Submitted July 2016

COWLITZ RIVER SALMON/STEELHEAD HOOKING MORTALITY STUDY PROPOSAL
COLUMBIA RIVER SALMON AND STEELHEAD ENDORSEMENT FUND
CRSSRAB FUNDING REQUEST, AUGUST 2016

Submitted by: *Mount Hood Environmental*
Prepared by: *Mount Hood Environmental* and the *WA Dept. of Fish & Wildlife*

MOUNT HOOD ENVIRONMENTAL

Fisheries and Aquatic Toxicology Research

PO Box 744
Boring, OR 97009
(o) 503-663-3697; (m) 503-421-8459
mthoodenvironmental.com

July 5, 2016

Dear CRSSRAB:

Mount Hood Environmental is pleased to submit a research project proposal to the CRSSRAB. Our proposed study aims to evaluate salmon and steelhead hooking mortality in the Cowlitz River, and our team offers a wealth of technical capability and professional experience in providing the services described in our study plan. In addition to offering the expertise of our company's research team, we have reached out and collaborated with key staff at the Washington Department of Fish and Wildlife (WDFW) and Tacoma Power. My coauthor on this proposal, Thomas Buehrens is recognized within WDFW for his quantitative expertise and will contribute to development of survival models and serve as an author on all reports. While assisting with proposal development, Thomas insured that our study design complements existing WDFW hooking mortality studies in the Wind River and Yakima River basins. WDFW Region 5 also provided technical review of our study design during proposal development. Keith Underwood, Tacoma Power's Natural Resources Manager, has reviewed our study plan and fully supports this endeavor. Tacoma Power staff graciously offered to support our effort by providing comments on our study design, collecting data, and tagging fish in their facilities at no charge to the project. Finally, we solicited feedback from a broad array of influential conservation and sporting fishing organizations. Many of these organizations endorsed our study (see support letter on page 22).

I will provide project management and leadership so that we are well coordinated in our efforts. I have extensive project leadership and scientific research experience, including numerous salmonid habitat assessments, fish population modeling analyses, and fish survival evaluations conducted in rivers throughout the Pacific Northwest and Northern California. It is our belief that a collaborative approach between MHE, WDFW, and Tacoma Power will provide the most cost-effective, rigorous study possible. The enclosed submittal will demonstrate that we have thoughtfully crafted our approach to meet our objectives. Please contact me by email or phone (provided below) if you have any questions about the information in the enclosed proposal. Our team is excited about the prospect of carrying out this research on behalf of the CRSSRAB.

Respectfully,

Ian Courter
Fisheries Scientist
Mount Hood Environmental
ian.courter@mthoodenvironmental.com
503-663-3697

TABLE OF CONTENTS

STUDY PLAN

Background

Implementation of gear-type restrictions has been an effective regulatory strategy for reducing the impact of sport fishing on naturally reproducing populations of fish in the Pacific Northwest, particularly for catch-and-release trout fisheries where resident fish are potentially caught multiple times during their life span (Taylor and White 1992). Such strategies have included restricting anglers to artificial flies and lures and limiting the number, type (single or multiple point) and/or size of hooks that can be used.

The Washington Department of Fish and Wildlife (WDFW) recently expanded the number of fisheries requiring anglers to use barbless hooks as a measure to protect natural-origin ESA-listed salmon and steelhead stocks throughout the Columbia River basin. Despite its popularity as a conservation measure for catch-and-release trout fisheries, it remains uncertain whether this regulation increases survival rates of hook-and-line captured salmon and steelhead. It is assumed that salmon or steelhead captured with a barbless hook will be released more quickly while sustaining less injury, thereby giving the fish a greater chance of survival. However, available empirical data from disparate studies suggest that hooking location may be more influential than hook type when determining causes of capture-related mortality (immediate and post release) for hook-and-line captured salmon and steelhead (Cowen et al. 2007; Lindsay et al. 2004; Taylor and Barnhart 1996). For these reasons, Washington State barbless hook regulations have generated concern among sport fishermen who question whether these regulations are effective at protecting natural-origin salmon and steelhead from capture-related mortality.

In addition to minimizing release mortality of natural-origin salmon and steelhead, Washington sport fisheries managers often aim to provide opportunities to harvest hatchery-origin fish. Successful capture and retention of hatchery-origin salmon and steelhead may reduce the risk of genetic and ecological impacts of hatcheries (Naish et al. 2007) in addition to generating economic activity and fulfilling fishery mitigation obligations related to the operation of hydroelectric projects. Unfortunately, fisheries regulations designed to protect wild stocks may be in direct conflict with those designed to achieve high hatchery fish retention rates if gear type restrictions intended to protect wild fish also result in reduced catch of hatchery fish. For example, anglers have made anecdotal claims of experiencing lower landing rates (number of fish released and/or retained divided by the total number of fish hooked) due to the propensity for fish to become unhooked while being brought to shore or boatside with barbless hooks. However, very little empirical data exists to affirm these anecdotal experiences.

Therefore, Washington's current regulatory policy to restrict salmon and steelhead sport fisheries to barbless hooks in some areas operates on the assumption that use of barbless hooks reduces-capture related mortality, and possible lower landing rates of hatchery-origin fish has been deemed an acceptable trade-off for this conservation measure.

In March of 2016, the Cowlitz River Ad-Hoc Group, representing sport fishing interests in the Cowlitz Basin, contacted Mount Hood Environmental (MHE) regarding preparation of a study plan to quantify the survival of salmon and steelhead captured with barbed and barbless hooks by sport fishermen in the Cowlitz River. The research project described here, a collaborative approach between MHE, WDFW, and Tacoma Power, reflects MHE's response to that solicitation. If we are successful in acquiring funding for the proposed study, the data we collect will be essential for developing scientifically-supported regulatory strategies that minimize the impact of sport fishing on protected natural-origin salmon and steelhead stocks while maximizing angling opportunity.

Objectives

Our primary research objectives are:

1) Determine whether use of barbless hooks increases survival of salmon and steelhead caught and released in the Cowlitz River.

2) Quantify the capture efficiency of barbed and barbless hooks while angling for salmon and steelhead in the Cowlitz River.

3) Use data collected in this study in conjunction with creel and catch record card data to model the impacts of barbless regulations on rates of wild fish mortality and hatchery fish harvest in two fisheries—a hatchery fish intensive fishery (e.g. Cowlitz) and a naturally supported catch-and-release fishery (e.g. Wind or SF Toutle).

WDFW is currently developing analytical tools to model the impact of different sport fishing gear-types on long-term steelhead survival (Buehrens and Cochran, WDFW, unpublished data) by relating gear type to hooking location and hooking location to mortality rate (Lindsay et al. 2004). It is our intent to ensure that hooking mortality data collected in the Cowlitz River serves to improve the predictive power of these models by collecting additional information on hooking location and short-term mortality rate, as well as gear type and hook type.

