Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

C S A S — **S C C S**

Canadian Science Advisory Secretariat / **Secrétariat canadien de consultation scientifique**

Research Document 2012/061 / **Document de recherche 2012/061**

Maritimes Region / **Région des Maritimes**

Recommendations for Science, Management, and an Ecosystem Approach in Fisheries and Oceans Canada, Maritimes Region

Recommandations scientifiques et de gestion et approche écosystémique pour la région des Maritimes de Pêches et Océans Canada

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ISSN 1499-3848 (Printed / Imprimé)
ISSN 1919-5044 (Online / En ligne)

Canada

"Ecosystem management is not a rejection of an anthropocentric for a totally biocentric worldview. Rather it is management that acknowledges the importance of human needs while at the same time confronting the reality that the capacity of our world to meet those needs in perpetuity has limits and depends on the functioning of ecosystems."

- The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management (Christensen et al., 1996)

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Correct citation for this publication:

Curran, K., Bundy, A., Craig, M., Hall, T., Lawton, P., and Quigley, S. 2012. Recommendations for Science, Management, and an Ecosystem Approach in Fisheries and Oceans Canada, Maritimes Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/061. v + 48 p.

ABSTRACT

Over the past few decades, a need has emerged for ocean regulators to embrace a broader approach to management that recognizes the complexities of marine ecosystems, confounding negative effects of incompatible management decisions, and the role of humans as agents and recipients of change. This is reinforced by the increase in degraded marine ecosystems and ocean user conflicts observed throughout the world. In Fisheries and Oceans Canada, Maritimes Region, a major change initiative is underway that is bringing together the various Departmental sectors in the region to develop a mutual path forward for incorporating an ecosystem approach into their daily operations, which is founded on an ecosystem approach and integrated approach to management. An ecosystem approach to management is management that places the ecosystem in the forefront, whereby its thresholds of change beyond those deemed to be acceptable determine the nature in which a collection of human activities should be managed, so the ecosystem remains within an acceptable range. Integrated management is the coordinated management between ocean regulators, sectors, and stakeholders of all human activities in a management area, so human-ecosystem and human-human interactions can be anticipated, supported, prevented, or mitigated. The goal of this research document is to recommend practical changes in support of an ecosystem approach that is consistent with the Department's regional Ecosystem Approach to Management Framework. Recommendations consider the scientific experiences gained from the Gulf of Maine Ecosystem Research Initiative, as well as strategic policy directions of the Department.

RÉSUMÉ

Au cours des dernières décennies, la nécessité pour les organismes de réglementation des océans d'épouser une approche de gestion plus large tenant compte des complexités des écosystèmes marins, des effets négatifs de décisions de gestion incompatibles ainsi que du rôle de l'homme en tant qu'agent et bénéficiaire du changement s'est manifestée. Le besoin d'une telle approche est renforcé par la dégradation accrue des écosystèmes marins et l'augmentation des conflits entre les utilisateurs des océans observées à l'échelle planétaire. Dans la région des Maritimes de Pêches et Océans Canada, est en cours une initiative de changement importante rassemblant les divers secteurs ministériels de la région en vue de l'élaboration d'une voie commune à suivre pour l'adoption d'une approche écosystémique dans les opérations quotidiennes qui est fondée sur une approche écosystémique et intégrée en matière de gestion. Par une approche écosystémique en matière de gestion, on entend une gestion qui met l'écosystème au premier plan, dont les seuils de changement dépassant ceux jugés acceptables déterminent la façon dont un ensemble d'activités humaines devraient être gérées afin que l'écosystème soit dans un état acceptable. La gestion intégrée est une gestion coordonnée assumée par les organismes de réglementation des océans, les différents secteurs et les intervenants de toutes les activités humaines prenant place dans la zone de gestion, afin de prévoir, d'appuyer, de prévenir ou d'atténuer les interactions entre les humains et les écosystèmes et celles entre les humains. Le but de ce document de recherche est de recommander des changements pratiques appuyant une approche écosystémique qui cadre avec l'approche écosystémique régionale du Ministère relativement au cadre de gestion. Les recommandations tiennent compte de l'expérience scientifique acquise dans le cadre de l'initiative de recherche écosystémique du golfe du Maine de même que des orientations stratégiques du Ministère.

1.0 INTRODUCTION

Prior to the 1970s, impacts of human activities on the natural environment were not considered in a systematic manner in federal government planning, management, or decision-making (Weston, 1992). The result was often serious or irreversible damage to the natural environment, detrimental impacts to human health, social well being and the economy, and costly compensation and remediation assumed by government (Weston, 1992). To address these issues various management approaches that centre on the ecosystem have been proposed (Weston, 1992; Grumbine, 1994; Christensen et al., 1996; Gavaris et al., 2005; Gavaris, 2009). In 2012, however, governments are still confronting the notion of ecosystem management, as legislation remains in line with sector-based authorities and supported by a discordant permitting system (Rosenberg and Sandifer, 2009). Christensen et al. (1996) have suggested the challenge confronting ecosystem management has been the difficulty for governments to readily adapt to changing ecosystems and incorporate new information and approaches into management practices, while Grumbine (1991) noted the propensity for management sectors to compete characterizes a general lack of cooperation in government. Due to such disparities, disconnected government decisions continue to yield unintended consequences that are apparent in the degraded marine ecosystems and ocean user conflicts observed throughout the world (Griffis and Kimball, 1996; Pew Oceans Commission, 2003; United States Commission on Ocean Policy, 2004).

In a manner well-understood by most, ecosystems can be viewed as service providers. Supporting services are those that sustain functioning ecosystems (e.g. nutrient cycling), while provisioning services (e.g. natural resources), regulating services (e.g. atmospheric carbon sequestration), and cultural services (e.g. recreation) are those most familiar to humans (Millenium Ecosystem Assessment, 2005; Rosenberg and McLeod, 2005; McLeod and Leslie, 2009a). Historically, governments have focused on managing the provisioning services of marine ecosystems (McLeod and Leslie, 2009a). As the range of services marine ecosystems provide is better understood, recognizing that the benefits of many marine ecosystem services extend far beyond the reaches of the sea (the air we breathe), governments are becoming more attuned to the value of all ecosystem services that support each and every citizen, while continuing to support the management of those services of traditional importance to coastal communities (Pew Oceans Commission, 2003; United States Commission on Ocean Policy, 2004; Leslie and McLeod, 2007). In light of this, governments are moving towards an ecosystem approach and integrated approach to management as means to better coordinate management sectors, consider the broader scope of marine ecosystems and ocean users in their decisions, and, ultimately, enhance the productive capacity of marine ecosystems for future generations.

An ecosystem approach to management (EAM) (also known as ecosystem-based management) is management that places the ecosystem in the forefront whereby its thresholds of change beyond those deemed to be acceptable determine the nature in which a collection of human activities should be managed, so the ecosystem remains within an acceptable range. Integrated management (also known as integrated coastal and oceans management) is the coordinated management between ocean regulators, sectors, and stakeholders of all human activities in a management area, so human-ecosystem and human-human interactions can be anticipated, supported, prevented, or mitigated. For simplicity, the term ‘ecosystem approach’ is used hereafter to refer to a management style that abides by both an ecosystem approach and integrated approach to oceans management.

The primary goal of an ecosystem approach is the management of human activities that supports a viable marine ecosystem and its use by humans over the long term (Rosenberg and McLeod, 2005). At its core are the principles of sustainable development, precautionary approach, and adaptive management (DFO, 2002). Sustainable development is economic development of resources that meets the needs of the present generation, but does not compromise the ability of future generations to meet their own resource needs (Brundtland – Our Common Future, 1987). Implicit in sustainable development is a recognition that social, economic, and environmental factors are connected and must be considered collectively in decision making. In theory, the three dimensions of sustainability should be given equal weight in the decision making process. In practice, however, their application often reflects a hierarchy of priorities that confront decision-making authorities. A precautionary approach to management errs on the side of caution in decision making in the absence of scientific certainty. The absence of scientific certainty, however, shall not halt economic development provided that the risks associated with proceeding are evaluated and can be justified prior to a decision being made (Government of Canada, 2003). Last, adaptive management recognizes that the landscape of management is continually changing (e.g. new persons, new information, and changing ecosystems), and that management practices must be able to accommodate and respond to these changes (Holling, 1978; Walters, 1986).

No one management sector has the authority to manage all ocean users or has the expertise to understand the complexities of entire marine ecosystems (Grumbine, 1994; Rosenberg and Sandifer, 2009; Ottersen et al., 2011). In this sense, an ecosystem approach considers the whole of ecosystems and human activities together in context of the range of possible management alternatives – all of the components, functions, and services, including humans and their cumulative impacts, and how they should be managed (Christensen et al., 1996; McLeod et al., 2005; McLeod and Leslie, 2009a). There is consensus that at minimum an ecosystem approach consists of three core elements (see Leslie and McLeod, 2007): 1) common vision that supports coherence in decisions between management sectors; 2) collaborative structure that supports communication between management sectors and the provision of advice; and 3) sound information (inclusive across the natural and social sciences) that underpins the decisions being made (e.g. Grumbine, 1994; Westley, 1995; Christensen et al., 1996; Grumbine, 1997; Rice, 2005a; Leslie and McLeod, 2007; Kenny et al., 2009; Leslie and Kinzig, 2009; McLeod and Leslie, 2009b; O'Boyle and Worcester, 2009; Rosenberg and Sandifer, 2009). To be practical, application of these elements must respect and accommodate the institutional structure of the day.

Favourably, Fisheries and Oceans Canada (DFO, the Department) has much authority over Canada's oceans and ocean users, which places a large proportion of the most influential oceans-related management decisions in one Department. The Department, however, is functionally divided into separate management sectors (e.g. fisheries, fish habitat, species at risk, and oceans), which have their own operational mandates. The operational sectors are supported by advice from the Department's Science and Policy and Economics sectors. In DFO, significant thought has been given to ecosystem assessments, as well as practical frameworks and "operational" indicators, in support of an ecosystem approach to oceans management: Zwanenburg et al. (2002); Vandermeulen and Cobb (2004); O'Boyle et al. (2004); Choi et al. (2005); Gavaris et al. (2005); O'Boyle et al. (2005a,b), Rice and Rochet (2005); Frank et al. (2005); O'Boyle and Jamieson (2006); Zwanenburg et al. (2006); Bundy et al. (2008); Gavaris (2009); and Rice (2011), to cite a few. The list of publications only partly comprises the significant body of literature on this topic (see Bundy et al., 2008).

Many believe the present state of marine ecosystem science more than satisfies the requirements to begin implementing an ecosystem approach (Guerry, 2005; Rice, 2005a; Watson-Wright, 2005; Frid et. al., 2006; Leslie and McLeod, 2007; Murawski, 2007; Bundy et al., 2008; Link et al. 2011). The application of frameworks and science advice, however, is only gradually gaining traction in management, and based on this, institutional structure and functioning (and not scientific knowledge) may be the culprit behind slowed implementation of an ecosystem approach in government (see Rice, 2009). In fairness, government sectors continue to grapple with the meaning and implications of this approach (Watson-Wright, 2005), while politics and vested interests often influence the application of public policy and decision making (Murawski, 2007; Bundy et al., 2008; Leslie et al., 2008); albeit not always in a transparent manner.

Changes in management structure and functioning are a practical means to reform management practice. This is particularly true given the burden of proof needed to justify legislative and regulatory reform or major policy shifts in Canada: there is reluctance in government to facilitate change that may be disruptive to a stable management regime (Rice, 2005b; Watson-Wright, 2005). Mindful of the need for such change, and for building capacity, two initiatives established over the past few years in the DFO Maritimes Region (DFO Maritimes, the Region) are intended to inform institutional change in support of an ecosystem approach. First, an EAM framework "major change initiative" has brought together various sectors of DFO Maritimes (i.e. fisheries, fish habitat, species at risk, oceans, science, and policy and economics) to further advance a mutual path forward for implementing an ecosystem approach. Second, the Ecosystem Research Initiative (ERI), centred on the Gulf of Maine area, including the west Scotian Shelf, is a science-based research initiative focused on developing greater scientific insight into the components and functions of this already well-studied marine ecosystem. Themes of the Gulf of Maine ERI are: 1) influence of climate change on the oceanography and ecosystems of the Gulf of Maine area; 2) spatial patterns in benthic communities; and 3) quantification of the impact of ecosystem interactions on fishery harvest rates and dynamics of commercially-targeted and non-targeted species.

The goal of this research document is to propose practical recommendations that support implementation of an ecosystem approach in the DFO Maritimes Region, with consideration of how natural science and social science advice may be provided in a more integrated manner, supported by the broad scientific approach of the ERI program. First, the document reviews the shift in DFO towards an ecosystem approach for the management of Canada's oceans, with reference to the EAM Framework that has been developed in the Maritimes Region. Second, the document characterizes the conventional approach to science at DFO, and then describes the cross-discipline approach that has been applied to the Gulf of Maine ERI. Third, the document provides a synopsis of the Department's operational management sectors, and the legislation, policies, and programs that govern them. An overview of the DFO Science sector's Canadian Science Advisory Secretariat (CSAS) and the Policy and Economics (P&E) sector, as two common threads that can be better used to streamline the information needs of various management sectors, is also provided. Last, the document proposes the regional EAM Framework as the *common vision* for individual sectors in DFO Maritimes to inform more integrated, ecosystem-based decisions, with the Canadian Science Advisory Secretariat, and possibly the Policy and Economic and/or Oceans sectors, as the *collaborative* means by which management sectors confer and bring together a range of relevant *information* to inform Departmental decisions in the region. This research document was presented as a working paper at the DFO Maritimes Centre for Science Advice regional workshop entitled 'Ecosystem Research Initiative (ERI) Synthesis: How can Ecosystem Research Initiative Results be Incorporated into Management Processes and Advice?', held in Dartmouth, Nova Scotia, during October 25-27, 2011.

2.0 ECOSYSTEM APPROACH

The *Oceans Act* received Royal Assent in 1996, signalling a new direction for oceans management in Canada: sustainable; precautionary; ecosystem-based; integrated; and adaptable. Since that time, DFO has developed new programs for oceans management and has been working to incorporate the principles of the *Oceans Act* into its traditional management sectors. In essence, the *Oceans Act* serves to harmonize DFO's application of the *Fisheries Act*, *Species at Risk Act*, and *Canadian Environmental Assessment Act* (O'Boyle and Worcester, 2009). It is the basis for an ecosystem approach to oceans management.

