Leque Island 2019 Pre-Restoration Fish Monitoring Technical Report

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Contents

Abstract

In 2019, pre-restoration fish sampling was conducted following methods of the Leque Island Restoration Monitoring and Adaptive Management Plan (Henrichs et al. 2020). From this effort, we caught 108,954 individual fish representing 12 species between March and July within the restoration area. Three spine sticklebacks dominated the catch within the restoration area while reference sites had a more diverse fish community. We documented juvenile chum salmon in the planned restoration area that was likely attributed to a faulty tide gate. Juvenile chum salmon were not observed after the tide gate was repaired in April 2019. Conditions within the restoration area seemed to be inaccessible to estuarine fishes once the tide gate was repaired and later in the season tended to have temperature and dissolved oxygen and water temperatures might be unsuitable for salmon rearing in its current state.

Introduction

Washington Department of Fish and Wildlife (WDFW) restored an approximately 240-acre parcel of former farmland (Leque Island restoration area) at the mouth of the Old Stillaguamish channel to tidal inundation in July 2019. Restoring tidal inundation intends to allow access to new habitats for sub yearling Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), and other estuarine fishes. Skagit River System Cooperative (SRSC) planned and assisted monitoring of fish use in Leque Island restoration area before the restoration action from which to support future evaluation of restoration effectiveness. This technical report summarizes the first year of pre-project monitoring of fish use within the Leque Island restoration area (see Henrichs et al. 2020 for more details).

The monitoring approach for Leque Island, with respect to fish use, is intended to assess if restoration actions result in more sub yearling Chinook salmon (and other fishes). Fish density measurements before and after the restoration action can inform if sub yearling Chinook salmon abundances increased. Local densities, however, are also controlled by regional abundances of out-migrating juvenile salmon from primarily the Stillaguamish River and the Skagit River and other extrinsic environmental forces that drive regional fish abundances. Reference locations can then inform temporal differences in regional pool of fish that can be compare to the locations that were restored. Thus, fish monitoring includes a before-after monitoring element to document the net gain of fish access to the site that can inform before-after/control-impact (BACI) comparisons (Underwood 1994).

The Leque Island Estuary Restoration Monitoring and Adaptive Management Plan currently calls for monitoring the site prior to restoration action (Henrichs et al. 2020). SRSC monitored the pre-restoration condition at the Leque Island restoration site in 2019 until construction within the site started in July 2019. This technical report summarizes the first year of pre-project monitoring of fish use and water parameters in the restoration area and associated reference areas.

Methods

This section summarizes the sites monitored and methods used for fish collection for a full description of field and analytical methods please refer to the Leque Island Monitoring and Adaptive Management Plan (Henrichs et al. 2021).

Sites and sampling effort

We sampled six reference locations and four treatment channel networks within the Leque Island restoration area during 2019 (Figure 1). The locations within reference and restoration areas were selected to be representative of environmental conditions of the Leque Island project area (Table 1). In addition, Leque Island is situated between Skagit Bay and Port Susan. South Pass which is nearest to Port Susan and West Pass which is nearest to Skagit Bay, and one reference site where South Pass and West Pass meet at Grand Junction were selected to bound the conditions of the regional fish use. We included reference locations within blind channels that will be similar to the blind channels once restoration is complete. Within the restoration project area, we sampled multiple locations in each of the channel networks that have been previously excavated as the first phase of the project (L1, L2 and L3). During our sampling, these channels were blocked by dike or tide gate to limit fish passage into these channels, however L1 had a failing tide gate that allow some fish passage until it was repaired in April 2019.

The monitoring period extended from March 12, 2019 until August 5, 2019 with sampling occurring every other week. A total of 99 small beach seine sets, 30 stick seine sets and 19 fyke trapping sets in the reference area and 90 small beach seines and 30 stick seine sets inside the restoration area (Table 2). Tidal and crew restraints resulted in not all sets being completed at each sampling event.

