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

3–7 February 2014

Falmouth, MA, USA

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

The fifth meeting of the Working Group on the Northwest Atlantic Regional Sea (WGNARS), chaired by Sarah Gaichas, USA, and Robin Anderson, Canada was held at the Waquoit Bay National Estuarine Research Reserve in Falmouth, MA, USA, from 3–7 February 2014. The meeting was well-attended, with 33 participants from the US, Canada, Norway, and the ICES Secretariat. 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 were reviewed at the meeting.

In this meeting, the group maintained a working format with emphasis on group discussion, interaction, analysis, and decision-making. WGNARS aims to produce parallel products: "worked examples" of linked IEA components making best use of the collective expertise in the group (primarily natural and social sciences and fisheries/ocean management), and more general scientific advice on the process for operational IEA implementation in the Northwest Atlantic. 2014 sessions were designed around two main theme areas: (1) ecosystem based management objectives and (2) large-scale ecosystem drivers and multiscale ecosystem responses. Working session goals were (1) review of existing ecosystem-based management objectives, discussion of processes for operationalizing these objectives, and selection of biological and socio-economic objectives for use throughout IEA "worked example" analyses, and (2) review of existing science on large-scale biophysical and anthropogenic drivers in the NW Atlantic Regional Sea, selection of key large-scale drivers to focus IEA "worked example" analyses, and selection and vetting of indicators to represent these processes in analysis.

The group made progress on identifying and operationalizing management objectives for a "worked example" IEA analysis for the Northwest Atlantic Regional Sea. Many objectives have been identified by various entities, but nearly all are high level aspirational objectives rather than operational objectives which can be directly incorporated within an IEA. The group began a process of translating example objectives into specific, measurable, achievable, relevant, and time-bound (SMART) operational objectives. However, time was inadequate to complete this task, in particular for socio-economic objectives, so work on these objectives will continue between the 2014 and 2015 meetings.

The group also made progress on identifying key biophysical drivers and anthropogenic interactions in the region, and identified two specific ecoregions to be compared within the Northwest Atlantic Regional Sea: the Georges Bank/Gulf of Maine ecoregion and the Grand Banks ecoregion. Bottom water temperature, surface water temperature, sea ice cover and timing, freshwater input, stratification and salinity were identified as key large-scale biophysical drivers. Fishing and energy development and/or exploitation were identified as the major large-scale anthropogenic interactions. The temporal scale for analysis will be the management-relevant time horizon of annual to decadal. Work on compiling and vetting indicator time-series for these large-scale drivers and interactions will continue between the 2014 and 2015 meetings.

WGNARS outlined a set of peer-reviewed articles addressing the two theme areas for 2014, and identified authors responsible for contributing to each. Work from 2014 informs further work planned for 2015 and 2016, with operationalized objectives, proposed alternative management strategies, and a set of vetted driver and response indicators ultimately being incorporated within an ecosystem-level management strategy evaluation.

1 Opening of the meeting

The ICES Working Group on the Northwest Atlantic Regional Sea (WGNARS) returned to the Waquoit Bay National Estuarine Research Reserve (WBNERR) in Falmouth, MA, USA for its 2014 meeting. Fred Serchuk, in his capacity as a USA Delegate to ICES and as an ICES Vice-President, welcomed the participants to the WGNARS meeting. As a WGNARS member himself, he looked forward to working with the group in successfully addressing the ToRs at this year's meeting. Fred subsequently gave a brief PowerPoint presentation on the new ICES Strategic Plan (2014–2018). He highlighted that the Plan commits to building a foundation of science around one key challenge, integrated ecosystem understanding, and that the development of integrated ecosystem assessments in regional seas is the fundamental link between ecosystem science and the advice required in applying the ecosystem approach. Hence, the work of WGNARS is critical to achieving these aspirations.

2 Adoption of the agenda

The 2014 Agenda was developed to address a subset of the three-year Terms of Reference (ToRs) for 2014–2016 developed by the WGNARS chairs in 2013. 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 the new ICES strategic plan, previous work by WGNARS and updates from the other Regional Seas WGs, 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 two main theme areas of the meeting were drawn from elements of the Levin *et al*. (2009) Integrated Ecosystem Assessment framework and included (1) review of existing ecosystem-based management objectives and selection of biological and socio-economic objectives for use in IEA "worked example" analyses, and (2) review of existing science on large-scale biophysical and anthropogenic drivers in the NW Atlantic Regional Seas, selection of drivers to focus IEA "worked example" analyses, and selection and vetting of indicators to represent these processes in analysis.

3 Introduction: Review of integrated ecosystem assessment activities in ICES, NAFO, DFO, and NOAA (ToR a)

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 the new ICES strategic plan, WGNARS own past work, and updates on IEA/EAM related work in ICES, NAFO, DFO, and NOAA.

ICES Strategic Plan (Fred Serchuk)

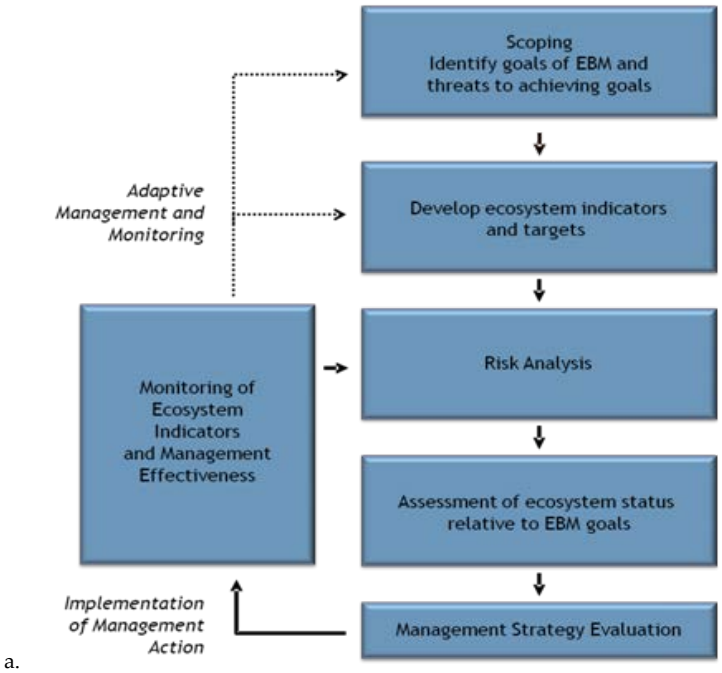
Fred gave a brief PowerPoint presentation on the new ICES Strategic Plan (2014–2018). He highlighted that the Plan commits to building a foundation of science around one key challenge, integrated ecosystem understanding, and that the development of integrated ecosystem assessments in regional seas is the fundamental link between ecosystem science and the advice required in applying the ecosystem approach. Hence, the work of WGNARS was critical to achieving these aspirations.

WGNARS background and overview of 2014–2016 ToRs (Sarah Gaichas)

Sarah briefly presented the topics of and results from past WGNARS meetings and the 2014–2016 ToRs. The Levin *et al*. (2009) IEA framework (Figure 1a) has structured the work of the group since the initial meeting in 2010. Visualization of the IEA framework has evolved since then (Figure 1b), but its components remain the same. Considerable work has already been done compiling and reviewing ecosystem indicators across the themes of climate, biodiversity and habitat. Social sciences were integrated within the group early on, and the group continues to work on more fully integrated ecological and human dimensions in IEAs, as well as improved integration of natural science, social science, and management expertise within the group. Issues of spatial scale have been important since the beginning because the Northwest Atlantic Regional Sea encompasses a variety of diverse ecoregions across a wide range of latitudes, physical oceanographic regimes, and habitats, as well as multiple administrative and management jurisdictions and boundaries.

In 2013, WGNARS transitioned to a working format with longer (5 day) meetings focused on reviewing IEA component methods and applying them to test cases in the region. 2013 sessions on IEA scoping, ecosystem indicator thresholds and performance testing, and risk analysis led to related peer-reviewed publications and established the context for development of three-year (2014–2016) ToRs (Annex 3). The 2014–2016 ToRs build upon the previous work to address linked IEA components including assessment of ecosystem status relative to EBM goals and management strategy evaluation. The ToRs for 2014, meeting workplan, and expected deliverables were reviewed with the group in the context of the full set of ToRs and the three year workplan. Ultimately, WGNARS plans to continue to develop parallel products: (1)

"worked examples" of linked IEA components, and (2) advice on developing processes for operational IEA implementation emphasizing the need for iteration between science, policy, and management.



