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Bandon Marsh National Wildlife Refuge Restoration Monitoring

Final Report

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U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office
Vancouver, WA 98683

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On the cover: *The Bandon Marsh National Wildlife Refuge Ni-les'tun Unit is the site of the largest tidal marsh restoration project in Oregon to date. It restored more than 400 acres of tidal wetlands and created over 5 miles of tidal channels. Photograph by Amy Horstman 2013.*

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BANDON MARSH NATIONAL WILDLIFE REFUGE RESTORATION MONITORING 2013 FINAL REPORT

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Abstract

Bandon Marsh National Wildlife Refuge (BMNWR) completed construction of a large-scale tidal marsh restoration project on the Ni-les'tun Unit within the Coquille River estuary in 2011. This monitoring project is focused on changes in the aquatic species community before and after the restoration construction. Stream sections were sampled on Fahys Creek and Redd Creek within the restoration site, reference areas in the Bandon Marsh Unit, and along the Coquille River. Fish were sampled by double hoop net, seine, and backpack electrofisher from 2007 to 2013. Invertebrates were collected and archived from the restoration area and reference area before and after construction. Biodiversity was assessed by community, species richness, distribution, relative abundance, and frequency of occurrence. The project positively benefits salmonids and juvenile estuarine fish by creating habitat and increasing access to the refuge. The overall assemblage of the fish community was not substantially different after construction; however, the number of estuarine species increased by 80% (4/5). Change in the Simpson Diversity Index differed by site, sample method, and season. Tidally influenced areas saw a decrease in richness where upper stream areas saw an increase. Salmonids were found in all areas of the refuge. Chinook (age-0), coho (age-1), and an increased number of sea-run coastal cutthroat trout were found primarily in tidally influenced areas. Newly constructed channels were occupied and used seasonally. Species found in these new channels include salmonids, introduced species, and estuarine species. Three spine stickleback and species of sculpin dominated the restoration area and reference area in abundance and capture frequency. Among salmonids, coastal cutthroat trout and coho had the highest frequency of occurrence and relative abundance before and after construction. After construction, estuarine fish increased in both abundance and frequency. Changes are likely due to improved access and changing habitat created by the reintroduced tidal regime. Future assessment of the Ni-les'tun Unit would continue to focus on changes in the aquatic species community over time for further evaluation of the success of the restoration.

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Introduction

The loss of tidal wetlands, primarily through dike construction and draining, has been identified as a major factor contributing to the decline of fish populations and overall productivity of estuaries (Simenstad 1996; Myers et al. 1998; Bottom et al. 2004). The U.S. Fish and Wildlife Service is conducting a large-scale tidal marsh restoration project on the Ni-les'tun Unit of the Bandon Marsh National Wildlife Refuge (BMNWR), within the Coquille River estuary. This project was designed to restore approximately 418 acres of important tidal wetlands. Restoration construction for Oregon's largest tidal marsh restoration in history was completed in fall 2011 (USFWS and FHA 2009).

Construction actions included dike and tide gate removals, culvert replacements, and channel and wetland construction. Utility and infrastructure portions of the construction included undergrounding of a power line that crossed the Ni-les'tun Unit and raising a county road (North Bank Lane) that would have been affected by the restoration. Phase one of the construction began in 2009, phase two was implemented in 2010, and the final phase completed in 2011. The complete construction and associated tasks had an estimated budget of over $9.5 million, and included more than 35 partners over a ten-year period. Similar construction efforts occurred in 2007 within the Nestucca Bay NWR where 1.13 km of dike along the Little Nestucca River was removed and 1.21 linear km of historic tidal channels were restored (USFWS unpublished data, Little Nestucca River Restoration, NFWF Project #2006-0175-003).

The short-term goals of the restoration project are to restore tidal wetlands by allowing unrestricted tidal inundation and improving fish access to the Ni-les'tun Unit (USFWS 2013, USFWS and FHA 2009). The long-term goals are to improve overall quantity and quality of tidal wetlands and estuarine conditions in the lower Coquille River watershed, which provide foraging and rearing habitats for a variety of aquatic species, including native trout and other salmonids (USFWS and FHA 2009). Since greater than 97% of the tidal marshes and swamps in the Coquille River estuary was estimated to have been lost between 1870-1970 (i.e., 13,970 of 14,350 acres), the project has provided a substantial contribution to habitat in the basin (Coquille Watershed Association 2003).

The Ni-les'tun Unit consists of floodplain lowlands encompassing portions of three drainages, Fahys, Overlook, and Redd creeks. Prior to the restoration, about 25 km of drainage ditches constructed by past landowners replaced the natural tidal channel system, and over 2.5 km of dikes and three tide gates impeded connectivity of the Ni-les'tun Unit with the estuary (USFWS and FHA 2009). Construction involved filling the large drainage ditches, disrupting small ditches, lowering much of the dikes, removing tide gates, improving culverts, and excavating five miles of tidal channels to facilitate natural tidal exchange and restore function for fish and wildlife. This monitoring project was focused on documenting the changes in the aquatic species community before and after the restoration construction occurring in 2010 and 2011. For the purposes of this report, construction is referred to as a specific action being implemented to achieve restoration of the tidal marsh. Objectives of the monitoring project are as follows:

1. Describe and compare the fish species communities within and among restoration areas and the reference area before and after construction.
2. Describe and compare the fish species' distributions within and among the restoration areas and the reference area before and after construction.
3. Describe and compare fish species' relative abundances within and among the restoration areas and the reference area before and after construction.
4. Collect aquatic invertebrates to archive from restoration areas and the reference area before and after construction.

Relationship to the Fisheries Program Strategic Plan

Implementation of this project demonstrates application of the Pacific Region's 2009-2013 Fisheries Program Strategic Plan. The following National goals (NG) and Regional objectives (RO) have been addressed by this project:

NG1 Open, interactive communication between the Fisheries Program and its partners.

RO1.1 Develop and maintain relationships with partners throughout the Pacific Region.

RO1.3 Improve data collection and management and internal and external reporting to reduce redundancy and improve access and usefulness for ourselves and our partners.

NG2 America's streams, lakes, estuaries, and wetlands are functional ecosystems that support self-sustaining communities of fish and other aquatic resources.

RO2.1 Facilitate management of aquatic habitats on national and regional scales by working with Tribes, States, partners and other stakeholders.

RO2.2 Develop and expand the use of its expertise to help avoid, minimize or mitigate impacts of habitat alteration on aquatic species and monitor and evaluate completed projects.

RO2.3. Coordinate with Service NWRs and NFHs to identify and implement opportunities for increasing the quantity and improving the quality of aquatic and riparian habitat.

NG3 Self-sustaining populations of native fish and other aquatic resources that maintain species diversity, provide recreational opportunities for the American public, and meet the needs of tribal communities.

RO3.2 Maintain healthy, diverse, self-sustaining populations of fish and other aquatic resources

RO3.3 Support the research and fish culture needed to prevent listing or to recover native species listed or proposed for listing under ESA.

NG9 Science developed and used by Service employees for aquatic resource restoration and management is state-of-the-art, scientifically sound and legally defensible, and technological advances in fisheries science developed by Service employees are available to partners.

RO9.1. Develop and share state-of-the-art, scientifically sound, legally defensible scientific and technological tools, including databases, with other Service programs and in conjunction with our partners.

RO9.2 Use state-of-the-art, scientifically sound, legally defensible scientific and technological tools in formulating and executing fishery-related plans and policies.

Study Area

The BMNWR is part of the Oregon Coast National Wildlife Refuge Complex and protects 889 acres (3.60 km^2) in two units: Bandon Marsh and Ni-les'tun. Located to the north and near the mouth of the Coquille River, the Ni-Les'tun Unit consists of 582 acres (2.36 km^2) of intertidal and freshwater marsh (Figure 1). The majority of the Ni-les'tun Unit lies within the 100-year floodplain (FEMA 2009). The primary streams that run through the Ni-les'tun Unit to the Coquille River are Fahys Creek at Coquille River kilometer (rkm) 5, No Name Creek (rkm 7), and Redd Creek (rkm 8). All three of these creeks were opened to tidal exchange during the construction.

