ABSTRACTS

2018 NMFS – Sea Grant Graduate Fellows Symposium

Table of Contents

Lisa Ailloud

College of William and Mary, Virginia Institute of Marine Science
Advisor: John Hoenig
NMFS Mentor: Matthew Lauretta
Population and Ecosystem Dynamics, 2015

Estimating catch-at-age of Western Atlantic Bluefin tuna: Can we do better than cohort slicing?

Lisa Ailloud, Matthew V. Lauretta, John F. Walter, and John M. Hoenig

Atlantic bluefin tuna is assessed using a Virtual Population Analysis model, which requires catch-at-age estimates as its main input. Traditionally, catch-at-age has been estimated using cohort slicing. This simple method proves very useful when age readings are unavailable as it only requires the knowledge of a growth curve. However, ages are often mis-assigned, leading to precision and bias issues in the resulting catch-at-age. One alternative class of methods commonly used for estimating catch-at-age when age data are available is the age-length keys (ALKs). These methods have been shown to perform well when ages are derived from annual length-stratified sub-samples of fishery landings. However, it is unclear how well these methods perform when data are incomplete and lack representativeness, as is the case with western Atlantic bluefin tuna. Using Monte Carlo simulation, we evaluate two methods capable of accommodating incomplete data – a novel hybrid ALK (combining forward ALKs and cohort slicing) and the combined forward inverse ALK – to determine if the methods perform better or worse than cohort slicing, given the data limitations outlined above. Results indicate that the combined forward inverse ALK may be a good option for bridging the gap between data poor and data rich years.

Caitlin Allen Akselrud

University of Washington
Advisors: Trevor Branch and André Punt
NMFS Mentor: Anne Hollowed
Population and Ecosystem Dynamics, 2017

Lowering the risk of overfishing while increasing profits for California's most valuable fishery, California market squid

Caitlin Allen Akselrud

The California market squid (*Doryteuthis opalescens*) fishery is the highest grossing commercial fishery in California, but is only lightly regulated. Current management is limited to a fixed annual maximum catch limit of 118,000 tons (since 2005), weekend closures, and some gear restrictions (CDFG, 2005). There is no in-season or adaptive management of this fishery, which is known to exhibit large annual fluctuations in biomass (eg. Dorval et. al, 2013), and is sensitive to environmental variation, performing poorly in El Niño years (eg. Koslow and Allen, 2011). Market squid cannot be assessed using many traditional methods due to the fact that they are short-lived (six to nine months, Butler et al., 1999; Zeidberg, 2013), and semelparous aggregate spawners (Hixon, 1983). Market squid are also an important component of the California CPS complex, whose collective biomass provides an essential prey source for higher trophic level predators (Koehn et al., 2016). The goal of this research is to investigate harvest control rules for the market squid population independently and as part of a management strategy evaluation for the California CPS complex, which includes sardine (*Sardinops sagax caerulea*), anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicas*), and jack mackerel (*Trachurus symmeticus*).

Anna Birkenbach

Duke University
Advisor: Martin Smith
NMFS Mentor: Min-Yang Lee
Marine Resource Economics, 2016

Empirical structural analysis of value generation in the northeast multispecies sector program

Anna Birkenbach, Martin Smith, Min-Yang Lee

A growing body of work to evaluate the impact of catch share programs and other fisheries policy interventions relies on treatment effects models, which identify the causal net effects of the policy change. Treatment effects models typically are unable to identify the underlying mechanisms driving changes. As a result, these models can have limited relevance for proposed new (out-of-sample) policies. To shed light on mechanisms, we develop and estimate a structural discrete choice model of individual vessel behavior in order to learn more about how catch shares influence micro-level decision-making on the water. This work seeks to improve our understanding of how catch shares—and the policies that they replace—influence species targets, timing of fishing activity, and the value generated from the resource. To allow study of inter-species substitutions in pre- and post-rationalization, we implement this model using fine-scale commercial fishing data from before and after the start of the Northeast Multispecies Sector Program. We predict stock-specific production at the vessel-day level in first-stage regressions and use these predictions in a second-stage discrete choice model of targeting decisions that controls for weather, costs, and prices. We include non-groundfish species in the choice set to capture outside/non-catch share options. From this second stage we recover structural parameters that capture how policies affect micro-level incentives. The second-stage estimates are used to simulate the effects of removing days-at-sea regulations and replacing them with catch shares, and we evaluate the performance of the model using data from the post-rationalization period.

