO *Code of Conduct for Responsible Fisheries* has been endorsed by all FAO members; it is widely recognised as the global standard for fisheries management and as a basis for reviewing and adopting national fisheries legislation that promotes ecosystem approaches (see Sections 6.1.2 and 6.3.2.1). FAO's policy guidelines have directly or indirectly led to national policy-making and production of information, e.g., DFO's bycatch policy, and activities related to the identification of ecologically and biologically sensitive areas (see Section 4.3.2.2).

Fisheries management continues to become more complex and NAFO, like other intergovernmental organizations, is striving to stay abreast of contemporary issues and global policy developed within FAO and the higher UN system (see Section 5.3.2.3). For instance, NAFO's work on VMEs is strongly driven by the UNGA Resolution 61/105 that initiated a chain of activities addressing impacts on ocean bottom habitats (FAO, 2009). Such UN General Assembly resolutions can also be viewed as a culmination of the complex interplay of information produced at the international (e.g., FAO), regional (e.g., NAFO), and national (e.g., DFO) levels.

Intergovernmental organizations, such as FAO and regional fisheries management organizations such as NAFO, can help resolve global fisheries management issues by setting the agenda of the international community, convening related meetings and negotiations, developing normative codes of conduct or soft law, and influencing state politics on issues. The FAO and other UN agencies provide a global framework for integrating advice to inform biological, ecological, economic, and social aspects of policy decisions. DFO National Capital Region (DFO-NCR) staff also referred to international policies and guidelines, particularly those by the FAO, e.g., the FAO *Code of Conduct for Responsible Fisheries* and the FAO's deep sea fishery guidelines. FAO is playing the role of a boundary organization by bridging decision-making at different geographic levels and bridging the science and decision-making communities (see Section 7.5.2 for details).

7.3.3. Trade

Trade in fish and fish products is another major driver in the production, communication, and use of marine fisheries information. Regulation of international trade in fish and fish products necessitates the production of market data and trade standards, e.g., the statistics compiled under the FAO Globefish project, and international environmental certification standards related to the traceability of fish and fish products, i.e., ecolabelling (see Section 6.3.2.3). Environmental certification, applied to products approved under specific standards, now requires the fishing industry to show that fishing practices are conducted sustainably. In a national context, the fishing industry is increasingly involved with DFO in the co-production of fisheries scientific information, thereby facilitating the industry to meet the requirements of the Marine Stewardship Council (MSC) (see Section 4.3.2.3). From an economic perspective, the fishing industry demands information on species sustainability, such as stock status and global capture fisheries production statistics, in its need to maintain markets.

7.4. Information Management Strategies of the Organizations

This section addresses the specific research question 2 – What are the information management strategies of the organizations, particularly with regard to communication; and question 3b – What are the institutional/social ***barriers*** to information use at the interface? (as presented in Table 16, p. 240).

7.4.1. The Separation of Science and Management

The separation of science and management was emphasized in DFO and NAFO where scientists stated unequivocally—and quite vehemently—that they were not allowed to present management recommendations to the managers, only scientific information and advice. In DFO and NAFO there are formal directives for scientists to provide scientific advice only and not recommendations; developing the latter is the role of the manager. The chair of the DFO CSAS meetings emphasized this position at the opening of each session (see Section 4.3.1.2). The separation of science and management appears to allow fewer opportunities for scientists to engage in advocacy to influence decision-making. The presentation of the scientific advice for fish stocks or for activities related to vulnerable marine ecosystems or ecologically and biologically significant areas has to be value neutral; all DFO and NAFO scientists and managers spoke about this neutrality (see, e.g., Section 4.3.1.3).

However, through direct observations at CSAS and NAFO scientific meetings, it was evident that scientists could still influence the management recommendations, whether intentionally or not, by their careful drafting of the scientific advice. The words are deliberately chosen and definitions of terms are debated extensively to elicit a certain response from managers. The advice is written in the plenary sessions with all scientists participating to ensure that there are no ambiguities in the text and to prevent different interpretations by managers (see Sections 4.3.1.2 and 5.3.1.3). In DFO, the advice is also discussed with the fishing industry in the CSAS meetings. The managers will then present the management advice to the decision-makers with details on the trade-offs that can be made socially, economically, and ecologically if the “optimal” decision is taken relating to a fishery, or what costs will be paid to maintain the status quo or increase the benefits in any of these sectors.

DFO managers stated that the information provided to the decision-makers leaves little room for questions or doubt with regard to the selection from the options provided. Scientists and managers agreed that the organizational processes may be in place to ensure that scientists produce value-neutral advice but the policy-makers can still make a politically motivated decision not based on the scientific evidence. Furthermore, the policy-makers are not expected to give an explanation as to why the scientific advice was not used. Political influences related to the fishing industry are a main barrier in the information pathways described for DFO. For instance, a DFO manager described an example of an incident in the aftermath of the collapse of the cod fishery where the Minister, responding to industry pressure, had to be convinced by the managers to act in favour of the scientific advice (Section 4.3.4.2).

DFO and NAFO staff described how scientists were still able to influence what research was completed. For instance, the NAFO Fisheries Commission “cannot ask outrageous questions and deliver it to the scientists” and the Commission’s annual request for advice is really finalized by the scientists based on the work that can be completed (NAFO 17). Scientists engage in a wide range of activities to influence decision-making without using advocacy. Managers and scientists in DFO and NAFO spoke of their ongoing formal and informal communication as a means of producing information that maintains scientific integrity and is useful for policy-making. Scientists maximize the iterative process to communicate the scientific advice to managers, but in so doing they can engage in advocacy. Framing research questions on issues can be deemed as advocacy.

The separation of science and management observed in DFO and NAFO differs from what previous studies prescribe – where making scientific advice more inclusive of the range of policy considerations can increase the impact of the advice on decision-making (Holmes and Lock, 2010; McNie, 2007). The expert group on the science-policy interface within the UN High-Level Political Forum on Sustainable Development (HLPF) that was established after the Rio +20 conference also advocates that the “scientific community still needs to take bolder steps to more effectively engage with policy-makers in order to apply science and shape up policies" (UN Department of Economic and Social Affairs, 2013a). The literature promotes a role of scientists in evaluating the full range of policy options in light of scientific information and scientific uncertainty, but this is not the practice in DFO and NAFO – scientists are expected to provide the facts only while managers may explore a wider range of policy alternatives in developing the management advice. Based on observations in DFO and NAFO, it is likely that the managers are now playing the roles that the literature prescribes as the roles of scientists. For instance, managers—not scientists— integrate ecological, economic, and social information and outcomes when advising decision-makers on risks, costs, and trade-offs of different management options. As a DFO-MR manager stated: "Because of this risk aversion, much more of the decision-making has now been bumped up to higher levels. So I like to facetiously state that I am no longer a manager, I am a recommender" (DFO 10).

The paradox of science and politics evident in the "scientification" of politics and the "politicisation" of science may be unavoidable. Political influences within NAFO and FAO are anticipated in relation to the source of donor funds for global projects coordinated by the FAO, for instance, the FAO-GEF Global Programme on Sustainable Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction (ABNJ) (FAO, 2014s). However, information production by authoritative bodies can guard against such politicization of science (Pielke, 2007). DFO, NAFO, and FAO are perceived as authoritative bodies; however, individuals in DFO and NAFO described the transparency of the decision-making process as an important characteristic separate from the authority of the organization (as seen in Section 7.3.1). "Scientification" of politics is evident in NAFO since the Contracting Parties negotiate and reach consensus on management decisions that are based on the science advice on fishery resources and marine ecosystems (see Section 5.3.3.3). Nevertheless, the paradox of science and politics can be resolved if the relationship between science and policy-making is considered to be reciprocal instead of linear (Weingart, 1999). This view suggests an approach similar to adaptive management where science communication to policy-makers and feedback becomes an iterative process. This adaptive role of science and politics was observed in FAO and NAFO (see e.g., Section 6.3.4.4). As an FAO staff member stated:

> I'm not saying that politics overrides scientific decisions but we have seen it in the world … the politics have overwritten science in many places. I don't think we can stop that – that's the way it is, its part and parcel of the whole system. That's why we have politics, that's why we need politics. That the science can just rule the world, it doesn't happen that way (FAO 22).

7.4.2. Addressing Scientific Uncertainty

The literature suggests that government scientists commonly provide the best scientific information and advice, i.e., credible, relevant, and legitimate. Such advice often involves high levels of technical details, in the form of complex statistics, due to the inherent uncertainties associated with the natural ecosystems and the data on a particular fishery (see Chapter 2). While the literature described scientific uncertainty as a major challenge in information use, this was not an obvious concern in the case study organizations particularly with regard to the fisheries scientific advice. Uncertainty related to fisheries scientific information, e.g., in stock assessments, was not regarded as a major challenge in DFO and NAFO. This represents a substantial shift in thinking in management and policy-making communities of the Contracting Parties participating in NAFO compared with events in NAFO and DFO in the 1980s and 1990s that reflect the contrary (Barry, Applebaum, & Wiseman, 2014; NAFO staff, personal communication, October 2013).

Uncertainty in the fisheries advice is now accepted by managers as part of the evidence (see Section 4.3.3.1). With regard to Canada as a Contracting Party, DFO scientists and managers participating in NAFO commented on the low profile of scientific uncertainty in discussions of the scientific advice during the briefing of delegations, for instance. As one manager stated: "The Fisheries Commission does not question the veracity or credibility of the scientific information, they just want further clarification … if I am fishing over there which is worth millions and jobs, I just have to look at the scientific advice more closely" (NAFO 17). The communication between scientists and managers has increased and it was seen that managers often come from science backgrounds, e.g., in DFO, and have a better understanding of technical concepts in fisheries management. Similarly, many long relationships between scientists and managers have engendered a level of trust that facilitates dialogue and scientists are more accepting of the management needs (e.g., DFO Direct Observations 6 through 8; NAFO Direct Observations 1 and 3). The level of uncertainty of fisheries advice at the science-policy interface is, therefore, not considered to be a critical barrier to fisheries decision-making in DFO and NAFO.

Conversely, communicating risk and uncertainty was a greater concern for ecosystem advice. The uncertainty in scientific advice for EAF was a major barrier to communication between fisheries scientists and decision-makers in DFO and NAFO. Observations at both fisheries and ecosystem assessment meetings in DFO and NAFO highlighted the differences in the interpretation of uncertainty by the groups, e.g., the fisheries scientists in DFO and NAFO and the ecosystem scientists in the Scientific Council and ecosystem working groups in NAFO (see Section 5.3.3.3). The EAF is a sector-crossing management concept that embraces the objectives of sustainable use, the precautionary approach, and the involvement of diverse stakeholders, and it has considerable potential to achieve change at the science-policy interface (Garcia et al., 2003). However, the ecosystem approach complicates rather than facilitates communication at the interface largely due to the inherent scientific uncertainty associated with ecosystem advice which is believed to surpass the uncertainty linked to fisheries scientific advice.

Ecosystem scientists have difficulty communicating with fisheries scientists on the benefits of incorporating ecosystem considerations in fish stock assessments. Provision of advice in DFO and NAFO is still focussed on basic fisheries management and the perception persists that ecosystem science is “not valid compared with stock assessment science” (NAFO 2). International policy developed by FAO, agreements made within NAFO, as well as national efforts to implement the ecosystem approach to fisheries management, have driven national policy-making in DFO, e.g., legislation and initiatives such as the Sustainable Fisheries Framework to implement EAF. However, the scientific information and advice needed to implement EAF is still lacking and perhaps impossible to obtain – a case of the policy preceding the science (e.g., Rice, 2005). Nevertheless, this provision of interdisciplinary information and the formation of wide peer review communities adhere to the principles of EAF.

7.4.3. Use of Grey Literature and Primary Literature

Scientific information produced by scientists in the DFO CSAS process and the NAFO FC annual request are the primary sources of advice. The information production, communication, and use of internal publications (grey literature) are guided by the formal protocols for these processes (see Sections 4.3.1 and 5.3.1). Within these processes, the scientific advice also undergoes a rigorous internal peer review by mostly the respective organization's scientists and, notably in DFO, the CSAS science reports are also referred to as "peer reviewed information." The advice used for decision-making is based on the responses to specific questions asked by managers within these formal processes. Peer review of FAO's grey literature by invited experts is a rigorous process carried out, for instance, in working groups coordinated by the organization.

Peer review of information and advice produced by the organizations differs from the conventional peer review process used by academic journals. For instance, academic journals utilize a single blind process where the reviewers are anonymous or a double blind process where the author and the reviewers are anonymous. Such processes are commonly used in scholarly publishing to authenticate the new work and to mitigate potential biases. In contrast, an open peer review process was evident in DFO and NAFO where the scientific information and advice was critiqued in scientific meetings. Multiple stakeholders attend the peer review meetings in the DFO CSAS process, including DFO scientists, managers, the fishing industry, NGOs, and academic researchers. Given the composition of the DFO meetings, the scientific rigour of the peer review process may not be at the level expected if the review was conducted by fisheries or ecosystem scientists only. The peer review process in DFO involves a trade-off in the attributes of information and is described further in Section 7.6.1.1 (see also Section 4.4).

The fisheries scientific publications (grey literature) produced by governmental organizations like NAFO and DFO are preferred in policy-making compared with the information in peer-reviewed scholarly journals, as the information presented in the grey publications is timely, i.e., the publications are produced in an annual cycle, and they are relevant because the information contained in the publications is in direct response to the fisheries management questions. Additionally, FAO staff stressed the preference for grey literature produced by governments – over individually authored publications – as background information sources for negotiations and at high policy-making fora in the UN system, e.g., the General Assembly and the UN New York office. Such publications are considered to be unbiased as they are not associated with an individual. Furthermore, summaries produced by UN agencies, such as FAO, are used since they are not linked to an individual member country or other organizational affiliations (see Section 6.3.1.4). FAO staff described this as a unique characteristic of grey literature produced by governmental organization. Within the UN system, such publications are considered to be the most credible source of information for use in international governance settings.

The preference for grey literature was also reported in previous studies which indicated that the less technical language and the timeliness of such publications can facilitate knowledge diffusion in policy settings (Holmes & Lock, 2010; Holmes & Clark, 2008). Scientists within the organizations also can publish their research in commercial, peer-reviewed journals but they rarely do so, given time constraints and the lack of direct benefits to their departmental work. The exception is the senior research scientists in DFO who are more inclined to publish in the primary literature as this is a performance indicator in their job descriptions, as well as being the ultimate forum to show their results.

In spite of being an authority on global fisheries information, FAO staff believed that publishing in the primary literature provided more credibility to their work than publishing in FAO technical series, i.e., grey literature. Issues related to open access and confidentiality were not highlighted as concerns, given the increasing volume of proprietary databases and information being used in partnership projects, e.g., in the iMarine project that supports EAF through development of a sustainability-driven data infrastructure governance model (FAO, 2014n) (see Section 6.3.2.1).

7.4.4. Dissemination of Information

The case study organizations used their websites as their main communication tool. Direct effort to communicate scientific advice outside of the DFO CSAS and NAFO processes was not considered necessary by either organization since the advice was being produced by scientists for managers for immediate fisheries decision-making. The role of the media, social networks, and other web-based information dissemination pathways in the marine environmental policy-making was discussed by few participants. Advances in information communication technology, such as social media, are increasing the extent and nature of national and international policy networks. However, national governments still experience challenges in overcoming the "digital divide" and in supporting wide policy networks and communities given time, money, and staff constraints. While DFO and NAFO had no formal use of social media, FAO was increasingly utilizing social media tools, such as Twitter, to communicate its mandate and engage discussions with like-minded organizations and the public, e.g., during international meetings such as the 2014 US State Department Our Ocean Conference (see Section 6.3.1.4). DFO staff members were generally constrained in their communication with the public and all external communication has to be vetted by the Communications Branch to meet current communication protocols (circa June 2014).

In spite of being described as a "knowledge organization," external communication of FAO technical project information is still pursued on an ad hoc basis, driven by the project leaders, and dependent on whether the dissemination of information to external audiences was a well-defined component of a project cycle (see Section 6.3.4.1). The barriers to communication of information within FAO were mainly due to the lack of dedicated staff to communicate information to member country focal points and other stakeholders. The critical role of personalities was highlighted, where information was communicated within the Fisheries and Aquaculture Department and to member countries based on the motivation of the individual.

Despite producing vast quantities of information for multiple audiences, FAO generally lacks the capacity to conduct systematic evaluations of its performance in facilitating national policy-making. For instance, one participant stated: "Dissemination is important but to really do the follow up and to really see that these techniques, these messages, this information, are systematically introduced at the various levels in the countries, there is still a long way to go" (FAO 2).

7.5. Enablers and Barriers to Information Use at the Science-Policy Interface

This section addresses the specific research question 3 – What are the institutional and social enablers and barriers in the organizations to scientific information use at the science-policy interface; and question 4 – Who are the actors involved in decision-making and what are their information behaviours? (as presented in Table 16, p. 240).

7.5.1. Overlapping Memberships Within and Among DFO, NAFO, and FAO

The input for the information produced by intergovernmental organizations like NAFO and FAO is primarily dependent on the participation of national experts, for instance, scientists, managers, and policy-makers from DFO. With regard to Canada as a Contracting Party to NAFO, the interface between the national organization (DFO) and NAFO is particularly important as most managers and national scientists described their work in NAFO as an extension of their national duties (see Section 5.3.3.3). Consequently, the success of NAFO as an RFMO in the Northwest Atlantic is largely influenced by its Contracting Parties. Similarly, FAO as an authority on fisheries statistics is dependent as well on the contribution of data by its member countries. Scientists who are specialists or experts in their respective areas are invited to participate in FAO's expert consultations (see Section 6.3.1.2). Such experts can be science advisors from the DFO-NCR.

The overlapping membership of DFO, NAFO, and FAO illustrates the multiple science-policy interfaces between the organizations as they interact with each other. The presence of multiple interfaces is also evident from the interactions among the different sectors and different levels of decision-making within each organization. Figure 16 shows the general interplay among the three case study organizations with regard to information production and the actors involved.

As illustrated in Figure 16, national organizations, such as DFO with scientists and managers participating in NAFO and FAO, act as both the drivers to work completed by these groups as well as the implementers of the work in the national context. FAO provides technical information and international policies to guide national policy-making in its member countries. The influence of FAO's information is applied at the regional level, i.e., through NAFO, and at the national level, in the member countries, for instance, in Canada's DFO. FAO's data and information, e.g., fisheries statistics, international guidelines, and voluntary instruments, are central to policy- and decision-making at the national and regional jurisdictional levels.

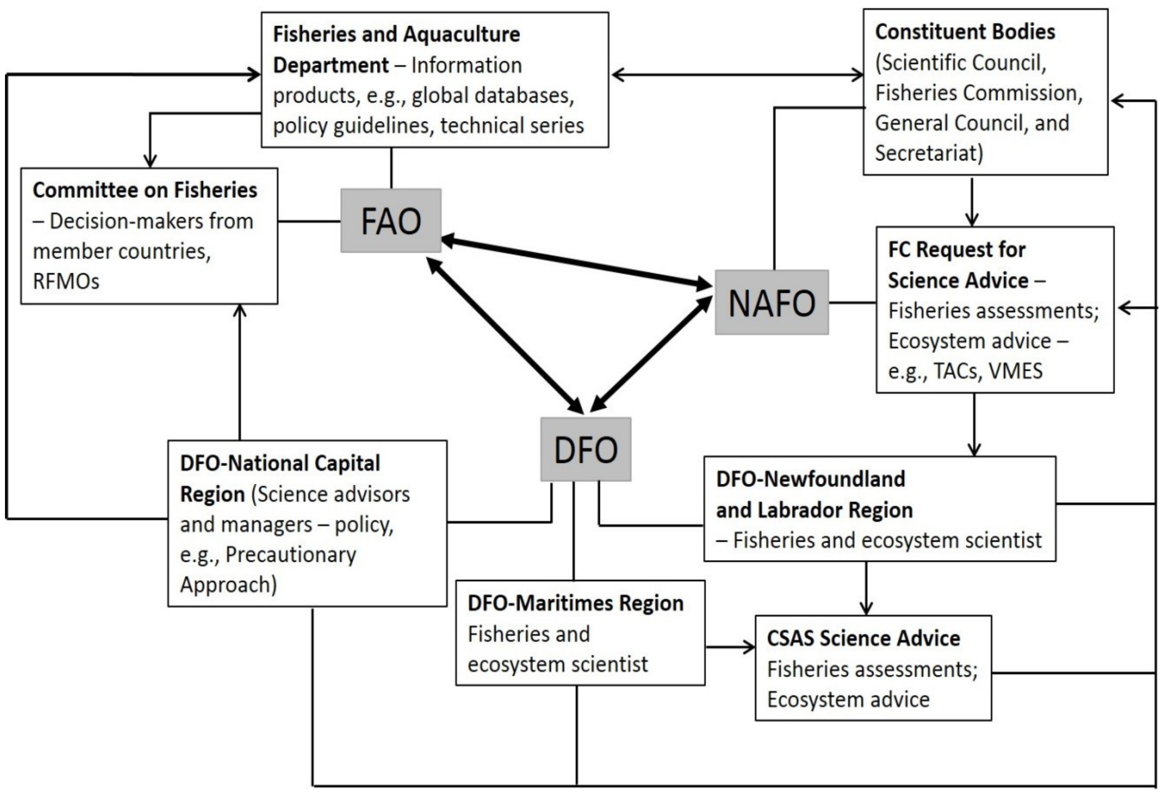

Figure 16. The general interplay among DFO, NAFO, and FAO.

