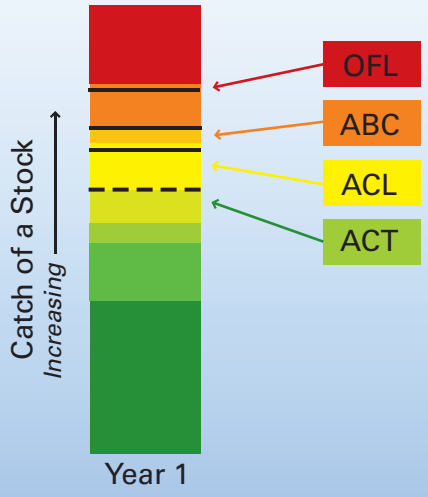
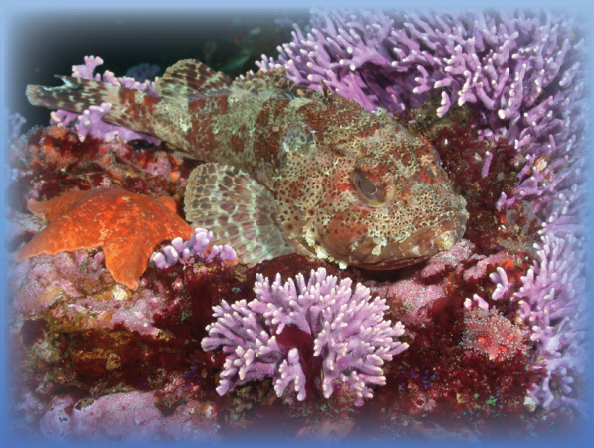
National Marine Fisheries Service

Joint National Stock and Habitat Assessment Workshops

St. Petersburg, FL • May 17-20, 2010

Program Guide





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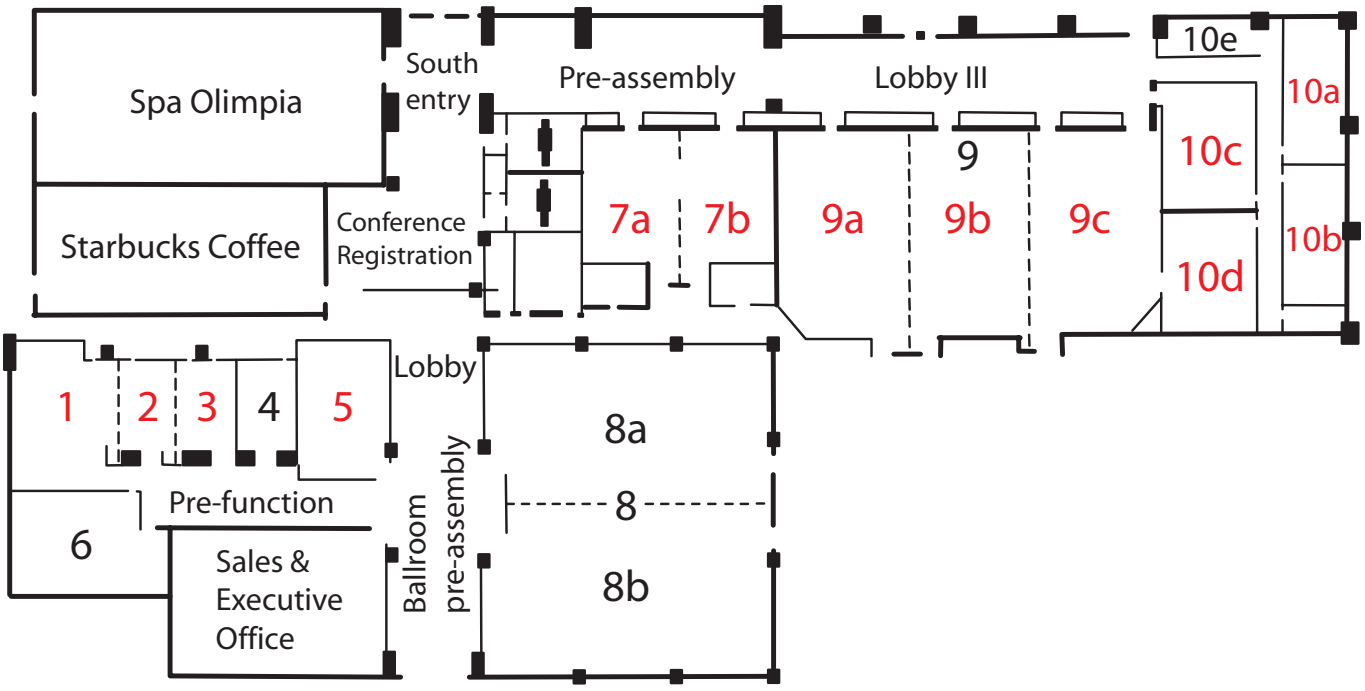


ROOM ASSIGNMENTS FOR NSAW-NHAW MEETINGS

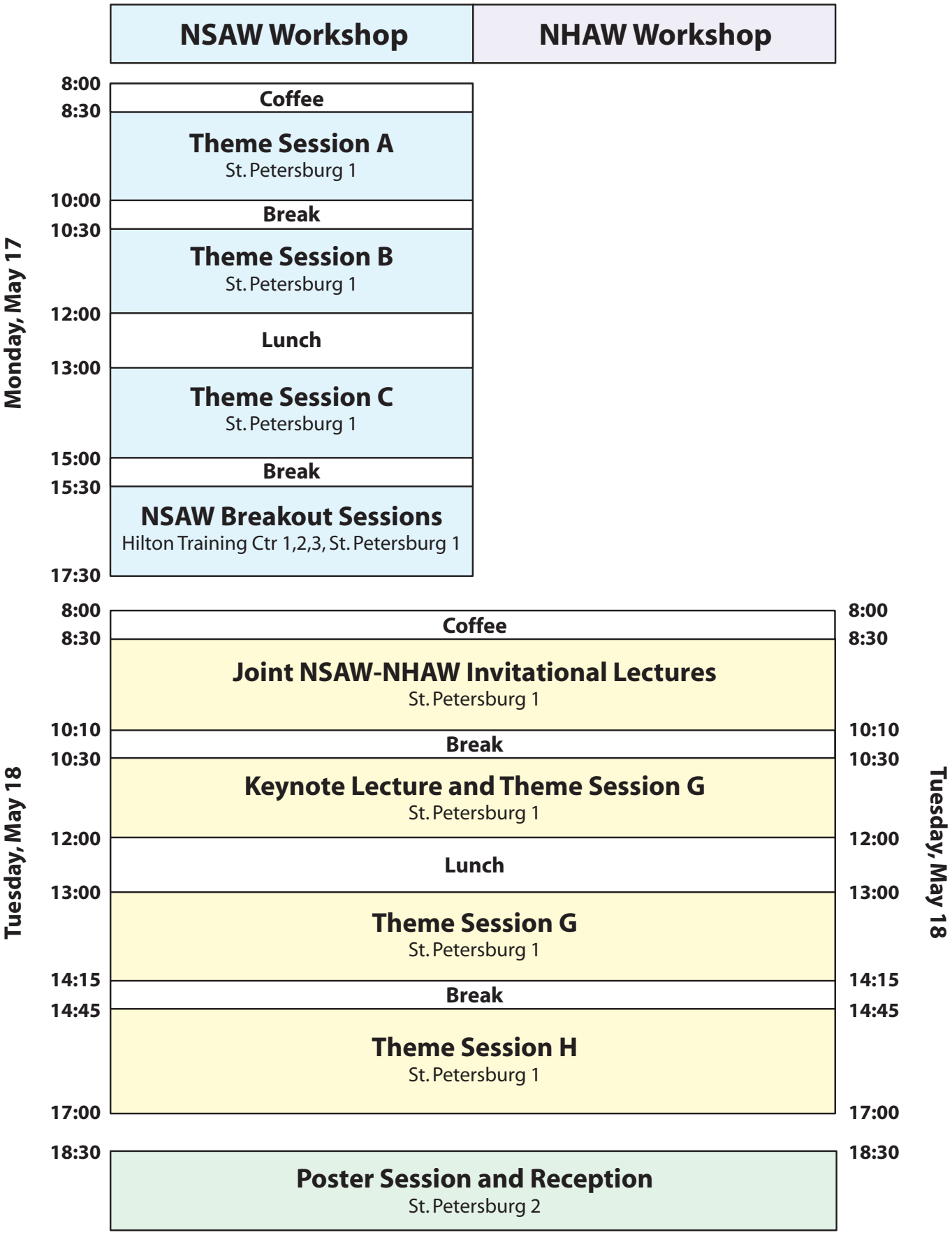
1. HARBORVIEW ..... Report writing (Fri)
2, 3. PIER-SKYWAY ..... ASTWG (Thur, Fri)
4. BOARDROOM
5. BAYBORO ..... Breakout Session (Thur)
6. PINELLAS ROOM

7. WILLIAMS & DEMENS
   - 7a. WILLIAMS ..... Breakout Session (Thur)
   - 7b. DEMENS ..... Breakout Session (Thur)
8. GRAND BAY BALLROOMS
   - 8a. GRAND BAY SOUTH
   - 8b. GRAND BAY NORTH

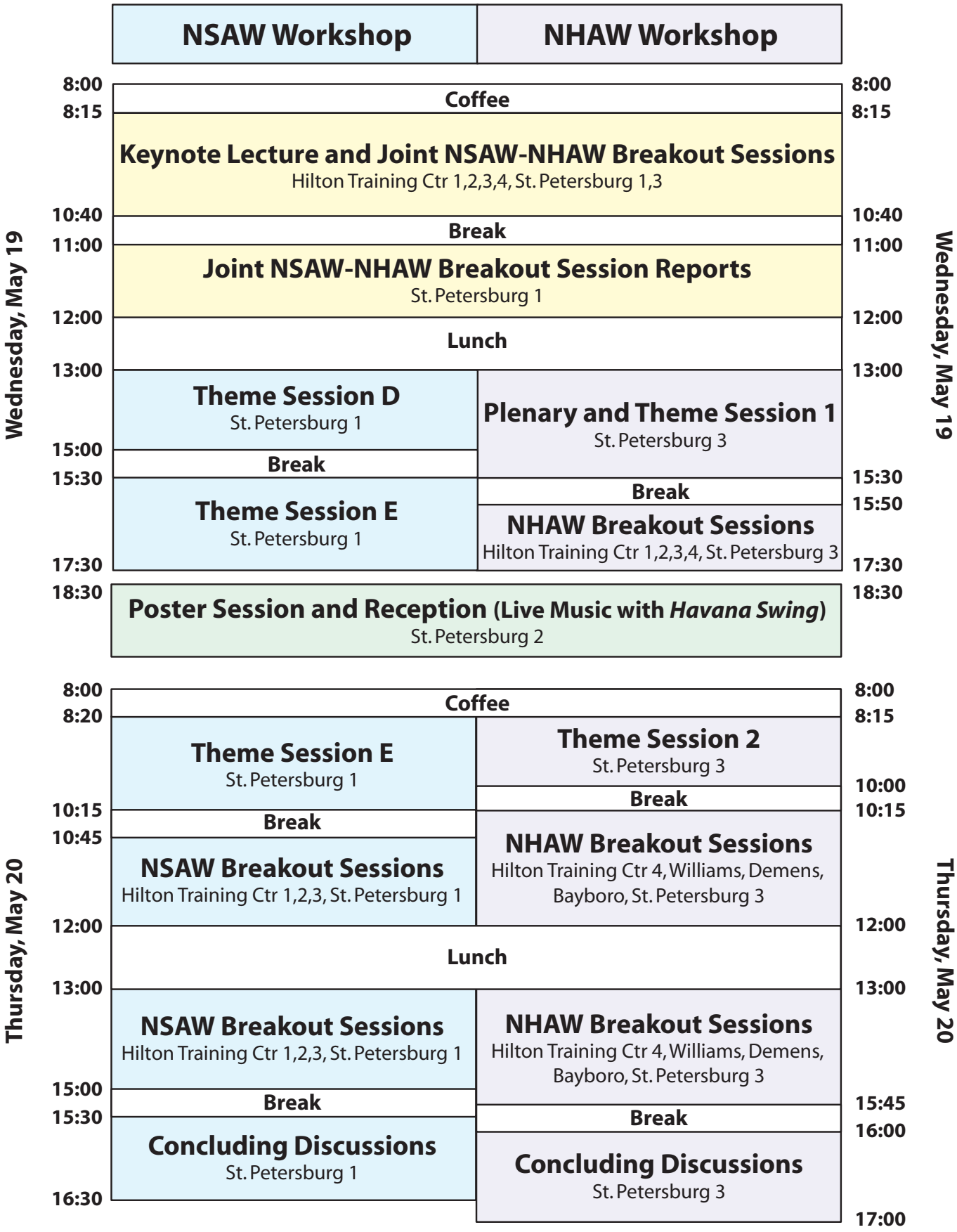
9. ST. PETERSBURG BALLROOM
   - 9a. ST. PETERSBURG 1 ..... NSAW and Joint Sessions (Mon, Tue, Wed, Thur)
   - 9b. ST. PETERSBURG 2 ..... Poster Session and Reception (Tue, Wed)
   - 9c. ST. PETERSBURG 3 ..... NHAW Theme Sessions (Wed, Thur)
10. HILTON TRAINING CENTER
   - 10a. HTC 1 ..... Breakout Session (Mon, Wed, Thur)
   - 10b. HTC 2 ..... Breakout Session (Mon, Wed, Thur)
   - 10c. HTC 3 ..... Breakout Session (Mon, Wed, Thur)
   - 10d. HTC 4 ..... ARA (Mon) and Breakout Session (Wed, Thur)

Contents

Schedule at a Glance



Schedule at a Glance



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Common Acronyms

AFSC	Alaska Fisheries Science Center
AKRO	Alaska Regional Office
NEFSC	Northeast Fisheries Science Center
NERO	Northeast Regional Office
NWFSC	Northwest Fisheries Science Center
NWRO	Northwest Regional Office
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SWFSC	Southwest Fisheries Science Center
SWRO	Southwest Regional Office
OST	Office of Science and Technology
OHC	Office of Habitat Conservation
OSF	Office of Sustainable Fisheries

Detailed Agenda

National Stock Assessment Workshop

Monday, May 17

Characterization of Scientific Uncertainty in Assessments to Improve Determination of Acceptable Biological Catches (ABC's)

8:00 Coffee
8:30 Welcome
8:40 Perspectives on current issues in fish stock assessments
Richard Methot

Theme Session A: Understanding the Trade-Off Between Simple and Complex Models

9:00 A1. Simple spreadsheet: Population models and policy simulations
Lombardi, Walters, Allen, Pine
9:20 A2. Determining yields for data-poor stocks using a DCAC-based stock reduction analysis of catch history
Dick, MacCall
9:40 Concluding discussions for Session A
10:00 **Break**

Theme Session B: Quantification of Uncertainty From Model Structure and Retrospective Patterns

10:30 B1. Addressing cohort-strength related ageing error in fisheries stock assessment
Hamel, Stewart
10:50 B2. Modeling recruitment along the continuum from data poor to data rich
Taylor, Methot
11:10 B3. Management strategy evaluation of a retrospective fix
Legault
11:30 B4. Reconciling uncertain and conflicting trends in petrale sole abundance
Haltuch, Hastie, Hicks, Whitmire
11:50 Concluding discussions for Session B
12:00 **Lunch**

Theme Session C: Addressing Uncertainty Due to Key Parameters, Especially Natural Mortality

13:00 C1. Estimating stock-recruitment steepness from life history information: A case study of North Pacific bluefin tuna, *Thunnus orientalis*
Brodziak, Mangel, DiNardo
13:20 C2. Incorporating egg predation by haddock into a population model for Atlantic herring
Richardson, Hare, Walsh
13:40 C3. An independent estimate of natural mortality for Atka mackerel using tagging data
McDermott, Ianelli, Lowe

14:00 C4. Do MPA's improve the ability to estimate biological parameters using an integrated stock assessment model?
Garrison, Punt
14:20 Concluding discussions for Session C
14:40 Review objectives for breakout sessions
15:00 **Break**
15:30 **Breakout Sessions**
Session 1: Protocols for ABC recommendations in data-poor situations
Session 2: Methods for quantifying uncertainty in assessments, including proxies for unmeasured variance components
Session 3: Evaluation of performance for ABC control rules; risk analysis; management strategy evaluation
Session 4: Addressing long-term climate/ecosystem factors affecting stock assessment and habitat
17:00 Reports from breakout sessions and concluding discussions
17:30 **Adjourn**

Wednesday, May 19

Characterization of Scientific Uncertainty in Assessments to Improve Determination of Acceptable Biological Catches (ABC's), Continued

Theme Session D: Incorporating Statistical Uncertainty From Sampling Error

13:00 D1. Specification of observation error variances
Thompson
13:20 D2. A hierarchical model to estimate relative catchability at size
Miller
13:40 D3. Mixture distribution models of Pacific rockfish schooling behavior
Thorson, Stewart
14:00 D4. Acoustical-optical surveys of coastal pelagic species, with emphasis on Pacific sardine, using improved allocation of effort, multifrequency acoustic methods, and a towed stereo camera system
Zwolinski, Cutter, Demer
14:20 D5. Trawl survey designs for reducing uncertainty in biomass estimates for patchily-distributed species
Spencer, Hanselman, McKelvey
14:40 Concluding discussions for Session D
15:00 **Break**

Theme Session E: Developing a Comprehensive Approach For Characterizing Uncertainty

15:30 E1. Calculating the uncertainty in fishery assessment forecasts
Methot
15:50 E2. Some aspects of scientific uncertainty in West Coast stock assessments
Ralston, Punt
16:10 E3. Dominant sources of scientific uncertainty in recent Gulf of Mexico stock assessments – implications for ACL's
Cass-Calay, Powers
16:30 E4. Estimating scientific uncertainty in ABC-control rules for Bering Sea Aleutian Islands (BSAI) crab stocks
Turnock, Foy, Hollowed, Punt, Rugolo, Stram
16:50 E5. Incorporating uncertainty into ABC control rules for Bering Sea Aleutian Islands (BSAI) crab stocks
Stram, Punt, Turnock, Rugolo, Foy, Hollowed

17:10 E6. Utilizing environmental information to reduce recruitment uncertainty in the Alaska sablefish stock assessment
Shotwell, Hanselman, Foley

17:30 **Adjourn**

18:30 **Poster Session and Reception - Live Local Music with *Havana Swing***

Thursday, May 20

Theme Session E: Developing a Comprehensive Approach For Characterizing Uncertainty, Continued

8:00 Coffee

8:20 E7. The relationship between MSY fishing rates (F_{MSY}) and productivity indices
Cope, Patrick, Methot

8:40 E8. Quantifying the tradeoff between precaution and yield in fishery reference points
Hart

9:00 E9. A review of harvest policies: understanding the relative performance of control rules
Deroba, Bence

9:20 E10. Setting allowable biological catch for stocks with reliable catch data only
Berkson, Barbieri, Cadrin, Cass-Calay, Cooper, Crone, Dorn, Friess, Kobayashi, Miller, Patrick, Pautzke, Ralston, Trianni

9:40 E11. Management uncertainty in the context of annual catch limits
Millikin, Tromble

10:00 Concluding discussions for Theme Session E

10:15 **Break**

10:45 **Breakout Sessions**
Session 1: Protocols for ABC recommendations in data-poor situations
Session 2: Methods for quantifying uncertainty in assessments, including proxies for unmeasured variance components
Session 3: Evaluation of performance for ABC control rules; risk analysis; management strategy evaluation
Session 4: Addressing long-term climate/ecosystem factors affecting stock assessment and habitat

12:00 **Lunch**

13:00 **Breakout Sessions, Continued**

15:00 **Break**

15:30 Reports from breakout sessions and concluding discussions

16:30 **Adjourn**

Joint Session of the National Stock and Habitat Assessment Workshops

Tuesday, May 18

Invitational and Keynote Lectures

8:00 Coffee
8:30 Welcome
Buck Sutter *Deputy Director, Southeast Regional Office*
8:40 Identifying the role of habitat science in NMFS
Ned Cyr *Director, Office of Science and Technology*
9:00 Developing and implementing the Habitat Assessment Improvement Plan
Mary Yoklavich *Southwest Fisheries Science Center*
9:20 Building and funding a national habitat science program in NMFS
Steve Brown *Office of Science and Technology*
9:40 The straight and narrow of fish stock assessment: getting to Acceptable Biological Catch
Richard Methot *Office of Science and Technology*
10:10 **Break**
10:30 Keynote Lecture: Informing and improving stock assessments with marine habitat information
Churchill Grimes *Southwest Fisheries Science Center*

Theme Session G: Incorporating Habitat Information into Stock Assessments

11:15 F1. A framework for incorporating climate impacts on pelagic ocean habitats into stock assessments
Hollowed, Greig, Logerwell, Wilson
11:30 F2. Incorporating the effects of an environmental regime shift in an assessment of Atlantic menhaden population dynamics
Quinlan, Schueller, Vaughan
11:45 F3. Insights for stock assessment and empirical pre-recruit indices from an environmentally forced individual-based model of early life history stages for West Coast rockfishes
Bjorkstedt, Ralston
12:00 **Lunch**
13:00 F4. A habitat-specific approach for incorporating environmental variation into stock forecasting models
Greene, Hall, Beamer, Pess
13:15 F5. Integrating habitat change and population dynamics: Using the Shiraz framework to evaluate salmon recovery efforts
Jorgensen
13:30 F6. Can habitat-based densities predict stock status in a heavily fished Caribbean gastropod?
Hill, McCarthy, Appeldoorn
13:45 F7. Can we use habitat information to derive prior distributions for virgin biomass of deepwater groupers and tilefish?
Walter, Cook, Lombardi, Quinlan
14:00 F8. Using statistical modeling and Ocean Observing Systems to identify fish habitat at broad scales: Potential applications for spatial planning, estimation of natural mortality, and reducing fisheries bycatch
Manderson, Kohut, Palamara, Grey, Oliver
14:15 **Break**

Theme Session H: Improving Calibration and Precision of Resource Surveys with Habitat Information

14:45 G1. Incorporating satellite derived environmental data with Gulf of Mexico pelagic longline observer data for the evaluation of bluefin tuna relative abundance and distribution patterns
Brown, Ramírez López, Quinlan

15:00 G2. Expansion of Atlantic croaker (*Micropogonias undulatus*) larval habitat on the northeast U.S. continental shelf
Walsh, Richardson, Hare, Marancik

15:15 G3. Habitat-specific survey methods to improve assessments of rockfishes off California and Alaska
Yoklavich, O'Connell

15:30 G4. Integrating benthic community structure data into a stratified random sampling design to improve reef fish abundance estimates in the Northwestern Hawaiian Islands
Helyer, Williams

