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

21–24 March 2016

Falmouth, USA

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

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Executive summary

The seventh meeting of the Working Group on the Northwest Atlantic Regional Sea (WGNARS), chaired by Robin Anderson, Canada and Geret DePiper, USA, was held at the Waquoit Bay National Estuarine Research Reserve in Falmouth, MA, USA, on 21–24 March 2016. The meeting was attended by 19 participants from the US and Canada, with an additional four participants calling in remotely. 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, and not specific policy statements. The Northwest Atlantic region has well-developed ocean observation systems, marine ecosystem surveys and habitat studies, though social and economic data collection systems are less well developed, 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 the 2016 meeting, the group maintained a working format with emphasis on group discussion, interaction, analysis, and decision-making. Over the past three years, WGNARS has produced 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. In 2014, the group identified three specific ecoregions to be compared within the Northwest Atlantic Regional Sea: the Georges Bank and Gulf of Maine ecoregions in the US and the Grand Banks ecoregion in Canada. Sessions in 2015 were designed to achieve two main goals: (1) identifying alternative management strategies to achieve objectives outlined in 2014 and (2) identifying multiscale ecosystem responses to large-scale drivers and key human activities outlined in 2014. (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.) This work culminated in an ecosystem-level management strategy evaluation (MSE) in 2016, focused primarily on US waters.

The 2016 meeting was primarily dedicated to two separate tasks: (1) finalizing the MSE model outputs for the Georges Bank and Gulf of Maine US ecoregions and (2) developing a draft MSE model for the Canadian Grand Banks ecoregion. The main products developed by WGNARS between 2013 and 2016 include the identification of a list of operational objectives derived from the relevant management regulations, time-series indicators tracking both these objectives and the physical and biological processes that mediate their achievement, conceptual models that link the ecosystem services and benefits derived from each ecoregion of study to the broadscale drivers in the system, and qualitative MSE results comparing the ability of a range of fishing strategies to attain management goals under shifting system drivers. This report focuses on the process used in developing the above-mentioned products, situating the WGNARS work in the broader IEA landscape and highlighting the decision-points, which shaped the outcomes.

1 Administrative details

Working Group name: WGNARS

Year of Appointment within the current cycle: 2013

Reporting year within the current cycle (1, 2 or 3): 3

2016 Chairs

Geret DePiper, US

Robin Anderson, Canada

Meeting venues and dates

3–7 February 2014, Falmouth, MA, (33)

23–27 February 2015, Dartmouth, CA, (20)

21–24 March 2016, Falmouth, MA, (23)

2 Terms of Reference a) – z)

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 Expert Groups (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).
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	Will review potential management tools and	3.1, 3.2	1 year (2015)	List of operational objectives, alternative

	drivers and responses at multiple scales (ToR c). Outline model requirements for management strategy evaluation.	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.			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).

3 Summary of 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.

4 Summary of Achievements of the WG during 3-year term

- List of management objectives for study ecoregions in US and Canada;
- Inventory of indicators for tracking performance of system in relation to management objectives and large-scale system drivers;
- Conceptual models linking large-scale drivers to human activities and benefits derived from the system;
- Qualitative model outputs from multiple softwares (Mental Modeler, Qpress, Loop Analyst) generating MSE output;
- ICES ASC 2014, Theme Session C: One Size Does Not Fit All – What Does an Integrated Ecosystem Assessment Mean to YOU?
- ICES CM 2014/3581 C:02 Presentation entitled "Describing the "Integrated" in Integrated Ecosystem Assessments";

- ICES CM 2014/3825 G:38 Presentation entitled "Towards Operational Assessments: Selection, Vetting, and Standardized Analysis of Ecosystem Indicators for the Northeast US Large Marine Ecosystem;
- ICES CM 2015/ M:18 Poster entitled "Seeing the forest and the trees: Application of hierarchy theory to integrated ecosystem assessment".

5 Final report on ToRs, workplan and Science Implementation Plan

The work done by the WGNARS is summarized, by ToR, below.

ToR a) Annual review of IEA activities.

The WGNARS work was greatly facilitated by member involvement in IEA work outside the group. In this section, we summarize the contribution of these external IEA activities, by region, to the completion of the WGNARS work and ToRs. We also provide a final update on each region.

Northeast US Regional IEA Program

The suite of indicators compiled for the Northeast US Regional IEA Program greatly facilitated the identification of appropriate indicators to support the IEAs for the Georges Bank and Gulf of Maine ecoregions. Additionally, the WGNARS group adopted the status and trend representation of indicators used by the Northeast US Regional IEA Program (Figure 5.1).

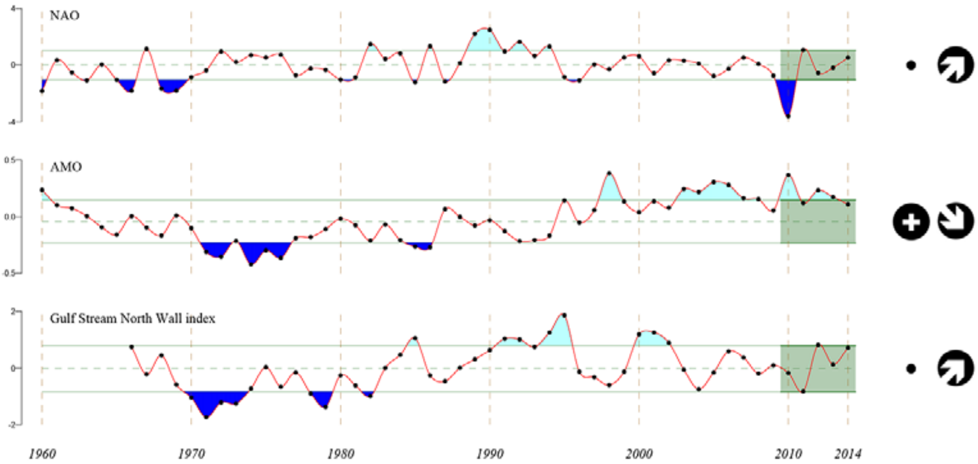

Figure 5.1. North Atlantic Oscillation (NAO) and Atlantic Multidecadal Oscillation (AMO) indices smoothed using a 10-year moving average, and Gulf Stream North Wall index.

The Northeast US Regional IEA has continued to make progress integrating informational products and processes into management. Mike Fogarty presented a State of the Ecosystem report to the New England Fisheries Management Council in April, 2015, which focused extensively on the suite of indicators developed by the Northeast US Regional IEA program. The preliminary WGNARS conceptual model and list of objectives developed at the 2015 WGNARS meeting were presented to the Mid-Atlantic Fisheries Management Council (MAFMC) by Sarah Gaichas, as part of their Species Interactions Workshop held in June 2015, and again at their Habitat Workshop in October 2015. The feedback to the workshops was positive enough that the Mid-Atlantic is currently exploring the potential implementation of a Management Strategy Evaluation case-study. The US goals and objectives developed at the 2015 WGNARS meeting have also been presented to the New England Fisheries Management Council, where they have been incorporated into drafts of both the Risk Policy and Fisheries Ecosystem Plan currently under development.

The Northeast program has substantially revamped its Ecosystem Considerations webpage (www.nefsc.noaa.gov/ecosys) as a vehicle for communication with a diverse audience of stakeholders. The Ecosystem Status Report has been converted to a web-based product with the intention of making it a living document

Over the next three years, the Northeast US Regional IEA program will look to finalize conceptual models of the Northeast US Continental Shelf Large Marine Ecosystem (NE LME), and define qualitative model analogues of the conceptual models. The conceptual models will primarily function as communications tools to stakeholders, while the qualitative models will serve to assess the impact, positive or negative, of perturbations in the system. The qualitative models are viewed as complements to more quantitative models such as Atlantis and the suite of multispecies models under development by the Northeast US Regional IEA program, in that they can provide a much broader understanding of the full system under consideration. Supporting these models is a suite of socio-ecological indicators that has been compiled for the region, and future research will focus on assessing their ability to provide leading indications of ecosystem service disruptions.

The regional impact of climate change is an undercurrent across all of the program’s work. Substantial focus has thus been placed on the development of high resolution climate models and output data streams. These products are used by both internal and external partners to better understand the sensitivity and susceptibility of the NE LME to a changing climate.

In all of its work, the Northeast US Regional IEA program will continue to engage regional management bodies including the New England and Mid-Atlantic Fishery Management Councils, the Northeast Regional Planning Body, and others. As such, the data products and models are being developed with an eye towards the different spatial extents, core priorities, and jurisdictions encapsulated by the varied management partners.

