Update Report

Period 3/1/2013 - 2/28/2014

Project E/I-19 - NMFS Population Dynamics Sea Grant Graduate Fellowship Exploring mechanisms of mortality in the first ocean year of Chinook salmon (Oncorhynchus tshawytscha). James Anderson in support of Jeffrey Rutter.

STUDENTS SUPPORTED

Rutter, Jeffery, jdrutter@uw.edu, University of Washington, Quantitative Ecology and Resource Management, status cont, field of study Modeling of Ecological Systems, advisor James Anderson, degree type PhD, degree date 2015-12-01, degree completed this period No
Student Project Title Exploring mechanisms of mortality in the first ocean year of Chinook salmon (Oncorhynchus tshawytscha).

Involvement with Sea Grant This Period fellow

Post-Graduation Plans NOAA or consulting work

CONFERENCES / PRESENTATIONS

"Change in Size Growth or Predation? a model to quantify the error in apparent growth" presented to NPAFC 3rd International Workshop on Migration and Survival Mechanisms of Juvenile Salmon and Steelhead in Ocean Ecosystems., public/profession presentation, 150 attendees, 2013-04-25

ADDITIONAL METRICS

K-12 Students Reached	Acres of degraded ecosystems restored as a result of Sea Grant activities
Curricula Developed	Resource Managers who use Ecosystem-Based Approaches to Management
Volunteer Hours	HACCP - Number of people with new certifications
Cumulative Clean Marina Program - certifications	

PATENTS AND ECONOMIC BENEFITS

No Benefits Reported This Period

TOOLS, TECH, AND INFORMATION SERVICES

Description		Developed	Used	Names of Managers	Number of Managers
CRITFC - Columbia River Inter-Tribal Fish Commission (annual sampling datasets)	Actual (3/1/2013 - 2/28/2014)	0	1		0
	Anticipated (3/1/2014 - 2/28/2015)	0	0		
PTAGIS - regional database of PIT Tagged salmonids in the Columbia River Basin	Actual (3/1/2013 - 2/28/2014)	0	1		0
	Anticipated (3/1/2014 - 2/28/2015)	0	0		

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices
Actual (3/1/2013 - 2/28/2014)
Anticipated (3/1/2014 - 2/28/2015)

Number of fishers using new techniques
Actual (3/1/2013 - 2/28/2014)
Anticipated (3/1/2014 - 2/28/2015)

Sustainable Coastal Development
Actual (3/1/2013 - 2/28/2014)
Anticipated (3/1/2014 - 2/28/2015)

Coastal Ecosystems
Actual (3/1/2013 - 2/28/2014)
Anticipated (3/1/2014 - 2/28/2015)

PARTNERS

No Partners Reported This Period

IMPACTS AND ACCOMPLISHMENTS

No Impacts or Accomplishments Reported This Period

PUBLICATIONS

No Publications Reported This Period

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

No Leveraged Funds Reported This Period

UPDATE NARRATIVE

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Project Goals

The overall goal is to explore the importance of the mechanisms underlying mortality, growth and maturation of Columbia River spring Chinook salmon. I am developing a model of size, growth, size-selective mortality, food competition, and maturation which captures the essential dynamics observed for 1-ocean returning (and not returning) fish to address the following specific questions:

1. How do elements of the system work together to create the apparent disconnect between the number of out-migrating smolts and the number of returning jacks?
2. What factors are related to the prodigious jack returns seen in 2009 & 2011?
3. What impacts could large hatchery-raised salmon populations have on the wild-reared salmon population, if any (especially in years of poor ocean conditions)?

Two new questions have arisen since the initiation of these investigations:

4. Can model-fitting techniques be used to separate the effects size-selective mortality and growth on the observed distribution of fish and thereby improve estimates of actual growth?
5. How do these models of growth and size-selective mortality inform the work of Passolt (2012), whose investigations linked initial length to survival?

Update Outline

My work over the past year can be placed in three broad categories: data activities, "apparent growth" model development and testing, and "first ocean year" theory development.

My primary data activity was the construction of a comprehensive dataset of PIT-tagged Columbia River Basin Chinook salmon for out-migration years 2006-2011 that includes source population and return year. Other minor data activities included the updating my databases of environmental covariates.

My "apparent growth" project is a spinoff of my examination of the system of ODEs used by Munch et al. (2003). I presented a theoretical examination of the techniques in Munch et al. (2003) used in the context of distinguishing actual from apparent growth at the NPAFC meeting in April 2013. Simulation testing revealed that simple parameter fitting does not produce reliable estimates of actual growth. I am presently testing three kinds of additional information to see which are most effective at improving accuracy and whether a reasonable amount of additional information will yield more reliable estimates of actual growth vs. apparent growth.

