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Integrated Ecosystem Assessments

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Integrated Ecosystem Assessments

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Executive Summary

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. An ecosystem approach to management (EAM) is one that provides a comprehensive framework for marine, coastal, and Great Lakes resource decision making. 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 socioeconomic 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.

An IEA uses approaches that determine the probability that ecological or socioeconomic 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 variability. To this end, IEAs should follow five steps:

1. Scoping. Identify management objectives, articulate the ecosystem to be assessment, identify ecosystem attributes of concerns, and identify stressors relevant to the ecosystem being examined.
2. Indicator development. Researchers 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.
3. Risk analysis. This analysis is hierarchical in approach and moves from a comprehensive, but initially qualitative analysis, through a more focused and semiquantitative approach, and finally to a highly focused and fully quantitative approach. 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.
4. Overall ecosystem assessment. Results from the risk analysis for each ecosystem indicator are then integrated in the assessment phase of the IEA. The assessment quantifies the overall status of the ecosystem relative to historical status and prescribed targets.
5. Evaluation. The final phase of the IEA evaluates the potential of different management strategies to influence the status of the ecosystem.

IEAs compel decision makers to squarely confront both the spatial and temporal scales over which ecosystem dynamics, management issues, and societal impacts occur. Scales must be consistent with the ability to recognize and explain the most important drivers and threats to the ecosystem.

There is a clear need to actively integrate diverse physical, biological, and socioeconomic data and think critically about the ways in which decisions affect the ecosystem goods and services that society values. The IEA process we describe accomplishes this task, and provides critical assessment support to the institutional framework upholding societal interests in healthy and productive ecosystems.

Acknowledgments

The authors thank the members of the Integrated Ecosystem Assessment Priority Task Team for comments on this paper. Discussions with Dave Fluharty, Mary Ruckelshaus, Tony Smith, Chris Harvey, Isaac Kaplan, Jameal Samhouri, Beth Fulton, John Stein, Chris Costello, Sarah Lester, Steve Gaines, Heather Tallis, and numerous participants of IEA workshops helped sharpen our thinking. We are extremely grateful to Lora Clarke for her hard work in creating this technical memorandum. Phillip Levin also thanks Alberto Contrador for inspiration over the final hurdles.

Abbreviations and Acronyms

DPSIR	Driver-Pressure-State-Impact-Response
EAM	Ecosystem Approach to Management
IEA	Integrated Ecosystem Assessment
MSE	Management Strategy Evaluation
NOAA	National Oceanic and Atmospheric Administration

Background

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 the National Oceanic and Atmospheric Administration (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)" (NOAA 2005). 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, an 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?

As defined by NOAA:

> "An ecosystem is a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics" (Murawski and Matlock 2006). NOAA further defines the environment as "the biological, chemical, physical, and social conditions that surround organisms. When appropriate, the term environment should be qualified as biological, chemical, and/or social" (Murawski and Matlock 2006).

What is an Integrated Ecosystem Assessment?

An Integrated Ecosystem Assessment (IEA) is a critical science-support element enabling an EAM strategy. An IEA is a formal synthesis and quantitative analysis of information on relevant natural and socioeconomic factors relative 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 technical memorandum, 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 such as 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 or management actions or both
- Periodic reevaluation of 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 toward clear, well-defined ecosystem objectives built on a science strategy that fuses ecosystem components into a single, dynamic fabric in which human and natural factors are intertwined. Periodic assessment of biological, chemical, physical, and socioeconomic 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 regional entities including other federal agencies, states, nongovernmental 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 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 are 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 Integrated Ecosystem Assessment Concept

An IEA uses approaches that determine the probability that ecological or socioeconomic 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 trade-offs in management strategies among potentially competing ecosystem use sectors.

A Five Step Process for an IEA

The five step IEA process discussed here is comprised of scoping, indicator identification and testing, risk analysis, risk analysis integration into the assessment process, and strategies evaluation. The process is conceptually portrayed in Figure 1.

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 makers need to consider.