NOAA National Integrated Ecosystem Assessment Program

"Conceptual models" developed for the California Current IEA were presented at the 2015 WGNARS meeting, and proved pivotal to the work completed during that meeting. Conceptual models are intended to provide a unifying framework that crosses disciplines, and to clarify system boundaries and any gaps in knowledge. They are invaluable as a communication tool within an IEA working group, with other scientists, and with the public. This framework allows linking of indicators with elements of the conceptual models, as well as linking concepts across ecological and social components of a given system. The California Current IEA project worked for over a year to produce a set of linked conceptual models in December 2014, as illustrated in Figure 5.2. A full description of the California Current conceptual models can be found at:

http://www.noaa.gov/iea/regions/california-current-region/products/index.html.

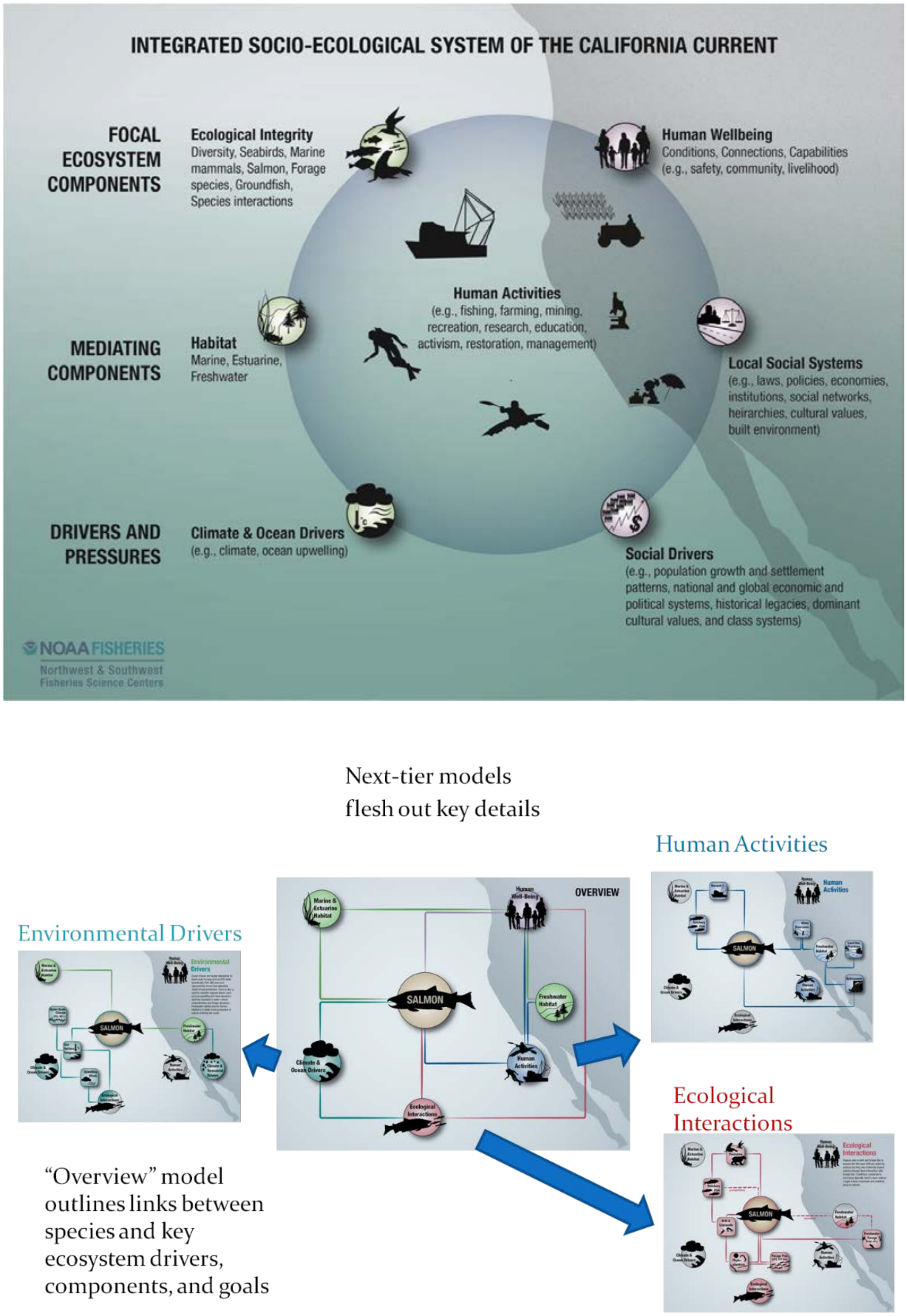

Figure 5.2. California Current conceptual models: overall system and detailed models linking environmental drivers, human activities, and ecological interactions for key ecosystem components. A set of models was developed for each focal component (salmon are shown here but others include coastal pelagics, marine mammals, etc.).

The currently active five regions of the national IEA program (California Current, Gulf of Mexico, Northeast Shelf, Alaska Complex, and Pacific Islands) have made substantial headway in developing conceptual models of each system, and a suite of indicators for the system components. The recent national IEA meeting, hosted

March 1–3, 2016 in Boulder, Colorado, USA, brought to the forefront the effective interpretation of indicators for management purposes and predictive models to assess potential future outcomes of management actions.

Recent interest in and work related to ecosystem tipping points continues to highlight the importance of translating ecological indicators into actionable management advice. For example, California Current Thresholds Working Group held a 3-day workshop in July 2015 aimed at assessing statistical inflection points and non-linearities in the ecological indicators. A manuscript on the outcomes from this workshop is nearing submission, and there are plans to broaden the implementation across additional regions.

"Safe and Just" operating spaces is also being discussed as an additional path forward, allowing indicator assessments to fully integrate human benefits derived from the environment in an intuitive manner (Dearing *et al.*, 2014). The general concept is that the relevant space of potential management outcomes necessitates understanding the bounds of both sustainability (the "safe" space) and social acceptability (the "just" space). In the case of fisheries management, the former would correspond to lower bounds on species biomass, while the latter as lower bounds on the economic benefits derived. The crux of implementing the "safe and just" framework lies in assessing the relevant boundaries within an interdisciplinary context. Although trade-offs between alternate strategies can be assessed relatively easily, at least qualitatively, thresholds in minimum bounds on the benefits themselves must be explicitly defined by managers. An approach like Management Strategy Evaluation can be used to identify the thresholds, but the elicitation process itself is likely to be slow, given the level of specificity necessary in defining the thresholds (i.e. the minimum acceptable number of jobs or lbs of food to be produced).

A multivariate assessment of indicator stability (or other statistical characteristics of the data) lacks the clear linkage to a management response, but can provide information on performance of a system lacking clear definition of the systems. The IEA program is likely to pursue both approaches in providing actionable management advice.

Ultimately, both science and management must be proactive in assessing potential outcomes and trade-offs of alternatives. In complex coupled socio-ecological systems with numerous management goals and objectives, understanding the differential impact of alternatives necessitates models that capture a priori trade-offs of interest. An example has been developed by Chris Harvey, Jonathan C. P. Reum, Melissa R. Poe, Gregory D. Williams, and Su J. Kim, for the California Current IEA program, with a manuscript currently in review. The manuscript uses Qualitative Network Models to assess the impacts of a number of environmental forcing scenarios on both the ecology and human components of the California Current, with salmon functioning as the focal component. The work generally can be thought of as creating a dynamic version of the conceptual models already developed, and a host of qualitative modelling techniques and software are available including PLS Path Analysis, QPress, Mental Modeler, Bayesian Belief Networks, Hugin, and Stella, to name a few. The utility of these models stems from their relative simple underlying mathematics, which allows for a much more extensive model to be developed and assessed. This simplicity can also allow for MSE-type participatory modelling with stakeholders, extensive sensitivity analysis surrounding modelling assumptions (including the use of qualitative data), and overall broader system assessment than quantitative models. Results of these qualitative models, in turn, can guide the development of more rigorous quantitative modelling and data collection endeavours. Given the breadth of the IEA mandate, these qualitative models are an important step in modelling the full system of interest to managers.

Canadian IEA activities update

While Canada does not have an IEA program outright as it pertains to the marine environment, in keeping with international advancements in integrated aquatic management, Fisheries and Oceans Canada (DFO) has been moving towards an ecosystem approach to management (EAM), and has many individual program components and/or initiatives that contribute to this. This work includes ongoing and new scientific monitoring and research, as well as various peer-review and advisory activities throughout each year, to inform oceans sector management considerations and decisions.

Notably, the newly elected Canadian government also recently announced key items within its new mandate for DFO, which are expected to significantly advance an ecosystem approach to management in the marine environment, including, among other things: increasing the proportion of Canada's marine and coastal areas that are protected (to five percent by 2017, and ten percent by 2020); ensuring scientific evidence is the basis for decision-making, and the precautionary principle and climate change are considered in managing species and ecosystems; advancing co-management of our oceans; and examining the implications of climate change on Arctic (and other) ecosystems.

