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Report of the Working Group on the Northwest Atlantic Regional Sea (WGNARS)

28 January – 1 February 2013

Dartmouth, Canada

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Contents

Executive summary

The fourth meeting of the Working Group on the Northwest Atlantic Regional Sea (WGNARS), chaired by Catherine Johnson, Canada, and Sarah Gaichas, USA, was held at the Bedford Institute of Oceanography in Dartmouth, NS, Canada, from 28 January-1 February 2013. The meeting was well-attended, with 35 participants from the US and Canada. The overarching objective of WGNARS is to develop Integrated Ecosystem Assessment (IEA) capacity in the Northwest Atlantic region to support ecosystem approaches to science and management. The NW Atlantic region has well-developed ocean observation systems, ecosystem surveys and habitat studies, and steps are being taken throughout the region to organize existing information and effectively communicate it to stakeholders and decision-makers. These continuing synthesis efforts and an updated list of observation assets were reviewed at the meeting.

The 2013 WGNARS meeting shifted from the 3-day presentation and informational format used in 2010-2012 to a longer, 5-day task-oriented working format to focus the group on more specific IEA analyses and products. From 2013-2016, WGNARS intends to produce tangible analytical products contributing to IEAs at the sub-Northwest Atlantic scale. In 2013, WGNARS working sessions identified the next steps for refining IEA goals and vetting core indicators with relevant stakeholders (federal and regional governments, coastal communities, fishers, etc.), evaluated ecosystem indicator performance with respect to ecosystem drivers and responses relative to threshold levels, and evaluated risk of multi-sector ocean uses impacts in the region. These three tasks were targeted at three components of the IEA process: scoping, ecosystem indicator and target development, and risk analysis, respectively.

The primary products of the 2013 WGNARS working sessions are reviews of existing scientific methods associated with each of the three tasks and findings for further development of best practices for each within the region, as well as preliminary analytical results testing selected methods for detecting indicator thresholds and for ecological risk assessment in the NW Atlantic. Working sessions were planned around the theme of climate change due to recent observations of record high sea surface temperatures throughout the WGNARS region in 2012. Therefore, preliminary analyses presented in this report employ threshold analysis methods to examine the behavior of sets of ecological indicators from WGNARS subregions in response to climate indicators, and tested a simple expert-opinion based risk assessment method to rank potential climate impacts on Northeast US Atlantic cod. In the process, the working group gained valuable insights into using these IEA tools operationally, and will build on this experience in work planned for 2014-2016 further addressing integrated assessment objectives, testing indicators of regional scale ecological response to basin-wide drivers, and evaluating potential scenarios within ecosystem level management strategy evaluation.


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1 Opening of the Meeting

The ICES Working Group on the Northwest Atlantic Regional Sea (WGNARS) returned to the Bedford Institute of Oceanography (BIO) in Dartmouth, NS, Canada for its 2013 meeting. BIO, which was established in 1962, is Canada's first and largest federal laboratory for oceanographic research. The meeting was opened by Dr Alain Vézina, the Regional Director of Science for Fisheries and Oceans Canada in the Maritimes and a former WGNARS co-chair, who noted the progress of the group in its four year history and highlighted its role in coordinating progress toward an Ecosystem Approach to Management in the Northwest Atlantic.

2 Development and Adoption of the agenda

The 2013 agenda was developed to address Terms of Reference (ToRs) developed by the WGNARS steering committee in 2012, with one additional ToR from ICES to review regional observing assets to support regional ecosystem assessments. Since the group's mandate requires coordination among many groups working toward development of Integrated Ecosystem Assessments (IEAs) and an Ecosystem Approach to Management (EAM), the meeting started with presentations reviewing work by WGNARS, the ICES Workshop on Benchmarking Integrated Ecosystem Assessments (WKBEMIA), and the NAFO Working Group on Ecosystem Approach to Fishery Management (WGEAFM), as well as updates on national and regional IEA and EAM activities in Canada and the US.

The three main theme areas of the meeting were drawn from elements of the Levin *et al*. (2009) Integrated Ecosystem Assessment framework and included (1) scoping to identify goals and objectives, (2) indicator performance, and (3) risk assessment. In developing the ToRs, these areas were all considered as both priorities for development of IEAs and also challenging topics for WGNARS. Two strategies were implemented by the group to tackle these topics. First, presentations were limited to brief reviews of relevant approaches and activities in order to accommodate discussions and working sessions addressing the theme areas. Second, experts from outside science, including fisheries and oceans managers and experts in ocean law and information management, were invited to participate. Both of these strategies contributed to progress and development of future directions in the theme areas.

3 Introduction – Integrated ecosystem assessment activities in ICES, NAFO, DFO, and NOAA (ToR e)

Work is underway in a variety of contexts around the North Atlantic to develop Integrated Ecosystem Assessment (IEA) methods and approaches to support an Ecosystem Approach to Management (EAM). To help coordinate these efforts and benefit from their progress, the WGNARS meeting opened with a review of its own past work and updates on IEA/EAM related work in ICES, NAFO, DFO, and NOAA.

3.1 WGNARS Background – Catherine Johnson

The overarching objective for WGNARS is to develop the scientific support for an IEA of the Northwest Atlantic region to support ecosystem approaches to science and management. Levin *et al*. 2009 defines IEA as "a synthesis and quantitative analysis of information on relevant physical, chemical, ecological, and human processes in relation to specified ecosystem management objectives," in other words, a tool to help link integrative scientific knowledge and analysis with ecosystem management actions in the context of EAM.

WGNARS is part of the ICES Steering Group on Regional Sea Programmes (SSGRSP), under the ICES Science Committee. The SSGRSP facilitates expert groups that work on regionalization of the science plan, with a main focus on advancing development of IEAs in the ICES ecoregions. WGNARS has a different connection to the advice process than the other IEA-oriented expert groups within the SSGRSP, because of its regional focus on the Northwest Atlantic where fisheries and oceans management advice is provided by NOAA and DFO rather than ICES. This unique position, both outside the ICES advice structure but engaged in ICES IEA development as part of the SSGRSP, provides an opportunity to advance the group's efforts toward IEA development through uptake of methodological advances from a variety of different sources.

In the US, development of EAM is supported by the National Oceans Policy (2010). There is national coordination for IEA development through the NOAA IEA program, and regional coordination in the northeast US through the NOAA Northeast Fisheries Science Center Ecosystem Assessment Program. In Canada, an Ecosystem Approach to Management is supported by the Oceans Act (1996). National coordination on EAM is currently under development, and there has been progress toward Integrated Management Planning and EAM in the Atlantic DFO regions. The NAFO Working Group on Ecosystem Approaches to Fisheries Management (WGEAFM) is also working toward EAM for Northwest Atlantic stocks and regions managed by NAFO, and there is close coordination between the WGEAFM and WGNARS.

WGNARS has adopted the Levin *et al*. (2009) framework for IEA to organize its work (Figure 3.1.1). This framework is an iterative process that includes scoping to identify goals and threats, development of indicators and targets, risk analysis, assessment of ecosystem status, management strategy evaluation, and monitoring. US IEA programs have explicitly adopted this approach, while Canadian EAM efforts have incorporated similar elements.

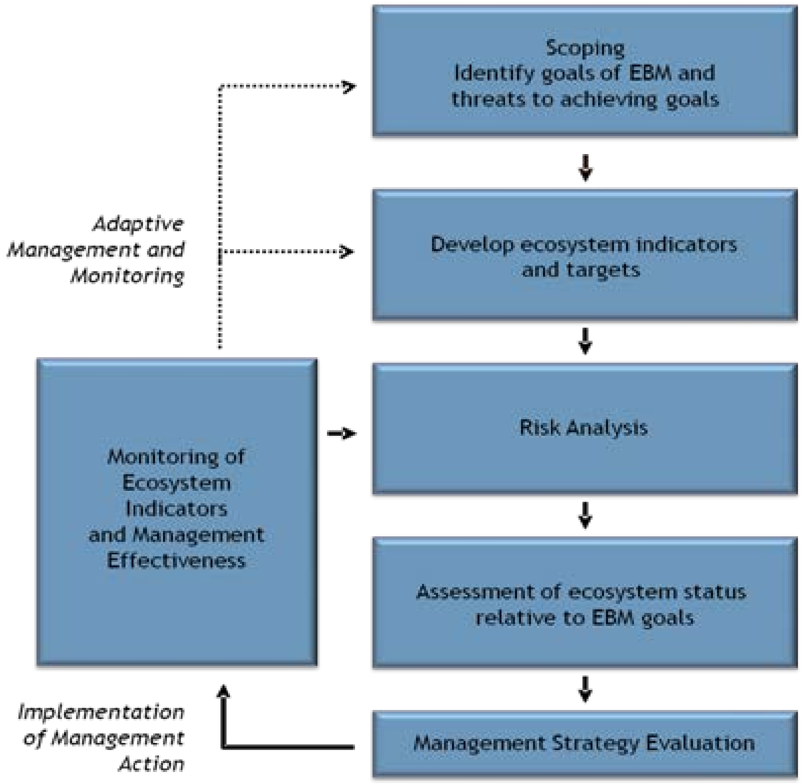


Figure 3.1.1 Levin *et al.* (2009) Framework for Integrated Ecosystem Assessment

The focus of WGNARS has shifted in each of its first four years to reflect the group's current priorities for advancing IEA development. The first WGNARS meeting, in 2010, focused on defining the spatial scope and degree of integration required and developed an inventory of available programs and information from surveys, ocean observing systems, and habitat research. The themes addressed by the group included climate, biodiversity, and habitat, and particular effort was taken to consider the challenges of incorporating information about processes acting across spatial scales. In 2011, the Levin *et al.* (2009) framework was used to organize WGNARS presentations. Major outcomes of the meeting included the development of a triad of ecosystem drivers, organization of ecosystem indicators into categories of drivers, use of habitat studies as an integrative theme, and introduction of human dimensions. The 2012 meeting focused on development of methods to identify indicator thresholds, methods to incorporate habitat and spatial information at appropriate scales into ecosystem assessment and management, and incorporation of social and economic context into ecosystem assessment.

Discussions of the WGNARS steering group in 2012 identified scoping with stakeholders to identify objectives, development of thresholds for management action, and evaluating indicator performance relative to ecosystem drivers as priority areas for the 2013 meeting. These activities will help to shift the focus of WGNARS toward developing initial integrated assessments in subregions of the Northwest Atlantic regions in the next three years. To more effectively address methodological development toward IEAs, the length of the meeting was increased to 5 days (three full and two partial) in 2013, and the format of the meeting minimized presentations and increased the time devoted to working sessions.

Terms of Reference for 2013 included the following:

a) Continue to develop the scientific support for an integrated assessment of the Northwest Atlantic region to support ecosystem approaches to science and management;

b) Review and summarize previous scoping exercises in integrated ecosystem assessment or similar initiatives for management objectives and socio-economic utilities. Identify next steps for refining goals for an IEA for the Northwest Atlantic as well as for vetting core indicators with relevant stakeholders (federal and regional governments, coastal communities, fishers, etc.).

c) Evaluate risk of various multi-sector ocean-uses impacts facing the Northwest Atlantic to assess relative susceptibilities;

d) Evaluate indicator performance with respect to important ecosystem drivers, emphasizing responses relative to candidate thresholds;

e) Review and report on the work of other integrated ecosystem assessment activities in ICES, NAFO and elsewhere;

f) Identify potential regional observing assets (both inside and outside ICES) necessary to support development of regional ecosystems assessments.

Much work remains to move forward with IEA implementation. Levin *et al*. (2009) provides guidance, but the process of IEA development will vary depending on the institutional context. IEA frameworks should be able to accommodate variation in governance and ecosystem context and work at different levels of complexity (e.g. in current Integrated Fisheries Management Plans as well as future EAM implementation). Management and stakeholder involvement is essential to Science to generate relevant advice through IEAs. Progress on EAM is being made in many venues, and ICES can provide coordination to develop IEA best practises.

WGNARS has depended on the enthusiastic participation of its members, with direction provided by its steering group, including Jason Link, Patricia Pinto da Silva, John Manderson, Robert Gregory, Dave Hebert, and Jon Hare in 2012. Starting in 2013, Sarah Gaichas replaced Steve Cadrin as co-chair with Catherine Johnson.

3.2 ICES Working Group on Benchmarking Integrated Ecosystem Assessments (WKBEMIA) - Steve Cadrin

ICES held a "Benchmarking Workshop" to initiate the transition of Integrated Ecosystem Assessments tasked to Regional Seas Expert Groups from scientific development to management advice. The term "benchmark" is used in the ICES advisory system for single-species stock assessments for the process of deciding on the most appropriate methodological approach for the provision of advice.

The Terms of Reference included starting a process on how to Benchmark Integrated Ecosystem Assessment (IEA) based on results in ongoing Integrated Ecosystem Assessments Expert Groups;

a) Make a brief review on the various concepts of Integrated Ecosystem Assessments including an evaluation of suitability to ICES needs in terms Science and Advice;

b) Review the Integrated Ecosystem Assessments in the ongoing Regional Expert Groups, with regards to methods, models and results;

c) Identify a common framework which will act as a guideline for Integrated Ecosystem assessments performed in ICES;

d) Based on ToR c, identify the need of supporting data, processes and products.

The workshop had participants from ICES leadership (e.g. the outgoing and incoming Science Committee Steering Group chairs for the Regional Seas Programme, a presentation by the Science Committee chair, and several ICES staff in the science and advisory programmes) as well as many leaders in Regional Seas expert groups.

The proposed ICES Strategic Plan places a central role for Integrated Ecosystem Assessment to link science and advisory programs (Figure 3.2.1). Two of the current science committee steering groups (black text boxes in Figure 3.2.1): 1) Ecosystem Pressures and Impacts, 2) Ecosystem Processes and Dynamics would provide knowledge to two intermediate groups: 1) Integrated Ecosystem Assessments and 2) Integrated Ecosystem Surveys that would serve both science and advisory programs. These products would support benchmarks, operational advice and implementation of ecosystem approaches under the advisory program (red text boxes in the figure).

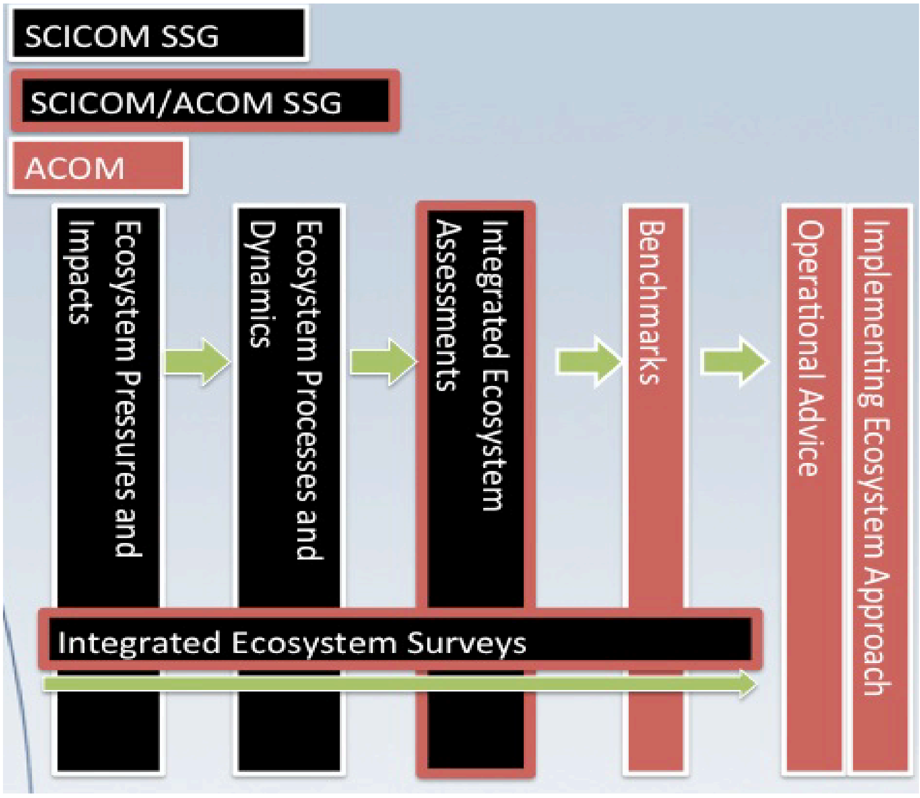


Figure 3.2.1 Context of Integrated Ecosystem Assessments in the ICES Strategic Plan

Progress in each regional sea programme (Baltic Sea, North Sea, Northwest Atlantic, Western Shelf Seas) was reviewed to identify common approaches, results and challenges for integrated ecosystem assessment. The workshop agreed to use a framework previously developed by FAO, WGECO and the US (Levin *et al*. 2009). Methods, models, results, and requirements for each component of the framework were identified. These will all be described in the final report.

The participants of WKBEMIA suggested that results from integrated ecosystem assessments can be used by ACOM for improving issue-based advice, providing ecosystem context for issue-based advice and possibly identifying new issues. There are recent examples of requests to ICES for advice that would have benefitted from an integrated approach. More integrated advice can be supported by considering results from integrated ecosystem assessments. Procedurally, there are two linkages between integrated ecosystem assessment and the ICES advisory process: 1) assessment groups can consider ecosystem states in their analytical decisions (e.g. assumptions about future recruitment, growth etc.), and 2) advice drafting groups can develop integrated advice by considering regional ecosystem state, impacts and utilities in the ICES response to issue-based requests. Logistically, the linkages between integrated ecosystem assessments and single species assessments can be facilitated by concurrent meetings of regional sea and ecoregion assessment expert groups, with some joint sessions. Such joint-meetings can take advantage of regional expertise and promote cross-discipline collaborations.

WKBEMIA suggested that certain areas of integrated ecosystem assessments need more attention, especially scoping for objectives, tool development for identifying indicators and thresholds, risk analysis and management strategy evaluations.

The SCICOM Steering Group on Regional Seas Programmes is planning a series of benchmark workshops for integrated ecosystem assessments. This first workshop is to be followed by a second benchmark workshop in 2014, with greater input from ACOM (e.g. co-chaired by ACOM and SCICOM representatives). A third benchmark meeting is planned for 2016 that will invite stakeholders. Throughout the benchmarking process, integrated ecosystem assessments will transition from SCICOM to an intermediate position in the ICES organization between SCICOM and ACOM.

The WKBEMIA and SSGRSP have noted the proposal of a new ICES Strategic Plan and Science Plan. The plan for continued benchmarking and integration into advice is congruent with the desire for a focal point on integrated ecosystem assessments and consequent integrated ecosystem advice. However, it is not clear what the remit will be for the IEA Expert Groups and how further development should be achieved without some substantial restructuring within ICES and a greater provision of resources. WKBEMIA noted that the suggested renewed Science plan is not proposing any extra supporting activities or resourcing to increase developing of the integrated ecosystem approach in the foreseeable future. SSGRSP and WKBEMIA advocate that Integrated Ecosystem Assessments form a strategic initiative between ACOM/SCICOM.

Members of WGNARS felt that the period for an Integrated Ecosystem Assessment cannot be annual, but progress can be made on components of the Levin *et al*. (2009) cycle each year. Therefore integrated ecosystem assessment cycles may be approximately a 5-year duration, but they would inform annual issue-based advice. WGNARS participants also felt that scoping and socio-economic analyses are needed to refine management objectives.

3.3 NOAA Integrated Ecosystem Assessment (IEA) Program: Update of Program Implementation – Rebecca Shuford

NOAA's approach to Integrated Ecosystem Assessments (IEAs) offers a way to better manage resources to achieve economic and societal objectives. IEAs provide a sound scientific basis for EBM. They are "a synthesis and quantitative analysis of information on relevant physical, chemical, ecological, and human processes in relation to specified management objectives" (Levin, *et al*. 2008, 2009, 2012). The resulting analyses, done at scales relevant to management questions, provide resource managers with information to make more informed and effective management decisions.

IEAs, as NOAA approaches them, provide a process to work closely with stakeholders and managers to identify priority management issues and provide robust decision-support information.

3.3.1 Updated IEA Approach Diagram

Many people are familiar with the six box process diagram that has been used to graphically depict NOAA's iterative approach to IEAs. As we have been developing and implementing IEAs across the country, we have evolved our approach and process. This will likely continue as we move forward, lessons are learned, and best practises are identified. The new diagram presented in Figure 3.3.1 is currently how we are conceptualizing the process. The fundamental approach and all "steps" are still encompassed at one point or another in the process. Some terminology has been modified and some of the "order of events" refined. The new representation portrays a more dynamic and fluid approach that still defines "national consistency with regional flexibility".

Define Ecosystem Management Goals and Targets: The IEA process involves manager engagement to identify critical ecosystem management goals and targets to be addressed through and informed by the IEA approach. The rest of the process is driven by these defined objectives. Engagement is continual throughout the entire IEA process.

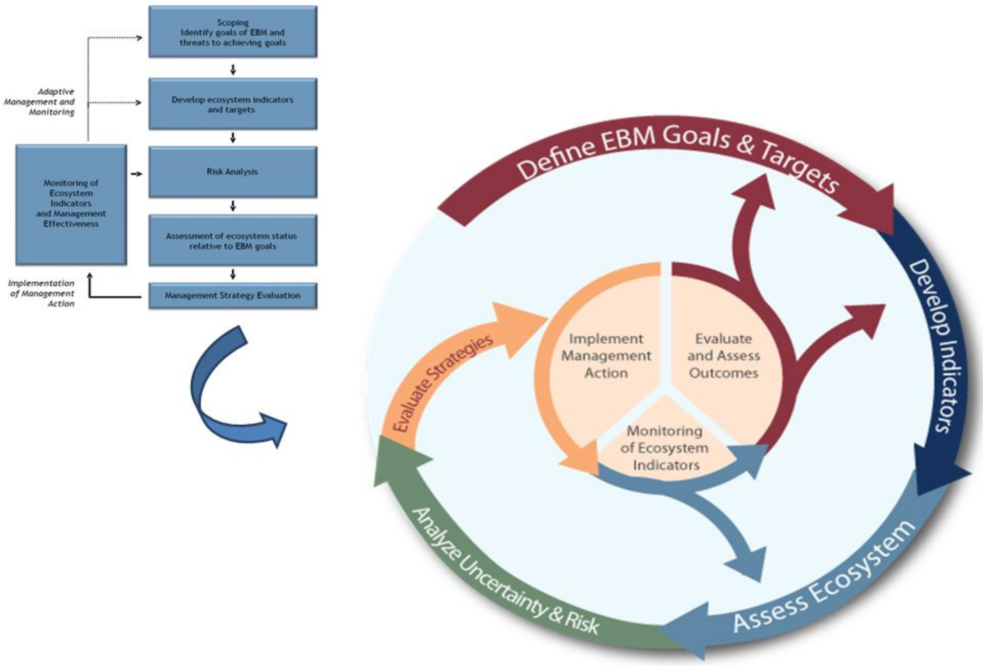


Figure 3.3.1 The NOAA IEA Approach

Develop Ecosystem Indicators: Indicators represent key components in an ecosystem and allow change to be measured. They provide the basis to assess the status and trends in the condition of the ecosystem or of an element within the system. Indicators are essential to all subsequent steps in the IEA approach.

Assess Ecosystem: Ecosystem indicator data are assessed together to evaluate overall ecosystem status and trends relative to ecosystem management goals and targets.

Individual indicators are assessed to determine the underlying cause for the observed ecosystem status and trends.

Analyse and Evaluate Uncertainty and Risk: Ecosystem analyses and models evaluate risk to the indicators and thus the ecosystem posed by human activities and natural processes. These methods incorporate the degree of uncertainty in each indicator's response to pressures. This determines incremental improvements or declines in ecosystem indicators in response to changes in drivers and pressures and to predict the potential that an indicator will reach or remain in an undesirable state.

Management Strategy Evaluation (MSE): MSE is useful to help resource managers consider the system trade-offs and potential for success in reaching a target which helps make informed decisions. It uses simulation through ecosystem modelling to evaluate the potential of different management strategies to influence the status of natural and human system indicators and to achieve our stated ecosystem objectives.

Taking, Monitoring, and Assessing Action: Based on the MSE, an action is selected and implemented. Monitoring of indicators is important to determine if the action is successful; if yes, the status, trends, and risk to the indicators continue to be analysed for incremental change; otherwise as part of adaptive management, the outcomes need to be assessed and evaluated to refine goals and targets or indicators towards achieving objectives.

3.3.2 US Regional Progress and Activities

Over the past several years, NOAA has been building a national IEA program that will include eight regions whose geographic boundaries are based on US Large Marine Ecosystems[1]. Currently there is IEA work being conducted to develop and implement IEAs in five regions: the California Current, the Gulf of Mexico, the Northeast Shelf, as well as the Alaska Complex and the Pacific Islands (Figure 3.3.2). Though NOAA has defined a national framework, there are regional distinctions in how this framework is applied, and each region is at different stages of implementation. Following are some highlights of select activities from 4 of the 5 regions:

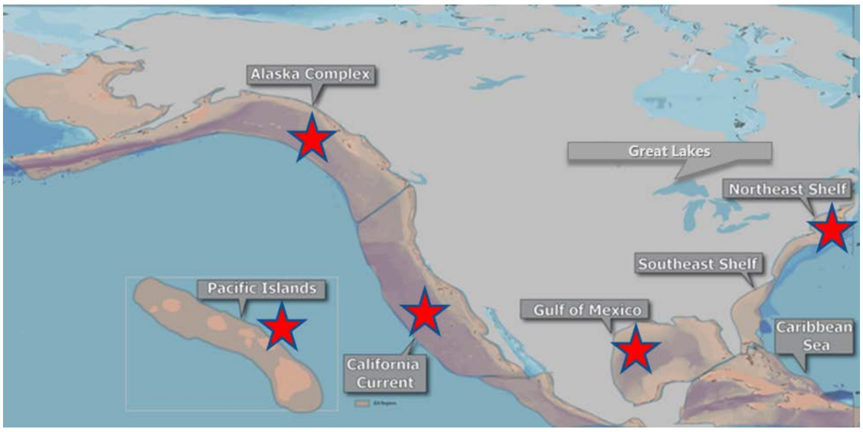


Figure 3.3.2 NOAA IEA Regions

[1] It is important to note that though the geographic bounds of the IEA regions are based on the US LME's, the IEA process can be implemented in a region any number of times at a scale that is relevant to the management question being addressed

California Current IEA: In 2009, the CCIEA began planning in earnest. By 2010 they had begun to build an IEA science toolkit including frameworks for indicators and for risk assessment as well as a suite of analytical tools to support the process. A 1st Generation CCIEA report was also complete. In 2011, engagement with science and manager partners was expanded. In 2012, the second Generation CCIEA report was complete and represented significantly expanded breadth in term of topics addressed (e.g. Ecological Integrity, Protected Species, Fisheries, and Human Communities). In 2013 they are working to expand and improve upon what has already been built towards a CCIEA 3.0 that will include additional human dimensions work, habitat, and highly migratory species; work on reference levels; and it is to be hoped an IEA Workshop in the region. Multiple IEA products have been produced including: Summary of atmospheric and ocean conditions, status and trends of major components of the CC ecosystem, State of the California Current report, Risk Assessment of groundfish fisheries on marine mammals, Atlantis ecosystem model, and Wave Energy analyses.

