

## Update Report

Period: 2/1/2014 - 1/31/2015

**Project: R/HCE-1 - Marine Survival of Puget Sound Chinook Salmon: Size-selective Mortality, Critical Periods, and Growth Limitation**

### STUDENTS SUPPORTED

**Duarte, Amy**, aed32@humboldt.edu, Humboldt State University, Dept. Fish & Wildlife Biology, status: new, field of study: Fish Biology, advisor: David A. Beauchamp (UW), degree type: BS, degree date: 2015-06-01, degree completed this period: No

Student Project Title:

Evidence for size-selective mortality by juvenile Chinook salmon in the Nisqually River estuary and offshore habitats

Involvement with Sea Grant This Period:

internship

Post-Graduation Plans:

grad school

**Gamble, Madilyn**, mgamble@u.washington.edu, University of Washington, School of Aquatic & Fisheries Science, status: new, field of study: Fod web ecology, advisor: David A. Beauchamp, degree type: MS, degree date: 2016-12-01, degree completed this period: No

Student Project Title:

Size-selective mortality, critical periods, and growth limitations for Puget Sound Chinook salmon during early marine life stages

Involvement with Sea Grant This Period:

Thesis research, graduate research assistant

Post-Graduation Plans:

Ph.D. (perhaps a MS-bypass), then academic position

### CONFERENCES / PRESENTATIONS

Beauchamp, D.A., J.A. Chamberlin, and M. Gamble. 2014. Size-selective mortality and Critical Growth Periods for Chinook Salmon in Puget Sound: Approach and status of critical growth study. U.S.-Canada Science Retreat, Salish Sea Marine Survival Project. Bellingham, WA. December 2, 2014., public/profession presentation, 45 attendees, 2014-12-02

Beauchamp, D.A., M. Gamble, J. Chamberlin, and E.J. Duffy. 2015. Identifying critical periods of growth and mortality in Pacific salmon-Then deciphering underlying mechanisms. 16th Annual Salmon Ocean Ecology Meeting. Victoria, BC., public/profession presentation, 90 attendees, 2015-03-25

Beauchamp, D.A. 2014. Marine Survival of Puget Sound Chinook Salmon: New studies on size-selective mortality and critical growth periods. Salish Sea Ecosystem Conference, Seattle. Invited speaker., public/profession presentation, 200 attendees, 2014-06-01

Beauchamp, D.A. 2014. Identifying Critical Periods of Growth and Mortality in Pacific Salmon-Then Deciphering Underlying Mechanisms. Alaska Sea Life Center, Science Colloquium. Invited Plenary speaker., public/profession presentation, 40 attendees, 2014-10-29

Beauchamp, D.A. 2015. Size-selective mortality and Critical Growth Periods: Diagnosing marine survival of juvenile Chinook Salmon in Puget Sound. Wildlife Seminar Series, School of Forest and Environmental Sciences. University of Washington., public/profession presentation, 300 attendees, 2015-01-26

### **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**

Partner Name: Department of Fisheries and Oceans Canada

Partner Name: Kwaiht, type: NGO, scale: Local

Partner Name: Long Live The Kings

Partner Name: Lummi Tribe, type: Other, scale: Tribal

Partner Name: Nisqually Tribe
Partner Name: NOAA Fisheries
Partner Name: Pacific Salmon Foundation
Partner Name: Skagit Cooperative Tribes, type: Other, scale: Tribal
Partner Name: Tulalip Tribe
Partner Name: U.S. Geological Survey, type: Government, scale: Federal or National
Partner Name: University of British Columbia
Partner Name: University of Victoria
Partner Name: Washington Department of Fish and Wildlife

## IMPACTS AND ACCOMPLISHMENTS

Title: **Washington Sea Grant investigates why young salmon are dying in the Salish Sea**

Type: accomplishment

Description:

Relevance: Chinook, coho, and steelhead populations in Salish Sea watersheds declined dramatically in the 1980s and have remained low. One major cause is high mortality in early life stages: healthy smolts grow, exit their natal streams, and are lost after entering marine waters. Determining the reasons for this high death toll is essential to saving salmon and steelhead runs and restoring fisheries.

