Coquille River Tidal Floodplain Use by Juvenile Coho and Fall Chinook Monitoring Proposal

Prepared
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1.0 Introduction

Valley floodplain wetland habitats are critical for overwintering of nomad and downstream migrating presmolt Coho that have left natal habitats in the late summer, early fall, and winter. Growth rates in these locations are often several hundred percent greater compared to in-river rearing locations (ODFW unpublished 2015, others). The elevated growth rates in floodplain channels and wetland habitats contribute to higher overall health/body condition and increased Smolt to Adult Survival Rates (SAR's). As a result, naturally functioning wetland habitats in the floodplain are capable of producing 10-17 returning adult Coho per acre (Nickelson 2012).

The Coquille River basin is 1,059 sq. miles in size and the largest coastal watershed that emanates from the coastal mountain range in Oregon (Figure 1). The river also has the longest tidally influenced estuary (41 miles) in Oregon, other than the Columbia River. Historically, the Coquille River was the largest producer of wild/natural Coho Salmon (*Oncorhynchus kisutch*) in the Oregon Coast ESU, other than the Umpqua River basin (Lawson et al. 2007). Euro-human perturbations to the streams, rivers, wetlands, estuary, and uplands in the basin have reduced the productive capacity for Coho by approximately 90% since the late 1800's. A major contributing factor to this decreased production has been the loss of tidal saline, freshwater, and non-tidal freshwater critical rearing habitats in the Coquille River valley floodplain. From 1880 to 1950 ~95% of these habitats were diked, tidegated, and drained. Benner 1991 documents that, historically, river floodplain tidal and non-tidal wetlands comprised at least 12,000 acres and perhaps as much as 17,000 acres (Figure 2). Currently, there is ~1,000 acres remaining. To partially address this decline and assist salmon recovery, two large-scale restoration actions will occur in the Winter Lake area of the Coquille River valley located at River Mile (RM) 22.0 in 2016/17 (Figures 1 and 3).

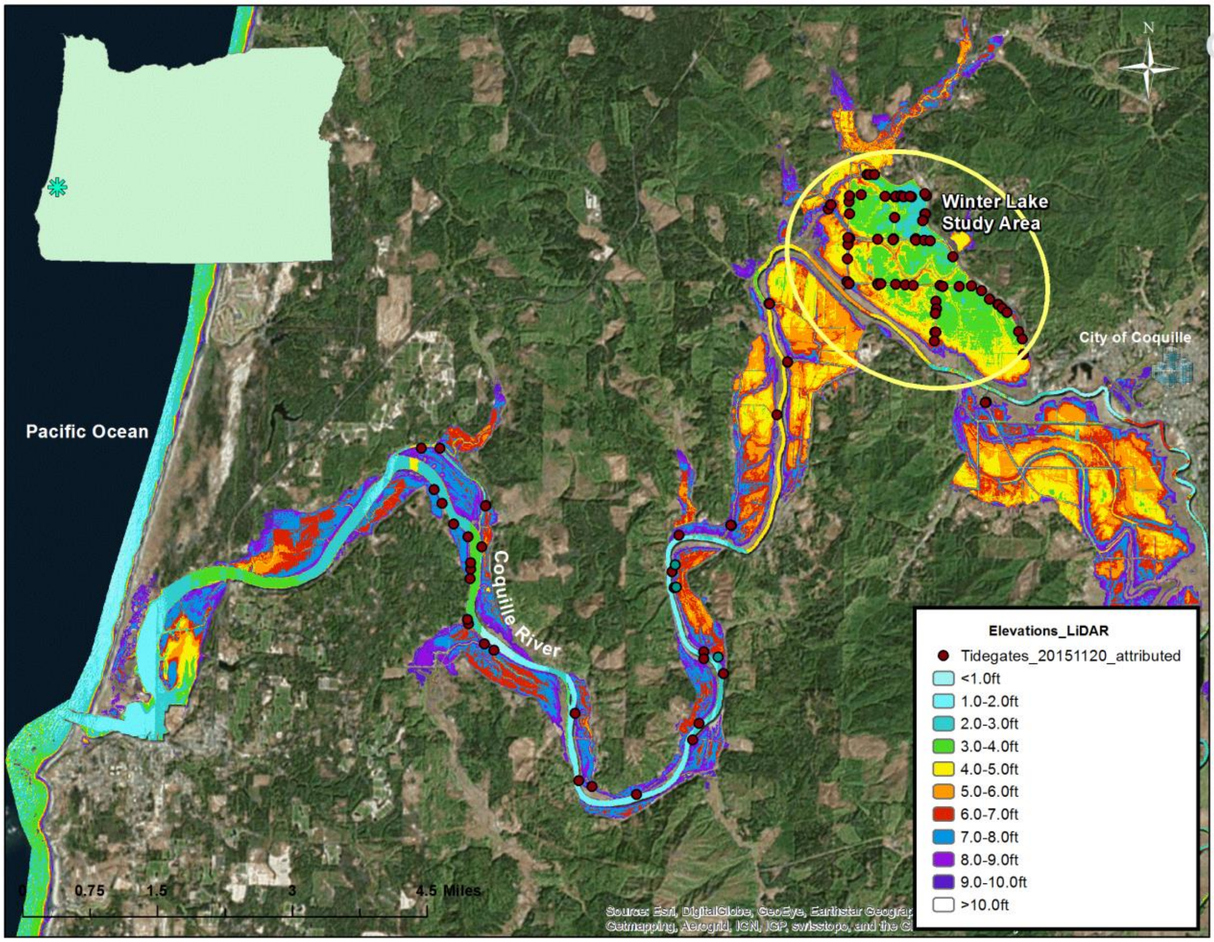

Figure 1. Lower Coquille River Valley, OR and Winter Lake proposed study area.