Erin Bohaboy

University of Florida
Advisor: William F. Patterson III
NMFS Mentor: Shannon L. Cass-Calay
Population and Ecosystem Dynamics, 2016

Harvest slots as a management tool to maximize marine recreational fishing opportunities and sustainability: Gulf of Mexico red snapper as a model species

Erin Bohaboy and William F. Patterson III

The Gulf of Mexico (GOM) red snapper (Lutjanus campechanus) stock is estimated to be overfished despite years of stringent recreational fishing regulations including daily bag limits, minimum size requirements, and seasonal closures. Studies of charter boat customers' discarding behaviors and attitudes, as well as successes in other recreational fisheries, suggest that harvest slots (a minimum and a maximum size regulation for harvested fish) may be a viable management tool for this valuable fishery. Preliminary analyses with simplified age-structured models indicate that if the stock is managed for a spawning biomass target, harvest slots may decrease overall fishing mortality, allowing for increased effort (longer seasons), higher catch rates of large fish, and decreased average size of harvested fish. However, the contribution of dead discards to total removals will decrease total landings and can reduce spawning stock biomass if catch rates in the fishery are high, especially with high discard mortality rates and narrow harvest slots. Future research will be conducted within Stock Synthesis (version 3.3), enabling a more dynamic analysis of the effects of recreational harvest slots on forecasted spawning biomass trajectories and stock rebuilding.

Reed Brodnick

University of Maryland
Advisor: Thomas Miller
NMFS Mentor: Kiersten Curti
Population and Ecosystem Dynamics, 2017

Analysis of the spatial and temporal population structure and dynamics of the mid-Atlantic Bight Black sea bass (*Centropristis striata*) stock- impacts of misspecification of spatial structure of assessment and stock on reliability of reference points

Reed Brodnick, Thomas Miller, and Kiersten Curti

The existence of spatial structure in populations of exploited marine fishes challenges our ability to develop reliable stock assessments. I will explore the impacts of the spatial resolution of population and assessment models on reference points generated by assessment models for the Mid-Atlantic Bight (MAB) Black Sea Bass stock (BSB - Centropristis striata; Hatteras, NC - Cape Cod, MA). The MAB BSB stock exhibits some degree of spatial structure, but spatially-structured assessment models are hindered by a lack of understanding of the degree of overwinter mixing, and could be improved through a better understanding of stock structure. I will use otolith chemistry to attempt to provide estimates of stock structure and winter mixing rates. I will conduct a management strategy evaluation (MSE) to investigate the implications of an assessment model which: 1) Correctly matches that of the underlying population dynamics when there is no spatial structure, 2) Correctly matches that of the underlying population dynamics when there is spatial structure, 3) Incorrectly matches that of the underlying population dynamics by assuming no population structure when it actually exists, and 4) Incorrectly matches that of the underlying population dynamics by assuming spatial structure when in fact none is present.

Brandon Chasco

Oregon State University
Advisor: Selina Heppell
NMFS Mentor: James Thorson
Population and Ecosystem Dynamics, 2016

An integrated growth model for deriving the age-at-sexual maturity from growth increment data: A case study for threatened Western Atlantic loggerhead sea turtles (*Caretta caretta*)

Brandon Chasco, Selina Heppell, James Thorson, Larisa Avens, Joanne Braun McNeill, and Eric Ward

The age at sexual maturity (ASM) is an important demographic parameter for the management of wild populations. Frequently, ASM is derived by inputting size at sexual maturity observations into the inverse of a size-at-age model. For some species such as sea turtles, size-at-age models are difficult to estimate because ageing data are not available. Using two independent time-series of growth increment data for a threatened population of Western Atlantic loggerhead sea turtles (*Caretta caretta*), we compare estimates of ASM from von Bertlanffy, gompertz and logistic size-at-age growth curves where age is treated as an unknown random effect. Furthermore, we examine changes in the estimated ASM for different scenarios of persistent and transient variability in the growth of individuals, and integrated versus independent data streams. Using AIC, we found the von Bertalanffy model best describes the size-at-age of loggerheads, and our ASM estimate of 38±6.5 years is similar to other studies using marked hatchlings that were later recaptured as neophyte nesters. This study suggests that for other populations that lack ageing data and where tracking individuals from birth to maturity is not reasonable, researchers can derive ASM from integrated models of size-at-age fit to growth increment data.

Jason Cope

Northwest Fisheries Science Center

Age structure considerations when expanding stock assessment reference points beyond biomass.

