Proceedings of the 2nd National Habitat Assessment Workshop

Fisheries Science to Support NOAA's Habitat Blueprint

Hosted by the Northwest Fisheries Science Center, Office of Science and Technology, and Office of Habitat Conservation

Edited by Lora M. Clarke

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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National Oceanic and Atmospheric Administration
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EXECUTIVE SUMMARY

The 2nd National Habitat Assessment Workshop (NHAW) brought together nearly 75 scientists and managers from across the Nation to focus on this year's theme, "Fisheries Science to Support NOAA's Habitat Blueprint." Representatives from every National Marine Fisheries Service Science Center and Regional Office, as well as from the Office of Science and Technology, Office of Habitat Conservation, National Ocean Service, and Oceanic and Atmospheric Research participated. The workshop was instrumental in developing recommendations to improve the quality of NMFS habitat science needed for improved stock assessments and essential fish habitat; encouraging increased communication and collaboration between scientists and managers; and developing recommendations to improve information transfer products that NMFS habitat managers can use to inform essential fish habitat consultations and discussions with fishery management councils.

Among other things, the Habitat Blueprint provides a framework for NOAA to be more effective in our goals of conserving habitat for fisheries management, while moving further toward ecosystem based management. One goal of the NOAA Habitat Blueprint is to implement a systematic and strategic approach to habitat science in order to inform effective decision making. Building on this goal, and recommendations put forth during the 1st NHAW and in the Habitat Assessment Improvement Plan (HAIP), sessions were developed on Prioritization of Stocks for Habitat Assessments; Tools for Successful Habitat Assessment for Fisheries; Incorporating Habitat Information in Stock Assessments; Rethinking Essential Fish Habitat; and Improving the Flow of Habitat Science Information to Management. Some of these sessions were designed to provide updates and increase the flow of information in order to improve habitat science across the Science Centers and Regional Offices, while other sessions provided opportunities for greater discussion and brainstorming through smaller breakout groups followed by report outs to the larger group. Summaries of the recommendations from those sessions are highlighted below:

Incorporating Habitat Information in Stock Assessments

In this session, participants identified the habitat science needs for stock assessments and ways habitat information can contribute to improving fisheries stock assessments by reducing uncertainty in assessment data inputs or assessment model projections. A better understanding of the specific short-to-medium term needs will better enable those working on habitat assessments to make data available to the stock assessment community in more meaningful ways.

***Top Conclusions and Recommended Next Steps*:**

- Habitat studies are not currently providing much information that can be readily incorporated in the stock assessment process, but habitat data could substantially improve assessments for many stocks where basic stock data (catch, abundance, life history) already exists.
- Although fitting ecosystem data into stock assessment models remains a challenge to be addressed, there are many examples where habitat data is already being used to inform the stock assessment process.
- Using habitat information to post-stratify abundance surveys can accomplish the

same goals as redesigning surveys based on habitat classifications, but offers greater flexibility and can inform survey design if necessary.
- Studies of density dependence should be conducted using a habitat context to examine the potential effects of habitat on catchability and selectivity.
- Increasing information on life history bottlenecks and the timing of mortality events relative to density dependent compensation is a critical next step.

Rethinking Essential Fish Habitat

In this session, each region discussed the opportunities and challenges associated with designating essential fish habitat (EFH) and using EFH designations to conduct meaningful consultations. Currently these designations are difficult to review/revise and not as helpful as they could be for NOAA to conduct consultations. Participants discussed specific EFH needs, challenges, and opportunities for moving forward.

Top Conclusions and Recommended Next Steps:

- NMFS scientists and managers should prioritize habitat research based on habitat productivity and threats to habitat health and functionality, but more basic habitat science research needs to be conducted to ensure competent decisions can be made.
- EFH designations, and HAPC designations in particular, should incorporate data that specifically addresses the conditions critical to early life history stages, with a special focus on productive habitats that are most at risk from anthropogenic or climate-induced degradation.
- Better mechanistic models should be developed to forecast responses under noel and/or rapidly-changing habitat conditions.
- Non-fishing impacts to EFH are becoming more prevalent. Proven conservation measures that address common threats to EFH from a variety of ocean and coastal developments should be identified and implemented through cooperative regional efforts.
- Research should be conducted to enable EFH designations to include complex, guild, or life-stage specific designations.
- Support from leadership at the regional and national levels is needed to make any of these a reality.

Improving the Flow of Habitat Science Information to Management

In this session, participants recommended information transfer products that NMFS habitat managers can use to inform EFH consultations with federal action agencies and EFH designation discussions with fishery management councils. This was a follow-up session to sessions held at the 1st National Habitat Assessment Workshop in 2010 that focused on current processes and strategies for providing incorporating habitat science into management.

Top Conclusions and Recommended Next Steps:

- An inshore-offshore decision support tool is needed to effectively help habitat managers evaluate the impacts of management decisions effecting onshore habitats on the productivity of offshore fish populations
- A small team of habitat managers and ecosystem scientists should be formed to further define and develop this tool and outline next steps.

The recommendations from each of these three sessions provide next steps for not only improving the quality of habitat science needed for NMFS to effectively sustain marine fisheries and associated habitats, but also to effectively communicate habitat science to managers. Habitat science is an essential aspect of ecosystem-based management and a vital step to improving NOAA's stewardship of living marine resources.

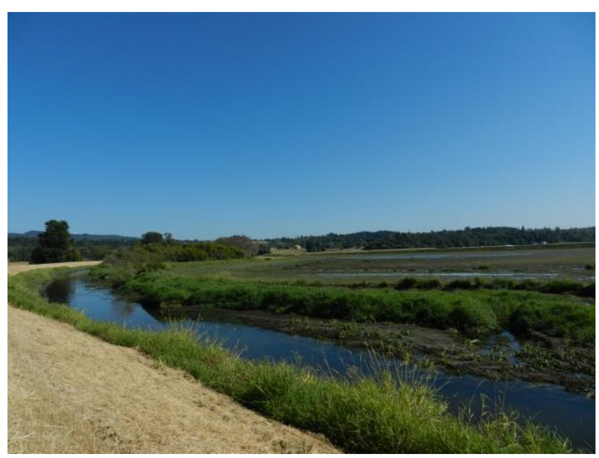
Introduction

The National Marine Fisheries Service (NMFS) held the agency's second National Habitat Assessment Workshop (NHAW) on September 5-7, 2012. The event was organized by the NMFS Office of Science and Technology and the Office of Habitat Conservation. It was hosted by the Northwest Fisheries Science Center's Montlake Laboratory in Seattle, Washington. The theme of the workshop was: "Fisheries Science to Support NOAA's Habitat Blueprint."

This workshop was a follow-up to the first NHAW, which was held in St. Petersburg, Florida in May 2010 (Blackhart 2010). That first workshop was a major milestone in the evolution of NMFS science programs, and coincided with the publication of the agency's *Habitat Assessment Improvement Plan* (HAIP, NMFS 2010). The theme of this first workshop was: "Habitat Science in Support of Management," and there was considerable discussion among habitat scientists and managers on how the HAIP could be implemented. The workshop also included a joint session with NMFS'11th National Stock Assessment Workshop, which provided a forum for discussions between habitat scientists and stock assessment scientists. The primary messages that came from these workshops were the needs to: 1) improve communication between scientists and managers; 2) develop a better understanding between habitat and stock assessment scientists of how habitat information can improve stock assessments; and 3) prioritize habitat assessments in each region to advance habitat science. Coincidentally, the first workshop took place during the Deepwater Horizon oil spill, and the then NMFS Chief Science Advisor, Dr. Steven Murawski, led a lively discussion of this event.

The second NHAW provided the agency's habitat scientists and managers an opportunity to assess progress and consider new factors that have emerged over the ensuing two years and that are affecting National Oceanic and Atmospheric Administration (NOAA) and our habitat programs. The ongoing development of NOAA's Habitat Blueprint (http://www.habitat.noaa.gov/habitatblueprint/), which is a cross-NOAA framework to improve habitat for fisheries, marine life, and coastal communities, is a major factor. Improving the quality and focus of NOAA's habitat science is a vital aspect of the Blueprint, which provided the theme for the second workshop.

The workshop was divided into several components. Prior to the workshop, the Restoration Center in the Northwest Region led a field trip to several sites in western Washington that have been undergoing habitat restoration to improve habitat function and ecosystem services.



Fisher Slough Levee Removal Project Site

The workshop began with some context setting, including remarks on the importance of habitat science from Dr. Richard Merrick, NMFS Chief Science Advisor; a presentation on the Habitat Blueprint from Brian Pawlak, Deputy Director of the NMFS Office of Habitat Conservation; and a presentation on the Blueprint's Northwest Regional Initiative from Will Stelle, Administrator of the NMFS Northwest Region. The section of the workshop concluded with a keynote lecture from the Northeast Fisheries Science Center's Dr. John Manderson, titled, "Can our habitat paradigm cross the land-sea boundary?"

The rest of the workshop consisted of five working sessions.

1. Prioritization of Stocks for Habitat Assessments, which addressed progress and lessons learned from the work done on this topic as a follow-up to a key recommendation in the HAIP and the first National Habitat Assessment Workshop (NMFS 2011).
2. Tools for Successful Habitat Assessment for Fisheries, which addressed an array of available assets for habitat science from across NOAA line offices, use of the ME-70 multi-beam echosounder that is deployed on the FSV40 class NOAA ships, and the Coastal and Marine Ecological Classification Standard, which was recently approved as a Federal Geographic Data Committee standard for analyzing and mapping habitat information.
3. Incorporating Habitat Information in Stock Assessments, which focused on how habitat information can contribute to improving fisheries stock assessments by reducing uncertainty in assessment data inputs or assessment model projections.
4. Rethinking Essential Fish Habitat (EFH), which addressed designation of EFH in ecosystem-based fishery management plans, in dynamic habitats (e.g., pelagic) and changing climates, and non-fishery impacts, such as ocean-based energy development.
5. Improving the Flow of Habitat Science Information to Management, which focused on success stories of scientific information or tools included in EFH and Fish and Wildlife Coordination Act consultations, and addressed issues that affect many consultations that would benefit from improved scientific information.

The second National Habitat Assessment Workshop provided an excellent opportunity for NMFS and other NOAA scientists and managers to discuss their needs and issues of common interest. The poster session and numerous break-out groups enhanced this communication by providing opportunities for small-group and one-on-one discussions. The workshop steering committee worked hard to design a useful agenda that addressed the key issues affecting NMFS' habitat science. Kirsten Larsen, Kristan Blackhart, and Tali Vardi from the Office of Science and Technology; Janine Harris from the Office of Habitat Conservation; and Christine Holt from the Northwest Fisheries Science Center devoted considerable time and effort to workshop organization and logistics, which greatly contributed to its success. The agency has made progress since the first workshop in 2010, but many challenges remain. Everyone who participated in the workshop looks forward to the promise of the Habitat Blueprint, and the opportunities it may provide for improving NOAA's habitat science and the contributions this can make to NOAA's stewardship mission.

Stephen K. Brown, Ph.D.
NMFS Office of Science and Technology
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DAY 1: INTRODUCTORY REMARKS AND KEYNOTE PRESENTATION

Remarks on the role of habitat science in fisheries management, Q&A
Dr. Richard Merrick, Director of Scientific Programs and Chief Science Advisor, NOAA Fisheries

From Caribbean coral reefs to Arctic sea ice, the United States is home to a wide range of habitats that provide foraging, spawning, and nursery grounds for our living marine resources. Marine and coastal habitats are under ever-increasing demands and face a growing number of threats (i.e. sea level rise, ocean acidification, coastal development) across the Nation. Many of these areas provide essential habitats for our living marine resources, yet our knowledge of how these areas impact fisheries productivity and other ecosystem services is lacking. In many cases, we also lack information about the association of marine species with various habitat types. Such knowledge can be used to inform stock assessments and advance ecosystem-based approaches to management. NOAA must gain a better understanding of the relationship between species and their environments to inform effective decision-making and management of the Nation's fisheries. As a result, habitat science is a top priority and we are working to raise awareness and improve the funding outlook for habitat science.

During the Q&A, participants asked questions regarding various budget scenarios. The Office of Science and Technology will continue to push for increased funds for habitat science. In order to improve stock assessments, NOAA must incorporate ecosystem parameters and improve funding for habitat science. The recommendations and needs identified during NHAW II will be an important part of that process.

The Role of Science in the NOAA Habitat Blueprint
Brian Pawlak, Deputy Director of NMFS Office of Habitat Conservation

The NOAA Habitat Blueprint is a forward-looking framework for NOAA to think and act strategically across programs and with partner organizations to address the growing challenge of coastal and marine habitat loss and degradation**.** The Blueprint is a framework for moving toward ecosystem based management to be more effective in our goals of conserving habitat for fisheries management, protected resources and coastal communities. We know that we most likely will not see more resources coming down the line in the near future, and cannot wait for perfect science to make ecosystem management decisions– we can and are under the authority to work with the best available information to make our management decisions. Connections between the science and management community under the blueprint framework and through workshops such as NHAW help us to work together with our available resources to study and manage our trust resources systematically.

The NOAA Habitat Blueprint was launched due to widespread habitat loss and degradation and the recognition that NOAA's current habitat work alone is not enough to meet these threats. The Blueprint is based around four principles which guide our actions and define how we do business:

- Prioritize resources and activities across NOAA to improve habitat conditions

- Make decisions in an ecosystem context and consider competing priorities
- Foster and leverage partnerships
- Improve delivery of habitat science to facilitate decision-making

These principles are implemented through three key approaches:

- Establish long-term Habitat Focus Areas
- Implement a systematic and strategic approach to habitat science; and
- Strengthen policy and legislation

As a first step to affirm commitment to the Blueprint and show short-term impact and start implementing core elements on the three key Blueprint approaches, NOAA launched regional habitat initiatives across the country in the fall of 2011. These regional initiatives were designed to increase collaboration between NMFS regional offices and science centers on habitat science and management by bringing staff together on specific place-based projects.

The habitat science approach of the Blueprint builds on the regional initiatives and the HAIP, which was completed in 2010, by promoting increased linkages between habitat scientists and managers on a national and regional level. One goal of the habitat science approach is to prioritize science activities to fulfill habitat needs. The habitat assessment prioritization process is being completed for each region to rank fish stocks most in need of habitat research. Other goals include integrating science with management actions to foster better decisions, coordinating and leveraging efforts across NOAA, improving the delivery of habitat science, and improving communication and coordination in habitat science. By holding the NHAW II, we are together working toward these Blueprint science goals. Through the presentations and discussions at the NHAW, we hope to generate more ideas and activities that can strengthen habitat science across the agency in order to advance our habitat conservation efforts

Northwest Regional Initiative
Will Stelle, NOAA Regional Administrator for the Northwest Region

Conserving and restoring aquatic habitats important for marine fisheries and shellfish species is a crucial aspect of NOAA Fisheries' mission in the Pacific northwest. The Pacific northwest has lost much of its estuarine wetlands and riparian habitat and this has had dramatic consequences for many fish stocks. To address this issue, NMFS's Northwest Region is collaborating with external partners on an enhanced approach to implement the Puget Sound Chinook Recovery Plan and to protect and restore salmon habitat throughout Puget Sound, the Columbia basin, and across coastal Washington and Oregon. Specifically, NOAA is prioritizing resources and actions to address three key factors limiting chinook salmon survival: estuarine and nearshore habitats; floodplain function and connectivity; and water quality. NOAA is also working with other federal agencies across this vast western coastal landscape to address the operation of federal dams, federal lands, and other federal activities that affect marine species that are listed as endangered or threatened under the ESA. This is why it is highly constructive that that the regional offices and science center work together on science needs to support the protection of endangered species and habitats of particular concern. NOAA recognizes the need to identify synergistic opportunity where it is effective and efficient to overcome these programmatic and institutional challenges in moving the Blueprint forward.

During the Q&A, participants asked questions regarding ways to improve gaps and uncertainty in habitat science for managed fisheries species. The Northwest region confronts these challenges by working with the Science Centers to formulate scientifically sound regulatory decisions, and evaluating direct, indirect and cumulative risks to the species and their habitats.

Keynote Presentation: Does our Habitat Paradigm Cross the Land-Sea Boundary?
Dr. John Manderson, Northeast Fisheries Science Center

Ecosystem assessment and management in the sea is holistic, based upon interdisciplinary science that considers physical, chemical and biological processes, including feedbacks with human ecological systems, that structure and regulate marine ecosystems**.** Space and time based tools for the management of human activities in the sea need to be informed by a regional scale habitat ecology that reflects the dynamic realities of the ocean. Current spatial management strategies are based upon the patch-mosaic paradigm of terrestrial landscape ecology modified to consider principles of dispersal ecology, primarily for pelagic early life history stages. This modification is not enough because fundamental differences in the role fluid properties and processes play in controlling ecological processes on land and in the sea makes blanket application of paradigms developed on land to the problems of ocean management fundamentally flawed.

Seascapes are not landscapes

In 1984, Paul Risser and collegues (Risser et al, 1984) summarized workshop deliberations to develop a modern framework for the science of landscape ecology using theoretical and empirical underpinnings of a broad scale spatially explicit ecology useful for terrestrial resource management. Landscape ecology rests primarily upon the patch mosaic paradigm of habitat in which patches are defined by sharp gradients in vegetation and geomorphology. Geography and geological processes, particularly soil development, that control fundamental processes including primary productivity are the foundations of landscape classification. In terrestrial ecosystems, most organisms and processes are decoupled from the atmosphere by gravity and physiological adaptation to extreme variations in atmospheric properties, including temperature. As a result, the primary features of terrestrial habitats and ecosystems are physical structures created by landform and plant communities that can be modified by disturbance. Community compositions are determined by climate. However, the role of the atmospheric fluid is of secondary importance and the space-time scales of terrestrial ecosystems [~ velocity, 0.1 cm sec^{-1}] are orders of magnitude slower than the atmosphere [100 cm sec^{-1}] and approximately the same speed as soil regeneration (Steele, 1991; Mamayev, 1996).

In contrast, the ocean is highly viscous and has a density close to that of living tissues. Most marine organisms are, therefore, nearly buoyant in a fluid with dynamics that control their motions and those of other important particles including essential ecosystem building blocks. Since the basic processes of cellular metabolism evolved in the sea, most living tissues are nearly isosmotic with seawater. This contrasts starkly with terrestrial organisms whose intracellular concentrations of solutes and water are dramatically different than the atmosphere. Finally the specific heat capacity and thermal conductivity of seawater are about four and twenty-three times that of atmosphere by weight, respectively. As a result, marine organisms experience much slower rates and ranges of temperature change than do terrestrial organisms. Temperature is tyrannical in the oceans where oxygen required for endothermic heat generation is limited and warm-blooded organisms are rare. It regulates critical rates across all levels of ecological organization from the cell to marine ecosystems.

Processes controlling primary productivity on land and the sea are also fundamentally different. In the ocean, nutrients required by plants constantly fall out of sunlit surface waters where photosynthesis is possible. As a result, tiny, fast living plants with high surface to volume ratios are entirely dependent on the oceans "plumbing" to deliver nutrients into the sunlit surface layers from sometimes remote land or deep waters sources. Phytoplankton have fast population dynamics to which other members of marine food webs must respond. In contrast, primary productivity on land depends on slow, local nutrient regeneration in soil at the interface with a nearly transparent atmosphere where sunlight is rarely in short supply. As a result, plants at the base of terrestrial food webs are often immobile, long lived, and have slow population dynamics to which higher trophic levels respond.

Due to the tight coupling of physiology, movement of organisms and other critical ecological processes to the oceans fluid, the fluid is the primary driver that structures seascapes and regulates seascape processes. As a result, ecological processes in the ocean operate at approximately the same space-time scales (~velocities [~1 cm sec^{-1}]) as ocean turbulence (Steele 1991, & Mamayev, 1996). Bottom features are important to some marine organisms, however, these features are frequently defined by fluid processes and properties. The functional importance of bottom features includes surfaces for concentrating advected materials; sites of energy acquisition and/or conservation in the face of fluid flows; and predation refugia in regions where preference for water properties such as temperature, salinity and oxygen are shared with predators.

In summary, differences in the nature of the ocean and atmospheric fluid and adaptations of organisms to those fluids produce at least two critical differences in the characteristics of seascapes and landscapes. Firstly, habitats in the sea have much faster spatial dynamics; their locations, volumes and quality change quickly at rates defined by the space-time scales of organisms responses to properties and processes of the oceans fluid which are in surn driven by atmospheric and planetary forcing. Secondly, because the ocean fluid is so viscous, horizontal and vertical currents driven by atmospheric and planetary forcing transport essential habitat resources from sometimes remote sources and concentrate them in particular areas and times. In such cases, habitats are not locations in space supported by local resources but nodes of networked resources and processes which may be derived from distant sources "upstream." For these reasons, relationships between habitat dynamics and processes regulating populations, including density dependent processes, are fundamentally different in the sea and on land. These differences in the nature of habitat in the ocean and on land are in fact responsible for the order of magnitude differences in changes in species distribution and abundance in the sea and on land (~10 km yr^{-1} vs ~ 1 km yr^{-1}) associated with recent rapid changes in climate (Chueng et al., 2009; Sorte et al., 2010).

Conclusion

Rapid changes in human demand and use patterns of marine resources, combined with the profound effects climate change is having on species distributions and the structure of marine ecosystems, have made the development of a regional scale seascape ecology reflecting the dynamic realities of the ocean increasingly urgent. The foundations of the landscape ecology synthesis in the early 1980s rested on (1) developments in satellite remote sensing that allowed researchers to place fine scale ecological studies in broader spatial contexts; (2) advances in ecological theory that elucidated the role of dispersal and connectivity in determining regional community dynamics; and (3) the advent of modern computing that allowed researchers to store, analyze, and model large amounts of spatially and temporally explicit data and explore relationships between the changing landscape patterns and the processes potentially causing them. The recent development of operational ocean observing systems that integrate assimilative hydrodynamic models, and observations from remote sensing and insitu platforms along with important advances in our understanding of micro to macro-ecological process in the sea have made the time ripe for a similar synthesis and the development of a robust science of seascape ecology useful for the management of marine ecosystems.

PRIORITIZATION OF STOCKS FOR HABITAT ASSESSMENT

Prioritizing Habitat Assessments
Stephen K. Brown, Office of Science and Technology

The Marine Fisheries Habitat Assessment Improvement Plan (HAIP) was developed by a NMFS team to meet the habitat-related mandates of the Magnuson-Stevens Act, and was published in May 2010. The Plan focuses on the 230 Fish Stock Sustainability Index (FSSI) stocks that comprise over 90% of U.S. landings. The primary goals of the HAIP are to:

- Improve identification and impact assessments of EFH;
- Reduce habitat-related uncertainty in stock assessments and facilitate a greater number of advanced stock assessments.

