Report of the Protected Species SAIP Tier III Workshop

7-10 March 2006

Silver Spring, MD

Richard Merrick (Chair)
Ruth Kelty
Tim Ragen
Teri Rowles
Paul Sandifer
Barbara Schroeder
Steve Swartz
Nathalie Valette-Silver

April 2007

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

Report of the Protected Species SAIP Tier III Workshop
7-10 March 2006
Silver Spring, MD

Richard Merrick (Chair)[1], Ruth Kelty[2], Tim Ragen[3], Teri Rowles[4], Paul Sandifer[5], Barbara Schroeder[4], Steve Swartz[4], Nathalie Valette-Silver[2]

[1]National Marine Fisheries Service, 166 Water Street, Woods Hole, Massachusetts 02543
[2]National Ocean Service, 1305 East-West Highway, Silver Spring, Maryland 20910
[3]Marine Mammal Commission, 4340 East-West Highway, Bethesda, Maryland 20814
[4]National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, Maryland 20910
[5]National Ocean Service, 331 Fort Johnson Road, Charleston, South Carolina 29412

April 2007
NOAA Technical Memorandum NMFS-F/SPO-78

U.S. DEPARTMENT OF COMMERCE
Carlos M. Gutierrez, Secretary

National Oceanic and Atmospheric Administration
Vice Admiral Conrad C. Lautenbacher, Jr., USN (ret.), Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service
William T. Hogarth, Assistant Administrator for Fisheries

This document will initially be issued only online. It will be available at:

http://www.nefsc.noaa.gov/nefsc/publications/

It will be available in PDF format so that a paper copy can be easily printed out. It may subsequently be issued on paper as well. If it is issued on paper, then copies would be available from:

Protected Species Branch
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543

This document may be cited as:

Merrick R (Chair), Kelty R, Ragen T, Rowles T, Sandifer P, Schroeder B, Swartz S, Valette-Silver N. 2007. Report of the Protected Species SAIP Tier III Workshop, 7-10 March 2006, Silver Spring MD. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-78, 79 p.

Table of Contents

List of Illustrations

List of Tables

Executive Summary

Early in the development of the National Oceanographic and Atmospheric Administration (NOAA) Fisheries Protected Species Stock Assessment Improvement Plan (SAIP), it was clear that there were to be two phases in its development. In the first phase, NOAA developed a plan to address the basic marine mammal and turtle assessment mandates of the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA). After long discussions within NOAA and with NOAA's partners, a two-tiered plan was developed: *Tier I - Improve Stock Assessments Using Existing Data Collection Resources*, and *Tier II – Elevate Stock Assessments to New National Standards of Excellence*. This phase culminated in publication of the protected resources SAIP report (NMFS 2004).

Agency scientists recognized that current methods would not provide all the information needed by a changing NOAA. The evolving information needs of NOAA and its partners will require a host of data items that have not traditionally been collected. These needs are subsumed under the second phase of the SAIP development: *Tier III - Next Generation Assessments*. This phase will involve expanding observing and research programs beyond the traditional single-species approach towards an ecosystem-based approach, and will complement the current efforts underway for improvements in NOAA's fisheries science as part of NOAA's Ecosystem Goal Program.

Given the progress in the development of the SAIP and NOAA's Ecosystem Approaches to Management (EAM), NOAA Fisheries Office of Protected Resources determined it was time to begin work on the development of a requirements plan to define and provide Tier III information for its protected species mission. The first step in this process was a workshop convened by NOAA in March 2006 to clarify the vision of EAM for protected species, and scope the data collection and research necessary to support Tier III. The Tier III workshop was designed to answer a series of key questions that can provide guidance to NOAA staff in their development of the Tier III Plan:

- How do Protected Species fit into NOAA's EAM?
- Should NOAA's focus be "Ecosystem Studies with A Protected Species Component," "Protected Species Studies with An Ecosystem Component," or both?
- Can we develop an ecosystem approach for protected species stock assessments (e.g., can PBR be further developed to provide an ecosystem based assessment?)
- How should NOAA deal with the governance issues related to EAM for protected species? That is, how can EAM be used by NOAA managers to meet their ESA/MMPA mandates?

The workshop was held over a four-day period (7-10 March 2006) in Silver Spring, MD, and included a diverse group of scientists and managers from NOAA, academia, and other government offices. The first day and a half of the four-day workshop was a plenary session providing case studies of what an EAM could be for protected species. The remainder of the workshop focused on four working groups' (WG) discussions:

- WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component

- WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component
- WG 3 – Assessments –Ecosystem Based Stock Assessments for Protected Species
- WG 4 – Governance – Incorporating EAM into Management of Protected Species

Each WG was tasked to develop a conceptual strategy for a national and regional program supporting their theme.

What characteristics should a region-specific, national program have?

The WG's suggested that a national program to support EAM with explicit protected species components should be based on a clearly stated national mission or vision, flexible enough to adapt to regional needs, and with goals, objectives and performance measures which are responsive to broader ecosystem information. The program should fulfill the ecosystem mandates under the Magnusson-Stevens Fishery Conservation and Management Act, the Marine Mammal Protection Act, and the Endangered Species Act. Such a program should involve coordination and collaboration, transparency in decision making, and precautionary approaches to management in a place-based fashion, focusing on issues/threats to ecosystem, rather than on species-specific management.

The scientific program should focus on the eight regional ecosystems, while recognizing the nested and cross-boundary nature of many protected species. Science-based decisions are made using multidisciplinary information. This program should establish a standardized evaluation process, be as exhaustive and inclusive as feasible of all ecosystem components, and ultimately support an ecosystem based management model. Products of the program should be reference documents describing each ecosystem, long term monitoring of the eight regional ecosystems, and sustained, coordinated funding for ecosystem research and research platforms.

Are there appropriate experiences worldwide that can inform NOAA's ecosystem-based protected species management?

Key examples provided by the WGs included the developing Aleutian Islands Fishery Ecosystem Plan, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), the International Whaling Commission (IWC), Northwest salmon recovery efforts (including the Puget Sound Restoration Plan and the Puget Sound Collective Process), and various Northern European efforts, including BORMICON, MULTISPEC, Barents, North, and Baltic Sea multispecies models.

What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making?

Guidance varied among the WGs based on their group theme. For example, WG1 (Ecosystem Studies) identified six broad themes for which tools are needed: trophodynamics, acoustics, health, climate, habitat, and social science. WG3 (Protected Species Assessments) suggested that EAM assessments should include traditional single-species scientific advice, but also include ecosystem considerations. An "ensemble approach" to assessment using multiple model types may be an appropriate framework. Assessment models enhanced by ecosystem considerations need to result in clearly defined control rules to inform management decisions. WG4 (Governance), on the other hand, identified the need for a better Decision Support system to provide a framework for incorporating ecosystem science into management decision-making.

What changes in policy, governance, or science administration are required to more effectively inform ecosystem approaches to protected species management?

The WGs agreed that the existing NOAA mandates under the ESA, MMPA, NEPA,MSFCMA, and other legislative drivers provided ample statutory authority for the NMFS to proceed with implementation of EAM. Actual governance remains a thorny issue, however. The WGs suggested that perhaps the establishment of a new regional governance body (e.g., a Marine Ecosystem Council) could fill this role. The Puget Sound Collective may provide a model for such a body. In the short term, the authority of existing governance structures (e.g., Fishery Management Councils, Take Reduction Teams) should be expanded so that they have broader stewardship responsibilities and wider spectrum of stakeholder participation.

There was also general agreement that NOAA Science needs to be better integrated across taxa and disciplines and this may require the establishment of integrated national and regional marine science groups. This will further require a clear mandate from NMFS HQ to the field that the Centers and Regions conduct ecosystem/integrative research and management.

I. Introduction

A. Background

The NOAA Fisheries' Protected Species Stock Assessment Improvement Plan (NMFS 2004) was crafted in two phases. In the first phase, NOAA developed a Plan to address the basic marine mammal and turtle assessment mandates of the ESA and MMPA. After long discussions within NOAA, and with NOAA's partners, about basic information requirements, a two-tiered plan was completed:

- *Tier I – Improve Stock Assessments Using Existing Data Collection Resources*: This tier maintains the status quo with no new assessment efforts.
- *Tier II – Elevate Stock Assessments to New National Standards of Excellence*: At this Tier the quality of all stock assessments should achieve a level commensurate with ESA and MMPA mandates.

This phase culminated in publication of the Protected Resources SAIP Report (NMFS 2004). Development of the requirements plan through Tiers I and II represented a simple evolution of past practices; however, agency scientists recognized that current methods would not provide all the information needed by a changing NOAA. The evolving information needs of NOAA and its partners require a host of data that have not traditionally been collected.

These themes and needs are addressed in the second phase of the SAIP development, "*Tier III - Next Generation Assessments:*"

- Collection of detailed data on ecology, habitat, behavior, and health of "Ecosystem Indicator Species" to provide a better understanding of how marine mammals and marine turtles function within their respective ecosystems
- Ecosystem-based approach to assessments

This phase in the development of NOAA Protected Species requirements plan involves expanding observing and research programs beyond the traditional single-species approach towards an ecosystem-based approach. This complements the similar efforts already underway for improvements in NOAA Fisheries science. For a few key protected species (i.e., "Ecosystem Indicator Species") the second phase involves the collection of a basic suite of data under all data categories discussed previously. For all species, the second phase requirements mean that stock assessments will be conducted with processes and models not previously used.

While the SAIP was under development, NOAA Fisheries made considerable progress in defining an Ecosystem Approach to Management (EAM), and the concept of EAM is now firmly a part of NOAA's Planning Programming, Budgeting, and Execution System. Initial guidance for the agency's approach to EAM is provided in the report to Congress by the Ecosystem Principles Advisory Panel (http://www.st.nmfs.gov/st2/Eco-bas-fis-man.pdf). NOAA managers and scientists are now implementing the EAM process, with pilot EAM projects initiating in FY07 in a limited number of ecosystems. NOAA scientists and managers met in Charleston, SC in late summer 2004 to (1) discuss the delineation of large ecosystems on the basis of natural science (not political boundaries), and (2) discuss how these ecosystems might be broken down into sub-areas, again, based on natural science criteria. As a result of the workshop, NOAA defined 10 ecosystems based on the Large Marine Ecosystem (LME) model. These ecosystem regions extend from coastal areas to the seaward boundaries of continental shelves and to the outer margins of the major current systems. These were later reduced to eight regional ecosystems: Alaska Ecosystem Complex, California Current, Caribbean Sea, Great Lakes, Gulf of Mexico, Northeast Shelf, Pacific Islands Ecosystem Complex, and Southeast Shelf (Fig. 1). A subsequent workshop was held in Key Largo, FL in February 2005 to discuss "Ecosystem-Based Decision Support Tools for Fisheries Management: http://www.st.nmfs.noaa.gov/st7/ecosystem/workshop/2005/index.html

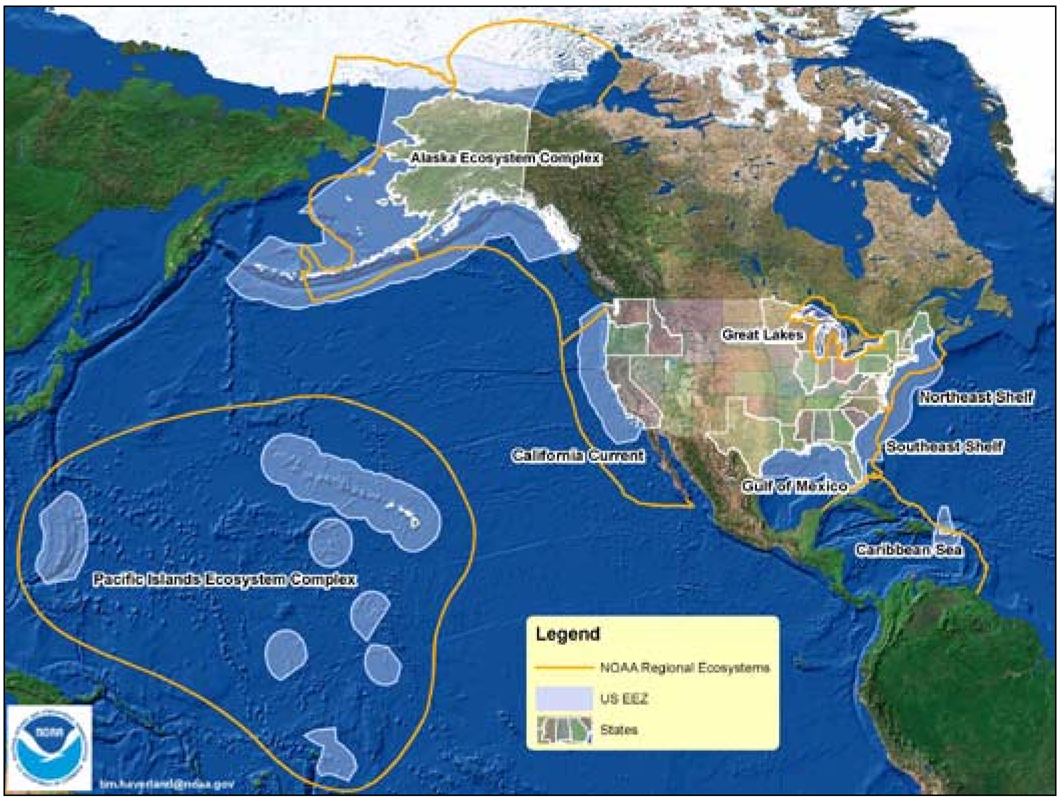

Figure 1. Eight regional marine ecosystems defined by NOAA.

Given the progress, in both the development of the SAIP and in EAM, NOAA Fisheries initiated work to develop a requirements plan to define and provide Tier III information for its protected species mission, and complement the existing Protected Species SAIP. The first step involved a workshop convened by NOAA in March 2006 to clarify the vision of EAM for protected species, and scope the data collection and research necessary to support Tier III. This workshop is to be followed by additional discussions within NOAA to prepare a Tier III Requirements Plan, and will culminate in an expanded version of the SAIP report to be completed in spring 2007.

B. Workshop Goals

The Tier III workshop was designed to address four key questions:

- How do Protected Species fit into NOAA's EAM?
- Should NOAA's focus be "Ecosystem Studies with A Protected Species Component", "Protected Species Studies with An Ecosystem Component," or both?
- Can NOAA develop an ecosystem approach for protected species stock assessments (e.g., can PBR be further developed to provide an ecosystem based assessment) ?
- How should NOAA deal with the governance issues related to EAM for protected species? That is, how can EAM be used by NOAA managers to meet ESA/MMPA mandates?

Other topics addressed included how the NOAA Ocean and Human Health Initiative fits into EAM, and how EAM can assist NOAA and its partners in meeting Tier III information needs.

These questions were addressed largely from the perspective of marine mammal, marine turtle, and salmonid conservation. However, the results of these discussions are applicable to other NOAA protected marine species.

Finally, results of the workshop, including the speaker and working group reports are available at https://reefshark.nmfs.noaa.gov/pr/saip/.

C. Workshop Format

The first day and a half of the four-day workshop was a plenary session (See Appendix I for the workshop agenda). The morning session of the first day was used to review current activities within NOAA is at this time with respect to EAM and SAIP development. The afternoon of the first day and the morning of the second day involved formal presentations and discussion of elements of EAM by invited speakers. Case studies were provided to generate discussion of what an EAM would be for protected species. The remainder of day 2, as well as most of day 3, focused on working group discussions designed to develop conceptual approaches to EAM for Protected Species.

The workshop included a diverse group of scientists and managers (see Appendix II):

- NOAA Fisheries staff representing Headquarters Office (F/PR, F/SF, and F/ST), and at least 1 representative from each of the Science Centers and Regional Offices
- NOAA NOS staff including staff from relevant NCCOS, Sanctuaries, NERR sites, and Ocean and Human Health
- DOI representatives from USFWS
- Marine Mammal Commission staff
- Selected scientists from outside of the US Government
- Selected scientists from other nations (e.g., Canada, UK)

The workshop was held over 7-10 March 2006 at the Hilton Silver Spring in Silver Spring, MD. NOAA provided full funding support for invited speakers and partial support for invited participants. This meeting was open to the public but did not include formal public comment sessions.

D. Working Group Terms of Reference

Plenary sessions of the meeting were chaired by Dr. Richard Merrick. Each working group had a facilitator and science/management chair working in tandem to move the discussions along. Rapporteurs were provided for each working group. Each working group produced a written report included later in this report.

Separate working groups were used to pursue four themes:

- **WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component**: What protected species information needs should be included in a national strategy to support EAM? Note that this ecosystem modeling is meant to include not only multispecies fishery assessments with predation explicitly included, but also ecosystem based acoustic analyses, ocean and human health, etc.
- **WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component:** What should a national strategy for ecosystem based protected species studies encompass?
- **WG 3 – Assessments –Ecosystem Based Stock Assessments for Protected Species:** Can traditional single-species protected species assessments (e.g., PBR) be made multi-species?
- **WG 4 – Governance – Incorporating EAM into Management of Protected Species:** How can NOAA implement ecosystem based management of protected species under MMPA and ESA?

Each WG was tasked to develop a conceptual strategy for a national and regional program supporting their theme, and to prepare a brief (~5 page) report on the outcome of the discussion. Each of the reports addressed, at a minimum, the following questions:

- What characteristics should a region-specific, national program have for this EAM theme?
- Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management (include appropriate references)?
- What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making?
- Based on the above, what changes in policy, governance, or science administration are required to more effectively inform ecosystem approaches to protected species management?

Participants were assigned to Working Groups generally based on their interests, although some balancing was done to assure roughly equivalent participation in each WG.

II. Workshop Presentations

A. Ecosystem Studies with A Protected Species Component

Disease and Ecosystems – Dr. Andy Dobson, Princeton University - Pathogens are a major component of biodiversity. In a healthy ecosystem, consideration of parasites may double the number of species. Absence of parasites is beneficial to invasive species. Shared pathogens and spillover create serious health problems for humans and endangered species. Biodiversity creates an important disease buffer, particularly against vector transmitted pathogens.

ICES Ecosystem Assessment WG – Dr. Jake Rice, Canadian Department of Fisheries and Oceans (DFO) - Jurisdictions around the world are facing many of the challenges to be addressed by Tier III assessments. The International Council for Exploration of the Sea (ICES), as the main provider of scientific advice to the European Community Director General for Fish and Environment, and to the fisheries and environmental commissions in the Northeast Atlantic, has been revising its Working Group structure and refocusing the activities of its Science and Advisory Committees to build capacity for integrated ecosystem assessments, and for provision of advice to management agencies which integrates fisheries issues, environmental quality, and species covered under the Species and Habitat Directive of the European Community. In Canada, the adoption of Canada's Oceans Strategy in 2002 and coming into force of the Species at Risk Act (SARA) in 2003 have required a similar restructuring of the approaches to assessments and provision of science advice. Ecosystem Assessments and a focus on recovery potential of species listed under SARA have taken a central place in DFO Science advisory tasks.

CCAMLR/SCAR – Dr. Christian Reiss, NMFS (SWFSC) - CCAMLR is an international body addressing living marine resource use and conservation in the Antarctic Ecosystem. Many of the assessment models for targeted and protected species are in some form linked to lower trophic level production, particularly of krill. Management decision criteria are developed in a precautionary manner, including “set asides” for krill. These can vary by species, but all are generally adaptive and coordinated.

EMAX – Dr. Jason Link, NMFS (NEFSC) - Energy Modeling and Analysis eXercise (EMAX) is a focused ecosystem study being conducted by the NEFSC. It is a network analysis model (aka a more nuanced energy budget) of the entire food web. It includes the entire Northeast US continental shelf, broken into 4 subregions, 34 network “nodes” or biomass state variables across a broad range of biology. The emphasis is on the role of small pelagics, with some pseudo-dynamic scenarios possible. Interactions with protected species are explicitly included.

