

WHITE PAPER

INTEGRATED ECOSYSTEM ASSESSMENTS

Background

The reports of the U.S. Oceans Commission, the Pew Oceans Commission, the Ocean Priorities Plan, and other nationwide reviews highlight the importance of incorporating ecosystem principles in ocean and coastal resource management. Specific to NOAA, a critical objective is to “Protect, Restore, and Manage the use of Coastal, Ocean, and Great Lakes resources through an Ecosystem Approach to Management (EAM)”. An ecosystem approach to management is one that provides a comprehensive framework for marine, coastal, and Great Lakes resource decision making. In contrast to individual species or single issue management, EAM considers a wider range of ecological, environmental, and human factors bearing on diverse societal objectives regarding resource use and protection.

What is an ecosystem?

An ecosystem is defined by NOAA as:

“An ecosystem is a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics.” NOAA further defines the environment as “The environment is the biological, chemical, physical, and social conditions that surround organisms. When appropriate, the term environment should be qualified as biological, chemical, and/or social.”

What is an Integrated Ecosystem Assessment?

Integrated ecosystem assessments (IEAs) are a critical science-support element enabling an EAM strategy. **An IEA is a formal synthesis and quantitative analysis of information on relevant natural and socio-economic factors in relation to specified ecosystem management goals.** It involves and informs citizens, industry representatives, scientists, resource managers, and policy makers through formal processes to contribute to attaining the goals of EAM. In this white paper, we outline a stepwise approach that will guide the science of IEAs.

IEAs begin with an identification of critical management and policy questions to define the scope of information and analyses necessary to inform management. IEAs use quantitative analyses and ecosystem modeling to integrate a range of social, economic, and natural science data and information to assess the condition of the ecosystem relative to the identified scope. IEAs also identify potential management options, and these are evaluated against EAM goals. IEAs are peer-reviewed and communicated to stakeholders, resource managers and policy makers. IEAs differ from other assessments like Environmental Impact Statements in that they

explicitly consider all components of the ecosystem and address the broad goals of EAM.

An IEA consists of the following components:

- Identification of key issues of concerns and stressors that management and policy should address
- Assessment of status, indicators and trends of the ecosystem condition relative to established management targets or thresholds
- Assessment of the environmental, social, and economic causes and consequences of these trends
- Forecast of ecosystem condition under a range of policy and/or management actions
- Periodically re-evaluate management effectiveness in the context of emerging ecosystem issues.
- Identification of crucial knowledge and data gaps that will guide future research and data acquisition efforts.

Why IEAs?

A key goal of IEAs is to move towards clear, well-defined ecosystem objectives built upon a science strategy that fuses ecosystem components into a single, dynamic, fabric in which both human and natural factors are intertwined. Periodic assessment of biological, chemical, physical and socio-economic attributes of ecosystems allows for coordinated evaluations of national marine, coastal and Great Lakes ecosystems to promote their sustainability under a variety of human uses and environmental stresses. Moreover, IEAs involve and inform a wide variety of stakeholders and agencies that rely on science support. IEAs integrate knowledge and data collected by NOAA and other regional entities including other federal agencies, states, non-governmental organizations, and academic institutions. IEAs also identify critical knowledge and data gaps, which, if filled, will reduce uncertainty and improve our ability to fully employ ecosystem approaches to management.

The importance of scale

IEAs must explicitly consider both spatial extent and the time domains over which ecosystem dynamics and management issues occur. Scales must be consistent with the ability to recognize and explain the most important drivers and threats to the ecosystem. Ecosystems typically do not have sharp boundaries; rather one ecosystem blends into another. As a consequence, ecosystem boundaries are human constructs, and a first step in any IEA endeavor must be to identify the spatial scale of the problem under consideration. The spatial scale of an IEA is a function of the ecology, geology, and oceanography of a region as well as the scale of management issues and governance structures. For example, while an IEA may focus on a small embayment, consideration of large-scale issues such as climatic variability as well as linkages to adjacent ecosystems is important. IEAs should address the linkage of terrestrial, coastal and oceanic environments as part of or affecting the ecosystem. Additionally, IEAs must be cognizant of appropriate temporal scales. In particular, IEAs require attention to the temporal baseline against

which current status is compared. For example, different conclusions may be drawn when the comparing current ecosystem conditions to those of 25 years versus 75 years ago.