To begin implementing the HAIP, a cross-NMFS team was charged by NMFS leadership to develop a prioritization process that can be used to develop defensible priority lists for habitat assessments in each NMFS region. The final document was completed in December 2011 (NMFS, 2011). Key features are:

- Stocks within a region are the units that are prioritized;
- Two types of criteria are applied sequentially;
  - Filter criteria to eliminate stocks from further consideration
  - Scorable criteria to determine the ranking of the remaining stocks
- Final ranks are binned into high/medium/low priority; and
- The end result is two priority regional lists of stocks for habitat assessments:
  - Stock assessments that will most benefit from habitat assessments
  - Stocks for which habitat assessments will most advance EFH.

A pilot was recently conducted in the Southwest Region, and the rest of the NMFS regions will apply a refined process based on this test case. Plans are to complete these regional processes in time to inform the Habitat Blueprint's process for identifying Blueprint Focus Areas.

Lessons Learned from Implementing the Prioritization Process in the Southwest
Korie Schaeffer, Southwest Regional Office

The Southwest Region was chosen to pilot the Habitat Assessment Prioritization Working Group process to prioritize managed stocks based on the degree to which stock assessments and EFH designations for each stock would benefit from a habitat assessment. A combination of key staff from the Southwest Fisheries Science Center, Southwest Region, and Office of Science & Technology participated in the pilot process, including participation in data gathering, several conference calls, and a two day face-to-face meeting. A total of 103 stocks were considered for prioritization, including only those stocks with significant catch in California and salmon stocks spawning in California. Staff relied on stock status, assessment and survey summary information; EFH sections of the Fishery Management Plans (FMPs); Productivity-Susceptability Analysis for groundfish; commercial landings and ex-vessel revenue data; and expert opinion to evaluate each stock against the three filters and eight scoring criteria. Scoring rubrics were modified for a number of criteria to account for information gaps and improve applicability to west coast species. The process was complicated by economic and ecological differences between stocks managed under different FMPs, specifically, differences between salmon stocks with both marine and freshwater life stages, stocks that are migratory and/or reside in the water column, and stocks that reside in marine, benthic habitats. Final scores and high-medium-low priority categories are still being evaluated. Preliminary scores indicate: (1) a subset of salmon and rockfish stocks would be high priority for habitat assessment contribution to EFH designations, and (2) a subset of salmon and rockfish stocks and Pacific bluefin tuna would be high priority for habitat assessment contribution to stock assessments.

Question and Answer Session

Leaders: Stephen Brown (S&T) and Korie Schaeffer (SWRO)

During the Q&A, participants asked questions regarding factors that were considered in the prioritization process. Climate change is rapidly changing such things as habitat availability and population dynamics and NMFS needs to have foresight into which stocks will be most affected and how this can be incorporated into the prioritization process. Climate change was discussed during the Southwest Habitat Assessment Prioritization Working Group Process, but it was difficult to determine which stocks would be most affected. This may be easier in other regions. Tribal priorities may also be an important consideration in some regions.

It was also clarified that the results of each regional prioritization process will be used as a layer of information to help inform the selection of the Habitat Blueprint Focus Areas. The prioritized list of stocks could be integrated with specific areas to determine high priority geographic areas.

TOOLS FOR SUCCESSFUL HABITAT ASSESSMENT FOR FISHERIES

One of the guiding principles of the NOAA Habitat Blueprint is to foster and leverage partnerships. With decreasing budgets and increasing pressures on habitat, institutions must find methods and places where missions overlap, and combine resources to get our respective and collective jobs done. With this collaborative spirit in mind at the 2nd NHAW, NMFS invited external speakers to showcase data and methods to assist fisheries habitat science and management. Presenters highlighted opportunistic data collection that helps refine trawlable bottom habitat, a wealth of bathymetric and shoreline data that can be accessed through geographic information systems (GIS) and web portals, shipboard video capabilities in unknown regions, and a new classification system for all marine data.

NOS Products that Support Fisheries Habitat Assessment
Mark Finkbeiner, Coastal Services Center, National Ocean Service

Understanding fisheries habitat requires information from many aspects of the environment. Although often developed for other purposes, many National Ocean Service (NOS) products provide this kind of information. These products include spatial data, analysis tools, technical reports, real-time conditional information and data access points.

NOS collects spatial data to support mission requirements and targeted stakeholders in the areas of safe navigation, disaster response, coastal and ocean stewardship, and services to coastal states. These data are intended to meet both local and national needs.

Derived data, that is data which is the result of some analysis or interpretation, include shallow water benthic habitats, land cover, National Estuarine Research Reserve monitoring data, bathymetry, shoreline characteristics, and Integrated Ocean Observation System (IOOS) products. Source data available from NOS include acoustic backscatter, LIDAR intensity, and airborne imagery. In addition, NOS provides several GIS tools to support further analysis of source and derived data.

NOS makes these data and products available through several web portals such as the Digital Coast, MarineCadastre, NOS Data Explorer, and the National Geophysical Data Center. Opportunities to collaborate with NOS are available through such efforts as the Integrated Ocean and Coastal Mapping program and other venues. A handout describing the many products in more detail and providing links for more information is available in Appendices 5-8.

Seafloor Characterization for Trawlability and Fish Habitat Using the Simrad ME70 Multibeam Echosounder in the Gulf of Alaska
*Jodi Pirtle***,** *University of New Hampshire*

Groundfish that associate with rugged seafloor types are difficult to assess with bottom-trawl sampling gear. Simrad ME70 multibeam echosounder (ME70) data and video imagery were collected to characterize trawlable and untrawlable areas and to ultimately improve efforts to determine habitat-specific groundfish biomass. We surveyed areas of the Gulf of Alaska (GOA) (20-500 m depth) aboard the NOAA ship *Oscar Dyson* during 2011, from the Islands of Four

Mountains in the Aleutians to eastern Kodiak Island. Additional ME70 data were collected opportunistically during the winter 2012 acoustic trawl surveys. ME70 data were collected continuously along the ship trackline (1-20 nmi spacing) and at fine-scale survey locations in 2011 with 100% seafloor coverage (n = 21). Video data were collected at fine-scale survey sites using a drop camera (n = 47 stations). ME70 data were matched to the spatial location of previously conducted AFSC bottom-trawl survey hauls (n = 582) and 2011 camera stations to discriminate between trawlable and untrawlable seafloor types in the region of overlap between the haul or camera path and the ME70 data. Angle-dependent backscatter strength, backscatter mosaics, and other multibeam metrics were extracted from the ME70 data at these locations. Haul locations show separation in backscatter strength based on performance, previously classified as successful or unsuccessful due to gear damage from contact with the seafloor. Successful haul locations have values that correspond to finer grainsize, or the lack of untrawlable features such as boulders and rock. A similar pattern was observed for the camera stations characterized as trawlable or untrawlable from video. The best descriptors for seafloor trawlability will be identified among multibeam metrics to map the predicted trawlability of the ME70 survey footprint. Continued opportunistic collection of ME70 data during *Oscar Dyson* operations will help refine existing classifications of untrawlable and trawlable areas in the GOA.

Implementing CMECS--the Coastal and Marine Ecological Classification Standard

Garry Mayer, NMFS Office of Habitat Conservation, and Mark Finkbeiner, NOS Coastal Services Center

In summer 2012, the Federal Geographic Data Committee approved the Coastal and Marine Ecological Classification Standard (CMECS) as the first-ever, comprehensive federal standard for classifying and describing coastal and marine ecosystems. CMECS development was a multi-year partnership led by NOAA with the U.S. Environmental Protection Agency, the U.S. Geological Survey, and NatureServe. NOAA Fisheries was a primary participant in these efforts. CMECS offers a simple, standard framework and common terminology for describing natural and human-influenced ecosystems from the upper tidal reaches of estuaries to the deepest portions of the ocean. The standard is designed to meet the needs of many users but has special relevance to fisheries-related research and management.

Practical fisheries-related applications include habitat assessments, especially descriptions of new or under-studied marine systems (e.g., deep-sea corals, the Arctic); improving EFH designations; mapping, planning and monitoring habitat restorations; climate-effects studies and monitoring; and regional governance. Specifically with regard to EFH, CMECS offers an opportunity to apply common habitat terminology and move towards a common format and greater consistency among designations. It provides a “platform” for adding relevant data from non-fishery sources and the possibility of more straightforward comparisons of EFH designations across Fishery Management Councils and geographic regions, within related taxa, and among unrelated but ecologically analogous species.

CMECS is sensor-independent and can be applied on scales ranging from local and regional to national and beyond. It articulates with other relevant FGDC standards and accepted classification approaches. Ecological units classified using CMECS can be mapped, compared, or otherwise analyzed with existing, available methods. CMECS accommodates biological, geological, chemical, and physical data in a single structure and facilitates data sharing, regional analyses and integration across observation methods and geographic scales. CMECS includes provisions to update and improve the standard as new information becomes available.

Using Environmental Data to Predict the Effects of Climate Change on Marine Fisheries

David Foley, Southwest Fisheries Science Center

A range of environmental data is needed to predict the effects of climate change on marine fisheries. The goals of this talk are to introduce readily available data sets, discuss efforts to improve data, discuss integration of environmental and biological data sets, offer several examples, and discuss predictions. Key data types include in situ data (CTD, gliders, tagged organisms etc.), satellite data (color, SST, height, and winds), and models. Data is distributed across a range of oceanic features important to living marine resources, such as ocean fronts, boundaries, edges, and mesoscale patterns. Satellites enhance spatial and temporal coverage and data help to resolve oceanic features at a variety of scales. However, there are some limitations to consider. For example, data is often limited to the very surface of the ocean and numerous factors need to be accounted for in the measurements. The data also only allow the derivation of basic oceanographic parameters, and clouds present a problem for all visible and infrared measurements. To mitigate data lost due to clouds, composite images can integrate across time on one platform and can also integrate across sensors and platforms (microwave and infrared). Sample applications include Google earth, ArcGIS, MatLab, IDL, and R. To choose the appropriate application it is important to balance needs for spatial resolution, spatial extent, temporal resolution, temporal extent, missing data, and accuracy of data.

OAR Science to Support NOAA Fisheries

Craig Russell, Office of Ocean Exploration and Research, OAR

The Office of Oceanic and Atmospheric Research (OAR) provides the research foundation for understanding the complex systems that support our planet. Working in partnership with other NOAA units, OAR provides better forecasts, earlier warnings for natural disasters and a greater understanding of the Earth. Our role is to provide unbiased science to better manage the environment, nationally and globally. OAR activities occur in seven research laboratories, four program offices, Sea Grant programs, and several cooperative institutes. These programs provide technology, data, models, and findings to aid NMFS habitat assessments. This presentation surveys select examples of OAR habitat related science activities under five major themes: Discover & Characterize; Advance Technology; Observe, Research, Monitor & Assess; Model & Forecast; Visualize & Communicate. Example activities include:

- Conducting interdisciplinary exploration and high risk research to provide information in unknown or poorly known regions, scales and in all three dimensions including the 4^{th} dimension – over time;
- Design, deployment, and analysis of data from fixed, buoy-based, vessel-based, aircraft-based, drifting, autonomous, and satellite observing systems in freshwater and marine environments to provide baseline and time-series ecosystem data;
- Field and laboratory studies in benthic ecology, lower food web process ecology, fish biology and ecology, phytoplankton ecology, and sediment transport with particular emphasis on invasive species, harmful algal blooms,

and time-series measurements in freshwater and coastal ocean systems;

- Developing and using earth system models, satellite observations and ecological forecasts to aid holistic understanding, simulations, prediction, and related management trade-off decisions;
- Engaging stakeholders, the public and students in collaborative, interactive, and innovative research, outreach and education, including making data easy to access.

Proactively engaging OAR labs, programs, and cooperative institutes will yield increased awareness of habitat related OAR activities and lead to collaborations with OAR to benefit multiple programs and partners.

DAY 2: INCORPORATING HABITAT INFORMATION IN STOCK ASSESSMENTS

Session Organizer: Kristan Blackhart (S&T)
Rapporteur: Janine Harris (OHC)

> ***Top Session Conclusions and Recommended Next Steps:***
>
> - Habitat studies are not currently providing much information that can be readily incorporated in the stock assessment process, but habitat data could substantially improve assessments for many stocks where basic stock data (catch, abundance, life history) already exists.
> - Although fitting ecosystem data into stock assessment models remains a challenge to be addressed, there are many examples where habitat data is already being used to inform the stock assessment process.
> - Using habitat information to post-stratify abundance surveys can accomplish the same goals as redesigning surveys based on habitat classifications, but offers greater flexibility and can inform survey design if necessary.
> - Studies of density dependence should be conducted using a habitat context to examine the potential effects of habitat on catchability and selectivity.
> - Increasing information on life history bottlenecks and the timing of mortality events relative to density dependent compensation is a critical next step.

Using habitat information to help inform and improve the stock assessment process is a major theme of the HAIP, and was also a major discussion topic at the 1st NHAW held in 2010. There, a joint session with the 11th National Stock Assessment Workshop was held with the intention of improving communication and collaboration between the stock assessment and habitat science communities. During the first NHAW, participants came up with a number of recommendations (see Blackhart 2010 for additional details):

- Habitat data should be integrated into resource survey sampling design where available to improve the precision and efficiency of surveys.
- NMFS should expand its capacity to collect habitat information and develop a comprehensive repository for existing and new habitat information. The highest priority to address is expanded habitat mapping and classification.
- Expanded collection of environmental data should occur during existing resource surveys, and development and implementation of advanced sampling technologies should continue.
- Cooperation and data sharing should be pursued and existing partnerships strengthened to make the best use of available habitat information.
- The accessibility of existing habitat data should be improved to facilitate inclusion in the stock assessment and management processes.

Progress has been and continues to be made on some of these recommendations, but budget restrictions and other challenges have limited implementation of others. This emphasizes the need for continued collaboration between the stock assessment and habitat science communities to meet current challenges.

The intent of this session was to focus on exploring the habitat needs for stock assessments and how habitat information can contribute to improving fisheries stock assessments by reducing uncertainty in assessment data inputs or assessment model projections. A better understanding of the specific short-to-medium term habitat science needs with respect to stock assessments will better enable those working on habitat assessments to make data available to the stock assessment community in more meaningful ways. The session began with several presentations from invited stock assessment scientists. These oral presentations are summarized below.

What Assessment Gaps need Habitat Information? Where Could Habitat-Specific Life History Rates Fit?
Richard Methot, NMFS Science Advisor for Stock Assessments

While it is generally understood that healthy fish populations require healthy habitat, the exact way in which fish depend upon habitat and respond to changes in habitat is not known. Thus, methods for fish stock assessment have evolved to not depend upon knowledge of the habitat linkages. This leaves fish assessments vulnerable to error by assuming constancy in factors that actually are changing.

There are four general categories of "soft spots" in fish assessments that are amenable to improvement through habitat-specific investigations:

1. Time series of survey trends may be too short to have observed historical trends, so it results in imprecise assessments. Here, direct measure of absolute abundance across the range of the stock (advanced tech surveys) or absolute fishing mortality rate (quantitative tag-recapture) are needed. Advanced tech surveys with a habitat specific design can be more precise and informative than generalized surveys.
2. Fish distribute over space/habitat according to age/size dependent preferences. Sampling all with equal (or at least known) probability is technically challenging. Studies of fish and fishery distribution across habitat types can improve direct information on selectivity.
3. Vital rates change over time in response to ecosystem, climate and habitat changes. Changes in body growth can be measured and easily accounted for, but field measurement of contemporary natural mortality rate is typically impractical. Although expensive and difficult, information on contemporary natural mortality rates across the range of the population can be obtained from extensive tag-recapture studies and/or predator-prey studies. Localized studies of natural mortality need to carefully account for fish movement.
4. The life stage in which the major compensatory response occurs is assumed to be during the larval-juvenile stage. This is because reduction in the stock's total reproductive output by fishing does not result in a proportional decline in the number of recruits that appear in the population months-years later. Sometime during this life stage, compensation for the reduced production of eggs is occurring. Knowledge of the life stage(s) at which this occurs, and the habitat in which in occurs, is a first step towards developing better prediction of the effect

of fishing and habitat loss on productivity of harvested fish populations.

The implications of untrawlable habitats on bottom trawl surveys for West Coast groundfishes

James Thorson, NWFSC

Bottom trawl sampling is used to estimate trends in stock abundance for groundfishes worldwide including Pacific rockfishes (*Sebastes* spp.). However, trawl sampling efficiency varies spatially, and the distribution of groundfish populations may change among easy- and difficult-to-survey areas over time. These concerns have prompted interest in using underwater vehicles (UVs), for which catchability is likely to decrease less in rocky habitats. In this study, we use simulation modeling to evaluate the abundance trends arising from bottom trawl sampling given density-dependent habitat selection and spatially-varying catchability. We first demonstrate that relative abundance indices in this case will generally be biased measures of changes in population abundance. We also propose and evaluate a sampling design that combines data from bottom trawl and UV gears. Combined sampling has greater precision than UV sampling, lower bias than bottom trawl sampling, and is robust to moderately-violated assumptions regarding sampling strata or spatial catchability. We conclude by recommending future research that could test the assumptions under which combined sampling is a feasible solution to spatially-varying catchability.

Expansion of Oxygen Minimum Zones may reduce available habitat for Tropical Pelagic Fishes

Eric Prince, SEFSC

Climate model predictions and observations reveal regional declines in oceanic dissolved oxygen (DO), which are likely influenced by global warming. Studies indicate on-going DO depletion and vertical expansion of the oxygen minimum zone (OMZ) in the tropical northeast Atlantic Ocean. OMZ shoaling restricts the useable habitat of billfishes and tunas to a narrow surface layer. We report a decrease in the upper ocean layer exceeding 3.5 mL L^{-1} DO at a rate of ≤1 m yr^{-1} in the tropical northeast Atlantic (0-25°N, 12-30°W), amounting to an annual habitat loss of ~$5.95 \times 10^{13} m^3$, or 15% for the period 1960-2010. Habitat compression was validated using electronic data from 47 blue marlin. This phenomenon increases vulnerability to surface fishing gears for billfishes and tunas, and may be associated with a 10-50% worldwide decline of pelagic predator diversity[10]. Further expansion of the Atlantic OMZ along with overfishing may threaten the sustainability of these valuable pelagic fisheries and marine ecosystems.

Incorporating temperature-dependent catchability in some Alaska flatfish stock assessments

Thomas Wilderbuer, AFSC

Temporal patterns in bottom trawl survey biomass estimates for flatfish species from the eastern Bering Sea have led to investigations examining whether these estimates co-vary with annual bottom water temperature. These patterns in catchability cannot be accounted for by the usual flatfish population dynamics and seem to operate through changes in the metabolism of the fish with water temperature and how it relates to both herding by the survey trawl gear sweep cables and availability to the trawl gear.

In the case of yellowfin sole, the variability of survey abundance estimates are in part due to the availability of yellowfin sole to the survey area. Yellowfin sole are known to undergo annual migrations from wintering areas off the shelf-slope break to near shore waters where they spawn throughout the spring and summer months. Over the past 15 years survey biomass estimates for yellowfin sole have shown a positive correlation with shelf bottom temperatures where estimates have generally been lower during cold years as the timing of the migration is longer. For other species, it is the temperature-driven metabolic response to being herded into the net path by the trawl sweep lines (greater in warm years) that has an effect on survey catchability.

To better understand how water temperature may affect the catchability of flatfish species to the survey trawl, catchability was estimated for each survey year in the stock assessment model as a nonlinear function of water temperature which responds to the metabolic aspects of herding or distribution (availability) and varies annually with bottom water temperature. The result of incorporating bottom temperature to estimate annual q resulted in a better fit to the survey biomass time-series.

Summary

Each of these presentations gave insight into the stock assessment process, outlined the places in the process where it is most feasible to use habitat information to improve stock assessments, and gave some specific examples of how environmental data is already being used in stock assessments.

The session next moved into a 'Question & Answer' panel to allow for group discussion of the themes raised during the earlier presentations. The discussion was facilitated by Terra Lederhouse (OHC) and panel members included Rick Hart (SEFSC), Richard Methot (S&T), Eric Prince (SEFSC), James Thorson (NWFSC), and Tom Wilderbuer (AFSC). Discussion themes included the habitat needs for stock assessment, current work incorporating habitat information in stock assessment, and what is feasible to be done in the short-to-medium term given current budget constraints.

Following the group discussion panel, participants were split into breakout groups to continue discussions on a smaller scale. The four breakouts grouped participants based on species/habitat expertise: 1) groundfish; 2) reef and untrawlable; 3) highly migratory and coastal pelagic species; and 4) estuarine and diadromous. Breakout groups were tasked with discussing habitat science priority needs (with respect to stock assessment), challenges, and opportunities for moving forward based on the presentations and dialogue during the first half of the session. Specifically, groups were given the following trigger questions to address:

1. Are there specific life-history traits associated with stocks where a habitat-incorporated approach is likely to improve estimates/reduce uncertainty? How and where would this information be incorporated? Two options are:
   a. Improving the design and interpretation of fishery-independent surveys to include catchability coefficients.
   b. Providing vital rates, stock-recruit functions, nursery function, or information on spatial and temporal scales of animal movements, to inform stock assessment models.
2. Are there stocks for which a traditional stock assessment approach is more appropriate?
3. What are the biggest challenges you face in terms of obtaining the habitat data you need and using habitat data in stock assessments? What are some solutions to the challenges identified?

4. Do opportunities exist for habitat-related collaboration or project development to improve stock assessment?

After breakout discussions, groups reassembled and each gave a short report on their discussions and overall conclusions. The session concluded with a short group discussion following the breakout group reports. In addition to registered NHAW participants, stock assessment scientists local to the Seattle area (i.e. NWFSC and AFSC) were invited to participate in this session. Summaries from each of the breakout groups can be found on pages 24-37.

Discussion of Habitat and Stock Assessment

One of the main topics of discussion during this session was where and how habitat information can be used in the stock assessment process. Although basic stock assessment data 'needs' and 'wants' do not include ecosystem data for many stocks, this does not mean that habitat studies provide no utility to the stock assessment process. In fact, there were many places where habitat information can and already is being utilized to improve stock assessments.

"Use" in stock assessments has not been well defined, although environmental information is incorporated into assessments in a number of ways already. In some places, good oceanographic time series are available and have been investigated for application to assessments. However, the assessment community needs to think in terms of moving away from environmental time series towards more comprehensive data sets. The next challenges will be developing new methods for incorporating a wider spectrum of ecosystem information into stock assessment models. Although there is some current modeling capacity, many models will need to be upgraded or replaced in order to take advantage of improved ecosystem data as it becomes available. Additional biological studies are also needed to improve understanding of how habitat factors affect marine populations.

