Item A USGS Agreement #__________

ESRP Agreement #7-1683, Nisqually Indian Tribe

U. S. Department of the Interior

U. S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER
505 Azuar Drive
Vallejo, CA 94592

9 September 2013

Assessing effects of restoration on the Nisqually River Delta: enhancing invertebrate prey to increase capacity for salmon

Statement of Work
1 July 2014 – 30 June 2016

Background and Justification

The River Delta Adaptive Management Strategy (RDAMS) for Puget Sound (Salish Sea Wiki 2013) identifies six Critical Dynamics for adaptive management of delta ecosystems. Our proposal addresses two of these Critical Dynamics: #3) Biodiversity and Food Web Development, and #4) Salmonid Rearing Services. Our learning project will investigate the capacity or spatial and temporal variability of food resources available to salmon and other species within distinct habitats of a large river delta restoration. It follows the RDAMS programmatic elements by providing managers with an assessment method for conducting adaptive management and by completing a study to help focus restoration design on critical habitats within restoration projects that may be otherwise neglected.

The Nisqually River Delta (Fig. 1) represents the single largest estuary restoration project in the Pacific Northwest that increased salt marsh habitat in southern Puget Sound by 50%, restored more than 35 km of tidal sloughs and channels, and re-established tidal flow to 360 ha of historic floodplain and delta. The restoration of this large river delta is expected to result in a substantial improvement in ecological functions and services of southern Puget Sound. Thus, the Estuary and Salmon Restoration Program (ESRP) has identified the Nisqually River Restoration as a Portfolio Project (#07-1680). The ultimate goal of the restoration is to increase the capacity of the estuary to support a diversity of wildlife, waterbirds, and native fish such as the Nisqually Fall Chinook (*Oncorhynchus tshawytscha*), a population listed as threatened under the federal Endangered Species Act (NCRT 2001).

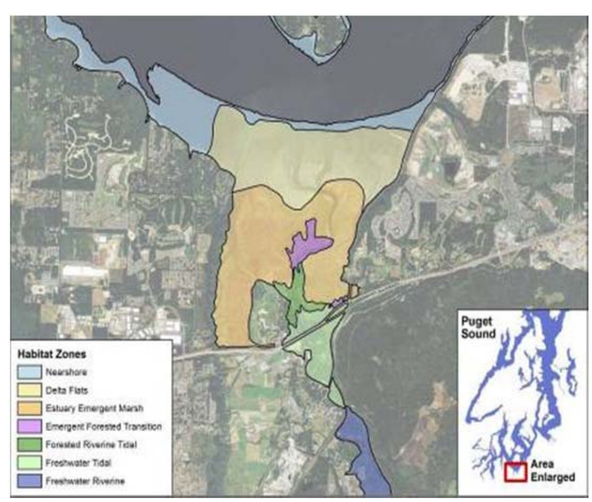

Figure 1. Nisqually River Delta habitat.

Our conceptual model (Fig. 2) was based on the Nisqually River Delta monitoring plan (Ellings 2008) that hypothesized that large river restoration improves growth of salmon smolts through increased opportunity in new delta habitats and enhances capacity with increased availability of invertebrate prey at specific, critical times. The abundance and distribution of the diverse invertebrate communities (terrestrial, aquatic, benthic, epifaunal) used by smolts varies spatially across Delta habitats and seasonally during their outward migration (Mar-Aug), but the capacity of these habitats has not been studied in an integrated manner on the Pacific coast. On the Atlantic coast, availability of invertebrate prey and their consumption by smolts were found to vary by habitat type along a salinity gradient (Meng and Powell 1999), from forested riverine tidal, emergent forested transition, estuary emergent marsh, delta mud flats, and eelgrass beds (*Zostera marina*).

Invertebrate species composition in smolt diets varies greatly during the outmigration as temperatures increase and vegetation structure changes across the Delta. Better understanding of food webs in Delta habitats may allow planners to include specific habitats into restoration designs. Relating invertebrate prey abundance to characteristics of their Delta habitats may better identify limiting factors for their populations and adaptive options for improving them through water management or habitat elements. At the same time, smolts must avoid predation from piscivores (Collis et al. 2002) or compete for the limited resources with large numbers of staging migratory birds in some of these habitats, and identifying the potential for those predator and competitor interactions may help to focus multi-species management efforts.