Ocean and Human Health Initiative – Dr. Teri Rowles, NMFS/NOS - The OHHI seeks to understand the nature of interactions between human health and ocean processes, and to provide useful information to policy and decision makers. Focus areas include marine toxins and infectious diseases, chemical pollutants, coastal water quality and beach safety, seafood quality, and sentinel species as indicators of both potential human health risks and of human impact on marine systems. Importantly, the OHHI also focuses on the positive benefits of the sea such as the ecologically sound discovery of curative agents and marine natural products.

B. Protected Species Studies with an Ecosystem Component

Amphibian (and other species) epizootics – Dr. Andrew Cunningham, Zoological Society of London - Without coordinated disease surveillance with collaborative, multi-disciplinary (often multi-national) investigations, important diseases which threaten biodiversity and, in some cases, economic activities and human health, would remain unrecognized and undiagnosed. The more you look, the more you find; disease surveillance is an essential component of ecosystem management, and there is a need to establish base-line parameters wherever and whenever possible. There is more to disease threats than just pathogens causing mass mortality events.

Ecopath/Ecosim model for green turtles in the Caribbean -- Colette Wabnitz, University of British Columbia - The roles of sea turtles as major consumers in many marine ecosystems have only recently been recognized. Green turtle (*Chelonia mydas*) biomass levels required to maintain "healthy" sea grass beds within the Caribbean were explored using a quantitative ecosystem model, Ecopath with Ecosim.

The Ecopath model was designed as a "snapshot" estimation of turtle density for the Puerto Rico/Virgin Island shelf region, and extrapolated to the Caribbean. Thus, the Ecopath result is an estimate of turtle biomass per km^2 of sea grass, given a number of trophic considerations. These biomass estimates were then evaluated over a range of conditions (e.g. competitive interactions) to determine turtle biomass levels needed to maintain a productive system. The Ecosim module allowed predicting changes in community structure under varying levels of turtle impact given fine-tuning of trophic mediations built into the system (e.g. impact of shorter sea grass canopy on refuge role afforded to juvenile fish populations). Important assumptions underlying the exploration of such interactions are that: i) shoot density is independent of blade length, thus an increase in sea grass biomass can be equated with longer blade length; and ii) an increase in biomass is coupled with a decrease in productivity:biomass ratios, which have been validated by simulated grazing experiments in the Bahamas. These explorations combined with apparent changes in community structure are used to characterize carrying capacity of green turtles for the Caribbean. Moreover, preliminary results highlight gaps in our understanding of sea grass ecosystem dynamics and allow us to draw up hypothetical scenarios of management decisions.

Canadian Research on Cod-Seal Interactions – Dr. Garry Stenson, Canadian Department of Fisheries and Oceans - The collapse of the Northwest Atlantic cod fishery has become a metaphor for ecological catastrophe and is universally cited as an example of failed management of a natural resource. Various hypotheses have been advanced for the demise of these once abundant stocks. One is that physical changes in habitat have led to the decline. Cold water, reduced salinity, and other environmental parameters have been posited as components of the problem by reputable researchers. Another hypothesis is that the decline resulted from overfishing of cod stocks, and a statistically significant relationship has been demonstrated between the decline of cod and commercial harvests (Hutchings and Myers 1994). A third alternative hypothesis is that harp seal (or grey seal) predation on cod has contributed to the decline of cod stocks and/or to the lack of recovery. Over the past decade(s) scientists at the Canadian DFO have studied the interaction between seals and cod in an attempt to explore this hypothesis. Work has focused on building accurate consumption models derived from the considerable data collected on seal population dynamics, physiology, prey consumption, and movements. These consumption models can then be incorporated into cod assessment models to evaluate seal impacts on cod stocks.

Ecosystem-scale analyses in support of management in Puget Sound – Dr. Mary Ruckelshaus and Dr. Michelle McClure, NMFS (NWFSC) - The Puget Sound ecosystem contains over 40 species currently listed on state and federal imperiled species lists, dead zones within certain embayments, and over a dozen Superfund sites within the Sound. These insults to the ecosystem impair the services that it provides—hindering not only recreational enjoyment of the region, but also human health, fishing and other economic pursuits. Scientific analyses in support of recovering and rebuilding species within the Puget Sound led inexorably towards ecosystem approaches to management. Ecosystem-scale scientific analyses have been used to develop a regional salmon recovery plan and are now being conducted to support regional efforts in ecosystem-scale management. The salmon recovery plans are based on restoring landscapes and habitat-forming processes in terrestrial, estuarine and marine environments. Recovery planners designed landscape restoration strategies based on models of the combined effects of habitat, hatchery and harvest management, and how alternative future climate scenarios impacted the predicted success of their proposed strategies. Given recent Orca listings, the strong food web interactions in marine waters, and water quality degradation in Puget Sound, it was recognized that a more scientifically explicit ecosystem framework was needed within which species and their habitats could be managed. In conjunction with a Puget Sound-wide ecosystem management initiative launched by Governor Christine Gregoire, there is a scientific effort to develop a collaborative 'state of the science' document. The document is authored by scientists from multiple agencies and universities, and provides a common vision of what is known about how the Puget Sound ecosystem functions, the ecosystem services it provides, key threats to those services, and socio-economic values. The document also contains a decision support framework illustrating how natural and social sciences will inform an eventual EAM plan for the Sound. Preliminary analyses are presented for several components of the ecosystem-scale modeling in Puget Sound.

Eastern Tropical Pacific (ETP) Dolphin Studies – Dr. Lisa Ballance, NMFS (SWFSC) - Incidental mortality of dolphins in the eastern tropical Pacific yellow fin tuna purse-seine fishery has been historically high. That mortality has dropped to values close to 0 since 1990. However, depleted populations of dolphins have not recovered as expected and the natural question is why? We posit four possible causes: time lag, fishery effects, a change in carrying capacity of the system, or some other factor. A major climate shift occurred in the North Pacific in the late 1970's. Evidence of ecosystem change in the ETP associated with this shift is equivocal. It is conceivable that environmental change at this time affected spotted and spinner dolphins, although it is unlikely to have caused the apparent 3- to 5-fold decrease in carrying capacity needed to explain the lack of recovery.

Linkages Between North Atlantic Right Whales and their Habitat – Dr. Andrew Pershing, Cornell University - Oceanographers and atmospheric scientists have done a good job describing the average, or climatological, conditions over the Earth, and in understanding the major processes that account for these conditions. There is now much interest in understanding what causes one year (or decade, or century...) to be different from another. Cornell researchers have conducted several studies of the changes in physical conditions in the Gulf of Maine since the 1950s and how these changes have impacted zooplankton populations. One current project uses this knowledge to develop predictive indices for physical and biological conditions in the Gulf of Maine. This is of particular importance in understanding survival and recruitment of North Atlantic right whales. With only a few hundred animals left, the North Atlantic right whale is one of the most endangered marine species. Cornell scientists have investigated the impact of interannual variability in copepods (e.g., *Calanus finmarchicus*) on right whale reproduction, and are currently studying factors which can be used to predict aggregations of right whales based on the distribution of their prey.

Ecosystem-Based Approaches to the Management of Coral Reefs – Dr. John Ogden, University of Florida - Over the past 50 years, global coral reefs have precipitously declined from synergistic combinations of three major human disturbances: fishing; land-based pollution; and global climate change. Reefs are biologically diverse and characterized by the diversity and strength of interactions between species, for example, in larval dispersal and recruitment, competition, predation, and herbivory. Reefs rapidly lose resilience with disturbances to key functional groups and with physical stresses, particularly temperature. Any coral reef ecosystem is the product of its geography and history and is dependent upon other coastal ecosystems, including sea grasses, mangroves, and adjacent land masses. These considerations argue for ecosystem-based approaches to management to preserve and restore ecosystem structure and function, to reduce stresses, and to separate conflicting and damaging human activities. The ecosystem approach is based upon mapping, assessment, monitoring, and modeling and is dependent upon stakeholder involvement and gap-filling research. The coral reef ecosystem is defined as the *area of concern* at a variety of geographic scales depending upon the scientific and social considerations central to any management plan. As with any place-based management, zoning is a critical tool-- applied with a precautionary strategy and adjusted adaptively with increasing knowledge.

III. Working Group Reports

A. Working Group 1: Supporting the NOAA vision of EAM--Ecosystem Studies with a protected species component

Facilitator : Cyr
Science Chair: Rowles, Link
Participants: Bigford, Clapham, Collins, Fair, Ford, Gerke, Hall, Hoffman, Lang, Lewandowski, McFaddern, Menashes, Norse, Reiss, Roden, Southall, Whaley

1. What characteristics should a region-specific, national program have for this EAM theme?

NOAA's vision of EAM explicitly calls for an interdisciplinary, cross-sector approach for managing coastal and oceanic resources (Ecosystem Goal Team [EGT], etc.). Thus, in the context of protected species, is necessary to consider a broader range of factors than under current single species protected resource management strategies. For example, ecosystem considerations as diverse as trophodynamics, acoustic environments, water quality, and ocean health will merit greater direct consideration in assessments. How these and other ecosystem factors directly impact protected species is probably best addressed in a single-species stock assessment context. How these ecosystem factors indirectly impact and are impacted by protected species, as well as cumulative systemic affects, are best addressed in a broader ecosystem context. Thus, a national program to support EAM with explicit protected species components should:

- Address major issues (e.g. trophodynamics, acoustics, water quality, ocean health, climate, habitat) by providing germane information required by other NOAA partners and stakeholders as well as EGT or Protected Resources (PR).
- Set national standards but be adaptable to regional needs
- Be responsive to legislative mandates
- Have a clearly stated national mission. However, this would need to be operable at the regional level. In general terms, we define the mission of this particular program as: "Provide protected species information to better understand broader ecosystem dynamics and to produce integrated regional assessments."
- Coordination and collaboration across line offices and other programs are critical to the success of this theme. As such, stakeholders, partners, and end-users need to be clearly identified and there needs to be adequate processes for stakeholder input and inclusion. Additionally, the program should have the ability to "kill two birds with one stone" from the same type of data provided or from coordinated platforms. For example, tissue plugs taken from marine mammals might be used to augment other efforts on trophic ecology, ocean health, human consumption of fish and sea mammals, and toxin biomagnification.
- Be as exhaustive and inclusive as feasible of all germane ecosystem factors. This would require objectives and performance measures for broader ecosystem information, and also require clearly identified processes for review of outputs. But arguably most prominent, the

national program needs to establish a standardized process to evaluate the most prominent factors in each regional ecosystem.

2. Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management?

A prime example can be found in the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), an international treaty administered in the United States by NOAA Fisheries. The CCAMLR approach sets out three broad objectives to the management and rational use (harvesting) of krill in the Southern Ocean. These include, a) Prevent decrease in size of harvested populations below that necessary for stable recruitment; b) Maintain ecological relationships between harvested, dependent and related species; c) Prevent or minimize risk of changes not reversible over two or three decades. The scientific input for CCAMLR is based, in part, on an age based fishery model; monitoring of krill and predator populations, reproduction and feeding ecology, and through development of ecological indicators of ecosystem state. Feedback mechanisms in the management arena provide the link between science and the fishery.

Other examples include[1]:

- Southern ocean GLOBEC
- NAMMCO- Norway/Iceland- BORMICON/MULTSPEC
- International Whaling Commission working groups
- Yodzis et al. model from Argentina and Yodzis et al. model from South Africa
- Ecopath w/Ecosim and marine mammals
- Australian Dugong management
- NMFS AKFSC- Steller Sea Lions and groundfish
- NMFS NEFSC- EMAX
- Sea otter, kelp interactions and trophic cascades
- NOAA's Ocean and Human Health initiative
- Discovery of toxoplasmosis in sea otters leading to evaluation of run-off from feral and domestic cats which may have human health implications
- Cold-water coral management in the North Atlantic (ICES, NMFS)
- Australia's Great Barrier Reef initiative

Considerable reference material is also available as part of the efforts to conserve Northwest salmon. One key research area is the use of habitat and environmental information to inform stock assessments or recovery plans (Bartz et al. 2006, Lawson et al. 2004, Logerwell et al. 2003, Scheuerell and Williams 2005, Scheuerell et al. 2006. A second area of active research is

[1] See: Bogstad et al. 1997, Butterworth and Thompson 1995, Courchamp et al. 1999, Constable 2001, Crooks and Soule 1999, Hannon 1973, Hannon and Joiris 1989, Hammond and Fedak 1994, Hedley et al. 1999, Hewit and Linen Lowe 2000, IWC 2001, 2002, 2003, Koen Alonso and Yodzis 2005, Leontief 1951, Mangel and Switzer 1998, McLaren et al. 2002, Mohn and Bowen 1996, Punt and Butterworth 1995, Stefansson and Palsson 1998, Thomson et al. 2000, Ulanowicz and Puccia 1990, UNEP 1999, Whipple et al. 2000, Yodzis 1988, 1998.

species interactions (Johnston et al. 2004, Levin and Williams 2002, Levin et al. 2001, Nickelson 2003, Ruggerone et al. 2005, Ruggerone and Nielsen 2004, Scheuerell et al. 2005)

3. What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making? - An ecosystem approach to management will require additional information on ecosystem structure and function, as well as managed populations. Just as an ecosystem approach will not replace, but enhance, existing single-species approaches to management, so too more and better ecosystem information will not replace the need for existing basic biological and physical data, research and modeling. The recommendations herein are intended as enhancements to existing programs.

The Working Group divided its charge into broad themes: trophodynamics, acoustics, ocean health, climate, and habitat (Appendix Table 1). For each, the Group identified priorities for new work in four areas: research, data collection, models and data management.

Trophodynamics - Key research questions include: What are the relative removals of and by protected species? What is the role of the abundance, distribution and nutritional quality of prey to changes in abundance and vital rates of protected species predators? What are the indirect effects of changes in prey to protected species? What is the role of competition with and among protected species?

Data to be collected on individuals or populations include: abundance, rate of increase and removals; vital rates (survival/mortality, maturity, reproduction); bioenergetic rates (metabolism, consumption, respiration); diet composition; foraging behavior; interspecific relationships (niche separation, competition, spatial/temporal overlap, dietary overlap); carrying capacity; and interactions with fisheries. Many models with which to analyze these data exist already, but need to be carefully parameterized and tested against data from ecosystem scenarios with known outcomes. A critical review of existing models is essential, and it would be useful to test multiple models on the same data sets to assess variability in reliability of output. Different data sources exist (many online), and these should be integrated.

Acoustics - Owing to the physical properties of water, sound is the principal means by which information is transferred over any appreciable distance. Sounds associated with marine biota, physical forces, and human activities provide detailed information with which both people and animals sense the marine environment. Further, sound can be used as an active investigative tool for locating objects. Because a wide range of biotic and abiotic information that may be obtained, an ecosystem approach to marine research and management should rely strongly on acoustic sensing. Specifically, passive acoustic sensors should be integrated into ocean observing systems to: 1) detect seasonal presence, activity, and (in some instances) abundance of species within ecosystems; 2) provide remote measurements of climatological and geological processes (*e.g.*, rain and earthquakes); and 3) assess ecosystem-specific, spatial and temporal trends in ambient noise 'budgets' from the range of source contributions. Active acoustic sensing should be applied and advanced, where appropriate, as a means of identifying specific features of marine ecosystems (*e.g.*, temperature, prey abundance, or the presence of specific species).

A systematic approach is required for assessing marine ecosystem elements using passive acoustics. Specific questions regarding biotic and abiotic contributions to marine ambient noise should be identified and relevant sampling regimes specified (*e.g.*, bandwidth, duty cycle, directionality) specified. Passive acoustic deployments to date have identified the seasonal presence of specific marine species, demonstrated human sound source contributions to marine ambient noise, and contributed to meteorological measurements. Further deployments and new sampling regimes should have the ability to assess spatial and temporal trends over a range of ecosystem features. Comparative ambient noise measurements should be taken across various marine ecosystems having variable anthropogenic influences. Acoustic data should be integrated with information on habitat and ecological factors to develop predictive ambient noise models. These will be distinct from the fairly well-derived sound propagation models for predicting received levels from a specified sound source. Ambient noise models would be useful in gauging not only estimated baseline conditions against which to assess anthropogenic inputs, but also in identifying environmental features relevant for active acoustic deployments. Data management should ensure maximal retention of raw data but be amenable to auto-recognition and other analyses.

Ocean and Human Health - Ocean and human health parameters have rarely been included in ecosystem models or in ecosystem approaches to management. Under this theme, a hypothesis driven research plan should be included to support an ecosystem approach to understanding causal relationships between humans, ocean processes, marine ecosystem health, human health, and protected species health outcomes. For this effort, ocean health encompasses multiple ecosystem stressors and the protected resources within such systems and includes anthropogenic persistent and non-persistent organic and inorganic compounds, naturally occurring harmful algal blooms and their associated biotoxins, pathogens (including parasites), pharmaceuticals, water quality, and nutrients that contribute to hypoxic events. This theme also ties in with the Habarca Act, OHHI and Title IV and CCM. In addition risk and hazard communication plans should be integrated into the data management plan for this theme.

Climate - Climatic and environmental data are critical components of any EAM approach to management, as they form the background state of the natural world in which protected resources reside. Any movement towards EAM with a protected species component will require a significant applied research program to support EAM, especially since EAM will naturally be adaptive, and region specific. Such a research program must elucidate linkages between ecosystem productivity, habitat structure and carrying capacity, as variability in the former two components will directly affect the latter. For example, climate variability may alter the productivity of the ocean or coastal environments. Such an ecosystem response would likely affect the ability to reach current rebuilding goals regardless of the protections afforded to species over projected time scales. Thus, research should include development of environmental and climate indicators and the refinement and validation of existing indicators. Such a research program should be broad, encompassing aquatic, terrestrial and atmospheric data, but should focus on providing information directly in support of EAM goals and regional species specific assessments.

Habitat - Developing a quantitative understanding of the relationships between habitat and ecosystem function will be a critical component of an ecosystem approach to management. In particular, for many species, habitat quantity or quality are key factors limiting species abundance and productivity. For some protected species, habitat quality or quantity may be a direct factor limiting their recovery, while for others habitat impacts may be important through indirect effects on prey species. Human activities have both dramatic and subtle impacts on marine and coastal habitats, and predicting and managing the effects of such activities on species abundance, productivity, spatial structure and diversity will be essential to an ecosystem approach to management. Climatic variability is also likely to alter the structure of habitats reinforcing the need to include habitat information in any EAM approach.

4. Based on the above, what changes in policy, governance or science administration are required to more effectively inform ecosystem approaches to protected species management?

It is arguable that an ecosystem approach to manage PR is doable now. There are a plethora of legislative mandates that provide the basis for ecosystem considerations. For instance, the Endangered Species Act, Marine Mammal Protection Act, Magnuson-Stevens Fishery Conservation and Management Act, and the National Environmental Policy Act all have implicit ecosystem components. Additionally, NOAA's Policy, Mission Statement, and Agency-wide goals have Ecosystem Approaches as a top element.

Within the NOAA Ecosystem Approach to Management initiative, issues of internal and external governance are keystone concepts. Internal governance issues relate to how NOAA structures itself as an organization, how responsibilities are delegated, and how these actions are prioritized, planned and funded. Enhanced internal coordination (across NOAA line offices) is clearly needed. External governance covers issues of how NOAA relates to other federal, state, local, and international governments; particularly cooperative linkages, agreements, and NOAA's role as a lead entity compared to one team member on any given issue.

There is also a need to establish regional bodies, akin to those identified in the U.S. Oceans and Pew Commission reports. As envisioned in this working group, these bodies would receive and evaluate integrated assessments in a coordinated manner. These assessments would be for an entire ecosystem with explicit PR components. The point of such subregional bodies would be to provide a forum for addressing trade-offs in broader, LMR decision making.

Finally, there is recognition that NOAA needs dedicated groups to perform integrated science within the context of national standards. Proceeding in an *ad hoc*, matrix-based manner has been tested at the operational, scientific level. The results clearly indicate major challenges and impediments for continued and escalating progress to actually implement an EAM for PR or other managed LMR. Within NOAA Fisheries, a dedicated group at each Science Center would greatly facilitate and rapidly increase our capability to implement EAM.