This path requires buy-in from managers on new methods as they are developed. Fisheries managers are accustomed to traditional assessment methods, so good communication is critical to improve understanding and acceptance in the management process.

Improving Survey Precision and Calibration

An important area where improved habitat information can contribute to the stock assessment process is providing information useful for improving calibration of fishery-independent population surveys. A common misconception is that comprehensive habitat maps are necessary to improve surveys. Such comprehensive maps are not necessarily needed; bottom roughness estimates are useful, but basic information on the proportion of habitat types is an important first step. However, making use of habitat type information requires additional information on habitat-specific densities to ensure proper interpretation. Failure to account for density dependent habitat selection, when present, leads to biased abundance indices.

The needs for 'habitat type' information vary by species. Survey scientists have been using 'habitat type' thinking in survey design for decades by stratifying surveys by depth. However, most current surveys are multispecies and need to stay that way, so there is not much room to include habitat stratification (which will vary for each species in a survey). Post-stratification of surveys, using improved habitat information as covariates in the analysis of survey, accomplishes the same goals as restratifying surveys based on habitat. Model-based approaches to the incorporation of habitat information are more flexible than redesigning surveys, and can also be more powerful.

Collection of habitat data concurrently during existing abundance surveys is a good approach to improving availability of habitat information for stock assessment. This approach takes advantage of existing resources and gives stock assessment scientists greater input into the collection of data that is useful to assessment. Such data collection can be accomplished using a variety of traditional and advanced sampling technologies, including bottom sampling, ocean instrumentation, and cameras, depending on need.

Catchability and Selectivitiy

A key assumption of stock assessment is that the catch-per-unit-of-effort (CPUE) varies proportionally with stock size (i.e. catchability is constant). However, catchability may change (increase or decrease) over time due to habitat/environmental conditions and density dependent population effects. Bottom trawls and other commonly used survey techniques are likely to be biased by spatially varied catchability resulting from density dependent habitat selection and a spatial redistribution of abundance. A number of methods are used to adjust catch rates to ensure that survey CPUE is proportional to biomass despite changes in catchability, but such techniques may be hindered by factors associated with habitat degradation or loss (including climate change). Studies of density dependence are more valuable in a habitat context, and additional studies focusing on catchability are needed to enable assessment scientists to separate catchability from habitat-specific effects. It is possible to build density dependent catchability into assessment models. For example, several stocks of flatfish in Alaska use environmental catchability modeling to account for changes in fish behavior and distribution (and thus survey availability) related to water temperature.

Selectivity, or the ability to target and capture fish based on size (age), behavior, and distribution, provides technical challenges to field surveys and stock assessment. If not properly accounted for, selectivity can be a potential source of bias or error in stock assessment. Accurate estimates of biomass (as well as fishing mortality and population size structure) require scientists to be able to specify how vulnerable fish are to capture by a particular gear at a particular age. Habitat affects selectivity through changes to fish behavior and distribution. For example, the vertical habitat use (and availability to fishing gear) of Atlantic blue marlin has changed over time in response to growing oxygen minimum zones and compression of pelagic habitat. Habitat-fish distribution studies can inform assessment models about the degree of selectivity.

Early Life History

Information on early life histories is largely lacking for many marine species. Although fishery and survey data is often adequate to measure annual recruitment fluctuations, better information on early life history stages and the recruitment process would allow scientists to both understand patterns and predict fluctuations. Initiating dedicated surveys or collecting comprehensive data on early life history stages may be cost-prohibitive in many situations, but there are several intermediate steps where habitat-specific information could be useful. Determining the environmental parameters that are correlated with recruitment is not a perfect approach, but cheaper and easier. Habitat-specific investigations to determine the life stage(s) most affected by density dependence and sensitivity to environmental fluctuations are also important. Such information on life history bottlenecks and the timing of mortality events relative to density dependent compensation is a critical next step. Because long-term trends in recruitment are easily confounded by other assessment aspects, habitat-specific information on probable trends in natural mortality and carrying capacity are needed.

Breakout Group 1: Incorporating Habitat Information in Stock Assessments with a Focus on Groundfish

Reporter: Matthew Eagleton (AKRO)
Facilitator: Terra Lederhouse (OHC)
Rapporteur: Jarad Makaiau (PIRO)

Top Conclusions and Recommended Next Steps:

- NOAA should incorporate information on juvenile and adult vital rates, habitat associations, and habitat-dependent densities into groundfish stock assessments. NOAA should also develop assessment methods that better account for juvenile life stages.
- NOAA should improve survey indices for groundfish species that are generally undersampled by existing survey methods due to their association with untrawlable habitats.
- In the long term, NOAA should develop precise assessment surveys across the full range of habitats occupied by a species.
- To improve the collection and sharing of habitat data, NOAA should better leverage resources within NOAA and across organizations.
- NOAA should announce ship deployment schedules earlier to improve planning and increase opportunistic sampling.
- NOAA should continue to implement the recommendations from the HAIP.

In this session, each breakout group was asked to answer a number of questions on how habitat information can contribute to improving stock assessments by reducing uncertainty in assessment data inputs or assessment model projections. The goal for this breakout group was to identify life history characteristics associated with groundfish stocks that could benefit from incorporating habitat information into the stock assessment process, high priority habitat science needs in relation to groundfish stock assessments, and opportunities for collaboration between the habitat and groundfish stock assessment communities.

The group discussed specific life-history traits associated with groundfish stocks where a habitat-incorporated approach is likely to improve estimates and reduce uncertainties. The group agreed that for juvenile and adult age classes, information on vital rates (e.g. natural mortality and growth), habitat associations with easily measured elements (e.g. abundance by sediment types), and habitat-dependent densities would be necessary for stock assessment scientists to effectively incorporate habitat information into groundfish stock assessments.

The group identified high priority science needs that would improve stock assessment approaches for groundfish and reduce uncertainty. Species that are distributed within habitat types that are difficult to survey (e.g. rocky reefs) are often under-sampled by traditional survey methods. In the short term, NOAA Fisheries could improve survey indices for these species (e.g. maps of trawlable vs. un-trawlable areas for assessment surveys). In the long term, NOAA Fisheries will need to develop precise assessment surveys across the full range of habitats occupied by a species. Another important step towards improving stock assessments and reducing uncertainty is improved representation of juvenile life stages in stock assessment models. This will require 1) increased data collection efforts and improved survey methodologies to better measure information for early life history stages; and 2) development of assessment modeling methodologies to incorporate improved juvenile stock data.

Stock assessment scientists identified a number of challenges to obtaining necessary habitat data. The cost of conducting habitat research and collecting relevant data is often prohibitive. Some solutions proposed by the group included better leveraging of resources within NOAA and across organizations. For example, NOAA could find opportunities to partner with other federal or state agencies and with other industries, making better use of data collected by other organizations and looking for opportunities to collect data collaboratively (i.e. platforms of opportunity). NOAA Fisheries scientists could also make better use of existing surveys and ship time by collecting habitat data concurrently, especially through use of advanced sampling technologies (e.g. acoustic and optical self-automated sensing technologies). Current impediments towards full utilization of ship time are the challenges associated with survey planning – scientists are often notified of ship deployment schedules with insufficient time to plan for surveys. Earlier notification of ship deployment schedules will lead to improved survey planning, allowing habitat and stock assessment scientists to take full advantage of the sampling opportunities afforded by each cruise.

Another challenge the group identified is data accessibility. NOAA Fisheries has a backlog of collected data that has not been analyzed or processed due to lack of staff resources. Once analyzed and processed, habitat data also needs to be made accessible in a format that is usable to stock assessment scientists. The breakout group proposed that NOAA should partner more with academic institutions and other scientific organizations that can provide data analysis, processing, and management for NOAA. Additionally, NOAA Fisheries scientists often have difficulty accessing existing federal datasets that could contribute to improved stock assessments. NOAA Fisheries habitat managers could request this data during habitat consultations so it can be incorporated into stock assessments and be used to improve monitoring of federal projects.

Breakout Group 2: Incorporating Habitat Information in Stock Assessments with a Focus on Reef Fish and Untrawlable Habitats

Reporter: David Stevenson (NERO)
Facilitator: Tali Vardi (S&T)
Rapporteur: Kimberly Clements (SERO)

Top Conclusions and Recommended Next Steps:

- Incorporation of habitat information into fishery-independent survey-generated measures of abundance would improve their accuracy, particularly for species that utilize rocky and coral reef habitats.
- Survey-generated abundance indices could be improved, for example, by (1) pre-or post-stratifying surveys to account for habitat variability and (2) including habitat variables when standardizing survey data (e.g., CPUE estimates).
- In order to properly translate index data from habitat-specific surveys, catchability and selectivity of target species in different habitats and sampling gears need to be better understood. For species that inhabit reefs and other untrawlable habitats, non-trawl survey gears such as traps, longlines, and video cameras are required.
- Large-scale stock assessments of species that occupy untrawlable habitats could be improved by incorporating habitat-specific variables in assessment models. These would include habitat-specific vital rates (e.g., growth and survival), recruitment, selectivity, and catch composition.
- As a first step in evaluating the effects of habitat variability on survey catch rates and size/age composition, existing trawl survey data from a specific region should be analyzed using post-stratification methods.
- A possible second step would be a pilot study with paired gears within an existing survey protocol to determine gear catchability and test for correlations between catch rates and habitat features. A long term solution is to design new surveys using sampling equipment that is suited for use in complex habitats.

This breakout group focused on how habitat information can contribute to improving fishery-independent surveys and stock assessments by reducing uncertainty in assessment data inputs or assessment model projections. Specific habitat science priority needs, challenges, and opportunities were identified for reef fishes and fishes inhabiting other untrawlable areas. Discussion focused on the bolded trigger questions below.

What type of habitat information could be incorporated into stock assessments of reef fish populations (or demersal continental shelf stocks that inhabit untrawlable habitats) to improve results and reduce uncertainty? How and where would this information be incorporated? Is the required information specific to certain life history stages? Two options are:

a. Improving the design and interpretation of fishery-independent surveys to include catchability coefficients.
b. Providing vital rates, stock-recruit functions, nursery function, or information on spatial and temporal scales

of animal movements, to inform stock assessment models.

For shallow-water (<30 meters) reef environments (e.g., Pacific islands), there is good fishery-independent data derived from diver surveys – visual counts, size estimates, and related habitat data. Deep-water reefs are more difficult to survey, but some progress has been made. In the Southeast and Southwest regions, the Caribbean, and Gulf of Mexico a variety of other survey methods are used, including fish traps, longlines, and remotely operated vehicles (ROVs). These survey techniques have been designed to specifically account for distinguishing characteristics of reefs and reef fish species (e.g., segregation in habitat use by life history stage, strong affinities for structure, highly variable size and species composition between reefs). However, lack of infrastructure and/or inability to conduct such sampling sometimes prevents the use of these methodologies. In such cases, modeling can be a reasonable alternative.

The group listed the parameters that are typically required in a "traditional" age or size-structured assessment model and identified which ones are more likely to be affected by the unique nature of habitats utilized by reef fishes (i.e., when more traditional stock assessment models are applied to reef fish populations, which parameters are most directly related to productivity and most likely to affect model output and performance?). The list included:

- catch data (by age or size),
- survey data,
- biological data: size at age, maturity, sex composition,
- natural mortality rate,
- gear selectivity, and
- stock-recruit relationships.

Reef habitats are most likely to enhance growth, survival, and reproductive success by providing shelter and food for resident fish and invertebrate populations and feeding opportunities for non-resident species. For species that utilize reef habitats at a particular life history stage or during a particular season, failure to account for the contribution of reef habitats, or discrete patches of hard-bottom habitat in continental shelf ecosystems, to stock productivity can easily lead to underestimates of stock size and optimum harvest rates, and a false understanding of population dynamics.

In summary, for these two discussion questions, the working group reached the following conclusions:

1. Habitat data could be used to stratify fishery-independent survey effort (e.g., by allocating effort, proportionally or according to habitat-specific variances in abundance), or to post-stratify survey data.
2. Habitat data could be used to standardize survey-generated measures of abundance (e.g., CPUE estimates).
3. Habitat-specific vital rates could be incorporated into assessment models, although habitat-specific information on vital rates is typically not well-known.
4. Stock assessment models capable of incorporating spatially explicit variances in species-specific abundances and vital rates are needed.

Are there stocks for which a traditional stock assessment approach is more appropriate?

More traditional stock assessment approaches may be more appropriate for temperate continental shelf species that inhabit structured habitats at some life history stage or time of year but otherwise occur in trawlable habitats. For example, black sea bass (*Centropristis striata*) in the mid-Atlantic and southeast Atlantic congregate over low-profile reefs in the summer and fall and move to the outer continental shelf in the winter. Use of more traditional stock assessment methods can work as long as vital rates (growth, survival, etc.) are estimated without bias and account for the ecological role of reefs in enhancing stock productivity.

What are the biggest challenges to obtaining habitat data and using habitat data in stock assessments? What are some solutions to the challenges identified?

Methods for assessing reef fish populations are very different from traditional methods/models that rely on large scale (e.g, bottom trawl) surveys. Reefs are often discrete, complex habitats in close proximity, yet they can have very different fish communities (sizes, species) because of strong affinities of reef fishes to highly variable, structured habitats. Reef fishes segregate by life history stage much more so than fishes in continental shelf environments. Vital population rates and life history traits vary from reef to reef. Visual surveys are labor-intensive and subject to bias in counts, species identifications, and size estimates. Catch rates in gears like traps have to be standardized for effort (soak time). Additionally, catch rates have to be related to effective fishing area for extrapolation to population size estimates. Assessment of reef fish populations probably requires a meta-population approach.

Continental shelf species that inhabit untrawlable bottom are not well sampled using traditional trawl survey methods. Collection of habitat data and modification of existing survey methods and data analyses could improve assessments. In this context, there was some discussion of gear selectivity and catchability and their effects on survey design and results. For bottom trawl surveys on the continental shelf, demersal fishes are harder to catch in structured benthic habitats. Other gear types (hook and line, longlines, traps) or survey methods (acoustics, photos) may need to be used. Assessments that rely on bottom trawl surveys could be improved by collecting habitat data (e.g., acoustic backscatter data) and relating catch data to habitat types in a post-stratification data analysis. Reliable estimates of catchability in trawlable and untrawlable habitats, and the amount of trawlable versus untrawlable area, would also be required.

Do opportunities exist for habitat-related collaboration or project development to improve stock assessment?

Several approaches were recommended for continental shelf species that inhabit untrawlable bottom at some point during their life history or during particular times of year (or all the time). The short term (1 to 2 years), and least costly solution, would be to add habitat covariates into a General Linear Model analysis of trawl survey data to identify correlations between catches and habitat types. This could be done with previously collected data in a post-stratification analysis. A mid-term solution (~5 years) would be to design and conduct a pilot study using paired gears to determine gear catchability within an existing survey protocol. Correlations between catch rates and habitat features also should be analyzed. A long term solution (10 years) would be to design new surveys using equipment that is better suited to sample complex habitats and multiple life stages. Surveys that are more habitat-focused could be stratified by habitat type (rather than just depth) and employ habitat-specific gears and data collection methods (e.g, acoustics).

Breakout Group 3: Incorporating Habitat Information in Stock Assessments with a Focus on Highly Migratory Species and Coastal Pelagic Species

Reporters: John Manderson (NEFSC), Eric Prince (SEFSC), and John Quinlan (SEFSC)
Facilitator: Kirsten Larsen (S&T)
Rapporteur: Lora Clarke (S&T)

Top Conclusions and Recommended Next Steps:

- Formalize the process of habitat assessment (Ecosystem Assessment Divisions) as an explicit part of the stock assessment process. This should be done at the Science Center level. Most importantly, the process should include assembling the necessary scientific expertise, (including Fisheries Science, Oceanography, and stock assessment modeling) necessary to address ocean scale Ecosystem level processes.
- Identify where and when limiting conditions occur in the habitats of these organisms and focus science there to identify import processes, opportunities to refine surveys, as well as methods for incorporation of impacts into the stock assessment process.
- Bring the full capabilities of IOOS, remote sensing, modeling, and Climate Change resources to bear on the problems of identifying important habitat and the dynamic use of that habitat for these species. The focus should be on how this information will be used in – or would be used to modify – the existing stock assessment approaches (which ranges from survey design to the provision of management advice).

Participants discussed how habitat information can contribute to improving fisheries stock assessments by reducing uncertainty in assessment data inputs or assessment model projections. Habitat science priorities, challenges, and opportunities moving forward specific to highly migratory species (HMS) and coastal pelagic species (CPS) were addressed. [Additional background, intro needed?]. Discussion focused on the bolded trigger questions below.

Are there specific life-history traits associated with stocks where a habitat-incorporated approach is likely to improve estimates/reduce uncertainty? How and where would this information be incorporated? Two options are:

a. **Improving the design and interpretation of fishery-independent surveys to include catchability coefficients.**

b. **Providing vital rates, stock-recruit functions, nursery function, or information on spatial and temporal scales of animal movements, to inform stock assessment models.**

Differences in life history strategies seem to require quite different considerations for habitat requirements of HMS (i.e., tunas, marlins) and CMS (i.e., squids, anchovies, sardines, mackerels). Many HMS are integrating environmental conditions on the scales of oceanic basins. Their mobility and observed foraging strategies (i.e., feeding on organisms from in the deep scattering layer to cannibalism and traveling to visit widely separated seamounts in a serial manner) suggest that HMS species can decouple their dynamics – to some degree – from purely local or even continental shelf scale habitat processes. On the contrary, CPS, while also exhibiting substantial movement patterns and in cases broad dietary niches, appears to be integrating processes on the scale of a large marine ecosystem (i.e., the continental shelf of a region). For these reasons and others, generalization across these groups could be problematic.

In many cases, including for some high profile species such as bluefin tuna, fishery independent data are largely unavailable and CPUE metrics from the fishery are used in assessment models. Catchability coefficients can indeed be modulated by environmental processes such as seasonal changes in water temperature that may result in range expansion and contraction. Catchability may also be modulated by long term directional changes in the environment such as expansion and shoaling of the Atlantic Oxygen Minimum Zone (OMZ) or warming such as that occurring in the Arctic. Such processes underscore the concept that habitat is dynamic for HMS and CPS and that these processes represent sources of uncertainty in assessments. At the extreme, such processes may result in fundamental shifts in basic relationships such as mortality, spawning success, stock-recruitment relationships, etc. However, these processes also represent opportunities to develop more effective surveys (based, for instance, on the concept of the timing of minimum habitat volumes) or to recast historical data (for instance, adjusting CPUE indices for a directional process such as that observed in the OMZ).

Another important consideration in the use of fishery-dependent data is fisher behavior as the environment changes or in response to regulations. If fisher behavior is changing (an example is the shift in the oceanic longline fleet in the Atlantic) assumed catchability may be incorrect, and the CPUE indices more uncertain or biased.

Because HMS (often top predators) and CPS (some of which are in the middle of the food web) are so ecologically important, additional information is clearly needed. For some species (particularly HMS) tagging efforts are providing pertinent information on how these animals are using the environment. For others, more limited information is available. Overall, several strategies were suggested to improve the collection of life history and habitat data for these organisms:

- Improve the understanding of how and when habitat is constrained for these animals and focus survey effort and vital rate science there. For example, spawning aggregations and winter habitat may be found in only limited areas. During these times, surveys may be particularly effective – and some NMFS surveys actually target these periods (spring larval bluefin tuna survey).
- Identify the locations and times when ecological processes are operating in a manner that may exert strong controls on the population. For instance, if winter habitat is constrained this may be a location where predator-prey interactions are amplified, or the time when animal condition critical. Metrics derived from such conditions may be exceptionally useful in not only adding a time series directly to the assessment process, but also in perhaps designing surveys to augment existing information streams.
- Develop a better understanding of how organism behavior effects survey gear performance. For instance, if there is a strong diel migration pattern that results in invulnerability to survey gear, then

there may a reduction in the effective number of 'replicate samples' in a given survey strata.

- Develop adaptive survey methodology that integrates information from fishers, integrated ocean observing systems, and numerical modeling which all provide information on the state of the ecosystem.
- Develop the ability to more synoptically survey the full range of the organisms at a particular time. This may not be entirely possible with HMS, but could be possible with CPS. It may also require an approach that varies from that of surveying a large marine ecosystem region with a single white boat over several weeks to months. New technologies such a mid-frequency acoustics, aerial LIDAR, etc could be important sources of information. Sampling for 'cryptic' life stages in novel, but potentially likely, habitats may be fruitful. Targeted pilot scale projects aimed at developing such surveys would be beneficial.
- Develop the capacity to more rapidly collect vital rate information. Fisheries are still generally using techniques that have been deployed for many decades. New technologies such as RNA:DNA, mico- and nano-tomography and the like may result in more efficient collection of age, growth, reproduction, and condition metrics for more specimens than can be managed currently. A 'modernization' of technology in this area is required.

Are there stocks for which a traditional stock assessment approach is more appropriate?

There appears to be several stocks for which traditional approaches work (i.e., herring). In other cases, base line fishery independent data are limited and relatively simple assessment processes are the only available option. Generally, this condition was viewed as a status quo situation and should not at all be the end goal as more advanced modeling frameworks (SS3 and beyond) would arguably provide better information for management.

What are the biggest challenges you face in terms of obtaining the habitat data you need and using habitat data in stock assessments? What are some solutions to the challenges identified?

The main barriers seem to be related to support, access to appropriate information, and entry points into the assessment process for habitat scientists. There are in some labs, structural impediments in the form of separations between assessment, survey, and habitat scientists. Survey data are often difficult to access. Assessment scientists are time limited due to an unrelenting need for assessments. Surveys are inflexible and there is often limited or no time available for research and development. The assessment process itself has a limited number of ways that habitat data can be used. NOAA has habitat data collection occurring across a number of not very well connected places (e.g., NOS, NMFS, NWS, OAR, etc). Every Science Center should have something like an 'Ecosystem Assessment Division' that is a cross-center group which has as its core mission overcoming these barriers, developing better survey and analysis approaches as well as assessment models, and moving the agency toward an ecosystem approach to management. In some regions Integrated Ecosystem Assessments are in development. However, most of these efforts seem to be oriented toward developing ecosystem models (Atlantis, Ecosim/Ecopath) and are not fully engaged in an iterative process of that focuses on how basic information is collected, analyzed, updated, and made useful for the assessment process.

HMS and CPS present a number of challenges regarding defining habitat. For instance, these organisms often have very large ranges and are exceptionally mobile. They often occupy habitats that are ephemeral and difficult to sample, and they are often able to avoid traditional survey technologies. Basic data are often sparse/nonexistent for several life stages and early life stages are often very short (eg., blue marlin). Furthermore, the prey base for these species could be patchy in the pelagic environment.