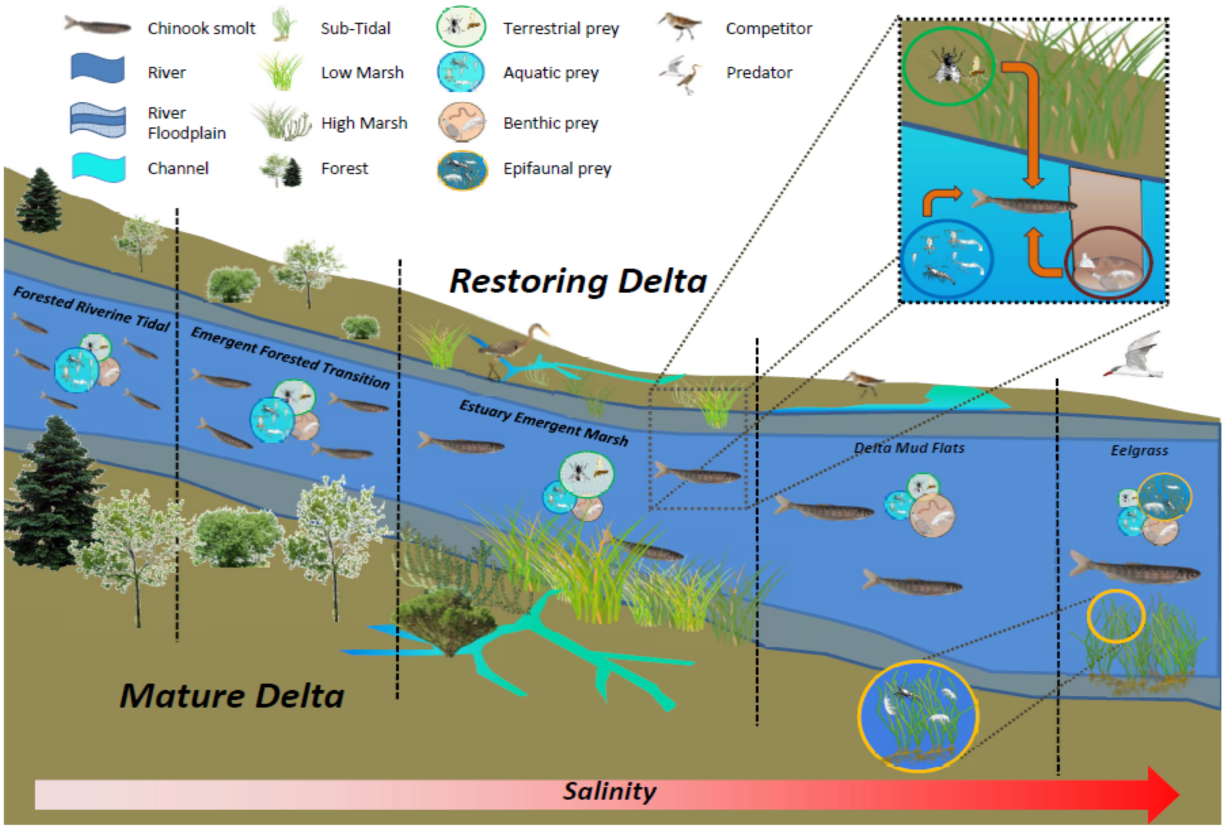

Figure 2. Conceptual model of Chinook salmon smolt outmigration on the Nisqually River Delta and invertebrate prey capacity. Invertebrate prey availability and composition in smolt diets varies between restoring and mature habitats along a salinity gradient.

We propose to build on existing habitat monitoring efforts closely coordinated with fish sampling by the Nisqually Indian Tribe (C. Ellings, pers. comm., Sep. 2013) to add detailed knowledge about spatial and temporal variation in the invertebrate prey communities in the mature and restoring Nisqually River Delta. Our understanding of the variation associated with season will underscore the importance of invertebrate prey availability as smolts grow, and the relationship of those invertebrates with temperature, conductivity, vegetation gradients through the outmigration season (Fig. 3). This learning project will help to identify habitats within the Delta mosaic that most benefit smolts, examine limiting factors for invertebrate prey that may be improved with adaptive management, and determine availability of invertebrates for smolts and competition with other vertebrate species to improve multi-species management.

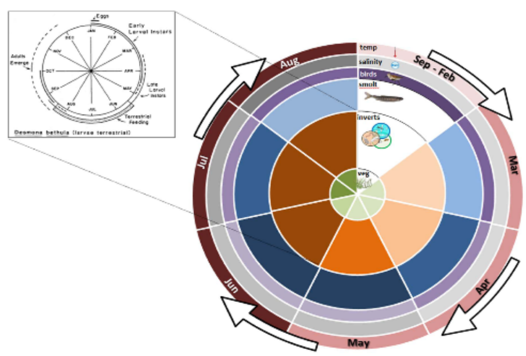

Figure 3. Seasonal changes in availability of invertebrate prey for salmon smolts during the outmigration (Mar-Aug). Darker shading of bands indicate potential increases in: temperature, salinity, avian competitor numbers, smolt size, invertebrate biomass, and vegetation growth.

The RDAMS supports public investment in river delta restoration of lost tidal wetlands (Simenstad et al. 2011, Cereghino et al. 2012, Lyons 2012) through strategic investment in restoration and monitoring. The focus on adaptive management is to integrate science, monitoring, and stepwise learning to help reduce uncertainty, predict future outcomes, and understand the effects of current efforts on ecosystem goods and services. Through focused studies, adaptive management increases our understanding of restoration actions and ecological response promoting science-based management and supporting restoration planning. Restoration monitoring serves as "the financial equivalent of accounting in restoration projects" (Lee 1993) -- it documents performance and determines whether goals were met and whether mid-course corrections are necessary (Williams et al. 2007). It forms the basis from which we develop our understanding of how actions affect complex ecological systems and tests our understanding of ecological theory such as succession and competition (Zedler 2005).