Cold-water Corals and Sponges

National Peer Review "Delineation of Significant Areas of Coldwater Corals and Sponge-dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters" was held in Halifax on 8–10 March 2016 (for terms of reference see http://www.dfo-mpo.gc.ca/csas-sccs/Schedule-Horraire/2016/03_08-10-eng.html). This review process was held in support of the Policy on Managing the Impacts of Fishing on Sensitive Benthic Areas (DFO, 2009). The objectives were to review techniques and data (including species distribution models), produce maps, recommend how to improve maps, produce a preliminary analysis of fishing effort and sensitive benthic areas overlap and make recommendations for how to use this information. The proceedings and the research documents produced for the meeting will be published on the CSAS website:

http://www.isdm-gdsi.gc.ca/csas-sccs/applications/Publications/index-eng.asp.

MPA Network Planning

Canada is committed to the development of a systematic network of Marine Protected Areas (MPAs) and network planning is ongoing in five priority bioregions. Current MPA Network Planning, in the Newfoundland and Labrador (NL) Shelves Bioregion, includes the "project area" Grand Banks ecoregion. While the primary goal is the conservation of marine biodiversity, ecosystem function, and special natural features; MPA Networks have the potential to yield various socio-economic (SE) benefits as well. Proposed conservation objectives and targets have been identified, and SE objectives are currently being developed in collaboration with various oceans sectors. The focus of SE objectives in the network context will be on conserving the ecological components that provide ecosystem services, not on the ecosystem services themselves. The objectives will be aimed at the ecological components from which SE values are derived, rather than broader issues of livelihoods, profitability, and other secondary SE benefits. The WGNARS work has informed the development of both conservation and SE objectives for MPA Network planning in the NL Shelves Bioregion.

PBGB LOMA Integrated Management Plan

The Placentia Bay/Grand Banks Large Ocean Management Area Integrated Management Plan (2012-2017) is a multiyear, strategic level plan for the integration of policies, programs, plans, measures and activities in or affecting the Placentia Bay/Grand Band Large Ocean Management Area (PB/GB LOMA). The Integrated Management Plan (IM Plan) was intended to provide a long-term direction for the development and implementation of action plans based upon priorities identified for environmental, social, cultural, and economic sustainability. The IM Plan follows an objectives based management approach with three overarching goals broken down into operable units, strategies and action plans for planning purposes. In order to focus these strategies for implementation, 4-5 priorities were identified for each of the three Goals. Priorities and objectives identified in this plan were used to develop draft SE objectives and indicators in early WGNARS work. A status report, highlighting the activities and initiatives taken in relation to these priorities is currently being developed.

NAFO Working Group on Ecosystem Science and Assessment

WGESA, the NAFO working group on Ecosystem Science and Assessment, was established to advise NAFO on aligning operations with the precautionary principal and the ecosystem approach to managing NAFO stocks, to advise on the protection of vulnerable marine ecosystems (VMEs) and to advance progress on the NAFO Roadmap to development of the ecosystem approach to fisheries (http://www.nafo.int/science/science.html). WGESA has long-term terms of reference and responds to specific requests from NAFO Scientific Council or Fisheries Commission. Much of the work of this group has focused on VMEs, the status and function of the marine ecosystem and applications to fisheries management. More recently, they have conducted a review of potential effects of other human activities with the NAFO convention area on fish and fish habitats.

At the most recent WGESA meeting in November 2015, the possibility of combining WGESA with WGNARS was discussed. There is precedent for joint ICES/NAFO working groups and it was thought that given the similarities in mandate and membership for the two groups that this might reduce duplication and time demands. This possibility was discussed at the WGNARS meeting, with an agreement that exploration of this topic should continue, but not impede the planning of WGNARS' future work.

United Nations Assessments

The World Ocean Assessment (WOA) has been released by the United Nations Convention on the Law of the Sea (UNCLOS). Although lacking policy analysis, the WOA presents the best information available on the status and trends of all ocean use industries and biodiversity at global and large-region scales. The biodiversity trends are delineated by major ocean basins, important species groups, and special marine habitats. WOA 1 is currently under review by member states and stakeholders. The *ad hoc* Working Group of the Whole (the United Nations General Assembly plenary for the WOA) will be meeting in August to review the input and plan for WOA 2. The

First Global Integrated Marine Assessment is now available on the website of the Division at www.un.org/Depts/los.

The Intergovernmental Panel on Biodiversity and Ecosystem Services Regional Assessments (IPBES) is modelled directly on the Intergovernmental Panel on Climate Change (IPCC). It hopes to repeat the success of that group in taking a topic that is inherently complex (biodiversity and ecosystem services), where a range of "expert opinions" have advocate in policy debates, the policy questions have large socio-economic implications, and there is agreement that time is running out for decisive actions to be taken.

After a successful pilot (Global Assessment of Pollinators), the IPBES Plenary approved four Regional Assessments – Europe and Central Asia, Southeast Asia and Oceania, Africa, and The Americas. Each of the four assessments has the same chapter structure:

1) Introduction (history of IPBES, scope and objectives of the assessment, general structure of the assessment, etc.);
2) Recent trends in human well-being, and how those trends are linked to trends in biodiversity;
3) Trends in Biodiversity, and how those trends are linked to various natural, social, and economic drivers;
4) Trends in the drivers;
5) Scenarios with different trajectories for the drivers;
6) Policy options and enabling factors to increase or decrease the likelihood of achieving different scenarios.

Several things make the IPBES assessments ground breaking. First, they acknowledge the existence of multiple knowledge systems, and give Indigenous Knowledge and Local Knowledge (ILK together) equal status with "scientific knowledge systems." This is being taken very seriously, rather than making the scientific knowledge system the primary basis for the assessment, and using ILK to plug holes or provide a Text-box here and there.

Second, they are decoupling the concepts of Ecosystem Services, Human Valuation Systems and Benefits. Just as IPBES acknowledges ILK as inherently of value in their own right, they also acknowledge that different cultures value the same ecosystem services in different ways, and no one value system is more or less legitimate than another. This has forced them to confront the complex but important reality that it is often the cultural services of an ecosystems where a) different societies trying to share an ecosystem often differ most in their valuations, b) monetized valuation approaches work most poorly, and c) some cultural services (e.g. identity for many Indigenous Peoples) are actually covered under Human Rights legislation, and Human Rights cannot be traded.

Third, there is a large demand for social sciences, and they are far better represented on the IPBES assessments than in traditional IEA groups.

These are all complex topics, but IPBES has had internal Expert Groups working on all of them; and many excellent reports and guidance documents on these and other topics are available on the IPBES website.

The most recent IPBES Plenary just confirmed that all the Regional assessments are expected to cover out to the 200 mile EEZ. The First-order draft is due within weeks, but is only for internal review, and there will be a Second-order draft due in the late fall. Many of the Regional assessment teams, including the Americas, may be looking for marine expertise to add to their teams of authors.

List of ToR b) strategic objectives, ToR d) operational objectives, and ToR c) indicators for objectives.

The management objectives can be broadly broken down between countries as well as between conservation and social objectives (the distinction between the latter two made because of the fact that conservation objectives are often specified with no consideration of social objectives). The alphabetically-identified strategic goals are followed by numerically-identified (long-term plan/project specific) objectives, which in turn are followed by operational (task-specific benchmark) objectives. The primary resource for deriving these goals was the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, US Public Law 109-479.

US Conservation Objectives

A. Healthy biomass and productivity of harvested and other species

1.Maintain fishing mortality within target reference points

- a) Individual harvested species fishing mortality below threshold;
- b) Limit disturbance in reproductively-important areas/seasons below threshold;
- c) Maintain incidental mortality of non-targeted species within acceptable levels.

2.Protect and/or facilitate recovery of at-risk or depleted species

3.Individual species mortality below threshold

4.Maintain total harvested species biomass above a dynamic biomass threshold

- a) Limit system-level fishing mortality below threshold;
- b) Limit total system removals below system threshold;
- c) Maintain harvested fisheries biomass above ecosystem level limit reference point (LRP).

B. Healthy trophic (ecosystem) structure

1.Maintain size structure within acceptable limits

- a) Large fish indicator/index.

2.Maintain trophic structure within acceptable limits

- a) Mean trophic level of catch;
- b) Marine trophic index of the community;
- c) Mean trophic level of the community;
- d) Mean trophic level of the modelled community.

3.Maintain functional group/guild structure within acceptable limits

- a) Functional group/guild biomass across ecosystem components.

