ICES WGNARS REPORT 2017

INTEGRATED ECOSYSTEM ASSESSMENTS STEERING GROUP

ICES CM 2017/IEASG:03

REF. SCICOM

Interim Report of the Working Group on the Northwest Atlantic Regional Sea

6-10 March 2017

Dartmouth, NS, Canada

ICES CIEM
International Council for the Exploration of the Sea
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

Recommended format for purposes of citation:

ICES. 2017. Interim Report of the Working Group on the Northwest Atlantic Regional Sea . ICES WGNARS Report 2017 6-10 March 2017. Dartmouth, NS, Canada. ICES CM 2017/IEASG:03. 19 pp. https://doi.org/10.17895/ices.pub.8611

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Executive summary

The eighth meeting of the Working Group on the Northwest Atlantic Regional Sea (WGNARS), chaired by Robert Gregory (Canada) and Geret DePiper (USA), was held at Northwest Atlantic Fisheries Organization Headquarters, in Dartmouth, NS, Canada, on 6–10 March 2017. The meeting was attended by 16 participants from the US and Canada, with an additional 2 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.

This report reviews WGNARS first meeting since the adoption of a new 3-year Terms of Reference (ToR) after the March 2016 meeting. The primary focus and outcome of the March 2017 meeting was the development of a work plan for the coming years, an issue of particular importance as a substantial amount of WGNARS work is now conducted between annual meetings. Placing emphasis on work between the annual meetings allows for contributions from a broader set of potential collaborators beyond workshop attendees, which we believe translates into a more robust assessment. In support of this, WGNARS has adopted standing virtual meetings every other month across the year to ensure progress toward ToR objectives.

WGNARS will be focusing on a number of specific actions across 2017. The development and integration of salient habitat objectives has been prioritized, in support of ToR d). In preparation for a statistical risk assessment (in likely conjunction with the US Mid-Atlantic Fishery Management Council), WGNARS will be linking indicators to objectives and assessing confidence/uncertainty of the indicators to track structural processes of interest, with the full list of indicators being culled for both statistical redundancy and ease of communication. The conceptual models will be further refined to better incorporate both habitat and commercially–exploited species.

1 Administrative details

Working Group name

Working Group on the Northwest Atlantic Regional Sea (WGNARS)

Year of Appointment within the current cycle:

2016

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

1

Chair(s)

Geret DePiper, US

Robert Gregory, Canada

Meeting venue

Dartmouth, NS, CA

Meeting dates

6–10 March 2017

2 Terms of Reference a) – f)

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).
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).

3 Summary of 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.

4 List of Outcomes and Achievements of the WG in this delivery period

- DePiper *et al.,* 2017. Operationalizing integrated ecosystem assessments within a multidisciplinary team: lessons learned from a worked example. *ICES J Mar Sci* 2017 fsx038. doi: 10.1093/icesjms/fsx038
- Patricia M. Clay co-Convened ASC 2016 Theme Session R
- ASC CM 2016/ R:643 Evolution of integration of Human Dimensions into WGNARS - challenges and possibilities.
- Developed conceptual model of Mid-Atlantic fisheries in the US
- Drafted work plan

5 Progress report on ToRs and workplan

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

5.1 ToR a) Develop IEA capacity, and detail IEA best practices

The process employed in WGNARS previous 3-year ToRs was detailed in DePiper *et al.* (2017), listed in section 3. The paper itself focuses on a discussion of best practices and lessons learned regarding the implementation of the Levin *et al.* (2008; 2009) IEA process, and a preliminary review was presented at the 2016 ASC as CM 2016/ R:643 Evolution of integration of Human Dimensions into WGNARS - challenges and possibilities.

During the 2017 WGNARS meeting, participants developed a flowchart of work expected to be conducted during the current three year ToRs, which is derived from the Levin *et al.*, IEA loop, but provides additional detail (Figure 5.1). This will serve as the work plan for the coming years, to facilitate the achievement of current WGNARS ToRs.