The research revealed the different interactions of FAO and NAFO with DFO headquarters (DFO-NCR) and the different administrative regions, such as the DFO-Maritimes Region (DFO-MR) and the DFO-Newfoundland and Labrador Region (DFO-NLR). FAO communicates with the national policy-making regions, i.e., DFO-NCR, and not with the other administrative regions such as DFO-MR or DFO-NLR. To be expected, scientists and managers in the DFO-MR did not typically refer to FAO information in their operational fisheries management in the coastal area. But of note, approximately half of the interviewees in the DFO-MR (54% - see Section 4.3.2.2) spoke generally about

Canada's role in supporting and implementing regional and international policy and national legislation as a driver to the production and flow of information. In contrast, all fisheries and ecosystem scientists from the DFO-NLR who participate in NAFO were aware of UN and FAO-led policies and referred to international fisheries conventions and UNGA resolutions, e.g., on deep sea fisheries, because of the relevance of the international guidelines to their regional work. DFO-MR staff appeared to be generally unaware of many of the developments in international fisheries policy-making. DFO-MR staff also seemed to be unaware of regional decision-making in NAFO – to be expected given the jurisdictional area of the Maritimes Region. DFO-MR staff did not mention sources of scientific information outside of DFO, nor did they place their work in the context of international policy, for instance, policies produced by the FAO. However, the observations support the view that was common among respondents based in the Maritimes Region that they were physically removed from policy-making and play the role of implementing policy without much understanding of the context for how it was developed.

7.5.2 Bridging the Gap between Science and Policy Communities

The literature describes boundary organizations as a means to bridge information flow between science and policy communities (Guston, 2000, 2001). The staff within a boundary organization facilitate a "bridging" role between these two communities. FAO is playing the role of a boundary organization through its interaction with scientists and policy-makers in member countries (see Section 6.1.2). For instance, with regard to its global inventory of marine resources and fisheries, the Fisheries and Resources Monitoring System (FIRMS), an FAO staff member noted that "we spend a lot of time trying to explain the need to scientists, sometimes fisheries ministers and a wide range of people, the importance of having a very nice, easy, and effective way of delivering information" (FAO 27). FAO uses tools like FIRMS as a means to bridge the science-policy gap as they provide rapid access to information for decision-making by managers. FAO also plays a "bridging" role between national scientists and managers in different fora, e.g., at the UNGA meetings and the Committee on Fisheries.

The political process was particularly evident in FAO – not within the internal operations of the organization itself but in the observations of interactions in meetings with its member countries. Political considerations inevitably occur, given that decision-making is completed by senior-government officials and politicians. For instance, the deliberations on the text of the small-scale fisheries technical guidelines was influenced—actually high jacked—by member countries that were safeguarding their foreign policies (see Section 6.3.4.4). Pielke (2007) described the roles of scientists in boundary organizations as science arbiters, issue advocates, or honest brokers. The science arbiter steers clear of political considerations but tries to meet policymakers' demands for assessment and information. In the issue advocate case, science is used to steer policy in a certain direction. The honest broker role acknowledges scientific uncertainties and recognizes a broad spectrum of values, including groups with diverging values. Depending on the issue at hand, FAO staff typically fluctuate among the three roles as described by Pielke (2007). The characteristics of FAO as a boundary organization are discussed further in Section 7.7 and in Table 19 (see p. 277).

Results from the DFO and NAFO studies showed the important role that actors play in "bridging" or connecting two disparate groups. The characteristics of a "bridger" include a manager with a background in science who understands the technical details of reports, or a manager who has developed a network within the science community and the decision-making community and can explain the management and policy needs and the scientific advice to the respective audiences. For instance, managers in DFO play a "bridging" role within their organization to communicate scientists' concerns to decision-makers. The ocean managers in DFO's Ocean and Coastal Management Branch are trained in biology and play a role as "bridgers" between the Science and the Management Sectors in their work related to marine protected areas (see Section 4.3.3.2). FAO staff did not describe themselves as scientists, largely because they were not engaged in primary research. While staff in FAO could not be defined as either scientists or managers, they have technical backgrounds in science, trade and economics, social science, and include individuals with expertise in governance, law, and policy. FAO staff consider it their role to be adept in knowledge translation and to act as "bridgers."

While NAFO is not operating as a boundary organization, it plays a "bridging" or intermediary role between FAO and national scientists and managers in DFO with regard to increasing awareness of the international agendas in fisheries management. "Bridgers" can facilitate internal and external communication in the case study organizations. Individuals or organizations acting in "bridging" roles are able to employ methods to communicate scientific information and management needs to the appropriate groups. The trust relationships that have developed by the iterative communication between scientists and managers in the DFO CSAS and NAFO annual request for advice processes also facilitate this "bridging." A major disadvantage of relying on individuals to act as "bridgers" within an organization is the increased risk of losing "institutional memory" when these individuals leave the organization, unless they have mentored their replacements.

In spite of the well-defined processes for operational decision-making in DFO and NAFO, the staff highlighted the need for a "champion" to lead particular research agendas, for example, to promote the EAF. Leadership is needed to ensure that the necessary information is considered in information production and in decision-making. Since the science and management roles have been separated in DFO and NAFO, and scientific advice is provided only for management questions that are asked, a likely role of these "champion" or leaders is to ensure that important issues do not go unnoticed. DFO-MR scientists perceive the separation of responsibilities of the DFO-MR and DFO headquarters related to operational policy-making as a disconnect between the two administrative regions. These scientists believe there is a need for a dedicated person in the region to act as a "champion" to liaise between the two administrative regions with regard to research agendas (see Sections 4.3.3.2 and 5.3.3.3). Managers in the DFO-NLR may be acting as this "champion" through their bridging role between the regional scientists and senior advisors, e.g., in the briefing of delegations prior to NAFO meetings; but this role is not obvious to them. Relationships based on trust have developed through the ongoing and frequent dialogue between scientists and managers in the formal DFO CSAS process and the annual NAFO Fisheries Commission request for advice and informal communication outside of these processes. Managers in the DFO-MR believed that this was a unique characteristic of this region and was critically important to the success of the CSAS process. Similarly, managers in the DFO-NLR spoke about their close working spaces in the same building as an enabler to communication and to building trust relationships.

7.5.3. Increasing the Communication between Ecosystem and Fisheries Scientists

Implementing the EAF promotes the interdisciplinary use of data in assessments and encourages increased communication and collaboration among multiple actors or stakeholders in information production. EAF can enhance the role of science in decision-making as seen in DFO's participation in the ICES Working Group on the Northwest Atlantic Regional Sea (WGNARS) (FAO, 2012; Levin, Fogarty, Murawski, & Fluharty, 2009). The challenge is in turning the principles and guidelines provided by organizations such as the FAO into operational objectives and ecosystem management plans that incorporate fisheries, e.g., in DFO and NAFO.

A main challenge for enhancing information flow related to EAF is the overall organizational structure and culture that are developed around fisheries management. Fisheries management continues to focus on single stocks and managers request annual scientific advice for selected species (e.g., see Section 4.3.4.1). The administration of fisheries in Canada, as other countries, is structured around the annual license arrangements. Ecosystem and environmental advice requires long time scales to be useful for management. The requirement of fisheries scientists to work with data from other disciplines is a challenge, e.g., the use of ecosystem assessments in NAFO is still a small component of the overall advice provided by the Scientific Commission where the majority of advice is still based on specific fisheries (see Section 5.3.3.1). Scientists dedicated to EAF are becoming more common in DFO and new staff members have different approaches that include multiple species models that incorporate environmental data. Other information needed for EAF is still not forthcoming, e.g., staff with social science training are still rare in fisheries departments.

The DFO CSAS process ensures that information that is useful and needed for decision-making is produced. In the CSAS process, scientists understand the specific decision-making contexts in which policy-makers are operating. Within NAFO, the formation of joint Fisheries Commission-Scientific Council working groups and specific SC working groups, such as the Working Group on Ecosystem Science and Assessments (WGESA), facilitate communication between scientists and managers and between fisheries and ecosystem scientists to increase understanding of ecosystem assessments and advice. Scientists ensure that the "best science advice" is available and used in the policy process; the research programs are planned to produce information that is seen to be relevant and credible.

7.5.4. Increasing Interagency Communication

Overlapping membership of scientific and policy working groups within and across the three case study organizations drives information use in policy-making and is a means of overcoming the communication challenges. Institutional interplay among fisheries organizations has been recognised as playing a role in policy-making (Young, 2004; 2008). For instance, Canada is a member of NAFO and DFO's scientists, fisheries managers, and policy-makers participate in NAFO's Scientific Council, Fisheries Commission, and General Council respectively (see Figure 16). FAO participates as an Observer in NAFO's annual meetings. Overlapping membership facilitates communication and information production and use among organizations. For instance, scientific working groups, such as the NAFO Working Group on the Ecosystem Science and Assessments (WGESA), are comprised of DFO scientists in addition to scientists from the other member states. NAFO also has a new Fisheries Commission Working Group of Fisheries Managers and Scientists on Conservation Plans and Rebuilding Strategies. Further, FAO has been actively collaborating with RFBs with a mandate to manage deep-sea fisheries on the development of the Areas Beyond National Jurisdiction Deep Seas Project (see Section 6.3.3.4). This overlap in institutional membership facilitated the flow of related information produced by DFO, NAFO, and FAO, into a global database on vulnerable marine ecosystems (FAO Direct Observation 1 and 2).

Overlapping memberships facilitate iterative communication which is a key characteristic of a collaborative model of the science-policy interface. Such communication also indicates the presence of multiple science-policy interfaces between the science and policy realms among and within each organizations (as described in Section 7.5.1).

Policy-makers in DFO, Contracting Parties to NAFO, and the NAFO Secretariat participate at high level decision-making in FAO, e.g., in the Committee on Fisheries. Scientists in DFO, through their participation in NAFO and ICES working groups, have been developing a science roadmap for EAF, including ecosystem objectives and supporting principles and to make them operational (e.g., CSAS, 2001). DFO scientists communicate within their fields of expertise and may participate in many national and international meetings on ecosystem-based approaches (Watson-Wright, 2005). DFO scientists may network with other science experts in other government departments, to the extent that issues related to ecosystem-based management are shared.

7.5.5. Actors in the Information Pathways

While scientists and managers are the key actors in information production in the governmental organizations, non-governmental organizations (NGOs) are important actors in the communication of advice at the science-policy interface. The involvement of NGOs was evident in direct observations at meetings such as the DFO CSAS meetings, the NAFO annual meeting, and the FAO Committee on Fisheries (COFI). FAO staff stated that these non-state actors can influence global, regional, and national fisheries policy and decision-making, either directly or indirectly, by defining issues, lobbying at the negotiating conferences, providing information for the public, having extensive civil society networks including the fishing industry, and in increasing awareness in regional and national groups on global discussions in which the NGOs participate.

NGOs vary considerably in the size of their constituencies, in their organizational structures, and in their effectiveness. International NGOs and local NGOs participating as Observers in NAFO Fisheries Commission and Scientific Council working groups and as invited “experts” at DFO CSAS review meetings were generally research-oriented and assisted in the production of advice for policy-makers. NGOs such as the World Wildlife Fund (WWF) and the Ecology Action Centre (EAC) were also a conduit for information on global agendas reaching the staff of the DFO-MR. Staff from the DFO-NCR would attend international meetings and communicate directly with organizations like FAO and related agencies in the UN system. The discourse at the international level is not typically communicated to the operational management levels in the administrative regions. In the

FAO context, NGOs were seen as key partners in information dissemination to member countries, in driving activities under global projects, and in strengthening fisher networks consequently increasing the lobbying capacity of the industry, e.g., as seen in the case of the adoption of the FAO small-scale fisheries guidelines. FAO acknowledges the important role that NGOs play in the two-way flow of information between the FAO and fishing communities (FAO, 2009).

The fishing industry is an increasingly important actor in information flow mainly due to its lobbying and pressuring of governments seen at all geographic scales in DFO, NAFO, and FAO. The fishing industry can influence what issues gain attention or are addressed by all players and it is also engaging in formal research partnerships with organizations like DFO and FAO. Advances in the organization of the industry and the education level of its members facilitate its participation in DFO CSAS science peer review meetings where industry members engage in the technical discussions (DFO Direct Observation 1 through 3). DFO managers stated that they speak regularly with members of the fishing industry and answer questions about the science advice and management decisions (see Section 4.3.3.3).

The important role of civil society in driving policy-making and related information production was also evident in the case of FAO, e.g., in the process leading to the adoption of the small-scale fisheries guidelines, where civil society representatives took the lead in promoting awareness of the guidelines in their respective communities by producing non-technical versions of the guidelines in regional dialects and in planning consultations at the local community level (e.g., see Section 6.3.2.2). The "power" of civil society was highlighted within FAO but not DFO and NAFO. In DFO and NAFO, the movement of scientific advice to management is confined within the organizations themselves. On the other hand, FAO reaches out to NGOs to disseminate information and is involved in global partnerships with multi-stakeholder organizations. Partnerships with the fishing industry and groups representing civil society are increasingly becoming an important means of information production because of the global austerity measures impacting on fiscal resources available for research.

7.6. Use of Scientific Information in the Case Study Organizations

In this section, the use of scientific information by the case study organizations is discussed in the context of the models of decision-making and information use at the science-policy interface that are described in Chapter 2 (Bremer & Glavovic, 2013; Knott & Wildavsky, 1980; Koetz et al., 2011; Nutley et al., 2007; Weiss, 1979). This section addresses the four specific research questions described in section 7.1. Table 17 presents a comparison of the models in the interface based on the results of the case studies (see p. 264).

7.6.1. Models of Decision-Making at the Science-Policy Interface

As Pielke (2007) described, the linear science-policy interface model is applicable in the simplest of decision-making contexts, while the collaborative model applies to international environmental governance settings. The science-policy interface in operational fisheries management in DFO, observed in the DFO CSAS process, and in NAFO, with regard to the NAFO FC annual request for scientific advice, corresponds to the linear interface model. In this linear model the collection of new scientific knowledge continuously feeds into decision-making and the organizational and governance structure are designed for this science-based approach to decision-making. Decision-making in a linear model is primarily based on the use of science and no other types of information, such as local knowledge.

The science-policy interface in FAO is best defined by the participatory or collaborative interface model described by Bremer & Glavovic (2013) which is based on the premise that enough knowledge already exists to support informed decisions but this knowledge is disaggregated and hence FAO's enormous efforts to integrate global datasets from a range of disciplines, such as biology, economics, and policy. FAO's mandate to collect, analyse, and disseminate knowledge demonstrates this participatory or collaborative interface. The organization is also increasingly engaging in global partnerships with a wide range of stakeholder groups that form the core of FAO's work programs, for example, the ABNJ and iMarine projects mentioned (also see Sections 6.3.2.1 and 6.3.3.2).

Table 17. Models of decision-making and information use in the science-policy interface in the case studies of DFO, NAFO, and FAO.

<table>
<tr><th>Models</th><th>DFO</th><th>NAFO</th><th>FAO</th></tr>
<tr><td>Decision-making</td><td colspan="2">Linear model – in the DFO CSAS and the NAFO FC annual request for fisheries management advice;
Emphasis on science;
Two communities – scientists and managers (Koetz et al., 2011)</td><td>Collaborative model – multidisciplinary information; Extended community, i.e., multiple stakeholder groups, in global fisheries management (Bremer & Glavovic, 2013)</td></tr>
<tr><td>Information Use
(Nutley et al., 2007; Weiss, 1979)</td><td colspan="2">Linear model – DFO CSAS and NAFO FC annual request for advice for making management decisions</td><td>Continuum model – two-way flow, i.e., the production of knowledge cycles between policy develop and information production</td></tr>
<tr><td>Category of Use</td><td>Direct (instrumental) use; DFO-MR – Advice is used for operational decision-making</td><td>Direct use; NAFO Convention Area – Advice is used by the Contracting Parties for negotiating and operational decision-making</td><td>Direct use: Indirect (conceptual) use; Global – e.g., statistical databases and technical guidelines intended to assist national policy-making; Information is used by a range of audiences</td></tr>
<tr><td rowspan="2">Typology of Information Use
(Weiss, 1979)</td><td colspan="2">Scientific information is used for “problem solving” in fisheries management;</td><td>Information production is “knowledge-driven” and serves an “enlightenment purpose” i.e., increases awareness and changes attitudes of decision-makers in member countries</td></tr>
<tr><td colspan="3">“Interactive” typology – Communication between decision-making groups and information producers is an iterative process, i.e., ongoing and frequent</td></tr>
<tr><td>Stages of Use
(Knott & Wildavsky, 1980)</td><td colspan="2">Information use moves through main stages of “ideal use:” reception, cognition (reading), reference, effort, adoption, implementation, and impact</td><td>Information products sent to the member countries moves through the stages in the national context</td></tr>
<tr><td>Overlapping Use</td><td>FAO reports are generally not referenced in the CSAS in the DFO-MR</td><td>CSAS and FAO documents are referenced by DFO-NLR staff</td><td>Scientific information produced by DFO and NAFO are used as national and regional data sources for developing FAO databases</td></tr>
</table>

7.6.1.1. Trade-offs in the Attributes of Information at the Science-Policy Interface

Trade-offs in the attributes of credibility, relevance, and legitimacy of information used in the science-policy interface ensure that the interface functions so that the mandate of the organization is met. For instance, credibility and relevance of information is favoured over legitimacy in the interface in the “matching-up” trade-off that was observed in DFO and NAFO. Credibility and relevance of the scientific information produced in these organizations are assured when specific questions are posed by the managers to the scientists, the advice is provided by the scientists, and the management decisions are made by managers based on the scientific advice (i.e., “matching up”). This process ensures that the scientific advice is available to meet the management needs.

A “consultation-peer review” trade-off was evident in DFO where legitimacy of the information was preferred over credibility since the robust science review that was characteristic of the CAFSAC process was replaced with the wide-peer review community in the CSAS process (see Section 4.1.4). Legitimacy in this instance would mean the involvement of actors other than managers. Nonetheless, DFO still regards the scientific advice as credible since it is produced in the CSAS process. However, participation of multiple stakeholders in the production of the scientific advice, e.g., the fishing industry, NGOs, academic institutions, government scientists, and managers, increases the legitimacy of the information. This trade-off is intended to address concerns with scientific uncertainty by increasing the understanding of the risk involved in decision-making and thereby guaranteeing the use of the advice. A similar trade-off was not observed in NAFO where the peer review of the scientific advice involved only the fisheries and ecosystem scientists of Contracting Parties who were participating in the standing committees of the Scientific Council. Other stakeholder groups are not invited to participate, except for accredited observers to NAFO, likely because of the underlying political or negotiating positions of the Contracting Parties.