This research is aimed to address a key unknown for the adaptive management of the Nisqually River Delta landscape mosaic. We anticipate that this learning project will identify the relative importance of habitat-specific capacity of the five major habitat types within the Nisqually River Delta. The relative contribution of terrestrial, aquatic, benthic, or epi-benthic derived invertebrates within each habitat type will allow managers to prioritize elements of their restoration and promote focused efforts on enhancing specific habitats and increased connectivity for foraging juvenile Chinook within the context of the landscape mosaic.

Objectives

We follow a three-tiered approach for assessing restoration actions for fish and wildlife. Our studies focus on determining changes in *Opportunity*, *Capacity*, and *Realized Function* of the

Nisqually River Delta Restoration to provide benefits for wildlife (in particular, Chinook smolts but also waterbirds that are predators and competitors; Simenstad and Cordell 2000). *Opportunity* is characterized by the habitat requirements that are conducive for juvenile Chinook to access the physical habitats including total habitat availability, habitat connectivity (tortuosity ratios), and amount of time the habitat mosaic is readily available. *Capacity* describes the ability of a restored area to support wildlife functions such as foraging habitat for juvenile Chinook through measurement of invertebrate prey production and availability. *Realized Function* integrates both *Opportunity* and *Capacity* to quantify how juvenile Chinook are taking advantage of both increased accessibility and food production by increased consumption or growth. *Realized Function* can be evaluated by comparing diet and isotope data, along with micro-otolith structure (led by C. Ellings NIT and K. Larsen and A. Null USGS WFRC). In addition, bioenergetics simulation models of habitat-specific growth potential at NRDR have been developed on the basis of predicted consumption, diet energy density, consumer energy density, consumer weight, and water temperature (David et. al., UW, in prep.). Development and integration of these studies will depend on the invertebrate data obtained in this learning project.

Thus, we propose to integrate the Tribe's ongoing fish sampling (beach seining) with habitat-specific hydrology and invertebrate capacity to determine the relative contribution of the NRDR landscape mosaic for juvenile Chinook. Our specific objectives are to:

1. Examine the opportunity for juvenile Chinook to access habitat mosaics.
2. Characterize the improved capacity offered by newly restored habitats for salmon smolts during the spring (Mar-Aug) with optimized prey sample efficiency.
3. Assess realized function of NRDR habitat types by comparing to Chinook diet with prey availability and isotopes from invertebrate prey guilds.

Sampling Methods and Analyses

Objective 1. Examine the opportunity for juvenile Chinook to access habitat mosaics

Restoration opportunity is characterized by the habitat requirements that are conducive for juvenile Chinook to access the physical habitat including total habitat availability, habitat connectivity (tortuosity ratios), and amount of time the habitat mosaic is readily available. To model habitat connectivity and accessibility, we will integrate existing hydrology and elevation datasets and fill in datagaps. Our team has created an inundation map based on hydrology and LiDAR imagery (Ellings et al., in prep.). For the estuary emergent marsh and mudflat habitat types, we can use existing and ongoing hydrology and RTK-GPS elevation data. No specific continuous water level, temperature, and conductivity data exist for the forested riverine tidal, emergent forest transition, and eelgrass habitat types; thus, we will install and maintain a logger within each habitat type to characterize habitat-specific hydrology patterns. We will use RTK-GPS elevation to fill datagaps in the forested riverine tidal, emergent forest transition, and eelgrass habitat types with a Leica Viva RTK GPS, echosounder, and total station (Takekawa et al. 2010) to help obtain readings where tree canopies might obscure satellite coverage to remote reference stations.

<u>Joint Analytical Product</u>**:** Combining GIS habitat mapping and inundation modeling (Ellings et al., in prep., Takekawa et al. 2013) will provide a measure of habitat accessibility and connectivity for the landscape mosaic. Anticipated outcomes include a comparison of the

accessibility times for juvenile Chinook to use each habitat type during outmigration, a summary comparison of water temperatures for each habitat type during outmigration, and comparisons of connectivity evaluated by tortuosity ratios (T = [total travel distance]/[the linear distance between two points] for juvenile Chinook; as in Moore et al. 2010, Ellings et al., in prep.).

Objective 2. Characterize the enhanced capacity of each habitat type to produce invertebrate prey resources

Chinook salmon are one of the most estuarine dependent salmonids and rapid growth during outmigration is a critical in helping juveniles consume larger prey, reduce predation risk by birds and other fishes, and ultimately increase their ocean survival (Duffy et al. 2010). Furthermore, poor quality foraging areas may result in increased predation risk and reduced residence times (Duffy et al. 2010); thus, we will assess the *Capacity* of each habitat type within the Delta landscape mosaic for invertebrate prey production during outmigration. Specifically, we will measure the composition of terrestrial, aquatic, benthic, and epibenthic food webs across habitat types. The invertebrate sampling will be temporally and spatially coordinated with the Tribe to represent each habitat mosaic and sample the areas where fish are beach seined.