Jason Cope and Lewis Barnett

Fishery management reference points in data-rich situations typically focus on current population size of reproducing individuals (e.g., spawning stock biomass or output) and the fraction of unfished egg production that would remain after fishing at a constant rate to equilibrium (i.e., spawning potential ratio, SPR). This approach ignores information in the underlying age-structure that can inform near-term variation in spawning output that may indicate the short-term risk of population decline below target or limit reference points. We explore how age structure of fished stocks changes over time, and whether metrics of age structure may be useful as a reference of population status. We use simple simulations of age-structured models to test the candidate metrics as indicators that capture the effects of recruitment fluctuation and age truncation on population inertia. We demonstrate how populations with identical vital and exploitation rates and resultant spawning output— but different underlying age structure— can greatly diverge in short-term population dynamics. We seek to identify metrics that capture these important dynamics and discuss the potential of integrating such metrics into management control rules.

Mary Donovan

University of Hawaii at Manoa
Advisor: Megan Donahue
NMFS Mentor: Ivor Williams
Population and Ecosystem Dynamics, 2015

Ecological indicators of coral reefs across multiple spatial scales in Hawai'i

Mary Donovan and Ivor Williams

Central to implementing ecosystem approaches to management is providing scientific support for the development of indicators for assessment and monitoring of ecosystem state. When estimating indicators from data it is important to consider several sources of variation that can affect the utility of the indicator for detecting change, such as the spatial and temporal scaling of the underlying ecological processes. This study is investigating ecosystem indicators for Hawaii's nearshore marine ecosystems with the goal of informing ecosystem-based management processes. The analysis utilizes a synthesis of biological monitoring datasets that is matched with data on environmental and human drivers, and tests for any non-linear relationships or thresholds for each indicator. These relationships are modeled with a Bayesian hierarchical model that accounts for variation due to data coming from multiple sources, and explicitly models relationships at multiple nested spatial scales. The results therefore include both information on indicators for assessing the status of the ecosystem, and the spatial scale at which the information is applicable. The results are important for multiple ongoing management planning processes in Hawaii that operate on fundamentally different spatial scales, and therefore may not be able to rely on the same suite of indicators.

Nichiolas Ducharme-Barth

University of Florida
Advisor: Robert Ahrens
NMFS Mentor: Kyle Shertzer
Population and Ecosystem Dynamics, 2015

Spatial métiers in the commercial vertical line fishery for reef fish in the Gulf of Mexico

Nicholas Ducharme-Barth and Robert Ahrens

The sustainable management of exploited fish stocks is challenging. Complicating factors include competing stakeholder groups, stock metapopulation structure, multi-species ecosystem interactions, and environmental stochasticity. These factors become compounded with spatial scale as heterogeneity increases across larger landscapes. Typically, management boundaries line up with geopolitical boundaries that may or may not be representative of the underlying system. Management frameworks like marine spatial planning or ecosystem based management could help address these challenges to sustainable management. However, a necessary first step towards moving to these more sophisticated management frameworks is identifying whether spatially explicit sub-fleets (or métiers) and species assemblages exist. We provide a foundation for this move by decomposing the spatial structure of the commercial vertical line fishery in the GoM. In this analysis, we identified métiers, and the spatial regions that they operate in, within the fleet using a multivariate clustering analysis of catch records and vessel locations. This work links exploited species, fishing grounds, and the coastal economies reliant on these marine resources. This information can be used by management to better understand the pathways that exist within the system and how perturbations to various components would impact the system.

Robert Dunn

San Diego State University and U.C. Davis
Advisors: Kevin Hovel and Marissa Baskett
NMFS Mentor: Stephan Munch
Population and Ecosystem Dynamics, 2016

Incorporating community ecology into harvested species recovery trajectories

Robert Dunn, Kevin A. Hovel, and Marissa L. Baskett

Efforts to recover or restore populations of harvested species can be highly dependent on environmental and community context. For instance, both predator-prey interactions and interspecific competition can alter the trajectory of harvested species recovery. Recent work using simple predator-prey models suggests that synchronized recovery of predators and prey leads to faster and less variable recovery trajectories than either predator- or prey-first recovery (Samhouri et al. 2017). Whether this is the case in more complex communities is unknown. Previously, we developed a tri-trophic level community dynamics model with size-structure aimed at investigating the impacts of multi-trophic level fisheries on rocky reef community dynamics. Here, we extend this model to investigate the importance of three alternative community ecology processes which are typically unaccounted for in harvested species recovery trajectories: 1) alternative stable states, 2) size-structured predation, and 3) non-consumptive effects of predators on prey behavior. Our results demonstrate the importance of incorporating community ecology into ecosystem and fisheries management, particularly because organism body size typically determines both susceptibility to a fishery and the ability to induce community-wide effects through behavioral mechanisms.