In 2001, a national workshop was held with DFO scientists and managers to discuss a path forward for achieving an ecosystem approach (the workshop is commonly referred to as 'Dunsmuir I' – see Jamieson and O'Boyle, 2001). The workshop proposed three policy objectives as guidance: 1) productivity objective – conserve enough components and functions so that an ecosystem can play its historic role; 2) biodiversity objective – conserve enough components and functions to maintain the natural resiliency of an ecosystem; and 3) habitat objective – conserve physical and chemical properties, so as not to negatively affect ecosystem components and functions (see: DFO, 2004a). The objectives were viewed as starting points for characterizing marine ecosystems throughout Canada regardless of their complexity or location. At that time, Canada's oceans were being organized into large ocean management areas (LOMA) for planning and management purposes (DFO, 2002). It was envisioned that an ecosystem overview and assessment process would be used to build understanding of each LOMA, including the connections to human activities. The idea was to "unpack" the ecosystem objectives into site-specific, operational level conservation objectives that would guide management of the pressures confronting each unique LOMA (see: DFO, 2007a; DFO, 2008a).

As a theoretical illustration of the approach envisioned by DFO Maritimes, consider a marine ecosystem in which knowledge regarding all of its components and functions are well understood. The ecosystem overview constitutes the first phase of the ecosystem overview and assessment process. First, sub-ecosystem types, or ecotypes, in a management area are identified based on their unique physical, chemical, and biological properties. Second, species and their trophic levels in each ecotype are identified per season, to account for seasonal changes in species. Last, habitat requirements for each seasonal species per ecotype are evaluated. This step identifies the physical, chemical, and biological range of properties that are required for a species to succeed in its ecotype. Collectively, these three steps define the seasonal habitat profile for species in each ecotype. The seasonal habitat profiles for each ecotype, coupled with the knowledge of species that occupy them, define the different ecozones of the management area. In theory, the ecosystem overview should provide enough understanding of the ecosystem from which an ecosystem assessment can proceed. In practical terms, there are very few components in natural systems that can be traced throughout these logic steps.

An ecosystem assessment constitutes the second phase of the proposed ecosystem overview and assessment process. The assessment phase draws on knowledge from the ecosystem overview to identify the unique, sensitive, and vulnerable attributes per ecozone that can be used as ecological indicators of change for that ecozone. Ecological indicators may include socially-valued or economically-valued ecosystem components and functions, such as at-risk marine species population levels or commercial fish species biomass. The conservation needs for each ecological indicator define the conservation objectives of the assessment area. Last, human activities that exhibit a negative effect on each ecological indicator are identified – these are referred to as human-induced pressures. The threshold levels beyond which a human-induced pressure becomes harmful to an ecological indicator define the ecological reference points. In practice, ecological reference points can be defined along a continuum of ecological harm, from the onset of harm to the point of irreversible damage, with science advising where along this continuum ecological reference points best mark the need for a management response that is consistent with the conservation objective. Refer to DFO (2005a) for more information regarding Ecosystem Overview and Assessment Reports.

The ecosystem overview and assessment process was intended to identify the valued, sensitive, and vulnerable ecosystem components and functions in LOMAs, linking them to human-induced pressures and metrics beyond which changes to the local environment caused by human activities would be harmful to the marine ecosystem. From this perspective, the ecosystem defines the degree of human-induced change it can tolerate, regardless of whether the change is due to a pressure associated with a single human activity or the sum of pressures associated with several human activities (i.e. cumulative effects) – the threshold levels remain the same. Accordingly, threshold levels associated with environmental indicators guide the management and planning of human activities in the management area, hence, an "ecosystem approach" to oceans management. To make the ecosystem overview and assessment process tractable, DFO has focused its efforts on the identification of unique, sensitive, and vulnerable ecosystem components and functions (and associated pressures) in an attempt to prioritize important marine attributes, while also continuing to pursue more generalized ecosystem research (DFO, 2008b). The intent of this approach is to synthesize existing knowledge of an ecosystem, coupled with the identification of its ecologically and biologically sensitive areas (EBSA – see: DFO, 2004b; DFO 2009), ecologically and biologically significant species and community properties (EBSSCP – see: DFO, 2006), degraded areas, and sensitive and threatened species (Rice et al., 2007; Sadler, 2008). The identification of unique, sensitive, and vulnerable ecosystem components and functions provides the foundation for defining relevant conservation objectives and ecological indicators within a management context.

Dunsmuir I envisioned a holistic ecosystem approach (top-down approach) to oceans management, whereby marine ecosystems and human activities would be considered in their entirety to inform how individual DFO sectors (and other government partners) should manage at LOMA scales. The holistic, LOMA-based approach, however, has proven challenging for many reasons. Pragmatic challenges have included: 1) inherent variability associated with natural systems through time; 2) complexities associated with managing large and ecologically-diverse ecosystems that exhibit an assortment of human uses; and 3) immense coordination and resource requirements needed to manage and monitor vast ocean spaces. Institutionally, additional challenges have included: 1) varying interpretations of an ecosystem approach to oceans management and how it applies to different management sectors; 2) difficulty for management sectors to transcend traditional mandates in support of the more nebulous ecosystem approach to oceans management mandate (the latter often not tied to many sector-based business lines); and 3) resource constraints (e.g. funding and time) to participate in cross-sector initiatives (particularly those not linked to a sector's legislative mandate). These challenges and others are similar to those that have been observed in the United States, and elsewhere around the world, in other attempts to incorporate an ecosystem approach into oceans management (see Barnes and McFadden, 2008).

At a follow-up national workshop held by DFO in 2007, scientists and managers considered the Department's experiences in implementing an ecosystem approach to oceans management at the LOMA-scale. The follow-up workshop is commonly referred to as 'Dunsmuir II' (no proceeding was completed, although a summary report was provided to senior management). Given the challenges that confronted the LOMA-based approach, Dunsmuir II supported an alternative direction for an ecosystem approach that reduced application of the ecosystem overview and assessment process to the scale of management sectors and/or ecosystem sub-units (although broad-scale oceans management initiatives remain, such as Marine Protected Area network planning). That is, recognizing the challenges confronting the broad scale of LOMAs, Dunsmuir II concluded in an incremental ecosystem approach (bottom-up approach) whereby individual sectors would incorporate ecosystem considerations into management using a common assessment framework. The ecosystem overview and assessment approach proposed at Dunsmuir I, however, would remain the basis of the framework with, for the most part, only the scope of focus reduced. The intent of this approach is to simplify the level of complexity that is faced when trying to manage at broad ocean scales.

At present, DFO is considering a renewed direction for an ecosystem approach at the national level: the need for a national policy regarding an ecosystem approach was adopted in principle in June 2011 by the DFO Sustainable Aquatic Ecosystems Strategic Outcomes Committee. Specifics surrounding the national direction, and the role that regional efforts to date may play in informing national policy, are being formulated. Concurrently, a DFO Maritimes regional working group, consisting of representatives from the various Departmental management and advisory sectors, continues to advance an ecosystem approach through a regional EAM framework (see Appendix 1.0). The framework is intended to prompt consideration of a variety of marine ecosystem attributes and management strategies across the range of regional decisions. The framework has received concurrence by senior management in the Maritimes Region, with next steps being its incorporation into broader management practice. The framework has been presented to the DFO Maritimes Policy Integration Committee at a meeting in Dartmouth, Nova Scotia, in July 2008, as well as at the above-mentioned national DFO Strategic Outcomes Committee meeting in June 2011.

The Resource Management sector in DFO Maritimes has already begun implementing the regional EAM Framework by incorporating it into Integrated Fisheries Management Plans (IFMP). The purpose of IFMPs, which are used in all DFO regions, is to provide a planning framework for the conservation and sustainable use of fisheries resources and the process by which a given fishery will be managed for a period of time (see Section 4.1.1 for more information). New guidelines and a template for IFMPs were issued by the Department nationally in the winter of 2010 (DFO, 2010). In DFO Maritimes, the new IFMP template was modified to accommodate the regional EAM Framework, and a set of guidance notes, including “questions and answers” and worksheets, was prepared to help regional resource advisors consistently incorporate the framework into IFMPs. To date, the focus in Resource Management has been on documenting how fisheries are currently managed using the terminology and structure of the framework, as well as on identifying significant gaps in the management regimes. Over time, it is expected that resource advisors will work incrementally with other sectors and stakeholders to improve the IFMPs by addressing these gaps, strengthening the relationship between framework elements, and developing reference points and monitoring systems where needed. It is also expected that as implementation of the framework progresses, both in Resource Management and other sectors in the Region, there will be incremental improvements in the extent to which cumulative impacts are accounted for across sector-based management plans.

3.0 SCIENCE

3.1 CONVENTIONAL SCIENCE APPROACH

The DFO Science sector is tasked with providing science advice to its Clients in support of delivering DFO's strategic outcomes: 1) Economically Prosperous Maritimes Sectors and Fisheries; 2) Sustainable Aquatic Ecosystems; and 3) Safe and Secure Waterways. The Clients for science advice range from internal DFO clients (resource management, fish habitat management, species at risk, and oceans) and external clients such as the fishing industry (which is made up of multiple clients reflecting different sectors), aquaculture industry, marine-related energy industries, and the Canadian public. Under various national and regional science advisory processes over the past decade there has been increased attention on defining the scope and range of factors (attributes, indices, and threshold levels) that should be explicitly considered in ecosystem-based decision-making (see www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm). As yet, however, there is no comprehensive mechanism in the Department for acquiring, consolidating, interpreting, and providing integrated science information products that can be readily accessed directly by client sectors, in support of the recently-adopted incremental ecosystem approach in the DFO Maritimes Region.

Traditionally, DFO Science has been structured to support the diverse advice required by its Clients, while also being aligned with DFO's mission that spans a wide range of scientific disciplines: from chemistry to physical and biological oceanography, invertebrate and vertebrate (primarily fish and marine mammal) biology, marine ecology, and quantitative fishery stock assessment. The DFO Martimes Region houses two science-based research institutes: the Bedford Institute of Oceanography (BIO) in Nova Scotia and the St. Andrews Biological Station (SABS) in New Brunswick. At present, the Science sector at BIO consists of three Divisions focused on particular sub-regions of research: Ocean Sciences Division; Ecosystem Research Division; and Population Ecology Division. Similarly, SABS, which represents a separate Division within Maritimes Region, consists of three Sections: Aquaculture and Biological Interactions Section; Coastal Oceanography and Ecosystem Research Section; and Population Ecology Section.[1] Other DFO science-based institutes have similarly named divisions and/or sections:

Ocean Sciences Division, BIO

The mandate of the Ocean Sciences Division (OSD) is the study of variability of the ocean and its ecosystems at all temporal and spatial scales. Aside from making important contributions to the DFO strategic outcomes, OSD programs contribute to wider priorities of the federal government of Canada and of the international community. These national and international programs are directed at important societal issues that cut across federal departments in which the ocean plays an important role. Issues such as global climate, climate change, ocean weather, safe and environmentally-sustainable marine developments (e.g. offshore petroleum sectors), and coastal zone impacts of ocean phenomena (e.g. extreme events) fall into this category. The diverse scientific activities in OSD provide the basis for advice provided to and in collaboration with other government agencies, non-government organizations, commercial and industrial businesses, and the general public. A significant effort is also devoted to marine monitoring, which is a vital activity for describing, understanding, and forecasting the state of marine ecosystems, oceanic variability, and its

[1] At the time of publication, the DFO Science sector in the Maritimes Region was undergoing change in its organizational structure. The following characterization of DFO Science, however, remains a relevant illustration of the nature of research currently being undertaken at BIO and SABS with, in many instances, only divisional and sectional reporting structures likely to be changed.

effects on regional and global weather (which in turn may affect the safety of marine activities). The Division's research targets all three of DFO's strategic outcomes.

Ecosystem Research Division, BIO

The Ecosystem Research Division (ERD) resulted from a reorganization of the DFO Maritimes Science sector in 2005, when parts of OSD and the former Marine Environmental Sciences Division (MESD) were amalgamated. The Ecosystem Research Division is responsible for delivery of the DFO Maritimes component of the Environmental Science Program. Its mandate is to develop and apply interdisciplinary approaches to studying and monitoring marine and estuarine ecosystems in support of sound, policy-relevant advice for integrated management. The Division is comprised of two science sections and a Centre of Expertise (COE): 1) the Habitat Ecology Section (HES) studies the impacts of disturbances on fish habitat, carries out predictive research and monitoring on effects of habitat changes, and provides assessments of actual or potential damage to aquatic populations; 2) the Ocean Research and Monitoring Section (ORMS) monitors biological and chemical oceanographic conditions, collecting information by satellite and at-sea sampling, and also carries out research on ecological and biogeochemical processes in the water column; and 3) the Centre for Offshore Oil, Gas and Energy Research (COOGER) coordinates the Department's research into the environmental and oceanographic impacts of marine energy development, including offshore petroleum exploration, production, transportation, and renewable energy (e.g. tidal power). The Division's major monitoring programs focus on environmental and lower trophic level conditions of the inshore, Scotian Shelf and Gulf of Maine, and the Labrador Sea, as well as on Aquatic Invasive Species throughout the Maritimes region. Principal areas of research include climate, biodiversity, microbial ecology, and energy. The Division's research activities primarily target DFO's strategic outcome of Sustainable Aquatic Ecosystems, but also supports the outcome of Economically Prosperous Maritimes Sectors and Fisheries.

Population Ecology Division, BIO

The Population Ecology Division (PED) was also a product of the DFO Maritimes Science sector reorganization in 2005, when the former Marine Fish Division, Invertebrate Fisheries Division, and Anadromous Fish Division were combined in response to a broader client base seeking an increasing range of advice. The principal focus of its mandate is "to provide scientific knowledge and interpretation on marine vertebrate, marine plants, marine invertebrate, diadromous fish populations, species interactions, and ecosystem structure and functioning, to provide advice to fisheries managers, oceans managers, and stakeholders with respect to the effects of human activities and natural disturbances on these species and ecosystems, and to promote sustainable resource use and conservation" (PED Strategic Plan, 2008-2013). Over 60% of the research conducted by PED is related to fish population and community productivity. Other national research priority areas include ecosystem assessment and management strategies, habitat and population linkages, climate change and variability, and ecosystem effects of energy development. Regional assessments that provide scientific advice for fisheries management decisions are the primary advisory products of PED. This advice is largely provided through the Canadian Science Advisory Secretariat (see Section 4.2.1 for more information). The Division's research activities target primarily DFO's strategic outcomes of Economically Prosperous Maritimes Sectors and Fisheries Sustainable Aquatic Ecosystems. Its activities contribute to the provision of healthy and productive aquatic ecosystems and sustainable fisheries and aquaculture.

Aquaculture and Biological Interactions Section, SABS

The multi-disciplinary approach to aquaculture research at SABS aims to enhance the economic and environmental sustainability of the Canadian aquaculture industry. Activities of the Aquaculture and Biological Interactions Section (ABI) include research on salmon culture, new finfish and shellfish species, multi-trophic aquaculture, oceanography, and environmental issues. In addition, a current focus is on the biological effects on various fish species of pesticides and contaminants associated with the aquaculture industry.

Coastal Oceanography and Ecosystem Research Section, SABS

The aim of the Coastal Oceanography and Ecosystem Research Section (COER) is to identify linkages between physical components (e.g. water temperature, salinity, and currents) and biodiversity components of the coastal marine ecosystem using a combination of field work, data analysis, and computer modelling. The Section's scientific research includes interactions between aquaculture and oceanographic conditions, advising the aquaculture industry on management areas to reduce its environmental impacts, benthic habitat mapping and biodiversity conservation approaches, monitoring phytoplankton, and aquatic invasive species.