The group also identified several barriers to using habitat data in stock assessments. There are limited opportunities to fully evaluate survey data in concert with available environmental data. This seems to be true across the board and possibly the result of a structural issue within NMFS owing to the real or perceived separations between habitat, assessment, and survey scientists. Additionally, there are limited opportunities to effectively move habitat information into the assessment process. Most contemporary assessment models simple do not avail themselves to sophisticated treatments of the environment.

Some potential solutions include:

- Revisiting the development of coupled bio-physical modeling (perhaps as seen in programs like South Atlantic Bight Recruitment Experiment (SABRE), Fisheries Oceanography Coordinated Investigations (FOCI), and Global Ocean Ecosystem Dynamics (GLOBEC) with the explicit charge of linking those approaches to IOOS programs (which were not in existence at the time) and transitioning to improved survey interpretation and design and improved assessments.
- Beginning an explicit program to develop ecosystem approaches:
    - HMS are at the top of the foodweb and CPS are often at the center, and could thereby serve as focal species for moving toward ecosystem assessments.
    - Habitat/environmental signals may be amplified in these species and they could therefore offer excellent indices into how the system is functioning (e.g., squid bycatch in the northeast is now very high, presumably due to a warm winter and low winter mortality – how might this signal cascade through the ecosystem?).
- Develop a program to construct 'next generation' assessment methods that are not necessarily constrained by existing methodology and approaches (e.g., Dr. Elizabeth North at the University of Maryland has a model that incorporates volume in the Chesapeake Bay).
- Develop program to include habitat as a dynamic variable in survey design and interpretation.

Do opportunities exist for habitat-related collaboration or project development to improve stock assessment?

There seems to be an improved understanding among habitat scientists regarding how habitat data can enter the assessment process. OMZ consideration in assessment of HMS species is a potential case study in how this can be achieved. Recent projects funded by S&T are additional examples of how research is attempting to achieve the goal of improving the assessment process via more advanced considerations of habitat. Additionally, the type and quality of habitat information available is dramatically improved when contrasted with previous decades and this presents tremendous opportunity to advance. For HMS and CPS, advances in satellite and IOOS capabilities, as well as methods for handling and interpreting data from these sources are very promising. But greater integration and availability of these data for assessment scientists needs to occur.

However, habitat science seems to be a lower priority than is traditional stock assessment. This is exemplified by the fact that habitat assessment prioritization was recently built from an assumption that it would be driven by the assessment of individual fish stocks, rather than from the perspective of the importance of particular habitat components to the overall ecosystem. Perhaps one of the most effective mechanisms for moving forward would be for the Agency to set up an initiative to facilitate advancements in the habitat/assessment arena with consistently funded programs in each Center. Each of these programs would be responsible for advancing the area locally, but would be attached to a national group that shares information sources, approaches, infrastructure, etc.

Breakout Group 4: Incorporating Habitat Information in Stock Assessments with a Focus on Estuarine and Diadromous Fish

Reporter: Tom Minello (SEFSC)
Facilitator: Steve Brown (S&T)
Rapporteur: Janine Harris (OHC)

Top Conclusions and Recommended Next Steps:

- Life tables are needed for fishery species with more information about vital rates and relationships between these rates and estuarine habitats.
- Estuarine habitats are susceptible to modifications from human impacts including climate change; protecting and restoring these habitats will require partnerships within NOAA and among federal, state, and local agencies that influence land use patterns.
- Density dependence and carrying capacity are important concepts that affect the role of habitats in population dynamics.

This breakout group focused on how habitat information can contribute to improving fisheries stock assessments by reducing uncertainty in assessment data inputs or assessment model projections. Specific habitat science priority needs, challenges, and opportunities were identified for estuarine and diadromous habitats. The discussion focused on the trigger questions bolded below.

Are there specific life-history traits associated with stocks where a habitat-incorporated approach is likely to improve estimates/reduce uncertainty? How and where would this information be incorporated?

Stock assessments for fishery species that depend upon estuarine and coastal freshwater habitats are likely candidates for the inclusion of habitat characteristics because estuarine and coastal habitats generally support juveniles of these species where growth and mortality rates are often high. In addition, variability in habitat characteristics is generally high in coastal areas compared with more stable marine environments, and much of this variability can be attributed to anthropogenic impacts because of concentrated human populations and development. Fishery species of particular interest in estuarine and coastal freshwater habitats include salmon, penaeid shrimps, striped bass, shad/herring, anchovies, sturgeon, menhaden, summer flounder, starry flounder, red drum, English sole, and American eels, and these species often use many different habitat types. Habitat characteristics that have been shown to affect growth and mortality include temperature, salinity, turbidity, dissolved oxygen, the presence of structure (e.g., vegetation, biogenic reefs), and tidal dynamics, and these characteristics are highly variable in the coastal zone in both space and time. Habitats and environmental conditions also can affect larval recruitment to estuaries and the ability of adults to reach spawning sites (e.g., salmon).

A first step in determining the role of habitats in population regulation is to develop a life table that summarizes the information available for different life stages. These tables require estimates of stage durations and of the variability in vital rates (i.e., growth, mortality, and reproduction) for different life stages. In general, rates of mortality (and often growth) are highest in early life history stages, and these stages often use habitats in coastal areas. Opportunities for habitat-related changes in these vital rates are likely in the coastal zone as well, and we need measurements of these potential changes. These measurements should take into account characteristics of the water column (e.g. water quality as habitat) as well as benthic structure and habitat complexity. The application of shallow water acoustic characterization, fish sampling, IOOS integrated coastal observations, ecological modeling (such as Atlantis and Ecopath with Ecosim), and CMECS standards are critical tools that should be applied.

Habitats in estuaries and coastal areas are subject to many anthropogenic changes that have potential effects on fishery species. Effects of climate change (e.g., sea level rise, changing freshwater runoff, changes in storm frequency and intensity) also may be more pronounced in estuarine and coastal habitats. The large and continuing movement of human populations to the coast puts increasing pressure on these fishery habitats. It is critical for NOAA to work in close partnership with state and local agencies engaged in land use planning, as well as other federal agencies and nongovernmental organizations to improve management practices that benefit estuarine dependent fish species, to help prevent habitat loss, and to promote habitat restoration. Incorporating habitat information into stock assessments will greatly assist in documenting and monetizing their fishery contribution and will promote efforts to protect and restore habitats. In addition, this work can be done at much less cost than similar ecosystem based studies requiring expensive ship time, which is already in high demand.

Density dependence is an issue that needs to be addressed in examining the role of habitats on fishery production. Habitat-related changes in natural mortality may have relatively little impact on the productivity of a fishery species if remaining individuals in a population benefit from the loss of others in the population. Such an effect from density dependence can occur at different life stages and should be considered in analyses of habitat effects. Similarly, the carrying capacity of the coastal environment is an important consideration.

Parent stock versus recruit relationships provide information about the potential utility of using habitat and environmental information to improve a stock assessment. If there is a tight stock-recruit relationship, the inclusion of habitat related information into the stock assessment may not be necessary. When there is a poor relationship between the parent stock and the number of recruits to the fishery (see Figure 1 for brown shrimp in the Gulf of Mexico), variability can be due to 1) poor estimates of the parent stock or number of recruits or to 2) the influence of environmental and habitat effects on early life history stages (i.e., the stages between spawning and recruitment to the fishery). Improved habitat information can be used to assess gear efficiency, often responsible for errors in estimating standing stocks. Shrimp for example can burrow in the substrate and avoid capture in trawls, the typical sampling gear for these species. Many environmental and habitat variables have been shown to affect burrowing in shrimp, and these habitat variables also can affect estimates of stock abundance. Habitat related information on growth and mortality in early life history stages can provide insights into potential effects on this stock-recruit relationship.

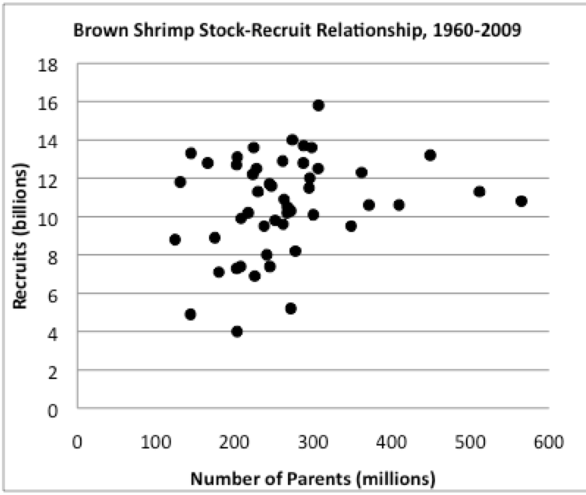

Figure 1. Stock-Recruit relationship for brown shrimp in the Gulf of Mexico (Nance, 2010).

What are the biggest challenges you face in terms of obtaining the habitat data you need and using habitat data in stock assessments? What are some solutions to the challenges identified?

Many challenges exist. Obtaining habitat data needed for stock assessments requires an understanding of the many habitat types used by juvenile fishery species. The same information needed to assess EFH is required to understand how these habitats affect fishery production, and how this information can be used in a stock assessment.

We need to be able to measure densities in different habitats, where structure often interferes with gear efficiency. We need to measure habitat-related growth and mortality, and combine these data in models to estimate the contribution of habitats to fishery production. Indicators related to this production need to be developed, and time-series of these indicators established in an appropriate format for use in stock assessments. Habitats also can affect managed stocks through their impact on forage species. Diet information is needed to assess the role of forage species in coastal ecosystems. More trophic models are needed to understand how predator-prey interactions can be incorporated into stock assessments.

RETHINKING ESSENTIAL FISH HABITAT

Session Organizers: Michael Parke (PIFSC) and Waldo Wakefield (NWFSC)

Top Conclusions and Recommended Next Steps:

- NMFS scientists and managers should prioritize habitat research based on habitat productivity and threats to habitat health and functionality, but more basic habitat science research needs to be conducted to ensure competent decisions can be made.
- EFH designations and HAPC designations in particular, should incorporate data that specifically addresses the conditions critical to early life history stages, with a special focus on productive habitats that are most at risk from anthropogenic or climate-induced degradation.
- Better mechanistic models should be developed to forecast responses under novel and/or rapidly-changing habitat conditions.
- Non-fishing impacts to EFH are becoming more prevalent. Proven conservation measures that address common threats to EFH from a variety of ocean and coastal developments should be identified and implemented through cooperative regional efforts.
- Research should be conducted to enable EFH designations to include complex, guild, or life-stage specific designations.
- Support from leadership at the regional and national levels is needed to make any of these a reality.

In this session, each region discussed the opportunities and challenges associated with designating EFH and using EFH designations to conduct meaningful consultations. Currently these designations are difficult to review/revise and not as helpful as they could be for NOAA to conduct consultations. As NMFS and the Fishery Management Councils develop and adopt Ecosystem Based Fisheries Management plans, as managers and scientists designate EFH in dynamic habitats under climate change, and as non-fishery impacts to habitats within EFH become more commonplace and extensive, scientists and managers need guidance to improve both the EFH reviews and the designations. The presentations summarized below highlighted EFH issues in broadly-defined marine habitats for each region.

Rethinking Essential Fish Habitat: Northeast Broad Continental Shelf
David K. Stevenson (NERO)

Ever since the first EFH maps for 38 federally-managed species in the Northeast region were generated, they have been based on level 2 relative abundance data (average numbers per tow) derived from 60 years of NEFSC spring and fall bottom trawl survey data binned into ten minute squares of latitude and longitude. More recent maps include state survey data and presence information for the continental slope, beyond the outer limit of the NEFSC surveys. Also, the catch data on the shelf are conditioned by preferred ranges of depth and average annual bottom temperature. In the Northeast, the Middle Atlantic and New England Fishery Management Councils have followed the advice provided in the EFH Final Rule and defined EFH in a risk-averse manner, i.e., over fairly broad geographic areas. Generally speaking, single species and life stage designations that are more habitat and area-specific are preferable for EFH consultation purposes, but in many cases (e.g., pelagic species) this is not practicable. Broader EFH designations that account for a wider range of temporal or spatial variability may be more "accurate", but less useful for consultation purposes than designations that focus on more normal or preferred ranges of depth, temperature, etc.

Climate change and changes in population size should be factored into future EFH designations in the Northeast region. The spatial distributions of 24 out of 36 New England and Mid-Atlantic stocks have shifted northwards or into deeper water in recent years in response to increasing seawater temperatures. Changes in distribution can easily be detected in the 60-year time series of bottom trawl survey data, so one obvious way to improve EFH designations in this region is to analyze a shorter and more recent time series of data rather than relying on the full 60 years of data. Including habitats or locations that have been used historically (e.g., at the southern limit of a species' range), as recommended in the EFH Final Rule, would no longer apply if this approach were taken. Analysis of relative abundance during periods of low and high population size in the trawl survey time series would reveal whether there are species that occupy more preferred habitats when they are less abundant. Accounting for these two factors when identifying and describing EFH may not be as easy as it sounds since climate change (a long-term trend in distribution) and population size changes (reversible, shorter-term "pulses" in distribution) overlap temporally and will differentially affect individual species and life stages. Habitat modeling that incorporates a broader range of habitat variables should also be evaluated as a means for improving future designations.

Rethinking EFH for Bering Sea groundfish – using periodic reviews and basin-scale modeling to refine and elevate the designations

Bob McConnaughey (AFSC) and Matt Eagleton (AKRO)

In 1996, Congress mandated NOAA Fisheries to describe and identify EFH for all federally managed species in the nation's Exclusive Economic Zone. By legal definition, EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Using the best scientific information, FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. These descriptions should explain the physical, biological, and chemical characteristics of EFH and must also identify the specific geographic location or extent of habitats described as EFH.

Designating EFH is particularly challenging in the Alaska region, since 70% of the U.S. continental shelf and more than 130 managed species occur there. Similar to other regions, useful environmental data are scarce. Currently, the EFH for a particular life stage of a managed species is defined as the area encompassing 95% of that Alaska population. This so-called general distribution is based on catch data from fishery-independent surveys and fishery observer reports where density data should reflect habitat utilization, and the degree to which a particular habitat is utilized is assumed to be indicative of habitat quality. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described. The Level-1 general distribution is used to describe EFH for all stock conditions whether or not higher levels of information exist, because the available higher level data are not sufficiently comprehensive to account for changes in stock distribution (and thus habitat use) over time. At present, Level-1 EFH descriptions are available for 45% of the 24 stocks x 5 life stages covered by the 2012 FMP for Groundfish of the Bering Sea – Aleutian Island Management Area. In many of these cases, there is considerable overlap in the geographic extents and the habitat descriptions for the species. Clearly, more refined designations would increase the significance of EFH in the resource conservation and management process.

In practice, there are a variety of methods that could be used to improve the EFH descriptions for the Alaska region. Some rely on purely geophysical characterizations but these are overly simplistic and may ignore significant factors such as temperature that affect species distributions. Similarly, standardized habitat-classification schemes are too restrictive in that they do not adequately account for the continuous nature of environmental variability or the associated continuous biological responses. In the eastern Bering Sea (EBS), abundance estimates from annual bottom trawl surveys are being combined with synoptic environmental data to develop basin-scale continuous-valued habitat models for groundfish and benthic invertebrates. The resulting Level-2 habitat definitions are objective and have quantifiable uncertainty. Predictions are possible and useful performance metrics can be developed when considering new environmental inputs. The models are developed with an iterative process that first assembles existing data to build 1st generation models. Promising new predictors are then evaluated in limited-scale pilot studies, followed by a direct comparison of alternative sampling tools. Finally, the most cost-effective tool is used to map the new variable over the shelf and the existing model for each species is updated to complete the iteration. As an example, the ongoing FISHPAC project is systematically investigating whether the existing habitat models for the full EBS continental shelf can be improved with quantitative information about seafloor characteristics.

In general, the Alaska region “rethinks” EFH on a continuing basis to ensure the highest level of scientific information is being used. This includes the incorporation of new analytical methods and a comprehensive review every five years (see the 2010 review at http://www.fakr.noaa.gov/habitat/efh/review.htm). Perhaps the single greatest challenge today is to develop a working definition of “essential” to identify the (necessary) habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem. To this end, close collaboration with stock assessment specialists would almost certainly be productive.

Rethinking Essential Fish Habitat (EFH) for Pacific Islands Coral Reefs
Robert Schroeder (PIRO)

In the US Pacific Islands Region, coral reef ecosystems provide over 15,000 km^2 of benthic habitat for several hundred federal management unit species listed in the Fishery Ecosystem Plans (FEPs) for American Samoa, the Mariana Archipelago (Guam and Commonwealth of the Northern Mariana Islands), the Hawaii Archipelago, and the Pacific Remote Island Areas (2010). The FEPs embody an ecosystem approach to management by including adaptive management that considers uncertainty. In addition to managing target taxa for sustainability, conservation of other ecosystem components, including EFH, is promoted.

Potential effects of climate change may impact coral reef habitat primarily through bleaching and ocean acidification, where resulting loss of structural complexity can reduce habitat essential to maintain reef fish abundance and diversity. Other concerns could be sea-level rise, shifts in major oceanic currents, and increased storms and wave energy, resulting in increased coastal erosion, and sedimentation and turbidity on reefs.

In the Pacific Region, consultations to avoid and minimize impacts to marine habitat impacts, consistent with a number of mandates (e.g., Magnuson-Stevens Fishery Conservation and Management Act, Fish and Wildlife Conservation Act, Clean Water Act), focus primarily on non-fishing impacts. These include cumulative effects of coastal development (e.g., Guam military build-up), and increasing offshore development (e.g., ocean-based energy [ocean thermal energy conversion, wind], and offshore aquaculture ventures).

EFH in the Pacific is defined broadly mainly by depth contours, which is not always most useful for consultations on impacts of federal agency actions. More detailed data are needed to inform EFH consultations from studies such as those that: 1) characterize the habitat/resources at local specific sites (vs. general status/trends at the island level), 2) determine the functionality of habitats (e.g. value of soft sediment, movement of eggs/larvae in water column), 3) characterize habitat response to the various impacts (e.g. impacts to eggs/larvae, corals, algae from discharge of cold/nutrient rich water shallow, impact to corals from turbidity/sedimentation, changing coral growth rates), and 4) better understanding the finer scale habitat utilization patterns, including determining spawning and nursery habitats of key coral reef ecosystem species.

Current progress to resolve such data gaps, while limited, includes: the Guam Habitat Blueprint, which intends to provide a review of the science and needs evaluation, analysis of fish-habitat links, development of an Atlantis Ecosystem Model (based on ecosystem and trophic structures), and improving the accuracy and defensibility of EFH consultations. Other efforts include studies of multi-ecosystem parameters of the reef to improve understanding of reef resilience related to climate change in Saipan, Commonwealth of the Northern Marianas.

Southeast United States and Caribbean Coral Reefs

Todd Kellison (SEFSC) and Jocelyn Karazsia (SERO)

The NMFS Southeast Region is entrusted with the conservation, management, and protection of marine fishery resources inhabiting federal waters off the southeastern United States from North Carolina through Texas and the U.S. Caribbean. The Region works directly with three Fishery Management Councils (Gulf of Mexico, South Atlantic, and Caribbean) to implement Fishery Management Plans for Corals and Coral Reefs, as well as numerous fish species that utilize coral reef habitats. The NMFS Southeast Fishery Science Center (SEFSC) performs surveys and multi-disciplinary research to support these efforts, including (1) acoustic mapping to determine the distribution of habitat types and (2) assessment of relationships between fish and invertebrate distributions and habitat characteristics. Both the Region and the SEFSC have responsibilities for understanding and addressing non-fishing impacts to coral reef ecosystems in the South Atlantic and Caribbean as well. Through gaining a better understanding of the distribution and types of coral reef habitats, the support functions these habitats provide to federally managed fisheries and connected habitats, and the threats they face, refinements can be made in designations for EFH and HAPCs.

Refining EFH for Species of the California Current Ecosystem in a Dynamic Landscape

Eric Chavez (SWRO) and Waldo Wakefield (NWFSC)

EFH has been designated for fishes that are managed under four FMPS in the California Current Ecosystem (CCE). These FMPs include Pacific Coast Salmon (Chinook, coho, and pink salmon), Pacific Coast Groundfish (over 90 flatfishes, rockfishes, and other groundfishes), Coastal Pelagic Species (Pacific sardine, Pacific mackerel, northern anchovy, jack mackerel, market squid, and krill), and Highly Migratory Species (sharks, tunas, billfish, and dorado). Designating and refining EFH effectively for these species can be challenging due to a variety of factors, including associations with dynamic habitat features (e.g., temperature regimes), habitat requirements in both fresh and marine waters, limited data for one or more life history stages, uncertainty regarding effects of environmental factors on productivity and the ability to anticipate those effects, and complex trophic interactions, such as predator-prey relationships among species managed under different FMPs. In addition, the ability to identify, and protect EFH from, anthropogenic threats is becoming increasingly important amid a growing human population, increased interest in marine hydrokinetic energy development, and climate change. Climate change is a particularly challenging threat given its potential for causing drastic changes in the CCE and our inability to predict what those changes may be. Ecosystem based management (EBM) could prove to be an effective tool for addressing these varied issues. The Pacific Fishery Management Council recognizes the importance of EBM and is developing a fishery ecosystem plan. However, this process is still in its early stages, and many of the details on how the plan will be implemented and incorporate EFH still need further development.

West Coast Ecosystem Based Fishery Management and Essential Fish Habitat Strategies

Yvonne deReynier (NWRO)

Since 2009, the Pacific Fishery Management Council (Council) has been engaged in parallel science and policy processes to develop an FEP and to conduct required 5-year reviews of EFH designations. The Council anticipates sending out a public review draft FEP in early 2013, and is tentatively scheduled to adopt a final FEP in March 2013. In 2015 and beyond, the FEP could spur a more coordinated look at EFH across the Council's fishery management plans. A coordinated, cross-species EFH review depends largely on whether NOAA can approach the science and policy preparations needed for EFH reviews as an ongoing dialogue, rather than as discreet events separated by 5 year increments.

NOAA has been developing science in support of ecosystem-based management through looking at ecological relationships that marine and estuarine species have with each other and with the biophysical environment. Applying the ecosystem approach to our habitat science and management would force us to think more about not just the particular habitat needs of our managed species, but also about how the habitat needs of all of our species interact with each other. At its simplest, ecosystem-based management is just a different way of thinking about the work that we are already doing. It requires not only new approaches to science and management, but also changes in agency culture. It requires, at all levels of the agency, that we listen to each other, to our colleagues in other agencies, and to the public, and that we think about how the connections between our work reflect the ecological connections between the resources we manage. Improving communication and understanding within and beyond NOAA can ultimately help us to support our forward-thinking Fishery Management Councils in all of their work, including their EFH efforts.