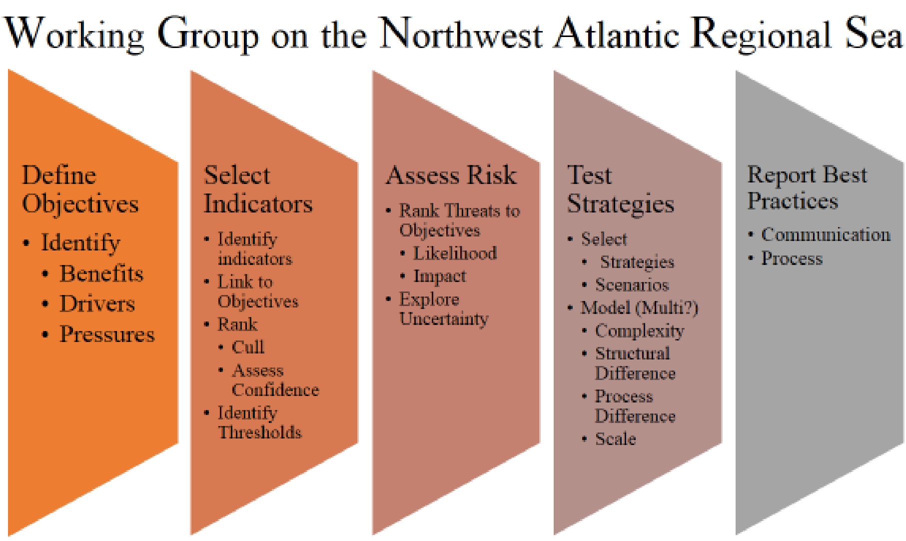

Figure 5.1. Expected work to be completed by WGNAR during the current 3 year ToRs, developed to ensure the consistency of members' expectations.

WGNARS felt this was important in developing a shared vision of the work, and to set expectations appropriately. Given previous products developed by WGNARS, much of the flowchart represents a revision, refinement, and extension of existing work.

Through discussion, WGNARS concluded that effective indicators should adequately describe the underlying processes of interest. In practice, this means that some indicators, such as sea surface temperature, will need to be calculated at an annual, if not sub-annual basis, while others indicators such as structural habitat quality or community vulnerability reflect longer term dynamics that can be adequately tracked at a much longer time-step. Theory will provide guidance as to the time-step at which indicators need be updated, and help efficiently focus limited scientific resources. There was consensus that this should rise to the level of a best practice in IEA development.

Given the focus on building IEA capacity in the Northwest Atlantic, progress on regional and national IEAs having implications for WGNARS work was reviewed during the 2017 meeting. Highlights of these reviews are provided below.

NOAA Northeast Integrated Ecosystem Assessment Program

The discussion of the 2017 State of the Ecosystem (SOE) reports has been folded into the discussion of ToR c) below.

Fisheries and Oceans Canada

In Canada, fisheries management policies are directed under the Fisheries Act, while implementation of ecosystem approaches is directed under the Oceans Act. Fisheries and Oceans Canada (DFO) has developed multiple policies aimed at developing an Ecosystem Approach to Fisheries (EAF).

Significant investments have been made in the past two years to improve science capacity within DFO. The Department is currently focused on developing two main priority areas in relation to both fisheries management and ecosystem management. For the former, DFO is reinvesting into extended single-species stock assessments; while the latter is being supported by heavily directed effort towards meeting Canada's commitments to Aichi Biodiversity Targets (i.e. protection of 5% of marine waters in Canadian by 2017 and 10% by 2020) by investing in new MPAs and analyses of existing area-based measures aimed at developing networks of protected areas.

Multispecies interactions and related trade-offs, while not explicit national priorities, are to some extent covered through targeted national funding and individual projects, e.g. DFO Fisheries Science and Ecosystem Research Program and DFO National Rotational Survey Program, both of these are focused on regional proposal for funding, as well as individual research projects resourced under DFO Strategic Program for Ecosystem Research and Advice (SPERA) and International Governance Strategy (IGS) funding envelopes. Currently, socio-economic and cultural issues remain largely dissociated from the biological-ecological analyses within an EAM framework.

