Update Report

Period 2/1/2013 - 1/31/2014

Project R/LME-7 - Recovery of Elwha River Salmon and Trout after Dam Removal Recolonization and the Awakening of Dormant Life History Diversity

STUDENTS SUPPORTED

Thornton, Emily, ethorn10@uw.edu, University of Washington, School of Aquatic and Fishery Sciences, status cont, field of study Aquatic and Fishery Sciences, advisor Thomas Quinn, degree type MS, degree date 2014-12-01, degree completed this period No
Student Project Title Ecological interactions between resident, non-native brook trout and re-colonizing coho salmon in the Elwha River

Involvement with Sea Grant This Period Graduate student supported by the grant

Post-Graduation Plans too soon to say

CONFERENCES / PRESENTATIONS

No Conferences / Presentations Reported This Period

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

Use of archived scales to assess marine ecology of wild and hatchery summer and winter runs of steelhead. R/LME-7	Actual (2/1/2013 - 1/31/2014) Anticipated (2/1/2014 - 1/31/2015)	1 0	0 0	0
Test of a hand-held microwave energy meter to compare summer and winter run steelhead body fat levels as a way to assign individual fish to one run or the other. R/LME-7	Actual (2/1/2013 - 1/31/2014) Anticipated (2/1/2014 - 1/31/2015)	1 0	0 0	0
Test of the utility of stable isotope methods to differentiate between steelhead and rainbow trout fry. R/LME-7	Actual (2/1/2013 - 1/31/2014) Anticipated (2/1/2014 - 1/31/2015)	1 0	0 0	0

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

Number of fishers using new techniques
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

Sustainable Coastal Development
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

Coastal Ecosystems
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

PARTNERS

Partner Name Coastal Watershed Institute

Partner Name Department of Fish and Wildlife

Partner Name Lower Elwha Klallam Tribe

Partner Name National Park Service

Partner Name NOAA

Partner Name Peninsula College

Partner Name US Fish and Wildlife Service (US DOI

Partner Name US Geological Survey

Partner Name Western Washington University

IMPACTS AND ACCOMPLISHMENTS

Title The Elwha dams come down, and Washington Sea Grant chronicles transformational encounters between salmon populations separated for nearly a century

Type accomplishment

Description Relevance The removal of the Elwha River dams in 2012-2014 and the restoration of what was one of the region's most productive salmon opens extraordinary opportunities to observe rapid change in an unusually diverse fish community. What happens when landlocked and oceangoing populations of various fish species comingle after almost a century apart? What can we learn from their interactions, and how do they and a rapidly evolving physical environment influence each other? Response Washington Sea Grant-supported researchers have joined a collaborative team of scientists from across state and local agencies, tribes and universities to gather extensive physiological, microchemical, isotopic, behavioral, and reproductive data on this complex ecosystem's numerous salmon and trout species. They also gathered vital baseline data over multiple years on limnology, chemistry, temperatures, stream flows, oxygen levels, stream flow, and plankton production

in Lake Sutherland and its outlet Indian Creek, above the old dams, and in the estuary downstream. Results Rapid change is still yielding more questions than answers. But the monitoring has already suggested some important and in some cases novel findings Attenuated stream flow and elevated water temperatures promote unusual autumn spawning by cutthroat trout. The Elwha's sockeye descend from local, anadromous ancestors rather than landlocked kokanee or recent colonizers. Pre-smolt coho salmon in the dammed estuary are larger and more prone to fall migration than those in a nearby, unblocked reference stream. Young coho move back and forth between estuaries and salt water and among river systems, so the expanded Elwha habitat may benefit other rivers' stocks as well. Hatchery-spawned juvenile Chinook move quickly through the estuary, but the smaller wild-spawned Chinook linger there.

Recap Washington Sea Grant-supported researchers investigate a wide range of ecosystems and salmonid populations in the newly reopened Elwha river system, documenting the "before" needed to understand the "after" that will follow two historic dam removals.

Comments Primary Focus Area OCEH (HCE) Secondary Focus Area LME (SSSS) State Goals Protect and restore marine, coastal and estuarine habitats (HCE Restore). Support conservation and sustainable use of living marine resources through effective and responsible approaches, tools, models and information for harvesting wild and cultured stocks and preserving protected species (SSSS Supply).