The “matching up” and “consultation-peer review” trade-offs in the attributes of information that are evident in DFO influence the decision-making process and information use at the science-policy interface. With trade-offs operating at the interface, defining decision-making and information use within the context of the models is not appropriate since the overall functioning of the interface cannot be easily categorised as a linear or a collaborative model. Specifically, a linear interface model was described for the CSAS process, however, there is increasing and frequent communication between scientists and managers to prioritize and finalize the management questions according to the capability of scientists to complete the assessments and provide the scientific advice within the timeframe of the CSAS process. Similarly, the extended peer-community facilitates frequent dialogue between DFO scientists and managers, and other groups – mainly the fishing industry. Overall, the trade-offs serve to increase the iterative communication among the central actors and extend the range of participants.

The trade-offs observed in DFO and NAFO, therefore, appear to combine the distinctive characteristics of the linear and the participatory or collaborative decision-making model. The apparent ambiguity between a linear and participatory science-policy interface in DFO appears contradictory but it is not entirely unique to DFO. An earlier study within ICES illustrated a linear approach to the science-policy interface even though the researchers believed that a more participatory or collaborative science-policy interface model was better suited to facilitate communication among government and stakeholders (Aps et al., 2012). The "matching up" trade-off associated with the DFO CSAS process and the NAFO request for advice where the science is in direct response to questions asked by managers may have its origins in the history of decision-making in the organizations. The CSAS process developed from the CAFSAC process after the collapse of the cod fishery and DFO staff explained that this was partly due to lessons learnt from the former process. The "matching up" trade off in NAFO guards against the intense disagreements and acrimonious relationships that were common among NAFO Contracting Parties between 1979 and 1994 and agreements in NAFO are also now developed by consensus (see Section 5.1.4). Iterative communication in the DFO CSAS process and the NAFO FC annual request for advice, as well as the communication in the expert and technical consultations within FAO, facilitate trust relationships and therefore facilitate a collaborative decision-making model.

Trade-offs among credibility, relevance, and legitimacy of information in the science-policy interface are common, dynamic, and dependent on the issue at hand as described in

Sarkki et al. (2014). Iterative communication has also been observed in the interface and Sarkki et al. (2015) have added "iterativity" to the attributes of information which describes the two-way communication among actors in the interface. The researchers concluded that "iterativity" in the science-policy interface in the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) is an important factor that influences the function of the interface.

A "production-communication" trade-off at the science-policy interface was revealed in FAO where priority is given to production of information to maintain the demand and supply of information, not on its communication. The organization produces statistical databases, syntheses, and guidelines, among other publications, for its member countries to guide policy-making and to increase awareness of issues in a range of audiences (see Section 6.3.1.3). Staff referred to FAO as a "knowledge organization," as it played a substantial role in the production of credible global information. Yet, the organization does not systematically follow through with communication of its information, largely due to staff workloads and the absence of communication staff. Despite the high volume of publications, FAO generally produces information without a specific target audience in mind. One FAO staff referred to the audience as a "vague type of user" (FAO 30). With regard to technical publications, FAO also produces a "generic" product that is expected to be used by a diverse audience, including policy-makers, managers, scientists, and the general public. FAO staff called this "a one size fits all" type of publication, for instance the global database on vulnerable marine ecosystems (FAO Direct Observation 1). Subsequently, the information may not be relevant to the specific needs of all member countries. This represents a trade-off in relevance. The "production-communication" trade-off is also evident by the absence of systematic monitoring or measuring the impact of projects by tracking the use of its publications.

The "production-communication" trade-off observed in FAO is also characterised by the production of less technical versions of documents to promote awareness of contemporary fisheries management issues and to elicit change in attitudes in decision-making and policy-making communities. The organization vigorously promotes the implementation of the EAF, the management of deep sea fisheries, and the elaboration of provisions of the small-scale fisheries guidelines in national policy within its member countries. The organization dedicates considerable resources to produce information products that are "very simple, but the message is clear," e.g., video, flyers, infographics, brochures, booklets, and sometimes cartoon-type materials are used to reach fishing communities (FAO 13). Such information materials are generally produced as output from technical studies and are based on scientific information.

The "production-communication" trade-off may also explain the apparent advocacy role of FAO since the organization dedicates considerable resources to produce such publications that contain simple messages aimed at different audiences, from fishing communities to policy-makers, and are particularly relevant to national policy-making in developing countries. An FAO staff member stated that the organization was moving "opportunistically towards an advocacy organization" by reducing posts and outsourcing the technical expertise to consultants from the market place (FAO 24).

Furthermore, FAO relies on groups, such as non-governmental organizations, to disseminate its information within member countries. NGOs are known to have extensive networks that include national fishers and other fishing industry stakeholders. NGOs can also lobby national governments and can criticize national governments' actions or inaction – something that FAO cannot do as a UN agency. FAO's "Blue Growth Initiative" is promoted as an important vehicle for mobilizing resources and advocacy in international fora to align FAO with other major global initiatives and partnerships related to the "green economy," i.e., sustainable use and conservation of resources in an economically, socially, and environmentally responsible manner (see Section 6.1.3).

DFO scientists and managers participating in NAFO also described heavy workloads, but this "production-communication" trade-off was not observed in the DFO and NAFO case studies. The DFO CSAS process and the NAFO Fisheries Commission annual request for advice eliminated the need for widespread communication, as the target audience – the managers – was part of the process. Also the work to be completed by DFO scientists is discussed and decided by managers in collaboration with the scientists, and therefore relevant to the decision-making process. The science advice produced by DFO and NAFO is published only in the technical series of the respective organizations.

7.6.2. Models of Information Use at the Science-Policy Interface

Following the models described in Nutley et al. (2007), information use in DFO and NAFO was direct or instrumental because the scientific advice was used in operational decision-making for fisheries management, e.g., for setting license conditions, TACs, and guiding fisheries negotiations. The DFO scientific advice was used in direct problem-solving through an interactive process, i.e., the DFO CSAS process, where managers prioritise their management questions based on the capability of the scientists to produce quality research and advice in the time required by managers to make a decision. In this process, there is a dynamic relationship between scientists and managers, and other actors in the fisheries management process, namely the industry, where continuous informal communication is common.

The evidence gathered in the case studies shows that the overall information flow in DFO and NAFO is characteristic of the earlier models of information, e.g., by Weiss (1979), where information flow is regarded as simple, occurring as a linear series of events, or "ideal use," from the request for advice by managers, the production of advice by scientists, the dissemination of scientific advice to managers leading to decision-making on fisheries license conditions in DFO or member country quotas in NAFO. The CSAS process follows a logical sequence of events in fisheries management (see Figure 6 in Chapter 4, p. 62) and the science advisory process within NAFO is guided by the annual meeting of the Fisheries Commission and General Council (see Figure 10 in Chapter 5, see p. 133). Information use at higher levels of decision-making in DFO was not explored, e.g., in strategic decision-making, since this process was primarily the responsibility of DFO-NCR, and outside of the parameters of this study.

Information flow in FAO is characteristic of the continuum model proposed by Nutley et al. (2007) where information use cycles between indirect or conceptual use and direct or instrumental use (see Figure 2 in Chapter 2, p. 18). As described in Chapter 6, the role of scientific information in FAO can be viewed from two perspectives: the use of FAO's information products for national policy-making in member countries and use by other groups, e.g., NGOs and civil society; and the use of information in decision-making within FAO, e.g., by member countries in governing bodies such as the Committee of Fisheries. FAO staff spoke primarily about the use of the organization's products by the external users, largely the developing countries, in relation to FAO's mandate. The use of FAO's information ranges from indirect to direct use and depends on the type of FAO information product and its intended use, purpose, and audience. Information from the global statistical databases are used directly by the fishing industry to obtain and maintain MSC certification. Conversely, products, such as the technical guidelines and the flagship publication, *The State of the World Fisheries and Aquaculture* (SOFIA), are used indirectly in national decision-making; the information contained in such publications can result in increased understanding and a change in attitudes of policy-makers and practitioners in the member countries, the information permeating over time into national decision-making. The stages between receiving information and adopting it in national policy-making in the member countries can progress over a number of years. Ultimately, the uptake of technical guidelines produced by FAO into national policy-making is the responsibility of the member countries. The information generally produced by FAO serves an "enlightenment" purpose given this indirect or conceptual use.

Based on the typologies of information use that were described by Weiss (1979), information produced by DFO and NAFO is mainly used for "problem solving," where the information provides advice to policy-makers and is intended to guide the selection of management solutions. In the case of FAO, information use is generally "knowledge-driven," where a product serves an educational purpose for the intended audiences in the member countries. In all three organizations the "interactive" typology is relevant, where decision-makers, e.g., policy-makers and managers, seek additional knowledge from scientists and other sources in an iterative process leading to the production of additional information and policies that drive the production of further information.

The research revealed whether scientific information was understood by managers in DFO and NAFO (e.g., see Sections 5.3.1.3 and 5.3.1.5). Using the seven-stage "chain of utilisation," information used in operational decision-making in DFO and NAFO flows through the main stages described by Knott and Wildavsky (1980), e.g., the managers receive the scientific advice, they acknowledge the advice and use it as a reference in preparing their briefing notes, they prepare management advice, and finally prepare and implement fisheries management measures. The iterative process involved in the DFO CSAS review and the briefing of the NAFO delegations, as well as the ongoing informal communication between scientists and managers for clarification of the science, provide evidence that decisions were being made by managers based on their understanding of the scientific advice (for example, see Section 5.3.1.5). With regard to the information produced by FAO, the organization is responsible for ensuring that the information is sent to the member countries but FAO is not always certain that the appropriate persons in the national fisheries authorities receive the publications. After the reception stage, FAO is unable to ascertain whether the information is read, understood, or acted upon. In a previous study of the use of FAO's technical publications in a Caribbean fishery context, it was seen that technical information was sent to the senior decision-makers, e.g., the Minister's office or to senior advisors in the national fisheries agency, based on FAO's dissemination protocol; however, these national stakeholders were generally not reading the reports (Soomai et al., 2011).

The DFO CSAS process and the NAFO FC annual request for advice are well-defined structured processes for operational decision-making that also follow the linear definitions of information use in the science-policy-interface. Given the frequent engagement of scientists, managers, policy-makers, and other groups, information use in DFO is expected to progress towards a continuum model, i.e., a two-way movement of information from multiple sources as information use cycles between indirect and direct use. In the continuum model of information use, scientific information cycles between conceptual and instrumental use (see Figure 2 in Chapter 2, p.18). Over time, awareness of the issue grows; research shapes problem-framing and problem-solving, e.g., in annual stock assessments; understanding is increased, e.g., scientific knowledge of scientists and managers on the EAF and the impacts of climate change improves gradually; attitudes change, ultimately leading to changes in the policy-making process and leading to direct use, e.g., in the development of national policies. It is expected that the use of scientific information in strategic decision-making in DFO, i.e., high level policy decisions made in the DFO-NCR will be characteristic of a continuum model since more senior managers and political decision-makers are involved. The information pathways in strategic decision-making in DFO and NAFO were not examined in this research.

7.6.3. Revisiting the Guiding Research Framework

The guiding framework for the research presents a generalised outline of information pathways in operational decision-making (see Figure 4 in Chapter 3, p. 40). This generalised framework is more applicable to a linear decision-making process and an ideal (linear) model of information use in the science-policy interface. The overall framework was validated by the information pathways evident in the DFO CSAS process and the process involved in the NAFO FC request for advice. The framework describes the demand and supply of information in DFO and NAFO, where the provision of scientific advice is a direct response to management requests and is used directly in decision-making. Decision-making in DFO and NAFO was based primarily on the scientific information produced by the organizations' scientists. The filtering of the information, as described in the guiding framework, represents the advice produced in the CSAS peer review process involving a wide peer review community and available to the managers for decision-making. However, in the NAFO Fisheries Commission annual request for advice, the input of stakeholder groups outside of the science and decision-making communities is limited. While the generalised framework seems to be corroborated by the DFO and NAFO case study findings as demonstrated in the information pathway diagrams in Figure 6 (see Section 4.3.1, p. 62) and Figure 10 (see Section 5.3.1, p. 133), it is expected that this general linear framework is nested within a collaborative decision-making model given the iterative communication among scientists, managers, and other key actors in the information pathways.

The guiding framework is an oversimplification of the information pathways observed in FAO (see Figure 13, Section 6.3.1, p. 187). The production of information involves experts who are not characterised as scientists or managers and the diverse group of actors and multiple interactions in the information pathways in FAO are not illustrated in the guiding framework (Figure 4, p. 40). FAO is playing the role of a boundary organization and the information pathways demonstrate collaborative decision-making and a continuum model of information use. A collaborative model of the interface is characterised by an extensive peer review community which includes groups apart from scientists and managers, partnerships with stakeholders in information production, and the framing of information which influences the attention given to particular issues.

7.7. Developing a Typology of Information Use

Table 18 presents 12 features or key characteristics of information use at the science-policy interface that can lead to the creation of credible, relevant, and legitimate scientific information in DFO, NAFO, and FAO. Seven of the 12 features describe production and five describe communication of information. The factors are linked to the relevant attribute(s) of information – credibility, relevance, and legitimacy. Assigning the presence of an attribute to an organization (indicated by ✓) was based on the interview responses and direct observations (Table 18). Table 18 also describes the characteristic of the feature and indicates the organization in which it was noticeable. Instances where an attribute was not assigned to a feature indicates that the feature was not described in detail by the respective staff, but the feature may still be evident in the organization.

The features listed as 1 through 4 in Table 18 demonstrate the core characteristics of the science-policy interface that promote credible, relevant, and legitimate scientific information in the three organizations, namely, its authority, its role in the supply and demand of information, iterative communication within the organization, and the presence of a well-defined process in the information pathways (Table 18). The information pathways in DFO, NAFO, and FAO demonstrate these four features, although there are differences in the characteristics of the features in each organization, as described earlier in this chapter.

The 12 features of production and communication of information are important characteristics of decision-making and information use (Table 18). Moreover, features 5 through 12 indicate the trade-offs in the attributes of information. The assignment of the key attributes to each feature indirectly indicates the associated trade-off in the attributes of information. The trade-offs facilitate communication of information at the science-

Table 18. Typology of information use at the science-policy interface.
(✓ the presence of the attribute)

FEATURE	CHARACTERISTICS	ATTRIBUTE	DFO	NAFO	FAO
PRODUCTION OF INFORMATION					
1. The authority of the organization	Organizational mandate for information production, management, and policy-making	Credibility Relevance Legitimacy	✓	✓	✓
2. The supply and demand for information	Guarantees the credibility, relevance, and legitimacy of the information	Credibility Relevance Legitimacy	✓	✓	✓
3. Iterative communication	Formal and informal networks that build trust among scientists and decision-makers; Scientific uncertainty is accepted	Credibility Relevance Legitimacy	✓	✓	✓
4. A well-defined process for producing scientific advice	Protocols for the provision of advice and decision-making are embedded in the organization; Advice is provided to specific management questions	Credibility Relevance Legitimacy	✓	✓	
5. Defined roles for scientists and managers	Separation of science and management – Scientists provide facts; Managers make recommendations	Credibility Relevance	✓	✓	
6. An extensive peer review community	Includes groups apart from scientists and managers; Wide peer community for understanding scientific uncertainty	Relevance Legitimacy	✓		✓
7. Partnerships in producing information	Involvement of external stakeholders enhance the attributes of the information	Relevance Legitimacy			✓
COMMUNICATION OF INFORMATION					
8. Formal process	Communication protocols are in place; communicating uncertainty	Relevance	✓	✓	
9. Multiple tools	Tools to disseminate information to a range of audiences	Relevance Legitimacy	✓	✓	✓
10. Framing of advice	Influences the attention given to issues	Relevance			✓
11. "Bridgers"	Increased dialogue – Individuals and structures connect groups that work independently	Relevance Legitimacy	✓	✓	✓
12. "Champions"	Individuals dedicating time to promote research agendas	Relevance Legitimacy			✓

policy interface and its use in policy- and decision-making, and enable the organizations to fulfill their mandates for fisheries management. For instance, defined roles of scientists and managers in information production and decision-making ensure the credibility and relevance of the information for decision-making (Feature 5 in Table 18); however, there is a trade-off in legitimacy as the information is not produced within a wide peer-review community. In a related example, an extensive peer review community (Feature 6) may pose a trade-off in credibility when rigorous scientific review is not possible. This trade-off is evident in the DFO CSAS process that facilitates "consultation" among DFO scientists and managers and a range of stakeholders, thereby enhancing the legitimacy and relevance of the information to multiple groups. For another example, the presence of "bridgers" (Feature 11) increases the relevance and legitimacy of the information in the science-policy interface as dialogue among stakeholders is increased.

It is important to note that the trade-offs in credibility, relevance, and legitimacy of information refer to the relative "weight" or "value" of the three attributes of information and not the elimination of one attribute in favour of another. For instance, increasing the legitimacy and relevance of the information produced by an extensive peer review community does not diminish the credibility of the information as it is produced in a process that is embedded within the organization with the authority for fisheries management (see Features 1 through 4 in Table 18).

The 12 key features can be regarded as a typology of information use at the science-policy interface (Table 18). These features can be applied to any model of decision-making, i.e., linear and collaborative models; or any model of information use, i.e., ideal (linear) and continuum models in the interface. The typology of use can reveal important differences among organizations with different mandates and levels of decision-making, e.g., national, regional, and international governmental organizations. The key features can be applied as a guide for future research within the organizations. For instance, to measure the legitimacy of an extensive peer review community (Feature 6 in Table 18), a list of criteria can be developed, e.g., the number of stakeholder groups involved in peer review meetings, the frequency of formal meetings, or the range of disciplines included in the peer review community, among other factors. This guide could also be used in other environmental resource management organizations.

Figure 17 is a diagrammatic representation of the typology of use described in Table 18. This figure relates the key factors in the science-policy interface that facilitate the production of credible, relevant, and legitimate information – thereby influencing its uptake in decision-making – to the four important characteristics of the interface as described in Chapter 2 (see Sections 2.6.1 through 2.6.4).

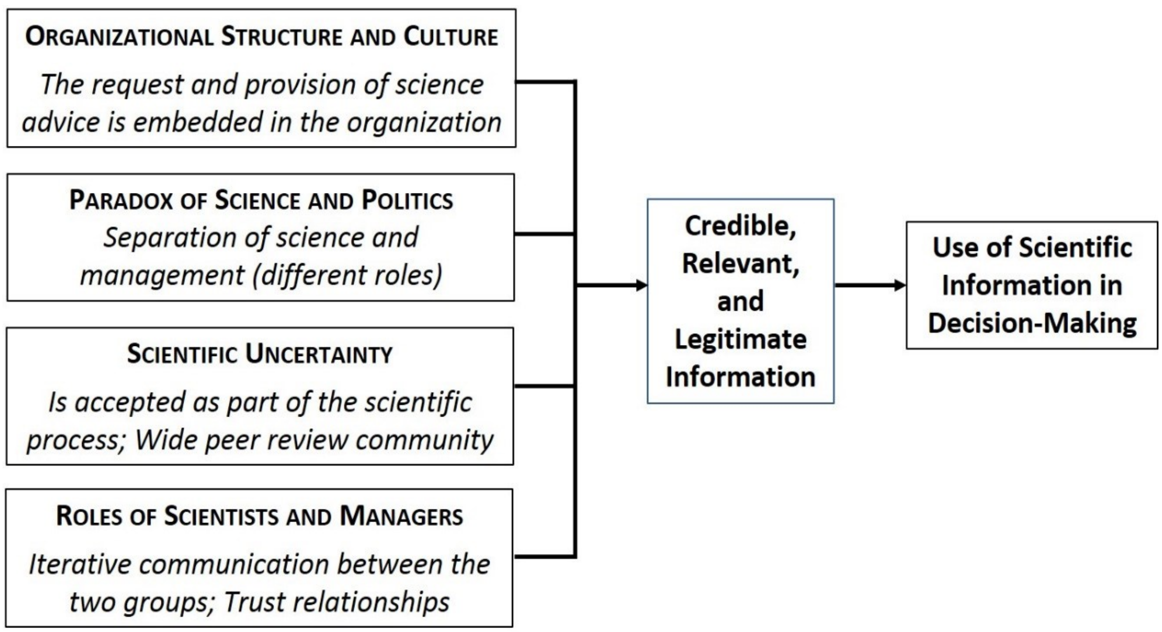

Figure 17. Generalised diagram of the factors at the science-policy interface that influence the uptake of scientific information in decision-making in national and regional fisheries management bodies.