North Atlantic Fisheries Organization

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 relationships among ecosystem components. The process and guiding principles that NAFO is following to achieve this approach are summarized in the organization's "Roadmap for developing an Ecosystem Approach to Fisheries for NAFO" (Figure 5.2). This roadmap represents an implementation of Integrated Ecosystem Assessments tailored to the needs and operational requirements of NAFO. Two fundamental elements of this implementation are a hierarchical approach to define exploitation rates, and the integration of the impacts on benthic communities (e.g. Vulnerable Marine Ecosystems –VMEs) associated with the different fisheries that take place within the ecosystem.

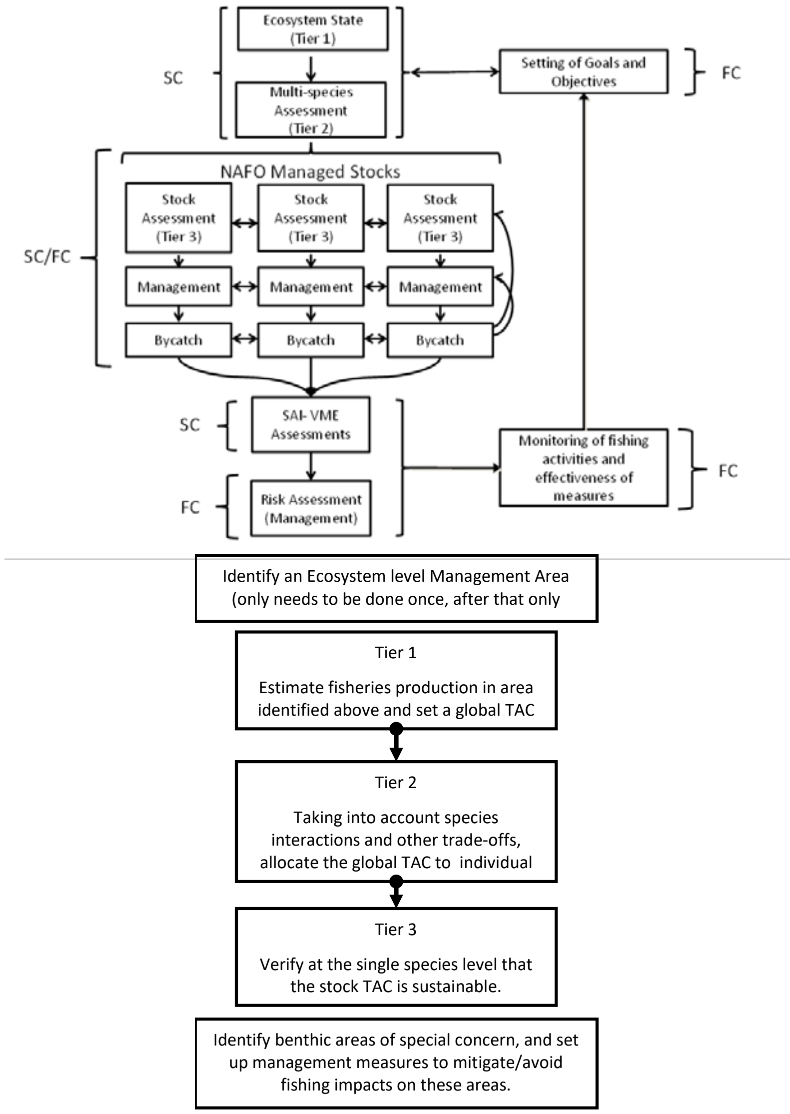

Figure 5.2. Current working template of the NAFO "Roadmap" (left), with a synoptic overview of the key steps required for using it (right). SC: Scientific Council, FC: Fisheries Commission, SAI: Significant Adverse Impact, VME: Vulnerable Marine Ecosystem

One practical feature of this roadmap is its modular conception. This plan is only partially implemented at the present time. Different elements will be brought online as their practical implementation becomes possible. Most progress has been made on the protection of VMEs. However, as these components are reaching maturity a shift in focus towards ecosystem state and multispecies assessments is expected in future years.

There was progress on different components of the roadmap during 2016. NAFO completed its first Assessment of Significant Adverse Impacts (SAIs) on Vulnerable Marine Ecosystems (VMEs), which is expected be repeated every five years henceforth. The results from this assessment prompted additional temporary closures on seapen VMEs, which will be revised in 2018.