B. Working Group 2: The Protected Species Vision - Protected Species Studies with an Ecosystem component

Facilitator: Salvini
Science Chair: Swartz
Participants: Balance, Coyle, Cunningham, DiGiovanni, Forst, Gulland, Hohn, McClure, Mesnick, Moy, Ogden, Pershing, Ruckelshaus, Schroeder, Schwacke, Thomas, Wabnitz, Ward, Wilkin

In expanding protected species studies to include ecosystem components, the WG suggested that NMFS start with a few achievable elements, build up over time, and revisit and adapt periodically. Studies should strive to be interdisciplinary, integrating physical, biological, social, and economic components, as well as parasites (e.g., pathogens and other health issues). NMFS needs to focus attention on finding and using existing data, and build the flexibility to respond to unexpected events, such as post-hurricane monitoring.

Building and formalizing partnerships is crucial within NOAA, as well as with other agencies, NGOs, academia, and international organizations. It may be necessary to re-think NMFS' current organizational structures to facilitate collaboration, communication, and data-sharing. Partnerships may be useful in obtaining funding for new initiatives, and to ensure the necessary funding consistency to support long-term research projects.

Finally, it is essential that NMFS efficiently communicate study results to researchers, management, and public in a way that addresses their concerns, demonstrates their connection to the resource, and is relevant and useful.

1. What characteristics should a region-specific, national program have for this EAM theme?

NOAA should create knowledge and procedures to make better informed decisions about protected species. These should take into account the species position in the ecosystem. For example, NOAA accounts for direct fishing impact on protected species through bycatch mitigation, but does not generally analyze the effect that fishing has on the prey of the protected species. Moving to this perspective will involve additional monitoring and process studies, and involve the development of new knowledge (models). It must encompass the public wherever possible and be presented in a way that encourages a "well informed public that acts as a steward of coastal and marine ecosystems." It will necessitate coordination between groups within the science centers, within NOAA, with other Federal and state agencies, and with NGOs and stakeholders including the public.

Development of these new procedures should begin with a baseline document describing the ecosystem, the protected species, and how these relate to each other. It should clearly identify what we do and do not know. It should clearly state the management goals, and be written in a non-technical way to engage a broad coalition of scientists, managers, and stakeholders.

Long-term monitoring programs are essential for any ecosystem approach to management. For a protected species, this has traditionally meant surveying for abundance, although recently, surveys have expanded to include distribution, stock structure, diet, and health. A truly ecosystem approach to management will require monitoring the quality of the protected species' environment, including physical and chemical conditions and the abundance of predators and prey. Monitoring should also consider anthropogenic and other perturbations to protected populations including fishing, habitat destruction, disease, climate variability, pollutants, and noise. Long term monitoring requires stability, both in the sense of funding, and also methodology and data management. Detailed process studies are also needed and should be a regular part of protected species studies. These process studies provide depth of knowledge and should be responsive to management needs. They will also require development of new technology to improve our knowledge and ability to monitor protected species.

Data from monitoring programs must eventually be used to guide decision making. Ecosystem based management models are needed that provide a formal representation of our knowledge of the species or ecosystem in question. Models provide a quantitative way to evaluate management options and can synthesize multiple data sources to provide better estimates of stock abundance. The modeling process should be transparent, with open access to code, documentation, and test cases. Because our knowledge is constantly changing as new data become available, it is essential that models be periodically revisited to assess their accuracy and ability to represent the system or process in question. Finally, models are never perfect, and it is vital that we quantify uncertainty and that this uncertainty is transmitted to decision makers.

There are also issues of scale which need to be addressed:

- NOAA has defined 8 Regional Marine Ecosystems (RMEs; Fig. 1). While the decision of demarcation was difficult, these RMEs are thought to adequately represent unique ecosystems, recognizing that each includes sub-units. The issue of what management area is too big to be managed or too small to be significant to the species in question is difficult. NOAA is now pursuing defining small regions within each RME to be more representative of "unique" areas within RMEs.
- Many protected species migrate through multiple RMEs and rely on resources within each (e.g., feeding and breeding areas and migration routes). This is true for salmon, whales, turtles which are transboundary, and do not fit very well in the proposed NOAA ecosystem model

The ecosystem approaches to management of protected species need to include all the components of ecosystems on which the protected species rely. Systems need to reach a state where they are not "out of balance" with respect to resource requirements for protected species. If a protected species recovers, the species and its habitats will need to be managed for sustainability. This presents potential problems with recovered populations that exceed the capacity of their ecosystems to support them. Culling is not popular, and historically has not been based on a complete understanding of the complex dynamics and relationships within the ecosystems in question. Management must apply to all aspects of ecosystem equally. Management should not focus on only some focal species at the expense of others in the community. While people care about marine mammals, sea turtles, and seabirds and these often are the focus of public concerns, other community species are equally at risk and are important within the ecosystem.

When management action is taken, follow-up monitoring is necessary to quantify efficacy. Certain systems and actions may provide unique opportunities to design management actions as experiments.

An ecosystem approach to management will require extensive collaboration and coordination. On the research and monitoring side, it is essential that NOAA scientists coordinate and collaborate with researchers in NOAA Line Offices, other federal and state agencies, NGOs, and academia. Coordination is also essential on the management side and will require communication within NOAA, with other Federal agencies, with fishery management councils, and with states and local governments. Finally, it is important to engage stakeholders, including the general public, in the process of monitoring, studying, and managing protected species. Opportunities for citizen science or cooperative research with fishermen should be encouraged. Results should be communicated to the public in an accessible format (e.g. regular "Ecosystem Considerations" reports as companion documents to fish or protected species stock assessment reports).

2. Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management?

For NOAA's Eastern Tropical Pacific Tuna/Dolphin Ecosystem Observation Program (ETP), the program driver is the Congressional mandate for information on the status on ETP dolphins. The core data collection effort supports an abundance estimate, which defines how the vessel surveys will be designed and the study area to be included. Additional ecosystem sampling then must conform to this survey design on a space available basis to maximize research opportunities.

In the Northeast Region, protected species research has been conducted independently of fisheries studies (e.g., the semi-annual bottom trawl surveys). However, protected species abundance surveys in the Northeast collect a variety of data on the physical and biological oceanography along the track lines. Recent studies have also included dedicated seabird observers. Despite the expanded data collection effort, integration of these additional data into the assessments remains awkward.

Pacific Northwest salmon population recovery actions & programs are good examples of approaches that obtain the necessary data on physical, biological, chemical, and socio-economic aspects for successful conservation. While many salmon stocks have yet to recover, the approach has been comprehensive and adequate to maintain most stocks even at low levels.
As the preceding suggests, many of the NOAA Fisheries' Science Centers (perhaps all) have made considerable progress in expanding the scope of the data collection effort to include ecosystem information. This has required better integration and coordination of survey designs between collaborators, development of tighter networks for data acquisition and exchange, and agreement upon spatial and temporal sampling scales.

Similar problems will be encountered when incorporating terrestrial information into protected species ecosystem assessments. For most terrestrial ecosystems (e.g., coastal wetlands, etc) there is no one source for all the information needed. This is partly the result of overlapping jurisdictions.

Examples of broad ecosystem approaches in a terrestrial context include the:

- Nature Conservancy's eco-regional planning program,
- Pew strategy program, and their "Land Reserves" program
- UK's Royal Society for Protection of Birds which protects single species by managing their ecosystems and all their components based on the requirement of the birds
- US National Audubon Society's annual breeding bird survey which collects a nation-wide data set by volunteers.

Examples in marine systems include:

- Coral Reef diver's organizations to collect data on reef communities and status.
- Whale watching operators for information on whale location.
- Citizen scientists (e.g., "environmental stewardship" programs) can potentially provide useful ecosystem data. Pelagic environments present other problems for volunteers and citizen observers because of the remote nature of these environments and difficult logistics (e.g., require large vessels).
- Fishermen could also potentially collect environmental and ecosystem information (e.g., water samples for domoic acid testing) provided that specific collection instructions and sampling protocols are provided and complete information is obtained (e.g. location, day, time, depth, etc.).

3. What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making?

Protected species studies having an ecosystem component will require a new approach to the species management paradigm, including an ecosystem approach to data collection and analysis. Both broad scale and fine studies will be required, for example, health assessment monitoring would need to include both scanning and targeted surveillance. Data needs will have to be identified at both a species and Regional Ecosystem level, and then prioritized.

More attention will need to be placed on information systems and data management. Specifically, metadata standards need to be established, data sharing agreements and structure to facilitate data sharing need to be crafted, dedicated database managers need to be assigned, and databases need to be linked to GIS and models for further analysis.

Further development is needed for EAM. In-house modeling capacity at the Centers needs to be strengthened. Risk-based models with probabilistic output should be developed to support management, and more attention should be paid to modeling experience from other disciplines and environments (terrestrial, economics, climates, disease, acoustic), including integration of existing complementary models (e.g., biochemical and trophic). Finally, criteria need to be established for validating models.

4. Based on the above, what changes in policy, governance or science administration are required to more effectively inform ecosystem approaches to protected species management?

A first step will be for NOAA to deal with changes that are achievable within the next few years:

- Construction of a "big-picture" document or knowledge inventory for each LME to include: identification of protected species occurring in the LME; general description of the physical and biological environments and other apex predators; identification of existing datasets and ongoing research activities, and research needs
- Implementation of a NOAA Fisheries intranet site (integrated with and across Science Centers and Headquarters) to facilitate communication of opportunities and ongoing research
- Establishment of a Seminar series highlighting multiple projects within a single ecosystem
- Hosting of a NCEAS-style workshop to identify datasets, research needs, and ongoing projects with overlapping interests
- Support of sabbaticals to allow scientists to interact with researchers involved in different disciplines and/or ecosystems
- Increased opportunities for short-term rotational assignments
- Increased use of existing opportunities to bring in visiting scholars (e.g. NRC Post-docs)
- Formalization of partnerships across Centers of Excellence, both within the agency, and between other government agencies, academic institutions, and NGOs, so that individual scientists do not have to create those partnerships on their own. (Examples: Marine Mammal Health and Stranding Program with science centers and regions)

NOAA should subsequently address permanent institutional changes which need to be made to incorporate EAM into daily business of the Agency. Because EAM is based on long-term monitoring of components of entire ecosystems, a long-term permanent source of funding is required. Clear prioritization of research needs (e.g. which components of the ecosystem will be monitored and what metrics for each will be used) is critical.

The current PPBES structure funnels funding for EAM through three programs. The benefits of such an approach is that if one source is reduced, certain aspects of the research can continue. The costs are that piecemeal funding may lead to false assumptions that reducing the funding from any one program will not severely affect the research of other programs. To maintain current funding levels and then strategize on increasing funds, NOAA needs to combine efforts to improve visibility to Congressionals and constituents.

Better communications are needed within NOAA Fisheries, between NOAA Line Offices and other government agencies, and with academia and NGOs. Within the Science Centers, there are divisions that prevent EAM. For example, staff may be organized around taxonomic groups rather than around LMEs. Science Centers are often disconnected geographically and informationally from their respective Regional Offices. A similar lack of communication occurs between the Science Centers and Headquarters.

Possible remedies include:

- an internal grants program with preference for multidisciplinary participation
- more integrated websites
- new positions within the Science Centers with their primary functions being to filter information from various levels to the appropriate individuals (for example, a liaison position designed to identify and facilitate communication between persons involved in research in the same Regional Ecosystems, or to communicate research and funding needs between a particular Science Center and Headquarters)
- Internal reorganization of Center science along Ecosystem lines

NOAA also needs to formalize its partnerships. EAM by definition requires integration between scientists and researchers representing a vast range of disciplinary and taxonomic expertise. Rather than re-inventing the wheel at each Science Center, we suggest identification of "Centers of Excellence" for those disciplines and taxa that are essential for effective EAM in each Regional Ecosystem. Centers of Excellence can be located in other federal or state agencies, in NGOs, or in academia. For example, most Science Center are already allied with an adjacent university. Because EAM requires knowledge of the physical and biological oceanography in each Regional Ecosystem, NOAA scientists involved in EAM could partner with oceanographers in these universities to obtain the necessary data, rather than hiring their own cadre of oceanographers.

C. Working Group 3: Ecosystem Based Stock Assessments For Protected Species

Facilitator: Valette-Silver
Science Chair: Palka, Ragen
Participants: Abbott, Baker, Barlow, Bengtson, Chaloupka, Cornish, Eagle, Garrison, Lawson, Merrick, Rice, Rosel, Seminoff, Stenson

Stock assessment refers to the synthesis of information to provide management advice. Often that synthesis involves quantitative models, but qualitative information is also relevant. Ecosystem-based stock assessment for protected resources therefore refers to those stock assessments that serve as the scientific basis for the management of protected species and include ecosystem considerations such as physical habitat, trophic and other biological interactions, pollutants, anthropogenic noise, disease, etc.

Ecosystem-based stock assessments cover a wide range, both in terms of the degree to which ecosystem data are included (Appendix Table 2) and the degree to which quantitative models are used to provide a synthesis of available information. The first step in ecosystem-based assessments is the use of ecosystem information to augment or enrich the interpretation of a single-species stock assessment. At the other extreme are models of entire ecosystems that include trophic interactions of all major components of the ecosystem and geo-chemical factors that affect these components. We include this full range of assessments in our consideration of ecosystem-based stock assessment.

Three guiding principles should be recognized in all assessments:

- ecosystems include interactions among many components, and extracting any component from an ecosystem can be expected to affect the other components,
- ecosystem interactions are complex, and there will always be considerable uncertainty in predicting indirect effects on other elements of the system, and
- ecosystems may change abruptly from one domain or stable state to another; these changes may not be predictable and may not be reversible on a decadal time scale.

Management advice from ecosystem assessments should emphasize these considerations.

1. What characteristics should a region-specific, national program have for this EAM theme?

To be most effective, a national program for incorporating ecosystem dimensions into protected resources assessments should have a region-specific focus. Moreover, it is likely that a variety of spatial scales will be appropriate when defining such regions. The eight Regional Ecosystems that NOAA has identified describe relevant regions at the broad scale. But within these Regional Ecosystems (two of which are considered LME “complexes” that encompass several diverse marine ecosystems), it would be desirable to define smaller areas defined by their ecological structure. Such “ecoregions” are likely to have a spatial extent of tens to hundreds of kilometers.

They may be characterized by physical and biological features such as bathymetry, physical oceanography, biological productivity, and biodiversity. It is expected that defining ecological subregions within LMEs will facilitate ecosystem-based assessments by organizing both the implementation and coordination of research and monitoring programs around ecological criteria.

A national program must have clear goals, be flexible, and be adaptive. The goals should be realistic under the time frames both for stock assessments and for ecosystem reviews. The national program should include:

- A structure which breaks down barriers within Centers and between agencies, thereby facilitating coordinated, efficient ecosystem based stock assessments
- Shared information systems
- A communication process that ensures dissemination of data and ideas between different scientific disciplines, and between scientists, managers, decision makers, and the public
- Staff that are knowledgeable of the EAM focus
- A data collection program to gather new data on the various important components of the ecosystem at the frequency and scale necessary to adequately detect changes, when these occur.
- Fora to discuss allocation among stakeholders (i.e., fishing industry, oil and gas, point source pollutant producers, etc.), and to review science and develop mitigation measures

Ecosystem based assessments should be:

- Multi-disciplinary and include appropriate biotic and abiotic factors, Allele and behavioral effects (if appropriate), anthropogenic interactions, and impacts that are acute (bycatch) and chronic (disease, pollutants).
- Explicitly include the target species, if possible.
- Simple, explainable, and effective.
- Robust to data-poor areas and species.
- Both quantitative and qualitative.
- Based on standardized terms and approaches for different parts of ecosystem research.
- Explicitly designed to deal with uncertainties, and include sensitivity analyses.
- Designed to include studies of the impacts of single/multiple stressors on the species (or area) of interest; utilize both top-down components (e.g., region-specific ecosystem review) and bottom-up components (e.g., enriched single species stock assessment); and use the most appropriate model (within the single species to bio-geochemical ecosystem modeling continuum) for the species/area of interest.
- Include a control law that builds upon the existing control laws and also explicitly incorporates ecosystem attributes.

2. Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management?

There are a number of examples worldwide of incorporating ecosystem information into assessments and advice on management of marine populations. Many of the best cases are not of protected species but, as noted elsewhere, address ecosystem considerations which are generic to all aquatic species and populations, and not specifically to protected species. Hence, insights can be gained from successes with ecosystem assessments of many types of species.

As described in the introduction, we define “assessments” as including more than just quantitative models of the dynamics of a population or aggregate of populations. There are both narrative and analytical components to an “assessment” and to the advice therein derived. Specific examples range from assessments that are largely narrative with very modest quantitative content to assessments which are heavily analytical and are associated with minimal text. With regard to successful examples of bringing ecosystem content into the analytical aspects of assessments, cases are presented here for several of the increasingly complex types of “analytical assessments.”

“Enriched” Single-species Assessment Models

These are stock assessment models designed to quantify the historic trajectory, current status and trend of species or stocks, and usually include short to medium term projections of a species’ or stock’s abundance. These models usually include as dynamic components (i.e. functional relationships are specified and parameterized) the effects of physical forces on population productivity (recruitment, growth or both) and first-order predator and prey linkages. The predator-prey linkages may be reflected in estimates of predation mortality, or in estimates of growth, maturity, fecundity or starvation due to the variability of prey species’ abundance.

There are many examples of “enriched” single-species models, for example Barents Sea cod (both water temperature and prey availability captured dynamically), Baltic Sea cod (effects of salinity and dissolved oxygen levels on recruitment), sardine and anchovy stocks in Iberian waters (related to upwelling), and various capelin assessments (predation mortality). The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) assessments of krill also includes predation mortality. The ETP tuna-dolphin model is another enriched single-species model, incorporating oceanographic forcing and other factors. In all of these cases the analytical model results may be directly incorporated into the scientific advice for management of the stocks, or used to provide insight into alternative options for management.

Multi-species Assessment models

These are assessments where a number of interacting predators and prey are linked dynamically, so increases in predators affect the mortality rate of their prey. In some cases, the effects are reciprocal, such that increases in prey affect growth and fecundity of predators; in other uses, it is assumed that prey included in the model obtain their energy from other prey not being explicitly modeled.

The most widely used multispecies model has been the Multispecies-Virtual Population Analysis (MSVPA), used in the North Sea and Baltic Sea to estimate predation mortality. These estimates are then transferred as the natural mortality parameters of single species models of each of the species in the MSVPA. MSVPA has been used in the Barents Sea and Icelandic waters, and in both cases marine mammal predators are included explicitly. Custom-made multi-species models were also developed for the Benguela Current system; in this model, predation by marine mammals was a core dynamic relationship. As is commonly the case, this application of a multi-species model is used to inform management strategies rather than as a basis for annual harvest advice. Multispecies models, including MSVPA and other custom-made models were also effective in exploring relationships between Steller sea lions and Bering Sea walleye pollock, and informing management decisions about the walleye pollock fishery.

Trophodynamic Models
Various trophodynamic models have been used to explore dynamic relationships among predators and prey, covering multiple trophic levels. Yields to harvesters and effects of physical forcing factors have often been included in these models.

There are well over 150 applications of Ecopath to marine systems, and other mass-balance models have also been employed. These models have been are used primarily for scenario exploration and to gain qualitative insight into effects of different management strategies. There are very few cases where serve as a basis for quantitative harvest advice. References are available from the University of British Columbia Fisheries Centre (www.fisheries.ubc.ca) and *The Sea Around Us* (www.seaaroundus.org) websites.

There have also been a number of size-based rather than species-based models of trophodynamics of interacting predators and prey. These models tend to include fewer trophic levels, and species – including protected species – are not represented explicitly, limiting the utility of these models as a source of advice for protected species. However, the models tend to be easily parameterized in systematic and rigorous ways, more readily constrained by available data, and can provide very useful results. They are in early stages of application as tools for evaluating management strategies in an ecosystem context, but are promising.