As illustrated in Figure 17, scientific advice is produced in a process that is embedded in the fisheries management body – which is the authority and responds to the demand and supply of information; the process has clearly defined roles for scientists and managers, thereby reducing science advocacy; scientific uncertainty is accepted as part of the evidence by a wide peer review community; and the process is conducted through ongoing and frequent, i.e., iterative, communication among scientists and decision-making communities. This diagram is applicable to decision-making and information use in DFO and NAFO. This framework can describe information flow in both a national fisheries management authority and a regional management authority.

Table 19 describes nine key characteristics of FAO as a boundary organization. The characteristics complement the typology of information use presented in Table 18. The first three characteristics are also evident in DFO and NAFO (Features 1 through 3 in Table 19). Most importantly, six features that are unique to FAO as a boundary organization were revealed (Features 4 through 9).

Table 19. The characteristics of a boundary organization as evident in FAO.

(* - Unique characteristics that are not evident in DFO and NAFO)

FEATURE	DESCRIPTION OF FAO AS A BOUNDARY ORGANIZATION
1. The authority of the organization	Organizational mandate for information production; Guide international, regional, and national policy-making.
2. Extensive peer review community	Includes groups apart from scientists and managers, e.g., a wide range of NGOs and civil society groups; Wide peer community for understanding uncertainty
3. Iterative communication	Formal and informal networks that build trust among scientists and decision-makers within member countries
4. * Framing of advice	Framing of information influences the attention given to issues and can also attract support from multiple donors
5. * Flexible cycles of information production	Long time scale for operating
6. * Partnerships in producing information	Partnering with NGOs, industry, RFBs, and academic institutions enhances the attributes of the information
7. * Principle of neutrality	Balances the political processes involved in interacting with its member countries
8. * Multiple communication tools	Relevant tools to disseminate information to a range of audiences – website, social media
9. * Staff as specialists who act as "bridgers"	Individuals and structures connect science and policy communities

An important characteristic of FAO as a boundary organization is the employment of specialists who can interpret or act as "bridgers" (Feature 9 in Table 19), between the science and the policy realms. FAO staff described themselves as neither scientists nor policy-makers; they see their role as translating technical information for policy-making communities and other non-technical groups such as the fisheries community and civil society to engage them in policy networks. Depending on the issue at hand, FAO staff fluctuate among the roles of science arbiters, issue advocates, or honest brokers as defined by Pielke (2007). The science arbiter steers clear of political considerations but tries to meet policymakers' demands for information. The issue advocate role uses science to steer policy in a certain direction. The honest broker role acknowledges scientific uncertainties and recognizes a broad spectrum of values, including groups with diverging values. As a regional body, NAFO plays a bridging or an intermediary role between its Contracting Parties and the FAO; however, NAFO is not categorised as a boundary organization as it does not exhibit the suite of characteristics as presented in Table 19.

Another key characteristic of FAO as a boundary organization is the recognition of the need for wider peer review communities involving collaboration of the scientific community, policy-makers, and other interested stakeholders to deal with uncertainty and disagreement in scientific advice, in a transparent and effective manner (Features 6 and 8 in Table 19). This collaboration, which draws on a wide range of NGOs and civil society groups, is part of the common approach to production of information practiced in FAO (FAO Direct Observation 1 through 3). Partnerships with a diverse group of stakeholders operating at national, regional, and international levels are common in the organization's work program. Multiple communication tools are utilised to communicate with this range of partners from the science and non-technical realms.

FAO's information production has flexible cycles and its uptake into national decision-making may emerge after many years and is often the result of increasing awareness of issues and attention at the global level, including political processes (Feature 5 in Table 19). This is evident in the continuing efforts of FAO to support member countries in adopting the *Code of Conduct for Responsible Fisheries* since 1995 (see Sections, 6.1.2, 6.1.3). Framing of fisheries management issues (Feature 4) influences the attention that they receive, for instance, issues framed in a sustainable economy context or a human rights context can enhance the relevance of information. The organization also operates under the principle of political neutrality in its interactions with its member countries (Feature 7).

CHAPTER 8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Introduction

The interdisciplinary approach taken in this research is unquestionably essential to studying information pathways – production, communication, and use – in the science-policy interface in the Canada Department of Fisheries and Oceans (DFO), the Northwest Atlantic Fisheries Organization (NAFO), and the Food and Agriculture Organization of the United Nations (FAO). The three organizations have different organizational structures and cultures, engage at different levels of decision-making, have different mandates related to fisheries management, and exercise their authority over different jurisdictions. Consequently, similarities and differences in the decision-making processes and the models of information use among the three organizations were analyzed.

The following five significant findings of the research are presented below:

1. A well-defined process for producing scientific advice and making management decisions – as seen in DFO and NAFO – is a key factor in producing credible, relevant, and legitimate information for decision-making.
2. FAO functions as a boundary organization as it bridges science and policy-making communities in its member countries.
3. Trade-offs in the attributes of information, i.e., credibility, relevance, and legitimacy, are necessary and always in action at the science-policy interface so that a fisheries organization can be successful in meeting their objectives.
4. A collaborative science-policy interface model is needed for decision-making and information use for the implementation of the EAF.
5. A new model of information use in operational decision-making for fisheries management is proposed. This model situates the unique drivers, enablers, and barriers in the information pathway; and includes the presence of trade-offs in the attributes of information used in the science-policy interface.

The chapter also reviews the research methodology and includes recommendations for future work and for improving information flows in the case study organizations.

8.2. Important Findings from the Research

8.2.1. Well-Defined Decision-Making Processes

A decision-making process that is well-defined, e.g., the DFO Canadian Scientific Advisory Secretariat (CSAS) process and the NAFO Fisheries Commission annual request for advice, is essential for ensuring that scientific advice received is credible, relevant, and legitimate for operational decision-making. Such a process includes protocols for providing advice that are developed in collaboration with scientists and decision-makers in a system where scientific study focusses on management objectives. The separation of science and management, where scientists provide facts and managers develops recommendations, ensures the credibility of information in this well-defined process. The embeddedness of the process within a recognized authority for fisheries management is a major factor that facilitates credibility and relevance of the information.

The organization in which the production of information is embedded, e.g., the fisheries and ecosystem assessments in DFO and NAFO and global databases in FAO, promotes the credibility, relevance, and legitimacy of the information. Fisheries decision-makers generally do not question the relevance or credibility of the advice coming from assessments produced within their organizations as the advice is tailored to inform their specific policy objectives (see Sections 4.3.1 and 5.3.1). Similarly, the authority of an organization also contributes to the credibility, relevance, and legitimacy of its information products. Staff of DFO and FAO, and DFO participants in NAFO perceived the respective organization as an authority for fisheries and ecosystem advice. It can be inferred that the authority of the organizations is also recognised by FAO member countries, NAFO Contracting Parties, and external groups such as NGOs and the fishing industry which used the scientific advice produced by these organizations.

Iterative communication, i.e., frequent two-way dialogue in the production of scientific advice, helps to establish trust and mutual understanding between scientific and decision-making communities. As a result, managers have a better understanding of science and scientists have a better understanding of management needs than would occur in the absence of this communication.

8.2.2. FAO as a Boundary Organization

FAO acts as a bridge between the global science and policy-making communities by connecting scientists and non-scientist communities through its production of technical information products aimed at a wide range of stakeholders in fisheries management (see Table 19 in Chapter 7, p. 277). At the global level, this practice is intended to increase awareness of fisheries issues, to call for action for fisheries management in its member countries, and to share information efficiently and quickly (scale and time) to guide international, regional, and national policy-making.

As a boundary organization, FAO employs specialists who bridge the science and the policy realms by translating technical information for policy-making communities and other non-technical groups such as the fisheries community and civil society to engage them in policy networks. FAO's principle of neutrality is needed to balance the political process which was particularly evident in the interactions with senior-government officials and politicians in its member countries (see Chapter 6, Section 6.3.4.4). FAO guidelines are sufficiently vague to be able to be applied in any national contexts (FAO 4).

FAO's information production has flexible cycles and its uptake into national decision-making may emerge after many years. Framing of fisheries issues influences the attention given, for instance, fisheries management issues framed in a sustainable economy context or a human rights context can enhance the relevance of information. FAO interacts with wide peer review communities involving collaboration of the scientific community, policy-makers, and other interested stakeholders on aspects including the choice of fisheries assessment methods, data collection strategies, interpretation of results, individual roles in knowledge production, open discourse on uncertainty, and the use of information in policy-making circles to represent the diversity of perspectives from which the policy problem and results of assessments can be viewed. Comprehensive datasets and publications can be produced in such partnership projects.

8.2.3. Existing Trade-offs at the Science-Policy Interface in DFO, NAFO, and FAO

The science-policy interface in fisheries management is dynamic – it involves continuous interactions between scientific and decision-making communities and external stakeholders to enable efficient flow of information at the interface. Endpoints are not only the use of information in decision-making but also the complex interactions of actors and events operating within a suite of trade-offs in the interface. Trade-offs occur in the weight or value given to the attributes of information, i.e., credibility, relevance, and legitimacy. Trade-offs are also contingent on the decision-making process (linear and collaborative) and information use models (linear and continuum). Trade-offs among the attributes of the information used at the science-policy interface do not exist in isolation; they are interrelated, dynamic, and depend on the issues and the actors. Trade-offs occur or evolve for information flow at the interface to be successful in meeting the objectives of an organization. Table 20 (p. 284) presents the general characteristics in the interfaces within DFO, NAFO, and FAO. Table 20 also includes the trade-offs, i.e., the "matching-up" of science and management, "consultation-peer review," and the "production-communication" trade-offs.

In the "matching up" trade-off, the well-defined processes for requesting and providing advice, as seen in DFO and NAFO, ensures that science advice is available for annual management, minimizes opportunities for advocacy by scientists, and performs a filtering role where the appropriate information is available for annual operational decision-making. Individuals described a general social culture within each organization about using scientific information produced by DFO and NAFO scientists as the main – or only – source of data and information for operational decision-making since this information was considered by the respective organizations to be the most credible and relevant compared with other sources. To reiterate, DFO scientists and NAFO participants did not rely on scientific information produced by sources outside of these organizations for their assessments. DFO and NAFO managers made decisions based only on the advice generated by their respective organization.

The trade-offs evident in DFO, NAFO, and FAO likely developed over time in response to external factors and the organizations may not be conscious of the trade-offs. For instance, the "matching up" of science and management in DFO and NAFO may have its origins in decision-making in the organizations in the 1980s and 1990s when overfishing and collapsing fisheries were intensely disputed in the Northwest Atlantic. "Matching up" of science and management may present a danger, however, as other sources of relevant information and issues may be overlooked.

Table 20. Characteristics of the science-policy interface in DFO, NAFO, and FAO.

CHARACTERISTIC OF THE SCIENCE-POLICY INTERFACE		DFO	NAFO	FAO
Model of Information Use	Direct use in operational management – Use of information to make annual fisheries management decisions	✓	✓	
	Indirect use in increasing awareness – Use of information for policy development, awareness building, and change in attitudes of decision-makers over years			✓
Decision-making process	Linear – information flows through simple linear processes; science is the focus	✓	✓	
	Participatory – Multiple information types; wide range of stakeholder groups			✓
Trade-offs	"Matching up" – Advice is provided in response to management questions but other information sources and issues can be overlooked	✓	✓	
	"Consultation-peer-review" – Wide peer community increases dialogue and legitimacy of the information but it prevents rigorous review of scientific information	✓		✓
	"Production-communication" – Production to maintain the demand and supply process with limited time for communication; Strong, simple messages versus technical details; Efforts intended to encourage specific policy actions			✓

The "consultation-peer review" trade-off is seen in the DFO CSAS process where the peer review of the scientific publications prepared by DFO scientists is carried out in a "consultation" type meeting involving a range of interest groups, thus broadening the scope of the peer review community and, in fact, incorporating different knowledge sets. This trade-off addresses the matter of scientific uncertainty as the involvement of multiple groups, including epistemic communities, can result in it being accepted in assessments.

This trade-off likely developed in response to the global efforts to implement the EAF which promotes the involvement of diverse stakeholder groups in management.

The "production-communication" trade-off seen in FAO may have developed in response to the needs of decision-makers for simple messages in policy-making contexts. This trade-off is also a characteristic of FAO as a boundary organization. More involved forms of multi-stakeholder engagement have become the normal method of operation in FAO where expert staff and consultants, although primarily with natural science backgrounds, are engaged more frequently in developing policy advice, e.g., international technical guidelines.

8.2.4. The Need for Collaborative Models of Decision-Making to Facilitate the Ecosystem Approach to Fisheries Management

Barriers to communication of information at the science-policy interface are more numerous for decision-making involving ecosystem science than for fisheries science. Traditional fisheries management is still a priority in most national and regional organizations in spite of the growing efforts to implement multi-species and ecosystem-based analyses. Administrative structures within the three organizations continue to support traditional stock assessments and have not yet been fully modified or developed to accommodate management based on ecosystem science. Many fisheries scientists have long working relationships with fisheries managers; the managers are science literate and the scientists understand the management needs. Each organization demonstrated attempts to integrate fisheries and ecosystem concerns. For instance, DFO created the Ocean and Coastal Management Division (see Chapter 4, Section 4.3.3.3), NAFO established dedicated working groups to facilitate discussions among scientists and managers to address ecosystem assessments (see Section 5.3.3.2), and FAO developed new strategic objectives for the organization (see Chapter 6, Section 6.1.3).

The structured processes seen in the DFO CSAS and the NAFO Fisheries Commission annual request for advice provide a transparent environment for decision-making, based primarily on fisheries science. However, when ecosystem advice is considered, the linear decision-making model of the science-policy interface does not appear to function, particularly with communication of uncertainty. A collaborative science-policy interface model is needed for the implementation of the EAF where all forms of knowledge are relevant as sources of information for decision-making. Such a model allows participation of multiple stakeholder groups and draws on different types and sources of knowledge, e.g., ecosystem science, local knowledge, and social and economic studies.

Decision-making for EAF is expected to be conducted through an interactive process between scientists and decision-makers. Furthermore, the knowledge needed for EAF is accumulated over time and follows the Nutley et al. (2007) continuum model of information use. A linear decision-making model can be adapted by particular trade-offs in the attributes of information flowing in the interface so that a more collaborative model, necessary for EAF, emerges. A linear model could be transformed into a collaborative model if appropriate changes in the organizational structures are made. For instance, in recent years, and as observed in 2013, NAFO established new joint working groups to increase dialogue between scientists and managers and NAFO now has working groups that allow observers, e.g., NGOs, to contribute in the development of the scientific advice (NAFO Direct Observation 1 through 3).

The ecosystem approach to fisheries management is a core principle within the UN system and FAO plays an important role in providing global guidance for implementing it. International policies developed within the UN system, including FAO as a specialised UN agency, make decision-making within a country increasingly more complex. In these instances, scientists working in national contexts have not yet developed the scientific knowledge to support the implementation of the desired policies. Organizational structures and institutional mechanisms have not yet been established to link local knowledge and science, and to ensure that all types of knowledge feed into policy, e.g., through translation and brokering of information so that the messages are understood by the multiple actors (see Sections 4.3.2.2 and 4.3.4.4). Governmental organizations are also constrained due to continuing austerity measures that limit actions to hire additional staff, e.g., more ecosystem scientists and social scientists. Fisheries and ecosystem scientists, who are conducting "basic research," are wary of incorporating information from alternative sources into their activities for fear of compromising their work.

Researchers have referred to this scenario as a policy occurring ahead of the science, which is evident in the case of the implementation of the EAF (Rice, 2005).

The main actors in the production and use of scientific information produced in DFO and NAFO are government scientists and managers. However, incorporating the views of external groups, such as NGOs, enhances the attributes of information. NGOs have also become important agents for disseminating information and they act as intermediaries in a two-way information flow, for instance, between the FAO and fishing industry, and the public at large (FAO, 2009).

8.2.5. A New Model of Decision-Making and Information Use

This study has shown that the models of decision-making and information use that were used as a framework to guide the research (see Chapter 2) complement each other. Information flow cannot be fully comprehended by using a single existing mode. Moreover, no single model of decision-making or information use adequately describes information flow in the organizations. None of the models was sufficiently explanatory partly due to the multiple science-policy interfaces within each organization and among the three organizations. Furthermore, the existing linear decision-making model conveys the idea that information pathways in decision-making contexts are simplistic and straightforward. In addition, the terminology used in the literature to describe a linear model conveys an image of a unidirectional flow of information. However, this is far from the reality as the case study organizations produced, communicated, and used scientific information in decision-making through considerable interaction among the key actors in the interface and through iterative communication, e.g., frequent two-way dialogue among scientists and managers. The information pathways in operational decision-making also indicate the presence of multiple science-policy interfaces within the organizations.

While the existing models of decision-making and information use (see Chapter 2) complement each other with regard to describing the information pathways, these models do not adequately describe the dynamic characteristics of the interfaces in evidence-based policy-making observed in this research. For instance, the existing models are limited as they do not describe the presence of trade-offs in the attributes of information used in activities in the science-policy interface.

As described in Sections 8.2.1 through 8.2.4, a linear decision-making model was observed in the DFO CSAS and the NAFO FC science-advisory and management processes, and a collaborative decision-making model was observed in the role that FAO plays in global scientific information production. In DFO and NAFO, this linear interface is nested within the interface involved in strategic decision-making, i.e., where policies are developed. In FAO, the collaborative interface model is also expected to be involved in strategic decision-making. Global environmental governance is shifting towards more collaborative models of science-policy interrelations, in part due to the public demand for increased transparency in science and policy-making. Groups outside of the fisheries management authority are increasingly becoming involved in the communication of scientific information to policy-making communities and the general public. This shift towards collaborative models of decision-making also indicate the presence of multiple science-policy interfaces.

The presence of trade-offs in decision-making can change the model of information use from a direct (instrumental) use to indirect (conceptual) use and vice versa. The Nutley et al. (2007) continuum model of information use provided a theoretical perspective for the research but it does not account for the role of trade-offs (see Chapter 2, Figure 2, p. 18).

Based on the empirical evidence obtained from the case studies of DFO and NAFO, a new model of information use in operational decision-making for fisheries management is presented in Figure 18. In government-driven generation of information – characteristic of DFO and NAFO – the request for scientific information is guided by a filtering process, including the framing of issues and agenda setting. The filtering process is influenced by a range of factors identified in the case studies, for instance, the supply and demand for information, and national, regional, and international policy development.

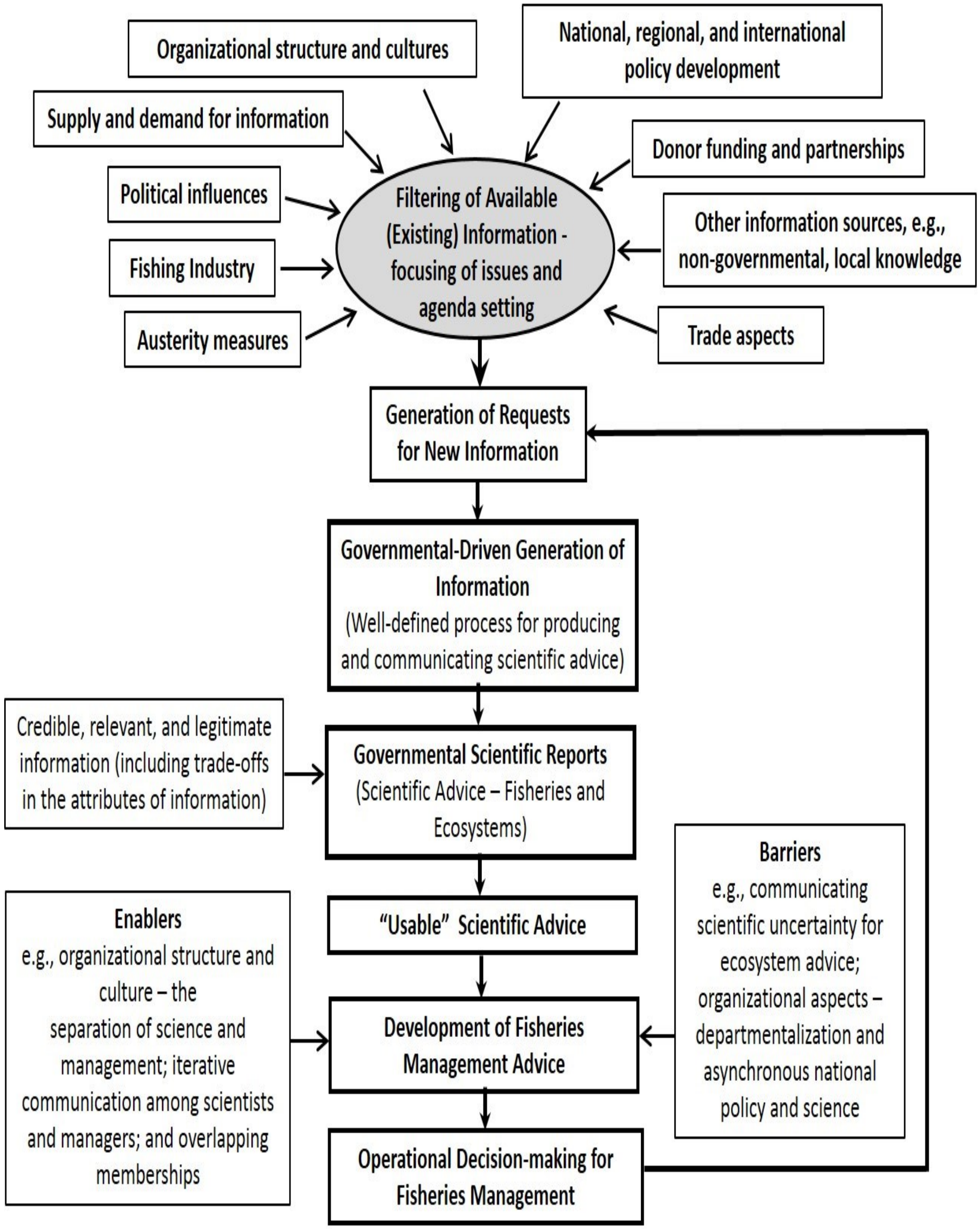

Figure 18. A new model of information use in operational decision-making for fisheries management.