Population Ecology Section, SABS

The main activities of the Population Ecology Section (PES) provide scientific advice for fisheries management and the Species at Risk program. It is similar to PED at BIO, although its primary geographic focus is the Gulf of Maine Area.

Typically, DFO Science Divisions and their component Sections have largely operated individually, each fulfilling their own mandates and missions in addressing the range of specified Client sector needs. To more fully understand the structure and functioning of Canada's marine ecosystems, however, and in order to provide the appropriate advice required by clients while adhering to DFO's mission, DFO Science needs to study the oceans from the interactive, interdisciplinary, and trans-disciplinary perspective inherent of an ecosystem approach. In applying the current DFO Canadian Science Advisory Secretariat (CSAS) advisory model to meet the now more clearly articulated requirement for integrated science in support of an ecosystem approach, a retrospective review of prior advisory structures, such as those under the DFO Canadian Atlantic Fisheries Science Advisory Committees (CAFSAC), may help inform multi-sectoral management requests for science advice that broaden the terms of reference of future science advisory meetings.

The CAFSAC model for developing science advice (CAFSAC preceded the present day CSAS – see Section 4.2.1) in the Atlantic Zone included integrative activities such as the Statistics, Sampling, and Surveys Subcommittee (SSSS), in addition to the subcommittees responsible for providing advice for groundfish fisheries, invertebrate fisheries, and marine mammals. The SSSS functioned from the mid-1980s. Most notably, its members and Chairs organized two very successful workshops: an Atlantic region workshop on retrospective trends in stock assessments (Atlantic Zone participants; see Sinclair et al., 1991) and an international workshop on risk evaluation and biological reference points for fisheries management (see Smith et al., 1993). The CAFSAC model also provided for more comprehensive and routine (in terms of annual stock assessment cycles) inter-regional interactions throughout the Atlantic zone. Stock assessment meetings under CAFSAC were typically structured as reviews of multiple stocks from different DFO Regions and, thus, benefited from contributions from stock assessment scientists working on a range of species in different ecological contexts. This was particularly the case with invertebrate stock assessment meetings that typically covered crab species, molluscan species, shrimp, and lobster stocks from across the Atlantic provinces. Due to many interacting factors, the advisory processes that have developed through the present day CSAS, although introducing a comprehensive national advisory model which enables greater consistency in regional application, has nonetheless led to stove piping whereby regional advisory processes often only provide for very limited cross-regional synthesis and peer review. Like CAFSAC before it, practical impediments such as cost, travel, and timeliness limit the ability of CSAS to facilitate integrated advisory meetings of broad scope.

The need for interdisciplinary approaches to science has been recognized by DFO senior management and, as part of DFO's science renewal, Ecosystem Research Initiative programs were launched nationally in 2008. There are many prior historical examples of cross-division research activities undertaken in the Maritimes Region, as well as earlier inter-regional research initiatives on particular strategic research topics. Some examples include: scientific contributions in support of Canada's claim to the International Court of Justice in the Hague regarding its border dispute with the United States; collaborative work on fish and habitat with Natural Resources Canada, DFO Newfoundland and Labrador Region, and the Canadian Hydrographic Service (CHS); projects funded under the Department's Strategic Science Fund such as Comparative Dynamics of Exploited Ecosystems in the Northwest Atlantic (CDEENA) and the Canadian Lobster Atlantic-Wide Studies; and a National Ecosystem Modelling Research Network known as EcoNet (DFO, 2008c). These prior interdisciplinary research experiences position DFO Science in the Maritimes Region to work in a more integrated fashion to more fully understand the structure and functioning of Canada's marine ecosystems. It is important to note that the common elements of success of these earlier interdisciplinary projects included a common funding source, shared goals, and strong leadership. The ERI is a recent example of a nationally-funded research program that brings researchers together to work on common goals from an interdisciplinary perspective.

3.2 ECOSYSTEM RESEARCH INITIATVE APPROACH

There is a long history of research on ecosystem processes in the Gulf of Maine; largely conducted by American scientists in U.S. waters. In the DFO Maritimes Region, the ERI was viewed as an opportunity to augment regional research programs that provide the scientific basis for achievement of productivity, biodiversity, and habitat-related objectives for an ecosystem approach in the Gulf of Maine area (GoMA). The area, like other ecosystems in the northwest Atlantic, has experienced changes in species and community composition, substantial declines in some commercial species, and threats due to invasive species. In parts of GoMA, groundfish biomass has declined, elasmobranches have increased, and overall fish size has decreased. Managers are asking to what extent these changes are the result of natural environmental changes or due to human exploitation. Managers and stakeholder communities around GoMA are also concerned about the cumulative impacts of all human activities on the ecosystem and the range of services it provides. There is the added concern regarding the implications of climate change. Given the emerging management issues, good historical databases available for developing baseline conditions, and potential for collaboration with U.S. colleagues on common ecosystem management issues, DFO Maritimes Region chose to focus its ERI on GoMA.

A point of discussion that emerged early on in the GoMA ERI is whether the Region should focus solely on what it presently monitors and can manage or if the scope of science and management needed to be broadened. Even for such a well studied marine ecosystem as the Gulf of Maine, the number of known species (presently a provisional total of 5569 - Incze et al., pers comm.) only represents a small and significantly skewed (towards larger marine organism sizes) portion of its overall biodiversity in the system. Perhaps of greater concern, the number of species routinely monitored is even further reduced, focused primarily on commercially-important species, bycatch species, at risk species, fecal coliform bacteria, and harmful algal blooms. Recent reviews regarding the level of understanding of the biodiversity in GoMA (Incze et al., 2010; Lawton et al., 2012), and a comparative assessment of several regional scale biodiversity programs internationally (Ellis et al., 2011), demonstrate emphasis on compositional and structural elements of biodiversity although, as yet, much uncertainty remains on how to manage marine system biodiversity with respect to retaining its functional elements. Clearly, ecosystem approach debates in management systems must focus on a subset of organisms and spatial and temporal scales of consideration at the expense of more complex system properties. It is important, however, to retain the perspective that these pragmatic considerations are nested within a broader set of questions on ecosystem structure and functioning. This helps focus management questions, yet leaves scope for the scientific research community as a whole to identify how their studies might contribute to current issues or identify novel approaches that may be incorporated into adaptive management practices (Lawton et al., 2012).

The overall goal of the DFO Maritimes ERI was to provide direction towards needed integration of science information and products in support of ongoing ecosystem overviews and assessments for integrated management (DFO, 2007b; DFO, 2008b). The GoMA ERI focused on three themes, adopting a thematic structure that encompassed a range of current management issues:

Theme I: Assess impacts of climate variability and climate change on the ecosystems of GoMA – led by OSD and ERD;

Theme II: Predict spatial patterns in benthic communities to assist management of human impacts – led by PED and COER; and

Theme III: Quantify the impacts of ecosystem interactions on harvest rates and dynamics of commercially-targeted and non-targeted species – led by PED and PES.

These themes directly addressed three priorities of DFO’s five-year agenda: Climate Change and Variability, Habitat and Population Linkages, and Fish Population and Community productivity. As such, the approach taken in the Maritimes Region ERI conforms to regional management’s adoption of a phased evolution of ecosystem overview and assessments through largely “bottom-up” approaches.

Based on the environmental scan of emerging priorities there was a decision to focus the Maritimes ERI predominantly on offshore portions of GoMA. In addition, the selection of research program areas was undertaken with consideration towards the likelihood for developing partnership-based approaches internally in the Department (e.g. link to Theme III on Ecosystem Modeling), with U.S. federal research in GoMA (e.g. link to Theme III on Ecosystem Modeling), and with the broader international community (e.g. link to Theme II on Census of Marine Life). Each theme enlisted scientists from multiple science divisions in the Region, resulting in new working relationships and synergies. As with any time-limited research program, the Maritimes ERI was not expected to deliver advisory products in a comprehensive manner across all aspects of an ecosystem approach; nor were new working relationships developed with the intent of forming the basis for internal reorganization of Science in the DFO Maritimes Region. The experience gained from undertaking the Maritimes ERI, however, was expected to inform such considerations.

Perhaps more fundamentally, the ERI has provided the framework and opportunity for DFO scientists at BIO and SABS to work together in an interdisciplinary fashion, with all but one (i.e. Aquaculture and Biological Interactions Section, SABS) of the six divisions/sections represented in the initiative. The three themes were led by two scientists from complementary disciplines and, in two cases, different research institutes. Regular meetings maintained good communication between theme leaders and themes. Although the initial objective of the ERI was to augment regional research programs, a second objective was to synthesize and integrate across the three themes to provide comprehensive science products. Theme leaders addressed the question of how ERI science can contribute to advice for an ecosystem approach and, in particular, to provide input into the DFO Maritimes EAM Framework (see Appendix 1.0).

The regional EAM Framework highlights differences between the disciplines involved in ERI and the facility with which they can be employed for management related science advice. There are essentially three forms that science advice can take, conceptual, strategic, and tactical. Conceptual advice provides science to further our understanding of the way that things work, that is, it addresses process-driven questions; strategic advice is linked to policy goals and tends to be long-ranged and broad based; tactical advice is shorter term and most familiar in the stock assessment world where quotas may be set on a seasonal to multi-year basis, depending on the stock and management requirements. Much of the science undertaken in ERI is most suited to the strategic and conceptual realms of science advice. A common issue facing researchers in the three themes of ERI during the formative stages of the program was the need to consolidate various scientific information streams encompassing available historical databases, derivation of new synoptic data products from existing environmental data coverage, and development of new analytical approaches. These are not described in detail here, although pertinent examples are provided in the other working papers presented at the ERI Maritimes regional advisory workshop, recently published departmental technical reports (e.g. Greenlaw et al., 2010; Araujo and Bundy, 2011; Shackell, 2012), and other scientific publications of the ERI Maritimes program (e.g. Brown et al., 2011; Johnson et al., 2011; Guénette and Stephenson, 2012).

Part of the challenge for ERI Maritimes scientists has been to understand the types of advice needed to inform application of the EAM Framework in management practice, and how to package it. The research in Theme I contained a component related to understanding present day physical and biological systems, as well as a component that considered possible future changes to these systems. Climate change is arguably one of the most significant environmental issues that will continue to confront the global community throughout this century. Theme I has identified the major natural modes of variability of key oceanographic and ecosystem features of GoMA, their linkage to larger scale processes in the atmosphere and ocean in the northwest Atlantic, and have considered the time-scales and extent of climate change in the region and its expected impacts on ecosystems. Theme I research also has shown that incorporating climate change into an operational EAM Framework is going to be a challenge, due in part to: 1) the inherent complexity of regional ecosystems and their response to environmental variability and 2) confounding anthropogenic pressures (e.g. fishing and habitat alteration) that influence the structure and functioning of ecosystems. It is apparent from Theme I results that over the short term and, of immediate concern to resource managers (years to a decade or so out), natural system variability and regional human-induced pressures are going to dominate the response of ecosystems in GoMA. Beyond a decadal-scale time horizon climate change is going to become a much more important factor.

Theme II has considered different approaches to benthic habitat mapping and the use of abiotic and biotic surrogates to predict spatial patterns. Through collaborations with scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), facilitated through the

Census of Marine Life, a new statistical approach has been developed to investigate the degree to which abiotic factors may explain benthic diversity patterns. Outputs of these analyses on GoMA are relevant to bioregional conservation planning (see Spatial Planning research document presented at the ERI Maritimes regional advisory workshop). Using a different set of analytical approaches to model benthic species distributions, new assessment approaches for scallop fisheries have been introduced relevant to bank-scale and habitat-explicit considerations in exploitation strategies (Brown et al., 2011; also see Resource Management research document presented at the ERI Maritimes regional advisory workshop).

The objectives of Theme III were to quantify the impact of ecosystem interactions on harvest rates and dynamics of commercially-targeted and non-targeted species using ecosystem models. Prior to this work, no multispecies or ecosystem models had been developed for NAFO Divisions 4X/5Y. Two ecosystem models of differing structure and complexity were developed under Theme III: a multispecies Virtual Population Analysis (VPA) focused on Southwest Nova herring (Guénette and Stephenson, 2012) and an Ecopath with Ecosim model for NAFO Division 4X (Araujo and Bundy, 2011). In addition, through the Canada-U.S. Ecosystem Working Group (CanUSE), and international collaborations with the U.S. Comparative Analysis of Marine Ecosystems (CAMEO) program (Link et al., 2011), Theme III contributed to the development of a suite of production models for 13 ecosystems. Together, these three modeling approaches provided tools with which to explore questions related to multispecies harvest rates and ecosystem structure, functioning, and response to environmental drivers. A challenge for such an approach is that ecosystem models have wider ranges of uncertainty then models traditionally used in single species stock assessment. This reflects the broader challenge of bringing the ecosystem into oceans management decisions: the realities of this challenge are being addressed in an interdisciplinary cooperative fashion through the ERI.

Canada has recently recognized climate change and its potential impacts as a national priority issue through the Government of Canada Federal Adaptation Policy Framework. Its goals are to “mainstream” climate change adaptation as a consideration for all aspects of the government’s business, explain climate change and its relevance to Canadians, and to provide the necessary knowledge and tools to adapt to change (and build resilience). The science conducted under the Maritimes ERI is an excellent precursor for this new initiative, having established working relationships and common understandings amongst the various divisions and sections at BIO and SABS. Thus, it is recommended that the science conducted under the Climate Change Adaptation Framework be interdisciplinary and build upon the lessons learned through the ERI. A range of additional recommendations is also listed below (see Chapter 5.0).

4.0 MANAGEMENT AND ADVICE

Fisheries and Oceans Canada and the Canadian Coast Guard deliver programs and services that support sustainable use and development of Canada’s oceans, waterways, and aquatic resources. The Department manages human activities in Canada’s oceans and waterways in accordance with the *Oceans Act*, *Fisheries Act*, *Species at Risk Act*, *Canadian Environmental Assessment Act*, *Canada Shipping Act*, and *Constitution Act*. Pursuant to the *Oceans Act*, DFO manages Canada’s oceans in a manner that balances the importance of marine conservation and economic prosperity. Pursuant to the *Fisheries Act*, DFO manages Canada’s fisheries resources and oversees the conservation and protection of fish and fish habitat. Last, pursuant to the *Species at Risk Act*, DFO oversees the conservation and protection of endangered or threatened aquatic species protected under the *Act*, including their critical habitat.

Management decisions made by the Department may be subject to the *Canadian Environmental Assessment Act* and the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals for Strategic Environmental Assessment. At present, program updates in DFO include Fisheries Renewal of fisheries management, Environmental Program Modernization Plan of fish habitat management and implementation of Aboriginal fisheries management, the Health of the Oceans Plan, and safe-guarding and recovery of aquatic Species at Risk. This section provides an overview of DFO's management programs: fisheries management program (excluding aquaculture management), fish habitat management program, species at risk management program, and oceans management program. It also describes the science sector's Canadian Science Advisory Secretariat and the Policy and Economics sector, which provide information support for decisions being made by the Region's management sectors.