__1. 1 Restoration:__ In 2016, three large top-hinged wooden tidegate structures that currently service 1,761 acres (Figure 3) will be replaced. Such tidegates can significantly restrict movements of juvenile Coho Salmon using estuarine/stream interface habitats (Bass 2010). The three Winter Lake channel networks at the replacement site will have new technology, side-hinged aluminum tidegates installed with Muted Tidal Regulator (MTR) equipment that allows for controlled inflow of tidal exchange to a set elevation. The MTR device allows for tidal inflow with the level set to a desired elevation, whereupon the door closes. This style of tidegates and the associated MTR's allow much greater capacity for fish movement as the duration of door opening is substantially increased compared to the existing structures. Additionally, we expect the channel networks upstream of the gates will have increased biological capacity as a result of increased tidal inflow, while maintaining water levels below that needed for continued agricultural production. The Units 1, 2, and 3 tidegates will function independently. Unit 2 will have a much more substantial tidegate array that has four 8x10 ft. gates to allow for maximum fish passage and tidal effect into Unit 2 (Figure 4).

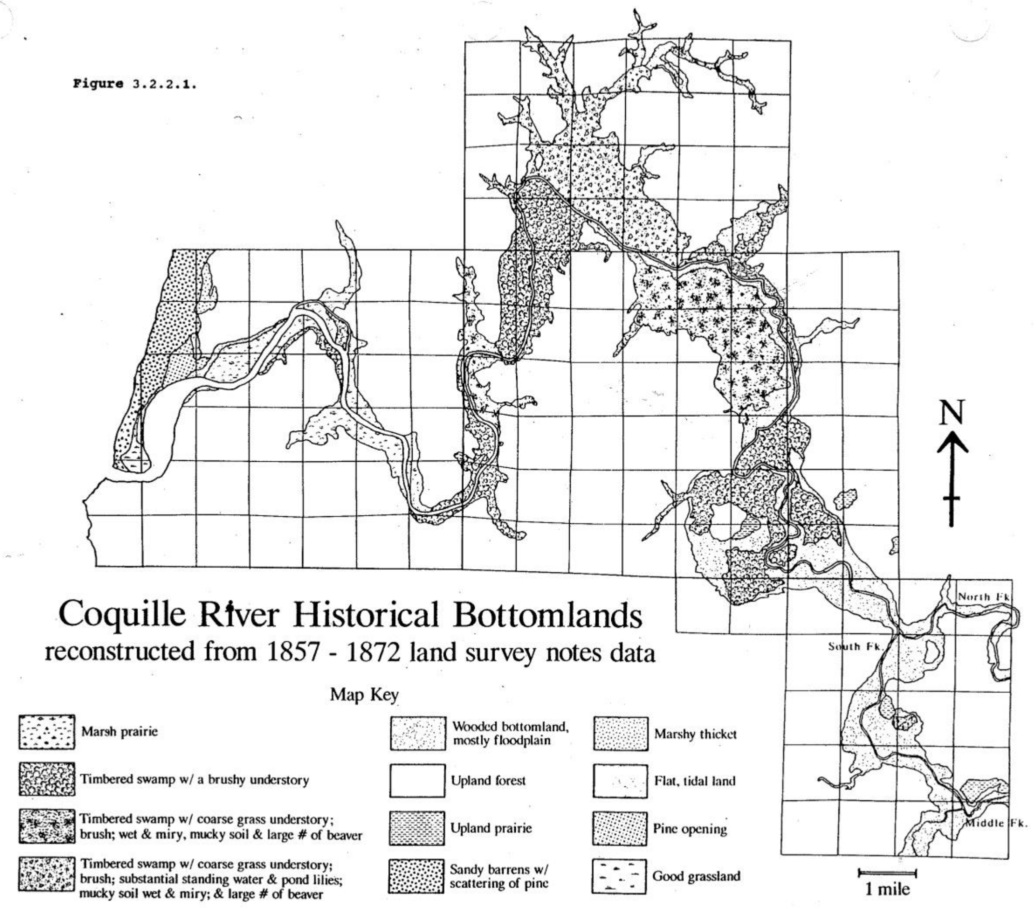

Figure 2. Coquille River Valley habitats as mapped in the late 1800's and noted in Benner 1992.

The Unit 2 lands (Figure 3) are owned by the Oregon Department of Fish and Wildlife (ODFW) and the China Camp Duck Club. Within Unit 2 there will be approximately seven miles of primary, secondary, and larger channels installed in 2017 (Figure 5). These channels should significantly improve the accessibility of juvenile fish to feeding areas adjacent to channels when flooding occurs, thereby increasing access to large quantities of macroinvertebrate and other food items. Additionally, the tidegate network servicing Unit 2 will have the ability to operate independently from Units 1 and 3. Unit 2 will be isolated by an improved diking network and managed to allow tidal inflow to a set level that will maximize fish and wildlife to the degree possible in coordination with adjacent land uses. We expect that implementation of the project will result in improved dissolved oxygen levels, reduced nutrients, decreased summer thermal extremes, greater accessibility, and a substantial increase in the food production for fish and other aquatic organisms. Grazing will be controlled for all locations near channels to allow for restoration of riparian plantings/natural regeneration and to prevent decreased water quality. Native riparian woody shrubs and appropriate vegetation will be planted on the streambanks of the newly constructed channels.