Applying the IEA Concept

An IEA uses approaches that determine the probability that ecological or socio-economic properties of systems will move beyond or return to within acceptable limits as defined by management objectives. An IEA must provide an efficient, transparent means of summarizing the status of ecosystem components, screening and prioritizing potential risks, and evaluating alternative management strategies against a backdrop of environmental (e.g., climatic, oceanographic, seasonal, real-time weather) variability. An IEA provides a means of evaluating tradeoffs in management strategies among potentially competing ecosystem use sectors.

A 5 step process for an Integrated Ecosystem Assessment

Step 1. A scoping process initiates the IEA. Scoping begins with a review of existing documents and information and concludes with stakeholder, resource manager, and policy maker involvement to identify the management objectives, articulate the ecosystem to be assessed, identify ecosystem attributes of concern, and identify stressors relevant to the ecosystem being examined. While general EAM goals may be broad, a key component of an IEA is to move from broad goals to specific ecosystem objectives that management and policy need to consider.

Step 2. Following the scoping process, researchers must develop and test indicators that reflect the ecosystem attributes and stressors specified in the scoping process. Specific indicators are dictated by the problem at hand and must be linked objectively to decision criteria. In some cases, this simply means following the abundance of a single species (for instance in the case of an endangered species) or suites of species (e.g., coral reefs, harmful algal blooms). In other instances, the indicator

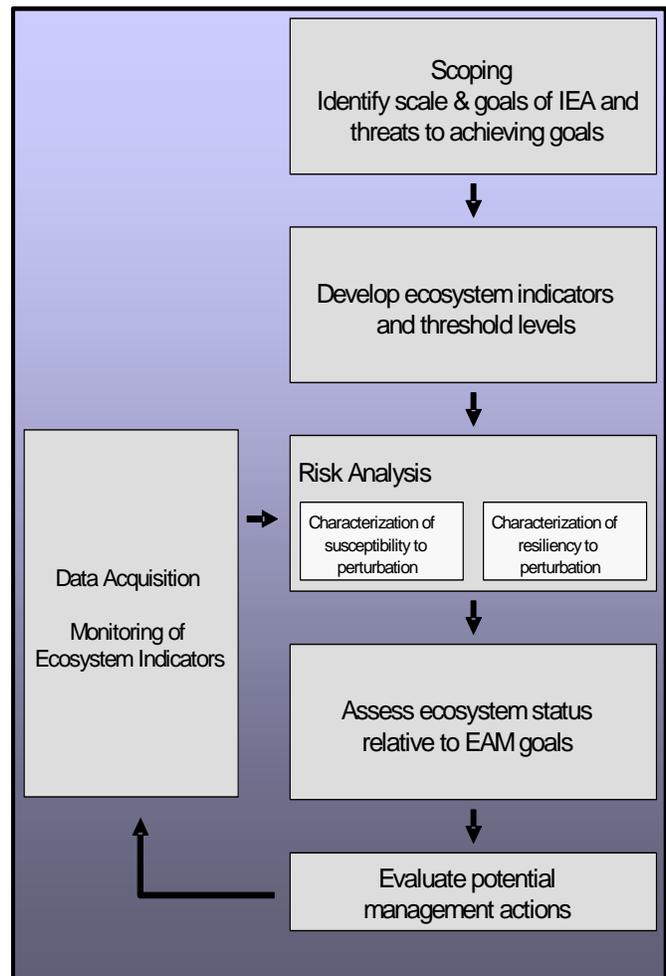


Figure 1. A 5 step process for an Integrated Ecosystem Assessment

may be a proxy for an ecosystem *attribute* indicated in Step 1. For example, resiliency to perturbation might be an attribute and species diversity might be an *indicator* of resiliency. For many problems, suites of indicators that span a wide range of processes (with different associated rates), biological groups, and indicator types (e.g., “early warning,” “integrated system state”) will be necessary. Importantly, this step allows us to identify indicators that should be monitored even when current monitoring efforts are insufficient.

Step 3. Once indicators are chosen, an analysis that evaluates the risk to the indicators posed by human activities and natural processes is performed. This analysis is hierarchical in approach and moves from a comprehensive, but qualitative analysis initially, through a more focused and semi-quantitative approach, and finally to a highly focused and fully quantitative approach. This step initially screens out many potential risks, so that more intensive and quantitative analyses are limited to a subset of ecosystem indicators and human or natural threats. The goal of these risk analyses is to fully explore the susceptibility of an indicator to natural or human threats as well as the ability of the indicator to return to its previous state after being perturbed. Another goal of these risk analyses is to explain whether, if the indicator has settled at a new value, the new value is due to natural variability in the system. A full discussion of ecological risk analysis as it pertains to marine ecosystems can be found in Hobday et al. (2006).