4.1 MANAGEMENT SECTORS

4.1.1 Resource Management

The *Fisheries Act* is one of the oldest pieces of federal legislation (it was enacted in 1868 following Confederation in 1867). The *Act* grants the federal government authority to manage fishery resources in Canada through leasing and licensing. Today, the *Act* outlines conditions in which fishing and fisheries are undertaken in Canada, including general prohibitions and habitat protection and pollution provisions. For most fisheries (some are managed by other authorities), fish licences are issued by the federal Minister of Fisheries and Oceans pursuant to the discretionary authority granted under the *Act*. A 'fish licence' authorizes a holder to harvest certain fish species or marine plants subject to conditions attached to the licence (DFO, 1996). Licence conditions and management plans provide a controlled approach by which DFO manages fisheries. Examples of management tactics that can be implemented through fish licensing include: number of issued licences, setting of a total allowable catch, types of fishing gear and fishing practices, fishing locations (including closures or moratoria), vessel restrictions (e.g. size), and vessel capability (e.g. post-catch processing at sea). To maintain authority over Canada's fishery resources, fish licence conditions are subject to an expiration date, with licence condition renewal occurring on an annual basis.

In 1999, DFO launched the Atlantic Fisheries Policy Review, the purpose of which was to modernize the policy framework that governed the management of fisheries in the Atlantic Region of Canada. Phase 1 was a review of existing DFO policies that applied to fisheries management in the East. Phase 2, which has been subsumed within "Fisheries Renewal", is the implementation of the framework. Fisheries Renewal is a broad initiative that consolidates national and regional policies and reforms related to fisheries management. It has three long-term objectives for the fishery: 1) sustainability; 2) economic prosperity; and 3) improved governance. For more information regarding Fisheries Renewal see: www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/index-eng.htm).

The first objective of Fisheries Renewal, sustainability, is the objective under which the ecosystem approach and precautionary approach are largely being implemented in the Department's management of commercial, recreational, and Aboriginal fisheries. The key to implementation is the Sustainable Fisheries Framework. The framework houses existing and new policies related to the conservation and sustainable use of fisheries resources, as well as tools for assisting with implementation of the policies (integrated fisheries management plans) and tools for measuring and reporting on the sustainability of individual fisheries (fisheries "checklists"). The newest policies are: A Fishery Decision-making Framework Incorporating the Precautionary Approach (PA Policy); a Policy for Managing the Impacts of Fishing on Sensitive

Benthic Areas (SBA Policy); and a Policy on New Fisheries for Forage Species. Additional policies will be developed and added to the framework as required. For instance, a draft policy on fishery bycatch and discards was released for public consultation in January 2012. The consultation period is now closed and DFO is currently reviewing all public submissions. No timeline has been identified for finalizing the policy.

Policies of the Sustainable Fisheries Framework provide direction for developing management strategies that will enable DFO and harvesters to meet strong conservation outcomes. For example, the PA Policy, which aims to conserve harvested stocks, describes a decision-making framework that incorporates biologically-based reference points and harvest decision rules. It requires that uncertainty and risk be explicitly accounted for. The Forage Species Policy complements the PA Policy and draws attention to species below the top of the aquatic food chain and are important sources of food to higher trophic species. The Policy requires that fisheries be managed in a manner that conserves not only the forage species, but also predators that depend on them. The policy applies to new fisheries on forage species as well as, where significant changes in a management approach are being considered, to existing fisheries on forage species such as herring and shrimp. The SBA Policy is about conservation of habitat. It outlines a process for preventing fishing from causing serious or irreversible harm to benthic features that are ecologically and biologically significant. Last, consistent with the International Guidelines on Bycatch Management and Reduction of Discards recently released by the Food and Agriculture Organization of the United Nations (FAO, 2011), a domestic policy on bycatch is likely to require that incidental mortality be explicitly considered in fisheries management and the impacts of fisheries on non-targeted species be sustainable.

The Sustainable Fisheries Framework (i.e. the suite of conservation and sustainable use policies) and some aspects of the EAM Framework are being implemented through IFMPs – comprehensive management plans for each fishery that serve as a vehicle for implementing each of the frameworks. As outlined in national guidance, an IFMP serves two purposes: 1) set out a planning framework for the conservation and sustainable use of fisheries resources and the process by which it will be managed for a period of time; and 2) provide a process for integrating expertise and activities of DFO sectors (under the leadership of Resource Management) and for involving partners and stakeholders (DFO, 2010). Integrated Fisheries Management Plans can be evaluated using Fishery Checklists. As stated above, a Fishery Checklist is a tool developed under the Sustainable Fisheries Framework to help the Department track progress in implementing its conservation policies in individual fisheries. The Fishery Checklists are also being used to report externally on the Department's overall performance regarding fisheries management.

4.1.2 Fish Habitat Management

In DFO, impacts to fish and fish habitat are managed primarily through the Habitat Management Program (HMP), which relies on a number of key internal and external partners for program delivery. The DFO Habitat Management Program manages the impacts of human developments and non-fishing activities on fish and fish habitat, as well as supports fish habitat restoration through stewardship, outreach, and partnerships. Fish, as defined under the *Act*, include: parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals. Fish habitat is: those parts of the environment on which fish depend, directly or indirectly, in order to carry out their life processes.

The Department's fish habitat management program is guided by the Habitat Protection Provisions of the *Fisheries Act*, the DFO Policy for the Management of Fish Habitat (DFO, 1986), and supporting operational policies that, together, provide a comprehensive framework for the administration and enforcement of the Habitat Protection and Pollution Prevention Provisions of the *Fisheries Act*. This is supported by enforcement from the DFO Conservation and Protection sector, and externally, HMP works with Environment Canada in delivering its administration and enforcement responsibilities pursuant to the Pollution Prevention Provisions of the *Act*. Note that the effects of fishing on fish habitat are managed by the resource management sector of DFO (as discussed above), while the oceans management sector and marine species at risk management sector also contribute to the management of fish habitat (as discussed below).

The Habitat Protection Provisions of the *Fisheries Act* prevent anyone from carrying out, unless otherwise permitted under the *Act* (e.g. fishing), a work or undertaking in or near water that may prevent, alter, or reduce fish passage or water flow, kill fish by means other than fishing, or cause a harmful alteration, disruption, or destruction (HADD) of fish habitat.[2] The policy objective of the program is a net gain of fish habitat in support of Canada's fishery resources. The federal government recognizes that some works or undertakings, despite having unavoidable impacts to fish and fish habitat, are necessary for Canada's economic and social well-being. Thus, the policy objective offers flexibility in management that allows for the harmful alteration, disruption, or destruction of fish habitat provided that an equivalent form, and ideally an improved form, of fish habitat can be achieved through other means (e.g. habitat restoration).

Prior to the issuance of a permit to contravene the Habitat Protection Provisions of the *Fisheries Act* (known as a *Fisheries Act* authorization), proposed works or undertakings are required to undergo an environmental assessment pursuant to the *Canadian Environmental Assessment Act*. The *Canadian Environmental Assessment Act* outlines the types of works or undertakings that require an environmental assessment under the *Act*, and defines the process and considerations that need to be included in an environmental assessment. The general purpose of an environmental assessment is to evaluate the need for a work or undertaking prior to its occurrence, identify means to mitigate any harmful effects with consideration of any residual effects that may remain after mitigation, and to consider the need for monitoring and habitat compensation if detrimental effects to fish and fish habitat are unavoidable yet justifiable. A challenge that confronts the fish habitat management program is that each work or undertaking is assessed largely on its own merit (as per the legislation), which makes it difficult to consider the cumulative effects of small, project-based impacts on fish and fish habitat at a broader scale (e.g. habitat fragmentation within watersheds). Cumulative effects assessment is, however, a requirement of project-specific environmental assessments, despite practical challenges to effectively address them.

In support of management renewal, the DFO fish habitat management program launched an 'Environmental Process Modernization Plan' in 2004; an effort to balance the importance of the environment and economy in its management decisions. The objective of the Environmental Process Modernization Plan is effective and efficient reviews of proposed works and undertakings, in support of sustainable development and "smart" regulation. The plan is underpinned by a risk management framework that provides a systematic, science-based approach to assessing the likelihood and magnitude of effects of a proposed work or

[2] On April 24, 2012, the Minister of Fisheries and Oceans Honourable Keith Ashfield announced the Government of Canada will be introducing legislative amendments that will change how the Department protects fisheries and fish habitat under the *Fisheries Act*; focusing on recreational, commercial, and Aboriginal fisheries and supporting their ongoing productivity. Considerable concerns regarding how the amendments may weaken DFO's ability to protect fish habitat have been voiced in the media. Details surrounding any change will become available in the coming months and, as of publication of this manuscript, it remains too soon to comment on what such change will mean for DFO's Fish Habitat Management Program.

undertaking on fish and fish habitat. This is supported by Operational Statements for select works or undertakings considered to be of low risk to fish and fish habitat (e.g. culvert maintenance).

4.1.3 Species at Risk Management

The Government of Canada enacted the *Species at Risk Act* (SARA) in 2003 to provide for the legal protection of at risk species. Environment Canada is the lead federal authority responsible for protecting Species at Risk, although aquatic species fall under the purview of DFO. The purpose of the *Act* is to prevent wildlife from becoming extinct, extirpated, endangered, or threatened. This is achieved through general prohibitions that prevent the killing, harming, or harassing of species at risk (including the buying, selling, or trading of species) or damage or destruction of the residence of a species if it is reintroduced into the wild. In addition, critical habitat prohibitions make it illegal to destroy any part of a habitat that is critical to the recovery of a listed species in which it has been recommended to be reintroduced into the wild (conditions under this prohibition invoke limitations to its application). The *Species at Risk Act* sets out the process of assessment, listing, recovery planning, and protection of an at risk species in Canada. The purpose of the DFO species at risk program is to provide for the recovery and management of at risk aquatic species. In addition, the program manages species of special concern, with the aim that the status of these species will not continue to deteriorate.

Prior to the listing of a species pursuant to the *Act* it is first assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC – see www.cosewic.gc.ca) to determine threats to its survival, status (e.g. endangered), and priority for assessment (species proposed for de-listing under the *Act* are also assessed by COSEWIC). If an aquatic species is deemed to be at risk by COSEWIC, DFO Science undertakes a recovery potential assessment (of species listed as more vulnerable than that of 'special concern') to determine what is needed to recover the species if recovery is possible. If it is deemed recovery is possible DFO management puts forward a recommendation to the Governor in Council on how the species should be listed pursuant to the *Act*. The Governor in Council has final determination if a proposed species is to be listed pursuant to Schedule 1 (officially-listed at risk species), Schedule 2 (listed species to be reassessed against post-1999 criteria), or Schedule 3 (species of 'special concern') of the *Act*. A regulatory impact assessment statement must also be drafted by the appropriate federal authority to inform the Governor in Council's decision. In unforeseen circumstances, the *Act* also allows for an emergency listing of species.

Upon listing of an aquatic species, the DFO species at risk program commences a recovery planning process that adheres to timelines under the *Act*. For extirpated, endangered, and threatened species, recovery strategies and action plans are completed and posted to the SARA Public Registry, in some instances, within a year of listing (for more information regarding the SARA Public Registry see: www.sararegistry.gc.ca). For species of special concern, management plans are completed and also posted to the SARA Public Registry. Recovery strategies include information on habitat, details of protection measures, and an evaluation of socio-economic costs and benefits. Action plans complement recovery strategies by providing a framework in which to reasonably implement a recovery plan: measures to implement recovery, monitoring, costs and benefits of the action plan, and any other matters of relevance under the regulations. Imperative to the preparation of recovery strategies, action plans, and management plans is the inclusion of science advice, traditional knowledge, and public engagement in the recovery planning process.

4.1.4 Oceans Management

The DFO oceans management program operates, in the interest of Canadians, in support of Canada's *Oceans Act* (1996) and in part to the nation's commitment as signatory to the Convention on Biological Diversity (1992). The *Oceans Act* sets out in law principles of oceans management that apply to all federal authorities that have some form of oversight of Canada's oceans, its resources, and users. The *Act* also sets out specific commitments to be facilitated by the federal Minister of Fisheries and Oceans that support marine conservation and integrated oceans management. Three primary commitments outlined under the *Act* are: 1) develop a national strategy for managing Canada's oceans; 2) establish a national network of Marine Protected Areas; and 3) promote the integrated management of Canada's marine activities. In the late-1990s, the oceans management program was established to facilitate advancement of these commitments.

Canada's Oceans Strategy (2002) provides guidance on the management of Canada's oceans, founded on principles of sustainability, precaution, and inclusiveness. The strategy is accompanied by the Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada (2002), which outlines an operational framework in which to advance the integrated management of marine activities. Release of these documents fulfilled the first commitment of the federal Minister of Fisheries and Oceans under the *Act*. In 2005, Canada's Federal Marine Protected Areas Strategy was released, setting a direction for building a national network of marine protected areas (MPAs). Protected areas are one of many management tools that contribute to the improved health, integrity, and productivity of marine ecosystems. A marine protected area is a coastal or marine area given special status to conserve and protect its natural habitat and marine life. The marine protected areas strategy is supported by the establishment of protected areas throughout Canada, as well as more strategic conservation planning initiatives that are currently underway. Fisheries and Oceans Canada oversees a number of MPAs across Canada designated under the *Act*, and manages Coral Conservation Areas pursuant to the *Fisheries Act*. The oceans management program, in addition to the management of existing protected areas, is undertaking a systematic approach to identifying unique, sensitive, and representative areas in each of the marine bioregions across Canada (DFO, 2004b; DFO, 2008c). Marine conservation planning continues to advance the second Ministerial commitment under the *Act*.

As the conservation network planning initiative advances, consideration is being given to the utility of spatial planning as a means to identify human-ecosystem and human-human interactions, so that they can be managed through an integrated approach across regulatory sectors, levels of government, and industries. To date, DFO has facilitated the integrated management of marine activities in five LOMAs (see Section 2). The LOMAs were pilot management areas used to develop capacity and experience with implementation of an integrated approach to oceans management. The pilot approach was meant to encourage practitioners to develop their own means to achieve integrated management, while employing the principles, concepts, and approaches outlined in the operational framework to maintain some level of national consistency. Apart from discussion of shared experiences, integrated management initiatives in each LOMA have been developed independently. The LOMA-based integrated management initiatives advanced the third commitment of the federal Minister of Fisheries and Oceans pursuant to the *Act*. As recently announced, experiences gained from the LOMA pilots are transitioning into applicaton at the bioregional scale, with integrated management approaches beginning to be applied in the Department's day-to-day operations.

