Update Report
Period: 3/1/2014 - 2/28/2015
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: 2016-05-01, degree completed this period: No
Student Project Title: none
Involvement with Sea Grant This Period: none
Post-Graduation Plans:
NOAA or consulting work

CONFERENCES / PRESENTATIONS

When Change In Size ≠ Growth: _using two sample size data to _estimate actual growth., public/profession presentation, 18 attendees, 2015-03-20

ADDITIONAL METRICS

P-12 Students Reached:	P-12 Educators Trained:
Participants in Informal Education Programs:	Volunteer Hours:
Acres of coastal habitat protected, enhanced or restored:	Resource Managers who use Ecosystem-Based Approaches to Management:
Annual Clean Marina Program - certifications:	HACCP - Number of people with new certifications:

ECONOMIC IMPACTS

No Economic Impacts Reported This Period

SEA GRANT PRODUCTS

No Sea Grant Products Reported This Period

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Number of stakeholders modifying practices:	Sustainable Coastal Development # of coastal communities:

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

Type: influenced Period: 2014-06-01: : 2015-05-31Amount: $64511
Purpose:
Expand and publish research from Passolt 2012.
Source: Bonneville Power Adminstration

UPDATE NARRATIVE

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Project Goals

My research is addressing the following questions:

1. Can I identify elements of the system that could result in the prodigious jack returns seen from the 2008 & 2010 out-migrating cohorts?
2. What kinds of impacts could the large numbers of hatchery-raised salmon have on the wild-reared salmon population, if any (especially in years of poor ocean conditions)?
3. What can these models tell us about the size of differences between apparent and actual growth? Can model-fitting techniques be used to reliably improve estimates of actual growth, given a measure of apparent growth and a system including size-selective mortality?
4. Using the general theory of size-mediated survival, how well can a simple model involving the initial size of a cohort of fish and a simple broad environmental covariate (e.g. PDO) model the Smolt-to-Adult survival in the system?

Item 4 is new this year, and was the focus of my work over the summer and fall.

Update Outline

My work over the past year can be placed in four broad categories: data activities, "apparent growth" model testing, "first ocean year" theory development, and SAR model development, research, and testing. I made a rather sharp deviation from my plans outlined in my previous update: namely I added a new research opportunity—related to my existing research, but focused more broadly on smolt-to-adult returns (SAR) based on initial size. Funding for this research, an extension of Passolt (2012), was available in a limited-time window. The SAR research is a nice precursor to my research, since it makes use of a reasonable and simple model, with just a few basic assumptions. I have worked to fill in the gaps and make it publishable.

My "first ocean year" project work was largely on hold, but I did make advances on a set of exact solutions using the method of characteristics. I also began a time series analysis to examine the time-series of 1-ocean returns with a set of broad-scale environmental covariates.

My "apparent growth" project examines a technique for estimating growth/mortality model parameters from Munch et al. (2003). I have tested three kinds of additional information: priors on sampling efficiency, priors on selectivity of mortality, and priors on growth itself. None improved accuracy noticeably unless the prior information was very informative. I recently presented this research at a local quantitative seminar and have some new lines to pursue before finishing it.

My data activities consisted of maintaining my comprehensive dataset of PIT-tagged Columbia River Basin Chinook salmon for out-migration years 2006-2011 (to which I've added 2012) and updating my databases of environmental covariates.

SAR Model Activities

I expanded on the smolt-to-adult survival model analysis presented in Passolt (2012). Namely I examined the assumptions underlying the model and the fitting algorithm. I discovered a bias in the parameter fitting which tends to shift the central size of the mortality curve (the mortality curve's inflection point) toward the central size of the population (the mean population size). This accounts, in part, for the most significant difference between the fitted mortality curve for hatchery fish and the corresponding curve for wild fish. I also investigated the impact of PDO in this model and found that its inclusion in the maximum mortality part of the model explained much of the variability between years. We will begin writing the manuscript for this in late March/early April.

Jack Returns Time Series Analysis

I examined the time-series of returning 1-ocean fish by looking at counts of jacks and full adults at the four dams on the lower Columbia River. I examined the percentage of each year's returns that was composed of jacks. I looked at three questions. First, is the percentage of jacks better modeled as an auto-regressive state-space model or as a mean-reverting process? Second are freshwater of marine covariates better predictors of the percentage of jacks? And finally, is the size of hatchery-raised fish in the fall before ocean entry a good predictor of the percentage of jacks? I found that jacks were best modeled as a mean-reverting process, suggesting that multiple years at sea continues to be an evolutionarily stable set of life-history strategies—the percentage will continue to vary, but the long-term average is stable. Both freshwater and marine covariates were important, although freshwater covariates may have been slightly more so. And finally, I found that the size of hatchery parr did not account for much of the variance in the percentage of jacks. After a round of peer review, I am making some changes to my data and analysis and plan to have a manuscript ready by June.

First Ocean Year Model

My "first ocean year" project work has been largely on hold. I did work on expanding a set of exact solutions to the McKendrick-von Foerster equations underlying my model using the method of characteristics. I also determined that the ideas from Barlow (1992), although initially attractive, proved to be too complex for my model. I do not have enough data to parameterize the density relationships meaningfully. I have therefor switched to a simpler model which uses a linear function of density, transformed into the (0,1) interval using the inverse logit.

Apparent Growth Model

The "apparent growth" project is a spinoff of my research into models of simultaneous growth and size-selective mortality. I presented a theoretical examination of the model outlined in Munch et al. (2003) to distinguish 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 presented an updated version of this talk at a quantitative methods seminar series at the University of Washington.

Simulation testing has shown that simple parameter fitting does not produce reliable estimates of actual growth. Optimization in stages, improved the computation time, but not the accuracy of the algorithm. I tested the addition of "prior" information to the likelihood in three categories: total cohort mortality, relative sampling efficiency (second sampling relative to the first), and mean actual growth. Even an extremely restrictive prior on sampling efficiency failed to produce more accurate actual growth estimates. The mortality and actual growth priors did improve accuracy, although they did need to be quite restrictive in order to get substantial improvement. I have the bones of a manuscript, and I am in the process of reviewing some suggested literature before putting the finishing touches on the manuscript.

Data Activities

My primary data activity was the maintenance of my dataset of PIT-tagged Columbia River Basin Chinook salmon for out-migration years 2006-2011, adding 2012 fish and a few late-returning 2010 & 2011 fish. This dataset was derived from 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). Other minor data activities included the updating of my database of environmental covariates, which now includes the Pacific Northwest Index (Ebbesmeyer 1995), PDO (Mantua et al. 1997), NPI (Trenberth and Hurrell 1994), AO (Thompson and Wallace 1998), and NPGO (Di Lorenzo et al. 2008).

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

Di Lorenzo, E., N. Schneider, K. M. Cobb, P. J. S. Franks, K. Chhak, A. J. Miller, J. C. McWilliams, S. J. Bograd, H. Arango, E. Curchitser, T. M. Powell, and P. Riviere. 2008. North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophysical Research Letters **35**.

Ebbesmeyer, C. C. a. R. M. S. 1995. Oyster Condition and Climate: Evidence from Willapa Bay. Page 11p *in* W. S. G. Program, editor., University of Washington, Seattle, WA.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society **78**:1069-1079.

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.

Thompson, D. W. J. and J. M. Wallace. 1998. The Arctic Oscillation signature in the wintertime geopotential height and temperature fields. Geophysical Research Letters **25**:1297-1300.

Trenberth, K. E. and J. W. Hurrell. 1994. Decadal Atmosphere-Ocean Variations in the Pacific. Climate Dynamics **9**:303-319.