Step 2. Following the scoping process, researchers 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 (e.g., in the case of an endangered species) or suites of species (e.g., coral reefs, harmful algal blooms). In other instances, the indicator 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 is performed that evaluates the risk to the indicators posed by human activities and natural processes. This analysis is hierarchical in approach and moves from a comprehensive, but initially qualitative analysis, through a more focused and semiquantitative approach, and finally to a highly focused and fully

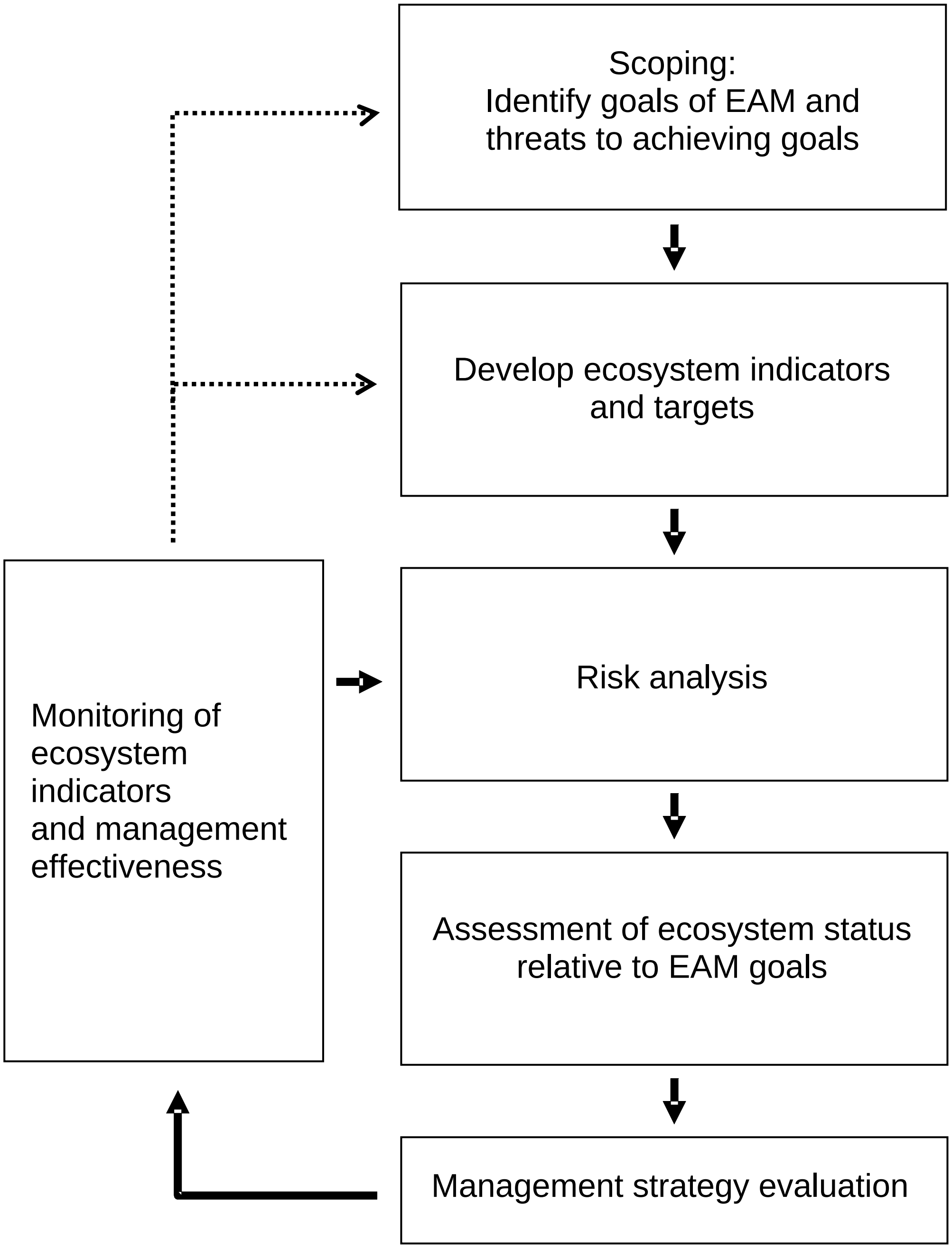

Figure 1. A five step process for an IEA. The solid line from the monitoring box to the risk analysis box indicates that analyses will be updated as more data become available. The dotted lines to the scoping box and the indicators and targets box indicate that these steps may need revisiting as more data are collected.