Response: In 2013, Washington Sea Grant provided critical impetus and early program funding for a five-year, \$20 million Salish Sea Marine Survival Project to unravel the mystery of low salmon survival in the Salish Sea. This WSG-supported project is examining patterns of size-selective mortality—at precisely what life stages and in which habitats young fish are most vulnerable. Using these findings, the project will assess and, if possible, guide management to correct causes of high salmon mortality such as limited food supply or quality, thermal stress, competition, and predation.

Results: Researchers developed individual growth trajectories for all life stages of sub-yearling Chinook from four target watersheds (Nisqually, Snohomish, Skagit, and Nooksack). Initial analyses suggest that size-selective mortality does occur and that its magnitude and timing vary between watersheds and between tagged and untagged fish within watersheds. The findings amplified earlier observations of increased predation on young salmon that are smaller when they enter the marine

watershed.

Recap:

Recap: Washington Sea Grant-supported research identifies size-selective patterns in the high loss of young salmon in the Salish Sea and investigates critical growth and survival periods and possible causes of loss.

Comments:

Primary Focus Area – HCE

Secondary Focus Area – SFA

Associated Goals: Ocean and coastal resources are managed using ecosystem-based approaches. (HCE)

Fisheries are safe, responsibly managed and economically and culturally vibrant. (SFA)

Partners:

Department of Fisheries and Oceans Canada

Kwaiht

Long Live The Kings

Lummi Tribe

Nisqually Tribe

NOAA Fisheries

Pacific Salmon Foundation

Skagit Cooperative Tribes

Tulalip Tribes

U.S. Geological Survey

University of British Columbia

University of Victoria

Washington Department of Fish and Wildlife

Related Partners: Long Live The Kings, NOAA Fisheries, Department of Fisheries and Oceans Canada, Washington Department of Fish and Wildlife, Tulalip Tribe, Nisqually Tribe, Skagit Cooperative Tribes, Lummi Tribe, Pacific Salmon Foundation

## **PUBLICATIONS**

Title: **Salish Sea Marine Survival Project**

Type: Internet Resources, Topical Websites Publication Year: 2014

Uploaded File: *none*

URL: <http://marinesurvivalproject.com/>

Abstract:

The Salish Sea Marine Survival Project is dedicated to determine the factors limiting production and survival of salmon and steelhead in Puget Sound and the Strait of Georgia. A series of top-down, bottom-up, and retrospective analysis studies are underway.

Citation:

N/A

Copyright Restrictions + Other Notes:

Journal Title: *none*

## **OTHER DOCUMENTS**

*No Documents Reported This Period*

**LEVERAGED FUNDS**

Type: influenced Period: 2014-03-01: : 2015-01-31 Amount: \$166667

Purpose:

Provide sampling support for estuarine delta and marine nearshore habitats associated with the 4 watersheds targeted. These programs supplied the samples required from these habitats and regions that were processed and analyzed as part of the SeaGrant project.

Source: Skagit River System Cooperative

Type: influenced Period: 2014-03-01: : 2015-01-31 Amount: \$166667

Purpose:

Provide sampling support for estuarine delta and marine nearshore habitats associated with the 4 watersheds targeted. These programs supplied the samples required from these habitats and regions that were processed and analyzed as part of the SeaGrant project.

Source: Tulalip Tribes

Type: influenced Period: 2014-03-01: : 2015-01-31 Amount: \$166667

Purpose:

Provide sampling support for estuarine delta and marine nearshore habitats associated with the 4 watersheds targeted. These programs supplied the samples required from these habitats and regions that were processed and analyzed as part of the SeaGrant project.

Source: Nisqually Tribe

Type: influenced Period: 2014-02-01: : 2015-01-31 Amount: \$223300

Purpose:

Salish Sea Marine Survival Project expanded on the spatial coverage of the SeaGrant project from 2 watersheds and offshore marine regions to 4 watershed-offshore regions, plus San Juan Islands and supplemental support for lab processing of samples

Source: Long Live The Kings

**UPDATE NARRATIVE**

Uploaded File: [Beauchamp\\_4614\\_update\\_....2.pdf](#), 1001 kb

The UW-NOAA-Tribal team successfully completed estuarine, nearshore marine, and offshore sampling during all targeted periods in 2014. The scheduled purse seining cruises occurred in early May, early/late June, early/late July, and early August to sample offshore habitats associated with all four watersheds (Nisqually, Snohomish, Skagit, and Nooksack plus San Juan Islands). In addition, supplementary purse seine sampling was conducted to monitor health and condition of steelhead smolts in Hood Canal (early May) and in the vicinity of the Duwamish River estuary (May and June). In addition, supplementary purse seine sampling was conducted to monitor health and condition of steelhead smolts in Hood Canal (early May) and in the vicinity of the Duwamish River estuary (May and June).