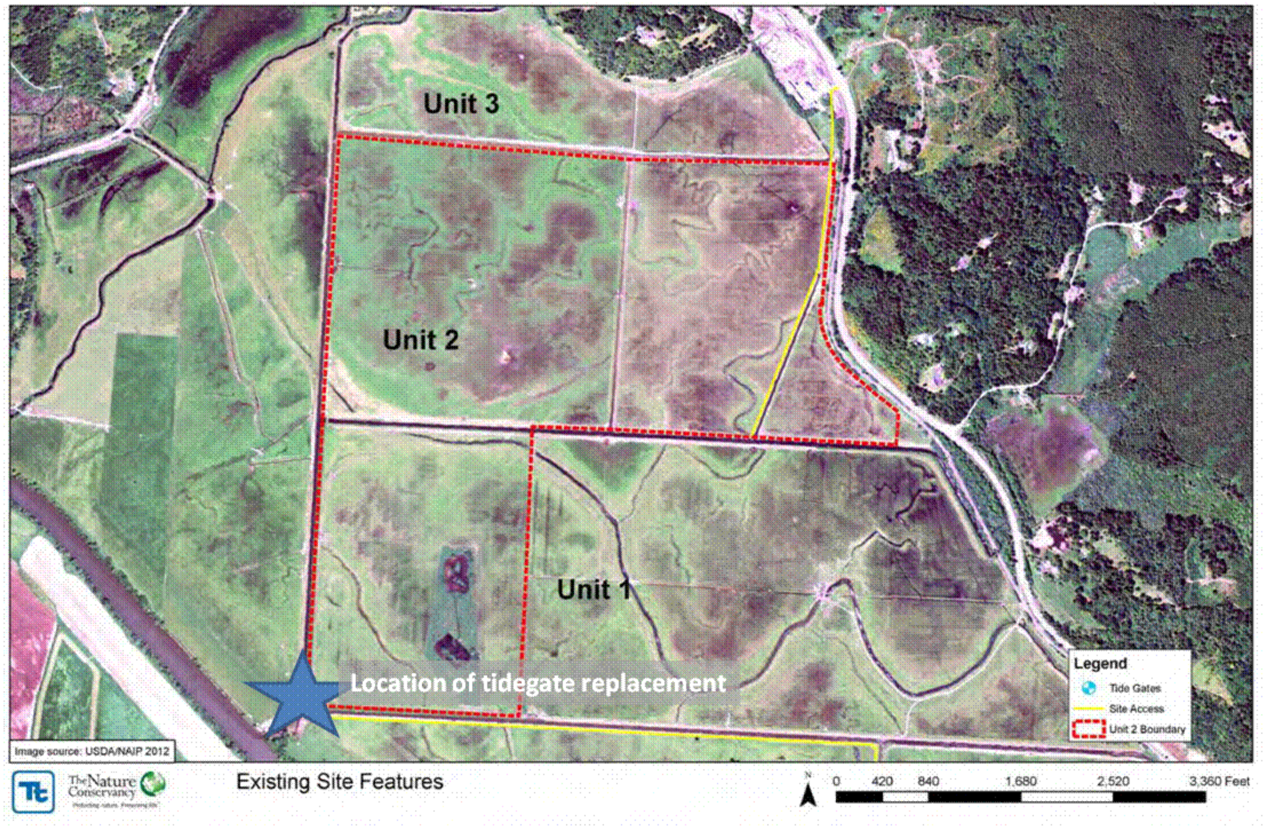

Figure 3. Location of existing tidegate that services proposed study area, Winter Lake. Image reflects existing land condition.

Understanding of floodplain habitat use by Coho and Fall Chinook (*O. tshawytscha*) is limited. However, data obtained to date fully indicates that these habitats are critical for recovery of Coho in the Coquille River basin and on the Pacific Coast and (NOAA 2007). We propose to conduct an extensive sampling effort through the Winter Lake valley floodplain and mid-lower Coquille River network to evaluate multiple hypotheses related to Coho and Fall Chinook and other salmonids survival, growth, movements, as well as obtain data on non-native fish species response to restoration, and general fish use of restored and unrestored floodplain tidal habitats. The initial study would be conducted for a period of five years.

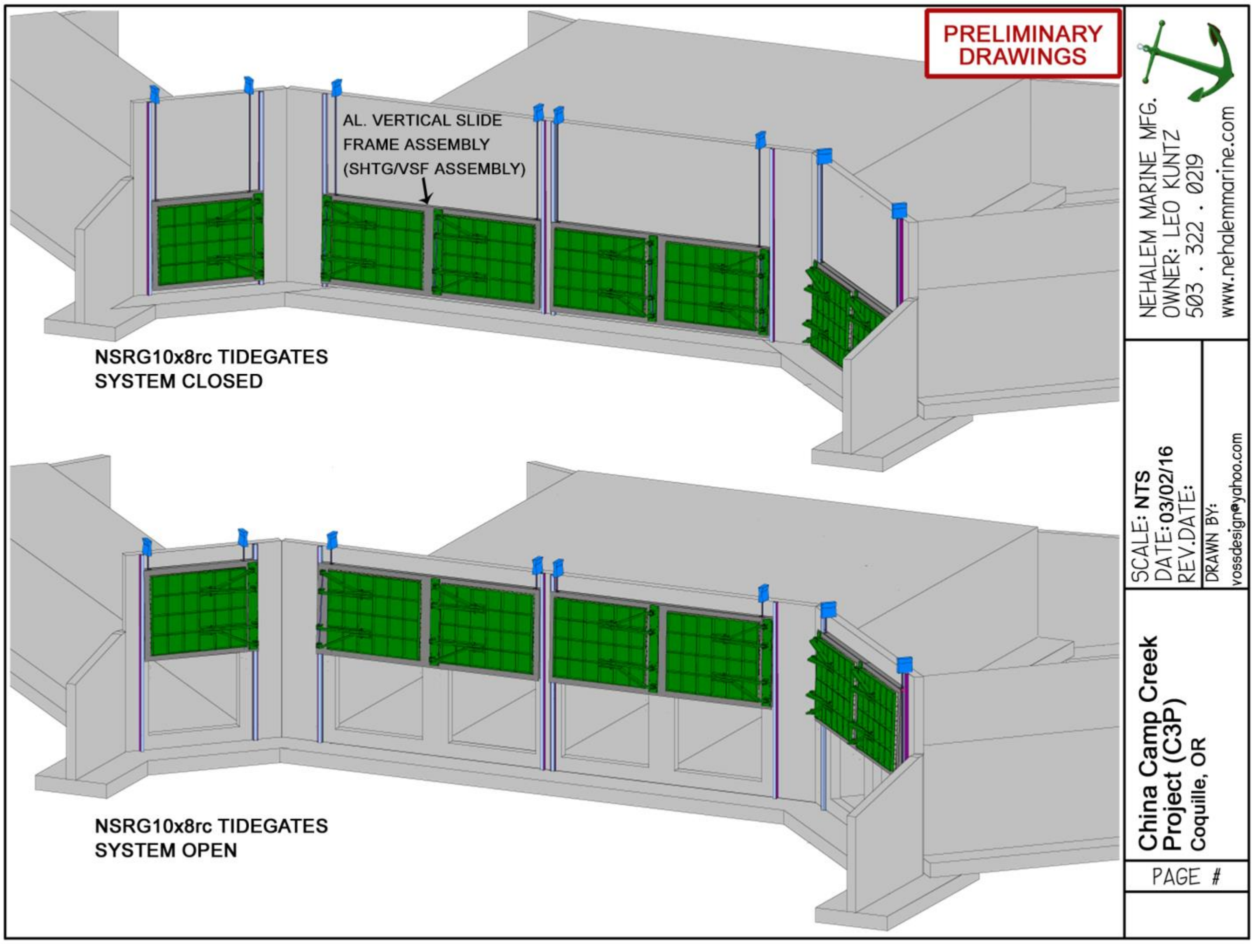

Figure 4. Depiction of tidegate network that will be installed to service Units 1, 2, and 3 in the Beaver Slough drainage district at Winter Lake.