Related Partners Coastal Watershed Institute, Lower Elwha Klallam Tribe, NOAA, Peninsula College, US Fish and Wildlife Service (US DOI, US Geological Survey, National Park Service, Department of Fish and Wildlife, Western Washington University

PUBLICATIONS

Title Juvenile Chinook salmon, Oncorhynchus tshawytscha, use of the Elwha river estuary prior to dam removal

Type Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year 2013 Uploaded File Quinn_et_al._2013_Elwh....n.pdf URL none

Abstract The estuary of the Elwha River, on Washington's Olympic Peninsula, has been degraded and simplified over the past century from sediment retention behind two large dams, levee construction, and channelization. With the removal of Elwha Dam and initiation of Glines Canyon Dam's removal in fall 2011, sediment deposits will change the estuary and affect anadromous and nearshore marine fishes. Juvenile Chinook salmon commonly use estuaries and the river's population is part of an Evolutionarily Significant Unit listed as Threatened under the U.S. Endangered Species Act. This study reports on monthly sampling in part of the river's estuary from March 2007 through September 2011 to characterize the seasonal changes in relative abundance of yearlings and sub-yearlings, and size distributions prior to dam removal. Most (69%) of the yearlings were caught in April, when this life history type was released from the hatchery, and to a lesser extent in May (28%) and June (3%). Yearlings caught in the estuary were smaller than those released from the hatchery (means 153 mm ± 28 SD vs. 175 mm ± 5 SD), suggesting more rapid departure by larger

fish. Sub-yearlings were much more abundant in the estuary, and were caught from March through November, increasing in mean fork length by 8.7 mm month-1. The hatchery-origin sub-yearlings were not marked externally and so were not distinguishable from natural origin fish. However, 39% of the sub-yearlings were caught prior to June, when sub-yearlings were released from the hatchery, indicating substantial use of the estuary by natural-origin fish. Thus, even in a reduced state after a century of dam operation, the highly modified estuary was used over many months by juvenile Chinook salmon. The information on juvenile Chinook salmon prior to dam removal provides a basis for comparison to patterns in the future, when the anticipated increase in estuarine complexity may further enhance habitat use by juvenile Chinook salmon

Citation Quinn, T.P., J.A. Shaffer, J. Brown, N. Harris, C. Byrnes, and P. Crain. Juvenile Chinook salmon, Oncorhynchus tshawytscha, use of the Elwha river estuary prior to dam removal. Environmental Biology of Fishes

Copyright Restrictions + Other Notes

Journal Title Environmental Biology of Fishes

Title Juvenile coho salmon, Oncorhynchus kisutch, in the Elwha River estuary prior to dam removal Seasonal occupancy, size distribution, and comparison to nearby Salt Creek

Type Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year 2013 Uploaded File none URL none

Abstract In addition to the downstream migration of smolts in spring, coho salmon also enter estuaries throughout the year but especially in spring as fry and in fall as parr. The removal of two large dams on the Elwha River, Washington has increased the area accessible to salmon and is affecting many aspects of the system. For comparison with the post-dam period, when the estuary will likely expand in size and complexity, monthly sampling was conducted from 2007 – 2011 in the estuaries of the Elwha River and Salt Creek, a nearby undammed stream, to determine patterns of coho salmon presence and size. The spring smolt migration in the Elwha River included a large fraction of unmarked fish primarily of natural origin, as well as marked fish from a hatchery on the river. Sub-yearlings entered both estuaries during much of the year, with a peak in September. Coho salmon from the Elwha River (including wild and hatchery origin fish) were larger than those from Salt Creek and were more heavily represented in the fall, relative to the spring smolt migration. Future patterns in the Elwha River may include reduced pre-smolt use of the estuary if the center of distribution is farther upriver but improved estuarine habitat may make it more suitable for pre-smolts.

Citation Quinn, T.P., Harris, N., Shaffer, J.A., Byrnes, C., and Crain, P. 2013. Juvenile coho salmon, Oncorhynchus kisutch, in the Elwha River estuary prior to dam removal Seasonal occupancy, size distribution, and comparison to nearby Salt Creek. Transactions of the American Fisheries Society 142 1058-1066.