Gear

A small net beach seine, stick seine, and fyke traps were used to collect fish at sample sites. Small net beach seine was 80-ft (24.4 m) by 6-ft (1.8 m) by 1/8-in (0.3 cm) mesh knotless nylon net. The net is set in “round haul” fashion by fixing one end of the net on the beach, while the other end is deployed by setting the net “upstream” against the water current, if present, and then returning to the shoreline in a half circle. Both ends of the net were then retrieved, yielding a catch. Average beach seine set area was 96 square meters (SRSC 2003). Stick seine was a 25-ft (7.6 m) by 6-ft (1.8 m) by 1/8-in (0.3 cm) mesh knotless nylon net attached on either end to two 8-ft (2.4 m) by 2-in (5 cm) by 2-in (5 cm) posts to sample smaller order “branch” channels within a restoration area. The net was set in a “J-set” fashion by fixing one end to the beach and the second end crossing the channel downstream of the posted end. The net was then walked “upstream” by walking against the water current in a J-shape. The first end is then posted in an upstream location while the second end crosses back over the channel creating a “purse” in the net and closure. The lead line was then elevated up the side of the bank yielding a catch. The area sampled by stick seine was estimated by measuring the length of the line walked and the wetted channel width.

Fyke traps were used to capture juvenile fish in small, blind tidal channel habitat. Fyke trap were constructed of 1/8-in (0.3cm) mesh knotless nylon with a 2-ft (0.6m) by 9-ft (2.7m) diameter cone sewn into a 40-ft (12.2 m) by 10-ft (3.05 m) net to collect fish draining out of the

blind channel site during an ebbing tide. Fyke nets were deployed at high tides and block fish immigrating or emigrating from the channel. Fish were caught through the ebb tide until either the channel is dewatered, or low tide has occurred. Total time of the fyke net effort was recorded to estimate juvenile Chinook salmon catch per unit effort (# of fish/hour).

Catch, Fish density, and abundance

For all species, we report raw catch totals to represent species richness and relative different in quantities of each fish species encountered. Estuarine systems can encompass both fresh water and marine fishes, many of these fishes are euryhaline and can occupy a large salinity gradient. We aggregate species by groupings of marine and freshwater, with salmon being salmon, as described by Wydoski and Witney (2003) and Piestch and Orr (2015).

For each seine set, the number of fish caught was divided by set area to established catch per unit effort (CPUE) for each sampling location. Set area for the small beach seine was calculated by multiplying the average area of a small beach seine (96 m^2) by the total percentage of the net deployed. For example, if the end of the net was not returned to the beach but instead had to be towed in by the wader/boat, the amount of the net deployed was estimated to be above 100 percent. For the stick seines, the length and width of the channel section that was seined was recorded at the time of sampling. This would produce CPUE in fish per meter squared. From these site specific CPUE estimates, we expanded to report fish per hectare by multiplying CPUE in m^2 by 10,000 to get CPUE in hectares (# fish per hectare).

Fyke net catches were summed total over the entire daily set that encompassed most of the ebb tide. Catch was adjusted by trap recovery efficiency (RE) estimate derived from mark-recapture experiments using a known number of marked fishes released upstream of the trap at high tide. RE is usually related to hydraulic characteristics unique to the site (e.g., change in water surface elevation during trapping, or water surface elevation at the end of trapping). Multiple RE tests (several times per season and over years) at each site were used to develop a regression model to convert the "raw" juvenile Chinook salmon catch to an estimated corrected abundance within the habitat upstream of the fyke trap on any sampling day (SRSC 2003). If salmon were not available for marking, peamouth chub were used as a mark group as they are similar sized as the Chinook salmon. Capture efficiency was estimated using a mean recapture rate evaluated throughout the sampling season. Corrected abundances were then divided by the total wetted area of the blind channel to estimate fish density within the blind channel that is comparable with beach seine sets.

For this report, we compared catch and CPUE between similar gear types. For seine sets, we compare total season catch and estimated CPUE means and standard errors for all sites. In addition, we estimated means and standard errors are larger extents that included channels networks, channel types (trunk or branch) and restoration and reference locations. Fyke sites included only two sites so catch and CPUE were represented. To compare salmon densities between restoration and reference locations, we did provide initial comparisons of densities between gear types that are considered preliminary since fyke trap RE estimates are still being developed.