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 the risk analyses is to explain, if the indicator has settled at a new value, whether 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).

The likelihood of an ecosystem changing 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. IEAs will also include a social and economic overlay to the ecological risk assessments to capture impacts to individuals and communities.

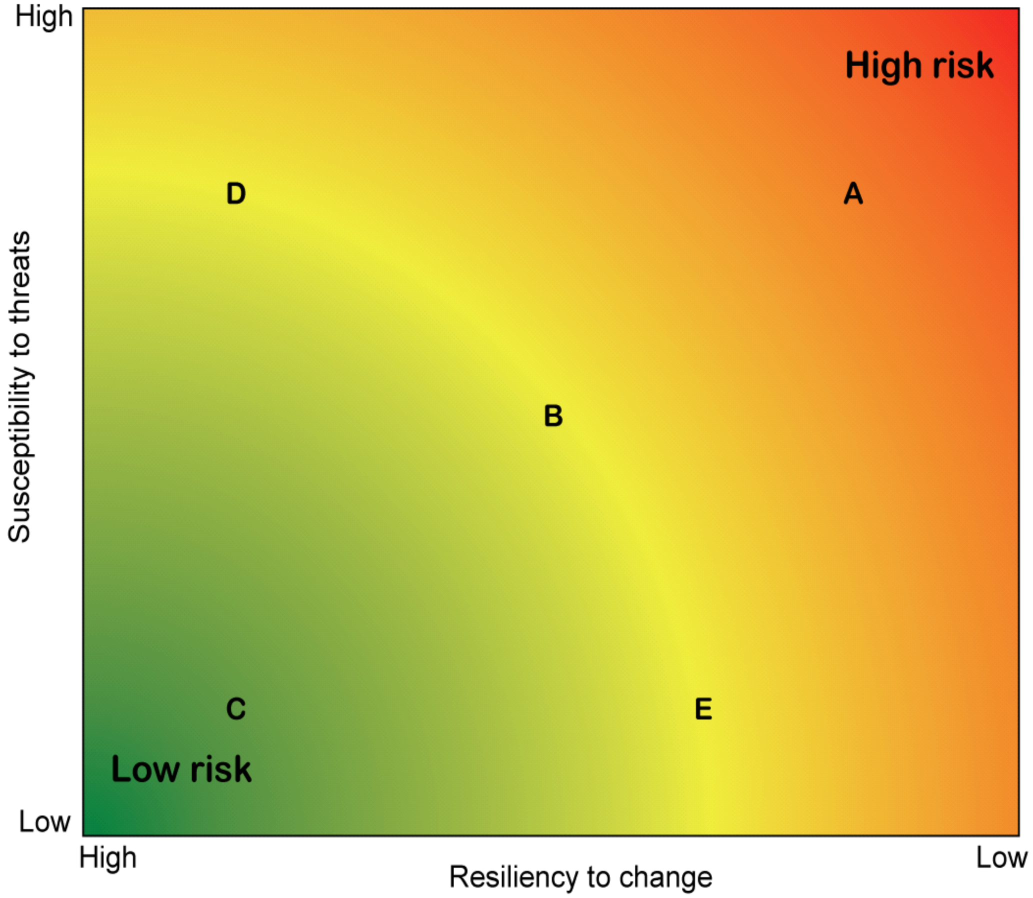

Figure 2. A visualization of the risk status of theoretical indicators. Indicator A has a low resiliency (ability to persist in the face of change) and high susceptibility to natural or human disturbance; thus it has a high risk. Indicator C shows an indicator with low susceptibility and high resilience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

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, then these data are passed to risk analysis and assessment 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, and decision rules. MSE 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).