15:45 G5. Collaborative Optically-assisted Acoustical Survey Technique (COAST) for surveying the distributions, abundances, and lengths of demersal fishes, by species
Demer, Butler, Cutter, Stierhoff, Byers, Murfin, Renfree, Mau, Sessions

16:00 G6. Using meso-habitat information to improve abundance estimates for West Coast groundfish: A test case at Heceta Bank, Oregon
Wakefield, Clemons, Stewart, Whitmire

16:15 G7. Modeling habitat relationships for rockfish to improve fishery independent survey biomass estimates
Rooper, Martin, Spencer

16:30 G8. Advances in conducting spatially-explicit, fishery-independent, ecosystem-based reef fish and habitat assessments
Bohnsack, Ruttenberg

16:45 Concluding discussions

17:00 **Adjourn**

18:30 **Poster Session and Reception**

Wednesday, May 19

Joint Session of the National Stock and Habitat Assessment Workshops, Continued

8:00 Coffee

8:15 Keynote Lecture: Are we running out of fish? And where will they live?
Steven Murawski *Director, Scientific Programs & Chief Science Advisor*

9:00 Charge to breakout groups, move to breakout rooms

9:15 **Breakout Sesssions**
Session 1: Using habitat information in survey design and analysis
Session 2: Including habitat-specific life history rates in population models
Session 3: Using time series of habitat information in population models

9:45 Breakout groups subdivide by habitat/species

10:40 **Break**

11:00 Report from breakout groups

12:00 **Lunch**

National Habitat Assessment Workshop

Wednesday, May 19

13:00 Welcome
Pat Montanio *Director, Office of Habitat Conservation*
13:15 Keynote Lecture: Confronting the ghosts of Christmases past: A new context for habitat assessments
John Boreman *Director (retired), Office of Science and Technology*
13:45 Outline session goals and objectives

Habitat Science in Support of Management, Session 1

14:00 Presentation: *An assessment of current processes for providing habitat science for management*
14:45 Panel Discussion: *Proposing alternatives to the current processes*
15:30 **Break**
15:50 Charge to breakout groups
16:00 Breakout Sessions: *Evaluating current Science Center, Regional Office, and Restoration Center interactions*
17:00 Report from breakout groups
17:30 **Adjourn**

18:30 **Poster Session and Reception**

Thursday, May 20

8:00 Coffee
8:15 Welcome

Habitat Science in Support of Management, Session 2

8:30 Presentation: *How do we develop long-term capacity in the Science Centers to meet management needs?*
9:15 Panel Discussion: *Proposing strategies for the development of habitat science capacity and the incorporation of habitat science into management*
10:00 **Break**
10:15 Breakout Sessions: *Evaluating strategies for the development of habitat science capacity and the incorporation of habitat science into management*
11:15 Report from breakout groups
12:00 **Lunch**

Habitat Science in Support of Management, Session 3

13:00 Breakout Sessions, organized by region: *How do we implement the proposed solutions in our region?*
15:00 Report from breakout groups
15:45 **Break**
16:00 Summary presentation: *Highlighting meeting accomplishments and identifying the next steps for habitat science and management*
16:30 Concluding remarks
17:00 **Adjourn**

Abstracts

*denotes presenting author

Keynote and Invited Speakers

Identifying the role of habitat science in NMFS

Ned Cyr

Office of Science and Technology, Silver Spring, MD

The continuing loss of marine and coastal habitats has been identified in the Magnuson-Stevens Act (MSA) as one of the "greatest long-term threats to the viability of commercial and recreational fisheries". The National Marine Fisheries Service (NMFS) has a mandated responsibility, via the MSA and other habitat-related legislation, to sustain marine fisheries and associated habitats. This requirement defines a unique role for NMFS in addressing the marine fisheries aspects of habitat science and providing the habitat information necessary to support informed management decisions. NMFS is working to develop a coordinated habitat science program that will deliver sound habitat science and make habitat information readily available for use by fishery managers. Improved habitat science information will find a wide number of uses throughout NMFS, including managing essential fish habitat, habitat restoration, stock assessment, integrated ecosystem assessment, coastal and marine spatial planning, understanding climate change, and ecosystem-based fishery management.

Developing and implementing the Habitat Assessment Improvement Plan

Mary M. Yoklavich

SWFSC, Santa Cruz, CA

The Habitat Assessment Improvement Plan (HAIP) is the first nationally coordinated plan to focus on the marine fisheries aspects of habitat science. It addresses the lack of knowledge regarding the association of marine species and their habitats, which impedes effective fisheries and habitat management, protection, restoration, and stock assessment. Questionnaire responses from NMFS managers and scientists indicated a lack of habitat-specific data, staff to collect such data, and knowledge of interactions within the ecosystem. The HAIP establishes the framework for NMFS to coordinate habitat research, monitoring, and assessments and to increase support for habitat science. The goals of the HAIP are to: 1) Assist NMFS in developing a habitat science program; 2) Improve our ability to identify Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern; 3) Provide information needed to assess impacts to EFH; 4) Reduce habitat-related uncertainty in stock assessments; 5) Facilitate a greater number of stock assessments that explicitly incorporate ecosystem considerations and spatial analyses; 6) Contribute to assessments of ecosystem services (i.e., the things people need and care about that are provided by ecosystems); and 7) Contribute to ecosystem-based fishery management, integrated ecosystem assessments, and coastal and marine spatial planning.

Building and funding a National Habitat Science Program in NMFS

Stephen K. Brown

Assessment and Monitoring Division, Office of Science and Technology, Silver Spring, MD

The team charged with developing the *Habitat Assessment Improvement Plan* (HAIP) has completed this task, which re-

quired about two years from start to finish. The NMFS Science Board has asked that this excellent team continue to work on implementing the *Plan*. This will be a more complex task in which the HAIP team, and NMFS as a whole, will have less control over events and outcomes. Success will depend on persistence, creativity and flexibility, and the merit of the ideas we generate and the initiatives we pursue.

The HAIP provides recommendations that should be addressed. We will need to develop new budget and staffing initiatives, because it is obvious that additional funding is needed. It is also apparent that existing partnerships will have to be strengthened, and new partnerships developed. On one hand, it's no secret that the Federal budget is under considerable strain, so funding for new programs, no matter how important they may seem, is likely to be quite limited in the foreseeable future. On the other hand, many entities within NMFS, within other NOAA line offices, and in other federal and state agencies, as well as in academia and the private sector, have needs for better habitat science. They also have resources, expertise, and potential sources of funding to bring to the table.

The HAIP contains other recommendations that can be implemented with little or no new funding. Many of these require changes in how we do business and how we relate with one another. Holding the 1st National Habitat Assessment Workshop, bringing together habitat scientists, stock assessment scientists, and habitat managers involved with habitat protection and habitat restoration is an important first step in bringing about these changes. This should be followed by concerted efforts to carry out ideas generated at the NHAW, as well as efforts to follow up on other recommendations of the HAIP. These include developing criteria to prioritize stocks and geographic areas that would benefit from habitat assessments, identifying and prioritizing data inadequacies for stocks and their habitats, implementing demonstration projects (we're already doing this!), convening additional regional and national workshops focused on habitat science and management issues, etc.

In the Forward to the HAIP, John Boreman, the recently retired Director of the NMFS Office of Science and Technology and prime instigator of the HAIP, closes by saying, "Now that we finally have the ball in play, let's not drop it." I'm looking forward to the group in this room, and to our colleagues around the agency and around the nation, to taking up this challenge. It'll be hard work, but it'll be worth it.

Informing and improving stock assessments with marine habitat information

Churchill B. Grimes*, Stephen Ralston, John C. Field, Brian Wells, and Mary M. Yoklavich

SWFSC, Santa Cruz, CA

Habitat degradation and destruction have long been recognized as among the principal causes of declining marine fish stocks. However, it was not until the 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act that NMFS was given statutory responsibility to incorporate habitat considerations into fishery management plans. Since that time the use of habitat information by scientists to inform and improve stock assessments has proceeded at a slow pace. For this presentation we define habitat as the space in which any life stage of fish species live as defined by any relevant physical and biological variables. For example, pelagic habitat might be described by such variables as upwelling, Ekman transport, sea surface temperature, chlorophyll concentration, and ocean environmental indices (e.g., PDO, ENSO), and benthic habitat by substratum type (e.g., rock, clay, reef), bottom temperature, depth, and vegetative cover (e.g., kelp, seagrass). Several species and habitat types will be used as examples of how habitat variables affect distribution, growth, recruitment, and natural and fishing mortality and potentially could be used to improve stock assessments.

Are we running out of fish? And where will they live?

Steven A. Murawski

Director, Scientific Programs and Chief Science Advisor, Silver Spring, MD

NOAA Fisheries Service is responsible for managing the Nation's marine fisheries, and for providing the best available science upon which management decisions must be based. Recovery of depleted fishery populations has become a consistent and increasingly important theme in national and international environmental negotiations and commitments regarding sustainability. We're not running out of fish, but we recognize that there are real concerns to be addressed for sustaining our fisheries in the future, and for increasing the economic and social benefits we obtain from them. We know that many of stocks are being sustainably fished, but that quite a few aren't. We also know what we don't know. The U.S. Ocean Policy Task Force specifically has called for the "protection, maintenance, and restoration of populations and essential habitats supporting fisheries, protected species, ecosystems, and biological diversity" to support ecosystems as one of its priority objectives. More and better data, and more broadly based management approaches for managing our Nation's marine ecosystems, are needed. It is clear that if we are to recover the majority of stocks classified world-wide as "overfished", it will take a more holistic, adaptive and ecosystem-based approach to fishery recovery that incorporates trophic dynamics, habitat protection and restoration, and climate effects, and is sensitive to life history and previous impacts of fisheries on stock resilience. Science supporting the implementation of ecosystem-based principles chiefly requires information on species interactions, climate-species relationships, and habitat-species dependencies. Basic habitat information including where important habitat is located and its condition are lacking for many species, and traditional assessment methods can not be used for many stocks due to habitat challenges. In addition, these basic categories of habitat science are needed to conduct Integrated Ecosystem Assessments, which are poised to boost the successful application of ecosystem based management (EBM). Without such information, environmentalists urge precautionary management, while existing use sectors demand more specificity in the issues to be considered under the EBM rubric, as well as an accounting of how current management fails to address important issues. A new, more effective, consistent, and politically supported stock recovery paradigm is necessary if society is to eventually meet its articulated sustainability goals for global fisheries.

Confronting the ghosts of Christmases past: A new context for habitat assessments

John Boreman

North Carolina State University, Department of Biology; formerly Director, Office of Science and Technology

The concept of a habitat assessment workshop is not new. Several similar attempts have been made by NMFS over the past 25 years – all have failed. Reasons for the failures include lack of standardized methods for habitat assessments, an essentially undefined role for habitat assessment in NMFS, and, most importantly, lack of buy-in from NMFS leadership. What is different this time, and how can the problems that plagued past attempts be avoided?

National Stock Assessment Workshop

Theme A: Understanding the Trade-off Between Simple and Complex Models

A1. Simple spreadsheet: Population models and policy simulations

Linda Lombardi[1,3]*, C. Walters[2,3], M. Allen[3], and W.E. Pine[3]

[1]SEFSC, Panama City, FL; [2]University of British Columbia, Fisheries Centre, Vancouver, BC; [3]University of Florida, School of Forest Resources and Conservation, Fisheries and Aquatic Sciences Program, Gainesville, FL

The simplest way to learn population dynamics is to use spreadsheet models. Spreadsheets allow the user to explicitly control the number and type of input parameters. Model complexity can range from surplus production and delay difference models incorporating recruitment anomalies, to stock synthesis and virtual population analysis involving age-specific growth, mortality, fecundity, selectivity and vulnerability vectors. Visually, basic graphics display how manual manipulations of parameters (e.g., exploitation, catchability, stock-recruitment relationship) affect the overall population levels. Alternative policy scenarios involving increased exploitation, closed areas, or changes in minimum size limits can also be simulated. Maximum likelihood parameter estimation and policy optimization can be done simply using the efficient Solver GRG algorithm. These methods are not only a useful tool for beginner assessment scientists but can be implemented by advanced modelers to test the results of more complicated assessment models. Simple spreadsheet stock assessment models can also provide a common platform for fisheries analysts and stakeholders to examine assessment model design, assumptions, uncertainties and outputs, given that spreadsheets are commonly used by citizen stakeholders in their daily lives.

A2. Determining yields for data-poor stocks using a DCAC-based stock reduction analysis of catch history

E.J. Dick* and Alec MacCall

SWFSC, Fisheries Ecology Division, Santa Cruz, CA

We describe a method for determining reasonable yield for data-poor species. Data requirements include estimates of annual catch, approximate natural mortality rate and age at maturity. The method produces management reference points concerning yield (OFL and MSY) and biomass ($B_{unfished}$, B_{MSY}, and $B_{current}$). The approach merges stochastic stock-reduction analysis (Walters et al., 2009) and depletion-corrected average catch (DCAC; MacCall, 2009), and is useful when only catch and basic life history data are available. Uncertainties in natural mortality, stock dynamics, optimal harvest rates, and stock status are incorporated using Monte Carlo simulation. Comparison of model outputs to data-rich stock assessments suggest that our method is effective, along with DCAC, for estimating sustainable yields for data-poor stocks with variable, but not highly episodic, recruitment.

Theme B: Quantification of Uncertainty from Model Structure and Retrospective Patterns

B1. Addressing cohort-strength related ageing error in fisheries stock assessment

Owen Hamel* and Ian J. Stewart

NWFSC, Seattle, WA

Age data are important in stock assessment for estimation of parameters such as growth rate, age of maturity, fecundity at age, natural mortality rate and recruitment. Unfortunately, age estimates are often subject to considerable error. Even given modern otolith annulus counting techniques, there continues to be substantial uncertainty in ages as shown by double read analy-

sis as well as various validation methods. Ageing uncertainty is typically included in stock assessments via lab- or era-specific ageing-error matrices, which generally result in improvements in both parameter estimation and fits to age data. In the course of the 2009 Pacific hake (*Merluccius productus*) stock assessment, however, poor fits to strong year classes were consistently seen, despite the use of ageing error matrices. We concluded that the most likely mechanism underlying these poor fits was the heretofore suspected tendency for structures with uncertain age determinations to be assigned to predominant year classes. The Pacific hake stock is characterized by infrequent strong year classes, typically surrounded by average and below average cohorts. This results in reduced mis-ageing of strong year classes, and perhaps increased mis-ageing of adjacent year classes. Results from the most recent Pacific hake stock assessment demonstrate the advantages of this technique through improved fitting of age data, and therefore improved estimation of year class strength. The 'strong cohort effect' is a potential problem for any species with appreciable ageing imprecision and a high degree of recruitment variability.

B2. Modeling recruitment along the continuum from data poor to data rich

Ian G. Taylor[1,2]* and Richard D. Methot, Jr.[3]

[1]NWFSC, Seattle, WA; [2]University of Washington, Seattle, WA; [3]Office of Science and Technology, Seattle, WA

Many stocks have adequate data, at least for recent years, to indicate that annual variability in recruitment plays a role in population dynamics, but insufficient data to precisely estimate recruitment values for all years with known removals. In these cases, the use of a spawner-recruit relationship with a penalty on deviations in recruitment provides a middle ground between biomass dynamics models and models with freely estimated recruitment in all years. The variability in the recruitment estimates around the spawner-recruit curve is shown to be a function of both the underlying population process and the amount of information in the data about this process. Therefore the data-richness needs to be accounted for in making a bias adjustment to the lognormal distribution typically used to model recruitment variability because the mean of the lognormal distribution is a function of the variance. A method of using the standard error of the estimated recruitment deviation parameters to refine this bias adjustment is presented.

B3. Management strategy evaluation of a retrospective fix

Chris Legault

NEFSC, Woods Hole, MA

Retrospective patterns in a stock assessment are an indication of model mis-specification, where a parameter or a process has a temporal component that is not included in the model dynamics. Three commonly investigated sources of retrospective patterns are 1) misreporting of catch, 2) a change in the natural mortality rate, and 3) a change in the survey catchability. Each of these sources can be used in a population simulator to create datasets for stock assessment models that will exhibit retrospective patterns similar to those observed in actual assessments. The timing of the change can be identified using a moving window analysis. However, the true source of the retrospective pattern cannot be identified. One approach to reduce the retrospective pattern is to split the survey time series at the time identified through the moving window analysis. A management strategy evaluation (MSE) is used to evaluate the consequence of applying this retrospective fix when the true source of the retrospective pattern is one of the three described above. The MSE uses the population simulator, virtual population analysis, and age-based projection programs from the NOAA Fisheries Toolbox along with a simple management rule to compare the ability to achieve the desired management objective with and without the retrospective fix. Preliminary results indicate that splitting the survey time series works as a retrospective fix no matter which of the three sources is the cause of the retrospective pattern.

B4. Reconciling uncertain and conflicting trends in petrale sole abundance

Melissa A. Haltuch*, James D. Hastie, Allan Hicks, and Curt E. Whitmire

NWFSC, Seattle, WA

Petrale sole are a commercially important flatfish that migrate seasonally between feeding and spawning grounds, and have recently been declared overfished. The summer trawl survey shows a decline in petrale sole abundance since 2005 similar to the unstandardized summer catch per unit effort (CPUE) from the fishery. However, many stakeholders disagree that petrale sole abundance has been declining, instead choosing to focus on the unstandardized winter CPUE that shows a strong increase beginning in 2000. The assessment attributes the increasing trend in winter CPUE to management actions that forced the fleet to 1) increase fishing effort during the winter, and 2) conduct winter fishing in locations with high historical catch rates. Standardized fishery CPUE was not used in the assessment due to changing management regulations beginning in the late 1990s and the high likelihood of a winter CPUE index showing hyper-stability due to the fishery focusing on the aggregated spawning stock. Given the potential discrepancy between the assessment results and the experience of the groundfish fleet, particularly during the winter fishing season, and the limited conclusions that can be drawn from unstandardized CPUE, this work explores the utility of the summer and winter fishery CPUE series as indices of abundance for the petrale sole stock assessment. The ultimate goals are to determine if an adequate index of abundance can be created using fishery CPUE, and to address the uncertainty due to the discrepancy between the fishery-independent and fishery-dependent data sources and therefore the perceived stock assessment uncertainty.

Theme C: Addressing Uncertainty Due to Key Parameters, Especially Natural Mortality

C1. Estimating stock-recruitment steepness from life history information: a case study of North Pacific bluefin tuna, *Thunnus orientalis*

Jon Brodziak[1]*, Marc Mangel[2], and Gerard DiNardo[1]

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The relationship between spawning stock and the resulting offspring added to the population (recruitment) is a fundamental research problem in fisheries science. The steepness of the stock-recruitment relationship is commonly defined as the fraction of unfished recruitment obtained when spawning biomass is 20% of its unfished level. Steepness has become widely used in fishery management, where it is usually treated as a statistical quantity. Here, we investigate the reproductive ecology of steepness, using biomass dynamics and age-structured models with compensatory recruitment dynamics. We show that if one has sufficient life history information to construct a density-independent population model then one can derive an associated estimate of steepness. Thus, steepness cannot be chosen arbitrarily. Given that survival of recruited individuals fluctuates randomly within a stock, a prior distribution for steepness can be estimated using Monte Carlo simulation and information about early life history survival and demographic parameters. We apply our approach to estimate a Bayesian prior distribution for steepness of North Pacific bluefin tuna (*Thunnus orientalis*) and discuss an extension for depensatory recruitment dynamics. We show that assuming that steepness is unity when recruitment is considered to be environmentally driven is not biologically consistent and leads to the wrong scientific inference.

C2. Incorporating egg predation by haddock into a population model for Atlantic herring

David E. Richardson*, Jonathan A. Hare, Harvey J. Walsh

NEFSC, Narragansett, RI

Predation on the early life stages of marine fishes may be a source of interannual and multidecadal variability in recruitment. However, quantifying predation-related mortality of eggs and larvae has proven difficult, hampering attempts to incorporate predation into population models. We developed an egg predation model to estimate the survival rate of Atlantic herring eggs on Georges Bank from haddock predation. The model assumed that larval herring abundance was a function of herring spawning stock biomass and egg survival from haddock predation, and that haddock exhibit a type III functional feeding response. Model parameters were estimated with time series of larval herring abundance, haddock predation intensity and herring spawning stock biomass from 1971-2005. The egg predation model was then incorporated into a herring population model that included a Beverton-Holt model describing the relationship between larval abundance and recruitment at age 2 y, and parameters accounting for growth, maturity, natural mortality and fishing mortality. The population model indicates that Georges Bank Atlantic herring have alternate stable equilibrium population levels and that fishing mortality or changes in haddock predation intensity can drive the population between high and low states. The model also indicates that a population collapse can occur even if fishing is maintained well below F_{MSY}. More specifically, the model predicts that the Georges Bank herring population will collapse with the recent recovery of the Georges Bank haddock population, a prediction that is supported by the declining abundance of herring since 2006 in a compilation of 14 fisheries-independent time series. These findings highlight the importance of integrating species interactions into population models.

C3. An independent estimate of natural mortality for Atka mackerel using tagging data

Susanne McDermott*, James N. Ianelli, Sandra A. Lowe

AFSC, Seattle, WA

The importance of reliable natural mortality (M) estimates has long been recognized for stock assessments as applied for fisheries advice. M is often confounded with other parameters (e.g., selectivity and catchability) and tagging studies hold promise to avoid these problems. For Atka mackerel (*Pleurogrammus monopterygius*) assessments in Alaska, M estimates have been derived from life history parameter correlates. Information outside the assessment is needed to configure appropriate prior distributions of M. Tagging data provide a means to estimate natural mortality independent of fishery or life history data. In this study a model of 3 years of tagging data from two distinct aggregations in the Aleutian Islands is proposed to estimate natural mortality. Preliminary results indicate that tagging data can provide supplemental information to stock assessments. However, more data are needed to validate assumptions from the tagging model (e.g., that the estimates reflect a long term average for the population or apply only for the period areas considered in the study).

C4. Do marine protected areas improve the ability to estimate biological parameters using an integrated stock assessment model?

Thomas M. Garrison[1]* and André E. Punt[2]

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Marine protected areas (MPA's) have gained popularity recently as an effective tool for the conservation and long-term protection of marine resources. However, their effectiveness from a traditional fisheries management perspective remains equivocal. One of the argued fisheries management benefits of an MPA is that because there is no fishing inside of the protected

area, it may be possible to precisely estimate the rate of natural mortality and better determine growth and maturity rates, parameters that are often assumed pre-specified in a stock assessment. This study aims to assess the degree to which having an MPA increases the ability to directly estimate these parameters in a integrated stock assessment model (Stock Synthesis), how long it would take for these benefits to be reflected in improved estimates of management quantities (e.g., B_{MSY}), and the extent to which these improvements will be reduced or lost if there is spillover of adults from the MPA. An age- and length-structured two-area simulation model has been parameterized for two generic fish with contrasting life-histories, a short-lived high-productive and long-lived low-productive species. This model forms the basis for a Monte Carlo simulation which examines the benefits of data from an MPA on estimation performance for Stock Synthesis. Preliminary results indicate that the extent of improvement in estimation of growth and maturity parameters from an MPA are slight compared to directly estimating these quantities using fishery data. Estimation of natural mortality from an MPA, however, does substantially improve estimation.