4.2 ADVISORY SECTORS

4.2.1 Canadian Science Advisory Secretariat

Science supports many policy and regulatory decisions of the Department. The Department is committed to quality, objectivity, and inclusiveness in its science advice. In the 1970s, DFO established the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC - see Section 3.1 for more information) to provide science advice in support of fisheries management decisions throughout Atlantic Canada. The committee ceased to exist in 1992, with only regional fishery science advisory processes and an Atlantic Document Secretariat being in place until 1996-1997. At that time, a Canadian Stock Assessment Secretariat (CSAS) was established at DFO Headquarters to provide national coordination to regional fishery science advisory processes. With promulgation of the *Oceans Act* (1996) and anticipated *Species at Risk Act* (2003), the science advisory questions being posed began to broaden beyond just stock assessment. This prompted a name change in CSAS to the Canadian Science Advisory Secretariat in 2001, which was only an update to what had become a inaccurate name for the Secretariat given the broader range of advice it was providing - the science advisory processes that characterized CSAS in 2001 were either well-established or under development by the time of its name change.

Throughout its evolution, procedures of the Secretariat were aligned with the Science Advice for Government Effectiveness (SAGE) Principles. In essence, the Principles call for: 1) early identification of the need for science advice; 2) inclusiveness of a range of experts in advisory processes (not limited to government); 3) sound and consistent science advisory processes; 4) consideration of uncertainty and risk of advice versus no advice; 5) transparency and openness in advice and decisions; and 6) review of science effectiveness and the decision making process (Government of Canada, 2000). The SAGE Principles were first put forward to Cabinet in 1999 by the Council of Science and Technology Advisors (Council of Science and Technology Advisors, 1999). In response, Industry Canada was tasked to integrate the principles into policy and, in 2000, the SAGE Principles were formally set out in the Government of Canada Framework for Science and Technology Advice: Principles and Guidelines for the Effective Use of Science and Technology Advice in Government Decision Making. The framework applies to all federal government departments and is cited in other Government of Canada policies including: Government of Canada's Framework for the Application of Precaution in Science-based Decision Making about Risk (2003) – Privy Council; and the Government of Canada Cabinet Directive on Streamlining Regulation (2007) – Treasury Board. Presently, DFO is the only government department with a Centre dedicated to upholding the SAGE Principles in the provision of its science advice, with CSAS informing application of the SAGE Principles in a federal science advisory context in the early days. Strengths of CSAS remain its consistent application of the SAGE Principles and independence from the decision making sectors of the Department (for more information regarding the Canadian Science Advisory Secretariat see: www.dfo-mpo.gc.ca/csas-sccs).

The Canadian Science Advisory Secretariat is located at DFO Headquarters in Ottawa. It is supported by regional offices, known as Centres for Science Advice (CSA). Both CSAS and CSA offices administer and coordinate the science peer review and provision of science advice to management on behalf of the DFO Science sector, while the peer review and science advice (including consideration of traditional ecological knowledge) comes from participants of the CSA science advisory processes (e.g. DFO scientists and other relevant experts from the management sectors, industry, non-government organizations, Aboriginal groups, and academics). The CSAS and CSA offices fall under the auspices of the DFO Science Branch. To plan for the provision of science advice, annually, CSAS places a call for requests for science advice to the various operational management sectors of the Department (e.g. fisheries, fish habitat, species at risk, and oceans). The requests for science advice are organized by topics of national, zonal, and regional interest, and a risk framework is applied to the requests to prioritize those that are of importance to Canadians and are achievable – the requests for science advice are considered against the risks of not providing advice. Risks are weighted in terms of the likelihood and magnitude of impact if advice is not provided with respect to: 1) a potential for harm to ecosystems, habitats, and/or species; 2) legal/regulatory incompliance assumed by the Department; 3) loss of public and stakeholder confidence; 4) failure to uphold Departmental priorities; and 5) a failure to uphold international commitments of the Department. The annual requests for science advice from the management sectors inform work planning of the Science sector.

If determined to be a priority, accepted requests for science advice are assigned a science review process depending on the nature and scope of the request (e.g. science advice in support of a major policy change versus a minor status update of a fishery stock). A national, zonal, and regional science advisory schedule is then posted to the CSAS website. The schedule includes contact information for each science advisory process to occur that year. The four types of science advisory processes are:

1. **Peer Review and Advisory Meetings (national, zonal, or regional in scope)** – the science advice reaches consensus by the meeting participants to inform a specific management decision (e.g. fishery reference points);

2. **Inclusive Review Workshops (national, zonal, or regional in scope)** – no science advice is provided, as the workshop is used to explore a relevant marine-related topic rather than inform a specific management decision (e.g. new approaches to environmental monitoring);

3. **Closed Review Workshops (national, zonal, or regional)** – no science advice is provided, as the workshop is used to explore a relevant DFO science/management topic rather than inform a specific management decision (e.g. review of in-house science initiatives – Ecosystem Research Initiative); and

4. **Science Special Responses (Regional)** –science advice reaches consensus from a small group of scientists, typically from DFO, to inform a specific management decision (e.g. advice needed immediately or of a minor science update).

Members of advisory meetings are termed ‘participants’ and not ‘representatives’, as participation is limited to expertise and not stakeholder views or personal beliefs. If the science advice is to support a decision being made by the Department that may have implications for the public, the science advisory meetings include external participants (e.g. industry, non-government organizations, Aboriginal groups, and/or academics). If the science advice is to help inform DFO of its internal affairs then external participation is not mandatory although, in many instances, external participation remains an integral part of these meetings.

Each science advisory process is assigned a meeting Chair-person, who works with the DFO requesting sector, CSA regional office, and applicable DFO Science division(s) to scope out an advisory meeting’s objectives, participant list, and other information that may be relevant to the meeting (e.g. context, date, and location). The information is listed in a meeting Terms of Reference that is posted on the CSAS national advisory schedule in advance of the meeting date. External participants can request to participate in an advisory process by contacting the meeting Chair-person or CSA Coordinator (also listed on the CSAS website). Approval of a request to participate is at the discretion of the meeting Chair-person, upon discussion with the DFO requesting sector, CSA regional office, and applicable DFO Science division(s) (e.g. approval contingent on expertise, need for expertise, etc.). Last, the meeting Chair-person is responsible for tracking progress of the science that is to be presented at the advisory meeting.

Following a science advisory meeting, mandatory documents are posted to the CSAS website subject to defined timelines. These may include an advisory report that reflects the consensus of science advice provided at the advisory meeting, a proceedings document that represents the nature of discussion, and the science research documents that served to inform the discussion. In most instances, a representative of the DFO management sector that requested the science advice is in attendance at the advisory meeting. Last, it should be noted that the science advice only serves to inform management decisions, being among the many other determinants that a decision maker may consider. Thus, in the end, the science advice may not be consistent with the final decision that is made.

4.2.2 Policy and Economics

The Policy and Economics Branch (P&E) in the DFO Maritimes Region consists of four divisions: 1) Strategic Priorities and Planning; 2) Policy Research; 3) Commercial Data; and 4) Economic Research. The P&E Branch provides management support by conducting the following activities: economic research, analysis, and advisory services in support of DFO programs and decision-making processes; policy research, analysis, and advice; horizontal policy and program coordination; collaboration and liaison services regarding intergovernmental initiatives; environmental scans, participation in strategic business planning, performance management input, and advice in the context of departmental planning processes; regional fisheries statistics in support of Resource Management, Science, external clients and stakeholders, international obligations, and decision making by senior management.

The Branch undertakes a number of activities or initiatives that support the management decision making process in relation to the EAM Framework. For instance, the DFO Maritimes Region's geographical span encompasses 16 First Nation Communities. The Strategic Priorities and Planning Division coordinates the DFO Maritimes Aboriginal Consultation and Engagement major change initiative, of which a key component is the integration of Traditional Knowledge (including ecological knowledge) into a holistic, ecosystem approach. Similarly, the DFO Maritimes Region's involvement in eco-certification processes contributes to the Department's current strategic outcomes Sustainable Aquatic Ecosystems and Economically Prosperous Maritime Sectors and Fisheries. Eco-certification is a market-based measure intended to improve the sustainability of fisheries. The Policy Research Division is responsible for managing the Region's participation in third-party assessments regarding eco-certification (e.g. Sea Choice, Marine Stewardship Council – MSC) and, in response, developed The Maritimes Region Framework for Participation in Third-Party Fishery Sustainability Assessments and Eco-labelling. The Framework outlines the Department's roles and responsibilities at various stages of the eco-certification process, including departmental response timelines and the identification of an eco-certification coordinator. Much of the requirements of eco-certification centre on ecosystem-based stewardship of the fishing industry.

In the DFO Maritimes Region, there are currently 16 fisheries at various phases of MSC certification; more than any other region in Canada (as of April 2012). The eco-certification coordinator, in the Policy Research Division, acts as the single point of contact, on behalf of the Department, with client groups and certifying bodies. The coordinator is responsible for liaising with the various sectors in the Department (e.g. Science, Resource Management, and Conservation and Protection) and responding to requests for information in a neutral, factual, and defensible manner. In addition, the Division is tasked with coordinating all meetings with client groups and certifying bodies at every phase of the eco-certification process, be it the initial phase of assessment or the discussion and determination of client action plans and the implications of these action plans on the Region's management of the resource in question. The eco-certification of a commercial fishery directly or indirectly impacts the Region's management of the marine resource being implicated: this may be related to the science for and management of the fishery achieving certification, bycatch of the species considered at risk, and/or the impacts of the certified fishery on marine ecosystems, including benthic habitats.

The Policy and Economics Branch supports DFO's involvement in the Canada–United States Transboundary Steering Committee. The Steering Committee meets bi-annually to address transboundary management issues associated with the Gulf of Maine and Bay of Fundy marine environments. The Steering Committee is co-chaired by the Regional Director-General, Maritimes Region, and the Northeast Regional Administrator of the National Marine Fisheries Service of the U.S. National Oceanic and Atmospheric Administration. Various committees and working groups act as advisors to the Steering Committee. These include the Transboundary Resource Assessment Committee (TRAC), Transboundary Management Guidance Committee (TMGC), Integration Committee, and Species at Risk Working Group. Fisheries and Oceans Canada, Maritimes Region, participation contributes to the overall objectives of the Steering Committee, as well as impacts the Department's work as it relates to oceans and ecosystems management, fisheries management, and conservation and protection. Members of the Steering Committee include representatives from DFO Maritimes, National Marine Fisheries Service, and both Canadian and American industry members. The manager of the Policy Research Division sits as Co-Chair of the Integration Committee and is responsible for ensuring a consistent approach between Steering Committee working groups being tasked with addressing transboundary co-management issues.

Last, the Commercial Data and Economic Research Divisions provide data and analyses that support initiatives being implemented to manage commercial fisheries and maintain sustainable ecosystems. The Commercial Data Division collects and provides statistical data to internal (e.g. Resource Management) and external (e.g. Industry) clients that is essential to the management and monitoring of commercial fisheries in the Maritimes Region. The Economic Research Division provides socio-economic analyses that are considered by the Region when drafting Integrated Fisheries Management Plans, designating Marine Protected Areas, and developing listing decisions and action plans related to Species at Risk.

5.0 CHALLENGES, OPPORTUNITIES, AND RECOMMENDATIONS

"Austerity", a response to non-sustainability, currently confronts the federal government as a consequence of uncertain global fiscal policy and a changing demographic. This section looks at the challenges and opportunities that confront the Region in further advancing an ecosystem approach in a fiscally-austere climate, and proposes simple and achievable recommendations for DFO Maritimes to consider. It makes two assumptions: 1) there are finite resources (financial, human, and material) to implement an ecosystem approach; and 2) proposed recommendations, if in line with assumption one, are reasonable for DFO Maritimes to consider. As a starting point, note the following results from a survey by Barnes and McFadden (2008) regarding implementation of an ecosystem approach at the U.S. National Oceanic and Atmospheric Administration (NOAA). The survey identified four main challenges perceived by staff that confronted incorporation of an ecosystem approach into management:

1. General misunderstanding of an ecosystem approach across the range of individuals with decision making authority (*Common Vision*);

2. Absence of partnerships due to competing mandates, interests, or sense of protectiveness (*Collaboration*);

3. Resource constraints including funding and time to participate in multi-disciplinary, ecosystem initiatives, particularly those not linked to a legislative mandate (*Collaboration*); and

4. Lack of integration of a broad range of science into ecosystem assessments, with the added challenge of effectively considering the social sciences and traditional knowledge (*Information*).

The above challenges point to the importance of each of the three key elements of an ecosystem approach – *common vision*, *collaboration*, and *information*. Assuming that DFO Maritimes is likely to be confronted with the same challenges as NOAA, the recommendations in this section are organized under each of the three key elements of an ecosystem approach. The recommendations are premised on the following: 1) the Maritimes Region EAM Framework provides the common vision for an ecosystem approach; 2) existing management structures enable the Region to plan for and receive advice through its CSA office and P&E sector, with an opportunity for the Oceans sector to contribute to this role; and 3) information is the information and expertise held by the different Departmental sectors in the Maritimes Region. The intent of this section is to outline some of the challenges and opportunities that confront each element, and to propose recommendations that can direct DFO Maritimes towards a more ecosystem approach.

5.1 *COMMON VISION* – EAM FRAMEWORK

A *common vision* is a vision for managing an ocean space that is shared by all management sectors (Leslie and McLeod, 2007). In theory, a common vision provides direction in how individual management sectors make their decisions and undertake their activities in line with an agreed upon set of goals (Leslie et al., 2008). In practice, a common vision needs to be consistent with the constraints of participating decision making bodies (e.g. legislation, policies, programs, and mandates). Having sectors develop a common vision together ensures that the limitations of all sector-based authorities are accounted for at the onset of planning.

5.1.1 Challenges

As part of the EAM major change initiative in the DFO Maritimes Region, a working group was established, representative of the various management and advisory sectors in the Region, to propose a framework for an ecosystem approach that can be applied to a range of management scenarios. The framework, outlined in Appendix 1.0, has been applied to two desktop pilot projects by members of the regional EAM working group to test its utility. The first scenario focused on management of multiple fisheries on Canada's portion of Georges Bank. Application of the framework in this context was limited in its completion due to changes in membership of the regional EAM working group – it has only been completed in draft. Notwithstanding, it has assisted the regional Resource Management sector in understanding how to apply the framework at the individual IFMP level and demonstrate how it can be used to assess cumulative impacts over time.

The second scenario focused on management of multiple marine activities in a coastal setting in southwest New Brunswick. It too was only partially completed. Both exercises proposed recommendations for improving the framework and supported the framework's utility and further development. As the Maritimes Region moves forward in implementing the EAM Framework across all sectors (Resource Management has already been applying the framework through IFMPs), some challenges that may be encountered include: 1) relevance of the framework to management activities of different sectors; 2) determination of types of management activities in which to apply the framework; and 3) ability of a range of DFO staff to independently apply the framework across the Region in a comprehensive and consistent manner.