In particular, we are interested in the trade-off between potential increases in hooking mortality and landing rates while using barbed hooks. In such a case,

higher landing rates while using barbed hooks in hatchery-augmented fisheries may offset the impact of higher hooking mortality rates on natural-origin fish if anglers are able to obtain their retention limit more quickly (less lost fish) and thereby hook fewer fish during each outing. Conversely, landing rates may be comparable for both barbed and barbless hook types, in which case barbless regulations are not reducing hatchery fish harvest rates as some have surmised.

Study Approach

The Cowlitz River is an ideal location to study salmon and steelhead hooking mortality. Each year, thousands of hatchery-origin salmon and steelhead return to the Cowlitz Basin, providing the largest harvest-oriented sport fishery in Washington outside of the Columbia River main stem. Adult hatchery-origin salmon and steelhead that evade capture and return to Cowlitz Salmon Hatchery and Cowlitz Trout Hatchery are used for broodstock, transported into the upper Cowlitz Basin for reintroduction and nutrient enhancement, recycled downstream for additional fishing opportunity, or distributed to food banks. Therefore, the return of large numbers of hatchery-origin fish provides an opportunity to angle hundreds of salmon and steelhead that can be reliably recaptured when they enter hatchery holding pens or become harvested in the fishery.

Between the fall of 2016 and summer of 2019, we will hook-and-line capture and release natural and hatchery-origin, spring and fall Chinook salmon, coho salmon, winter steelhead, and summer steelhead with barbed and barbless hook types using a variety of terminal tackle commonly deployed by Cowlitz River sport fishermen (Table 1). A combination of experienced and naïve fishermen will participate as anglers during the study. However, our primary aim is to capture large numbers of salmon and steelhead (Table 2); therefore, experienced anglers will do the majority of the fishing. Fishing efforts will target areas within approximately 5-10 miles downstream of Mayfield Dam because this is the river segment where the highest concentrations of fish may be found and capturing fish near the hatcheries will increase our chances of recapturing angled fish.

After a capture event, each fish will be randomly assigned a handling time ranging from short (<1 minute) to long (>1 minute). During handling, fish will receive two t-bar anchor tags with unique identification numbers, one on each side of the dorsal fin attached to the pterygiophores (Dell 1968). The use of two tags should minimize the risk that captured fish will be unidentifiable due to tag loss, and double-tagging will allow us to estimate the rate of tag loss for incorporation into our survival models. Further, we will employ a method previously described by Hyun et al. (2012) to account for potential loss of both tags in mark-recapture studies. For each tagged fish, in accordance with WDFW creel and hooking mortality study protocols, we will also document its species, origin (hatchery/natural), sex, hooking location, hook type, gear type, angling

method, fight-time, fish condition factor, fish length, handling time, and the water temperature. Fish with previously sustained injuries, such as unhealed gillnet or lamprey wounds, will be released untagged. The number of fish hooked, but not landed (by species and origin (hatchery/natural) when possible), and hours fished per angler will also be recorded.

There are a variety of biotic and abiotic factors that may influence hooking mortality rates. Therefore, fishing effort will be distributed spatially and temporally to represent the wide range in conditions experienced by salmon and steelhead caught in the lower Cowlitz River sport fishery downstream of Mayfield Dam. To achieve our target sample sizes (Table 2), we anticipate averaging 30-60 rod hours per week during periods of high catch-per-unit-effort when large sample sizes may be most easily obtained, with additional fishing time invested as needed to maintain adequate tagging rates. The most intense fishing effort will occur during the peak adult migration period for each salmon/steelhead race evaluated. Sample sizes were chosen based on a predetermined level of angling effort before being examined post-hoc with statistical power analyses to verify their adequacy for testing our hypotheses (see page 7).

To make relative comparisons between survival rates for fish caught on barbed and barbless hooks, tagged fish will be recaptured via one of three methods: 1) collection at the Cowlitz Salmon Hatchery fish separator, 2) angler reporting, or 3) creel surveys. The Cowlitz Salmon Hatchery fish separator will serve as our primary point of recapture. Depending on species and race, approximately 30-90% of the fish we tag and release while sport fishing are expected to return to the separator located downstream of Mayfield Dam. Angling is our second most likely method of recapture. Anchor tags will be custom printed with a website address and phone number anglers can use to report their catch in the event that a tagged fish is caught in the fishery prior to entering the hatchery separator. Harvest rates differ for each race, with fall runs experiencing the lowest harvest rates (~10%) and spring and summer runs experiencing the highest harvest rates (~40-70%), but they do provide reasonable expectations about the proportion of tagged hatchery-origin fish that may be harvested by anglers (Table 2). While voluntary tag reporting rates are uncertain, a reasonable assumption is that at least 18% of harvested fish with anchor tags will be reported by anglers (T. Kock, USGS pers. comm.). We may also be able to achieve a higher reporting rate if we implement a rewards program. Anglers will be educated and encouraged to report capture of both hatchery and natural-origin fish. Finally, existing creel surveys conducted in the Lower Cowlitz River will also provide recapture data. WDFW creel surveyors are already recording anchor tag numbers for other salmon/steelhead monitoring efforts. Anchor tag colors and numbers will facilitate identification of our study fish so that data can be efficiently shared with our research team.

For the purpose of monitoring long-term survival of angled fish, tagged salmon and steelhead will be opportunistically retained and held as hatchery broodstock until maturity. Broodstock collection occurs on a set schedule throughout each adult salmon and steelhead migration period with in-season adjustments as needed to meet broodstock targets. Broodstock fish are transferred to hatchery holding pens and held until spawning. WDFW and Tacoma Power staff have agreed to incorporate hatchery-origin tagged fish when available into their broodstock so that prespawning mortalities can be monitored in the hatchery. Mortalities will be recorded during normal raceway maintenance operations and surviving fish will be recorded prior to use for broodstock, or other purposes. During days when broodstock are not collected, tagged winter steelhead, spring Chinook salmon and coho salmon will be incorporated into the Upper Cowlitz Basin adult salmon and steelhead trap and haul program. These fish will be relocated to the Tilton, Upper Cowlitz, and Cispus Rivers where additional recapture data will be obtained via sport fisheries in the Tilton River and Lake Scanewa. A subsample of untagged fish collected in the separator will also be anchor-tagged during sorting at the separator to serve as control groups for both hook-and-line caught fish held in the hatchery, as well as for fish transported to the Upper Cowlitz River. The number of control fish in each control group will be proportional to the number of angled fish released at each location in the Upper Cowlitz Basin, and retained in the hatchery for broodstock.

Finally, to provide additional context for application of our study findings to fisheries management, field technicians will observe and record angler handling practices at popular fishing areas, such as Blue Creek and downstream of Mayfield Dam. The purpose of this component of our study is to determine how natural-origin fish are typically handled and released. The majority of fish tagged in our hooking mortality study will be handled by experienced biologists and anglers in accordance with our handling protocols and WDFW regulations for release of unmarked fish. Therefore, an understanding of the proportion of fish caught in the fishery and released following practices required by law for release of natural-origin fish may be important for understanding the transferability of our findings to the fishery.