C. Conservation of habitat integrity

1.Maintain habitat productivity

2.Maintain habitat diversity

3.Maintain habitat structure and function for harvested species

4.Minimize risk of permanent (> 20 years) impacts

US Social Objectives

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

1. Optimize Food
   a) Percentage of landings used as domestic food.
2. Optimize Profits
   a) Reported Commercial revenue;
   b) Survey-calculated recreational for-hire revenue.
3. Optimize Employment
   a) Model-derived total employment from both recreational and commercial fishing.
4. Optimize Recreation
   a) Survey-calculated angler trips.
5. Optimize Stability
   a) Fleet diversity;
   b) Model-derived income from both recreational and commercial fishing;
   c) Model-derived expenditures from both recreational and commercial fishing;
   d) Model-derived value-added sales from both recreational and commercial fishing.

Canadian Objectives

Overarching Conservation Goal: Sustainable Aquatic Ecosystems

1. Maintain healthy biomass and productivity of harvested and other species
2. Support conservation of biodiversity at local, regional, and national scales
3. Protect and/ or facilitate recovery of at-risk or depleted species
4. Maintain habitat integrity, including structure and function

Overarching Social Goal: Economically Prosperous Maritime Sectors

1. Optimize ocean sector[1] revenues
2. Optimize ocean sector[1] employment

ToR c) Identification of System Drivers and indicators for said drivers

The following large-scale drivers were identified for both the US (Georges Bank, Gulf of Maine) and Canadian (Grand Banks) ecoregions unless otherwise noted. Nested under each driver is the indicator selected to assess the state of the driver.

A. Tidal Forcing (Georges Bank, Gulf of Maine)

   No indicator, but the process was noted as being extremely important in the system dynamics on both Georges Bank and the Gulf of Maine.

1 * Oceans sector = e.g. fishing, aquaculture, petroleum exploration and production, marine transportation, tourism etc.

B. Winds (Georges Bank, Gulf of Maine)
   1) Total Windstress
   2) East-West Windstress
   3) North–south Windstress
C. Air Temperature
   1) Seasonal Time-series of air temperature
D. Source Water
   1) Labrador Current Volume Transport (Gulf of Maine, Grand Banks)
   2) Cold intermediate layer thickness (CIL) (Grand Banks)
E. Water Temperature
   1) Summer Extended Reconstructed Sea Surface Temperature (US coastwide, Grand Banks)
   2) Winter Extended Reconstructed Sea Surface Temperature (US coastwide, Grand Banks)
   3) Surface Temperature (Georges Bank, Gulf of Maine, Grand Banks)
   4) Bottom Temperature (Georges Bank, Gulf of Maine, Grand Banks)
F. Salinity (Georges Bank, Gulf of Maine, Grand Banks)
   1) Bottom Salinity
   2) Surface Salinity
G. Stratification (Georges Bank, Gulf of Maine, Grand Banks)
   1) 0–50 Meter Stratification
H. Freshwater Input (Georges Bank, Gulf of Maine)
   1) River Discharge
I. Ice Cover (Grand Banks)
   1) Timing of sea-ice retreat
   2) Maximum ice volume
J. North Atlantic Oscillation (Grand Banks)
   1) NAO Index

ToR b) Conceptual models

The conceptual models became a key component, and product, of the WGNARS work, allowing the integration of knowledge across disciplines and standardizing the manner in which information was incorporated into the work. A separate conceptual model was created for each ecoregion: Georges Bank, Gulf of Maine, and Grand Banks. The conceptual models themselves contained two separate components.

The first was a flow-chart representation of the system, which details the focal components, large-scale drivers, objectives, and the linkages between each, including sign, magnitude, and direction of the linkages. An initial overview model for each region was developed at the 2015 WGNARS meeting. For the 2016 meeting, Mental Modeler, a versatile collaborative modelling software, was used to develop both the US and Canadian conceptual models. Separate submodels were developed for the biological, physical, and social components of the system and then merged into a full model. Examples of the US Gulf of Maine submodels are presented in Figures 5.3-5, and the Canadian full-system model can be found in Figure 6. Generating each submodel separately allowed the lens to be shifted between disciplines (for example, the most important species from a foodweb perspective is not necessarily the most important to the commercial/recreational fishery), and provides a fuller representation of the key system components. As previously mentioned, the US conceptual model has been presented to the Mid-Atlantic Fishery Management Council, with positive feedback regarding the representation.

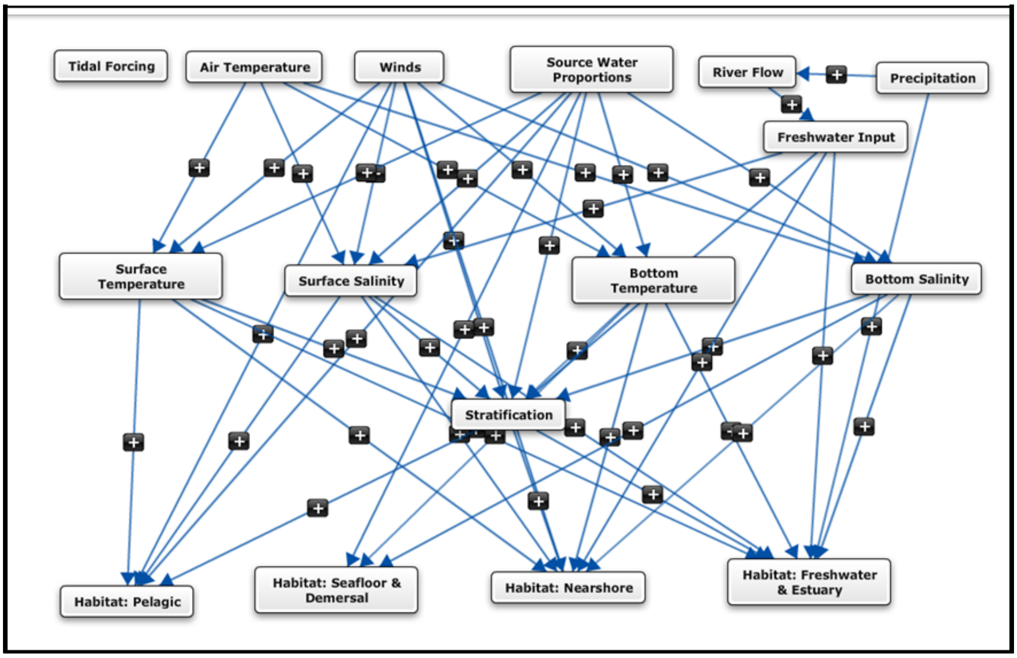

Figure 5.3. Gulf of Maine Climate submodel.

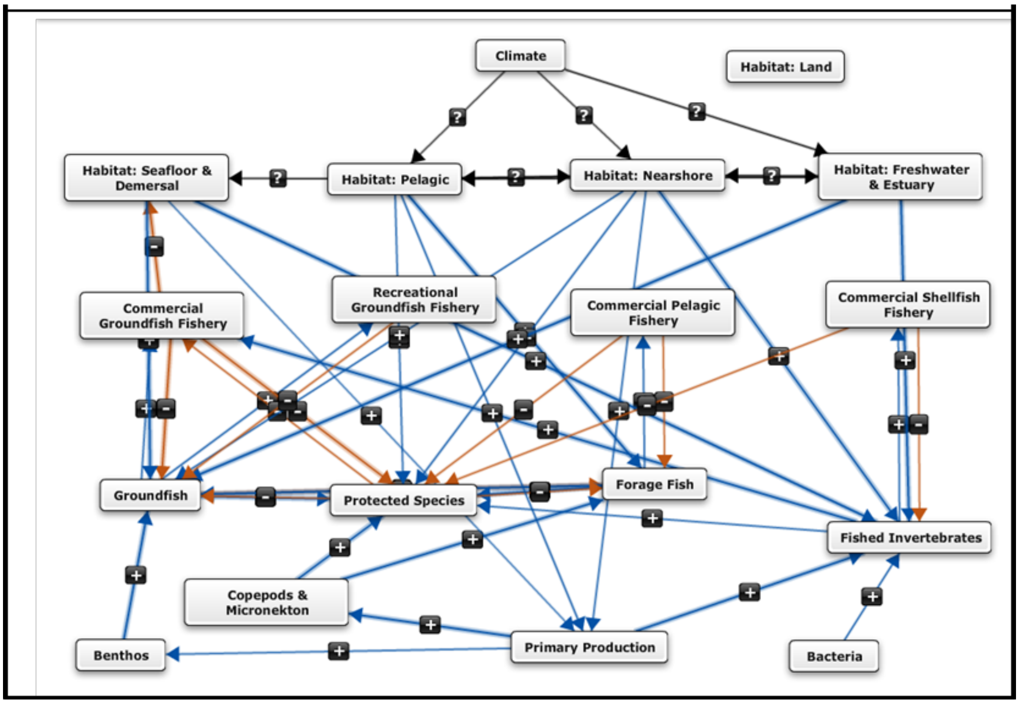

Figure 5.4. Gulf of Maine Ecological submodel.