NAFO Scientific Council (SC) also updated its guidance on Total Catch Ceilings (TCCs) for the Flemish Cap (3M), Grand Bank (3LNO), and Newfoundland Shelf (2J3K), but at present no management measures have been adopted based on this advice. NAFO

Fisheries Commission (FC) requested further analysis before using this kind of advice in management decisions. NAFO SC also started work in developing summary sheets at the scale of the Ecosystem Production Units (EPUs), which should complement the stock-level summary sheets currently being used for summarizing stock status and trends. There is also an ongoing process aimed at updating the NAFO Precautionary Approach (PA), which includes exploring means by which to incorporate ecosystem consideration within the PA.

However, progress on EAF implementation during 2017 is expected to be somewhat limited compared with previous years. NAFO priorities for 2017 are centered in the Greenland Halibut Management Strategy Evaluation and the 3M Cod benchmarking exercise, both currently single-species exercises.

5.2 ToR b) Evaluation of current suite of indicators and assessment of ability to provide proactive advice.

Catalina Gomez from Fisheries and Oceans Canada presented an overview of an indicator selection and vetting process, which has been adopted by WGNARS for implementation over the coming year. The guidance framework for the selection and evaluation of ecological indicators is described below, and is in preparation for formal publication (Bundy, Gomez, and Cook, 2017).

The published literature on indicator selection criteria was reviewed (Excel table with sources has been added to the WGNARS SharePoint site) to establish a set of eight overarching criteria for selecting ecological indicators: 1) public awareness, 2) coordination and tractability, 3) theoretical basis and ecological significance, 4) measurability, 5) sensitivity, 6) specificity, 7) responsiveness, and 8) redundancy. Although ideally indicators should meet all strategic and scientific criteria, there are limited guidelines concerning whether an indicator should meet all criteria and the extent to which an indicator must meet any single criterion (ICES, 2012). Some criteria may be given more weight than others, depending on the issue being considered (e.g. some criterion may be considered essential or core, and others desirable (Kershner *et al.*, 2011; ICES, 2013)). Furthermore, while some of the selection criteria are first applied qualitatively to screen the initial list of indicators, the same criteria can also be applied more quantitatively and rigorously in a second iteration once indicators are calculated. Overall, assessments should be explicit as to which criteria will be used to screen and select screened indicators using expert opinion and *post hoc* quantitative analysis.

Our literature review resulted in a list of 185 indicators that can be used as proxies for the following ecosystem attributes: Biodiversity, Ecosystem structure and functioning, Ecosystem stability and resistance to perturbations and Resource Potential. Initially, we qualitatively evaluated these indicators based on the following selection criteria: public awareness, coordination and tractability, theoretical basis and ecological significance, measurability, sensitivity, specificity, responsiveness and non-redundancy. This qualitative screening process reduced the number of indicators to 68, and we calculated these indicators from the DFO Research Vessel survey database (43 state indicators) and commercial fisheries landings (24 pressure indicators) over a 42-year period (1970–2015).

The objective of one of the non-redundancy criterion is to reduce the list of indicators to a minimum, parsimonious and complementary suite that addresses all ecosystem attributes or objectives of a given ecosystem (Rice and Rochet, 2005; Blanchard *et al.*, 2010; Greenstreet *et al.*, 2012). We quantitatively evaluated this criterion using two complementary analyses: hierarchical cluster analysis (HCA) and non-parametric Spearman rank correlations. HCA was used to statistically classify indicators into clusters based on their dissimilarities. The correlation between indicators was used to verify the strength of the relationships among indicators to a given cluster, and in some cases, to assign cluster membership. Indicators that were consistently included in clusters were classified as "redundant" and those that were not were "singletons". This redundancy analysis was conducted independently at the large scale (Shelf, Western Scotian Shelf, Eastern Scotian Shelf, and NAFO divisions 4VS, 4VN, 4W and 4X) and small scale (48 strata). Results were then compared to evaluate the consistency among clusters and singletons at all spatial scales. A final stepwise process was used to reduce the number of indicators: 1) indicators were first selected to address each of the ecosystem attributes, subattributes and pressures identified earlier in this project; 2) only one redundant indicator was selected per sub-attribute, and per cluster. This resulted in a suite of 30 non-redundant, complementary indicators representing ecosystem attributes, sub-attributes and fishing pressure in the Scotian Shelf bioregion.