Theme D: Incorporating statistical uncertainty from sampling error

D1. Specification of observation error variances

Grant G. Thompson

AFSC, Resource Ecology and Fisheries Management Division, Seattle, WA

Except for pure process error models, all stock assessment models require specification of observation error variances. However, there appears to be no consensus among practitioners as to how this should be done. One school of thought holds that the specified variances should be equal to the values implied by the respective sampling designs. A problem with this approach is that the distributional assumptions included in 'off the shelf' stock assessment packages may not correspond to the actual sampling designs. For example, most stock assessment packages assume that age/size composition data are drawn from a multinomial distribution, but actual sampling may violate the multinomial assumption. In such cases, it is necessary to compute a multinomial sample size that produces a variance equal to that from the actual sampling distribution. An example will be given in this talk. A second school of thought holds that the specified variances should be larger than those implied by the respective sampling designs, so as to compensate for any process error not included explicitly in the model. These larger values are typically determined within the stock assessment model itself by iterative re-weighting. However, this practice is at best an approximation, as it can be shown that adjusting observation error variances cannot compensate completely for un-modeled process error. Moreover, this practice has the effect of adding parameters to the model, thus tending to increase the variances of estimates in general. As an alternative, this talk will demonstrate that it is better to model the process error explicitly.

D2. A hierarchical model to estimate relative catchability at size

Tim Miller

NEFSC, Woods Hole, MA

Annual trawl surveys supply important information on relative abundance to stock assessment models. Sometimes the vessel or gear changes due to new technology or aging equipment and the new vessel/gear configuration will sample populations differently from the old one. To use both sources of information, we must measure the differences in catchability of the old and new survey gear/vessel configurations. The catchability of a survey is often thought of as a constant value across all tows made with a particular gear/vessel configuration, but it can vary from tow to tow due to random variation in the environment and towing procedures. In most cases, the problem will be further complicated by differences in catchability across sizes of individuals. At the NEFSC, the *Henry B. Bigelow* replaced the *Albatross IV* in 2009 as the bottom trawl survey vessel and new gear and fishing protocols were also implemented. Over the course of 2008, a paired-tow study was conducted to provide conversion factor estimates for catches made by the two vessels. We present a beta-binomial model that allows estimation of

size-specific conversion factors and illustrate the method with an example.

D3. Mixture distribution models of Pacific rockfish schooling behavior

James T. Thorson[1*] and Ian J. Stewart[2]

[1]University of Washington, School of Aquatic and Fisheries Sciences, Seattle, WA; [2]NWFSC, Seattle, WA

Seven Pacific rockfish (*Sebastes* spp.) are currently listed as overfished. These and other rockfish species are constraining to fisheries management owing to target and non-target catch limits. Indices of abundance for rockfish are frequently derived from a bottom trawl survey that occasionally yields extraordinary catch events (ECE's), in which catch per unit area is much greater than usual. ECE's strongly violate index standardization model assumptions, and removing or including them can cause considerable changes in the indices of abundance used in stock assessments and potentially affect stock assessment results. We hypothesize that ECE's result from trawl catches of fish schools. In this study, we develop models for positive catch rates of rockfish from the bottom trawl survey using a mixture distribution composed of two generalized linear models (GLM's): one for low catches (i.e., solitary individuals) and one for ECE's (i.e., schools). These models can incorporate spatial covariates within both GLM's, and can select a parsimonious model using Akaike's information criterion. Bayesian hierarchical analysis can also be applied to multi-species data to estimate the distribution of differences in density between schooling and solitary individuals among rockfish. Preliminary exploration shows that mixture distributions often fit catch data better than single-distribution GLM's. Bayesian hierarchical analysis can also determine the ratio of densities among solitary and schooling individuals and this information may be especially valuable for infrequently encountered species. Use of mixture-GLM methods for positive catch rates will improve existing survey standardization methods by providing results that are more robust to the occurrence of ECE's.

D4. Acoustical-optical surveys of coastal pelagic species, with emphasis on Pacific sardine, using improved allocation of effort, multifrequency acoustic methods, and a towed stereo camera system

Juan P. Zwolinski*, George R. Cutter, Jr., and David A. Demer

SWFSC, La Jolla, CA

Acoustic surveys are currently used for wide-scale monitoring of many coastal pelagic species and are the primary source of fisheries-independent information used in their assessments. The recent decreasing trend in the abundance of Pacific sardine stock in the California Current Ecosystem (CCE) triggered the need for detailed monitoring of its spatial distribution and demography. In 2006, the SWFSC initiated a series of coast-wide acoustic-trawl surveys in the CCE, and the preliminary results were encouragingly similar to those from relevant stock assessments. To improve the efficiencies of the acoustic surveys, and the accuracies and precisions of their estimates of fish distribution and abundance, efforts were made to optimize the sampling timing and design based on the remotely-sensed distribution of essential oceanographic habitat for the Pacific sardine. Based on historical information of essential habitat, the survey timing can be selected to match the timing of condensed habitat or to include the spatial location of the seasonal commercial fishery to improve species classification and the gathering of biological data. Immediately prior to the survey, the tracklines are allocated based on a remotely-sensed distribution of essential oceanographic habitat for optimal sardine surveying. The echo energy is apportioned to the various species present using a combination of probabilistic classification including a variety of information such as essential habitat, acoustic scattering spectra and intensity, and aggregation depth. The classifications are validated and the models refined using independent observations from a net, egg pump, and a new towed stereo camera system. The foundation for these methods and some example results from recent surveys are presented.

D5. Trawl survey designs for reducing uncertainty in biomass estimates for patchily-distributed species

Paul Spencer[1]*, Dana H. Hanselman[2], and Denise McKelvey[1]

[1]AFSC, Seattle, WA; [2]AFSC, Juneau, AK

'Patchiness' in the spatial distributions of marine populations such as Alaska rockfish can arise from heterogeneous habitat characteristics, and can result in errors in survey biomass estimates when high-density patches are either over-represented or under-represented in survey trawls. In this study, we developed a spatial survey simulation model to evaluate the influence of spatial aggregation on biomass estimation, and considered alternative trawl survey designs intended to reduce the variability of biomass estimates. Variants of double sampling procedures were simulated in which high-density areas identified from acoustic data in the first sampling phase were then assigned increased trawl sampling densities in the second sampling phase. Geostatistical analyses of hydroacoustic data collected in Alaskan trawl surveys were used to simulate spatial distributions of fish populations. Simulated survey biomass estimates and sampling variability were evaluated as functions of several factors, including the spatial aggregation of the population and sampling density. When the relationship between the hydroacoustic data and fish density was strong, the double sampling procedure resulted in reduced variance in estimated biomass relative to simple random sampling with equivalent sample size. However, the variance in estimated biomass from the double sampling design was not substantially reduced when the relationship between hydroacoustic data and fish density was weak. The potential improvement in variance when a strong relationship exists between hydroacoustic data and rockfish density offers motivation to continue to refine analyses of hydroacoustic data and rockfish spatial patterns.

Theme E: Developing a comprehensive approach for characterizing uncertainty

E1. Calculating the uncertainty in fishery assessment forecasts

Richard D. Methot, Jr.

Office of Science and Technology, Seattle, WA

Fishery forecasting models are used to project future catch and stock abundance levels expected from a specified harvest policy. These projections are central to determination of acceptable biological catch (ABC) for one to several years into the future, and to evaluation of longer-term rebuilding plans. The simplest of these projections use a point estimate of the stock abundance at the end of the assessment time series and a point estimate of the target fishing mortality rate for the period of the forecast. Typically, future recruitment is treated as a random process so a probability distribution of future catch and abundance is forecast. More complete implementations also take into account uncertainty around the estimates of current abundance and target fishing mortality rates. Where fisheries are managed to achieve a specified target catch, it is important to also take into account the fact that future F levels resulting from this catch will depend upon current and future recruitment levels, which are not known at the time of setting the target catch level. There can be a several year time lag between the last year for which recruitment deviations can be estimated and the last year for which an ABC forecast is needed. The forecasting approach developed by Shertzer, Williams, and Prager takes this 'calculate F from catch' rather than 'calculate catch from F' approach and also takes into account implementation error in management of the fishery to attain the target catch. Here, I show how a comparable procedure can be implemented within the Stock Synthesis assessment model which conducts the forecast as a continuous time series process in the final stage of an assessment analysis. In this approach, the forecast time period will include annual values for quantities like the probability that F exceeds the overfishing limit and the probability that biomass is below the overfished limit.

E2. Some aspects of scientific uncertainty in West Coast stock assessments

Stephen Ralston[1]*, André E. Punt[2], and other members of the Pacific Fishery Management Council Scientific and Statistical Committee

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The 2006 re-authorized Magnuson-Stevens Fishery Conservation and Management Act requires that the Scientific and Statistical Committees (SSC) of the Regional Fishery Management Councils provide acceptable biological catch recommendations, which must account for scientific uncertainty in the estimation of overfishing limits (OFL's). Quantifying scientific uncertainty in estimates of OFL is challenging. Multiple sources of error are likely to occur, including measurement error, parameter estimation error, model specification error, forecast error, and uncertainty about overall stock productivity. Although many sources of uncertainty exist, the focus of the Pacific Fishery Management Council's SSC has been on quantification of parameter estimation error and model specification error, particularly the latter. While not all inclusive, the study of these two factors is possible using currently available information. We summarize the first order approximate estimates of the standard error on terminal biomass from stock assessments, which we term 'within' variation. To quantify variation 'among' stock assessments, as a proxy for model specification error, we characterize retrospective variation among multiple assessments of the same stock. Results show that for 16 stocks the mean of the coefficient of variation on terminal biomass ('within' variation) is 0.19 (s.d. = 0.09). In contrast, the average coefficient of variation ascribable to model specification error (i.e., among-assessment variation) is 0.51 (s.d. = 0.19), which is the far greater of the two sources of uncertainty.

E3. Dominant sources of scientific uncertainty in recent Gulf of Mexico stock assessments – implications for ACL's

Shannon L. Cass-Calay[1]* and Joseph Powers[2]

[1]SEFSC, Miami Laboratory, Miami, FL; [2]Louisiana State University

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 mandates the use of annual catch limits (ACL's) set such that overfishing does not occur, and calls for strong accountability measures to prevent exceeding the ACL. Furthermore, the law assigns enhanced responsibilities to the Scientific and Statistical Committees (SSC's) of the Regional Fishery Management Councils (Councils). The SSC's have been charged with reviewing the relevant scientific information, considering the scientific uncertainty and recommending appropriate ACL's to the Councils, who cannot exceed the ACL specified by the SSC. The precise methodology for quantifying scientific uncertainty has not been described or uniformly applied across Councils. Sources of scientific uncertainty include, but are not limited to: measurement error, model structure, model mis-specification, uncertainty regarding biological parameters, and forecast error. This study will identify the dominant sources of scientific uncertainty for several frequently assessed Gulf of Mexico stocks including: king mackerel, gag grouper and red grouper. This information could be used by the Gulf of Mexico Council SSC to assist the construction of appropriate buffers to prevent overfishing.

E4. Estimating scientific uncertainty in ABC control rules for Bering Sea Aleutian Islands (BSAI) crab stocks

Jack Turnock[1]*, Robert Foy[2], Anne B. Hollowed[1], André E. Punt[3], Lou Rugolo[1] and Diana L. Stram[4]

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A shared management scheme exists for the BSAI crab stocks, between the federal government and the State of Alaska. ACL provisions of the Magnuson-Stevens Fishery Conservation and Management Act require that ACL control rules be devised that establish a buffer between the OFL and an ABC to account for scientific uncertainty in the OFL. Scientific uncertainty

arises from several sources, but can be divided into two main categories for computing the ABC: (1) uncertainty within a stock assessment that can be quantified using standard methods of variance estimation, and (2) sources of uncertainty which cannot be captured in this way. Examples of the latter include: (a) errors in proxy definitions for F_{MSY} and B_{MSY}, (b) errors associated with the values for pre-specified parameters of population models (e.g., natural mortality, M, and catchability, q), (c) methodology (e.g., how survey area swept estimates are computed), and (d) the choice of which data sources are included in assessments. For stocks with functional assessment models, within-assessment uncertainty is a standard output while additional uncertainty can be estimated using other methods (retrospective analyses, between-year variability in assessment outcomes). In these cases, the relationship between P^* (the probability that the ABC exceeds the true OFL) and the buffer between the OFL and ACL, can be estimated by stock. For stocks without assessment models, the scientific uncertainty associated with OFL can be computed using Monte Carlo simulation. For stocks with insufficient biomass data, the OFL is based on historical catch data, and a default buffer must be assumed based on informed judgement.

E5. Incorporating uncertainty into ABC control rules for Bering Sea Aleutian Islands (BSAI) crab stocks

Diana L. Stram[1]*, André E. Punt[2], Jack Turnock[3], Lou Rugolo[3], Robert Foy[4], and Anne B. Hollowed[3]

[1]North Pacific Fishery Management Council, Anchorage, AK; [2]University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA; [3]AFSC, Seattle, WA; [4]AFSC, Kodiak, AK

The North Pacific Fishery Management Council (Council), the AFSC, and the Alaska Department of Fish and Game (ADF&G) are developing ABC control rules for BSAI crab stocks which explicitly account for scientific uncertainty to meet ACL requirements. There are 10 crab stocks under federal management in the BSAI, with federal OFLs annually established for each stock. Catch levels below the OFL are managed by ADF&G under a deferred management agreement; however, the Council must now modify its management of these stocks to incorporate annual ACL levels. Alternative ABC control rules which account for scientific uncertainty in the OFL are being developed, employing a probability (P^*) approach to compute appropriate buffer values between ABC and OFL. Crab stocks are annually classified into a 5-tier system based upon availability of assessment information, with most stocks in lower tier levels owing to poor data. The OFL control rule is prescribed based on tier level and stock status within each tier. P^*s are being considered in the range 0.1 - <0.5. Depending upon the individual stock (and hence the estimated amount of scientific uncertainty) and P^*, these translate into a range of buffers below the OFL. Several options are considered for incorporating additional uncertainty outside of the assessment itself. Two policy alternatives are being considered (by stock or tier): a fixed P^* leading to an annually-varying buffer; or a fixed buffer leading to an annually-varying P^*. The final selection of P^* and/or buffer value will be the Council's policy decision.

E6. Utilizing environmental information to reduce recruitment uncertainty in the Alaska sablefish stock assessment

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Alaska sablefish (*Anoplopoma fimbria*) are a fast-growing, highly valuable commercial groundfish species in the North Pacific. Relatively little is known about their early life history. Spawning takes place at depth in early spring and larvae swim to the surface, developing offshore. Juveniles drift inshore in late summer to overwinter and begin offshore movement the following summer. Sablefish are assessed as a single population in an age-structured model and do not fully recruit to the fishery or survey until four to five years of age. Therefore, information to estimate recent recruitment is sparse and highly variable. Additionally, recruitment appears to be more related to the environment than to spawning biomass. Our objectives are to evaluate the various sources of early life history data and explore integration of several environmental time series within the sablefish stock assessment model to reduce the uncertainty of recent recruitment estimates. We collected all available early life history survey data to describe the spatial distribution of larval and juvenile sablefish. A qualitative comparison with model recruit-

ment estimates reveals potential critical spatial pathways during high recruitment years. Following this we considered potential mechanisms influencing recruitment and selected environmental indices representing these mechanisms. We considered large scale climate indices to high resolution satellite-derived regional time series. Preliminary model comparisons suggest large scale changes in climate, freshwater, and cross-shelf transport explain some of the recruitment variability of sablefish. Reducing recruitment uncertainty may increase efficiency in harvest decisions, improve geographic catch apportionment, and allow for more reliable future harvest projections.

E7. The relationship between MSY fishing rates (F_{MSY}) and productivity indices

Jason M. Cope[1]*, Wesley S. Patrick[2], and Richard D. Methot, Jr.[3]

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The 2009 revision of the National Standard 1 Guidelines describe a hierarchal approach to prescribing precautionary catch recommendations (i.e., overfishing limit (OFL) ≥ acceptable biological catch (ABC) ≥ annual catch limit). This presentation focuses on the specification of the ABC, which is the scientific recommendation for a level of catch that would prevent overfishing. To do this, it must take into account any scientific knowledge about the stock, and uncertainty in the estimate of OFL (where OFL = $F_{MSY} * B_{current}$). The F_{MSY} is typically based on proxies and incompletely accounts for all biological factors that could influence the true F_{MSY}. It has been proposed that indices of stock productivity, which potentially consider more factors than are directly accounted for in F_{MSY} proxy calculations, could contribute to the scaling of the buffer between OFL and ABC. In extreme data-poor situations, it is possible that a productivity measure could be the sole source of information with which to set ABC relative to historical catch levels. As a first step, we investigated the strength of the relationship between productivity indices and commonly used measures of F_{MSY}. The goal is to determine if productivity measures could serve as a proxy for F_{MSY} in data-poor situations and could provide useful supplementary information for scaling ABC relative to OFL even in more data-rich situations.

E8. Quantifying the tradeoff between precaution and yield in fishery reference points

Deborah R. Hart

NEFSC, Woods Hole, MA

There is nearly universal agreement that fishery reference points should be set using a precautionary approach. This means that the target fishing mortality should be set below that which is expected to give the greatest yield. However, there has been little discussion regarding tradeoffs between the level of precaution used and the concomitant loss in expected yield. Here, I explore this tradeoff with Monte Carlo simulations. Uncertainties in the input parameters to yield per recruit and stock-recruit analysis is first quantified. These uncertainties are then used to estimate the uncertainty in reference points such as F_{max} and F_{MSY}, the fishing mortalities that produce maximal yield per recruit and fishery yield. At fishing mortalities near these reference points, reductions in fishing mortality will substantially reduce the risk of overfishing at little cost of lost expected yield. However, at lower fishing mortality rates, further reductions in fishing mortality result in less marginal benefits in terms of reduced overfishing risk, and greater losses in expected yield. Less resilient, 'low steepness' stocks require additional precaution due to the risk of complete population collapse. If implementation uncertainty (i.e., uncertainty in actually achieving a given fishing mortality target) is incorporated in the analysis, the risk of overfishing as well the loss of yield due to precaution at a given target fishing mortality rate is increased, except possibly at fishing mortalities near or above F_{MSY}.

E9. A review of harvest policies: Understanding the relative performance of control rules

Jonathan J. Deroba[1*] and James R. Bence[2]

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Rational fishery harvest policies use control rules and associated policy parameters to dictate fishing mortality or catch and yield levels. Common control rules include constant catch, constant fishing mortality rate, constant escapement, or a few variations of these. Selecting the 'best' control rules to meet common fishery objectives (e.g., maximizing yield) has been a source of controversy and contradiction in the literature. We reviewed relevant literature to compare the ability of control rules to meet widely used fishery objectives and identify potential causes for these apparently contradictory results. The relative performance of control rules at meeting common fishery objectives was affected by: 1) whether uncertainty in estimated stock sizes is included in analyses, and 2) whether the maximum recruitment level (e.g., the asymptote of a Beverton-Holt stock-recruit function) was varied in an autocorrelated fashion over time. Relative performance of control rules also depended on fishery objectives, and the amount of compensation in the stock-recruit relationship. The influence of assessment error on the relative performance of control rules depended upon whether policy parameters were fixed using those that performed best without errors, or if the best policy parameters were found while including assessment error. More research is needed to compare control rules when: 1) accounting for uncertainty in key population parameters, 2) stock-recruitment or other population dynamic parameters vary over time, and 3) fisheries have non-yield-based or competing objectives.

E10. Setting allowable biological catch for stocks with reliable catch data only

Jim Berkson[1*], Luiz Barbieri[2], Steve Cadrin[3], Shannon L. Cass-Calay[4], Andy Cooper[5], Paul Crone[6], Martin Dorn[7], Claudia Friess[8], Don Kobayashi[9], Thomas Miller[10], Wesley S. Patrick[11], Sarah Pautzke[12], Stephen Ralston[13], and Michael Trianni[14]

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For many stocks, reliable catch data are the only data available for assessing population status. For the purpose of this document, only reliable catch stocks will be referred to as ORCS. Without additional data, traditional stock assessment techniques cannot be applied. There have been a number of alternative methods proposed for and applied to develop total allowable catch, and now acceptable biological catch (ABC), for ORCS. Participants at the Second National Meeting of Regional Fishery Management Councils' Scientific and Statistical Committees (SSC's), held in November of 2009 on St. Thomas, USVI, discussed the pressing need to evaluate existing and potential methods for setting ABCs for these stocks. A working group was established to identify, share, and evaluate alternative approaches (regional, national, and international) for setting ABC's for ORCS. Members of the working group represent seven of the eight SSC's, as well as academic institutions, an NGO, a Regional Fishery Management Council, a state agency, and five of the six NMFS Science Centers. This talk will present the results of the working group. This information can contribute to a common framework, established among regional SSC's, for setting ABC's for these ORCS. Such a framework would need to incorporate flexibility to allow for regional differences in risk tolerance and preference of methods, but would provide a common foundation for all Councils.

E11. Management uncertainty in the context of annual catch limits

Mark Millikin* and Galen Tromble

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NMFS provides in the National Standard 1 (NS1) guidelines that accounting for both scientific and management uncertainty is necessary when setting annual catch limits that prevent/end overfishing. Management uncertainty is the difference between what you plan to catch and what you actually catch for a stock in a fishing year. Catch includes fish that are retained for any purpose, as well as mortality of fish that are discarded. Chief sources of management uncertainty include: (1) inadequate (not timely, or incomplete) catch data; (2) conservation and management measures that don't take advantage of available data; and (3) methods or models and/or quality of stock and fishery data used to estimate future catches that result in poor estimates of actual catch. Consequences of management uncertainty could include: (1) exceeding the annual catch limit (ACL) or even the overfishing limit (OFL) more often, and (2) more difficulty in achieving optimum yield. NMFS recommends the use of an annual catch target (ACT) to address management uncertainty. When following the NS1 guidelines, OFL > ABC, and ABC ≥ ACL. An ACT < ACL would provide separate transparent accounting of management uncertainty with scientific uncertainty accounted for in the difference of OFL > ABC. Use of an ACT is appropriate when: (1) past performance shows that a stock's actual catch has often exceeded its catch quota or limit, or (2) fisheries are being managed with annual catch targets and catch limits for the first time when ACL's are first implemented. A Fishery Management Council can ask its Scientific and Statistical Committee (SSC) for advice on how to calculate management uncertainty based on past fishery performance; still SSCs are not required to recommend ACL's and ACT's. Assigning ACL's to data-poor stocks will be very challenging. Data-poor stocks that have catch data have some basis for setting ACL's, even if catch per unit effort data and discard mortality is poorly understood. Data-poor stocks without catch data should be considered for assigning to a stock complex/species group if appropriate; otherwise the basis for allowing harvest of the stock needs to be carefully evaluated and an ACL is still needed. Improving data should be a high priority. Councils are currently considering frameworks for ACL's that include OFL > ABC, ABC = ACL and ACL > ACT, or OFL > ABC, ABC > ACL and no use of ACT. The former framework is less likely to trigger accountability measures (AM's) for a stock in a subsequent fishing year. The latter framework would benefit greatly from precautionary inseason AM's.