A pre-restoration smolt assessment with an analysis of their invertebrate prey (Ellings and Hodgson 2007) forms the baseline from which to compare post restoration outcomes. The learning study will allow advancements to incorporate habitats and seasons in a recently developed bioenergetics model (A. David, UW, in prep.) and will support explaining changes in realized function contributed by different habitat types (C. Ellings, K. Larson, A. Lind-Null, USGS Western Fisheries Research Center).

Invertebrate sampling: To capture the seasonal variation (Simenstad and Cordell 2000, Gray et al. 2002, Ellings and Hodgson 2007), we will sample bi-monthly during outmigration (Mar-Aug). Invertebrates will be sent to the WERC invertebrate laboratory for identification and enumeration. Specimens will be sieved with a 0.5 mm screen, preserved in a 70% ethanol/rose-bengal solution for later identification, enumeration, and biomass. Subsampling may occur if the resulting error (difference from projected and actual density) is $\leq$ 10%. We will use multivariate analysis of variance (MANOVA) for each habitat type with repeated measures (periods) to examine abundance differences among major prey types between mature and restored areas.

Terrestrial—terrestrial invertebrates will be collected with fall-out traps, 55-cm x 38-cm plastic basins filled with soapy water and attached to PVC poles at the edge of tidal channels (Simenstad et al. 2011, Gray et al. 2002). Three traps will be deployed for a tidal cycle in each habitat (2 ages, 4 habitats, 3 periods, 3-6 reps: n = 72) reported as density per m^2.

Aquatic—aquatic invertebrates will be collected with neuston and nekton net tows. A neuston or nekton net will be pulled along the surface of a channel. During the low tide, when the channel or substrate bottom is exposed, another tow will be conducted to capture mysids and crustaceans (Rozas and Minello 1998). We will collect three samples (2 ages, 5 habitats, 3 periods, 3-6 reps: n = 90) reported as density per Liter.

Benthic-- benthic invertebrates will be sampled with cores (60 cc cylinders at 4 cm depth, subsampled by area; see Woo and Takekawa 2008) will be collected (2 ages, 5 habitat types, 3 periods, 3-6 reps: n = 90) from each habitat type and reported as density per m^2. Subsampling techniques will be optimized for efficiency, depending on the step which is most time intensive, below.

Epibenthic— epibenthic invertebrates will be sampled on eelgrass. Eelgrass forms a unique community providing habitat for smolts (Simenstad 1994), and spawning and nursery habitat for herring. Epifauna are found among the blades and inflorescences. Benthic and epifaunal invertebrates are denser in eelgrass beds than in similar unvegetated substrates (Hemminga and Duarte 2000, Nakaoka et al. 2001) and flowering shoots harbor greater densities than vegetative shoots (Carr et al. 2011). We will sample shoots (1 habitat, 3 periods, 10-20 shoots: n = 30) to measure density, diversity, and biomass of epifaunal invertebrates (Bostrom and Bonsdorff 1997, Carr et al. 2011) reported as number per cm.

Anticipated uncertainties: Because benthic invertebrate processing is time intensive and costly, we will optimize processing strategies where tradeoffs between costs (labor or time), sampling intensity, and error rates (Fig. 3) are calculated through double-sampling protocols prior to sampling reductions. Reductions are most effective when based on known accuracy or precision consequences (Baker and Huggins 2005). Since invertebrates need not always be identified to lowest taxonomic level, we will identify to functional or taxonomic guilds that still allow for diet and bioenergetics analyses. We will explore the tradeoffs in the frequency of gathering monitoring data with discussions of time savings and implications for data analysis. Invertebrates also have strong spatial and seasonal patterns (Franca et al. 2009), which will be addressed by sampling all habitat types within the same month so that habitat-based comparisons can be made.

Joint Analytical Product**:** Results from this objective includes density of prey availability amongst terrestrial, aquatic, benthic, or epibenthic strata for each habitat type. Biomass will be measured or calculated from existing or locally-developed wet to dry weight equations, and prey energetic estimates will be applied from the literature.

Objective 3. Assess realized function of NRDR habitat types by comparing Chinook diet with prey availability and isotopes from invertebrate prey guilds

We hypothesize that available prey will differ between habitat types (Duffy et al. 2010) as salmon smolts outmigrate. We are working closely with the Tribe (C. Ellings, pers. comm., Sep 2013) to integrate findings from Objectives #1 and #2 to identify the *Realized Function* of different habitats to provide food resources for smolts over time. Diet samples (collected by the Tribe) from each habitat type will be sent to the WERC invertebrate laboratory for further processing (stomach wet weight, fullness, prey content, prey biomass). Diet samples will be compared with prey availabilities to compare the relative contribution of terrestrial, aquatic, benthic, or epibenthic to juvenile Chinook diet by habitat type.