Table 1. Sport fishing methods/gear-types and races of salmon and steelhead to be evaluated during the Cowlitz River Hooking Mortality Study.

	Lure Single/Treble Hook	Baited Lure Treble Hook	Bait Single Hook Under Float Single/Double Hook Troll	Jig	Fly
Spring Chinook	✓	✓	✓		
Fall Chinook	✓	✓	✓		
Coho	✓	✓	✓	✓	
Winter Steelhead	✓	✓	✓	✓	✓
Summer Steelhead	✓	✓	✓	✓	✓

Table 2. Lower Cowlitz River hatchery-origin return (HOR) sport fishing harvest rates, expected Cowlitz Salmon Hatchery (CSH) fish separator recapture rates, combined expected recaptures of anchor-tagged fish, and target sample sizes for each species/race evaluated in the Lower Cowlitz Hooking Mortality Study. HOR harvest and CSH recapture rates extracted from the In-season Implementation Tool (Tacoma Power 2013).

	HOR Harvest	CSH Recapture	Combined Recapture Rate*	Annual Angling Target
Spring Chinook	38%	62%	69%	87
Fall Chinook	9%	91%	93%	65
Coho	10%	90%	92%	87
Winter Steelhead	60%	40%	51%	197
Summer Steelhead	70%	30%	43%	235

* Assumes an 18% angler reporting rate for harvested fish

Analytical Approach

At the conclusion of each year of data collection, survival estimates, encounter rates (hatchery-origin / natural-origin), and landing rates will be generated for each species and gear-type combination. A logistic regression model where survival is a function of hooking location, angling method, hook type, gear type, fight-time, fish length, handling time, and water temperature and species will be used to estimate relative survival of fish angled on barbed and barbless hooks. This will allow us to quantify the effect of hook type (barbed or barbless) on post-release survival for salmon and steelhead relative to other influential factors.

Power Analysis

Our study design is intended to measure potential differences in survival of fish as a function of biological and fishing characteristics. A potential outcome is that we will quantify statistically and biologically significant effects of variables such as species, barbed vs. barbless hook type, angling gear, and other factors. However, the absence of a measurable effect is not unequivocal because our ability to quantify effects is a product of our study design and sample sizes achieved. It is therefore necessary to estimate the probability that an effect will be detected if it is present.

We conducted a power analysis in which we simulated equal numbers of fish being captured and released on barbed and barbless hooks. The proportion recovered was assumed to be a random draw from a binomial distribution with the probability equal to the recovery rate multiplied by the relative survival of the treatment. Sample sizes were allowed to vary from 1-401 for each treatment, totaling 2-802 tagged fish. The relative survival was 100% for barbless caught fish and we simulated relative survivals for barbed-caught fish between 80% and 98%. We repeated this simulation 500 times for each sample size and for each iteration we recorded two metrics:

1) We fit a logistic regression where the response was whether a fish was recovered or not and the covariate was whether it was caught on a barbed or barbless hook. We recorded the proportion of the 500 simulations in which this logistic regression yielded a significant effect of hook type on recovery rate using two thresholds ($\alpha = 0.05$, $\alpha = 0.10$).

2) We calculated the relative recovery rate ($Recovery_{barbed}$ / $Recovery_{barbless}$) for each of the 500 simulations and constructed boxplots displaying the median, interquartile range, 95% confidence intervals and outliers, and we plotted these against the expected value (“true” relative survival) in a particular simulation.

Results of Power Analysis

Given a 60.5% weighted average recovery rate across all species (Table 2) the probability of detecting a significant difference in relative survival between barbed and barbless-caught fish is high ($1-\beta > 0.8$) for a single study year if the true relative survival rate is ~85% or less, and sample sizes for each treatment group are 300-400 fish per treatment or more (Figure 1). This compares with our expected sample size of roughly 315 fish per treatment annually (pooling species and gear types; Table 1), meaning we will likely detect statistically significant differences between barbed- and barbless-caught fish if the relative survival of fish caught on barbs is < 85% of those caught on barbless gear.

Although power to detect statistically significant differences between survival of barbed and barbless-caught fish will be modest for a direct statistical test following the first year of data collection, a more relevant question for managers may be one of biological significance: whether barbed hooks result in additional mortality. The probability of obtaining a relative survival parameter estimate of less than 1 in our simulations was >80% when relative survival was less than 96% and sample sizes per treatment were greater than ~300, meaning that if the survival deficit caused by barbed hooks is greater than 4% we are likely to measure reduced survival (though not necessarily precisely) with our anticipated sample size of 315 fish per treatment annually (Figure 2). This suggests that our study should have sufficient power to measure additional mortality resulting from barbed hooks (if it exists), even if the relative effect of barbed hooks is small. Pooling all three years of data (target n = ~2000 fish combined for both treatments, barbed and barbless hooks) will result in a highly sensitive test for negative impacts of barbed hooks on salmon and steelhead catch-and-release relative survival.