Breakout Groups

After the presentations, participants broke out into smaller groups to further discuss specific EFH needs, challenges, and opportunities moving forward. Each group focused on one of four scenarios: ecosystem-based fisheries management (EBFM), habitat and stock size variability, variability due to climate change, and non-fishing impacts. Managers need guidelines on how to incorporate the growing list of variables and impacts into EFH designations, and how EFH reviews can be incorporated into an EBFM framework. Though the effects of fishing on EFH have been considered extensively, natural variability and non-fishing impacts (e.g. offshore development, aquaculture, cumulative shoreline development) have not. This session was designed to identify the steps necessary to improve the accuracy of EFH designation in light of these challenges.

Breakout Group 1: Rethinking Essential Fish Habitat with a Focus on Ecosystem-Based Fishery Management

Reporter: Pace Wilber (SERO)
Facilitator: Steve Brown (S&T)
Rapporteur: Terra Lederhouse (OHC)

Top Conclusions and Recommended Next Steps:

- Engage scientists from NMFS Science and Technology, Office of Habitat Conservation (e.g., NOAA Chesapeake Bay Office), NOAA science centers, and fishery management councils for guidance on where habitat management can impact stock status
- Efforts to examine the ecology of early life stages of fishes should match the efforts spent on adult fishes and begin by committing resources to understand the habitat requirements and ecology of the life history stages of fishes that create "bottlenecks" to the productivity of managed fish species
- Develop EFH designations that focus more on habitat conditions that are truly essential to species productivity, especially larval and early juvenile life stages that utilize inshore habitats that are most at risk from environmental loss and degradation
- Investigate opportunities for including risk management approaches in EFH designations and habitat management decisions
- Develop protocols for determining the habitats most vulnerable to specific threats on a local basis
- Increase communication between biologists and hydrographers to determine how technologies such as airborne LIDAR and multibeam sonar can be used to increase knowledge of shallow water habitats and how multibeam echo sounders (e.g., ME70) can increase knowledge of coastal habitats.

Current statutes address the protection and conservation of EFH. While the 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) is most closely identified with protection and conservation of EFH, protection of habitats that are EFH is addressed by the Federal Power Act (1920), Fish and Wildlife Coordination Act (1934), Clean Water Act (1972), Endangered Species Act (1973), Executive Order 11990 - Wetland Protection (1977), Executive Order 13089 - Coral Reef Protection (1998), and Coral Reef Conservation Act (2000), among others. So why is the amount of habitat used by fishery species still being lost (Stedman and Dahl 2008, Dahl 2011)? Workshop participants agree that broad EFH designations hamper the protection and conservation of EFH. They also agree that geographically focused EFH designations based on strong scientific principles will garner the support necessary to reverse the loss of habitats essential to supporting fisheries and providing other ecosystem services necessary to sustain resilient and thriving marine and coastal resources, communities, and economies. Current EFH regulations set the stage for a geographically focused, scientifically justified EFH program. The regulations identify four levels of

EFH information: distribution data; habitat-related densities; growth, reproduction, and survival rates within habitats; and production rates by habitat (50 CFR 600.815(a)(iii)(A)) and require EFH designations at the highest information level supported by the available scientific information (50 CFR 600.815(a)(iii)(B)). In other words, EFH designations would ideally focus upon locations where production is high and fishes experience superior rates of growth, survival, and reproduction, and reviews of impacts to EFH from proposed projects would focus upon actions that diminish these rates.

The report from this breakout group uses two questions to summarize the discussions:

- How can EFH designations and reviews of proposed impacts to EFH be improved?
- What research is needed to improve EFH reviews and designations?

These discussions included identification of reasonable next steps, which was the third item the group was asked to address. While other breakout groups from the *Rethinking Essential Fish Habitat* session also focused on these questions, our group was tasked with examining these questions from the perspective of ecosystem-based fishery management (EBFM). Our breakout group did not begin by defining EBFM, but basic principles outlined within NOAA's 1999 report to Congress on ecosystem-based fishery management were touched upon in the discussion, namely habitat and species diversity are important to ecosystem functioning, multiple scales interact within and among ecosystems, components of ecosystems are linked, ecosystem boundaries are open, and ecosystems change with time. The majority of our discussion was in on improving EFH designations and reviews by focusing management efforts on the habitats used by the early life stages of fishes.

How can reviews of proposed impacts to EFH be improved?

The breakout group strongly believes NOAA should focus more attention upon habitat requirements and ecology of the early life stages of fishes. Traditional fishery management studies the ecology of adult fishes and forecasts their abundance because, generally speaking, adults make up most of the fishable population. Due mostly to passage of the MSA in 1976, NOAA Fisheries has made great strides in managing populations of adult fishes by limiting fishing mortality. A similar effort is needed for larval and juvenile fishes (especially young-of-the-year juveniles) because these life stages are where most habitat-related mortality occurs, and where habitat management can have the most positive effect.

Refined EFH designations for larval and juvenile fishes should focus on habitat conditions that are truly essential to species productivity. One way to focus habitat protection and restoration efforts would be to designate areas with habitat mosaics (e.g., tidal creeks in close proximity to oyster bars, intertidal mud flats, and salt marsh vegetation) that afford larval and juvenile fishes with more opportunities to grow and survive to adulthood as Habitat Areas of Particular Concern (HAPCs). An additional approach would base HAPC designations on groups of species with similar habitat requirements and geographic distributions, and this may include using indicator species or life stages as an efficient way to proceed. Further, NOAA should use its broader authorities to focus habitat protection measures on habitat mosaics and multi-species HAPCs that are strongly associated with other ecosystem services in addition to serving as fish nursery areas. For example, while there is no federal fishery management plan for American shad, its abundance in coastal waters affects the value of EFH by contributing to the amount of food present for federally managed species. The Federal Power Act affords NOAA Fisheries with one of its stronger environmental authorities, and exercising this authority 100 or more miles from the coast in support of ocean-river migratory fishes nonetheless affects the level of support that EFH provides to species managed under the Magnuson-Stevens Act.

The EFH 5-year reviews required by the Magnuson-Stevens Act provide a means for focusing attention upon habitat requirements and ecology of the early life stages of fishes. NOAA Fisheries leadership provided general guidelines for accomplishing the initial round of EFH 5-year reviews. Guidelines for the next set of 5-year reviews should focus on using EBFM principles to identify and bolster protection of fish nursery areas. This goal should be set as early as possible so that fishery management councils, NOAA Fisheries regional offices, and NOAA's science centers can obtain the resources needed to make recommendations in 5-year reviews that can be immediately used to augment EFH designations.

As noted above, a specific point that should be addressed for the next set of 5-year reviews is the value to basing EFH designations on groups of species with similar habitat requirements and geographic distributions regardless of whether the species are grouped in the same fishery management plan. Most multispecies fishery management plans were set before the Magnuson-Stevens Act included EFH provisions. While the groupings may support fishery management in the traditional sense, the groupings may obscure shared dependencies in habitat use. This approach would more readily illustrate the value of particular habitats as EFH that accumulates when multiple fishery management plans are considered concurrently.

Another specific suggestion made by the group for identifying life history stages and habitats that are most in need of protection and/or restoration is to evaluate relative habitat value by life stage using a rank ordering approach that includes life stage sensitivity (to habitat impacts), habitat rarity, and threats to habitat as weighting factors. This approach would probably work best for species that rely on inshore habitats and for which there is sufficient information to support scientifically defensible scoring. This approach also could be part of the next cycle of 5-year reviews.

What research is needed to improve EFH reviews and designations?

The boundary between adopting a new review process and researching a new review process is not distinct because improving reviews of proposed impacts to EFH grades into improving the science that underlies those reviews. This is especially true for the next recommendation.

NOAA Fisheries should assess the value of using risk management approaches for EFH designations and reviews. This assessment would include determining if use of risk management approaches would require changes to EFH regulations. Risk management is the identification, assessment, and prioritization of risks (defined as the effects of uncertainty on environmental and project objectives). The prioritization of risks is followed by coordinated and economical application of resources to minimize, monitor, and control the probability or impact of unfortunate events or to maximize the realization of opportunities. Risk management has an extensive literature in fields similar to habitat and fishery management. Breakout group participants believe initial results from EFH reviews that used risk management principles are encouraging and NOAA would benefit from an assessment of a broader use of risk management approaches. A first step to applying risk management principles to EFH designations and reviews would include quantifying the habitat available and assessing whether the amount of habitat is limiting generally or under specific environmental conditions (e.g., identification of "bottlenecks").

Regardless of whether NOAA Fisheries broadly adopts risk management approaches for EFH designations and reviews, additional data are needed on historical, current, and projected future conditions of habitats used by larval and juvenile fish. Projected future conditions should consider reasonable rates of climate change and human population growth. The central question for this research should be identification of limiting habitats or the environmental conditions under which a habitat becomes limiting. For example, the combination of salinity and temperature optimal for growth of penaeid shrimp may currently place larval shrimp in the portion of estuary where sufficient salt marsh is present to provide food and protection from predators. However, sea level rise and climate change may move the envelope of optimal salinity and temperature upriver into portions of the estuary where less marsh habitat is present placing a higher premium on protecting the marsh in these upriver areas.

NOAA Fisheries' future efforts to examine the ecology of early life stages of fishes should match the efforts spent on adult fishes. Several states and universities already are examining inshore habitat-related growth and mortality of fishes as well as conducting general assessments of inshore populations, habitats, and habitat threats. Mining these data and collaborating on future research efforts present opportunities to improve our understanding of early life stages of fishes. The workshop included presentations from NOAA Oceans and Coasts and NOAA Research on their research efforts and technology transfer products that could inform EFH designations and reviews, especially if accessibility to the data and products is improved. Examples include monitoring of physical conditions (such as Integrated Ocean Observing Systems Regional Associations), habitat classification systems (such as the CMECS), and habitat mapping and modeling (such as the mapping of coral reef habitats by the Center for Coastal Monitoring and Assessment).

Breakout Group 2: Rethinking Essential Fish Habitat with a Focus on Habitat and Stock Variability

Reporter: Waldo Wakefield (NWFSC)
Facilitator: Jaclyn Daly (SERO)
Rapporteur: Kimberly Clements (SERO)

Top Conclusions and Recommended Next Steps:

- Science Centers should do more to work with managers to determine the highest-priority habitats, in terms of conservation need, and the impacts most likely to affect those habitats. Regions need to better communicate science needs to Centers, while Centers need to better communicate their science to managers.
- In some respects, the current broad approach to EFH designation does not need to be refined, and broad designation allows NMFS greater flexibility in developing consultations.
- Our current understanding of potential impacts is limited by the amount of level-3 (growth, reproduction, or survival rates within habitats) and level-4 (production rates by habitat) data.
- Consider refining EFH designation to enable complex-, guild- or life-stage specific designations.
- HAPCs remain a critical tool to prioritize EFH consultations.
- The integration of modeling with GIS tools, and emerging and associated internet-based data catalogs and mappers, will facilitate consideration of spatial and temporal variability in stocks and habitats.
- Prioritize habitat research based EFH designation.

This breakout group tackled a number of questions regarding the opportunities and challenges associated with designating EFH and using EFH designations to conduct meaningful consultations.

What are realistic expectations over the short- to medium-term for refining EFH designations?

The discussion began with a consideration of what are realistic expectations over the short- to medium-term for refining EFH designations. Rather than focusing on refining designations some members of the group took an alternative view that the current broad approach to designation does not need to be refined, and that broad designation allows NMFS greater flexibility in developing consultations. This broad approach runs counter to an often voiced criticism that in EFH designation, “everything is essential.” As species-specific information on habitat function continues to be limiting, HAPCs remain a critical tool to prioritize EFH consultations. Given the current funding and staffing outlook, there was a consensus that only minor changes would occur in the knowledgebase on EFH for any given FMP.

What are the main impediments to using EFH for meaningful consultations?

The main impediments to using EFH for meaningful consultations include the static and somewhat vague language providing guidance on the description, and identification of EFH in FMPs, adverse impacts on EFH, and actions to conserve and enhance EFH - this is of particular concern for nearshore consultations. In the future, having more level 3 (growth, reproduction, or survival rates within habitats) and level 4 (production rates by habitat) information will improve the understanding of potential impacts. In a changing, potentially more variable environment, with a broad array of existing and emerging non-fishing impacts, it will be important to maintain existing and develop new partnerships with institutions and agencies outside of NMFS. The breadth of expertise and resources required to keep pace with emerging habitat-related research needs demands that NMFS continue to foster partnerships with other groups, both within and outside of NOAA.

What science is needed to revise/refine EFH designations to better meet the needs of the management community?

The group recognized the basic need for information on habitat associations and habitat use when discussing science in support of revising or refining EFH designations to better meet the needs of the management community. For example, how does a species use the habitat being impacted - for shelter, foraging, reproduction, etc. The group also put a great deal of stock in GIS tools and fishery modeling in developing a better understanding of how fishes use habitat both spatially and temporally, especially in a changing environment. GIS tools were also highlighted for making EFH information more accessible during 5-year reviews – especially when used in conjunction with Internet-based data catalogs and mappers.

Breakout Session, Group 3: Rethinking Essential Fish Habitat with a Focus on Non-Fishing Impacts

Reporter: John Stadler (NWRO)
Facilitator: Janine Harris (OHC)
Rapporteur: Kristan Blackhart (S&T)

Top Conclusions and Recommended Next Steps:

- Comprehensive, detailed, and up-to-date descriptions of non-fishing impacts to EFH and associated conservation measures allow action agencies and applicants to improve their actions and reduce consultation requirements.
- Comprehensive descriptions of specific categories of non-fishing impacts to EFH and applicable conservation measures should be developed cooperatively for all regions. Support from leadership at the regional and national levels is needed.
- Additional participation from Science Center staff in the development of the descriptions of specific categories of non-fishing impacts and applicable conservation measures would lend such efforts greater scientific credibility.
- Documentation of the specific categories of non-fishing impacts and the applicable conservation measures must be updated regularly to remain timely and should be viewed as a "living document."

In this session, each breakout group was asked to answer a number of questions regarding the opportunities and challenges associated with EFH and using EFH designations to conduct meaningful consultations. However, because the effects of non-fishing activities on EFH are not directly related to the designation of EFH, this breakout group did not focus on the trigger questions. Instead, the group spent time discussing the opportunities and challenges associated with describing, in FMPs and elsewhere, the non-fishing activities that may adversely affect EFH and how those descriptions and associated conservation measures can be used to improve consultations. Ultimately, collating conservation measures for categories of non-fishing impacts could reduce consultation workload and increase the predictability of the outcomes of consultations for the public and federal action agencies.

The goal for this breakout group was to develop 2 to 3 reasonable next steps for improving descriptions of specific categories of non-fishing activities that may adversely affect EFH and the conservation measures that can be recommended to avoid, minimize, or otherwise offset those effects.

The non-fishing effects section of FMPs can be utilized in subsequent EFH consultations in several ways. The primary value of this section is to provide guidance to Federal action agencies and the public on how NOAA Fisheries will analyze the effects of proposed actions and the types of measures likely to be recommended to avoid, minimize, or mitigate those effects. When an action is designed to account for these effects, EFH is conserved and the post-application EFH consultation workload is lessened. This can be especially important in regions where the EFH consultation workload puts severe demands on human resources and the regions are forced to prioritize which consultations, or types of consultations, to work on. Having a comprehensive, detailed, and up-to-date description and associated conservation measures for activities that may adversely affect EFH could be considered a quasi-programmatic consultation that action agencies and applicants can use to improve their actions, thereby reducing the consultation workload. This could also improve the prioritization process in the regions. Such a compilation of descriptions and conservation recommendations, including updates as necessary, should be a top priority for all regions.

Comprehensive descriptions of non-fishing activities that may adversely affect EFH have been developed by several regions. The first was a 2003 cooperative effort by the Southwest, Northwest, and Alaska Regions (Hanson et al. 2003) that included non-fishing activities in riverine, estuarine, and coastal and marine environments. This effort produced a stand-alone document that contains generic descriptions and conservation recommendations that were not targeted at a specific FMP. It was subsequently incorporated, as written, by the Pacific Fisheries Management Council as an appendix the Pacific Coast Groundfish FMP. This document was also incorporated into North Pacific Fishery Management Council FMPs, but in a modified form to make it more regionally-applicable. Since then, both the Northeast and Alaska Regions have produced updated and regionally-specific versions of the 2003 document.

The group discussed approaching this issue from a national perspective and whether it made sense to put together a comprehensive description of the non-fishing effects to EFH that would be applicable across all regions. There was general consensus that if such a document were developed, it would need to be tailored to the specific needs of each region, much as the 2003 document was tailored to the needs of the Alaska Region. Opinions were varied over the utility of a national effort with some members of the group holding the position that inter-regional differences in activities and habitat types were sufficiently large to negate the advantages of a national effort. Examples of regional differences include: 1) agriculture may have significant effect on EFH in some regions, but not in others (e.g. Alaska); and 2) shallow, reef-forming corals are important habitats in some regions (e.g. Southeast, Pacific Islands) but not in others (e.g. Northwest, Northeast).

Others recognized the regional differences, but held the opinion that efficiencies could be gained from such an effort because the underlying effects and conservation recommendations for many of the activities would be widely applicable. For these activities, it makes sense to cooperate across the regions when developing those sections. Doing so would ensure that the descriptions and conservation recommendations are based on the same underlying data for all regions, even if they vary for regional-specific reasons. For other activities the regional differences could negate any gains in efficiency. One approach would be for each region to develop or update their non-fishing effects document individually, but commit to share their products with other regions. An important point regarding pursuing this as a national effort – there will be a need for support from NOAA Fisheries managers, at both the regional and national levels, to ensure that the required resources are made available to support the effort.

Regardless of whether or not a national effort is pursued, the group thought that the descriptions of the individual activities should include a section that describes the data and research needs. For many of these non-fishing activities, the effects on aquatic resources are not fully understood.

Another topic discussed by participants is the extent of involvement from Science Centers. For the 2003 non-fishing activities document produced by the Northwest, Southwest, and Alaska Regions, the descriptions and conservation recommendations were developed by Habitat Conservation Division staff from the three Regions. While Science Center staff reviewed much of this text, they did not take an active role in its development. One advantage of more active involvement from Science Centers in future development of similar documents would be to improve the technical merit of the final products and perhaps result in greater acceptance by action agencies and the public – leading to better project design that can eliminate the need for, or reduce the time required to conduct, EFH consultations. Science Center participants agreed with this concept and also agreed to try to increase their involvement in the process. However, representation by Science Center staff was limited in this breakout group so widespread commitment was not possible. It should be noted that greater cooperation between the Regions and Centers is called for under the Habitat Blueprint.

Greater technical merit could be also gained by subjecting non-fishing impact descriptions to peer- review, publishing documents through the NOAA Technical Memo series, or publishing through the American Fisheries Society, which would lend the most credibility. However, it is important to bear in mind the need to ensure that such peer reviews or publications are done in a timely manner so that NOAA Fisheries can meet the timing of the EFH reviews and to ensure that the information is still relevant and not out of date. In addition, most members of the group preferred to look at the descriptions as a "living document" – one that would allow NOAA experts to update the descriptions and conservation measures as new information became available.

While the group discussion was focused primarily on the best means of developing comprehensive, up-to-date descriptions and conservation recommendations for activities that may adversely affect EFH, we did discuss two other topics. The first regarded the issue of invasive species (e.g. lionfishes and invasive tunicates) and how to consider them in the context of non-fishing impacts. It was suggested that because the presence of these species may impair normal habitat functions and their presence can be mapped (e.g. invasive tunicates that smother the benthic community), it may make sense to incorporate the presence of some of these into the EFH designation process. However, some managers expressed the concern that the ability to conserve EFH could be weakened by such an approach. There was general consensus that invasive species is a serious concern, but there was no consensus on how to address this issue. While the topic of invasive species is incorporated into the descriptions of other activities, the challenge is that NOAA can address them only when they are tied to a Federal action. Addressing these issues more strongly in the non-fishing activity descriptions can help but it does not solve the problem.

The group briefly discussed efforts by the Office of Habitat Conservation to develop a new GIS tool for use in the Chesapeake Bay that prioritizes key restoration and protection areas. The utility of such a tool for EFH consultations was discussed. It has ancillary benefits in that it can provide information to be used in the development of EFH Conservation Recommendations, but is generally applicable at the site-specific scale. While this tool has utility in EFH consultation processes, it is currently limited to the Chesapeake Bay and would be difficult and costly to expand it to a larger scale to make it more broadly applicable.

Breakout Group 4: Rethinking Essential Fish Habitat with a Focus on Climate Change

Reporter: John Manderson (NEFSC)
Facilitator: Tali Vardi (S&T)
Rapporteur: Lora Clarke (S&T)

Top Conclusions and Recommended Next Steps:

- Mechanistic models are needed to forecast responses under novel habitat conditions.
- EFH needs to evolve to include a mechanistic understanding of habitat effects on vital rates and productive capacity.
- We need to extend existing time series across warm and cold water regimes. Particular focus should be on maintaining annual time series, re-extending original spatial coverage, and increasing temporal resolution (seasonal sampling) of monitoring studies.
- We need to develop sophisticated techniques for both downscaling global climate models to forecast critical ocean habitat features and for upscaling process based habitat studies of habitat effects on vital rates so we can extrapolate responses over the broad space and time scales at which populations and ecosystems operate.

This breakout group discussed opportunities and challenges associated with designating EFH and using EFH designations to conduct meaningful consultations in the context of climate change. Under the direction of the facilitator, the group focused on the bolded trigger questions below. Discussions centered on the requirement that mechanistic understanding of species and community rate responses (e.g. growth, mortality, reproduction, production) to habitat features and changes in habitat features are required in the face of climate change because organisms are being exposed to novel habitat conditions as a result of climate change. Mechanistic models are required for the forecasting of novel states.

What are the impediments of including climate change in EFH?

Dynamic climate driven pelagic habitat properties and processes must be considered in EFH if we are going to understand the effects of climate change on marine habitats. Many of these, including temperature, dissolved oxygen, pH, and circulation, are driven by climate, and are fluid properties and processes essential to forming habitats in the sea.

EFH needs to evolve beyond merely cataloguing where animals are (level 1) and environmental characteristics organisms are currently associated with (level 2) to a mechanistic understanding of habitat effects on vital rates and productive capacity (levels 3 & 4). Only this will allow for the development of forecast models required. This type of work is being done right now for both terrestrial and marine species and ecosystems (see Journals like Global Change Biology). Setting this as a near term goal is possible and not an overreach.