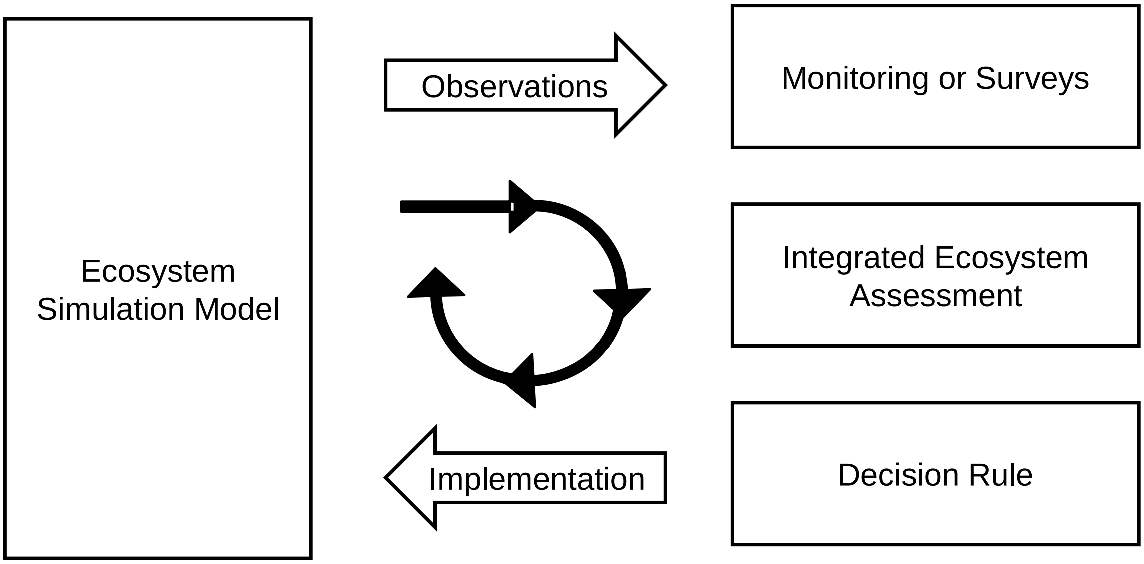

Figure 3. A schematic of the MSE. An ecosystem model is used to simulate the ecosystem. The ecosystem is then “sampled,” an IEA is performed, and a management strategy is implemented. The cycle is then repeated, and ultimately the potential outcomes of a range of management strategies can be estimated.

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 MSE framework or as Web-based dynamic documents that are updated as new data become available. The frequency with which IEAs should be revised and updated cannot 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 a number of examples are 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.

Butterworth, D. S., and A. E. Punt. 1999. Experiences in the evaluation and implementation of management procedures. ICES J. Mar. Sci. 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, and T. Walker. 2006. Ecological risk assessment for the effects of fishing: Methodology. Rep. R04/1072 for the Australian Fisheries Management Authority, Canberra.

Murawski, S. A., and G. C. Matlock (eds.). 2006. Ecosystem science capabilities required to support NOAA's mission in the year 2020. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-F/SPO-74.

NOAA (National Oceanic and Atmospheric Administration). 2005. New priorities for the 21st century—NOAA's strategic plan: Updated for FY 2006-FY 2011. U.S. Dept. Commer., NOAA, Silver Spring, MD. Online at http://www.ppi.noaa.gov/PPI_Capabilities/Documents/Strategic_Plans/FY06-11_NOAA_Strategic_Plan.pdf [accessed 27 June 2008].

Appendix A: The DPSIR framework

The strategy described in this technical memorandum 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 terrestrial and aquatic ecosystems.

Drivers are factors that result in pressures that in turn cause changes in the system. For the purposes of an Integrated Ecosystem Assessment (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, 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.