A distinctive feature of this new model is the sequence of the filtering process relative to the generation of information by the organization. A major filtering process occurs prior to the generation of requests for information which drives the well-defined processes for producing information, such as the DFO CSAS and the NAFO FC science-advisory and management processes. In models such as Ascher et al. (2010) (see p. 21), this filtering process occurs after the "useable" information is produced. The new model presented in Figure 18 is likely to be applicable to national and regional fisheries management organizations with mandates similar to DFO and NAFO.

This new model can serve as a guide to understanding the information pathways for scientists and managers within the organizations. Additionally, this model can guide other public sector scientists and mangers. Moreover, the model can guide other individuals and organizations, e.g., research scientists in academic settings, NGOs, and other actors who wish to contribute to important societal issues in fisheries or environmental management but who may be unfamiliar with the ways in which scientific information is communicated to managers. Knowledge of these information pathways can enable actors to determine their most appropriate entry point in the decision-making process.

8.3. Review of the Research Methodology and Recommendations for Future Work

8.3.1. Benefits and Limitations of the Research Methodology

This research effectively tested a methodology for measuring and describing information use at the science-policy interface. The research showed that using mixed methods – interviews, direct observations, and content analysis – for studying fisheries management in multiple case study organizations was appropriate. The methodology was possible primarily due to the ability to be present within the organizations during the data collection phase. The results of the interviews of scientists and managers, direct observations at science and management meetings, and content analysis of key publications were important for triangulation which served to verify data collected from interviews, direct observations, and content analysis against each other. The three methods provided a means of supplementing and complementing the data collected from each method. The data obtained from the three methods were used to develop an understanding of the information pathways that enabled comprehensive understanding of the science-policy interfaces in DFO, NAFO, and FAO, and the role of information in the organizations at the present time.

The multiple case study approach comprising interlinked organizations that operate at different scales, i.e., national, regional, and international (DFO, NAFO, and FAO respectively) facilitated comparison and generalizations across the organizations. This nested hierarchical research design also contributed to the breadth of understanding of the role of information at the science-policy interface.

While the benefits of using mixed methods are apparent, it is also recognised that the research methods can introduce biases in the data collection and analysis. With regard to data collection, the research findings was contingent on individuals who were willing to participate in interviews. Furthermore, attendance at science and management meetings at which direct observations were conducted was opportunistic and was related to the scheduling of the internships in the organizations. Such meetings addressed specific science and management issues and could likely introduce potential biases in the data collection since the participants knew they were being observed. Open-ended questions provided the opportunity to probe or ask follow-up questions related to the direct observations to mitigate observer bias and also to yield additional information. With regard to the coding of interview responses and direct observations, attempts were made to reduce biases. For instance, the coding of anonymized interview transcripts was validated by an independent qualitative researcher to reduce biases in the data analysis.

8.3.2. Recommendations for Future Research and for the Organizations

The research examined the information pathways in operational decision-making in DFO and NAFO and the general information pathways of global policy-making in FAO. Access to higher level decision-makers and internal documentation to track scientific information use over time could reveal the information pathways at these decision-making levels. For instance, what is the role of scientific information in the DFO-NCR in national policy-making? Examining the pathways of information in different levels of decision-making would provide a broader perspective of the role information at the science-policy interface. Understanding the role of scientific information in policy-making in the upper levels of decision-making in the organization necessitates a similar case study being conducted in the DFO-NCR. While it is anticipated that senior managers and policy-makers may not be willing to answer questions on information use, direct observations of science and policy discussions, e.g., at the federal House of Commons and Senate committee meetings, could reveal the role of science in these decision-making groups.

Studying the role of knowledge networks in the science-policy interface in the organizations can add other dimensions to understanding their information pathways. Such studies can reveal the networks in the information pathways and identify the critical actors that connect groups within the policy-making network. Network analysis can reveal greater detail about the characteristics of overlapping memberships among the organizations.

The typology of information use with 12 key characteristics that indicate an effective functioning interface could assist future studies aimed at understanding information pathways in governmental organizations (see Table 18 in Chapter 7, p. 274). Such a methodology can be applied to governmental organizations in other fields of resource or environmental management. A set of indicators and metrics could also be developed for each of the 12 characteristics to be used in interviews of key actors.

Based on the knowledge gained on the information pathways in DFO, NAFO, and FAO these organizations can evaluate or modify their production and communication practices to increase the credibility, relevance, and legitimacy of their information and increase its uptake in decision-making. Specific conclusions have been provided at the end of each case study (see Chapters 4 through 6). The following key recommendations include:

1. Attention should be placed on the factors influencing the production and communication of scientific advice and its use in national policy-making since these factors can influence the information pathways in the regional and international levels.

Since multiple science-policy interfaces exist within each organization and among the three organizations, a range of factors – social, economic, political, and others – can influence the information pathways. For example, for Canada, austerity measures being faced by DFO, e.g., limited resources for research and travel for collaboration on joint assessments, can weaken the contribution of scientific information by Canada as a Contracting Party to NAFO. These challenges at the national level can have a direct impact on the success of NAFO in maintaining its mandate.

2. Efforts to modify the organizational structures and cultures to incorporate ecosystem science and advice in decision-making must be continued.

Communicating ecosystem advice is challenging in DFO and NAFO because the demand for scientific information is still driven by the need to manage fisheries and not ecosystems. Scientific uncertainty in ecosystem science is considered to be greater than the uncertainty associated with fisheries science and it is interpreted differently.

Specifically, in NAFO, ecosystem science and advice will be given more weight in the Scientific Council's advice to the Fisheries Commission if the current Working Group on Ecosystem Assessments is transformed to a Standing Committee. In DFO, scientists and managers believe that more interaction from the policy and economics sector will improve their understanding of the policy actions in the DFO-NCR with regard to EAF and decision-making outside of the CSAS process.

3. Changes must be made to facilitate the production and use of scientific information for future decision-making with a growing demand for fisheries science and management that incorporates climate change considerations.

Such changes can facilitate the inclusion of additional sources of information, apart from that produced by the organization, in decision-making for fisheries management. Particularly with regard to DFO and NAFO, relying on information produced within the DFO CSAS process and the FC request for advice can mean that other important issues or information are ignored.

Specifically, in DFO, immediate review of its organizational structures is needed, e.g., the CSAS process, to facilitate the supply of relevant scientific advice. The CSAS process may provide the framework for engaging with industry to initiate discussions on management adaptations in the face of climate change.

4. FAO can strengthen its role as a boundary organization by increasing the level of attention given to communication of its information products.

A defined plan is needed for communication of FAO's information to member countries. This plan should include a dedicated fisheries communications staff in FAO's Fisheries and Aquaculture Department and a program to monitor or measure the use and impacts of its information on national, regional, and international policy-making.

REFERENCES

Alcock, F. (2004). The institutional dimensions of fisheries stock assessments. *International Environmental Agreements, 4*(2), 129-141.

Anastas, J. W., & MacDonald, M. L. (1994). *Research design for social work and the human services.* New York: Lexington Books.

Aps, R., Fetissov, M., Holmgren, N., Norrstrom, N., & Kuikka, S. (2012). Fisheries management: From linear to collaborative science-policy interface. *Management of Natural Resources, Sustainable Development and Ecological Hazards, 3*(148), 3-14.

Ascher, W., Steelman, T., & Healy, R. (2010). *Knowledge and environmental policy: Reimagining the boundaries of science and politics*. Cambridge, MA: MIT Press.

Aucoin, P., Smith, J., & Dinsdale, G. (2004). *Responsible government*. Ottawa: Canadian Centre for Management Development.

Avdic, V. (2013). Measuring use and influence: An assessment of the FAO's flagship report *The State of World Fisheries and Aquaculture*. (Unpublished Master's thesis). Dalhousie University.

Bardach, E. (2004). *A practical guide for policy analysis: The eightfold path to more effective problem solving.* Washington: CQ Press.

Barry, D., Applebaum, B., & Wiseman, E. (2014). *Fishing for a solution: Canada's fisheries relations with the European Union 1977 - 2013*. Calgary: University of Calgary Press.

Bianchi, G. (2008). The concept of the EAF in FAO. In G. Bianchi & H. R. Skjoldal (Eds.) *The ecosystem approach to fisheries* (pp. 20-37). Rome: FAO.

Bogenschneider, K., Olson, J. R., Linney, K. D., & Mills, J. (2000). Connecting research and policymaking: Implications for theory and practice from the family impact seminars. *Family Relations, 49*(3), 327-339.

Bremer, S., & Glavovic, B. (2013). Mobilizing knowledge for coastal governance: Re-framing the science-policy interface for integrated coastal management. *Coastal Management, 41*(1), 39-56.

Brodhag, C., & Talière, S. (2006). Sustainable development strategies: Tools for policy coherence. *Natural Resources Forum, 30*(2), 136-145.

Bulkeley, H. (2005). Reconfiguring environmental governance: Towards a politics of scales and networks. *Political Geography, 24*(8), 875-902.

Bundy, A., Chuenpagdee, R., Jentoft, S., & Mahon, R. (2008). If science is not the answer, what is? An alternative governance model for the world's fisheries. *Frontiers in Ecology and the Environment 6*(3), 152-155.

Canadian Library Association. (CLA). (2014, February 18). *Statement regarding federal government library consolidation and closure*. Retrieved from https://www.cla.ca/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=14959

Canadian Science Advisory Secretariat. (CSAS). (2014). *Canadian Science Advisory Secretariat policy on distribution of publications*. Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/process-processus/PubDistribution-eng.html

Caplan, N. (1979). The two-communities theory and knowledge utilization. *American Behavioral Scientist*, *22*(3), 459-470.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., Jäger, J., & Mitchell, R. B. (2003). Science and technology for sustainable development special feature: Knowledge systems for sustainable development. *Proceedings of the National Academy of Science, 100*(14), 8086-8091.

Central Office of Information. (2012). *Social media guidance for government*. London: The Home Office. Retrieved from http://www.cabinetoffice.gov.uk/sites/default/files/resources/Social_Media_Guidance.pdf

Chasek, P., Downie, D., & Brown, J. W. (2014). *Global environmental politics* (6th ed.) Boulder, CO: Westview Press.

Cicin-Sain, B. & Knecht, R. W. (1998). *Integrated coastal and ocean management: Concepts and practices*. Washington, USA: Island Press.

Clark, R., & Holmes, J. (2010). Improving input from research to environmental policy: Challenges of structure and culture. *Science and Public Policy, 37*(10), 751-764.

Clark, W. C., Tomich, T. P., van Noordwijk, M., Guston, D., Catacutan, D., Dickson, N. M., McNie, E. (2011). Boundary work for sustainable development: Natural resource management at the Consultative Group on International Agricultural Research (CGIAR). *Proceedings of the National Academy of Sciences of the United States of America*. Retrieved from http://www.pnas.org/content/early/2011/08/11/0900231108.abstract

Clark, W. C., Mitchell, R. B., and Cash, D. W. (2006). Evaluating the influence of global environmental assessments. In R. B. Mitchell, W. C. Clark, D. W. Cash & N. M. Dickson (Eds.), *Global environmental assessments: Information and influence* (pp. 1-28). Cambridge: MIT Press.

Cochrane, K.L. (2002a). Fisheries management. In K. L. Cochrane. (Ed.), *A fishery manager's guidebook. Management measures and their application*. *FAO Fisheries Technical Paper, 424,* 1-20. Rome: FAO.

Cochrane, K.L. (2002b). The use of scientific information in the design of management strategies. In K. L. Cochrane. (Ed.), *A fishery manager's guidebook. Management measures and their application. FAO Fisheries Technical Paper, 424,* 95-130. Rome: FAO.

Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. Thousand Oaks: Sage.

Coll, M., Libralato, S., Pitcher, T. Solidoro, C., & Tuleda, S. (2012). Sustainability implications of honouring the Code of Conduct for Responsible Fisheries. *Global Environmental Change*, *23*, 157-166.

Contandriopoulos, D., Lemire, M., Denis, J. L., & Tremblay, E. (2010). Knowledge exchange processes in organizations and policy arenas: A narrative systematic review of the literature. *The Milbank Quarterly, 88*(4), 444-483.

Cossarini, D. M. (2010). *Marine environmental grey literature: A case study of the Gulf of Maine Council on the Marine Environment.* (Unpublished Master's thesis). Dalhousie University.

Cossarini, D. M., MacDonald, B. H., & Wells, P. G. (2014). Communicating marine environmental information to decision-makers: Enablers and barriers to use of publications (grey literature) of the Gulf of Maine Council on the Marine Environment. *Ocean & Coastal Management, 96*, 163-172.

Cossins, D. (2014, October 1). Setting the record straight. *The Scientist*. Retrieved from http://www.the-scientist.com/?articles.view/articleNo/41056/title/Setting-the-Record-Straight/

Costello, C., Ovando, D., Hilborn, R., Gaines, S. D., Deschenes, O., & Lester, S.E. (2012). Status and solutions for the world's unassessed fisheries. *Science, 338,* 517-520.

Curran, K., Bundy, A., Craig, M., Hall, T., Lawton, P., & Quigley, S. (2012). *Recommendations for science, management, and an ecosystem approach in Fisheries and Oceans Canada, Maritimes Region* (DFO Canadian Science Advisory Secretariat Research Document 2012/061). Retrieved from http://www.dfo-mpo.gc.ca/Csas-sccs/publications/resdocs-docrech/2012/2012_061-eng.pdf

Dankel, D. J., Aps, R., Padda, G., Rockmann, C., van der Sluijs, J. P., Wilson, D. C., & Degnbol, P. (2012). Advice under uncertainty in the marine system. *ICES Journal of Marine Science, 69*(1), 3-7.

Davies, H. T. O., Nutley, S. M., & Smith, P. C. (2000). *What works?: Evidence-based policy and practice in public services.* Bristol: The Policy Press.

Delaney, A., & Hastie, J. (2007). Lost in translation: Differences in role identities between fisheries scientists and managers. *Ocean & Coastal Management, 50*, 661-682.

Delaney, A. E., McLay, H. A., & van Densen, W. L. T. (2007). Influences of discourse on decision-making in EU fisheries management: The case of North Sea cod (*Gadus morhua*). *ICES Journal of Marine Science, 64*(4), 804-810.

Department of Internal Affairs. (2012). *Social media in government. High-level guidelines.* Wellington, New Zealand: Government Information Service, Department of Internal Affairs; 2011. Retrieved from http://webtoolkit.govt.nz/files/Social-Media-in-Government-High-level-Guidance-final.pdf

Department for International Development (DFID). (2008). Research strategy 2008-2013. *Working Paper Series on Research Communication*. London: DFID.

De Santo, E. M. (2010). "Whose science?" Precaution and power-play in European marine environmental decision-making. *Marine Policy 34*, 414-420.

DFO. (2009a). *A fishery decision-making framework incorporating the precautionary approach*. Retrieved from http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm

DFO. (2009b). *Sustainable fisheries framework*. Retrieved from http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm

DFO. (2013a). *Assessment of scallops* (Placopecten magellanicus) *in scallop production areas 1 to 6 in the Bay of Fundy* (DFO Canadian Science Advisory Secretariat Science Advisory Report 2013/001). Retrieved from http://www.dfo-mpo.gc.ca/library/348487.pdf

DFO. (2013b). *Guidance on implementation of the policy on managing bycatch*. Retrieved from http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/bycatch-guide-prise-access-eng.htm

DFO. (2013c). *Policy on managing bycatch*. Retrieved from http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/bycatch-policy-prise-access-eng.htm

DFO. (2014a). *Aquatic Climate Change Adaptation Services Program (ACCASP)*. Retrieved from http://www.dfo-mpo.gc.ca/science/oceanography-oceanographie/accasp/index-eng.html

DFO. (2014b). *Assessment of Nova Scotia (4VWX) snow crab* (DFO Canadian Science Advisory Secretariat Science Advisory Report 2014/033). Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2014/2014_033-eng.pdf

DFO. (2014c). *Canadian Science Advisory Secretariat (CSAS)*. Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm

DFO. (2014d). *Ecosystem management*. Retrieved from http://www.inter.dfo-mpo.gc.ca/Maritimes/Oceans/Ecosystem

DFO. (2014e). *Fisheries and Oceans Canada Maritimes Region overview*. Retrieved from http://www.inter.dfo-mpo.gc.ca/Maritimes/Oceans-Maritimes-Region-Overview

DFO. (2014f). *Frequently asked questions*. Retrieved from http://www.dfo-mpo.gc.ca/libraries-bibliotheques/FAQ-eng.htm

DFO. (2014g). *Integrated fisheries management plans*. Retrieved from http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/index-eng.htm

DFO. (2014h). *Large ocean management areas*. Retrieved from http://www.dfo-mpo.gc.ca/oceans/marineareas-zonesmarines/loma-zego/index-eng.htm

DFO. (2014i). *Management methods*. Retrieved from http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/index-eng.htm

DFO. (2014j). *Offshore ecologically and biologically significant areas in the Scotian Shelf bioregion* (DFO Canadian Science Advisory Secretariat Science Advisory Report 2014/041). Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/publications/sar-as/2014/2014_041-eng.pdf

DFO. (2014k). *Our organization*. Retrieved from http://www.dfo-mpo.gc.ca/about-notre-sujet/org/index-eng.htm

DFO. (2014l). *Science*. Retrieved from http://www.dfo-mpo.gc.ca/science/index-eng.htm

DFO. (2014m). *The facts on library consolidation at Fisheries and Oceans*. Retrieved from http://www.dfo-mpo.gc.ca/media/npress-communique/2014/20140107-en.html

DFO. (2014n). *The role of the Canadian government in the oceans sector*. http://www.dfo-mpo.gc.ca/oceans/publications/cg-gc/index-eng.htm

Dicks, L. V., Walsh, J. C., & Sutherland, W. J. (2014). Organizing evidence for environmental management decisions: A “4S” hieararchy. *Trends in Ecology & Evolution, 29*(11), 607-613.

Dilling, L., & Lemos, M. C. (2011). Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. *Global Environmental Change, 21*(2), 680-689.

Doern, G. B., & Reed, E. (2000). *Risky business-Canada’s changing science-based policy & regulatory regime*. Toronto: University of Toronto Press.

Doulman, D. J., & Swan, J. (2012). A guide to the background and implementation of the 2009 FAO agreement on port state measures to prevent, deter and eliminate illegal, unreported and unregulated fishing. *FAO Fisheries and Aquaculture Circular, 1074*.