Several efforts have been made to develop multiple, independent and structurally different ecosystem models for the same system for "ensemble forecasts". These efforts are not intended to be actual assessments of the component species (or species groups), but rather identify system dynamics important to capture in much simpler assessment models, and to illustrate robustness of alternative management strategies to uncertainties about ecosystem structures and functions.

The Atlantis model (Fulton et al. 2003) captures relationships among multiple trophic levels and effects of environmental forcing. Atlantis is not intended to be a basis for the annual (or regular) assessment process, but is used to evaluate the robustness of management strategies to uncertainties concerning relationships among ecosystem components and future states of nature.

Using trophodynamic models, CCAMLR has explored many potential approaches for evaluating and testing robustness of management strategies. CCAMLR has several mechanisms for incorporating an "ecosystem approach" into fisheries management and conservation efforts in the Antarctic, although many involve data collection and harvest control rules rather than assessment models. The CCAMLR Ecosystem Monitoring Program (CEMP) monitors seabird and marine mammal status (e.g., abundance, reproductive success, vital rates, foraging ecology) to: 1) detect changes in key bird and mammal population parameters over time (i.e., to identify ecological changes within the marine ecosystem), and 2) differentiate between natural and anthropogenic (e.g., indirect effects of commercial fisheries) effects on the marine ecosystem (i.e., using protected resources as indicator species).

The International Whaling Commission (IWC) also uses models with multi-species dynamics, and has several types of forcing functions. The IWC assessment models have a variety of levels of ecosystem content, reflecting variable levels of knowledge and information. The models are designed to test the robustness of harvest control rule and to provide a quantitative basis for advice on stock recovery potential (and possible trajectories), and harvests.

Full bio-geo-chemical ecosystem models

The Everglades model (e.g., deAngelis and Cornutt 2002) builds all the way from basic primary productivity driven by nutrients and physical conditions to individually-based models (IBMs). It is a conspicuous success, but the costs (dollars and scientific expert time) for development and ongoing operations make it a challenging model to replicate.

The Puget Sound Collective has model development as one aspect of its activities, and addresses problems similar in scope and complexity to those of the deAngelis Everglades team. The Collective's approach is much "softer" and more qualitative, but still requires expertise from many sources (both formal science disciplines and types of experiential knowledge). Progress is faster, but the quantitative content of the results is not nearly as high. The resultant "models" are useful for interactive scenario exploration, but less so for formal testing of robustness of management strategies.

Another activity in which ecosystems are considered is the evaluation process of eco-certification as developed by the Marine Stewardship Council (MSC; www.msc.org). The MSC process is a rigorous and systematic procedure for ensuring that the full range of ecosystem considerations are addressed in evaluating the status and the effectiveness of management actions. The MSC evaluation process addresses a large number of ecosystem factors, including environmental forcing, predator and prey relationships, and fishery effects on non-target species and habitats. Although the MSC's evaluation of a fishery is not the same as evaluating the status of a protected species, the approach is comprehensive and operational, and there may be many useful lessons to be learned from the process.

3. What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making?

Research and Data Requirements

Research and data collection to support ecosystem based stock assessments should relate to one of NOAA Fisheries' three legislative mandates: Marine Mammal Protection Act, Endangered Species Act, or Magnusson-Stevens Fishery Conservation and Management Act. As such, the output of EAM needs to be augmented assessments. These assessments should include a broad range of biotic or abiotic factors into the assessment framework, and the outcomes need to be the delivery of scientific advice to the management decision processes. EAM assessments should include traditional single-species scientific advice, but also consider that 1) extracting resources from any systems affects other elements of the system, 2) these are complex systems and there will always be uncertainty in predictions about them, and 3) ecosystems changes may include abrupt state changes, that often do not reverse quickly. Research and data collection to support EAM should explicitly incorporate uncertainty and provide advice as to how uncertainty is treated in assessments and management advice. Finally, although these comments are directed toward Protected Resources, there is nothing unique in these suggestions.

A number of initial steps can be made prior to the initiation of an EAM program using information now available. The first group of activities can be accomplished with research and data programs that presently exist within Protected Resources:

- There needs to be an initial review of existing information.
- This would lead to data inventories of accessible data and metadata.
- Equally important we need to identify what we don't know. It is imperative to get basic fundamental information on poorly characterized stocks. Stock structure, abundance, distribution, and trends need to be elevated to Tier II levels.
- There needs to be a synthesis of current research efforts. We need synthesis papers 1) that examine why certain stocks have failed to recover while others have, as well as 2) process case studies of indirect ecosystem impacts, and 3) case studies of ecosystem state changes.
- EAM research and data collection programs need to develop research program review structures, and must include periodic outside reviews.
- A system should be developed to codify best practices about how to transfer knowledge from one area to another. Again, a need exists to inventory data and metadata.
- We should review data on the distribution in space and magnitude of diverse human activities on the seas, on coastal boundaries, and terrestrial systems.
- There needs to be a review of data on human demography, distribution, and resource needs.
- Abiotic data needs to be collected for thermal components of marine and terrestrial systems.

Appendix V includes a list of research topics identified by the working group.

Models

Incorporating ecosystem considerations into assessment models primarily involves increasing the complexity of models (i.e., adding parameters), thereby increasing the uncertainty in both model outcomes and data demands. Ecosystem approaches to fisheries assessment have proceeded along a gradient of increasing complexity from the single species approaches (where all processes except for fisheries removals are implicit in a small number of parameters) to trophodynamic and biogeochemical models (which attempt to model energetic flows and environmental forcing among multiple ecosystem components and across trophic levels and scales). Generally, the increased complexity of these models requires greater aggregation of nodes and processes such that the specificity of management advice declines. Therefore, for assessing the dynamics and status of specific species and/or stocks, models best categorized as "augmented" single species approaches are likely to be the most tractable. Ideally, this augmented model structure will be standardized across species (and perhaps species groups) so as to create, at least conceptually, consistency in the methods used to assess and manage protected species within an ecosystem context.

The majority of fisheries based augmented and multispecies assessment tools have focused on understanding trophic dynamics so as to improve estimates of predation mortality and identify potential linkages between commercially exploited and non-target species. However, for many protected species, trophic dynamics will not be the primary factor limiting population dynamics and recovery. Likewise, many protected species do not play a significant energetic role in their ecosystems. A suite of processes including disease, exposure to persistent organic pollutants, toxicity due to algal blooms, exposure to noise, and other factors are important acute and chronic stressors. Significant research and model development efforts will be required to incorporate these environmental effects into assessments. As well, there will be increased data demands to understand population-level effects of chronic and acute exposure to environmental stressors.

Spatially explicit and habitat based models will also be important for assessing risks and environmental impacts on protected species stocks. To some extent, this need for improved understanding of fine-scale spatial patterning is incorporated in existing standards for Tier II assessments. However, it will also be important to relate population movements to exposure to various stressors. For example, large scale migratory movements of calving right whales may increase their exposure to vessel strikes. Seasonal residence of bottlenose dolphins inside of estuaries may increase exposure to pollutants and toxins arising from terrestrial sources. Thus, linking movements and habitat use to exposure to risks will be an important added component of assessment models.

No single model framework will be sufficient to incorporate all extant data and serve as the best mechanism to represent all important processes. Therefore, an ensemble approach to assessment using multiple model types may be a more appropriate framework. This is consistent with many of the larger ecosystem approaches where multiple, independent models have been developed and applied to the same system. Evaluating the performance and uncertainty associated with different models may improve the understanding of the system, identify major processes, and highlight critical data gaps.

Ultimately, assessment models enhanced by ecosystem considerations should result in clearly defined control rules to inform management decisions. Several basic principles should guide the development of this framework. First, models and the control rules they support should have an explicit approach for dealing with uncertainty in model structure, data limitations, and process variability. Second, formal procedures should be developed to verify model/control rule performance including simulation studies and sensitivity analyses. Third, recognizing that some processes can only be dealt with through qualitative assessment and advice, there should be a specific decision support framework for incorporating information into assessments, control rules, and management decisions. The assessment framework should explicitly identify the qualitative components of the management advice and how they should be incorporated into decision rules. A Bayesian risk assessment framework will be likely be a fruitful approach for augmented assessment tools; however, there are a variety of decision support approaches that are available across multiple disciplines.

Information systems

Expanding the scope of assessment models necessitates the use and integration of additional data. The majority of these data cannot be collected within the framework of a "protected species" focused program. This is particularly the case with data derived from remote sensing, data on pollution sources, land use information, etc. However, these data collection programs do exist within other line offices of NOAA, in other federal and state agencies, and in academic institutions. Thus, a core goal of a developing an ecosystem assessment program should be the development of information systems which will facilitate warehousing, exchange, and access to a broad suite of environmental data. Further, collaborations across institutional boundaries must be developed to allow a more diverse suite of expertise to be actively involved in the assessment process.

As the scope of users will expand under EAM, it is essential that information systems contain appropriate and standardized metadata to allow the effective search, download, and use by a range of users. Likewise, for each data type or monitoring program, a codified set of best practices should be developed so that data quality is well understood.

The primary goal of the information management system is to facilitate access and sharing of collected data across line offices and institutions. Some attention must be focused on the effective translation of information to managers and on access to information to support risk assessments or decision rules. A unified information management system would therefore include not only data inputs for assessment models, but would also facilitate access to and exploration of outputs.

4. What changes in policy, governance or science administration are required to more effectively inform ecosystem approaches to protected species management?

The current mandates of the MMPA and ESA, with respect to ecosystem-based management, compel us to move forward using existing knowledge. Rather than wait for an ecosystem-driven policy and governance structure, we have the components and drivers to implement EAM right now.

The unique characteristics of an ecosystem-based protected species management program should be emphasized within any EAM document. However, such a document should also recognize the commonalities between research geared towards fisheries and protected species, and capitalize on these developing integrated ecosystem-based research programs.

Public education should be considered when planning ecosystem-based research and management program, to elicit awareness and support for such programs.

Policy

Policy level commitment to EAM is wide-spread and strong. The missing elements are clear structures and practices to implement policies. Some of these require, or would be facilitated by changes to legislation. Others require regulatory modifications, different emphases or modification of agency-level practices.

Legislation: Identify and link language supporting EAM into existing statutes. For example, PBR could be expanded to include direct or indirect sublethal (chronic) effects. However, direct mortality is simple to assess compared to non-lethal stressors; thus, the two types of factors should not be easily mixed.

Another approach would be to create a mixed body of stakeholders, scientists and managers (like a TRT) to account for all activities that affect protected species and design an overall approach to limit take or habitat modification that would allow protected species to remain functioning elements of their ecosystems.

Regulations: Consolidate fishery management and protected species regulations to clarify the full range of requirements.

In both regulations and explicit policy statements, specific guidance is needed for management practices. This guidance could be developed using simple, transparent support rules for ecosystem considerations that explicitly consider uncertainty. If feasible, such rules should be incorporated directly into statutes. The issue of rights versus privileges is important in granting access to resources or governance of resources.

Agency-level changes in practice include greater use of qualitative information in decision making using more risk averse strategies (accept a lower standard of evidence for supporting protective measures), and thinking in terms of aggregate rather than cumulative impacts. The latter would remove the constraint that the last resource user in the ecosystem has to use existing levels of take or modification as a baseline. Rather, an ecosystem advisory body would consider the aggregate effects of all potential users in the affected areas.

Policies and practices need to address human elements in the ecosystem. Humans clearly affect other components of ecosystems and are, in turn, affected by other components. Human behavior and cultural factors also need to be incorporated in the EAM.

Governance

The concept of a Marine Ecosystem Council was proposed as the ideal governance instrument by which all of the current species-based governance structures (e.g., Fishery Management Councils [FMC], Take Reduction Teams [TRT]) would be overseen (and perhaps even subsumed). This would allow for better integration and incorporation of ecosystem-based principles in actual practice.

Recognizing that there may be considerable resistance to a new governance structure, a more pragmatic recommendation was for the current species-based structures to have broader representation from all ecosystem components. For example, protected species and habitat representatives would serve as active members of Fishery Management Councils.

The group also strongly encouraged expanding the authority of current protected species-based governance structures (such as TRTs) so that they have a broader stewardship mandate and a broader group of stakeholders. This was in recognition that "objectives-based management" is now widely accepted, but in practice there are few fora for reconciling objectives across multiple interest groups and industries/communities. In the case of Alaska, there are currently no TRTs from which to build this type of structure, therefore, an alternate forum would need to be implemented there.

There needs to be a clarification between central and regional roles in existing governance structures, and a mechanism should be developed for funding critical governance structures and operations, such as observer programs and enforcement.

Science Administration - Structure and Execution

Implementing EAM will mean that institutional inertia in NOAA Fisheries must be overcome. To do so, a clear mandate and directive is required from HQ to the Science Center Directors regarding the need to conduct ecosystem/integrative research. In turn, Center Directors must structure their Centers' scientific enterprise to facilitate ecosystem studies. This will involve budgets, personnel, ship time, and external partnerships. There should also be a coordinated information system support across Center organizational units.

The above process will necessarily involve eliminating barriers between PR, Fisheries, habitat, and oceanographic researchers and then bringing them together to conduct Ecosystem Assessments (will also likely include State, FWS and others). This could involve multi-disciplinary task forces/working groups to address *areas* rather than *species* groups.

Success stories exist in fully integrated priority and objective setting, knowledge integration, planning and management (i.e. Puget Sound salmon example). Recognizing that the science and communication overhead to make these efforts work is huge, and cannot be replicated for all species and areas, there is a need to develop ways to transfer lessons learned without duplicating efforts each time. Along the same lines, NOAA should look to other agencies that have attempted to implement EAM, and learn about their experiences.

Review/Evaluation

The group recognized that evaluation of ecosystem assessments is an important element. One aspect of this is an honest and transparent accounting of the costs for conducting such assessments. While these may be high, it was noted that integrated research would likely involve cost efficiencies compared to independent studies.

Two suggestions were offered for reviewing ecosystem science. The first was to create a forum for reviewing ecosystem assessments akin to the MMPA's Scientific Review Groups. Another suggestion was to hold multi-disciplinary workshops/conferences into people working on various aspects in the same or similar ecosystems to facilitate exchange of data, develop partnerships and provide peer review.

Other Issues

It was agreed that a great need exists to ensure that science for supporting management (including ecosystem science) is independent (not biased toward pre-determined outcomes).

Finally, there was a suggestion based on the Canadian experience that there should be just "one window" for science advice for all NOAA clients (fisheries, protected resources, sanctuaries, etc.) to ensure a consistent message.

D. Working Group 4: Governance-Incorporating EAM for Protected Species

Facilitator: Kelty
Science Chair: Gouveia, Payne
Participants: Barnes, Bernhardt, English, Fahy, Hill, Jacobs-Spaulding, Kinan, Mengerink, Rusin, Scida, Simpkins, Thom, Trumble, Wakeford, Williams, Wilson, Yuen

1. What characteristics should a region-specific, national program have for this EAM theme have?

Vision

A governance system that sustains and nurtures healthy and productive ecosystems by managing the impact of human activities on ecosystems while taking into account natural variation and change in the systems.

Goal

Create a governance framework supporting the vision [allowing for input and integration of information to make decisions] with the following characteristics:

- Retain the authority of existing legal mandates (including, but not limited to ESA, MSA, MMPA, NMSA);
- Emphasize a precautionary approach to management in response to uncertainty at various levels;
- Maintain a healthy and productive ecosystem while allowing sustainable use;
- Manage in a "placed-based" fashion, focusing on issues/threats to the ecosystem, rather than species-specific management;
- Identify the scale of management units taking into consideration nested and transboundary ecosystem components;
- Manage human activities to identify and separate conflicting uses and account for variability and patchiness within ecosystems (e.g., zoning);
- Make proactive decisions using a NEPA-like process (i.e., examine broad social, economic, biological, and cumulative impacts prior to making management decisions);
- Facilitate transparent communication of knowledge, experience, and the decision-making process;
- Support collaboration between stakeholders/constituents and state, federal, and international agencies/governments;
- Create synergy among groups resulting in improved cost effectiveness;
- Support partnerships for joint management and research initiatives on national and international scales;
- Recognize adaptive and incremental processes and be flexible enough to allow changes suggested by information acquired through process and outcome reviews;
- Dedicate appropriate levels of funding for adequate durations, providing long-term and stable fiscal support required for cost-effective science and management;

- Make science-based decisions using multidisciplinary information from social science, ecology, biology, oceanography, and climatology;
- Address data needs through identification of data gaps, prioritization of data needs, data collection to address research questions and management needs, establishment of targets or thresholds, including precautionary targets for data poor components of an ecosystem; and monitoring and evaluation of EAM processes and outcomes.

2. Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management?

The WG suggested that there were a number of good examples of EAM:

Aleutian Islands Fishery Ecosystem Plan

The North Pacific Fishery Management Council is considering preparing a Fishery Ecosystem Plan (FEP) for the Aleutian Islands region. This FEP would be a pilot initiative to begin the Council's development of a process for ecosystem-based fishery management in the North Pacific. The FEP would describe the environmental processes of the Aleutian Islands ecosystem and how fisheries and fishery management interact with these processes. Initially, at least, the FEP would have no regulatory authority. Rather, the FEP would help the Council explicitly focus and consider ecosystem components when considering fishery management actions.

Puget Sound Restoration Plan

The Puget Sound region of Washington State has used a collaborative, multi-agency and public process to develop and implement a regional anadromous salmon recovery plan. The collaborative process created a non-profit group—the Shared Strategy—that coordinates and works with federal, tribal, state and local governments, and with interests from business, agriculture, forestry, fishing, conservation and the general public. Fourteen watershed groups plus a nearshore-marine group identified the actions to recover salmon and commitments needed to achieve them. They also worked with state and tribal co-managers to incorporate hatchery and harvest actions to ensure these are consistent with salmon recovery. The Puget Sound Technical Recovery Team (TRT) is an independent group of scientists that provided ESA delisting criteria and technical guidance for evaluating alternative sets of watershed- and regional-scale actions for the recovery plan. The Shared Strategy builds on assessments, processes, programs, and regulations already underway and knits them together into a comprehensive strategy to recover salmon at a regional scale. The regional consensus process ensured that the recovery plan ultimately reflected local needs and priorities while meeting ESA requirements. The plan was published in the Federal Register in January, 2006, and has broad support and a robust financing strategy. The Shared Strategy continues as a body to coordinate early funding priorities and implementation of the hatchery, harvest, and habitat actions outlined in the plan.

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)

CCAMLR was established in 1982 as part of the Antarctic Treaty System. Central to the Convention is Article II, which providers the three guiding principles of conservation for the conservation of Antarctic marine living resources: (a) prevention of declines in any harvested population to levels below those which ensure stable recruitment; (b) maintenance of ecological relationships between harvested, dependent and related populations, and (c) prevention of changes or minimization of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

CCAMLR approached the first and last parts of Article II by applying standard fisheries management techniques to Antarctic problems. A working group on Fish Stock Assessment was created in 1984 and one on Krill in 1986. The second part of Article II, the ‘ecosystems approach’ required the development in 1985 of an Ecosystem Monitoring Program for the Antarctic marine environment which involves monitoring selected predator, prey and environmental indicators of ecosystem performance. The aim of the program is to detect changes in these indicators and evaluate whether these changes are due to natural events or harvesting activities.

3. What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making?

There is a major need for a better Decision Support System (including relevant models). Such a System should: (a) provide a framework for incorporating science into decision-making; (b) facilitate the evaluation of alternative sets of ecosystem management strategies using conceptual and quantitative ecological and socioeconomic models; and (c) provide a set of scientific tools that help policy makers identify and minimize potential conflicts (Mangel 2000).

The complexity of managing an ecosystem requires a decision-support system that relates the ecological and socioeconomic consequences of potential specific management actions to broader policy goals. Sainsbury et al. (2000) coined the phrase Management Strategy Evaluation (Fig. 2) to describe a decision-support system that uses the following elements:

- Evaluate the status of the system being managed as a whole (not just isolated parts);
- Specify policy objectives and performance measures that are connected to those objectives;
- Relate alternative management strategies to predicted changes in the performance measures;
- Monitor the system; and
- Provide for iterative decision making that is based on data from the monitoring program.