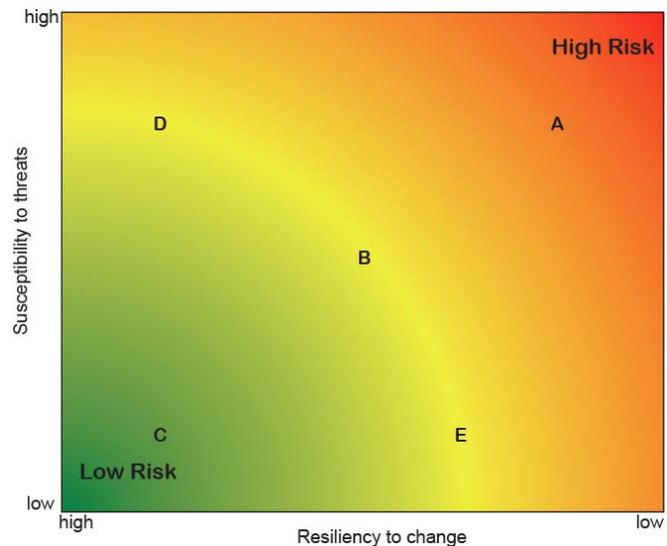


Figure 2. A visualization of the risk status of theoretical indicators. Indicator A has low resiliency (ability to persist in the face of change) and high susceptibility to natural or human disturbance; thus, it has a high risk. C shows an indicator with low susceptibility and high resilience and thus has low risk. B, D, and E have different combinations of susceptibility and resilience yielding a moderate level of risk

The likelihood of an ecosystem to change can be viewed as the relationship of the susceptibility of a particular indicator to impact versus the resiliency of the indicator (Figure 2). An indicator is likely to change when susceptibility to impact is high and resiliency is low, while an indicator is not likely to change when susceptibility to impact is low and resiliency is high. A full discussion of ecological risk analysis as it pertains to marine ecosystems can be found in Hobday et al. (2006). IEAs will also include a social and economic overlay to the ecological risk assessments to capture impacts to individuals and communities.

Step 4. Results from the risk analysis for each ecosystem indicator are then integrated in the assessment phase of the IEA. The assessment quantifies the status of the ecosystem relative to historical status and prescribed targets. Thus, the risk analysis rigorously quantifies the status of

individual ecosystem indicators, while the full assessment considers the state of all indicators simultaneously.

Step 5. The next phase of the IEA uses ecosystem modeling frameworks (e.g., the Atlantis ecosystem model, Brand et al. 2007) to evaluate the potential of different management strategies to influence the status of natural and human system indicators. To accomplish this, a formal Management Strategy Evaluation (MSE) is employed (Figure 3). In MSE, a simulation model is used to generate ‘true’ ecosystem dynamics. Data are sampled from the model to simulate research surveys, and then these data are passed to risk analysis and assessment

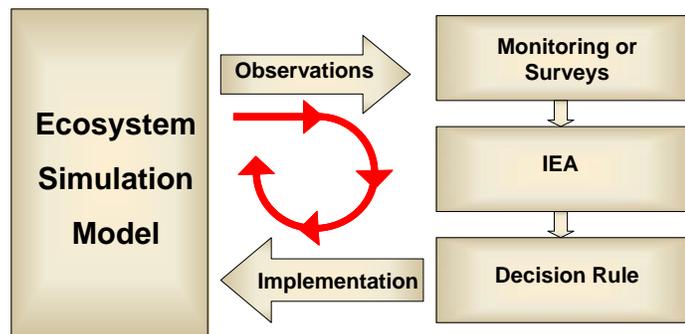


Figure 3. A schematic of the, an ecosystem model is used to simulate the ecosystem. The ecosystem is then “sampled”, an IEA is performed and a management strategy is implemented. The cycle is the repeated, and ultimately, the potential outcomes of a range of management strategies can be estimated.

models. These assessment models estimate the predicted status of individual indicators and the ecosystem as a whole. Based on this assessment of the simulated ecosystem, a management decision is simulated. Human response to this simulated decision is modeled, and potentially influences the simulated ecosystem state. By repeating this cycle, we can simulate the full management cycle. This allows us to test the utility of modifying indicators and threshold levels, assessments, monitoring plans, management strategies, or decision rules. Management Strategy Evaluation in the context of an IEA can thus serve as a filter to identify which policies and methods meet stated management objectives (e.g. Butterworth and Punt 1999).