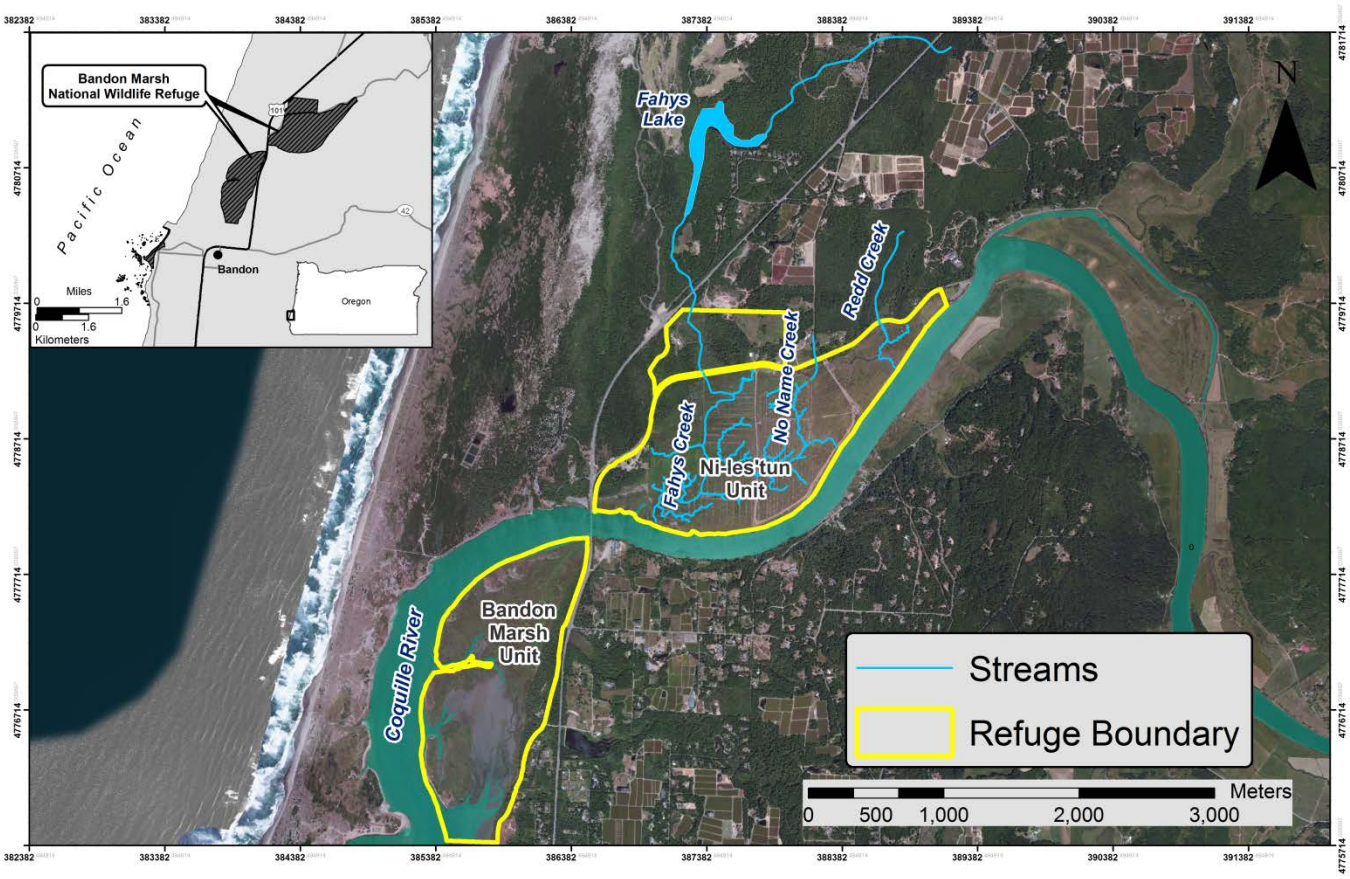


Figure 1. Bandon Marsh National Wildlife Refuge area of study

Methods

Site Selection

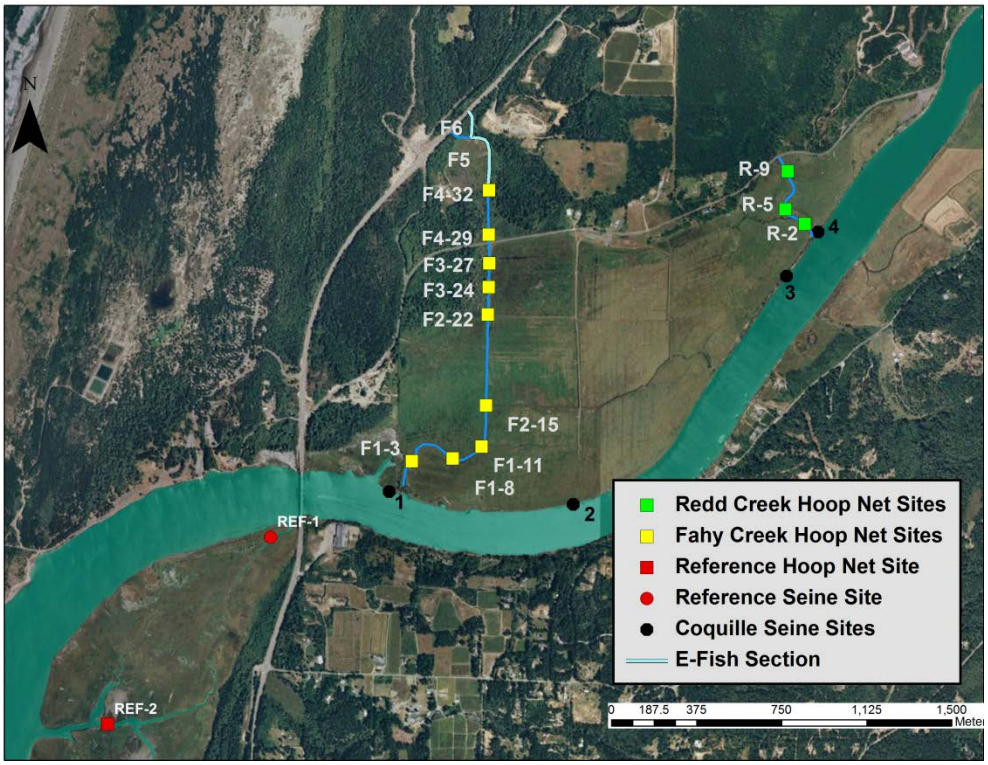
Fahys Creek

Stream sections within Fahys Creek were determined based on habitat characteristics before construction began (Hudson et al. 2010). All sections within Fahys Creek are located within the previously diked areas of Ni-les'tun and have been impacted by past agricultural and forestry practices (Figure 2). Section 1 begins on the north side of the former Fahys Creek tide gate and is 700 m of meandering channel with grasslands on both banks. Section 2 (400 m) is a previously channelized section of Fahys Creek with grasslands on both banks. Section 3 (300 m) was channelized with beaver dams, forested wetlands on the west bank of the creek, grasslands on the east bank of the creek and ends on the south side of North Bank Lane where tidal influence ends. Section 4 (250 m) was once a channelized section that is currently a braided channel completely within forested wetlands located on the north side of North Bank Lane. Stratified random sample sites (n=9), each representing 50 m reaches, were identified across the four lower sections (Figure 2). Four sites (F2-15, F3-24, F3-27, and F4-29) were repositioned to accommodate the restored channel. For example, F4-29 was moved below the North Bank Lane culvert when a rock-lined slope was built upstream to transition the channel gradient.

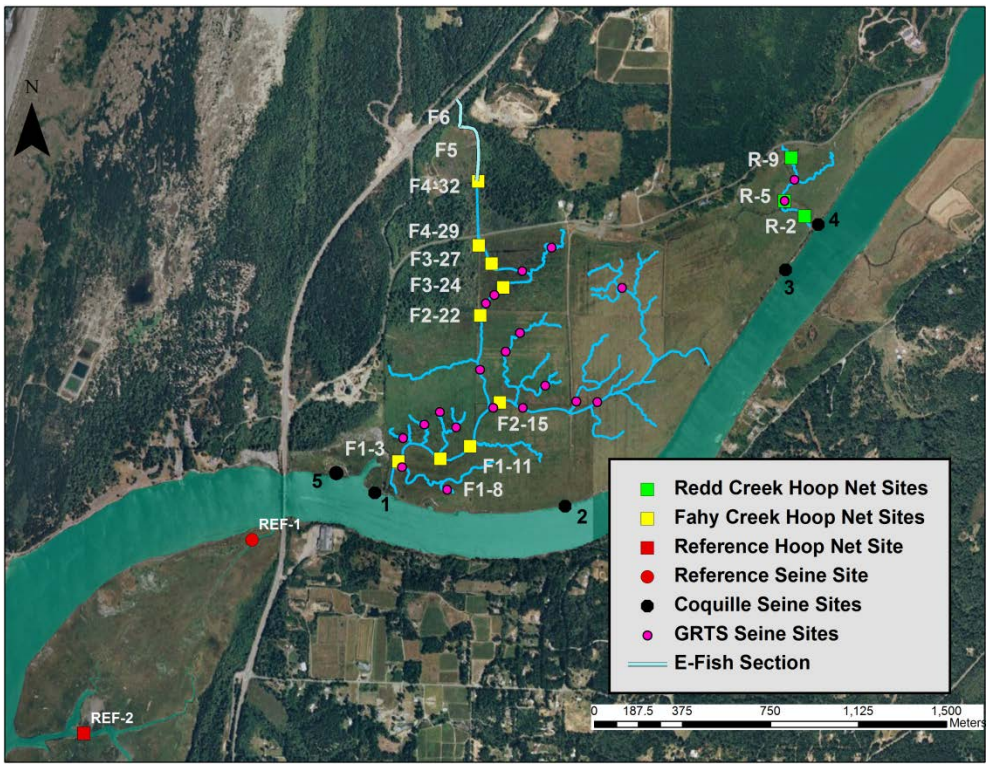
Section 5 (250 m) was historically a forested wetland that was channeled and diked around an abandoned cranberry bog and contained a number of beaver dams before construction. After construction, the section was returned to a meandering stream. The east bank is forested wetlands that transition into lowland forest. Section 6 (150 m) is upstream from the former cranberry bog and below Highway 101. Both banks in Section 6 are lowland forest. Section 7 (600 m) is above Highway 101 and below Fahys Lake. Both banks in Section 7 are lowland forest transitioning to upland forest.

Redd Creek

Redd Creek sampling occurred between the tide gate/mouth and the culvert south of North Bank Lane (Figure 2). A single section 400 m in length comprised the study area. The section meandered for the bottom 300 m and was channelized for the upper 100 m. Grasslands dominated both banks for the entire section, with trees and shrubs lining the channelized portion. Stratified random sample sites (n=3), each representing 50 m reaches, were identified. Site R-9 was moved directly to the east to accommodate the new channel (Figure 2).



a)



b)

Figure 2. Bandon National Wildlife Refuge hoop net, seine, and electrofishing sample sites a) pre-construction, b) post-construction. Tide gates were located at the outlets of Fahys (western drainage) and Redd (eastern drainage) creeks.

GRTS Sites

To analyze the fish community in newly restored channels throughout the Ni-les'tun Unit, sample sites were determined using a random, spatially-balanced design (Generalized Random-Tessellation Stratified, GRTS, design; Stevens and Olsen 2004). This design identified random, spatially-balanced sample sites (n = 50), each representing 50 m reaches in all channels of the Ni-les'tun Unit. The first eight viable reaches were sampled; sites were eliminated if dewatered or too deep to wade at the time of sampling. Eight reaches were identified for sampling each trip to provide a well-distributed sample throughout the study area while accounting for logistical challenges of completing the sampling. To account for seasonal variation within and among sites while maintaining the spatially-balanced design, four reaches from the previous trip and the next four ordered reaches were sampled on each subsequent trip. High water events in fall 2011, spring 2012, and winter 2012 prevented access to sample sites. Beginning in fall 2011, 26 different reaches were sampled over the 12 trips conducted (Table 1).

Table 1. GRTS reaches sampled post construction

Year	Season	Restoration Phase	Ordered GRTS Sites Sampled
2011	Fall	Post	2, 8, 9, 10, 11, 12, 18, 38
2012	Winter	Post	8, 9, 10, 11, 12, 13, 14, 15
2012	Spring	Post	13, 15, 16, 18
2012	Spring	Post	13, 15, 16, 18, 19, 20, 21, 22
2012	Summer	Post	18, 19, 20, 21, 22, 24, 25, 28
2012	Fall	Post	2, 3, 6, 7, 22, 24, 25, 28
2012	Winter	Post	38
2013	Winter	Post	2, 3, 6, 7, 8, 9, 10 11
2013	Spring	Post	8, 9, 10 11, 12, 13, 14, 15
2013	Spring	Post	12, 13, 14, 15, 16, 17, 18, 19
2013	Summer	Post	16, 17, 18, 19, 20, 21, 22, 23
2013	Fall	Post	20, 21, 22, 24, 25, 26, 27, 28

Reference Area

Bandon Marsh Unit

Two reference areas were sampled in the Bandon Marsh Unit, a separate, non-diked tidal marsh with functioning natural channels on the west side of the refuge. Two random sample sites, representing 50 m reaches, were identified in the reference area. Reference-1 (REF-1) is located west of Hwy 101 south of the Coquille River, and Reference-2 (REF-2) is located southwest of REF-1 (Figure 2).

Coquille River

To gather information on fish community in the Coquille River, five beach seine sites were sampled on the mainstem, adjacent to BMNWR (Figure 2). Five sample sites were chosen on the north bank of the Coquille River (Hudson et al. 2010). Site 5 was added in fall 2011 to accommodate the restored mouth of Fahys Creek.

Fish Sampling

Fahys Creek

Double Hoop Netting

For Sections 1-4, we used a system of double hoop (DH) nets to provide the ability to block a channel during a sampling period (Figure 3). Each hoop net had two wings that extended from both sides of the open end. Each wing had floats on the top half and lead weighted rope along the bottom. The cod ends of the two nets were attached and the four wings were staked out to the width of the channels. This technique was determined to be the most appropriate approach for collecting a representative fish sample after testing a variety of approaches and designs while working at the Nestucca Bay NWR (USFWS unpublished data, Little Nestucca River Restoration, NFWF Project #2006-0175-003).

Net sizes deployed at each site were selected to be appropriate for the channel size and water depth at the site. Net sizes used were as follows: 0.76 m diameter, with 4 hoops, and wing size 0.61 m x 1.83 m; 0.91 m diameter, with 5 hoops, and wing size 0.91 m x 3.05 m; and 1.22 m diameter, with 7 hoops, and wing size 1.22 m x 4.57 m. All nets were 6.35 mm mesh.

Fishing occurred overnight for over 21 hours on average, resulting in sampling nearly two tidal cycles. By blocking channels in both directions, fish could be captured on both incoming and outgoing tides or by upstream and downstream movements. Nets were pulled in the order by which they were set to allow for similar fishing effort (i.e., hours fished). The time of deployment and removal of the nets were recorded as well as the size of the net used. Water temperature, conductivity, and salinity measurements were taken at each site. Each individual net was named by site number and location relative to its partner net, such as the North and South net.

Pre-construction sampling occurred once a season from fall 2007 through fall 2008 and twice a season from winter 2008 through winter 2010. Post-construction sampling occurred at least once a season from fall 2011 through fall 2013 (Table 2).

Each net was emptied into an aerated 5-gallon bucket where fish were visually identified and measured for fork length (mm). Weight (g) was collected on all salmonid species. Measurements were taken from the first 20 individuals of each species netted out of the bucket. If more than 20 individuals were present, a plus count enumerated the additional fish of each species. All fish were released at the capture site immediately following workup.