Joint Session of the National Stock and Habitat Assessment Workshops

Theme F: Incorporating Habitat Information Into Stock Assessments

F1. A framework for incorporating climate impacts on pelagic ocean habitats into stock assessments

Anne B. Hollowed*, Angie Greig, Libby Logerwell, and Chris Wilson

AFSC, Seattle, WA

The volume of suitable pelagic ocean habitat can influence the dynamics of recruitment and growth of marine fish. In the case of recruitment, habitat volume influences survival through its role in governing the overlap of predators and prey and through its role in governing competition for limited resources. In the case of juvenile and adult growth, habitat volume influences the probability of spatial overlap between predators and prey. We present a framework for quantifying climate induced shifts in pelagic ocean habitats and incorporating these shifts into the walleye pollock stock assessment as explanatory variables governing growth and recruitment. In this study acoustic backscatter and oceanographic data collected on the eastside of Kodiak Island from 2001-2006 is used to demonstrate the analytical approach. In most years, dominant pelagic fish species are walleye pollock and capelin. These species exhibit niche partitioning in most years and patterns of habitat association are used to identify proxies for essential foraging habitats for capelin and pollock. The volume of suitable habitat for the western

central Gulf of Alaska is estimated by applying these habitat definitions using GIS software. The role of habitat volume is compared to time trends in size at age and reproductive success to establish functional relationships between habitat volume and key life history parameters. These estimates are incorporated into stock assessments to assess the influence of these factors on the resource.

F2. Incorporating the effects of an environmental regime shift in an assessment of Atlantic menhaden population dynamics

John A. Quinlan[1]*, Amy M. Schueller[2], and Douglas S. Vaughan[2]

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Large scale environmental processes may result in alteration of stock productivity. Incorporating such environmental shifts into stock assessments should provide a better understanding of the status of a stock and the levels of fishing that fall within acceptable levels. Beginning in the mid-1990s Atlantic menhaden began to experience what has been termed a 'recruitment failure' which coincided temporally with a shift in the Atlantic Multidecadal Oscillation (AMO; an index of sea surface temperature in the North Atlantic) and a shift in the North Atlantic Oscillation. An analysis of available data indicated that menhaden recruitment success, cohort growth rates, and indices of larval and juvenile abundance in the Mid-Atlantic Bight all appeared to vary with the AMO. This suggests that sea surface temperatures, as indexed by the AMO, played a role in determining spawning habitat use, vital rates, and stock productivity. Working under the hypothesis that menhaden exhibit an AMO-linked two-state productivity regime we constructed a size- and age-structured forward-projection model using Stock Synthesis. The model was designed to allow for important temperature-modulated life history characteristics, such as time varying growth and recruitment processes, identified in the previous analysis. Although focused on menhaden, varying habitat use and vital rate shifts are common features in many fisheries and we offer an example of how these processes can be pragmatically included in working stock assessment modeling.

F3. Insights for stock assessment and empirical pre-recruit indices from an environmentally forced individual-based model of early life history stages for West Coast rockfishes

Eric Bjorkstedt[1,2]* and Stephen Ralston[3]

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Recruitment variability to populations of winter-spawning rockfish derives primarily from highly variable survival through the larval stage, presumably as a consequence of environmental and ecological conditions affecting early life history stages. Existing studies relate recruitment success to mean environmental conditions over (biologically) arbitrarily defined periods spanning one or more months, yet environmental processes thought to be critical to productivity (hence larval survival) vary substantially at shorter time scales, and spawning does not occur with uniform intensity over protracted periods. We have developed and continue to extend a modeling framework in which individual-based models for larval and juvenile rockfish are used to integrate the effects of wind-forced cross-shelf circulation and production in a coastal upwelling system on growth, transport, and survival. Predictions of recruitment success are obtained by integrating the joint probability of (1) survival conditional on birth date, and (2) entering the plankton on a given date, where the latter is based on the distribution of spawning over time. Comparison to recruitment indices taken from stock assessments indicates that the model performs best for spawning seasons matching those reported in the literature. In contrast, recruitment indices based on fixed-time surveys (e.g., oceanographic surveys, diver surveys, and seabird diets) are best predicted for (hypothetical) spawning seasons consistently centered in March, regardless of species, which suggests that, for some rockfish species, such indices are a biased measure of reproductive success.

F4. A habitat-specific approach for incorporating environmental variation into stock forecasting models

Correigh Greene[1]*, Jason Hall[1], Eric Beamer[2], and George Pess[1]

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Habitat conditions for pelagic species are known to vary widely in time and place, creating challenges for accurately predicting the productivity of fishery stocks. We discuss a conceptual approach incorporating habitat transitions to improve the forecasting power of fishery stocks using environmental predictors. We tested this conceptual approach in Puget Sound Chinook salmon populations. On one hand, empirical estimation of population size and productivity is relatively simple compared to marine fish stocks due to the anadromous and semelparous life history of salmon, yet these same characteristics often result in large fluctuations in abundance, and low predictive power for standard stock forecasting approaches that assume static juvenile mortality across years. We conceptualized the Chinook salmon life cycle into four habitat-specific life stages (freshwater, tidal delta, bay, and ocean), and developed environmental predictors that coincided with the periods of residency in these habitats. The best predictors of recruitment in two populations included a combination of freshwater and marine predictors and an estimate of egg production. Our models explained 75-95% of the variation in return rate, had very high forecasting precision, and outperformed model forecasts that assumed natural mortality of each age class was fixed among cohorts. Our results suggest that an environmental-based forecasting approach that utilizes the concept of life-stage specific variation tied to habitats offers a way to surmount the challenge of incorporating highly variable natural juvenile mortality in some pelagic stocks.

F5. Integrating habitat change and population dynamics: Using the Shiraz framework to evaluate salmon recovery efforts

Jeff Jorgensen

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Few tools are available to evaluate changes in habitat condition and the associated effects on population dynamics. The quality and quantity of available habitat can have large impacts on populations. We describe a modeling framework, developed for anadromous salmonids, that focuses on freshwater habitat influences in a spatially explicit life stage-specific manner. Survival is estimated via multiple Beverton-Holt spawner-recruit functions that estimate survival at life stage transition points, from egg through spawning adult. Freshwater spawning and rearing habitat can vary by spatial subunits, and fish movement and survival depend on habitat conditions within the subunits. We recently applied this framework to Wenatchee River basin spring-run Chinook salmon to evaluate alternative states of freshwater habitat condition as a consequence of restoration actions. Relationships were established between landscape-scale attributes (forest cover, road density, precipitation, etc.) and fish habitat characteristics (stream temperature and substrate features). The habitat values were inputs for the population dynamics model. Thus, populations responded to habitat changes as a consequence of alterations to the landscape. Considerable flexibility allows the framework's focus to be directed toward other factors affecting survival, such as changes in ocean conditions, climate, harvest policies, genetic and ecological impacts from hatcheries, and alternative operations of the Columbia River hydropower system. They can be investigated discretely, as we did with habitat, and scenarios can be developed where factors can be evaluated collectively to understand the sensitivity of populations to changes across a host of factors affecting survival.

F6. Can habitat-based densities predict stock status in a heavily fished Caribbean gastropod?

Ronald L. Hill[1]*, Kevin McCarthy[2], Richard S. Appeldoorn[3]

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During a recent stock assessment of Queen conch (*Strombus gigas*) in the U.S. Caribbean, the lack of adequate data negated attempts to use traditional stock assessment models. The nature of the fishery, with recreational (subsistence), commercial, and artisanal components, makes it especially difficult to quantify all the segment's landings and effort. An alternative approach was attempted using fishery-independent survey data in a GIS with benthic mapping to estimate population size and size structure across the fishable depths of the insular shelves of the U.S. Virgin Islands (USVI). These characteristics were compared with densities reported from other fished areas where conch stocks are known to range from healthy to severely overfished. Using this metric for comparison, stocks in the USVI were judged to be mildly overfished but showing some signs of recovery. Comparison surveys in the VI and Puerto Rico (e.g., SEAMAP-C) suggested similar temporal trends. Subsequent peer-review of the alternative method for examining stock status did not fully endorse the approach but the exercise offered suggestions for the way forward. Recommendations for incorporating habitat-based survey data into future conch assessments and alternate models are presented.

F7. Can we use habitat information to derive prior distributions for virgin biomass of deepwater groupers and tilefish?

John F. Walter[1]*, Melissa Cook[2], Brian Linton[1], Linda Lombardi[2], and John A. Quinlan[1]

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Yellowedge grouper and tilefish are relatively sedentary, long-lived fish and occupy burrows, pits, and trenches in discrete habitats along a narrow fringe of the continental shelf break in the Gulf of Mexico. Both species are targets of fisheries with relatively consistent landings of approximately 400 and 180 metric tons, respectively, with little trend in catch per unit effort (CPUE) since inception of the fishery in the late 1970's. Particularly with uninformative CPUE and constant landings, assessment models have little ability to differentiate between whether near constant landings result from sustainable harvest of a large or productive population or represent unsustainable depletion of a declining population. This is problematic for sedentary, low productivity species for which serial depletion can lead to hyperstable CPUE and landings, while overall biomass and reproductive potential is 'mined'. Bayesian priors can often assist in distinguishing between two otherwise equally likely hypotheses. We examine the potential to use habitat maps from the marine substrate geodatabase, scientific survey data and burrow estimates derived from early 1980's-vintage submersible video surveys to develop prior distributions for virgin recruitment as input to Stock Synthesis III (SSIII). We first use a logistic regression to map the area of potential habitat. Then we multiply this habitat area by estimates of burrow densities, numbers of fish per burrow and percent burrow occupancy to obtain initial numbers of animals per square kilometer of habitat. From these, we back-calculate numbers of age-1 fish under a stable age distribution and then examine the performance and implications of the SSIII models with the derived priors for virgin recruitment.

F8. Using statistical modeling and Ocean Observing Systems to identify fish habitat at broad scales: Potential applications for spatial planning, estimation of natural mortality, and reducing fisheries bycatch

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Pelagic habitat processes are at least as important as benthic processes in regulating the recruitment of marine species. However, the absence of data describing pelagic processes at broad spatial but fine time scales has made it difficult to consider these processes in habitat assessments. Ocean Observing Systems (OOS) now sample pelagic processes at ecologically relevant space-time scales. As a first step toward integration of OOS data into fish habitat assessment, we use generalized additive modeling to evaluate the power of OOS to explain abundance variation in two pelagic (longfin inshore squid, butterfish) and two demersal (summer flounder, spiny dogfish) species which interact on the northwest Atlantic continental shelf. Regardless of species lifestyle, OOS data (e.g., ocean color, surface advection velocity, divergence potential) increased the power of models by 20-30% above models that considered only traditional benthic and pelagic variables (e.g., sediment grain size, bottom rugosity, depth, bottom temperature, salinity). We also show how OOS-informed habitat models may be used to 1) refine single species habitat designations for spatial management, 2) model habitat specific encounter probabilities of predators and prey for estimation of natural mortality rates, and 3) model the co-occurrence of target and bycatch species to provide fishers with tactical advice to reduce bycatch.

Theme G: Improving Calibration and Precision of Resource Surveys With Habitat Information

G1. Incorporating satellite derived environmental data with Gulf of Mexico pelagic longline observer data for the evaluation of bluefin tuna relative abundance and distribution patterns

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In the Gulf of Mexico, bluefin tuna are captured as bycatch in the prosecution of the yellowfin tuna longline fisheries of both the United States and Mexico. Analyses of catch rates for this fishery can provide indices of abundance that can be used in stock assessments of these commercially and recreationally important species. Data on individual set catch and effort have been collected through the scientific observer programs of each country, beginning in 1992 for the U.S. and in 1993 for Mexico, and have been combined through an ongoing cooperative program into a database providing complete coverage of the Gulf of Mexico. Information is recorded on gear configuration, bait, timing, and location, permitting the standardization of catch rates accounting for changes in these factors. Catch rate standardization, however, is incomplete because tuna are known to respond to hydrographic features in their environment and the observer records contain little environmental data, making it impossible to disentangle habitat effects from abundance trends. This may be particularly important in the case of bluefin tuna, which are more sparsely distributed in the catches than yellowfin. The use of satellite-measures of sea surface temperature, ocean color, and sea surface height may enable standardization of the longline data and the development of improved indices of abundance for bluefin and yellowfin tuna. In this paper, we present the results of our efforts to overlay longline monitoring records on satellite derived measures of the environment in the Gulf of Mexico to develop a standardized catch per unit effort index.

G2. Expansion of Atlantic croaker (*Micropogonias undulatus*) larval habitat on the northeast U.S. continental shelf

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Climate change has the potential to affect the abundance and distribution of marine fish species. The NEFSC has conducted larval sampling programs along the northeast U.S. continental shelf since the early 1970's. Two programs, Marine Resources Monitoring, Assessment and Prediction (1977 to 1988) and Ecosystem Monitoring (1999 to present), provide shelf-wide data from Cape Hatteras, North Carolina, to southern New England. These data were used to identify changes in abundance and distribution of larval croaker over a 30-year period. Atlantic croaker larval distribution expanded northward from the 1980s to present. A non-linear least-squares larval-index indicates an increase in larval croaker abundance concomitant with the expansion in distribution. Analysis of larval habitat use (i.e., water temperature, salinity, and water depth) indicates preferred larval habitats have not changed over the same time periods. Together, these analyses suggest Atlantic croaker larval habitat has expanded on the northeast U.S. shelf, potentially contributing to the increase in abundance. Atlantic croaker provides an example of how habitat modeling of long-term abundance and environmental data already in existence can be used to identify habitat changes on the shelf. In addition, combining larval-indices and larval habitat models will improve the data available for stock assessments.

G3. Habitat-specific survey methods to improve assessments of rockfishes off California and Alaska

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Many fish stocks have strong affinities to specific habitats, resulting in patchy spatial distributions in abundance. Sample stratification or otherwise explicitly incorporating habitats into survey design can increase precision and accuracy of estimated densities of these stocks. Several economically valuable rockfish species off Alaska and the West Coast of North America occur in rugged rocky terrain, making them impossible to accurately survey using such conventional methods as bottom-trawl gear. We have developed direct-count, habitat-specific methods to improve stock assessments of a number of these species in the Gulf of Alaska and California. Seafloor maps of substratum type and bathymetry are used to identify and quantify rockfish habitats on a large spatial scale, providing the frame within which to distribute sampling effort. Fish surveys, distributed by habitat, are conducted from a human-occupied research submersible. Abundance and biomass are estimated from fish density, size composition, and area of the habitat. These habitat-specific visual survey methods not only contribute to improved assessments of rockfish stocks, but also are necessary for an ecosystem approach to the management of diverse communities on rocky areas of shelf and slope. Additionally, we are using these methods to characterize fish and habitat associations to improve identification of essential fish habitats, to design and monitor marine protected areas, and to understand the significance of deep-sea coral habitats.

G4. Integrating benthic community structure data into a stratified random sampling design to improve reef fish abundance estimates in the Northwestern Hawaiian Islands

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From 2007 to 2009, the PIFSC Coral Reef Ecosystem Division participated in a pilot study to assess the feasibility of a stratified random survey design (StRS) aimed at collecting fishery independent data on the spatial distribution, abundance, size

composition, and habitats of coral reef fishes in the Northwestern Hawaiian Islands (NWHI). The sampling design used a combination of reef zone (forereef, lagoon, and backreef) and depth categories (shallow: 0-6 m; moderate: 6-18 m; and deep: 18-33 m) to partition the survey domain into strata. Concurrent with a subset of fish surveys, benthic cover and coral population (density and size-structure) data were collected. Analysis of benthic cover and coral abundance data revealed high spatial heterogeneity within habitat strata; therefore, we post-stratified the survey domain to incorporate the two predominant wave regimes in the NWHI (northwest swell and trade wind swell) which previous studies have shown greatly influence benthic community structure. Post-stratification results indicate an increase in precision of domain-wide estimates of benthic cover and coral abundance compared to the original StRS design as well as improved precision of abundance estimates for eight candidate fish species. Variability of benthic habitats within several 'post-strata' suggests that further refinement of habitat maps could improve performance of fish stock assessments in the NWHI. We recommend an approach to improving habitat maps based on higher resolution wave exposure data.

G5. Collaborative Optically-assisted Acoustical Survey Technique (COAST) for surveying the distributions, abundances, and lengths of demersal fishes, by species

David A. Demer*, John Butler, George R. Cutter, Jr., Kevin Stierhoff, Kyle Byers, David Murfin, Josiah Renfree, Scott Mau, and Thomas S. Sessions

SWFSC, La Jolla, CA

The Collaborative Optically-assisted Acoustical Survey Technique (COAST) was developed at the SWFSC to survey rockfish dispersions and abundances, by species, throughout the Southern California Bight (SCB). The technique uses historical fishing maps to initially define the survey sites; active-acoustics to map the dispersion and abundance of rockfish; and video and still images to estimate the mixture of species and their sizes. The cameras are deployed from a remotely-operated vehicle. The physical oceanographic habitat is sampled using a conductivity, temperature, and depth sensor with a dissolved oxygen sensor and an acoustic Doppler current profiler; and the seafloor is imaged and classified using new multifrequency biplanar interferometric techniques. Automated data processing algorithms will be explained, and some results will be presented from the 2004-2005 and 2007-2008 surveys of 44 sites distributed throughout the SCB.

G6. Using meso-habitat information to improve abundance estimates for West Coast groundfish: A test case at Heceta Bank, Oregon

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Historical in situ observations of benthic fishes and invertebrates represent an opportunity for establishing fishery-independent benchmark estimates of abundance from specific time points and in both trawlable and untrawlable habitats. Depending on the original intended purpose of a given study, the direct count data may be non-random in nature. The objective of this talk is to show how a new method for treating such data was used by combining in situ fish observation data and a habitat map to estimate fish abundance. We evaluated whether increased resolution of habitat information could improve the precision of population estimates. For this study we used an existing and previously published data set from Heceta Bank, Oregon. Heceta Bank is one of the largest rocky banks along the U.S. West Coast containing a diverse array of habitats supporting numerous species of commercially important groundfish, including a diverse assemblage of rockfishes (*Sebastes* spp.). We looked at fish observations relative to the variables of habitat type, depth, backscatter intensity and relative elevation (i.e., topographic position index) and post-stratified the data according to levels of sampling effort. We also looked at two levels of habitat detail: four habitat types, and 'hard' vs. 'soft' substrate. We then calculated the density and variance of fish species for each habitat type and then estimated fish abundance for a select group of groundfish species. Based on these results it appears that improved precision of more geographically comprehensive abundance estimates may be achieved through pre-survey

stratification based on currently available habitat information.

G7. Modeling habitat relationships for rockfish to improve fishery-independent survey biomass estimates

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Rockfish species are notoriously difficult to assess using multi-species bottom trawl survey methodology. Typically, biomass estimates have high coefficients of variation and can fluctuate outside the bounds of biological reality from year to year. This is thought to be due in part to their patchy distribution related to very specific habitat preferences. We modeled the distribution of twelve commercially important and abundant rockfish species including Pacific ocean perch (*Sebastes alutus*) and shortspine thornyhead (*Sebastolobus alascanus*) in the Gulf of Alaska. The Pacific ocean perch trawl survey biomass estimate has had coefficients of variation of ~35% in recent years, while the shortspine thornyhead coefficients of variation have been ~20%. A two-stage modeling method (modeling both presence/absence and abundance) and a collection of important habitat variables were used to predict bottom trawl survey catch per unit effort. The resulting models explained ~35% of the variation in Pacific ocean perch distribution and 72% of the variation in shortspine thornyhead distribution. The models were largely driven by depth, seafloor slope, bottom temperature, and measures of ecosystem productivity. The residuals of these models were assumed to reflect inter-annual variability and used as an index of the time series of abundance. The trajectories of both population indices were similar to the existing estimates of biomass. However, the habitat-based indices exhibited less interannual variability and lower error estimates. These indices may provide stock assessment models a more stable alternative to current biomass estimates produced by the multispecies bottom trawl survey in the Gulf of Alaska.

G8. Advances in conducting spatially-explicit, fishery-independent, ecosystem-based reef fish and habitat assessments

James A. Bohnsack* and Benjamin Ruttenberg

SEFSC, Miami, FL

Successful marine spatial planning requires measuring impacts of management interventions at small and large, ecosystem-level, spatial scales. In a collaborative effort, NOAA (SEFSC and Florida Keys National Marine Sanctuary, NOS), the Florida Wildlife Research Institute, the University of Miami, and the National Park Service have adopted a single standardized, non-destructive, fishery-independent visual approach using stationary circular plots to assess coral reef habitats in southern Florida and the Florida Keys. Data collected include habitat metrics and reef fish species composition, total abundance, size distributions, and habitat usage. This approach is optimized by using two-stage, random stratification based on depth, habitat type, management zone, and region. By combining efforts, agencies get more data, increase their efficiency, and provide significantly more precise estimates of population abundance and other parameters than previously possible. These data can be used to assess individual species, communities, and management impacts at multiple spatial scales. Monitoring in the Florida Keys and Dry Tortugas over the last decade shows highly significant increased population abundance and size of exploited species in no-take reserves. Impacts of marine reserves, hurricane disturbance, and fishery regulations on reef fish communities and dynamics were also detected.