Copyright Restrictions + Other Notes

Journal Title Transactions of the American Fisheries Society

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

No Leveraged Funds Reported This Period

UPDATE NARRATIVE

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Recovery of Elwha River Salmon and Trout after Dam Removal: Recolonization and the Awakening of Dormant Life History Diversity

Funding from Sea Grant began in April 2012 and we recruited Emily Thornton as a master's student at the School of Aquatic and Fishery Sciences, University of Washington. She spent much of the summer of 2013 living in Port Angeles and doing field work on her thesis project, and also conducting lab experiments at the USGS facility at Sand Point. Her project, on competition between resident but non-native brook trout and colonizing but native coho salmon went well and I anticipate her completion in fall 2014.

In addition to Emily's work, we have made progress on many fronts. The pace is exceptionally fast as the river is changing constantly, and the agencies are making rapid decisions and taking quick action. This is revealing the wisdom in our proposal's broad approach rather than rigidly defined studies. The report below is in outline form to facilitate review but our success in research, local involvement, and education has been above our expectations. In addition to the project co-investigators, all of whom have contributed greatly, special mention should be made of John McMillan, an exceptionally talented and dedicated biologist who has contributed a great deal in terms of data collection and insights. Many biologists working for the Lower Elwha Klallam Tribe (LEKT, e.g., Rebecca Paradis, Matt Beirne and Raymond Moses) have also been tremendously helpful, reflecting their expertise and dedication. Without the efforts of such skilled and motivated people, on-site, a project of this kind simply could not be carried out.

Steelhead – rainbow trout

1) **Title**: Characterization of redds by made steelhead and rainbow trout.
   Leads: John McMillan and George Pess (NOAA), Thomas Quinn (UW)
   Goal: Find ways to correctly classify redds by origin of mother to facilitate assessment of spatial distribution of breeding by the two forms, relative abundance, progress of colonization, and habitats used when sympatric.
   Method: Measure redd area and gravel at known rainbow and steelhead redds.
   Results/status: Data have been collected with excellent classification success indicated by univariate analyses. We are combining these data with #2 below in one paper, nearing completion.

2) **Title:** Use of steelhead and rainbow trout fry size for classification, and otolith chemistry for validation of maternal origins.
   Leads: John McMillan and George Pess (NOAA), Lance Campbell (WDFW) and TQ (UW)
   Goal: Determine whether steelhead fry (spawned earlier and from larger eggs) differ enough in size from rainbow trout for use to assess distribution, relative abundance, and in-stream ecology of age-0 fish after dam removal.
   Methods: Measure fry from areas occupied by rainbow and steelhead prior to dam removal as a function of date, develop a classification system, and then validate it with "unknown" fish collected in the post-dam period, identified with otolith micro-chemistry.
   Results/status: The pre-dam-removal data show excellent classification success, and samples of "unknown" fish were prepared for otolith analysis, and that should be completed soon. A draft MS has been started.

3) **Title**: Use of nitrogen stable isotope signal to distinguish steelhead and rainbow trout fry.
   Leads: Emily Thornton, Erica Curles, Lindsay Hart (UW) and Ron Hardy (U of Idaho)
   Goal: Develop and test methods to classify *O. mykiss* fry by maternal origin from stable isotopes to facilitate in-stream sampling and identification of mixed origin fish.

Method: Obtained eyed eggs from steelhead, reared some fry on non-marine derived food and some on a diet with marine sources, and sampled fry periodically as they grew for stable isotopes in fin tissue to see the decline in ^{15}N enrichment from the marine maternal signal to baseline.
Results/status: The experiment was a success and we are preparing the paper, as all the data are in.

4) **Title**: Wild and hatchery steelhead life history inferred from archived scale data.
Lead: Patrick Crain (NPS, formerly WDFW), George Pess (NOAA), Michael McHenry (LEKT) and TQ (UW)
Goal: Test the hypothesis that wild and hatchery steelhead in the Elwha River were similar with respect to return timing against the alternative that wild fish returned later, as would be expected if they retained ancestral traits. The secondary goals are to describe the return timing of wild steelhead in the past for evidence of summer vs. winter runs, and to determine the basic life history of the wild fish in the period prior to dam removal.
Method: Examine data from Elwha River gill-net caught steelhead from 1981 – 2001 (N = 18212 in total), including freshwater and marine age, capture date, and wild/hatchery origin and length.
Results/status: The data are in well-organized spread-sheets. Preliminary analysis (TQ) suggests some interesting patterns of overall arrival timing and linkage between freshwater age and return date, etc. There are some uncertainties regarding the nature of the fisheries (i.e. possible sampling bias) so analysis must be cautious. Given the termination of Sea Grant funding it is not likely that this will be completed, or at least not soon.