We will use multivariate canonical correspondence analyses (ter Brack and Smilauer 1998, Takekawa et al. 2006, in R Statistical Software) and AIC analyses (Burnham and Anderson

1998) to examine the relationship of invertebrate abundance by strata (TER or EEL, AQU, BEN) and season (3 periods) with biophysical parameters (temperature, salinity, sediment texture, vegetation, competitor index). A percent similarity index (PSI) will be used to examine the similarity between the composition of the Chinook diet samples and the composition of the fallout, neuston/nekton, and benthic core samples from each site (Gray et al. 2002). A high PSI value for a given sampling location indicates that the diet composition of the fish is similar to the composition of the sampled invertebrate population. PSI will be calculated with the following formula (Hurlbert 1978; Yoklavich et al. 1991): PSI = $\Sigma \min (p i_{1i,} p_{2i})$, where p_{1i} is the percentage of individuals from a taxonomic grouping in sample 1 and p_{2i} is the percentage of individuals from a taxonomic grouping in sample 2.

Stable isotope analysis, used in conjunction with stomach content analysis, is a valuable tool for examining food web interactions because ratios of naturally occurring isotopes provide information about the longer-term feeding history of the fish and may help to identify recent migrants to an area. A combined approach with diet analysis, stable isotope analysis (C, N, isotopes, analyzed in R statistical software, SI-R package), and bioenergetics modeling will help to identify spatial, and inter-annual shifts in trophic interactions for juvenile salmon as they migrate through the Nisqually Delta.

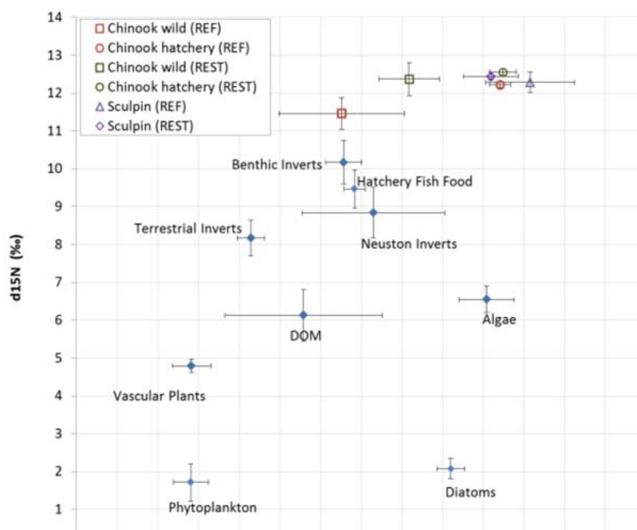

Figure 4. C and N isotope biplot for Chinook (wild and hatchery) within reference (REF) and restored (REST) habitat types. Invertebrate prey were pooled by strata across sites and primary producers were also pooled across sites.

Previously analyzed C and N stable isotope data (Figure 4) indicated that wild and hatchery Chinook from reference sites fed on prey with distinct carbon signatures; however this separation is not as apparent at the restored sites. Our initial results were pooled to obtain sufficient biomass; however, we were able to detect some emerging patterns. The primary producers (vascular plants, phytoplankton, diatoms, and algae) are unlikely significant carbon sources for juvenile Chinook, and these primary producers will not be sampled. By partitioning invertebrate prey resources by habitat type, we hope to reduce the variability within the prey and consumer isotopic signatures.

Isotopes from major taxa within each invertebrate strata will be collected in close coordination and timing with Tribe fish collections. Invertebrate samples will be collected without any use of preservative for isotopic analyses (C^{13}, N^{15}). All samples will be frozen with dry ice and shipped to the WERC invertebrate laboratory where samples will be triple-washed in distilled water, pooled to obtain sufficient biomass, blotted dry and weighed for wet biomass, oven dried to a constant weight, and shipped to a stable isotope facility for analysis.

Joint Analytical Product**:** Data will include: diet comparison by habitat type and between wild and hatchery Chinook (sampled by the Tribe); analysis of percent similarity to compare the similarity between prey availability and prey consumed; and isotopic analysis (R software, Stable Isotope package) to provide a range of estimates of relative contribution of prey types in the diet. These data can provide evidence for the relative contribution of specific habitat types for a large delta restoration and can be integrated with individual growth estimates derived from otolith microstructure (led by C. Ellings of the Tribe; K. Larsen and A. Null, USGS WFRC). Fish otoliths will be collected and stored, and analyses will be funded through other sources (C. Ellings, pers. comm., Sep. 2013). Results will contribute to the understanding of the relative contribution of the mosaic of habitat types available for foraging Chinook smolts. This information can be used for managers in Puget Sound to prioritize further restorations, habitat enhancements, or needs of increased connectivity for targeted habitat types. Joint USGS-Tribe-Refuge products will be developed as an outcome of these collaborative studies.

Timeline and Reporting

We will commence with field and sampling preparations 1 Jan 2014 and collect data for two field seasons (Mar-Aug). Data analyses and reporting will be completed by 30 Sep 2016. Sampling plans will be coordinated with the Tribe for paired invertebrate and fish sampling locations and coordinated logger placement. Maintenance of hydrology data loggers will occur through the course of the project with a goal of continuous logging for at least one year to develop local tidal datums. Email summary updates will be provided electronically annually on 30 Sep 2014 and 30 Sep 2015, and a data summary report will be completed upon completion of the work. Data updates may be provided sooner, as requested.