Cassie Finer

Oregon State University
Advisor: David J. Lewis
NMFS Mentor: Cameron Speir
Marine Resource Economics, 2016

Dike removal and saltmarsh restoration for fish habitat: Estimating the effects on coastal land markets

Cassie Finer and David J. Lewis

Restoring degraded estuary and freshwater rearing habitat constitutes the "single overriding focus" for federal salmon recovery plans (NMFS 2016). Restoration plans, however, do not consider landowner costs beyond lost acreage (Ewald & Brophy 2012). While previous empirical hedonic work suggests coastline structure capitalizes into adjacent property values, a gap exists in estimating this relationship for West Coast land markets. Understanding the effect of marine conservation practices on interconnected land-based systems plays an essential role in efficient conservation policy. This research examines the question: how do dike removals aimed at restoring salmon habitat affect adjacent land markets? This research will provide foundational empirical evidence for the economic relationship between marine habitat restoration and human systems. In addition, parcel-level analysis allows for spatially explicit economic impact assessment. This provides valuable information conspicuously missing from current restoration policy.

References:

Ewald, M., and L. Brophy. 2012. Tidal Wetlands Prioritization for the Tillamook Bay Estuary. Tillamook Estuaries Partnership. Garibaldi, Oregon.

NMFS. 2016. Final ESA Recovery Plan for Oregon Coast Coho Salmon (*Oncorhnchus kisuth*)

Robby Fonner

Northwest Fisheries Science Center

Prioritizing habitat restoration for salmon recovery: Cost effectiveness analysis and beyond

Robby Fonner

In the Pacific Northwest of the United States significant resources are allocated to restoring habitat for salmon populations. Allocating these resources poses a challenge for restoration managers. Part of this challenge is evaluating alternative projects, which is necessary since undertaking one restoration project usually implies foregoing other worthwhile restoration projects or conservation activities. Providing restoration managers with information on the relative cost-effectiveness of candidate restoration projects is a first step towards improving the allocation of restoration resources. We discuss the use of cost effectiveness analysis (CEA) for salmon habitat restoration prioritization, and present an application to illustrate its utility. Key biophysical and economic processes that drive CEA outcomes are identified and assessed. Finally, we discuss future directions for habitat prioritization research in the Pacific salmon context.

Melissa Haltuch

Northwest Fisheries Science Center

Assessing the effects of climate change on U.S. West Coast sablefish productivity and on the performance of alternative management strategies

Melissa A. Haltuch[1], Teresa A'mar[2], Nicholas Bond[3], Juan L. Valero[4]

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U.S. west coast sablefish are commercially valuable, making assessing and understanding the impact of climate change on the California Current (CC) stock a priority for (1) forecasting future stock productivity, and (2) testing the robustness of management strategies to climate variability and change. The horizontal-advection bottom-up forcing paradigm describes large-scale climate forcing that drives regional changes in alongshore and cross-shelf ocean transport and directly impacts the transport of water masses, nutrients, and organisms. This concept describes a mechanistic framework through which climate variability and change alter sea level (SL), zooplankton community structure, and sablefish recruitment, all of which have been shown to be regionally correlated. This study forecasts potential future trends in sablefish productivity using SL from Global Climate Models (GCMs) as well as explores the robustness of harvest control rules (HCRs) to climate driven changes in recruitment by conducting a management strategy evaluation (MSE) of the currently implemented 40-10 HCR as well as an alternative Dynamic Unfished Biomass 40-10 HCR. A majority of the GCMs suggest that after about 2040 there will be a slight trend towards generally lower SLs relative to the global mean, with an increasing frequency of low SLs outside of the range of the historical observations, suggesting favorable conditions for sablefish in the northern CC by 2060. Projected SLs from the GCMs suggest that future sablefish recruitment is likely to fall within the range of past observations but may be less variable and is likely to exhibit decadal trends that result in recruitments that persist at lower levels (through about 2040) followed by somewhat higher levels (from about 2040 through 2060). Although this MSE suggests that spawning biomass and catches will decline, and then stabilize, into the future under both HCRs, the sablefish stock is not projected to fall below the stock size that would lead to a fishery closure during the period analyzed (through 2060).