Gulf of Mexico IEA: The GoMIEA has established a regional steering committee which is divided into 4 subcommittees to allow focused discussions on how to achieve their IEA goals (i.e. Management and Outreach, Indicators, Modelling, Data). The steering committee is comprised of members from across NOAA line offices as well as external partners in the region (e.g. other federal agencies, states, international, NGOs, and academic institutes). In 2012 they held their first workshop where they discussed what IEA-related activities were already underway and identified priorities for the following year. To date a lot of work has been done in relation to indicators, including to determine current and historical ecosystem status; to inform risk analysis and parameterize models; and to determine relative effect of proposed management strategies. They have also developed a Gulf Atlas that will serve as their data portal, as well as a Trophic Database that will ensure all models for the IEA are using the same, most accurately available, information which is important since the GoMIEA is using an ensemble model approach to conduct Management Strategy Evaluation. The region has also developed an EBM-DPSER model to help identify links between pressures, states, ecosystem services, and responses.

Northeast Shelf IEA: The NEIEA has been working on the development of IEAs for several years. Currently they are planning to broaden the focus to include an ecosystem services perspective. Additionally, they are approaching IEAs from a place-based perspective, and working with managers in the region to support coastal and marine spatial planning efforts. The NEIEA has produced updated Ecosystem Status Reports and Ecosystem Advisories and they continue to build out their modelling initiatives including EcoSim and Hydra (in addition to existing efforts such as with Atlantis). One of the focuses of the regional IEA efforts is to bring in climate considerations and make climate connections to understanding the ecosystem. The region also is working very closely with the Mid-Atlantic and New England Fisheries Management Councils on activities and approaches needed for Ecosystem-based Fisheries Management, including development of Fishery Ecosystem Plans.

Pacific Islands IEA: Kona was selected as the initial location for the PIIEA due to its dynamic ecology and history of research. Several potential management issues that could be addressed through the IEA approach exist in the area including: Aquaculture and Cageculture; commercial, recreational, and aquarium fisheries; shared use areas (e.g. fisheries and tourism); climate and anthropological impacts on ocean/ land ecosystem; and cetaceans and other marine mammals. The Kona IEA has several projects either completed or ongoing based on scoping that has been done as well as the work's relationship with identified management issues. This includes: modelling projects to understand the dynamic system (e.g. Ecopath model, coupled circulation-larval transport model, cetacean habitat modelling); development of socio-economic indicators; oceanographic baseline assessment; and outreach projects (i.e. research symposia; website).

For more information on NOAA's Integrated Ecosystem Assessment program and regional activities, visit the IEA website at: http://www.noaa.gov/iea/

3.4 An Ecosystem Approach to Management: A Canadian Perspective – Marc Clemens

Despite the absence of a departmental framework or policy on the ecosystem approach to management (EAM), considerable work has been done to advance ecosystem approaches to management across Fisheries and Oceans Canada's programs. Individual programs (Aquaculture, Fisheries, Habitat, Oceans, and Species at Risk) have applied aspects of an EAM – with more progress in some areas and activities than others. The Department has introduced policies and tools to manage the impacts of activities (e.g. fisheries, aquaculture, and seismic exploration) on ecosystem components and others are on the way. Further, integrated management plans have been developed for five large ocean management areas, Marine Protected Areas (MPA) have been designated under the Oceans Act and other areas of interest are at various stages of progress towards MPA designation.

The recent reorganization of the Science sector supports better delivery of ecosystem science. In addition, the recent reorganizations involving the Ecosystems and Fisheries Management and Program Policy sectors supports better integration of operational decisions and policy frameworks respectively.

The Science sector has two new programs that focus on ecosystem issues, the Strategic Program for Ecosystem-based Research and Advice (SPERA) program and the Climate Change Adaptation program. While both have their own distinct mandates, there are some elements of these programs that may be compatible with addressing some aspects of the integrated ecosystem assessment in the Northwest Atlantic Region; however, resources are limited and the focus of these two programs is on projects that will allow for broader (National) scale application.

Ecosystem assessments can be "integrated" in three different conceptual ways each with its own advantages and disadvantages: from "physics to fish"; across multiple uses of the ocean; and across ecological, social, and economic dimensions of sustainable use. The latter is most directly relevant to policy-making at single sector and integrated levels. It directly supports analyses of policy trade-offs, which is one of the priorities for the policy and management sectors. However, it is outside traditional areas of research for most of the science community.

DFO is moving incrementally to implement ecosystem approaches to management within and across sectors and this is dictated by (1) the identification of management needs and priorities and the availability of information (2) stakeholder involvement and opportunities for cooperation, and (3) the availability of resources and capacity.

3.5 Integrated Oceans and Coastal Management on Canada's East Coast – Glen Herbert and Heather Breeze

Various integrated oceans and coastal management initiatives have been coordinated by regional offices of Fisheries and Oceans Canada on Canada's east coast. Integrated oceans and coastal management is defined as a planning process that brings all ocean interests together to develop common management objectives and strategies. It considers the relationships between different ocean interests, as well as the interactions between users and the environment. Integrated management was spurred by the 1996 Oceans Act and associated policies. The national Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments provided guidance on the process, with six steps: defining and assessing a management area, engaging affected interests, developing an integrated management plan, endorsement of plan by decision-making authorities, implementing the plan, and monitoring and evaluating outcomes.

On Canada's east coast, the implementation of integrated management was initially started in three large ocean management areas (LOMAs): Placentia Bay/Grand Banks, Gulf of St Lawrence, and the Eastern Scotian Shelf (ESSIM). The Eastern Scotian Shelf was the first offshore initiative and aimed to address multiple ocean uses and jurisdictions as well as competition for space. It used a collaborative process to develop and implement an integrated ocean management plan. Activities that took place under the ESSIM initiative can be grouped under the six steps of the national Policy and Operational Framework; some of the steps occurred simultaneously and some steps were returned to over the course of the initiative. In addition to the initiatives coordinated by DFO, the province of Nova Scotia is developing a Coastal Strategy with goals and strategies, and the Gulf of Maine Council has developed an Action Plan with goals and actions across multiple government agencies in two nations. The steps in DFO's Policy and Operational Framework were compared to the steps in Levin *et al*. (2008, 2009). The steps can be matched, although the emphasis is different: Levin *et al*. focuses on the science and analyses needed for ecosystem-based management, while the Policy and Operational Framework focuses more on the management and coordination that is needed.

3.6 Application of the Maritimes EAM Framework EAM Framework to an Area-Based Assessment on the Eastern Shore of Nova Scotia – Tana Worcester

DFO Maritimes is conducting a pilot exercise to apply the Maritimes EAM Framework to an Area-Based Assessment on the Eastern Shore of Nova Scotia. In preparation for the exercise, overarching objectives and strategic objectives ("strategies") for conservation were identified, the geographic area of the assessment was defined, and participation was sought from federal and provincial government agencies, aboriginal organizations, fisheries and aquaculture industry organizations, NGOs, community members, and academics. This exercise is envisioned as a ten step process. The first step of the process identified relevant ocean activities in the areas, and then key pressures were prioritized (step 2). For each activity, a triage was conducted to prioritize the key pressures induced by that activity. A "Pathways of Effects" approach was used, where available, to identify the linkages between strategies, key pressures, and the attributes that they impact. These analyses identify a subset of strategies, activities, and attributes for more detailed analysis. The third step of the process is to identify the current management units associated with the attributes (e.g. Lobster Fishing Areas), if they exist. Following this, the process will determine ways to monitor the key pressures (step 4) and attributes (step 5), incorporating reference points. A dynamic perspective may be required to incorporate the impacts of ecosystem changes over time. Step 6 identifies appropriate existing tactics (i.e. management tools) to implement the strategies. The exercise envisions four additional steps to complete the process, including incorporating strategies into management plans (step 7), conducting performance evaluations (step 8), monitoring attributes and pressures (step 9), and reviewing overall process and management framework, including building stakeholder capacity (step 10).

3.7 Integrated Fisheries Management Plans at Fisheries and Oceans Canada – Sara Quigley

Integrated Fisheries Management Plans (IFMPs) were first introduced at Fisheries and Oceans Canada (DFO) in the mid-1990s. The goal of IFMPs 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. They are considered both a process and a document. As a document they are an important tool and source of information on a given fishery for people both within and outside DFO. As a process they integrate the expertise and activities of DFO sectors in fisheries management planning, and they allow for input from resource users and other stakeholders and decision-makers. While there will be some variability of the content of IFMPs across the country, all IFMPs must incorporate the “Sustainable Fisheries Framework” that has been adopted by Fisheries Management within DFO. The Sustainable Fisheries Framework provides the basis for ensuring Canadian fisheries are conducted in a manner that supports conservation and sustainable use. Policies under the Sustainable Fisheries Framework currently are a policy on a precautionary approach to decision-making in fisheries management, a policy on the protection of sensitive benthic areas from fishing, and a policy on forage species. A policy on by-catch is under development. More information on IFMPs and the Sustainable Fisheries Framework is available on the DFO website.

3.8 NAFO Working Group on the Ecosystem Approach to Fisheries Management update – Mariano Koen-Alonso

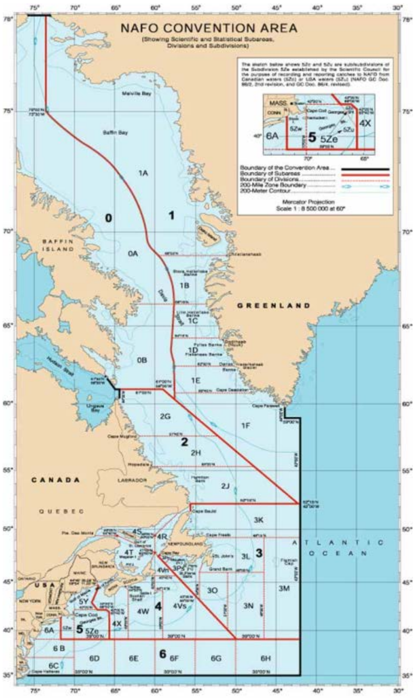
The Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries came into force in 1979, replacing the 1949 International Convention for the Northwest Atlantic Fisheries. In doing so, it established the Northwest Atlantic Fisheries Organization (NAFO), which replaced the International Commission for the Northwest Atlantic Fisheries (ICNAF).

NAFO is functionally organized around two main bodies, the Scientific Council (SC), and the Fisheries Commission (FC). In simple terms, SC is responsible for the provision of science advice, while FC is responsible for the actual management actions. In addition to these two bodies, there is an overarching General Council responsible of the internal affairs and external relationships of NAFO, and a Secretariat that coordinates the work of the different NAFO bodies, and runs NAFO day-to-day operations.

Both SC and FC have their own Standing Committees to deal with areas/topics that are part of their regular operations, and when required, they create working groups to deal with emerging issues. The lifespan and precise nature of these working groups is dictated by the specific issue at hand. In some instances, joint SC and FC WGs have been established to address topics which required simultaneous input and exchange of ideas between scientists and managers.

NAFO FC manages fisheries on the NAFO Regulatory Area (NRA, outside the EEZs of coastal states), and straddling stocks, but the entire convention area (Figure 3.8.1a) is considered for assessment and advice when required. At the present time NAFO SC provides advice for more than 20 stocks, eighteen of which are actually managed by NAFO.

a)



b)

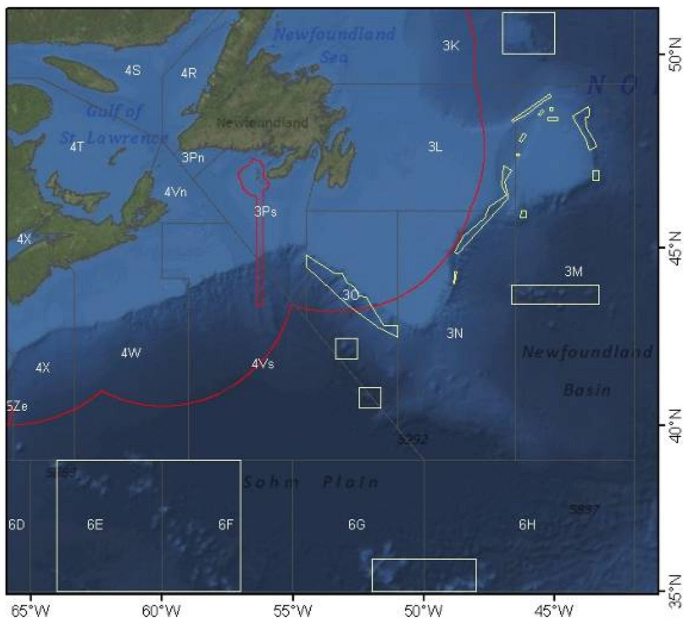


Figure 3.8.1. a) NAFO Convention Area; the NAFO Regulatory Area (NRA) comprises the Convention Area outside the EEZ of coastal states. b) areas bounded in white represent all areas currently closed to bottom fishing to protect significant concentrations of corals and sponges and seamount habitats in the NRA.

In 2007 NAFO adopted a document entitled "Amendment to the Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries"; this was the first formal step towards a reformed Convention for NAFO. In this reformed Convention, which is currently in the process of being ratified by contracting parties, NAFO commits to *apply an ecosystem approach to fisheries management in the Northwest Atlantic that includes safeguarding the marine environment, conserving its marine biodiversity, minimizing the risk of long-term or irreversible adverse effects of fishing activities, and taking account of the relationship between all components of the ecosystem*.

Although the reformed convention is not yet in force, it still crystallizes the direction NAFO has been moving towards over the last decade. NAFO formally adopted the precautionary approach in 2004, has implemented a Management Strategy Evaluation approach for Greenland halibut, one of the most important stocks under NAFO management, and it is developing rebuilding plans for several of its managed stocks. As part of this general direction, SC created in 2007 its Working Group on Ecosystem Approaches to Fisheries Management (WGEAFM). The results of the work of this SC WG, together with the work done by the FC Working Group of Fisheries Managers and Scientists on Vulnerable Marine Ecosystems (FC WGFMS-VME), have been the underpinnings for the many measures that NAFO has implemented over the last 5 years for the protection of Vulnerable Marine Ecosystems (VMEs) like the implementation of encounter protocols and closed areas (Figure 3.8.1b). During its 2012 Annual Meeting, NAFO has taken further steps by replacing its FC WGFMS-VME with a joint FC-SC Working Group on Ecosystem Approaches to Fisheries Management. The Terms of Reference for this new joint WG are currently in development, but it is expected that this new WG will complement the work currently being done by SC WGEAFM.

Since its creation, NAFO SC WGEAFM has had two primary activities, the development of a long-term basis for an Ecosystem Approach to Fisheries (EAF) for NAFO, and to provide advice and information on specific requests related to ecosystem issues. In order to achieve its goals, WGEAFM operates with a stable set of Terms of Reference, which are addressed over multiple meetings.

In terms of EAF, WGEAFM work has provided the basis for the development of the "SC Roadmap to EAF" (NAFO 2010), which constitutes the template proposed by SC on how NAFO could move forward towards implementing an ecosystem approach for the fisheries under NAFO management.

The "Roadmap to EAF" is being developed around the concept of Integrated Ecosystem Assessments (IEA) (Levin *et al*. 2009) (Figure 3.8.2), and its core premises are: a) the approach has to be objective-driven, b) it should consider long-term ecosystem sustainability, c) it has to be a place-based framework, and d) trade-offs have to be explicitly addressed.

The initial development was organized around three practical steps (Figure 3.8.2). These steps were defined with the purpose of making tractable the process of developing the EAF framework and were focused on the definition of regional ecosystem units, the understanding of ecosystem state and key functional processes, and examination and development of management tools. In terms of setting sustainable exploitation levels, the overall framework can be summarized as a 3-tiered, hierarchical one. The first tier defines fishery production potential at the ecosystem level, taking into account environmental conditions and ecosystem state. This allows a first order consideration for the potential influence of large-scale climate/ecological forcing on fishery production, as well as explicitly considering the basic limitation imposed by primary production on ecosystem productivity. The second tier utilizes multispecies models to allocate fisheries production among a set of commercial species, taking into account species interactions as well as considerations on the resilience and stability of the exploited assemblage. This tier explicitly considers the trade-off among fisheries, and allows identifying exploitation rates which are consistent with multispecies sustainability. The third tier involves single-species stock assessment, where the exploitation rates derived from tiers 1 and 2 can be further examined to ensure single-species sustainability. This hierarchical sequence considers the sustainability of the exploitation at the ecosystem, multispecies assemblage, and single-stock level. In addition to this hierarchical approach to define exploitation rates, the current operational template of the "Roadmap to EAF" also integrates the impacts on benthic communities (e.g. VMEs) associated with the different fisheries that take place within the ecosystem (Figure 3.8.3).

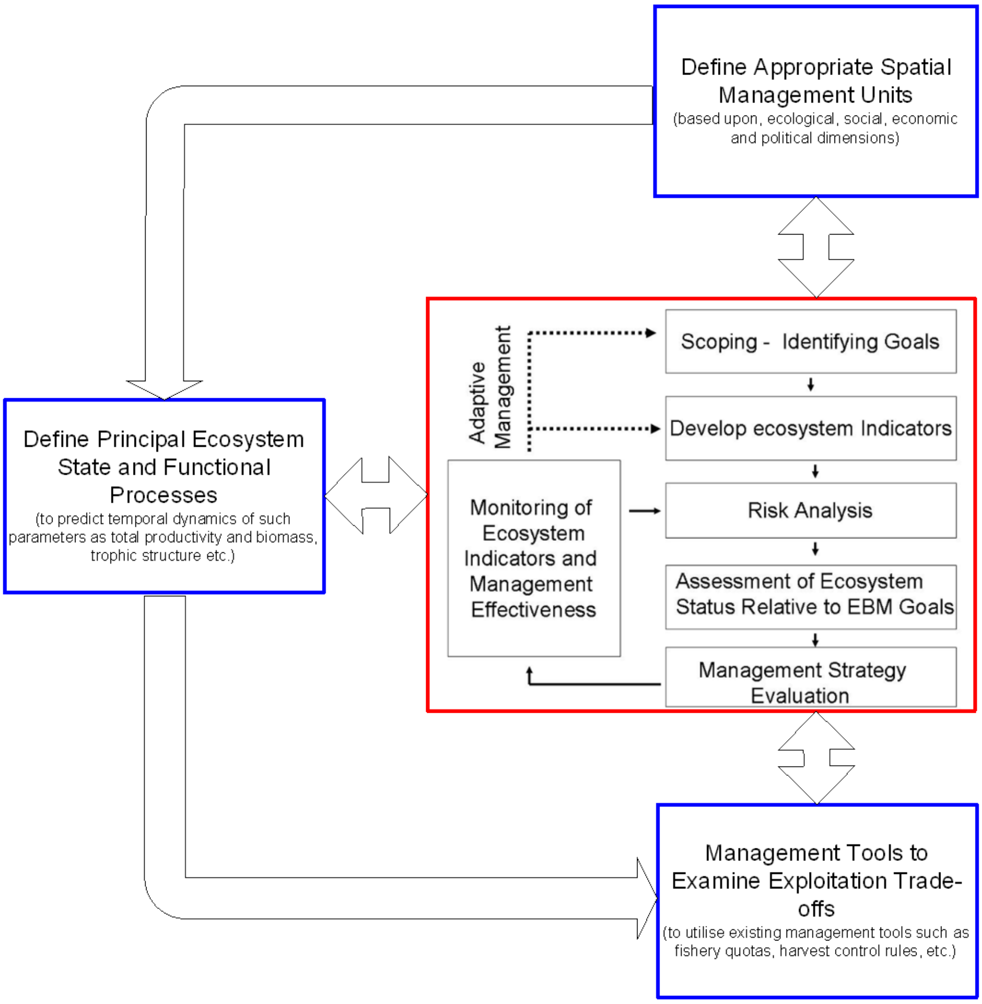


Figure 3.8.2. NAFO SC "Roadmap to EAF." The relationship among the 3 practical steps in moving towards the implementation of an ecosystem approach to fisheries management (blue boxes) and the steps required to deliver effective holistic integrated ecosystem assessments (IEA) shown in the red box; b) Current working template on how the NAFO SC "Roadmap to EAF" could be made operational.

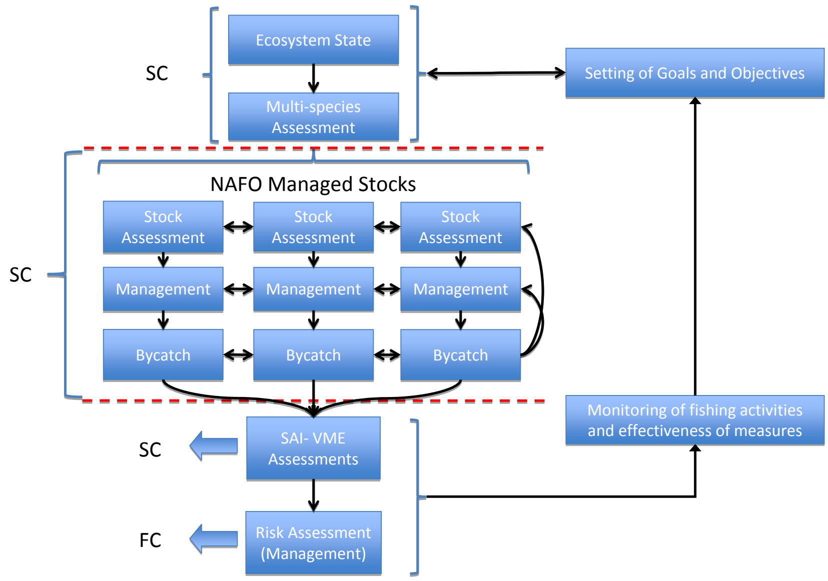


Figure 3.8.3. NAFO SC "Roadmap to EAF." Current working template on how the NAFO SC "Roadmap to EAF" could be made operational.

During the 5th WGEAFM meeting (21-30 November 2012, Dartmouth, NS), the WG continued advancing its multiyear agenda towards fully developing the "Roadmap to EAF", as well as addressing specific ecosystem-related requests. Some of the key topics addressed at the 2012 meeting included:

- Development of a workplan for producing the analyses required for the review of all VME-related NAFO closures (i.e. areas of high concentrations of corals, sponges, and seamounts) which is scheduled for the 2014 NAFO Annual Meeting.
- Exploration of the variability of the ecoregion structure of the Newfoundland-Labrador shelves ecosystem over time, and preparatory work towards a Northwest Atlantic-scale ecoregion analysis.
- Report on progress on the development of Fisheries Production Potential (FPP) models.
- Further analysis of the structure and dynamics of the Flemish Cap, including estimations of food consumption by cod and redfish, as well as updated results from a cod-redfish-shrimp model.
- Update on ecosystem studies in the Newfoundland-Labrador shelves ecosystem, including linkages between environmental drivers and capelin, the study of the impacts of food availability, fishing, and harp seal predation on the trajectory of northern cod, trends in the fish community, and diets for key species in this ecosystem.
- Development and analysis of encounter thresholds and move-on rules for small gorgonian corals, large gorgonian corals, sea squirts, erect bryozoans, crinoids and cerianthid anemones.
- Initial work towards the development of a risk assessment of significant adverse impacts on VME indicator aggregations and VME elements in the NAFO Regulatory Area.

- Re-development of the workplan for the reassessment of NAFO fisheries in 2016, based on the feedback received from FC at the 2012 NAFO Annual Meeting.

4 Observing Assets (ToRs f)

4.1 Introduction, Conclusions and Recommendations - David Hebert and Paula Frantantoni

This session addressed ToR f, "Identify potential regional observing assets (both inside and outside ICES) necessary to support development of regional ecosystems assessments", which was added at the request of ICES. A summary of some of the observing activities conducted by NOAA-NMFS at the NEFSC and by DFO and some of the other oceanographic activities such as the Ocean Observatories Initiative (OOI), Integrated Ocean Observing System (IOOS) and Ocean Tracking Network (OTN) were presented at the meeting. There was discussion of what activities should be listed and the desired information that should be included in the list of observing assets. A draft table of activities was circulated via e-mail to the participants for input. We present the resulting table as preliminary; additional details and any other observing assets not listed or listed by name only will be added to this table over the upcoming years.

This exercise, even if partial, makes it clear that there are many observing assets in the WGNARS region spanning from physical and chemical oceanography to socio-economic data, and many time-series are ongoing. This rich data environment is poised to support IEA development very well in the region. However, once IEA objectives are established, information gaps may exist and should be identified. We recommend continued refinement of this table to be used as a resource in future meetings and for any management bodies or stakeholders in the WGNARS region.