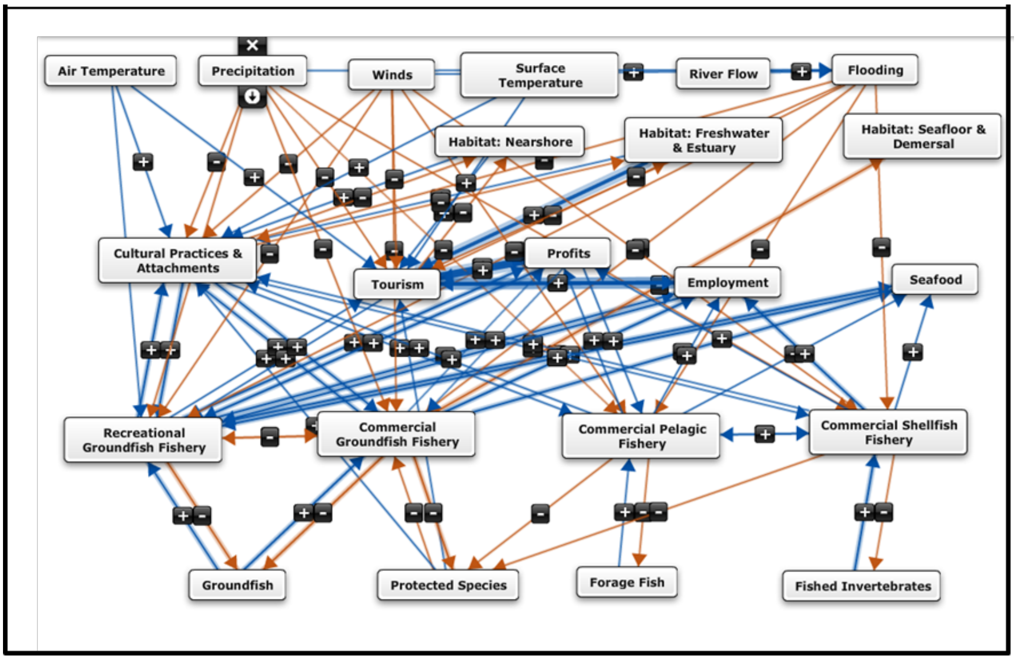

Figure 5.5. Gulf of Maine Human Dimensions submodel.

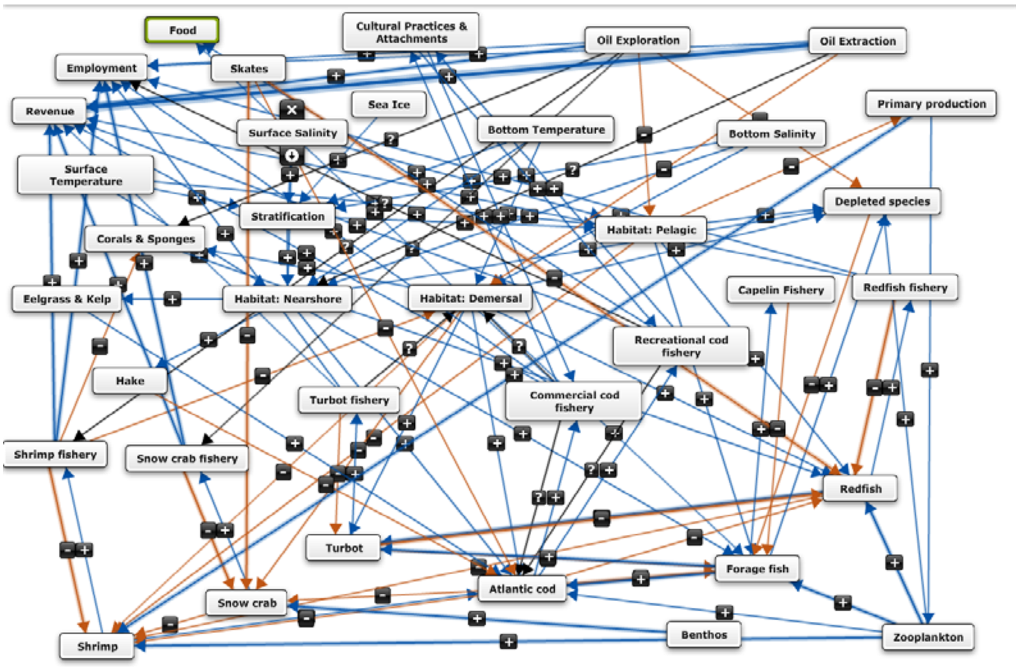

Figure 5.6. Grand Banks Conceptual Model example: overall system linking environmental drivers, human activities, ecological interactions, and societal benefits for key ecosystem components.

The second component of the conceptual models is the support table, which provides transparency for the rationale underlying the linkages delineated in the visual representation of the conceptual models. This documentation also allows for reproducibility, generally agreed to be a key component of the scientific process. An entry of the support table is presented in Table 5.1, slightly modified to fit in the report. Of note is that both the conceptual model and support table are static and linear, in that they represent linkages within a prescribed time horizon. This topic will be addressed in more detail through the discussion of the MSE approaches and results.

Beyond recognizing the static nature of the relationships represented, the support table is key in documenting the nuances that are lost when aggregating species, fleets, or other system components in a conceptual representation. For example, although both the Georges Bank and Gulf of Maine models incorporate a commercial shellfish fishery, the species harvested and technology employed in each is different. In the Gulf of Maine the primary shellfish fishery is a pot fishery targeting lobsters, while a dredge fishery targeting scallops is the dominant component of the Georges Bank shellfish fishery. These nuances have important ramifications regarding the linkages between the shellfish fishery and other components of the system, which is detailed in the support table.

Table 5.1. Single entry for the support table underlying and describing the conceptual models developed for the US ecoregions. Each link detailed in Figure 5.3 has a similar entry.

	FROM		TO					
Submodel	Focal Component	Focal Element	Linked Component	Linked Element	Link Description	Link Magnitude	Link Uncertainty	Supporting Information
Ecological Interactions	Georges Bank Forage Fish	Georges Bank Commercial small pelagics	Georges Bank Groundfish	Georges Bank Groundfish	Prey	++	Low, based on food habits data	Summed flows from EMAX across demersals: omnivores, benthivores, piscivores to characterize total groundfish. EMAX dominant foodweb flows; include > 10% as +; > 20% as ++ link magnitude

ToR d) List of alternative management strategies and ToR e) methods for MSE

WGNARS employed a qualitative MSE to assess the sensitivity of results across different base years. The goal of this approach is to assess the robustness of simple management strategies across different scenarios, defined here as periods corresponding to differences in system drivers. During the 2015 WGNARS meeting, two separate periods (1995–1999 vs. 2010–2014) were identified for assessing the impact of large-scale drivers on MSE outcomes, and these are the scenarios referred to throughout this report. The strategies themselves corresponded to changing fishing pressure on each fishing fleet between the two scenarios, and involved assessing relative changes in outcomes related to the previously identified objectives.

The scenarios for each ecoregion differed slightly, and were drawn directly from the indicators and detailed in the conceptual model support tables, all of which are described above. As an example, the magnitudes for three indicators in the Georges Bank ecoregion were substantially different between the two scenarios, with the threshold for substantial being set at greater than one standard deviation (either positive or negative) from the 1995–1999 level (Figure 5.7). This information was then used to scale the magnitude of the effect these focal components exert on directly linked components of the system. Additionally, the functional form linking some of the components is theoretically non-linear, while qualitative models tend to assume linearity, or a local linear approximation of a non-linear functional form, which are most appropriate to marginal changes in the system. In order to better approximate these non-linearities, the linkages between surface temperature and pelagic habitat was changed from low positive to low negative, indicating an inflection in the functional relationship between water temperature and habitat suitability.

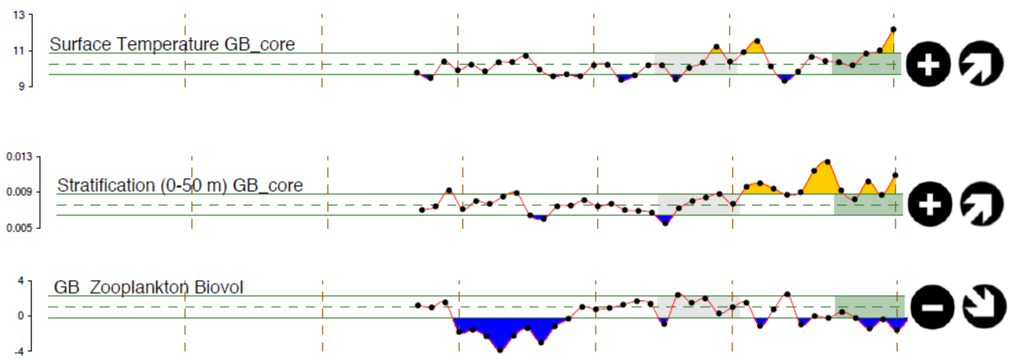

Figure 5.7. Magnitude and trend for difference between 1995–1999 and 2010–2014 scenarios for the three indicators for which the magnitude was substantially different in Georges Bank.