The group further agreed to use the approach applied in Tam *et al.* (2017) to assess thresholds for both the biological system and human benefits being monitored. These thresholds could then be used to provide management advice on system performance. This approach will form a core component of the risk assessment outlined in ToR a). Both indicators for social objectives and ecological dynamics will be assessed, although the group noted that the thresholds will likely be interpreted very differently. Whereas thresholds in the ecological literature are often interpreted as tipping points to be avoided or as indications of shifts in productivity, thresholds across social objectives cannot be interpreted in a similar manner. This is because the trade-offs across social objectives are subjective in nature, with no clear theoretical guidance as to which states are preferable, particularly when dealing with objectives spanning across social disciplines.

5.3 ToR c) Best practices on communication of indicator meaning, uncertainty, and results to stakeholders

WGNARS meeting participants agreed that the culling and ranking of indicators in support of ToR b), as described above, are an integral component of communication best practices, in that only the most salient and informative indicators should be presented to stakeholders. The group also discussed the need to present the data in multiple concurrent channels. While some individuals will be content with figures of indicator time-series and conceptual models, others will prefer a stronger narrative, possibly best delivered through presentations and more informal discussions, while others may like spatial representation of data (e.g. maps).

Beyond these observations, WGNARS held substantial discussions regarding indicator visualization. During the meeting, a draft of the US Mid-Atlantic Fishery Management Council's (MAFMC) SOE report was completed, and Sarah Gaichas presented it to participants. The SOE was substantially redesigned between 2016 and 2017, with the inclusion of a conceptual model to situate the reader, an executive summary detailing an overarching narrative for the report, and direct focus on management objectives, as previously identified through WGNARS work. Figure 5.3 presents the list of objectives, and indicators linked to identified objectives, for assessing system performance.

Ecosystem status: Executive summary

We have organized this report using a proposed set of **ecosystem-scale objectives** derived from US legislation and current management practices. We also report single-species status relative to established objectives and reference points.

Objective Category	Indicators reported here
Seafood production	Landings by functional group, mariculture
Profits	Revenue by functional group
Recreation	Numbers of anglers and trips
Employment	Indicator under development (see p. 4)
Stability	Diversity indices (fishery and species)
Social-Cultural	Community vulnerability, fishery engagement and reliance
Biomass	Biomass or abundance from surveys, biomass relative to reference
Productivity	Condition and recruitment, fishing mortality relative to reference
Trophic structure	Relative biomass of trophic groups
Habitat	Thermal habitat volume, physical properites

Figure 5.3. Executive Summary from draft 2017 Mid-Atlantic Fishery Management Council State of the Ecosystem Report, highlighting objectives and their indicators.

The redesign also included a new indicator representation, which moves towards highlighting only significant information, as determined by Mann-Kendall nonparametric tests for monotonic time-series trends (Figure 5.4). Although the redesign was generally appreciated, some discussion focused on the 10-year window for the short-term trend analysis. Of particular discussion was whether there should be a single length window across all indicators, and whether data or theory can help identify the appropriate window length. These issues will continue to be explored as the report is refined.

Both the New England Fishery Management Council (NEFMC) and MAFMC will be presented tailored SOE reports for their respective regions. There was general agreement that tailoring reports for individual stakeholder groups was an important best practice to promote understanding and relevance.