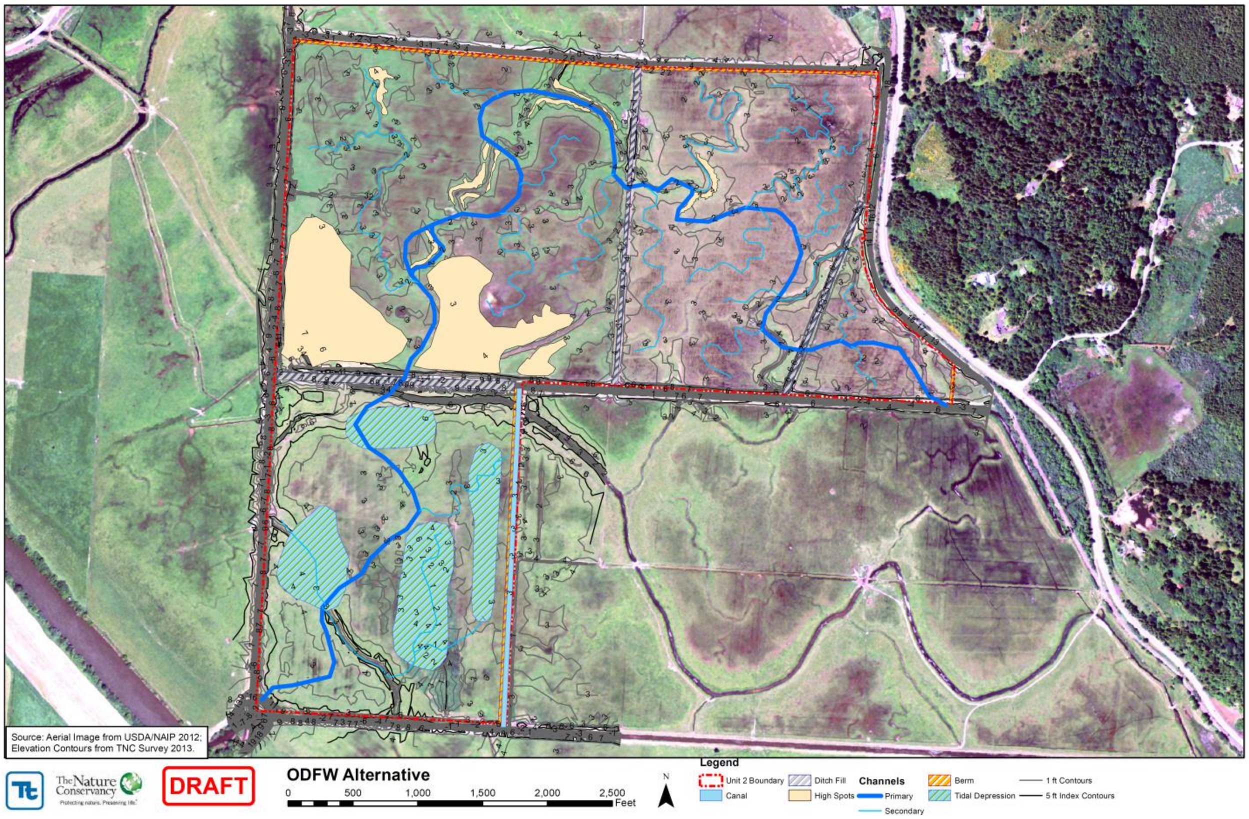
Source: Aerial Image from USDA/NAIP 2012; Elevation Contours from TNC Survey 2013.

Figure 5. Depiction of Unit 2 planned channel construction and habitat restoration.

2.0 Study Methods

The study area will include Units 1 and 2. Study control sites will be located in Beaver Slough Unit of the Coquille Valley Wildlife Area with a second control potentially located in a typical top-hinged tidegated channel network within five to eight miles of the primary study area.

The restoration occurring at Winter Lake (see above for description) is expected to provide several benefits to native salmonids, including (but not limited to)

1. Increase in use of restored area by juvenile Coho (and other native species).
2. Increase in habitat quality as measured by increased over-winter survival and increased growth/condition of juveniles prior to outmigration.
3. Increased survival of juvenile Coho from smolt to returning adult.
4. Decrease in non-native fish abundance and diversity
5. Increase in the contribution of lower river rearing sites to adult returns in the basin

To assess whether these benefits are realized, and determine whether the new tidegates allow fish passage, the following discussion outlines the monitoring that would be needed and the expected benefits obtained by fully implementing the monitoring program.

2.1 Study Period: The study would be initiated as grant funds are available for a period of five years. Field work and data collection would begin in fall 2016 or spring 2017 and continue until 2021 or 2022.

2.2 Evaluation of Site Level Benefits:

2.2a *Effect of restoration on the overwinter abundance, growth/condition, and survival of juvenile Coho salmon*

Complex overwinter habitat limits the capacity of many coastal basins to support juvenile Coho salmon (Oncorhynchus kisutch) in Oregon (ODFW 2007). Off-channel habitats that provide velocity refuge and cover have a relatively high capacity to support overwintering juvenile Coho (Nickelson et al.1992; Nickelson and Lawson 1998; Solazzi et al. 2000), but these low-gradient habitats are particularly scarce in areas converted to agricultural use (Anlauf et al. 2009). Recent studies also have demonstrated that off-channel habitats in areas of tidal influence can enhance juvenile Coho salmon growth (Craig et al. 2014) and support rearing juveniles that contribute significantly to adult returns (Jones et al. 2014; Bennett et al. 2015). Winter Lake's position low in the basin and in the freshwater-marine ecotone makes it well situated to benefit overwintering juvenile Coho salmon.