IEA Products

IEAs are peer-reviewed and communicated to stakeholders, resource managers and policy makers. IEAs may be communicated in the form of a static Management Strategy Evaluation (MSE) framework. In MSE document, but may also be web-based dynamic documents that are updated as new data become available. The frequency with which IEAs should be revised and updated cannot not be fully prescribed. As new information arises or management changes occur, risks can be reevaluated, and documented as before. IEA products may also serve as a tool to educate a variety of stakeholders.

Further reading on IEAs

The concept of IEAs is well established, and there are a number of examples relevant in both domestic and international settings. Appendix B provides a selected annotated bibliography of existing IEA documents as well as web-based resources describing the concept in more detail.

References

- Brand, E.J., I.C. Kaplan, C.J. Harvey, P.S. Levin, E.A. Fulton, A.J. Hermann, and J.C. Field. 2007. A spatially explicit ecosystem model of the California Current's food web and oceanography. U.S. Dept. Commer., NOAA Tech.Memo. NMFS-NWFSC-84, 145 p.
- Butterworth, D.S., and Punt, A.E. 1999. Experiences in the evaluation and implementation of management procedures. *ICES Journal of Marine Science*, 56: 985-998
- Hobday, A. J., A. Smith, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, T. Walker. 2006. Ecological Risk Assessment for the Effects of Fishing: Methodology. Report R04/1072 for the Australian Fisheries Management Authority, Canberra.

Appendix A. The Driver-Pressure-State-Impact-Response (DPSIR) framework

The strategy described above can be cast in the context of a Driver-Pressure-State-Impact-Response (DPSIR) framework for classification of indicators. The DPSIR approach has been broadly applied in environmental assessments of both terrestrial and aquatic ecosystems. *Drivers* are factors that result in pressures that in turn cause changes in the system. For the purposes of an IEA, both natural and anthropogenic forcing factors are considered; an example of the former is climate variability while the latter include factors such as human population size in the coastal zone and associated coastal development, demand for seafood, etc. In principle, human driving forces can be assessed and controlled. Natural environmental changes cannot be controlled but must be accounted for in management. *Pressures* include factors such as coastal pollution, habitat loss and degradation, and fishing effort that can be mapped to specific drivers. For example, coastal development results in increased coastal armoring and the loss of associated intertidal habitat. *State* variables are indicators of the condition of the ecosystem (including physical, chemical, and biotic factors). *Impacts* comprise measures of the effect of change in these state variables such as loss of biodiversity, declines in productivity and yield, etc. Impacts are measured with respect to management objectives and the risks associated with exceeding or returning to below these targets and limits. *Responses* are the actions (regulatory and otherwise) that are taken in response to predicted impacts. Forcing factors under human control trigger management responses when target values are not met as indicated by risk assessments. Natural drivers may require adaptational response to minimize risk. For example, changes in climate conditions that in turn affect the basic productivity characteristics of a system may require changes in ecosystem reference points that reflect the shifting environmental states.

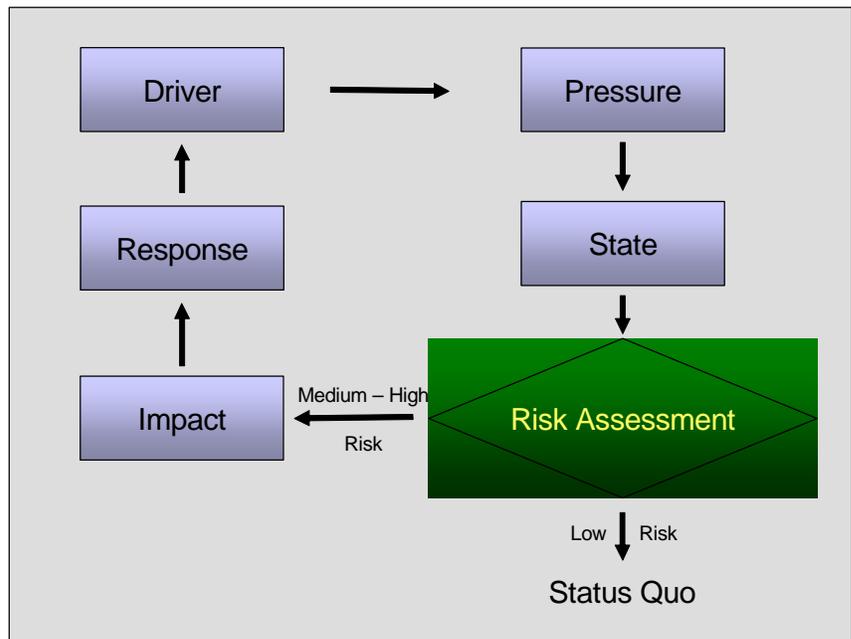


Figure 4. The Driver-Pressure-State-Impact Response framework for classification of ecosystem indicators

The different classes of indicators identified within the DPSIR framework can be mapped to the needs of the management strategy evaluation described above and identified with respect to their roles in model formulation, parameterization, and validation.