Poster Session

1. Essential Fish Habitat three-year strategic implementation plan: Priority habitats and data needs for improving EFH protection

Karen Abrams, Terra Lederhouse, and Kara Meckley

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A three-year strategic implementation plan is under development for the Essential Fish Habitat (EFH) protection program to identify more strategic, focused, and transparent national EFH protection priorities. Key objectives of the plan are to implement more efficient and effective approaches for protecting EFH from priority threats, improve EFH program planning, and improve the communication of EFH program priorities and accomplishments to internal and external partners. EFH priorities were identified by each Regional Office and the Office of Habitat Conservation. Comparisons and discussions of these regional priorities led to the selection of four national priority EFH focus areas: submerged aquatic vegetation, tidal wetlands and associated shallow water habitats, coral and marine live bottom aggregations, and riverine spawning and migratory habitat. A simplified logic model was utilized to articulate a strategy for achieving specific outcomes for each of the four EFH habitat focus areas. Key outcomes identified by the plan include increased knowledge of spatial distribution of these habitats, increased knowledge of the linkage between these habitats and managed fish species, and increased ecosystem functioning. Specific products requiring Science Center support will be identified through the plan, which will contribute to the broader discussion of habitat research needs.

2. Prioritizing data collection for assessments based on a cost-benefit analysis

Kate I. Andrews and Linda Lombardi

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All stock assessment scientists are aware that uncertainties are unavoidable in fishery science. We do our best to identify uncertainties and fully describe them using the best modeling approaches available. Our models are only as good as our data, and 'gather more data' always seems to be a research recommendation. The question is left: what kind of data? We cannot have more of all types of data when we are working on a budget, so how do we make an intelligent recommendation of which type of data to prioritize? The cost of data collection varies widely depending on the type of data. It costs about $1200 per sea day for observer coverage in the southeast U.S. whether or not data are collected. Each otolith costs approximately $20-$32 to age. Each recreational angler intercept survey runs $35-$40 depending on the season, and it costs $70 per successful phone interview. The research fishery vessel is the most expensive and variable at $6000-$22,000 for a day of sampling. In our study, we explore the impacts of improving data collection of various data types on the stock assessment of a simulated population of fish. We couple those simulations with a cost-benefit analysis to determine if there is one type of data that is best to fund. Through this heuristic experiment, we hope to fuel the discussion of which data to collect with a little more applied information.

3. A spatially explicit assessment of the adverse effects of fishing on benthic habitats in the Northeast U.S.: The Swept Area Seabed Impact model

Michelle Bachman[1], Chad Demarest[2], Steve Eayrs[3], Jonathan Grabowski[3], Bradley Harris[4], Vincent Malkoski[5], David Packer[2], David K. Stevenson[6]

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The Magnuson-Stevens Fishery Conservation and Management Act requires fishery management plans to minimize to the extent practicable the adverse effects of fishing on fish habitats. To meet this requirement, fishery managers would ideally be able to quantify such effects and visualize their distributions across space and time. The Swept Area Seabed Impact (SASI) model provides such a framework, enabling managers to better understand: (1) the nature of fishing gear impacts on benthic habitats, (2) the spatial distribution of benthic habitat vulnerability to particular fishing gears, and (3) the spatial and temporal distribution of realized adverse effects from fishing activities on benthic habitats. The model combines fishing effort data with substrate data and benthic boundary water flow estimates in a geo-referenced, GIS-compatible environment. Quality-adjusted area swept, our measure of the adverse effect from a unit of fishing on fish habitat, is calculated by conditioning a nominal area swept value by the nature of the fishing gear impact, the susceptibility of benthic habitats likely to be impacted, and the time required for those habitats to return to their pre-impact functional value. SASI increases the utility of habitat science to fishery managers by translating susceptibility and recovery information into a quantitative evaluation of fishing impacts on fish habitat. It is currently being used in New England to design and evaluate anticipated impacts of fishery management alternatives.

4. The value of habitat information at different life stages in refining white shrimp stock assessments in the Gulf of Mexico

Ron Baker[1], Tom Minello[1], and Phil Levin[2]

[1]SEFSC, Galveston Laboratory, Galveston, TX; [2]NWFSC, Seattle, WA

Stock assessments of white shrimp in the northern Gulf of Mexico generally provide reasonable predictions of stock size. However, the considerable noise in the stock-recruit relationship implies that processes acting on early life stages are important in regulating the population. We developed a stage-based matrix population model for white shrimp to explore the effects of variability in vital rates of each life stage on overall population growth rate (λ). The model indicates that λ is orders of magnitude more sensitive to variability in early life stage survival rates than it is to variability in vital rates of the fished stock. Changing adult survival in the model between scenarios with zero and maximum fishing mortality has relatively little effect on λ and stock size. In contrast, changing juvenile survival to account for variability in mortality rates regulated by tidal flooding and access to the protective marsh surface had large effects on λ. While white shrimp stock assessments should clearly benefit from the incorporation of information on variability in juvenile mortality, the regulation of vital rates in early life stages involves a complex interplay between a range of processes that are highly variable and difficult to measure. For example, juvenile mortality may be strongly influenced by unpredictable pulse events that create significant bottlenecks in the lifecycle. Deriving a simple metric or parameter to incorporate habitat processes into stock assessment models currently appears unrealistic, but our modeling approach emphasizes the importance of research into environmental and biological processes that regulate juvenile shrimp mortality.

5. The Species Information System: Tracking success of the Stock Assessment Improvement Plan

Kristan Blackhart and Richard D. Methot, Jr.

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The Species Information System (SIS) is a web-enabled database developed and managed by the Office of Science and Technology that provides NMFS scientists, resource managers, and policy coordinators with user-friendly applications for data entry, retrieval, and report generation. SIS acts as a central repository to collect and manage regional and national data across NMFS program offices. The data housed within SIS includes the most up-to-date information on the status of managed stocks and stock assessment results, as well as a growing collection of historical records and other important associated information. This information is necessary to support services NMFS provides to fisheries conservation and management efforts, as mandated by the Magnuson-Stevens Fishery Conservation and Management Act. SIS directly supports a number of agency reporting requirements, including the Office of Sustainable Fisheries' *Annual Report to Congress on the Status of U.S. Fisheries* and performance measures under the Government Performance and Results Act, and has significantly reduced the number of data calls passed to Science Center representatives. Soon, the database will begin tracking basic catch data and annual catch limits (ACL's), and expand to include protected resources. Development is also underway for a public website linked to the database that will offer value-added data products based on current stock information.

6. The Advanced Sampling Technology Working Group's recent efforts in improving NMFS's stock and habitat assessment science

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With increasing demands for accurate, precise, and timely information upon which to base assessments of living marine resources (LMR's) and their habitats, the NMFS Science Board established the Advanced Sampling Technology Working Group (ASTWG) to lead the ongoing process of improving the quality of assessments through development, evaluation, and implementation of innovative sampling technology. The ASTWG fosters communication and collaboration among experts in sampling technology at the six Science Centers, facilitating increased technical staff capabilities and expedited development of sampling technologies through synergy in research endeavors. The thrust of the ASTWG mission is to improve the accuracy, precision, and efficiency of living marine resource assessments. The ASTWG principally focuses on acoustics, optics, electronic tagging, and other relevant technologies, recognizing that the agency has other working groups addressing different research areas (e.g., Biotechnology, Bycatch Reduction Engineering). Key to this strategy is the involvement of quantitative scientists involved in LMR stock assessments. The Science Centers will identify and prioritize gaps or constraining levels of uncertainty in stock assessments and habitat inventories for each region and identify candidate technologies to reduce uncertainty and fill the gaps. This information will be used to solicit proposals to address sources of uncertainty and information gaps in population assessments. Recent projects funded by ASTWG include: 1) evaluation of bioelectrical impedance analysis to measure fish energy density and reproductive potential for stock assessment (NEFSC/SEFSC); 2) autonomous gliders for real-time passive acoustic remote sensing (NEFSC); 3) automated feature detection, shape estimation, and identification using disparity and spectral information in stereo imagery (SWFSC); 4) estimating abundance of krill-dependent penguin and seal populations breeding on inaccessible islands in Antarctica using vertical take-off and landing craft equipped with cameras (SWFSC); 5) improving visual survey methods for groundfish and reef fish using the Seabed AUV (NWFSC/PIFSC); 6) advancing remote marine mammal stock assessment with passive acoustic gliders (PIFSC); 7) development of an optical sampling trawl for use in groundtruthing species and size composition of acoustic backscatter (AFSC); and 8) modifications to a stereo video camera for improved fish measurements (AFSC).

7. R MAPS: R Mapping and Plotting Scripts for stock assessment

Elizabeth Brooks and Chris Legault

NEFSC, Woods Hole, MA

Visualization tools such as maps are one way of understanding the spatial-temporal nature of your data. They can highlight data gaps, sparseness of coverage, or important patterns that may provide insight into fish or fishery behavior. The patterns that emerge could reflect a response to environmental features, such as depth or season, or to management actions, such as closed areas or fishing seasons. Understanding these data nuances can be helpful in deciding whether the data are appropriate for inclusion in your stock assessment, and if so, how that data should be treated. We have developed scripts in R that work with existing GIS shape files to create maps of typical fisheries data (landings, discards, observer coverage) and fisheries-independent data (surveys, tagging studies). Mapping in R has several advantages. First, the images can be produced with a very small file size, which reduces the overall file size (and enhances the portability) of assessment documents. Second, the ability to automate the scripts to quickly produce many maps where only the year (or gear or species) is changing makes it simple and fast to create many plots from within a single script. Additionally, the capability to directly import raw data, and to analyze and summarize the data prior to plotting, makes for flexible, 'one-stop shopping'. We illustrate some insights gained from recent applications of the mapping scripts, and illustrate the general technique of incorporating shape files into R plots.

8. Pilot habitat assessment of a mesohaline embayment of the Chesapeake Bay

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Acoustic habitat mapping and fish census techniques were integrated in an attempt to quantify the ecological importance of oyster shell habitats in the Chesapeake Bay. Forty-one km2 of seabed was mapped at the confluence of the Rhode, South, and West rivers in Maryland. A side scan sonar system provided two dimensional textural imagery and a single beam echosounder collected bathymetric and seabed classification data. Cover maps were derived from the integration of all three acoustic datasets and grab sample data. Benthic habitat classifications were Clay/Silt, Sand, Silt/Sand, Patchy 3-D Oyster Shell with Mud, 2-D Oyster Shell with Mud, and 2-D Oyster Shell with Sand. An otter trawl was used to collect organisms present within GIS derived habitat polygons. We used generalized linear models to assess the relationship between fish community metrics and a suite of habitat variables. Dependent variables were abundance of pooled fish species (number/m^2), the Shannon-Wiener diversity index, and abundance of the five most frequently observed fish taxa. Independent variables were benthic habitat type, season, a habitat type x season interaction, bottom salinity, bottom dissolved oxygen, bottom temperature, and trawl start depth. Benthic habitat type, followed by the habitat type x season interaction term, was the most significant factors contributing to variation in fish community metrics. One-way analyses identified significant variation in pooled abundance and species abundance relative to habitat type alone. Diversity did not vary significantly with habitat type. Contrary to expectations, abundance was generally greatest on Clay/Silt, Silt/Sand, and Oyster Shell with Mud bottoms; abundance was lowest on Sand bottoms.

9. On the road to extinction? Monitoring population trends of the endangered white abalone, *Haliotis sorenseni*

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White abalone (*Haliotis sorenseni*) became the first marine invertebrate to be listed as endangered under the Endangered Species Act in 2001. Low densities and recruitment failure due to Allee effects were identified as being the major threats to the

species' existence. Beginning in 2002, the Benthic Resources Group at the SWFSC has conducted fine-scale habitat mapping using multibeam sonar and visual transect surveys using a remotely-operated vehicle to monitor the status of white abalone populations at Tanner Bank, an offshore bank in southern California. Results of surveys conducted since the listing indicate continuing declines in total numbers and densities (39-63%, depending on depth) at Tanner Bank between 2002 and 2004. Between 2004 and 2008, white abalone populations appear to have remained relatively stable. Changes in the size distribution over this same time period indicate a population that is growing larger (and older) with no small individuals recruiting to the population. Only five 'pairs' of white abalone were sighted in the 2008 survey (compared to nine pairs and one group of five individuals in 2002, and two pairs in 2004), which suggests that the likelihood of reproductive success of this population remains very low. Continued monitoring is needed to determine whether rebuilding, however slight, may be occurring. More 'active' rebuilding measures (e.g., captive breeding and stock enhancement) may be necessary to reverse the present trend toward extinction.

10. The effect of contaminant exposure on the behavior and growth of young-of-the-year bluefish, *Pomatomus saltatrix*

Allison Candelmo[1,2], Ashok Deshpande[2], and Judith S. Weis[3]

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Certain populations of young-of-the-year (YOY) bluefish (*Pomatomus saltatrix*) may utilize the habitats and prey resources of contaminated estuaries of the mid-Atlantic bight during their early life history. YOY bluefish from the Tuckerton, NJ area of Great Bay (TK) were fed daily in a laboratory with common prey fish, menhaden and mummichog, from two sites: TK (reference) or Hackensack River (HR) (contaminated). Hackensack-fed lab bluefish, HR-field collected bluefish, HR prey fish, and stomach contents from HR bluefish all had significantly elevated concentrations of PCBs, DDT and mercury. Hackensack-fed bluefish had reduced feeding, activity, and growth. Furthermore, the percentage of HR-field bluefish caught with food in the stomach was low (29%) compared to YOY bluefish reported from other regions, suggesting reduced feeding behavior. The size of HR-field bluefish was also significantly less than the TK-field bluefish. In addition, contaminant concentrations in prey fish from the stomachs of the HR bluefish were higher than those in the field-caught specimens. Prey with higher body burdens may be slower and easier to capture due to adverse neurotoxic effects. If bluefish are preferentially foraging on such prey, greater amounts of contaminants can be trophically transferred. Decreased feeding, activity level and growth in the exposed YOY bluefish may make them more vulnerable to predation and starvation and have detrimental effects on their overwinter survival and recruitment success. The inclusion of the contaminated fish in catch per unit effort surveys may produce misleadingly inflated year class estimates. These findings substantiate the importance of the integration of habitat quality information into stock assessments.

11. A mesohaline submerged aquatic vegetation survey of the U.S. Gulf of Mexico coast

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Submerged aquatic vegetation (SAV) is important habitat for fish and decapods. We conducted a survey of SAV along the northern Gulf of Mexico coast to determine species distributions and characterize estuarine SAV communities. We visited 276 SAV beds in the states of Florida, Alabama, Mississippi, Louisiana, and Texas in 2001-2002 in oligohaline to polyhaline salinities. A total of 20 species were identified and habitat characteristics such as salinity, water depth, pH, conductivity, turbidity, dissolved oxygen, and sediment composition were collected. Fourteen aquatic macrophytes occurred two or more times in our samples. *Ruppia maritima* occurred most frequently (n = 148). The next most common species were *Eleocharis*

sp. (n = 47 characterized with an emergent growth form), and *Halodule wrightii* (n = 36). The invasive SAV species *Myriophyllum spicatum* (n = 31) and *Hydrilla verticillata* (n = 6) were collected in fresh water. We analyzed species occurrence and environmental characteristics using Canononical Correspondence Analysis and Two-Way Indicator Species Analysis, which indicated five species assemblages distinguished primarily by salinity and depth.

12. The role of the thermal habitat niche on mortality and recruitment in summer flounder, *Paralichthys dentatus*

R. Christopher Chambers

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A predictive understanding of how the environment, and the thermal regime in particular, might affect the survival and duration of pre-recruit life-stages is fundamental to habitat use and to quantifying habitat quality. Summer flounder presents an intriguing example of a fish whose habitat in early life varies dramatically depending on when and where adults spawn. Most summer flounder spawn in continental shelf waters in autumn as adults egress from inshore summer habitats. When and where spawning occurs is likely to influence whether offspring reach metamorphic competency, ingress, and settle in embayments in the autumn or the following spring. We provide evidence of the duration of pre-settlement life stages under experimental scenarios designed to mimic variations in season and latitude at spawning. We use these data to predict the likelihood of ingress prior to winter and to estimate the sizes at ingress as a function of larval habitat. Offspring of adults that spawn at thermal regimes typical of southern latitudes or of early autumn at northern ones are likely to initiate metamorphosis, ingress, and settle before water temperatures drop too low to support further development. Offspring of adults that spawn in thermal regimes characteristic of the autumn at northern latitudes are unlikely to reach metamorphic competency in autumn, and therefore not ingress until spring warming albeit at a significantly larger body size. Data such as these can be used to estimate the volume and quality of larval habitats, to illuminate mechanisms underlying changes in larval indices, and to inform survey designs.

13. Proposing a framework for integrating habitat science and management

Louis A. Chiarella

NERO, Habitat Conservation Division, Gloucester, MA

The NMFS Habitat Program has been engaged in habitat protection activities for over 25 years. The early efforts within this program focused mainly on traditional coastal development projects regulated by the Army Corps of Engineers. Today, the Habitat Program works with a wide variety of stakeholders to protect and restore habitat that supports living marine resources. However, the implementation of the Habitat Program is still mostly reactionary as opposed to strategic. A framework is being proposed that will allow managers to better utilize science in the implementation of the Habitat Program. In addition, this framework guides the science that needs to be undertaken for management purposes. The principals of this framework have been adopted from the 2006 National Fish Habitat Action Plan which specifies that a plan should: 1) Be strategic rather than merely opportunistic; 2) Address the causes of and processes behind fish habitat decline, rather than the symptoms; 3) Provide increased and sustained investment to allow for long-term success; 4) Monitor and be accountable for scientifically sound and measurable results; and 5) Share information and knowledge at all levels from local communities to Congress. Utilizing these principals, the proposed framework is supported by a strong science-based foundation. Existing and emerging science-based tools must be used to target priority areas and implement appropriate strategies within the management program. In order to accomplish this it is proposed that the Science Centers initiate comprehensive regional fish habitat assessments. Initial assessments would be undertaken utilizing existing data and supplemented with new data where needed. Habitat identification, characterization and mapping would be an integral part of this effort. Once the assessments are completed, priority fish habitats and their threats could be identified and utilized by the Habitat Program to develop regional habitat protection and restoration plans. Implementation of these regional habitat plans will yield strategic, comprehensive

and coordinated efforts to protect and restore fish habitats required by living marine resources. Results on the effectiveness of this program would be monitored in a scientifically sound manner by the Science Centers. Monitoring results and trends would be reported on a periodic basis in the form of a Fish Habitat Report Card. Results of the report card would be utilized to assess the efficacy of the Habitat Program, which would influence development of new strategic plans. Gaps in assessment information as well as other scientific needs can be addressed through targeted research projects conducted by the Science Centers. The results of such studies would feed directly back into this management framework. The integration of science and management in this type of framework insures that: the science that is being produced is relevant to management; management is utilizing the best available science to implement strategic programs; mechanisms exist to feed new science into the process; and management results are being measured in a scientifically sound manner.

14. AUV (Autonomous Underwater Vehicle) for monitoring fish and their habitat on the U.S. West Coast

M. Elizabeth Clarke[1], Erica Fruh[2], Curt E. Whitmire[2], and Hanumant Singh[3]

[1]NWFSC, Seattle, WA; [2]NWFSC, Newport, OR; [3]Woods Hole Oceanographic Institution, Woods Hole, MA

The NWFSC and the PIFSC have worked with researchers at Woods Hole Oceanographic Institution (WHOI) to redesign the Seabed AUV to overcome the difficulty of monitoring fish populations and habitat in rocky areas. Traditional fish monitoring techniques such as bottom trawl surveys have some limitations for assessing groundfish populations and their habitat throughout their range because of the abundance of rugged terrain. Hover-capable bottom tracking AUV's, on the other hand, offer a unique tool that is appropriate for work in such areas. The Seabed AUV developed by Hanumant Singh at WHOI is a multi-hull hover-capable vehicle that unlike traditional torpedo shaped AUV's is capable of working extremely close to the seafloor while maintaining very precise altitude and navigation control. Its small footprint coupled with its 2000 meter depth rating makes it an ideal platform for conducting surveys off the continental shelf on ships ranging from standard oceanographic vessels to smaller fishing vessels. Key modifications have been made to the AUV to simultaneously obtain forward- and downward-looking bottom imagery. In addition, a multibeam echosounder is mounted on the AUV to collect very high-resolution bathymetry that is co-registered with digital photographs. Use of the Seabed AUV will allow the development of non-extractive surveys to monitor groundfish and their habitats in previously unassessed rocky habitats. The Seabed AUV is expected to provide better monitoring of groundfish communities in untrawlable habitats and increased resolution and positional accuracy of seafloor imagery, while simultaneously reducing ship time requirements.

15. Interactive habitat database for the Pacific Coast Ocean Observing System (PaCOOS): An ecosystem observing tool for the California Current

M. Elizabeth Clarke[1], Chris G. Romsos[2], Chris Goldfinger[2], Bob Gref[1], W. Waldo Wakefield[3], and Marlene Bellman[1]

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Building on databases assembled for the development of an Essential Fish Habitat Environmental Impact Statement for West Coast groundfish, we have developed a data portal that links several remote servers and delivers a variety of habitat relevant data including benthic, biological and oceanographic data, and allows multilayer query and reporting and query comparisons (http://pacoos.coas.oregonstate.edu/). This data server is part of Pacific Coast Ocean Observing System (PaCOOS), whose long-term objective is to develop and maintain an integrated distributed data access, transport, and analysis system serving data and products and meeting research and management needs for multiple users in the California Current Ecosystem. The habitat data portal provides for data-discovery, direct client access to data, custom/interactive view environments, as well as developing integrated decision support tools for ecosystem-based management. Specific examples of data available via the portal are: seafloor habitat data, bottom trawl survey data, non-confidential observer and fishing activity information, cold-water coral locations and management areas and boundaries. These data are linked to a habitat utilization database for West

Coast groundfish (> 90 species). Our immediate goal is to provide a portal that allows data exploration by experts as well as by managers and stakeholders to support decision making for such things as spatial management. Our long-term goal is to bring the 2-D geospatial world and the 4-D oceanographic world closer to seamless exploration by examining interoperability between these two inherently different data structures.

16. Estimating biomass from in situ counts of demersal fishes – the challenge in creating a random sample from data collected non-randomly

Julia E. R. Clemons, W. Waldo Wakefield, Ian J. Stewart, and Curt E. Whitmire

NWFSC, Newport, OR

The objective of this poster is to provide a detailed layout of the methodology for a statistically sound and organized approach for combining non-randomly collected in situ direct count fish observation data with a habitat map to estimate fish biomass. Specifically, how does one treat a non-random data set that was collected with potentially different objectives in mind, in this case, fixed station and geological reconnaissance? For this study we used an existing and previously published upon data set from Heceta Bank, Oregon. Heceta Bank is one of the largest rocky banks along the U.S. West Coast containing a wide range of habitats supporting numerous species of commercially important groundfish, including a diverse assemblage of rockfishes (*Sebastes* spp.). We used high-resolution bathymetry and backscatter imagery of the bank collected with a Simrad EM 300 multibeam echo sounder, and strip transect video surveys of habitat and demersal fishes, using a remotely-operated vehicle. We examined fish observations relative to the habitat variables of depth, sediment type, backscatter intensity and relative elevation (i.e., topographic position index). We post-stratified the data to address sampling bias toward shallower water (along the top of the bank) and present abundance estimates for select species of groundfish to illustrate the method. This type of approach could be evaluated for non-randomly collected data wherever the most important habitat information dictating fish abundance is available.