5.1.2 Opportunities

DFO Maritimes possesses many of the building blocks necessary for the regional EAM Framework to succeed: 1) senior level support for the framework – a mandate to cooperate; 2) much authority over oceans management (e.g. fisheries, fish habitat, species at risk, and marine conservation); and 3) significant regional expertise in marine science and policy. Informed by experience with the LOMA approach (Section 2), application of the EAM Framework has been designed to proceed with incremental development and manageable scope; increased complexity and broader scope of application will be achieved through time.

As the framework prompts greater thought and discussion, the Maritimes Region could turn to other similar examples of an ecosystem approach that offer additional learning opportunities, such as the federal environmental assessment process or ecosystem approach initiatives undertaken in other countries (e.g. Australia). In particular, the federal environmental assessment process offers a comparable framework in which to evaluate the effects of human activities on natural systems that is supported by much guidance on topics such as scope, cumulative effects, level of significance of effects, and risk analysis.

5.1.3 Recommendations

1. **Continue to implement the EAM framework incrementally**. Resource Management has already begun incorporating the EAM Framework into fisheries management planning through IFMPs. There is a need to both broaden implementation of the framework across all sectors in the Region and to take a more holistic, spatial approach. To facilitate this, priority management areas should be identified that involve a variety of activities managed by the Maritimes Region (e.g. recovery of SARA-listed species, aquaculture, and project assessment) and that require integrated management of different anthropogenic pressures (e.g. cumulative impacts on selected attributes from hydroelectric damns, fishing, transportation, and waste-water treatment). An example of such a priority area may be St. Mary's Bay, Nova Scotia, whereby the natural environment, coastal communities, traditional fisheries, aquaculture, and emerging tidal industry are increasingly intersecting. In addition, the CSA process needs to approach fisheries assessments spatially, assessing the impact of multiple sector activities on productivity, biodiversity, and habitat.

2. **Incorporate EAM exercises into sector work plans.** Integrated work planning at the regional level would assist in identifying appropriate projects, individuals, and timelines for carrying out EAM initiatives, as well as commit partnering sectors to cooperate. Success of this approach should be evaluated in order to track opportunities and challenges that confront cooperation between management sectors in the Region. The regional EAM working group approach, although it has made significant headway, does not have a say in regional planning. Similarly, progress on the working group's work load often is slowed by the divided attention of its members, whom often have to focus on their more pressing

sector-specific priorities. If EAM is to further advance it must be built into and receive priority in sector work plans.

3. **Develop EAM guidance and training materials.** At present there is not enough guidance regarding the EAM Framework to support its consistent application across sectors. Many regions and sectors in DFO, and associated Centres of Expertise, have developed guidance and tools for evaluating and assessing the effects of human activities on the marine ecosystem, and these require further incorporation into the EAM Framework (e.g. ecological risk assessment and pathways of effects models). Similarly, the Canadian Environmental Assessment Agency provides guidance that may be relevant to the regional EAM Framework, including tools for evaluation and assessment (website: www.ceaa.gc.ca). Last, international efforts also provide opportunities in which to learn, compare, and contrast the regional EAM Framework (e.g. European Marine Strategy Framework Directive). In essence, the EAM working group should transition into an educational centre that provides tools and guidance necessary for decision makers to apply the EAM Framework to the decision making process in a consistent manner.

5.2 *COLLABORATION* – COORDINATED PLANNING AND ADVICE

Inclusive collaborative systems are generally practical (e.g. not too large or complex) and democratic. In practice, collaboration can vary from complex systems, such as those used to administer countries, to more simplified systems of participative processes. Qualities of inclusive collaboration, regardless of a system's complexity, include: accountability, transparency, responsiveness, equitability, effectiveness, and judiciousness. In Canada, an integrated approach to management tends toward a more participative system of collaboration, since decisions remain in the divisions of sector-based authority.

As such, an integrated collaborative structure aims to foster communication, cooperation, and awareness among stakeholders rather than assume a greater form of authority over them. It remains, however, that some decisions still lack justification, accountability, and consistency, so any improvements to collaboration that promote transparency and inclusiveness in the decision making process are desirable. This point is evident in the statement made by Sue Kirby, former Associate Deputy Minister of Fisheries and Oceans Canada, "national coherence and predictability in decision-making are critical for program fairness and credibility" (DFO, 2005b). Although CSA is not a decision making forum, it embodies many of the elements noted above.

5.2.1 Challenges

The Centre for Science Advice provides an alternative forum in which transparent and inclusive discussion between sectors regarding the EAM Framework can exist (compared to the EAM Working Group). There are certain down sides, however, to incorporating greater scientific involvement in the advancement of the EAM Framework over the short term, namely DFO Science and CSA are currently at capacity in regard to their manageable work load. For example, annually the requests for science advice from the management sectors of DFO exceed the Science sector's ability to respond. Based on this, how can Science reasonably accommodate an increased work load associated with an ecosystem approach in the short-term, even though it is the most suitable sector to contribute to such a task? It is argued that small changes in how the Region plans for science advice and aligns its information needs with Departmental policy can provide practical solutions to freeing up time for the Science sector to participate (see recommendations below).

Rice (2005a) argued that inclusive and collaborative mechanisms have positive effects towards sustainability, as they expand the scope of knowledge and understanding that informs broader implications of a range of possible decisions. This noteworthy view thus raises questions regarding the role social sciences and traditional knowledge should play in the EAM Framework (Bundy and Davis, 2012). Currently, there is no formal consideration of the social sciences and traditional knowledge within the EAM framework; consideration of such knowledge is typically left to the discretion of individuals within each decision making authority. Hence, this approach raises further questions regarding the consistency with which the social sciences and traditional knowledge is considered within the range of decisions made across the Maritimes Region.

5.2.2 Opportunities

Contributing to the success of EAM is the need for science capacity and a science advisory infrastructure that integrates across multiple management sectors (Rosenberg and Sandifer, 2009). Science and science advice in support of an ecosystem approach should provide: 1) a range of scientific expertise; 2) synthesis of information across many disciplines; and 3) transparent and inclusive peer review of conclusions (Rosenberg and Sandifer, 2009). In practice, DFO Science and CSA do not constitute collaboration in context of mutually-agreeable decisions, as they lack decision-making authority: science is an advisory sector. An ecosystem approach, however, is not intended to conclude in decisions; rather it is to ensure that decisions consider the whole of ecosystems before they are made – CSA supports the type of collaboration and information sharing necessary for EAM.

It can be argued that CSA also provides an existing, suitable mechanism in DFO Maritimes to openly evaluate EAM exercises over the short term, based on its transparency, access to a range of natural sciences expertise, and its administrative mechanism that promotes integrated planning and cross-sector participation (see Section 4.2.1). Briefly, the CSA office considers all requests for science advice collectively to determine if any requests can be considered together, and to identify those of lower priority that can not be addressed. The office then works with the sectors to define the scope of the science advice, as well as coordinates with the Science sector's Branch Management Committee to ensure that the science advisory needs for the upcoming year are incorporated into the work plans of its divisions.

Thus, CSA offers future EAM exercises an administrative mechanism for integrating cross-sector science needs into the Science sector's annual work plan, oversight that tracks science-based project status, and inclusion of a range of experts in the science-based peer-review process. Last, the Science sector, through CSA, offers a public accountability function in the publishing of its science advisory reports to a web-based registry. This last function lends transparency and can help promote a greater understanding of the role the EAM Framework could play in decision making processes across the Region.

5.2.3 Recommendations

1. **Greater Science discussion regarding the EAM Framework.** To date, much scientific expertise that can help inform (e.g. guidance materials) or refine the EAM Framework has been excluded by virtue of the working group model. Although the EAM Framework was originally developed in Science (Gavaris, 2009), the broader Science sector currently is not engaged in a regional EAM discussion .To date, there has been no opportunity to openly and more inclusively debate merits of the EAM Framework within DFO Science or across DFO management sectors.

2. **Strategic work planning and a longer science advisory planning horizon.** Under the current planning approach, annually the Science sector makes a call to management sectors for their requests for science advice. In many instances, the short planning horizon comes at the expense of advisory processes not being broad in scope, as the time frame often does not allow for proper coordination and the appropriate questions to be asked (Rice, 2005b). Similarly, some science advisory responses (namely science special responses) become centred on literature reviews rather than empirical evidence, since there is often not enough time to undertake additional research. By identifying science needs early on in project management, relationships between scientists and managers can be established well in advance of the need for a science advisory process (there is a need for coordinated strategic planning among sectors, in order to identify common project requirements that can be incorporated into science work plans along similar time lines). For certain management sectors tied to regulatory timelines or unanticipated work loads a longer planning horizon may not be feasible (e.g. fish habitat management). For other sectors, however, moving toward a multi-year science planning cycle may free up time in the science sector to support fewer science advisory processes that are broader in scope. For instance, of the 27 science advisory meetings scheduled or tentative in the DFO Maritimes Region for fiscal year 2011-2012 (excluding requests for a special science response), 18 are in support of the Resource Management sector. Gains through multi-year planning may be achieved by better organizing this sector's needs alone.

3. **Define CSA meeting Terms of Reference (TOR) using the EAM Framework.** Typically, the scope of CSA meetings is defined by the requesting sector's perceived science needs – it currently resides with management sectors to determine what scientific information they require to fulfill their application of the EAM Framework. Under this model CSA can continue to expect multiple science requests that only partly fulfill science needs, on a year-to-year basis, for managing resources, protected areas, and at-risk species. To provide Science with more certainty, the EAM Framework should become the basis in which projects are planned and the terms of reference of CSA meetings defined, with the intent of having fewer, but more thorough advisory processes. In essence, the EAM Framework should become a template Terms of Reference that provides a starting point in which to map out science needs that begins at a project's inception.

4. **Develop a mechanism to better incorporate social science and traditional knowledge into decisions (i.e. traditional, economic, and social information).** The general literature suggests that natural sciences are the foundation for an ecosystem approach, while other aspects of advice such as the social sciences and traditional knowledge are poorly integrated into the EAM processes (Endter-Wada et al., 1998; Bundy et al., 2008). This particular challenge confronts DFO Maritimes, whereby traditional knowledge is often not effectively addressed in the science advisory process despite an allowance for its consideration. Further, consideration of information from the social sciences (e.g. economic, social, and cultural) is guided by a suite of government policies and guidelines, however, it remains with individuals to interpret how and when this type of information should be incorporated into the decision making process. Interestingly, social information is of great importance to the decision making process (e.g. economy being the basis of many decisions), often exhibiting significant influence over decision outcomes, yet it remains outside of any structured forum that supports transparent discussion regarding its relevance to the decision being made. It is recommended that guidance be developed regarding a consideration of the social sciences and traditional information into the decision making process (e.g. traditional knowledge, economic, social, cultural, etc.), in support of consistency among decisions and for sake of public accountability. In the extreme, a Centre for Management Advice (similar to the model of the Centre for Science Advice) could be

considered over the long term – a transparent forum of critical discussion surrounding the role of the social sciences and traditional information into the decision making process (as could an expanded role of CSAS to include all forms of information that advise decisions). Of course, there are down-side costs associated with the inclusion of more information into the advisory process, including longer timelines for the provision of advice, increased fiscal support for advisory meetings of broader scope, and difficulties associated with multiple points of view (Rice, 2005a). These costs need to be weighed relative to the value in which the natural sciences, social sciences, and traditional information best inform the decision making process.

5.3 *INFORMATION* – INFORMED DECISIONS

Information is the experiential knowledge derived from investigation, study, or instruction. It informs decisions by reducing the uncertainty surrounding unintended consequences. Information, however, does not ensure sound decisions, since decisions depend on an individual's awareness, interpretation, and willingness to accept information. Thus, presentation, communication, and peer review of information are often of equal importance to the information itself, since the form in which information is presented, communicated, and peer reviewed provides context to how the information should be interpreted (Leslie and McLeod, 2007). In terms of an ecosystem approach, access to and presentation of information that is representative of the broad range of interests (i.e. natural sciences, social sciences, and traditional knowledge) remains the basis for which sound decisions, in line with a common vision, can be made.

5.3.1 Challenges

A primary challenge facing the Department is the sheer volume and diversity of information that it possesses – including timely access to it. Further, DFO too is complex, making it difficult for most employees to fully comprehend what each sector does. As a result, the Region, in many respects, is missing the "big picture" of marine ecosystems and their associated human uses, including how they have changed in context of natural variation and changing human use patterns (DFO Maritimes currently does this in its parts). In absence of characterizing the "big picture", it is difficult for the Region to evaluate the overall effectiveness of the range of management measures that it employs (this too is done in parts). With changing demographics and the loss of institutional knowledge, the Region should adopt a bigger picture approach (which EAM supports), particularly in consideration of the role that external participants may play in the provision of future information needs.

Other information challenges also confront the Region. In the past decade, various sectors of DFO have seen changes in their policies. With change, the information needed to support new policies also changes. As such, it is easy to lose sight of the common information requirements of each sector. Presently, only the Species at Risk Program has undertaken a cross-walk exercise of its information requirements in context of the decision points governed by its legislation and policies for at-risk species recovery potential assessments (see DFO, 2007c) – it is understood that a similar exercise has recently been completed for aquaculture management. In the absence of such an exercise for all management sectors, a broader understanding of the linkages between policies and information requirements between sectors remains difficult. This poses challenges for the Region to strategically align its priority information requirements, despite the many common themes that exist among different management sectors (e.g. consider potential similarities in the DFO fisheries sensitive benthic habitat policy, DFO fish habitat protection policy, DFO species at risk critical habitat policy, and DFO marine protected areas policy).

5.3.2 Opportunities

Arguably, there are no more intensively studied marine ecosystems on Earth than those off our shores (i.e. Scotian Shelf, Georges Bank, and Gulf of Maine-Bay of Fundy). In many instances, however, DFO's knowledge does not extend comprehensively across all aspects of these marine ecosystems. Despite such gaps, the large scientific presence of DFO in the region has provided a wealth of information regarding previous and existing states of the marine ecosystems it manages. Such gaps need not stand in the way of progress on an ecosystem approach: strategies robust to such gaps should be developed, while the gaps are noted, and when possible, addressed.

Given the vast knowledge held by DFO, there is opportunity to revisit and make use of the range of information currently in its possession to better speak to changing marine ecosystems and how the Region may manage human activities into the future. In addition to DFO regional research capacity, the marine science research community in Altantic Canada is increasingly becoming aligned with the Department's science mandate, offering both a major resource of scientific information and expertise, as well as research infrastructures and opportunities that complement the Department's own capacities. Existing national research networks such as the Canadian Healthy Oceans Network and the Canadian Capture Fisheries Research Network provide DFO Maritimes the opportunity to develop strong working relationships on EAM-related topics.

5.3.3 Recommendations

1. **Identify the Region's common information requirements.** All management sectors should review their legislative and policy decision points and identify the type of information they need to inform their decisions in context of the EAM Framework (consistent with recommendation 3 in Section 5.2.3 above). This would allow DFO Maritimes to identify and consolidate the information typically required by its decision makers into readily accessible information products. Similarly, this exercise would allow the science sector to manage similar information requirements of different sectors by aligning and expanding the scope of science advisory processes and to guide future scientific programs (similar to that of ERI).