Dunn, W. N. (1990). Justifying policy arguments: Criteria for practical discourse. *Evaluation and Program Planning*, *13*(3), 321-329.

Dutra, G., English, C., Gunawan, T., Hastings, J., Katz, L., Kelty, R., McField, M., Nunez, E., Obura, D., Ortiz, F., Quesada, M., Sivo, L., Stone, G. (2011). *Science-to-action guidebook*. Arlington, Virginia: Conservation International.

EIUI. (2015). *Investigating and enhancing the policy relevance of marine scientific information (especially grey literature) through multipartner collaboration*. Retrieved from http://eiui.ca/?page_id=678

Elsbach, K. D., Barr, P. S., & Hargadon, A. B. (2005). Identifying situated cognition in organizations. *Organization Science, 16*(4), 422-433.

European science policy on the move. (2013). *Report from the American Association for the Advancement of Science conference, Boston, February 14-18*. Retrieved from http://news.aaas.org/2013_annual_meeting/0216european-science-policy-on-the-move.shtml

FAO. (1993). *FAO agreement to promote compliance with international conservation and management measures by fishing vessels on the high seas*. Rome: FAO. Retrieved from http://www.fao.org/fishery/topic/14766/en

FAO. (1995). *Code of conduct for responsible fisheries*. Rome: FAO. Retrieved from http://www.fao.org/docrep/005/v9878e/v9878e00.htm

FAO. (1996). Precautionary approach to capture fisheries and species introductions. *FAO Technical Guidelines for Responsible Fishing, 2*. Rome: FAO.

FAO. (2001). *The Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem. Reykjavik, Iceland, 1-4 October, 2001. C 2001/INF/25*. Rome: FAO. Retrieved from ftp://ftp.fao.org/fi/DOCUMENT/reykjavik/y2198t00_dec.pdf

FAO. (2002). Guidelines on the ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fishing, 9*. Rome: FAO.

FAO. (2003). Fisheries management. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries, 4* (Suppl. 2).

FAO. (2009a). Information and knowledge sharing. *FAO Fisheries Technical Guidelines for Responsible Fisheries*. No. 12. Rome, FAO. 2009.

FAO. (2009b*). International guidelines for the management of deep-sea fisheries in the high seas*. Retrieved from http://www.fao.org/docrep/011/i0816t/i0816t00.htm

FAO. (2009c). Report of the expert consultation on international guidelines for bycatch management and reduction of discards. 30 November-3 December 2009, Rome. *FAO Fisheries and Aquaculture Report, 934*. Rome: FAO.

FAO. (2009d). Report of the twenty-eighth session of the Committee on Fisheries. 2-6 March 2009, Rome. *FAO Fisheries and Aquaculture Report, 902*. Rome: FAO.

FAO. (2010). Report of the technical consultation to develop international guidelines on bycatch management and reduction of discards, 6-10 December 2010. *FAO Fisheries and Aquaculture Report, 957.* Rome: FAO.

FAO. (2011a). *International guidelines on bycatch management and reduction of discards.* Rome: FAO.

FAO. (2011b). Review of the state of world marine fishery resources. *FAO Fisheries and Aquaculture Technical Paper, 569*. Rome: FAO.

FAO. (2011c). Report of the twenty-ninth session of the Committee on Fisheries. 31 January-4 February 2011, *FAO Fisheries and Aquaculture Report, 973*. Rome: FAO.

FAO. (2012). Report of the thirtieth session of the Committee on Fisheries. 9-13 July 2012, *FAO Fisheries and Aquaculture Report, 1012*. Rome: FAO.

FAO. (2013). *Basic texts*. Retrieved from http://www.fao.org/docrep/meeting/022/k8024e.pdf

FAO. (2014a). *About FAO*. Retrieved from http://www.fao.org/about/en/

FAO (2014b). *Aquatic Sciences and Fisheries Abstracts (ASFA)*. Retrieved from http://www.fao.org/fishery/asfa/thesaurus/en

FAO. (2014c). *Blue growth- unlocking the potential of seas and oceans*. http://www.fao.org/zhc/detail-events/en/c/233765/

FAO. (2014d). *Codex Alimentarius*. Retrieved from http://www.codexalimentarius.org/

FAO. (2014e). *Committee on Fisheries*. Retrieved from http://www.fao.org/cofi/en/.

FAO. (2014f). *Coordinating Working Party on Fishery Statistics (CWP)*. Retrieved from http://www.fao.org/fishery/organization/24536/en.

FAO. (2014g). *Deep–Sea high seas news*. Summer 2014. Rome: FAO.

FAO. (2014h). *FAO and regional fishery bodies*. http://www.fao.org/fishery/topic/16918/en

FAO. (2014i). *FAO major fishing areas: Northwest Atlantic (Major Fishing Area 21).* Retrieved from http://www.fao.org/fishery/area/Area21/en

FAO. (2014j) *Fisheries & Aquaculture Branch Librar*y. Retrieved from http://www.fao.org/fishery/topic/18054/en

FAO. (2014k). *Fisheries and Aquaculture Department*. Retrieved from http://www.fao.org/fishery/en.

FAO. (2014l). *Globefish*. Retrieved from http://www.globefish.org/homepage.html

FAO. (2014m). *Governing and statutory bodies*. Retrieved from http://www.fao.org/unfao/govbodies/gsbhome/gsb-home/en/

FAO. (2014n). *iMarine project*. Retrieved from https://i-marine.d4science.org/web/guest%3bjsessionid=0B79FC466B725BB7467B40A7A4A586D5

FAO. (2014o). *International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC)*. Retrieved from http://www.iamslic.org/

FAO. (2014p). Report of the FAO Workshop on the Global Database for Vulnerable Marine Ecosystems. Rome, 7–9 May 2014. *FAO Fisheries and Aquaculture Report No. 1093*. Rome. http://www.fao.org/3/a-i4209e.pdf

FAO. (2014q). *Report of the thirty-first session of the Committee on Fisheries, Rome, 9-13 June 2014*. Retrieved from http://www.fao.org/3/a-ML770e.pdf

FAO. (2014r). *Statutory bodies - Fisheries and Aquaculture Department*. Retrieved from http://www.fao.org/fishery/topic/2940/en

FAO. (2014s). *Strengthening global capacity to effectively manage areas beyond national jurisdiction linking global and regional/national processes*. Retrieved from ftp://ftp.fao.org/FI/brochure/GEF-ABNJ/ABNJ_Flyer_060714.pdf

FAO. (2014t). *The FAO strategic objectives*. Retrieved from http://www.fao.org/resources/videos/strategic-objectives/en/

FAO. (2014u). *The state of world fisheries and aquaculture 2014*. Rome: FAO.

FAO. (2014v). *VME database*. Retrieved from http://www.fao.org/in-action/vulnerable-marine-ecosystems/en/

FAO. (2014w). *Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication*. Retrieved from http://www.fao.org/fishery/ssf/guidelines/en

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 25(7), 739-755.

Garcia, S. M. (2008). Fisheries assessment and decision-making: Towards an integrated advisory process. In G. Bianchi & H. R. Skioldal (Eds.), *The ecosystem approach to fisheries* (pp. 158-196). Rome: FAO.

Garcia, S. M., & Cochrane, K. L. (2005). Ecosystem approach to fisheries: A review of implementation guidelines. *ICES Journal of Marine Science*, *62*, 311-318.

Garcia, S. M., Zerbi, A., Aliaume, C., Do Chi, T., & Lasserre, G. (2003). The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. *FAO Fisheries Technical Paper, 443*. FAO: Rome.

Glasziou, P., & Haynes, B. (2005). The paths from research to improved health outcomes. *Evidence Based Nursing, 8*, 36-38.

Global Partnership for Oceans (GPO). (2014). *Partners*. Retrieved from http://www.globalpartnershipforoceans.org/partners

Gluckman, P. (2013). The role of evidence in policy formation and implementation. A report from the Prime Minister's Chief Science Advisor. Auckland: Office of the Prime Minister's Science Advisory Committee.

Gluckman, P. (2014). *Evidence based policy: A quixotic challenge?* Address given at the invitation of the Science Policy Research Unit, University of Sussex, Brighton, UK. Retrieved from www.pmcsa.org.nz/wp-content/uploads/Sussx_Jan-21_2014_Evidence-in-policy-sPRU.pdf

Government of Canada. (2000). *A framework for science and technology advice: Principles and guidelines for the effective use of science and technology advice in government decision-making*. Retrieved from http://strategis.gc.ca

Government of Canada. (2011). *Guidelines for external use of Web 2.0.* Ottawa: Treasury Board of Canada Secretariat. Retrieved from http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=24835&section=text

Government of Canada. (2012). *Budget 2012*. Retrieved from http://www.budget.gc.ca/2012/home-accueil-eng.html

Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist*, *53*(1), 5-26.

Greenhalgh, T. R., Bate, G. P., Kyriakidou, O., Macfarlane, F., & Peacock, R. (2004). *How to spread good ideas: A systematic review of the literature on diffusion, dissemination and sustainability of innovations in health service delivery and organization*. London: National Co-ordinating Centre for NHS Service Delivery and Organisation R & D (NCCSDO).

GreyNet. (2015). *Grey literature- GreyNet. Grey literature network service*. Retrieved from http://www.greynet.org/greynethome/aboutgreynet.html

Guston, D. H. (2001). Boundary organizations in environmental policy and science: An introduction. *Science, Technology, and Human Values, 29*, 87-112.

Guston, D. H., Clark, W., Keating, T., Cash, D., Moser, S., Miller C., & Powers, C. (2000). *Report of the Workshop on Boundary Organizations in Environmental Policy and Science*. Rutgers University, 9-10 December 1999. The Environmental and Occupational Health Sciences Institute, Rutgers University, UMDNJ-RWJMS, and the Global Environmental Assessment Project. Retrieved from http://environment.harvard.edu:80/gea/pubs/huru1.html

Hallsworth, M., Parker, S., & Rutter, J. (2011). *Policy-making in the real world: Evidence and analysis*. London: Institute for Government.

Hanney, S. R., Gonzalez-Block, M. A., Buxton, M. J., & Kogan, M. (2003). The utilisation of health research in policy-making: Concepts, examples and methods of assessment. *Health research policy and systems, 1*(2), 1-28. Retrieved from: http://www.health-policy-systems.com/content/1/1/2

Hartley, T. W. (2010). Fishery management as a governance network: Examples from the Gulf of Maine and the potential for communication network analysis research in fisheries. *Marine Policy, 34*(5), 1060-1067.

Hartley, T. W., & Glass, C. (2010). Science-to-management pathways in US Atlantic herring management: Using governance network structure and function to track information flow and potential influence. *ICES Journal of Marine Science, 67*(6), 1154-1163.

Hastie, J. (2008). The role of scientific advice in the management of international fisheries. (Unpublished doctoral dissertation). UK: University of Essex.

Hauge, K. H. (2011). Uncertainty and hyper-precision in fisheries science and policy. *Futures, 43*(2), 173-181.

Head, B. W. (2008). Three lenses of evidence-based policy. *Australian Journal of Public Administration, 67*(1), 1-11.

Healy, R. G., & Ascher, W. (1995). Knowledge in the policy process: Incorporating new environmental information in natural resource policy-making. *Policy Sciences*, *28*, 1-19.

Heazle, M. (2004). Scientific uncertainty and the international whaling commission: An alternative perspective on the use of science in policy-making. *Marine Policy, 28*(5), 361-374.

Hellstrom, T., & Jacob, M. (2000). Scientification of politics or politicization of science? Traditionalist science-policy discourse and its quarrels with Mode 2 epistemology. *Social Epistemology, A Journal of Knowledge, Culture and Policy, 14*(1), 69-77.

Hemsley-Brown, J. (2004). Facilitating research utilisation: A cross-sector review of research evidence. *The International Journal of Public Sector Management, 17*(6), 534-552.

HLPE. (2014a). *HLPE - High Level Panel of Experts on Food Security and Nutrition*. Retrieved from http://www.fao.org/cfs/cfs-hlpe/en/.

HLPE. (2014b). *Sustainable fisheries and aquaculture for food security and nutrition*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2014. Retrieved from http://www.fao.org/3/a-i3844e.pdf

Hoag, H., (2012, March 30). Canadian budget hits basic science. Innovation wins over basic science and the environment. *Nature News*. doi:10.1038/nature.2012.10366

Holmes, J., & Clark, R. (2008). Enhancing the use of science in environmental policy-making and regulation. *Environmental Science & Policy, 11*, 702-711.

Holmes, J., & Lock, J. (2010). Generating the evidence for marine fisheries policy and management. *Marine Policy, 34*, 29-35.

Holmes J., & Savgard, J. (2008). Dissemination and implementation of environmental research– including guidelines for best practice. *Swedish Environmental Protection Agency Report, 5681*.

Hoydal, K. (2007). Viewpoint: The interface between scientific advice and fisheries management. *ICES Journal of Marine Science, 64*(4), 846-850.

Huberman, M. (1994). Research utilization: The state of the art. *Knowledge, Technology & Policy, 7*(4), 13-33.

Huitema, D., & Turnhout, E. (2009). Working at the science-policy interface: A discursive analysis of boundary work at the Netherlands Environmental Assessment Agency. *Environmental Politics, 18*(4), 576-594.

Hutchings, J. A., & Post, J. R. (2013). Gutting Canada's Fisheries Act: no fishery, no fish habitat protection. *Fisheries, 38,* 497-501.

Hutchings, J. A., Walters, C., & Haedrich, R. L. (1997). Is scientific inquiry incompatible with government information control? *Canadian Journal of Fisheries and Aquatic Sciences, 54*, 1198-1210.

ICES. (2013). Report of the Working Group on the Northwest Atlantic Regional Sea (WGNARS), 28 January- 1 February, 2013, Dartmouth, Canada. *ICES WGNARS Report 2013, ICES CM 2013/SSGRSP:03*. SCICOM Steering Group on Regional Sea Programmes (SSGRSP). Retrieved from http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGRSP/2013/WGNARS13.pdf

International Institute for Sustainable Development (IISD). (2014, April 2014). *Global Oceans Action Summit Bulletin, 186 (3).* IISD and the World Bank. Retrieved from http://www.iisd.ca/download/pdf/sd/crsvol186num3e.pdf

Irvine, J. R. (2009). The successful completion of scientific public policy: Lessons learned while developing Canada's Wild Salmon Policy. *Environmental Science & Policy, 12*, 140-148.

Jackson, W. (2003). *Methods: Doing social research.* Toronto: Prentice-Hall Inc.

Jasanoff, S. (1994). *The fifth branch: Science advisers as policymakers*. Cambridge, MA: Harvard University Press.

Jasanoff, S. (2010). Contested boundaries in policy-relevant science. *Social Studies of Science, 17*(2), 195-230.

Jentoft, S. (2004). Institutions in fisheries: What they are, what they do, and how they change. *Marine Policy*, *28*, 137-149.

Kahan, D. (2010). Fixing the communications failure. *Nature, 463*(7279), 296-297.

Keller, A. (2009). *Science in environmental policy: The politics of objective advice*. Cambridge, MA: MIT Press.

Knott, J., & Wildavsky, A. (1980). If dissemination is the solution, what is the problem? *Knowledge: Creation, Diffusion, Utilization 1*(4), 537-578.

Koetz, T., Farrell, K. N., & Bridgewater, P. (2011). Building better science-policy interfaces for international environmental governance: Assessing potential within the Intergovernmental Platform for Biodiversity and Ecosystem Services. *International Environmental Agreements: Politics, Law and Economics, 12* (1), 1-21.

Knol, M. (2010). Scientific advice in integrated ocean management: The process towards the Barents Sea plan. *Marine Policy, 34*(2), 252-260.

Kondracki, N. L., Wellman, N. S., & Amundson, D. (2002). Content analysis: Review of methods and their applications in nutrition education. *Journal of Nutrition Education and Behavior, 34*(4), 224-230.

Lackey, R. T. (2006). Science, scientists, and policy advocacy. *Conservation Biology, 21*(1), 12-17.

Landry, R., Amara, N., & Lamari, M. (2001). Climbing the ladder of research utilization: Evidence from social science research. *Science Communication*, *22*, 396-422.

Lalor, B. M., & Hickey, G. M. (2013). Environmental science and public policy in executive government: Insights from Australia and Canada. *Science and Public Policy, 40*, 767-778.

Lawrence, A., Houghton, J., Thomas, J., & Weldon, P. (2014, November 17). *Where is the evidence? Realising the value of grey literature for public policy & practice*. Swinburn Institute for Social Research, Melbourne, Australia. Retrieved from http://apo.org.au/research/where-evidence-realising-value-grey-literature-publi-policy-and-practice

Leedy, P., & Ormrod, J. E. (2013). *Practical research: Planning and design* (10th ed.) New Jersey: Prentice-Hall Inc.

Lemos, M. C. & Morehouse, B. J. (2005). The co-production of science and policy in integrated climate assessments. *Global Environmental Change, 15*(1), 57-68.

Levin, P. S., Fogarty, M. J., Murawski, S. A., & Fluharty, D. (2009). Integrated ecosystem assessments: Developing the scientific basis for ecosystem-based management of the ocean. *Plos Biology, (7)*1, 23-28.

Likens, G. E. (2010). The role of science in decision-making: Does evidence-based science drive environmental policy? *Frontiers of Ecology and the Environment, 8,* 1-9.

Lindblom, C. E. (1959). The science of "muddling" through. *Public Administration Review, 19*(2): 79-88.

Liverani, M., Hawkins, B., & Parkhurst, J. O. (2013). Political and institutional influences on the use of evidence in public health policy. A systematic review. *PLoS ONE, 8*(10). E77404.

MacDonald, B. H., Ross, J. D., Soomai, S. S., & Wells, P. G. (2015). How information in grey literature informs policy and decision-making: A perspective on the need to understand the processes. *The Grey Journal, 11*(1), 7-16.

MacDonald, B. H., Cordes, R. E., & Wells, P. G. (2004). Grey literature in the life of GESAMP: An international marine scientific advisory body. *Publishing Research Quarterly, 20*, 26-41.

Maxim, L., & van der Sluijs, J. P. (2011). Quality in environmental science for policy: Assessing uncertainty as a component of policy analysis. *Environmental Science and Policy, 14*(4), 482-492.

McNie, E. (2007). Reconciling the supply of scientific information with user demands: An analysis of the problem and review of the literature. *Environmental Science & Policy*, *10,* 17-38.

Mitchell, R. B. (2010). *International politics and the environment*. London: SAGE Publishing Ltd.

Mitchell, R. B., Clark, W. C., Cash, D. W., & Dickson, N. M. (2006). Information and influence. In R. B. Mitchell, W. C. Clark, D. W. Cash, & N. M. Dickson (Eds.), *Global environmental assessments: Information and influence* (pp. 307-338). Cambridge, MA: MIT Press.

Mol. A. P. J. (2008). *Environmental reform in the information age. The contours of informational governance.* New York: Cambridge University Press.

Morton, T. A., Rabinovich, A., Marshall, D., & Bretschneider, P. (2011). The future that may (or may not) come: How framing changes responses to uncertainty in climate change communications. *Global Environmental Change, 21*(1), 103-109.

Moynihan, D. P., & Landuyt, N. (2009). How do public organizations learn? Bridging structural and cultural perspectives. *Public Administration Review*, *69*(6), 1097-1105.

NAFO. (2004a). *Convention on future multilateral cooperation in the Northwest Atlantic fisheries*. Retrieved from http://www.nafo.int/about/frames/convention.html

NAFO. (2004b). *NAFO Precautionary Approach Framework*. NAFO annual meeting, September 2004. NAFO/FC Doc. 04/18, N5069. Retrieved from http://www.nafo.int/science/research/docs/fcdoc04-18.pdf

NAFO. (2009). Coral identification guide NAFO area. *NAFO Scientific Council Studies, 42*. Retrieved from http://www.nafo.int/publications/studies/coral-guide.html.

NAFO. (2010). Sponge identification guide NAFO area. *NAFO Scientific Council Studies, 43.* Retrieved from http://www.nafo.int/publications/studies/sponge-guide.html.

NAFO. (2011a). *NAFO performance review*. Dartmouth, Canada: NAFO.

NAFO. (2011b). *Roadmap for developing an ecosystem approach to fisheries for NAFO WGEAFM Report* (NAFO SCS 10/19). Dartmouth, Canada: NAFO.