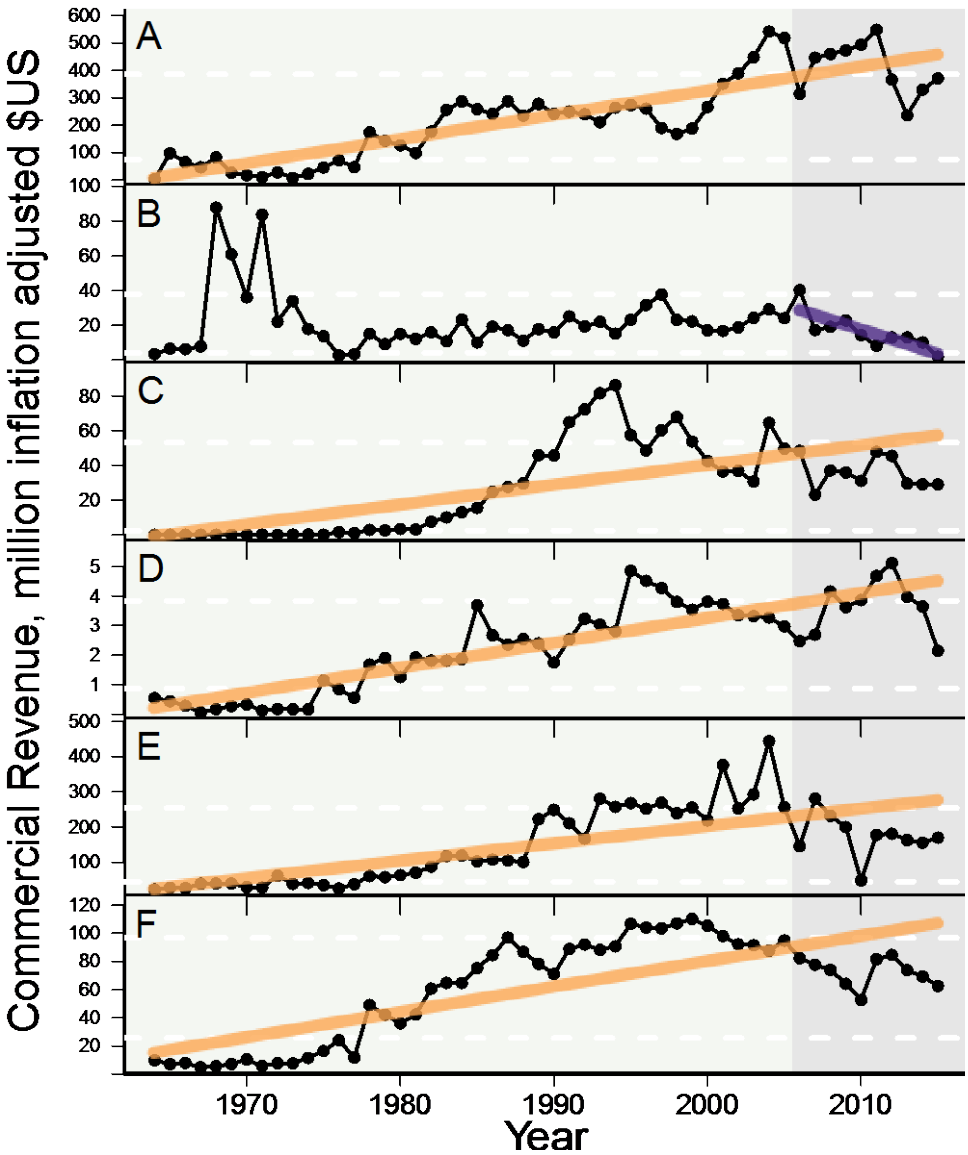

Figure 5.4. Redesigned indicator presentation, with significant long-term trend lines in yellow, and significant 10-year trend lines in purple.

5.4 ToR d) Assess system productivity under shifting processes

WGNARS members agreed that scale plays an important role in how habitat should be incorporated into the models which will ultimately be used in support of ToR f), and that the risk assessment encapsulated in ToR b) will be a critical component of identifying the appropriate spatial scale to model. Though not unique to habitat considerations, the exact model components will not be specified until after the risk assessment and scenarios for strategy evaluation are identified.

Nevertheless, a substantial portion of the meeting was devoted to discussing habitat considerations, particularly within the Canadian contingent. The reason for this was twofold. First, there was substantial Canadian habitat expertise present during the meeting. Second, habitat protection is a core focus of the current Canadian government, particularly in support of both Aichi biodiversity targets and the World Summit on Sustainable Development international agreements (e.g. Fisheries and Oceans Canada 2016).