We expect enhancement of fish passage and restoration of habitat at Winter Lake will benefit Coho salmon by providing for increased use of improved channel habitat. These benefits are expected to be manifest in terms of the abundance, growth/condition, and survival of juvenile salmon during the critical overwintering period:

> *Abundance* - We hypothesize that enhanced fish passage and habitat restoration will increase overwintering habitat capacity for juvenile Coho salmon. If the restoration actions increase overwintering habitat capacity, we predict an increase in the winter abundance of juvenile Coho. Our objective is to evaluate the post-construction change in juvenile abundance relative to the pre-construction baseline and a reference site.
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> *Growth/Condition* - We hypothesize that enhanced fish access and habitat restoration in Zone 2 will increase the overwinter growth of juvenile Coho salmon. We predict that the overwinter growth of juvenile Coho in the restoration area will increase relative to that observed at a reference site. Our objective is to evaluate the post-construction change in the overwinter grown of juvenile Coho salmon relative to the pre-construction baseline (pre-construction) and a reference site (control).
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> *Survival* - In addition to growth, overwinter survival can provide an index of habitat quality. We hypothesize that enhanced fish passage and habitat restoration will increase the overwinter survival of juvenile Coho salmon. Therefore, we predict that the overwinter survival of juvenile Coho in the restored portion of Winter Lake will increase relative to that observed at a reference site. Our objective is to evaluate the post-construction change in the overwinter survival of juvenile Coho salmon relative to the pre-construction baseline (pre-construction) and a reference site (control).

Methods: Ocean conditions and other stochastic events can strongly regulate Coho salmon productivity (e.g., Mantua et al. 1997). Therefore, our field methodology will be based on a Before-After-Control-Impact (BACI) design (Stewart-Oaten et al. 1986). This design allows for an evaluation of the Before (pre-construction baseline) and After (post-construction) condition as well as a comparison of a Control (reference site) and Impact site (restoration site). The Before and After sampling will be used to determine how juvenile abundance, growth/condition, and survival have changed at the site through time from its historical, pre-project condition. The Control and Impact sampling will allow the effects of restoration actions to be discerned from natural variability, stochastic events, and underlying trends in the larger area.

A combination of passive and active capture techniques (e.g., trap nets, minnow traps, beach seines) will be used to sample juvenile Coho salmon in the restored area of Winter Lake (impact area) and a reference area (control area) throughout the winter period (October – March) before and after construction. Capture efforts will be systematically spaced within the sample frames in both the control and impact areas. Capture efforts will center on three sample periods during the winter period. During each sample period, we will conduct sampling on 3 occasions to estimate recapture probabilities for juvenile Coho salmon for each gear type.

During each capture event, all juvenile Coho salmon will be counted and measured for fork length (L_F) and wet mass. A subset of juvenile Coho with $L_F \geq 65$mm will be tagged with Passive Integrated Transponder (PIT) tags to allow for the identification of individual fish on recapture. Tracking individual fish through the winter period will be necessary to support objectives related to growth/condition and survival. At each recapture, all juvenile Coho will be scanned for the presence of a PIT tag using a hand-held scanner. As needed, the project may also individually mark juvenile Coho with an external mark to further allow for more differentiation and expedite handling time. If identification of individual fish is deemed unnecessary or infeasible, fish will be marked by a small caudal fin clip or injected with a Visible Implant Elastomer (VIE) tag.

Analysis (Abundance): We will pilot the use of a traditional mark-recapture (M-R) approach to estimate the overwinter abundance of juvenile Coho at each site. However, M-R can be labor intensive, and small population size or low capture probability may preclude reasonable abundance estimates. Therefore, we will also use an N-mixture or binomial-mixture model, which uses data from spatially replicated populations (i.e., sampling sites) with temporally replicated counts of independent individuals (i.e., multiple sampling occasions) within a period of closure (i.e., assuming no immigration, emigration, or mortality) to estimate abundance and capture probability for juvenile Coho salmon at each sampling location (Royle 2004; Kéry and Schaub 2012). The N-mixture model will also allow us to evaluate evidence for the effect of covariates on both capture probability and abundance at a sample site.

Analysis (Growth/Condition): The overwinter growth of individual Coho salmon will be determined as the change in L_F from one capture event to the next or averaged over multiple recaptures. We will evaluate differences in L_F, mass, and growth among years and locations within and between control and impact areas. Size (L_F and mass) at initial capture and tagging may be used as a covariate in evaluating growth rates.

Analysis (Overwinter Survival): We will apply our M-R data to a multi-state capture-recapture model (Lebreton et al. 2009) to estimate overwinter survival. A traditional capture-recapture model can provide an estimate of apparent survival, which reflects a joint probability of surviving *and* remaining at the sampling site through the sampling period. A multi-state model will allow us to consider an additional probability factor – the probability that an individual moves among locations during each interval at-large. This approach will be amenable to our field methodology, which utilizes multiple capture-recapture locations within both the control and restoration areas.

This allows us to consider an additional probability factor, the probability that an individual moves among locations during each interval at-large. In addition to facilitating estimates of survival, this approach will allow for evaluation of site fidelity and dispersal among sites within the restoration and control units.

Expected Benefits and Uncertainties: An evaluation of the overwinter abundance, growth, and survival of juvenile Coho salmon in the restored portion of Winter Lake relative to the pre-construction baseline and the control site will provide a means by which to assess the combined effectiveness of the passage enhancement and habitat restoration. This information may help to guide adaptive management of tidegate operation or continued habitat restoration actions. The field methodology and analytical approaches outline above have several caveats. The most important is that the utility of the BACI approach is contingent on both adequate baseline (pre-construction) data and the identification of an adequate control site. Several candidate sites are available in close proximity to Winter Lake, but accessibility for sampling is contingent on landowner permission. An absence of adequate baseline and reference site data will limit the temporal and spatial inference with which conclusions may be drawn. It is likely that winter flooding will occasionally eliminate closure between the restored portion of Winter Lake (Zone 2), unrestored portions of Winter Lake (Zones 1 and 3), the mainstem, and other portions of the floodplain, potentially including the reference site. However, such flooding is not anticipated to occur on an annual basis, and fish movement is likely to be limited during such high flow events.

Even with a fully implemented BACI design, the objectives related to overwinter abundance, growth/condition, and survival will depend on the precision of estimates and the statistical power to detect differences among sites and trends through time. If populations are small or detection probabilities low or unstable, we may lack sufficient power to discern differences attributable to the restoration.