Table 4.1.1. Observing assets available in the WGNARS region

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Acoustic	Annual, fall	Atlantic Herring, hydrography	1998	ongoing	Northern Georges Bank; Gulf of Maine	fish stocks	http://www.nefsc.noaa.gov/fernad/ecosurvey/acoustics
NOAA/NMFS	Benthic	Annual, summer	Process Studies; Deep-water corals, hydrography	2000	ongoing	Limited; recently flank of Georges Bank and deep canyons in MAB	physical, chemical, number/weight of biological components	http://www.nefsc.noaa.gov/epd/coasteco
NOAA/NMFS	EcoMon	Quarterly	Plankton, hydrography, nutrients, carbonate chemistry, optical	1977	ongoing	Shelf-wide, Nova Scotia to Cape Hatteras, NC	temperature, salinity, nutrients, zooplankton, ichthyoplankton	http://www.nefsc.noaa.gov/epd/ocean/MainPage/
NOAA/NMFS	Groundfish	Biannual, spring/fall	Abundance, dist., feeding ecology, size/age composition, hydrography, plankton	1963	ongoing	Shelf-wide from Nova Scotia to Cape Hatteras, NC	Bottom Trawls: species, weighed and measured, sex and maturity; Water column hydrography and plankton data	http://www.nefsc.noaa.gov/fernad/ecosurvey
NOAA/NMFS	N. Shrimp	Annual, summer	Pandalus borealis in W. Gulf of Maine, also used for Atlantic herring assessment	1980 (began annual)	ongoing	Western Gulf of Maine	shrimp trawl: Length, sex, spawning condition; bottom temperatures	http://www.nefsc.noaa.gov/fernad/ecosurvey

Organization	Surveys	Timing	Focus	Start Date	End Date (if known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Scallop	Annual, spring	Placopecten magellanicus in MAB and Georges Bank, hydrography	1975	ongoing	Mid-Atlantic Bight and Georges Bank	Scallop dredge; Water column hydrography at ~1/3 sites; HABCAM	http://www.nefsc.noaa.gov/fernad/ecosurvey
NOAA/NMFS	Surfclam, Ocean Quahog	Every 3 yrs, summer	Spisula solidissima and Arctica islandica in the MAB	1978	ongoing	Mid-Atlantic Bight	distribution, relative abundance and biological data for surf clams (Spisula solidissima) and ocean quahogs (Arctica islandica)	http://www.nefsc.noaa.gov/fernad/ecosurvey/mainpage
NOAA/NMFS	Pelagic Longline	Biannual	Shark populations, hydrography	1986	ongoing	Florida to Mid-Atlantic Bight	Shark population abundance; tagging; age validation; biological samples (age, growth, reproductive biology, trophic ecology, etc)	http://na.nefsc.noaa.gov/sharks/survey.html

Organization	Surveys	Timing	Focus	Start Date	End Date (if known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Protected Species	Ship-based, spring-summer	Areal (sighting) and ship-based (sighting, acoustic, hydrography, plankton)	1991	ongoing	Shelf-wide, Nova Scotia to Cape Hatteras, NC	distribution, abundance and habitat of marine mammals and turtles; annimal behaviour and position, photographs for species id; sightings	http://nefsc.noaa.gov/psb
NOAA/NMFS	SOOP	Monthly	Ship of opportunity oceanographic sampling	1961	ongoing	NJ-Bermuda and Boston-Nova Scotia	XBT temperature (sfc-750 m), zooplankton and large phytoplankton (CPR), ADCP velocity data	http://www.nefsc.noaa.gov/epd/ocean/MainPage/soop.html
NOAA/NMFS	eMOLT	Hourly obs.	Environ. Monitors on lobster traps	2001	ongoing	Nova Scotia to Hudson Shelf Valley	primarily bottom temperature	http://emolt.org
NOAA/NMFS	Commercial Fisheries	Ongoing	Dealer purchase records (ME to VA)	1964	ongoing	NMFS Fisheries Reportig Specialists	commercial fisheries dealer purchase records (weighouts); Species/market code prices paid	none

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Vessel Trip Reports	Ongoing	Commercial fishing trip reports	1994	ongoing	Northeast US Shelf	Trip reports from commercial fishing vessel; catch (hail weight), fishing effort, fishing area (water body), port of landing, date/time of sailing and landing and the dealer purchasing the catch. Basic gear characteristics such as size and quantity are also recorded.	none
NOAA/NMFS	Observer Program	Ongoing	Kept/discarded weights, length, bycatch, incidental takes	1989	ongoing	Northeast US Shelf	kept/discarded weights; length data, sampled species; bycatch; incidental takes; gear characteristics on haul-by-haul basis; basic level economic variables	http://www.nefsc.noaa.gov/fsb/

ORGANIZATION	SURVEYS	TIMING	FOCUS	START DATE	END DATE (IF KNOWN)	ZONAL EXTENT	WHAT IS SAMPLED	LINK
DFO (Maritimes, Québec, Newfonudland)	Atlantic Zone Monitoring Program	Biannual, spring/fall	Pelagic environment and lower trophic levels	1999	ongoing	Labrador Shelf to western Scotian Shelf	Plankton, hydrography, nutrients, chlorophyll, optical properties	http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html
DFO (Maritimes, Québec, Newfoundland)	Atlantic Zone Monitoring Program	semi-monthly or monthly	Pelagic environment and lower trophic levels	1999	ongoing	Time-series stations, Newfoundland shelf to Bay of Fundy	Plankton, hydrography, nutrients, chlorophyll, optical properties	http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html
DFO	Atlantic Salmon Monitoring Program	Annual	Atlantic Salmon	late 1980s - early 1990s	ongoing	Throughout island of Newfoundland and Southern Labrador	Abundance (smolt, adult) and size/age composition	
DFO (Maritimes)	Multispecies Surveys	Annual	Abundance, distribution, feeding ecology, length composition, age composition (certain species), maturity staging (certain species), hydrography, plankton		ongoing	Eastern Gulf of Maine, Georges Bank, Scotian Shelf, Southern Gulf of St Lawrence (different areas covered in different seasons)		

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
DFO	Snow Crab	Annual	Snow crab	2004	ongoing	Scotian Shelf (4WV, inshore 4X)	Abundance of male snow crab > 95 mm caraoace width	
DFO	Northern Shrimp	Annual	Northern Shrimp, Pandalus borealis	1982-88; 1993; 1995-	ongoing	Eastern Scotian Shelf	Adult biomass, juvenile recruitment index, biological characteristics (e.g. length/weight distributions, maturity, sex ratio), bycatch, bottom temperature	
DFO (Maritimes)	Scallop	Annual	Abundance, distribution, size/age composition, temperature; inshore surveys also track major commercial groundfish and lobster	Variousye ars from 1981 to 2001	ongoing	Many areas covered in eastern Gulf of Maine and Scotian Shelf	Offshore: Modified New Bedford dredge; Inshore: Digby drags, Miracle drags. Gear-mounted temperature sensors	
DFO	Pelagic Longline							

ORGANIZATION	SURVEYS	TIMING	FOCUS	START DATE	END DATE (IF KNOWN)	ZONAL EXTENT	WHAT IS SAMPLED	LINK
DFO	Protected Species							
DFO	Continuous Plankton Recorder on Ships of Opportunity	Monthly	Plankton	1992 (intermittent in 1960s and 1970s)	ongoing	Scotian Shelf to Newfoundland Shelf	Phytoplankton color index, large phytoplankton abundance, zooplankton abundance	
DFO	Long-term temperature Monitoring Program	Hourly	Temperature recorders on lobster traps/piers	Varies	ongoing	Coastal Canadian NW Atlantic		
DFO	Commercial Fisheries							
DFO	Sentinel Program							
DFO	Vessel Tracking and Reporting							
DFO	Observer Program							
NOAA/IOOS	NERACOOS							

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
Ocean Tracking Network	Ocean Tracking Network Canada	Ongoing	Marine Species tags			Scotian Shelf, Cabot Strait, Strait of Belle Isle	Acoustic tag id; bottom temperature, salinity and oxygen across the Scotian Shelf near the Halifax Line, currents and bottom temperature and salinity near AZMP's HL1 and HL2 stations.	

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
Canada-Newfoundland and Labrador Offshore Petroleum Board	Hibernia Environmental Effects Monitoring (EEM)	Annual or every second year	Effects of oilfield development	1998, 1999, 2000, then every second year	ongoing	Grand Banks, near 46° 45.03′ N 48° 46.98′ W	Sediment: particle size, organic and inorganic carbon, metal and hydrocarbon concentrations. Bacterial luminescence (Microtox), amphipod survival, polychaete growth and survival. Commerical Fish: American plaice tissue chemical profiles; American plaice sensory evaluation (taint). American plaice health indicators (haematology, histopathology, mixed function oxygenase. American plaice morphometrics and life-history characteristics. Water Quality: CTD; oxygen, temperature, salinity and pH profiles, water chemistry;	http://www.cnlopb.nl.ca/

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
Canada-Newfoundland and Labrador Offshore Petroleum Board	Terra Nova Environmental Effects Monitoring (EEM)	Annual or every second year	Effects of oilfield development	2000, 2001, 2002, then every second year	ongoing	Grand Banks, near 46° 28.50′ N 48° 28.77′ W	Sediment: particle size, organic and inorganic carbon, metal and hydrocarbon concentrations. Bacterial luminescence (Microtox), amphipod survival. Benthic community structure Commerical Fish: Iceland scallop and American plaice body burden, Iceland scallop and American plaice taint. American plaice health indicators; haemalogy, tissue histopathology, mixed function oxygenase. American plaice and Icelandic scallops morphometrics Water Quality: oxygen, temperature, salinity, pH, chemistry; metals and	http://www.cnlopb.nl.ca/

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
Canada-Newfoundland and Labrador Offshore Petroleum Board	White Rose Environmental Effects Monitoring (EEM)	Annual or every second year	Effects of oilfield development	2004, 2005, 2006, then every second year	ongoing	Grand Banks, near 46° 47.32′ N 48° 0.9′ W	Sediment: particle size, organic and inorganic carbon, metal and hydrocarbon concentration. Bacterial luminescence(Microtox), Amphipod survival. Benthic community structure. Commercial Fish: Snow crab and American plaice body burden. Snow crab and American plaice taint. American plaice health indicators; haematology, histology, mixed function oxygenase. Snow crab and American plaice morphometrics and life-history characteristics. Water Quality: Organic and inorganic carbon, TSS, Ammonia, metals, BTEX, >C10-C21 and >C21-C32	http://www.cnlopb.nl.ca/

ORGANIZATION	SURVEYS	TIMING	FOCUS	START DATE	END DATE (IF KNOWN)	ZONAL EXTENT	WHAT IS SAMPLED	LINK
DFO (Gulf)	Acoustic	Annual, fall	Atlantic Herring, hydrography	1988	ongoing	NAFO 4T	herring	
DFO (Gulf)	Scallop	Annual, summer	giant scallops, survey rotates annually to different fishing grounds	2012	ongoing	NAFO 4T	Scallop dredge	
DFO (Gulf)	Commercial Fisheries	Ongoing	Landings, fishing effort	<1960	ongoing			
DFO (Gulf)	Observer Program	Ongoing	Kept/discarded weights, length, bycatch, incidental takes	1980s	ongoing	NAFO 4RST		
DFO (Gulf)	Groundfish/ Multispecies Surveys	Annual	Abundance, dist., size/age composition, hydrography/plankton	1971	ongoing	NAFO 4T	all fish; macroinvertebrates; hydrography/plankton	
DFO (Gulf)	Snow crab	Annual	Abundance, dist., size/age composition, hydrography	1988	ongoing	NAFO 4T	all fish; macroinvertebrates; hydrography	
DFO (Gulf)	Multispecies coastal survey	Annual	Abundance, dist., size/age composition, hydrography/plankton	2001	ongoing	Northumberland Strait (Gulf of St Lawrence)	all fish; macroinvertebrates; hydrography	

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
DFO (Quebec)	Mackerel egg biomass survey	Annual	Atlantic Mackrel, plankton, hydrography	1982	ongoing	NAFO 4T	mackerel eggs/larvae, hydrography/plankton	
DFO (Quebec)	Groundfish/ Multispecies Surveys	Annual	Abundance, dist., size/age composition, hydrography/plankton	1990	ongoing	NAFO 4RST	all fish; northern shrimp, macroinvertebrates; hydrography, plankton (since 2006)	
DFO (Quebec)	Commercial Fisheries	Ongoing	Landings, fishing effort	1990	ongoing	NAFO 4RST	Landings, fishing effort	
DFO (Quebec)	Scientific surveys	Ongoing	Snow crab abundance, size structure	1992 or 1994	ongoing (generally every two years, different fishing zones every year)	Fishing zones in NAFO 4T, 4S	Abundance, size structure, recruitment index based on small-scale (fishing zone) independent trawl/cage surveys	
DFO (Quebec)	Scientific surveys	Every two years	Scallop density, size structure, bycatch	1987	ongoing	NAFO 4T (Magdalen Islands)	Density, size structure, bycatch	
DFO (Quebec)	Scientific surveys	Every two years	Scallop density, size structure, bycatch	1990	ongoing	NAFO 4S (Mingan Islands-northern GSL)	Density, size structure, bycatch	
DFO (Quebec)	Acoustic	Every two years, Fall	Atlantic Herring, hydrography		ongoing	NAFO-4R		

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
DFO (Quebec)	Scientific surveys	Annual	Lobster Population fecundity and recruitment indices	1985 (Fecundity); 1996 (recruitment)	ongoing	NAFO 4T (Magdalen Islands, Gaspesia)	Adult female size distribution, fecundity, index of larval fixation (recruitment)	
US Census Bureau	Census	Decadal	Human population demographics for place-based communities (including those where fishing occurs)	1790 - with change over time	ongoing	Mid-Atlantic - New England	Population counts, community sex, age, race, ethnicity, language, housing, education, income, employment, household size, etc.	http://www.census.gov/#

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Community profiles	Approx. every 5 years	Communities where fishing occurs that meet certain indicator thresholds	2007	ongoing	Mid-Atlantic - New England	Data under the categories of: People and Places (Regional Orientation, Historical/Background, Demographics, Issues/Processes, Cultural Attributes); Infrastructure (Current Economy, Government, Institutional, Physical); Involvement in Northeast Fisheries (Commercial, Recreational, Subsistence) and Future.	http://www.nefsc.noaa.gov/read/socialsci/communityProfiles.html

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Community Snapshots	Annual fisheries data; decadal Census data	Communities where fishing occurs that meet certain indicator thresholds	2013	ongoing	Mid-Atlantic - New England	Species caught, Vessel Length, Educational Attainment, Most common jobs, Unemployment rate, Age structure, Ethnicity and race, Language and marginalization.	http://www.nefsc.noaa.gov/read/socialsci/communitySnapshots.php

ORGANIZATION	SURVEYS	TIMING	FOCUS	START DATE	END DATE (IF KNOWN)	ZONAL EXTENT	WHAT IS SAMPLED	LINK
NOAA/NMFS	Community Vulnerability Indicators	Ongoing	All communities where fishing occurs	2010	ongoing	Mid-Atlantic - New England	Using secondary data, a total of 14 indices were developed by principal component analysis frm 61 different variables. These 14 indices can be categorized into three broad areas: social vulnerability, gentrification pressure, and fishing dependence. Social vulnerability covers the economic reality and social diversity of a community, and includes poverty rates, population composition, and personal disruption measures. Gentrification pressure identifies community issues associated with aging populations, land conversion	website in production.

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Commercial vessel owner socio-economic survey	annual 2013 - 2015, biennial after 2015	Owners of commercial fishing vessels	April 2013	ongoing	Mid-Atlantic - New England	primary fisheries, vessel ownership structure, household income, family involvement in commercial fishing, crew payment system, attitudes towards fisheries management regulations, job-satisfaction, health insurance status, well-being	http://www.nefsc.noaa.gov/read/socialsci/crewOwnerSurvey.html

Organization	Surveys	Timing	Focus	Start Date	End Date (if known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Commercial fishing crew socio-economic survey	annual 2012 - 2014, biennial after 2014	Crew of commercial fishing vessels	October 2012	ongoing	Mid-Atlantic - New England	primary fisheries, household income, family involvement in commercial fishing, position and experience in commerical fishing, crew payment system, attitudes towards fisheries management regulations, job-satisfaction, health insurance status, well-being	http://www.nefsc.noaa.gov/read/socialsci/crewOwnerSurvey.html
NOAA/NMFS	Fixed cost survey	2006, 2007, 2008, annual 2012 on	Commercial fishing vessels	August 2012	ongoing	Mid-Atlantic - New England	Vessel ownership structure, vessel value, repair,maintenance, improvements, crew payments, other annual fishing related costs	http://www.nefsc.noaa.gov/read/socialsci/fixedCostSurvey.html

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Processed Products Survey	annual	Processing plants	1918; The survey in its current form began in 1969.	ongoing	National	Contact information, employment by month, species processed, how it was processed, the quantity and FOB value of products	Data are in Fisheries of the US: http://www.nmfs.noaa.gov/stories/2012/09/09_19_12fisheries_of_the_us.html. The processed products survey is at: http://www.st.nmfs.noaa.gov/commercial-fisheries/survey-of-fisheries-products/index.
NOAA/NMFS	Marine Recreational Information Program, or MRIP (replaces legacy MRFSS - Marine Recreational Fisheries Statisticcs survey)	annual	Recreational fishers	MRFSS began in 1979. MRIP angler intercept survey begins 2013. MRIP mail survey begins 2014.	ongoing	Mid-Atlantic - New England (National available)	Catch, expenditures, effort	http://www.st.nmfs.noaa.gov/recreational-fisheries/index

Organization	Surveys	Timing	Focus	Start Date	End Date (if Known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Permit database	ongoing	Owners of commercial fishing vessels	1970s, but reliable data with all fields begin ~1994-1997	ongoing	Mid-Atlantic - New England	Permitted fisheries and categories, vessel horsepower, length, gross/net tons, year built, hold capacity, construction/propulsion type	http://www.nero.noaa.gov/permits/
NOAA/NMFS	Vessel Monitoring System	every half hour to hour	Vessels	1994	ongoing	Mid-Atlantic - New England	Vessel location for scallop, monkfish, multispecies, surfclam/quahog, herring fisheries.	http://www.nero.noaa.gov/nero/vms/
Bureau of Labor Statistics	County business patterns data	Snapshot every March	US counties (a subdivision of states)	1986 - present	ongoing	National	Quarterly/annual payroll, wages, number of businesses by size, SIC/NAICS code	http://www.nefsc.noaa.gov/publications/tm/tm211/

Organization	Surveys	Timing	Focus	Start Date	End Date (if known)	Zonal Extent	What is Sampled	Link
IMPLAN	County economic data	annual	US counties (a subdivision of states)	2004, 2008	ongoing	Northeast	Annual NAICS business activity estimates and multipliers for input-output economic analysis. Base IMPLAN tables have been heavily customized to more accurately represent fisheries in the Northeast US	http://www.nefsc.noaa.gov/publications/tm/tm188/index.htm
NOAA/NMFS	Recreational for-hire fisheries	weekly	For-hire (charter/head boat) fisheries	2005	ongoing	Maine - Georgia	Trip characteristics, costs, revenue, area fished, gear, target species, number of anglers	http://www.st.nmfs.noaa.gov/recreational-fisheries/in-depth/our-surveys-counting-catch-and-effort/survey-materials/for-hire-survey
NOAA/NMFS	Large pelagics survey	weekly	Atlantic HMS permit holders (recreational)	1992	ongoing	Maine - Georgia	Effort, catch, target species, gear, location, water depth, water temperature, tournament participation	http://www.st.nmfs.noaa.gov/recreational-fisheries/in-depth/our-surveys-counting-catch-and-effort/survey-materials/large-pelagic-survey-lps

Organization	Surveys	Timing	Focus	Start Date	End Date (if known)	Zonal Extent	What is Sampled	Link
NOAA/NMFS	Retail/Restaurant seafood purchases	annual	Industry Input Output	2007	ongoing	National	Employment, income, sales, total value added	https://www.st.nmfs.noaa.gov/apex/f?p=160:1:654160316164713
Census Bureau	Trade data	annual aggregate	Seafood import and export data	1996	ongoing	National	Quantity and value by import and export countries, species, and product form	http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/index
NOAA/NMFS	Market Report	daily	price reporting from fish exchanges and auctions	2005	ongoing	Mid-Atlantic - New England	prices by species/market category	http://www.st.nmfs.noaa.gov/commercial-fisheries/index

5 Scoping (ToR b)

5.1 Introduction – Patricia Pinto da Silva, Heather Breeze, Catherine Johnson

This session addressed ToR b, "Review and summarize previous scoping exercises in integrated ecosystem assessment or similar initiatives for management objectives and socio-economic utilities. Identify next steps for refining goals for an IEA for the Northwest Atlantic as well as for vetting core indicators with relevant stakeholders (federal and regional governments, coastal communities, fishers, etc.)." ToR b was developed in 2012 in recognition that explicit objectives, defined with the engagement of stakeholders, are a key pre-condition to developing scientific advice that will be used to inform decisions in an Ecosystem Approach to Management (EAM) context. To allow evaluation of trade-offs in decision-making, objectives should address economic, conservation, and social goals.

The first step of the Levin *et al*. (2009) framework for IEA is "Scoping to identify the goals of Ecosystem-Based Management and threats to achieving them," and WGNARS recognizes the critical role of stakeholder engagement at an early stage in an Ecosystem Approach to Management. However, scientists engaged in IEA do not have the authority to define management goals, set up stakeholder advisory processes, or define management units. Instead, their role in scoping should be to provide information on ecosystem structure and status, drivers, and pressures that is necessary to inform EAM scoping processes. Once strategic objectives and management units are defined, scientists can provide information required for decision-making through development of operational objectives, indicators, risk analysis, evaluation of trade-offs and cumulative effects, and management strategy evaluation through IEAs. In the present context of evolving policy and institutional support for an Ecosystem Approach to Management in North America, it has been a challenge for WGNARS to identify the most effective points of engagement for its work. This session was intended to evaluate some of the challenges related to scoping in WGNARS and identify short- and long-term solutions.

The session was organized to emphasize discussion of a predetermined set of questions related to scoping, listed below, with several presentations providing supporting information on previous scoping efforts in the US and Canada, ecoregion analysis to inform the definition of management units, and next steps for refining goals. To incorporate expertise in management and policy, WGNARS invited participants from DFO Maritimes who have been involved in integrated management planning in the fisheries context and oceans management context, a representative of DFO Maritimes Policy and Economics, and representatives from the DFO national-level Ecosystems and Ocean Science sector and Program Policy sector.

Discussion topics:

- What is the most appropriate spatial scale for IEAs in the NW Atlantic?
- Are the goals identified in past scoping exercises adequate to start IEA development?
- How can tactical goals be developed from strategic goals in target regions?
- What are the next steps for refining goals for IEA in the target regions?
- How can science and management best interact to develop scoping activities?
- What are the next steps for vetting target indicators with relevant stakeholders in the target regions?

5.1.1 Presentation overview

The presentations focused on reviewing efforts to date in Eastern Canada and the Northeast US to identify goals and objectives for ecosystem based management (EBM). Presentations described multiple processes, scales and methods that were used to define goals. It is clear that no single set of goals and objectives is likely to emerge from the WGNARS region. While there are a number of efforts underway, and desired outcomes overlap, there also appear to be significant differences as well as a range of scales for these efforts.

Patricia Pinto da Silva and Katie Lund of NOAA reviewed current efforts for implementing EBM at a variety of spatial scales in the United States and the associated efforts to define specific goals and objectives for EBM or Ocean Planning. The presentation revisited definitions of ecosystem based management (the overall framework or approach), Ocean Planning (the political process of implementing EBM in the United States), and IEA (the monitoring and evaluation framework for guiding decision-making) and the need for these to be better connected in order to be more effective.

Mike Fogarty of NOAA presented information related to the US Regional Planning Bodies (RPB) and to the Executive Order 13547 that led to their establishment. Importantly, he noted that goals and objectives should be determined about EBM more broadly before identifying objectives to the ocean planning process. He also reminded us that the Regional Planning Bodies do not have the decision-making authority to act on the information that we provide and that we need to continue to work with existing legal authorities related to fisheries management, coastal-zone management, transportation, etc.

Additionally, this presentation described the establishment of the 9 regional planning bodies in the United States that will further Ocean Planning in the US. Two of these regional planning bodies (the Mid-Atlantic and Northeast Regional Planning Bodies) fall within the WGNARS boundaries. This ocean planning process is the most inclusive in terms of the sectors and federal and state entities that it involves. They are also the largest scale efforts underway in the US portion of the Northwest Atlantic Regional Sea and are the best match for the scale on which WGNARS is interacting.

Heather Breeze of Fisheries and Oceans Canada (DFO) described how objectives were established for the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative led by DFO in the Maritimes Region. Like other DFO integrated management initiatives, the healthy ecosystem goals were adapted from a 2001 national DFO workshop on objectives and indicators for ecosystem-based management (Jamieson and O'Boyle, 2001). Thus, all the DFO integrated management initiatives (i.e. Placentia Bay-Grand Banks Integrated Management Initiative, Gulf of St Lawrence Integrated Management) within the WGNARS area are likely to have similar objectives related to the ecosystem. The socio-economic and collaborative governance objectives were developed by a stakeholder working group and accepted by the ESSIM Stakeholder Advisory Council. A number of objectives and associated strategies were initiated under the ESSIM Plan, such as marine protected area network planning, coral and sponge conservation, advancement of the ecosystem approach to fisheries management, and development of marine spatial planning approaches and tools. With the recent conclusion of the ESSIM Initiative, work is now underway to advance a region-wide approach to ocean and coastal management, drawing on the knowledge gained from the ESSIM experience.

Pierre Pepin of DFO described an initiative to delineate ecoregions, in this case ecological subareas of the NAFO region. These ecoregions are intended to help determine the appropriate scale on which integrated ecosystem assessments can be conducted.

Tanya Koropatnick of DFO provided a brief overview of a process with stakeholder involvement for establishing monitoring indicators for the Gully Marine Protected Area. A draft monitoring framework was developed for the MPA and reviewed by other DFO sectors, other government departments, industry, academics, NGOs, Aboriginal groups and communities. Forty-seven indicators were identified, but a monitoring plan for those indicators has not yet been implemented. A subsequent workshop evaluated the feasibility of the indicators with respect to existing data, monitoring programs and methods to evaluate the indicators.

There is no silver bullet for determining a clear set of objectives for EBM in either Eastern Canada or the Northeast US. Nevertheless, multiple initiatives exist and suggest a core set of desired strategic outcomes that can be used to help guide the development of IEAs and the related supporting science in the region.

The following paragraphs developed by presenters describe each of the presentations in greater detail.

5.2 The Role of Integrated Ecosystem Assessments in Marine Ecosystem-Based Management – Michael J. Fogarty

Marine Ecosystem-Based Management (mEBM) provides an integrated framework for the sustainable delivery of ecosystem services from the sea. Marine and coastal ecosystems have long provided human societies with a broad spectrum of benefits ranging from high quality food reserves to transportation, recreation, and protection from storms and climate change.

One of many possible roadmaps to mEBM is depicted in Figure 5.2.1. The elements comprise specification of our overarching aspirational goals, identification of relevant spatial management units, and selection of strategic objectives. It entails assembling an integrated management plan incorporating consideration of the entire panoply of ocean use sectors. Our aspirational goals encompass the fundamental requirement to protect ecosystem structure. We can only protect the flow of ecosystem services and the human communities by first ensuring the structural integrity of the underlying ecosystem. Because ecosystems are typically defined in space, we require designation of spatial boundaries for management with the recognition that these units are open and interconnected. Strategic objectives translate our broad vision related to overarching goals into specific statements providing a blueprint for action. Embedded in this concept is the need not only to clearly articulate our objectives but to devise strategies to assess the state of the system as a whole and to specify reference points to guide management actions to meet these objectives. Some form of Integrated Ecosystem Assessment [IEA – sometimes designated simply as Integrated Assessment (IA)] is necessary to meet this requirement. With the development of an integrated management plan comes the need to incorporate sub-objectives for different ocean use sectors, to deal directly with the trade-offs that will inevitably emerge, and to select the appropriate management tools to meet these needs. The latter will include spatial management strategies through some form of marine spatial planning and zoning as a major component. It will also require tactics to control and limit the effect of anthropogenic stressors to the extent possible and/or to modulate the extraction of resources.