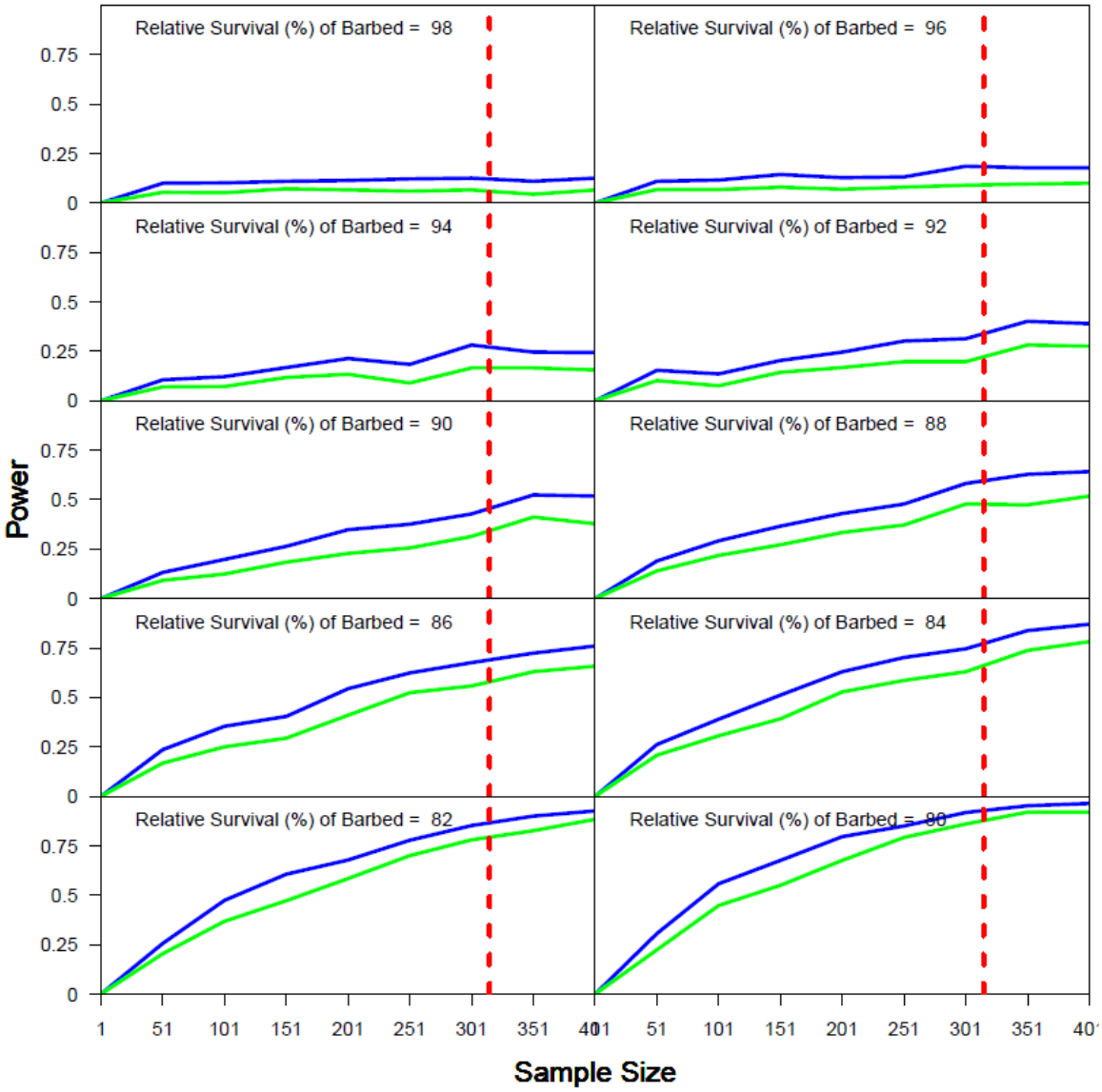

Figure 1. The probability (power) of measuring a statistically significant difference (α = 0.10 blue, α = 0.05 green) between fish caught on barbed vs. barbless hooks as a function of the sample size per treatment group. Different panels represent different "true" relative survival values. A red vertical line denotes the planned sample size for this study. Results are based on 500 simulations.

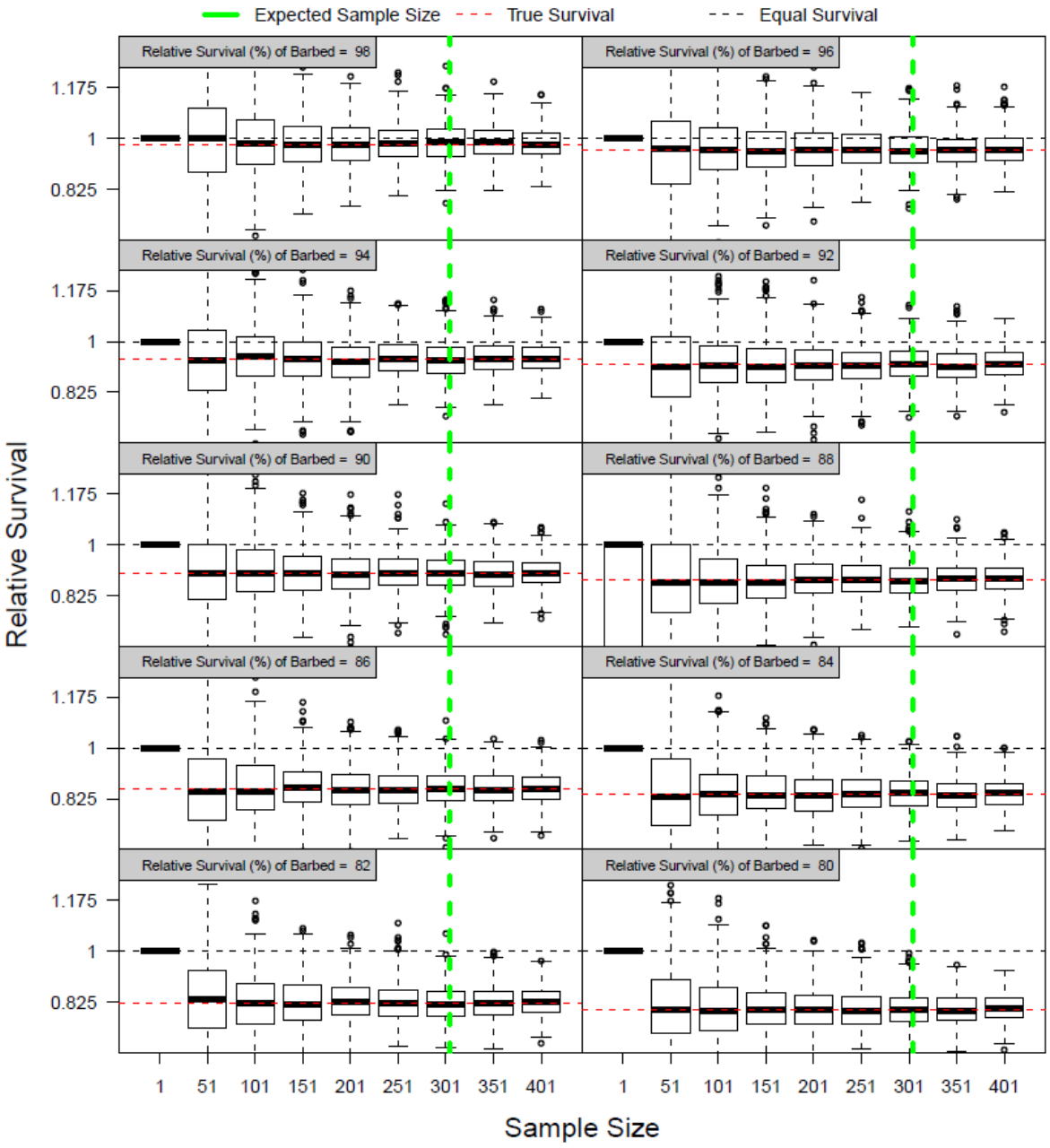

Figure 2. The distribution of observed survival of fish caught on barbless hooks relative to barbed hooks as a function of sample size per treatment group (boxplots). Different panels represent different "true" relative survival values. Relative survival of 1.0 is shown as a black dashed line and the modeled "true" relative survival is shown in red. A green dashed vertical line denotes the expected sample size in this study

Project Leadership and Research Partners

The proposed project will be a collaborative effort between MHE, WDFW, and Tacoma Power (Figure 1). Primary contacts for each organization are Ian Courter, MHE, Thomas Buehrens, WDFW and Keith Underwood, Tacoma Power (owners/funders of Cowlitz Salmon and Trout Hatcheries). Ian will be principally responsible for project leadership, analysis, and reporting. Thomas will ensure that the study design complements existing WDFW hooking mortality studies in the Wind River and Yakima River basins, and he will assist Ian with coordination with WDFW staff. Thomas is also recognized for his quantitative expertise within WDFW and will contribute to development of survival models and serve as coauthor on all reports. Keith will serve as a liaison between MHE and Tacoma Power staff. Fieldwork responsibilities will be shared by all three parties. Hook-and-line fish capture will be carried out by MHE staff with participation by WDFW as time and staff availability allows. MHE will also oversee development and management of a web-based portal for angler reporting, as well as an angler reporting hotline. Tacoma Power staff will be responsible for recording tagged fish recaptured at the Cowlitz Salmon Hatchery separator, sorting fish for relocation to the Upper Cowlitz Basin and hatchery holding pens, and tagging control fish. WDFW staff will document mortality of tagged fish in the hatcheries and collect creel survey data in the Lower Cowlitz River.