Figure 3. Example of double hoop net approach

Table 2. Pre and Post construction sample dates

Year	Construction Phase	Season	Date
2007	Pre-Construction	Fall	November 13-15
2008	Pre-Construction	Winter	January 28-30
	Pre-Construction	Spring	April 14-16
	Pre-Construction	Summer	May 27-28
	Pre-Construction	Fall	November 17-19
2009	Pre-Construction	Winter	January 26-28
	Pre-Construction	Winter	March 16-17
	Pre-Construction	Spring	April 27-30
	Pre-Construction	Spring	June 1-2
	Pre-Construction	Summer	July 27-28
	Pre-Construction	Summer	September 1-2
	Pre-Construction	Fall	October 26-28
	Pre-Construction	Fall	December 14-16
2010	Pre-Construction	Winter	January 19-21
	Pre-Construction	Winter	March 8-9
2011	Post-Construction	Fall	December 5-8
2012	Post-Construction	Winter	January 30-February 2
	Post-Construction	Spring	April 9-12
	Post-Construction	Spring	May 29-31
	Post-Construction	Summer	July 9-11
	Post-Construction	Fall	September 10-13
	Post-Construction	Winter	December 3
2013	Post-Construction	Winter	February 4-7
	Post-Construction	Spring	April 1-4
	Post Restoration	Spring	June 10-12
	Post-Construction	Summer	August 5-8
	Post-Construction	Fall	September 23-27

Electrofishing

Electrofishing (EFish) was conducted in sections F5 and F6 of Fahys Creek. Electrofishing was completed with a Smith Root LR-24 electrofisher and conducted moving upstream with two netters working with one electrofisher. Electrofisher settings, determined for the environmental conditions (i.e., depth, conductivity, temperature), were 24 Hz, 15 % Duty Cycle, and 350 Volts. Electrofishing was completed once in the fall and once in the spring of each year. Data collected from captured fish followed methods as described for fish captured in double hoop netting.

Redd Creek

Double hoop nets were used in Redd Creek, as described for Fahys Creek. Sampling occurred on the same schedule as Fahys Creek beginning in fall 2008. Data was collected from captured fish as previously described in Fahys Creek.

GRTS Sites

GRTS Seining

To prevent fish stranding due to the tidal and ephemeral nature of the newly functioning channels, we seined using a 0.06 cm mesh, 5 m bagged seine (as opposed to hoop nets). A block net was set 25 m upstream of each site. The seine was pulled upstream to the block net where all fish collected in the bag were documented as described in Fahys Creek. Sampling began after construction and occurred on the same schedule as Fahys Creek. Sites inundated during high water events were inaccessible and not sampled.

Reference Area

Bandon Marsh Unit

The same double hoop net methodology described for Fahys Creek was used for the Bandon Marsh Unit. Fish were sampled as described in Fahys Creek. Hoop net sampling took place at REF-1 and REF-2 on the same schedule as Fahys Creek with REF-1 beginning in fall 2008 and REF-2 beginning in summer 2009.

Seining

To reduce potential mortality during low tides, REF-1 was changed from a hoop site to a seine site in fall 2009. An unbagged, 15.20 m long, 1.8 m deep, 0.6 cm mesh seine with float and lead lines was used to collect fish. One end of the net was held at shore while the other was pulled out in a wide arc and towed back to the bank, the drag lines were then pulled to shore simultaneously. Data was collected from captured fish as previously described in Fahys Creek.

Coquille River

Seining was conducted as described for the Bandon Marsh Unit. Sampling occurred on the same schedule as Fahys Creek beginning in winter 2009.

Macro-invertebrate Sampling

Fahys Creek

Macro-invertebrate sampling reaches were located on both ends and between each of the hoop net sites for Sections F1-F4. Sections F5 and F6 were combined to represent one reach. A total of 11 reaches were sampled. Water column and water surface samples were collected. Efforts were taken so that sampling methods provided both quantitative and qualitative results that could be compared throughout the range of sites as well as with future surveys.

Collection of water column and surface invertebrates was conducted using a unique drift net design (Figure 4). The nets were 250 micron-mesh with a 30.5 cm^2 opening and a one meter long capture bag that tapered down into a 500 ml collection bottle. Three of these nets were used alongside each other. In the center of each net was a 2030R standard mechanical flow meter. Methods for sampling a reach depended on the conditions of the individual sites. If sites were deep enough, a boat was used for collection efforts. For sites that did not allow for boat access, stationary set-nets were staked into position at the bottom of the reach with the mouths facing upstream allowing them to capture any drifting surface/subsurface invertebrates. Set net sites were deployed for 20-minute periods. In areas where flow was too low to gather readings on the mechanical flow meter, an orange and stopwatch were used to calculate approximate flow (Orth 1983). Sampling depth of the net depended on the water depth at the site. Attempts were made to capture as much of the water column near the surface as possible while trying to avoid scraping or disturbing any of the substrate along the bottom. Collected invertebrate specimens were transferred and stored in 500 ml bottles filled with isopropyl alcohol. All samples were preserved and archived at the USFWS Columbia River Fisheries Program Office in Vancouver, Washington. Invertebrate sampling occurred during the spring of 2008, 2009 and 2011.

Reference Area

Macro-invertebrate sampling was also conducted at REF-1. The same methods were applied in REF-1 as described above for Fahys Creek macro-invertebrate sampling. Sampling occurred in spring 2009.

a) b)

Figure 4. Invertebrate sampling nets being used in deeper water conditions a) active boat-drift sampling and b) shallow water conditions (set-netting)

Biodiversity Data Analysis

Capture efficiency for a given species can vary depending on method of capture and habitat. Variable capture efficiency can influence the analysis of biodiversity. However, methods were selected to maximize capture efficiency for respective habitats, and facilitate comparison of changes in diversity among areas. Lapointe et al. (2006) found that seines produced significantly higher richness and diversity than hoop nets and electrofishing in shallow offshore waters of large rivers (i.e., Mainstem Coquille). Clark et al. (2007) found that fyke nets produced significantly higher richness and diversity than seines when sampling littoral fish communities in floodplain lakes (i.e., Lower Fahys, Redd, and the Reference area). In addition, Lapointe et al. (2006) also found that samples obtained by hoop nets and electrofishing were not significantly different in richness and diversity. If the fish community consists of species with similar catch vulnerabilities, a seine is suitable to measure the population (Parsely 1989). These findings suggest the methods we selected provide useful measures for comparison of frequency of occurrence (ecological classification), species richness (Simpson Diversity Index), and similarity (Jaccard's coefficient). We recognize that potential differences in capture efficiency among methods also affect abundance data (i.e., ecological classification).

Community

To compare the fish assemblage before and after construction, similarity was based on species presence/absence. Jaccard's coefficient (Urbani 1980) was used to calculate the proportion of unique species captured before and after construction.

$$S_J = \frac{a}{(a + b + c)}$$

Where *a* is the number of species present before and after construction, *b* is the number of species unique pre-construction, and *c* is the number of species unique post-construction. This coefficient ranges from 0 for no shared species to 1.0 to identical species composition. Values of less than 0.60 are thought to indicate substantial differences (Gauch 1982). Jaccard's coeffecient was calculated to compare 1) the Ni-les'tun Unit before and after construction, 2) the Ni-les'tun Unit before construction to the reference area before construction, and 3) the Ni-les'tun Unit after construction to the reference area after construction.

Species Richness

The Simpson Diversity Index is an index of species richness, or number of species within a sample area.

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

Where *n* is the number of individuals from one particular species and *N* is the total number of individuals found. The index approaches 1.0 when numbers of individuals collected are evenly distributed among the number of species present (evenness of abundance). The Simpson Diversity Index was calculated for data collected by DH (Fahys Creek, Redd Creek, and reference area), electrofishing (Fahys Creek), and seine (GRTS Sites, and reference area) for

each sample event. ANOVA was used to compare differences in mean Simpson Diversity Index of DH values between Fahys Creek, Redd Creek, and the reference area pre and post construction, significance levels were set at $\alpha = 0.05$.

Salmonid Life History Diversity

Relative percent length-frequency histograms were used to document the population structure for multiple age classes of salmonids collected in the Ni-les'tun Unit before and after construction. Catch rates of > 30 individuals/species were used to conduct length-frequency analysis. Mean fork length (± SD) of all salmonids was calculated in each sample area. Salmonid fork length frequency was distributed into 50 mm-wide bins and separated by species, sample area, and construction phase. Coastal cutthroat trout (*Oncorhynchus clarki clarki*) (CCT) were categorized as juveniles (<100 mm fork length), large juveniles (100-200 mm), adults (200-300 mm), and sea run (>300 mm) (Giger 1972). Chinook salmon (*O. tshawytsha*) (CHN), and coho salmon (*O. kisutch*, Oregon Coast ESU threatened) (COHO), were categorized as age-0 (<60 mm fork length) and age-1 (60-150 mm) (Miller and Sardo 2003). The number of size classes present on the Ni-les'tun Unit (Fahys Creek Above North Bank Lane, Fahys Creek Below North Bank Lane, Redd Creek) and the reference area were qualitatively compared before and after construction.

Ecological Classification

All species encountered within the Ni-les'tun Unit's restoration area through the period of monitoring were ecologically classified according to average relative abundance and percent frequency of occurrence (González-Acosta 1998, González-Acosta et al. 2005). This method of classification is based on Olmstead-Tukey's test (Sokal and Rohlf 1969) and allows an ecological and quantitative classification of the species in each area (González-Acosta et al. 2005). The analysis results in the division of species present into four ecological categories (dominant, common, occasional, and rare) represented by quadrants of a scatter plot that is divided by two axes identifying the mean frequency of occurrence and mean relative abundance for a specific area. Ecological classification was conducted for four distinct areas of the study area (Fahys Creek, Redd Creek, GRTS sites, and the reference area) and three sample methods (double hoop net, electrofish, and seine) before and after the construction period. Classification of each species was compared in the Ni-les'tun Unit before and after construction and the Ni-les'tun Unit to the reference area after construction to document changes in the community.

Results

Fish Sampling

Fahys Creek

During the pre-construction phase, double hoop nets were deployed for all 15 sampling trips between November 2007 and March 2010. After construction, double hoop nets were deployed for all 12 sampling trips between December 2011 and September 2013 (Appendix A). Native fish species captured within Fahys Creek included northern anchovy (*Engraulis mordax*) (ANC), bay pipefish (*Syngnathus leptorhynchus*) (BAP), CCT, CHN, COHO, gunnel fish (Pholidae) (GUN), cutthroat/steelhead hybrids (HYB), sculpin (Cottidae) (SCP), three-spine stickleback (*Gasterostreus aculeatus*) (SKB), smelt (Osmeridae) (SMELT), shiner perch (*Cymatogaster aggregata*) (SP), starry flounder (Platichthys stellatus) (STF), and steelhead (*O. mykiss*) (STH). Introduced fish species included American shad (*Alosa sapidissima*) (AMS), bluegill (*Lepomis macrochirus*) (BG), brown bullhead (*Ameiurus nebulosus*) (BBH), common carp (*Cyprinus carpio*) (CARP), crappie sp. (*Pomoxis sp.*) (CRAP), largemouth bass (*Micropterus salmoides*) (LMB), and mosquito fish (*Gambusia affinis*) (MQF). Amphibian species observed included rough skinned newts (*Taricha granulose*) (RSN), red-legged frogs (*Rana aurora*) (RLF), bullfrogs (*Rana catesbeiana*) (BF), and northwestern salamanders (*Ambystoma gracile*) (NWS). Shrimp, Dungeness crab juveniles, and jellyfish were also observed and recorded in Fahys Creek. Composition and frequency of species captured varied for each sampling trip (Appendix A).