There also is uncertainty with regard to the feasibility of a M-R approach in this system as well as potential bias introduced by (1) marking a truncated size distribution and (2) differential effects of tagging on mortality and growth (e.g., Brakensiek and Hankin 2007; but see also Tiffen et al. 2015 for consideration of smaller tag sizes). If the M-R approach proves infeasible due to permitting restrictions, small population sizes, or insufficient recaptures, the mean size (length and mass) and length-frequency distribution of juvenile Coho salmon can be compared among sites. This will provide some information about growth and condition through the overwinter period, but any observed differences in mean size or length-frequency distributions may be confounded with differential movement by fish of different sizes.

2.2b Effect of restoration on non-native fish abundance:

The Winter Lake floodplain currently supports a variety of non-native species, including brown bullheads (*Ictalurus nebulosus)*, bluegills (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus)*, and largemouth bass (*Micropterus salmoides)*. Several of these species are known predators of native salmonids (Counihan et al. 2012; Poe et al 1994; Rieman et al. 1991). The habitat (temperature, flow) at Winter Lake currently favors non-native species over native species; however, the planned restoration is intended to increase water exchange and reduce temperatures to favor native salmonids. Thus, we hypothesize that habitat restoration will decrease the abundance of non-native fish in Unit 2 of Winter Lake. Our objective is to evaluate whether the changes in habitat result in decreased abundance of non-native fish in the restored area.

Methods: Both passive and active capture techniques (e.g., beach seines, trap nets, trammel nets, gill nets, minnow traps) will be used to sample the fish assemblage in the restored area of Winter Lake throughout the summer period. The restored region of Winter Lake will be divided into a grid and sample sites will be selected systematically within the grid. Sampling at each site will occur during three sample periods during the summer (early, mid, late). During each sample period we will conduct sampling on 3 occasions (consecutive days) to estimate recapture probabilities for each species/size class/gear type combination. All individual fish captured will be identified to species and counted; at least 100 individuals of each species will be measured for length, when available, Additionally, any non-native fish captured during winter sampling periods will be counted, classified to species level and measured.

Analysis: We will use an N-mixture or binomial-mixture model, which uses data from spatially replicated populations (i.e., sampling sites) with temporally replicated counts of independent individuals (i.e., multiple sampling occasions) within a period of closure (i.e., a sample period during which we assume no immigration, emigration, or mortality) to estimate abundance and capture probability for non-native species at each sampling location (Royle 2004; Kéry and Schaub 2012). The N-mixture model also allows us to evaluate evidence for the effect of covariates on both capture probability and abundance at a sample site. We will include habitat covariates such as temperature, depth, aquatic vegetation, and cover in the model.

Expected Benefit and Uncertainties: We expect to obtain point estimates of the abundance of non-native fish species at each sampling period. The precision of these estimates at a site is directly related to the variability in counts of a species between successive capture events at a site within a sampling period. The level of variability will influence our power to detect a change in non-native fish abundance between sampling periods or between years. Additionally, we expect to determine which habitat variables are associated with the highest abundance of non-native fish. This information can be used to direct further restoration.

Note: We will test the assumption of closure using data gathered from PIT tags as described in Section 2.2a.

2.2c Evaluation of passage effectiveness at the modified tide gate structure:

Tide gates limit fish passage and typically provide lower ecological benefit than natural systems (Beamer 2014), although self-regulating tide gates (SRTs) can provide greater ecological benefits than traditional flap gates. Fish movement past tide gates is a function of the opening period, tidal flow, and an individual's motivation to move past the tide gate. Research suggests that access is most strongly affected by door opening during non-ebb tides (Beamer 2014). Additionally, the effectiveness of tide gates varies by species and life history types. We hypothesize that juvenile Coho will be able to move between the Coquille River and the restored area during periods the tidegates are open. Our objective is to evaluate whether 1) native salmonid juveniles pass through the modified tide gate and 2) movement is associated with particular flow conditions.

Methods: We will capture juvenile Coho salmon (N≈200) from the Coquille River margins upstream of the tide gate structure using beach seines and boat e-fishing. Additionally, juvenile Coho will be captured behind the tide gates during sampling for PIT tagging (See Section 2.2 above). At least 200 fish of the appropriate size from each location will be PIT tagged and released. We will deploy PIT tag arrays at three locations around the tide-gate structure (in-front, in-structure, and behind-structure) to monitor fish approach and passage through the tide gates.

Analysis: We will construct capture histories for each PIT tagged individual and use a CJS model to determine detection efficiency at the arrays, and determine the proportion of fish that approach the tidegates and successfully pass versus fail to pass.

Expected Benefit and Uncertainties: We expect to determine whether juvenile Coho are able to pass the new tide gate structure. Additionally, we expect to determine the relationship between flow conditions (tide, river level) and passage occurrence. In the absence of a control site we will not be able to determine whether the new tide gate represents a barrier under certain flow conditions. Similarly, the lack of pre-restoration data means we cannot determine whether the modified structure has improved fish passage.

2.3 Evaluation of Population Scale Benefits:

2.3a Evaluation of the contribution of lower river rearing sites to adult returns.

A number of salmonid populations have a component that utilizes a lower river/tidal rearing life history strategy (Bennett et al. 2014; Jones et al, 2014; Miller and Sadro 2003). Recent research suggests that this life history can contribute substantially to adult returns (Bennett et al. 2014; Jones et al, 2014). The restoration of habitat and tidal influence in Unit 2 of the Winter Lake floodplain is expected to provide additional rearing capacity and increased survival in the lower Coquille River (see above). Thus, we hypothesize that there will be a concomitant increase in the proportion of adult spawners that utilize the floodplain (containing Unit 2) during the parr stage. Detection of such an increase is difficult to measure. ODFW conducts annual spawning ground surveys to assess adult abundance. However, the variation surrounding these estimates is considerable, meaning it is likely not possible to detect a change in adult abundance as a result of the restoration. Additionally, spawner surveys do not provide information on the juvenile rearing history of returning adults. Otolith and scale microchemistry have been used successfully to infer the rearing locations of juvenile salmonids (Adey et al. 2009; Ramsay et al. 2007; Volk et al. 2010). The ability to infer rearing location during the juvenile stages is dependent on the ability to differentiate water chemistry at different locations within the basin and the amount of time juveniles spend in an area. We hypothesize that restoration in the lower river, including at Winter Lake, will result in an increase in the proportion of returning adults that spent some portion of their freshwater rearing period in the lower river. Our objective is to evaluate the utility of scale and otolith microchemistry to determine 1) the proportion of adult spawners with a lower river isotope signal and 2) whether there is an increase in the proportion of spawners with a Winter Lake isotope signal.