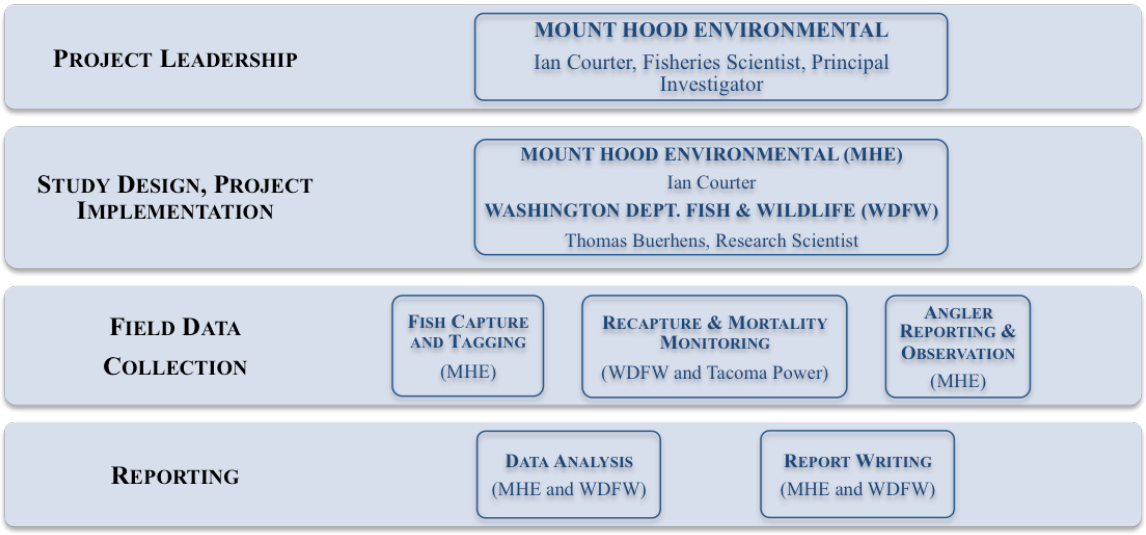

Figure 1. Diagram of roles and responsibilities for organizations implementing the Cowlitz River Hooking Mortality Study.

References

Cowen L, Trouton N, Bailey RE. 2007. Effects of angling on Chinook salmon for the Nicola River, British Columbia, 1996–2002. North American Journal of Fisheries Management 27(1):256-267.

Dell MB. 1968. A new fish tag and rapid, cartridge-fed applicator. Transactions of the American Fisheries Society 97(1):57-59.

Hyun S-Y, Reynolds JH, Galbreath PF. 2012. Accounting for tag loss and its uncertainty in a mark–recapture study with a mixture of single and double tags. Transactions of the American Fisheries Society 141(1):11-25.

Lindsay RB, Schroeder RK, Kenaston KR, Toman RN, Buckman MA. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24(2):367-378.

Naish KA, Taylor JE, Levin PS, Quinn TP, Winton JR, Huppert D, Hilborn R. 2007. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. Advances in Marine Biology 53:61-194.

Tacoma Power. 2013. Annual Project Review Procedures Manual: Steps for Implementing the Cowlitz Annual Project Review: 20 pp.

Taylor G, Barnhart RA. 1996. Mortality of angler caught and released summer steelhead: Steelhead trout catch report. California Cooperative Fishery Research Unit; Humboldt State University Foundation; California Department of Fish and Game. 31 pp.

Taylor MJ, White KR. 1992. A meta-analysis of hooking mortality of nonanadromous trout. North American Journal of Fisheries Management 12(4):760-767.

TCW Economics. 2008. Economic Analysis of the Non-Treaty Commercial and Recreational Fisheries in Washington State. 36 pp.

BUDGET REQUEST

MOUNT HOOD ENVIRONMENTAL

Estimate

PO Box 744
Boring, Oregon 97009
503-663-3697

Date
07/01/16

Funding Request: Columbia River Salmon Steelhead Enhancement Fund
Cowlitz River Salmon/Steelhead Hooking Mortality Project
August 2016 - June 2017

Description	Quantity	Rate	Total
FISH TAGGING & ANALYSIS			
IAN COURTER, Principal Investigator: Project Management	96	90.00	8,640.00
IAN COURTER, Principal Investigator: Project Planning/Meetings	80	120.00	9,600.00
IAN COURTER, Principal Investigator: Analysis & Reporting	160	120.00	19,200.00
THOMAS BUEHRENS, WDFW Senior Scientist: Project Planning/Meetings	80	50.00	4,000.00
THOMAS BUEHRENS, WDFW Senior Scientist: Analysis & Reporting	240	50.00	12,000.00
Field Technician I: Fish Capture and Tagging	860	32.00	27,520.00
Field Technician III: Fish Capture and Tagging	860	46.00	39,560.00
FISH TAGGING & ANALYSIS SUBTOTAL			120,520.00
ANGLER OBSERVATION			
Field Technician I	160	32.00	5,120.00
Field Technician III	160	46.00	7,360.00
ANGLER OBSERVATION SUBTOTAL			12,480.00
GUIDED FISHING	10	450.00	4,500.00
GUIDING SUBTOTAL			4,500.00
FIELD EQUIPMENT & SUPPLIES			
Daily Boat Rental (MHE), Fuel, Maintenance Costs	82	200.00	16,400.00
Monthly Truck Rental (MHE)	12	380.00	4,560.00
Truck Mileage, Maintenance Costs	17,200	0.54	9,288.00
Fish Tagging Equipment & Supplies	1	1,093.00	1,093.00
Sampling Supplies: Bait	42	60.00	2,520.00
Sampling Supplies: Rods & Reels	12	225.00	2,700.00
Sampling Supplies: Lures	42	50.00	2,100.00
Sampling Supplies: Line, Hooks	4	525.00	2,100.00
Sampling Supplies: Swivels, Weights, Divers, Misc.	4	580.00	2,320.00
FIELD EQUIPMENT & SUPPLIES SUBTOTAL			43,081.00
		Total	$180,581.00

*All MHE charges include administrative costs. The hourly rate for Thomas Buehrens does not include WDFW's 28% overhead for WDFW staff time.