2. **Rationalize existing frameworks with respect to ecosystem indicators.** A focused science-based assessment should be undertaken of the concepts and system interactions behind currently proposed indicators. An example perhaps most easily understood is that the current ecosystem indicators for groundfish derive primarily from the regional ecosystem trawl survey. In contrast, although there are a number of different benthic system indicators to be monitored in the EAM Framework there, as yet, is no standardized and comprehensive shelf-scale capacity for ongoing monitoring of the benthic system. A similar argument can be made for the pelagic realm, including several functional groups such as meroplankton, small pelagic fish, large pelagic fish, and marine mammals. As such, a serious discussion needs to occur regarding the suite of indicators required to implement the EAM Framework, supported by resource support to track these indicators. This discussion should be complemented by the identification and general consensus in the Maritimes Region of ecologically and biologically sensitive areas (EBSA), ecologically and biologically significant species and community properties (EBSSCP), degraded areas, and sensitive and threatened species.

3. **Greater need for geospatial information products and decision support.** There is a need to consolidate and expand internal capacities for the acquisition, analysis, interpretation, archiving, and development of geospatial information products. At present,

capabilities to access geospatial information in the region is limited in terms of the availability of personnel and their technical proficiency in the use of geospatial decision support tools. To meet anticipated future demands for geospatial information in the decision making process, this present limitation should be a priority consideration that factors into all resource planning decisions of today.

4. **Pursue marine spatial planning.** Marine spatial planning should be pursued to identify marine areas that exhibit signs of heightened human-ecosystem and human-human conflicts. At present, DFO Maritimes does not fully understand the spatial context regarding the range of human use patterns amidst the marine ecosystems it manages. In this absence, it is difficult to identify, prioritize, and evaluate those marine areas that require some form of priority management attention. To date, the Oceans sector has been working towards the compilation of region-wide data sets in support of its conservation planning exercise. Similarly, available human use data is also currently being compiled by the sector. The next step is to analyze the human use data in context of the ecosystem data, in order to inform marine planning and management beyond a case-by-case basis. Although marine spatial planning connotes some form of master plan and zoning akin to a municipal planning strategy, when viewed in context of a planning process and not an end point, it offers a powerful tool to inform strategic management action and policy direction in the Region. Its intent is to anticipate human-ecosystem and human-human conflicts prior to their occurrence, in order to inform proactive decisions. The role of CSAS, P&E, and the Oceans sector as purveyors of different types of information may require further thought in context of marine spatial planning.

5. **Support a DFO Maritimes state of the marine ecosystem conference.** The objective of the conference would be to build a “big picture” understanding of the changing marine ecosystem around us. The conference would focus on topics that report on trends in the traditional disciplines of oceanography, but should also include new science and changing patterns of human use (e.g. climate change), the social sciences, economics, and conservation and protection in the Region. The conference could be organized by bioregional sub-units (e.g. Scotian Shelf, Gulf of Maine-Bay of Fundy, and coastal Nova Scotia), with its proceedings acting as a reporting mechanism for the state of our marine ecosystems. The advantage of a conference, rather than a state-of-knowledge report, is the opportunity for open dialogue and cross-sector discussion (scientific conferences centred on regions and not themes remain uncommon – attention to the Gulf of Maine is an exception). Such conferences, however, require planning, resources, and, perhaps most importantly, a commitment to follow through regarding post-conference synthesis and reporting once they have been completed.

6. **Discuss the roles of government, academics, and the private sector in supporting government information requirements.** A significant source of information and expertise in marine science and policy resides in the surrounding academic institutions and private sector organizations of the Maritimes Region, and elsewhere in Canada. There is a long history of productive working relationships with these communities. In terms of leveraging the capacity of the Canadian Science and Technology community towards an ecosystem approach, however, there is a need for more comprehensive guidance and formalization of broad-scale administrative and funding structures. As the Region moves forward, in light of changing demographics, a discussion regarding the role of outside contributors to the fulfillment of government science and policy should be considered. This may include internal guidance on the acceptable use and practice of external experts for the provision of advice to DFO Maritimes (e.g. contractors). Current national research networks funded through the Natural Sciences and Engineering Research Council, within which many in the Region are

key partners, provide potential models moving forward (e.g. Canadian Healthy Oceans Network, Canadian Capture Fisheries Research Network, and Ocean Tracking Network). Similarly, the role of DFO Science in maintaining an internal capacity for fundamental science development versus application to management and policy also warrants discussion, as this determines the modes of acceptable funding that is available to DFO science practitioners.

6.0 CONCLUSION

Over the past few decades, a need has emerged for ocean regulators to embrace a broader approach to management that recognizes both the complexities of marine ecosystems and the confounding negative effects of incompatible management decisions. This is reinforced by the increase in degraded marine ecosystems and ocean user conflicts observed throughout the world. In DFO Maritimes, a major change initiative is underway that is bringing together the various management sectors in the Region to further advance a mutual path forward for implementing an ecosystem approach into its management operations. An ecosystem approach to management (also known as ecosystem-based management) is management that places the ecosystem in the forefront whereby its thresholds of change beyond those deemed to be acceptable determine the nature in which a collection of human activities should be managed, so that the ecosystem remains within an acceptable range. Integrated management (also known as integrated coastal and oceans management) is the coordinated management between ocean regulators, sectors, and stakeholders of all human activities in a management area, so that human-ecosystem and human-human interactions can be anticipated, supported, prevented, or mitigated.

There is consensus that an ecosystem approach requires three common elements: common vision, collaboration, and information. A common vision is a vision for managing an ocean space that is shared by all management sectors (Leslie and McLeod, 2007). Collaboration refers to the means of working together to achieve a goal of mutual interest. Last, information is the experiential knowledge derived from investigation, study, or instruction. It informs decisions by reducing the uncertainty surrounding unintended consequences. Favourably, DFO has much authority over oceans management and, in particular, already has the necessary infrastructure and support in place to support each of these elements. It is believed that DFO Maritimes already has in place many of the building blocks needed to successfully pursue an ecosystem approach, although the elements are currently not utilized in context of integrated, multi-sector management needs. Thus, in its continued pursuit of an ecosystem approach, there is a call for strategic thought on how these elements can be organized in a manner that supports greater integration of information in support of robust, transparent decisions, yet, can accommodate the existing institutional structure in the midst of capital restraint and a changing Regional demographic. Regional discussions to date are framed within an incremental ecosystem approach.

The first element is the *common vision* – the regional EAM Framework. Although the framework has been approved by regional management it has not received much uptake into management practice aside from Resource Management. This is largely related to the lack of introduction to the Region at the practitioner level, particularly in context of how the framework may be incorporated into existing management decision making processes. As such, it is recommended that the framework begin being implemented into the various management sectors, in order to test its utility about different management scenarios. This, of course, should occur incrementally and be applied first to relatively straight-forward management activities. In order to do this successfully, the EAM Framework needs to be incorporated into sector work plans. Last, as the framework is applied, there will be a need for centralized support, guidance, and training, and this too will require further consideration by DFO Maritimes.

The second element is *collaboration* – coordinated planning and advice. If an ecosystem approach is to expand outside of individual sectors then a mechanism is required to integrate the various sectors of the Region at a planning level. Currently, the regional CSA office provides a mechanism by which the science needs of various management authorities can be considered in their entirety to allow for better alignment and, ideally, fewer and more comprehensive science advisory processes. A move to multi-year science planning on a spatial basis, would better integrate requests for science advice across sectors, help reduce common science needs that are addressed in different fiscal years, and enable a more integrated, ecosystem approach to management. Last, over the long term, a mechanism that supports a more equitable consideration of the social sciences and traditional knowledge into the decision making process may be considered.

The last element is *information* – informed decisions. As the Region moves towards “aligning its science resources to reflect the transition to an ecosystems approach to science” (from Transformations at Fisheries and Oceans Canada, DFO Deputy Minister Claire Dansereau, October 13, 2011), thought must be given to how science results may serve multiple management needs. The first step would be to identify the science requirements of each management sector, defined by the legislation, regulations, and policies that govern them, in order to identify common science requirements among sectors. This would require consideration of the ecological indicators that the Maritimes Region currently tracks and those others that may require further consideration for action, recognizing that many sectors, outside of science, also have expertise and data that may be relevant. Notwithstanding, greater geospatial capacity and more proactive marine planning and management are required to anticipate, prevent, and mitigate detrimental human uses of the ocean prior to their occurrence (e.g. regional planning beyond project-specific environmental assessment). The role of CSAS, P&E, and the Oceans sector as purveyors of different types of information may require further thought. Such pursuits would advance DFO Maritimes towards a more holistic ecosystem approach, while minimizing its exposure to a reactionary mode of doing business. Last, given the realities surrounding fiscal constraint and changing demographics that are influencing government support for Science, there is a need to discuss the role academic and private sector science may play in informing DFO’s regional policy and management needs.

7.0 ACKNOWLEDGEMENTS

Sincere appreciation is given to participants of the Maritimes Region Ecosystem Research Initiative (ERI) Science Advisory Process and members of the Maritimes Region Ecosystem Approach to Management Working Group for their input that has contributed to a strengthened research document. Special thanks are also given to Chris Annand, Jake Rice, Michelle Greenlaw, and Donald Humphrey for their reviews, thoughts, and insights on this topic.

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APPENDIX 1.0: Ecosystem Approach to Management (EAM) Framework

An Outline of the DFO Maritimes Region Framework for an Ecosystem Approach to Management

Introduction

This document summarizes how Fisheries and Oceans Canada (DFO) plans to implement an Ecosystem Approach to Management (EAM) within the Maritimes Region. An EAM takes a broad view of the interactions between human activities and all components of the ecosystem. While its general principles have gained wide popularity and support, work remains to find effective ways of translating those into operational plans.

The *Oceans Act* gives DFO the lead role in managing the effects of human activities on estuaries, coastal and marine waters. Thus DFO, in addition to being a regulator of fisheries with legislative authority in the marine environment, is also required to act as a leader and facilitator of a management planning process that includes other federal and provincial regulatory agencies and ocean users.

An Ecosystem Approach to Management

An ecosystem approach to the management of a human activity requires consideration of its impact on all ecosystem components, not just the impact on the resource being used, while taking recognition of how environmental forces that also affect ecosystems influence management of that human activity. Also, many human activities impact the marine ecosystem. For an ecosystem approach to be effective, consideration must be given to the combined effects on a particular ecosystem from all activities. This requires bringing together the diversity of ocean users and regulators to consider all factors necessary for the conservation and sustainable use of marine resources and shared ocean spaces, and the drawing-up of plans for the integrated management (IM) of ocean uses. Although DFO has been assigned this integrating role, the other regulatory authorities nonetheless remain responsible and accountable for implementing IM objectives within their established mandates and jurisdictions.

It is the intention of DFO Maritimes Region to implement an EAM in a step by step, evolutionary way, building on existing management processes. Advances will be made incrementally, additional levels of integration being added as required to take account of the cumulative effects of multiple uses. The highest priorities and issues offering the greatest scope for improvement will be identified for the information and action of decision makers. The capacity of DFO, and of the other agency or agencies involved in a particular issue, to accommodate change will also be considered in determining where emphasis will be given.

DFO as Leader and Facilitator

As a leader of the management planning process, it is for DFO to facilitate development of an overall plan. The management planning process must:

- accommodate broad stakeholder representation,
- establish objectives,
- agree on strategies for meeting these objectives, and
- provide for performance evaluation.

There needs to be an overall governance structure to develop and administer this general plan, but it makes the most sense to implement it through separate management plans for each sector, e.g. fisheries, oil and gas, transportation. Thus, in support of the overall structure, existing committees will evolve and new committees will be created where needed to coordinate management of particular activities, i.e. devise tactics to implement the strategies in the plan for that sector, implement these and evaluate results. These committees will bring together representatives of both government agencies and stakeholder groups, as appropriate to the committee's work. There is a need for the building of capacity within stakeholder groups, so that they can participate fully and effectively within these committees.

It is crucial to effective management that there be evaluations (audits) of the performance of sector plans or specific elements of them, to determine whether the rules and regulations that were employed are being effective and thus that the strategies in the overall plan are being adequately implemented in that sector. The importance of having a common framework for EAM is that it also allows for evaluation of cumulative performance through an integrated assessment of these sector evaluations. The general plan evaluation will determine whether:

- the strategies are being implemented satisfactorily overall,
- the strategies are doing their job in meeting the plan objectives, and
- the plan identifies and addresses all the important impacts of human activities on the ecosystem in question (has something new happened, has anything been missed?).

It is necessary to define the area to which any plan will apply but ecosystem components, from geological and oceanographic characteristics through phytoplankton and zooplankton to benthic invertebrates, fishes, birds and marine mammals, do not have coincident boundaries. The spatial distribution of some components is localized, e.g. coral beds, while that for others extends beyond the boundaries of Maritimes Region, e.g. tunas. Political and jurisdictional boundaries also matter when establishing practical areas for management. Thus, the application of an EAM must be at various spatial scales consistent with the issues being addressed. The Maritimes Region itself was defined on the basis of just such ecological and political considerations. Within the Region, there are three large areas, the eastern Scotian Shelf, southwest Scotian Shelf/Bay of Fundy and Georges Bank/Gulf of Maine, that differ sufficiently in their oceanographic and biological features that they, also, can be used as areas for practical application of an EAM. Nonetheless, the management areas will need to be tailored to address specific pressures from human activities, e.g. disturbance of coral beds.

DFO as Fishery Regulator

As a regulator of the commercial fishing industry, DFO will implement the strategies in the general plan for EAM within the fisheries sector, i.e. the Department has a dual role, the longstanding one of directly managing the fishery for sustainability and the more recent one of overseeing the impacts of all marine activities on ecosystems. The management process in DFO is already well developed for fisheries and much of the existing infrastructure of advisory and consultative committees can be reformed satisfactorily for EAM application. However, additional levels of integration may be added as required, to take account of the cumulative effects of multiple uses in relation to the broader EAM considerations.

For commercial fishing, control of fishing mortality remains an important strategy and will continue to demand attention. However, to fulfill its EAM responsibilities, greater attention must be directed towards monitoring and managing bycatch/discards and habitat disturbance from commercial fishing (see Management Planning below). While work on habitat disturbance is ongoing with respect to engaging stakeholders and pursuing implementation, first emphasis is being given to management of bycatch/discards.

Management Planning

Management planning requires the specification of objectives (what is to be achieved), of strategies (what will be done to control pressures from human activities affecting attainment of objectives) and of tactical management measures (how the strategies will be implemented). The success of the planning process is reliant on inclusion of representation for all major users and affected parties. The management planning elements described below are the foundation of the DFO Maritimes Region Framework for an Ecosystem Approach to Management, which is summarized in Table 1.