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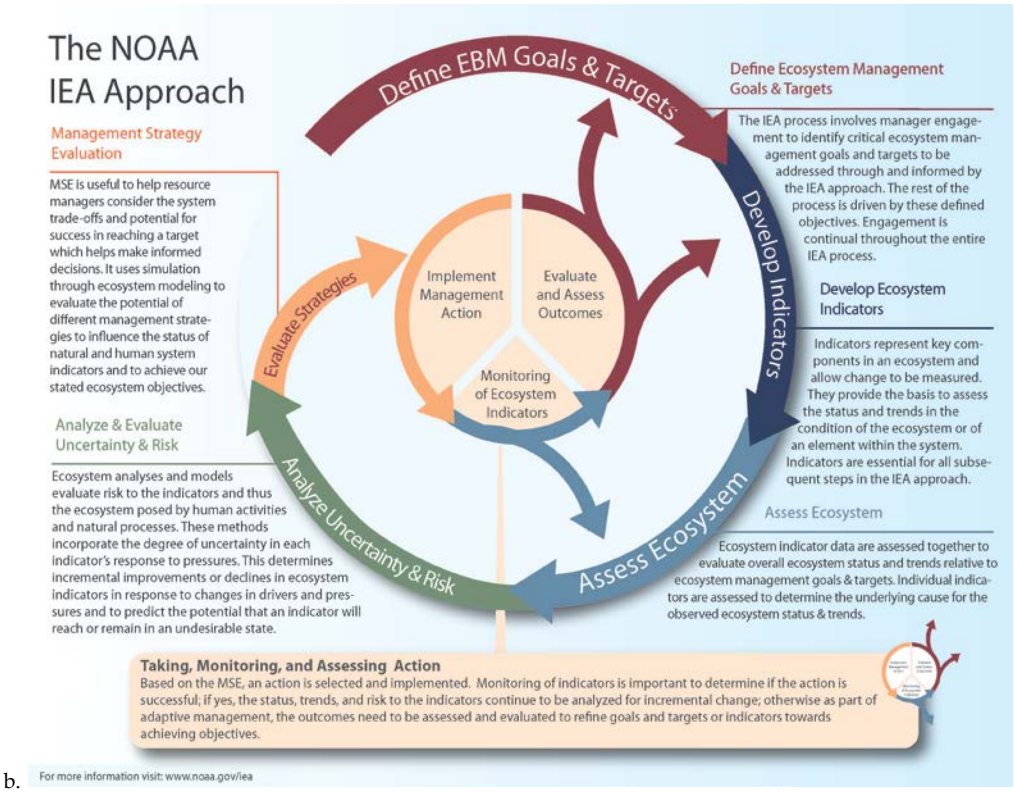

b.

Figure 1. Visualizing IEAs. a. Levin *et al.* (2009) b. Refined IEA representation.

NOAA Integrated Ecosystem Assessment Program: 2014 Update (Rebecca Shuford)

NOAA's Integrated Ecosystem Assessment (IEA) program (www.noaa.gov/iea) continues to make progress in all 5 regions where it is currently being implemented (i.e. California Current, Gulf of Mexico, Northeast Shelf, Alaska Complex, and Pacific Islands).

Following is a brief summary of four selected examples of work being done within the IEA context for "science to support management" objectives.

Humpback Whale National Marine Sanctuary – Cetacean Habitat Mapping, Kona, HI: Research is underway on three species of cetaceans to assess relationships between population densities and environmental variables. Species-specific models are being developed to allow managers the ability to forecast seasonal areas of maximum probability of presence. The capacity to predict this probability can greatly assist in designating critical habitat during the ESA process.

Assessing potential conflicts with wave energy generation along the Oregon coast: Researchers in the California Current IEA have done a demonstration analysis on wave energy and how it might conflict with other existing activities. While waves can provide a source of clean and renewable energy, wave energy facilities could hinder fishing opportunities, supplant recreational activities, diminish aesthetic views, and create navigational hazards. The results of the analysis demonstrate how potential conflicts with existing marine uses can be identified. Simple spatial representations can present planners with a screening tool, identifying areas where a more refined investigation is worthwhile.

Management Strategies for a changing climate, Alaska: One of the NPFMC priority objectives is to incorporate and monitor effects of climate change on Bering Sea and Aleutian Islands marine ecosystems and their dependent fisheries. IEA scientists are using multispecies foodweb and assessment models to link changes in the physical environment and foodweb to recruitment and survival and help distinguish fishery impacts from large-scale climate pressures. Results of model simulations have helped IEA scientists understand and predict how future climate driven changes to the system may impact predation and fishery harvest limits.

PSE model and risk assessment: The Gulf of Mexico IEA has developed a network model that quantifies the linkage between pressures, states, and ecosystem services. This model allows managers to account for the trade-offs essential in decision-making that incorporates the 3 major Gulf of Mexico marine industries – Commercial and recreational fishing, tourism, and oil/gas. The model can also be used in scenario analysis to determine the effect of potential management actions on the production of ecosystem services.

Additionally, the NOAA IEA program has recently developed a 3-year plan (FY2014–2016) to set some key priorities and guide our regionally implemented national program. There are four pillars that underpin the plan, and four main goals (each with several objectives, not listed here):

Four Pillars of the Plan:

Science Research and Development: Includes, but not limited to, the science behind IEA products. May include methodologies, indicators, risk assessments, models, and other products developed and used during each IEA process.

Transferring Scientific Knowledge to Management: Also defined as Decision-Support, includes engagement with management partners to assist in identification of management objectives; conversion of science to products useful for management purposes;

converting science into management action; Management Strategy Evaluations (MSE), and other steps.

Communication: Results in effective communication through outreach and collaboration with stakeholders; development of products that convey scientific findings on the health of marine, coastal, estuarine, and Great Lakes ecosystems in an open and transparent format on a regular basis; and provision of timely and sound scientific advice to managers and the general public.

Evaluation: Provides information on how effectively science-based decision-support has been provided and used by management during the IEA process. Can include steps such as gap analysis, which identifies what we are missing in the process to help improve decision-support (center section of the IEA loop). Can also identify lessons learned during the process, which will be used to inform next steps and future strategic planning efforts.

Four Main Priorities (Goals) of the Plan:

- More fully implement IEA in at least one additional US LME
- Identify methodology to develop *reference points*
- Develop framework to fully incorporate human dimensions
- Ensure climate-change is being appropriately incorporated

Northeast US IEA activities update (Mike Fogarty)

Within a broad ecosystem services framework this group is working to document threats and impacts to sustainable ecosystem services. This includes modelling in support of EBM (and fisheries EBM) using many modelling approaches as these need to be tailored to the needs of decision-makers. Model categories include contextual models, assessment models, forecasting models, operating models. Products include an ecosystem advisory report and an ecosystem status report.

Canadian IEA activities update (contributions from Catherine Johnson, Heather Breeze, Sara Quigley, Alida Bundy, and Robin Anderson)

Various DFO sectors have undertaken activities contributing to development of IEAs and Integrated Oceans Management (IOM) in the past several years, but coordination among these activities and implementation of the results have not always occurred. There may be opportunities for enhanced coordination of IOM and IEA following the departmental reorganization that is underway. At the national level, policy for Arctic EAM is under development for the Arctic Council, and the Arctic Council's Ecosystem Approach Expert Group has plans for work to resolve data issues, to compile strategic ecosystem objectives and species and habitat management strategies, develop pilot programs in the Arctic LMEs, and coordinate of EAM in the Arctic and with other DFO regions.

Substantial guidance for working through various elements of the Levin *et al.*, 2009 framework has been developed by the DFO Oceans and Science branches and is documented in DFO reports and publications. In addition, EAM Working Groups have been set up in both at the national level and the Maritimes region, although their work is currently on hold during the departmental reorganization. In the DFO Maritimes region, an Ecosystem Assessment team has been formed in the Science Branch, and work is underway to mobilize support for the team. The Maritimes region Ecosystem Management branch plans to use large marine ecosystems (LMEs) as the relevant scale for implementation of integrated management (IM). Their current focus is on developing

profiles of Ecologically or Biologically Sensitive Areas (EBSAs) with priority determined by level of human activity. Investigators supported by two DFO internal funding pools, the Aquatic Climate Change Adaptation Services Program (ACCASP) and the Strategic Program for Ecosystem-Based Research and Advice (SPERA) have undertaken projects relevant to IEA, including evaluation of integrated ecosystem status, trends and assessment and development of tools to identify which stocks are most vulnerable to climate change. However, the total funding to these programs is limited and must serve the entire country, and therefore most funding has gone to urgent issues rather than strategic needs. Policy and management challenges remain to address even well documented ecosystem-level issues such as the need for management tools to address multispecies fisheries interactions.