FISHERY BENEFITS

With an estimated total economic value in excess of $20 million annually[1], Cowlitz River fisheries are arguably the most heavily utilized salmon and steelhead sport fisheries in Washington State. Whether current barbless hook regulations provide the intended benefit for protection of natural-origin salmon and steelhead is a key concern for this fishery and others throughout the Columbia Basin. If use of barbless hooks reduces sport fishing impacts on natural-origin salmon and steelhead, policy-makers may choose to implement similar rules statewide as a measure to recover ESA-listed stocks and to protect non-listed stocks against overutilization. Conversely, if barbless hooks do not reduce catch-and-release mortality, the unintended impacts of these regulations may be higher hook encounter rates for natural-origin fish, higher stray rates of hatchery fish, reduced angling satisfaction, and reduced opportunity for inexperienced and young anglers. Our findings will provide empirical data to support management decisions regarding barbless hook regulations for salmon and steelhead fisheries in Washington. This data is essential to the protection of native salmon and steelhead populations, as well as the vibrancy and sustainability of sport fishing in the region.

[1] 5 year average in-river harvest (Tacoma Power 2013) multiplied by 10 angler days per fish and $58 per fish (TCW Economics 2008).

PROJECT LEADER QUALIFICATIONS

Ian Courter, M.S.
Senior Fisheries Scientist

Ian Courter is the cofounder of Mount Hood Environmental, a fisheries and toxicology consulting firm in Boring, Oregon, specializing in fisheries research and aquatic toxicity testing. Prior to establishing Mount Hood Environmental, Ian provided project leadership, management, design, analysis, and data collection for Cramer Fish Sciences (CFS) in Gresham, Oregon. In addition to his role as a senior scientist, Ian served as the Program Lead for CFS Oregon operations. He has a Master's degree in Fisheries Science with a minor in Natural Resource Policy and Law from Oregon State University, a bachelor's degree in Environmental Biology from Pacific University, and a Project Management certification from Portland State University, among other certifications.

Ian has served as principal investigator on a variety of salmonid research projects in the Klamath, Willamette, Yakima, Wenatchee, Methow, Deschutes, Owyhee, and Sacramento/San Joaquin River Basins. Of particular note is his experience leading population dynamics modeling projects in the Klamath, Yakima, and Deschutes River basins. The primary aim of these investigations was to quantify the effects of flow and temperature on salmon and steelhead populations. For example, Ian recently led a team of scientists to evaluate the relationship between resident and anadromous *Oncorhynchus mykiss* and quantify the effects of Bureau of Reclamation project operations on abundance of resident rainbow trout and anadromous steelhead life-histories in the Yakima River basin. Ian implemented a similar modeling approach to support water management decisions in the Crooked River, Oregon. Subsequent to these analyses, Ian led a team of researchers to develop a population viability model for Yakima Basin steelhead. This work was recently highlighted in the National Marine Fisheries Service life-cycle modeling report for the Columbia Basin, which documents available modeling approaches for assessing effects of management actions on ESA-listed anadromous salmonid populations.

Ian is an expert in the study of steelhead/rainbow trout population dynamics and life-history diversity. He has written numerous reports and publications and frequently gives technical presentations at regional science meetings, including Washington and Oregon AFS, as well as the biennial Pacific Coast Steelhead Management Meeting convened by the Pacific States Marine Fisheries Commission. He is regularly invited to be a guest lecturer at technical symposia and he provides technical review of research reports on behalf of clients, as well as peer-review for scientific publications. In addition to his modeling experience, Ian has designed and implemented a variety of customized field and laboratory data collection projects to address questions about water management and

hydropower impacts on anadromous fish. Specific examples include spring Chinook smolt survival studies in the Yakima River, Washington; adult lamprey migration monitoring in the Willamette River, Oregon and Snake River, Washington; steelhead and bull trout entrainment monitoring in the Tualatin River, Oregon and Tieton River, Washington; instream flow studies in the Wenatchee and Methow Basins, Washington; redband trout monitoring in the Crooked River, Oregon; cutthroat trout surveys in the Umpqua Basin, Oregon; salmonid habitat surveys in the Yakima, Lewis, Sandy, and Owyhee River basins; adult steelhead otolith collections and analysis in the Yakima Basin, Washington; and steelhead broodstock evaluations in the American River, California.

Education and Training

M.S., Fisheries Science, Minor in Natural Resource Policy and Law. Oregon State University, Corvallis, Oregon. 2005.

B.A., Environmental Biology. Pacific University, Forest Grove, Oregon. 2002

Project Management Certification. Portland State University, Portland, Oregon. 2008.

SSI Diver, 2007

Oregon Boater Education, 2003

Employment History

Senior Scientist, Owner. Mount Hood Environmental, Boring, Oregon. March 2014-Present.

Oregon Program Technical Lead. Cramer Fish Sciences, Portland, Oregon. April 2013-February 2014.

Senior Scientist. Cramer Fish Sciences, Portland, Oregon. 2010-February 2014.

Fisheries Biologist. Cramer Fish Sciences, Portland, Oregon. 2006-2010.

Marine Policy Intern. Oregon Department of Fish and Wildlife, Newport, Oregon. July 2005-December 2005.

National Science Foundation Fellow. Oregon State University, Corvallis, Oregon. July 2004-June 2005.

Selected Publications and Reports

Courter II, TM Garrison, TJ Kock, RW Perry, DB Child, JD Hubble. (201x) Benefits of prescribed flows for salmon smolt survival enhancement vary longitudinally in a highly managed river system [*in press*].

Perry RW, TJ Kock, **II Courter**, TM Garrison, JD Hubble, DB Child. (201x) Dam operations affect route-specific passage and survival of juvenile Chinook salmon at a mainstem diversion dam [*in press*].

Clemens BJ, L Wyss, R McCoun, **I Courter**, L Schwabe, C Peery, CB Schreck, EK Spice, MF Docker. (201x) Annual differences in genetic population structure and migration behavior of Pacific lamprey *Entosphenus tridentatus* [*under review*].

Courter LA, Garrison T, **Courter II**. (2016) Herbicide toxicity in salmon and steelhead revised after application of a novel seawater challenge assay. *Bulletin of Environmental and Contaminant Toxicology* 96(5): 573-579.

Stevens, P., **I. Courter**, C. Peery, and C. Caudill. 2016. Evaluation of Adult Pacific Lamprey Passage at Lower Snake River Dams. 2015 Annual Report prepared for the U.S. Army Corps of Engineers. Contract: W912EF-14-P-5061. Submitted April 2016, 66pp.

Courter, I., K. Ceder, C. Fisher, and S. Schaller. 2016. Impacts of Stream Flow on Salmonid Production Potential in Stapaloop and Swimptkin Creeks, Washington. 2015 Annual Report prepared for the Colville Confederated Tribes, Omak, Washington, 27pp.