<u>Objectives</u>: Objectives for an EAM are primarily about ensuring that human activities do not have unacceptably severe adverse effects on ecosystems. However, it is impractical to pursue conservation in isolation from the economic, social and cultural aspirations of users and these must be recognized in any plan if it is to be successful. Yet, concern about the state of resources and ecosystems has focused attention on conservation. The overarching conservation objectives are:

- Do not cause unacceptable reduction in productivity so that components can play their role in the functioning of the ecosystem.
- Do not cause unacceptable reduction in biodiversity in order to preserve the structure and natural resilience of the ecosystem
- Do not cause unacceptable modification to habitat in order to safeguard both physical and chemical properties of the ecosystem.

<u>Strategies</u>: Objectives are general statements that are translated into practical operational terms as strategies. A strategy for maintaining the productivity of fish populations, for example, is already familiar to the fishing industry – that is to keep fishing mortality moderate. A working list of strategies to meet the conservation objectives described above has been developed and is elaborated in Table 2. The list identifies strategies to manage *pressures*, such as fishing mortality, disturbance of bottom habitat and introduction of pollutants, that are imposed by human activities in order to control their impact on valued ecosystem *attributes* of fish populations such as spawning biomass size/age structure and genetic diversity and, similarly, ecosystems attributes such as the area of a particular habitat type and the balance of predators to prey. Two important characteristics of pressures are that they are measurable and they can be regulated. There are initiatives by DFO to identify ecologically or biologically sensitive areas (EBSAs), ecologically or biologically sensitive species (EBSSs), Depleted Species and Degraded Areas that are also viewed as attributes of an ecosystem.

<u>Attributes</u>: The valued ecosystem attributes are the means by which the broadly stated objectives are given specificity. There may be interest about the condition of many traits of an ecosystem. However, attributes, described in Table 3, are the special subset of traits that respond to human induced pressures. Strategies state how the pressures imposed by human activities will be managed, e.g. what level of fishing mortality is acceptable; how much bottom habitat disturbance is too much? This is done by using *reference points* to define pressure levels that cause unacceptable or undesirable impacts on valued ecosystem attributes. When knowledge is weak or information is poor, reference points may be simply based on historical trends. When more is known, their determination may involve evaluation of alternative population/ecosystem dynamics models, ranging from 'single species' to 'full ecosystem'

models. Reference points will require periodic revision as the human and environmental factors affecting ecosystems become better understood or to adapt to dynamical changes in the environment. Strategies and reference points that are robust to a wide range of conditions and natural forces are favored.

The basis for determining reference points is fundamentally founded on evaluation of the projected long-term responses of attributes to alternative pressure reference points. Such evaluation requires measurement of the attributes and understanding of the relationships between the pressures and attributes. The realized state of an attribute is not solely a function of the human induced pressures, but also an outcome of other forces in the environment. Therefore, management strategies do not necessarily aim to keep attributes in desired states. They specify pressure reference points that leave attributes in comparatively ‘better’ states than alternative reference points, all other things being equal. However, attribute thresholds may be used as beacons to signal when the realized attribute state is outside the range of the projected long-term response. This may trigger a pre-agreed adjustment to the reference points or a review of the strategies and reference points.

Tactics: Tactics are management measures that are usually specific to particular human activities (in contrast to strategies that are generic and pertain to all human activities). For example, to limit disturbance on a particular bottom habitat, there would be different tactics for a groundfish fishery, a scallop fishery and for an aggregate extraction industry, all of which contribute to that *pressure* on the habitat.

Implementation Elements

The implementation of EAM involves an appreciation of the suite of human activities that are contributing to pressures on the marine ecosystem in the area of interest, designation of management units over which the pressures can be measured and regulated, establishment of reference points to guide decisions, incorporation of strategies into management plans to regulate key pressures, performance evaluations to determine if the tactics are effective and if the strategies are suitable, and evolution of the governance institutions to address the hierarchical structure of EAM management planning. The process is illustrated in Table 4 and the elements are described below. The elements are not necessarily conducted in a sequential order and there may be requirement for iteration between subsets of steps.

- List the activities occurring in an EAM area that are managed by DFO, or subject to DFO purview under the *Oceans Act*, *Species at Risk Act* or *Canadian Environmental Assessment Act*, and identify the managing authority.

- For each activity, review the list of strategies and identify/prioritize the key pressures it exerts. Define the 'management units' for all the key pressures in the area. For each pressure, review the list of attributes to identify all that are relevant.

- Determine a way to measure and monitor the key pressures, or a reasonable proxy of them, using the best available information.

- Determine a way to measure and monitor the relevant attributes, or a reasonable proxy of them, using the best available information.

- Establish an appropriate operational reference point for the pressure or its proxy to control the impact on all relevant ecosystem attributes, including pertinent EBSAs and EBSSs.

Consider establishment of attribute thresholds and associated adjustments to the reference points.

- Identify a suitable suite of tactics to implement the strategies.

- Incorporate strategies in plans or regulations for all key pressures. Provide support for tactical and strategic decisions required to implement the plans or regulations. For 'projects' being reviewed by Habitat Management, use a 'pathways of effects' analysis to identify the key pressures, the required strategies and potential mitigation measures

- Conduct performance evaluations regularly (appropriate intervals to be defined) to determine if tactics are effective at keeping the pressures within established reference points, both within sectors and overall in an area. Adjust tactics as required. Remedy identified gaps in fishery or ecosystem monitoring that inhibit performance evaluation of the tactics.

- Monitor attributes regularly and periodically (as problems become apparent) determine whether the impact on them is unacceptable. Initiate review and consultations to revise reference points and/or strategies as required. Remedy identified gaps in fishery or ecosystem monitoring that inhibit evaluation of reference points.

An over-arching element is the review and reform of management committees as required by EAM and development of mandates with clear statements of expected products. To accomplish this, it will be necessary to promote the building of capacity, within stakeholder groups, to participate in the process.

Table 1. Attributes and strategies are generic and pertain to all managed activities. A strategy specifies what will be done about a pressure and a reference, determined on the basis of impact on attributes, signals when the pressure is unacceptable. Explicit references, which are case specific, for the pressures are required to make the strategies, expressed generically here, operational. Tactics, specific to the nature of the activity (those shown are a selection that are applicable to harvest fisheries), are used to implement the strategy. An Ecosystem Approach for Management expands the scope of pressures and attributes considered and addresses the cumulative effects.

ATTRIBUTES	OBJECTIVES • STRATEGIES with associated pressures	MANAGED ACTIVITIES				TACTICS
		Groundfish Fishery	Herring Fishery	Salmon Aquaculture	etc.	
EXPANSION OF ATTRIBUTES CONSIDERED air quality biomass breeding behavior community assemblage genetic structure habitat structure organism health population richness forage predators primary production recruitment sediment quality size spectrum size/age structure spatial extent spatial occupancy 'special places' 'special species' trophic structure water quality yield	**Productivity:** Do not cause unacceptable reduction in productivity so that components can play their role in the functioning of the ecosystem		EXPANSION OF PRESSURES CONSIDERED			catch control effort control gear specification, size-based release area/season closure ballast water control
	• Keep fishing mortality moderate					
	• Allow sufficient escapement from exploitation for spawning					
	• Limit disturbing activity in important reproductive areas/seasons					
	• Control alteration of nutrient concentrations affecting primary production					
	Biodiversity: Do not cause unacceptable reduction in biodiversity in order to preserve the structure and natural resilience of the ecosystem		CUMULATIVE EFFECTS			
	• Control unintended incidental mortality for all species					
	• Distribute population component mortality in relation to component biomass					
	• Minimize unintended introduction and transmission of invasive species					
	• Control introduction and proliferation of disease/pathogens					
	• Minimize aquaculture escapes					
	Habitat: Do not cause unacceptable modification to habitat in order to safeguard both physical and chemical properties of the ecosystem					
	• Manage area disturbed of habitat					
	• Limit introduction of pollutants					
	• Minimize introduction of debris					
	• Control noise disturbance					
	• Control light disturbance					

Table 2. The strategies, which state how pressures induced by human activities will be managed are discussed and elaborated. The strategies are classified under the three conservation objectives, though it is recognized that the boundaries between them are blurred. For example, strategies that address habitat disturbance may also have implications for biodiversity. Similarly, strategies dealing with biodiversity may make a difference to productivity. Productivity, biodiversity and habitat are inter-connected.

Productivity

- Keep fishing mortality moderate

  Harvested fishery resources are often managed using an exploitation policy to regulate the mortality due to fishing. This includes managing the discards associated with harvesting and any appreciable deaths caused by lost gear. Evaluation of fishing mortality reference points can include consideration of broader ecosystem attributes like forage for predators, trophic structure and implications of selective removals on the life history traits, in addition to the traditional attributes of yield and productivity for the harvested resource. When biomass is low, consideration could be given to reducing harvesting further in order to promote more rapid and secure biomass increase.

- Allow sufficient escapement from exploitation for spawning

  Some harvested fishery resources are managed using an escapement policy, rather than regulating fishing mortality, where the aim is to permit sufficient spawners to evade the fishery and contribute to reproduction. This approach is common for salmon where the spawners in excess of the capacity of the spawning habitat are considered surplus. The approach is also used in some crab fisheries where harvesting is limited to males because the females are considered to be the limiting factor to reproductive success.

- Limit disturbing activity in important reproductive areas/seasons

  This strategy pertains to disturbance of spawning behaviour and not to prevention of capture of spawning fish. While the scientific support for benefits due to prevention of spawning disturbance through season/area closures are equivocal, such measures are widely supported by fishermen.

- Control alteration of nutrient concentrations affecting primary production

  Alteration of nutrient concentrations is most evident in coastal areas and associated with land based effluent discharge, typically waste/sewage disposal or agricultural runoff, and with near shore aquaculture waste.

Biodiversity

- Control unintended incidental mortality for all species

  Incidental mortality refers to unintended deaths, most commonly caused by fish harvesting operations, but also includes other causes such as ship strikes. Most fisheries catch unintended species and cause incidental mortality. The consequences of this mortality depend on the species' abundance, their life history characteristics and the magnitude of other sources of mortality. Even where catches of unintended species are low, they may cause sufficient incidental mortality to be a concern, either because the population abundance is low or the life history characteristics of the particular species render them vulnerable, e.g. low reproductive rate. Deaths caused by lost gear or industrial infrastructure, e.g. dam turbines, should also be considered.

Habitat

- Manage area disturbed of habitat

  Activities that contact the sea floor can disturb bottom habitat, particularly in highly structured areas such as tree coral grounds. Restrictions on activities in such areas have already been considered. Broader plans for limiting the general impact of activities on the sea floor are currently under development. In addition to the physical characteristics of benthic habitat, altering the physical characteristics of the pelagic habitat, e.g. heat released from power generation facilities, should also be a consideration.

- Limit introduction of pollutants

  As with alteration of nutrient concentration, introduction of pollutants is generally associated with disposal of municipal sewage/waste water and agricultural runoff in coastal areas, but may occur from industrial activity in offshore areas.

- Minimize introduction of debris

  Debris in the marine environment may come from either vessels or coastal activities practicing poor waste management. Debris may cause injury/death if ingested or by posing physical hazards.

- Control noise disturbance

  The introduction of noise that appreciably alters ambient conditions of natural habitats may modify fish behavior, cause injury or possibly result in death. Seismic activity is a particular concern.

- Control light disturbance

  The introduction of light that appreciably alters ambient conditions of natural habitats, such as the operation of lights for industrial activity may modify fish behavior, cause injury or possibly result in death.

Table 3. Definition of the attributes listed in Table 1.

Air quality	The composition of air, including the quantities of pollution found in the air.
Biomass	Biomass is the total weight of adults (spawners), population, stock, functional group, or ecosystem biomass from a particular geographic region, including lower trophic levels.
Breeding behavior	Actions and activities manifested by a particular species or population during a breeding (e.g., spawning) season
Community assemblage	A community assemblage is a collection of organisms that co-exist in a particular site and time, that are not strictly inter-dependent but interact in a variety of ways such as predation and competition.
Genetic structure	Genetic structure refers to the genetic composition of a population, stock or species
Habitat structure	Habitat refers to the area or environment where an organism or ecological community normally lives. Habitat structure is largely defined by physical characteristics, which in the marine realm include sandy, cobble, rocky, banks, basin, and slope, but includes biogenic characteristics.
Organism health	The general well-being of an organism, including physiology, nutrition, metabolism and disease.
Population richness	Population richness refers to the number of populations inhabiting a particular geographic unit (i.e., habitat, biotope, community assemblage, ecosystem).
Primary production	Primary productivity refers to the production by marine plants and phytoplankton at the base of the food web whereby inorganic carbon is fixed through the process of photosynthesis into a form that is readily available to other organisms as food.
Predator forage	Forage species are an important source of food for predators. They experience high predation mortality and may undergo large natural fluctuations in abundance in response to environmental factors, on time scales comparable to or shorter than a generation. They usually form dense schools for at least a part of the annual cycle, are relatively short lived and are mid to low trophic level species. From the perspective of fisheries management, the species will fully recruit to the fishery at ages which still experience high mortality due to predation.
Recruitment	Recruitment refers to the magnitude of incoming year classes.
Sediment quality	Sediment quality normally refers to the concentration of potentially harmful chemicals in sediments but consideration must also be given to situations where changes in sediment texture or composition can impact habitat leading to alterations in species abundance and diversity.
Size spectrum	Size spectrum refers to the variation in a community property (such as biomass, numbers or diversity) across the size range of fish in the community.
Size/age structure	Size/age structure is the relative abundance of different size/age classes within a population, stock, or community.
Spatial extent	Spatial extent is the known area of geographic distribution of a population, stock or species.
Spatial occupancy	Spatial occupancy is a measure of the proportion of the spatial extent that is used by a population, stock or species.
Special places	Special places include spawning areas, Ecologically and Biologically Significant Areas (EBSA), Marine Protected Areas and SARA Critical Habitat.
Special species	Special species include those designate as Ecologically and Biologically Significant Species (EBSS) and species at risk, which are species or populations that are listed according to one of several “at-risk” categories under the Species at Risk Act.
Trophic structure	Trophic structure results from the way that energy is transfered in an ecosystem or foodweb, from the base of the foodweb to top predators through predator-prey interactions and is represented by the amount of biomass at each trophic level.
Water quality	Water quality refers the physical and chemical properties of water which may be altered by foreign substances.
Yield	The yield of a particular fish stock is its catch in weight.

Table 4. Elements that may be considered in implementing an Ecosystem Approach to Management. Although the elements flow from top to bottom they may not necessarily be conducted in a sequential order, and there may be requirement for iteration between each step.

Understand the EAM

- List activities under DFO purview
- Review strategies and identify key pressures
- Define management units
- Review and identify attributes

Establish Operational Reference Points

- Measure and monitor key pressures
- Measure and monitor relevant attributes
- Establish appropriate operational reference points

Management Planning

- Identify tactics
- Incorporate strategies/tactics in plans or regulations
- Conduct performance evaluations of tactics
- Monitor attributes to evaluate reference points
- Review and reform management committees