Methods: Water samples will be collected monthly from locations throughout the Coquille basin to determine whether trace elements differ sufficiently within the basin to use scale/otolith micro-chemistry to infer rearing history of Coho. We will compare water chemistry between upper and lower river sites and between Winter Lake and all other sites. If the differences in chemistry are sufficient, we will sample returning adults for otoliths and scales. The otoliths/scales will be subject to microchemistry analysis. Additionally, we will submit scales from ODFW's archive for microchemistry analysis.

Analysis: Microchemistry data will be analyzed following the methods described in Volk et al. (2010). We will test for changes in the proportion of adults with lower river and upper river signatures and for changes in the proportion of Coho spawners with a Winter Lake isotope signal.

Expected Benefit and Uncertainties: We expect to determine the proportion of adult spawners that exhibit a lower river rearing signal. This information can be used to infer the relative value of these habitat types based on the area of the basin. The ability to detect a signal from juveniles that rear in Winter Lake is contingent on that area having sufficiently different water chemistry from other areas and fish spending sufficiently long in the area to incorporate the signal. The ability to determine changes in the proportion of spawners with a lower river or Winter Lake signal will depend on the retention of the early rearing signal in scale samples currently archived by ODFW.

3.0 Study Infrastructure/Equipment

Equipment will be managed and maintained in good working order by ODFW and Tribal staff.

3.1 PIT antenna sites: PIT antennas will either be built within ODFW or purchased from a contractor. Antennas will be installed upstream and downstream of the three tidegates that will be reconstructed at the channel outflow from Units 1, 2, and 3. Fish detection data from these sites will be used to determine:

- Information on numbers and timing of fish moving into the site from the Coquille River
- Numbers and timing of fish leaving the site and entering the Coquille River
- Residence time of fish within the study and restoration area and the individual units respectively
- Information on movements of fish between the individual units
- Directionality of fish movements
- Assist with determining growth rates per time spent within study area

4.0 Project Management/Data Management

4.1 Project Staffing: ODFW Corvallis Research and the local ODFW District staff will hire and supervise field staff working on the project. Coquille Tribal staff will also be funded in the grant and will work in collaboration with ODFW staff.

4.2 Data Management: ODFW Corvallis Research and the local ODFW District office will be responsible for collection, processing, analysis, compilation, report writing, and sharing of data with project partners. Data will be summarized into annual reports and shared via the ODFW website and upon request.

5.0 Project Funding/Grant Administration

5.1 Project Funding: The project is planned for a five year period beginning as funds are available. The annual project costs have been calculated at a year one initial cost with purchase of supplies including PIT tag antennas and PIT tag digital monitoring equipment and personnel of $155, 532 and total study expenditures of $568,222 for five years.

5.2 Grant Administration: PCSRF grant funds will be held and administered by the Coquille Tribe. ODFW administration will invoice the Tribe for ODFW agency staff work activities on the project at regular intervals agreed upon by ODFW and the Tribe.

6.0 Budget

Note: *Budget is total for annual expenses over five years of study.*

- ***Personnel Services and Fringe Benefits= $372,332.55***
- ***Services and Supplies= $59,130***
- ***Contracted Services= $66,000***
- ***Indirect Costs=$70,758***

Budget Total 2017-2021 **= $568,221.43**

Complete line item budget costs are in Appendix A.

References

Adey E, Black K, Sawyer T, Shimmield T, Trueman C (2009) Scale microchemistry as a tool to investigate the origin of wild and farmed *Salmo salar*. Mar Ecol Prog Ser 390:225-235

Anlauf, K.J., K.K. Jones and C.H. Stein. 2009. The status and trend of physical habitat and rearing potential in Coho bearing streams in the Oregon Coastal Coho evolutionary significant unit. OPSW Report OPSW-ODFW-2009-5. Oregon Department of Fish and Wildlife, Salem, Oregon.

Bass, A. 2010. Juvenile Coho Salmon Movement and Migration Through Tide Gates. Masters Thesis Oregon State University, Corvallis, OR. 2010: 125p.

Benner, Patricia, 1991, Historical reconstruction of the Coquille River and surrounding landscape, in Near coastal waters national pilot project—The Coquille River, Oregon. Action plan for Oregon coastal watersheds, estuary and ocean waters, 1988—91. Prepared by the Oregon Department of Environmental Quality 81 for the U.S. Environmental Protection Agency, Grant X-000382-1: Portland, Oregon.

Bennett, T.R., P. Roni, K. Denton, M. McHenry and R. Moses. 2015. Nomads no more: Early juvenile Coho salmon migrants contribute to the adult return. *Ecology of Freshwater Fish*. 24:264-275.

Brakensiek, K.E. and D.G. Hankin. 2007. Estimating overwinter survival of juvenile Coho salmon in an northern California stream: Accounting for the effects of Passive Integrated Transponder tagging mortality and size-dependent survival. *Transactions of the American Fisheries Society*. 136: 1423-1437.

Counihan, T.D., Hardiman, J.M., Burgess, D.S., Simmons, K.E., Holmberg, G., Rogala, J.A., and Polacek, R.R., 2012 Assessing native and introduced fish predation on migrating juvenile salmon in Priest Rapids and Wanapum Reservoirs, Columbia River, Washington, 2009–11: U.S. Geological Survey Open-File Report 2012-1130, 68 p.

Craig, B.E., C.A. Simenstad and D.L. Bottom. 2014. Rearing in natural and recovering tidal wetlands enhances growth and life history diversity of Columbia Estuary tributary Coho salmon *Oncorhynchus kisutch* population*. Journal of Fish Biology*. 85: 31-51

Jones, K.K., T.J. Cornwell, D.L. Bottom, L.A. Campbell and S. Stein. 2014. The contribution of estuary-resident life history strategies to the return of adult *Oncorhynchus kisutch*. *Journal of Fish Biology*. 84: 52-80.