Three separate modelling software packages were selected for the MSE completed in fulfilment of ToR e), with each briefly detailed below.

Mental Modeler

Mental Modeler is a software package that allows the user to build Fuzzy-logic Cognitive Maps, which is a parameterized form of concept mapping (Kosko, 1986; Gray *et al.*, 2013). These maps are used to create qualitative static models, which are translated into semi-quantitative dynamic models using fuzzy math. The methodology parallels the derivation of the conceptual maps, with nodes representing the focal model components and the linkages between the nodes limited to six strengths: H- (-1.0), M- (-0.5), L- (-0.25), L+ (0.25), M+ (0.5), H+ (1.0). A link can also be set to indeterminate, which mathematically is the equivalent to the link not existing, but can be used to indicate a theoretical link with indeterminate sign and magnitude. A stable state is generated from the created model, and a scenario can be run by fixing a box to one of the same values allowed to be set for the link strengths. Mental Modeler then calculates a new stable state and displays the results in a bar chart showing direction of change for each box.

Qpress

Qpress is a stochastic qualitative network modelling software package available for the R program (Melbourne-Thomas *et al.*, 2012; R Development Core Team, 2015). Theoretically, the model relies on differential equations representing the system of interest (in our case, the focal components of the system). Operationally, a community matrix is developed, with each cell of the matrix representing a steady-state linearized approximation to the partial derivative of the system of equations with respect to the focal components and drivers of the conceptual models (defining the linkages between the drivers and focal components). Each cell of the community matrix is represented by signed diagraphs (either positive, negative, or zero values). In each simulation, a random value is drawn from (0,1] for the positive or negative cells in the matrix, retaining the appropriate sign. The stability of the matrix is then assessed, which corresponds to checking that all eigenvalues are negative. If unstable, the matrix is discarded and another random draw is initiated. If stable, the system is perturbed, which in our case corresponds to the employment of management strategies, and the impact of this perturbation (positive or negative) is assessed for each focal component.

LoopAnalyst

Qualitative loop analysis (Levins, 1974; Dambacher *et al.*, 2003) was applied to the conceptual model of the Georges Bank social-ecological system by adapting the conceptual model into a signed digraph, retaining directed links with their positive and negative influences but removing link scalar magnitudes. This signed digraph can be represented by the community matrix, which assumes system components within columns affect other components in the rows of the matrix. Loop analysis assumes linear relationships between network components, which are defined in the elements of the community matrix. Negative self-regulation of all elements was imposed to ensure stable equilibrium of the system (Justus, 2005) (i.e. all diagonal elements of the community matrix were assumed negative). Press perturbations (Dambacher *et al.*, 2003) were simulated for each component to reflect a sustained increase in a component until the system reached equilibrium. Press perturbations were calculated as the adjoint of the negative community matrix using the LoopAnalyst package in R (R Development Core Team, 2015). The resulting matrix indicates the qualitative effect (positive or negative) on each component in the system identified down the rows of a column corresponding to the increased system component. The elements of the press perturbation matrix can be interpreted as the cumulative indirect feedback that the system has on the row components, given an increase in the column component. The weighted feedback matrix was also calculated for the Georges Bank system as the absolute value of the adjoint matrix elements divided by the total number of feedback loops involving that system component. Values below 0.5 in the weighted feedback matrix indicate a large number of potential pathways to the affected component.

ToR e) Results of methods applied for NW Atlantic systems

There are a number of margins on which comparison of MSE results are of interest. The first is comparing the same strategy across scenarios within the same modelling software. Thus, for example, a decrease in the pelagic fishery in the 1995–1999 scenario results in different outcomes than a decrease in the pelagic fishery in 2010–2014 scenario (Figure 5.8). Whereas the decrease in fishing pressure resulted in nine desirable outcomes in the 1995–1999 scenarios, only eight desirable outcomes occur using the same strategy in the 2010–2014 scenario. Although preliminary, these results underline the importance of system drivers on strategy outcomes.

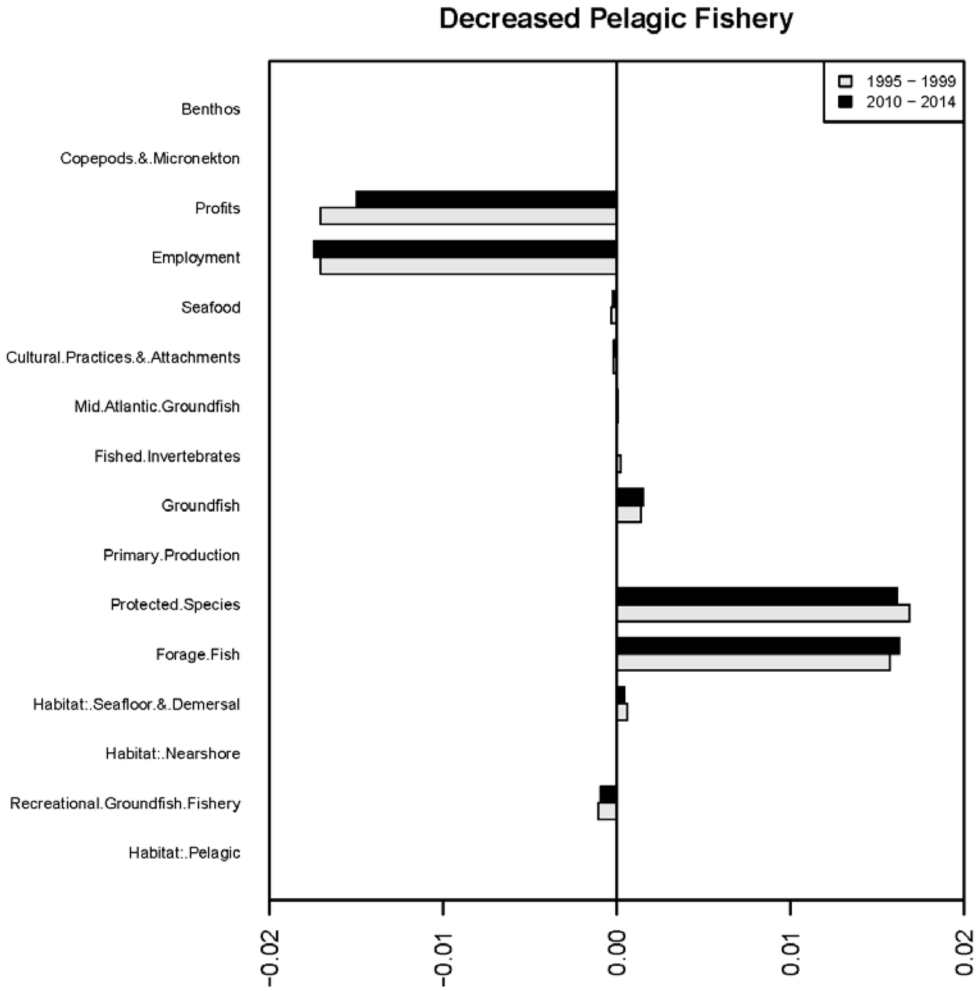

Figure 5.8. Mental Modeller results for decreasing fishing pressure on forage fish in the Georges Bank ecoregion for two different scenarios

The second margin of interest is comparing the same strategy and same scenario across two different software packages. Figure 5.9 presents the results of the decrease in the pelagic fishery within the 1995–1999 scenario, as assessed through Qpress. As a stochastic software, the results of the decrease in fishing pressure are assessed through simulation, and Figure 5.9 presents the percentage of the 1000 simulations generating negative (black), neutral (dark grey), and positive (light grey) outcomes. In contrast to mental modeller, the impact of a decrease in fishing pressure on forage fish is indeterminate, with an equal number of positive and negative outcomes likely, due to the high levels of natural mortality. This differential impact on forage fish underlines the importance of multi-model inference, although more work is necessary in understanding how best to combine the outcomes of different models with respect to management advice.