Adam Hayes

University of Washington
Advisor: David Layton
NMFS Mentor: Alan Haynie
Marine Resource Economics, 2017

Network analysis of Pacific halibut quota trading in Alaska

Adam Hayes and Alan Haynie

Catch shares are a common policy instrument to mitigate the common pool resource problem associated with fisheries while avoiding perverse incentives that lead to overcapitalization of fishing fleets. A key feature of many catch share programs is that holders of quota can transfer their catch share rights, either temporarily or permanently. I focus on the Pacific halibut fishery which became a catch share fishery beginning in 1995. As of 2015, the number of quota holders has indeed declined by 56% compared to the initial allocation in 1995. Using data on halibut catch share trading in Alaska for the years 2000-2016, I model price dispersion and quota trading behavior over time using a network analysis approach to account for the non-independence of trades within the network. I explore the degree to which buyers and sellers remain segmented over time and the affect this segmentation has on prices and trades in the catch share market. I use this model to estimate the relationship between total allowable catch levels in each IFQ area and the corresponding prices and fishery participation decisions, as well as how prices and trades have changed since the Guided Angler Fishing charter program was introduced in 2014.

Quang Huynh

College of William and Mary, Virginia Institute of Marine Science
Advisor: John Hoenig
NMFS Mentors: John F. Walter, III and Jon Brodziak
Population and Ecosystem Dynamics, 2015

Estimating total mortality rates from mean lengths and catch rates in nonequilibrium situations

Quang Huynh, Todd Gedamke, Clay E. Porch, John M. Hoenig, John F. Walter III,, Meaghan Bryan, Jon Brodziak, and Nancie Cummings

A series of estimates of the total mortality rate (Z) can be obtained by using the Beverton–Holt nonequilibrium-based approach of Gedamke and Hoenig (2006) on observations of population mean length over time (ML model). In contrast, only relative mortality rates (not absolute values) can be obtained from a time series of catch rates. We derived the transitional behavior of the catch rate following a change in total mortality in the population. From this derivation, we developed a new method to estimate Z that utilizes both mean lengths and catch rates (MLCR model). Both the ML model and the MLCR model assume constant recruitment in the population. Simulations over various scenarios of Z and recruitment variability showed that there may be correlated residuals in the mean lengths and catch rates arising from fluctuations in recruitment. However, the root mean square errors of the Z estimates and the change point (i.e., the year when mortality changed) were smaller in the MLCR model than in the ML model, indicating that the MLCR model can better account for variable recruitment. Example applications of both methods illustrate their potential application to assess data-limited stocks.

Jason Link

NOAA Fisheries Senior Scientist for Ecosystem Management

System-level optimum yield: Increased value, less risk, improved stability, and better fisheries

Jason Link

The discipline and practice of fisheries science and management have had an useful, successful, and interesting history. The discipline has developed over the past century and a half into a very reductionist, highly quantitative, socially impactful endeavor. Yet given our collective successes in this field, some notable challenges remain. What if we managed fisheries in marine ecosystems such that: risk of overfishing and ancillary ecosystem impacts are minimized; populations of fishes, catches, and profits are stable; overall value and biomass across all stocks are maximized; bureaucratic oversight and regulatory interventions are minimized; stakeholder disenfranchisement and legal challenges are minimized; and catch and yield are optimized? By adopting systems thinking and specifically hierarchy theory—leading to a portfolio approach that uses system-level optimal yield— we can move towards these goals. Though the question remains - will we choose to do so?

Natalie Lowell

University of Washington
Advisor: Lorenz Hauser
NMFS Mentors: Eric Ward and Robin Waples
Population and Ecosystem Dynamics, 2017

Genetic risk assessment of native shellfish aquaculture

Natalie Lowell, Eric Ward, Brent Vadopalas, Bobbi Hudson, Benoit Eudeline, Bob Sizemore, and Lorenz Hauser

Aquaculture is rapidly developing worldwide. Introduction of non-native species for aquaculture is severely restricted or prohibited, motivating shellfish growers to expand cultivation of native shellfish species. However, aquaculture of native species may pose genetic risks to wild populations if farmed and wild individuals interbreed. These genetic risks include loss of fitness due to domestication selection, and loss of genetic diversity within and among populations. We aim to quantify these genetic risks by building an individual-based simulation model of shellfish production. The model will consist of hatchery broodstock, whose offspring are reared on a farm and then interbreed with wild conspecifics in local and distant populations. Genetic impacts of this interbreeding on wild populations will be tracked. To ensure our results are useful for decision makers, the model is informed by (i) life history parameters from the literature, (ii) empirical genetic data on population structure of three native species, and (iii) reported growing practice parameters from native shellfish growers. Using the model, we will conduct a management strategy evaluation to compare current practices with feasible alternatives. Our study will provide an important synthesis of these risks as well as potential solutions to inform decision makers in the shellfish aquaculture industry.