Lawson, P.W., E.P. Bjorkstedt, M.W. Chilcote, C.W. Huntington, J.S. Mills, K.M.S. Moore, T.E. Nickelson, G.H. Reeves, H.A. Stout, T.C. Wainwright, and L.A. Weitkamp. 2007. Identification of historical populations of Coho salmon (Oncorhynchus kisutch) in the Oregon coast evolutionarily significant unit. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS-NWFSC-79, 129 p.

Lebreton, J.D., J.D. Nichols, R.J. Barker, R. Pradel, and J.A. Spendlow. 2009. Modeling individual animal histories with multistate capture-recapture models. *Advances in Ecological Research*. 41: 87-173.

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.

Nickelson, T.E., J.D. Rodgers, S.L. Johnson and M.F. Solazzi. 1992. Seasonal changes in habitat use by juvenile Coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. *Canadian Journal of Fisheries and Aquatic Sciences*. 49: 790-794.

Nickelson, Thomas, 2012. Futures Analysis for Wetlands Restoration in the Coquille River Basin: How many adult Coho Salmon might we expect to be produced? A Report to the Nature Conservancy. November 2012: 16p.

Nickelson, T.E. and P.W. Lawson. 1998. Population viability of Coho salmon, *Oncorhynchus kisutch*, in Oregon coastal basins: Application of a habitat-based life cycle model. *Canadian Journal of Fisheries and Aquatic Sciences*. 55: 2383-2392.

NOAA 2007. Coquille River Subbasin Plan. Prepared for NOAA Fisheries Service June 2007 by the Coquille Indian Tribe. 2007: 254p.

ODFW. 2007. Oregon Coast Conservation Plan for the State of Oregon. Oregon Department of Fish and Wildlife. Salem, Oregon.

ODFW 2015. Coquille Valley Wildlife Area fish sampling information. Unpublished data documenting fish presence and general abundance. Oregon Department of Fish and Wildlife, Charleston, OR.

ODFW 2010. Unpublished file data documenting green sturgeon (*Acipenser medirostris)* capture from sampling completed in Coos Bay through the early 2000's. Oregon Department of Fish and Wildlife, Charleston, OR.

Poe, T.P., R.S. Shively, and R.A. Tabor. 1994. Ecological consequences of introduced piscivorous fishes in the lower Columbia and Snake rivers, pp. 347–360. *In* D.J. Stouder, K.L. Fresh, and R. Feller (eds.), Theory and Application in Fish Feeding Ecology. The Belle Baruch Library in Marine Science, University of South Carolina, Belle Baruch Press. Columbia.

Ramsay, A.L., Milner, N.J., Hughes, R.J., McCarthy, I.D 2011.Comparison of the performance of scale and otolith microchemistry as fisheries research tools in a small upland catchment. Canadian Journal of Fisheries and Aquatic Sciences, 2011, 68:823-833, 10.1139/f2011-027

Rieman, B.E., R.C. Beamesderfer, S. Vigg, and T.P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 448–458

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. *Canadian Journal of Fisheries and Aquatic Sciences*. 57: 906-914.

Stewart-Oaten, A., W.W. Murdoch and K.R. Parker. 1986. Environmental Impact Assessment: "Pseudoreplication" in Time? *Ecology*. 67:929-940.

Tiffan, K.F., R.W. Perry, W.P. Connor, F.L. Mullins, C. Rabe and D.D. Nelson. 2015. Survival, growth, and tag retention in age-0 Chinook salmon implanted with 8-, 9-, and 12-mm PIT tags. *North American Journal of Fisheries Management*.

USGS Streamstats 2016. Watershed hydrology parameter calculation engine. http://water.usgs.gov/osw/streamstats/oregon.html.

Volk E.C., Bottom D.L., Jones K.K., Simenstad C.A. (2010) Reconstructing juvenile Chinook salmon life history in the Salmon River Estuary, Oregon, using otolith microchemistry and microstructure. Trans Am Fish Soc 139:535–549

Appendix A. Coquille Valley Floodplain Monitoring Budget

Project Title:	**Coquille R. Tidal Flodplain Restoration Effectiveness Monitoring**					
Project Start Date:		**1/1/2017**		**Project End Date: 12/31/2021**		
PERSONAL SERVICES (this information is tabulated in column I)						
Class Title				**Salary**	**OPE %**	**Total Amounts**
NRS-4						$ -
NRS 2				$ 4,791.00	64.70%	$ 86,798.55
						-
EBA				$ 2,188.00	74.00%	$ 95,178.00
EBA				$ 2,188.00	74.00%	$ 95,178.00
EBA				$ 2,188.00	74.00%	$ 95,178.00
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
		Total Personnel Services & Fringe				**$ 372,332.55**
		Personnel Services Subtotal				**$ 216,801.00**
		Fringe Subtotal				**$ 155,531.55**

Appendix A cont.

Services and Supplies description	**Total Amounts**
Supplies (consumable supplies and materisl <$5,000/unit value	
vehicle (5 Mo/yr)	$ 18,750.00
Hoop Traps 4ft diameter (4 x $700=$2800) + 3ft (6 x $650 =$3900); Purse Seine $1,800 (GV and CWC)	$ 8,500.00
minnow traps (100 @ $9 ea)	$ 1,780.00
PIT tags 8 mm (200 @ $2.2 ea)	$ 2,400.00
PIT tags 12 mm (400 @ $1.8 ea)	$ 4,500.00
Pit array setup (4 arrays @~3000 ea)	$ 12,000.00
Pit reader (2 @~600)	$ 1,200.00
misc (boat fuel, maintenance, uniforms etc)	$ 10,000.00
Travel (include number of people, days, airfare and per diem costs):	
Other (e.g. utilities, temp employees; but do not include contingency):	
Service and Supplies Subtotal	**$ 59,130.00**
Personnel Services and Supplies Subtotal:	**$ 431,462.55**
Indirect Costs:	**$ 70,758.88**
Contracted Services/Subgrants/Fish Feed (list individually)	**Total Amounts**
microchemistry analysis	$ 16,000.00
water sample analysis	$ 50,000.00
Contracted Services/Personnel Services Contracts Subtotal	**$ 66,000.00**
Capital Outlay (Equipment >$5,000/unit or public improvement)	**Total Amounts**
Captial Outlay Subtotal:	
Total Project Costs:	**$ 568,221.43**