DFO SPERA process and NAFO IEA activities update (Mariano Koen-Alonso, chair NAFO WGESA)

The Northwest Atlantic Fisheries Organization (NAFO) is committed 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.

As part of this process, the "Roadmap for developing an Ecosystem Approach to Fisheries for NAFO" (hereafter referred as "Roadmap") was initially conceived in 2010 as a conceptual foundation from where NAFO Scientific Council (SC) could discuss and propose a way forward for an ecosystem approach to fisheries for NAFO. Since then it has served as the organizing framework that SC in particular, and NAFO in general, are following to develop an Ecosystem Approach to Fisheries (EAF) for the organization. The Roadmap is not a fixed plan; as its name indicates, it is a guiding set of ideas whose details evolve as it is developed and implemented.

The Roadmap was originally developed around the concept of Integrated Ecosystem Assessments (IEA), 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.

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 assessments 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 allows considering the sustainability of the exploitation at the ecosystem, multispecies assemblage, and single-stock level.

The current representation of the Roadmap (Figure 2) provides an operational perspective of how the EAF could be implemented in a possible work-flow process. This schematic incorporates the hierarchical approach to define exploitation rates, and

integrates the impacts on benthic communities (e.g. Vulnerable Marine Ecosystems – VMEs-) associated with the different fisheries that take place within the ecosystem.

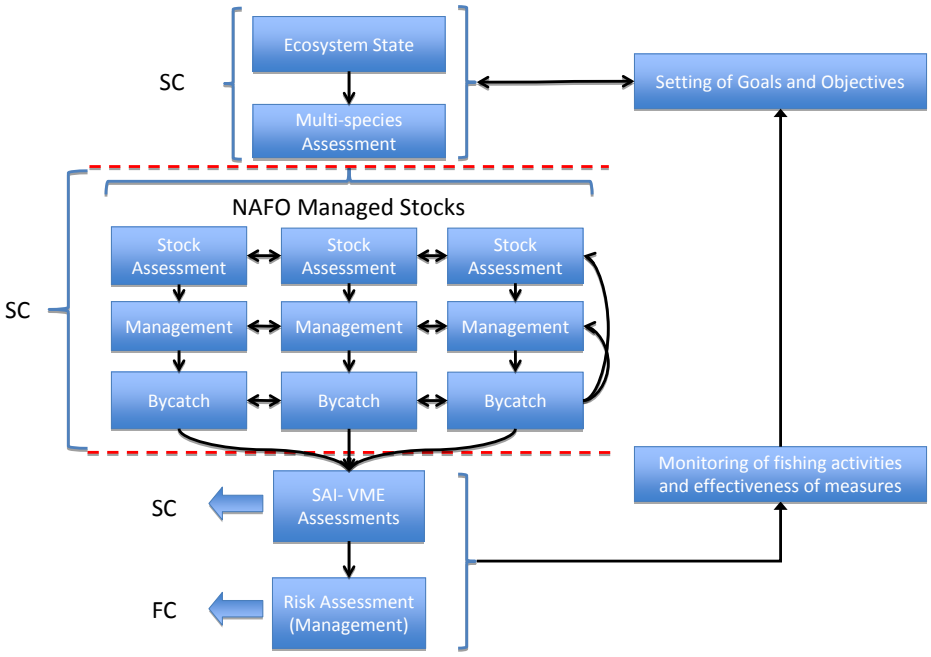

Figure 2. Current working template of the NAFO "Roadmap".

In the context of the Roadmap (Figure 2), NAFO SC explicitly identified the need for developing more specific/functional connections and collaborations with ICES WGNARS on, but not limited to:

- Ecosystem State (Tier 1)
  - defining spatial management units
  - exploring temporal variability of units
  - defining productivity state and its variability
- Multispecies assessment (Tier 2)
  - description of species interactions and trends
  - quantification of diets and predation
  - understanding the role of environmental drivers in ecosystem structure and dynamics
  - understanding the response of foodwebs to anthropogenic impacts
  - definition of multispecies reference points
  - provision of advice on candidate TAC based on multispecies considerations

During 2013 NAFO has also formalized the creation of two joint Fisheries Commission-Scientific Council working groups on Risk-Based Management Strategies (FC-SC WGRMS) and Ecosystem Approach Framework to Fisheries Management (FC-SC

WGEAFFM). FC-SC WGRMS will be focused on the development and effective implementation of management strategies, based on the application of the precautionary approach, including conservation plans and rebuilding strategies, and to facilitate dialogue between SC and FC. FC-SC WGEAFFM will be focused on making recommendations to the FC and feedback to SC on the development and effective implementation of ecosystems approaches to fisheries management. To prevent confusions with the recently created joint WG, the SC Working Group on Ecosystem Approaches to Fisheries Management was renamed as SC Working Group on Ecosystem Science and Advice (WGESA), but its role within SC remained unchanged.

ICES Regional Seas Groups update (Mark Dickey-Collas)

Mark provided an overview of Integrated Assessment in ICES. This is the provision of joined up advice to address society's needs to manage anthropogenic pressures on the ecosystem. It requires exploration of the space available for decision-making and that advice must be consistent across issues. 3 of 7 goals in ICES Strategic Plan specific to integrated understanding (these three are the most important). There are 6 Regional Seas working groups each with its own approach (this is good). Some provide input vis-à-vis EU Marine Framework Directive. Most objectives are at a high level to be populated by science. For example: Evaluate top pressures for 5 regional seas based on national reports. Management objectives include those society may choose objectives that are difficult to justify by science. They provide a target and allow a dialogue regarding trade-offs. The process requires integration of mixed evidence and objectives. IEA requires a participatory process to build useful tools and protocols. ICES will complete 3–4 IEAs and this will be an iterative and continually improving process.

4 Working session on Management Objectives (ToR b)

Work under this ToR was structured into a morning presentation and discussion session and an afternoon working session.

Morning Session

- What ocean related conservation, management, social, and economic objectives have been identified in the WGNARS region?
- How are these objectives related to each other? Can we identify whether or where they conflict?

Afternoon Session

- Can we reshape these conservation, social, and economic objectives into ecosystem-based management objectives, if they are not already stated as such? (In our report, can we identify a process for downscaling the high level objectives we may have from national and international law and even from national and regional policy to more tangible objectives for the ecoregions that are to be managed? Who would be involved in developing such a process? Science only, or a multi-sector group?)
- From the compiled lists and analysis of relationships and our discussions, identify a set of objectives for WGNARS to work from. We want a short list of clearly described ecosystem-based objectives which we will evaluate using indicators and performance thresholds selected and developed under ToRs c) and d). The ecoregion-level objectives should be Specific, Measureable, Achievable, Relevant, and Time-bound (SMART).

During the morning session, Heather Breeze and Patricia Pinto da Silva reviewed extensive lists of ocean management objectives that have been identified for various sectors and localities in the WGNARS region. Cross-sector ocean management objectives have been outlined in both Canada (the Eastern Scotian Shelf Integrated Ocean Management Plan, ESSIM, and for the Grand Banks region of the Placentia Bay Grand Banks Integrated Ocean Management Plan (Park *et al.*, 2011; DFO, 2007; DFO, 2012)) and in the US (the Northeast Regional Ocean Planning Body (NROPB 2014)). Fisheries sector objectives are also available for both Canada and the US from both national legislation and regional governance groups. Many of the objectives are similar across plans, and are best characterized as aspirational, high-level objectives, rather than operational objectives. It was therefore difficult to envision how many of these ocean management objectives as stated would relate to "on the ground" management in a particular ecoregion or local jurisdiction, and therefore how they might be analysed within an IEA. After considerable discussion, the group agreed on the following points:

1) Operational (SMART) ocean or ecosystem management objectives need to be clearly defined in an inherently political and interactive process including diverse stakeholders, managers, policy-makers, and scientists. As a primarily scientific working group, WGNARS will not define actual operational management objectives for IEA, and is not the appropriate group to lead such a process.

2) To implement IEAs in specific ecoregions in the WGNARS area, a well-defined process to engage stakeholders, manage conflicts, and facilitate ecosystem-based management in defined geographic regions would be essential to determine the actual operational management objectives. (This echoes a recommendation from the 2013 meeting's session on scoping). Multiple existing regional planning bodies and integrated management initiatives have initiated this work, so it may be a matter of WGNARS members becoming more "embedded" in existing processes. WGNARS could add value to these processes by further clarifying operational objectives, and examining alternative management strategies and tools to achieve them in an IEA context.