We must assess the vulnerability of regional ecosystems, including the human communities that depend on them, to climate related shifts in distributions of habitats, species and species communities. Ecosystems and species compositions are changing and are going to continue to change dramatically with climate change. We must relinquish our view that habitat, species distributions and ecosystems are static in space and time in the sea if we are to establish effective adaptive management strategies in the face of climate change

What climate change science is needed to inform EFH?

We need to monitor important ocean habitat features that are driven by atmospheric forcing at broad spatial scales and fine time scales. Specifically, there is a need to extend or build upon existing time series that cross warm and cold water regimes. Particular focus should be on maintaining annual time series, re-extending original spatial coverage, and increasing temporal resolution (seasonal sampling) of monitoring studies. This monitoring is essential if we are to detect important but subtle changes in phenology that will impact habitat suitability and thus important species vital rates. Changes in the timing and forcing of factors controlling production cycles may be critical in determining whether there are matches or mismatches between habitat conditions and the life history event schedules of species. Some of these essential climate driven habitat features could now be cast relatively accurately over broader spatial and finer time scales than data collected using data assimilative models.

We need to develop sophisticated techniques for downscaling global climate models so as to forecast critical ocean habitat features beyond just temperature. This includes circulation patterns that control both population and trophic connectivity, dissolved oxygen concentrations, and primary and secondary production. Similarly, we need to develop methods to "upscale" process based habitat studies of habitat effects on vital rates so we can extrapolate responses over the broad space and time scales at which populations and ecosystems operate. This is essential for developing an understanding of linkages of individual species response (e.g., physiology, behavior, survivorship) to that of climate change, habitat dynamics, population dynamics, and ecosystem dynamics. Arguably, the effects of climate change on populations and ecosystems may be best understood through mechanisms of habitat dynamics.

Because climate change is producing novel environmental conditions, mechanistic and process based understanding of habitat effects on vital rates and productive capacity are absolutely essential. Correlative, empirical models will not accurately forecast responses under novel sets of habitat conditions. Mechanistic models are required.

How can data be made available?

Internet and visualization tools can be used to make data more available.

DAY 3: IMPROVING THE FLOW OF HABITAT SCIENCE INFORMATION TO MANAGEMENT

Session Organizers: Pace Wilbur (SERO) and Korie Schaeffer (SWRO)

Top Conclusions and Recommended Next Steps:

- An inshore-offshore decision support tool is needed to effectively help habitat managers evaluate the impacts of management decisions affecting onshore habitats on the productivity of offshore fish populations
- A small team of habitat managers and ecosystem scientists should be formed to further define and develop this tool and outline next steps.

The goal of the session was to recommend information transfer products that NMFS habitat managers can use to inform EFH consultations with federal action agencies and EFH designation discussions with Fishery Management Councils. This was a follow-up session to sessions held at the 1st National Habitat Assessment Workshop in 2010 that focused on current processes and strategies for providing incorporating habitat science into management. During the first NHAW, participants came up with a number of recommendations for improving the process, including improved communication and coordination between regional Science Centers, Regional Offices, Restoration Centers, and NMFS Headquarters (See Blackhart 2010).

To help facilitate improved communication and coordination, this session specifically focused on information transfer products that can be used to improve the flow of scientific information to management. The session began with a presentation from each region summarizing the manner in which consultations currently utilize scientific information, successful examples of scientific information or tools included in EFH or FWCA consultations, and descriptions of one or two habitat management issues that affect many consultations and would benefit greatly from the attention of NOAA scientists.

Improving The Flow And Utility Of Information From Science Centers To Managers: Examples From The Northeast Region
Louis Chiarella (NERO)

Although our National discussions are focused on improving habitat science for management purposes it is first important to recognize our success. Since the implementation of the EFH requirements of the MSA in 1998, the Northeast Region has engaged in a variety of activities to improve our understanding and management of fisheries habitat.

These initial activities focused on providing critical habitat and species information for all the MSA managed species in the Northeast Region. The results were the EFH Source Documents developed by the Northeast Fisheries Science Center which were utilized in the identification and description of EFH. More recent activities include development of a deep sea coral predictive model to assist us in the development of a deep sea coral conservation strategy; a food habitat study to better assist us in managing anadromous fisheries through hydro dam licensing activities; and the GIS mapping of oceanographic and ecosystem parameters to help us better understand potential resource impacts from offshore energy development.

As with most of the science and management issues within our organization we are still faced with obstacles to more enhanced collaborations. These include lack of dedicated funding for habitat science, lack of implementation of the strategic plan for habitat science (Habitat Assessment Implementation Plan), and the inability to compete for funding with the Stock Assessment Program.

Three major areas where managers need better habitat science include the areas of Offshore Energy Development and the assessment of potential resource impacts from these activities; general productivity issues linking fish production to habitat variables; and the economics of habitat protection as it relates to costs and benefits to our resources from various development activities.

Improving the Flow of Habitat Science Information to Management in the Southeast Region

Pace Wilber (SERO)

The NMFS Southeast Region works directly with the Gulf of Mexico Fishery Management Council (GMFMC), Caribbean Fishery Management Council (CFMC), and South Atlantic Fishery Management Council (SAFMC) to protect, conserve, and restore EFH. These Councils designated EFH through comprehensive amendments to their respective fishery management plans, and these amendments are updated as new fishery management plans are adopted (e.g., SAFMC's fishery management plan for dolphin and wahoo) or new information became available (e.g., SAFMC's designations for tilefish). The EFH amendments and supporting National Environmental Policy Act documentation are the chief reference materials for information about EFH in the region, although SAFMC supplemented these materials in 2009 with *Fishery Ecosystem Plan of the South Atlantic Region*. SAFMC, GMFMC, and CFMC have completed their 5-year reviews of EFH designations as required by the Magnuson-Stevens Act. All three Councils relied upon a contractor or Council advisory panels to complete the reviews. While SEFSC scientists were not formally part of the 5-year review process, SEFSC scientists contribute significantly to the EFH programs primarily by examining habitat-related growth and survival rates, mapping distributions of deepwater corals, and examining the early life history stages of coral reef fishes. NOAA's National Centers for Coastal and Ocean Science also contributes significantly to the EFH program by mapping seagrass, coral, and hardbottom habitats and by developing mitigation plans for impacts to seagrass habitat. New information and tools that would enhance reviews of proposed impacts to EFH include quantifying the habitat and ecosystem service linkages between inshore nursery areas and offshore fisheries, identification of habitat bottlenecks for fishery populations, and refining time-of-year restrictions on construction projects to optimize their use in protecting the vulnerable, early life stages of fishery species.

Improving the Flow of Habitat Science Information to Management in the Southwest Region

Korie Schaeffer (SWRO)

EFH provisions of the Magnuson Stevens Fishery Conservation and Management Act require that NMFS and Fishery Management Councils designate EFH for all life history stages of managed fishes and that Federal agencies consult with NMFS regarding federal actions that may adversely affect EFH. In California, EFH designations for 136 species of groundfish, coastal pelagic, salmonids, and highly migratory species encompass the entire US Economic Exclusive Zone and many of the coastal watersheds. While a subset of managed fish species utilizes the estuaries and nearshore marine areas for some part of their life history, many are found primarily in offshore marine areas. EFH consultations are not distributed evenly throughout designated EFH, but occur primarily in coastal estuaries and nearshore marine habitats, with hotspots in San Francisco Bay and Southern California. EFH consultations often focus on urban, residential and agriculture development; transportation projects; and shoreline protection. Southwest Region (SWR) staff conducts consultations with the assumption that estuaries and nearshore marine areas provide primary and secondary productivity for offshore areas, and therefore, have important habitat function for managed species that occur in these habitats as well as for those species found in offshore habitats. NMFS SWR staff primarily use the EFH sections of Fishery Management Plans, scientific journal articles, and data generated by state and regional partnerships and monitoring as sources of information to conduct EFH consultations. An ongoing issue of concern in the SWR is the need to better understand the link between estuaries and nearshore marine areas and sustainability of offshore fish populations. Other ongoing concerns include cumulative impacts of small footprint projects, benthic community response to disturbance, and the relative intensity and relationship of fishing impacts versus non-fishing impacts to habitat.

Habitat Science Support for ESA and EFH Consultations Northwest Region
Michael Tehan (NWRO)

In NMFS' Northwest Region, the ESA listing of over 20 species (evolutionary significant units) of Pacific salmonids and rockfish has resulted in considerable overlap in consultations conducted under section 7 of the ESA and the EFH provisions for managed species under the MSA. Both ESA and EFH consultations on actions that may affect fish habitat are conducted primarily by the Habitat Conservation Division. Both the ESA and EFH regulations require use of the best scientific data available. The NWRO has forged strong working relationships with several programs at the NWFSC and employs multiple strategies for integrating cutting edge habitat science into its consultation products. The NWRO looks for opportunities to collaborate with the NWFSC to develop models, analytical frameworks, or other science tools that are broadly applicable to a host of situations. Examples of previous successes include the River Restoration and Analysis Tool for analyzing stream engineering, management and restoration proposals, and science findings and recommendations for protecting temperature and large wood recruitment functions in riparian thinning proposals. Among the many emerging needs for science support for habitat consultations include tools to assess the effects of instream flow withdrawals, toxic substances in water bodies, hydro acoustic effects of pile driving, livestock grazing; as well as the habitat requirements of newly listed species such as the eulachon.

Improving the Flow of Habitat Science Information to Management in the Alaska Region
Matthew Eagleton (AKRO)

The Alaska Regional (AKR) Office of Habitat Conservation Division (HCD) and Alaska Fisheries Science Center (AFSC) developed a process to integrate habitat science and fishery management in 2000. From the onset of the MSA/EFH provisions, AKR commits the majority of regionally-allocated EFH funds to EFH-specific research. This 'arrangement' has evolved to become a scientifically-driven RFP process. This process ensures we do not lose focus on providing the best science available in EFH descriptions and analysis. Importantly, all EFH-related discussions are vetted through FMP stock assessment Plan Teams (Pacific Salmon species off AK is the exception, as no plan team exists.).

The AKR process is not perfect, however, and improvements are continually sought. For example, the process struggles with the amount of effort required to answer large-scale regional questions given miniscule funds – all the while managing multi-billion dollars fisheries. Or more simply, to study the most basic Alaska marine/coastal habitat questions costs more than we are receive in any given year. We are fortunate to have a solid, historic fishery survey and observer-based commercial data set. However, we lack 1) scientific survey in all regions (near-shore waters; estuaries; Arctic region); 2) a complete region-wide bathymetric profile (many areas rely on lead line surveys dated early 1900's); 3) a region-wide marine bottom composite (benthic data is limited to random surveys or large scale 10nm x10nm grids); 4) early life history stage information (~4 life stages x 60 species); 5) year-round oceanic condition monitoring – all necessary information to assess habitat.

EFH consultation for fishery activities occurs continuously between HCD and Sustainable Fisheries Division and North Pacific Fisheries Management Council (NPFMC). EFH Conservation Areas, including HAPCs, are drafted as needs are brought out by our Council process or the 5-year EFH review. EFH staff (John Olson) participate in annual FMP SAFE reports and consult on the Total Allowable Catch specifications - the process which allows for a sustainable fisheries.

EFH consultation for those activities other than fishing is done by HCD staff in Juneau and Anchorage. Science is integrated and includes many sources of expertise outside of NMFS. AFSC does not specifically have a non-fishing effects program. A Habitat Assessment and Marine Chemistry Division exists at Auke Bay Lab and focuses on 1) fate and effects from oil spills; 2) site-specific intertidal habitat surveys. However, oil spill effects are only one of several activities affecting EFH. Other actions include major harbors, coastal roadways, human infrastructure, offshore marine mining, seafood and sewage wastes, and great circle international trade transiting within sensitive, pristine marine environments (Arctic; Aleutian Islands). AKR HCD is expanding EFH Programmatic Consultation agreements to focus activity reviews towards only those actions requiring NMFS expertise. As climates warm and change, AKR HCD faces enormous work-related uncertainties.

Below is information on several processes HCD uses with AFSC and NPFMC. Also listed are a few sites specific to AKR EFH Issues.

ASFC Research Priorities

The Habitat Ecological Processes Research program oversees an annual EFH research proposal process (~$450k). Research priorities include Coastal areas facing development; Characterize habitat utilization and productivity; Sensitivity, impact and recovery of disturbed benthic habitats; Validate and improve habitat impacts model; and Seafloor mapping. http://www.afsc.noaa.gov/HEPR/efh.htm

NPFMC Research Priorities

The NPFMC, along with NMFS, maintains a list of Immediate Concerns and Ongoing Needs to better fishery management. Specific to habitat, the list includes Evaluating HAPCs, Baseline conditions, Effects from fisheries, Mapping, Habitat function, Effective monitoring techniques, and Ecosystem indicators (http://www.fakr.noaa.gov/npfmc/PDFdocments/MISC/ResearchPriorities712.pdf).

EFH Consultation Tools

- Fishery Interactions & Science Alaska Essential Fish Habitat Research Plan http://www.afsc.noaa.gov/HEPR/efh.htm

- Evaluation of Fishing Activities that May Adversely Affect Essential Fish Habitat - Fujioka & Rose Model (Appendix B, 2005 EFH FEIS Alaska Region) http://www.fakr.noaa.gov/habitat/
- seis/final/Volume_II/Appendix_B.pdf

- Fishing Restrictions and EFH Conservation Areas (http://alaskafisheries.noaa.gov/npfmc/conservation-issues/habitat-protections.html)

- Non-Fishery Interactions Research Priorities developed with NPFMC (http://www.fakr.noaa.gov/npfmc/PDFdocuments/MISC/ResearchPriorities712.pdf)

- NPFMC & AKR Non-fishing Consultation Process (http://www.fakr.noaa.gov/npfmc/PDFdocuments/conservation_issues/EFH/BBRKC_EFH212.pdf)

- Impacts to EFH from Non-fishing Activities in Alaska (http://www.fakr.noaa.gov/habitat/efh/nonfishing/impactstoefh112011.pdf)

Improving the Flow of Habitat Science to Management in the Pacific Islands Region
Robert Schroeder (PIRO)

The scientific basis for EFH consultations in the Pacific Islands Region relies initially on the reviewer's cumulative technical expertise (e.g., standard best management practices for coral reef conservation). We also base reviews on in-water surveys by the applicant's consultants and by our own fish/habitat biologists, NOAA/GIS habitat maps, Google Earth, locally relevant published literature, and United States Fish and Wildlife Service marine habitat surveys.

One important scientific tool that supports EFH consultations is a Habitat Equivalency Analysis (HEA)-like modeling framework. The model is used to estimate replacement of ecological function associated with any unavoidable marine habitat loss (coral reef, fish habitat), consistent with the 2008 Mitigation Rule. It attempts to quantify the lost habitat, and its respective ecological functions and services, and determine through calculation of gain, an appropriate mitigation project that will replace the function of the lost marine habitat. Application of HEA-like modeling in the Pacific typically considers unlike units and uses a trade-off model for compensation.

Another scientific tool starting to be used in the Pacific Islands is the Atlantis Ecosystem Model. This comprehensive model considers biophysical, economic, and social aspects of the marine ecosystem to aid adaptive management planning. Impacts to the fish-habitat ecosystem from coastal development, pollution, and fishing are evaluated. The Atlantis Model integrates early ecosystem models, such as ECOPATH and ECOSIM, based on trophic biomass and flow trends. In the Pacific Islands, the current focus is on data collection, in partnership with PIFSC, at Guam where an imminent military buildup is expected to have extensive impacts to the coastal and marine ecosystem, particularly EFH. Results should help us refine local EFH and improve the effectiveness of specific habitat consultations.

Related habitat data needs to improve management and EFH consultations include: 1) data on important links between types of habitat and management unit species (MUS) (e.g., species-habitat utilization patterns or requirements, spawning and nursery areas for key species, coral distribution models that link predictor variables with species presence); 2) data to assess habitat specific functionality (e.g., value of soft sediment); and 3) data on responses of EFH (including MUS and their prey) to the main site-specific impacts of coastal projects (e.g., impact to corals from turbidity/sedimentation).

Breakout Sessions

After the regional presentations, participants broke out into three smaller groups to discuss and recommend possible information transfer products. Groups were given a list of possible sample products to help initiate the discussion, but discussions were not limited to the examples provided. Participants were asked to consider products that would be applicable nationwide, but have a general design that could be tailored to meet region-specific needs. They were also asked to consider the technical elements and general format of the product, value to regional habitat staff and interest from regional scientists, and expected time of development and resources needed. The expectation is the NHAW endorsement will carry weight within Science Centers and NOAA offices that fund habitat work.

Breakout Group 1: Improving the Flow of Habitat Science Information to Management

Reporter: Richard Hartman (SERO)
Facilitator: Tali Vardi (S&T)
Rapporteur: Lora Clarke (S&T)

Top Conclusions and Recommended Next Steps:

- NMFS habitat protection efforts could be strengthened by developing a stronger connection between offshore managed stocks and nearshore/onshore habitats where most coastal development and regulated activities occur.

After discussing the possible sample information transfer products designated for discussion, the group decided to concentrate on Onshore-Offshore Habitat Linkages. The primary reason for that decision was a strong need by those in the Habitat Program to be able to link nearshore/onshore estuarine habitats and their fishery standing crops with offshore production. Current stock assessments provide fishery managers with information about offshore adult populations harvested by user groups, but very little is known about linkages between onshore populations and their habitats with that offshore harvest. Much of the focus of the Habitat Program has historically been on conservation and restoration of onshore impacts. Most of the Habitat Programs habitat protection opportunities are associated with regulatory reviews of coastal and nearshore development activities under a variety of laws and regulations. The Habitat Program could be more effective in convincing Federal action agencies to adopt protection measures for onshore EFH if it could establish a more quantifiable connection between offshore fish populations and onshore habitat productivity. The Chesapeake Bay region also is interested in being able to evaluate habitat impacts to some non-Federally managed species.

It is important to:

- Prioritize systems and habitats that support the greatest levels of marine fishery production. For example, ten acres of salt marsh in one basin may not be as important to marine fishery production as ten acres of salt marsh in an adjacent estuary.
- Develop a spatially explicit habitat-based GIS map based on fishery models. The models and GIS should incorporate layers that include forage species, hydrodynamics, water quality, various life stages of the species of concern, and temporal scales.
- Identify questions up front to make sure models are sensitive to major changes. It is thought that if the model can quantify impacts of major changes, it may be possible to extrapolate those impacts to smaller changes in the environment in a fashion that would be legally defensible.
- Communicate early in the process between habitat managers and model developers to ensure the questions to be answered are being adequately addressed by the model. At present, communication between managers and modelers is inadequate.

- Identify a model that is sufficiently robust to fulfill the needs of the managers. The ATLANTIS or ecopath/ecosym type trophic models may be an example of a model type that could be used as a basis for regional models.
- While it was believed that the overall effort should be nationally supported, it was recommended the model be regionally based. Given regional differences in funding availability, it is important that funding shortages in one area not hold up the development of models in regions having better funding levels. In addition, there are variations in regional needs for these models and GIS ouptputs. In some regions, Federal action agencies such as the U.S. Army Corps of Engineers (USACE) rarely question recommendations provided by NMFS. In other cases, action agencies question and oppose NMFS recommendations without a strong linkage between regulated impacts and fishery production.

It is thought by some that the GIS data model could be developed first and, as more information becomes available, it could be connected to Integrated Ecosystem Assessments in development around the nation.

Most models are dependent on a large amount of data inputs. It is believed model development and use would help identify important data gaps for future research. Those data gaps can be prioritized and when filled, the models can be improved to increase predictability and credibility and lessen uncertainty.

It is believed there is poor communication among many modelers working within NOAA, other federal and state agencies, and academia developing layers and inputs that would assist in this effort. NOAA should attempt to improve communication with and among modelers in an attempt to better utilize existing information and data that could be available.

Breakout Group 2: Improving the Flow of Habitat Science Information to Management

Reporter: Korie Schaeffer (SWRO)
Facilitator: Korie Schaeffer (SWRO)
Rapporteur: Kimberly Clements (SERO)

Top Conclusions and Recommended Next Steps:

- A small working group should be formed to examine use of spatially explicit simulation models embedded with habitat to improve management decisions.
- A formal process is needed for communication between science center and habitat managers in each region for EFH 5-year reviews in order to help managers with EFH consultations.

The group discussed how best to inform managers regarding the effects of activities in nearshore areas to offshore fish populations. Three main information transfer products were identified: (1) Estuarine Living Marine Resources (ELMR) or ELMR-like databases, (2) longterm, nearshore monitoring, and (3) simulation modeling.

ELMR databases provide information on species life stages occurring in coastal estuaries, and can be very useful in the short-term to document what species are found in the estuaries and when they are found there. Information tables using ELMR databases could help identify priority areas of interest based on number of species life stages using specific areas. Diet matrix tables could help identify estuary species that are important prey for offshore stocks. ELMR databases will not, however, describe connections between impacts to inshore habitats and productivity of offshore stocks. The information also may be dated in many cases.

Improved or coordinated nearshore monitoring would increase information regarding the quality of nearshore habitat and use by managed species. Monitoring should be designed as fixed-site monitoring to represent breadth of estuaries and nearshore habitats. Some of this monitoring may already be implemented by states or regional entities. A standardized approach to monitoring would allow us to develop and test hypotheses regarding impacts of human activities. This effort would likely require new resources and significant time to design, implement, and accumulate data.

Simulation models could be developed that are spatially explicit with habitat embedded into the model. Models would simulate sensitivity on a species-by-species basis (e.g., summer flounder), but could be developed for representative species, or focused on species that rank as high priority under the Habitat Assessment Prioritization Working Group process. A modeling effort could be developed as a national framework modified with regional inputs (e.g., habitat assessment modeling framework). The effort could be complete within 3 years, but would require a working group with regional managers and science center modelers. Other NOAA line offices (e.g., NOS) should be involved in model development and data compilation. Nearshore monitoring discussed in (2) above would help to evaluate and test simulation models over time.

The group agreed the idea of simulation modeling is most promising, since it directly addresses managers' questions regarding effects of human activities and could be completed within a reasonably short time frame (i.e., 3 years). The group recommends this idea be further delineated by a small working group and then brought to the Science Board as a priority. This effort supports the NOAA Habitat Blueprint by improving habitat science to support more efficient and effective EFH consultations. This effort also could lead into Integrated Ecosystem Assessments and be coupled with economic models.

The group also discussed the need for a formal process for communication between science center and habitat managers in each region for EFH 5-year reviews in order to help managers with EFH consultations.