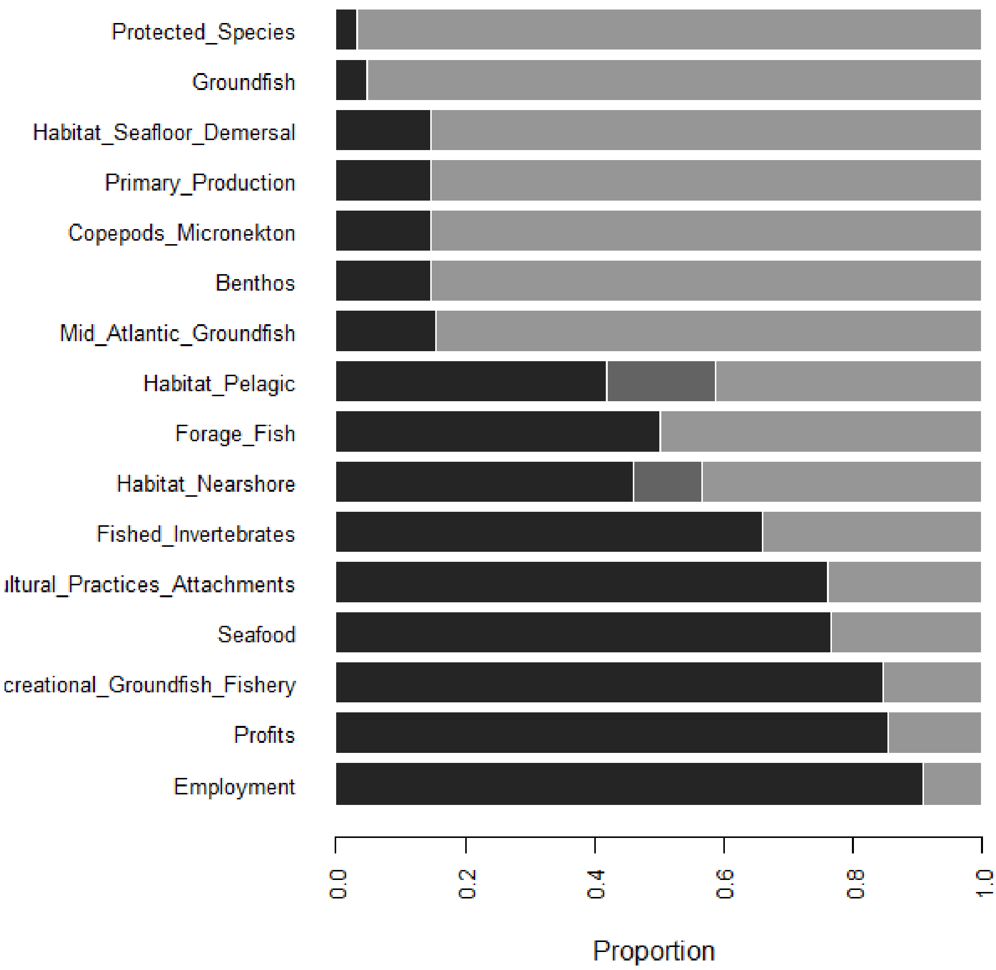

Figure 5.9. Qpress results for decreasing fishing pressure on forage fish in the Georges Bank ecoregion for the 1995–1999 scenario. Black = Negative outcomes, Light = Positive outcomes, Medium Grey = Neutral outcomes.

A third margin of interest is assessing the same strategy across different ecoregions, as presented in Figure 5.10, in which the mental modeller results are presented for the decreased pelagic fishery pressure strategy for both the 1995–1999 and 2010–2014 scenarios in the Gulf of Maine ecoregion. Although the number of desirable outcomes are the same across scenarios for the decrease pelagic fishery strategy in the Gulf of Maine, the 2010–2014 scenario leads to an additional undesirable outcome of the strategy. This is in contrast to the Georges Bank results, in which the number of neutral and undesirable outcomes are constant across scenarios. Thus, preliminary results indicate that the shift in underlying drivers is affecting each ecoregion differently. This means that the spatial resolution of the model is likely an important component of assessing system variability and outcomes, as these differences would not have been identified within the combined Georges Bank and Gulf of Maine model originally envisioned for this work.

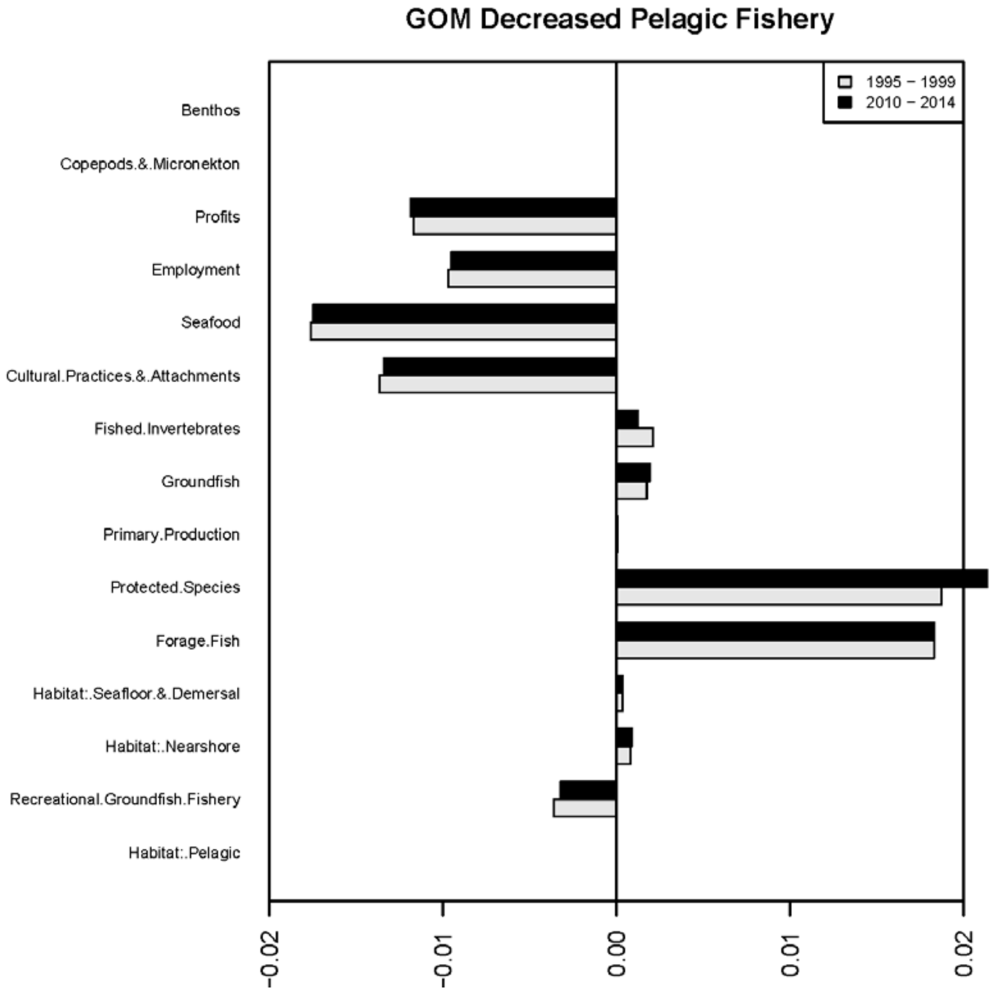

Figure 5.10. Mental Modeller results for decreasing fishing pressure on forage fish in the Gulf of Maine ecoregion for two different scenarios

It is expected that the full suite of results will be published as a separate product to be developed over the coming months.

6 Cooperation

WGNARS has been informally collaborating with the NAFO WGESA, for which there is crossover in membership. There is a desire to assess the practicality and utility of merging the two groups formally, and this will be explored over the coming year.

7 Summary of Working Group self-evaluation and conclusions

A copy of the full Working Group self-evaluation should be included in the report as an annex.

8 References

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Annex 1. 2016 List of participants (subset of individuals that actually contributed to work in 2015 and 2016)

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Annex 2. Recommendations

RECOMMENDATION	ADRESSED TO
1.WGNARS should meet in 2017 in Dartmouth, NS, Canada	SSGRSP
2.Guidance and best practices should be developed on integrating Human Dimensions into IEA work	SSGRSP

Annex 3. WGNARS new terms of reference

Working Group on Northwest Atlantic Regional Sea (WGNARS), co-chaired in 2016 by Geret DePiper, USA and Robin Anderson, Canada will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2017	March 2017	Canada	Interim report in 2017 to SSGRSP	New Canadian Chair will be appointed
Year 2018	March 2017	Falmouth, USA	Interim report in 2018 to SSGRSP	
Year 2019	March 2017	Canada	Final report in 2019 to SSGRSP	New US Chair will be appointed

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. Compile and provide guidance on best practices for each step of integrated ecosystem assessment.	a) Science Requirements: see below b) Advisory Requirements: none	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 27	3 years (2017,2018,2019)	Summary review paper of lessons learned for each step of the process in the Northwest Atlantic using results from 2019, ToRs b, c, d, e below. Brief interim progress reports to ICES (2017, 2018).

b	Adopt process for evaluating current suite of indicators and assess their ability to provide proactive management advice.	Will utilize methodology akin to gap analysis. Will update and 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 biophysical system uses,and social and economic systems.	1, 6, 7, 8, 9, 10, 11, 14, 18, 19, 20, 21, 22, 23, 27	2 years (2017,2018)	Best practices for quantitative approach to evaluating time-series indicators and integrating qualitative information/knowledge into IEA process (2017). Documentation of knowledge gaps, prioritized using qualitative models developed in 2016 and other appropriate approaches (2018).
c	Develop process for distilling information for management use.	Will require participation by scientific experts in oceanography, habitat, biology, fisheries and other system uses, and social and economic systems.	1, 6, 8, 9, 10, 11, 14, 17, 18, 19, 22, 23	2 years (2017,2018)	Best practices surrounding the communications of indicator meaning, uncertainty, and results to stakeholders (2017,2018).