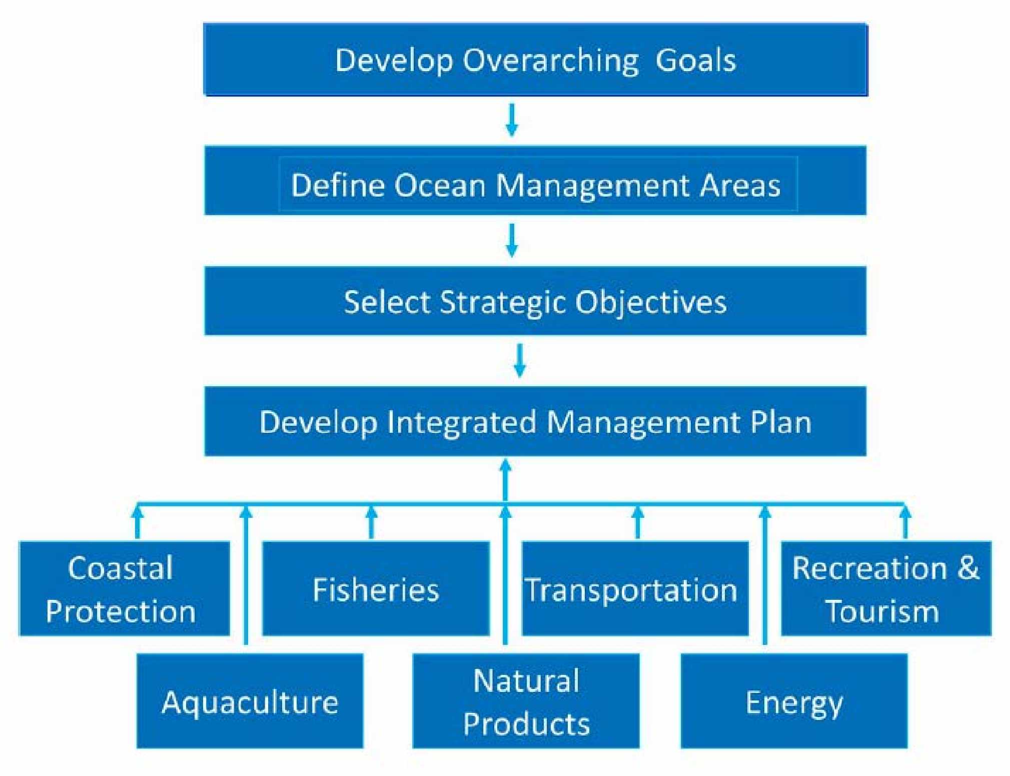


Figure 5.2.1. Roadmap to marine ecosystem-based management culminating in development of an integrated management plan incorporating sectoral consideration from a selection of ocean use communities.

We can visualize the mEBM process as comprising an interrelated set of elements starting with scoping and stakeholder engagement and leading to the specification of objectives and choice of management units; the development of IEAs to determine targets and limits for management action and evaluation of the current state of the system supported by ecosystem research and monitoring; the selection of tactical management tools to meet our strategic objectives; and culminating in the formulation of management advice (Figure 5.2.2). The IEA process itself can be further decomposed into components related to selection of informative ecosystem indicators to monitor the state of the system, implementation of some form of operating model that allows creation of a virtual world in which ecosystem, assessment and management processes can be simulated and the performance characteristics of different management strategies can be evaluated. It is then necessary to determine the risks associated with alternative management actions. In this construct, IEAs and MSP are viewed as inter-related parts of the overall mEBM process and not separate entities (or substitutes for the whole mEBM process). In the past, spatial strategies such as the designation of Marine Protected Areas have been discussed as if they were synonymous with mEBM rather than as a critical element of the toolkit to implement the broader dimensions of mEBM.

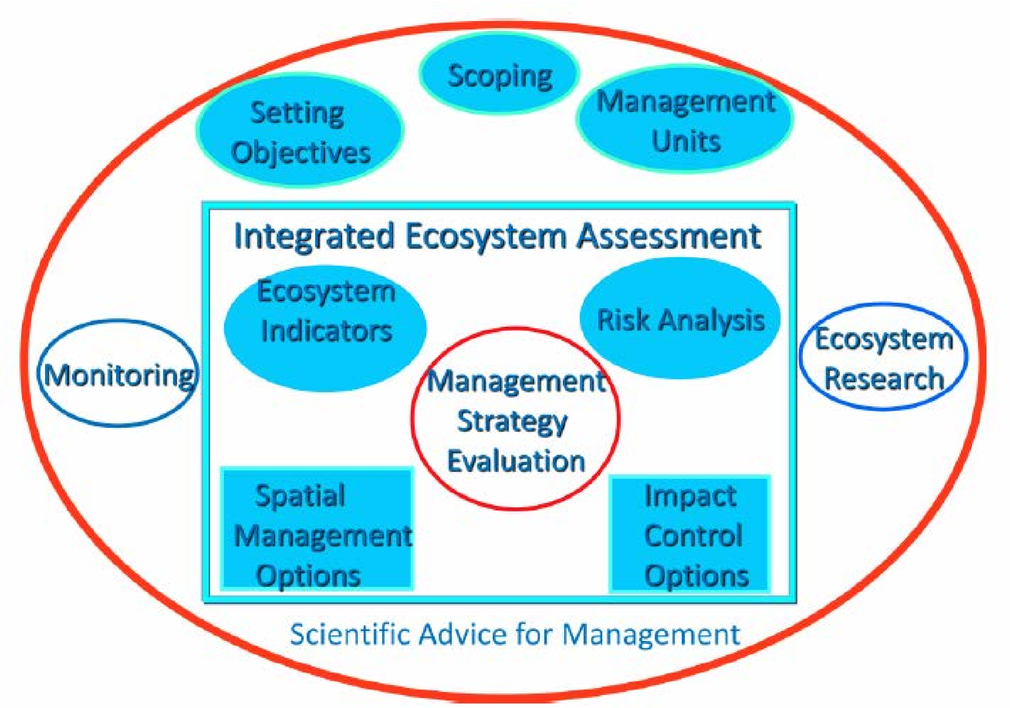


Figure 5.2.2. Elements of marine ecosystem-based management engagement with stakeholders (scoping and setting objectives); selection of spatial management units, ecosystem research and monitoring, integrated ecosystem assessment [incorporating selection of indicators, management strategy evaluation, risk analysis and choice of tactical management tools (including spatial management strategies and input or output controls affecting ecosystem impacts)] and development of scientific advice for management.

5.3 Defining/Refining goals and objectives for Ocean Planning in the Northeast US – Patricia Pinto da Silva, Katie Lund

Defining desired outcomes for ecosystem based management is a critical step in aligning Integrated Ecosystem Assessments (IEA) with the overall decision-making process. If not clearly defined, IEAs run the risk of producing science without the critical link to informing action. While critical, desired outcomes are often not clearly defined or are defined differently (and may even conflict) at multiple scales within the ecosystem. The question also arises as to who should be involved in defining these goals? At what scale and scope are they most meaningful? And how can they be crafted to best connect to a suite of relevant ecosystem assessment endpoints or indicators?

In the Northeast US, multiple processes are underway in support of EBM at multiple scales. Executive Order 13547 on Stewardship of the Ocean, Our Coasts and the Great Lakes established 9 regional ocean planning bodies (Figure 5.3.1). The Northeast and Mid-Atlantic Regional Planning Bodies are the largest scale within the WGNARS region. Their membership includes representatives from all the states, federal agencies and federally recognized tribes along with an ex officio member and a seat for Mid-Atlantic Fisheries Management Council and the New England Fisheries Management Council respectively. Smaller scale initiatives include the Gulf of Maine Council which works to foster cooperative actions in the Gulf of Maine Watershed. Additionally, states (such as Rhode Island and Massachusetts) have engaged in long-term ocean planning exercises with other efforts forming at even more refined scales (e.g. the Penobscot East Resource Center’s work). Each of these processes has engaged in a scoping process, involving the public and different stakeholder groups to differing degrees.

The Regional Planning Bodies are most aligned with the WGNARS scale in the United States, as well as the US scale on which science for IEAs and EBM generally is being produced. While coordination on ocean planning has been building for some time via the Northeast Regional Ocean Council, the Northeast Regional Planning body only recently became active. This RPB is working towards having a draft set of goals and objectives for ocean planning in the region by summer of 2013. Once defined, these goals can provide the integrated ecosystem assessment process with a direction and help ensure that the best available science is used to inform the decision-making process.

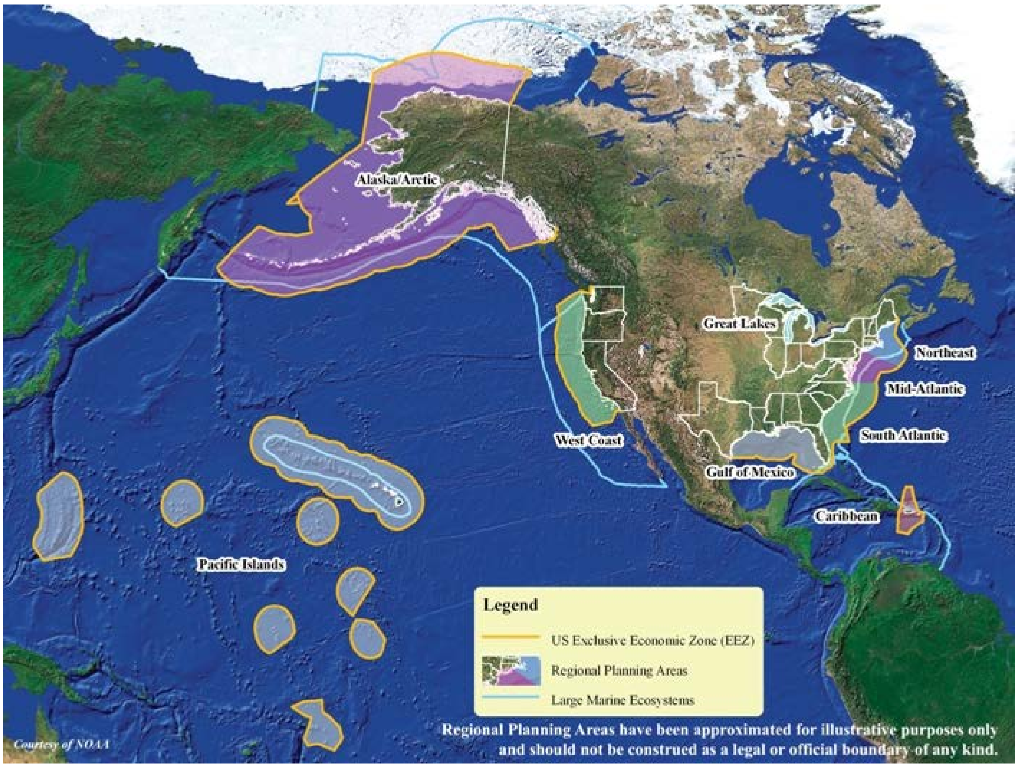


Figure 5.3.1. 9 US Regional Ocean Planning Bodies

5.4 Developing Objectives for the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative – Heather Breeze, Glen Herbert

The Eastern Scotian Shelf Integrated Management Initiative (ESSIM) developed an integrated management plan for the eastern portion of the Scotian Shelf. The plan was developed in a collaborative manner, where stakeholders (industry, non-government organizations, academics, community groups) and multiple government departments and levels of government agreed on goals, strategic objectives, and management strategies. The goals were listed under three theme areas: collaborative governance and integrated management, sustainable human use, and healthy ecosystems. The healthy ecosystem goals were derived from a 2001 national DFO workshop on objectives and indicators for ecosystem-based management (Dunsmuir I; Jamieson and O'Boyle, 2001). These objectives – generally interpreted as maintaining biodiversity, habitat and productivity – are found in some form in all the integrated management plans led by DFO on the east coast. For the ESSIM plan, the collaborative governance and the sustainable human use goals and objectives were developed by an ESSIM stakeholder working group, and accepted by the ESSIM Stakeholder Advisory Council (SAC).

The plan was an objectives-based plan – it was intended that the strategic objectives and management strategies be "unpacked" to operational objectives, management actions and outcome indicators. Most sectors developed an "action plan" that attempted to do this; however, some of the sectors and their government regulators were not familiar or comfortable with this approach.

Collaborative governance was considered an important theme of the ESSIM plan and it was also considered to be an area where it would be possible to set indicators and show progress within the five-year time frame of the plan. It seemed likely that it would take longer to show progress against the other objectives. For that reason, the SAC and the ESSIM Secretariat decided to implement a State of the Scotian Shelf Report to look at progress on the other objectives. The objectives were grouped into different themes, with papers developed on each theme. Nearly all the theme papers are completed; completed papers can be found on the website: http://coinatlantic.ca/index.php/state-of-coast-and-ocean/state-of-the-scotian-shelf

5.5 Ecoregion Summary –Pierre Pepin

NAFO's WGEAFM (Working Group on Ecosystem Approach to Fisheries Management) objectives toward an Ecosystem Based Approach for Fisheries Management identified a need for the "Delineation of ecoregions [spatial management units] in the NAFO area" (ToR 1B). The purpose is to "Define ecological subareas based on physiographic, oceanographic and biological variables (Fogarty and Keith 2009) to reflect the relationships among all ecosystem components". To date, work has been carried out separately for the US-continental shelf (Fogarty and Keith 2009), the Canadian Scotian Shelf (Zwanenburg *et al*. 2010) and the Newfoundland Shelf (Pepin *et al*. 2010). The approach consists of gathering data for a multitude of physiographic, oceanographic and biological variables that are clustered based on the results of a multivariate analysis, which served as a method to standardize approaches across the three jurisdictional areas. The outcome of these analyses essentially and correctly identified the major ecological regions which researchers had expected, but boundaries between those units were, in some instances, not at the same locations as existing management units. However, the differences were generally minor. The outcomes of these analyses reaffirmed that many of the major management units had been based on sound biological understanding of the key physical and ecological relationships that were reflected in the major commercial stocks. Furthermore, these structures are largely stable over time, but spatial fragmentation appears to vary during periods when ecosystems are under stress. However, the work raised some concerns about how to combine and/or distinguish some of the finer scale ecological units identified in the analyses. To address this issue, a workshop, involving all the contributors to the project, will take place in 2013/2014 to "Define objective criteria to identify biogeographic zones and the ecoregions (possible management subunits) within them" based on data from Hudson Strait to the mid-Atlantic Bight. A number of methodological issues will have to be addressed in order to combine data across regions.

5.6 Discussion overview and next steps – Patricia Pinto da Silva, Heather Breeze, and Catherine Johnson

The afternoon discussion shifted from identifying specific sets of goals and objectives to clarifying fundamental issues associated with how WGNARS can effectively work to engage with appropriate decision-makers in an EAM context to create science advice that will be used. Currently, the policy guidance and institutional infrastructure required to implement advice addressing trade-offs among different objectives in an EAM context is developing in the Northwest Atlantic and worldwide, but the points of engagement for WGNARS are still not well defined. WGNARS and other Regional Seas groups need to develop strategies for engagement with decision-makers for both the short term and the future. Discussion themes related to this topic included the WGNARS mandate, capabilities and potential clients, and identification of goals.

5.6.1 WGNARS mandate

The overall goal of WGNARS is to develop science support for an integrated assessment of the Northwest Atlantic region to support ecosystem approaches to science and management. There are several challenges related to implementing this mandate. One substantial challenge is how the group will engage with authorities who can make EAM decisions. In both Canada and the US, resource management decisions are not yet made in an EAM context, although ecosystem considerations are increasingly included in the context of individual programs such as single-species fisheries management and Marine Protected Area planning. In the current management context, potential points of engagement for WGNARS are numerous, each with specific information needs, and integrated advice such as trade-off analyses that WGNARS envisions as important may not fit well into the current needs of managers. Given this mismatch, the group is trying to define its role and identify the most effective venues where its advice could be used.

Another challenge is to define whether the scope of the group's work should encompass an Ecosystem Approach to Management (EAM) or a more limited Ecosystem Approach to Fisheries Management (EAFM). The scope of the group is intended to be EAM, but without clear objectives and institutional links to management agencies outside DFO and NOAA, this may be an intractable problem for the group to tackle. In the short term, focusing on EAFM would allow the group to use existing policy documents, such as the Canadian Sustainable Fisheries Framework, readily identifiable goals, and more limited linkages to existing management processes. A focus on EAFM is also relevant to EAM, since fishing and climate effects on fisheries, both of which fit into an EAFM, are important drivers of NW Atlantic shelf ecosystems. While limiting the initial scope of WGNARS work to EAFM would allow the group to more readily work through the exercise of developing advice that could immediately be applied, it diverges from the group's mandate and does not provide the best example case for moving forward with multi-sector involvement. Nevertheless, this would likely be the most effective way for the group to make progress, especially if future expansion to EAM is considered as the goal, once multi-sector objectives and clients are identified.

The scope that WGNARS addresses at this stage has implications for identifying clients for the group's products. If it limits current work to EAFM, the main clients for its products would be DFO and NOAA and their industry clients. Clients for methods WGNARS develops would also include ICES and NAFO. If WGNARS addresses EAM, clients would include other government agencies and industry, but if these links are not already established by EAM authorities, WGNARS does not have the capacity or authority to make them.

An additional challenge for WGNARS is one of resources. Since the group has no dedicated resources, its projects and products rely on support for its members' work from their home institutes, mainly in NOAA and DFO. WGNARS is best equipped to address the science aspects of IEA, while it must incorporate or link to institutional support and management expertise in a variety of programs in order to address all aspects of IEA. WGNARS has the capacity to coordinate, document and share best practises. Its spatial scope allows the group to address large-scale climate forcing, connectivity and trans-boundary interactions in the larger ecoregion. Group members will address the challenge of limited capacity by soliciting support and working opportunistically on elements of IEA, with coordination from the group.

5.6.2 Identifying goals

Scoping in the traditional sense is not something WGNARS has the authority or resources to undertake. In a sense, IEA groups are clients of the information emerging from the public participation and outreach processes conducted by, for example, the Regional Planning Bodies in the US and integrated management initiatives in Canada. However, science advice from WGNARS and regional IEA efforts should inform them as they move forward.

Strategic-level conservation objectives have been identified through past and current processes such as the ESSIM strategic plan (http://www.mar.dfo-mpo.gc.ca/e0010316), Large Ocean Management Areas (LOMAs; DFO 2007), and the DFO Sustainable Fisheries Framework (http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/overview-cadre-eng.htm). International obligations and national laws also provide guidance for strategic goals and objectives, e.g. sustainable development language. Similarly, the Marine Strategy Framework Directive's (MSFD) Good Environmental Status (GES) indicators are high-level objectives for EU waters. Many of the strategic conservation goals identified through different processes are complementary. Social and economic objectives such as maximizing economic benefits and promoting stability, fleet diversity, safety, and support for coastal communities have received less attention than conservation objectives, but they are equally important to include in IEAs to allow explicit evaluation of trade-offs and the performance of management measures.

Although there is congruence among many of the strategic conservation objectives developed in previous processes, they may be too general and high level to provide adequate guidance for regional IEA development. Regional IEAs will require development of more specific, operational objectives that address a suite of specific ecosystem components and ocean uses (e.g. Jamieson and O'Boyle 2001 developed general objectives that will need to be unpacked). WGNARS scientific expertise could contribute to the further development of methods and guidelines for unpacking strategic objectives to identify operational objectives that are complete and effective in guiding good decision-making.

One of the strengths of WGNARS is its large spatial scale, which allows it to incorporate information about the strong influence of upstream processes on downstream regions in this area. The original vision for WGNARS considered a single IEA for the entire Northwest Atlantic region, but it is now recognized that this region is too diverse in processes, habitats, ecosystem services, human uses, and management objectives for effective development of a single IEA. Regional differences in the ecosystem and ocean uses as well as the scales of jurisdictional boundaries set the scales at which ecosystem advice can be most effectively developed. In addition, NW Atlantic organizations in different regions are at different stages in the implementation of EAM and IEAs, and thus they have different information and science advice needs. Decisions about management units for EAM will not be set by scientists through the IEA process; however, analyses of ecoregions, as described by Pierre Pepin, can help to inform these decisions. Although IEAs will be constrained to an ecoregional scale, they will need to incorporate the influence of processes at smaller and larger scales, such as the NW Atlantic scale.

5.6.3 Next steps for defining goals and objectives in WGNARS

In order to be relevant to EAM or EAFM, the IEA process needs to be integrated and driven by need. While it is clear that the role of WGNARS is not to define goals or objectives, science can still play an important role in the process.

One key scoping area that needs more work is in enhancing communication between scientists and policy-makers, decision-makers and stakeholders. One way to do this would be to broaden the membership of WGNARS and consider including individuals involved and familiar with the policy and management components of the process. While it would be difficult to engage all relevant expertise at one meeting, the group could draw on different skill sets at different stages/meetings as well as outside the context of the annual meeting. Building relationships and communication across science policy boundaries was discussed as important, and while this would not be a role for all scientists, some could serve as 'boundary agents' (e.g. Mike Fogarty's role in the NE US) to keep the conversation going. Effective communication about how science can support decision-making, providing examples, is also important. Analysis of how information flows among scientists, managers, and stakeholders (e.g. Soomai *et al.*, 2013, Hartley and Glass, 2010) would enhance understanding of effective strategies and gaps for linking science advice to management decisions.

Another priority area is the identification of goals and objectives. The group will coordinate analysis reviewing strategic and operational goals developed in past and current scoping exercises in the US and Canada, incorporating social and economic goals as much as possible in addition to conservation goals. This type of analysis is intended to identify common, complementary, and conflicting goals (e.g. Pinto da Silva *et al.*, 2013, Figure 5.6.1), and it will provide the basis from which the group can work toward developing methods for identifying suites of operational objectives for the regions. Development of pilot IEA exercises in the NW Atlantic regions can be initiated once operational objectives have been identified.

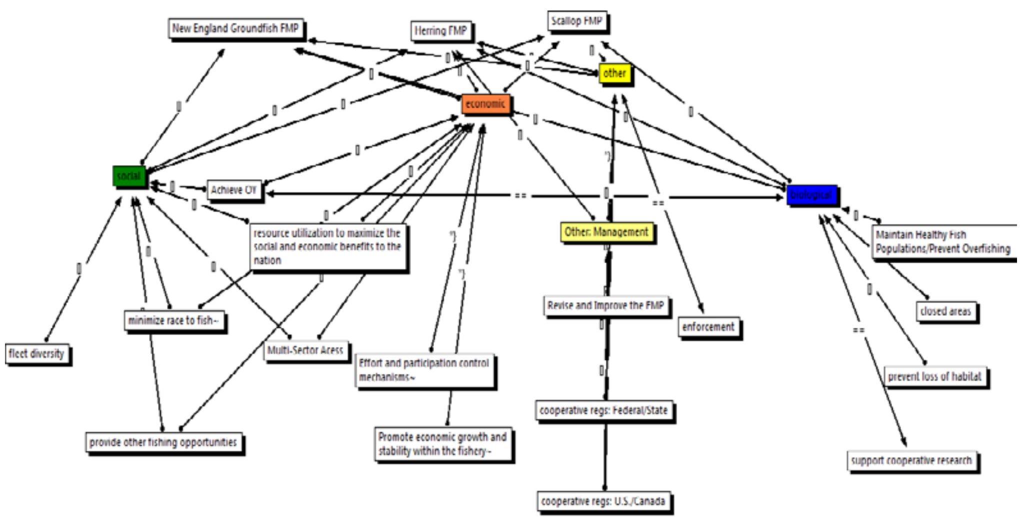


Figure 5.6.1 Goals and objectives drawn from key New England herring, groundfish, and scallop Fishery Management Plan amendments, summarized using Atlas Ti (Pinto da Silva *et al.*, 2013)

6 Indicator Performance (ToR d)

6.1 Introduction – Gavin Fay and Scott Large

This session addressed ToR d: "Evaluate indicator performance with respect to important ecosystem drivers, emphasizing responses relative to candidate thresholds." Indicators of ecosystem status are useful in characterizing marine communities and the relative influence of human and environmental stressors. Ecological and socio-economic indicators are widely available, but translating these indicators into management action is necessary before an ecosystem approach to management can be implemented. One approach to using indicators in this context is to identify levels where drivers significantly influence indicator response and thus elicit management action. The session began with a series of presentations on existing and new indicators for the WGNARS area and on methods to identify thresholds in indicators and evaluate indicator performance. These presentations were followed by a working session to identify indicators and thresholds, focusing on ecosystem responses to climate variability and fishing pressure.

The first set of presentations provided information about metrics and programs that could contribute to the analysis of indicator thresholds developed in the working session. Presentations included a framework for selecting trawl-based indicators that is being used by DFO to assess the utility of indicators (Catalina Gomez); efforts toward integrated syntheses of data on the pelagic environment and lower trophic levels from the Atlantic Zone Monitoring Program (AZMP, Pierre Pepin); an overview of work on mapping a wide range of human activities on the Scotian Shelf (Heather Breeze); and an overview of trends and projections for key climatological and oceanographic indicators for the Atlantic Large Aquatic Basin, from DFO's Aquatic Climate Change Adaptation Services Program (Blair Greenan). An overview of the recent meeting of the Working Group on the ICES ACOM/SCICOM Workshop on Ecosystem Overviews (WKECOVER) presented guidance on the purpose, format, and content of ecosystem overviews in ICES (Ken Frank).

The second set of presentations described approaches to defining thresholds in pressure-response relationships using generalized additive models (GAMs) in univariate, multivariate, and time-series settings (Scott Large) and options for defining reference points in indicators and using simulation models of foodwebs and management systems to evaluate the performance of indicator thresholds as management tools under Ecosystem-Based Fisheries Management (Gavin Fay).

In the working session, discussion focused on identifying a subset of comparable indicators for four regions within the WGNARS area that could be used to apply the GAM-based indicator threshold methods presented by Scott Large. Data for these indicators were then assembled, and analyses conducted by Scott Large and Gavin Fay, with presentation of preliminary results during the meeting session the following day. Initial results showed that thresholds could be identified in some cases with these methods. Analyses that considered multivariate response of indicators to drivers and also indicator response to both climate and fishing effects showed promise and will be developed further. Additional discussion focused on the sorts of indicators required and what needed to be done to further evaluate indicator performance, and on moving the initial analyses forward to form the basis of a publication that would compare indicator responses among regions within the WGNARS area.

6.2 Ecosystem indicators for ecosystem monitoring at different scales – Catalina Gomez, Adam Cook, Alida Bundy

Ecosystems are complex, dynamic systems: in order to effectively use indicators to assess their status, a suite of indicators is required to reflect that complexity. The main objective of this project was to select and evaluate a suite of indicators to assess their utility for DFO. The two main questions that we address are (i) the sensitivity of trawl-based indicators to non-catchability and catchability adjusted estimates of abundance, and (ii) the spatial scales at which the indicators provide useful information. This study focuses on the Scotian Shelf, but the results are generally applicable to other regions. In this presentation, we focused on (i).