3) Ultimately, we aim to demonstrate how we would do the IEA analysis given the explicit objectives provided through a client stakeholder consultation process. Lacking these explicit objectives at present, in order for WGNARS to move forward in providing a "worked example" of an IEA, we propose to translate a subset of existing, high-level ocean management objectives into SMART operational objectives to be carried through the IEA steps. We will translate a small set of both socio-economic and biological/ecological objectives to demonstrate how they are related and where potential conflicts may arise. We will document our translation process in order to provide one example of developing operational objectives for IEAs. One potential benefit of the "worked example" approach is that it may provide a roadmap for regional planning bodies to consider in future efforts.

During the afternoon session (and in a follow-up session the following afternoon) the group reviewed the most specific sets of ocean management objectives available (from ESSIM) to select a subset for further translation into SMART operational objectives. Working with the socio-economic objectives outlined in ESSIM was particularly difficult as they were extremely general. In addition, we noted that scientists may not agree with some objectives identified by stakeholders, making discussion difficult, but stake-

holder processes were set up to reflect societal values rather than purely scientific values. Eventually, the group proposed a more specific socio-economic objective which combined several of the ESSIM objectives. A task group has been assigned to derive SMART operational objectives from this overarching human dimensions objective prior to the 2015 meeting:

Optimize the flow of benefits generated from ocean resources, for both producers and consumers, given the other objectives.

Further reshaping of this objective may be necessary if parallel structure with the other objectives is desirable. We will illustrate this process within the task group. It was noted by group's members with experience in stakeholder and management processes that operational objective-setting has been portrayed as a much more linear process than it actually is in "real life". Often multiple iterations are necessary as people work out what the objectives actually mean in implementation. This is why objectives will be revisited under ToR d) in 2015.

The group found the biological/ecological (or conservation) objectives listed in ESSIM considerably easier to translate, perhaps because they were phrased more specifically, and the group is more experienced with biologically based management objectives for fisheries. After some discussion of the full list, the group selected the following set of linked objectives:

Biomass and productivity of harvested and other species are healthy. Trophic structure is healthy, and habitat integrity is conserved.

The work of translating these overarching objectives into SMART operational objectives involved first addressing the terms "healthy" and "integrity." While most work on this translation will also be finished by a dedicated task group prior to the 2015 meeting, the group suggested the following starting points:

Biomass and productivity of harvested and other species are healthy: Maintain all stocks above a (dynamic) minimum biomass threshold. Establish and maintain a (dynamic) cap on total anthropogenic removals. Dynamic properties of these thresholds and removal limits should be determined by environmental conditions. An alternative would be to ensure that anthropogenic pressures do not drive biomass and productivity outside historical limits.

It is clear that further specification is necessary. For example, to ensure that anthropogenic pressures do not drive biomass and productivity outside historical limits, we must specify biomass and productivity of what? What is the historical range, and what is the relationship between anthropogenic pressures and biomass/productivity? To apply minimum biomass thresholds to aggregate groups, it is necessary to specify who is in the aggregate, what is the aggregate biomass / how is it measured, what is the threshold and how is it measured, what is the threshold in response to dominant environmental pressures, and what are the dominant environmental pressures? By outlining these questions, the task group will be able to further specify the objectives, documenting the process to illustrate one way to go about developing SMART operational objectives from overarching goal statements. A practical advantage of this process is that it specifies and justifies the knowledge gaps that must be filled; it is not simply an interesting academic question.

Similarly, two task groups were formed to address the trophic and habitat portions of the overarching objective prior to the 2015 meeting. During the meeting, the full working group suggested the following triggers for specifying trophic and habitat objectives:

Maintain habitat integrity: Benthic, pelagic, and acoustic habitat is not unacceptably damaged by human activities. Influence of environmental variation on habitat is considered in management.

Trophic structure is healthy: Trophic structure is not unacceptably damaged. Energy pathways are maintained within historical limits. Manage forage fish to support trophic structure. Exploitation scheme is consistent with fundamental trophic, size, and demographic structure and life histories.

A paper summarizing the process for operationalizing these selected example ecosystem based management objectives was outlined on the final day of the meeting and will report on the work of the three task groups, once completed.

5 Working session on Large-scale Drivers and Indicators (ToR c)

Work under this ToR was structured into a two day session with morning presentation and discussion sessions and afternoon working sessions. Discussion topics and tasks included:

1) Discussion
   a) What is the most effective product that WGNARS can produce on this topic? Take advantage of our interdisciplinary group, including oceanographers, social scientists, and managers. Develop consistent terminology (e.g. DPSIR).
   b) How will the large-scale drivers be linked to risks to achieving ecosystem management objectives? Could this go beyond fisheries?
   c) How can we incorporate the idea of interaction of processes across scales (e.g. the response to climate variability might look different at the mesoscale than macroscale)?
   d) How have the other regional seas program working groups integrated this information?
   e) What would be the best strategy for developing a publication initiated through the two days of work at the meeting?
2) Compile and review a list of key large-scale drivers for the full WGNARS region
3) Select a short list of key drivers as a group during a working session
4) Identify a set of indicators for each key driver
5) Apply the methods demonstrated last year (or propose new methods) to test the performance of these indicators so that our final set has been scientifically vetted.
6) Discussion
   a) Can we standardize indicators across the WGNARS region?
   b) How will we address multiscale responses with indicators?
   c) In 2015, we continue ToR c) to examine multiscale responses to the large-scale drivers we identify this year. The drivers we identify and corresponding indicators that we test and vet in 2014 will also be used in analyses under ToRs d) and e) in 2015–2016.

The group first discussed general products from WGNARS. We agreed that a sample exercise working through an IEA approach would be useful throughout the region to serve as a starting point for planning bodies considering IEA as a tool for implementing ecosystem-based management. We discussed specific products related to both ToRs b) and c), and concluded that as a scientific group our most effective product was a series of peer-reviewed scientific papers. However, these papers would include a "lay summary" that described the main points for a general audience. This summary would then be available to groups involved in ocean resource and industry sector management and those considering integrated management approaches. Some WGNARS members are involved with ocean management groups within the WGNARS ecoregions, so these members could transmit the summaries to those groups. In addition, ICES may use Twitter and NOAA may use other forms of social media to distribute work to a wider audience.

An initial decision made by the working group was the scale for IEA analysis. The ecoregion scale was considered most appropriate for the worked example IEA component analyses. Further, the examples will be applied in a subset of the ecoregions so that the group may focus its limited resources and take advantage of access to available information. After reviewing work on defining ecoregions that had been presented at the WGNARS meeting in 2013 (Figure 3), the group selected two specific ecoregions to be compared within the Northwest Atlantic Regional Sea: the Georges Bank/Gulf of Maine ecoregion and the Grand Banks ecoregion. These regions were selected to compare US and Canadian national jurisdictions, contrasting human uses and physical drivers, and a range of data availability.

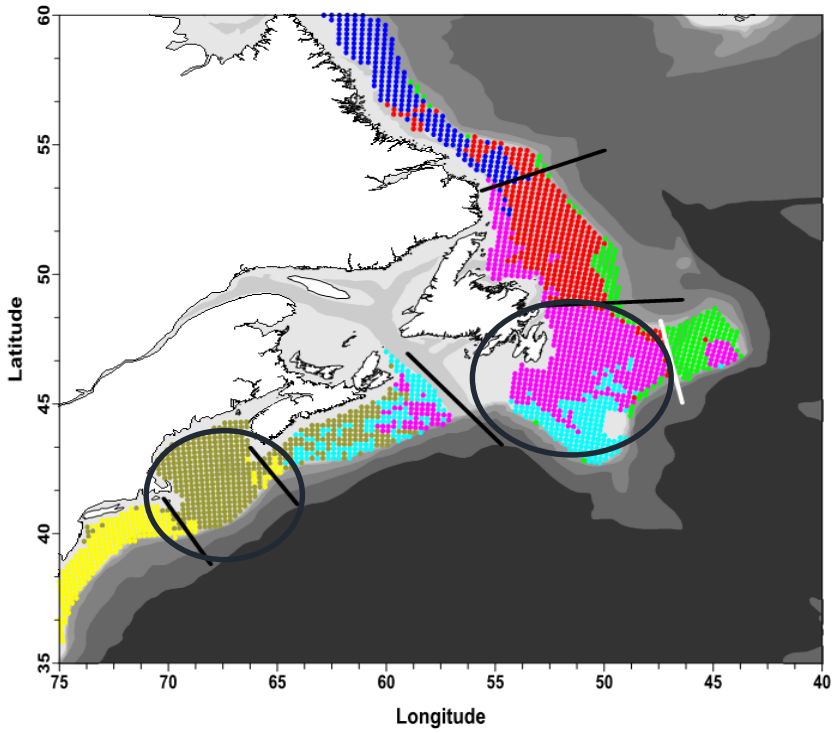

Figure 3. Ecoregions selected (circled) for comparative IEA worked examples.