My "first ocean year" project work has focused on improved computer algorithms and a new functional form for including density dependence. I am now using a solver for the McKendrick-von Foerster PDE based on the method of characteristics. The performance and accuracy of the new algorithm are much improved. This performance improvement is critical for a complete exploration of the model's properties. The new improved density dependence model assumes a relationship between total biomass instead of total number of individuals. Biomass is estimated from lengths using an allometric relationship between size and mass.

Data Activities

My primary data activity was the construction of a comprehensive dataset of PIT-tagged Columbia River Basin Chinook salmon for out-migration years 2006-2011. This dataset was derived from the regional data center, PTAGIS, with added processing to establish direction of movement at each detection and the date of first detection after returning from the ocean. This dataset allows me to compare frequency of returns after a number of years-at-sea across multiple spatial scales (from a single source or from aggregated sources). This task proved to be much more challenging than expected, but having the data available will be useful for testing and parameterizing the other models—as well as examining the distribution of precocious returns, i.e. jack salmon. Other minor data activities included the updating of databases of environmental covariates.

Apparent Growth Model

The apparent growth project is a spinoff of my examination of the system of ODEs used in (Munch et al. 2003). At the NPAFC meeting in April 2013, I presented a theoretical examination of the use of techniques outlined in (Munch et al. 2003) to examine a different problem: distinguishing actual growth (the mean change in size of individuals using repeated measures of the same individuals) from apparent growth (the change in mean size of individuals from samples taken at two times).

I continued this investigation by examining practical aspects. The utility of this technique for estimating actual growth from apparent growth has shown promise. Simulation testing has shown that simple parameter fitting does not produce reliable estimates of actual growth. I am presently testing three kinds of additional information to improve estimation of actual growth. The essence of these additions is the application of "prior" distributions on total cohort mortality, relative sampling efficiency (between first and second samples), and mean actual growth. Another improvement performs the optimization in stages—first tuning the growth model alone (so that growth without mortality fits the observed apparent growth), then size-selective mortality is added to get a better fit to the data, using the growth-only model parameters as a starting point.

This investigation was originally intended to take 2-3 months, but has taken far more time. However, the fruits of the investigation may prove useful. I intend to complete the research on this project in April, 2014 and complete the manuscript in June 2014.

Freshwater Size-Selective Mortality Model

I have also begun recasting the work of Passolt (2012) in the light of the ODE model from Munch et al. (2003). This research examines the impact of initial size on survival, focusing on the freshwater system, but also examining smolt-to-adult returns. Combining the two works lends interpretability to the model parameters in Passolt (2012). With coauthors Passolt and Anderson, we intend to have a manuscript ready by December 2014.

First Ocean Year Model

I have added some of the complexity discussed in last year's review, essentially breaking the problem into three parts, with three separately parameterized models of growth and mortality. Tests of this three-part model show promise for producing jack returns which appear de-coupled from the number of out-migrating smolts.

Density dependence model: Predation & Resource competition

Predation is being modeled in a straightforward predator-prey fashion, with the number of predators able to consume a prey of a given length being determined by the distribution of predator sizes within the population of predators: $m(x,t) = \alpha \Pr(y > x)$ where x is the size of individuals in the population of interest, $m(x,t)$ is the per capita mortality rate, α is a parameter incorporating predator abundance and efficiency, and y is the gape limit of predators in the population. At present, predators are modeled in a simple fashion, using normal distributions (as I would envision with actual data on predators).

Ideas from Barlow (1992) led to a new way to relate density to growth rate. The first concept is the use of biomass instead of counts of individuals. Additionally, the growth parameters have some nominal value (related to environmental covariates) and are adjusted by a function of total biomass (e.g. for a Von Bertalanffy growth curve, $L(L_i, t) = L_\infty - [(L_\infty - L_i)\exp(-k\,t)]$. Both of the parameters could be impacted by environmental and density factors. I assume L_∞, has a nominal value $L_\infty = f_0 = X^T\beta$, where X is a vector of environmental covariates and β is a vector of coefficients. Then the density-dependent adjustment becomes $L_\infty = f_0 - \left(\frac{M}{\rho_1}\right)^{\rho_2}$ where ρ_1 and ρ_2 are fitted values and M is the total biomass in the system.)

Maturation model

Little additional progress has been made on the maturation model. Next steps include rerunning the analysis I had previously performed on my newly minted dataset. Following that exercise I will be integrating the size-at-age model into my first ocean year model.

Barlow, J. 1992. Nonlinear and Logistic Growth in Experimental Populations of Guppies. Ecology **73**:941-950.

Munch, S. B., M. Mangel, and D. O. Conover. 2003. Quantifying Natural Selection on Body Size from Field Data: Winter Mortality in Menidia Menidia. Ecology **84**:2168-2177.

Passolt, G. 2012. A Predator Susceptibility Model of Juvenile Salmon Survival. University of Washington.