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 A-1 provides examples of DPSIR components. Figure A-1 shows the conceptual framework.

Table A-1. Examples of DPSIR components of interest for IEAs.

Components	**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 and 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 and fish farming production Water quality and 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 Nonindigenous 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	

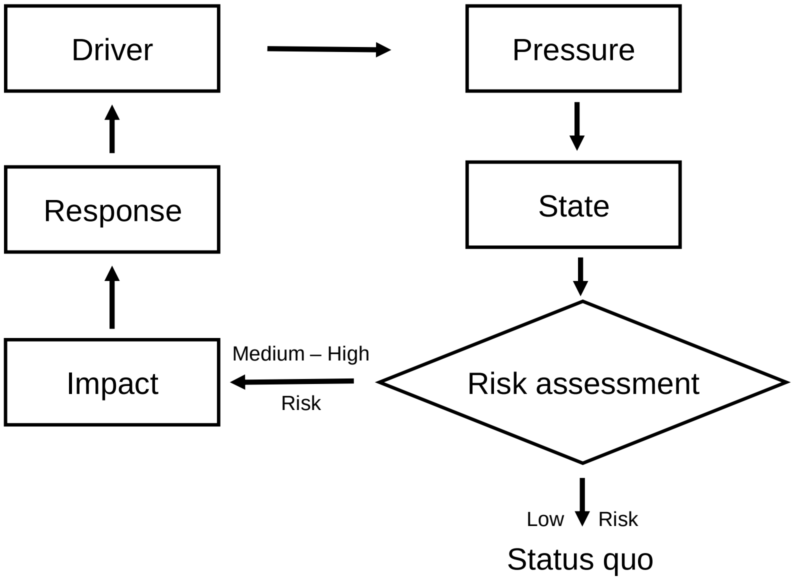

Figure A-1. The DPSIR framework for classification of ecosystem indicators. The process begins with the driver box.

Appendix B: Bibliography

The following is a bibliography, annotated for many documents, of integrated ecosystem assessment concepts, methods, evaluations, and implementation examples.

Conceptual Framework Documents

DFO Canada (Dept. Fisheries and Oceans Canada). **Canada's oceans strategy: Policy and operational framework for integrated management of estuarine, coastal, and marine environments in Canada.** 2002. Dept. Fisheries and Oceans Canada, Oceans Directorate, Ottawa, Ontario. Online at http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/ri-rs/index_e.asp [accessed 12 June 2008].

The Canadian 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 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.

Link, J. S. 2005. **Translating ecosystem indicators into decision criteria.** ICES J. Mar. Sci. 62:569–576.

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 multiattribute control rules will be less straightforward than those applied typically in single-species management, and may represent 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.

Rice, J. 2003. **Environmental health indicators.** Ocean Coast. Manag. 46:235–259.

Sherman, K. 1991. **The large marine ecosystem concept: Research and management strategy for living marine resources.** Ecol. Appl. 1(4):349–360.

Methods and Tools

DFO Canada (Dept. Fisheries and Oceans Canada). 2006. **Identification of ecologically significant species and community properties.** DFO Canadian Science Advisory Secretariat, Science Advisory Rep. 2006/041. Online at http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/ESR2004_006_E.pdf [accessed 12 June 2008].

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.

For a recent geographic application of these criteria please see: Dept. Fisheries and Oceans Canada. 2006. Proceedings of the zonal workshop on the identification of ecologically and biologically significant areas within the Gulf of St. Lawrence and estuary. DFO Canadian Science Advisory Secretariat Proceed. Ser. 2006/011. Online at http://www.dfo-mpo.gc.ca/csas/Csas/Proceedings/2006/PRO2006_011_B.pdf [accessed 12 June 2008].

Edmonds, J. A., and N. J. Rosenberg. 2005. **Climate change impacts for the conterminous USA: An integrated assessment.** Clim. Change 69:1–162.

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 climate change scenarios 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.