Anticipated Work Schedule	2014				2015				2016			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1. Examine the *Opportunity* for juvenile Chinook to access habitat mosaics												
1.1: install and maintain water level loggers for each habitat type	X	X	X	X	X	X	X	X				
1.2: Obtain habitat-specific elevations	X	X										
1.3: Model inundation and accessibility times								X				
Objective 2: Characterize the invertebrate *Capacity* during outmigration using invertebrate efficiency measures												
2.1: Collect terrestrial, aquatic, and benthic invertebrates from each habitat type	X	X	X		X	X	X					
2.2: Sieve, sort, and identify invertebrates to major taxonomic groups		X	X	X	X	X	X					
2.3: Obtain biomass and energy content based on existing data or literature of invert taxonomic groups						X	X	X				
Objective 3: Assess *Realized Function* by comparing Chinook diet with prey availability and isotopes												
3.1: Process Chinook gut contents for diet samples		X	X	X	X	X	X	X				
3.2: Collect and send juvenile Chinook and prey samples for C, N, and S isotope analysis during peak outmigration			X				X					
3.3: Data analyses: compare diet with prey availability with Index of Relative Importance				X	X			X				
3.4: Isotope analyses to discern relative contribution of terrestrial, aquatic, and benthic invertebrate prey to juvenile chinook at each habitat type (SI-R Statistical package)				X	X			X				
Reporting								X	X	X		

Principal Investigator

John Y. Takekawa, USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592; john_takekawa@usgs.gov, 707/562-2000.

Co-Investigators

Ashley Smith, USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592; alsmith@usgs.gov, 707/562-3003.
Isa Woo, USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592; iwoo@usgs.gov, 707/562-2001.

Partners

Christopher Ellings, Nisqually Indian Tribe, Natural Resources Department, Salmon Recovery Manager. 12501 Yelm Highway SE, Olympia, Washington 98513; ellings.christopher@nisqually-nsn.gov, 360-438-8687 ext. 1270.
Glynnis Nakai, USFWS, Nisqually National Wildlife Refuge Manager, 100 Brown Farm Road, Olympia, WA 98516; glynnis_nakai@fws.gov, 360-753-9467

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Table 1. Restoration Monitoring Matrix by monitoring group and partner role over time at the Nisqually River Delta Restorations.

Restoration Monitoring on Nisqually Delta	Pre-Restoration		Post restoration					
		2009	2010	2011	2012	2013	2014	2015
Aerial Photography/Remote Sensing		X	X	X	X			
Aerial Photograph: Nisqually Delta	WERC, NNWR	X	X	X	X	no		
Photodocumentation: NNWR	NNWR, NIT	X	X	X	X	X		
Channel digitizing	WERC, NIT	historic		X				
Habitat classification types	WERC, NNWR, NIT	X	X					
Hydrology and Water Quality								
Tidal inundation: water level, temp, conductivity loggers	WERC	X	X	X	X	X	ESRP	ESRP
Geomorphology and Sedimentation								
Channel cross sections:	NIT, WERC	X	X	X	X	X		
Sedimentation: (Sediment pins, SET, marker horizons)	WERC, NNWR, NIT	X	X	X	X	X	WERC	WERC
RTK GPS for each habitat type	WERC, NNWR, NIT						ESRP	
Terrestrial LiDAR	CMG, NNWR, NIT			X				
Vegetation								
Vegetation transect, circular plot surveys	NNWR, WERC, NIT	X	X	X	X	X		
Veg+RTK GPS point intercept survey	WERC, NNWR, NIT				X			
Invertebrates								
Invertebrate across Delta: onshore to offshore gradient	WERC, WFRC, CMG, NIT, NNWR	X	X	X	X	no		
Invertebrates associated with fish diets (see below)	NIT, WERC	Tribe	X	X	X	no	ESRP	ESRP
Fish								
Fish Fyke trapping: abundance in Nisqually Delta restored, restoring, and reference marshes	NIT, WERC, CMG, WFRC		X	X	X	no	no	no
Fish Beach Seining: multiple habitat types	NIT	X	X	X	X		Tribe	Tribe
Hydrodynamics affecting sediment transport/fluvial sediment inputs from Nisqually River	NNWR, Batelle, CMG-CHiPS, NIT		X	X	X			
Delft 3D modeling sediment transport	CMG, CHiPS, NIT				X	X		
Assessing Chinook response to restoration with otoliths	WFRC, NIT		X	X	X		Other	Other
Invertebrate prey availability: terrestrial, aquatic, and benthic	WERC, NIT		X	X	X		ESRP	ESRP
Chinook diet samples	NIT, WERC, UW		X	X	X		ESRP	ESRP
Foodweb isotopes	WERC, NIT				X		ESRP	ESRP
Bioenergetics modeling	NIT, UW, WERC				X	X		
Birds								
Midwinter waterfowl (aerial surveys), waterbird, and landbird survey datasets	NNWR (1975-)	X	X		X		NNWR	NNWR
Annual delta-wide boat bird survey, winter	WERC, NNWR	X	X	X	X	X	WERC	WERC
Monthly-bimonthly bird surveys	WERC, NNWR, NIT		X	X	X	X	WERC	
Archived bird data analysis: restoration effects on waterbirds	WERC, NNWR				data entered		WERC, NNWR	
Avian habitat use in relation to available invertebrate prey						WERC		