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
d	Assess system productivity under shifting oceanographic processes and improve integration into IEA products.	Will develop concept of habitat beyond a mediating component, and fully link to benefits derived from the system using semi-quantitative and qualitative models. Will reconcile place-based and process based models, and shifting drivers.	1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 14, 15, 16, 17, 18, 19, 21, 22, 23	2 years (2017,2018)	Updated qualitative models from 2016 MSE with more rigorous treatment of linkages between ecological system drivers, habitat, and benefits (2017,2018).
e	Evaluate approaches to integrating multi-spatial scale models into integrated management advice.	Will assess and develop advice from multiple models at different spatial resolution. Will expand analysis in ToR f beyond current focus on a single underlying "model" assessed through multiple qualitative software packages.	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 14, 15, 17, 18, 19, 21, 22, 23	2 years (2018,2019)	Develop suite of alternative models that can be used in MSE context (2018,2019).
f	Evaluate ecosystem trade-offs using a range of management strategy evaluation (MSE) methods.	Assess robustness of strategies to underlying assumptions. Evaluation of uncertainty surrounding models and indicators using simulation.	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 14, 15, 17, 18, 19, 21, 22, 23	1 year (2019)	Use results of ToR b, c, d, e to investigate robustness of management strategies to different underlying assumptions in scale, system linkages, and baseline (2019).

Summary of the Work Plan

Year 1	Develop process for assessing and communicating indicators, refine existing models.
Year 2	Develop alternative models representing marine ecological and human systems at multiple scales.
Year 3	Evaluate the robustness of alternative management strategies to achieve candidate operational objectives given alternate models developed.

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 marine 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 this 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 (e.g. the Workshop on Benchmarking Integrated Ecosystem Assessments) and other groups and workshop within ICES (e.g.the Working Group on Marine Systems).
Linkages to other organizations	The NAFO Working Group on Ecosystem Science and Assessment has made progress toward similar objectives and will be a resource for collaboration.

Annex 4. Working Group self-evaluation

1) **Working Group name:** Working Group on the Northwest Atlantic Regional Sea

2) **Year of appointment**: 2013

3) **Current Co-Chairs:** Geret DePiper (US), Robin Anderson (Canada)

4) **Venues, dates and number of participants per meeting:**

3–7 February 2014, Falmouth, MA, (33)

23–27 February 2015, Dartmouth, CA, (20)

21–24 March 2016, Falmouth, MA, (23)

WG Evaluation

5) **If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.**

The WGNARS work contributes towards the following Priority Areas of the ICES 2014–2018 Science Plan:

1. Assess the physical, chemical and biological state of regional seas and investigate the predominant climatic, hydrological and biological features and processes that characterize regional ecosystems

2. Quantify the nature and degree of connectivity and separation between regional ecosystems

3. Quantify the different effects of climate change on regional ecosystems and develop species and habitat vulnerability assessments for key species

4. Understand the influence of climate impacts across a range of temporal and spatial scales, from local to global and from seasonal to multidecadal and identify indicators of climate driven biotic responses and forecast trajectories of change

6. Investigate linear and non-linear ecological responses to change, the impacts of these changes on ecosystem structure and function and their role in causing recruitment and stock variability, depletion and recovery.

7. Develop end to end modelling capability to fully integrate natural and anthropogenic forcing factors affecting ecosystem functioning

8. Define and quantify North Atlantic Ecosystem Goods and Services, model their dependence on ecosystem processes and habitat condition and their social, economic and cultural value.

9. Identify indicators of ecosystem state and function for use in the assessment and management of ecosystem goods and services

10. Develop historic baseline of population and community structure and production to be used as a basis for population and system level reference points.

11. Develop methods to quantify multiple direct and indirect impacts from fisheries as well as from mineral extraction, energy generation, aquaculture and other anthropogenic activities and estimate the vulnerability of ecosystems to such impacts.

12. Develop approaches to mitigate impacts from these activities, particularly reduction of non-target mortalities and enhancement/restoration of habitat and assess the effects of these mitigations on marine populations

14. Evaluate ecological, economic and social trade-offs between ecosystem protection and sustainable use to advise on management of human activity in marine ecosystems

15. Develop tactical and strategic models to support short and long-term fisheries management and governance advice and increasingly incorporate spatial components in such models to allow for finer scale management of marine habitats and populations

17. Develop science in support of advisory needs in marine aquaculture systems, minimizing environmental impacts and integrating other marine sectors

18. Identify objectives for IEA's that address ecosystem stability and health, taking cognizance of ecological, social and economic sustainability goals as well as multi scale issues

19. Identify issue based ecosystem questions relevant to science and management needs that can be addressed by developing IEA's

21. Conduct pilot studies in data rich areas for alternative IEA approaches, linking quantitative and qualitative methods at appropriate spatial and temporal scales

22. Determine and demonstrate what modelling and analytical approaches will allow projections of ecosystem states in IEA's

23. Use IEA's to in informing management about the effects of cumulative pressure and additive and non-additive impacts, and which provide risk evaluations and analyses of trade-offs between sectoral objectives.

6) **In bullet form, list the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc.**

- List of management objectives for study ecoregions in US and Canada
- Inventory of indicators for tracking performance of system in relation to management objectives and large-scale system drivers
- Conceptual models linking large-scale drivers to human activities and benefits derived from the system
- Qualitative model outputs from multiple softwares (Mental Modeler, Qpress, Loop Analyst) generating MSE output
- ICES ASC 2014, Theme Session C: One Size Does Not Fit All – What Does an Integrated Ecosystem Assessment Mean to YOU?
- ICES CM 2014/3581 C:02 Presentation entitled "Describing the "Integrated" in Integrated Ecosystem Assessments"
- ICES CM 2014/3825 G:38 Presentation entitled "Towards Operational Assessments: Selection, Vetting, and Standardized Analysis of Ecosystem Indicators for the Northeast US Large Marine Ecosystem
- ICES CM 2015/ M:18 Poster entitled "Seeing the forest and the trees: Application of hierarchy theory to integrated ecosystem assessment"

7) **Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.**

WGNARS has not directly contributed towards ICES advisory needs.

8) **Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly**

emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

WGNARS members have participated in WGESA, the NAFO working group on Ecosystem Science and Assessment. The preliminary WGNARS conceptual model and list of objectives developed at the 2015 WGNARS meeting were presented to the US Mid-Atlantic Fisheries Management Council (MAFMC), as part of their Species Interactions Workshop held in June, 2015, and again at their Habitat Workshop in October, 2015. The US goals and objectives developed at the 2015 WGNARS meeting have also been presented to the US New England Fisheries Management Council, where they have been incorporated into drafts of both the Risk Policy and Fisheries Ecosystem Plan currently under development. In Canada, the WGNARS work has informed the development of both conservation and Social and Economic objectives for MPA Network planning in the NL Shelves Bioregion.

9) **Please indicate what difficulties, if any, have been encountered in achieving the workplan.**

The major difficulties encountered in the WGNARS work was its lack of direct funding, and concurrent reliance on volunteerism, and the time needed for such a diverse interdisciplinary working group to shift from discussion to modelling and analysis.

Future plans

10) **Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)**

The group feels that, although substantial progress has been made, IEAs are by definition an iterative process, and that the preliminary models and techniques applied can and should be refined

11) **If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.**

N.A.

12) **What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?**

The group feels that a cross-disciplinary team is key to the continued success of the working group, and would specifically like to ensure the continued engagement of oceanographers and social scientists in what has historically been a biologically-focused enterprise.

13) **Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)**

The conceptual models were an important component of the work conducted by WGNARS and, though most often used for communication with broader stakeholders, their utility in facilitating cross-disciplinary scientific understanding should not be overlooked.