Another important decision made by the group is that our worked example analyses should consider multi-sector human interactions with the ocean. Our IEA analyses will explicitly consider both fisheries in a multispecies context and energy development and/or exploitation in both of the identified ecoregions. In addition to long-standing

and culturally important multispecies fisheries in the selected ecoregions, an oil and gas industry already exists on the Grand Banks, and both wind and tidal energy projects are in development in the Georges Bank/Gulf of Maine ecoregion. WGNARS members are reasonably well connected with fisheries science and management, but the group recognized that additional representatives from the energy sector will need to be included as invited experts in task groups between meetings and in upcoming working group meetings to enhance the planned multi-sector IEA examples.

The working group then reviewed large-scale drivers in the WGNARS area (many of which had been presented at previous working group meetings). Catherine Johnson presented time-series of physical data for all WGNARS regions spanning 50+ years (DFO, 2013). Despite the strong interdecadal variability across the area in many physical parameters, the time-series also clearly showed an extreme warm event in 2012 throughout the region. Historical trends and projections for air temperature, run-off, sea ice, SST, and salinity are available throughout the region and are displaying impacts of climate change, including increased air and water temperatures and decreased salinity. These current and projected trends in physical pressures were identified in the 2013 WGNARS meeting and were used in a risk assessment exercise, which was later extended to a publication for the northeast US portion of the WGNARS region (Gaichas *et al.*, in press). Catherine noted that further analysis of the extreme warm event in 2012 appeared to be driven by local warming, the NAO, recent history and horizontal advection. Smaller cell sizes in phytoplankton were observed, as were changes in zooplankton. The warm conditions were unfavourable for cold-adapted calanoid copepods, an important forage species for some fish and marine mammals.

The group discussed the observed interdecadal variability and noted the difference between this and the temporal scale of the 2012 warming event—how would we deal with this difference in temporal scale within an IEA analysis? It was suggested that we could try to bracket the likely variability at a management-relevant time-scale, which would be annual to decadal, rather than interdecadal: therefore, analysis of extreme events would be important but evaluating the likelihood of an extreme event over the management time horizon would also be important. It is also important to evaluate multiple environmental drivers because their importance has changed over time—would we be able to demonstrate this in our example analyses? Could we predict whether managers could generally expect stability or change, given current and projected conditions? We also discussed which elements of the system would be most important to focus on for responses: communities, functional groups, and individual species? The level of focus may determine which drivers we focus on. It was noted that further information on physical pressures, system state and response variables could be gleaned from state of the system reports for the Canadian regions (http://coinatlantic.ca/index.php/state-of-the-scotian-shelf; http://www.gulfofmaine.org/2/resources/state-of-the-gulf-of-maine-report/), and the Ecosystem Status Report (ESR) for the US (http://www.nefsc.noaa.gov/publications/crd/crd1207/crd1207.pdf).

Several more presentations reviewed some potential indicators relevant to the large-scale drivers and physical pressures that Catherine presented. Jon Fisher presented a "scope for growth" indicator combining several variables to define habitat quality in space and time. The variables include chlorophyll, temperature, temperature variability, oxygen, and a measure of disturbance, which indicate potential for biomass distribution and changes in this distribution over time. This indicator nicely illustrates the complexity of habitat for marine species and includes mechanisms for changes in distribution that may be driven by climate variability or anthropogenic effects. The group discussed how to address uncertainty in the indicator to determine when to call a shift

in the annual average of the index meaningful for analysis, and also discussed overlaying actual measurements of fish distribution with the index. It was suggested that this indicator might be effectively incorporated into stock assessments for individual species to affect fishery management advice.

Nancy Shackell and Phil Greyson contributed (highly) preliminary work presented by Catherine Johnson examining the distribution of fish in warm and cool conditions throughout the WGNARS region. They examined metrics to analyse movement of populations in response to these conditions, but found even including years with temperature extremes that 4 major fish species had little change in population centroids. The working group discussed what type of change we might expect to see in systems characterized by high variability—could we characterize that in an IEA context and then evaluate whether we would expect a change outside observed conditions given projected conditions? Alternatively, could we estimate how much environmental variability would be required to see a substantial change in distributions, and in which ecoregions? And would other metrics be more sensitive?

Day one discussions for ToR c) culminated in selection of a short list of physical drivers/pressures: Bottom water temperature, surface water temperature, sea ice timing and cover, and freshwater input/stratification/salinity. Taken together, these describe the major physical habitat conditions changing over management-relevant time-scales via the large-scale system drivers (NAO, global climate, etc.). These conditions in turn directly affect biota, and these effects are important to achieving socio-economic and conservation objectives. In all cases, changes in these physical pressures will need to be put in the context of the characteristic (high) temporal and spatial variability of WGNARS ecoregions. Therefore, beginning the IEA analyses in the 1950s where the data support it would help capture the observed range of variability. Some important indices may not have long time-series, such as pH, but could be monitored within the IEA for threshold effects or tipping points. The group discussed evaluating tipping points in other physical pressures such as Gulf of St Lawrence oxygen, cold water from the Labrador shelf, and oxygen, which has a clear threshold effect with respect to survival and distribution of marine biota. Work on indicator thresholds was presented in 2013 by Scott Large, with his recent publications on the topic briefly reviewed at this meeting (Large *et al*., 2013, Fay *et al*., 2013). In particular, the multivariate thresholds may be useful for identifying relevant thresholds in selected physical pressure indicators and response variables to be determined prior to and at the 2015 meeting.

Day two working group discussions focused on identifying indicators related to the large-scale drivers (physical pressures and anthropogenic activities—fishing and energy) and evaluating the relevance and performance of these indicators. The task was to outline consistent methods for use between meetings. The group first asked whether the selected physical pressures would accurately represent biologically relevant changes in the selected WGNARS ecoregions, and then whether there were adequate indicator time-series to represent changes in the physical pressures. The main questions were whether combination of SST and bottom temperature gave enough information on temperature conditions, and whether salinity, freshwater inflow and stratification (as well as sea ice timing and extent in higher latitude ecoregions) gave enough information on water column structure to predict impacts on biota. Further, would these represent basin scale processes adequately? Is there enough mechanistic understanding of the system to predict temperature changes or changes in water column structure (over the annual-decadal time-scale) based on other large-scale drivers such as NAO or Labrador Current conditions?

Paula Fratantoni and invited experts Mike McCartney and Ke Chen addressed some of the questions on predictability of physical pressures from large-scale drivers. Some of the influences of NAO on boundary currents and of boundary currents on physical habitat characteristics (temperature, salinity) are known, but the mechanistic knowledge is not perfect. Relationships that have been observed can break down. However, Kevin Friedland pointed out that forecasts 9 months out are being developed by NOAA, and could be included in IEA analyses for some ecoregions. If the group can focus on ranges of water column properties that are most relevant to system productivity, distribution of biomass and key species, etc., these wider ranges or changes between key ranges of combined temperature/salinity conditions may be more feasible to predict and management relevant than precise temperatures or salinities at a given time or location.

Discussion next focused on evaluating indicators for use in IEAs. Mark Dickey-Collas highlighted the indicator evaluation criteria used by ICES for advice to HELCOM and OSPAR (ICES, 2013), which was well-received by client groups. There are 16 criteria summarizing indicator type, 5 aspects of data quality, 6 aspects of adequacy for management, 3 conceptual qualities, and evaluating correlation between indicators for indicator suites. The group worked though a brief example evaluation applying the criteria for the US bottom water temperature index.