Electrofishing above North Bank Lane was conducted five times pre-construction (mean effort: 2,628 seconds) and four times post-construction (mean effort: 1,997 seconds) (Table 3). Native fish species captured above North Bank Lane included, CCT, COHO, HYB, SCP, SKB, and STH. Introduced fish species included BG, LMB, and smallmouth bass (*Micropterus dolomieu*).

Table 3. Electrofishing capture results: bluegill (BG), coastal cutthroat trout (CCT), coho salmon (COHO), cutthroat/steelhead trout hybrid (HYB), largemouth bass (LMB), sculpin (SCP), three-spine stickleback (SKB), Smallmouth Bass (SMB), steelhead trout (STH), and trout fry (TF)

Year	Season	Restoration Phase	Site	BG	CCT	COHO	HYB	LMB	SCP	SKB	SMB	STH	TF
2007	Fall	Pre	F5-6		160	30	1	1			1		5
2008	Fall	Pre	F5-6		56	22	6					8	2
2008	Spring	Pre	F5		108	43						4	5
2009	Fall	Pre	F5-6		72	8			11	8		1	4
2009	Spring	Pre	F5-6		61	6	14					4	2
2012	Spring	Post	F5-6	1	22	9							13
2012	Summer	Post	F5-6		39	1	4		13	2			11
2013	Fall	Post	F5-6		40		2		61	11			46
2013	Spring	Post	F5-6		33	32	1		70				2

Redd Creek

During the pre-construction phase, double hoop nets were deployed for all 11 sampling trips between November 2008 and March 2010. After construction, double hoop nets were deployed for all 12 sampling trips between December 2011 and September 2013 (Appendix A). Native fish species captured within Redd Creek included ANC, CCT, CHN, COHO, GUN, HYB, SCP, SKB, SMELT, SP, STF and TF. Introduced fish species found included BBH, BG, CRAP, and MQF. Amphibian species observed included RSN, RLF, and NWS. Shrimp, Dungeness crab juveniles, and jellyfish were observed and recorded in Redd Creek. Composition and frequency of species captured varied for each sampling trip (Appendix A).

GRTS Sites

After construction, 26 GRTS sites were sampled (range 1 – 8 times) between December 2011 and September 2013. Native fish species captured on the Ni-les'tun Unit included CHN, COHO, SCP, SKB, and SP. The only introduced fish species captured were MQF. Amphibian species observed included RSN, RLF, and NWS. Shrimp, Dungeness crab juveniles, and jellyfish were also captured on the Ni-les'tun Unit. Composition and frequency of species captured varied for each sampling trip (Appendix A).

Reference Area

Bandon Marsh Unit

During the pre-construction phase, double hoop nets were deployed for all 11 sampling trips between November 2008 and March 2010; a seine was used on five trips between September 2009 and March 2010. After construction, double hoop nets and seines were used for 11 sampling trips between December 2011 and September 2013. The reference area was not sampled in December 2012 due to a high water event.

Native fish species captured in the reference area included CHN, COHO, GUN, Pacific lamprey (*Entosphenus tridentatus*) (PL), SCP, SKB, SMELT, SP, and STF. The only introduced fish species captured were AMS. Amphibian species observed included RSN, RLF, and NWS. Shrimp, Dungeness crab juveniles, and jellyfish were observed and recorded in the reference area. Composition and frequency of species captured varied for each sampling trip (Appendix A).

Coquille River

During the pre-construction phase, the Coquille River was seined during nine sampling trips between March 2009 and March 2010. After construction, the Coquille River was seined during 11 sampling trips between December 2011 and September 2013. The Coquille River was not sampled in December 2012 due to a high water event (Appendix A).

Native fish species captured on the Coquille River included BAP, CHN, COHO, GUN, SCP, SKB, SMELT, SP, and STF. Introduced fish species captured were AMS and LMB. Amphibian species observed included RSN, RLF, and NWS. Shrimp, Dungeness crab juveniles, and jellyfish were also observed on the Coquille River. Composition and frequency of species captured varied for each sampling trip (Appendix A).

Biodiversity

Community

A total of 21 fish species were present in the Ni-les'tun Unit over the course of 27 sample events. Thirteen were present pre and post construction, three were detected pre-construction only (CARP, SMB, and STH), and five were detected post-construction only (ANC, AMS, BAP, STF, and CRAP) (Table 4).

Table 4. Fish species present on the Ni-les'tun Unit and reference area before and after the construction timeframe.

Species	**Acronym**	**Genus Species**	**Construction Area**		**Reference Area**	
			Pre	Post	Pre	Post
American Shad*+	AMS	*Alosa sapidissima*		X	X	X
Bay Pipefish+	BAP	*Syngnathus leptorhynchus*	X	X		X
Blue Gill*	BG	*Lepomis macrochirus*	X	X		
Brown Bullhead*	BBH	*Ameiurus nebulosus*	X	X		
Carp*	CARP	*Cyprinus carpio*	X			
Chinook Salmon	CHN	*Oncorhynchus tshawytscha*	X	X	X	X
Coastal Cutthroat Trout	CCT	*Oncorhynchus clarki clarki*	X	X		
Coho Salmon	COHO	*Oncorhynchus kisutch*	X	X	X	X
Cottid spp. +	SCP	*Cottidae sp.*	X	X	X	X
Crappie sp.	CRAP	*Pomoxis sp.*		X		
Gunnel fish sp.+	GUN	*Pholidae*	X	X	X	X
Hybrid CCT/STH	HYB	*Oncorhynchus sp.*	X	X		
Largemouth Bass*	LMB	*Micropterus salmoides*	X	X		X
Mosquito Fish*	MQF	*Gambusia affinis*	X	X		
Northern Anchovy+	ANC	*Engraulis mordax*		X		
Pacific Lamprey	PL	*Entosphenus tridentatus*				X
Smallmouth Bass*	SMB	*Micropterus dolomieu*	X			
Smelt sp.+	SMELT	*Osmeridae*	X	X	X	X
Starry Flounder+	STF	*Platichthys stellatus*		X	X	X
Steelhead	STH	*Oncorhynchus mykiss irideus*	X			
Shiner Perch+	SP	*Cymatogaster aggregata*	X	X	X	X
Three Spine Stickleback +	SKB	*Gasterosteus aculeatus*	X	X	X	X
Trout Fry (< 100 mm)	TF	*Oncorhynchus sp.*	X	X		

*Introduced Species

+Estuarine Species

Jaccard's coefficient for similarity of all species present in the Ni-les'tun Unit before and after construction was not substantially different (S_J = 0.619). The same four salmonid species were present before and after construction (CHN, COHO, CCT, and STH) S_J = 1.00. However, the presence of introduced species and estuarine species was substantially different after construction. Although eight introduced species were present in Ni-les'tun before and after construction, two species, CARP and SMB, were present before construction only, while AMS and CRAP were present post-construction only (S_J = 0.500). There were substantially more estuarine species present after construction. Five estuarine species were present before construction (GUN, SCP, SP, SMELT, and SKB); after construction, four additional species were present (AMS, BAP, ANC, and STF) S_J = 0.556 (Table 4).

Jaccard's coefficient for similarity of species present in the Ni-les'tun Unit before construction and the reference area before construction was substantially different (S_J = 0.368). Ten species were present in the Ni-les'tun Unit, seven were present in both the Ni-les'tun Unit and reference area, and two were present in the reference area only. After construction, the similarity of species present in the Ni-les'tun Unit and the reference area was still substantially different, but to a lesser degree (S_J = 0.579). Seven species were present in the Ni-les'tun Unit, eleven were present in both the Ni-les'tun Unit and reference area, and one was present in the reference area only (PL) (Table 4).

Species Richness

The Simpson Diversity Index was documented for all seasons, sample areas, and methods by sample event. The Simpson Diversity Index ranged from 0.000 to 1.000 (Appendix B). After construction, the Simpson Diversity Index increased slightly for Fahys Creek electrofishing, Redd Creek DH, and reference area seining (Table 5). Fahys Creek DH showed a significant decrease after construction, the reference area exhibited the same trend, however not significantly.

Table 5. Mean (± SE) Simpson Diversity Index across sample areas before and after construction by sample method double hoop (DH), Electrofish, and Seine. Statistically significant changes in pre and post construction are denoted by * (ANOVA p< 0.05).

Sample Area		Method	Pre-Construction	Post-Construction	Change
Ni-les'tun Unit	Fahys Creek	DH	0.560 ± 0.022	0.453 ± 0.028	-*
Ni-les'tun Unit	Fahys Creek	Efish	0.422 ± 0.040	0.578 ± 0.048	+
Ni-les'tun Unit	Redd Creek	DH	0.560 ± 0.048	0.563 ± 0.034	+
Ni-les'tun Unit	GRTS	Seine		0.315 ± 0.057	N/A
Reference Area	Marsh Unit	DH	0.469 ± 0.077	0.336 ± 0.055	-
Reference Area	Coquille River	Seine	0.410 ± 0.045	0.532 ± 0.057	+

Salmonid Life History Diversity

Fahys Creek and Redd Creek

Above North Bank Lane, multiple size classes of CCT were present before and after construction (Table 6). Before construction, 469 CCT (mean FL 118 ± 30.82 range 56-231) representing three size-classes (juvenile, large juvenile, and adult) were captured. After construction, 191 CCT (mean FL 135 ± 29.34 range 91-286, DH) representing four size-classes (juvenile, large juvenile, adult, and sea run) were captured. One size class of COHO (age-1) was present above North Bank Lane before and after construction. Before construction, 118 COHO (mean FL 97 ± 11.64 range 68-127) were captured. After construction, 89 COHO (mean FL 101 ± 15.94 range 75-183) were captured. Relative percent length-frequency histograms were generated for CCT and COHO above North Bank Lane (Figure 5a and 5c).

Below North Bank Lane, multiple size classes of CCT were present before and after construction (Table 6). Before construction, 186 CCT (mean FL 165 ± 42.36 range 79-327) representing four size-classes (juvenile, large juvenile, adult, and sea run) were captured. After construction, 33 CCT (mean FL 187 ± 65.07 range 100-400) representing four size-classes (juvenile, large juvenile, adult, and sea run) were captured. Two size classes (age-0 and age-1) of COHO and CHN were present below North Bank Lane before and after construction. Before construction, 1,331 COHO (mean FL 92 ± 16.50 range 53-138). After construction, 236 COHO (mean FL 89 ± 16.51 range 56-152) were captured. Before construction, 34 CHN (mean FL 95 ± 22.32 range 47-134) were captured. After construction, 124 CHN (mean FL 62 ± 17.16 range 41-129) plus one hatchery marked CHN that measured 145 FL were captured. Relative percent length-frequency histograms were generated for CCT, COHO, and CHN below North Bank Lane (Figure 5b and 5d).

In Redd Creek, two size classes (age-0 and age-1) of COHO were present before and after construction (Table 6). Before construction, 270 COHO (mean FL 84 ± 18.10 range 50-145) were captured. After construction, 214 COHO (mean FL 82 ± 17.59 range 44-132) were captured. Relative percent length-frequency histograms were generated for COHO in Redd Creek (Figure 6).