Kristin Marshall

Northwest Fisheries Science Center

Management strategy evaluation for ecosystem-based fisheries management: Climate, food webs, and people

Kristin Marshall

Revealing tradeoffs among objectives is a key step in Management Strategy Evaluation (MSE). Yet, in the context of Ecosystem-based Fisheries Management (EBFM), balancing complexity and simplicity in objectives, performance indicators, management strategies, and operating and estimation models can be a challenge. In this talk, I will compare the application of EBFM principles in two MSE-related projects focusing on fisheries with differing social and ecological contexts. Pacific hake is an abundant migratory groundfish, managed under an international treaty between the U.S. and Canada. Growing recognition that environmental drivers may influence the age-dependent movement of hake raises concerns that spatial population structure could affect harvest rates in both countries. Pacific herring is an important cultural, economic, and ecological resource along the west coast of North America, and central to recent management conflicts in Canada. Using these examples, I illustrate how a MSE approach can reveal or hide social and ecological tradeoffs, depending on the scale at which objectives and performance indicators are set and the types of management strategies, operating models and uncertainties that are considered. This work demonstrates the adaptability of applying EBFM principles through an MSE approach to tackle challenging problems in fisheries management.

Richard D. Methot

NOAA Fisheries Senior Scientist for Stock Assessments

Advancements and challenges in the stock assessment enterprise

Richard D. Methot

The U.S. stock assessment enterprise continues to advance on numerous fronts to provide better advice for fish stock status determinations and fishery catch quotas. Some advances focus on model precision including ensemble modeling, data weighting, and random effects. Others expand the scope to remove biases due to non-fishery factors, including climate and ecosystem effects. Other efforts seek to improve model inputs. These include improved spatial modeling of surveys and fishery catch rates, calibration of catchability for surveys, improved statistical basis for recreational fishery catch monitoring. As the collection of analyzed stocks grows, we also see more meta-analysis of factors such as life history rates and spawner-recruitment curvature. Assessment models also get entrained into the estimation loop of management strategy evaluations seeking improved fishery harvest control rules. As we begin to implement the updated Stock Assessment Improvement Plan, we intend to build a strong assessment research enterprise to advance these many factors, and to provide a pathway for moving these advancements into the operational assessment models used for management advice.

Elizabeth Ng

University of Washington
Advisor: Timothy Essington
NMFS Mentors: Jonathan Deroba
Population and Ecosystem Dynamics, 2017

Does predation information improve stock assessment?

Elizabeth Ng, Jonathan J. Deroba, and Timothy E. Essington

Multi-species stock assessments are advantageous because they incorporate a higher degree of biological realism than single-species assessments. In particular, multi-species assessments model species interactions, which are particularly important for forage fish species that experience high rates of predation in addition to harvest. However, complexity can be costly, especially in systems that lack data or that have historically used single-species assessments. One compromise is to incorporate predator diet data into single-species assessments to provide information about predation mortality. There are a variety of ways to include predator diet data, but methods depend on the quality and availability of diet data, which are affected by underlying ecological dynamics. We aim to characterize the effects of these ecological dynamics, such as predator-prey spatial overlap and predator functional responses, on diet data and, subsequently, performance in single-species assessments. We will use the Gulf of Maine/Georges Bank Atlantic herring complex as a case study. Our objectives are to 1) evaluate the relationship between predator diet composition and relative prey abundance, 2) develop and operating model to simulate diet data given underlying ecological dynamics, and 3) evaluate management advice from stock assessments that incorporate diet data in different ways.

Cecilia O'Leary

Stony Brook University
Advisor: Janet Nye
NMFS Mentor: Tim Miller
Population and Ecosystem Dynamics, 2015

Effects of climate-dependencies and estimation methods on biological reference points

Cecilia O'Leary and Janet A. Nye

Biological Reference Points are indices of stock status used by fisheries managers to maintain a fish stock's growth and sustainability. However, there is much disparity in the BRP calculation depending on the estimation method used and this disparity may be compounded when environmental indices are used in the stock assessment. Oceanographic conditions were previously demonstrated to play a role in summer flounder's fluctuating abundances in addition to changes in fishing pressure over the past 40 years. Summer flounder exposure to a shift in environmental conditions, the availability of multiple population models with different climate assumptions, and its data richness makes summer flounder an ideal to consider a BRP posterior probability distribution to understand the impact of different climate change assumptions on fish population dynamics. The purpose of this exercise was to evaluate the implications of both estimation method and climate assumptions on the BRP value output. We want to determine (1) how variable the climate-dependent BPRs are over the recently observed period; (2) whether conditional or dynamic BRPs are more variable over time; and (3) whether there is any long-term trend in BRPs for summer flounder. Results indicated that BRP values vary depending on both the climate-dependency incorporated and the estimation method used, emphasizing the importance to consider what attributes are important to your fishery before implementing BRP estimation and to consider comparing BRP values from different estimation methods and climate-dependency assumptions before adoption of any BRP.