Bottom water temperature is a pressure indicator (therefore scoring 0 by default for several criteria; however, we intend to use it to indicate the pressure rather than the state (in response to pressure) of the system). The bottom temperature indicator data are supported by an ongoing monitoring program (ECOMON) using consistent protocols accounting for spatial and temporal heterogeneity. Water temperature is easily and accurately determined with high signal to noise, and is quantitatively measured and appropriately aggregated into time-series from multiple annual measurements. Measurements come from throughout the US ecoregions with good spatial resolution to consider physically different regions separately (e.g. the GOM and the GB subregions). Therefore, data quality criteria for this indicator are fully met. The group only partially addressed the management criteria. There is not a target set for water temperature, nor a trend direction established, although managers might desire a system where temperature had no trend such that this influence would be constant. Temperature is easily understood and consequences of variation relatively easy to communicate. Bottom water temperature is an established pressure indicator and cost-effective for use. Therefore, the indicator fully met 3 of the 4 possible criteria for adequacy for management, and would meet all 4 if ocean managers established a target or target trend for bottom water temperature. Conceptual criteria apply directly to the EU's Marine Strategy Framework Directive (MSFD) and so were not addressed by the group, but some parallel criteria could be developed by WGNARS addressing relevance to management objectives and cross-application potential. Overall, the group agreed that this set of criteria would be useful for application to selected indicators for WGNARS IEA worked example analyses.

Evaluating the indicator time-series led to further discussion of how it would be most appropriately used in IEA analysis. Paula noted that it would not be appropriate to aggregate bottom temperature for the full selected WGNARS ecoregion combining the GOM and GB subregions—these regions are sufficiently different to require separate indicators. Similar considerations may apply in the Grand Banks ecoregion. Determining the relevant spatial scale will be an important first step, as well as the temporal scale—how to treat a seasonal signal, or which data to use to characterize the annual signal?

It was noted that for the larger set of indicators required to address our selected management objectives that we should take advantage of previous work, such as that of IndiSeas (Shin and Shannon, 2010; Bundy *et al.*, 2012). Alida Bundy briefly summarized how IndiSeas first examined state indicators, then pressure indicators, and was now adding human dimensions indicators. Modelling work is ongoing to address indicator performance with respect to sensitivity, responsiveness, and specificity. WGNARS could use or slightly modify indicator time-series collected for the IndiSeas project as appropriate. In particular, previous work on fishing indicators (for one major anthropogenic driver) would need to encompass changes in the biotic communities as well as feedbacks to the socio-economic system to address our selected conservation and socio-economic objectives.

Considering fishing in space will also be important to our analyses. Erik Olsen (a visiting expert from IMR, Norway) presented simulation work in progress using the NE US Atlantis model which showed differences in biological responses to changes in fishing that were global, vs. changes that happened in specific areas within the ecosystem. Atlantis is a spatial simulation model which includes physical processes, multispecies interactions, and human dimensions (Link *et al.*, 2010). This model may be particularly useful for WGNARS work in 2015 and 2016 on management strategy evaluation (MSE) for IEAs. The group greatly appreciated seeing this application of the model which illustrated another important tool for integrated assessment. This led to further discussion of how to design the IEA so that we make best use of the available data, modelling tools, and visualization tools to reach both scientific and policy/management/stakeholder audiences.

The day concluded with a discussion of terminology and potential workflow to be used in our worked example IEA analyses. Gavin Fay pointed out that standardized terminology is available in the MSE literature for operational objectives, performance measures, and indicators that may differ from what WGNARS has been using in discussion, leading to potential confusion. In addition, the DPSIR framework has its own terminology. The group decided to settle on and fully describe its terminology going forward, a task to be completed prior to the 2015 meeting (and submission of the planned papers outlining management objectives, large-scale drivers, and indicator vetting.

Catherine Johnson envisioned the following workflow for our IEA example analyses, following Figure 1 and our 2014–2016 ToRs:

(Implicit risk analysis performed to prioritize objectives)

Decision (made at 2014 meeting):

- Focus on managing multispecies fisheries and other human activities in response to environmentally driven community dynamics
- Consider energy development

1) Unpack operational conservation, social, and economic objectives (2014)

2) Identify effective (criteria applied and performance tested) indicators for each operational objective (Indicators of ecosystem status -> reference points, targets, thresholds; 2014–2015)

Note: Indicators include both single issue and ecosystem level

3) What is the status of the system relative to each objective? (2014–2015)

4) What are the risks to each ecosystem objective, i.e. pressures (indicators) (climate, fishing, unbalanced fishing, bottom impacts, oil and tailings pollution, …; partial work on climate risks initiated in 2013, to continue 2015–2016)

5) Prioritize risks (partial work on climate risks initiated in 2013, to continue 2015–2016)

6) What management strategies are currently in use; identify others that could be used (scheduled for 2015 meeting)

7) Management strategy evaluation, maybe including framework for including single, vs. ecosystem and different time-scales of decision-making (scheduled for 2016 meeting, work needs to start prior)

6 Work plan developed by the group for 2015–2016 meetings

On the final day of the meeting, the working group made a plan to complete the work started in 2014 and to begin work necessary prior to the 2015 and 2016 meetings to meet the three-year ToRs (see Annex 3).

Task groups outline February 7, 2014

Groups structured around responses but considering selected example drivers (climate) and anthropogenic pressures (fishing, energy development/exploitation). Groups will be bilateral with links among them to coordinate methods.

a) habitat group
b) socio and economic (human dimensions) group
c) foodweb/ecological productivity group

Tasks:

1) finish 2014 work
    a) ToR b)—management objectives
        i) social and economic objective—refine overarching objective, identify needs for further specification, potential performance measures, available data (tor c, below), etc. (Sarah and Patricia to organize group: Brian Leung, Heather Breeze, Geret DePiper, Jamie Cournane, Sara Quigley, others to be identified)
        ii) conservation/biological objective—continue to id potential performance measures, connect to driver and response indicators (add biodiversity?)
            (1) habitat group (Robin Anderson, Bob Gregory, John Manderson, Jon Fisher, Nancy Shackell, Sara Quigley)
                (a) unpack objectives (e.g. "acceptable" damage—define)
                (b) performance measures for habitat objectives
            (2) foodweb/productivity group, same process as above (biodiversity; Sean Lucey, John Manderson, Nancy Shackell, Pierre Pepin, Catherine Johnson, Mariano Koen-Alonzo, Alida Bundy, Mike Lowe, Sarah Gaichas)
        iii) develop peer reviewed paper(s) focusing on the two regions selected
            (1) outline it now: SMART objectives for Integrated Ecosystem Objectives (Catherine Johnson leads; helping: someone from each subject

task group, and Sarah Gaichas, and interested parties from each group above once work nearly done)
(a) background on project, IEA diagram and where this fits
(b) review of high level objectives from various sources
(c) how do we clarify/operationalize/downscale—identify a process
(d) emphasize cross disciplinary nature of unpacking, multiple aspects of high level objectives.
(e) which ones did we choose and why (socio/econ and biological /conservation)
(f) what do they look like going into the IEA in each region
(g) discussion—need to invest in iterative stakeholder process to do in real life

b) ToR c)—drivers and responses, vetted indicators for each
i) finish identifying indicators, evaluating performance using criteria (*lead for now)
(1) climate driver group--identify indicators (mainly done, *Pierre Pepin, Paula Fratantoni, Kevin Friedland, Vince Saba, John Manderson, Dave Hebert, Nancy Shackell, Scott Large, Catherine Johnson,)
(2) pressure group—identify indicators (fishing, gears, energy development; Heather, *Sarah Gaichas, Jon Fisher, Sean Lucey, Laurel Smith, Robin Anderson, Jamie Cournane, Hugues Benoit, Jason Link (start with WGNARS spreadsheet from 2 yrs. ago), similar group to socio/econ [human dimensions] objectives group)
(a) GOM ecosystem indicator partnership, GOM council; Christine Tilburg a contact?
(b) Grand Banks start with stuff Oceans has compiled; Memorial University
(3) and vet using criteria (16 ICES or other); both groups
ii) develop peer reviewed papers focusing on work to date
(1) Paper 1? (Sarah Gaichas and Robin Anderson to outline the paper, seek people to do parts)
(a) background on project, IEA diagram and where this fits (Sarah/Robin)
(b) DPSIR framework (briefly) for terminology (Sarah/Robin)
(c) summarize large-scale mechanistic drivers presented in past; Collie and Rochet paper (Paula Fratantoni, Pierre Pepin)
(d) justify selection of environmental pressures for our analysis—temperature (surface, bottom), sea ice (extent, timing), water column structure (freshwater input, salinity, stratification; Pierre Pepin, Paula Fratantoni, …)
(e) also, major anthropogenic pressures we focus on: fishing, energy (Robin/Sarah, Sara Quigley,…)
(f) review of existing indicators for each driver and pressure (Pathways of effects work, presentations at previous WGNARS meetings, …)

(g) what indicators will we use in each region?
(h) Preview of coming attractions—indicator evaluation and performance testing
(2) Paper 2 and review at next meeting? Or all in one?
(a) Evaluate the indicators using criteria (16 ICES, other?)
(b) Indicator performance testing/simulation in models (if possible)