Table 6. Number of salmonids used for length frequency analysis by size class

	CCT				COHO		CHN	
Size Class	Juvenile <100 mm	Large Juvenile 100-200 mm	Adult 200-300 mm	Sea Run >300 mm	Age-0 <60 mm	Age-1 60-150 mm	Age-0 <60 mm	Age-1 60-150 mm
Above NB Lane Pre-Construction	127	318	9	0	0	118		
Above NB Lane Post-Construction	4	170	13	3	0	88		
Below NB Lane Pre-Construction	5	147	33	1	6	696	3	31
Below NB Lane Post-Construction	18	11	2	2	2	219	79	46
Redd Pre-Construction					8	189		
Redd Post-Construction					14	111		
Reference Area Pre-Construction					5	44	2	16
Reference Area Post-Construction					6	59	65	48

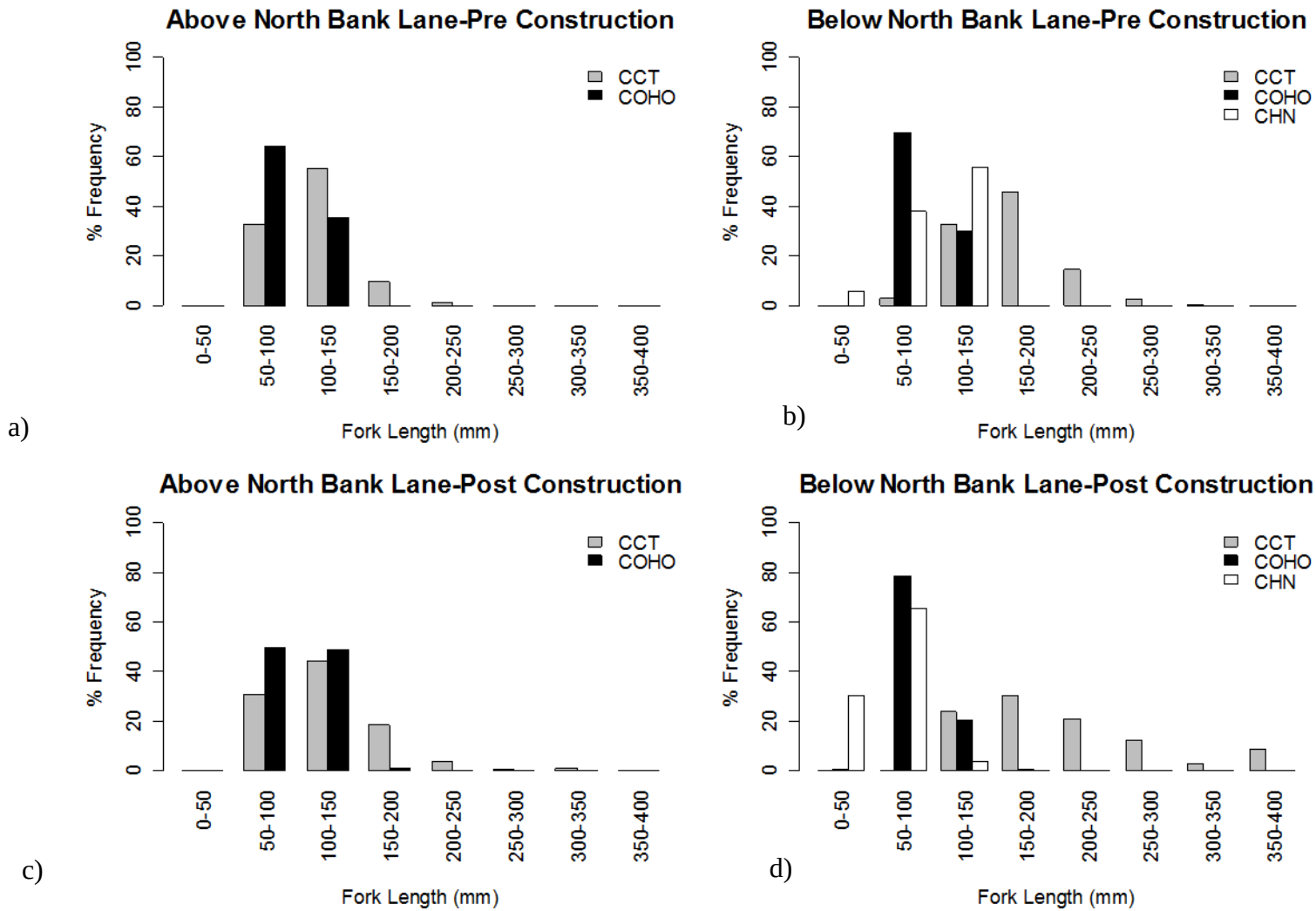
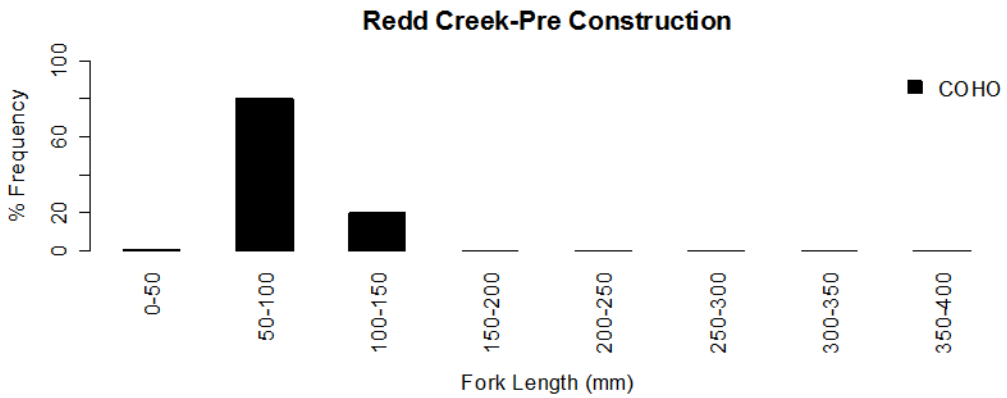


Figure 5. Percent frequency of coastal cutthroat trout (CCT), coho salmon (COHO), and Chinook salmon (CHN) fork length captured across all double hoop netting, seining, and electrofishing efforts in Fahys Creek



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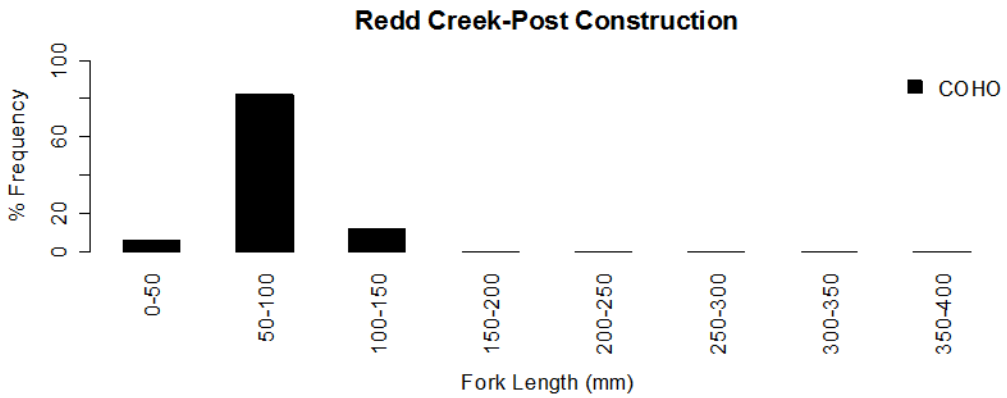


b)

Figure 6. Percent frequency of coho salmon (COHO) fork length captured across all double hoop-netting efforts in Redd Creek

Reference Area

Two size classes (age-0 and age-1) of COHO and CHN were present in the reference area before and after construction (Table 6). Forty-nine COHO (mean FL 80 ± 19.73 range 40-124) and 18 CHN (mean FL 71 ± 10.71 range 49-90) were captured. After construction, 121 COHO (mean FL 91 ± 19.65 range 44-131) and 132 CHN (mean FL 63 ± 19.36 range 42-124) were captured. Relative percent length-frequency histograms were generated for COHO and CHN in the reference area (Figure 7).

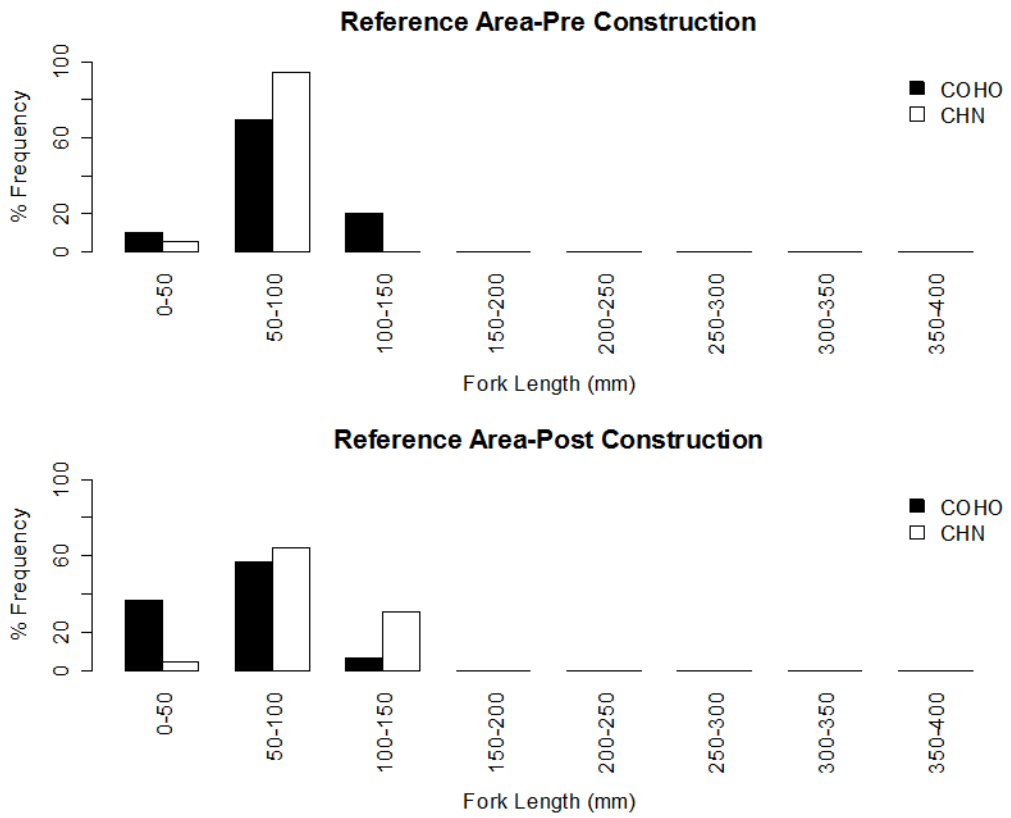


Figure 7. Percent frequency of coho salmon (COHO) and Chinook salmon (CHN) salmon fork length captured across all double hoop netting and seining efforts in the reference area

Ecological Classification

Ecological classification indicates similarities and differences in capture frequency and relative abundance of species in the Ni-les'tun Unit before and after construction (Figure 8). Classification of each species was compared in the Ni-les'tun Unit before and after construction and the Ni-les'tun Unit to the reference area to identify changes in the population after construction. Three spine stickleback and SCP were most commonly classified Dominant across all areas except when electrofishing was used as a capture method (Table 7). Steelhead were Common when electrofished in Fahys Creek above North Bank Lane but were not found in the Ni-les'tun Unit after construction. COHO were Dominant before the construction but were reclassified as Common after the construction due to the greater relative abundance of other

species on the refuge. This reclassification of COHO is analogous to the reference area before and after the construction period. New species of estuarine fish found in the Ni-les'tun Unit after construction included AMS (Rare), ANC (Rare), BAP (Rare), and STF (Common). Estuarine fish found in the Ni-les'tun Unit before the construction (SP and SMELT) increased in both capture frequency and relative abundance after the construction. Although SMELT remained classified as Rare, SP were so abundant when captured, they were reclassified as Occasional, which closer reflects the reference area. Capture frequency and relative abundance of GUN was similar before and after construction. Introduced species such as BBH and MQF had a lower capture frequency after construction and relative abundance where BG stayed the same.