Table 1. Summary of fish sampling sites of the Leque Island estuary restoration project in 2019.

Site	Type	Spatial	Gear Type	Comment
Leque 1 (L1)	(Restored Area) Treatment	Within project	Beach seine	3 sets in a tidal channel
Leque 2 (L2)		Within project	Beach seine	4 sets in a tidal channel
Leque 3 (L3)		Within project	Beach seine	2 sets in a tidal channel
Davis Tidegate		Within project	Stick seine	3 sets in a tidally restricted channel. The tidegate will be removed and the channel excavated in July 2019
West Pass Blind Channel	Reference Area	Adjacent to project	Fyke trap	Blind channel sampled by fyke trap Reference blind channel downstream of the project
South Pass		Downstream of project	Beach seine	3 sets along mainstem channel
Grand Junction		Adjacent to project	Beach seine	3 sets along mainstem channel
West Pass RB		Upstream of project	Beach seine	3 sets along mainstem channel
Davis Slough		Adjacent to project	Stick seine	3 sets within channel. Stick seine instead of small beach seine due to tidal constraints.

Table 2. Summary of fish sampling effort (# of sets) by reference and restored areas, month, and gear type during the 2019 monitoring period.

	Reference			**Restoration**	
Month	Fyke Trap	Small beach seine	Stick Seine	Small Beach seine	Stick seine
March	3	18	6	18	6
April	4	18	6	18	6
May	4	18	6	18	6
June	2	18	6	18	6
July	4	18	6	18	6
August	2	9	0	0	0

Figure 1. Fish sampling location map for monitoring the Leque Island estuary restoration project in 2019.

Results and discussion

Restoration Area Fish Catch

Within the Leque Island restoration area 108,954 individual fish representing 12 species were enumerated (Table 3). The fish community within the restoration area was dominated by a common estuarine species, three spine sticklebacks (*Gasterosteus armatus*). Three spine stickleback catches were highest in the largest channel in the restoration area; L2 with 54,716 individual fish being caught over the monitoring period. Catches were smaller in L1, L3 and Davis Slough Inside Tidegate (DSIT) having large but decreasing catches of three spine sticklebacks. Overall, three-spine sticklebacks comprised 99.05% of the total restoration area catch with 107,926 three-spine sticklebacks being caught. The rest of the fish community comprised less than 1% of the total catch. The remainder of the catch consisted of common Puget Sound species, such as Pacific staghorn sculpin (*Leptocottus armatus*), starry flounder (*Platyicthys stellatus*) and surf smelt (*Hypomesus pretiosus*).

There were 16 sub yearling chum salmon and no sub yearling Chinook salmon captured within the Leque Island restoration area. The chum salmon caught within the restoration area coincided with chum salmon caught in the nearby reference sites. Leque Island restoration area had channels pre-excavated and sealed off from tidal inundation by dike repair material and tide gates. These actions were intended to prepare the restoration area in case of levee failure before restoration actions (Loren Brokaw, WDFW, personal communication). It was intended that the restoration area remain isolated from tidal influence and fish use until the dikes were breached. The tide gate at the mouth of L1 was damaged and allowed a limited amount of tidal exchange occur that seemed to allow fish access for an undetermined amount of time. The faulty tide gate was repaired in April 2019. After the tide gate was repaired, no salmonid species were detected within the restoration area.

Table 3: Total beach seine and stick seine catch by channel network within the Leque restoration area over the monitoring period.