5) **Title**: Wild and hatchery steelhead life history inferred from body fat content
Lead: Mara Zimmerman and Jamie Lamperth (WDFW), TQ (UW)
Goal: Test the hypothesis that body fat of adult steelhead varies with return date, seasonal run (winter vs summer) and between wild and hatchery origin fish. Do fish adapted to return early (i.e., summer steelhead) arrive with more body fat than winter steelhead? Given the variation in return date observed from gillnet catch data (#4) and recent weir counts, are there remnant summer steelhead in the Elwha River or just early fish on the edge of a normal distribution?
Method: Test native wild and hatchery summer and winter steelhead at the Kalama River to quantify the variation in long-established populations for subsequent comparison with Elwha River fish. Scales are also being taken for age determination and stable isotope analysis.
Results/status: The meter has assessed fat content in wild and hatchery summer and winter steelhead at the Kalama River. All fat meter data are in, and we are in the process of preparing the manuscript.

6) **Title**: Wild and hatchery steelhead marine ecology inferred from stable isotope analysis
Lead: Mara Zimmerman (WDFW), Jamie Lamperth, (WDFW) and TQ (UW).
Goal: Use stable isotopes from scales to determine whether wild and hatchery fish make different use of the ocean for feeding, as an indirect inference method.
Method: Take scales from wild and hatchery steelhead from Kalama River fish to determine whether stable isotopes of N and C indicate differences in marine ecology.
Results/status: Full sets of scales were collected from wild and hatchery summer and winter steelhead from the Kalama River. Some are already being processed for stable isotopes and the rest will be prepared shortly.

Sockeye salmon - kokanee

1) **Title**: Life history of Lake Sutherland kokanee: Implications for ancestral origins
Lead: TQ and Morgan Bond (UW) and Hans Berge (King County)
Goal: The first goal is to characterize the current life history and phenotypic traits of *O. nerka* in Lake Sutherland as a baseline against which anadromous fish can be compared. The second goal

is to be able to determine, in the future, whether anadromous sockeye originated from non-anadromous parents or whether they were colonists from elsewhere, with the eventual goal of determining the mix of anadromous and non-anadromous fish in the lake. The third goal is to help determine whether the sockeye salmon are descended from native or stocked fish.
Methods: Obtain specimens of adult *O. nerka* from Lake Sutherland, process for length, weight, egg size and fecundity if possible, measure body shape, take digital photos, sample muscle for stable isotopes, and remove otoliths for age determination and later micro-chemical analysis. Augment these data with data from sockeye and kokanee from other populations for comparisons.
Results/status: Marcia House (NWIFC) and Rebecca Paradis (LEKT) provided us with adult samples from 2010 and 2012 (n = 190). The results show patterns of life history suggestive of anadromous ancestry (large egg size for a given body size) and local origin (deep bodies in males, consistent with beach spawning). 2013 samples were collected but not yet processed. After they are we will move forward with a paper.

2) **Title**: Ecology and nutrient cycling of Lake Sutherland
Lead: Rebecca Paradis and Matt Beirne (LEKT), TQ, Morgan Bond, David Beauchamp (UW)
Goal: Characterize the current ecology and nutrient base in Lake Sutherland as a baseline against which future years, when anadromous fish enter the system, can be compared. The question is whether (or when) the sockeye salmon will make detectable contributions to the ecosystem of the lake, and what the carrying capacity would be for anadromous rather than resident fish.
Methods: LEKT limnology sampling provides monthly depth-specific data at six stations in the lake. We have initiated monthly zooplankton sampling and processed the first series for species identification and stable isotope analysis, and plan on regular processing. We will also use bioenergetics models to estimate the eventual carrying capacity for sockeye rather than kokanee, based on volume of water, thermal and oxygen conditions, and plankton density.
Results/status: The limnology data have been examined and indicate a possible temperature-DO squeeze in late summer. Zooplankton species have been identified and stable isotope analysis indicated sufficiently low ^{15}N levels that an increase in the future from salmon carcasses should be detectable. However, with termination of Sea Grant support it is unlikely that this will continue, or at least I will not be able to be involved.