Lab processing and analysis of scales and diet composition for Chinook was initiated and achieved routine production level using a core group of trained lab and field scientists and technicians. Additional coordination was necessary to develop a streamlined sequence for proceeding from the initial lab dissections of thawed specimens (FL, wt, scales, fin clips, diet at UW) to extraction of otoliths (USGS) and coded wire tags (CWT). Additional responsibilities for some of the otolith and CWT extraction and CWT reading was shifted to the UW dissection sessions in order to streamline processing and minimize deterioration of samples from repeated thawing and handling. This sample processing plan will be repeated next year to expedite in-season sample processing.

Scale samples were processed and analyzed for subyearling Chinook during peak periods in each habitat for all 4 watersheds and the San Juan Islands. Stomach content analysis was completed for juvenile Chinook from the Nooksack and a subset of Nisqually watershed. Selected tissue for genetics and plasma samples from the Skagit, Nooksack, and San Juan Island regions have been transferred to labs at Washington Department of Fish and Wildlife and NOAA/NWFSC, respectively, for processing. Scale sample processing is continuing for Chinook scales from sampling periods directly adjacent to peak migration periods for specific life stages. Initial results on evidence for size selective mortality and initial diet data were presented for the Nisqually watershed at the US/Canada retreat in early December 2014. Diet analysis is ongoing and some processing effort will shift to a prioritized subset of the 2014 Coho samples in April or May. Bioenergetics simulations to diagnose the underlying factors limiting growth during critical growth periods will begin this spring in conjunction with a graduate-level "Bioenergetics Modeling" course at UW.

**Results:** Average and individual growth trajectories have now been developed for each life stage of subyearling Chinook salmon from each of the 4 watersheds for specific CWT marked groups, all marked juveniles combined, and unmarked juveniles. The initial analyses suggest evidence for size-selective mortality (SSM) and that the magnitude and timing of SSM varies among watersheds and within watersheds among marked and unmarked cohorts. Juvenile Chinook salmon exhibited discrete pulses through specific life stages and associated habitats (**Figure 4**). These pulses and the modal scale circulus count associated with these events were used to interpret scale-based growth trajectories of juvenile Chinook salmon through their early marine life stages in four watersheds.

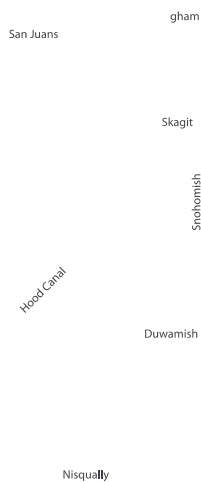
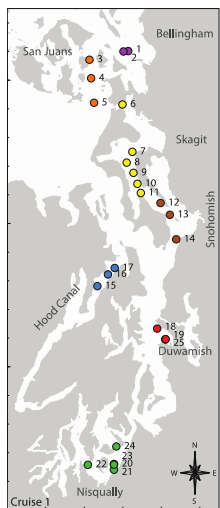
The magnitude and timing of size-selective mortality (SSM) varied among watersheds and within watersheds among marked and unmarked cohorts (**Figure 5**). The Skagit watershed exhibited little to no measurable SSM among life stages nor between marked and unmarked groups.

No consistent trends in growth patterns were evident between marked versus unmarked groups across watersheds.