Breakout Group 3: Improving the Flow of Habitat Science Information to Management

Reporter: Steve Edmondson (SWRO)
Facilitator: Kirsten Larsen (S&T)
Rapporteur: Janine Harris (OHC)

Top Conclusions and Recommended Next Steps:

- Need to provide regular forums to increase and improve communication and collaboration between scientists and managers.
- A nationwide process to direct and deliver science would help managers make better informed decisions.

There seemed to be broad consensus that greater collaboration between centers and regions would improve the delivery and efficacy of science. However, several participants noted, this message and conclusion is often repeated without effective resolution (déjà vue). There were also several cautionary comments regarding the dynamic tension between improving the applicability of science center products in management decision making and the need to protect the integrity of the science (need to maintain firewalls).

Participants discussed some of the challenges associated with transferring science to managers. Managers have limited time to review science products. Accordingly, it is not reasonable to expect managers to search and read literature to first, interpret and determine relevance and second to determine how to integrate into decision making process. On the other hand, Science Center scientists intend to deliver information to managers in a form they can use and desire managers to incorporate latest science into management decisions. However, Centers are often not aware of pending management actions or the scale or format necessary to be useful in decision making.

There exists an inherent conflict in attempts to "package science" so that it can be easily assimilated into management decisions. For instance, managers wish to better direct science and specific questions addressed through research. In this way research can be better focused on specific management decisions and results of research can be directly applied as explicit management recommendations. However, this approach is inherently problematic. Blurring the line between centers and regions can undermine the credibility of the science product and thus limit its value. Also, in some circumstances managers have been frustrated when they believe centers "cross the line" and interfere with or complicate management decisions. Clearly, many issues could be resolved or avoided through better communications. A clear and systematic process for information exchange would be useful. A nationwide process for iteratively guiding science and integrating into management decisions does not exist. Rather, each region defines the way for science recommendations to be developed by centers and delivered to managers.

A nationwide process to direct and deliver science would greatly empower regional managers who need to better understand the relative value of habitats and the impact of disturbance on populations of managed stocks. However, regions often don't have the resources necessary to fund all their science needs. This tension between funding and need, calls for strategic thinking and communications between Regions and Centers regarding the delivery of science to managers.

Recommendations

- Science papers should include management recommendations
- Define vehicle and systematic process to deliver science to regions
- Provide regular forum for Science Center staff to discuss science with managers
- Provide access to new work with abstracts
- Need to go beyond e-mails and create forum for discussion
- Regions need to better brief science centers on management concerns
- Consider opportunities for region and science center staff to collaborate on science
- Science center librarians should send new papers with summaries to regions
- Use media releases on papers and research to make more accessible public
- Liaison between science and managers
- Systematic task based approach
- Use electronic Annual Operating Plan (eAOP) milestones to inform regions about ongoing projects. This will require re-formatting to make the information more accessible to regions.
- Stress greater regional office input
- Define where in the process of setting science priorities the regions get involved
- Involve senior management in science communications

Desired Science Products

- Work exclusion windows in Alaska
- Historical ecology to better understand management goals and ensure we are managing for the right conditions
- A geospatial decision support tool that can query specific information needs based upon location
    - Need to make EFH Mapper more useful and need to keep operating it and updating it. Making EFH Mapper national in scope has a higher chance of funding than regional specific, but need to recognize some regional tailoring
- Science supporting cumulative impact assessments would be very valuable
- Legal determination for where to set baseline for starting clock for threshold measurement
- Thresholds: examples (habitat area and other biological parameters),
    - Red drum complete most of their life cycle in or near a marsh. If you are targeting a specific amount of red drum in the system, you will need to identify how much marsh and tidal creek are needed in the system to support that target.

Group Discussion

After reconvening and hearing report outs from each of the breakout groups, participants discussed which of the possible information products would most meet managers' needs and should therefore be considered the highest priority product. A common theme amongst the breakout groups was the need for an advanced modeling effort. Habitat managers lack the necessary tools to evaluate the effects of management decisions (e.g. shore modification) impacting onshore habitats on the productivity of offshore fish populations. Current EFH mapping tools are very limited and often lack the necessary data to inform these decisions. The group recommended that a process model linking onshore and offshore productivity be the highest priority decision support tool. Such a tool could be adapted at the regional level and would help to inform habitat management decisions.

Another recommended tool was a spatially-explicit habitat based GIS map that can show movement patterns of marine fishery resources on varying temporal scales. This would provide a tangible tool on which to base discussions between scientists and managers.

A small team comprised of both managers and modelers will be assembled to further develop and define a product. Having managers on the team will help to ensure that their needs are being met and modelers are developing a useful tool. The team will be mindful of existing models and products in order not to duplicate other ongoing efforts within NOAA. The Leadership Council should be briefed on this priority recommendation with an estimate of cost and time. A one page description will be developed to summarize the goal of this potential product and identify a path forward.

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COMMON ACRONYMS

AFSC	Alaska Fisheries Science Center
AKRO	Alaska Regional Office
CFMC	Caribbean Fishery Management Council
CMECS	Coastal and Marine Ecological Classification Standard
CPS	Coastal Pelagic Species
CPUE	Catch Per Unit Effort
EBM	Ecosystem-Based Management
EBFM	Ecosystem-Based Fisheries Management
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FMP	Fishery Management Plan
FEP	Fishery Ecosystem Plan
GIS	Geographic Information System
GMFMC	Gulf of Mexico Fishery Management Council
HAIP	Habitat Assessment Improvement Plan
HAPC	Habitat of Particular Concern
HMS	Highly Migratory Species
IOOS	Integrated Ocean Observation System
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEFMC	Northeast Fisheries Management Council
NEFSC	Northeast Fisheries Science Center
NERO	Northeast Regional Office
NHAW	National Habitat Assessment Workshop
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPFMC	North Pacific Fisheries Management Council
NWFSC	Northwest Fisheries Science Center
NWRO	Northwest Regional Office
OAR	Oceanic and Atmospheric Research
PFMC	Pacific Fisheries Management Council
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
S&T	Office of Science and Technology
SAFMC	South Atlantic Fishery Management Council
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SWFSC	Southwest Fisheries Science Center
SWRO	Southwest Regional Office

APPENDIX 1: WORKSHOP STEERING COMMITTEE

Kristan Blackhart, S&T
Stephen Brown, S&T
Matthew Eagleton, AKRO
Janine Harris, OHC
Kirsten Larsen, S&T
Michael Parke, PIFSC
Korie Schaeffer, SWRO
David Stevenson, NERO
Tali Vardi, S&T
Waldo Wakefield, NWFSC
Pace Wilbur, SERO

Appendix 2: Workshop Agenda

National Habitat Assessment Workshop: Fisheries Science to Support NOAA's Habitat Blueprint

NWFSC Montlake Lab, Seattle, September 5-7, 2012

Tuesday, September 4

1:00 Restoration Project Field Trip
5:00-8:00 Registration, Silver Cloud Inn University Lobby

Wednesday, September 5

7:30 Registration, Montlake Lab

INTRODUCTORY SESSION

8:30 Introductory remarks, logistics (***Stephen Brown***)
8:40 Welcome (***John Stein***)
8:50 Remarks on the role of habitat science in fisheries management (***Richard Merrick***, *via video*)
9:10 Q&A with Chief Scientist
9:40 The NOAA Habitat Blueprint (***Brian Pawlak***)
10:00 Northwest Regional Initiative (***Will Stelle)***
10:20 Break
10:40 Can our habitat paradigm cross the land-sea boundary? (***John Manderson***)

PRIORITIZATION OF STOCKS FOR HABITAT ASSESSMENT

11:10 Prioritizing habitat assessments (***Stephen Brown***)
11:30 Lessons learned from implementing the prioritization process in the southwest region (***Korie Schaeffer***)
11:50 Question and answer session ***(Stephen Brown, Korie Schaeffer, Dale Sweetnam***)
12:10 Lunch

TOOLS FOR SUCCESSFUL HABITAT ASSESSMENT FOR FISHERIES

13:30 NOS products that help habitat scientists achieve NMFS core mission ***(Mark Fink-beiner***)
14:00 Seafloor Characterization for Trawlability and Fish Habitat Using the Simrad ME70 Multibeam Echosounder in the Gulf of Alaska (***Jodi Pirtle***, *UNH*)
14:30 Implementing the Coastal and Marine Ecological Classification Standard (CMECS) (***Garry Mayer, Mark Finkbeiner)***
15:00 Question and answer on CMECS implementation (***Garry Mayer, Mark Finkbeiner***)
15:30 Using environmental data to predict the effects of climate change on marine fisheries (***David Foley)***

16:00	Availability of OAR products that can help habitat scientists achieve NMFS core mission (***Craig Russell***)
16:30	Adjourn

17:30-19:30 POSTER SESSION at Northcut Landing, 5001 25th Avenue NE (across from hotel)

Thursday, September 6

INCORPORATING HABITAT INFORMATION IN STOCK ASSESSMENTS

This session will focus on how habitat information can contribute to improving fisheries stock assessments by reducing uncertainty in assessment data inputs or assessment model projections.

8:00	Introduction (***Kristan Blackhart***)
8:05	What assessment gaps need habitat information? Where could habitat-specific life history rates fit? (***Richard Methot***)
8:35	The implications of untrawlable habitats on bottom trawl surveys for West Coast groundfishes (***James Thorson***, *Elizabeth Clarke, Ian Stewart, André Punt*)
8:50	Expansion of oxygen minimum zones may reduce available habitat for tropical pelagic fishes (***Eric Prince***)
9:05	Incorporating temperature-dependent catchability in some Alaska flatfish stock assessments (***Thomas Wilderbuer***, *Buck Stockhausen, Ingrid Spies*)
9:20	Panel Discussion - (*Richard Methot, James Thorson, Eric Prince, Thomas Wilderbuer, Rick Hart*)
10:20	Instructions for breakout session (***Kristen Blackhart***)
10:25	Break
10:45	Breakout Session
12:00	Reports from breakout sessions
12:30	Lunch

RETHINKING ESSENTIAL FISH HABITAT

For their broadly defined ecosystems, each region will present the challenges associated with the changing nature of EFH given the move towards Ecosystem Based Fisheries Management (EBFM) plans, the challenges associated with designating EFH in dynamic (e.g. pelagic) habitats and under climate change, and the growing importance of non-fishery impacts to EFH (e.g. from ocean-based energy development).

13:30	Introduction (***Michael Parke, Waldo Wakefield***)
13:35	Northeast broad continetnal shelf (***David Stevenson***, *John Manderson*)
	Basin-scale models in Alaska's broad continental shelf (***Bob McConnaughey,*** *Matt Eagleton*)

14:05	Pacific Islands coral reefs (***Bob Schroeder***, *Michael Parke*), Caribbean coral reefs (***Jocelyn Karazsia,*** *Todd Kellison*)
14:35	California current (***Eric Chavez***, *John Stadler*, *Waldo Wakefield)*
	State of EBM in the context of EFH in the California current (***Yvonne deReynier***)
15:05	Instructions for breakout session (***Michael Parke, Waldo Wakefield***)
15:10	Break
15:30	Breakout Session
16:30	Reports from breakout sessions
17:00	Group discussion
17:30	Adjourn for the day

Friday, September 7

IMPROVING THE FLOW OF HABITAT SCIENCE INFORMATION TO MANAGEMENT

Each region will present the manner in which consultations currently utilize scientific information, successful examples of scientific information or tools included in EFH or FWCA consultations, and descriptions of one or two habitat management issues that affect many consultations and would benefit greatly from NOAA scientist attention.

8:00	Introduction (***Pace Wilber, Korie Schaeffer***)
8:05	Northeast Region (***Lou Chiarella***)
8:15	Southeast Region (***Pace Wilber***)
8:25	Southwest Region (***Korie Schaeffer***)
8:35	Northwest Region (***Michael Tehan***)
8:45	Alaska Region (***Matt Eagleton***)
8:55	Pacific Islands Region (***Bob Schroeder***)
9:05	Instructions for breakout session (***Pace Wilber, Korie Schaeffer***)
9:10	Break
9:30	Breakout Session
10:30	Reports from breakout sessions
11:00	Group discussion on recommendations to endorse
11:30	Closing remarks on workshop (***Stephen Brown***)
12:00	Adjourn workshop

APPENDIX 3: LIST OF WORKSHOP PARTICIPANTS

Name		Affiliation
Tim	Beechie	NWFSC
Laurel	Ben	AKFSC
Thomas	Bigford	OHC
Kristan	Blackhart	S&T
Christopher	Boelke	NERO
Raymond	Boland	PIFSC
Stephen	Brown	S&T
Eric	Chavez	SWRO
Lou	Chiarella	NERO
Lora	Clarke	S&T
Kimberly	Clements	SERO
Jason	Cope	NWFSC
Steve	Copps	NWRO
Sean	Corson	OHC
Russell	Craig	OAR-OER
Jaclyn	Daly	SERO
Gerry	Davis	PIRO
Yvonne	de Reynier	NWRO
Matthew	Eagleton	AKRO
Steve	Edmondson	SWRO
Mark	Finkbeiner	NOS-CSC
David	Foley	SF
Kurt	Fresh	NWFSC
Correigh	Greene	NWFSC
Melissa	Haltuch	NWFSC
Jeanne	Hanson	AKRO
Janine	Harris	OHC
Rick	Hart	SEFSC
Richard	Hartman	SERO
Ron	Heintz	AKFSC
Ron	Hill	SEFSC
Chris	Jordan	NWFSC
Jocelyn	Karazsia	SERO
Todd	Kellison	SEFSC
Kirsten	Larsen	S&T
Ben	Laurel	AKFSC
Terra	Lederhouse	OHC

Chris	Long	AKFSC
Jarad	Makaiau	PIRO
John	Manderson	NEFSC
Garry	Mayer	OHC
Bob	McConnaughey	AKFSC
Carey	McGilliard	AKFSC
Richard	Methot	S&T
Katharine	Miller	AKFSC
Tom	Minello	SEFSC
Martha	Nizinski	NEFSC
John	Olson	AKRO
Michael	Parke	PIFSC
Brian	Pawlak	OHC
George	Pess	NWFSC
Jodi	Pirtle	UNH
Eric	Prince	SEFSC
John	Quinlan	SEFSC
Phil	Roni	NWFSC
Craig	Russel	OAR-OER
Korie	Schaeffer	SWRO
Robert	Schroeder	PIRO
Linda	Shaw	AKRO
Ole	Shelton	NWFSC
John	Stadler	NWRO
Jennifer	Steger	OHC
Will	Stelle	NWRO
David	Stevenson	NERO
Kevin	Stierhoff	SWFSC
Rusty	Swafford	SERO
Dale	Sweetnam	SWFSC
Michael	Tehan	NWRO
James	Thorson	NWFSC
Tali	Vardi	S&T
Waldo	Wakefield	NWFSC
Pace	Wilber	SERO
Tom	Wilderbuer	AKFSC

APPENDIX 4: POSTER ABSTRACTS

A tidal creek restoration prioritization framework in the Charleston Harbor watershed

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In 2010, NOAA's National Marine Fisheries Service (NMFS) launched its Habitat Blueprint with the goal of implementing new habitat-based solutions to support healthy and productive ecosystems. With continued widespread loss and deterioration of coastal and marine habitats, NOAA recognized the need to increase the sustainability and productivity of our fisheries by focusing on protecting habitat and the coastal resources on which our communities depend. Tidal creeks, in particular, serve important services - fishery production, water quality, flood protection, and human health services – and, in the southeast, are designated as EFH under the federal fishery management plans for penaeid shrimp and select snapper/grouper species. As such, the Blueprint for NMFS' Southeast Region consists of a prioritized and spatially mapped inventory of current and select historical tidal creek and salt marsh restoration opportunities in the Charleston Harbor watershed, South Carolina. Sites in need of restoration were identified from compiling existing habitat assessments, local partner knowledge, and GIS-based desktop investigations. In total, we found opportunity to restore almost 5,000 acres of tidally-influences wetland habitat. We then developed a model for prioritizing tidal creeks for restoration using the following criteria: ecological value, acreage, creek order, nearby existing investments, and degree of current impairment to rank sites. The prioritization framework will be used to develop practical and ecologically meaningful mitigation and habitat restoration plans for large-scale public works projects, NOAA Community-based Restoration Program, Atlantic Coast Fish Habitat Partnership, Damage Assessment, Remediation and Restoration Program, or similar initiatives.

Evaluating the status of Puget Sound's nearshore pelagic foodweb

Correigh Greene, Casimir Rice, Linda Rhodes, Brian Beckman, Joshua Chamberlin, Jason Hall, Anne Baxter, and Sean Naman

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The pelagic zone is a large and important component of Puget Sound's ecosystem, but basic information is lacking on differences among oceanographic basins and the effects of anthropogenic activities. This dearth of information complicates our ability to identify useful metrics to measure the pelagic zone's key characteristics determining ecological health. To address these issues, we conducted a multi-trophic level assessment in six oceanographic basins within Puget Sound using a sampling scheme designed to detect both basin-wide differences and relationships between pelagic ecosystem attributes and land use in catchments surrounding sites. We measured over 20 potential indicators of nearshore pelagic ecosystem health at 79 sites in six oceanographic basins of Puget Sound. These metrics included measurements of abiotic conditions and nutrient availability, and abundance and diversity of phytoplankton, bacteria, zooplankton, jellyfish, and pelagic fish species. In many taxa from lower to middle trophic levels, and for a comprehensive suite of abiotic attributes, we observed strong seasonal and spatial structure. Furthermore, many of the potential indicators we measured were sensitive to land use, with a general pattern that abiotic and lower trophic patterns were most sensitive, and patterns in fish abundance and diversity were the least sensitive. We found positive relationships between land use and jellyfish abundance, as well as shifts of jellyfish diets to lower trophic levels in sites with greater land use. These findings provide empirical support for the bifurcated foodweb hypothesis, which predicts that stressors from development simplifies foodweb structure, leading to cascading effects on middle trophic levels like planktivorous salmon and forage fish, and favoring jellyfish and other consumers of microplankton. The strong spatial structure observed in our results indicates that different pelagic food webs exist across the system. Consequently, target conditions, current health status, or both, cannot be uniform across greater Puget Sound.

Habitat Suitability Modeling for Deep-Sea Corals in the Northeast and Mid-Atlantic Regions

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Deep-sea corals are a diverse and valuable resource, serving as important providers of habitat structure for fishes and invertebrates. Because of their slow growth rates and vulnerability to bottom disturbance, deep-sea coral ecosystems are of particular conservation concern. However, because of the logistical difficulty and expense of deep-sea exploration, much less is known about the distribution of deep-sea corals than their shallow-water counterparts. Predictive modeling of deep-sea coral habitat is essential to support conservation planning, planning of offshore activities affecting the seafloor, and targeting areas for future mapping and exploration. In this study we used the modeling technique known as Maximum Entropy (MaxEnt) to predict locations that may be suitable for corals based on presence-only records. We combined databases of known deep-sea coral locations assembled by NOAA's Northeast Fisheries Science Center (NEFSC) and Deep-Sea Coral Research and Technology Program (DSCRTP) with environmental and oceanographic predictor variables to generate predictive models of deep-sea coral distribution for the northeastern U.S. (Maine to North Carolina). Our results produced predictive habitat suitability maps and model evaluation statistics for the three main orders of corals (Alcyonacea (including Gorgonians and Non-gorgonians), Scleractinia, and Pennatulacea) found in the U.S. Northeast region. Model evaluation statistics included Test AUC and permutation importance. Test AUC was ≥ 0.8 for all three orders, highlighting the strong predictive power of the model. Permutation importance indicated the top three predictor variables of suitable habitat. These varied by order. Depth, slope (5km) and slope of slope (1500 m) were most important predictors for Alcyonacea habitat; depth, annual bottom salinity, and gravel for Scleractinia; and

depth, annual bottom dissolved oxygen, and mean phi for Pennatulacea. This is the first regional deep-sea coral predictive habitat model for the U.S. northeast/mid-Atlantic regions.

Cannibalism in red king crabs: Effects of habitat, predator interference, and predator size on the functional response

William Christopher Long, Jessica Popp, Laura Whitefleet-Smith, Katherine Swiney, Scott Van Sant

Kodiak Laboratory, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA

Red king crab (*Paralithodes camtschaticus*) juveniles are highly vulnerable to predation and generally seek out habitats that minimize their predation risk. In this study we perform a series of experiments to examine how habitat interacts with predator interference, predators reducing foraging efficiency though interactions with each other, and predator size to determine the predator functional response, or the effect of prey density on predation rate, on juvenile red king crabs. We used year-1 and year-2 red king crabs as predators and year-0 red king crab as prey. Trials were run in mesocosms with either a bare sand bottom or with macroalgae mimic, whole bivalve shells (shells), or crushed bivalve shells (shell hash) on top of sand at six prey densities. In the first experiment year-1 predators exhibited a type II functional response in sand, shell hash, and shell, and the predation rate was lower in shell than in shell hash or sand, but it did not differ between sand and shell hash. In the second experiment, year-1 predators exhibited minimal interference with each other at low prey densities. In the third experiment, year-1 predators exhibited a type II functional response in sand and a type I in the macroalgae mimic, while year-2 predators exhibited a type I functional response in sand and a type III in macroalgae mimic. For both sizes of predators predation was lower overall in the macroalgae mimic, though the difference in foraging efficiency was much greater for the year-2 predators. This work demonstrates that the functional response and predation risk for juvenile red king crabs varies with habitat, predator density, and predator size. Further, it shows that complex, three dimensional habitats are critical for the persistence of red king crab juveniles.

Northeast Regional Habitat Blueprint Initiative: Multibeam Mapping and Visual Survey Efforts Increase Knowledge of Deep-sea Coral Distributions and Diversity in Northeast Submarine Canyons

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Submarine canyons on the northeast continental shelf and slope are diverse and unique habitats that provide refuge for a variety of fauna. However, most canyons are poorly known, yet are of great interest to federal and state management agencies. Because of the prohibitive costs and lo-

gistical difficulties of surveying these areas, the Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) partnership was designed to make efficient use of research ships' resources, allowing for effective and efficient data collection, and capitalizing on complementary capabilities of NOAA assets to produce an integrated, coherent dataset. ACUMEN's goals included field efforts to support the NOAA Habitat Blueprint northeast regional initiative and NOAA Integrated Ocean and Coastal Mapping efforts, as well as sharing of data and data products across platforms to guide and refine expedition plans in near real-time. Priority areas along the continental shelf/slope from Virginia to Rhode Island were identified for exploration by NOAA and external partners. Five expeditions, conducted between February-August 2012, focused on submarine canyons, to gather baseline information to support science and management needs. The expeditions highlighted the complementary capabilities of three NOAA ships: *Okeanos Explorer*, *Ferdinand R. Hassler*, and *Henry B. Bigelow*. The *Hassler* and *Okeanos Explorer* collected high-resolution bathymetry data that was quickly processed into mapping products to inform the *Bigelow's* ground-truthing mission two weeks later. Scientists aboard *Bigelow* used these maps to identify habitats where deep-sea corals were likely to occur. The Woods Hole Oceanographic Institution's towed camera system was used to image these sites. Scientists collected contemporary, geo-referenced data on corals, validated a coral habitat suitability model, and identified coral hotspots. These data increased our knowledge of coral diversity and distribution exponentially. Results will direct future coral research planning efforts, guide regional Fishery Management Councils in development of coral protection zones, and revise/refine habitat predictive models.