Several frameworks have been suggested for the selection of indicators to evaluate the effects of anthropogenic activities on aquatic ecosystems (e.g. Rice and Rochet 2005; Shin *et al*. 2012; WGECO 2012). These have been used here to develop a framework for the selection of indicators for ecosystem monitoring and assessment at different scales (Figure 6.2.1). This framework is divided into 8 steps; here we focus on Steps 1 – 4.

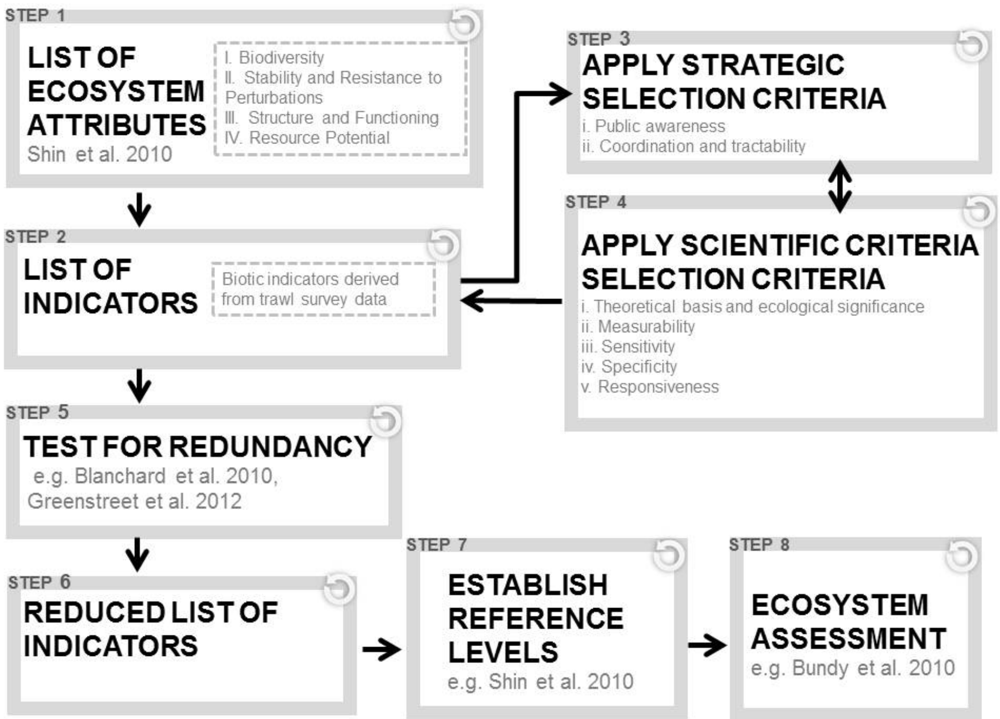


Figure 6.2.1. Summary of the eight steps process to select and evaluate indicators for ecosystem monitoring.

Step 1: In order to ensure that ecosystem complexity is captured and thus structure the selection of indicators, we identified 4 fundamental attributes of the ecosystem to assess and monitor: biodiversity, ecosystem stability and resistance to perturbations, structure and functioning and resource potential.

Step 2: We reviewed the recent literature on ecosystem indicators and then identified suitable indicators to provide a measure for each of these attributes. Where possible, indicators should have a pedigree, i.e. have been used and evaluated in other Ecosystem Approach to Management studies. Indicators may be drawn from the literature, previous use by DFO and examples from other systems.

Step 3: Evaluate indicators against strategic selection criteria (Figure 6.2.1). These criteria and those in Step 4 are based on Shin *et al*. (2010, 2012).

Step 4: Here we focus on the sensitivity of the suite of indicators identified in Steps 2 and 3 to trawl survey data derived from non-catchability- and catchability-adjusted data. At the current stage of our project we are interested in understanding how adjustments for catchability affect our estimates and overall understanding of the ecosystem. Fish and invertebrates are not caught equally by research vessel trawl surveys, which, on the east coast, were originally designed to sample large groundfish species. Fish size, shape, swimming speed and behavior all affect catchability. Catchability is not usually taken into consideration in the estimation of ecosystem indicators that aggregate across species, yet this could have a fundamental impact on the indicator value and trend. Therefore, we used catchability corrections from Harley and Myers (2001) to obtain length-specific catchability corrections for most species.

We found four patterns of the effect of including catchability-adjusted data in the estimation of indicators: 1) some indicators, such as the condition of the community, are not influenced by catchability, 2) some indicators, such as mean length of fish in the community, show similar trends from catchability- and non-catchability-adjusted data, 3) some catchability-corrected indicators, such as proportion of predatory fish in the community, seem to respond earlier and thus these might be useful due to their apparent early warning behavior, and 4) some indicators, such as biomass of the community, show different trends from catchability- and non-catchability-adjusted data. In this case, adjustments from catchability affect our estimates and potentially our overall understanding of the system.

The next steps of this project are Steps 5, 6 and 8[2] which will: 1) evaluate redundancy of indicators within and across ecosystem attributes, 2) assess the status of the western Scotian Shelf and compare with the eastern Scotian Shelf, 3) evaluate information provided at different scales (strata, bank, NAFO Division), and 4) assess the viability of using these indicators to assess the effectiveness of closed areas (which typically are at smaller scales than research vessel surveys such as Marine Protected Areas).

Acknowledgements: Strategic Program for Ecosystem-based Research and Advice (SPERA) for funding and other project members: Catherine Johnson, Kenneth Frank and Maxine Westhead.

6.3 Atlantic Zone Monitoring Program Synthesis – Pierre Pepin

The Atlantic Zone Monitoring Program (AZMP) reports annually on the state of physical, chemical and biological oceanographic elements in the Canadian Atlantic waters of the Newfoundland Shelf, Gulf of St Lawrence, and Scotian Shelf. The program consists of seasonal sampling of oceanographic sections (spring, summer, autumn) and semi-monthly collections at high frequency monitoring sites. As a result of the large body of information currently available, the program is undertaking a synthesis with the aim of providing an integrated perspective of the state of the Northwest Atlantic based on identifying the fundamental relationships between drivers (processes) and response (state) variables. The first phase of this process is focused on zooplankton distributions and environmental relationships. The outcomes will result

[2] It is out with the scope of this project to address Step 7, but this is a key step. The ecosystem assessment (Step 8) will be conducted using trends.

in development of an Atlas of species distribution and variability, an assessment of consistencies in community structure using unconstrained (exploratory) and constrained (factor-driven) multivariate methods, identification of indicator species, and identification of patterns in diversity. Examples of these outcomes were presented at the meeting, including metrics for the indicator thresholds working session analysis, and the program will continue to inform WGNARS about developments and outcomes as the synthesis progresses.

6.4 Mapping human activities in the Maritimes region of DFO – Scott Coffen-Smout, Tanya Koropatnick, Heather Breeze

The Oceans and Coastal Management Division (OCMD), Maritimes Region, Fisheries and Oceans Canada has compiled, analysed and mapped spatial data related to many different human activities occurring on the Scotian Shelf. In some cases, the dataset extends to regions east, north or south of the Scotian Shelf. This information is used in ocean planning and management. For fisheries, data have been aggregated to 2 x 2-minute grid cells for landings (2000-2010) and fishing effort (1995-2009) for a broad suite of gears and species. Composite maps of the entire period as well as annual maps are available. An important fishery, inshore lobster, reports by management area or sub-management area instead of latitude and longitude. Efforts have been made to analyse and map those records as well (Coffen-Smout *et al*. 2013). Analyses using vessel monitoring system (VMS) data have been carried out for small areas of the Scotian Shelf, and region-wide for mobile bottom-contacting gear. In addition to fisheries records, OCMD has analysed records of shipping traffic (Koropatnick *et al*. 2012), ballast water exchange, and seismic surveys (OCMD 2005). The division has created maps of management areas (e.g. fishing zones, oil and gas licences, management zones for other regulatory authorities), dredge and disposal areas, location of exploratory wells drilled by the petroleum industry, pollution sightings, aquaculture sites, shipping lanes, submarine cables, pipelines, etc. OCMD plans to continue to compile and map coastal and offshore human activities in order to support informed decision-making and marine planning in the region. These database can provide spatially resolved information about human pressures on the Scotian Shelf ecosystem.

6.5 DFO Aquatic Climate Change Adaptation Services Program (ACCASP): Trends and Projections – Blair Greenan, John Loder

Climate change is an important global issue that has the potential to affect the DFO's ability to meet its mandated obligations and commitments. Climate change issues are complex and it is often difficult to predict how, where, when, and at what magnitude the impacts will occur. For the Atlantic Large Aquatic Basin (LAB), the geographic scope of the advice includes both marine (Gulf of St Lawrence, Scotian Shelf/Slope and Gulf of Maine, and the Newfoundland-Labrador Shelf/Slope) and select freshwater environments. Although significant differences exist in the physical climatologies of these sub-basins, the departmental risk assessment will be based on integrated information from the sub-basins and will be delivered as advice for the entire Atlantic LAB.

The oceanographic setting of the Atlantic LAB involves a transition from subpolar waters in the north to a mix of subpolar and subtropical waters at mid-latitudes, with strong seasonal atmospheric forcing and run-off from the North American continent. In the north, the Labrador Shelf and Slope are dominated by the influence of the Northwest Atlantic's Subpolar Gyre, involving the Labrador Current carrying relatively cool and freshwater, as well as sea ice, south from the Subarctic to the Newfoundland Shelf and Slope (including the Grand Banks). The southern part of the

LAB, from the southern flanks of Flemish Cap and the Grand Banks, across the Scotian Shelf and Slope to the Gulf of Maine, is a transition zone with a subpolar influence dominating over most of the shelf, but with increasing subtropical influence from the Gulf Stream system as one proceeds westward. The semi-enclosed Gulf of St Lawrence is somewhat unique, with waters primarily of subpolar origin, but with a strong influence from the freshwater discharge of the St Lawrence River system and seasonal ice cover dynamics, and a weak influence from subtropical water at depth. There is strong seasonality in near-surface temperatures in the Atlantic LAB, in particular associated with solar and atmospheric variability, and additional seasonality from run-off and strong current systems.

Based on synthesis of published literature and new targeted analysis, trends and projections have been produced for the Atlantic LAB with a focus on two periods of 10 and 50 years. Projections for the next 10-year were obtained from recent trends as well as scaling of the 50-year projections. There are currently no models that can predict the combination of natural and anthropogenic changes at the regional level on the decadal scale.

Projections for the 50 year time-scale were developed using results from the Fourth Assessment Report (IPCC 2007) of the Intergovernmental Panel on Climate Change (IPCC) and from other more recent global climate models (GCM), regional climate models, scientific literature, and observed trends. The ensemble mean from the six state-of-the-art coupled climate models being assessed for the IPCC's Fifth Assessment Report (2013) was used in the 50-year projections for key atmospheric and ocean variables, following IPCC practise that no single model should be relied upon for climate projections.

Overall, there remains substantial uncertainty in climate projections for the Atlantic LAB. Climate projections over larger scales and longer time frames have more certainty than those in the near-term and at the sub-basin scale. The uncertainty is in part due to the large spatial gradients in Arctic, continental and ocean circulation influences, and the strong natural decadal-scale variability such as the North Atlantic Oscillation (NAO) and the Atlantic Multi-decadal Oscillation (AMO). Furthermore, the limited spatial resolution of GCMs means that there is reduced confidence in certain key elements in the Atlantic LAB such as: the Arctic-Atlantic linkage including the through-flow in the Canadian Arctic Archipelago (CAA); proper representation of the major transport conduits (e.g. Labrador Current, Gulf Stream) in the subpolar and subtropical ocean gyres; and sea ice variability and regional spatial structure. Lastly, there is no regional atmospheric climate model with active ocean and ice components.

The 50-year projections for key atmospheric variables include a general increase in air temperature and precipitation with seasonal and regional variations, a poleward shift in storm tracks, and an increase in the number of fall storms in the northern part of the LAB. The key projections for hydrologic and cryospheric variables are a decrease in the extent and duration of sea ice, a decrease in the duration of the iceberg season south of 48°N, an earlier spring peak of river run-off, and lower summer river levels at some sites. For oceanographic variables, sea temperature is expected to increase everywhere and in all seasons, salinity is expected to decrease in all seasons with the exception of deep-ocean areas in the south where it may increase, and seasonal near-surface stratification is expected to increase everywhere (with associated reduced mixed-layer depths) with the possible exception of areas which no longer receive advected sea ice. Expectations for chemical oceanographic variables are widespread reductions in subsurface concentrations of dissolved oxygen, lowering of pH with associated shallowing of $CaCO_3$ saturation depths, and reductions in the supply of nutrients to the euphotic zone.

There is also clear evidence that coastal sea level is already rising significantly in the southern part of the LAB, associated with a combination of land subsidence and anthropogenic climate change. It is expected that mean and extreme high sea levels will continue to rise in these areas and this will expand to all areas on the 50 year scale.

On the decadal time-scale, it is expected that there will be a tendency toward much smaller changes of the same sign for most variables, but these may be dominated in some (perhaps many) cases by unpredictable natural decadal-scale variability. Anthropogenic changes which are nonetheless considered likely on the decadal scale include warmer sea temperatures, earlier spring freshets, reduced sea ice extent, higher coastal mean sea levels, and reduced pH.

6.6 Overview of the Working Group on the ICES ACOM/SCICOM Workshop on Ecosystem Overviews (WKECOVER) – Ken Frank

The Working Group on the ICES ACOM/SCICOM Workshop on Ecosystem Overviews (WKECOVER) met in January 2013 to develop a consensus on the purpose, format, and content of ecosystem overviews in ICES. Ecosystem overviews are intended to describe the location, scale, management and assessment boundaries of ecoregions; to alert expert groups to situations within the environment and ecosystems that are expected to significantly influence their advice; to describe the distribution of human activity and resultant pressure (in space and time) on the environment and ecosystem; and to describe the state of the ecosystem (in space and time) and comment on pressures accounting for changes in state. Ecosystem overviews are intended to be living documents that are regularly reviewed and responsive to the needs of clients. The workshop recommended a format and elements required to address the four reporting areas described above. The regional integrated assessment groups, such as WGNARS, should be main players in this process, to screen the wide range of environmental and ecosystem signals and to identify key signals that would have a significant effect on the way in which other Expert Groups would develop advice.

More information can be found in the group's report: http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2013/WKECOVER/WKECOVER%202013%20report.pdf

6.7 Identifying indicator thresholds – Scott Large, Gavin Fay, Kevin Friedland, Jason S. Link

Here, we describe a method that aims to identify trends and thresholds in univariate indicator response to environmental and human drivers (Large *et al.* in press). As a suite of indicators is most useful to understand complex systems, we briefly describe a method to expand this univariate technique into a multivariate framework.

We used a generalized additive model (GAM) to determine if a driver (e.g. Atlantic Multidecadal Oscillation; AMO) significantly influenced a suite of ecological and socio-economic indicators (Figure 6.7.1a-b, dashed line). When these relationships were significant ($p < 0.05$) and provided a better fit than a generalized linear model, we estimated the first and second derivative of the GAM smoother line (Figure 6.7.1c-d, solid line). We calculated 95% confidence intervals (CI) with a parametric bootstrap of the GAM smoother line and both derivatives. When the derivative CI's passed above or below zero we identified a significant negative or positive response, denoting regions where exploitation or the environment significantly influence indicators of ecosystem status (Figure 6.7.1c-d, arrow).

We can expand this analysis from a univariate comparison between a single indicator-driver relationship with a multivariate comparison of a suite of indicators using dynamic factor analysis (DFA). DFA is a dimension-reducing technique that identifies common patterns between a set of time-series and explanatory variables. Using AIC selection criteria, we can identify the appropriate number of trends in a suite of indicators. Using each DFA trend as the dependent variable, we can apply the GAM-derivative method previously described to identify trends and thresholds in multivariate responses to human and environmental drivers.

Using the empirical approaches outlined above, we can begin to identify levels where human and environmental pressures influence indicators of ecosystem status, which will be useful in establishing decision criteria that to inform management action. However, further work expanding these methods to account for multiple drivers will be necessary to account for the complexities of human use and the environment.

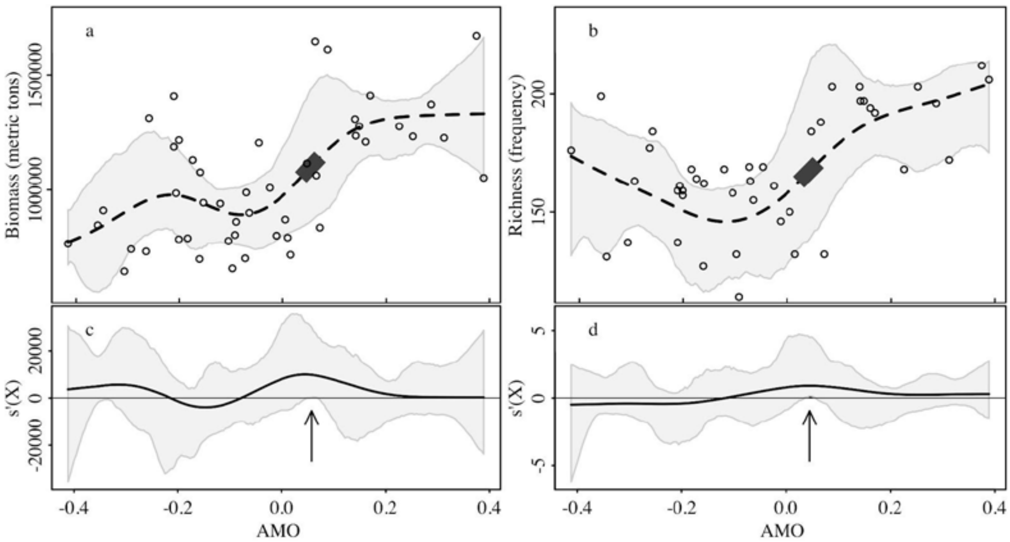


Figure 6.7.1. GAM of indicators' response to drivers, where the dashed line represents the GAM smoother, the grey polygon represents 95% CI, points represent the raw data, black solid lines indicate significant positive or negative trends, and grey solid lines indicate significant thresholds. The first derivative of the GAM smoother line is below (c and d), where the solid line indicates the first derivative of smoother line, grey polygon represents 95% CI, black polygon and arrows indicate direction (positive or negative) of the trend where the 95% CI pass above or below zero, representing a significant deviation from zero. (a) biomass ($p < 0.001$, deviance explained = 0.44), (b) species richness ($p < 0.001$, deviance explained = 0.36). Figure from Large *et al.* in review.

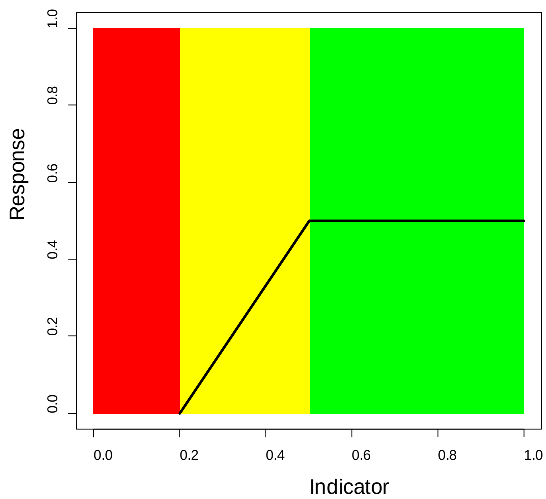
6.8 Simulation modelling for testing performance of ecosystem indicators – Gavin Fay

Successful implementation of Ecosystem Based Fisheries Management (EBFM) requires practical methods of translating information on system status into management actions. Threshold values in ecosystem indicators have been demonstrated to provide insight for characterizing change points in marine ecosystems and have been suggested as reference points for EBFM. Threshold values for use as indicator reference points can be obtained from empirical analysis, expert opinion, historical conditions, and modelling. These approaches can consider indicator reference points in response to a range of system drivers (e.g. climate and fishing), and be both univariate (single response indicator and driver) and multivariate (simultaneous consideration of several indicators). Simulation modelling tools, including Management Strategy Evaluation, can be used to test the performance of thresholds in indicators as reference points for ecosystem-based fishery control rules.

We outline approaches for constructing indicator-based fishery control rules (e.g. Figure 6.8.1), and outline examples of performance testing to see how thresholds in indicators obtained from ecosystem modelling simulations can be used for setting ceilings on system-level catch. In an application to the finfish community on Georges Bank (Fay *et al*. in review), setting ceilings on system-wide annual catches successfully constrained values for indicators and revealed levels of system catch associated with indicator change. Catch ceilings based on thresholds in community composition indicators more frequently resulted in higher yields and fewer species being overfished than when ceilings were set using total biomass or when no ceiling was in place. Analyses that reduced groundfish productivity as a proxy for an effect of climate impacts resulted in altered threshold values in response to fishing for some indicators, demonstrating the need to understand indicator response across a range of drivers.

Although the examples presented focus on fish and the effects of fishing, the simulations demonstrate how ecosystem models can be used to evaluate indicator behavior given different system drivers, and for a full range of indicator types. Additional ongoing work on this topic will compare performance of candidate control rules and reference points given known true conditions and system dynamics against a range of management objectives, and also extend the analyses to the End-to-End system model Atlantis, allowing a more complete suite of environmental pressures and socio-economic indicators to be evaluated.

a)



b)

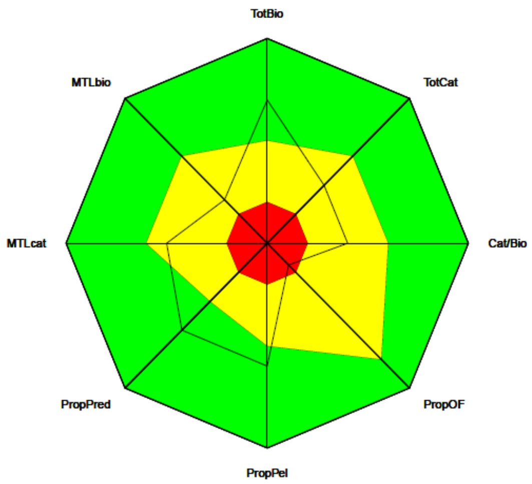


Figure 6.8.1. Example indicator-based control rule. (a) As the value for an indicator crosses a threshold, a management response is triggered (yellow), with extreme response as the indicator crosses a limit reference point (red). Taking a multivariate perspective (b), threshold and limit reference points for a suite of indicators can be visualized, with current ecosystem status (black line polygon) demonstrating that for some indicators, the system is above threshold values (polygon lies in green shaded area) but has crossed threshold (green-yellow boundary) or limit (yellow-red boundary) reference points for others.

6.9 Working session: identifying indicator threshold responses to climate change and fishing

The working session was envisioned as a combination of work on a simple analysis and development of a strategy for future work. It was recognized ahead of the meeting that it would be necessary to subdivide work into different regions, owing to differences in data availability. The session first consisted of a discussion surrounding selection of indicators (driver/pressures and response), indicator selection, data assembly, data analysis by Scott Large and Gavin Fay, and a follow-up discussion of preliminary results and potential avenues for further work.

Prior to the meeting, it was proposed to limit the scope of the session by focusing on a single driver, climate change, and specifically increased temperature as a proxy for climate change. Analyses focused on identifying thresholds in pressure-response relationships associated with both climate and fishing drivers.

Data for response indicators and drivers were assembled for four regions: the Northeast US Shelf (NES), Western Scotian Shelf (WSS), Eastern Scotian Shelf (ESS), and Southern Gulf of St Lawrence (SGSL).

6.9.1 Indicator selection

Data availability differs among regions, meaning that the same indicators were not available for all regions within the WGNARS area. During discussion, the group decided to focus on obtaining indicators that had consistent descriptive function among regions even if the actual indicators were not identical. Driver indicators (Table 6.9.1) were chosen to reflect an index of thermal habitat, temperature, and fishing effects. For the latter, metrics of system exploitation rate (Landings / Biomass) or fishing effort were chosen in preference to proxies for total fisheries removals (e.g. landings). There was some discussion as to potential use of predation indices as being important pressure variables for some regions (e.g. SGSL, seals).

Response indicators (Table 6.9.2) were chosen for each system to represent the following categories: system biomass, community structure, condition factor, zooplankton biomass, and fishery revenue. It was noted during discussion that most of the currently compiled indicators are biological, with socio-economic indicators limited to fisheries. However, as noted during the morning presentations, many more socio-economic indicators and indicators related to other human activities besides fishing are becoming available. It was noted that for some regions (particularly those at the northern and southern extremes of the area), there may be additional indicators that provide information about system response to climate change, such as the proportion of Arctic or warm-water species. Phenology of plankton blooms was also discussed but these data were not on hand at the meeting. Following from the earlier presentation on the human use atlas, the group discussed the importance of being able to convert additional spatial indices into time-series, to calculate new sets of indicators that could be analysed in additional ways. Examples include the volume of certain habitats and phenological indices that could be analysed using landscape and fragmentation methods.

Table 6.9.1. Driver Indicators for each region selected for the threshold analyses.

	Drivers			
Region	Fishing	Temperature	Habitat	Thermal envelope
Northeast US Shelf (NES)	Exploitation (landings / biomass) (1964-2010)	Summer Extended SST (1964-2010)	Thermal envelope (1958-2007)	
Western Scotian Shelf (WSS)	Exploitation (landings / biomass) (1970-2010)	Bottom Temperature (1970-2012)	Thermal envelope (1958-2007)	Cold intermediate layer Volume (1972-2012)
Eastern Scotian Shelf (ESS)	Exploitation (landings / biomass) (1970-2010)	Bottom Temperature (1970-2012)	Thermal envelope (1958-2007)	Cold intermediate layer Volume (1972-2012)
Southern Gulf of St Lawrence (SGSL)	Fishing effort (1971-2008)	Temperature (1971-2008)		

Table 6.9.2. Response Indicators for each region selected for the threshold analyses.

	Response				
Region	Biomass	Community structure	Condition factor	Zooplankton	Economic
Northeast US Shelf (NES)	Total Survey Biomass (1964-2010)	Mean trophic level of the landings (1964-2010)	Butterfish condition factor	Zooplankton biovolume (1977-2008)	Total adjusted revenue (1964-2010)
Western Scotian Shelf (WSS)	Survey biomass (1970-2010)	Mean trophic level of the landings (1970-2010)	Condition factor (1970-2012)		

Eastern Scotian Shelf (ESS)	Survey biomass (1970-2010)	Mean trophic level of the landings (1970-2010)	Condition factor (1970-2012)	
Southern Gulf of St Lawrence (SGSL)	Survey Biomass (1971-2008)	Community Structure (1971-2008)	Condition (1971-2008)	Zooplankton biomass anomaly (1982-2005)

6.9.2 Hypotheses

Part of the discussion addressed expected outcomes of the analyses of indicator responses to drivers. The group acknowledged that direct effects might be difficult to detect, and although the fundamental relationships might be the same in the different regions, variability might preclude full regional analysis. Similarly, differences in the scale of effects might complicate analyses (e.g. large-scale climate drivers vs. regional environmental variability vs. localized fishing activity). A nested analysis to accommodate these differences would be valuable and was noted as potential for the work coming out of this session for a possible publication.