Table 1. Examples of drivers, pressures, states, impacts, and responses of interest for integrated ecological assessments

	Anthropogenic	Natural
Drivers	Human Population Size in the Coastal Zone Per Capita Seafood Demand Water-dependent international trade Coastal Development	Temperature Precipitation Winds Ice Cover Hydrodynamics
Pressures	Fishing Effort Habitat Loss/Degradation Pollution transport and fate Marine Transportation Effluent Discharges Oil and hazardous material spills Pathogens Land use patterns	Extent of Thermal Habitat Nutrient Regeneration Current speed and direction Habitat change Species range shifts
States	Commercial Fishery Landings Recreational Fishery Landings Aquaculture/Fish Farming Production Water quality/quantity	Chlorophyll Concentration Zooplankton Biomass Benthic Biomass Shellfish Biomass Fish Biomass Harmful Algal Blooms Pathogens Aquatic Mammal Abundance
Impacts	Fishery Yield Aquaculture Production Recreational Income Non-indigenous species Human health risks Employment Loans at Risk Commercial Cash Value	Biodiversity Changes in Ecosystem Function
Responses	Alter fishing mortality Alter stormwater regulations Require watershed buffers Restore habitat Contaminant mitigation	

Appendix B. Annotated Bibliography of Integrated Ecosystem Assessment Concepts, Methods, Evaluations, and Implementation Examples (NOAA IEA Task Team on June 7, 2007)

Conceptual Framework Documents

Canada's Oceans Strategy/Policy and Operational Framework for Integrated Management of Estuarine, Coastal, and Marine Environments

The Oceans Act calls on the Minister of Fisheries and Oceans to lead and facilitate the development of a national oceans strategy that will guide the management of Canada's estuarine, coastal, and marine ecosystems. This strategy provides the overall strategic framework for Canada's oceans-related programs and policies, based on the principles of sustainable development, Integrated Management, and the precautionary approach. The central governance mechanism of the Strategy is applying these principles through the development and implementation of Integrated Management plans. This document is intended to foster discussion about Integrated Management approaches by setting out policy in the legislative context, along with concepts and principles. The document also proposes an Operational Framework with governance, management by areas, design for management bodies, and the type of planning processes that could be involved.

Canada's Oceans Strategy: Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada. 2002. Fisheries and Oceans Canada, Oceans Directorate, Ottawa, Ontario. ISBN 0-662-32449-8.

Source: http://www.cos-soc.gc.ca/doc/pdf/im_e.pdf

Translating Ecosystem Indicators into Decision Criteria

Defining and attaining suitable management goals probably represent the most difficult part of ecosystem-based fisheries management. To achieve those goals we ultimately need to define ecosystem overfishing in a way that is analogous to the concept used in single-species management. Ecosystem-based control rules can then be formulated when various ecosystem indicators are evaluated with respect to fishing-induced changes. However, these multi-attribute control rules will be less straightforward than those applied typically in single-species management, and may represent a gradient, rather than binary decision criteria. Some ecosystem-based decision criteria are suggested, based on indicators empirically derived from the Georges Bank, Gulf of Maine ecosystem. Further development in the translation of ecosystem indicators into decision criteria is one of the major areas for progress in fisheries science and management.

Link, J.S. 2005. Translating ecosystem indicators into decision criteria. *ICES Journal of Marine Science*, 62:569-576.

Source: The full text version of this paper is available via <http://www.sciencedirect.com/>

Environmental Health Indicators

Rice, J. Environmental health indicators. *Ocean & Coastal Management* 46 (2003) 235-259.

Source: The full text version of this paper is available via <http://www.sciencedirect.com/>

The Large Marine Ecosystem Concept: Research and Management Strategy for Living Marine Resources (circa 1991)

Sherman, K. The large marine ecosystem concept: research and management strategy for living marine resources. *Ecological applications*, 1(4), 1991, 349-360.

Source: The full text version is available via JSTOR.