Work in Canada will expand beyond the current focus on the Grand Banks, to include the Scotian Shelf. WGNARS membership will be expanded appropriately.

5.5 ToR e) Evaluate approaches to integrating multiple spatial scale models

WGNARS participants agreed that this ToR should be clarified to include not only issues of scale, but of scope as well, such that the MSE will encapsulate multiple models/modelling assumptions beyond multiple scales.

Robert Wildermuth provided an update of work he is conducting using Bayesian Belief Networks, and WGNARS participants felt it would be a valuable addition to the suite of models being developed in preparation of the 2019 MSE. Bayesian network methods (McCann *et al.,* 2006) use semi-quantitative descriptions of system characteristics from prior information and expert knowledge to derive inference about multiple system components for which data may be unavailable. Bayesian networks are composed of: 1) a graph describing causal relationships among system components, and 2) the probability relationships between these system components. Each component can have multiple states (e.g. high, low, or average precipitation; greater than or less than 50 000 tonnes of groundfish etc.), and relationships between components and their states can be defined from patterns in the data, theoretical functional responses, or with expert opinion.

The fully specified model ultimately defines the prior joint probability of all component states in the system, and provides probabilistic estimates of how the marine system may respond under various scenarios (Aguilera *et al.,* 2011). For example, the model can be queried for the response of commercial species biomass under current fishing pressure given an increase in sea surface temperature. A Bayesian network can also reflect changes in the probabilities of component states before and after management actions, creating a dynamic Bayesian decision network (Landuyt *et al.,* 2013, Nyberg *et al.,* 2006). Dynamic Bayesian decision networks may provide an efficient means of exploring the effects of model assumptions and management strategies while also considering uncertainty in the simulated projections.

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6 Revisions to the work plan and justification

No revisions are deemed necessary, although ToR e) has been reinterpreted to include multiple models and modelling software.

7 Next meetings

2018 meeting will likely be held in Falmouth, MA, USA, during March.

2019 meeting will likely be held in Dartmouth, NS, CA, during March.

Annex 1: List of participants

Name	Address	E-mail
Geret DePiper	NOAA Fisheries USA	Geret.depiper@noaa.gov
Robert Gregory	Fisheries and Oceans Canada Canada	Robert.gregory@dfo-mpo.gc.ca
Gavin Fay	School for Marine Science & Technology USA	gfay@umassd.edu
Patricia M. Clay	NOAA Fisheries USA	Patricia.Clay@noaa.gov
Sean Lucey	NOAA Fisheries USA	Sean.Lucey@noaa.gov
Catalina Gomez	DFO Bedford Institute of Oceanography Canada	Catalina.Gomez@dfo-mpo.gc.ca
Alida Bundy	DFO Bedfort Institute of Oceanography Canada	Alida.Bundy@dfo-mpo.gc.ca
Danielle Dempsey	Canada	Danielle.Depmsey@dal.ca
Kate Dalley	DFO Bedfort Institute of Oceanography Canada	Kate.Dalley@dfo-mpo.gc.ca
Michael Fogarty	NOAA Fisheries USA	Micahel.fogarty@noaa.gov
M. Robin Anderson	Fisheries and Oceans Canada Canada	m.robin.anderson@dfo-mpo.gc.ca
Fred Phalen	Northwest Atlantic Fisheries Centre Canada	Fred.Phelan@dfo-mpo.gc.ca
Rebecca Shuford	NOAA Fisheries USA	Rebecca.Shuford@noaa.gov
Robert Wildermueth	School for Marine Science & Technology USA	rwildermuth@umassd.edu
Jamie Tam	NOAA Fisheries USA	jamie.tam@noaa.gov
Andrew Applegate	New England Fishery Management Council USA	aaplegate@nefmc.org
Sarah Gaichas	NOAA Fisheries USA	

Annex 2: Recommendations

Recommendation	Adressed to
1. Guidance should be developed on the use of interim meetings between WG annual meetings to broaden participation in IEA work.	IEASG
2. Guidance should be developed in assessing the ability of indicators to track structural processes within the ecosystem, to include statistical redundancy, uncertainty, and communication to stakeholders.	IEASG