Given that this was mainly an example to illustrate the methods, and that we were only using one climate driver, the group generally agreed that it would be expected that: (1) increased temperature would lead to increased productivity, (2) earlier phytoplankton bloom would result in fatter (higher) condition factors (unless it was too hot), (3) system biomass would not increase with changes in temperature, and (4) diversity of community structure would increase with temperature and then decrease.

6.9.3 Analysis

Data were analysed using GAMs as presented earlier in the session. Univariate and multivariate responses to individual drivers were considered. Multivariate analyses considered the other drivers as potential covariates in the Dynamic Factor Analysis. Data were analysed by region, rather than together. Dr Large provided R script used in his analyses for the group to use.

Bivariate GAMs were also considered, whereby a single response indicator (which could be a multivariate synthesis of many indicators) was regressed in a GAM that included an interaction smoother term for two drivers, resulting in a response surface (e.g. Figure 6.9.1). This method potentially allows the response of an indicator to values for one driver to depend on the value for another driver (e.g. interaction in indicator response to both fishing and climate drivers).

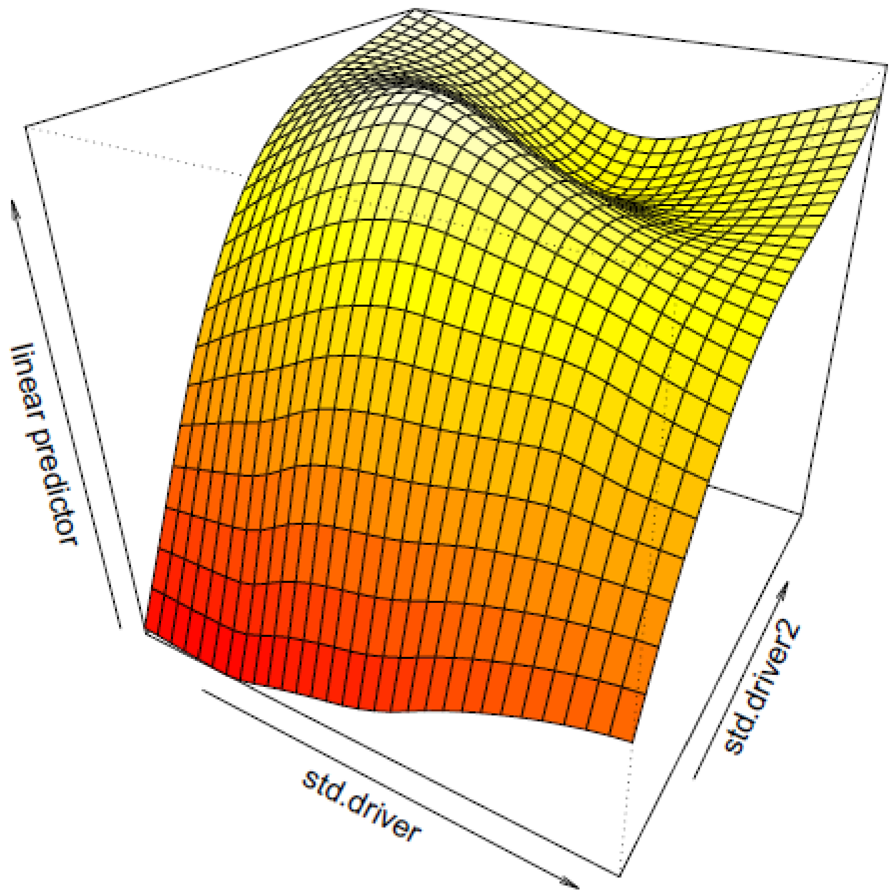


Figure 6.9.1. Schematic response surface for bivariate GAM

Additional methods discussed for identifying patterns/changes in indicators over time (and space) that might be candidates for future work or in a literature review in the worked example included CUSUM control charts (e.g. Mesnil and Petitgas 2009) and chronological clustering. The group agreed that simulation models would be useful for comparative work between regions. This would require regional ecosystem models in which the performance of some indicators could be tested by calculating metrics and comparing simulations across regions. It was noted that this approach would not require the same models in each region. An alternative proposal was for retrospective analysis of indicator performance, which would not require these simulation models. Habitat modelling exercises would be required to synthesize spatial indicators (both ecological and human use) into time-series. There are models for evaluating trade-offs (e.g. Marxan) and there has been work in the Marine Protected Area development process, but the group acknowledged that such a process would be difficult in an EBM context when there are lots of objectives. For spatial indicators, ultimately it will be important to understand what spatial features are most relevant to indicators.

6.9.4 Results and Discussion

The analysis methods to identify thresholds/trigger points provide a pathway to move the science of indicators from heuristic understanding and status determination to decision criteria that can be used for strategic and tactical management under EBM frameworks.

Dr Large provided an overview of some initial results from the threshold analyses of pairwise drivers and indicators. For the Scotian shelf, condition factor increased with bottom temperature. The relationship between SGSL fishing effort and biomass was non-intuitive, perhaps indicative of changes in the structure of the system. Example results for NES indicator responses to exploitation are shown in Figure 6.9.2. Revenue and survey biomass showed significant decreases with increasing exploitation rate. For the WSS, thermal envelope appeared to be related to the trophic level of the landings, but not so much biomass or silver hake condition factor (Figure 6.9.3). Example results of dynamic factor analysis for WSS (Figure 6.9.4) demonstrated a significant change in the value for the estimated Hidden Trend associated with changes in the values for the size of the thermal envelope (Figure 6.9.4). Indicators with high loadings on this hidden trend included the mean trophic level of the landings (as in the univariate case), but also the condition factor.

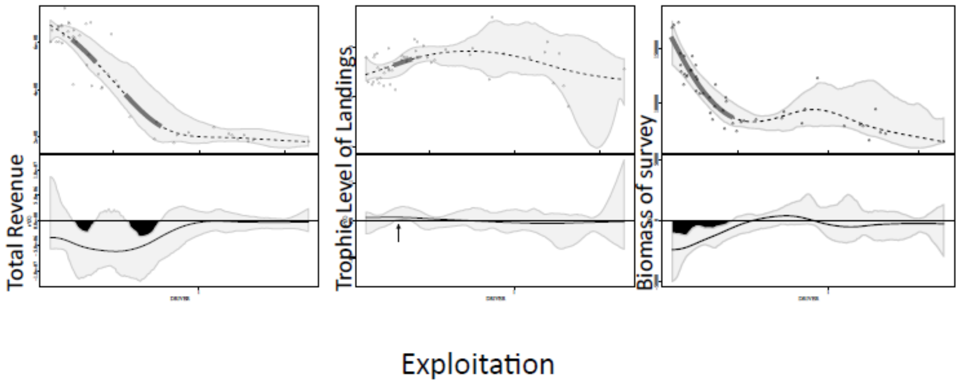


Figure 6.9.2. GAM results for univariate analyses for the Northeast US shelf (NES), with response of revenue, trophic level of landings, and biomass indicators to exploitation driver. GAM fits are shown in the upper panels, with the central 95% bootstrapped confidence interval. Bold areas of the curve in the upper panels indicate values for the driver where >95% of the bootstrap replicates had a first derivative that were solely positive or negative (bottom panels).

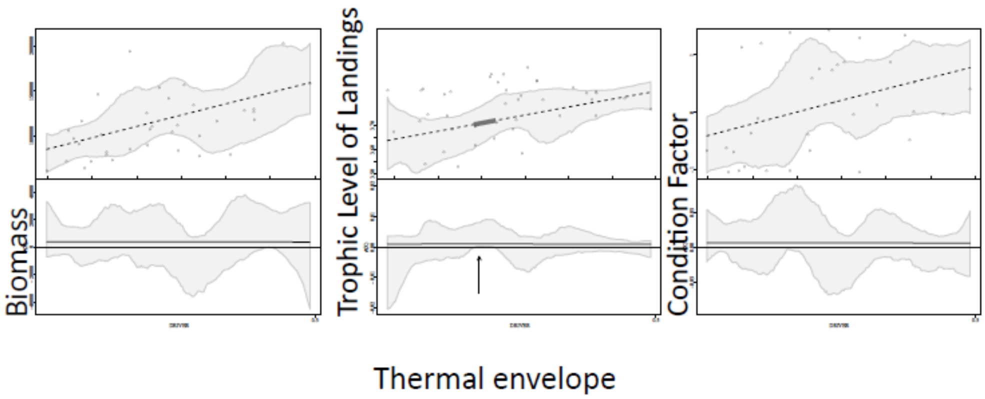
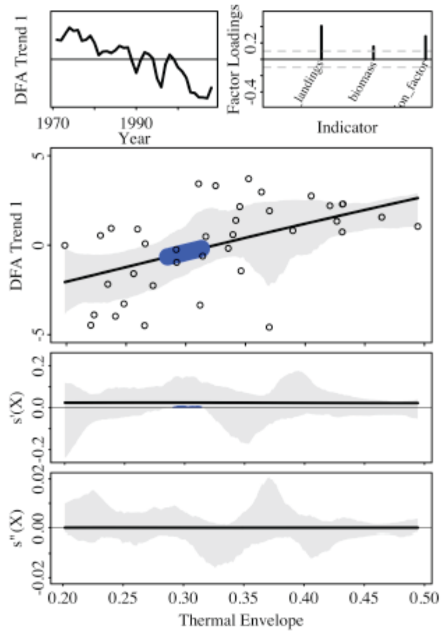
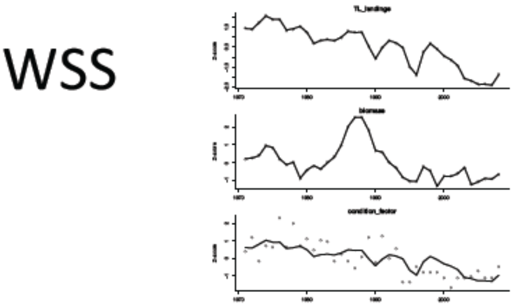


Figure 6.9.3. GAM results for univariate analyses for the Western Scotian Shelf (WSS), response of biomass, trophic level of landings, and condition factor indicators to the thermal envelope driver. Organization and labels of panels and curves as for Figure 6.9.2.





R	m	Covariate	logLik	AICc	delta.AICc
diagonal and unequal	2	exploitation	-72.62847	169.8452	0.000000
unconstrained	2	exploitation	-70.86404	173.9705	4.125339
diagonal and unequal	2	BottomTemp.exp	-71.13892	174.5203	4.675097
diagonal and unequal	2	thermal_envelop.exp	-71.51789	175.2782	5.433034
unconstrained	2	BottomTemp.exp	-68.90350	178.1820	8.336839
unconstrained	2	thermal_envelop.exp	-70.14736	180.6697	10.824561
diagonal and unequal	2	NA	-88.72699	194.8254	24.980232
diagonal and unequal	2	BottomTemp	-86.22826	197.0448	27.199590
diagonal and unequal	2	thermal_envelop	-87.68753	199.9633	30.118128
diagonal and unequal	1	exploitation	-90.57203	200.8748	31.029656
unconstrained	2	NA	-88.18128	200.9508	31.105624
unconstrained	2	BottomTemp	-84.77606	201.7946	31.949385
diagonal and unequal	1	BottomTemp.exp	-88.95532	204.9997	35.154576
unconstrained	2	thermal_envelop	-87.12260	206.4876	36.642453
diagonal and unequal	1	thermal_envelop.exp	-90.03589	207.1609	37.315729
unconstrained	1	exploitation	-90.28217	207.6534	37.808273

Figure 6.9.4. Results of GAM threshold analysis on the output of DFA for the Western Scotian Shelf, focusing on the relationship between the first hidden trend (DFA Trend 1) and the thermal envelope driver indicator. The DFA model chosen included exploitation as a covariate. Indicators with high loadings on DFA Trend 1 were the mean trophic level of landings, Condition factor, and biomass (loading was less for biomass than the other indicators). Blue highlighted region of GAM fit indicates range of thermal envelopes over which greater than 95% of the bootstrapped GAM fits had a positive first derivative.

Dr Fay showed preliminary results of fitting bivariate GAMs to both climate and fishing drivers, which produces an indicator response-surface (e.g. Figure 6.9.5). The group agreed that these analyses were very relevant, and encapsulated the problem of the combined drivers. However, data availability is an issue, as the analyses could not be performed with fewer than 20 years of data, and although variability can be seen, evaluating significance in the estimated relationships is non-trivial. A suggestion was made to pool data among regions to potentially improve the power of the analyses. As with the previous analyses, all code is on the share point site for group members' use.

It was noted that it would be important to show results for pairwise analyses that did not have change-points (as defined by the methods), to see whether there is a linear relationship between the driver and indicator (the automated model selection method outputs this, but it was not presented at the meeting). In such instances of linear relationships, defining reference points for indicators will be more challenging.

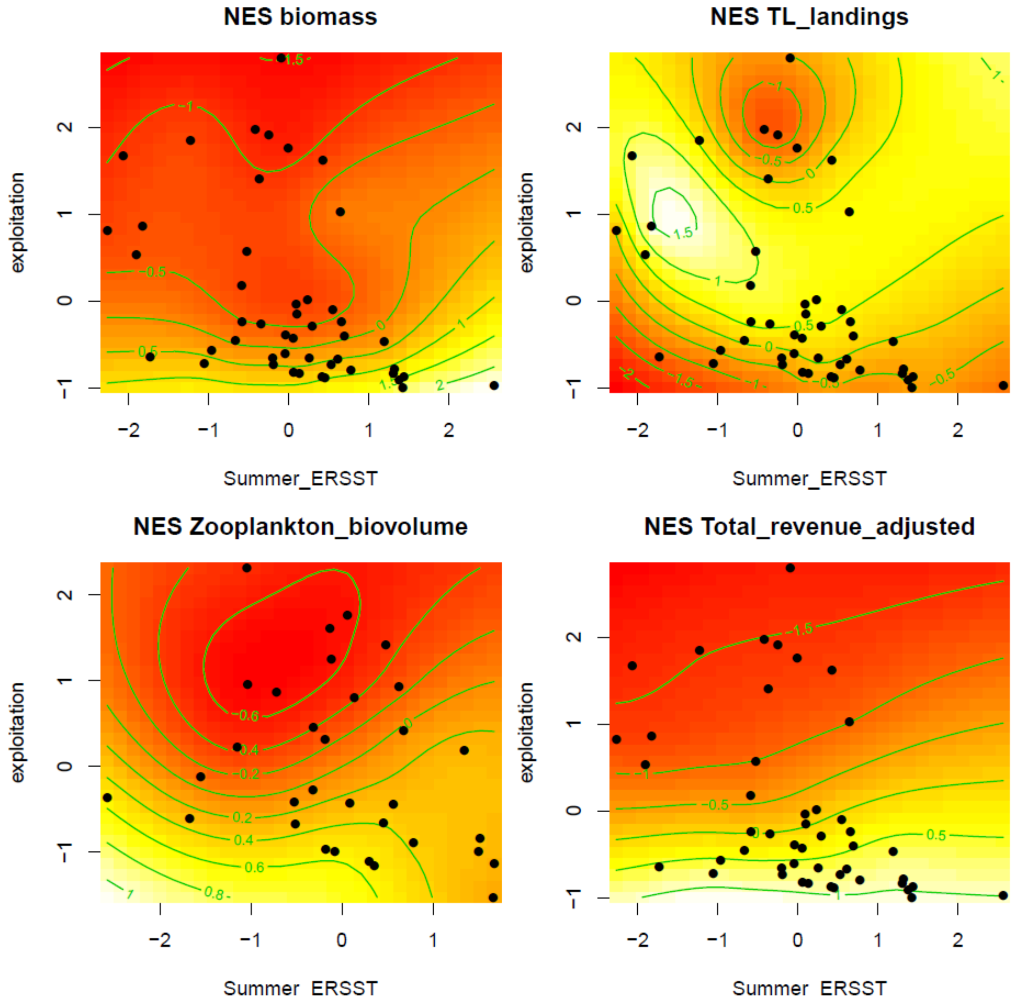


Figure 6.9.5. Example results of bivariate GAMs fitted to NES data. Shown are surface responses of biomass, community structure, zooplankton biovolume, and total revenue to both temperature and exploitation rate.

6.9.5 Conclusions and plans for further work

The Tor D session (along with the Tor C session on risk assessment) represented a transition of WGNARS from presentation to working session. The group found this to be somewhat successful, in particular as the worked analyses provided a framework for discussion that was focused on product delivery. The work on indicators is highly relevant as it provides links with Management Strategy Evaluation, Risk Assessment, and other components of the Levin *et al*. (2009) framework for IEAs.

It was agreed to continue with the analyses begun during the workshop. Dr Large and Dr Fay will lead efforts to write a journal article focusing on nested analyses of indicator thresholds and responses across the WGNARS regions to the fishing and climate drivers outlined. Dr's Large and Fay will circulate a draft work plan to WGNARS members out of session. This work plan will include plans to improve the data sources for the paper, with a better discussion of appropriate indicators and how to standardize indicators among regions. The possibility of including indicators from the Newfoundland region will be investigated by Dr Koen-Alonso.

7 Risk Analysis (ToR c)

7.1 Introduction – Sarah Gaichas

This portion of the meeting focused on ToR c, "Evaluate risk of various multi-sector ocean-uses impacts facing the Northwest Atlantic to assess relative susceptibilities." A work plan distributed prior to the meeting outlined two main tasks, (1) presentations and discussion of background information during the morning session, and (2) work through a simple risk assessment exercise as a group during the afternoon session.

Presentations and discussion during the morning session centered on the following questions and topics: What is risk? What is risk assessment? Risk analysis? When do you use different levels of risk assessment/analysis within the IEA process? Define and review potential frameworks, methods, and applications from other regions outside WGNARS (Australia, Alaska). Review examples of risk assessments and or analyses that have been done in the WGNARS region. Below, we present extended abstracts from the three presentations and summarize the discussion.

The proposed approach for the afternoon session was to work out an example qualitative risk assessment related to climate impacts on groundfish fisheries. This topic was selected because it was related to the previous day's work, limited in scope, and incorporated prior discussions from the meeting. The proposed steps of the exercise included listing system attributes, activities, and conditions leading to risk, including unknown factors, and characterizing risk on three axes: (1) How likely is attribute/activity/condition to occur? (2) How big an impact (ecological and/or economic, can rate separately) will the attribute/activity/condition have? (3) What are the consequences of a change in the attribute/activity/condition? The risk of each was rated as low, medium, or high likelihood, impact, or consequences of change. This exercise feeds back into determining which indicators are best suited to identify when the system has changed, and it can also help prioritize actions both for managing the system and for increasing scientific knowledge.

The development and results of the risk assessment exercise, including difficulties that we encountered in applying risk assessment methods, are described in section 7.5. Overall, we expect that future WGNARS work and ToRs will expand the risk analysis to more ocean uses and drivers and across more regions and develop a more quantitative risk assessment as IEA objectives and management thresholds are further developed.

Three presenters provided background material and examples for the working session discussion and results. Roland Cormier spoke about a DFO initiative to adapt ISO risk assessment and management standards at the ecosystem level. M. Robin Anderson presented a risk assessment framework and application for the Placentia Bay Grand Banks Large Ocean Management Area. Finally, Sarah Gaichas provided example risk assessments used by the US Environmental Protection Agency, NOAA, and the Australian Ecological Risk Assessment framework. Each presentation is detailed in sections 7.2-7.4 below.

7.2 A risk management approach to ecosystem-based management – Roland Cormier

7.2.1 Introduction

An ecosystems approach to marine spatial planning (MSP) is primarily a process of planning and regulating all human uses in a given marine area of the sea while protecting marine ecosystems (EC 2012). Similarly, integrated coastal and oceans management (ICOM) is a process for the management of the coast using an integrated approach that takes into account all aspects of coastal and oceans human activities within a geographical or political boundary to achieve sustainability (DFO 2002). In brief, it involves identifying needs, establishing authority and the boundaries; organizing governance structures and stakeholder advisory processes; developing and getting approval of the management plan; implementing, monitoring and evaluating the performance of the management plan as well as adapting the management plan as new uses are introduced or new scientific knowledge is available (UNESCO 2009). Environmental management also relies extensively on environmental assessments to inform policy decisions, similarly to the use of strategic environmental assessments or in relation to the use of environmental impact assessments in the approval (licensing) of development projects (EU 2001, USEPA 1969). These assessments, however, can be descriptive in nature providing the basis for the subsequent development of the management measures during the project approval process. From an ecosystem approach to management perspective, management measures also include spatial and temporal approaches to activities and development as well as environmental quality standards.

The challenge of such processes lies in the best use of current scientific and technical knowledge to inform decision-making and in the deployment of management strategies to address priorities of highest ecosystem, socio-economic and policy risks. Using the DPSIR definitions (UNEP/GRID-Arendal 2002), the management of any environmental issues requires the application of measures that eliminate, control or mitigate the pressures resulting from the drivers of human activities occurring in a given area. These are typically implemented in the form of regulations, policies, programs, best management practises, standard operating procedures, management targets and even stewardship and education, to name a few. In practise, environmental management measures are designed and implemented for the relevant drivers and their specific pressures to reduce the risks of adverse environmental effects and subsequent impacts to vulnerable ecosystems and environmental services valued by humans. From an implementation and risk management perspective, management strategies and measures have to reduce risk to a level that is "as low as reasonably practicable" (ALARP).

Risk assessment and risk management is widely used in various management constructs from civil and mechanical engineering to food safety and human health (WTO 1999, IPPC 2001). Several ecological and environmental risk frameworks have been developed with similar objectives of identifying risks to ecological components (USEPA 1998, Australia 2011) using empirical and Delphic (i.e. expert opinion) approaches. Each framework uses a broad variety of terms and definitions that, at times, can hamper comparisons and interoperability between jurisdictions. The International Standards Organization (ISO) has also published a standard on risk management and risk assessment techniques (ISO 2009a, 2009b, 2009c). In this standard, the management of risks is based on a risk assessment that is set within a management context that includes the identification, analysis and evaluation of risk to determine if risk treatment (risk management) is required. It also includes the need for risk communication and consultation as well as review and monitoring.

From an environmental management perspective, such framework can provide a consistent and standardized approach across jurisdictions and industries. Bridging an ecosystem approach to management with risk management frameworks integrates the risk assessment in the decision-making management context in terms of ecosystem vulnerabilities and the assessment of management options against explicit risk criteria (Cormier *et al*. 2013, Australia 2006). This paper bridges the ISO 31000 risk management framework to an ecosystem approach to management (Figure 7.2.1).

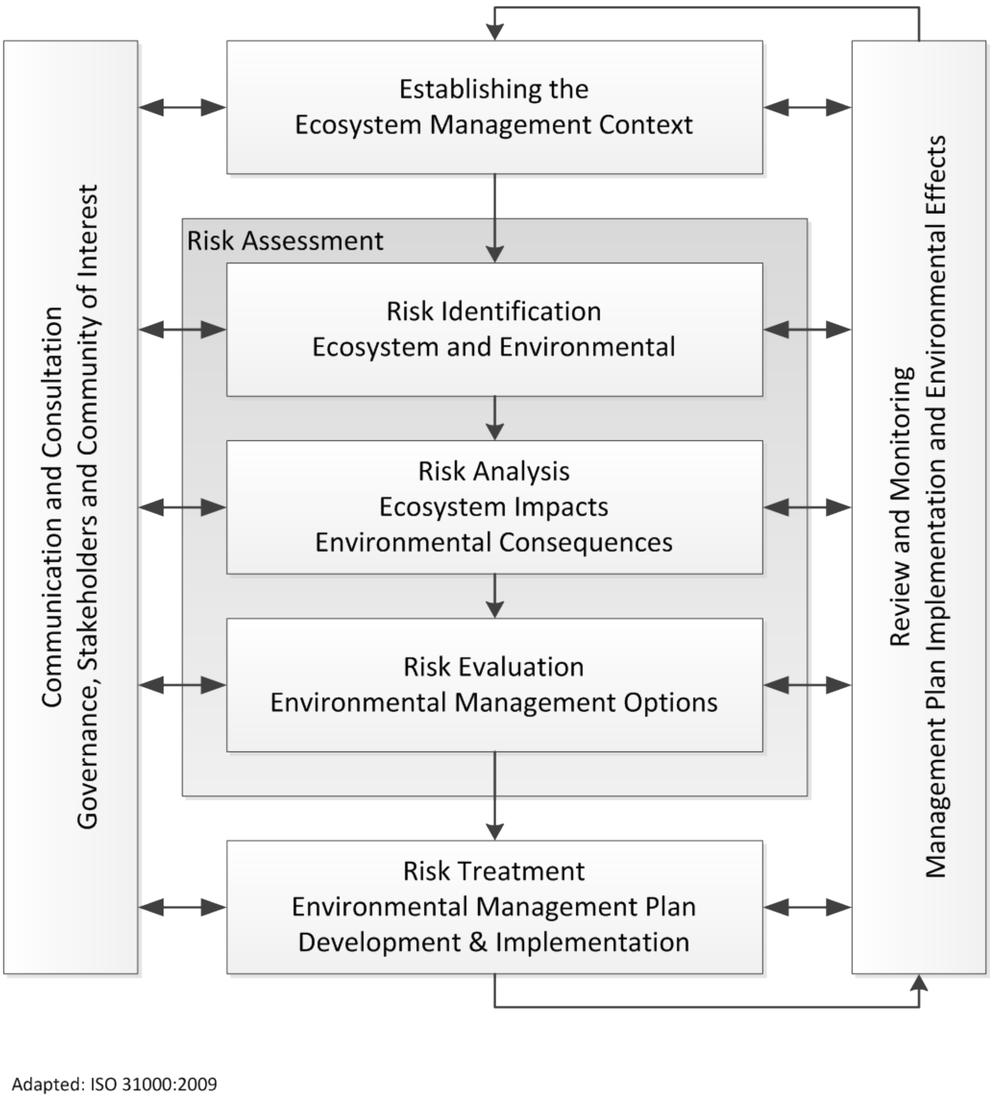


Figure 7.2.1 A risk management framework applied to an ecosystem approach to management.