Methods/Tools

Identification of Ecologically Significant Species and Community Properties

As with the criteria described above for Ecologically and Biologically Significant Areas, consistent criteria and guidance for their application are needed also for the identification of species and community properties for which protection should be enhanced, while allowing sustainable activities to be pursued in the ecosystem. This report contains the results of a national workshop held in 2006 to develop *a priori* criteria to assess species and community properties that are “particularly important” or “significant” with regard to maintaining ecosystem structure and function. Assessments using these criteria as a tool to rank species and community properties by their ecological significance are an important step in developing ecosystem objectives for integrated management.

Department of Fisheries and Oceans, 2006. Identification of Ecologically Significant Species and Community Properties. DFO Can. Sci. Advis. Sec. Sci. Advis. Report 2006/041.

Climate Change Impacts for the Conterminous USA: an Integrated Assessment

This special issue of the journal *Climatic Change* describes an effort to improve methodology for integrated assessment of impacts and consequences of climatic change. The methodology developed involves construction of scenarios of climate change that are used to drive individual sectoral models for simulating impacts on crop production, irrigation demand, water supply and change in productivity and geography of unmanaged ecosystems. Economic impacts of the changes predicted by integrating the results of the several sectoral simulations models are calculated through an agricultural land-use model. While these analyses were conducted for the conterminous United States, their global implications are also considered, as is the need for further improvements in integrated assessment methodology. The final chapter summarizes highlights of the first seven sector-specific chapters that constitute this special issue. These projects were supported by the National Science Foundation through the Methods and Models in Integrated Assessment Program and in some cases also by the U.S. Department of Energy Integrated Assessment Program, Biological and Environmental Research.

Edmonds, J.A., and N.J. Rosenberg. 2005. Climate change impacts for the conterminous USA: an integrated assessment. *Climatic Change* 69, 1-162. (the link to the summary chapter below (pgs 151-162))

Identification of Ecologically and Biologically Significant Areas

Department of Fisheries and Oceans, 2004. Identification of Ecologically and Biologically Significant Areas. DFO Canadian Science Advisory Secretariat. Ecosystem Status Report 2004/006.

Source: http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/ESR2004_006_e.pdf

Note: For a recent geographic application of these criteria please see:

DFO, 2006. Proceedings of the Zonal Workshop on the Identification of Ecologically and Biologically Significant Areas within the Gulf of St. Lawrence and Estuary. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2006/011.

Source: http://www.dfo-mpo.gc.ca/csas/Csas/Proceedings/2006/PRO2006_011_B.pdf

Documentation for the Energy Modeling and Analysis eXercise (EMAX)

Link, J.S., Griswold, C.A., Methratta, E.T., and Gunnard, J. (Editors). 2006. Documentation for the Energy Modeling and Analysis eXercise (EMAX). Northeast Fisheries Science Center. Ref. Doc. 06-15, 166 pp.

Source: <http://www.nefsc.noaa.gov/nefsc/publications/series/crdlist.htm>

Computer-Based Models in Integrated Environmental Assessment

Peirce, Martin. 1998. Computer-based Models in Integrated Environmental Assessment. Technical report no 14, prepared for the European Environment Agency, Copenhagen, Denmark. 60 pp.

Source: can be downloaded at <http://reports.eea.europa.eu/TEC14/en>

Self-Organizing Map Methods in Integrated Modeling of Environmental and Economic Systems

Shanmuganathan, S., P. Sallis, and J. Buckeridge. 2006. Self-organizing map methods in integrated modeling of environmental and economic systems. *Environmental Modeling & Software* 21, 1247-1256.

Source: The full text version of this paper is available via <http://www.sciencedirect.com/>

Linking Ecology and Economics for Ecosystem Management

Farber, S. et al. 2006. Linking Ecology and Economics for Ecosystem Management. *BioScience* 56, 121-133.

Source: http://www.uvm.edu/giee/research/publications/Farber_et_al_2006.pdf

Supporting European Marine Integrated Ecosystem Assessments (SEMIEA)

ICES. 2004. Supporting European Marine Integrated Ecosystem Assessments: Specific Support Actions. Copenhagen, Denmark. 36 pp.

Source: <http://www.ices.dk/globec/regns/SEMIEA.pdf>

Evaluations of Integrated Assessment Products and Processes

Canadian Guidelines on Evaluating Ecosystem Overviews and Assessments: Necessary Documentation

The integrated management of human activities on the sea under Canada's Oceans Act calls for implementation strategies based on an ecosystem approach. In planning many of

the activities necessary for integrated management, such as setting ecosystem objectives, identifying areas requiring enhanced protection, and developing regulatory approaches to various activities, it is necessary to have a reasonable understanding of the ecosystem being managed. The Department of Fisheries and Oceans has adopted an approach of preparing two types of documents--Ecosystem Overview Reports and Ecosystem Assessments to provide a common factual basis for dialogue among the parties in integrated planning and management. Initial ecosystem overview reports and partial integrated ecosystem assessments were prepared for two ecosystems for which integrated management approaches are currently being developed: the Eastern Scotian Shelf and Gulf of St. Lawrence systems. The overview and assessment documents for the two systems were prepared in different ways, allowing the Department of Fisheries and Oceans to report here on insights gained from a review held in 2005 on the desirable contents to be included in both types of documents.