Courter, I., T. Garrison, T. Kock, and R. Perry. 2015. Evaluation of Stream Flow Effects on Smolt Survival in the Yakima River Basin, Washington. Final Report Prepared for the Yakima Basin Joint Board and U.S. Bureau of Reclamation, 66pp.

Courter, I., K. Ceder, C. Fisher, and S. Schaller. 2015. Impacts of Stream Flow on Salmonid Production Potential in Stapaloop and Swimptkin Creeks, Washington. 2014 Annual Report prepared for the Colville Confederated Tribes, Omak, Washington, 23pp.

Courter, I. and J. Caldwell. 2015. Instream Flow Assessment for Mid-Columbia Coho Reintroduction Project, Early Winters Creek Acclimation Site. Report submitted to Seasprings Co., March 2015, 18pp.

Stevens, P., **I. Courter**, C. Peery, and C. Caudill. 2015. Evaluation of Adult Pacific Lamprey Passage at Lower Snake River Dams. 2014 Annual Report prepared for the U.S. Army Corps of Engineers. Contract: W912EF-14-P-5061. Submitted April 2015, 44pp.

Courter, I. and D. Child. 2014. Life-history diversity increases resilience of rainbow trout populations in the Columbia Basin. Pages 35-42 in R. F. Carline and C. LoSapio, editors. Wild Trout XI: Looking Back and Moving Forward. Wild Trout Symposium, West Yellowstone, Montana.

Courter I., K. Ceder, M. Vaughn, R. Campbell, F. Forrester, and G. Engelgau. 2014. Evaluation of steelhead trout and Chinook salmon summer rearing habitat, spawning habitat, and fish passage in the upper Deschutes Basin. Report prepared for the Deschutes Basin Board of Control and City of Prineville, Oregon, 63pp.

Courter I., F. Forrester, K. Ceder, and P. Gaskill. 2014. East Fork Owyhee River Salmon and Steelhead Recovery Project. Report prepared for The Shoshone-Paiute Tribes of the Duck Valley Indian Reservation, Owyhee, Nevada. 106pp.

Courter, I., D. Child, J. Hobbs, T. Garrison, J. Glessner, and S. Duery. 2013. Resident rainbow trout produce anadromous offspring in a large interior watershed. Canadian Journal of Fisheries and Aquatic Sciences, Vol. 70, Num. 5, Page(s): 701-710

Zabel, R., T. Cooney, C. Jordan, R. Charmichael, … **I. Courter**, and 30 others. 2013. Life-cycle models for salmonid populations in the interior Columbia Basin. National Marine Fisheries Service Technical Report. 438 pp.

Courter, I., T. Garrison, and F. Carpenter. 2013. Swift Reservoir floating surface collector juvenile salmon collection efficiency pilot study. Report prepared for Pacific Power. 43 pp.

Courter, I., J. Vaughan, and S. Duery. 2012. Crooked River Redband Trout Study. Report Prepared for Ochoco Irrigation District, Prineville, Oregon, Page(s): 21 pp.

Courter, I., L. Courter, T. Garrison, D. Cramer, S. Duery, D. Child, T. Hanna, and E. Buckner. 2012. Effects of the Aquatic Herbicide Cascade on Survival of Salmon and Steelhead Smolts During Seawater Transition. Report prepared for the Washington State Water Resources Association.

Courter, I., S. Duery, J. Vaughan, C. Peery, M. Morasch, R. McCoun, B. Clemens and C. Schreck. 2012. Migration Behavior and Distribution of Adult Pacific Lamprey in the Willamette Basin. Report prepared for The Columbia River Inter-Tribal Fish Commission.

Courter, I., S. Duery, and J. Vaughan. 2011. Steelhead Radio Telemetry, Fish Assemblage, and Salmonid Fry Monitoring at Spring Hill Pumping Plant, Tualatin River, Oregon. Report prepared for the U.S. Bureau of Reclamation, 12pp.

Courter, I. and J. Vaughan. 2011. Hydropower Operations Reduce Bull Trout Entrainment Mortality at Tieton Dam. Series: Hydro Review, Vol. 30, Num. 5, Page(s): 100-107

Courter, I. 2011. Crooked River steelhead life-history response model conceptual basis, model construct, and preliminary results. Technical Memorandum prepared for the Deschutes River Conservancy, 18pp.

Courter, I., B. Lister, S. Cramer, J. Vaughan, S. Duery and D. Child. 2010. Evaluation of effects of resident rainbow trout and hatchery strays on steelhead production within the Middle Columbia River Oncorhynchus mykiss Evolutionarily Significant Unit. Report prepared for Yakima Basin Joint Board and submitted to the National Marine Fisheries Service.

Ericksen, R., C. Watry, **I. Courter**, J. Vaughan, and S. Duery. 2010. Effects of Surface Water Withdrawals on Listed Fish. Report prepared for the Yakama Nation Fisheries Program in support of the mid Columbia coho reintroduction program.

Courter, I., Casey Justice, and Steve Cramer. 2009. Flow and temperature effects on life history diversity of *Oncorhynchus mykiss* in the Yakima River basin. Report prepared for the Yakima Basin Joint Board. 46pp.

Courter, I.I., S.P. Cramer, R. Ericksen, C. Justice, T. Nickelson, and B. Pyper. 2008. Klamath Coho Life-Cycle Model Final Report. Prepared for the U.S. Bureau of Reclamation, Klamath Basin Area Office. 152pp.

Ackerman, N., B. Pyper, **I. Courter**, and S. Cramer. 2006. Estimation of Returns of Naturally Produced Coho to the Klamath River. Technical Memorandum prepared for the U.S. Bureau of Reclamation, Klamath Basin Area Office. 25pp.

Justice, C. and **I. Courter**. 2007. Juvenile Coho Emigration Survival in the Klamath River. Technical Memorandum prepared for the U.S. Bureau of Reclamation, Klamath Basin Area Office. 24pp.

Bartholomew, J.L. and **I.I. Courter**. 2007. Disease Effects on Coho Survival in the Klamath River. Technical Memorandum prepared for the U.S. Bureau of Reclamation, Klamath Basin Area Office. 26pp.

Ericksen, R.P., S.P. Cramer, **I.I. Courter**, and K. Arendt. 2007. Simulation of the Life Cycle of Klamath Coho from Adult Entry to Summer Rearing. Technical Memorandum prepared for the U.S. Bureau of Reclamation, Klamath Basin Area Office. 30pp.

Fox, M., **I. Courter**, B. Pyper, and S. Cramer. 2007. Evaluation of the Effects of "Flip-Flop" Operations on Spring Chinook Production in the Yakima Basin. *Flow evaluation study*. Prepared for The Yakima Basin Joint Board, Yakima, Washington. 85pp.

Courter, I. 2005. Defining What Constitutes a Wild Salmon. Masters Thesis submitted to Oregon State University.