17. Demographics by depth: Spatially-explicit densities and life history dynamics of hogfish (*Lachnolaimus maximus*) in the eastern Gulf of Mexico

Angela B. Collins[1] and Richard S. McBride[2]

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A combined approach of SCUBA observations and life history analyses revealed spatially-specific demographic patterns of hogfish (*Lachnolaimus maximus*) in the eastern Gulf of Mexico. Hogfish (64-774 mm fork length and 0-19 years old) were widespread, existing in harems year-round over multiple habitat types, in depths from 1 to 69 m. As depth increased, density decreased but size and age increased, demonstrating a cross-shelf ontogenetic migration. Size at age was smaller in nearshore (< 30 m) habitats, suggesting that faster-growing fish migrate offshore sooner. A strong red tide, occurring the year before sampling began, likely affected hogfish in nearshore waters, at least partially influencing demographic structure. Specifically, maximum size and age was smaller and younger in nearshore waters. Fishing pressure is also presumably higher nearshore and presents a confounding source of increased mortality. Size and age at sex change of nearshore hogfish were half that of offshore hogfish and were coincident with the minimum size limit, which indicated effective, selective harvesting. These spatial patterns were not evident prior to this research because this stock component was previously assessed in aggregate. Despite evidence of fishing effects, persistent escapement of fish to offshore habitats indicates that the aggregate status of this stock component is still stable.

18. Integrated habitat restoration monitoring for program planning and project implementation

Mathias J. Collins[1] and Bryan DeAngelis[2]

[1]NOAA Restoration Center, Gloucester, MA; [2]NOAA Restoration Center, Narragansett, RI

The NOAA Restoration Center has recently improved project monitoring for stream barrier removals. This has been accomplished through two distinct, yet related efforts: (1) development and publication of the Gulf of Maine Council's *Stream Barrier Removal Monitoring Guide* and (2) development and nascent implementation of the Open Rivers Initiative *Stream Barrier Removal Performance Measures and Project Monitoring*. These efforts built upon an earlier improvement of salt marsh restoration monitoring through the development, publication, and implementation of the *Gulf of Maine Salt Marsh Monitoring Protocol*. Similar to the experience with salt marsh monitoring, improved stream barrier removal monitoring at the site-scale does not necessarily translate to information that facilitates regional-scale analyses suitable for program planning. To have restoration project monitoring that produces useable, planning-level feedback requires a network of sites carefully chosen to illuminate broad-scale questions. Also needed are: systematic data capture, storage and management; project- and regional-level data analyses by project type; and mechanisms for adaptive management that allow information learned from project monitoring to affect program priorities, project selection, and/or technique selection. We report on our recent experience in the northeast United States to develop a network of stream barrier removal monitoring sites explicitly selected to facilitate regional analyses and program planning by representing the range of habitat types and scales typically used by NOAA trust resources in the region. We also describe our efforts to generalize this experience to inform restoration monitoring of all project types and to develop systematic data handling, analyses, and feedbacks for program planning and project implementation.

19. Estimating total spawning abundance from index area counts using a GIS-based habitat intrinsic potential model

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Counts in selected stream sections (index reaches) have been used to monitor trends in steelhead (*Oncorhynchus mykiss*) abundance in several mid-Columbia River tributaries. Index reaches are visited one or more times during the spawning season to generate an estimate of the number of steelhead redds (spawning nests). Index areas were selected based on a number of criteria including accessibility and the relative potential to observe spawning under a range of relative abundance levels. As a result, while index area counts may reflect year to year patterns in abundance, expansions based on the ratio of habitat area within index reaches to the total available for spawning are likely biased. We applied a GIS-based habitat intrinsic potential model that uses empirically derived relationships to assign a spawning potential rating to stream reaches based on physical characteristics. The model was used to expand from annual index redd counts to total population spawning abundance estimates for several mid-Columbia steelhead populations. Comparisons to abundance estimates based on alternative methods (e.g., weir counts, randomized sampling) indicate that expansions from index counts to total abundance based on habitat intrinsic potential outperformed expansions based on linear stream miles.

20. Multifrequency biplanar interferometric imaging for ultra high-resolution three-dimensional imaging of seabed habitat

George R. Cutter, Jr. and David A. Demer

SWFSC, La Jolla, CA

The resolution of 3-D seabed imaging is greatly improved using a new multifrequency biplanar interferometry (MBI) tech-

nique. Using data from a multifrequency-acoustic pulse-echo system (e.g., Simrad EK60 or ME70), ranges to coherent targets, estimated from propagation delays, and the phase differences between echoes received with four quadrants of a split-aperture array are converted to Cartesian distances, and transformed into Earth coordinates. The collective data set is interpolated to create a surface closely approximating the target's image. The resolution of the resulting image is improved orders of magnitude relative to those created with measures based on echo-intensity or single-frequency uniplanar interferometry. The MBI method allows estimation of seabed slope and surface scattering as a function of incidence angle for seabed characterization on a sub-beam basis. We present results from MBI applied to data from split single (EK60) and multibeam (ME70) echosounders.

21. Under what circumstances, if any, do we need to post-stratify species/habitat data?

Doug DeVries, Chris Gardner, John Brusher, and Gary Fitzhugh

SEFSC, Panama City, FL

To optimize survey resources and develop abundance estimators for a given species, a sampling protocol incorporating pre-stratification by habitat type would certainly improve efficiency and is deemed important in survey design. But the issue becomes complex when we consider the numbers of species needing assessment and the diversity of habitats. Of necessity there may be a need to post-stratify collection records, perhaps censoring many records depending on the species. It is no secret that the heavily exploited reef fishes (mostly serranids and lutjanids) in the northeastern Gulf of Mexico are closely tied to hard/live bottom habitat most or all of their lives. Cross-shelf multibeam and side scan mapping and ROV and stationary drop camera video surveys conducted by the SEFSC revealed not only that such habitat is widespread and quite extensive across the West Florida shelf off northwest Florida; but also that it varies widely in vertical relief, rugosity, morphology, density, area, and in density and composition of sessile invertebrate and algal cover. Not surprisingly, these different forms of habitats tend to hold different suites and densities of reef fishes; and the demographics within species may also vary. Variability related to depth and zoogeographic boundaries is also common. We will present some species-habitat-location examples and will welcome feedback regarding the need and means to objectively post-stratify fishery-independent survey results.

22. The role of socio-economics in habitat conservation

Peter E.T. Edwards

Office of Habitat Conservation, Silver Spring, MD

Ecosystem services are the benefits people obtain from ecosystems. Examples include services such as water purification, flood protection, recreation, aesthetics, and climate regulation. Improving habitat conservation will require resource managers to have better information about how ecosystems contribute to society's well-being and how management actions might affect those contributions. Valuation of ecological systems may sometimes be required for national rulemaking. For example, legislative and executive orders often require that cost-benefit analyses be part of the decision-making process. Additionally, ecosystem service valuation (ESV) can play an important role in setting program priorities and in assisting governmental and non-governmental organizations in choosing among environmental options and communicating the importance of their actions to the public. ESV utilizes an integrated methodological approach and requires collaboration among a wide range of disciplines, including ecologists, economists, and other social and behavioral scientists, at each step of the valuation process. Social sciences and economic valuation have a role to play in habitat conservation. These methods can assist in measuring the social outcomes of the results of habitat conservation. Socio-economic data can improve the decision making process, assist in prioritization and support and justify the need for conservation funding. Socio-economic data can be very important to the consultation process and should be central when applying a cost-benefit analytical approach for decision making. Data collected using social science approaches can improve habitat managers' understanding of the public's preferences for conservation and therefore assist with public relations and education.

23. Identification and monitoring of dynamic habitat in the changing ocean

David G. Foley

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There is an increasing emphasis on the employment of ecosystem-based management towards the stewardship of living marine resources. This inherently includes a requirement for the accessibility of timely descriptions of the aspects of marine environment that are relevant to a given ecosystem. In the past decade there has been a proliferation of publicly available oceanographic data sets derived from a variety of platforms and sensors. National, provincial, and municipal researchers and managers who are not necessarily expert in the production and distribution of oceanographic satellite data often face a bewildering, and seemingly contradictory, array of options when choosing data for use in their applications. We offer examples of applications, including several client-side tools designed to extract environmental data within the spatial-temporal locus of a given animal track, and to then import this data directly into the working environment with which a given research or managerial team is comfortable. Additionally, we present sample applications employed along the North American Pacific Coast in the support of management of both fisheries and protected species. These examples utilize highly-derived products that fully integrate data provided by electronic tags placed on Chinook salmon (*Oncorhynchus tshawytscha*) and more traditional cetacean surveys with environmental data derived from remotely sensed and in situ data, and model output using the various dissemination systems discussed. Such integrated data suites will allow for improvement of the identification and monitoring of essential habitat over a broad range of spatial and temporal scales.

24. Mapping hard bottom reef fisheries habitat off northwest Florida – needs, methods, and status

Chris Gardner[1], Doug DeVries[1], and David Naar[2]

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The west Florida shelf (WFS) supports some of the most valuable reef fish fisheries in the U.S. Gulf of Mexico. However, very little of its area has been mapped with enough resolution to accurately locate and quantify the hard/live bottom habitat these fisheries are so strongly tied to. Such maps are essential for designing an efficient fishery-independent survey of reef fishes, enabling pre-stratification by habitat, and thereby minimizing variance and optimizing survey resources. Accurate habitat maps will also be critical for ecosystem-based fisheries management and marine spatial planning. In support of a recently expanded fishery-independent reef fish survey, the SEFSC began mapping cross-shelf transects on the northern WFS using multibeam and side scan sonar. Two transects ~1.5-2.5 x 30 nm were mapped with a 300kHz multibeam sonar and seven single swath cross-shelf transects ~20-30 nm x 150 m were mapped using a 600 kHz side scan sonar. An inexpensive live video drop camera and occasionally an ROV were used for visual ground truthing. Although the multibeam provided bathymetry and backscatter data at very high resolution, the side scan hardware and software was much more user friendly and provided data on which hard/live bottom habitat could, after a very short learning curve, be easily identified. Given the scale of most interest for fisheries-related needs, the 600 kHz side scan sonar may be the most cost-effective tool for our purposes.

25. Growth variability of the splitnose rockfish (*Sebastes diploproa*) in the northeast Pacific Ocean: Pattern revisited

Vladlena V. Gertseva[1], Jason M. Cope[2], Sean E. Matson[3]

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Understanding patterns of somatic growth within populations greatly contributes to fisheries stock assessment and helps

determine the proper model structure. Splitnose rockfish was reported as having a striking pattern of latitudinal growth variability from studies conducted in the 1980s. We investigated variation in growth parameters of splitnose rockfish by latitude using recent data from the NMFS Groundfish Survey (2003-2008), current ageing techniques and advanced modeling and statistical methods to provide an updated understanding of growth along this species' latitudinal range. Age data generated from sectioned otoliths was fit to a von Bertalanffy growth function incorporating ageing error. Growth parameters were estimated for each of five International North Pacific Fisheries Commission (INPFC) areas along the U.S. West Coast. Generalized linear models and Akaike's Information Criteria were used to evaluate hypotheses for growth parameter relationship with latitude. We found that splitnose rockfish exhibited a cline in asymptotic length (L_∞) with L_∞ increasing with rising latitude. We also found that although the growth coefficient (k) was smallest in the Conception INPFC area, there was no apparent cline along the coast; a northward cline in k has previously been reported in the literature. We propose that differences in fishing intensity could be responsible for cline in L_∞, as higher fishing pressure in the south could skew the size distribution of the population in that region, and reduce southern L_∞ estimates. We also attribute slower growth in the Conception area to the oceanographic characteristics and low productivity of the area south of Point Conception.

26. Mapping marine benthic habitats along the U.S. West Coast: Current status, future plans and applications

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Seafloor mapping serves a variety of needs for habitat scientists and resource managers. Maps of marine benthic habitats are a fundamental part of any habitat assessment and are clearly useful for marine spatial planning. Many fish stocks have strong affinities for specific habitat characteristics, resulting in patchy spatial distributions of abundance. Incorporating habitat characteristics into survey designs and stock assessments could increase their accuracy and precision while potentially reducing field effort, resulting in improved identification and conservation of Essential Fish Habitat (EFH). Working with academic and agency partners in 2003, NMFS developed the first comprehensive seafloor habitat map for the West Coast as part of a habitat assessment of EFH for West Coast groundfish. Although useful, the effort clearly illustrated gaps in the knowledge base for West Coast benthic habitats. Since 2003, there has been a major increase in both coverage of high-resolution swath mapping and habitat interpretations concentrated in the state waters of Oregon, California and Washington (Puget Sound) and at select deep-water sites. Significant areas of the continental shelf and slope have not been mapped. Within the past several years, in part stimulated by the *Action Plan* of the *West Coast Governors Agreement on Ocean Health*, the three states have conducted seafloor-mapping workshops to document the status of habitat assessments, identify seafloor-mapping priorities and develop strategies to obtain funding. This presentation identifies initiatives and gains in mapping West Coast marine benthic habitats over the past six years and presents plans and expectations for the future.

27. Biotopes in a fisheries 'habitat hot spot': Investigating Georges Bank patch complexes in the larger context of habitat assessment

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We explored the occurrence of individual fisheries species and the distribution of seabed characteristics on the northern edge of Georges Bank in August 2009 using visual imagery obtained by the USGS Seaboss vehicle and water column temperature

profiles. Demersal and benthic stocks occur in a complex physical and biological setting where movement of a strong tidal front causes bottom temperatures at a location to vary from < 1° to 7° C during a semi-diurnal tidal cycle. Distributions of geological, hydrological, and biostructural factors create small scale (i.e., hundreds of meters) habitat patches, each with a potentially different value to various resource species. Preliminary analysis shows habitat areas defined by the occurrence of individual species do not correspond precisely with habitats defined by sediment types, topography, hydrology, and epifauna. Sea scallop habitats of sand and gravel partly overlapped, but were not identical, with similar habitats occupied by haddock, cod, and silver hake. Bottom water warmer than 14° C, associated with the invasive colonial tunicate *Didemnum vexillum*, rarely overlapped the occurrence of juvenile cod. Gravel habitat characterized by dense benthic epifauna dominated by the erect bryozoan *Eucratia loricata* supported cod and haddock but not silver hake, which were observed on adjacent mobile sand substrate. We suggest that in such complex areas the roles of habitats in species' life histories need to be modeled on a fine scale based on real data to complement coarser scale modeling appropriate for more spatially homogeneous regions.

28. Patterns and processes underlying Pacific hake (*Merluccius productus*) migrations: Progress on developing forecast tools to predict distribution and density

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The spatial distribution of Pacific hake (*Merluccius productus*) exhibits strong environmentally-driven inter-annual variation during the stock's annual northerly migration, impacting monitoring, assessment, and management of this species. Spawning and rearing habitat temperatures and strength of alongshore currents are hypothesized drivers of that variation, both of which may be impacted by global climate change. Prediction of hake distribution is important for long-term planning under future climate scenarios, and short-term decisions. Specifically, hake management would be enhanced via optimized survey design and planning from improved estimates of hake distribution and density. Given the ability to predict the distribution and density of hake prior to a survey, survey effort could be distributed to minimize (expected) variance. Substantial benefits, in terms of more precise estimates of abundance, could be possible for the hake survey off the West Coast of North America which forms the basis for stock assessment and management advice. This presentation discusses the development of a forecast tool for predicting hake distribution and abundance based on fitting spatial time-series models with environmental covariates. Previous studies have modeled hake distribution and density. However the covariates for this project are derived from real-time satellite data and short-term ocean model forecasts, and hence have the potential for a more spatially explicit and extensive predictive tool than previous efforts. While these forecasts focus on time scales from weeks to seasons, developing the ability to produce reliable short-term forecasts for hake is a precursor to forecasting the longer-term impacts of global climate change on the hake stock.

29. Application of an adaptive acoustic/trawl survey to reduce uncertainty in rockfish biomass estimates

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Survey biomass estimates of several Alaskan rockfish species have shown large interannual variations that are not consistent with their longevity. This variability reflects the 'patchiness' of the spatial distribution of the population. This study evaluates an experimental survey design to reduce the variability in estimated biomass for Pacific ocean perch (POP). The design is a variant of adaptive sampling and uses acoustic information to distinguish strata of different densities. In addition to planned trawl stations, additional trawl tows are conducted in the high density fish areas identified during the cruise. The rationale of the design is to reduce sampling variability by allocating more sampling effort in the areas of higher fish density. Reducing the uncertainty of biomass estimates for patchily distributed rockfish has been identified as an assessment and management

priority. We analyzed historic echosign data to delineate patch strength and size. In August 2009, we conducted a 12 day pilot survey on the F/V *Sea Storm* near Yakutat, AK to test the design. A total of 59 trawl hauls were completed, with 19 'patch' stations and 40 background stations. Catch of all species was 30.1 tons with 55% of the catch comprised of POP. Mean catch per unit effort of POP in the 'patch' stations was 42,540 kg/km^2 and 7,540 kg/km^2 in background stations. We compare the hybrid estimates from the study to simple random sampling and stratified random sampling in terms of precision and efficiency. We also compare the results to the NMFS trawl survey conducted weeks earlier.

30. Gulf of Mexico pink shrimp stock assessment model recalibration and model migration to Stock Synthesis

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The SEFSC pink shrimp stock assessments currently use only fisheries-dependent data, including landings, port agent interviews, and electronic logbooks estimating fishing effort. The Gulf of Mexico pink shrimp stocks were deemed undergoing overfishing in 2008. This designation was made because the SEFSC virtual population analysis (VPA) model results indicated the spawning stocks fell below overfishing limits. However, because other fishery indicators (e.g., catch per unit effort (CPUE)) did not corroborate this finding, SEFSC staff recommended maintaining the current stock status designation until the VPA model could be reviewed to determine if this designation should be supported. In June 2009 an internal NMFS review panel was convened to critically review the VPA. The panel concluded the presently used VPA is not suitable for making a status determination for the Gulf pink shrimp stocks. In addition the panel stated new fisheries models should be investigated for future assessments. In light of these findings, we have migrated our pink shrimp assessment data into Stock Synthesis (SS3). We tested the applicability of SS3 to the commercial pink shrimp data using a preliminary model setup of just one random year of data (1976). In this test configuration, SS3 was able to fit both the weight and age composition data. Subsequent full time series runs in SS3 illustrated the model's ability to fit the expected and observed values of CPUE, revealing the applicability of this model to these data. In these full time series runs, spawning biomass, numbers of recruits, as well as the CPUE estimates, were also generated. Upon completion of the model calibration with commercial shrimp data, we hope to incorporate fishery-independent surveys of shrimp abundance, as well as environmental data into future models. We believe environmental factors are of primary importance in regulating pink shrimp populations in the Gulf of Mexico.

31. Market-based size selection in the Bering Sea pollock fishery

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For every fish species, future potential harvests are impacted by current catch levels and patterns. Traditionally, managers use regulations on gear (e.g., mesh size) to control so-called growth overfishing. Such regulations are likely economically inefficient due to increased search costs and lower catch rates. Bioeconomic models typically evaluate efficiency for the fleet as a whole (e.g., Gates 1974, Thunberg, Helser, and Mayo 1998, Eggert and Ulmstrand 2000). Here, we propose that optimizing a fishery should focus instead on individual vessel operator behaviors. That is, vessels targeting young fish impose an 'externality' on the rest of the fleet, meaning that the stock costs are born by the fishery as a whole rather than the individual vessel. In a fishery with observer data on fish size, a fee or quota adjustment can eliminate the externality that vessels impose on other members of the fleet in choosing to fish on less-than-optimal aged fish. Unlike gear restrictions, this allows vessels to catch younger fish when the cost of avoiding them is larger than the future benefit to the fish population. Here we conduct a retrospective analysis to explore the potential impacts of providing quota and fee incentives to the pollock fishery to target fish of different age classes.

32. Delay-difference, age-structured, and state-space models: Are hyphenated models useful for assessing stocks of orange roughy?

Allan Hicks

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Age-structured models are commonly used to assess orange roughy stocks, but many of the life-history parameters are assumed known and a deterministic biomass trajectory (no recruitment variability) is often estimated. A simpler model is the delay-difference model, which can capture much of the same dynamics as an age-structured model without keeping track of individual ages. However, the assumptions made in these deterministic models may result in biased estimates and underestimate the true uncertainty. Through simulation, this study compares the ability and the usefulness of three models to estimate a biomass trajectory and catchability parameters that mimic a stochastic orange roughy population depleted to three different levels. The three models are a delay-difference model with observation error, an age-structured model with observation error, and a state-space delay-difference model with both process and observation error. Results showed that estimates of depletion were biased with the state-space model showing the least bias. Estimates of virgin biomass from the state-space model, however, were highly variable and showed a large positive bias. This was related to the amount of process error and the bias was reduced with some prior information on virgin biomass or catchability from one or more surveys. The deterministic delay-difference and age-structured models performed similarly under these assumptions and the inclusion of process error in the state-space model resulted in less biased estimates of depletion but much more variable estimates of virgin biomass.

33. Recent findings and accomplishments of NOAA's Fisheries and the Environment (FATE) program

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The goal of the Fisheries and the Environment (FATE) program is to provide the information necessary to effectively forecast these changes to evaluate management strategies needed to sustain fisheries while preserving ecosystem structure and function. In support of this goal, the FATE program was developed to accelerate the development of next generation forecasting tools. The FATE program provides leading indicators of ecological and oceanographic change at the population and ecosystem level and local to ocean basin scales. FATE supports research on the functional relationships between environmental forcing, competition for prey, or predation on the growth, distribution or reproductive success of managed species. This presentation provides highlights and results from projects funded in 2007 and 2008. These examples demonstrate that FATE research projects are now being incorporated into population dynamics models used to inform managers of the implications of their actions on the current and future status of marine resources. In some regions, FATE indices provide early warnings of major shifts in the productivity or distribution of key stocks. While the program is based on an ecosystem approach, it targets a suite of commercially important species including groundfish, coastal pelagics, Pacific salmon and highly migratory fishes as well as protected species.