NAFO. (2013a). *Report of the Fisheries Commission and its Subsidiary Body (STACTIC), 35th annual meeting*. 23 - 27 September 2013 Halifax, Nova Scotia, Canada. (NAFO/FC Doc. 13/30).

NAFO. (2013b). *Report of the General Council and its Subsidiary Body (STACFAD), 35th annual meeting*. 23 - 27 September 2013 Halifax, Nova Scotia, Canada. (NAFO/FC Doc. 13/7).

NAFO. (2013c). *Report of the sixth meeting of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WGESA)*. NAFO Headquarters, Dartmouth, NS, Canada 19 - 29 November 2013. (NAFO SCS Doc. 13/024).

NAFO. (2014a). *About NAFO*. Retrieved from http://www.nafo.int/about/frames/activities.html

NAFO. (2014b). *NAFO annual report 2013*. Retrieved from http://archive.nafo.int/open/ar/ar2013/AR2013.swf#p=16

NAFO. (2014c). *Northwest Atlantic Fisheries Organization conservation and enforcement measures.* Retrieved from http://www.nafo.int/fisheries/frames/cem.html

NAFO. (2014d). *Precautionary Approach - Chronology*. Retrieved from http://www.nafo.int/fisheries/frames/precautionary.html

NAFO. (2014e). *Publications by NAFO Scientific Council*. Retrieved from http://www.nafo.int/publications/frames/publications.html

NAFO. (2014f). *Report of Fisheries Commission and Scientific Council Joint Working Group on Risk-Based Management Strategies*. 5-7 February 2014, Halifax, Nova Scotia, Canada. (NAFO/FC-SC Doc. 14).

National Research Council (NRC). (2002). *Science and its role in the National Marine Fisheries Service*. Washington, DC: National Academy Press.

National Research Council (NRC). (2012). *Using science as evidence in public policy*. Washington, DC: The National Academies Press.

Nettleship, D. N., Gordon, D. C., Lewis, C. F. M., & Latremouille, M. P. (Eds.) (2014). *Voyage of discovery: Fifty years of marine research at Canada's Bedford Institute of Oceanography*. Dartmouth, Nova Scotia: BIO-Oceans Association.

Newman, J. & Tanguay, A. B. (2002). Crashing the party: The politics of interest groups and social movements. In J. Everitt, & B. O'Neill (Eds.), *Citizen politics: Research and theory in Canadian political behaviour* (pp. 387-412). Toronto: Oxford University Press.

Nursey-Bray, M. J., Vince, J., Scott, M., Haward, M., O'Toole, K., Smith, T., Harvey N. and Clarke, B. (2014). Science into policy? Discourse, coastal management and knowledge. *Environmental Science & Policy, 38*, 107-119.

Nutley, S., Walter, I., & Davies, H. T. O. (2007). *Using evidence: How research can inform public services*. Bristol: The Policy Press.

O'Boyle, R., & Jamieson, G. (2006). Observations on the implementation of ecosystem-based management: Experiences on Canada's east and west coasts. *Fisheries Research, 79,* 1-12.

Oberthür, S., & Gehring, T. (2004). Reforming international environmental governance: An institutionalist critique of the proposal for a world environment organization. *International Environmental Agreements: Politics, Law and Economics, 4*(4), 359-381.

OECD. (2000). *Knowledge management in the learning society*. Paris: OECD. Retrieved from http://ocw.metu.edu.tr/file.php/118/Week11/oecd1.pdf

Oh, C. H. (1997). Explaining the impact of policy information on policy-making. *Knowledge, Technology & Policy, 10*(3), 25-55.

Ouimet, M., Bédard, P., Turgeon, J., Lavis, J. N., Gélineau, F., Gagnon, F., & Dallaire, C. (2010). Correlates of consulting research evidence among policy analysts in government ministries: A cross-sectional survey. *Evidence & Policy*, *6*(4), 433-460

Owens, B. (2014, January 17). Canadian government accused of destroying environmental archives. *Nature News*, doi:10.1038/nature.2014.14539.

Pal, L. A. (2009). Policy instruments and design. In *Beyond policy analysis: Public issue management in turbulent times* (pp. 143-203). (4th ed.). Scarborough: Thompson Nelson.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. *Science, 279*, 860-863.

Pedwell, T. (2012, July 12). Scientists take aim at Harper cuts with “death of evidence” protest on Parliament Hill. *The Globe and Mail*. Retrieved from http://www.theglobeandmail.com/news/politics/scientists-take-aim-at-harper-cuts-with-death-of-evidence-protest-on-parliament-hill/article4403233/

Peterman, R. (2004). Possible solutions to some challenges facing fisheries scientists and managers. *ICES Journal of Marine Science, 61*(8), 1331-1343.

Petersen, A., Cath, A., Hage, M., Kunseler, E., & van der Sluijs, J. (2011). Post-normal science in practice at the Netherlands Environmental Assessment Agency. *Science Technology and Human Values*, *36*, 362-388.

Pielke, R.A. (2002). Policy, politics and perspective. *Nature, 416,* 367-368.

Pielke, R. A. (2007). *The honest broker. Making sense of science in policy and politics*. Cambridge: Cambridge University Press.

Pihlajamaki, M., & Tynkkynen, N. (2011). The challenge of bridging science and policy in the Baltic Sea eutrophication governance in Finland: The perspective of science. *Ambio, 40*(2), 191-199.

Raadgever, G. T. (2009). *Does collaboration enhance learning? The challenge of learning from collaborative water management research*. Delft, the Netherlands: VSSD Delft Academic Press. Retrieved from http://www.vssd.nl/hlf/f042.htm

Renn, O., Klinke, A., & van Asselt, M. (2011). Coping with complexity, uncertainty and ambiguity in risk governance: A synthesis. *Ambio, 40*(2), 231-246.

Rennie, M., & Leech, A. (2015, May 22). Government scientists should speak freely – sometimes. *The Globe and Mail.* Retrieved from http://www.theglobeandmail.com/globe-debate/government-scientists-should-speak-freely-sometimes/article24552056/

Rice, J.C. (2005). Implementation of the ecosystem approach to fisheries management – asynchronous co-evolution at the interface between science and policy. *Marine Ecology Progress Series, 300*, 25-30.

Rice, J. C. (2011). Advocacy science and fisheries decision-making. *ICES Journal of Marine Science, 68*(10), 2007-2012.

Roqueplo, P. (1995). Scientific expertise among political powers, administrations and public opinion. *Science and Public Policy, 22*(3), 175-182.

Rosenberg, A. A. (2007). Fishing for certainty. *Nature, 449*, 989.

Ross, J. D. (2015). *What do users want from a state of the environment report? A case study from the State of the Scotian Shelf Report*. (Unpublished master's thesis). Dalhousie University, Halifax.

Ross, J. D. & Breeze, H. (in press). What do users want from a state of the environment report? A Case Study of Awareness and Use of Canada's State of the Scotian Shelf Report. In B. H. MacDonald, S. S. Soomai, E. M. De Santo, & P. G. Wells (Eds.), *Science, information, and policy interface for effective coastal and ocean management*. Boca Raton, Florida: CRC Press, Taylor and Francis Group.

Runhaar, H., & van Nieuwaal, K. (2010). Understanding the use of science in decision-making on cockle fisheries and gas mining in the Dutch Wadden Sea: Putting the science-policy interface in a wider perspective. *Environmental Science & Policy, 13*(3), 239-248.

Sandstrom, A. (2010). Institutional and substantial uncertainty-explaining the lack of adaptability in fish stocking policy. *Marine Policy, 34*(6), 1357-1365.

Sarewitz, D. (2004). How science makes environmental controversies worse. *Environmental Science & Policy, 7,* 385-403.

Sarewitz, D. (2013). Science's rightful place is in service of society. *Nature, 502,* 595.

Sarewitz, D. (2014). Science should keep out of partisan politics. *Nature, 516*, 9.

Sarewitz, D., & Pielke, R. (2007). The neglected heart of science policy: Reconciling supply of and demand for science. *Environmental Science & Policy, 10*, 5-16.

Sarkki, S., Niemelä, J., Tinch, R., van den Hove, S., Watt, A., & Young, J. (2014). Balancing credibility, relevance and legitimacy: A critical assessment of trade-offs in science–policy interfaces. *Science & Public Policy, 41*(2), 194-206.

Sarkki, S., Tinch, R., Niemelä, J., Heink, U., Waylen, K., Timaeus, J., Young, J., Watt, A., Neßhöver, C., & van den Hove, S. (2015). Adding "iterativity" to the credibility, relevance, legitimacy: A novel scheme to highlight dynamic aspects of science–policy interfaces. *Environmental Science and Policy*, *54*, 505-512.

Schwach, V., Bailly, D., Christensen, A., Delaney, A. E., Degnbol, P., van Densen, W. L. T., . . . Wilson, D. C. (2007). Policy and knowledge in fisheries management: A policy brief. *ICES Journal of Marine Science, 64*(4), 798-803.

Scott, J. M., Rachlow, J. L., & Lackey, R. T. (2008). The science-policy interface: What is an appropriate role for professional societies? *Bioscience, 58*(9), 865-869.

Sharp, D. (2014, February). Writing on the wall in closing of federal libraries. *Carleton Now*. Retrieved from http://carletonnow.carleton.ca/february-2014/writing-on-the-wall-in-closing-of-federal-libraries/

Singh, G. G., Tam, J., Sisk, T. D., Klain, S. C., Mach, M. E., Martone, R. G., & Chan, K. M. A. (2014). A more social science: Barriers and incentives for scientists engaging in policy. *Frontiers in Ecology and the Environment, 12*(3), 161-166.

Somers, B. (2008). *Panel says scientific advocacy can help resolve important issues, warns of its misuse*. Washington, DC: American Association for the Advancement of Science (AAAS). Retrieved from http://www.aaas.org/news/releases/2008/0519stpf_advocacy.shtml

Soomai, S. S. (2009*). Information and influence in fisheries management: A preliminary study of the shrimp and groundfish resources in the Brazil-Guianas Continental Shelf*. (Unpublished master's report). Halifax: Dalhousie University.

Soomai, S. S., MacDonald, B. H., & Wells, P. G., (2011a). The 2009 state of Nova Scotia's coast report: An initial study of its use and influence. Halifax: Dalhousie University.

Soomai, S. S., MacDonald, B. H., & Wells, P. G., (2011b). The state of the Gulf of Maine report: An initial study of awareness, use and influence. Halifax: Dalhousie University.

Soomai, S. S., MacDonald, B. H., & Wells, P. G. (2013). Communicating environmental information to the stakeholders in coastal and marine policy-making. Case studies from Nova Scotia and the Gulf of Maine/Bay of Fundy region. *Marine Policy, 40*, 176-186.

Soomai, S. S., Wells, P. G., & MacDonald, B. H. (2011). Multi-stakeholder perspectives on the use and influence of "grey" scientific information in fisheries management. *Marine Policy 35*, 50-62.

Spillane, J. P., Reiser, B. J., & Reimer, T. (2002). Policy implementation and cognition: Reframing and refocusing implementation. *Review of Educational Research*, *72*(3), 387-431.

Stojanovic, T. A., Ball, I., Ballinger, R. C., Lymbery, G., & Dodds, W. (2009). The role of research networks for science-policy collaboration in coastal areas. *Marine Policy, 33*, 901–911.

Sullivan, P. J., Acheson, J. M., Angermeier, P. L., Faast, T., Flemma, J., Jones, C. M.,…Zanetell, B. A. (2006). Defining and implementing best available science for fisheries and environmental science, policy, and management. *Fisheries, 31*(9), 460-465.

Sutherland W. J. , Bellingan, L. , Bellingham, J. R. , Blackstock, J. J. , Bloomfield, R. M. , ... Zimmern, R. (2012). A collaboratively-derived science-policy research agenda. *PLoS ONE, 7*(3), e31824.

Teddie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioural sciences*. Thousand Oaks, California: Sage Publications, Inc.

Tribbia, J., & Moser, S. C. (2008). More than information: What coastal managers need to plan for climate change. *Environmental Science & Policy, 11*, 315-328.

Turner, C. (2014). *The war on science: Muzzled scientists and wilful blindness in Stephen Harper's government*. Canada: Greystone Books.

UNEP, FAO, IMO, UNDP, IUCN, World Fish Center, & GRID-Arendal. (2012). *Green economy in a blue world*. Retrieved from http://www.unep.org/pdf/green_economy_blue.pdf

UNEP & IOC-UNESCO. (2009a). *An assessment of assessments, findings of the group of experts. Chapter 2. Definitions and analytical framework*. Retrieved from http://www.unga-regular-process.org/images/Documents/aoa%20report_chapter%202.pdf

UNEP & IOC-UNESCO. (2009b). *An assessment of assessments, findings of the group of experts. Summary for decision makers.* Retrieved from http://www.unep.org/regionalseas/globalmeetings/12/wp04-assessment-of-assessments.pdf

United Nation (UN). (1972). Report of the United Nations Conference on the Human Environment. Stockholm, 5-16 June, 2015. New York: United Nations. Retrieved from http://www.un-documents.net/aconf48-14r1.pdf

United Nation (UN). (1982). *United Nations Convention on the Law of the Sea of 10 December 1982. Overview and full text*. Retrieved from http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm

United Nations (UN). (1992). Agenda 21. Rio declaration on environment and development. In *Report of the United Nations Conference on Environment and*

Development. Rio de Janeiro, UN Doc. A/CONF.151/26/Rev.1 (Vol. 1), Annex II. Retrieved from http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm.

United Nations (UN). (1995). *Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks.* United Nations conference on straddling fish stocks and highly migratory fish stocks. Sixth session, New York, 24 July - 4 August 1995. (A/CONF.164/37).

United Nations (UN). (2002). *Report of the World Summit on Sustainable Development: Johannesburg, South Africa, 26 August-4 September 2002*. A/CONF.199/20002. New York: United Nations. Retrieved from http://www.unmillenniumproject.org/documents/131302_wssd_report_reissued.pdf

United Nations (UN). (2012). *Resilient people, resilient planet: A future worth choosing*. Report of the UN Secretary General's high level panel on global sustainability. New York: United Nations. Retrieved from http://www.un.org/gsp/sites/default/files/attachments/GSP_Report_web_final.pdf

United Nations (UN). (2014). *United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea*. Retrieved from http://www.un.org/depts/los/consultative_process/consultative_process.htm

United Nations Department of Economic and Social Affairs (UN DESA). (2013a). *Expert group meeting on the science-policy interface*. Retrieved from https://sustainabledevelopment.un.org/?page=view&nr=471&type=13&menu=236

United Nations Department of Economic and Social Affairs (UN DESA). (2013b). *Summary. Expert group meeting on the science - policy interface.* Retrieved from https://sustainabledevelopment.un.org/content/documents/2075Summary%20of%20science-policy%20interface%20EGM_final.pdf

United Nations Environment Programme (UNEP). (2012). *21 issues for the 21st century: Results of the UNEP foresight process on emerging environmental issues*. Retrieved from http://www.globalfoodsec.net/static/text/Foresight_Report.pdf

United Nations General Assembly (UNGA). (2007). *Resolution 61/105 Sustainable fisheries, including the 1995 agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of Straddling fish stocks and highly migratory fish stocks, and related instruments.* UNGA/RES/61/105. Retrieved from http://www.un.org/Depts/los/general_assembly/general_assembly_reports.htm.

United Nations General Assembly (UNGA). (2012). *The future we want*. Sixty-sixth session, Agenda item 19: Sustainable development. A/66/L.56.

van Densen, W. L. T., & McCay, B. J. (2007). Improving communication from managers to fishers in Europe and the US. *ICES Journal of Marine Science, 64*(4), 811-817.

van den Hove, S. (2007). A rationale for science-policy interfaces. *Futures, 39*(7), 807-826.

van der Sluijs, J. (2005). Uncertainty as a monster in the science-policy interface: Four coping strategies. *Water Science and Technology, 52*(6), 87-92.

van der Sluijs, J. P., Petersen, A. C., Janssen, P. H. M., Risbey, J. S., & Ravetz, J. R. (2008). Exploring the quality of evidence for complex and contested policy decisions. *Environmental Research Letters, 3*(2), 1-9.

Van de Riet, O. (2003). *Policy analysis in multi-actor policy settings. Navigating between negotiated nonsense and superfluous knowledge*. (Doctoral dissertation). Delft University of Technology, the Netherlands: Eburon Publishers.

Vatn, A. (2005). Rationality, institutions and environmental policy. *Ecological Economics, 55*, 203-217.

Walter, I., Nutley, S., Percy-Smith, J., McNeish, D., & Frost, S. (2004). *Improving the use of research in social care. Knowledge Review 7*. Bristol: The Policy Press.

Wardekker, J. A., van der Sluijs, J. P., Janssen, P. H. M., Kloprogge, P., & Petersen A. C. (2008). Uncertainty communication in environmental assessments: Views from the Dutch science-policy interface. *Environmental Science & Policy, 11*(7), 627-641.

Watson-Wright, W. M. (2005). Policy and science: Different roles in the pursuit of solutions to common problems. *Marine Ecology Progress Series, 300*, 291-296.

Webster, J., & Collins, J. (2005). *Fisheries information in developing countries. Support for the implementation of the 1995 Code of Conduct for Responsible Fisheries*. Rome: FAO.

Weingart, P. (1999). Scientific expertise and political accountability: Paradoxes of science in politics. *Science and Public Policy, 26*(3), 151-161.

Weiss, K., Hamann, M., Kinney, M., & Marsh, H. (2011). Knowledge exchange and policy influence in a marine resource governance network. *Global Environmental Change, 22*(1), 178-188.

Weiss, C. H. (1977). Research for policy's sake: The enlightenment function of social science. *Policy Analysis, 3*(4), 531-545.

Weiss, C. H. (1979). Many meanings of research utilization. *Public Administration Review, 39*(5), 426-431.

Wells, P. G. (2003). State of the marine environment reports – a need to evaluate their role in marine environmental protection and conservation. *Marine Pollution Bulletin, 46*, 1219-1223.

Wells, P. G. (2013a). Editorial. Canadian aquatic science and environmental legislation under threat. *Marine Pollution Bulletin, 69*, 1-2.

Wells, P. G. (2013b). Editorial. Supporting science in Canada. *Proceedings of the Nova Scotian Institute of Science, 47*(2), 205-210.

Wells, P. G. (2014). Managing ocean information in the digital era – Events in Canada open questions about the role of marine science libraries. *Marine Pollution Bulletin, 83*(1), 1-4.

Williams, V., Eiseman, E., Landree, E., & Adamson, D. (2009). *Demonstrating and communicating research impact*. RAND Cooperation. Retrieved from http://www.rand.org

Wilson, D. C. (2009). *The paradoxes of transparency: Science and the ecosystem approach to fisheries management in Europe.* MARE Publication Series, 5. Amsterdam: Amsterdam University Press.

Wilson, D. C., & Delaney, A. E. (2005). Scientific knowledge and participation in the governance of fisheries in the North Sea. In T. S. Gray (Ed.), *Participation in fisheries governance* (pp. 319-338). Dordrecht: Springer.

Wilson, D. C, & Pascoe, S. (2006). Delivering complex scientific advice to multiple stakeholders. In L. Motos, & D. C. Wilson (Eds.), *The knowledge base for fisheries management* (pp. 329-353). Amsterdam: Pergamon Press.

World Bank & FAO. (2009). *Sunken billions. The economic justification or fisheries reform*. Retrieved from http://www.worldbank.org/en/topic/environment/brief/global-programme-on-fisheries-profish

Worm B., Barbier, E. B., Beaumont, N., Duffy, E., ...Watson, R. (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science, 314*, 787-790.

Worm, B., Hilborn, R, Baum, J., & others. (2009). Rebuilding global fisheries. *Science, 325*, 578-585.

WWF. (2014). *Living planet report 2014: Species, and spaces, people and places*. Retrieved from http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/

Yang, T., & Maxwell, T. A. (2011). Information-sharing in public organizations: A literature review of interpersonal, intra-organizational and inter-organizational success factors. *Government Information Quarterly, 28*(2), 164-175.

Ye, Y., Cochrane, K., Bianchi, G., Willmann, R., Majkowski, J., Tandstad, M., & Carocci, F. (2013). Rebuilding global fisheries: The World Summit Goal, costs and benefits. *Fish and Fisheries, 14*(2), 174-185.