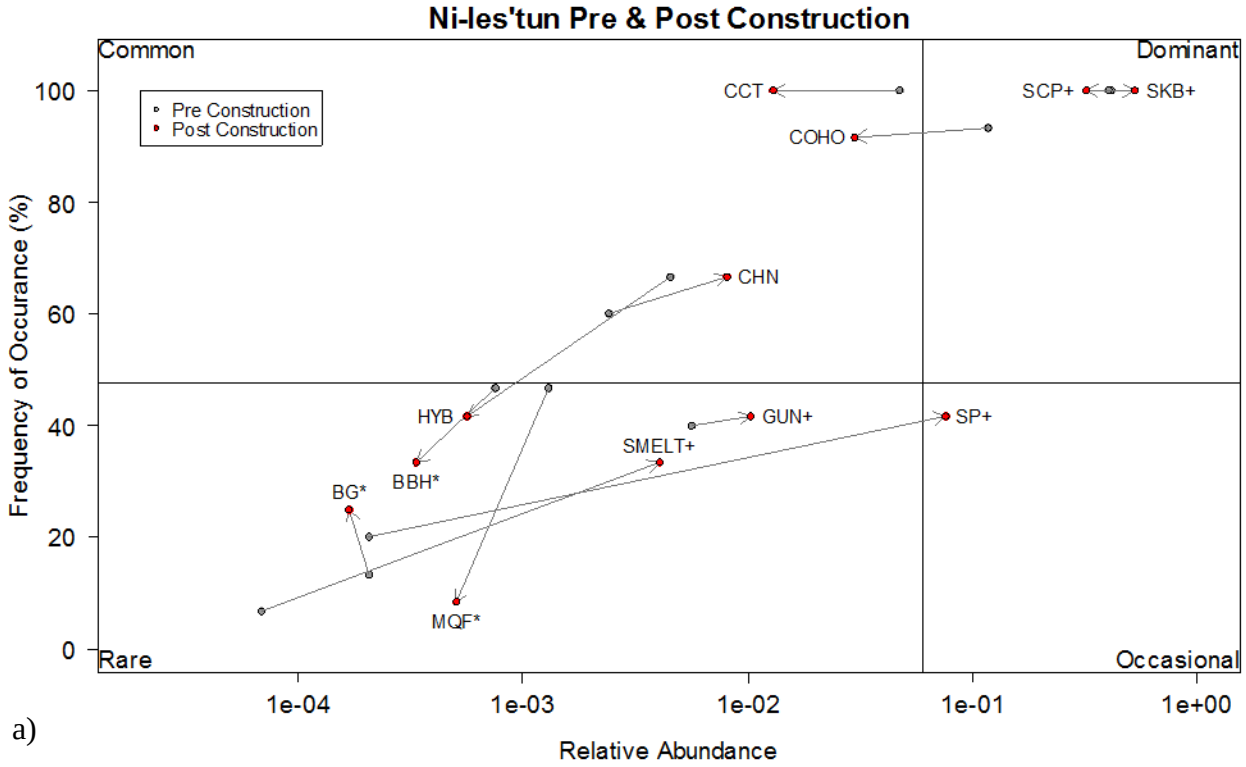
Ecological classifications of species in the Ni-les'tun Unit were comparable to the classifications of species in the reference area (Figure 9). Before and after construction in both the Ni-les'tun Unit and reference area, SKB and SCP were Dominant, and SMELT and GUN were Rare. Although frequency of SP increased after construction in both the Ni-les'tun Unit and the reference area, their relative abundance decreased in the reference area. After construction COHO, CHN, AMS, BAP, and STF on the Ni-les'tun Unit were similar to their classifications in the reference area after construction. On the Ni-les'tun Unit, COHO shifted from Dominant to Common, and the newly present AMS, BAP and STF were classified as Rare. In the reference area, CHN shifted from Rare to Common after construction. Cutthroat trout and introduced species (with the exception of AMS and LMB) were not present in the reference area.

Table 7. Ecological Classification

Construction Phase	Sample Method/ Area	AMS*+	ANC+	BAP+	BBH*	BG*	CARP*	CCT	CHN	COHO	CRAP*	GUN+	HYB	LMB*	MQF*	PL	SCP+	SKB+	SMB*	SMELT+	SP+	STF+	STH
Pre	All				R	R	R	C	C	D		R	C	R	R		D	D	R	R	R		R
Pre	DH				R	R	R	C	C	D		R	C	R	R		D	D		R	R		R
Pre	EFish							D		D			C	R			R	R	R				C
Pre	Fahys				C	R	R	C	C	D		R	C	R	C		D	D		R	R		R
Pre	Redd				R	R		C	R	C		R	C		R		D	D			R		
Post	All	R	R	R	R	R		C	C	C	R	R	R		R		D	D		R	O	C	
Post	DH	R	R	R	R	R		C	C	C	R	R	R		R		D	D		R	O	C	
Post	EFish					R		D		C			C				D	R					
Post	Seine								R	R					R		D	D			R		
Post	Fahys	R	R	R	R	R		C	C	C	R	R	R				D	D		R	C	C	
Post	No Name								R						R		D	D					
Post	Redd	R			C			R	R	C	R	R	R		R		D	D		R	D	R	
Pre	Reference	R							R	C		R					D	D		R	O	C	
Post	Reference	R		R					C	C		R		R		R	D	D		R	C	C	

*Introduced Species

+ Estuarine fish



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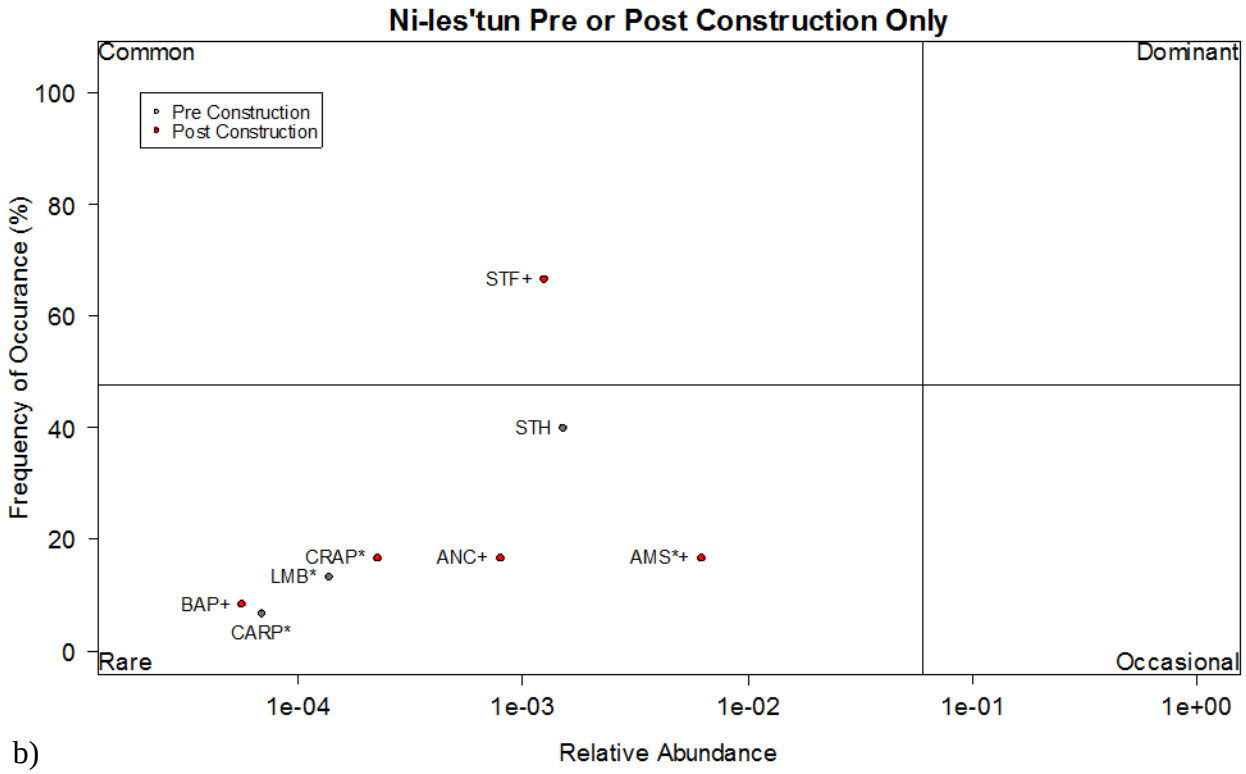

b)

Figure 8. Ecological classification of all species captured across the Ni-les'tun Unit a) present before *and* after construction and b) present before *or* after construction (*Introduced Species, +Estuarine Species)

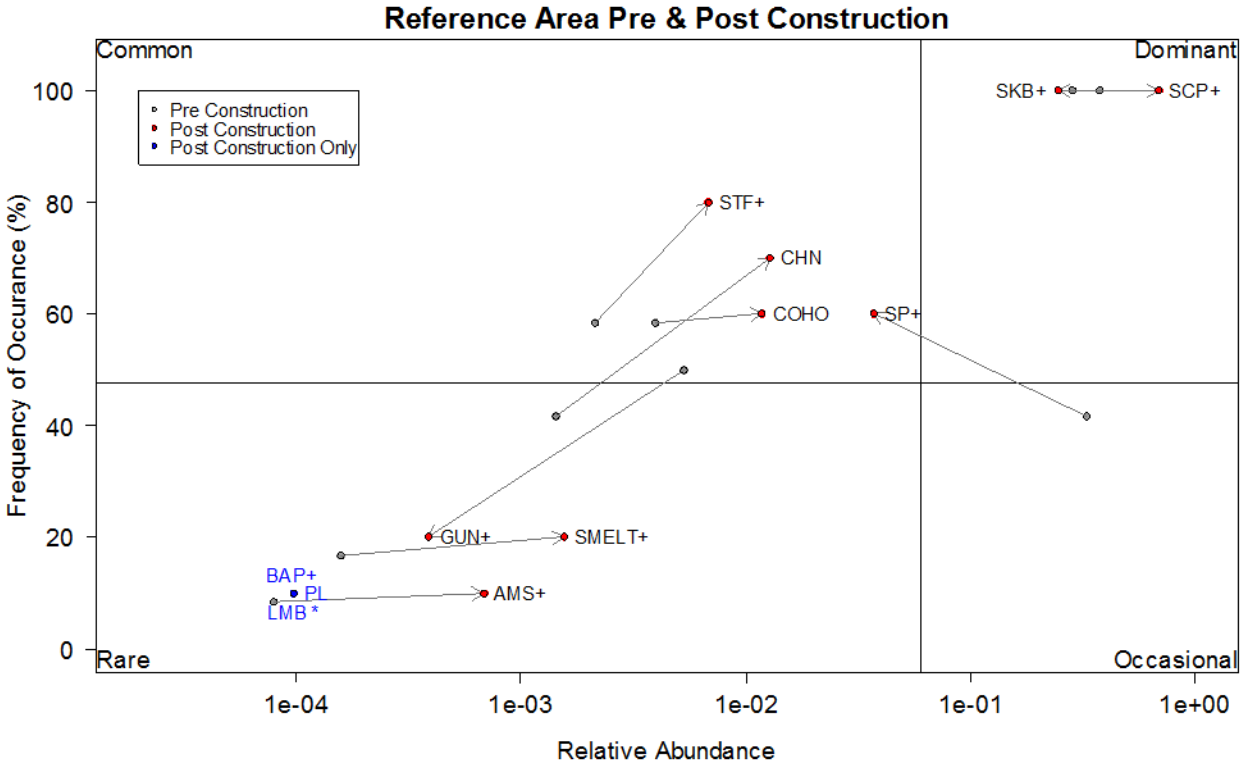

Figure 9. Ecological classification of all species captured in the reference area before and after construction (*Introduced Species, +Estuarine Species)

Conclusions

Proper restoration benefits salmonids and juvenile estuarine fish by creating habitat and increasing access to additional forage and cover (Shreffler et al. 1992; Miller and Simenstad 1997; Gray et al. 2002). Within three years after restoration construction, the population of fish in the Ni-lest'un Unit was more similar to that of the reference area. More estuarine fish species, age-0 CHN, and sea-run cutthroat trout were present in the Ni-lest'un Unit. By reintroducing a natural tidal regime, brackish tidal flows penetrate to the uppermost channels on the Ni-lest'un Unit. This increases water salinity, groundwater levels, and provides longer hours of inundation (Brophy 2014). The addition of large woody debris creates a dynamic habitat by forming scour pools and sediment bars (Keller and Swanson 1979). Along with increased channel complexity, over 8 km of new tidal channels were created on the refuge. The removal of tide gates allows access to these channels for migrating salmonids and estuarine fish. Long-term assessment of the fish community and their use of this habitat will help us evaluate the success of this restoration project.