This formal adaptive-management approach can be used to investigate the consequences of a variety of scenarios derived from a range of models. The approach is designed to enable decisions in data poor environments, and can be transparent and collaborative if resource managers and stakeholders have input into selecting candidate models and management scenarios. The approach encourages all participants to be explicit about their goals, and helps make the decision-making process more transparent to the public.

Building a decision-support system requires both scientific and policy inputs, with the two spheres interacting as the framework is developed and implemented. A formal decision-support system contributes to the transparency of making management decisions and encourages a collaborative process which strengthens the system. Formal modeling (conceptual and quantitative) of both the ecological and socioeconomic components of the ecosystem is an important element of a decision-support system.

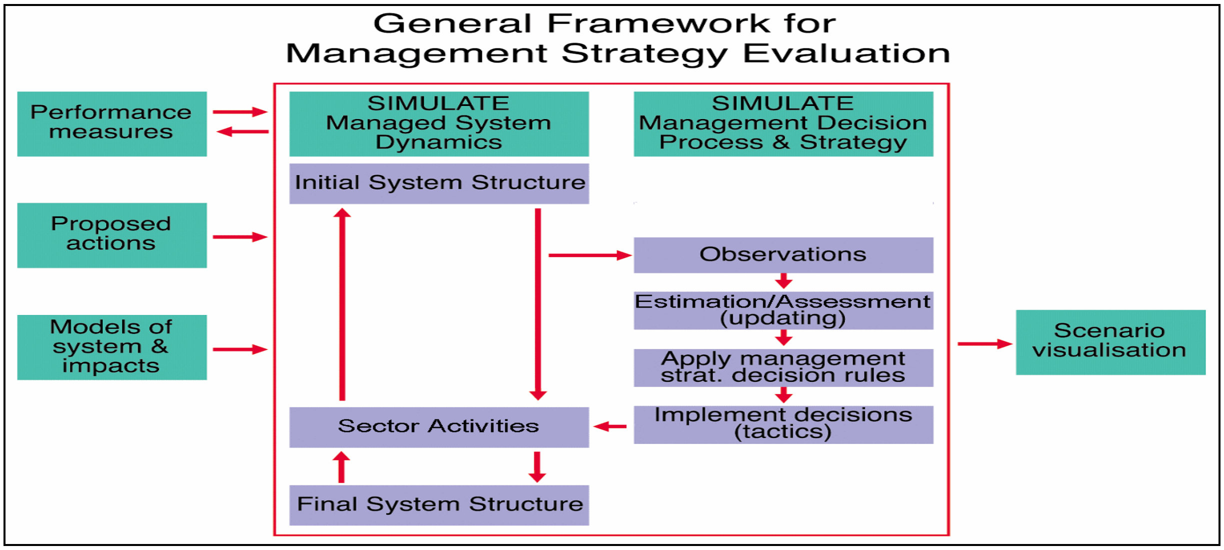

Figure 2. General framework for management strategy evaluation (Sainsbury et al. 2000)

Such a system will require an inventory of partners, collaborators, stakeholders, and constituents within an ecosystem, including:

- Who will participate?
- Who will coordinate data collection and sharing?
- What are the jurisdictions and authorities?
- Who can take action?

It will also require an information management system feeding the decision support system with data inputs, data and model output, and an identification and prioritization of data gaps.

4. What changes in policy, governance or science administration are required to more effectively inform ecosystem approaches to protected species management?

A functional governance structure for EAM must be developed. A variety of governance structures could provide adequate support for EAM (Appendix Table 3) but, in all cases, several crucial governance roles must be assigned to specific entities:

- Setting a national vision and goal(s) for EAM
- Setting national EAM policy (e.g., approved EAM measures, decision rules, required responses to "ecosystem problems," and regional management and decision-making structures)
- Collection and integration of scientific data necessary for EAM (e.g., conducting ecosystem studies, evaluating ecosystem health via decision rules)

- Making EAM decisions regarding the need for action to address ecosystem problems and identifying agencies that must respond to problems
- Implementation of EAM decisions
- Monitoring and evaluation of the effectiveness of EAM implementation, including the decision-making process and the outcomes of management actions.

As mentioned above, a decision support system will be necessary to support an EAM governance structure, and the support structure should be seamlessly integrated into the governance structure. Similarly, scientific advice and stakeholder input must be integrated seamlessly into the governance structure. This may involve the creation of science and stakeholder advisory boards or integrated ecosystem advisory boards.

As governance roles are distributed among existing or new entities, several important issues should be considered. At each level, one must decide what source(s) of information will be used to fulfill the assigned roles. For example, at the highest level, will a national vision and goals be set based solely on scientific information, and will they include input from diverse government agencies, stakeholders, and/or the public. Such decisions become especially important when determining the source(s) of information making and implementing EAM decisions. The level of stakeholder input, in particular, must be determined as this can range from simply informing decisions to participating in developing consensus decisions. The trade-offs between developing support for EAM decisions among stakeholders (thereby promoting compliance with EAM guidelines or regulations) vs. the potential for stakeholders to promote less precautionary EAM actions (which are less detrimental to stakeholders' vested interests in the ecosystem) must be considered carefully.

IV. Summary and Conclusions

A. What characteristics should a region-specific, national program have for EAM?

Each of the four WG provided a different perspective in answering this question; however, all the groups generally agreed on the same general characteristics. NOAA's vision of EAM explicitly calls for an interdisciplinary, cross-sector approach for managing coastal and oceanic resources (EGT, etc.). Thus, in the context of protected species, it will be necessary to consider a broader range of factors than under current single species protected resource management strategies. A national program to support EAM with explicit protected species components should be based on:

- A clearly stated national mission or vision, which is flexible enough to reflect regional needs
- Goals, objectives and performance measures which are responsive to broader ecosystem information.
- A response to legislative ecosystem mandates.
- Coordination and collaboration across line offices and other programs
- An ability to address major issues by providing germane information required by other NOAA partners and stakeholders as well as EGT or PR.
- Collaboration with (and inclusion of) stakeholders, partners, and end-users.
- Transparent communication of knowledge, experience, and decision-making.
- Precautionary, proactive approaches to management.
- Management in a place-based fashion, focusing on issues/threats to ecosystem, rather than species-specific management

The scientific program should:

- Focus on the eight regional ecosystems, while recognizing the nested and cross-boundary nature of many protected species.
- Establish a standardized process to evaluate the most prominent ecosystem factors in each regional ecosystem.
- Be as exhaustive and inclusive as feasible of all ecosystem components.
- Provide for and support an ecosystem based management model.
- Provide a reference document describing each ecosystem.
- Recognize adaptive and incremental processes and be flexible enough to allow changes suggested by information learned through process and outcome reviews.
- Provide for long term monitoring of the components of the eight regional ecosystems
- Support partnerships for joint management and research initiatives on national and international scales.
- Coordinate funding, research, and research platforms.
- Foster science-based decisions using multidisciplinary information.

B. Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management?

All of the Working Groups were able to provide examples of existing approaches to ecosystem-based protected species management, and consistently listed the following examples:

- NOAA Fisheries' Alaska work conducted by the NPFMC, Alaska Fisheries Science Center, and Alaska Regional Office on Steller sea lion and groundfish interactions, including the developing Aleutian Islands Fishery Ecosystem Plan
- Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
- The International Whaling Commission (IWC)
- Northwest salmon recovery efforts, including the Puget Sound Restoration Plan and the Puget Sound Collective Process
- Various Northern European efforts, including BORMICON, MULTISPEC, Barents, North, and Baltic Sea multispecies models

A number of other examples are provided in Appendix Table 4. Through not accomplished at the Workshop, a review document summarizing these efforts would provide useful guidance to further advance NOAA's Ecosystem Approaches to Protected Species Management.

C. What new research, data, models, or information management systems are required to advance the discipline and provide the basis for ecosystem-based decision making?

Guidance varied among the WG based on their group theme. The Governance WG identified the need for a better Decision Support system (including relevant models). Such a system would provide a framework for incorporating ecosystem science into decision-making, and provide a set of scientific tools that help policy makers identify and minimize potential conflicts and impacts. WG1 identified six broad themes for which tools are needed: trophodynamics, acoustics, health, climate, habitat, and social science.

With respect to EAM protected species assessments, WG3 suggested that these assessments should include traditional single-species scientific advice, but also include ecosystem considerations. An "ensemble approach" to assessment using multiple model types may be an appropriate framework. Assessment models enhanced by ecosystem considerations need to result in clearly defined control rules to inform management decisions.

A core goal in developing an ecosystem assessment program should be the establishment of information systems that will facilitate warehousing, exchange, and access to a broad suite of environmental data.

Further, it is essential that collaborations across institutional boundaries be developed to facilitate a more diverse suite of expertise to be actively involved in the assessment process.

D. What changes in policy, governance, or science administration are required to more effectively inform ecosystem approaches to protected species management?

The WGs generally agreed that existing NOAA mandates under the MSFCMA, ESA, MMPA, NEPA, and other legislative drivers provided ample statutory authority for the NMFS to proceed with implementation of EAM.

Actual governance remains a thorny issue, however. This was a central issue in the U.S. Oceans and Pew Commission reports. The WGs suggested that perhaps the establishment of a new regional governance body (e.g., a Marine Ecosystem Council) would fill this role. The Puget Sound Collective may provide a model for such a body. In the short term, the authority of existing governance structures (e.g., Fishery Management Councils, Take Reduction Teams) should be expanded to cover ecosystem aspects so that they have a broader stewardship responsibilities and a broader spectrum of stakeholders.

Science needs to be better integrated across taxa and discipline, and this may require the establishment of integrated national and regional marine science groups. This will further require a clear mandate from NMFS HQ to the field that the Centers and Regions conduct ecosystem/integrative research and management.

Other charges that were identified by the WGs included:

- Need to have a clear definition of what kind of Assessments are most relevant for ecosystem purposes. There is a continuum from single species assessment to ecosystem assessments
- Work on all the above should proceed at the same time
- Examples exist worldwide that demonstrate how assessments can be accomplished in an ecosystem framework (Everglades, ICES, etc)
- We need to learn from the successes and failures of other projects
- To accomplish our ecosystem goals, investments must be made in:
    - Multidisciplinary basic and applied research to understand processes including economic and social sciences
    - Data acquisition and reanalysis of data to ensure all sets are compatible and available
    - New and more integrated models that allow for forecasting of management decision impact and results
    - Improved communications using information systems that allow for seamless management of data, sharing of information, and best practices.
- Changes in policy, governance and science administration:
    - Changes in policy include: consolidation of legislation using a common language, and more emphasis on the human element
    - Changes in governance: creation of ecosystem councils as an umbrella under which government structures might function.
    - Changes in science administration: eliminate institutional barriers in units within the NMFS Science Centers and Regional Offices, other NOAA Lines Offices, and other Agencies of the Federal government

All of these activities or changes will be challenging to implement, because they require changes in structure, reallocation of budgets, support of stakeholders, partners, etc. Consequently, incremental implementation must be pursued.

None the less, progress towards ecosystem-based assessments of protected species can be made immediately by fostering better communications and by including a section on ecosystem consideration in all MMPA Stock Assessment reports and ESA status reviews.

Literature Cited

Agnew, D.J. 1997. The CCAMLR Ecosystem Monitoring Programme. Antarctic Sci. 9 (3): 235-242.

Bartz, K., Lagueux, K., Scheuerell, M.D., Beechie, T, and Ruckelshaus, M. 2006. Translating alternative land use restoration scenarios into changes in stream conditions: a first step in evaluating salmon recovery strategies. Can. J. Fish. Aquat. Sci. 63: 1578-1595.

Bogstad, B., Hiis-Hauge, K., and Ulltang, O. 1997. MULTSPEC – A Multi-species Model for Fish and Marine Mammals in the Barents Sea. J. Northwest Atl. Fish. Sci. 22:317-341

Butterworth, D. S., and Thompson, R.B. 1995. Possible effects of different levels of krill fishing on predators - some initial modeling attempts. CCAMLR Sci. 2:79-97.

Constable, A.J. 2001. The ecosystem approach to managing fisheries: achieving conservation objectives for predators of fished species. CCAMLR Sci. 8:37-64.

Constable, A.J., de la Mare, W.K., Agnew, D.J., Everson, I. and Miller, D. 2000. Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the conservation of Antarctic Marine Living Resources (CCAMLR). ICES J. Mar. Sci, 57: 778-791.

Courchamp, F., Langlais, M. and Sugihara, G. 1999. Cats protecting birds: modeling the mesopredator release effect. J. Anim. Ecol. 68: 282-292.

Crooks, K.R., and Soulé, M.E. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400: 563-566.

DeAngelis, D. E. and Curnutt, J.L. 2002. Integration of Population, Community, and Landscape Indicators for Assessing Effects of Stressors. In, Biological Indicators of Aquatic Ecosystem Stress. American Fisheries Society, Bethesda, MD. pp. 509-532.

Fulton, E, Smith, A.D.M., and Punt, A. 2003. Which ecological indicators can robustly detect effects of fishing? ICES J. Mar. Sci. 62(3): 540-551.

Hammond, P., and Fedak, M.A. (eds.). 1994. Grey seals in the North Sea and their interactions with fisheries. Final Report to the UK Ministry of Agriculture, Fisheries and Food on Contract MF0503. Sea Mammal Research Unit, Cambridge.

Hannon, B. 1973. The structure of ecosystems. J. Theor. Biol. 41: 535-546.

Hannon, B. and Joiris, C. 1989. A seasonal analysis of the southern North Sea ecosystem. Ecol. 70(6): 1916-1934.

Hedley, S., Buckland, S. T., and Borchers, D. L. 1999. Spatial modelling from line transect data. J. Cet. Res. and Manage. 1(3): 255-264.

Hewitt, R.P., and Linen Lowe, E.H. 2000. The Fishery on Antarctic Krill: Defining an Ecosystem Approach to Management. Reviews in Fisheries Science 8(3): 235–298.

IWC. 2001. Report of the Scientific Committee of the International Whaling Commission. J. Cet. Res. and Manage. 3 (Suppl).

IWC. 2002. Report of the Scientific Committee of the International Whaling Commission. J. Cet. Res. and Manage. 4 (Suppl).

IWC. 2003. Report of the Scientific Committee of the International Whaling Commission. J. Cet. Res. and Manage. 5 (Suppl).

Johnston, N.T., MacIsaac, E.A., and Tschaplinski, P.J. 2004. Effects of the abundance of spawning sockeye salmon (*Oncorhynchus nerka*) on nutrients and algal biomass in forested streams. Can. J. Fish. Aquat. Sci. 61 (3): 384-403.

Koen-Alonso, M., and P. Yodzis. 2005. Multispecies modelling of some components of the marine community of northern and central Patagonia, Argentina. Can. J. Fish. Aquat. Sci. 62: 1490–15

Lawson, P. W., Logerwell, E. A., Mantua, N., Francis, R. C., and Agostini, V. N. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 61: 360-373.

Leontief, W.W. 1951. The structure of the U.S. economy, 2nd ed. Oxford University Press, New York.

Levin, P. S., and Williams, J. G. 2002. Interspecific effects of artificially propagated fish: an additional conservation risk for salmon. Cons. Biol. 16: 1581-1587.

Levin, P. S., Zabel, R. W., and Williams, J. G. 2001. The road to extinction is paved with good intentions: negative associations of fish hatcheries with threatened salmon. Proc. Royal. Soc. Lond. B. 268: 1153-1158.

Logerwell, E. A., Mantua, N., Lawson, P. W., Francis, R. C., and Agostini, V. N. 2003. Tracking environmental processes in the coastal zone for understanding and predicting Oregon coho (*Oncorhynchus kisutch*) marine survival. Fish. Ocean. 12: 554-568.

Mangel, M. 2000. Irreducible uncertainties, sustainable fisheries and marine reserves. Evol. Ecol. Res. 2: 547–557.

Mangel, M., and Switzer, P. V. 1998. A model at the level of the foraging trip for the indirect effects of krill (*Euphausia superba*) on krill predators. Ecol. Model. 105: 235-256.

McLaren, A., Brault, S., Harwood, J. and Vardy, D. 2002. Report of the Eminent Panel on Seal Management. Department of Fisheries and Oceans, Ottawa, Canada.

Mohn, R. and Bowen, W. 1996. Grey seal predation on the eastern Scotian Shelf: modeling the impact on Atlantic cod. Can. J. Fish. Aquat. Sci. 53: 2722-2738.

Nickelson, T. E. 2003. The influence of hatchery coho salmon (*Oncorhynchus kisutch)* on the productivity of wild coho salmon populations in Oregon coastal basins. Can. J. Fish. Aquat. Sci. 60:1050-1056.

NMFS. 2004. A Requirements Plan for Improving the Understanding Of the Status of U.S. Protected Marine Species. Report of the NOAA Fisheries National Task Force for Improving Marine Mammal and Turtle Stock Assessments. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-F/SPO-63, 112 p.

Punt, A. E. and Butterworth, D. S. 1995. The effects of future consumption by the Cape fur seal on catches and catch rates of the Cape hakes. 4. Modeling the biological interaction between Cape fur seals *Arctocephalus pusillus pusillus* and the Cape hake *Merluccius capensis* and *Merluccius paradoxus*. South African J. Mar. Sci. 16: 255-285.

Ruggerone, G. T., Farley E, Nielsen J, and Hagen P. 2005. Seasonal marine growth of Bristol Bay sockeye salmon (*Oncorhynchus nerka*) in relation to competition with Asian pink salmon (*O. gorbuscha*) and the 1977 ocean regime shift. Fish. Bull. 103 (2): 355-370.

Ruggerone, G. T., and Nielsen, J. L. 2004.   Evidence for competitive dominance of pink salmon (*Oncorhynchus gorbuscha*) over other salmonids in the North Pacific Ocean. Rev. Fish Biol. Fisheries 14 (3): 371-390.

Sainsbury, K.J., Punt, A. E, and Smith, A. D. 2000. Design of operational management strategies for achieving fishery ecosystem objectives. ICES J. Mar. Sci. 57: 731.

Scheuerell, M. D., Hilborn, R., Ruckelshaus, M., Bartz, K. L., Lagueux, K., Haas, A., and Rawson, K. 2006. The Shiraz model: a tool for incorporating anthropogenic effects and fish-habitat relationships in conservation planning. Can. J. Fish. Aquat. Sci. 63: 1596-1607.

Scheuerell M. D., Levin P. S., and Zabel R.W. 2005. A new perspective on the importance of marine-derived nutrients to threatened stocks of Pacific salmon (*Oncorhynchus spp*.). Can. J. Fish. Aquat. Sci. 62 (5): 961-964.

Scheuerell, M.D., and Williams J.G. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fish. Ocean. 14 (6): 448-457.

Stefansson, G. and Palsson, O. K. 1998. The framework for multispecies modeling of Arcto-boreal systems. Rev. Fish Biol. Fisheries 8:101-104.

Thomson, R. B., Butterworth, D. S., Boyd, I. L., and Croxall, J. P. 2000. Modeling the consequences of Antarctic krill harvesting on Antarctic fur seals. Ecol. Appl. 10:1806-1819.

Ulanowicz, R.E., and Puccia, C. J. 1990. Mixed trophic impacts in ecosystems. Coenoses 5:7-16.

UNEP. 1999. Report of the Scientific Advisory Committee of the Marine Mammals Action Plan. United Nations Environment Program.

Whipple, S.J., Link, J.S., Garrison, L.P. and Fogarty, M.J. 2000. Models of predation and fishing mortality in aquatic ecosystems. Fish. Fish. 1: 22-40.

Yodzis, P. 1988 The indeterminacy of ecological interactions as perceived through perturbation experiments. Ecol. 69: 508-515.