Dan Ovando

University of California, Santa Barbara
Advisor: Steven Gaines
NMFS Mentor: Jason Cope
Population and Ecosystem Dynamics, 2016

Using economic information to improve data-limited stock assessments

Dan Ovando, Jason Cope, Ray Hilborn, Chris Costello, Steve Gaines, and Merrill Rudd

Many fisheries around the world require management guidance but lack the robust data that underpin state-of-the-art fisheries management. To resolve this problem, a large and growing suite of "data-limited stock assessments" (DLAs) has emerged, designed to provide management advice using relatively minimal data (but generous assumptions). Interestingly though, nearly all of the quantitative DLAs established rely exclusively on fish-centric data, for example length frequency distributions, catch data, or CPUE trends. While these data are clearly critical to proper understanding of a fishery's status, the economic history of a fishery can also shed light on its current biological status. This project proposes to address this challenge, by developing a quantitative method for integrating economic information into the stock assessment process. Length-based DLAs provide a useful entry point for this process. Length-based DLAs either rely on equilibrium assumptions or are faced with the challenge of disentangling trends in fishing mortality from trends in recruitment. We demonstrate how integration of often available data on the economic history of a fishery, such as prices, costs, and labor, can improve the performance of these length-based DLAs. Our expected result is a user-friendly tool for helping communities utilize length and economic data to better manage their fisheries.

Zack Oyafuso

Unviersity of Hawaii at Manoa
Advisor: Erik Franklin
NMFS Mentor: Jon Brodziak
Population and Ecosystem Dynamics, 2016

Simulation testing the utility of systematic reserve design to fulfill bioeconomic fisheries objectives

Zack Oyafuso, Jon Brodziak, and Erik Franklin

Systematic reserve design (SRD) is the mathematical approach of marine reserve design to objectively address explicit fishery management goals. Examples of reserve goals include total area, reserve shape, conservation value, and opportunity cost. The proof of concept for SRD is whether the bioeconomic effects of these placements reflect the bioeconomic goals defined in the SRD process. To address this, we developed a spatially explicit operating model (OM) with biomass-pool population dynamics, individual-based fleet dynamics, and spatiotemporal variation in fishery accessibility. Under the OM, we then calculated reserves designed under two management scenarios using a multi-objective integer linear programming model. First, reserves were optimized within the conventional practice of SRD: optimization of reserve placements that minimized opportunity cost while meeting explicit area, shape, and conservation goals. Second, reserves were optimized based on closing areas of high fisheries activity, i.e., optimization of reserve placements that maximized opportunity cost while meeting explicit area, shape and conservation goals. The OM was then continued and various bioeconomic metrics were tracked over time. Different scenarios of stock productivity and movement rates were simulated to evaluate reserve effects for different fishery scenarios. The preliminary results presented here will address the utility of SRD in fisheries management.

Cassidy Peterson

College of William & Mary, Virginia Institute of Marine Science
Advisor: Rob Latour
NMFS Mentor: Enric Cortes
Population and Ecosystem Dynamics, 2017

When can we use dynamic factor analysis to reconcile conflicting indices of relative abundance?

Cassidy Peterson and Robert J. Latour

Comprehensive trends in abundance are generally data requirements for many stock assessment models and are ideally calculated using fishery-independent surveys. For spatially wide-ranging species with slow-growing life histories and complex life cycles, like sharks, comprehensive population-wide surveys are unrealistic, such that assessments must rely on independent and spatially fragmented surveys to each generate a discrete index of relative abundance. When compiled, despite sampling the same population, multiple survey-based indices of relative abundance frequently conflict with one another, hindering interpretation and model assessment performance. Dynamic factor analysis (DFA), a multivariate, dimension reduction technique, has been proposed to rectify conflicting indices of relative abundance by extracting latent trends from a collection of time series data. The population of a small coastal shark species was simulated, fished, and surveyed using an age-structured production model. The simulated population was used to explore the circumstances under which DFA adequately estimates underlying abundance trends from conflicting indices of relative abundance. Unsurprisingly, DFA performs poorly when the underlying data lacks contrast and when surveys experience unaccounted changes in catchability. Future research will explore whether reduced DFA trends can be used in place of conflicting indices of relative abundance in stock assessment models.