A drawback of this project was the availability of reference sites for comparison of all habitats on the Ni-les'tun Unit. The two reference sites available were on the Bandon Marsh Unit located downstream of the Ni-les'tun Unit on the Coquille River. The Bandon Marsh Unit is exposed to greater tidal inundation, wave exposure, and other factors associated with being closer to the mouth of the Coquille River. In addition, the two sites were tidal sloughs with little surface freshwater output. This is in stark contrast to Fahys Creek and Redd Creek, both of which are perennial streams whose lower reaches are affected by the tidal cycles. The reference area showed the fish community did not change substantially before and after the construction period, however, a similar decrease of species richness was observed when DHs were used. Ecological classification of fish species was similar between Ni-les'tun Unit and the reference area after construction. CCT were not present in reference area, this is likely due to the lack of spawning in or above the sample sites versus the Ni-les'tun Unit where spawning occurred and was a source of CCT. The close proximity of these two sites and the lack of additional sites outside the Ni-les'tun Unit may not permit an appropriate comparison between the restoration area and the reference areas (Short et al. 2000). Therefore, we have limited our discussion here based only on results pre- and post-construction within the Ni-les'tun Unit.

The overall fish community was not substantially different before and after construction, however, substantial differences were found in the communities of estuarine and introduced species. This is likely due to the creation of tidal habitat for fish from the estuary while preserving freshwater habitat for species that exist upstream. According to Gauch (1982), there was not a substantial difference of all species present in the Ni-lest'un Unit after construction (Jaccard's coefficient > 0.60). Additionally, there was no difference in the salmonid community; the same four species were present after the construction. There were differences, however, in the estuarine and introduced species communities after construction. The number of estuarine species increased by 80% when four additional estuarine species were present, a substantial difference. Previous studies (Williams and Zedler 1999; Madon 2008) support this observation, finding estuarine fish colonization to be rapid in constructed and reconnected channels. Of particular interest was the finding by Madon (2008) that juvenile halibut will occupy this type of restored habitat where they can feed on small-sized prey that are typically less abundant in larger

stream bodies. Similarly, we observed an analogous estuarine species utilizing the Ni-lest'un Unit following construction, the starry flounder. The introduced species community changed substantially as well. Eight introduced species were present before and after construction. After construction, CARP and SMB were not detected; AMS (an estuarine fish) and CRAP were present instead. These findings are consistent with the basic principles of altered flow regimes for aquatic biodiversity in floodplain wetland ecosystems (Moyle and Light 1996; Bunn and Arthington 2002). Namely, the success of introduced species is facilitated by the alteration of flow regimes, and the greater the magnitude and persistence of the disturbance, the greater the probability of long-term success for the introduced species. Therefore, with restored hydrologic function in the Ni-lest'un Unit to a flow regime that more resembles the historic, we would expect a shift benefitting the native estuarine species. With time, we expect this to continue.

After construction, species richness (Simpson Diversity Index) increased in Redd Creek and more so in Fahys Creek above North Bank Lane. This increase in species richness is not surprising, with more access to these areas, the relative proportion of CCT in Fahys Creek and SCP and SKB in Redd Creek decreased. Conversely, access in Fahys Creek below North Bank Lane resulted in a decrease in species richness, likely due to an ability of migratory species to move in and out of the area while SCP and SKB continued to be a dominant proportion of the catch. Species richness in the GRTS sites was low relative to all other sites. There were large numbers of SCP and SKB, with few individuals of other species. This may indicate the habitat was more suitable for species that can withstand great changes in temperature, salinity, and periods of dewatering. It is important to note the channels were only sampled at low tide when the habitat was accessible. During high water events, the channels are inundated for longer periods with cold water from outside the refuge. It will be valuable to understand how other species may be using these newly constructed channels during high tide and over time as these channels change and adjust with regular inundation. Overall, species richness was highly variable in the study area across seasons and among years. This is similar to findings in restored tidal wetlands on the West coast of the United States (e.g., Simenstad and Thom 1996; Williams and Zedler 1999).

Restoration resulted in a change in fish distribution on the Ni-les'tun Unit. The distribution of many native estuarine fishes changed significantly with the documentation of new species using the Ni-les'tun Unit. Similarly, the distribution of introduced species changed with the loss of some species (CARP and SMB) and the documentation of others (AMS and CRAP). Alternatively, we observed similar distributions of salmonids (COHO, CHN, and CCT) before and after construction. As noted previously, the distribution of these fish into newly constructed channels may be limited at times. However, the presence of sea-run coastal cutthroat trout and relatively larger CHN (>120 mm) using the Ni-les'tun Unit after construction suggests an expanded distribution for different life history strategies of those species.

Distribution of salmonids, native estuarine fish and introduced species in tidal wetlands is correlated to channel width, salinity, dissolved oxygen (Williams and Zedler 1999), water depth, proximity and type of channel vegetation (Baltz et al. 1993; Peterson and Turner 1994), habitat structural composition, flow velocity, stream order, wave exposure, and turbidity (Gorman and Karr 1978; Allen 1985; Meffe and Sheldon 1988; Ruiz et al. 1993; Paller 1994; Kirchhofer 1995; Clark et al. 1996). With the removal of the dike on the Ni-lest'un Unit, there are documented changes in some of these parameters (e.g., salinity, channel morphology; Brophy 2014) and the

expectation that others have changed with the more direct, open connection to the Coquille River intertidal zone (e.g., flow velocity, wave exposure). This study was not designed to analyze the relationship between fish distribution and these parameters. However, higher temperatures above North Bank Lane and higher salinity in the tidally influenced area can explain observed shifts in coho distribution further upstream through the improved culvert under Highway 101 to lower temperature and freshwater. Over time, with the re-establishment of historic habitat features associated with a functioning tidal wetland (e.g., channel vegetation, increased water depth) that benefit salmonids and other native estuarine species, we expect distribution of fish species to continue shifting (Williams and Zedler 1999; Brown 2003).

Restoration resulted in a pronounced shift in the ecological classification of species, specifically for native estuarine species. While SCP, SKB, COHO, CHN, and CCT were relatively abundant before and after construction, we observed significant increase in SP, and the arrival of species such as STF, SMELT, ANC, and BAP. Similarly, Able et al. (2000) found greater relative abundance of fish species in restored intertidal creeks when compared to pre-restoration condition. As the Ni-les'tun Unit continues to adjust with the restored tidal connectivity, the relative abundance of the estuarine species may increase along with additional species using the available habitat.

The goal of this project was to improve overall quantity and quality of tidal wetlands and estuarine conditions for a variety of aquatic species, including native trout and other salmonids. The conditions created by the return of a natural tidal regime provide habitat that can support these aquatic species. Overall, the short-term response of fish species to the restoration actions in the Ni-les'tun Unit appears positive. There are more estuarine fish present and all salmonid species and their size classes are still supported. Long-term monitoring of this area to assess changes in fish community, distribution, and relative abundance will provide added insight to the degree of benefit this type of project provides to salmonids and other native estuarine species. We recommend continued monitoring using this approach for a period of two years every 5-10 years.

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In the seven years of monitoring during implementation of the restoration actions on the Ni-les'tun Unit, the Refuge and Fisheries partnership has been mutually beneficial. Fisheries provided a standardized sampling approach for a long-term assessment and monitoring program, technical expertise, and resources to help answer restoration questions. Refuges provided a unique opportunity for CRFPO to be involved in tidal marsh restoration projects and provided funding for continued monitoring.

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Appendix A: Catch table for all sample methods

Year	Season	Creek	Method	AMS	ANC	BAP	BBH	BG	CARP	CCT	CHN	CHN-HAT	COHO	CRAP	GUN	HYB	LMB	MQF	PL	SCP	SKB	SMB	SMELT	SP	STF	STH	TF
2007	Fall	FAHYS	DH				1			10			22			3		3		74	103			1			
2007	Fall	FAHYS	EFISH							160			30			1	1					1					21
2008	Winter	FAHYS	DH							25	1		242			1				73	60						
2008	Spring	FAHYS	DH				1			11	3		88							461	659						
2008	Spring	FAHYS	EFISH							108			43													4	5
2008	Spring	FAHYS	DH				3			12	6		22		7	3				2752	618						
2008	Fall	COQUILLE	DH										2		14					45	20			11			
2008	Fall	FAHYS	DH				1	2		18	14		226		1	4	1	5		61	257						
2008	Fall	FAHYS	EFISH							56			22			6										8	2
2008	Fall	Redd	DH							2			69							184	724						
2009	Winter	COQUILLE	DH																	13	45						
2009	Winter	FAHYS	DH							16	1		180			5				47	413						1
2009	Winter	Redd	DH										50							21	38						1
2009	Winter	COQUILLE	DH	1							1		8							365	16						
2009	Winter	COQUILLE	SEINE										1							23	1				3		
2009	Winter	FAHYS	DH							24	5		407			5				235	387		1				
2009	Winter	Redd	DH				3			3			35			1				38	45						
2009	Spring	COQUILLE	DH												1					131	26						
2009	Spring	COQUILLE	SEINE								3		1							106							
2009	Spring	FAHYS	DH							16			68			6				244	289					2	
2009	Spring	FAHYS	EFISH							61			6			14										4	2
2009	Spring	FAHYS LAKE	ERaft																	3	8						
2009	Spring	FAHYS LAKE	Minnow Trap																	4	26						
2009	Spring	Redd	DH							3			24			3				315	338						3
2009	Spring	COQUILLE	DH								2				2					1488	2727			7	1		
2009	Spring	COQUILLE	SEINE								5		1							128	1				7		

Appendix A: Catch table for all sample methods (continued)

Year	Season	Creek	Method	AMS	ANC	BAP	BBH	BG	CARP	CCT	CHN	CHN-HAT	COHO	CRAP	GUN	HYB	LMB	MQF	PL	SCP	SKB	SMB	SMELT	SP	STF	STH	TF
2009	Spring	FAHYS	DH				1			27	3		1					2		389	949						1
2009	Spring	FAHYS LAKE	Gill Net							8										1	1						
2009	Spring	Redd	DH					1		7			10		29	1				225	162						
2009	Summer	COQUILLE	DH								5				19					299	610			2740			
2009	Summer	COQUILLE	SEINE												8					21	1			834	5		
2009	Summer	FAHYS	DH				1			3	1							1		202	218						
2009	Summer	FAHYS LAKE	DH																	8	27						
2009	Summer	Redd	DH							5			3		29	2				350	118			1			
2009	Summer	COQUILLE	DH												4					136	300			234			
2009	Summer	COQUILLE	SEINE								2				5					10	2			115	7		
2009	Summer	FAHYS	DH							3								1		149	109						
2009	Summer	Redd	DH							2	1				15	1		3		115	102			1			
2009	Fall	COQUILLE	DH																	132	401			172			
2009	Fall	COQUILLE	SEINE																	18	2			17	2		
2009	Fall	FAHYS	DH							7								3		33	63					1	
2009	Fall	FAHYS	EFISH							72			8							11	8					1	4
2009	Fall	Redd	DH							2					1					29	99						
2009	Fall	COQUILLE	DH										16							286	296		1				
2009	Fall	COQUILLE	SEINE																	1							
2009	Fall	FAHYS	DH						1	4			20					1		15	52						
2009	Fall	Redd	DH							1			74								14						
2010	Winter	COQUILLE	DH										3							51	25						
2010	Winter	COQUILLE	SEINE										2							5					1		
2010	Winter	FAHYS	DH							10			30							13	16					1	
2010	Winter	Redd	DH										1							3	2						
2010	Winter	COQUILLE	DH										9		14					261	248						
2010	Winter	COQUILLE	SEINE										7							72	1				1		