Examples of Elwha Dam Removal Restoration Monitoring

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[2] Lower Elwha Klallam Tribe
[3]United States Geological Survey
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[6]WA Department of Fish and Wildlife

The purpose of evaluating the removal of the Elwha River dams is to determine if removal results in the establishment of self-sustaining salmon populations, and to identify the primary variables that influence salmon colonization success. With respect to both juvenile and adult salmon we are evaluating distribution and abundance, habitat conditions, wild/hatchery interactions, and ecosystem response.

Seafloor Characterization for Trawlability and Fish Habitat Using the Simrad ME70 Multibeam Echosounder in the Gulf of Alaska

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Groundfish that associate with rugged seafloor types are difficult to assess with bottom-trawl sampling gear. Simrad ME70 multibeam echosounder (ME70) data and video imagery were collected to characterize trawlable and untrawlable areas and to ultimately improve efforts to determine habitat-specific groundfish biomass. We surveyed areas of the Gulf of Alaska (GOA) (20-500 m depth) aboard the NOAA ship *Oscar Dyson* during 2011, from the Islands of Four Mountains in the Aleutians to eastern Kodiak Island. Additional ME70 data were collected opportunistically during the winter 2012 acoustic trawl surveys. ME70 data were collected continuously along the ship trackline (1-20 nmi spacing) and at fine-scale survey locations in 2011 with 100% seafloor coverage (n = 21). Video data were collected at fine-scale survey sites using a drop camera (n = 47 stations). ME70 data were matched to the spatial location of previously conducted AFSC bottom-trawl survey hauls (n = 582) and 2011 camera stations to discriminate between trawlable and untrawlable seafloor types in the region of overlap between the haul or camera path and the ME70 data. Angle-dependent backscatter strength, backscatter mosaics, and other multibeam metrics were extracted from the ME70 data at these locations. Haul locations show separation in backscatter strength based on performance, previously classified as successful or unsuccessful due to gear damage from contact with the seafloor. Successful haul locations have values that correspond to finer grainsize, or the lack of untrawlable features such as boulders and rock. A similar pattern was observed for the camera stations characterized as trawlable or untrawlable from video. The best descriptors for seafloor trawlability will be identified among multibeam metrics to map the predicted trawlability of the ME70 survey footprint. Continued opportunistic collection of ME70 data during *Oscar Dyson* operations will help refine existing classifications of untrawlable and trawlable areas in the GOA.

Tools and Strategies to Address Coastal Wetland Loss

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Wetlands in coastal areas are under pressure from numerous sources, both human (e.g., development, shoreline hardening) and natural (e.g., storms, sea-level rise). A 2008 report on wetlands in the coastal watersheds of the eastern United States concluded that between 1998 and 2004 more than 360,000 acres of wetlands in those watersheds were lost. To develop a better under-

stand of the underlying causes of this loss, the Environmental Protection Agency and NOAA co-led a series of workshops in specific watersheds around the country, focusing on those where the greatest amount of wetland loss was occurring. Although the locations were as diverse as Cape Cod, Massachusetts and Mississippi Sound, Mississippi, a number of common themes emerged.

Population growth and development, sea-level rise, and the limitations of regulatory programs (which can manifest as non-jurisdictional and/or unauthorized wetland losses) were identified as common stressors. In the north Atlantic region, tidal restrictions, dams, and excess nutrients create additional stress on aquatic systems. In the mid-Atlantic region, extensive shoreline armoring alters habitat and creates the need for more shoreline armoring. In the south Atlantic region, agriculture, silviculture, and significant alterations to hydrology compound the effects of development. In the Gulf of Mexico region, substantial losses of estuarine wetlands are accompanied by even greater losses of freshwater wetlands to development and silviculture.

To address these stressors, workshop participants identified tools and strategies that are currently successful and could be applied more widely. These varied regionally but included low-impact development, high-resolution mapping, watershed-based management, living shorelines, interagency collaboration, and public outreach and education. The use of living shorelines (as opposed to hard armoring) was identified as an important strategy and future policy priority for addressing shoreline stabilization at multiple workshops. Educating and empowering local governments was viewed as one way to address the limitations of federal and state wetland regulatory programs and successful examples of this included the local conservation commissions of Massachusetts and adoption of wetland minimum standards by counties in Florida. Unfortunately, although unauthorized and non-jurisdictional wetland loss was identified as a universal problem, very few successful approaches to address it currently exist. Future work through the National Ocean Policy and the Interagency Coastal Wetlands Working Group will strive to fill this need.

Northeast region habitat initiative: A partnership to develop a conservation strategy for deep-sea corals

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The New England and Mid-Atlantic Fishery Management Councils, in collaboration with the Northeast Regional Office and the Northeast Fisheries Science Center, are currently developing management measures for protecting deep-sea corals (DSC) from the effects of existing and future fishing activities using the discretionary authority of the Magnuson-Stevens Act. To date, DSC management alternatives rely primarily on observations of DSC during surveys on the outer continental shelf in the late 1970s and 1980s and on what is known or can be inferred about the suitability of deep-sea canyons as habitats for DSC. Two types of DSC protection zones have been identified for consideration: 1) a large area that extends from the edge of the continental shelf out to the outer limit of the Exclusive Economic Zone, and 2) a number of smaller discrete areas for 22 canyons, one area on the continental slope, four seamounts, and two areas in the Gulf of Maine. Final action to protect DSC in the region is expected by the end of 2014.

Data to Support a Review of Essential Fish Habitat for Pacific Coast Groundfish

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In this poster, we provide a summary of data used to support Phase I of a 5-year Review of EFH for 91 species of groundfish off the Pacific Coast of the US. We highlight some of the key products developed for this review and are now available to the public. Initial EFH designations were based on best available data developed from 2002 to 2005; NOAA's National Marine Fisheries Service (NMFS) approved these designations in May 2006. Beginning in 2010, the Pacific Fisheries Management Council (PFMC), Northwest and Southwest Fisheries Science Centers, and the NMFS Regions initiated the first mandatory 5-year review for EFH provisions of the groundfish Fishery Management Plan. In Phase I of this process, we evaluated the extent of new information available for the review and for potential modifications of current EFH designations. Sources of information included published scientific literature and unpublished scientific reports; solicitation of data from interested parties; and the review of previously unavailable or inaccessible data sets. Coast-wide maps were updated for (1) bathymetry and interpreted groundfish habitat types; (2) the distribution and extent of groundfish fishing effort (as potential impact to EFH); (3) the distribution and relative abundance of biogenic habitat (i.e., sponges and corals); and (4) spatial management boundaries (as potential mitigation of impacts). This poster emphasizes geospatial datasets. Additional new information has been identified, e.g., habitat associations for the 91 groundfish species, modeling efforts relevant to the determination and designation of EFH, non-fishing activities that may affect EFH, and new information on prey species. This new information, in the form of a written report and supporting Internet database, will be presented to the PFMC, its advisory bodies, and the public, at the Council's September 2012 meeting. Phase II of the process will include a six month public review period and NMFS internal review. As part of Phase II, the Council will solicit proposals to modify EFH and HAPC. This 5-year review represents a major update of the groundfish habitat assessment for the California Current and will have research and management applications well beyond satisfying the regulatory guidelines associated with EFH.

Beaver Dam Failure and Abandonment: Complexity Lost?

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Beavers (Castor canadensis) are frequently referred to as 'ecosystem engineers' because of the profound influence their dams and associated networks of dens, side-channels and pools have on the heterogeneity and complexity of the environments they occupy. Increasingly, beaver are being employed as a restoration agent, particularly in incised streams with homogenized habitat. Beaver dams promote aggradation that is hoped can increase floodplain connectivity and channel complexity. If actively colonized, a beaver dam complex might persist for decades or even centuries. As part of their natural cycle, some dams may come and go, alternating between occupation and abandonment, but eventually most are abandoned. However, when a dam is breached and abandoned, are the restoration benefits sought from beaver (e.g., richer habitat, greater degree of floodplain connectivity) lost? Beavers are starting to be used as restoration agents to promote bed aggradation, reconnection of channels with their floodplains and improvement of physical habitat complexity for fish. To rely on beavers to provide such passive restoration and ecosystem services, a clear understanding of the cyclic nature of beaver pond evolution is necessary. This poster shows one example of how channel complexity was not lost following a partial beaver dam failure & abandonment. In fact, a geomorphic change detection analysis demonstrated that the abandon beaver dam was a net sink for sediment accumulation following abandonment. Ongoing monitoring of this and other abandon sites will be used to assess how general this result is and how long it persists for. Eventually we hope to improve our theoretical understanding of the cycle of beaver pond evolution and provide better information to help restoration practitioners manage their expectations about the dynamic responses of such projects.

Southern California Bight Habitat Initiative: Characterizing Deep-water Demersal Communities In and Out of MPAs

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NOAA Fisheries and its partners will evaluate change in biodiversity, abundance, and size composition of demersal fish stocks and their habitat following the closure of selected areas of the Southern California Bight (SCB) to bottom-contact fishing gear. This study will enhance our understanding of the effectiveness of habitat conservation measures on rebuilding commercially valuable fish stocks and on the demersal communities of which they are a part. This information will help to tailor management measures that meet NOAA's conservation mandates more efficiently and with less economic impact. The results of the study will be provided to the Pacific Fishery Management Council (PFMC), which will allow them to assess the appropriate ways to successfully use fishing closures to rebuild fish stocks and associated habitats. Nationally, this study will provide much-needed information on the response of demersal habitats and fish stocks to the removal of fishing impacts to seafloor communities.

Incorporating environmental and habitat characteristics into the brown shrimp *Farfantepenaeus aztecus* stock assessment for the northern Gulf of Mexico

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The economic value of the Gulf of Mexico shrimp fishery has fueled over 50 years of research into the population dynamics of brown shrimp and the development of fishery production forecasting methods. Recently, emphasis has been placed on examining the mechanisms through which habitats influence growth and survival of juveniles in estuarine nurseries. The estuaries in the northern Gulf of Mexico associated with large shrimp populations are dominated by *Spartina* salt marshes. However, production of sub-adults from different estuaries can vary widely by location. Studies in Texas and Louisiana on juvenile brown shrimp have demonstrated that growth and survival in estuarine nurseries depend upon temperature, salinity, and access to emergent marsh vegetation. Modeling these highly dynamic variables and their interactions is a cognitively and mathematically complex task. Several brown shrimp models have been described including a spatial density model, individual based models, a bioenergetics model, and various correlative models. Currently we are working on a model whose output can be used as input to the most recent stock assessment model (Stock-Synthesis III) in an attempt to incorporate habitat data into the assessment.

Appendix 5. National Ocean Service Data Supportive of Fisheries Habitat Assessment

Derived Spatial Data

Data Type	Agency Source	Resolution/Scale	Dates	Coverage	Range	Format	Habitat Variables	Links
Shallow-Water Benthic Habitats	NCCOS/CCMA	0.25 acre	Variable, single-dates	Coral ecosystems: South Florida, Caribbean, Hawaiian Islands, Pacific Territories. Also selected NMS.	MHW to ~ -30 m	.shp	General substrate type, Dominant Biota	http://ccma.nos.noaa.gov/products/biogeography/
Shallow-Water Benthic Habitats	CSC	100 m^2	1995 - 2011	Selected mainland estuaries or state coasts	MHW to </= 10 m	.shp	General substrate type, Dominant Biota	http://www.csc.noaa.gov/digitalcoast/data/benthiccover
Land Cover	NERR/SWMP	~1:12,000	Variable, single-dates	NERR watersheds	Upland to intertidal zone	.shp	Dominant cover including wetlands, and riparian corridors	http://cdmo.baruch.sc.edu/get/landing.cfm
Land Cover	CSC/C-CAP	30 m^2	1995 - 2012 (5-year cycle)	National-coastal counties	Upland to intertidal zone	Imagine Image (.img)	Dominant cover including wetlands, and riparian corridors	http://www.csc.noaa.gov/digitalcoast/data/ccaphighres
Land Cover	CSC/C-CAP	</= 5m^2	2001-2009	Selected project areas in VI, Pacific Territories, Pacific Coast	Upland to intertidal zone	Imagine Image (.img)	Dominant cover including wetlands, and riparian corridors	http://www.csc.noaa.gov/digitalcoast/data/ccaphighres/
Shoreline	NGS	1:10K - 1:80K (OCS); 1:70K Med. Res.		National	MLLW and MHW	.shp	Dominant cover including wetlands, and riparian corridors	http://shoreline.noaa.gov/
Environmental Sensitivity Index Maps	ORR	1:24,000 &1:64,000 (AK)		National	MLLW	.moss, .shp, gdb, .pdf	Biologic resources, human impacts, spill sensitivity	http://response.restoration.noaa.gov/esi
Estuarine Bathymetry	SPO	30 m^2	1998	Selected estuaries nationwide	Subtidal zone	.dem	Bathymetry	http://estuarinebathymetry.noaa.gov/finddata.html
General Bathymetry	OCS		1800s - 2000s	National	Intertidal and subtidal zones	.dem	Bathymetry	http://ngdc.noaa.gov/mgg/bathymetry/hydro.html
								http://maps.ngdc.noaa.gov/viewers/bathymetry/
Non-charting Bathymetry	CSC	<= 10 m^2	2004-2007	Selected mainland estuaries	Subtidal zone	GRID, .tif	Bathymetry	http://www.csc.noaa.gov/digitalcoast/data/shallowwaterbathy
Non-charting Bathymetry	NCCOS/CCMA	<= 10 m^2	2004-2011	Caribbean Territories, Florida Deep Coral Areas, Stellwagen Bank NMS	Subtidal zone	GRID, .tif, .xyz, .xtf,.bag	Bathymetry	http://ccma.nos.noaa.gov/products/biogeography/usvi_nps/data/
Bathymetric Rugosity	NCCOS/CCMA	<= 10 m^2	2004-2007	Caribbean Territories, Florida Deep Coral Areas	Subtidal zone	GRID, tif	Rugosity	http://ccma.nos.noaa.gov/products/biogeography/
Bathymetric Slope	NCCOS/CCMA	<= 10 m^2	2004-2007	Caribbean Territories, Florida Deep Coral Areas	Subtidal zone	GRID, tif	Slope	http://ccma.nos.noaa.gov/products/biogeography/
Sea-Surface Temperature	Coastwatch	1 km^2 or 250 m^2	daily, weekly, or monthly composites	All U.S. Coasts, 6 Regional Nodes	Open ocean to shoreline	.hdf	Temperature, thermal fronts	http://coastwatch.noaa.gov/
Chlorophyll A	Coastwatch	2 km^2 or 250 m^2	daily, weekly, or monthly composites	All U.S. Coasts, 6 Regional Nodes	Open ocean to shoreline	.hdf	Productivity	http://coastwatch.noaa.gov/
Electronic Navigational Charts	OCS	1:10,000-1:1.500,000		All U.S. coasts	Open ocean to shoreline	.shp	Bathymetry	http://www.nauticalcharts.noaa.gov/mcd/enc/download_agreement.htm
Sediment & Benthic Grab Samples	CSC	N/A	1995 - 2009	Selected mainland estuaries	Nearshore subtidal areas	.shp	Sediment composition, infauna	http://www.csc.noaa.gov/digitalcoast/data/benthicgrab
Sediment Profile Imagery	CSC	< 1 m^2	1995 - 2003	Selected mainland estuaries	Nearshore subtidal areas	.shp	Sediment character, infauna	http://www.csc.noaa.gov/digitalcoast/data/benthicspi
Sediment Sample Descriptions	OCS	N/A	1800s - 2000s	Individual Samples Collected Nationally	Subtidal zone	tabular	Sediment character	http://ngdc.noaa.gov/geosamples/survey.jsp
Ocean Uses Data	MPA Center		2010	California, NH and southern Maine, NW HI	Shoreline to EEZ	.gdb	Human impact and contamination risk	http://www.mpa.gov/dataanalysis/ocean_uses/
Shellfish Growing Areas	SPO	1:70,000	1999	National	Intertidal and subtidal zones	.shp	shellfish suitability and harvest management	http://coastalgeospatial.noaa.gov/back_gis.html#shellfish
CTD Data	NERR/SWMP	N/A	1995 - Ongoing	4 sites per NERR	Subtidal near bottom	Tabular	temp, Sal, turbidity, depth, pH, DO	http://cdmo.baruch.sc.edu/get/landing.cfm
Tides and Currents Data	CO-OPS	N/A		Selected stations on U.S. coasts	Nearshore tidal stations	Tabular	Water levels and tidal regime	http://nowcoast.noaa.gov/
								http://www.tidesandcurrents.noaa.gov/products.html
ROV Video	NCCOS/CCMA	<10 m^2 field of view	2004-2007	Caribbean Territories	Nearshore subtidal areas	.shp, .tif	Biotic cover, general substrate character	http://www8.nos.noaa.gov/bhv/bhvMapBrowser.aspx
Salinity Zones	?	.03 mi^2	1999	132 U.S. estuaries	Nearshore subtidal areas	.shp	Salinity	http://coastalgeospatial.noaa.gov/data_gis.html

NOS Data Supportive of Fisheries Habitat Assessment

Source Spatial Data

Data Type	Agency Source	Resolution	Dates	Coverage		Format	Habitat Variables	
Aerial Multi-Spectral Imagery	NGS	0.5 m^2	Variable	National, coastal margin	Nearshore uplands and coastal waters		Nearshore and shallow submerged features	http://www.ngs.noaa.gov/web/APOS2/APOS.shtml
Aerial Multi-spectral Imagery	CSC	Variable, < 1 m^2	2002- Ongoing	Selected coastal areas	Nearshore uplands and coastal waters	.tif, .img	Nearshore and shallow submerged features	http://www.csc.noaa.gov/digitalcoast/data/highresortho
Multi-Beam Backscatter Imagery	CCMA	Variable, < 10 m^2	2004-2011	Caribbean Territories	Subtidal zone	.tif	Bottom hardness, rugosity, sediment physical characteristics	http://www.csc.noaa.gov/digitalcoast
Aerial Hyperspectral Imagery	CCMA	1 m^2	2000	Main Hawaiian Islands	Nearshore uplands and coastal waters	.sid	Nearshore and shallow submerged features	http://ccma.nos.noaa.gov/products/biogeography/hawaii_cd/data/

Guide to Acronyms:
CSC = Coastal Services Center
C-CAP = Coastal Change Analysis Program
CCMA = Center for Coastal Monitoring and Assessment
CO-OPS = Center for Operational Oceanographic Products and Services
IOCM = Integrated Ocean and Coastal Mapping
NCCOS = National Centers for Coastal Ocean Science
NERRS = National Estuarine Research Reserve System
NGS = National Geodetic Survey
NMS = National Marine Sanctuaries
OCS = Office of Coast Survey
ORR = Office of Response and Restoration
SPO = Special Projects Office
.bag = Bathymetric Attributed Grid
.gdb = ESRI Geodatabase
.hdf = Hierarchical Data Format

Appendix 6. National Ocean Service Tools Supportive of Fisheries Habitat Assessment

Fisheries Assessment Tools

Tool	Links
NMFS Toolbox	http://nft.nefsc.noaa.gov/
GIS Tools for Ecosystem Approaches to Fisheries Management	http://ccma.nos.noaa.gov/publications/TechMemoNCCOS75.pdf
NCCOS Overview of NOS EFH Products	http://ccma.nos.noaa.gov/products/biogeography/carib-efh/products.aspx
NCCOS Spatial Analysis Tools	http://http://ccma.nos.noaa.gov/about/biogeography/biogeo_prod.aspx

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Appendix 7. National Ocean Service Technical Information Supportive of Fisheries Habitat Assessment

Technical Information

Report Type	Agency Source	Time Frame	Scope	Links
CCMA Ecological Assessments	NCCOS/CCMA	Single-date	National in scope	http://ccma.nos.noaa.gov/products/biogeography/cinms/data/
				http://www2.coastalscience.noaa.gov/publications/
COAST Products and Tools	NCCOS/CCMA	Various	National in scope	http://ccma.nos.noaa.gov/about/coast/products.aspx
NMS Conditional Reports	NMS	5-year cycle	All NMS	http://sanctuaries.noaa.gov/science/condition/welcome.html
National Benthic Inventory	NCCOS/CCMA	1991 - ongoing	National in scope	http://www.nbi.noaa.gov/
COAST National Status and Trends	NCCOS/CCMA	Various	National in scope	http://ccma.nos.noaa.gov/stressors/pollution/nsandt/

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Appendix 8. National Ocean Service Data Access Nodes Supportive of Fisheries Habitat Assessment

Data Access

Portal Name	Agency Source	General Content	Links
NGDC Geodata Portal	NGDC	Hydrographic data, tools, and products	http://ngdc.noaa.gov/mgg/bathymetry/hydro.html
NOS Data Explorer Geoportal	NOS	Bathymetry, Environmental Monitoring, Geodesy, Hurricanes, Marine Boundaries, Nautical Charting, Remotely Sensed Imagery, Shoreline, Tides and Currents	http://nosdataexplorer.noaa.gov/NOSDataExplorer/catalog/search/search.page
CoRIS Geoportal	NOAA/CRCP, U.S. CRTF	Coral Reef data, Publications, Links	http://www.csc.noaa.gov/digitalcoast
Digital Coast	NOS/CSC	Data, Tools, Training, Case Studies	http://coris.noaa.gov/geoportal/
IOOS Data Catalog	Interagency	Real-time data bouy information	http://www.ioos.gov/catalog/
NCCOS Publications database	NOCS/NCCOS	Environmental Assessments, Fish Habitat Assessments	http://ccma.nos.noaa.gov/about/biogeography/prod_table.aspx
Marine Cadastre	NOS/BOEM	Framework Marine Data, Ocean Use Data, Physical Data, Navigation Data, Marine Mammal Data	
CO-OPS Data Access	NOS/CO-OPS	Tidal, water level and real-time oceanographic data	http://opendap.co-ops.nos.noaa.gov/
NODC Geoportal	NESDIS	Chemical and biological oceanographic data, Links to non-NOAA data	http://www.nodc.noaa.gov/General/getdata.html

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NGDC = National Geophysical Data Center