34. The Deep Sea Coral Research and Technology Program: Assessing deep-sea habitats

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Deep-sea corals and sponges can form complex biogenic habitats of astonishing biological diversity. In several regions, such biogenic habitats have been identified as Essential Fish Habitat by Regional Fishery Management Councils. Before most areas have even been surveyed, however, these deep-sea communities are threatened by damage from fishing gear and other activities. In 2009, the NOAA launched the Deep Sea Coral Research and Technology Program, called for in the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act. The program conducts targeted field expeditions using state-of-the-art mapping and research technologies, and analyzes and integrates existing information on the deep-sea coral ecosystems and human activities that may impact them. Initial program priorities are to identify and map deep-sea coral habitats and understand their relationship to managed fisheries species. In its first year, new mapping and exploration in deeper waters off Florida identified new coral-rich areas that informed the final boundaries in the South Atlantic Fishery Management Council's historic efforts to enhance protection for over 23,000 square miles of complex deepwater coral habitats located off the coasts of the Carolinas, Georgia, and eastern Florida. In 2010, the Deep Sea Coral Research and Technology Program is expanding new field research to the U.S. West Coast, in partnership with the region's five National Marine Sanctuaries and the Pacific Fishery Management Council. This poster summarizes the program's first year of activities and identifies future plans that will inform NOAA's fisheries habitat assessments.

35. Incorporating the negative impacts of chemical habitat quality into stock assessments

John Incardona, Nathaniel Scholz, and Tracy Collier

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Emerging science indicates a need for incorporating information on the impact of pollution (or 'chemical habitat quality') on fish stocks. In the past, there was little focus on this area, because toxicology emphasized acutely lethal effects of chemical contaminants, occurring at high concentrations rarely achieved in open water. Using more sophisticated techniques adopted from biomedical research, recent NOAA ecotoxicological research has identified sublethal and indirect effects on fish at different life history stages that can produce population level impacts. These findings represent key impacts of coastal development and non-point source pollution on fresh water, estuarine, and other nearshore habitat that support early life history stages and food webs required for ecologically and commercially important fish species. Coastal development and population growth are only expected to be an increasing threat to nearshore habitats nationwide. Four broad areas relating to habitat and stock assessment would benefit strongly from an increased focus on chemical habitat quality: (1) overall ecological considerations, particularly those relating to the conservation and recovery of threatened or endangered species, or those that are otherwise imperiled by over-fishing or habitat loss, including indirect effects on fish stocks through food web impacts; (2) the potential for maritime accidents or natural disasters to impact commercially important species, highlighted by the potential effects of oil spills on the herring fisheries of Prince William Sound and San Francisco Bay; (3) the potential for bioaccumulative contaminants to impair seafood safety; and (4) the potential loss of tourism revenue due to coastal habitat degradation.

36. Adding ecological context to Essential Fish Habitat models using groundtruthing technologies

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Variable absorption and reflection by geological and biological materials affect the acoustic returns from seafloor mapping sonars. Subsequent groundtruthing enables ecological interpretations of the acoustic information, and can be a useful component of seafloor characterization. In order to improve our understanding of the seafloor as an element of Essential Fish Habitat (EFH), we use three different devices to groundtruth acoustic backscatter: (1) a Free Fall Cone Penetrometer (FFCPT), (2) a SEABed Observation and Sampling System (SEABOSS), and (3) a Towed Auto-Compensating Optical System (TACOS). The FFCPT is a probe designed to free fall through the water column and can penetrate the seabed to 3 meters depth. Measurements of both acceleration and pressure allow a profile of sediment types to be determined. The SEABOSS allows us to observe surficial sediment properties and acquire physical seabed characteristics using a single instrument deployment. Digital still and video cameras are configured to image the seafloor surface while simultaneously obtaining a physical sample with a van Veen grab. The TACOS design provides the ability to capture downward-looking video streams in a towed application. An industrial machine-vision camera provides overlapping video frames that can be mosaicked into a seamless picture providing greater spatial context of seabed composition and biological attributes than is possible through single image exposures. These devices provide complementary information on seafloor characteristics and generate a multi-faceted view of the physical and biological components of habitat. Such views improve our understanding of ecological relationships and guide the formulation of our quantitative EFH models.

37. Can fishery policies for the U.S. West Coast simultaneously sustain habitat, target species, and ecosystem health?

Isaac Kaplan and Peter Horne

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Fishery managers need tools to evaluate how alternative management actions will simultaneously impact target stocks, habitat, and other components of the ecosystem. In this context, here we use an Atlantis ecosystem model to test five broad options for managing fishing impacts on the U.S. West Coast, both coast-wide and then specifically in central California. These five management scenarios include a mix of spatial planning and shifts to alternate gears. We score the scenarios relative to metrics based on economics, target species management, and ecosystem considerations. Ecosystem metrics include bycatch and truncation of rockfish (*Sebastes* spp.) age structure, the abundance of protected species, and damage to habitat. We quantify the impact of fishing gear on habitat very simply, by measuring the footprint of each fleet in each scenario, scaled by the habitat types and sensitivity indices presented in the 2005 Pacific Coast Groundfish Essential Fish Habitat Environmental Impact Statement. The results suggest that scenarios that shift to alternate (non-trawl) gears perform the best in terms of reducing both bycatch and habitat destruction. Spatial management scenarios lead to more mature age structure for rockfish, but intermediate overall biomasses. The scenarios illustrate strong tradeoffs between economic objectives and ecological objectives related to habitat and fish populations. On the other hand, economic yield is more compatible with the abundance of protected species such as birds and mammals. The strategic application of Atlantis to screen policy scenarios is one of the modeling approaches useful within NOAA's Integrated Ecosystem Assessment framework.

38. A multispecies bioeconomic model with biological and harvesting interactions using a surplus production model of stock dynamics

Stephen Kasperski

AFSC, Seattle, WA

This paper develops a multispecies bioeconomic model that incorporates biological and harvesting interactions to determine the optimal effort and stock size for each species. A surplus production model of each population including the interactions between species is estimated and explores how the inferences drawn from the single species bioeconomic model may differ from inferences drawn from the multispecies bioeconomic model. The model also separates fishing effort by target species and allows for bycatch and combined harvesting of multiple species to differ by target species. The empirical application uses the pollock, Pacific cod, and arrowtooth flounder populations in the Bering Sea/Aleutian Islands region of Alaska as a case study. Between 1990 and 2008 in the Bering Sea/Aleutian Islands region, estimates of the pollock and Pacific cod population have declined by 46% and 39% respectively, while estimates of the arrowtooth flounder population have increased by 105% over the same time period. As arrowtooth flounder are a low value species which preys on pollock and competes with Pacific cod for resources, it is possible that increases in the arrowtooth flounder population reduce the value of this multispecies fishery. This paper also explores the value of these relatively simple bioeconomic models in relation to more complex biological and economic models.

39. Developing an Essential Fish Habitat geodatabase, workflow and data model

Charles Keith

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The NEFSC has been tasked to create up-to-date Essential Fish Habitat (EFH) map products for use by fisheries managers and Regional Fishery Management Councils for selected commercial species inhabiting the eastern U.S. continental shelf. Maps, in conjunction with detailed written descriptions, represent the full extent of a species' EFH as required by the Magnuson-Stevens Fishery Conservation and Management Act. EFH maps were previously developed using separate computer programs to analyze datasets, and then compiled in a piecemeal stand-alone GIS. Currently, a geodatabase has been created to store the necessary building blocks, which through geoprocessing steps and calculations creates EFH features and surfaces. Within the geodatabase, relationships and behavior rules can be created to accurately represent the spatial relationships of EFH feature classes, tables, and raster datasets. The workflow and data model diagrams create a road map of how EFH representations were created, allowing the data products to be easily replicated. Accurate metadata can be easily generated as well. The data model can be updated and changed as new datasets are developed and EFH geoprocessing methodologies advance. Help files can guide the GIS analyst in creating new or updating existing EFH. Ideally, future work will result in a web-published geodatabase and mapping application for public access and downloading.

40. Assessment of geomorphological characteristics and reef fish utilization of reported reef fish aggregation sites in the Florida Keys, USA

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Fish spawning aggregations (FSA's) are a vital part of the life cycle of many reef fish species. In many cases, a lack of knowledge of the location of FSA sites prohibits their protection and effective management, and practical approaches to identify those

sites and assess their utilization by aggregating species are needed. We are using acoustic technologies at reported FSA sites in the Florida Keys to accomplish two objectives: (1) assess whether reported FSA sites are characterized by similar habitat characteristics, with a focus on geomorphological features, and (2) determine whether sites reported to have been 'fished out' in previous decades are currently utilized by remnant or recovering aggregations. For the habitat component, preliminary results from the upper Florida Keys indicate that drowned, margin-parallel, rocky ridges, known locally as outlier reefs, are features found in proximity to all FSA sites studied. In particular, three geomorphic characteristics were consistently observed: a steep slope of the landward boundary of the upper-slope terrace; an exposed outlier reef forming the seaward boundary of the upper-slope terrace; and at least one other exposed outlier reef on the upper-slope terrace. For the fish utilization component, initial surveys indicate positive signs of aggregating fish during predicted aggregation periods, but true spawning aggregations have not been observed. From a management perspective, the results suggest the benefit of using acoustic and habitat approaches to identify critical sites for fisheries monitoring and management focus.

41. Multivariate models to predict distribution of structure-forming benthic invertebrates

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The California Seafloor Mapping Project (CSMP) is a collaborative venture designed to create comprehensive maps of the seafloor, which are derived from high-resolution multibeam echo sounder data collected within state waters (shoreline to 3 nautical miles). CSMP will result in a suite of maps detailing seafloor morphology and geology, and characterizing potential benthic habitats. Groundtruthing these seafloor data and surveying biological components of benthic habitats are a major part of CSMP. We are using a towed camera sled to collect presence/absence data of macro-invertebrates associated with specific sediment types, depth, and latitude. We have developed multivariate models using logistic regression to predict the distribution of key species (including some deep-sea coral species), and couple these results with spatial information on sediments and depth to map the probability of occurrence of these important components of seafloor communities on a coast-wide scale. These maps will provide managers, policy makers, and the public with information that can be used in the conservation and management of sustainable marine resources. We will demonstrate this approach using data from southern California.

42. Successes and challenges in displaying Essential Fish Habitat spatial data through the EFH Mapper

Terra Lederhouse, Mike Onzay, Karen Abrams, and Kara Meckley

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The Essential Fish Habitat (EFH) Mapper is a web-based tool that is the first of its kind to display Essential Fish Habitat data and maps nationally. The interactive Mapper enables users to query information from multiple Fishery Management Plans at once to view habitat maps and species lists for a specific location. The Mapper uses a customized ArcIMS HTML viewer to create a platform for distributing spatial habitat data, providing a user-friendly and highly interactive upgrade to the static maps of the past. The Mapper provides a coordinated interactive map service that houses EFH data for regions that do not have GIS applications on the internet while connecting users to those existing systems operated by Regional Offices and Regional Fishery Management Councils. Key challenges include the limited ability of the Mapper to accurately host and display EFH designations for each life stage of each managed species. The spatial data necessary to depict individual designations in a GIS format varies in quality and availability by region. Improving the spatial description of EFH designations and the resolution of regional EFH data will allow users to perform more accurate location-specific queries, thereby improving the functionality of the Mapper for the public and resource managers. The mapper may be found at: http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/index_GIS.htm.

43. Predicting the distribution of anadromous fish in fresh water using habitat models

Steve Lindley

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Effective management of anadromous species under the Endangered Species Act is facilitated by a comprehensive understanding of historical distribution. Elevation, climate and hydrologic data can be used with a number of modeling approaches to predict species distributions for large areas. In this paper I review methods based on bioclimatic envelopes, multivariate distance metrics, and literature-derived habitat preferences and applications to green sturgeon, coho salmon and steelhead. Output from these models has been influential in designating management units, critical habitat, and recovery goals for anadromous species inhabiting the U.S. West Coast.

44. Deciphering environmental patterns and effects from messy data

Sandra A. Lowe and Jim N. Ianelli

AFSC, Seattle, WA

Alaska Atka mackerel (*Pleurogrammus monopterygius*) are an important component of the Aleutian Islands ecosystem and support a large commercial fishery. Sustainability of this population has been dependent on highly variable recruitment and the consistent appearance of strong year classes. Interestingly, strong year classes of Aleutian Islands Atka mackerel have occurred in years of hypothesized climate regime shifts 1977, 1988, and 1999, as indicated by indices such as the Pacific Decadal Oscillation. El Nino Southern Oscillation (ENSO) events are another source of climate forcing that influences the North Pacific. Preliminary analyses have not indicated a relationship between strong year classes of Aleutian Atka mackerel and ENSO events. We re-examine this relationship in light of significant recent recruitment events. Quantitative observations about the ENSO effects on fishes can be difficult, and as such we also examine anomalies of weight-at-age tracked by cohort to decipher potential patterns that may reflect environmental influences. We suggest ways that environmental indicators of growth patterns may be incorporated into the stock assessment.

45. The role of SEAMAP plankton surveys in monitoring the pelagic habitats of early life stages of fishes in the Gulf of Mexico

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Plankton samples and associated environmental data have been collected during annual Southeast Area Monitoring and Assessment Program (SEAMAP) surveys in the Gulf of Mexico since 1982. This time series of observations has produced an extensive database on the early life stages (ELS) of fishes and their pelagic habitats. The associated environmental (hydrographic) data have not undergone the same rigorous scrutiny as plankton sample data and, therefore, their value is not fully realized. In recent years, habitat-related data collection has been expanded to include: fluorometric chlorophyll a measurements; quantification of net-collected *Sargassum* and gelatinous zooplankton; and continuous surface zooplankton sampling with corresponding environmental measurements. The vertical dimension of larval fish habitat is also now being described through discrete depth sampling during SEAMAP surveys on an 'as time permits' basis. These new data on pelagic habitats along with recent analysis of archived hydrographic data reveal the importance of considering habitat when interpreting survey-generated occurrence and abundance data for gray triggerfish, snappers and groupers. This set of geo-referenced observations describes the physical and environmental characteristics of habitats where larvae of fishery species have been consistently found over the past three decades. These depictions of essential ELS habitat represent baselines for future habitat assessments

and marine spatial planning. They also provide guidance for improving SEAMAP survey design and alternate means of predicting/identifying locations of spawning habitat.

46. Large decline in resource species accompanied by a changing habitat in southern New England and New York since the mid-1980's

Clyde L. MacKenzie, Jr.

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In the estuaries and coastal zones of southern New England, Connecticut to Cape Cod, and Long Island, NY, the water temperature has risen about 1˚C and concentrations of pollutants, mainly nitrates, have risen and eutrophication has prevailed since the mid 1980s. Over this time, the abundances of some commercially-important resource species, such as winter flounders and some other demersal fishes, oysters, softshell clams, bay scallops, and lobsters, have declined sharply. Surfclams have also become scarce off coastal New Jersey. The reasons for the declines may be due to changes in foods for the larvae and juveniles, higher predation rates, and increased metabolic rates while the animals grow. Eelgrass meadows, an important component of estuarine habitats, also have become scarcer. The abundances of two types of species that prey on important mollusks have also changed sharply. Crabs have become more abundant while starfish have become scarce. A scarcity of starfish in Connecticut may be the reason for a large increase in abundance and commercial landings of hardclams in that state, the rise in clam abundance there being an exception among the mollusks. Similar abundance declines had occurred in the 1930's, a decade when temperatures were unusually warm. There was a return to higher abundances when the waters became cooler during the 1940's to early 1980's.

47. A Coastal and Marine Ecological Classification Standard (CMECS)

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The Coastal and Marine Ecological Classification Standard (CMECS) provides a uniform approach for identifying, characterizing and naming ecological units in coastal and marine systems. It is intended to facilitate the study, monitoring, protection, restoration and management of habitats supporting commercially- and recreationally-important species, vital habitats for protected species, unique biotic assemblages, and key ecosystem features. CMECS describes standards for classifying ecological units in the benthic, sub-benthic, geological, and water column regimes and proposes unit definitions for inventorying, sampling, and mapping activities. CMECS is intended to create a comprehensive ecological classification, build on existing work, be easily compatible with mapping, document terminology, and allow for dynamic content. It is the product of development, testing and validation by experts from multiple federal and state agencies, academia and non-governmental organizations, led by NOAA and NatureServe. It is designed for use in North American marine, estuarine, and Great Lakes ecosystems, but is applicable world-wide. In April 2010, CMECS was submitted to the Federal Geographic Data Committee's Standards Working Group. This is the first official step in vetting the proposed standard prior to its publication for public comment in the *Federal Register*. The CMECS team is interested in receiving comments from NMFS scientists on the proposed standard. It also encourages pilot projects and crosswalks with approaches presently in use to test and enhance the compatibility and applicability of CMECS.

48. Mapping environmental variables to produce Essential Fish Habitat models

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We are developing quantitative models to explain the distribution and abundance of fish on the continental shelf of the eastern Bering Sea (EBS). This effort addresses the Essential Fish Habitat (EFH) mandate that applies to all life stages of all federally managed species. The large number of species, their considerable value, and the enormity of the U.S. EEZ dictate a descriptive approach that is both rigorous and efficient. In practice, we use systematic trawl survey data to identify EFH as those areas supporting high relative abundance. This approach presumes that density data reflect habitat utilization, and the degree to which a particular habitat is utilized is considered to be indicative of habitat quality. When the trawl data are combined with existing environmental data, preliminary models can be developed that spatially link fish abundance with relevant physical and biological variables. By this empirical method, habitat quality is judged 'through the eyes of fish' (rather than through those of the scientist). Unfortunately, only limited environmental data are available for this purpose and development of new variables is required for model improvements. For example, pilot studies with historical data demonstrate that surficial sediments are useful for characterizing EFH in the EBS. However, these data are sparse and additional sampling with grabs and cores would be prohibitively inefficient. For this reason, we are investigating more cost-effective methods such as acoustic seabed mapping. Ecological interpretation of these habitat measurements is based on diverse groundtruthing information.

49. Using acoustics to characterize sediments for Essential Fish Habitat models

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The importance and broad scope of the Essential Fish Habitat (EFH) mandate requires a rigorous and efficient process for describing and mapping the habitats of federally managed species. To this end, we are developing quantitative habitat models for eastern Bering Sea (EBS) species, using density estimates from annual bottom trawl surveys and synoptic environmental data. Previous research with sparse historical data indicates that surficial sediments affect the distribution and abundance of EBS groundfish. Traditional sampling with grabs and cores is, however, impractical over large areas. Acoustic tools, on the other hand, are suitable for large-scale surveying but it is unknown whether they measure the relevant properties of sediments. Pilot studies with a split-beam echosounder (38 kHz) and a side scan sonar (455 kHz) were used to examine marginal contributions of acoustic data for explaining fish and invertebrate abundance in our habitat models. After processing with proprietary software (QTCView and Sideview, Quester Tangent Corporation, Sidney, BC), statistical analyses indicate relatively minor contributions from the echosounder data (2-13%) as compared to the side scan sonar predictors (9-54%). Based on these findings, a definitive experiment is being conducted in the EBS to compare the statistical value of normalized backscatter data from several different hull-mounted and towed systems, including a prototype long-range side scan sonar. Ultimately, the most cost-effective system will be deployed in the EBS for acquiring data to improve our shelf-scale continuous-valued habitat models.

50. Science support needs for East Coast diadromous fish protection and restoration: Addressing management priorities

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NMFS is responsible for protecting and restoring diadromous fishes and their habitat under the Magnuson-Stevens Fishery Conservation and Management Act, Fish and Wildlife Coordination Act, Federal Power Act, and Endangered Species Act. These regulatory efforts are based on the best available science. The Northeast Regional Office (NERO) and Southeast Regional Office (SERO) have identified limited technical expertise in the Regional Offices and limited Science Center research support as key challenges facing effective hydropower relicensing and diadromous fish habitat restoration. NERO and SERO organized a joint hydropower program planning, capacity building and research coordination workshop. A primary component of this workshop identified priority East Coast diadromous fish science and technical expertise needs, and outlined proposals for addressing these needs. The workshop was an opportunity for the Regional Offices to share these needs and strategies with relevant Science Center and Office of Science and Technology representatives. As an example of how science and management are currently working together, NERO is undertaking a study looking at the link between diadromous fishes and federally managed fish predators in support of the NERO hydropower program. The results of this study could have far reaching benefits for other NMFS offices engaged in habitat conservation activities as well as influencing fisheries management actions. This study is a model for how science and management can work together to insure the science being produced is relevant to management and that management is utilizing the best available science.

51. Determination of best scientific information available for Acceptable Biological Catch and other fishery conservation and management measures

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Fishery conservation and management measures, such as acceptable biological catch (ABC), should be determined using the best scientific information available (BSIA) as stated in the Magnuson-Stevens Fishery Conservation and Management Act (MSA) section 301(a)(2). Fishery stock assessments and other pertinent science undergo a series of evaluations and review processes involving internal workshops conducted by NMFS, external peer reviews, and evaluation by the Scientific and Statistical Committees (SSC) for the purpose of providing ABC recommendations and other advice to their Regional Fishery Management Council (FMC). Scientific peer review plays an important role in ensuring the credibility and reliability of the science, and peer review processes are established and utilized in each region. Examples include the Southeast Data Assessment Review (SEDAR), Stock Assessment Review Committee (SARC), West Coast Stock Assessment Review (STAR), and Western Pacific Stock Assessment Review (WPSAR). Peer reviews frequently include both regional and external expertise to balance perspectives, and reviewers from the Center for Independent Experts (CIE) are often contracted to ensure high standards for expertise and independence without perceived conflicts of interest. The NMFS, CIE, and SSC partnership in the determination of BSIA is an iterative process because the goal is to continuously develop and improve the science required for the FMC's fishery management decisions to achieve sustainable living marine resources and conserve their essential habitats. Presently, NMFS is proposing to revise the MSA section 301(a)(2) provision, referred to as National Standard 2 (CR 600.315), to provide national guidelines on BSIA, peer review standards, the SSC's role in the review of scientific information, and requirements for Stock Assessment and Fishery Evaluation reports (FR Doc. E9-29556, Filed 12-10-09).

52. Merging abundance and habitat modeling: A predictive spatial approach

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Ecosystem approaches to fisheries management require a solid understanding of species habitat, biological and environmental conditions that influence managed populations. Marine mammals are long-lived, apex-predators and have been used as good indicators of complex ecosystem changes. The bottlenose dolphin, the most prevalent coastal marine mammal in the Gulf of Mexico (GOM), interacts with the highly valuable shrimp fishery. Identifying prime habitat of bottlenose dolphins on the GOM shelf can help reduce uncertainty in fisheries stock assessments by accounting for predation by dolphins as a fish mortality source. Also, dolphins can be used as indicators of high productivity areas for fisheries. We developed a fine-scale (20x20 km) predictive, spatial abundance model for bottlenose dolphins on the GOM continental shelf. Combining GIS, Density Surface and Generalized Additive Modeling techniques, we accounted for imperfect detection of dolphins and evaluated relevant environmental predictors of abundance, including oceanographic and topographic conditions, chlorophyll and oil platform density. Dolphin responses to environmental gradients were non-linear. Dolphins were more abundant at about 650 km from the Mississippi River in water approximately 25 m deep. To identify mutually important habitat for dolphins and fisheries, we will use a summer scenario to compare the degree of overlap of high abundance of dolphins, shrimp fishery effort and red snapper catches. The latter are based on commercial and fisheries-independent data. A similar approach can be used for other key species to build spatially-explicit ecosystem models.