Department of Fisheries and Oceans, 2005. Guidelines on Evaluating Ecosystem Overview and Assessments: Necessary Documentation. DFO Canadian Science Advisory Secretariat Report 2005/026.

Source: http://www.meds-sdmm.dfo-mpo.gc.ca/csas/applications/publications/publication_e.asp?year_selected=2005&series=SSR

Participatory Integrated Assessment Methods – An Assessment of Their Usefulness to the European Environmental Agency

Toth, F.L. 2001. Participatory Integrated Assessment Methods – An Assessment of Their Usefulness to the European Environmental Agency. Technical Report No 64 prepared for the European Environment Agency, Copenhagen, Denmark. 82 pp.

Source: can be downloaded at http://reports.eea.europa.eu/Technical_report_no_64/en

Integrated Assessment and Environmental Policy Making: in Pursuit of Usefulness

Parsons, E. 1995. Integrated assessment and environmental policy making: in pursuit of usefulness. *Energy Policy* 23:463-475.

Source: The full text version of this paper is available via <http://www.sciencedirect.com/>

Oversight Review Board Report on the Experience and Legacy of the National Acid Precipitation Assessment Program

National Acid Precipitation Assessment Program (NAPAP). 1991. Report from the Oversight Review Board. 1991. The Experience and Legacy of NAPAP. Washington, D.C.

Source: This report is available in hard copy only, unless the document can be scanned.

Understanding and Solving Environmental Problems in the 21st Century: Toward a New, Integrated Hard Problem Science

Costanza, R. and S.E. Jorgensen (Editors). 2002. Understanding and Solving Environmental Problems in the 21st Century: Toward a New, Integrated Hard Problem Science. Elsevier Science. ISBN: 978-0-08-044111-5, 346 pp.

Source (description):

http://www.elsevier.com/wps/find/bookdescription.cws_home/623393/description#description

Integrated Assessment Implementation

National Examples:

National Assessment of Harmful Algal Blooms in U.S. Waters

CENR. 2000. National Assessment of Harmful Algal Blooms in U.S. Waters. National Science and Technology Council Committee on Environment and Natural Resources, Washington, DC.

Source: http://www.cop.noaa.gov/pubs/habhrca/Nat_Assess_HABs.pdf

An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters

CENR. 2003. An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters. National Science and Technology Council Committee on Environment and Natural Resources, Washington, D.C.

Source: <http://coastalscience.noaa.gov/documents/coastalhypoxia.pdf>

The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States (2002)

Turgeon, D.D., et al. 2002. The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States:2002. National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science, Silver Spring, MD. 265 pp.

Source: http://coastalscience.noaa.gov/documents/status_coralreef.pdf

The State of coral Reef Ecosystems of the United States and Pacific Freely Associated States (2005)

Waddell, J.E. (ed.) 2005. The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005. NOAA Technical Memorandum NOS NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD. 522 pp.

Source: http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/

Regional Examples:

Report on the Status of the Northeast U.S. Continental Shelf Ecosystem

Link, J. and Brodziak, J. (Editors). 2002. Report on the Status of the Northeast U.S. Continental Shelf Ecosystem. Northeast Fisheries Science Center Ref. Doc. 02-11, 245 pp.

Source: <http://www.nefsc.noaa.gov/nefsc/publications/series/crdlist.htm>

A Biogeographic Assessment of the Channel Islands National Marine Sanctuary: A Review of Boundary Expansion Concepts for NOAA's National Marine Sanctuary Program

NOAA National Centers for Coastal Ocean Science (NCCOS) 2005. A Biogeographic Assessment of the Channel Islands National Marine Sanctuary: A Review of Boundary Expansion Concepts for NOAA's National Marine Sanctuary Program (DVD). Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 21. 215 pp.