2) begin 2015 work in advance of meeting
a) identify who needs to go from both nations and start travel paperwork.
b) Location and dates (doodle poll). Possibly NAFO. Much better connectivity for remote access.
c) Structure around task groups and possibly concurrent breakout sessions
d) tor c—ecosystem impacts (responses), vetted indicators for each
i) all groups—id multiscale ecosystem impacts (responses) to drivers (Habitat: Jon Fisher, Bob Gregory, John Manderson)
ii) all groups—list of potential indicators for multiscale responses (some preselection or performance testing if possible)
iii) Paper 2 and review at next meeting? Or all in one?
(1) Review system impacts, etc. structured similarly to large-scale drivers above
(2) Evaluate the indicators using criteria (16 ICES, other?)
(3) Indicator performance testing/simulation in models (if possible)
e) ToR d)—management strategies, further operationalized objectives, identify models for MSE
i) review management strategies currently used to achieve objectives (single sectors?; Sean Lucey, Heather Breeze, Sara Quigley, Kim Houston, Jason Sims?, Becky Shuford for background general US, others to be identified)
(1) "horizon scan" already done and can review, also for gaps and needs
ii) id multiple management strategies specifically to achieve our selected objectives
(1) how to integrate across multiple objectives?
(2) What information is missing?
iii) MSE analytical frameworks (Sean Lucey, Gavin Fay, Sarah Gaichas, Mariano Koen-Alonso, Alida Bundy)
(1) What models are currently available in each system? Briefly describe.
(2) Qualitative frameworks—review. Broader set of people.
(3) What information is available? (already done under indicators) Identify gaps.

3) begin 2016 work in advance of meeting
a) tor e)—management strategy evaluation, to be determined in 2015 based on above work

7 Conclusions

The group made progress on identifying and operationalizing management objectives for a "worked example" IEA analysis for the Northwest Atlantic Regional Sea. However, work on these objectives will continue between the 2014 and 2015 meetings. The group also made progress on identifying key biophysical drivers and anthropogenic interactions in the region, and identified two specific ecoregions to be compared within the Northwest Atlantic Regional Sea: the Georges Bank/Gulf of Maine ecoregion and the Grand Banks ecoregion. Bottom temperature, surface temperature ice timing and cover, freshwater input, stratification and salinity were identified as key large-scale biophysical drivers. Fishing and energy development and or exploitation were identified as the major large-scale anthropogenic interactions. The temporal scale for analysis will be the management-relevant time horizon of annual to decadal. Work on compiling and vetting indicator time-series for these large-scale drivers and interactions will continue between the 2014 and 2015 meetings.

8 References

Bundy, A., Coll, M., Shannon, L. J., Shin, Y.-J. 2012. Global assessments of the status of marine exploited ecosystems and their management: what more is needed? Current Opinion in Environmental Sustainability, 4: 292–299.

DFO. 2007. Placentia Bay-Grand Banks Large Ocean Management Area Conservation Objectives (Rep. No. 2007/042). Canadian Science Advisory Secretariat Science Advisory Report.

DFO. 2012. Placentia Bay-Grand Banks Large Ocean Management Area Integrated Management Plan 2012–2017. http://www.pbgbloma.ca/Files/PBGB%20LOMA%20IM%20Plan%20-%20En.pdf

DFO. 2013. Risk-based assessment of climate change impacts and risks on the biological systems and infrastructure within Fisheries and Oceans Canada's mandate - Atlantic Large Aquatic Basin. DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/044. http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2012/2012_044-eng.html

Fay, G., Large, S. I., Link, J. S., Gamble, R. J. 2013. Testing systemic fishing responses with ecosystem indicators. Ecological Modelling, 265:45–55.

ICES. 2013. OSPAR special request on review of the technical specifications and application of common indicators under D1, D2, D4, and D6. ICES Advice 2013, Book 1, Section 1.5.6.3. http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/Special%20requests/OSPAR_3-2013.pdf

Large, S. I., Fay, G., Friedland, K. D., Link, J. 2013. Defining trends and thresholds in responses of ecological indicators to fishing and environmental pressures. ICES J Mar Sci., 70:755–767.

Levin, P. S., Fogarty, M. J., Murawski, S. A., and Fluharty, D. 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. PLoS Biology, 7: 23–28.

Link, J.S., E. A. Fulton, and R. J. Gamble. 2010. The Northeast US Application of ATLANTIS: A full system model exploring marine ecosystem dynamics in a living marine resource management context. Progress in Oceanography, 87:214–234.

NROPB, 2014. Framework for Ocean Planning in the Northeast United States. http://neoceanplanning.org/wp-content/uploads/2014/02/NE-Regional-Ocean-Planning-Framework-February-2014.pdf

Park, L. E., Beresford, L. A., and E. Kissler. 2011. Prioritization of Key Ecosystem Components Based on Risk of Harm from Human Activities within the Placentia Bay/Grand Banks Large

Ocean Management Area. Oceans, Habitat and Species at Risk Publication Series, Newfoundland and Labrador Region. 0004: vi + 9 p. + working notes (2422p.) http://www.dfo-mpo.gc.ca/Library/342998.pdf

Shin, Y.-J., and Shannon, L. J. 2010. Using indicators for evaluating, comparing and communicating the ecological status of exploited marine ecosystems. Part 1: the IndiSeas Project. ICES Journal of Marine Science, 67: 686–691.

Annex 1: List of participants

NAME	AFFILIATION	E-MAIL
Robin Anderson	DFO-Newfoundland	M.Robin.Anderson@dfo-mpo.gc.ca
Heather Breeze	DFO-Maritimes	Heather.Breeze@dfo-mpo.gc.ca
Alida Bundy	DFO-Maritimes	Alida.Bundy@dfo-mpo.gc.ca
Ke Chen	WHOI	KChen@whoi.edu
Jamie Cournane	NEFMC	jcournane@nefmc,org
Geret DePiper	NOAA/NEFSC	geret.depiper@noaa.gov
Mark Dickey-Collas	ICES	Mark.dickey-collas@ices.dk
Gavin Fay	NOAA/ST	gavin.fay@noaa.gov
Jon Fisher	Memorial University	Jonathan.fisher@mi.mun.ca
Michael Fogarty	NOAA/NEFSC	Micahel.fogarty@noaa.gov
Paula Fratantoni	NOAA/NEFSC	Paula.fratantoni@noaa.gov
Kevin Friedland	NOAA/NEFSC	Kevin.Friedland@noaa.gov
Sarah Gaichas	NOAA/NEFSC	Sarah.gaichas@noaa.gov
Robert Gamble	NOAA/NEFSC	Robert.gamble@noaa.gov
Alyssa Gervais	McGill University	Alyssa.gervais@mail.mcgill.ca
Robert Gregory	DFO-Newfoundland	Robert.gregory@dfo-mpo.gc.ca
Catherine Johnson	DFO-Maritimes	Catherine.johnson@dfo-mpo.gc.ca
Brian Leung	McGill University	Brian.leung2@mcgill.ca
Mike McCartney	WHOI	MMcCartney@whoi.edu
Matt McPherson	NOAA/NEFSC	Matthew.McPherson@noaa.gov
Mariano Koen-Alonso	DFO-Newfoundland	Mariano.koen-alonso@dfo-mpo.gc.ca
Scott Large	NOAA/ST	Scott.large@noaa.gov
Jason Link	NOAA/ST	Jason.link@noaa.gov
Mike Lowe	WHOI	Mlowe@whoi.edu
Sean Lucey	NOAA/NEFSC	Sean.lucy@noaa.gov
Marie-Caroline Martin	NOAA/NEFSC	Marie.caroline.martin@noaa.gov
Erik Olsen	IMR	Eric.olsen@noaa.gov
Pierre Pepin	DFO-Newfoundland	Pierre.pepin@dfo-mpo.gc.ca
Patricia Pinto da Silva	NOAA/NEFSC	Patricia.pinto.da.silva@noaa.gov
Sara Quigley	DFO-Maritimes	Sara.quigley@dfo-mpo.gc.ca
Rebecca Shuford	NOAA/ST	Rebecca.shuford@noaa.gov
Fred Serchuk	NOAA/NEFSC	Fred.serchuk@noaa.gov
Laurel Smith	NOAA/NEFSC	Laurel.smith@noaa.gov

NOAA/ST = Oceanic DFO = Fisheries and Oceans Canada

IMR = Institute of Marine Research, Norway

NEFMC = New England Fishery Management Council

NOAA/NEFSC = National Oceanic and Atmospheric Administration / Northeast Fisheries Science Center, USA and Atmospheric Administration / Office of Science and Technology, USA

WHOI = Woods Hole Oceanographic Institute, USA

Annex 2: Agenda

ICES Working Group on the Northwest Atlantic Regional Sea Agenda

Waquoit Bay Research Reserve, Falmouth, MA, USA

3–7 February 2014

Monday, 3 January 2014

Afternoon – Opening and Review (13:30 – 17:00)

ToR 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 practices for each step of integrated ecosystem assessment.