53. Where should they spawn? An assessment of the oceanic habitat of larval brown shrimp using dynamic linkages between offshore waters and estuarine nursery grounds

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Several commercially important fish and Crustacea in the northern Gulf of Mexico migrate as larvae from offshore spawning grounds to coastal estuarine nurseries. For most species this oceanic phase is poorly known but likely contributes to yearly variability in recruitment. A behaviorally cued Lagrangian particle tracking model was used to determine the intrinsic oceanographic linkages between the continental shelf and coastal estuaries for larval brown shrimp, *Farfantepenaeus aztecus*. This was accomplished by running the tracking model over several years of high resolution oceanographic nowcast data from the northern Gulf of Mexico Nowcast Forecast System to derive ensemble averages of thousands of migration paths. Initially, several migration models were compared to select the best possible combination of behaviorally based environmental cues linking larval age and growth to the dynamic ocean environment. The resultant winning model was used in the final shelf-wide assessment. The migration paths demonstrate strong spatial fidelity of larvae and estuaries with most successful larvae likely recruiting from a 30-60 nautical mile distance. Some regions of the shelf are likely spawning hot spots, with a high chance of recruitment of propagules into local estuaries while other regions are of low quality, with most propagules being lost at sea. An overall shelf-wide oceanographic-based assessment is proposed using larval characters representative of many species as a quantitative technique to assess habitat that encompasses the seasonal climate dynamics of the ocean environment.

54. River response to dam removal: The Souhegan River and the Merrimack Village Dam, Merrimack, New Hampshire

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The Souhegan River is a tributary of the Merrimack River that drains a 443 km^2 watershed in southern New Hampshire. The lowermost barrier on the Souhegan River was the ~4-m high Merrimack Village Dam (MVD, ~500 m upstream of the confluence with the Merrimack River), which was breached and removed starting on August 6, 2008. The MVD was built in 1906 at a location where various dams have existed since the 18th century. Based on a pre-removal sediment-thickness survey, the MVD impounded at least 62,000 m^3 of sediment, mostly sand. We use a May 2008 ground penetrating radar survey of the impoundment to better constrain this sediment volume and stratigraphy. We also use historical maps and aerial photographs to estimate the possible extent of dam-influenced deposition at the site. We use 12 monumented cross sections, longitudinal profiles, repeat photography, and sediment samples to document the response of the Souhegan River to the removal of the MVD. Our study is part of the first full application of a recently published guide for stream barrier removal monitoring. Prior to dam removal, in August 2007 and June 2008, we surveyed the cross sections and longitudinal profile. We conducted re-surveys after removal in August and October 2008, and again in July and August 2009. Comparison between pre- and post-removal surveys shows that, in a 495-m reach upstream of the former location of the MVD, the Souhegan River eroded a net 38,100 m^3 (47,900 metric tons) of sediment. This response began with rapid (hours to days) incision of a narrow channel, exhuming in some places bedrock and boulders that likely formed the pre-dam riverbed. Over the year since dam removal, the channel has widened by bank erosion but this process is limited by root strength and recruitment of large woody debris in the riparian zone of the former impoundment. Downstream of the former dam location, during the first days after removal, a sand deposit up to 1.0 to 3.5 m thick, or approximately 18,500 m^3 (23,500 metric tons), prograded almost to the confluence with the Merrimack River. From August 2008 to August 2009, the Souhegan River removed a net 8,400 m^3 (10,700 metric tons) of this sediment leaving 11,100 m^3 (14,100 metric tons) from the initial post-removal pulse. Over this interval, the unaccounted 27,000 m^3 (33,800 metric tons) of sediment eroded from the former impoundment left the study reach and discharged into the Merrimack River. The Souhegan River experienced massive change during our two year study and continues to evolve as a new channel forms and stabilizes upstream and downstream of the former dam site.

55. Ocean scale hypoxia-based habitat compression of Atlantic Istiophorid billfishes

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Oxygen minimum zones (OMZ's) below near-surface optimums in the eastern tropical seas are among the largest contiguous areas of naturally occurring hypoxia in the world oceans and are predicted to expand and shoal with global warming. In the eastern tropical Pacific (ETP), the surface mixed layer is defined by a shallow thermocline above a barrier of cold hypoxic water, where dissolved oxygen levels are ≤ 3.5 mL L^{-1}. This thermocline (~25-50 m) constitutes a lower hypoxic habitat boundary for high oxygen demand tropical pelagic billfish and tunas (i.e., habitat compression). To evaluate similar oceanographic conditions found in the eastern tropical Atlantic (ETA), we compared vertical habitat use of 32 sailfish (*Istiophorus platypterus*) and 47 blue marlin (*Makaira nigricans*) monitored with pop-up satellite archival tags in the ETA and western North Atlantic (WNA). Both species spent significantly greater proportions of their time in near-surface waters when inside the ETA compared to those in the WNA. We contend that the near surface density of billfish and tunas increases as a consequence of the ETA OMZ, therefore increasing their vulnerability to overexploitation by surface gears. Since the ETA OMZ encompasses nearly all Atlantic equatorial waters, the potential impacts of overexploitation are a concern. Because of

the obvious differences in catchability inside and outside the compression zones, it seems essential to standardize these catch rates separately in order to minimize inaccuracies in stock assessments for these species. This is especially true in light of global warming which will likely exacerbate future compression impacts.

56. Benthic habitat assessment and mapping in the Pacific Islands region

John Rooney, Jonathan Weiss, Emily Donham, Frances Lichowski, and Joyce Miller

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Since 2001, the PIFSC has been conducting systematic mapping of coral reef ecosystems and deeper habitats around the U.S.-affiliated islands in the central and western Pacific Ocean. Funding for this work has been derived entirely from sources outside of NMFS, mostly from the NOAA Coral Reef Conservation Program (CRCP). Mapping has focused on developing a series of map layers of seafloor characteristics with biological significance that are logistically feasible to produce. To date more than 67,400 km^2 of high-resolution bathymetry and acoustic backscatter imagery have been collected at depths from ~20 - >3000 m. Video and still imagery are also collected, using camera sleds, ROVs, and more recently, a SeaBED AUV, and used to characterize and map benthic and demersal communities and provide validation of acoustically delineated habitat characteristics. Optical imagery covering more than 635 linear kilometers of seafloor at depths below ~30 m has been collected. For shallower depths not feasible to be mapped acoustically, depths are being estimated from satellite imagery. Several products are standardly derived from bathymetric data, including slope, rugosity, and Bathymetric Position Index zones and structures. These bathymetry-derived products and optical map data are being used in ENVI® software to generate maps of hard (rock, boulders, rubble) versus soft (sand, mud) substrates to use as the basis for stratification to improve sampling design and efficiency for reef fish surveys. Using similar methods, maps predicting fish distributions and algal meadows serving as juvenile fish habitat are also being developed.

57. Estimates of rockfish habitat utilization and biomass on an isolated rocky ridge using acoustics and stereo image analysis

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For those marine fish species with specific habitat preferences, a habitat-based assessment may provide an alternative to traditional surveys. We conducted a habitat-based acoustic and stereo-camera stock assessment survey for rockfish on a rocky ridge habitat in the eastern Bering Sea. Video analysis suggested that juvenile and adult rockfish were more abundant on the seafloor in the rocky ridge area than on the surrounding sandy flats. Over the ridges, the distribution of rockfish was uniformly low in the water column during nighttime surveys and higher during daytime surveys. The opposite pattern was observed in the video on the seafloor between night (high density) and day (lower density) indicating that fish in the water column during the day moved to the seafloor at night. Mean biomass of adult rockfish for the rocky ridges was 15,447 t based on acoustic data. The biomass of juvenile fish was estimated to be 916 t. Utilization of similar survey methodologies on a larger scale may improve assessment of rockfishes not only in Alaska, but throughout their range where fishery-independent biomass estimates have been difficult to obtain.

58. The effects of bottom fishing on the benthic macrofauna and demersal fish feeding habits of northern Georges Bank

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The impact of mobile bottom fishing gear on marine benthic habitat and demersal communities has been well documented for Georges Bank in the northwest Atlantic and elsewhere. However, few studies have examined the effects of bottom fishing on the feeding habits of benthivorous fishes within this shelf region. Here, we quantified the differences in the benthic macrofaunal and demersal fish communities between sites with disparate levels of disturbance from mobile bottom fishing gear for northern Georges Bank (i.e., the Habitat Area of Particular Concern (HAPC) of northern Closed Area II, and a contiguous Canadian region). The study compares a suite of benthic macrofaunal and fish diet indices across year and fishing disturbance level as fixed effects. Fishes selected for diet comparisons included winter skate (*Leucoraja ocellata*), little skate (*Leucoraja erinacea*), Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), winter flounder (*Pseudopleuronectes americanus*), and longhorn sculpin (*Myoxocephalus octodecemspinosus*). Benthic macrofaunal abundance (n/L), biomass (g/L), and species richness were generally higher in the non-fished areas, whereas an evenness index was greatest in areas disturbed by bottom fishing. Within the HAPC region, the effect of fishing was less pronounced and additional factors were proposed. Nonetheless, marked differences in fish feeding habits were present and predator-prey dynamics were shown to be altered by a fishing disturbance effect. In several cases, prey that contributed to the diet dissimilarity between sites were taxa most sensitive to the impact of bottom fishing disturbance as shown in the benthic macrofaunal community, yet these results were variable on Georges Bank.

59. An assessment of coastal and nearshore fish habitat for the National Fish Habitat Action Plan

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The National Fish Habitat Action Plan is a multi-partner effort to address the loss and degradation of fish habitat by taking a science-based regional partnership approach to identifying conservation priorities and leveraging resources to address those priorities. As part of this effort, scientists from a number of agencies and academia are working together to produce a national assessment of fish habitat. NOAA is responsible for the coastal and nearshore portion of the assessment. This study synthesizes existing nation-wide data sets on anthropogenic disturbance and natural drivers affecting coastal and estuarine ecosystems, and includes indicators of connectivity, hydrology, benthic complexity, and water quality. A quantitative assessment of habitat components will be nested into a multi-scale spatial framework for the coastal Atlantic, Pacific, and Gulf of Mexico using NOAA's Coastal Assessment Framework (CAF). In 2010, indicator values will be assigned to units within the CAF and composite habitat condition scores will be assessed using principal component analysis and other data reduction methods. Work in 2011 will focus on testing how these scores predict fish species composition and abundance metrics of well-studied stocks.

60. Evaluating the habitat impacts of non-fishing human activities in federal fishery management plans

David K. Stevenson

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A section of the Essential Fish Habitat (EFH) Final Rule requires that Regional Fishery Management Councils (FMC's) 'identify activities other than fishing that may adversely affect EFH' and 'recommend options to avoid, minimize, or compen-

sate for the adverse effects' of non-fishing activities on EFH. FMC recommendations could be very persuasive in encouraging responsible agencies and organizations to take action that would help to conserve and protect federally-managed fishery resources from the detrimental effects of a variety of non-fishing activities, yet they are seldom included in federal fishery management plans (FMP's) because the Councils have no direct authority to regulate these activities. A fundamental problem has been the scarcity of information required to evaluate ways in which specific human activities can adversely impact exploited resource species and populations. This situation is improving with the recent publication of a NOAA Technical Memorandum (Johnson et al., 2008) which describes a range of non-fishing activities that affect marine habitats in the northeastern U.S. and ranks them in terms of their potential impacts. Summary information from this Technical Memorandum has been included in a draft of an amendment to the Mid-Atlantic FMC's Squid, Mackerel, and Butterfish FMP and will be presented in this poster to demonstrate what can be done with the available information and what still remains to be done to generate information that is specific enough to support effective conservation recommendations. More active strategic partnering between the Science Centers, Regional Offices, other government agencies, and academic institutions is needed in order to ensure that this information is made available to the FMC's.

61. Incorporating environmental factors affecting recruitment into the stock assessment for snow crab in the Bering Sea

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Bering Sea snow crab (*Chionoecetes opilio*) are currently designated as overfished and are under a rebuilding plan. However, the dynamics of snow crab abundance are driven not only by fishery-induced mortality, but also by large fluctuations in recruitment. Fishery management advice is based on the assessment model for this stock, which is sex- and size-structured and estimates annual recruitment starting at 25mm carapace width. In common with many fishery resources, very little of the variation in snow crab recruitment can be explained by changes in female spawning biomass, and no significant correlation has been found between recruitment estimates for snow crab from the stock assessment and ecosystem-scale environmental indices in the past. We outline an approach in which environmental factors can be incorporated directly into the stock assessment to assess whether these factors determine recruitment. This allows the uncertainty associated with any relationship between recruitment and environmental covariates to be quantified. We illustrate the approach using cold pool data and outline other environmental covariates which quantify plausible environmental drivers of recruitment.

62. Incorporating food web and habitat interactions in a forage fish stock assessment

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Some researchers have suggested that because of the multiple sources of mortality that forage fish face, fisheries managers could use other biological reference points – e.g., total mortality (Z) – as a benchmark for making management decisions. Doing so would require accounting for other sources of natural mortality. In this paper, we outline the potential for using ecosystem and habitat models to estimate natural mortality for forage fish stocks. We use the Chesapeake Bay Fisheries Ecosystem Model (CBFEM) to generate various sets of a time series for predation mortality on Atlantic menhaden. In alternative runs of the CBFEM, we use forcing and mediation functions to influence physical factors-species interactions and generate additional time series of natural mortality. Then using a simple stock assessment model and the time series generated with the CBFEM, we compare the fit of the various formulations (i.e., constant natural mortality, variable natural mortality based on trophic effects alone, and variable mortality based on physical factors and trophic interactions) to determine the utility of incorporating physical and trophic interactions into stock assessment models. These model scenarios and stock assessment approaches are presented to gain insight into the possible responses of menhaden to fishery management and water quality management actions.

63. Science needs for coastal and marine spatial planning for offshore renewable energy siting

Sue Tuxbury and Chris Boelke

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As the implementation of the Ocean Policy Task Force's Interim Framework on Coastal and Marine Spatial Planning moves forward, NOAA will be looked upon to provide critical data for developing regional plans. The use of coastal and marine spatial planning for the purpose of siting offshore renewable energy has already rapidly taken off on a state level in New England. The Massachusetts Ocean Plan and the Rhode Island Ocean Special Area Management Plan have led the nation in coastal and marine spatial planning for offshore wind development. These states have looked to NOAA for data and guidance on information needs for management decisions. Though experiences from Europe have provided some insight, questions remain on how these renewable energy projects may affect marine resources off our coasts. We provide an overview of offshore renewable energy planning efforts for New England, information resource managers' need for review of such projects, and science needs to help close the data gaps. Lessons learned from these smaller scale projects may provide insight into information needs for planning on a regional scale.

64. Identifying pelagic habitat in Shelikof Strait and the Bering Sea using GIS-based tools for analysis and visualization

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Healthy habitat is crucial to the survival and recovery of commercially and recreationally important species as well as endangered species. Climate change, environmental variability, and increased anthropogenic modification of the oceans add a sense of urgency to the correct identification, monitoring and conservation of Essential Fish Habitat. While marine habitat is commonly thought of as the seafloor that supports benthic organisms, there are also marine organisms that occupy a fully three-dimensional pelagic habitat. Identifying essential habitat in three dimensions (width, breadth and depth) is the first step in being able to set conservation priorities to mitigate changes in the environment caused by any of these drivers. The ability to create these types of analyses for pelagic species will also improve our ability to support integrated ecosystem assessments under changing environmental conditions. GIS has been used extensively to define and describe benthic habitat. Tools have been developed to integrate a number of environmental variables to determine the location and size of optimal benthic habitats. For example, sediment type, depth, rugosity and aspect can be integrated to characterize habitat usability for corals in American Samoa (Lundblad et al., 2006). This poster will describe HabitatSpace, a tool developed to extend these types of analyses to three-dimensional pelagic habitats. Using a combination of ESRI's ArcGIS software and Unidata's Integrated Data Viewer, it allows users to load environmental data and specify parameters for habitat based upon an organism's environmental requirements. The tool outputs both 2-D and 3-D visualizations of the volumetric habitat defined by the input parameters. Statistical analyses such as mean center and area of the habitat volume can be calculated.

65. Hypoxia: An important component of benthic habitats for U.S. West Coast groundfish stocks

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Understanding the relationship between environmental variables and fish distribution and abundance has long been a goal of

fisheries biologists. A recent report prepared by NMFS identified 'insufficient research on environmental effects' as a major obstacle (among several) to producing and using habitat science in stock assessments and management. Since 2002, hypoxic conditions have been observed on the continental shelf off the coast of the Pacific Northwest in a region not previously characterized by low bottom oxygen concentrations. Major declines in dissolved oxygen have been observed in the oxygen minimum zone (OMZ) of the southern California Current as well as a shoaling of the OMZ. Despite recent increases in the frequency, duration and spatial extent of hypoxia and the recognition of hypoxia as a threat to worldwide fish production, little is known about its effects on upper trophic levels. In 2007, the NWFSC initiated studies on the extent of hypoxic conditions on the continental shelf and slope and the influence of hypoxia on demersal fishes and invertebrates. This project was an extension of the NWFSC Groundfish Bottom Trawl Survey. Studies in 2007 and 2008 focused on a segment of the Oregon coast – an established area for ongoing interdisciplinary studies on hypoxia. In 2009, working with oceanographers at Oregon State University, the NWFSC expanded its hypoxia research by incorporating an oceanographic sensor package into the NMFS coast-wide survey. This poster summarizes the results of ongoing research and discusses some implications for stock assessments and management.

66. Pelagic habitats and ecosystem considerations for salmon and other pelagics of the central coast of California

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The productivity of salmon and the ecosystem of central coastal California are dependent on upwelling, wind strength, and wind structure which respectively determine the degree of enrichment, concentration, and retention of nutrients and prey items regionally. To examine the role of these factors on the ecosystem we have developed a hierarchal, mechanistic ecosystem model for estimating productivity of krill, rockfish, and seabirds along central California. Once these relationships were quantified we used our findings to explore potential causes of recent poor salmon production. Evidence suggests that weak upwelling reduced enrichment and below average wind turbulence led to a shallow mixed-layer and diffusion of krill (a dominant prey item) southward from the primary habitat of juvenile salmon. Also, increasing winds seaward moved the convergent zone, which retains local production and pelagic prey items, offshore and beyond the range of juvenile salmon. In total, recent years may have represented a restructuring of the marine habitat whereby krill, pelagic fish prey, and salmon were not overlapping which led to reduced survival of juvenile salmon.

67. Identifying coral habitat areas that are potentially vulnerable to fishing interactions

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Due to their sessile nature and slow growth rates, deep-sea corals are vulnerable to a variety of anthropogenic stressors, most notably bottom trawling. Off the West Coast of the continental U.S., corals are encountered during research trawl surveys and recorded as bycatch by fishery observers during commercial fishing operations. With the reauthorization of the Magnuson-Stevens Fisheries Conservation and Management Act in 2006, NOAA and the Regional Fishery Management Councils were mandated to minimize interactions between corals and fishing gears. In order to minimize interactions, it is necessary to first identify areas of coral habitat that are vulnerable to such interactions. One method is to simply overlay coral observations onto a map of fishing intensity. Due to confidentiality requirements for commercial fishing information, however, intensity data is often aggregated to large blocks (e.g., 10x10 km, 10' latitude x 10' longitude). Unfortunately, mapping of intensity data at such coarse spatial scales precludes any meaningful analysis of risk. For this study, we developed a metric of vulnerability defined not only as a factor of fishing intensity, but also relative coral abundance and taxon rarity. What makes this metric unique is that vulnerability is defined from the perspective of the coral habitat area, thus preserving the confidentiality of commercial fishing information. In other words, vulnerable coral habitats can be identified on a map without directly showing

the distribution of fishing intensity. Such maps may be used by fishery managers to develop gear modifications or regulations that protect these vulnerable habitats from damage by fishing gears.

68. Catch composition in the NMFS West Coast bottom trawl survey as a predictor of habitat complexity

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For many assessments of West Coast fish stocks, an annual bottom trawl survey is the main source of fishery-independent information on biomass trends. Unfortunately, these biomass estimates are made under the assumption that densities of fish observed in the trawl catches are uniform across all benthic habitats. From in situ habitat studies, we know however that density can vary significantly in relation to various habitat types. The recent availability of coast-wide maps of surficial geologic habitat off the West Coast has provided the opportunity to explore trawl survey catch rates in the context of seafloor characteristics. For this study, we compared catch per unit effort data for select species of demersal fishes and benthic invertebrates to the habitat types encountered during the trawl. These trawls were conducted between 2003 and 2009 by the NWFSC as part of an annual trawl survey of commercially important groundfishes. The species used in this analysis were chosen due to their ubiquitous distributions and strong affinities to certain benthic habitat types – either soft, unconsolidated sediments or hard, rocky outcrops. We hypothesize that for trawls that encounter a variety of habitats, the catch composition will reflect those changes in habitat type. In other words, for those trawls that cross varying habitats, we expect to see a more diverse set of species with varying habitat affinities. If our hypothesis is correct, we hope to develop a model using catch composition as a predictor of greater habitat complexity, particularly in areas where habitat information is lacking.

69. Multivariate bathymetry-derived landscape ecology model accurately predicts rockfish distribution in Cordell Bank National Marine Sanctuary, CA, USA

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Accurate, efficient estimation of actual and potential species distribution is a critical requirement for effective ecosystem-based management and marine protected area design. Here we test the applicability of a terrestrial landscape modeling technique in a marine environment for predicting the distribution of ecologically and economically important groundfish, using three species of rockfish at Cordell Bank National Marine Sanctuary as a model system. Autoclassification of multibeam bathymetry along with georeferenced submersible video transect data of the seafloor and demersal fishes were used to model the abundance and distribution of rockfish. Generalized Linear Models were created using habitat classification analyses of high-resolution (3m) digital elevation models combined with fish presence/absence observations. Model accuracy was assessed using a reserved subset of the observation data. The resulting probability of occurrence models generated at 3m resolution for the entire 120 km^2 study area proved most reliable in predicting the distribution of the two species associated with rocky habitat, *Sebastes rosaceus* and *S. flavidus*, with accuracies of 80% and 70%, respectively. The models did not do as well for *S. elongatus*, a species associated with low relief, mixed and sedimentary habitats, and thus not as amenable to analysis based solely on bathymetry-derived geomorphology metrics. These results indicate that site- and species-specific algorithmic habitat classification applied to high-resolution bathymetry data can be used to accurately extrapolate the results from in situ video surveys of demersal fishes across broad areas of rocky habitat.

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