NNWR: Nisqually National Wildlife Refuge; **NIT**: Nisqually Indian Tribe; **WERC**: USGS Western Ecological Research Center; **CMG-ChiPS**: USGS Coastal Marine Geology/Coastal Habitats in Puget Sound; **WFRC**: USGS Western Fisheries Research Center

Table 2. Budget estimate

Category	Obj. 1 Opportunity: Characterize habitat mosaic	USGS Contributed	Obj. 2 Capacity: Prey availability optimized sampling	USGS Contributed	Obj. 3 Chinook Realized function: diet, Isotope	USGS Contributed	Total	Total USGS Contributed
SALARY[1]								
Principal Investigator	-	*5,364*	-	5,364	5,364	*10,728*	**5,364**	***21,457***
Program Biologist	6,464	*12,929*	6,464	12,929	19,393	*12,929*	**32,322**	***38,786***
Restoration Biologist	31,373	-	23,007	-	34,929	-	**89,309**	**-**
Invert.Biologist	-	-	26,770	-	19,046	-	**45,816**	**-**
Invert technician	-	-	44,488	-	10,880	-	**55,368**	**-**
Field technician	29,212	-	22,471	-	-	-	**51,683**	**-**
Fisheries technician[2]	46,146	-	-	-	-	-	**46,146**	**-**
OPERATING COSTS[3]								
Level, Temperature, Conductivity meters	3,750	*5,500*	-	-	-	-	**3,750**	***5,500***
Isotope CNS ($20/sample, 1350 samples)	-	-	-	-	27,000	-	**27,000**	**-**
Lab supplies (ethanol, jars,	-	-	680	-	385	-	**1,065**	**-**
Field supplies (tablet, trap gear)	635	-	-	-	-	-	**635**	**-**
TOTAL COSTS	117,581	*23,793*	123,880	*18,293*	116,997	*23,657*	**358,458**	***65,743***

[1] Salary and Operating costs fully-loaded rate includes benefits and admin costs, partially offset by USGS Western Ecological Research Center. For personnel see Budget Narrative.

[2] Fisheries technician to assist Tribe fish sampling through Nisqually River Foundation

[3] Supplies and Equipment offset by USGS Wetland Restoration Program includes unfunded labor assessment, boat, vehicle, benthic sampling gear, microscopes, drying oven, dessicator, computers, computer software and expertise, database management.

Budget Narrative

The multiagency, restoration partnership at the Nisqually River Delta includes monitoring and applied research matching resources from the Tribe, Refuge, USGS Western Ecological Research Center, USGS Coastal and Marine Geology, USGS Western Fisheries Research Center (Table 1), US Fish and Wildlife Service Region 1 Inventory & Monitoring Programs, USGS Patuxent Wildlife Research Center, USGS Native American SISNAR program (Students Interns in Support of Native American Relations), USGS National Association of Geoscience Teachers internship program. We have also partnered with numerous local universities, colleges, and non-profits including: The Evergreen State College, San Francisco State University, and Solano Community College), the Nisqually Reach Nature Center, and the Nisqually River Foundation.

We are requesting $358,458 to fulfill the objectives of assessing the timing and spatial variability of the increased *Opportunity, Capacity*, and *Realized Function* of invertebrate prey in the habitat mosaics that comprise the Nisqually River Delta Restoration. ESRP support for these objectives is essential at this time because it would represent an early-phase evaluation of the restoration for improved capacity to produce a variety of invertebrate prey resources. Matching and leveraging funds support the monitoring and assessment program.

The Refuge provided the initial support for WERC to develop a monitoring plan based on an existing Monitoring Framework (Ellings 2008) and conduct post-restoration monitoring. WERC enlisted USGS Coastal Marine Geology to assess estuary and nearshore changes. The Tribe led multi-agency collaborative research through an EPA Tribal Assistance Grant ($600K in 2011). The Tribe contributed $12K for invertebrate analyses. Funds from the USFWS Inventory and Monitoring Program for the response of waterbirds to tidal marsh restoration and from USGS-USFWS Science Support Partnership for benthic invertebrate processing of fish fyke trapping locations have helped maintained the monitoring program ($30K, $30K respectively).

The Refuge, DU, and the Nisqually River Foundation provide support of a field technician for monitoring, valued at $45K. WERC received internship support from the USGS National Assoc. of Geoscience Teachers internship program ($5K), and the USGS Youth intership ($4K), with additional support through an unpaid internship through The Evergreen State College). Invertebrate sampling will be closely coordinated with the Tribe, who is leading beach seining within the proposed habitat mosaics. These complimentary studies well-coordinated and leveraged to obtain the greatest output amongst the partners in the Nisqually River Delta.