Planned outcome: Brief interim report section updating other integrated ecosystem assessment activities, with components written by talk leads and context drafted by discussion leaders

Discussion led by Sarah Gaichas and Robin Anderson

Rapporteur: Robin Anderson

13:30 Welcome and Introductions

13:45 Fred Serchuk – Opening of the meeting

14:00 Sarah Gaichas – Background of WGNARS and overview of 3 year ToRs (appended to agenda)

14:20 Brief (10–15 min) updates on integrated ecosystem assessment, only if new information:

Rebecca Shuford, Mike Fogarty – US and Northeast Regional Ocean

?– Canada

Mariano Koen-Alonso – NAFO

Other relevant organizations (Detailed list and speakers TBD)

15:00 Break

15:20 Brief updates continued

Update on expanded ocean observing inventory from last year

16:00 Discussion of working sessions plan for days 2–4; introduce all discussion topics and tasks

17:00 Adjourn for Day

Tuesday, 4 February 2014

Morning –ToR a cont'd; Ecosystem Based Management Objectives: Review existing (09:00 – 12:30)

09:00 Mark Dickey-Collas – Update on integrated ecosystem assessment: ICES

ToR 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. Expected deliverables: Conceptual model of relationships between current objectives, identifying which conflict. Candidate list of objectives for analysis.

Discussion leaders: Patricia Pinto da Silva and Heather Breeze

Discussion topics and tasks

1. What ocean related conservation, management, social, and economic objectives have been identified in the WGNARS region?
2. How are these objectives related to each other? Can we identify whether or where they conflict?
3. Can we reshape these conservation, social, and economic objectives into ecosystem-based management objectives, if they are not already stated as such? (In our report, can we identify a process for downscaling the high level objectives we may have from national and international law and even from national and regional policy to more tangible objectives for the ecoregions that are to be managed? Who would be involved in developing such a process? Science only, or a multi-sector group?) Scoping process provides education—see discussion from 2013.
4. From the compiled lists and analysis of relationships and our discussions, identify a set of objectives for WGNARS to work from. We want a short list of clearly described ecosystem-based objectives which we will evaluate using indicators and performance thresholds selected and developed under ToRs c) and d). The ecoregion-level objectives should be Specific, Measureable, Achievable, Relevant (requires public input), and Time-bound (SMART). What are the elements of an effective operational objective? What do you do when there are trade-offs?

09:30 Discussion topics/tasks 1–2: Patricia Pinto da Silva and Heather Breeze: Review and discuss lists of objectives and qualitative maps evaluating relationships among objectives

10:30 Break

10:50 Continue Discussion topics 1–2 as necessary

Begin topic/task 3: ecosystem based management objectives from existing objectives

12:30 Lunch

Tuesday, 4 February 2014

Afternoon - Ecosystem Based Management Objectives: Select for WGNARS (13:30 – 17:00)

13:30 Working session, tasks 3 and 4: Select working set of management objectives for WGNARS to work from both conservation/biological AND social/economic objectives. Canada: ESSIM example—how to adapt/downscale/operationalize these objectives?

15:00 Break

15:20 working session continued

14:30 Review working set of management objectives, summarize decisions for ToR b) report

17:00 Adjourn for day

Wednesday, 5 February 2014

Morning – Large-scale drivers: identification (09:00 – 12:30)

ToR 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. Expected deliverables: Short list of large-scale drivers and vetted set of indicators for changes in those drivers (2014). List of vetted indicators for key ecosystem responses at several scales (2015).

Discussion leaders: Catherine Johnson and Sarah Gaichas

Discussion topics and tasks:

1. Discussion
    a. What is the most effective product that WGNARS can produce on this topic? Take advantage of our interdisciplinary group, including oceanographers, social scientists, and managers. Develop consistent terminology (e.g. DPSIR).
    b. How will the large-scale drivers be linked to risks to achieving ecosystem management objectives? Could this go beyond fisheries?
    c. How can we incorporate the idea of interaction of processes across scales (e.g. the response to climate variability might look different at the mesoscale than macroscale)?
    d. How have the other regional seas program working groups integrated this information?
    e. What would be the best strategy for developing a publication initiated through the two days of work at the meeting?
2. Compile and review a list of key large-scale drivers for the full WGNARS region
3. Select a short list of key drivers as a group during a working session

4. Identify a set of indicators for each key driver

5. Apply the methods demonstrated last year (or propose new methods) to test the performance of these indicators so that our final set has been scientifically vetted.

6. Discussion

    a. Can we standardize indicators across the WGNARS region?

    b. How will we address multiscale responses with indicators?

    c. In 2015, we continue ToR c) to examine multiscale responses to the large-scale drivers we identify this year. The drivers we identify and corresponding indicators that we test and vet in 2014 will also be used in analyses under ToRs d) and e) in 2015–2016.

09:00 Discussion of ToR c) strategy (Discussion topic 1, a-e.)

10:00 Discussion/task 2: Catherine Johnson, Vince Saba, Nancy Shackell, Pierre Pepin, other presentations?? Review of large-scale drivers summarized from previous meetings, with any updates, clarifications, or new hypotheses.

10:30 Break

10:50 Discussion/task 2 continued

Discussion/task 3—select one to three combined large-scale drivers that explain substantial variation in the system with respect to objectives discussed under ToR b) and considering that we will be examining multiscale responses under ToR d) in 2015.

e.g.: if maintaining fisheries productivity above a threshold over a range of expected climate conditions is a biological objective, what are the most important biophysical drivers? Are there drivers that directly impact economic or social objectives, or would impacts be mediated by changes in ocean species composition and or productivity?

Discussion/task 4—what indicators are available to assess the selected large-scale drivers?

(Also, looking ahead, what multiscale indicators will be available to assess responses to these drivers?)

12:30 Lunch

Wednesday, 5 February 2014

Afternoon - Large-scale drivers: available indicators (13:30 – 17:00)

13:30 working session, tasks 3 and 4—finalize short list of large-scale drivers, compile corresponding indicator time-series across WGNARS region

15:00 Break

15:20 working session continued

16:50 Strategy for tomorrow: review progress on tasks 3–4, schedule tasks 5, 6

17:00 Adjourn for day

Thursday, 6 February 2014

Morning – Large-scale drivers: indicator performance testing (09:00 – 12:30)

ToR c (continued) 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.

09:00 Discussion topic/task 5: methods to apply to current set of indicators for large-scale drivers, when will we consider an indicator's performance acceptable?

Scott Large/Gavin Fay: Briefly review indicator thresholds and performance testing methods and results from 2013

10:30 Break

10:50 Discussion topic 6: standardized indicators, multiscale responses, and links to other ToRs

12:30 Lunch

Afternoon - Large-scale drivers working sessions (13:30 – 17:00)

13:30 working session—continue as necessary all ToR c) tasks

15:00 Break

15:20 working session continued

16:30 Discussion: what work still needs to be done? How to get it done prior to next meeting?

17:00 Adjourn for day

Friday, 7 February 2014

Morning – Review and wrap-up (09:00 – 12:30)

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

12:00 Final wrap-up

12:30 Adjourn meeting

Annex 3: WGNARS 2014–2016 Terms of Reference

2013/MA2/SSGRSP01 The **Working Group on the Northwest Atlantic Regional Sea** (WGNARS), Co-chairs: Sarah Gaichas, USA, and M. Robin Anderson*, Canada, will meet in Falmouth, USA on 3–7 February 2014.

The Second Interim meeting of the **Working Group on the Northwest Atlantic Regional Sea (**WGNARS) Co-chairs: Sarah Gaichas, USA, and M. Robin Anderson, Canada) will meet in Dartmouth, NS, Canada on 23–27 February 2015.

WGNARS will report on the activities of 2014 **(the first year)** by 1 March 2014 to SSGRSP and the **second year** by 1 April 2015.

ToR descriptors

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 practices 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).
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).
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).
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	Adressed to
Guidance should be developed on selection of thresholds and generally operationalizing objectives for Integrated Ecosystem Assessment	SSGRSP
WGNARS should meet 23–27 February 2015 in Dartmouth, NS, Canada	SSGRSP