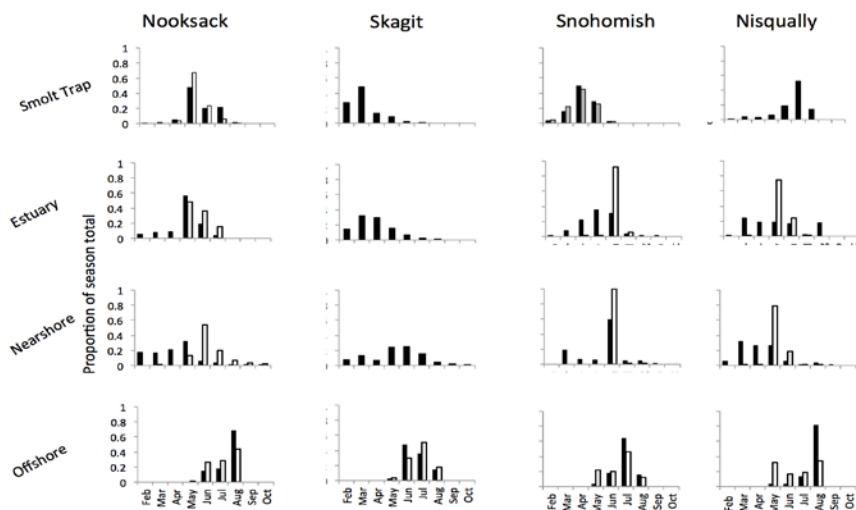
Growth trajectories for unmarked Chinook salmon were more diverse among life stages than marked groups in the Snohomish. (Nooksack unmarked Chinook were less variable than marked; Nisqually UM similar to pooled M group).

SSM was strong against the small earliest offshore migrants in Nisqually (Unmarked May) and Snohomish (Unmarked in June). Sequential SSM was evident among (mostly offshore life stages) in Nisqually and Snohomish, suggesting that SSM was ongoing through most of the summer growing season for these populations. In contrast, juvenile hatchery Chinook from the Nooksack exhibited strong SSM

from the estuarine-nearshore to offshore life stages. Within watersheds, known CWT groups and the pooled hatchery groups showed similar patterns in growth trajectories.

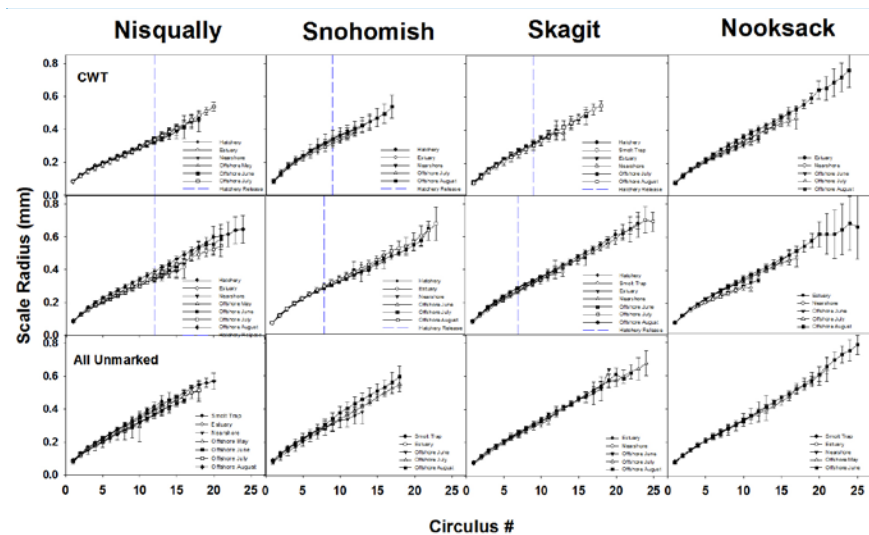


**Figure 2.** All 2014 purse seine set sites. Cruise 1: May 6-13; cruise 2: June 2-8; cruise 3: June 16-19; cruise 4: July 7-10; cruise 5: July 21-25; cruise 6: August 4-7.



**Figure 4.** Life history pulses of juvenile Chinook salmon as indicated by normalized CPUE for each watershed. CPUE values were graphed as proportions of the summed CPUE over the entire season for the specific sampling method used within each watershed and habitat type.

**Commented [MG1]:** I know the marked fish are missing for most of the Skagit – I've asked Josh to put those in and send me the updated version.



**Figure 5:** Mean ( $\pm 2$  SE) growth trajectories of specific CWT groups, all marked, and all unmarked juvenile Chinook sampled during peak periods of use for each habitat in each watershed. Dashed lines represent the median circulus # (age) at hatchery release for each cohort.

**Commented [MG2]:** I need to fix one or two formatting mistakes with this figure. Should I also include separate figures for each watershed?

**DB-**Use the same symbols consistently for each life stage or sampling period, so plot an empty column when data don't exist or are inadequate for a specific period.

Also be certain that the tick marks are synched and aligned among CWT, All Marked, and UnMarked groups