Yodzis, P., 1998. Local trophodynamics and the interaction of marine mammals and fisheries in the Benguela ecosystem. J. Anim. Ecol. 67: 635-658

Acknowledgments

We, the Convenors, gratefully acknowledge the many individuals that helped to make this workshop possible. First of all, our thanks to NOAA staff who provided tremendous background logistical support including Angela Collins-Payne, Michelle Ordono, and Karen Salvini. Secondly, the speakers all provided impressive presentations and deserve our great thanks for coming, in many cases, thousands of miles to present a brief talk and then hang-on to contribute invaluably to the WG discussions. Thus, we thank Elliott Norse (our keynote speaker), Lisa Ballance, Andrew Cunningham, Andy Dobson, Jason Link, Michelle McClure, John Ogden, Andrew Pershing, Christian Reiss, Jake Rice, Teri Rowles, Mary Ruckelshaus, Garry Stenson, Steve Swartz, and Colette Wabnitz. A special thanks for Steve Murawski for breaking from his busy schedule to present and prove that NOAA is indeed intent on implementing an Ecosystem Approach to Management for all species within the NOAA trust.

The individuals who acted as facilitators and rapporteurs made the working group sessions possible. This included Kelsey Abbott, Ney Cyr, Sarah Howlett, Mary Jacobs-Spaulding, Ruth Kelty, Patricia Lawson, Kate McFadden, Karen Salvini, Nathalie Valette-Silver, and Sarah Wilkin. The chairs of our working groups, David Gouveia, Jason Link, Debra Palka, Michael Payne, Tim Ragen, Teri Rowles, and Steve Swartz, kept the WGs focused and on track.

A special thanks to the few individuals who took the time to wade through early drafts of this manuscript and provided extremely helpful comments—Jason Link, Nathalie Valette-Silver, and Fred Serchuk.

Finally, our thanks to NMFS, NOS and the Marine Mammal Commission for providing financial support for the Workshop!

Appendix I

Agenda

Day 1

9-10:15	Welcome, Intent/Scope of the Workshop – Jim Lecky, F/PR SAIP Background -- Richard Merrick, NEFSC PPBES and Ecosystems GT -- Steve Swartz, F/S&T How this meeting will progress – Richard Merrick, NEFSC
10:15-10:30	Break
10:30-12:00	Big picture talk on Ecosystems Approach to Management – Elliot Norse The Global EAM Perspective & NOAA's Approach to EAM – Steve Murawski
12:00-1:00	Lunch
1:00-5:00	Ecosystem Studies with A Protected Species Component *(30 min case studies)*

Disease and Ecosystems – Andy Dobson

ICES Ecosystem Assessment WG – Jake Rice, DFO

CCAMLR/SCAR – Christian Reiss, SWFSC

2:30-2:45	Break

EMAX – Jason Link, NEFSC

Ocean and Human Health Initiative – Teri Rowles, NMFS/NOS

Panel Discussion -- The afternoon's presenters summarize what they conceive off as the lessons that can be learned from their experience with EAM.

5:00	Break for Day

Day 2

8:30-1:00 Protected Species Studies with an Ecosystem Component *(30 min case studies)*

Frogs – Andrew Cunningham

Ecopath/Ecosim model for green turtles in the Caribbean, Colette Wabnitz, Univ of British Columbia

Canadian Research on Cod-Seal Interactions – Garry Stenson, DFO

10:00-10:15 - Break

Ecosystem-scale analyses in support of management in Puget Sound - Mary Ruckelshaus and Michelle McClure, NWFSC

ETP Dolphin Studies – Lisa Ballance, SWFSC

Linkages Between North Atlantic Right Whales and their Habitat – Andrew Pershing, Cornell

Ecosystem-Based Approaches to the Management of Coral Reefs – John Ogden, Univ Florida

Panel Discussion -- The morning's presenters summarize what they conceive off as the lessons that can be learned from their experience with EAM.

1:00-2:00 Lunch

2:00-2:15 Charge for Working Group (Merrick)

2:15-5:00 Working Group (WG) sessions begin

5:00-5:30 Working Group Rapporteur and Chairs meet to discuss progress

5:30 Break for day

DAY 3

8:30-9:00 Convene in Plenary: Working Groups give Brief Status Reports

9:00-12:00 Continue WG discussions

12:00-1:00 Lunch

1:00-5:00 Continue WG discussions

5:00-5:30	Working Group Rapporteur and Chairs meet to discuss results and presentation
5:30	Break for Day

DAY 4

8:30-10:00	Convene in Plenary: Working Groups present findings
10:00-10:15	Break
10:15-1:00	Synthesis discussion of WG results Discuss next steps
1:00	Adjourn Workshop

Appendix II

List of Participants

Last Name	First Name	Organization	State	Zip Code	Phone	Fax	E-Mail
Abbott	Kelsey	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2289		kelsey.abbott@noaa.gov
Adams	Peter	NOAA Fisheries/SWFSC	CA		831-420-3922		peter.adams@noaa.gov
Baker	Jason	NOAA Fisheries/PIFSC	HI	96822	808-983-5711	808-983-2902	jason.baker@noaa.gov
Ballance	Lisa	NOAA Fisheries/SWFSC	CA	92037	858-546-7173	858-546-7003	Lisa.Ballance@noaa.gov
Cassandra	Barnes	NOAA OAR	DC				cassandra.barnes@noaa.gov
Bengtson	John	NOAA Fisheries/AFSC	WA	98115	206-526-4016	206-526-6615	john.bengtson@noaa.gov
Bigford	Tom	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-4300	301-713-4305	thomas.bigford@noaa.gov
Chaloupka	Milani	Western Pacific Regional Fishery Management Council	HI	96816			m.chaloupka@uq.edu.au
Clapham	Phillip	NOAA Fisheries/AFSC	WA	98115	206-526-4037	206-526-6615	phillip.clapham@noaa.gov
Collins	M. Anthony	NOAA/NOS/CCEHBR	SC	29412	843-762-8597		Anthny.Collins@NOAA.gov
Conant	Therese	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2522	therese.conant@noaa.gov
Cornish	Vicki	NOAA Fisheries/SERO	FL	33701	727-551-5771	727-824-5309	vicki.cornish@noaa.gov
Coyle	Carol	National Center for Cool and Cold Water Aquaculture	MD	21701	301-698-2425		ccoyle@ncccwa.ars.usda.gov
Cunningham	Andrew	Institute of Zoology, Zoological Society of London	UK	0	207-449-6674		a.cunningham@ioz.ac.uk
DiGiovanni	Robert	The Riverhead Foundation for Marine Research and Preservation	NY	11901	631-369-9840	631-369-9826	rdigovanni@riverheadfoundation.org
Dortch	Quay	NOAA/NOS/NCCOS/CSCOR					Quay.Dortch@noaa.gov
Eagle	Tom	NOAA Fisheries, Office of Protected Resources	MD	20852	301-713-2322	301-427-2522	Tom.Eagle@noaa.gov
English	Elizabethann	NOAA Fisheries	MD	20910	301-713-2276		Liz.English@noaa.gov

Last Name	First Name	Organization	State	Zip Code	Phone	Fax	E-Mail
Fahy	Christina	National Marine Fisheries Service/SWRO	CA	90802	562-980-4023	562-980-4027	Christina.Fahy@noaa.gov
Fair	Pat	NOAA/NOS/CCEHBR	SC	29412	843-762-8597		pat.fair@noaa.gov
Ford	Michael	NOAA Fisheries/NWFSC	WA	98112	206-860-5612		mike.ford@noaa.gov
Forst	Mark	Shippensburg University	PA	18972			preservnation@comcast.net
Garrison	Lance	NOAA Fisheries/SEFSC	FL	33027	305-361-4488		Lance.Garrison@noaa.gov
Gerke	Brandee	NOAA Fisheries/PIRO	HI	96814	808-944-2239		brandee.gerke@noaa.gov
Gill	Tracy	NCCOS	MD	20910	301-713-4384		tracy.gill@noaa.gov
Gittings	Steve	NOAA - National Marine Sanctuary Program	MD	20910	301-713-7274	301-713-0404	steve.gittings@noaa.gov
Gouveia	David	NOAA Fisheries/NERO	MA	01930	978-281-9280	978-281-9394	david.gouveia@noaa.gov
Gulland	Frances	The Marine Mammal Center	CA	94965	415-289-7344	415-289-7333	gullandf@tmmc.org
Hall	Ailsa	Sea Mammal Research Unit	UK				ajh7@st-andrews.ac.uk
Hill	Scott	NOAA Fisheries/SWRO	CA	90740	562-980-4029	562-980-4027	scott.hill@noaa.gov
Hoffman	Philip	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2319	301-427-2524	philip.hoffman@noaa.gov
Hohn	Aleta	NOAA Fisheries/SEFSC	NC	28516	252-728-8797	252-728-8784	aleta.hohn@noaa.gov
Jacobs-Spaulding	Mary	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2332	301-427-2520	mary.jacobs-spaulding@noaa.gov
Kelty	Ruth	NCCOS	NY	12518	845-534-4836		ruth.kelty@noaa.gov
Kinan	Irene	Western Pacific Regional Fishery Management Cncl.	HI	96816	808-522-8220	808-522-8226	Irene.Kinan@noaa.gov
Lang	William	National Science Foundation	VA	22230	703-292-7857	703-292-9085	wlang@nsf.gov
Larsen	Kirsten	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2522	kirsten.larsen@noaa.gov
Lawson	Patricia	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2522	patricia.lawson@noaa.gov
Lecky	Jim	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2332	301-713-0376	jim.lecky@noaa.gov
Lent	Rebecca	NOAA Fisheries	MD	20910	301-713-2276		rebecca.lent@noaa.gov
Lewandowski	Jill	Department of Interior/Minerals Management Service	VA	20170	703-787-1703	703-787-1026	Jill.Lewandowski@mms.gov
Link	Jason	NOAA Fisheries	MA	02543	508-495-2340	508-495-2258	Jason.Link@noaa.gov
LoSchiavo	Andrew	NOAA Fisheries	MD	20910	301-713-4300	301-713-4305	andy.loschiavo@noaa.gov

Last Name	First Name	Organization	State	Zip Code	Phone	Fax	E-Mail
McClure	Michelle	NOAA Fisheries/NWFSC	WA	98112	206-860-3402	206-860-3400	michelle.mcclure@noaa.gov
McFadden	Kate	NOAA Fisheries	MD	20910	301-713-1401		katherine.mcfadden@noaa.gov
Menashes	Emily	NOAA Fisheries	MD	20910	301-713-9075		Emily.Menashes@noaa.gov
Mengerink	Kathryn	Environmental Law Institute	DC	20036	202-939-3825	202-939-3868	mengerink@eli.org
Merrick	Richard	NOAA Fisheries/NEFSC	MA	02543	508-495-2291	508-495-2066	richard.merrick@noaa.gov
Mesnick	Sarah	NOAA Fisheries/SWFSC	CA	92037	858-546-7148	858-546-7003	sarah.mesnick@noaa.gov
Moy	Connie	NOAA/NOS/NCCOS/CCMA/Biogeography Team	MD	20910	301-713-3028		connie.moy@noaa.gov
Nojek	Larissa	NOAA Fisheries	MD	20910	301-713-2251		larissa.nojek@noaa.gov
Norse	Elliot	Marine Conservation Biology Institute	WA	98004	425 968 0449	425 274 1183	elliott@mcbi.org
Ogden	John	Florida Institute of Oceanography	FL	33701	727-553-1100	727-553-1109	jogden@marine.usf.edu
Palka	Debra	NOAA/Northeast Fisheries Science Center	MA	02543	508-495-23878	508-495-2066	debra.palka@noaa.gov
Pershing	Andrew	Cornell University	NY	14853	607 255-5552	607 255-2106	ajp9@cornell.edu
Pittman	Simon	NOAA NOS/Biogeography	MD	20910	301-713-3028		simon.pittman@noaa.gov
Ragen	Tim	Marine Mammal Commission	MD	20814	301-504-0087	301-504-0099	tragen@mmc.gov
Reilly	Steve	NOAA Fisheries/SWFSC	CA	92037	858-546-7173	858-546-7003	steve.reilly@noaa.gov
Reiss	Christian	NOAA Fisheries/SWFSC	CA	92037	858-546-7173	858-546-7003	christian.reiss@noaa.gov
Rice	Jake	Department of Fisheries and Oceans - Canada	Can		613-990-0288	613-954-0807	ricej@dfo-mpo.gc.ca
Roden	Carol	Department of Interior/Minerals Management Service	LA	70123	504-736-2877	504-736-2901	Carol.Roden@mms.gov
Rosel	Patricia	NOAA Fisheries/SEFSC	LA	70506	337-291-2123		patricia.rosel@noaa.gov
Rowles	Teri	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2522	teri.rowles@noaa.gov
Ruckelshaus	Mary	NOAA Fisheries/NWFSC	WA	98112	206-860-3266	206-860-3335	mary.ruckelshaus@noaa.gov
Rusin	Jeremy	NOAA Fisheries/SWFSC	CA	92037	858-546-7101	858-546-7003	Jeremy.Rusin@noaa.gov
Salvini	Karen	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2319	301-427-2514	Karen.Salvini@noaa.gov
Sandifer	Paul	NOAA NOS/Hollings Marine Laboratory	SC	29412	843-762-8814	843-762-8737	paul.sandifer@noaa.gov

Last Name	First Name	Organization	State	Zip Code	Phone	Fax	E-Mail
Schroeder	Barbara	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2522	barbara.schroeder@noaa.gov
Schwacke	Lori	NOAA NOS	SC	29412	843-762-8541	843-762-8700	Lori.Schwacke@noaa.gov
Scida	Pasquale	NOAA Fisheries/Northeast Regional Office	MA	1930	978-281-9208	978-281-9394	pasquale.scida@noaa.gov
Seminoff	Jeffrey	NOAA - National Marine Fisheries Service	CA	92117	858-546-7152	858-546-7003	jeffrey.seminoff@noaa.gov
Shenot	Jeff	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-0174		jeff.shenot@noaa.gov
Simpkins	Michael	Marine Mammal Commission	MD	20814	301-504-0087	301-504-0099	msimpkins@mmc.gov
Southall	Brandon	NOAA Fisheries, Office of Science & Technology	MD	20910	301-713-2363		Brandon.Southall@noaa.gov
Stenson	Garry	Dept. of Fisheries and Oceans, Canada	Can		709-772-5598	709-772-4105	stensong@dfo-mpo.gc.ca
Swartz	Steven	NOAA Fisheries, Office of Science & Technology	MD	20910	301-713-2363	301-713-1875	steven.swartz@noaa.gov
Thom	Barry	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2319	301-427-2524	barry.thom@noaa.gov
Thomas	James	NOAA Fisheries, Office Habitat Conservation	MD	20910	301-713-0299	301-713-1043	James.Thomas@noaa.gov
Trumble	Robert	MRAG Americas	FL	33609	813-639-9519		bob.trumble@mragamericas.com
Valette-Silver	Nathalie	NOAA/NOS	MD	20910	301-713-3020	301-713-4353	nathalie.valette-silver@noaa.gov
Wabnitz	Colette	Fisheries Centre (University of British Columbia)	BC		604-822-1636	604-822-8934	c.wabnitz@fisheries.ubc.ca
Wakeford	Robert	MRAG Americas	FL	33609	913-639-9519		robert.wakeford@mragamericas.com
Ward	John	NOAA Fisheries	MD	20910	301-713-9507	301-713-2384	John.M.Ward@noaa.gov
Wedell	Vicki	NOAA NOS/National Marine Sanctuary Program	MD	20910	301-713-3125		vicki.wedell@noaa.gov
Whaley	Janet	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2525	Janet.Whaley@noaa.gov
Wilkin	Sarah	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2322	301-427-2522	sarah.wilkin@noaa.gov

Last Name	First Name	Organization	State	Zip Code	Phone	Fax	E-Mail
Williams	Mike	NOAA Fisheries/Alaska Regional Office	AK	99508	907-271-5117	907-271-3030	michael.williams@noaa.gov
Williams	Phil	NOAA Fisheries, Office of Protected Resources	MD	20910	301-713-2332	301-713-0376	phil.williams@noaa.gov
Wilson	Bill	North Pacific Fishery Management Council	AK	99501	907-271-2809	907-271-2817	bill.wilson@noaa.gov
Yuen	Michelle	NOAA Fisheries/Pacific Islands Regional Office	HI	96814	808-944-2243	808-944-2124	michelle.yuen@noaa.gov

Appendix III

Suggested Readings in Ecosystem Approaches To Management for Workshop Participants

Background Readings

Babcock, E. A. and E. K. Pikitch. 2004. Can We Reach Agreement On A Standardized Approach To Ecosystem-Based Fishery Management? Bull. Mar. Sci., 74(3): 685–692.

Boesch, D.F. 2006. Scientific requirements for ecosystem-based management in the restoration of Chesapeake Bay and Coastal Louisiana. Ecol. Eng. 26: 6–26.

Brodziak, J. K. T., P. M. Mace, W. J. Overholtz, and P. Rago. 2004. Ecosystem Trade-Offs In Managing New England Fisheries. Bull. Mar. Sci. 74(3): 529–548.

Dunnigan, J.H. 2006. NOAA's Ecosystem Approach To Management. Presentation. NOS Science Seminar. February 7, 2006.

Greene, C. H. and A. J. Pershing. 2004. Climate and the conservation biology of North Atlantic right whales: the right whale at the wrong time? Front Ecol Environ 2004; 2(1): 29–34. (Protected Species in EAM working group)

ICES. 2005. Report of the Study Group on Multispecies Assessment in the North Sea (SGMSNS), 5–8 April 2005, ICES Headquarters. ICES CM 2005/D:06. 163 pp. (Protected Species in EAM working group)

Link, J.S. 2002. Ecological considerations in Fisheries Management-When does it matter? Fish. 27: 10-17.

Link, J.S. 2002. What does ecosystem-based fisheries management mean? Fish. 27: 18-21.

Mangel, M., et al. 1996. Principles for the conservation of wild living resources. Ecol. App. 6(2): 338–372.

Meyerson, L. A., J. Baron, J. M. Melillo, R. J. Naiman, R. I. O'Malley, G. Orians, M. A. Palmer, A. S. P. Pfaff , S. W. Running, and O. E. Sala. 2005. Aggregate measures of ecosystem services: can we take the pulse of nature? Front. Ecol. Environ. 3(1): 56–59. (EAM with Protected Species working group)

NMFS. 2001. Marine Fisheries Stock Assessment Improvement Plan. Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-F/SPO-56. 69 pp.

Pew Oceans Commission on Ocean Policy. 2005. America's Living Oceans, Charting a Course for Change. Washington, DC. 166 pp.

Pikitch, E. K., C. Santora, E. A. Babcock, A. Bakun, R. Bonfil, D. O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heneman, E. D. Houde, J. Link, P. A. Livingston, M. Mangel, M. K. McAllister, J. Pope, K. J. Sainsbury. 2004. Ecosystem-Based Fishery Management. Science 305:346-347.

Sherman, K., P. Celone, and S. Adams. 2005. NOAA Fisheries Service's Large Marine Ecosystems Program: Status Report. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-NE-183, 21 pp.

U.S. Commission on Ocean Policy. 2004. An Ocean Blueprint for the 21st Century. Final Report. Washington, DC. 676 pp.

Recommended Readings

Barnes, C., L. Bozzi, and K. McFadden. 2005. Exploring An Ecosystem Approach To Management: A Review Of The Pertinent Literature. Unpubl. rpt. Ecosystem Goal Team, NOAA. 19 pp.

Browman, H. I., And K. I. Stergiou. 2005. Theme Section: Politics and Socio-Economics of Ecosystem-Based Management Of Marine Resources . Marine Ecology Progress Series. 300: 241–296. (Governance working group)

Evans, D. and B. Wilson. 2005. Role of the North Pacific Fishery Management Council in the development of an Ecosystem Approach to Management for the Alaska large marine ecosystems. Unpubl rpt. 23 p. Available North Pacific Fisheries Management Council, Anchorage, AK. (Governance working group)

Ferguson, M.C., J. Barlow, P. Fiedler, S.B. Reilly, and T. Gerrodette. 2006. Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. Ecological Modelling 193: 645-662.