Appendix A: Catch table for all sample methods (continued)

Year	Season	Creek	Method	AMS	ANC	BAP	BBH	BG	CARP	CCT	CHN	CHN-HAT	COHO	CRAP	GUN	HYB	LMB	MQF	PL	SCP	SKB	SMB	SMELT	SP	STF	STH	TF
2010	Winter	FAHYS	DH							12			34							15	46					1	
2010	Winter	Redd	DH							1			4							2	3						
2010	Fall	COQUILLE	DH																	297	452						
2010	Fall	COQUILLE	SEINE										1							11				3			
2010	Fall	FAHYS	DH							27			2					2		45	59						
2010	Fall	FAHYS	EFISH							25			4							4	1						2
2010	Fall	FAHYS	SEINE															2			490						
2010	Fall	REDD	DH										4					1		4	106						
2011	Winter	COQUILLE	DH										6							196	139						
2011	Winter	COQUILLE	SEINE										6							34							
2011	Winter	FAHYS	DH							11			25							11	21						
2011	Winter	FAHYS	SEINE										2							6	4						
2011	Winter	NONAME	SEINE										14								3						
2011	Winter	Redd	DH				1			1			28							7	23						
2011	Spring	COQUILLE	DH								28		69							1144	235						
2011	Spring	COQUILLE	SEINE								21		3							67	1						
2011	Spring	FAHYS	DH				2			14	8		45							76	167						
2011	Spring	FAHYS	EFISH							28			1							3							1
2011	Spring	FAHYS	SEINE										5							12	25						
2011	Spring	NONAME	SEINE																		41						
2011	Spring	REDD	DH				1			9	4		62							16	148						
2011	Spring	REDD	SEINE							1			14							1	79						
2011	Summer	COQUILLE	DH																	181	233						
2011	Summer	COQUILLE	SEINE								18		7		2					62			2	2	3		
2011	Summer	FAHYS	DH							8	5		2							49	196						
2011	Summer	FAHYS	SEINE																		233						
2011	Summer	REDD	DH							7			12							13	201						
2011	Summer	REDD	SEINE										6							1	449						

Appendix A: Catch table for all sample methods (continued)

Year	Season	Creek	Method	AMS	ANC	BAP	BBH	BG	CARP	CCT	CHN	CHN-HAT	COHO	CRAP	GUN	HYB	LMB	MQF	PL	SCP	SKB	SMB	SMELT	SP	STF	STH	TF
2011	Fall	COQUILLE	DH																	10	19		1				
2011	Fall	COQUILLE	SEINE																	3	1						
2011	Fall	FAHYS	DH							27			69							106	2570		62				
2011	Fall	FAHYS	SEINE																	5	17						
2011	Fall	REDD	DH										109			1				14	185						
2012	Winter	COQUILLE	DH																	31	139						
2012	Winter	COQUILLE	SEINE										3				1								1		
2012	Winter	FAHYS	DH					1		8			96			2				78	56				1		
2012	Winter	FAHYS	SEINE										9							6	6						
2012	Winter	REDD	DH				1						58							11	30						
2012	Spring	COQUILLE	DH										23							202	415						
2012	Spring	COQUILLE	SEINE										4							14					4		
2012	Spring	FAHYS	DH				1			11			25							51	16						
2012	Spring	FAHYS	EFISH					1		22			9														13
2012	Spring	FAHYS	Seine										6							13	35						
2012	Spring	NONAME	SEINE																	4							
2012	Spring	REDD	DH				2						10							40	30				1		1
2012	Spring	REDD	SEINE																	21	11						
2012	Spring	COQUILLE	DH								2									2032	130			1			
2012	Spring	COQUILLE	SEINE								14		2							62	19				1		
2012	Spring	FAHYS	DH							11	10		3							708	408						
2012	Spring	FAHYS	SEINE																	32	86						
2012	Spring	NONAME	SEINE																	2	8						
2012	Spring	REDD	DH							1	3		13							109	232						
2012	Spring	REDD	SEINE																		41						
2012	Summer	COQUILLE	DH																	102	561			22			
2012	Summer	COQUILLE	SEINE								6									104	1			134	24		
2012	Summer	FAHYS	DH		3	1				7	9				7					1271	695			47	1		

Appendix A: Catch table for all sample methods (continued)

Year	Season	Creek	Method	AMS	ANC	BAP	BBH	BG	CARP	CCT	CHN	CHN-HAT	COHO	CRAP	GUN	HYB	LMB	MQF	PL	SCP	SKB	SMB	SMELT	SP	STF	STH	TF
2012	Summer	FAHYS	SEINE																	46	870						
2012	Summer	REDD	DH				1						3		1					72	336			103	3		
2012	Summer	REDD	SEINE										6							4	72						
2012	Summer	COQUILLE	DH												2					858	286			19	1		
2012	Summer	COQUILLE	SEINE								4				1					22				8	4		
2012	Summer	FAHYS	DH							11	1				62					371	945		1	180	2		
2012	Summer	FAHYS	EFISH							39			1			4				13	2						11
2012	Summer	FAHYS	SEINE																	5	71						
2012	Summer	REDD	DH												1					79	66			780			
2012	Summer	REDD	SEINE																	115	249						
2012	Fall	FAHYS	DH					1		7			30	3						23	61						
2012	Fall	FAHYS	SEINE								1										17						
2012	Summer	FAHYS	DH							11	1				62					371	945		1	180	2		
2012	Summer	FAHYS	EFISH							39			1			4				13	2						11
2012	Summer	FAHYS	SEINE																	5	71						
2012	Summer	REDD	DH												1					79	66			780			
2012	Summer	REDD	SEINE																	115	249						
2012	Fall	FAHYS	DH					1		7			30	3						23	61						
2012	Fall	FAHYS	SEINE								1										17						
2013	Winter	COQUILLE	DH										75							27	37						
2013	Winter	COQUILLE	SEINE																	3							
2013	Winter	FAHYS	DH							8			14							102	8				1		
2013	Winter	FAHYS	SEINE																	47	3						
2013	Winter	REDD	DH										7							13			5				
2013	Spring	COQUILLE	DH								6		8						1	187	217						
2013	Spring	COQUILLE	SEINE								70		4							114	7						
2013	Spring	FAHYS	DH							1	65		21							454	129						

Appendix A: Catch table for all sample methods (continued)

Year	Season	Creek	Method	AMS	ANC	BAP	BBH	BG	CARP	CCT	CHN	CHN-HAT	COHO	CRAP	GUN	HYB	LMB	MQF	PL	SCP	SKB	SMB	SMELT	SP	STF	STH	TF
2013	Spring	FAHYS	EFISH							33			32			1				70							2
2013	Spring	FAHYS	SEINE								9		2							103	26						
2013	Spring	NONAME	SEINE								3									6	4						
2013	Spring	REDD	DH								9		7	1						34	48						
2013	Spring	COQUILLE	DH																	2261	81						
2013	Spring	COQUILLE	SEINE			1					24		2							138	135		3	171	29		
2013	Spring	FAHYS	DH								19		2		38					449	84			21	3		
2013	Spring	FAHYS	SEINE								1									397	92						
2013	Spring	REDD	DH				1			1	7									58	88			14			
2013	Spring	REDD	SEINE																	5	28						
2013	Summer	COQUILLE	DH												1					792	69						
2013	Summer	COQUILLE	SEINE								2									10	2		13	4	1		
2013	Summer	FAHYS	DH	1						1	3				67					341	54		4	28	9		
2013	Summer	FAHYS	SEINE																	77	415			2			
2013	Summer	NONAME	SEINE																		2						
2013	Summer	REDD	DH							2					4					22	48			93			
2013	Summer	REDD	SEINE																	1	68						
2013	Fall	COQUILLE	DH																	36	283			7			
2013	Fall	COQUILLE	SEINE	7							4									50	127			14	5		
2013	Fall	FAHYS	DH	109						1	3	1			3					238	482			72			
2013	Fall	FAHYS	EFISH							40						2				61	11						46
2013	Fall	FAHYS	SEINE																	6	672						
2013	Fall	NONAME	SEINE															4		6							
2013	Fall	REDD	DH		11								1					5		9	31			4	1		
2013	Fall	REDD	SEINE																	2				1			

Appendix B: Simpson Diversity Index by season, sample area, and method

			Ni-les'tun Unit								Reference Area		
Year	**Season**	**Phase**	**Section 1 (DH)**	**Section 2 (DH)**	**Section 3 (DH)**	**Section 4 (DH)**	**Section 5 (EFish)**	**Section 6 (EFish)**	**Redd Cr (DH)**	**GRTS (Seine)**	**Reference (Hoop)**	**Reference (Seine)**	**Mainstem Coquille (Seine)**
07	F	Pre	0.5312	0.4867	0.8304	0.7957	0.3591	0.2126					
08	W	Pre	0.6065	0.4162	0.7166	0.7667							
08	Sp	Pre	0.6054	0.4434	0.7410	0.5083	0.4869	0.3765					
08	Sp	Pre	0.2889	0.5309	0.5652	0.3425							
08	F	Pre	0.5773	0.5750	0.7428	0.8114	0.6004	0.2857	0.4132		0.6830		
09	W	Pre	0.3257	0.5300	0.7290	0.6686			0.6434		0.3539		
09	W	Pre	0.6511	0.4132	0.7807	0.8095			0.7040		0.1312		0.3228
09	Sp	Pre	0.4855	0.5754	0.6564	0.5852	0.4469	0.5328	0.5459		0.2873		0.0712
09	Sp	Pre	0.4416	0.3487	0.5903	0.3560			0.5899		0.4600		0.1850
09	Su	Pre	0.4958	0.4231	0.5366	0.2849			0.4689		0.4094		0.0783
09	Su	Pre	0.4867	0.3347	0.6071	0.0588			0.5880		0.6415	0.0323	0.5105
09	F	Pre	0.5505	0.5813	0.5619	0.2476	0.5682	0.3529	0.3825		0.5827	0.4167	0.5954
09	F	Pre	0.7018	0.5241	0.5333	0.7424			0.2870		0.5312		
10	W	Pre	0.3072	0.7500	0.7469	0.8000			0.7333		0.4878	0.6667	0.8000
10	W	Pre	0.6400	0.6985	0.4095	0.7455			0.8000		0.5868	0.6667	0.5714
11	F	Po	0.6955	0.0590	0.0534	0.1994			0.5167	0.3680	0.5034	1.0000	0.0000
12	W	Po	0.4951	0.5514	0.5287	0.6193			0.5671	0.6857	0.3000		0.7000
12	Sp	Po		0.4731	0.6154	0.5411	0.6353	0.6444	0.6383	0.5623	0.4826		0.5714
12	Sp	Po	0.2641	0.4819	0.3584	0.4674			0.4873	0.3233	0.1155	0.5285	0.4675
12	Su	Po	0.4383	0.4335	0.3233	0.1415			0.5232	0.1066	0.3065	0.2857	0.5919
12	Su	Po	0.7158	0.4669	0.4397	0.4189	0.5954	0.6615	0.2784	0.3976	0.3984	0.8333	0.6017
12	F	Po			0.3969	0.7364				0.1111			
13	W	Po	0.1548		0.7473	0.7211			0.6367	0.1151	0.6046	0.0000	
13	Sp	Po	0.3071	0.6472	0.5430	0.5767	0.2637	0.5973	0.6401	0.4551	0.5333	0.5294	0.4936
13	Sp	Po	0.3273	0.5501	0.5152	0.4615			0.6060	0.3572	0.0668	0.5232	0.4749
13	Su	Po	0.4716	0.6520	0.4916	0.1571			0.6024	0.2445	0.1496	0.6667	0.6872
13	F	Po	0.6422	0.5129	0.1389	0.4158	0.6974	0.5263	0.6975	0.0539	0.2345	0.3665	0.7782

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