7.2.2 Ecosystem Management Context

The ecosystem management context sets the scope and defines the external and internal parameters that have to be taken into account in the development and implementation of management measures designed to reduce environmental risks. The Seven Tenets of Environmental Management (Elliot 2011) can provide insight into the external and internal contexts that have to be taken into account:

- Environmentally sustainable: Good for nature now and in the future
- Technologically feasible: With appropriate methods and equipment
- Economically viable: At a reasonable and tolerable cost
- Socially desirable: Wanted by our societies
- Legally permissible: Within our defined laws at national and international level
- Administratively achievable: Carried out by our system of departments, agencies and governments
- Politically expedient: Consistent with the prevailing political climate and have the support of political leaders

The context also requires more specific ecosystem management outcomes needed to achieve sustainability. Decisions are based on environmental risk criteria that define risk tolerance parameters used to characterize ecosystem impacts and environmental consequences during the risk analysis step as well as assess and select management options during the risk evaluation step (DFO 2009b). The ecosystem boundaries must take into account the ecosystem level impacts while the management area boundaries set the governance and jurisdictional mechanizms to implement the management measures. Communication and consultation are important prerequisite activities to ascertain that the management outcomes are in line with the governance policies, stakeholder development aspirations and community of interest conservation objectives.

7.2.3 Risk Identification: Vulnerable ecosystem and environmental components

Risk identification is used to identify the ecosystem and environmental vulnerabilities in relation to potential environmental effects that are caused by pressures as a result of the drivers of human activities in the management area. The intensity of the drivers occurring in the management area is considered in terms of their potential impacts at the ecosystem scale. This includes the identification of significant ecological and environmental components and services that are valued by stakeholders and the community of interest (DFO 2004, 2006a, 2009a). In the ISO 31000 framework, the environmental effects are considered as the risk event (ISO 2009c) to be avoided. From a risk avoidance perspective, environmental effects are central to the risk management process and the achievement of the ecosystem management outcomes. Communication and consultation activities are used to ensure that the identified ecosystem vulnerabilities are in line with the values of the community of interest and regulatory and policy context.

7.2.4 Risk Analysis: Ecosystem impacts and environmental consequences

Risk analysis is used to characterize the ecosystem impacts, socio-economic consequences and regulatory and policy repercussions in the event that environmental effects are manifested. This step is very similar to typical ecological risk assessments. However, it also includes the analysis of the cause-and-effect pathways (ISO 2009a) linking drivers to the pressures that are contributing to environmental effects. In addition to developing an understanding of the risk, its causes, impacts and consequences, the current management measures are also documented and analysed in terms of their effectiveness to prevent or mitigate the risk. The Bowtie analysis (ISO 2009a) has proven to be a useful tool to conduct regulatory and policy gap analysis (Figure 7.2.2). Based on the risk criteria identified in the context, the likelihood and magnitude of the impacts and consequences are characterized and the resulting risk profile is used to identify management priorities. Communication and consultation activities are then undertaken to explain the resulting risk profile and confirm the priorities that will form the basis of the risk evaluation to determine if the risk is tolerable or needs treatment.

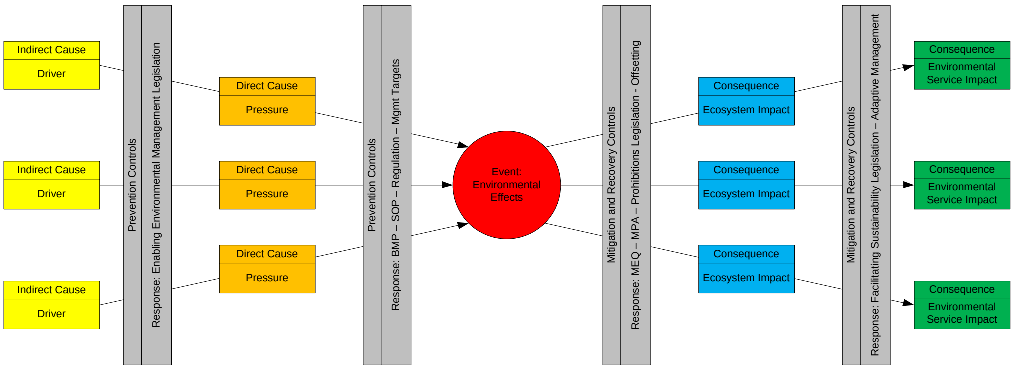


Figure 7.2.2 The Bowtie analysis of regulatory and policy gaps (Adapted: ISO 31010:2009)

7.2.5 Risk Evaluation: Environmental Management Options

The purpose of risk evaluation is to review the risk profile that was produced during the risk analysis to determine if there is a need for any management measures, if existing management measures are adequate and if enhanced or additional management measures are required. During the evaluation, previous ecosystem health monitoring reports and the performance of existing measures are also considered. Communication and consultation activities are used to characterize the level of risk tolerance from the perspective of public policy and communities of interests as well as to determine what level of management measures that should be enhanced or added to further reduce the risk from the perspective of the regulators and the driver stakeholder community.

7.2.6 Risk Treatment: Environmental management plan development and implementation

Risk Treatment is the development and implementation of enhanced or new management strategies and measures designed to eliminate, control or mitigate the risks of environmental effects. Based on the risk evaluation results, this step assesses the effectiveness and feasibility of the management options including the cost and benefits of implementation. Once the management strategies and measures have been selected, a management plan is developed and implemented by the management body responsible for its administration and operation. While in operation, the management body conducts performance and effectiveness audits, oversees environmental effects monitoring and prepares reviews. These provide the basis for future adaptive management strategies in light of new ecosystem, social, cultural or economic knowledge as well as new management technologies and trends in the development of new drivers or pressures.

7.2.7 Communication and Consultation: Governance structures, stakeholder and communities of interest

There are several elements of communication and consultation that occur throughout the entire risk management process. When operating in a multi-jurisdictional environment, risk management has to provide a governance forum for interagency collaboration and coordination to ensure that management measures, developed by individual agencies, are complementary at achieving the ecosystem management outcomes. Risk management bridges the context of public policy, scientific and socio-economic policy advice as well as legislative requirements. It also links ecosystem management outcomes and the management measures addressing the concerns of the community of interest and the stakeholders that have to implement the management measures.

7.2.8 Review and Monitoring: Management plan implementation and environmental effects

Throughout the entire risk management process, scientific and policy advisory processes play a key review role in setting risk criteria, defining the ecological basis for management and in assessing the risks and management options. It also includes the operational aspects of managing the process and implementing the management plan. Performance and effectiveness audits and environmental effects monitoring are used to ascertain if the management plan is meeting ecosystem management outcomes. When new scientific knowledge or ecological trends cannot be explained by the performance of the management measures, the entire risk management process may need a complete review starting the entire process over again.

7.2.9 Conclusion

Elements of risk management are found in a variety of risk assessment and risk management frameworks or guidelines. In some cases, planning processes rely upon risk assessment frameworks to ascertain risk without a clear sense of the ecosystem management context. Based on perceived management needs, the results of such risk assessment are sometimes misaligned or irrelevant to the ecosystem management context. In addition, risk assessment frameworks typically focus on the characterization of the likelihood and magnitude of ecological impacts. They seldom ascertain socio-economic consequences in relation to the communities of interest that depend on the ecosystem management outcomes being achieved and the regulatory or policy repercussions that depend on the governance structures needed to achieve the ecosystem management outcomes. Few frameworks provide the evaluation step to determine what level of management should be considered in light of a gap analysis of existing legislation and policy. The ISO 31000:2009 standard does provide a comprehensive structure, tools and definitions that can be used within the context of an ecosystem approach to management. It establishes the ecosystem basis for management and can integrate the precautionary approach for management scenarios in light of uncertainty as well as adhere to adaptive management principles as stipulated by the need for monitoring and review.

7.3 Risk assessment framework and its application to the Placentia Bay Grand Banks Large Ocean Management Area - M. Robin Anderson, Laura E. Park and Laura A. Beresford

The Placentia Bay Grand Banks Large Ocean Management Area (PBGB LOMA) stretches from the Laurentian Channel to the Bonavista Channel and includes the Grand Banks. Eleven ecologically and biologically sensitive areas (EBSAs) have been identified for the LOMA (Templeman, 2007). Conservation objectives for the PBGB LOMA were developed using environmental information in a science based process. An extensive literature review and subject matter expert interviews (Templeman, 2007) formed the basis for a peer review (Fisheries and Oceans 2007) that identified 94 valued ecosystem components (VEC) and their associated conservation objectives.

We subsequently developed a semi-quantitative risk assessment framework (Park *et al.*, 2010) to evaluate the potential consequences of threats to the VECs and to aid in setting priorities for conservation action within the LOMA. A list of activities and stressors that affect the LOMA was developed for the analysis. A detailed literature review and expert consultation documented the potential effects of each activity and stressor. The framework broke the assessment down into three phases followed by an analysis of the uncertainty, for the risks associated with each conservation objective. Phase one is a scoping step to determine which of the activities and stressors affect the VEC. The most harmful (up to a maximum of 8) are then screened in to Phase 2. Phase 2 is the quantification and analysis. Risk of harm is evaluated based on the magnitude of the interaction and the sensitivity of the VEC (Figure 7.3.1). Wherever possible, spatially explicit quantitative information was used for the analysis. In Phase 3 the risks of harm from each stressor or action are summed and the conservation objectives are ranked to prioritize them for management action by the cumulative risk of harm for each. Finally an uncertainty assessment is carried out to assess the availability and quality of information used in the analysis.

Key elements of this approach to risk assessment include a preliminary scoping step to reduce the number of elements considered to manageable and scientifically defensible proportions, the use of spatially and temporally explicit data for the risk analysis wherever possible and the application of an uncertainty index to the final outcome.

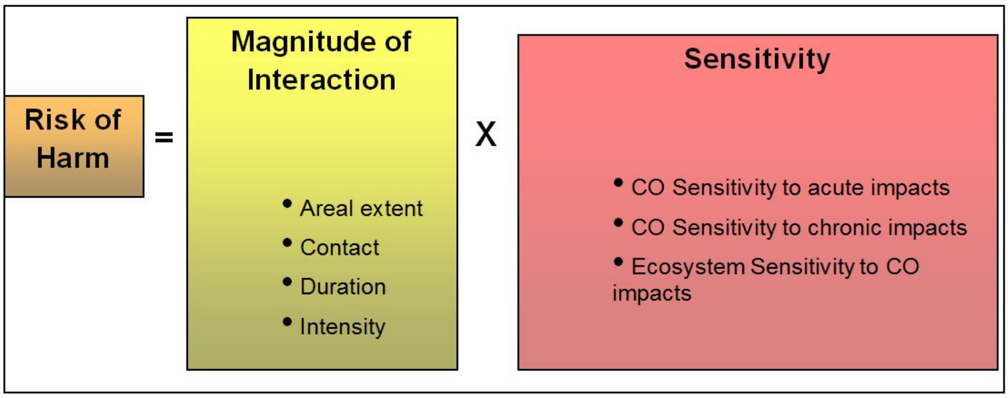


Figure 7.3.1. Quantitative/qualitative factors included in Phase 2 – the characterization and analysis of risk of harm to specific conservation objectives (CO).

7.4 Risk assessment overview and examples - Sarah Gaichas and Jason Link

We reviewed frameworks for conducting risk assessment and methods for risk analysis as background for activities related to ToR c. This presentation was background for general discussion including the following topics:

- What methods of risk analysis are DFO and NOAA using at present?
- What are the strengths and weaknesses?
- How are cumulative effects incorporated?
- What is required to apply risk analysis to target regions?

Within the presentation we first addressed basic motivations for conducting risk analysis and definitions of risk, risk assessment and risk analysis. We attempted to use ISO definitions with assessment as the wider framework and analysis as the technical methods applied to enumerate risk. Here, we reviewed risk assessment frameworks and risk analysis methods used in various parts of the US and in Australia, while previous presentations reviewed risk assessment frameworks for Canada.

Risk analysis is a specific component of the Levin *et al.* (2009) Integrated Ecosystem Assessment (IEA) framework. Further, aspects of risk assessment may be helpful for the scoping component of the IEA framework, in particular for identifying priority objectives and threats to achieving them. An additional motivation for conducting risk assessment in the Northwest Atlantic region relates to climate change, since some of the largest rates of sea surface temperature increase observed worldwide are in the Northwest Atlantic (Figure 7.4.1). Therefore, evaluation of climate related risks to ecosystem services in the WGNARS region would be an important contribution to IEA development.

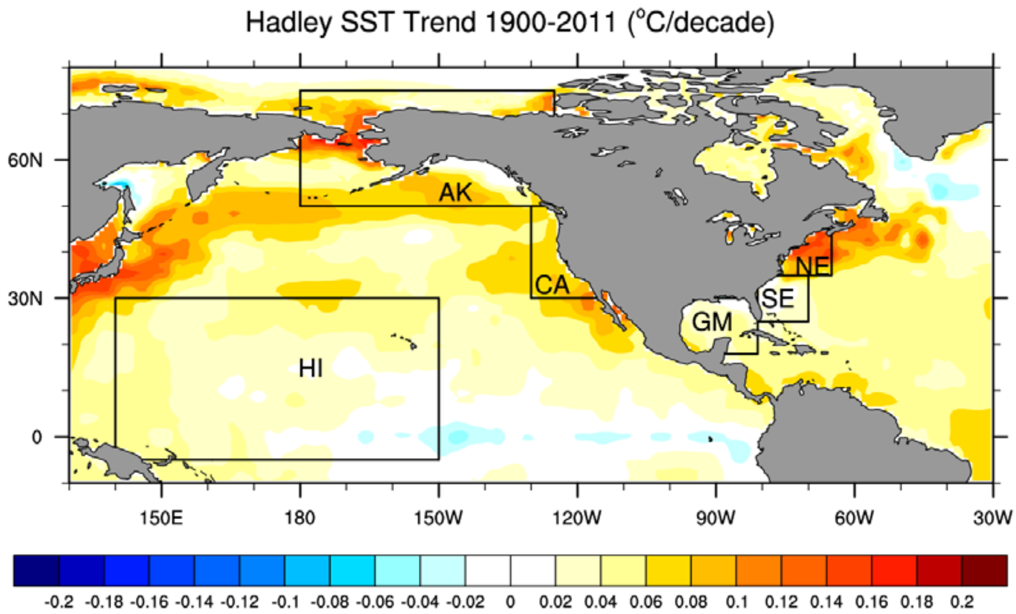


Figure 7.4.1 Observed sea surface temperature trend. Boxes indicate general regional management areas in the US. Source: Michael Alexander (NOAA/ESRL/PSD), Jamie Scott (CIRES), and Antonietta Capotondi (CIRES).

The US Environmental Protection Agency (EPA) guidelines for ecological risk assessment are based on the ISO standard, and are structured around initial planning, followed by a three step risk assessment followed by communication of results and links to risk management frameworks (USEPA 1998). Data acquisition is an iterative process feeding into all aspects of risk assessment. The risk assessment steps are problem formulation, risk analysis (including characterization of exposure and ecological effects), and risk formulation. This basic format can be expanded for specific uses, such as risk assessment for US Superfund (hazardous waste contamination) sites (see http://www.epa.gov/R5Super/ecology/8stepera.html). This framework also represents the building block for all other frameworks we examine.

The US EPA framework has flexibility to be applied in several ways; we reviewed a relevant example of a rapid climate vulnerability assessment for Massachusetts Bays in the US. In this application, expert opinion was used to develop a risk assessment for climate impacts on nearshore coastal ecosystem processes and services. Scoping was done in advance to define the problem and identify relevant experts. Meeting materials and "homework" were distributed and assigned prior to the two day workshop where most analysis was completed. Key interactions were identified and climate impacts on these interactions were developed by the experts using a predefined ratings system, which included a rating of certainty for each assessed impact. The final product identified pathways for managing and mitigating climate impacts on the ecosystem services (Figure 7.4.2). An interim report is available at **Error! Hyperlink reference not valid.**http://cfpub.epa.gov/si/si_public_file_download.cfm?downloadID=503752

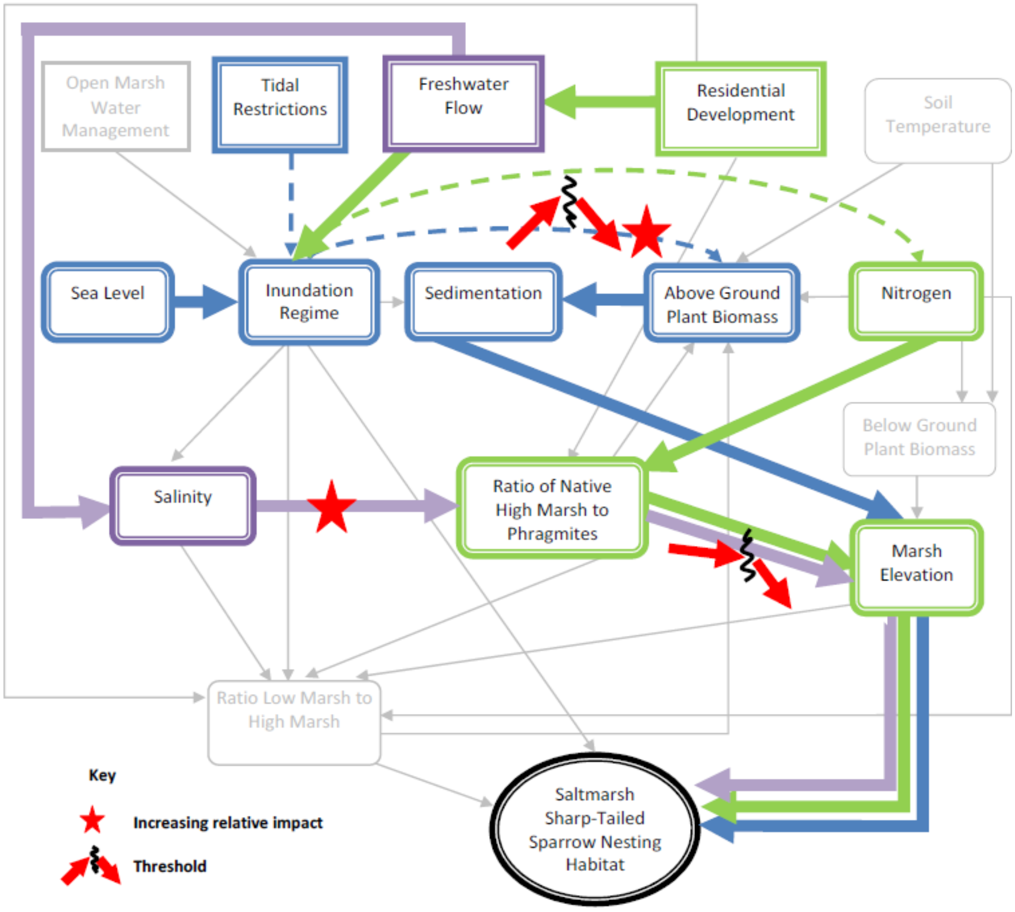


Figure 7.4.2 Top pathways for management arising from the EPA rapid climate vulnerability assessment for Massachusetts Bay

The Australian Ecological Risk Assessment (ERA) framework contains the same processes as the US EPA and ISO risk assessment frameworks, but reframes them in a hierarchical set of methods going from most comprehensive, simplest, and least expensive to most focused, complex, expensive and time consuming for ecosystem components or services determined to be facing the highest risks (Hobday *et al*. 2007). ERA for fisheries is part of a suite of scientific tools supporting EBFM which range from simpler to more complex, depending on the application (Smith *et al*. 2007). The ERA process applies across 5 components: target species, bycatch species, threatened/protected/endangered species, habitats, and communities. The process outlines extensive scoping to determine operational objectives for species, habitats or communities in each component, and gives rating criteria for impacts of fishing activities as well as consequences at the simplest Level 1. Results of the Level 1 analysis are used to screen those species, habitats and communities not at risk under fishing activities from further analysis, with those at risk subjected to the next level of analysis. Level 2 analysis consists of a Productivity-Susceptibility analysis (PSA; see also Patrick *et al*. (2010)) determining which species are at highest risk from fishing activities based on life-history characteristics combined with exposure to fishing (uncertainty arising from data quality can also be included; Figure 7.4.3). The subset of species at highest risk under PSA, if any, are then subjected to the most complex Level 3 risk assessment using much more elaborate stock assessment, habitat assessment, or ecosystem assessment models. Therefore, only the species at highest risk from fishing are subjected to the most labor intensive and expensive assessment methods, optimizing the use of limited assessment resources.

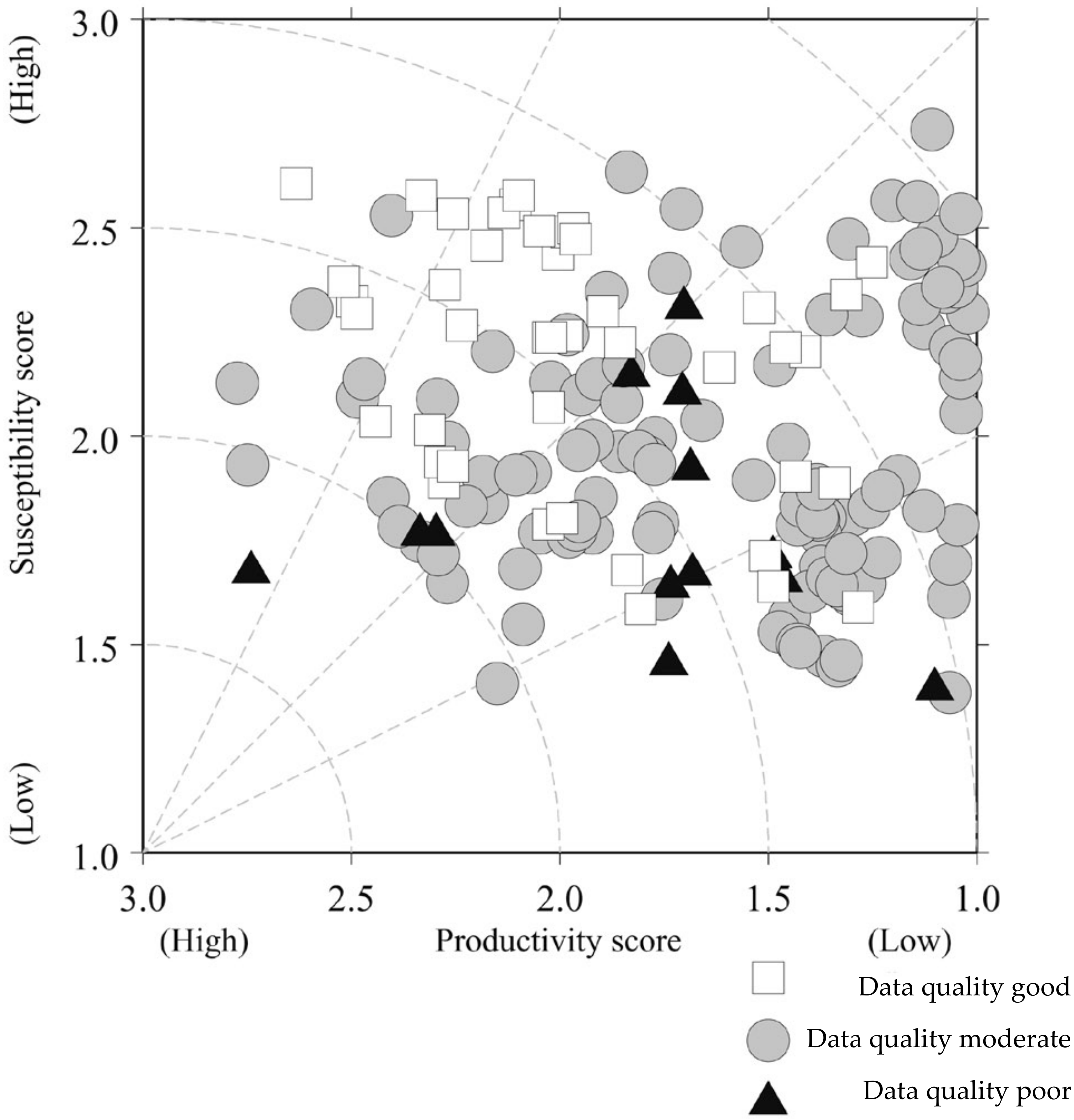


Figure 7.4.3 PSA analysis data quality ratings, from Patrick *et al*. 2010

A combination of both the US EPA and PSA risk analysis methods described above was applied within an ecosystem based management framework for Puget Sound in WA, USA (Samhouri and Levin 2012). In this example, a set of indicator species (selected through an extensive stakeholder process) were assessed for combined risk due to exposure and sensitivity across four human use sectors: fishing, coastal development, residential land use, and industrial land use. Criteria for assessing exposure and sensitivity were modified from previous Australian and US PSA applications, and uncertainty was addressed using data quality ratings for each criterion, as well as jackknifed estimates of exposure and sensitivity scores. In addition, baseline risk (independent of human use), spatial risk (at the subregional level) and community risk (across all species) were assessed.

Finally, a simple ecosystem based risk assessment for the Aleutian Islands in Alaska was reviewed (AIFEP Team 2007). In this application, expert opinion was used to first develop a set of key ecosystem interactions not currently assessed or monitored within the fisheries management system, and then to rate the probability of key ecosystem interactions occurring and the impact of the interaction to identify the highest risk interactions as those with high probability and high impact. Similar to the Australian Level 1 assessment, this risk assessment both identified high priority interactions and potential indicators suited to monitoring changes in the interactions. A quick assessment like this can form the basis for further development of management objectives. This contrasts with a more quantitative (e.g. Level 3) risk analysis that would be done once objectives are established, which would evaluate the risk of not meeting the management objectives, possibly under alternative management scenarios as in a management strategy evaluation.

7.5 Risk Assessment Summary and Recommendations – Sarah Gaichas and Jason Link

After the presentations, the working group discussed several aspects of risk assessment within the IEA framework, and proceeded to plan the afternoon working session. Discussion first centered on the general agreement that despite some contrasts in the application of risk assessment frameworks, the steps are generally the same. Regardless of application to ecosystem based management, fishery management, business management, etc., the risk assessment process remains similar. There are commonalities across all frameworks, including an initial triage or scoping phase to identify priority risks to achieving management objectives, the use of quantitative methods where necessary and possible, and the inclusion of certainty or reliability of information within assessments. Based on the presentations and discussion, the working group developed the following list of general findings for IEA risk assessments:

1) Risk assessment is a critical component of IEA development because this is where scientific information feeds directly into management decision-making, in particular in developing risk criteria and consequences.
2) Risk assessment helps managers to decide where to focus limited resources by clarifying priorities.
3) These methods could be used much more often for screening out issues of lesser importance that may currently have equal or more resources devoted to them than higher risk issues.
4) There are existing frameworks and best practises for environmental risk assessment, including an ISO standard. Many example applications exist around the world and within the WGNARS region.
5) Existing risk assessment frameworks should be adopted where possible (don't reinvent the wheel). However, risk assessment frameworks developed for single species or a limited number of ecosystem attributes will require further adaptation for operational IEAs.