Guerry, A. D. 2005. Icarus and Daedalus: conceptual and tactical lessons for marine ecosystem-based management. Front. Ecol. Environ. 3(4): 202–211.

NMFS. 2004. A Requirements Plan for Improving the Understanding of the Status of U.S. Protected Marine Species. Report of the NOAA Fisheries National Task Force for Improving Marine Mammal and Turtle Stock Assessments. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-63. 112 p.

NMFS. 2005. Workshop on Ecosystem-Based Decision Support Tools for Fisheries Management. February 14–18, 2005, Key Largo, FL.

NOAA Regional Ecosystem Delineation Workgroup. 2004. Report on the Delineation of Regional Ecosystems. Regional Ecosystem Delineation Workshop. August 31–September 1, 2004. Charleston, S.C. 54 pp.

Reilly, S. B., M. A. Donahue, T. Gerrodette, K. Forney, P. Wade, L. Ballance, J. Forcada, P. Fiedler, A. Dizon, W. Perryman, F. A. Archer, and E. F. Edwards. 2005. Report of the scientific research program under the International Dolphin Conservation Act. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SWFSC-372. 100 pp.

Appendix IV

Expanded WG1 Answer to Question 3 – New Research, Data Collection, Models and Data Management Required To Support And EAM.

Trophodynamics

Population size and structure of prey and competitor species: While some prey/competitor species populations can be addressed through fishery assessment methods, other methods of population assessment are needed for many species which are either not fished commercially, or which are only fished incidentally to more commercially valuable species. Surveys are therefore required to provide at least indices of abundance. Not all relevant species will be adequately sampled by a single survey method, and it is therefore likely that several survey methods might be required to estimate the abundance of all the relevant prey or competitor species. It is clear that for any surveys some definition or assessment of selectivity is required, as the assumption that all species and size classes are equally catchable under any one survey method will lead to biased assessments.

Consumption rates by protected species: There are a number of studies that have used estimates of daily rates of prey consumption by protected species in ecosystem models. Many of these the studies scaled prey consumption rates to body mass of the predator using the general relationship $R = A\,M^B$, where R is the consumption rate, M is body mass, with A and B estimated from a number of different data sources. These data sources all relied on consideration of allometric relationships between energy requirements and body size rather than direct measurements of food consumed. For large whales, the value of B is the most influential but this is invariably derived from a regression with few data points for larger species. The studies considered fell into three categories, low values of B around 0.5-0.6, medium values of around 0.75-0.8, and the high value of 1 when consumption is just a straight percentage of body mass. This range of values creates considerable uncertainty about the energy requirements of large whales. This uncertainty increases with body mass because of the non-linear relationship between body mass and consumption and the difficulties of studying metabolic rates in larger animals. For a forty tonne whale the estimates of daily food requirements considered differed by a factor of ten.

Some alternative approaches to estimating consumption rates in large whales were also considered including direct measurement of intake from behavioural studies, estimates of intake based on analysis of stomach contents, and estimates of energy requirements based on utilisation of blubber stores. Estimates of maximum daily consumption based on feeding rates were considered for filter feeding whales based on measurements of plankton concentrations and estimates of the volume of water filtered. North Atlantic right whales were chosen as a case study and it appeared very unlikely that they could physically achieve the consumption estimates generated using the above equation with medium to high values of B. In addition, filter feeding whales suggest a theoretical basis for values of B of less than 0.67 otherwise larger whales would need to spend longer feeding, or swim faster. Estimates of energy requirements in fin whales based on measurements from whaling data of the amount of blubber stored on feeding grounds in the Southern Ocean and North Pacific fell below all the allometric predictions. Direct estimates from stomach contents for fin and sei whales were also lower than the allometric predictions, except for the lowest value of *B* of 0.52.

The studies reviewed indicated that neither theoretical considerations or data support high values of *B* close to 1 and there is evidence for values of 0.67 or less. Although from a modelling perspective consumption rates may not be the greatest source of uncertainty, it is nevertheless important to understand the sensitivity of any model predictions to uncertainty in consumption rates. Hence, estimates of consumption based on low values of *B* should also be included within the range of input values for large whales.

By extension, many of these approaches are germane to odontocetes and pinnipeds. However, other protected species such as corals or chelonians have had much less work executed on estimates of their consumption.

These estimates coupled with estimates of prey population allow one to evaluate the relative impacts of protected resources on prey populations, the potential production limitations of prey populations on protected resources, and for predators the relative effects of removals on protected resources.

<u>Diet composition:</u> Several reviews have noted various approaches to assess diet composition, with comments on their potential and limitations. Five approaches were presented. Only one of these, analyses of contents from stomachs, intestines and scats, had been developed specifically to address questions relating to predator diets. Four other approaches, fatty acid signatures, stable isotopes, genetics, and remote monitoring were originally developed for other purposes, but have in recent years been adapted for use in marine mammal diet studies. Application of these new methods in cetacean diet studies has been particularly motivated by the need to develop non-lethal methodologies.

Studies of the diets of protected species based on analyses of either stomach, intestinal or scat (faeces) contents is based on the assumption that the relative frequencies of recovered undigested specimens, including otoliths, beaks, exoskeletons and other hard parts, reflect the frequencies of fish, cephalopods, crustaceans and other invertebrates in the diet in some known manner. The methodological problem with erosion of otoliths, which has been well studied in the context of seal diets, is less conspicuous in studies of whale diets. Most cetaceans have a multi-chambered stomach system, starting with the non-glandular forestomach where otoliths and various other calcareous remains usually stay undigested. Certainly, differential passage and degradation rates of different fish and cephalopod types, and also the possible accumulation of some hard parts, represent methodological problems that have yet to be accounted for adequately in cetacean diet analyses.

The fatty acid composition of a prey is species specific and, as these compounds are assimilated through the diet and accumulated in the fatty tissues of predators (e.g. in blubber), they can be used as tracers of diet. To assess the diet of the predator, fatty acid signatures from its blubber are compared with fatty acid signatures from a variety of potential prey species using classification and regression tree analysis. The principle of the stable isotope method is that ratios of heavier vs lighter isotopes of particular elements (carbon, nitrogen, oxygen sulphur) in tissues of predators can be traced to those of their prey as they are assimilated in the diet. Both the fatty acid method and the stable isotope method require a prey library. Assuming that food web fatty acid and isotopic signatures are reflected in the tissues of organisms and that such signatures can vary spatially based on a variety of biogeochemical processes, both methods can be used to trace nutritional origin and migration in animals.

Genetic analyses of remains from scats or contents in the gastrointestinal tract may be used to identify prey species consumed. Originally the method was applied in combination with more traditional scat analyses, primarily to identify the individual predator or species for individual scats, assuming that epithelial cells from the colon wall, sloughed off and deposited in scats, are a reliable source of DNA to determine species of origin. A reference database for the genetic signature of actual prey species is needed.

Remote monitoring of protected species, using either data loggers or satellite-linked time-depth recorders, has been used to indicate potential prey or feeding areas. The approach is based on comparing data on temporal and spatial distribution of the predator, including the vertical movements (dive depths), with related data for potential prey species, to identify matches that may indicate the likely prey species of the predator. For co-occurrence of predators and prey in time and space to be indicative of predation, confirmatory observations by other means are always required.

Although identifying and measuring items in vomit, scats, and gastrointestinal contents has several disadvantages and sources of errors, it still provides more information at considerably less cost than other new methods (such as fatty acid signatures, stable isotopes and genetics), and has not been replaced effectively by any other method at present. Advantages of the traditional methods over the new ones include that they:

- provide information on meal size and relative composition of prey for each predator
- provide knowledge of size classes of prey
- allow for understanding of small scale spatial and temporal distribution of diets
- allow for small scale studies of predator-prey dynamics
- are subject to easily obtainable samples from hunts, bycatch, culling or strandings
- are subject to laboratory treatment of samples that are simple.

The main problem with several of the new methods is the very coarse spatial and temporal resolution that prevents quantitative descriptions of relative diet composition. However, new methods based on fatty acid signatures and stable isotopes have some advantages over the traditional methods in that they:

- integrate data over a longer period
- may detect shifts in diet
- may yield knowledge of distribution, migration and stock structure.

These methods also allow for the understanding of habitat utilisation and trophic relationships of the predators. All of the new methods will certainly be useful in studies of depleted, threatened and endangered species.

Linkages – inter/intra species predation*:* A discussion on predator-prey linkages and trophic complexity relative to model structure and characterization is key for any ecosystem approach to management. Determining what predator-prey linkages should be included in a model depends on the types of questions being raised, the modelling approach and data availability. One key issue in modelling is whether there is an optimal level of realism, and hence complexity, in relation to model performance. Reducing complexity can be achieved by removing linkages or by aggregating linkages, both approaches resulting in a reduced number of weak links being represented in the model. Previous work on weak links has shown that they may have an important influence on model stability. The effects of model complexity, removal and aggregation of linkages, is an area of research that warrants further study. Other key issues include:

- The effects of model 'biases' (marine mammal centric versus fish centric versus benthos centric model 'designs'),
- The inclusion of size/age structure (what level of complexity is necessary to consider ontogenetic changes in diets?),
- Spatial and temporal heterogeneity in linkages: the way that available prey are defined (different approaches in models - vulnerability, suitability, spatial overlap)
- Multispecies functional responses.

It was agreed that systematic and thorough investigations of trophic complexity in models relevant to whale-fishery interactions are needed to address the necessary levels of complexity needed in models posing questions about cetaceans and fishery competition.

Interactions between Protected Resources and Fisheries: The interaction between fisheries and protected resources is an important trophodynamic consideration. To evaluate these potential interactions, knowledge of fishery spatial/temporal distribution integrated with protected species spatial/temporal distribution is needed. More specifically:

- Stage specific information on prey items and overlap with fishery (ontogenetic diet composition, life stage targeted by fishery, etc.)
- Foraging behaviour integrated with depth overlap with fishery
- Indirect effects of fishery removals on protected species prey availability or foraging ability (stage-composition shifts and consequences to spawner recruitment, trophic cascading resulting from fishery removals, localized depletion, etc.)
- Direct mortality of protected species – not linked to obvious energetic changes in the system
- Economic analyses of alternate fishery management regimes to protect species

The key point is to evaluate the relative source of mortality caused by protected species and fisheries on a targeted stock. In some cases, the potential for competition between protected resources and fisheries can be quite high.

Interactions between Protected Resources and other Competitors: The question of whether, how, and under what circumstances certain species or conspecifics out compete others for available resources has long been debated in ecology. Connell (1983) reviewed experimental field studies of competition (both intra- and inter-specific) and found that competition among conspecifics was as strong or stronger than that between species in three-quarters of the studies in which the two types could be separated. He also noted that there was a greater incidence of competition among marine organisms than in terrestrial or freshwater species, and that large-sized organisms were more prone than smaller ones to competitive interactions. Schoener (1983) conducted a similar review, and also found a greater tendency toward competition among large (compared to small) heterotrophs. In addition, he concluded that greater ecological overlap between species resulted in a greater likelihood of competition, and noted that larger species were significantly more likely to out compete smaller ones. Neither review dealt with cetaceans, but both emphasized the complexity of interactions involved and the difficulty of elucidating genuine competitive effects in a non-experimental situation. In addition, Schoener noted the lack of any obvious patterns in competition within and between marine species. A further level of difficulty exists when one attempts to use short-term data to predict future effects; Yodzis (1988) concluded that short-term observations of systems subject to perturbations are not useful for estimating long-term impacts.

For competition between species to be demonstrated, reliable data on several variables must be obtained. First, the species in question must be shown to be resource-limited (Milne, 1961); that is, the availability of food cannot be effectively unbounded, either absolutely or in such areas as individuals are limited (by time, energetics, experience or other factors) to searching. Second, there must be substantial overlap in spatio-temporal distribution of the two species. Third, both species must occupy essentially ecological similar niches. Note that it is not necessarily sufficient to demonstrate that both feed on the same prey; they must also exploit similar types (e.g. age class) of that prey, and forage at a similar level (e.g. depth, patch size, et cetera). Finally, opposite population trajectories are also a needed requirement indicative of competition.

<u>Overall- Key variables for trophodynamic considerations:</u>

- Abundance and rate of increase
- Vital rates (survival/mortality, maturity, reproduction)
- Bioenergetic rates: metabolism, consumption, respiration
- Diet composition
- Foraging behaviour
- Interspecific relationships (niche separation, competition, spatial/temporal overlap, dietary overlap among species)

Acoustics

Owing to the physical properties of water, sound is the principal means by which information is transferred over any appreciable distance. Sounds associated with marine biota, physical forces, and human activities can provide detailed information with which both people and animals can sense the marine environment. Further, sound may be used actively as an investigative tool for locating objects. Because of the wide range of biotic and abiotic information that may be obtained, an ecosystem approach to marine research and management should rely strongly on acoustic sensing. Specifically, passive acoustic sensors should be integrated into ocean observing systems to: 1) detect seasonal presence, activity, and (in some instances) abundance of species within ecosystems; 2) provide remote measurements of climatological and geological processes (*e.g.*, rain and earthquakes); and 3) assess ecosystem-specific, spatial and temporal trends in ambient noise 'budgets' from the range of source contributions. Active acoustic sensing should be applied and advanced, where appropriate, as a means of identifying specific features of marine ecosystems (*e.g.*, temperature, prey abundance, or the presence of specific species).

A systematic approach to assessing marine ecosystem elements using passive acoustics is required. Specific questions regarding biotic and abiotic contributions to marine ambient noise should be identified and relevant sampling regimes (*e.g.*, bandwidth, duty cycle, directionality) specified. Passive acoustic deployments to date have identified seasonal presence of specified marine species, demonstrated human sound source contributions to marine ambient noise, and contributed to meteorological measurements. Further deployments and sampling regimes should be selected that maximize the ability to assess spatial and temporal trends for a range of ecosystem features. Comparative ambient noise measurements should be made across various marine ecosystems with variable anthropogenic influence. Acoustic data should be integrated with information on habitat and ecological factors to derive predictive ambient noise models. These will be distinct from the fairly well-derived sound propagation models for predicting received levels from a specified sound source. Ambient noise models would prove useful in gauging not only estimated baseline conditions against which to assess anthropogenic input, but also environmental features relevant for active acoustic deployments. Data management should ensure maximal retention of raw data but be amenable to auto-recognition and other analyses.

Ocean and Health

<u>Research:</u>

- What is the fate and transport of contaminants/ pathogens/ nutrients/ toxins through the ecosystem?
- What is the basic ecology and pathogenesis of emerging and resurging infectious agents?
- What are the biological effects (dose response, identification of sensitivity to vital rates
- How can protected species be used as indicators and sentinels and models
- How can tools to detect exposure and effects of multiple stressors in a cost effective manner be developed?
- Can protected resources be used as effective platforms for ocean observations for these compounds?
- What are the links between terrestrial and marine ecosystems?
- What are the links between man's exploitation of marine resources (e.g. aquaculture) and the risk of pathogen transmission and ocean health risk?
- What are the linkages between the stressors (directly or indirectly via host-pathogen interactions), not just effects independently in organisms?
- Are protected resources vectors of pathogens and how do they move between ecosystems?
- Could diseases be transported into novel ecosystems, both marine and terrestrial in this way?

<u>Data (monitoring and observations):</u>

- Inter-disciplinary collaborations
- Long term monitoring of all identified stressors
- Standardization of tools and techniques and validation thereof
- Expand use of protected resource sentinels and other early warning indicators to detect anomalies, perturbations and trends

- Sample archiving for future retrospective analysis
- Quality assurance systems
- Identify surrogates for monitoring (use of in vitro approaches)

Models:
- Develop models to understand linkages/impacts of ocean health on protected resources
- Identify existing models to use (inventory of models)
- Ensure existing ecosystem models are sufficiently flexible so that ocean health data can be incorporated.
- Expand use of risk assessment models
- Frameworks for model testing and validation

Data Management:
- Must include system for easy retrieval and interpretation for managers and public

Climate

Annual or less frequent fishery and protected resource assessments have found correlations between environmental or climatic variability and abundance and distribution of species at two principal time scales: The quasi-decadal variability (ACW, NAO and PDO) and the more variable ENSO type (4 to 6 yr) variability. Little information exists to link changes in weather (<12 months periodicity) and the productivity of ecosystems and the corresponding direct or indirect impacts on PR. Such research is critical in ascertaining the long-term effects of single large events (Hurricane Katrina) vs. longer term changes in weather (more violent or frequent storm events).

Tele-connections (ocean-atmosphere connections) that are associated with climate variability are not well understood at a number of ecosystem levels. Yet, regime shifts in the Southern Ocean (1989-1990) have occurred at the same time as in other high latitude systems (Bering Sea; 1989-1990). For large, highly migratory PR, whose ecosystem extends many degrees of latitude there is little understanding of the role of these global scale climatic teleconnections on their life history or productivity.

Regional data and indicators, while important, are less so for a national strategy, as effort to develop such indices cannot be scaled up to describe the general state of the ecosystem. In contrast, large, LME scale, or broader indicators have a greater justification precisely because they inform about the ecosystem at the scale of the species, or population range. Smaller scale indices may be important (river quality indices) but are probably not where the national program should focus. An example is the 500 mb pressure field used to understand national weather. Daily maps provide information for local weather to be predicted. Local weather maps provide no information about the national weather picture. But, over the long-term, local weather data will be able to track low frequency, broad scale climate patterns, much like individual SST data track the low frequency climate shifts in the north pacific.

Data (monitoring and observations): Current data acquisition programs include shipborne, moored, and satellite data. Any EAM with a protected species component will require continuous (annual, semi-annual, monthly (region and ecosystem specific)) data collection programs. Fortunately, much of this abiotic data is currently collected as part of resource surveys. However, where high frequency (mostly very local in space or time) data may be necessary emerging technology (environmental monitoring by animals or autonomous vehicles) may provide important abiotic and biotic data at regional scales. Augmenting data collection on current ecosystem surveys using towed, or expendable instrumentation will provide future interpretations with up-to-date climate data, as such data sets become part of the long-term data-stream.

Models: Climatic models, both statistical and numerical, are advancing at a very rapid rate. An EAM with protected resources component should actively encourage and support the use and development of climate modeling. NOAA has expertise in several areas of climate modeling, and NMFS has particular expertise in serving these data. Such models or output will provide the canvas of background information to build interpretations about the ocean and coastal environment. Models or model output will need to be validated as part of the longer term monitoring program.

Data management*:* Under current auspices of NOAA, and under the IOOS banner, climatic data derived from surveys, or from models will be required to be available in a timely manner, and to be served to users. Under an EAM with a protected species component, climatic, and environmental data will be integrated and served in both raw form (available to individual researchers) and in product form (time and space series).

Habitat

Research: The primary habitat-related research need is to develop a good understanding of the relationship between measurable habitat attributes and species abundance and productivity. This is necessary to predict how changes in habitat attributes will affect the viability (abundance, productivity, and diversity) of species of interest, including protected species and other species upon which they many depend. Specific examples include (among many others): effects of alternative watershed management or restoration strategies on anadromous fish production, effects of trawling on species composition and abundance, effects of noise on marine mammal and fish behavior and productivity, effects of coastal development (including alternative mitigation strategies) on fish, marine mammal, or turtle abundance. Much of this research will be of necessity long-term and will need to be conducted on a spatial scale much larger than has been typical for most ecological experiments. For example, many populations of marine species have vast ranges (thousands to millions of square kilometers), and measuring a population response to habitat perturbations may therefore require experiments or monitoring on a similar scale.

Monitoring: For many protected species there is a need for basic information on where the species live and what habitat they utilize throughout their life-cycle. For example, some protected species (including fish, turtle and marine mammal species) are observed only during a portion of their life-cycle. An effective ecosystem approach to management will require at least a basic understanding of what habitat a protected species is utilizing over its entire life-cycle. In addition, there is a need for standardized and statistically valid habitat monitoring across multiple scales and jurisdictions. Long-term monitoring data are essential for detecting trends and for developing hypotheses for functional relationships between habitat attributes and ecosystem function. To be most effective, however, such monitoring needs to occur in a systematic, unbiased manner, and data collected by multiple agencies and institutions needs to be standardized.