Objective 1: Examine the opportunity for juvenile Chinook to access habitat mosaics (forested riverine tidal, emergent forest transition, estuary emergent marsh, mud flat, eelgrass). To achieve this objective, we will require a Principal Investigator Program lead (Takekawa), Program Biologists (Woo, Smith), a Restoration Biologist, and a field technician. Cost estimates for the work are based on four years of on the ground monitoring experience and RTK-GPS experience on numerous sites. Additionally, salary estimates include a fisheries technician (Duval), to conduct Tribe fish surveys.
Personnel and Fringe Benefits: Project PI (base salary $103.44/hr + 29.6% benefit rate = $134.10/hr, 0 hrs; 40 hrs contributed) is needed for project direction and consult. Program Manager/Biologist (base salary $62.32/hr + 29% benefit rate = $80.80/hr, 80 hrs; 240 hrs

contributed) is needed for project management, coordination, troubleshooting, data analyses, and dissemination of findings. Restoration Field Biologist (base salary $41.51/hr + 26% benefit rate = $52.29/hr, 600 hrs; 0 hrs contributed) is needed to install water level, temperature, and conductivity loggers and conduct RTK-GPS surveys at each habitat type, based on site knowledge. A field technician (base salary $25.31/hr + 11% benefit rate = $28.09/hr, 1040 hrs; 0 hrs contributed) is needed to assist with water level logger installation and maintenance and RTK-GPS surveys, and data entry. The fisheries technician (Duval) will assist the Tribe with fish sampling (Nisqually River Foundation: salary $33/hr, 1400 hrs)
Travel: none
Equipment: Hobo water level logger $550/unit and temperature and conductivity loggers (Odyssey loggers $200/unit) for $750/unit, 5 habitat types=$3,750.
Supplies: Field supplies are estimated at $635 for trapping and invertebrate collection gear
Contractual: Nisqually River Foundation salary for Fisheries Technician, $46,146
Land: n/a
Other: none
Indirect: n/a

Objective 2. Characterize the improved capacity offered by newly restored habitats for salmon smolts during the spring (Mar-Aug) with optimized prey sample efficiency. Cost estimates for the work are based on four years of previous field sampling and travel times, as well as invertebrate laboratory processing (with optimized processing techniques). Project PI (base salary $103.44/hr + 29% benefit rate = $134.14/hr, 0 hrs; 40 hrs contributed) is needed for project direction and consult. Program Biologists (base salary $62.32/hr + 29% benefit rate = $80.80/hr, 80 hrs; 240 hrs contributed) needed for project management, coordination, troubleshooting, data analyses, reporting, and dissemination of findings. Restoration Field Biologist (base salary $41.51/hr + 26% benefit rate = $52.29/hr, 440 hrs; 0 hrs contributed) is needed to implement the sampling design, conduct invertebrate field collection at all habitat types, direct field crew, basic data summaries. An Invertebrate Biologist (base salary $37.98/hr + 39% benefit rate = $52.91/hr, 506 hrs; 120 hrs contributed) is needed for invertebrate processing (sorting, identification to broad taxa, QA/QC of samples, coordination of sample chain of custody procedures) within different habitat types, and training a summer invertebrate intern. We will employ established subsampling techniques to increase processing efficiency and use paid interns to help with additional sorting to broad taxonomic groupings or sieving. A full-time, seasonal field technician (base salary $25.31/hr + 11% benefit rate = $28.09/hr, 800 hrs; 0 hrs contributed) is needed to carry out field work of monthly invertebrate prey collection at all habitat types, invertebrate sieving, and data entry. An invertebrate technician is needed to assist in invertebrate sorting to broad taxa, weighing samples for biomass, and data entry (base salary $27.47/hr + 11% benefit rate = $30.22/hr, 1242 hrs; 0 hrs contributed).
Travel:
Equipment: none
Supplies: lab supplies (ethanol, sealed jars, vials) $680
Contractual: none
Land: n/a
Other: none
Indirect: n/a

Objective 3. Assess realized function of NRDR habitat types by comparing to Chinook diet with prey availability and isotopes from invertebrate prey guilds. Cost estimates for this objective are based on previous GIS work estimates for similar models of avian foraging carrying capacity studies; field sampling and travel times; and invertebrate laboratory processing with optimized processing techniques. Project PI (base salary $103.44/hr + 29% benefit rate = $134.10/hr, 40 hrs; 80 hrs contributed) is needed for analytical direction and consult. Program Biologist time (base salary $62.32/hr + 29% benefit rate = $80.80/hr, 240 hrs; 360 hrs contributed) is needed for coordination, data analyses, and dissemination of findings. Restoration Field Biologist (base salary $41.51/hr + 26% benefit rate = $52.29/hr, 668 hrs; 0 hrs contributed) is needed to gathering prey samples for isotopic analyses, data summaries and draft reporting. An invertebrate biologist (base salary $37.98/hr + 39% benefit rate = $52.91/hr, 360 hrs; 0hrs contributed) is needed for diet and prey processing for isotopes (triple wash, sorting, pooling samples) and weighing for biomass.
Travel: none
Equipment: none
Supplies: Isotope sampling supplies: dry ice, whirl packs, coolers $385.
Contractual: Lab analyses include estimated an isotope analysis subcontract ($20/sample for C,N isotopes and grinding/packing tin fee, 1,350 samples includes 5 fish, 3 benthic, 3 neuston, 3 terrestrial for each 5 habitat types, over 2 years = $27,000).
Land: n/a
Other: none
Indirect: n/a