Source: Available in DVD format via

<http://ccmaserver.nos.noaa.gov/products/biogeography/cinms/order.html>

An Ecological Characterization of the Stellwagen Bank National Marine Sanctuary Region: Oceanographic, Biogeographic, and Contaminants Assessment

Source: <http://www.ccma.nos.noaa.gov/products/biogeography/stellwagen/welcome.html>

An Integrated Assessment of Hypoxia in the Northern Gulf of Mexico

CENR. 2000. Integrated Assessment of Hypoxia in the Northern Gulf of Mexico. National Science and Technology Council Committee on Environment and Natural Resources, Washington, D.C. 58 pp.

Source: http://www.nos.noaa.gov/products/pubs_hypox.html#fia

An Integrated Assessment of the Introduction of Lionfish (*Pterois volitans/miles* complex) to the Western Atlantic Ocean

Hare, J.A., and P.E. Whitfield. 2003. An Integrated Assessment of the Introduction of Lionfish (*Pterois volitans/miles* complex) to the Western Atlantic Ocean. NOAA Technical Memorandum NOS NCCOS 2. 21 pp.

Source: http://coastalscience.noaa.gov/documents/lionfish_ia.pdf

Chapter on Ecological Consideration in Alaska Ocean Ecosystems for 2007

Stock Assessment and Fishery Evaluations. Draft Section on Ecosystem Considerations for 2007. November 2006. Jennifer Boldt (ed.) Appendix C. Alaska Fisheries Science Center, Seattle, WA. 360 pp.

Source: <http://access.afsc.noaa.gov/reem/EcoWeb/content/pdf/AppendixC.pdf>

National Coastal Condition Report II (2005): Chapter 9 – Health of Galveston Bay for Human Use

U.S. EPA (U.S. Environmental Protection Agency). 2005. National Coastal Condition Report II. EPA-620/R-03/002. Office of Research and Development and Office of Water, Washington, DC.

Source: http://www.epa.gov/owow/oceans/nccr/2005/Chapter9_GalvestonBay.pdf

An Approach to Integrated Ecological Assessment of Resource Condition: the Mid-Atlantic Estuaries as a Case Study

Brown, B.S., W. Munns, Jr. and J.F. Paul. 2002. An approach to integrated ecological assessment of resource condition: the Mid-Atlantic estuaries as a case study. *Journal of Environmental Management* 66: 411-427

Source: This article is available via <http://www.sciencedirect.com/>

International Examples:

ICES Regional Ecosystem Study Group of the North Sea Report

The report summarizes the results of a meeting of the study group held in May 2006 to evaluate and prepare plans for finalization of an integrated assessment of the North Sea Ecosystem, an activity initiated by this group in 2003. The assessment, based on the compilation and analyses of a comprehensive integrated data set, has provided some valuable insights into the significance of the relationships between different human pressures (e.g., nutrient inputs and fisheries) and state changes (e.g., plankton, fish and seabirds) at different spatial scales and the time scales over which changes take place. For example, plankton community data in relation to the physical and chemical oceanography reveals both gradients of response to the major riverine inputs of nutrients into the North Sea and sources of nutrients from the Atlantic. In addition an assessment of all variables reveals two relatively stable states in the North Sea, one pre-1983 and the other post-1997. The intervening years are dominated by high ecosystem variability which represents a transition from one state to another and in part explains the number of studies which highlight different years for regime shifts. The sensitivity of such analysis to changes in temporal and spatial scales is explored as is the dependency on the number and type of ecosystem variables. By better understanding the relationship between the causes of change at different scales in time and space, it should be possible to set more realistic targets for the management of human pressures.

ICES. 2006. Report of the Regional Ecosystem Study Group of the North Sea (REGNS), 15-19 May 2006, ICES Headquarters, Copenhagen. ICES CM 2006/RMC:06. 111pp.
Source: <http://www.ices.dk/reports/RMC/2006/REGNS/regns06.pdf>

State of the Eastern Scotian Shelf Ecosystem

DFO, 2003. State of the Eastern Scotian Shelf Ecosystem. DFO Can. Sci. Advis. Sec. Ecosystem Status Report 2003/004.
Source: http://www.dfo-mpo.gc.ca/csas/Csas/status/2003/ESR2003_004_e.pdf

The European Environment – State and Outlook 2005

European Environment Agency. 2005. The European environment – State and outlook 2005. Copenhagen. 570 pp. State of Environment Report No 1/2005. (ISBN: 92-9167-776-0).
Source: The report can be accessed via:
http://reports.eea.europa.eu/state_of_environment_report_2005_1/en

The Changing faces of Europe's Coastal Areas

European Environment Agency. 2006. The changing faces of Europe's coastal areas. Copenhagen. 107 pp. EEA Report No 6/2006. (ISBN 92-9167-842-2)
Source: http://reports.eea.europa.eu/eea_report_2006