Models: A number of useful models already exist for relating habitat attributes to species/population abundance [citations]. Parameterizing and validating these models is probably more important than developing new models.

Data management: *S*tandard needs (accessible, integrated across sources, etc). Habitat data needs to be collected on same scale as the population/species of interest.

Appendix V

WG3's List of Research Priorities for Incorporating Ecosystem Considerations into Protected Resource's Assessments.

The list of issues raised by participants in a round robin discussion of "research and data needs" for ecosystem based stock assessments for protected species included:

Very important

- better long-term spatially resolved monitoring data to better understand environmental variability
- better long-term spatially resolved data on human marine/maritime activities for risk assessment
- better time series data to help calibrate and validate numerical models
- better trend, biomass and abundance estimates
- better estimation of trophic transfer rates
- better historical data series (reconstructed?)
- better information on habitat use and dispersal to estimate exposure to various anthropogenic hazards
- better understanding of the acute and chronic effects of various stressors on morbidity not just mortality
- better understanding of marine species behaviour to better evaluate effects of external stressors
- better information on disease/parasite effects
- better information on stock structure (age-sex, spatial)

Important

- ask more insightful ecological questions
- consider boundary issues such as land-sea interface
- better methods for data assimilation in ecological models
- better evaluation of the efficacy of management actions to reduce mortality
- better information on foraging ecology
- better indices to support objective decision making
- better sub-sea surface oceanographic data (temperature, currents etc)
- better understanding of environmental forcing
- better understanding of food habitat requirements (use bycatch)
- better understanding of life history traits
- better understanding of the effects of anthropogenic sound
- better understanding of the effects of catastrophic events on species viability and survival (especially at low population levels)
- contemporaneous sampling of environmental factors
- develop indicators to help monitor health of protected species
- development of informative case studies of ecosystem change

- diagnosis of reasons for why some stocks fail to recover while others do recover
- external review of research projects
- readily accessible data inventories and meta-data
- socio-economic research (human demands for resources)
- undertake comparative life history studies

Appendix VI

Glossary of Terms

ACFM – ICES Advisory Committee on Fishery Management
AKFSC – NMFS' Alaska Fisheries Science Center
BORMICON – Boreal Migration and Consumption model
CCAMLR – Convention for the Conservation of Antarctic Marine Living Resources
CEMP – CCAMLR Ecosystem Monitoring Program
DFO – Canadian Department of Fisheries and Oceans
DOC – U.S. Department of Commerce
DOI – U.S. Department of Interior
EAM – Ecosystem Approaches to Management
ECOPATH – Ecosystem mass balance simulation model
ECOSIM – Ecosystem Simulation model (usually used with ECOPATH as a time dynamic simulation module for policy exploration)
EGT – NOAA's Ecosystem Goal Team
EMAX – Energy Modeling and Analysis Exercise
EPA – U.S. Environmental Protection Agency
ESA – U.S. Endangered Species Act
ESU - Evolutionary Significant Unit
ETP – Eastern Tropical Pacific tuna/dolphin research program
F/PR – NMFS Headquarters Office of Protected Resources
F/SF – NMFS Headquarters Office of Sustainable Fisheries
F/ST - NMFS Headquarters Office of Science and Technology
FEP – Fishery Ecosystem Plan
FMC – Fisheries Management Council
GIS – Geographic Information System
GLOBEC - Global Ocean Ecosystem Dynamics program
ICES – International Council for Exploration of the Sea
IWC – International Whaling Commission
LME – Large Marine Ecosystem
LMR – Living Marine Resources
MMC – U.S. Marine Mammal Commission
MMPA – Marine Mammal Protection Act
MSC – Marine Stewardship Council
MSA – Magnusson Stevens (Fishery Conservation) Act
MSVPA – Multispecies Virtual Population Analysis model
MULTISPEC – Multispecies Assessment fishery model
NAMMCO – North Atlantic Marine Mammal Commission
NCCOS – National Centers for Coastal and Ocean Science
NEFMC – New England Fisheries Management Commission
NEPA – National Environmental Policy Act
NERR – National Estuarine Research Reserve
NGO – Non Governmental Organization

NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NOS – NOAA's Ocean Service
NEFSC – NMFS' Northeast Fisheries Science Center
NMSA – U.S. National Marine Sanctuaries Act
NPFMC – North Pacific Fisheries Management Commission
NWFSC – NMFS' Northwest Fisheries Science Center
OHHI – Ocean and Human Health Initiative
PBR – Potential Biological Removal (under the MMPA)
REA – Regional Ecosystem Area
SAIP – Stock Assessment Improvement Plan
SARA – Canadian Species At Risk Act
SCAR – Scientific Committee on Antarctic Research
SWFSC – NMFS' Southwest Fisheries Science Center
TNC – The Nature Conservancy
TRT – Take Reduction Team
USFWS – U.S. Fish and Wildlife Service
VPA – Virtual Population Analysis model
WG – Working Group

Appendix Table 1. Major themes to consider for ecosystem-based decision making relative to EAM for Protected Resources.

Theme	Tropho-dynamics	Acoustics	Ocean and Human Health	Climate	Habitat
Research (Process studies)	1) What are the relative removals of/by protected resources? 2) What is role of prey to production of protected resources? 3) What are indirect effects of changes to prey on protected resources and their competitors?	1) Passive acoustic sensing of animals, natural processes, human input 2) Ability to char. spatial/temporal trends in ambient noise 3) Ability to identify discreet acoustic events 4) Biological sensing (including protected resources)	1) Fate/transport of high priority contaminants & toxins; 2) Biological effects 3) Use of Protected Species as indicators 4) Development of tools to detect multiple pathogens at once 5) Where contaminants end up and their effects 6) Links between terrestrial and marine ecosystems 7) Standardizing tools/techniques 8) Tests of appropriate models	1) Data not at same long-term scale (climate effects at regional scales, decadal scale variability, severe weather events) 2) How does climate effect distribution and abundance of protected species 3) Under various climate scenarios, do we expect recovery plans to meet their goals?	1) Better data on status/trends of habitat 2) Relationship between habitat and productivity 3) Abundance related to habitat 4) Habitat restoration techniques 5) Acoustic habitats 6) Effects on multiple uses of habitat
Data (Monitoring and Observation)	1) Population vital rates 2) Diet composition 3) Abundance of predators, prey, and competitors, 4) Interactions with fisheries	1) Info contained in passive sensing of anthropogenic sources, protected species, natural processes, using animals as sensors	1) Collaboration; need to collect pathogen data 2) Start standardized tools/techniques 3) Expand use of protected species sentinels to use for early warning	1) Physical oceanography and climatology measurements 2) Measures of abundance, vital rates	1) Info on where species go during migrations 2) Habitat utilization

Theme	Tropho-dynamics	Acoustics	Ocean and Human Health	Climate	Habitat
Models	1) Need to parameterize models that already exist 2) Information about ecosystem models that are out there; 3) Set up review process for models (run data on different models, etc)	1) Propagation models (limitations in shallow water/complex areas) 2) Predictive models of ambient noise based on biological, physical, anthropogenic sources 3) Observation system must be comparative.	1) Develop models to understand linkages/impacts of ocean health on protected resources; 2) Identifying existing models to use (inventory of models)	1) Question specific models need to be developed	1) Question specific models need to be developed
Data Mgmt	1) Integration of different data sources 2) Data online and available	1) Value in having as much raw data as possible 2) Provide more bandwidth	1) All needs improved	1) Data integration	1) Data integration

Appendix Table 2. Types and attributes of stock assessments for protected species.

Type of Assessment	"Target" species of mgmt	Physical Oceanographic Forcers	Predators& Prey	Lower trophic level Processes	Stressors Activities	
					Direct Mortality	Chronic
"Classic" Single Species Assessment	Explicit; Dynamic	Static; Observed series or average recruitment and growth	Static; Fixed external Parameters	Absent	Usually Fisheries (Single type of mortality)	Rare
"Augmented" or "Enriched" Single Species Assessment	Explicit; Dynamic	Dynamic (or static) External inputs	Dynamic & unidirectional (or Static); External inputs	Absent	Usually Fisheries (Single type of mortality)	Rare
Multi-species Assessment	Explicit; Dynamic	Static (usually) recruitment, dynamic or static growth	Dynamic & reciprocal; Explicit	Absent	Multiple Fisheries (single type of mortality	Rare
Trophodynamic Ecosystem Models	Explicit or Implicit	Usually static	Dynamic & reciprocal; Explicit	Dynamic & reciprocal; Explicit	Single or Multiple	Rare
Bio-geo-chemical Ecosystem Models	Rarely Explicit	Dynamic; Explicit	Dynamic and reciprocal; Explicit	Dynamic & reciprocal; Explicit	Single or multiple	Pollution, eutrophication, others
Assessments For Protected Resources	Usually explicit	Often explicit & dynamic, external, esp if associated with a risk.	Explicit, dynamic, reciprocal	Dynamic only when threat is lower trophic level issues	Usually multiple explicit	Usually multiple explicit

Appendix Table 3. Matrix of governance options.

Governance levels/roles	Options				
Sets national vision and goals for EAM	Legislation	Interagency Committee (IAC)*	IAC with stakeholder input (SI)**		
Sets national EAM policy	Legislation	IAC	IAC with SI	NOAA's Ecosystem Goal Team (EGT)	EGT with SI
Collects/integrates scientific data necessary for EAM	Regional interagency science boards	NOAA Fisheries Science Centers			
Makes EAM decisions	Regional interagency ecosystem teams (RET)	RET with SI	NMFS' regional offices (with partner agencies via NEPA)		
Implements EAM decisions	Relevant agencies	Relevant agencies with SI			
Monitors effectiveness of EAM implementation (process and outcomes of management actions)	RET	NOAA Fisheries Science Centers			

*For all Committees, Boards, and Teams, must decide whether membership is mandated/required or voluntary.
**For stakeholder input, must decide (for each instance) the level of input, ranging from simply informing decisions to participating in decisions to developing consensus decisions.

Appendix Table 4. Summary of Working Group responses to the four questions.

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
What characteristics should a region-specific, national program for this EAM theme have?	1. Set national standards but be adaptable to regional needs 2. Be responsive of legislative mandates 3. Have a clearly stated national mission. 4. They would need to be operable at the regional level 5. Coordinate and collaborate across line offices and other programs 6. Be as exhaustive and inclusive as feasible of all germane ecosystem factors.	1. NOAA should create knowledge and procedures to make better informed decisions about protected species. 2. Development of these new procedures should begin with a reference document describing the ecosystem 3. Long-term monitoring programs are essential for any ecosystem approach to management. 4. Data from monitoring programs must eventually be used to guide decision making. 5. There are issues of scale which need to be dealt with. 6. Ecosystem	1. To be most effective, a national program for incorporating ecosystem dimensions into protected resources assessments should have a region-specific focus. 2. A variety of spatial scales will be appropriate when defining such regions. 3. A national program must have clear goals, be flexible, and adaptive. 4. Ecosystem assessments should be a national priority. 5. They should break down stove pipes within Centers and between agencies to allow coordinated, efficient ecosystem based stock assessments. 6. EAM should provide	1. Retain the authority of existing legal mandates 2. Emphasize a precautionary approach to management 3. Maintain a healthy and productive ecosystem while allowing sustainable use; 4. Manage in a “placed-based” fashion, focusing on issues/threats to the ecosystem, rather than species-specific management; 5. Identify the scale of management units taking into consideration nested and transboundary ecosystem components; 6. Manage human activities to identify and

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
		approaches to management for Protected Species needs to include all the components of ecosystem on which the Protected Species rely. 7. An ecosystem approach to management will require extensive collaboration and coordination.	forums to discuss allocation among stakeholders, review science, and Develop mitigation measures from any stakeholder 7. EAM should be based on realistic goals 8. Ecosystem based assessments should be multi-disciplinary and include appropriate biotic and abiotic factors 9. The Assessment methodology should be robust to data-poor areas and species 10. Assessments can be both quantitative and qualitative. 11. Assessment should use standardize terms and approaches for different parts of ecosystem research. 12. Assessments should explicitly deal with uncertainties, and should	separate conflicting uses and account for variability and patchiness within ecosystems (e.g., zoning); 7. Make proactive decisions using a NEPA-like process 8. Facilitate transparent communication of knowledge, experience, and the decision-making process; 9. Support collaboration between stakeholders 10. Create synergy among groups 11. Support partnerships for joint management and research initiatives on national and international scales; 12. Recognize adaptive and incremental processes

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
			include sensitivity analyses 13. They should include studies of the impacts of single/multiple stressors on the species (or area) of interest; 14. They should utilize both top-down components and bottom-up components 15. Should be the most appropriate type (within the single species to bio-geochemical ecosystem model continuum) for the species/area of interest. 16. Assessment should include a control law that builds upon the existing control laws and also explicitly incorporates ecosystem attributes.	13. Dedicate appropriate levels of funding for adequate durations 14. Make science-based decisions using multidisciplinary information

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
Are there appropriate experiences worldwide that demonstrate how this theme can inform ecosystem-based protected species management (include appropriate references)?	1. Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) Southern ocean GLOBEC 2. NAMMCO 3. Norway/Iceland-BORMICON/MULTSPEC 4. International Whaling Commission working groups 5. Yodzis et al. model from Argentina and Yodzis et al. model from South Africa 6. Review by Trites re: Ecopath w/Ecosim and marine mammals 7. Australian Dugong management 8. NMFS AKFSC- Steller Sea Lions and groundfish 9. NMFS NEFSC-EMAX 10. Sea otter, kelp interactions and trophic cascades 11. NOAA's Ocean and	1. ETP tuna-dolphin research 2. NEFSC cetacean surveys 3. Pacific NW salmon 4. Nature Conservancy ecoregional planning 5. PEW strategy program 6. U.K. Royal Society for Protection of Birds 7. U.S. Audubon Christmas bird counts 8. Citizen activism efforts	1. "Enriched" single-species models: a. Barents's Sea cod b. Baltic Sea cod c. Sardine and anchovy stocks in Iberian waters d. Most capelin assessments e. CCAMLR assessments of krill f. South-central Pacific tuna-dolphin model 2. Multi-species Assessment models - a. The most widely used multispecies model is the multispecies – VPA (e.g., North Sea and Baltic Sea marine fish assessments) 3. **T**rophodynamic models – a. there are well over 150 applications of Ecopath to marine systems, and other mass-	1. Puget Sound Restoration Plan. 2. CCAMLR - 3. Aleutian Islands Fishery Ecosystem Plan -

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
	Human Health initiative 12. Discovery of toxoplasmosis in sea otters leading to evaluation of run-off from feral and domestic cats which may have human health implications 13. Cold-water coral management in the North Atlantic (ICES, NMFS) 14. Australia's Great Barrier Reef initiative 15. NW salmon		balance models have also been tried. b. CCAMLR International Whaling Commission 4. Full bio-geo-chemical ecosystem models – a. The Everglades model developed by deAngelis et al. b. The Puget Sound Collective process	
What new research, data, models, or information management system is required to advance the discipline so that its products form the basis for ecosystem-based decision making?	The Working Group divided its charge into five broad themes: trophodynamics, acoustics, ocean health, climate, and habitat (see Appendix Table 1)	1. Information Systems & Data Management: a. Establish metadata standards b. Establish data sharing agreements and structure to facilitate data sharing c. Dedicated database managers d. Databases linked to GIS and models for further analysis (multi-	1. Research and data collection to support ecosystem based stock assessment will have to relate back to one of NOAA Fisheries' three legislative mandates. 2. The output of EAM needs to be augmented assessments. 3. These EAM assessments would need to include traditional single-species scientific	There is a major need for a better Decision Support System (including relevant models). Such a System should: 1. Provide a framework for incorporating science into decision-making – 2. It should provide a set of scientific tools that help policy makers identify potential

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
		criteria evaluation) 2. Data Needs -There should be an iterative approach to management, data collection and analysis 3. Modeling – a. Expand and strengthen in-house modeling capacity b. Develop risk-based models with probabilistic output to support management c. Draw from modeling experience from other disciplines and environments (terrestrial, economics, climates, disease, acoustic), including integration of existing complementary models (e.g., biochemical and trophic) d. Develop "metadata" for models to ensure reproducibility (e.g.,	advice, but also include wider considerations. 4. Incorporate ecosystem considerations into assessment models 5. An ensemble approach to assessment using multiple model types may be an appropriate framework. 6. Assessment models enhanced by ecosystem considerations need to result in clearly defined control rules to inform management decisions. support approaches that are used across multiple disciplines. 7. Expanding the scope of assessment models necessitates the use and integration of additional data. 8. A core goal of a developing ecosystem assessment program	conflicts and minimize their occurrence

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
		assumptions and initial conditions) e. Develop a set of criteria for validating models	should be the development of information systems that will facilitate warehousing, exchange, and access a broad suite of environmental data. 9. Further, it is essential that collaborations across institutional boundaries be developed to allow a more diverse suite of expertise to be actively involved in the assessment process.	
Based on the above, what changes in policy, governance, or science administration are required to more effectively inform ecosystem approaches to protected species management?	1. There are a plethora of legislative mandates that provide the basis for these ecosystem considerations (Endangered Species Act, Marine Mammal Protection Act, Magnuson-Stevens Fishery Conservation and Management Act, and the National Environmental	1. First a. Construction of a “big-picture” document or knowledge inventory for each LME b. More effective NOAA Fisheries website c. Seminar series d. NCEAS-style workshop	1. Overarching - The current mandates of the MMPA and ESA, with respect to ecosystem-based management, compel us to move forward with the state of knowledge that exists today. 2. Policy - Policy level commitment to EAM is	1. A functional governance structure for EAM must be developed. 2. Setting a national vision and goal(s) for EAM; 3. Setting national EAM policy 4. Collection and integration of scientific

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
	Policy Act, among the 46 other legislative drivers for NOAA) 2. Issues of internal and external governance are keystone concepts need to establish regional bodies, akin to those calls from the U.S. Oceans and Pew Commission reports 3. Need dedicated groups to perform integrated science within the context of national standards. .	e. Paid sabbaticals f. Formalize partnerships across Centers of Excellence 2. Then a. Provide a long-term commitment to a permanent source of funding. b. Clear prioritization of research needs c. NOAA should also provide for better communication, within NOAA Fisheries, between government agencies, with academia and NGOs. Formalize partnerships by identification of "Centers of Excellence" for those disciplines and taxa that are essential for effective EAM in each LME.	abundant and strong. 3. Legislation: Identify and link language supporting EAM into existing statutes. 4. Regulations: Consolidate fishery management and protected species regulations to clarify that governing bodies need to consider the full range of requirements. 5. Governance - The concept of a Marine Ecosystem Council was strongly recommended as the ideal governance system by which all of the current species-based governance structures 6. The group also strongly encouraged expanding the authority of current species-based governance structures (such as TRTs) so that	data necessary for EAM 5. Making EAM decisions regarding the need for action to address ecosystem problems and identifying agencies that must respond to problems 6. Iimplementation of EAM decisions; and 7. Monitoring and evaluation of the effectiveness of EAM implementation, including the decision-making process and the outcomes of management actions.

Questions	WG 1 – Supporting the NOAA vision of EAM - Ecosystem Studies with A Protected Species Component	WG 2 – The Protected Resources Vision - Protected Species Studies with An Ecosystem Component	WG 3 – Assessments – Ecosystem Based Stock Assessments for Protected Species	WG 4 – Governance – Incorporating EAM into Management of Protected Species
			they have a broader stewardship mandate and a broader group of stakeholders. 7. Science Administration, Structure and Execution- A clear mandate and directive is required from HQ to the Science Center Directors that they must conduct ecosystem/integrative research. 8. Review/Evaluation - create a forum for reviewing ecosystem assessments akin to the Scientific Review Groups (SRGs), and hold multi-disciplinary workshops/conferences	