Farber, S., R. Costanza, D. L. Childers, J. Erickson, K. Gross, M. Grove, C. S. Hopkinson, J. Kahn, S. Pincetl, A. Troy, P. Warren, and M. Wilson. 2006. **Linking ecology and economics for ecosystem management.** Bioscience 56:121–133.

ICES (International Council for the Exploration of the Sea). 2004. **Supporting European marine integrated ecosystem assessments: Specific support actions.** Copenhagen, Denmark. Online at: http://www.ices.dk/globec/regns/SEMIEA.pdf [accessed 12 June 2008].

Link, J. S., C. A. Griswold, E. T. Methratta, and J. Gunnard (eds.). 2006. **Documentation for the Energy Modeling and Analysis eXercise (EMAX).** Northeast Fisheries Science Center. Ref. Doc. 06-15. Online at http://www.nefsc.noaa.gov/nefsc/publications/series/crdlist.htm [accessed 12 June 2008].

Peirce, M. 1998. **Computer-based models in integrated environmental assessment.** Tech. Rep. 14, prepared for the European Environment Agency, Copenhagen, Denmark. Online at http://reports.eea.europa.eu/TEC14/en [accessed 12 June 2008].

Shanmuganathan, S., P. Sallis, and J. Buckeridge. 2006. **Self-organizing map methods in integrated modeling of environmental and economic systems.** Environ. Model. Softw. 21:1247–1256.

Evaluations of Integrated Assessment Products and Processes

Costanza, R., and S. E. Jorgensen (eds.). 2002. **Understanding and solving environmental problems in the 21st century: Toward a new, integrated hard problem science.** Elsevier Science. Online (description) at http://www.elsevier.com/wps/find/bookdescription.cws_home/623393/description#description. [accessed 12 June 2008].

DFO Canada (Dept. Fisheries and Oceans Canada). 2005. **Guidelines on evaluating ecosystem overview and assessments: Necessary documentation.** DFO Canadian Science Advisory Secretariat Rep. 2005/026. Online at http://www.dfo-mpo.gc.ca/csas/Csas/status/2005/SAR-AS2005_026_E.pdf [accessed 12 June 2008].

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.

NAPAP (National Acid Precipitation Assessment Program). 1991. **Report from the Oversight Review Board. The experience and legacy of NAPAP.** National Science and Technology Council, Washington, DC.

Parsons, E. 1995. **Integrated assessment and environmental policy making: In pursuit of usefulness.** Energ. Policy 23:463–475.

Toth, F. L. 2001. **Participatory integrated assessment methods—An assessment of their usefulness to the European Environmental Agency.** Tech. Rep. 64, prepared for the European Environment Agency, Copenhagen, Denmark. Online at http://reports.eea.europa.eu/Technical_report_no_64/en [accessed 12 June 2008].

Integrated Assessment Implementation

National Examples

CENR (Committee on Environmental and Natural Resources). 2000. **National assessment of harmful algal blooms in U.S. waters.** National Science and Technology Council, Washington, DC. Online at http://www.cop.noaa.gov/pubs/habhrca/Nat_Assess_HABs.pdf [accessed 12 June 2008].

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Turgeon, D. D., R. G. Asch, B. D. Causey, R. E. Dodge, W. Jaap, K. Banks, J. Delaney, B. D. Keller, R. Speiler, C. A. Matos, J. R. Garcia, E. Diaz, D. Catanzaro, C. S. Rogers, Z. Hillis-Starr, R. Nemeth, M. Taylor, G. P. Schmahl, M. W. Miller, D. A.Gulko, J. E. Maragos, A. M. Friedlander, C. L. Hunter, R. S. Brainard, P. Craig, R. H. Richond, G. Davis, J. Starmer, M. Trianni, P. Houk, C. E. Birkeland, A. Edward, Y. Golbuu, J. Gutierrez, N. Idechong, G. Paulay, A. Tafileichig, and N. Vander Velde. 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. Online at http://coastalscience.noaa.gov/documents/status_coralreef.pdf [accessed 12 June 2008].

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Regional Examples

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This 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 this group initiated 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.

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