6) Terminology should be standardized so that the process is transparent to all participants, and methodology should be clearly defined (and tested) in advance of the analysis.
7) Managers and scientists must communicate iteratively and early on in the process to define management needs for decision-making. Challenges include:
    a) Clearly defining objectives for the risk assessment,
    b) Getting political support to pursue a risk assessment approach, and
    c) Making the risk assessment approach administratively achievable.
8) Scientists can improve aspects of risk assessment and risk communication.
    a) Cumulative impacts across sectors or uses can be addressed through risk assessment, but many applications to date address linear and/or additive cumulative effects. More evaluation and investigation of synergistic or antagonistic effects is necessary.
    b) Both temporal and spatial scales for risk assessment need to be explicit. The level of detail in attributes and data should also be consistent to avoid gaps in analyses or over informing the process. Approaches to reducing complexity and standardizing the information databases for analyses should be explored.
    c) Mathematical modelling is necessary to evaluate risks associated with complex interactions and responses in linked marine ecosystems and human communities.
    d) Risk assessment results can be presented to facilitate performance comparisons for alternative management strategies, and to illustrate where potentially incompatible management objectives exist.

The group also agreed that many risk assessment questions and issues would be clarified by working through an example. The afternoon working session centered on a review of DFO's recent assessment of vulnerabilities to climate change presented by Pierre Pepin, followed by an exercise where the group evaluated the risk of climate change on Gulf of Maine/Georges Bank Atlantic cod using the set of climate change processes and ecological attributes identified in the DFO climate vulnerability risk assessment for this region. In completing the exercise, the working group identified and worked through difficulties with risk assessment methodology which may be encountered within the IEA process.

Pierre Pepin presented the methodology used in the forthcoming report, "Risk-based assessment of climate change impacts and risk on the biological systems and infrastructure within Fisheries and Oceans Canada's mandate—Atlantic Large Aquatic Basin." (The final workshop report is now posted at http://www.dfo-mpo.gc.ca/science/oceanography-oceanographie/accasp/workshop-procee-science-eng.html). The process used a pathways of effects approach involving expert analysis of available scientific information on climate trends and projections and potential impacts at the ecosystem level, summarized within Risk Summary Sheets across 6 climate change related risks, followed by a group peer-review of these summaries, and a group risk evaluation using predefined criteria and a voting process. Identifying gaps in knowledge was also an important part of the assessment process. This presentation focused on risks of ecological and fisheries degradation and damage, changes in biological resources, including species reorganization and displacement, and preliminary results of the assessment. The assessment addressed climate change projections at the 10 and 50 year temporal scales, and at the full (Canadian) Atlantic Basin and regional ecosystem spatial scales. The anticipated environmental changes included warmer water, altered boundary currents, fresher water, impeded vertical mixing, lower dissolved oxygen, increased acidity, less sea ice, and increased intensity and frequency of severe weather. The attributes of concern at the ecosystem level included production, community structure, foodweb structure, species interactions, physiology, phenology, change in distribution, and habitat effects.

The WGNARS group used the environmental changes listed above to evaluate climate risks to the attributes for a single commercially important species in one regional ecosystem, using a qualitative scale and group expert opinion (Table 7.5.1). After some discussion of alternative approaches, the group simplified the ratings to evaluate whether an impact from the anticipated change on the attribute was expected (Y - yes or N - no), the direction of impact (N - negative, 0 - neutral, P - positive), the magnitude of the impact (L - low, M - moderate, H - high), and the group's confidence in the ratings (N - none, L - low, M - moderate, H - high, VH - very high). Where there was not enough knowledge among the group to make a rating based on scientific evidence, columns were left blank.

Several difficulties were encountered with applying the risk assessment framework, many of which related to lack of clarity in the ground rules for conducting the assessment. This highlights the need for thorough scoping of objectives and clearly defined methodology beforehand. The group had difficulty defining what specific risk was being assessed, and settled on "Risk to resource" which was more general than "Risk to achieving management objectives (e.g. rebuilding, fishing sustainably)". Defining the biological attributes too broadly or in too much detail also led to confusion (e.g. what do we mean by Production? Is it limited to recruitment or growth? Ultimately, it encompassed all of these processes). In working through the anticipated change/attribute pairs, it became clear that the group could only predict three cod responses to climate with any confidence (changes in physiology, phenology, and distribution). In trying to permute these changes into the larger set of attributes, the group determined that impacts of changes in community structure or predator–prey interactions would need to be evaluated through modelling exercises even to determine the direction of change; an expert opinion approach is not sufficient for this level of assessment.

It was noted that getting into too much detail on any aspect of the risk assessment would translate to an impossible task when scaled to the ecosystem level—the skill here is interpreting the science and assessing the risk defensibly, but without resorting to minutiae that could overwhelm the process. Once the group arrived at a set of agreed ground rules, filling in impacts, direction, and magnitude became easier for each change/attribute pair for cod, and confidence assignments were much easier because rationales for the previous columns had already been developed.

In a final summary discussion of the risk assessment exercise (the next morning, after the dust had settled), the group concluded that there is a clear need to produce risk assessments where existing methods are adapted for cross-sector risks and levels of organization above the single species. The working group did not have time to identify gaps in knowledge during this exercise, but agreed that this would also be an important component of IEA risk assessment. Overall, the review of the risk assessment frameworks and applications was useful, but further work is necessary to apply some of these frameworks (e.g. the Australian ERA for fisheries at the single species level as well as to habitats and communities) at the IEA scale, given the resource constraints we have. In particular, it would be helpful to seek advice from other practitioners on reducing complexity in the analysis to achieve consistent and timely results across a large matrix of ecosystem components ranging from individual species to biological and human communities and economies.

Overall, the risk analysis step in the IEA process requires significant iterative interaction between managers/policy-makers and scientists. However, this interaction can be immediately productive in building understanding of management structures and policy goals for scientists and likewise an understanding of ecosystem science for managers. Managers and policy-makers outline goals and objectives and define risk tolerance while scientists examine ecosystem and human-driven processes which support and threaten the policy goals; risk analysis then provides the framework for transparent and rigorous assessment, and the associated risk management then applies management options, actions, and audits to evaluate whether objectives are being met. This is closely related to the management strategy evaluation step of the IEA process, which WGNARS will address in future ToRs. We anticipate that further interaction between managers and scientists, which started very productively at this meeting, will be necessary both to execute the work of WGNARS and more generally to contribute to operational IEAs in the Northwest Atlantic regions.

Table 7.5.1 Results of the WGNARS climate risk assessment exercise conducted during the meeting (see text for methods and definition of abbreviations). Blank rows in the table indicate inadequate knowledge to address the impact of the anticipated change on the attribute; blank cells indicate inadequate knowledge to evaluate direction or magnitude of impacts.

REGION: GEORGES BANK / GULF OF MAINE					
Target: Groundfish	Cod for now; later add Yellowtail Flounder, Black Sea bass?				
Risk to resource					
COD					
		Y yes, N no	N negative, 0 neutral, P positive	L low, M moderate, H high	L low, M moderate, H high
Anticipated change	Attribute (subcomponents)	Impact	Direction	Magnitude	Confidence
Warmer	Production	Y	N	H	M
Warmer	Community Structure				
Warmer	Foodweb Structure	Y	P	M	L
Warmer	Species Interactions	Y			L
Warmer	Physiology	Y	N	H	H
Warmer	Phenology	Y			L
Warmer	Change in distribution	Y	N	H	H
Warmer	Habitat	Y	N	H	H
Altered boundary current	Production	Y	N	H	

Altered boundary current	Community Structure				
Altered boundary current	Foodweb Structure	Y	N	H	L
Altered boundary current	Species Interactions	Y			L
Altered boundary current	Physiology	N			L
Altered boundary current	Phenology	N			L
Altered boundary current	Change in distribution				
Altered boundary current	Habitat	Y			L
Fresher	Production				
Fresher	Community Structure				
Fresher	Foodweb Structure				
Fresher	Species Interactions				
Fresher	Physiology	N			H
Fresher	Phenology	N			H
Fresher	Change in distribution	N			H
Fresher	Habitat	N			H
Impeded vertical mixing	Production	Y	N		L
Impeded vertical mixing	Community Structure				
Impeded vertical mixing	Foodweb Structure				
Impeded vertical mixing	Species Interactions	Y	N		L
Impeded vertical mixing	Physiology	N			H
Impeded vertical mixing	Phenology	N			H
Impeded vertical mixing	Change in distribution	N			H
Impeded vertical mixing	Habitat	N			H
Lower dissolved Oxygen	Production				
Lower dissolved Oxygen	Community Structure				
Lower dissolved Oxygen	Foodweb Structure				
Lower dissolved Oxygen	Species Interactions				
Lower dissolved Oxygen	Physiology				

Lower dissolved Oxygen	Phenology			
Lower dissolved Oxygen	Change in distribution			
Lower dissolved Oxygen	Habitat			
Increased acidity	Production			
Increased acidity	Community Structure			
Increased acidity	Foodweb Structure	Y	N	L
Increased acidity	Species Interactions	Y	N	L
Increased acidity	Physiology	Y	N	L
Increased acidity	Phenology			
Increased acidity	Change in distribution			
Increased acidity	Habitat			
(I) More severe weather	Production	N		H
(I) More severe weather	Community Structure	N		H
(I) More severe weather	Foodweb Structure	N		H
(I) More severe weather	Species Interactions	N		H
(I) More severe weather	Physiology	N		H
(I) More severe weather	Phenology	N		H
(I) More severe weather	Change in distribution	N		H
(I) More severe weather	Habitat	N		M

8 Conclusions

WGNARS has made considerable progress toward developing the methodology, background knowledge, and relationships required to support IEA development in the NW Atlantic by working its way through the iterative process outlined by Levin *et al*. (2009). The background work of gathering indicator lists and integrating disciplines during the first three WGNARS meetings set the stage for the transition this year into a working format with preliminary analytical products as well as reviews or methods and lists of potential best practises for IEA component steps.

This year there was also further clarification of the role of WGNARS in regional IEA development. WGNARS has a different connection to the advice process than the other IEA-oriented expert groups within the SSGRSP, because of its regional focus on the Northwest Atlantic where fisheries and oceans management advice is provided by NOAA and DFO rather than ICES. This unique position, both outside the ICES advice structure but engaged in ICES IEA development as part of the SSGRSP, provides an opportunity to advance the group's efforts toward IEA development through uptake of methodological advances from a variety of different sources. WGNARS will work to maintain linkages with NAFO integrated management efforts and other SSGRSP regional seas groups as well as provide scientific support for US and Canadian government integrated management objectives as they develop.

Therefore, WGNARS continues to focus on developing both best practises and scientific support for IEAs at the subregional scale for Canada and the US in the NW Atlantic. It was again clear that the appropriate scale for IEAs is smaller than the WGNARS region and is best related to the ecoregions further identified at this meeting, and to existing jurisdictional boundaries.

A key aspect of WGNARS work will be the continued integration of regional managers and scientists within the working group, as was initiated in 2013. Further, the combination of scientists across disciplines ranging from physical oceanography and habitat through biology and fisheries to economics, law and social sciences will continue to be critical to achieving the goals of WGNARS. To accomplish this, the scoping work this year identified a need to develop more communication with managers, policy-makers, stakeholders and identify more effective, efficient methods for communication of ecosystem science advice. Further, there is a need for more work to develop guidelines for development of operational objectives. Strategic conservation objectives identified by different processes are generally similar, but operational objectives are dependent on the management unit and ecoregion, and economic and social objectives have received less attention than conservation objectives, but need to be explicit in order to evaluate trade-offs and state relative to targets.

Tools and products developed this year are available to all participants (i.e. list of observing assets, R code for indicator threshold analysis, methods review for risk assessment with preliminary application). In the coming years, an even more focused program will incorporate additional IEA components and contribute synthetic science within the region. The work on scoping and objectives will continue in 2014 with a review and qualitative mapping of EBM objectives in each region and the selection of a subset of example integrated management objectives to structure further WGNARS analyses. The primary work on indicators will span two years, focusing both on thresholds and indicator performance testing related to large-scale ecosystem drivers (2014) and to regional scale ecosystem responses at multiple spatial scales (2015) in the NW Atlantic. Operationalizing the selected potential integrated management objectives and outlining a range of potential alternative management strategies to achieve them, given the indicators work will also be done in 2015. These two meetings lead up to integrating all of this information in a management strategy evaluation framework in 2016, illustrating the analytical methods and potential types of advice that can arise from applying the combined aspects of the IEA framework.

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Annex 2: Agenda

ICES Working Group on the Northwest Atlantic Regional Sea Agenda

Needler Boardroom, Bedford Institute of Oceanography, Dartmouth, NS, Canada

28 January – 1 February 2013

Monday, 28 January 2013

Afternoon – Opening and Review (13:30 – 18:00)

ToR a) Continue to develop the scientific support for an integrated assessment of the Northwest Atlantic region to support ecosystem approaches to science and management.

ToR e) Review and report on the work of other integrated ecosystem assessment activities in ICES, NAFO and elsewhere.

ToR f) Identify potential regional observing assets (both inside and outside ICES) necessary to support development of regional ecosystems assessments.

Planned outcome: Report section, with components written by talk leads and context drafted by discussion leaders

Discussion led by Catherine Johnson and Sarah Gaichas

Rapporteur: Sarah Gaichas

13:30 Welcome and Introductions

13:45 Alain Vézina – Opening of the meeting

14:00 Catherine Johnson – Background of WGNARS

14:20 Steve Cadrin – Report on the Workshop on Benchmarking Integrated Ecosystem Assessments (WKBEMIA)

14:40 Rebecca Shuford / Jason Link – Update on US and Northeast IEA Activities

15:00 Kim Houston and Marc Clemens – National plan for Ecosystem Based Management in DFO

15:20 Break

15:50 Heather Breeze– Integrated Management in the DFO Maritimes and other Atlantic regions

16:10 Tana Worcester – EAM Framework for the Eastern Shore of Nova Scotia

16:30 Sara Quigley – Integrated Fisheries Management Plans in DFO

16:50 Mariano Koen-Alonso – IEA activities in the NAFO WGEAFM

17:10 Discussion of ToR f, led by Dave Hebert

17:40 Discussion of plan for days 2-4

18:00 Adjourn for Day

Tuesday, 29 January 2013

Morning – Scoping (09:00 – 12:00)

ToR b) Review and summarize previous scoping exercises in integrated ecosystem assessment or similar initiatives for management objectives and socio-economic utilities. Identify next steps for refining goals for an IEA for the Northwest Atlantic as well as for vetting core indicators with relevant stakeholders (federal and regional governments, coastal communities, fishers, etc.).

Planned outcome: Report section, with components written by talk leads and intro/conclusions drafted by discussion leaders

Discussion leaders: Patricia Pinto da Silva and Heather Breeze

Discussion topics:

-What is the most appropriate spatial scale for IEAs in the NW Atlantic?

-Are the goals identified in past scoping exercises adequate to start IEA development?

-How can tactical goals be developed from strategic goals in target regions?

-What are the next steps for refining goals for IEA in the target regions?

-How can science and management best interact to develop scoping activities?

-What are the next steps for vetting target indicators with relevant stakeholders in the target regions?

Rapporteurs: Jon Fisher and Pierre Pepin

09:00 *Review and summarize previous scoping exercises*

Talks:

-Heather Breeze: Scoping in the Eastern Scotian Shelf Integrated Management Plan

-Patricia Pinto da Silva: Northeast US EBM organizations, interactions, and progress

-Pierre Pepin: Integrating ecoregion analysis in DFO, NOAA, and NAFO

Discussion

10:30 Break

10:50 *Next steps for refining goals for an IEA*

Talks:

-Mike Fogarty to call in: Next steps for refining IEA goals in the NEUS

-Heather Breeze: Next steps for vetting core indicators with relevant stakeholders in DFO Maritimes
-Patricia Pinto da Silva: Next steps for vetting core indicators with relevant stakeholders in NOAA NEUS

DFO, discussion: Next steps for refining IEA goals in the Atlantic Canadian regions

Discussion

12:30 Lunch

<u>Afternoon - Scoping (13:30 – 17:30)</u>

13:30 *Discussion*

15:00 Break

15:20 *Discussion*

17:30 Adjourn for day

Wednesday, 30 January 2013

<u>Morning – Indicator performance (09:00 – 12:00)</u>

ToR d) Evaluate indicator performance with respect to important ecosystem drivers, emphasizing responses relative to candidate thresholds

Planned outcomes: Report section, with components contributed by talk leads and additional text drafted by discussion leaders, including simple data analysis. White paper on indicator performance testing methods with examples from this region.

Discussion leaders: Scott Large / Gavin Fay and Adam Cook

Rapporteurs: Jamie Cournane and Sarah Gaichas

Topics (See also the plan for ToR d)

-Parameters for analysis and comparison of ecosystem indicators for target regions

[agree to target regions, candidate set of available indicators (e.g. AZMP environment and lower trophic level, IndiSeas, economic), and discuss methods in advance of the meeting]

-What methods are available to evaluate indicator performance relative to ecosystem drivers?

-What is needed for next steps?

09:00 Short talks on available data products [May need to trim this to preserve working and discussion time]
Fish: Scott Large/Gavin Fay, Adam Cook, Catalina Gomez, Hugues Benoit

Environment/ lower trophic levels: Catherine Johnson, Pierre Pepin (AZMP Synthesis)

Heather Breeze: Ocean use

Blair Greenan/John Loder: NW Atlantic Climate Change Trends and Projections

Ken Frank: ICES Workshop on Ecosystem Status reporting

10:30 Break

10:50 *Discussion*

Methods to evaluate indicator performance

Strategy for afternoon session

12:30 Lunch

Afternoon - Indicator performance (13:30 – 17:30)

13:30 *Working session*

15:00 Break

15:20 *Discussion*

Next steps

17:30 Adjourn for day

Thursday, 31 January 2013

Morning – Risk Assessment (09:00 – 12:00)

ToR c) Evaluate risk of various multi-sector ocean-uses impacts facing the Northwest Atlantic to assess relative susceptibilities

Planned outcomes: Report section, with components contributed by talk leads and additional text drafted by discussion leaders. White paper reviewing risk assessment frameworks and methods with worked example(s) from this region.

Discussion topics

What methods of risk analysis are DFO and NOAA using at present?

What are the strengths and weaknesses?

How are cumulative effect incorporated?

What is required to apply risk analysis to target regions?

Discussion leaders: Jason Link, Sarah Gaichas

Rapporteurs: Kristian Curran and Robin Anderson

09:00 Talks

Roland Cormier: Ecosystem-based risk management

Sarah Gaichas/Jason Link: Risk Assessment examples

Robin Anderson: Framework for the Characterization of Risks to Key Ecosystem Components and Properties
Test case for Scotian Shelf and Eastern Shore

10:30 Break

10:50 Discussion:
What is risk? Definition.

What is risk assessment? Risk analysis? When do you use different levels of risk assessment/analysis within the IEA process?

Define and review potential frameworks, methods, and applications from other regions outside WGNARS (e.g. Australia, Alaska).

What risk assessments and or analyses have been done in the WGNARS region? Examples from Canada and the US.

12:30 Lunch

Afternoon - Risk Assessment (13:30 – 17:30)

13:30 Worked example

Proposed approach (which can be modified to reflect work done in the morning session):

Work out an example qualitative ("Level 1") risk assessment related to climate impacts on groundfish fisheries in the WGNARS regions (we selected this because it is related to previous day's work, limits our scope and potentially takes advantage of thinking already done). List system attributes, activities, and conditions leading to risk, including unknowns. Characterize risk on three axes: 1. how likely is attribute/activity/condition to occur? 2. How big an impact (ecological and or economic, can rate separately) will the attribute/activity/condition have? 3. What are the consequences of a change in the attribute/activity/condition? Rate each as low, medium, high likelihood, impact, consequences of change. This feeds back into indicators—which indicators are best suited to tell us when the system has changed? Combining just the first two axes into a plot (see attached) can help prioritize what the next steps should be both for managing the system and for increasing scientific knowledge.

The outcomes of this session could be framed as a review and worked example paper of risk assessment for an IEA. We would review the morning session as background, then show the work example(s) for a single region or several.

Future work and ToRs would attempt to expand this to more ocean uses and or drivers and across more regions, and go further into more quantitative risk assessment as IEA objectives and management thresholds are developed.

15:00 Break

15:20 Discussion

17:30 Adjourn for day

Friday, 1 February 2013

Morning – Review and wrap-up (09:00 – 12:00)

09:00 Review ToR products, continue or revise
Develop plan for follow-up and completion of report

Produce table of progress, plans, and gaps in the framework elements

10:30 Break

11:00 Review recommendations

Proposed Terms of reference for 2014-16

13:30 Final wrap-up

14:00 Adjourn meeting

Annex 3: Working group draft resolution for multi-annual ToRs (Category 2)

The **Working Group on the Northwest Atlantic Regional Sea** [WGNARS] (Co-chairs: S. Gaichas, USA; M. R. Anderson, Canada) will meet in Falmouth, MA on 3-7 February 2014.

WGNARS will report on the activities of 2014 (the first year) by 1 March 2012 to SSGRSP.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Develop the scientific support for an integrated assessment of the Northwest Atlantic region to support ecosystem approaches to science and management. Review and report on the work of other integrated ecosystem assessment activities in ICES, NAFO and elsewhere. Compile and provide guidance on best practises for each step of integrated ecosystem assessment.	a) Science Requirements: see below b) Advisory Requirements: none c) Requirements from other EGs: status updates from other groups employing IEA framework components.	1.1, 1.3, 1.4, 2.1, 2.4, 3.1, 3.2, 3.4	3 years	Summary review paper of lessons learned for IEAs in general and for each step of the process in the Northwest Atlantic using results from 2013, annual reviews of IEA activities, and ToRs b, c, d, e below (2016). Brief interim progress reports to ICES (2014, 2015).

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
b	Evaluate relationships among ecosystem level management objectives developed by past and current ecosystem based management frameworks for the NW Atlantic and identify candidate objectives for analysis.	Will employ scoping overview and qualitative mapping methods reviewed in 2013. Requires participation by managers.	3.1, 3.4	1 year (2014)	Conceptual model of relationships between current objectives, identifying which conflict. Candidate list of objectives for analysis (2014).

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
c	Identify key large-scale drivers that influence the whole NW Atlantic and how the ecosystem response varies at different spatial scales; select and vet indicators for these drivers and responses.	Will employ indicator performance testing and risk assessment methods reviewed in 2013 for both driver and response indicators. Requires participation by scientific experts in oceanography, habitat, biology, fisheries and other system uses, and socio-economics.	1.1, 1.3, 1.4, 2.1, 2.4	2 years (2014: identify drivers, vet key indicators; 2015: identify regional ecosystem responses, vet key indicators)	Short list of large-scale drivers and vetted set of indicators for changes in those drivers (2014). List of vetted indicators for key ecosytem responses at several scales (2015).

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
d	Identify alternative management strategies to achieve objectives (ToR b) based on drivers and responses at multiple scales (ToR c). Outline model requirements for management strategy evaluation.	Will review potential management tools and approaches for coordinating their use. Will operationalize ToR b objectives using indicator threshold analysis and risk analysis methods reviewed in 2013. Requires participation by managers and all scientists listed under ToR c.	3.1, 3.2	1 year (2015)	List of operational objectives, alternative management strategies, and approaches for coordinating managment for NW Atlantic systems. Description of model requirements for MSE (2015).

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
e	Evaluate ecosystem trade-offs using a range of simple management strategy evaluation (MSE) methods.	Will require regional models for capable of incorporating results of ToRs b, c, d. Requires participation by managers and all scientists listed under ToR c.	1.1, 1.3, 1.4, 2.1, 2.4, 3.1, 3.2, 3.4	1 year (2016)	Review of MSE methods available. Results of methods applied for NW Atlantic systems (2016).

Summary of the Work Plan

YEAR 1	IDENTIFY CANDIDATE ECOSYSTEM BASED MANAGEMENT OBJECTIVES AND KEY LARGE-SCALE ECOSYSTEM DRIVERS (W/VETTED INDICATORS) IN NW ATLANTIC.

Year 2	Identify key ecosystem responses to large-scale drivers at multiple scales (w/vetted indicators) and alternative management strategies based on candidate objectives (operationalized) and drivers/responses.

Year 3	Evaluate the ability of the alternative management strategies to achieve candidate operational objectives given large-scale drivers and multi-scale responses and report on trade-offs.

Supporting information

Priority	A regional approach to marine science is essential to address high priority research topics in the ICES Science Plan associated with understanding ecosystem functioning, particularly climate change processes (1.1), biodiversity (1.3) and the role of coastal-zone habitat in ecosystem dynamics (1.4), as well as understanding the interactions of human activities with ecosystems, particularly fishing (2.1) and impacts of habitat changes (2.4). Identifying potential objectives and evaluating alternative management strategies to achieve them addresses the development of options for sustainable use of ecosystems, specifically marine living resource management tools (3.1) and operational modelling combining oceanography, ecosystem, and population processes (3.2). Work identifying candidate ecosystem based management objectives and evaluating potential trade-offs through MSE contributes to socio-economic undestanding of ecosystem goods and services and forecasting the impact of human activities (3.4). Therefore, our workplan addresses all three thematic areas in the ICES Science Plan and multiple high priorities in each.
Resource requirements	Components of the integrated approach, such as ocean observation systems, ecosystem surveys, development of integrated modelling approaches and management objectives are being maintained by member countries, and the programme will coordinate and synthesize existing programmes.
Participants	The Group is normally attended by some 25-35 members and guests. However, expertise needed for each ToR differs so total participants over 3 years could be >50.
Secretariat facilities	Report preparation and dissemination
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	During the development stage, there will be no direct linkages with advisory committees, but the integrated approach is expected to eventually support advice for implementing IEAs in NW Atlantic subregions, and may link to future ICES IEA advice in other regions.
Linkages to other committees or groups	There is a close working relationship with a number of the working groups and workshops under the Steering Group on Regional Seas, such as the Workshop on Benchmarking Integrated Ecosystem Assessments, and others within ICES, such as the Working Group on Marine Systems.
Linkages to other organizations	The NAFO Ecosystem Based Management Working Group has made progress toward similar objectives and will be a resource for collaboration.

Annex 4: Recommendations

Recommendation	Addressed to
Guidance should be developed on selection of thresholds and generally operationalizing objectives for Integrated Ecosystem Assessment	SSGRSP
WGNARS should meet 3-7 February 2014 in Falmouth, MA, USA	SSGRSP
M. Robin Anderson should replace Catherine Johnson as co-chair of WGNARS	SCICOM