Young, J. C., Watt, A. D. van den Hove, S., & the SPIRAL project team. (2013). *Effective interfaces between science, policy and society: the SPIRAL project handbook*. http://www.spiralproject.eu/content/documents.

Young, O. R. (2004). Institutions and the growth of knowledge: Evidence from international environmental regimes. *International Environmental Agreements: Politics, Law and Economics, 4*, 215-228.

Young, O. R. (2008). Institutions and environmental change. The scientific legacy of a decade of IDGEC research. In O. R. Young, L. A. King, & H. Schroeder (Eds.), *Institutions and environmental change: Principal findings, applications, and research* (pp. 3-46). Cambridge MA: MIT Press.

APPENDIX 1. Letter of Research Ethics Approval

DALHOUSIE UNIVERSITY
Research Services

Social Sciences & Humanities Research Ethics Board
Letter of Approval

October 22, 2013

Ms Suzuette Soomai
Graduate Studies\Graduate Studies

Dear Suzuette,

REB #: 2013-3093
Project Title: The Role of Fisheries Scientific Information in Policy-Making for Fisheries Management: An Example from Marine Bycatch Management

Effective Date: October 22, 2013
Expiry Date: October 22, 2014

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Sophie Jacques, Chair

APPENDIX 2. Letter of Informed Consent

INTRODUCTION

You are invited to participate in a research project being conducted by Suzuette Soomai, a doctoral student in the Interdisciplinary PhD Program at Dalhousie University, Halifax, Canada. The doctoral research project *"The Role of Fisheries Scientific Information in Policy-Making for Marine Fisheries Management"* is being conducted within the Environmental Information: Use and Influence (EIUI) research program based in the School of Information Management, Faculty of Management, Dalhousie University (www.eiui.ca). The doctoral research is supervised by Dr. Bertrum MacDonald, Professor of Information Management, Dalhousie University.

PURPOSE OF THE STUDY

The principal research question for the doctoral research is: What role(s) does fisheries scientific information fulfill in development of fisheries policy decisions and fisheries management. The main objective of the research is to determine how fisheries information is used in policy decisions by identifying instances where information is or can be used in fisheries policy development and management decisions.

STUDY DESIGN

To develop an understanding of the role(s) of fisheries scientific information in policy-making, case studies of three inter-related organizations – Food and Agriculture Organization of the UN (FAO), the Northwest Atlantic Fisheries Organization (NAFO), and the Canada Department of Fisheries and Oceans (DFO) – are being conducted.

The doctoral research will utilize interviews, direct observations, and content analysis to develop an understanding of information flows and how individuals in the policy-process use information in developing fisheries policy. Data collection will be completed during three-month internships within each of the case study organization.

The FAO, NAFO, and DFO are supporting this research through formal partnerships with the EIUI research program in studies about the awareness, use, and influence of their publications.

PARTICIPATION IN THE STUDY

You have been invited to participate in this study because of your role in production and communication of information and/or development of fisheries policy. If you agree to participate, you will be interviewed by the principal researcher, Suzuette Soomai, in person at a time convenient to you.

The interview will last for approximately 45 minutes. You will be asked questions about the pathways of scientific information and related activities associated with the development of fisheries policy. With your permission, the interview will be audio recorded. When a transcription of your interview has been completed by the interviewer, the audio recording will be erased. Should you prefer that the interview not be audio recorded, the interviewer will make notes of your responses during the interview. Following the interview, you will be sent a copy of the transcript of the recording or notes to verify your responses. You may be engaged with the research during the three-month period of the internship in the case study organization (FAO).

If you choose to participate, please e-mail me at suzuette.soomai@dal.ca. The attached **consent form 1** will be used as a record of your participation in the study and can be signed at the time of the interview. You will be asked to sign **consent form 2** after you complete an interview.

POSSIBLE RISKS

Participation in this study should be of minimal risk to you. The probability of any harm occurring because of disclosing information regarding your role in the fisheries policy process is no greater than risks encountered by you in your daily work life. Participation in the study is voluntary and you can withdraw at any time.

BENEFITS

It is anticipated that there will be benefits to the case study organizations as the research will generate substantial new data and information to advance understanding of the role of scientific information at the science-policy interface.

CONFIDENTIALITY AND ANONYMITY

With your permission, your responses to questions may be included in reports and publications arising from this research. Your anonymity will be guaranteed as any responses used will not be attributed to you. An alpha-numeric code rather than your name will be assigned to the transcript and notes from this interview. All transcripts and notes from this research will only be accessible to the principal investigator and her supervisor and will be retained in secured cabinets and on password-protected computers at Dalhousie University for five years after which they will be destroyed.

Questions

If you wish to obtain further information about this research, email the principal investigator, Suzuette Soomai (e-mail: suzuette.soomai@dal.ca; suzuette.soomai@fao.org).

If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study you may contact my supervisor, Professor Bertrum MacDonald at (902) 494-2472, bertrum.macdonald@dal.ca or Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics Administration, at (902) 494-1462, catherine.connors@dal.ca.

Suzuette Soomai

Faculty of Graduate Studies
Dalhousie University, Halifax,
Nova Scotia, Canada
Email: suzuette.soomai@dal.ca; suzuette.soomai@fao.org

CONSENT FORM 1

"The Role of Fisheries Scientific Information in Policy-Making for Marine Fisheries Management"

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in this study. I realize that my participation is voluntary and that I am free to withdraw from the study at any time.

Please indicate whether you agree to audio recording of the interview (as applicable):

☐ I agree to audio recording of the interview.

☐ I do not agree to audio recording of the interview.

____

Signature of Participant

____

Signature of Researcher

____

Date

CONSENT FORM 2

"The Role of Fisheries Scientific Information in Policy-Making for Marine Fisheries Management"

Having now completed the interview, I hereby consent to the conditions regarding any quotations from my interview outlined below.

Please indicate if you wish to be quoted (as applicable):

☐ I agree to the use of direct quotations from my interview in reports and publications arising from this research. I will not be identified as author of any direct quotations used from my interview.

☐ I do not agree to the use of direct quotations from my interview in reports and publications arising from this research.

____

Signature of Participant

____

Signature of Researcher

____

Date

APPENDIX 3. Interview Protocol for Scientists

(These generic questions were adapted during each case study.)

Questions for Scientists

A. Production of scientific information.

1. What is your role in the organisation?
    a) What is your role in the production of scientific information for fisheries management? How long have you acted in this role? Who do you report to?
2. How do you produce scientific reports?
    a) Describe the stages involved in the production of a report.
    b) Who requests advice? Who is the intended audience for your work?
    c) What are your data sources for assessments?
    d) Who do you consult or collaborate with in completing scientific assessments? Who validates research findings?
3. In your opinion, what drives the production of advice?

B. Communication of scientific information.

1. What mechanisms are used to distribute assessments?
    a) Is there a formal protocol for information production and dissemination within your organization?
    b) Where are reports deposited?
2. How do you disseminate scientific publications?
    a) Describe the stages involved in the dissemination of a publication.
    b) Who do you send copies of publications to? Who requests scientific information?
    c) What mechanisms are used to distribute information? What fora or events present opportunities for disseminating information?
    d) What types of products are developed for policy-makers and other audiences?

3. What are the mechanisms for communicating scientific advice to other scientists, i.e., at the national or regional levels?

a) What scientific working groups do you belong to? Is there a formal mechanism for communication of information within these groups?
b) What fora or events present opportunities for communication? How do scientists and policy-makers interact? Which groups do you share information with?
c) How do scientists seek out information? How do you share information? Who do you share information with?
d) Do you use the media or social media? How?

4. What are the mechanisms for communicating scientific advice to policy-makers i.e., at the national or regional levels?

a) How is information distributed from scientists to policy-makers? How do scientific research findings reach policy-makers? When do scientists communicate results to policy-makers? Who informs policy-makers on the scientific evidence? Is there a formal mechanism for communication of information to policy-makers?
b) Do policy-makers alert the scientific community about their priorities and concerns?
c) What fora or events present opportunities for communication? How do scientists and policy-makers interact?
d) Are there intermediaries in the flow of information from scientists to policy-makers? Who or what groups? What are the information seeking and sharing behaviours of these intermediaries?
e) Do you use the media or social media? How?

C. Use of scientific information in research and policy-making.

1. How do you use scientific information in your work?

a) Which publications did you use? How did you use them?
b) Do you use government publications or papers published in peer-reviewed journals in your work? How? Is there a preference? Why?

2. How is information from fisheries and ecosystem analyses used in decision-making?

APPENDIX 4. Interview Protocol for Decision-Makers (Managers and Policy-Makers)

(These generic questions were adapted during each case study.)

Questions for Decision-Makers (Managers and Policy-Makers)

A. Use of scientific information on in decision-making.

1. What is your role in the organisation?

    a) What is your role in policy and decision-making for fisheries management? How long have you acted in this role? Who do you report to?

2. How do you use scientific reports?

    a) What information do you require for decision-making? What are your data sources for decision-making? Do you use scientific information? Is the science presented in a format that can be used in decision-making? Describe the format.

    b) How do you use scientific advice in decision-making? What is the frequency of using scientific reports? Which publications did you use? How did you use them?

    c) How is information from fisheries stock assessments and from ecosystem analyses used in decision-making?

    d) Who do you consult or collaborate with to obtain scientific advice? Do you request scientific advice? How and though what mechanisms?

    e) Do you validate the scientific advice? Do you value the scientific evidence against other sources of advice?

    f) How did you interpret the scientific advice? Did it change your perception of issues? How?

    g) Do you use government publications or papers published in peer-reviewed journals in your work? How? Is there a preference? Why?

3. In your opinion, what drives the production of information?

B. Dissemination of scientific information.

1. What mechanisms are used to distribute advice?

   a) Is there a formal protocol for information production and dissemination within your organization? Where are reports deposited?

2. What are the mechanisms for receiving scientific advice from scientists at different levels, i.e., national, regional?

   a) Do policy-makers alert the scientific community about their priorities and concerns?

   b) Is there a formal mechanism for communication of information to policy-makers?

   c) What fora or events present opportunities for communication? How do scientists and policy-makers interact? How do policy-makers seek out information? How do they share information with other actors? Which groups do you share information with?

   d) Are there intermediaries in the flow of information from scientists to policy-makers? Who or what groups? What are the information seeking and sharing behaviours of these intermediaries?

   e) Do you use the media or social media? How?

3. What are the mechanisms for communicating scientific advice to other policy-makers at different levels, i.e., national, regional?

   a) What management groups do you belong to? Is there a formal mechanism for communication of information within these groups?

   b) Is there a formal mechanism for communication of information to senior decision-makers?

   c) What fora or events present opportunities for communication to the higher levels of decision-making? How do senior decision-makers seek out information?

   d) Are there intermediaries in the flow of information from managers to senior-decision-makers? Who or what groups? What are the information seeking and sharing behaviours of these intermediaries?

   e) Do you use the media or social media? How?

APPENDIX 5. Protocol for Direct Observations within the Case Study Organizations

1. How scientists share information with other scientists

a) Interactions among scientists during presentations of scientific reports (e.g., where scientists of different units sit in relation to each other, familiarity with other, who is the primary spokesperson in a group).

b) The types of documents that are produced (e.g., technical reports, reviews, summaries, printed and digital formats of documents).

c) Particular strategies for communicating scientific information and advice to other scientists in other jurisdictions, e.g., departmental, national, regional (e.g., organization's website, documents, meetings, news media, social media such as Twitter).

2. How scientists and policy-makers communicate

a) How scientists and policy-makers interact at the meetings (e.g., which scientists takes the lead in communicating with a policy-maker, and vice versa; who is the primary "go-to" person for advice or decision-making).

b) The types of documents or information products that were developed for policy-makers and other audiences (e.g., fact sheets, manager's summaries, documents produced by government scientists or non-governmental researchers).

c) Particular strategies for communicating scientific advice to policy-makers in other jurisdictions, e.g., departmental, national, regional, e.g., organization's website, documents, meetings, news media, social media such as Twitter).

d) Groups or people who may be acting as intermediaries between scientists and policy-makers. How these intermediaries receive and share information.

3. How policy-makers communicate with other policy-makers

a) How policy-makers interact at meetings (e.g., which DFO policy-maker takes the lead in communicating with other policy-makers at NAFO and FAO meetings).

b) The types of documents or information products that were developed by policy-makers for decision-making (e.g., policy notes, policy briefs).

c) Particular strategies for communicating scientific advice to policy-makers in other jurisdictions, i.e., departmental, national, regional (e.g., organization's website, documents, meetings, news media, social media such as Twitter).

d) Groups or people who may be acting as intermediaries between policy-makers (e.g., who is a manager, policy-maker, and decision-maker; what are their roles and are these groups different; how intermediaries receive and share information).

4. Drivers, enablers, and barriers of scientific information production, communication, and use

a) Management or research priorities and concerns raised by scientists (e.g., what are the concerns, whether concerns were made verbally or documented, period of time over which concerns were raised, whether concerns changed over time).

b) Management or research priorities and concerns raised by policy-makers (e.g., what are the concerns, whether concerns were made verbally or documented, period of time over which concerns were raised, whether concerns changed over time).

c) Identify other groups, apart from scientists and policy-makers, which enter into discussions (e.g., concerns raised by stakeholders, such as non-governmental organizations and the fishing industry).

5. Use of information and actors involved (Based on a spectrum of use, ranging from indirect to direct use in policy-making).

a) How scientists use information to develop scientific advice (e.g., what are the main data sources, who comprise the peer communities).

b) How policy-makers use the scientific advice (e.g., reports which cite the scientific advice, policy documents produced, who are the technical advisors, who are the decision-makers).

c) Understanding and communicating advice (e.g., which reports changed the actors' views of issues, which reports were shared with others, and the identity of these groups).

APPENDIX 6. Characteristics of the Case Study Organisations Related to Communication of Scientific Information

SUB-CATEGORY	DFO	NAFO	FAO
1. ORGANIZATIONAL STRUCTURE AND CULTURE			
Geographic scale	Local (DFO Maritimes Region – DFO-MR)	Regional (Northwest Atlantic)	Global
Departmentaliz-ation	Decentralised structure; Remote location of offices, e.g., DFO-MR, from the national capital region (DFO-NCR)	Constituent bodies – Scientific Council (SC) and Fisheries Commission (FC); Contracting Parties, e.g., Canada, represented by DFO	Highly centralised operation in FAO headquarters; Field offices
	Science and Management Sectors	Fisheries and ecosystem science working groups; Joint SC-FC working groups	Fisheries and Aquaculture Department; Regular program and extra-budgetary-funded projects
Key actors in information production, communication, and use	Main actors – scientists and managers; Extended peer community – includes industry, NGOs, academic institutions	Canada (Contracting Party) – Scientists and managers from DFO Newfoundland and Labrador (DFO-NLR) DFO-NLR and DF-NCR; Observers, e.g., NGOs and research institutions	Science and policy experts offering technical back-stopping to member countries; A diverse range of stakeholders – UN system, national fisheries agencies in the member countries, NGOs, civil society
	Clear distinction between scientists and manager		Neither scientists nor managers
Request for advice and its provision	Well-defined process for annual requests and science advice embedded in the organization		Indirect and direct pathways – over long time scales
	Advice provided only for management questions asked		Formal requests from member countries at the biennial COFI meeting and in the UN system
	Annual requests for advice		Asynchronous UN system
	Internal "peer review" of science advice		Technical advice and policy guidelines are produced by global experts

<table>
<tr><th>Sub-category</th><th>DFO</th><th>NAFO</th><th>FAO</th></tr>
<tr><td></td><td colspan="2">Evidence-based decision-making – management decisions are based on advice produced by the organization (grey literature)</td><td>Provides guidelines for national policy-making in member countries</td></tr>
<tr><td>Communication of science advice</td><td>Well-defined process - CSAS</td><td>Well-defined process – annual meeting, SC working groups</td><td>Acts as a boundary organization – connects science and policy groups</td></tr>
<tr><td rowspan="2">Decision-making</td><td colspan="2">Risk adverse at higher management levels</td><td rowspan="2">Characteristic of the UN system</td></tr>
<tr><td colspan="2">EAF policy preceded the science</td></tr>
<tr><td colspan="4">2. Different Motivations of Scientists and Managers</td></tr>
<tr><td rowspan="5">Trust relationships between scientists and managers</td><td colspan="2">Formal and informal communication among the two groups</td><td rowspan="5">FAO is acting as a boundary organization – staff are experts in various scientific fields and in policy; Staff play a bridging role with the science and decision-making communities in the member countries</td></tr>
<tr><td colspan="2">Personal trust and respect aspects may be unique to the DFO-Maritimes Region and facilitated by lengthy employment</td></tr>
<tr><td colspan="2">Managers have an increased understanding of science, i.e., they have science backgrounds and engage in iterative communication with scientists; Scientists have an increased understanding of management needs</td></tr>
<tr><td colspan="2">The decision-maker is separate from the management advice process</td></tr>
<tr><td colspan="2">Senior decision-makers have to be convinced by managers through formal communication</td></tr>
<tr><td rowspan="3">Communication</td><td colspan="2">Website – a main tool for communication</td><td>Website – a main tool; Various non-technical versions of scientific reports are produced</td></tr>
<tr><td>No social media used</td><td>Limited use of social media for events</td><td>Formal use of social media, e.g., Twitter</td></tr>
<tr><td>Inadequate efforts by the Communications Department to promote awareness of critical changes in DFO can lead to news media biases</td><td>Annual meeting’s press release; Contracting Parties are responsible for their communication with the relevant national stakeholders</td><td>Inadequate resources for communication – no dedicated staff;
Inadequate communication plans</td></tr>
<tr><td>“Bridgers”</td><td>Fisheries managers act as “bridgers” to link science and policy sectors; Ocean managers can link the science and management sectors</td><td>Establishment of joint scientists and managers working groups; Acts as a “bridger” between FAO and the national agencies, i.e., DFO</td><td>Acts as a boundary organization;

Staff are experts in various disciplines and adept at knowledge translation</td></tr>
</table>

SUB-CATEGORY	DFO	NAFO	FAO
3. PARADOX OF SCIENCE AND POLITICS			
Separation of between science and management	Different roles of scientists and managers: Scientists are expected to provide facts only, i.e., advice only – scientists do not give recommendations		Staff are neither managers or scientists but provide "technical backstopping"
	Managers develop recommendations based on the facts		Neutral position of a UN agency
	Maintains the credibility of the information and strengthens the perception that the science process is providing objective information to support management options		Acting as a boundary organization to connect science and policy-making groups
Austerity measures	Federal funding for research and staff is decreasing	Austerity measures in national agencies in the Contracting Parties affect the quantity and quality of work completed	Donors can push agendas (e.g., GEF); Donor funding growing as government contributions decrease
Political decision-making	Between policy-makers and industry	Between policy-makers and industry	In FAO member countries
4. SCIENTIFIC UNCERTAINTY			
Understanding of science	Scientific uncertainty is not considered to be a limiting factor in information use		Production of different formats (e.g., summaries)
	Managers and decision-makers understand the information that they receive		Multiple non-technical versions produced
Ecosystem science	Ecosystem advice is considered to have more uncertainty than fisheries advice from stock assessments		
Implementing EAF	Request for ecosystem advice in the CSAS process is low	Scientific Working Group to implement an EAF roadmap	Global guidelines and databases developed to assist member countries in implementing EAF
Authority of information	Managers and scientists used only their organization's information		Members view FAO as an authority
Attributes of information	Credible, legitimate, relevant		Credible, legitimate, but not always relevant to all member countries
	No explicit recognition of "information"		No explicit recognition of "information;" Use of the term "knowledge"
	Each organization is considered an authority based on its mandate		
5. EXTERNAL INFLUENCES			
Overlapping memberships	National, regional, and international policy-development		

SUB-CATEGORY	DFO	NAFO	FAO
Stakeholders	Importance of NGOs in the "peer review" in the CSAS process	NGOs can ensuring that the global dialogue on governance and management issues is included in national and regional advice	Important role of NGOs in disseminating knowledge from FAO publications to the fishing industry; role as project partners
Trade	Eco labelling		
Partnerships	University	Other RFMOs; FAO	RFMOs; NGOs – close link to industry and civil society