Cutthroat trout

1) **Title**: Life history and breeding timing of Indian Creek cutthroat trout
Lead: John McMillan and George Pess (NOAA), Michael McHenry (LEKT) and TQ (UW)
Goal: Cutthroat trout were observed spawning in Indian Creek, the outlet of Lake Sutherland, in fall rather than the more normal spawning period in spring. This is a most unusual trait and worthy of full documentation. It is not clear how this trait might change in the post-dam removal period but change is certainly possible as the "fall-spawning" coho salmon will likely spawn later than the cutthroat, reversing the normal patterns, and perhaps disturbing the redds from the smaller trout. The goal is to more formally document this phenomenon, and deploy temperature loggers to estimate developmental rates and emergence based on thermal sums models.
Methods: Direct observations of courting and redd construction, and positive ID of the fish (from photos) were obtained, redds were measured for size, and temperature loggers deployed.
Results/status: Data were collected and a MS has been completed and will be submitted shortly.

Elwha River estuary

1) **Title:** Use of the Elwha River estuary by juvenile salmon and trout
Lead: J. Anne Shaffer (CWI), Nicole Harris (WWU), Justin Brown, Jon Wittouck and TQ (UW)
Goal: Determine the patterns of occupancy by salmon in the estuary of the Elwha River and nearby Salt Creek in the period prior to dam removal, for comparison to the future.

Methods: Monthly beach seining has been conducted at two sites in each estuary by the CWI since 2007, with all fish identified and counted, and a sub-set measured for length.
Results/status: A MS on coho salmon was published in Transactions of the American Fisheries Society and one on Chinook salmon is in press (on-line published, not paginated). Analyses of data on chum salmon and cutthroat trout are on-going but with termination of support it is uncertain whether my involvement will continue.

Pink salmon

1) **Title:** Migration timing and life history of pink salmon
Lead: Joe Anderson (WDFW), George Pess (NOAA), Michael McHenry (LEKT), TQ (UW)
Goal: Determine the patterns of body size and return timing of Elwha River pink salmon for comparison with conspecifics in the Dungeness River. Does the Elwha River have early and late runs, as does the Dungeness? Is the timing similar or different between rivers? Are the fish of the same body size in the early and late components, and in the two rivers? Are the runs synchronous between rivers and between early and late or asynchronous, as might suggest that they are independent populations?
Methods: Monitor arrival timing or live counts in the two rivers, especially on odd-numbered years. Measure body size of carcasses in both rivers throughout the run(s).
Results/status: Preliminary data indicated bimodal run timing in the Elwha River, and we obtained data in 2013. Analysis has yet to be undertaken.

Bull trout

1) **Title**: Non-lethal sampling to develop migration chronologies for bull trout
Leads: Roger Peters (USFWS), Sam Brenkman (NPS), Lance Campbell (WDFW)
Goal: Refine non-lethal techniques for reconstructing the migration history of fish from fin rays as an alternative to otolith extraction, to determine whether fish from the above-dam area become anadromous, and the extent of anadromy by fish below the dam sites.
Methods: Obtain and prepare pectoral fin rays from anadromous and non-anadromous bull trout to determine the success in detecting their recent migrations from Sr/Ca ratio.
Results/status: Campbell has already demonstrated that pectoral fin rays can archive migration history and the techniques are being refined to minimize harm to the fish. This project is on hold.

2) **Title**: Tracking of anadromous bull trout
Lead: Roger Peters (USFWS), Jeffrey Duda (USGS), Sam Brenkman (NPS), Michael McHenry (LEKT) and TQ (UW)
Goal: Characterize the timing of movement upstream and downstream by anadromous bull trout and the distribution along the marine shoreline.
Methods: Catch fish within the river for implantation with radio tags, and deploy self-contained receivers at strategic locations.
Results/status: This project is on hold until conditions in the river become more favorable for the field work, perhaps in summer 2014.

Conclusion

The proposal to continue the project was denied so we are trying to wrap up the many, many aspects of this project that were initiated, and seek funding from other entities. This is very disappointing because a great deal of effort was required to organize this complex, multi-facetted project and we were making outstanding progress by any standard. It is a shame because the full potential of the project is just getting realized, and indeed the best is yet to come. I fully intend to carry out as many of the project elements as I can, even without Sea Grant support. However, there is no doubt that the full benefit of the project will be very much less than it might have been. So it goes.