Thomas Buehrens, M.S.

Senior Fisheries Scientist

Thomas Buehrens is a Research Scientist within the Science Division of the Fish Program of the Washington Department of Fish and Wildlife. In his current capacity as the Lower Columbia River Lead Salmon and Steelhead Scientist Thomas is responsible for statistical study design and analysis of WDFW's Viable Salmon Population (VSP) monitoring program throughout the lower Columbia region. Thomas is also concurrently completing his doctoral studies at the University of Washington School of Aquatic and Fishery Sciences. Thomas holds an M.S. in Aquatic and Fishery Sciences from the University of Washington (2011) and a B.A. in Biology and Environmental Studies from Bowdoin College (2007).

Thomas has extensive experience in the design, implementation, and analysis of quantitative ecological studies on Pacific salmon and steelhead. He currently oversees WDFW's long term Wind River steelhead life-cycle monitoring project, a large study of hatchery steelhead genetic introgression in wild populations, and analytical aspects of WDFW's salmon and steelhead fishery and escapement monitoring programs from the Columbia Gorge to the mouth of the river. His team also oversees tributary fishery creel study designs and analysis as well as an ongoing complimentary study of hooking mortality on wild steelhead in the Wind River basin. Thomas and his team have a track record of publishing in the peer-review literature and are widely respected throughout the Pacific Northwest for their analytical abilities and knowledge of salmon and steelhead populations.

Education and Training

Ph.D. Candidate, Fisheries Science. University of Washington, School of Aquatic and Fishery Sciences, Seattle, Washington.

M.S., Fisheries Science. University of Washington, School of Aquatic and Fishery Sciences, Seattle, Washington. 2011.

B.A. Biology. Bowdoin College, Brunswick, Maine. 2007.

Employment History

Research Scientist, Washington Department of Fish and Wildlife, Lower Columbia Lead Salmon and Steelhead Scientist Vancouver, Washington. July 2012 – Present.

Research Fishery Biologist Wild Fish Conservancy Duvall, Washington. June 2011 – June 2012.

Graduate Research Associate. NOAA Northwest Fisheries Science Center Seattle, Washington. July 2008 – June 2011.

Teaching Assistant University of Washington Seattle, Washington. March 2000 – June 2010.

Biologist. Wild Fish Conservancy Duvall, Washington. June 2007 – July 2008.

Selected Publications and Reports

Bennett, S., G. Pess, N. Bouwes, P. Roni, R. Bilby, S. Gallagher, J. Ruzycki, **T. Buehrens**, K. Krueger, W. Ehinger, J. Anderson, C. Jordan. 2016. Progress and challenges of testing the effectiveness of stream restoration in the Pacific Northwest using Intensively Monitored Watersheds. Fisheries 41(2): 92- 103.

Atlas, W.I., **T.W. Buehrens**, D. McCubbing, R. Bison, and J.W. Moore. 2015. Implications of spatial contraction for density dependence and conservation in a depressed population of anadromous fish. Canadian Journal of Fisheries and Aquatic Sciences 72:11, 1682-1693.

Buehrens, T.W., P. Kiffney, G.R. Pess, T.R. Bennett, S.M. Naman, G. Brooks, T.P.Quinn. 2014. Increasing juvenile coho salmon densities during early recolonization have not affected resident coastal cutthroat trout growth, movement, or survival. North American Journal of Fisheries Management 34:5, 892-907.

Kendall, N.W., J.R. McMillan, M.R. Sloat, **T.W. Buehrens**, T.P. Quinn, G.R. Pess, K.V. Kuzishchin, M.M. McClure, and R.W. Zabel. 2015. Anadromy and residency in steelhead and rainbow trout Oncorhynchus mykiss: a review of the processes and patterns. Canadian Journal of Fisheries and Aquatic Sciences. 72:30, 319-342.

Buehrens, T.W., J. Glasgow, C.O. Ostberg, T.P.Quinn. 2013. Spatial segregation limits hybridization between sympatric native steelhead and coastal cutthroat trout. Transactions of the American Fisheries Society 142:1, 221- 233.

Naman S.M., P.M. Kiffney, G.R. Pess, **T. Buehrens**, T.R. Bennett. 2013. Abundance and body condition of sculpin (Cottus Spp.) in a small forest stream following recolonization by juvenile coho salmon Oncorhynchus kisutch. River Research and Applications 30:3,360–371.

Goetz, F., Baker, B., **T. Buehrens**, T.P. Quinn. 2013. Diversity of movements by individual anadromous coastal cutthroat trout in Hood Canal, Washington. Journal of Fish Biology 83,1161-1182.

Thompson, A., J. Glasgow, **T. Buehrens**, E. Drucker. 2011. Mortality in juvenile salmonids passed through an agricultural Hidrostal pump. Fisheries Management and Ecology 18:4, 333-338.

LETTER OF SUPPORT

July 5, 2016

Columbia River Salmon Steelhead Recreation Advisory Board (CRSSRAB)

Subject: Cowlitz River Salmon/Steelhead Hooking Mortality Study Proposal

Dear CRSSRAB:

The Cowlitz River Ad-Hoc Group directly influences management of fisheries in the Cowlitz River through collaboration with Tacoma Power, Washington Department of Fisheries and Wildlife, the Cowlitz Tribe, and the National Marine Fisheries Service. Our members are strong proponents of fish conservation and the sustainability of vibrant salmon and steelhead fisheries in the Cowlitz Basin and throughout Washington State. In accordance with these objectives, we urge you to approve the proposed Cowlitz River Salmon/Steelhead Hooking Mortality Study Proposal submitted by Mount Hood Environmental (MHE). The study proposal includes funding for both MHE and WDFW participation and will give our fish managers the scientific information and data they need to make future fishery management decisions for the Cowlitz River–one of most heavily sport-fished rivers in Washington.

I have presented the study plan to numerous sport fishing and conservation groups with an interest in the Cowlitz and Lower Columbia Rivers to solicit their feedback. We collectively agree that this study is a high priority and will fill an important data gap concerning the impact of sport fishing on recovery of native salmon and steelhead populations. The study will also provide a much-needed examination of the utility barbless hook regulations as a conservation measure. Below is a list of the many different conservation and sport fishing organizations that support the proposed Cowlitz River Salmon/Steelhead Hooking Mortality Study Proposal:

1. Coastal Conservation Association Washington
2. The Conservation Angler
3. Steelhead Trout Club of Washington (oldest Sport fishing Organization in WA)
4. Clark-Skamania Flyfishers
5. Cowlitz Game & Anglers
6. Friends of the Cowlitz
7. CPR-Fish (Cowlitz Plan for Restoration-Fish)
8. Barrier Dam Camp Ground
9. Steelhead & Cutthroat Policy Advisory Group: Jim McRoberts, David Duvall, Bob Reid, and Mark Heirigs

Sincerely,

Bob Reid
Cowlitz River Ad-Hoc Group