Mikaela Provost

University of California, Davis
Advisor: Louis Botsford
NMFS Mentor: Michael O'Farrell
Population and Ecosystem Dynamics, 2016

Differences in life-history mediated temperature effects on population responses to environmental variability: Atlantic cod (*Gadus morhua*) as an example

Mikaela Provost and Louis Botsford

Temperature is known to be an important influence on fish life histories which, in turn, plays a substantial role in the sensitivity of populations to fishing, and consequently to population responses to their environment. Previous work on Atlantic cod shows that life-history mediated temperature affects result in populations in warmer regions of the Northeast Atlantic Ocean better able to sustain higher fishing rates than those in the cooler Northwest (Wang et al. 2014). Given that variation in cod life history, how do these different populations then respond differently to a variable environment? We use stochastic age-structured models to describe time series of abundance for 13 cod populations in the North Atlantic. Preliminary findings suggest that temperature strongly influences the sensitivity of populations to environmental variability. And that, cod populations follow a pattern of sensitivity to different frequencies of environmental variability: populations are more sensitive to frequencies on generational timescales and very low frequencies.

Amanda Warlick

Northwest Fisheries Science Center

Economic data collections: A multitude of benefits that facilitate academic research and the examination of profitability and fishery outcomes after the implementation of catch shares

Amanda Warlick

The Northwest Fisheries Science Center has been collecting cost earnings data through both voluntary and mandatory surveys from commercial fishing vessels on the West Coast for more than a decade. The analysis of this information contributes directly to ongoing academic research and fisheries management policy decisions, particularly evident throughout the development and completion of the five-year review of the West Coast groundfish trawl catch share program. The wealth of cost earnings data has been critical to examining the economic impacts of the implementation of catch shares for participants targeting Pacific whiting and other groundfish species across four fishery sectors and diverse fishing strategies. The Economic Data Collection Program data highlight changes in costs, net revenue, operational characteristics such as days at sea, and processing production value since the implementation of the catch share program in 2011. In addition to these performance metrics, we review the breadth of research that these data facilitate, including changes in spatial distribution of fish processing capacity, outcomes for crew, safety at sea, and the impacts of ocean conditions on profitability. We review examples of how these and other research projects are used to support ongoing decisions at the fishery management council level as stakeholders continue to adjust to changes brought on by the implementation of catch shares.

Charlie Waters

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Population and Ecosystem Dynamics, 2016

Modeling the effects of inbreeding in salmon hatcheries on the eco-evolutionary dynamics of supplemented wild populations

Charlie Waters, Jeffrey J. Hard, David E. Fast, Kenneth I. Warhelt, Curtis M. Knudsen, William J. Bosch, and Kerry A. Naish

It is widely acknowledged that captive breeding programs, including salmon hatcheries, can reduce the fitness of cultured organisms and negatively affect the wild populations they are intended to support. While research efforts have focused on the impacts of domestication selection, the consequences of inbreeding have received little attention, partly because detecting inbred individuals traditionally relied on pedigrees. However, inbreeding can now be accurately estimated in natural populations using advanced genomic approaches. Here, we quantified inbreeding in two closely related hatchery populations of Chinook salmon across four generations using genomic data. The populations were derived from the same source but now maintain contrasting levels of gene flow with the natural population, representing demographic extremes relevant to parameterization of population models. Next, the effect of inbreeding coefficient on eight fitness-related traits was quantified using linear models. We then explore the incorporation of these results and those from similar studies into an Integral Projection Model (IPM) to determine how inbreeding affects phenotypic variability and population productivity in supplemented wild populations over time. The IPM may improve our understanding of the long-term effects of supplementation programs and can be used to identify critical levels of inbreeding to avoid in hatchery propagation.

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Population and Ecosystem Dynamics, 2017

Estimating individual- and population-level variation in space use of white sharks off Cape Cod, Massachusetts, from passive acoustic telemetry data

Megan Winton, Gavin Fay, John Chisholm, and Gregory Skomal

Spatial management measures for coastal shark species are often based on trends in space use inferred from data collected using passive acoustic telemetry arrays. Variability in site fidelity and residency often leads to a disproportionate number of detections logged by certain individuals, which can bias population-level estimates of space use and associations with environmental covariates. Here we develop a model to identify relationships between species' occurrence and environmental covariates from acoustic telemetry data that directly accounts for differences in the spatial distribution of tagged individuals as well as the detection process. Our approach extends the generalized linear modeling framework often used to infer trends from acoustic telemetry data by accounting for individual heterogeneity using spatial random effects. We use simulation testing to compare the performance of the proposed model with spatial models that do not account for individual effects, as well as with the non-spatial generalized linear modeling approaches most frequently used. We fit the models to acoustic detection data collected from 10 tagged white sharks in the coastal waters off Cape Cod during 2016 and demonstrate how the models can be used to quantify the relationship between environmental covariates and predict both individual- and population-level space use.