Group	Species	L1	L2	L3	DSIT	Species Total
Salmon	Chum salmon (sub yearling)	0	16	0	0	16
Marine Flatfish	Starry flounder	7	85	0	0	92
Marine Forage Fish	Surf smelt	28	525	3	0	556
	Sand Lance	0	1	0	0	1
	Herring	1	55	0	0	56
Marine Sculpin	Pacific staghorn sculpin	30	327	33	0	390
Freshwater Sculpin	Prickly sculpin	7	15	0	0	22
Freshwater Minnow	Peamouth chub	0	0	1	0	1
Common estuarine/ nearshore	Three-spine stickleback	30,174	54,716	22,170	668	107,728
	Shiner surf perch	6	46	0	0	52
	Arrow goby	0	40	0	0	40
	Site Total	30,253	55,826	22,207	668	

Reference Area Fish Catch

In the reference area, 99 small beach seine sets, 30 stick seine sets and 19 fyke trapping sets resulted in 6,668 individual fish being caught across 16 species (Table 4). The fish community within the reference area was more diverse and dominated by common forage and estuarine fish species. Shiner perch (*Cymatogaster aggregata*) comprised 58.8% of the total catch. Starry flounder and three spine sticklebacks were the next most common fish caught and composed 11.9% and 9.2% of the total catch. Surf smelt, Pacific staghorn sculpin and peamouth chub (*Mylochelius caurinus*) composed the majority of the remaining catch in equal proportions with only a few Northern anchovy (*Engraulis mordax*), prickly sculpin (*Cottus asper*) and herring (*Culpea pallasii*) occurring over the monitoring period .

In the reference areas, 207 sub yearling chum salmon, 44 NOR sub yearling Chinook salmon, 5 hatchery origin (HOR) sub yearling Chinook salmon, 2 sub yearling coho salmon (*Oncorhynchus kisutch*) and 1 Dolly Varden/Bull trout (*Salvelinus confluentus*) were caught over the monitoring period. South Pass and West Pass to the east and Davis Slough to the west connect Port Susan Bay and Skagit Bay to the east and Davis Slough connects the bays to the west. These sites contained NOR sub yearling Chinook salmon and sub yearling chum salmon (combined NOR sub yearling Chinook; n = 32, combined sub yearling chum; n = 194). Relatively few sub yearling salmonids were caught at Grand Junction, despite being at the confluence of South and West Pass (NOR sub yearling Chinook; n = 2, chum; n = 13). HOR sub yearling Chinook salmon were distributed evenly across all four sites, though there were relatively few caught.

Additionally, in the reference area, 19 fyke trapping events resulted in 1,662 individual fish representing 11 species being caught (Table 5). There were fewer NOR sub yearling Chinook salmon caught within zis a ba W of 3 compared to the West Pass Blind Channel (n= 2 vs. n = 9 respectively), but the same number of sub yearling chum salmon. Sub yearling coho salmon were only caught in the West Pass Blind Channel. The rest of the fish community within the monitored blind channels was dominated by shiner perch.

Table 4: Total small beach seine and stick seine catch by location within the reference areas over the monitoring period.

Group	Species	Davis Slough	Grand Junction	South Pass	West Pass	Species Total
Salmon	Chum salmon (sub yearling)	38	13	47	109	207
	Chinook salmon (NOR sub yearling)	16	2	9	17	44
	Chinook salmon (HOR sub yearling)	0	2	2	1	5
	Coho salmon (NOR sub yearling)	0	1	0	1	2
	Bull trout	0	0	1	0	1
Marine Flatfish	Starry flounder	20	287	91	398	796
Marine Forage Fish	Surf smelt	1	125	156	40	322
	Northern anchovy	0	0	10	0	10
	Herring	0	6	1	0	7
Marine Sculpin	Pacific staghorn sculpin	36	132	87	95	350
Freshwater Sculpin	Prickly sculpin	1	3	3	1	8
Freshwater Minnow	Peamouth chub	0	186	18	155	359
Common estuarine/ nearshore	Three-spine stickleback	198	49	91	276	614
	Shiner surf perch	159	602	385	2,777	3,923
	Arrow goby	14	2	4	0	20
Non-native	American Shad	0	1	2	0	3
	Site Total	483	1,362	907	3,870	

Table 5: Total catch by fyke traps within the reference area over the monitoring period. Mean CPUE (# of fish/hr) is presented within the parentheses.

Group	Species	West Pass Blind Channel	W of 3
Salmon	Chum salmon (sub yearling)	8 (0.24, SE=0.22)	8 (0.28, SE=0.14)
	Chinook salmon (NOR sub yearling)	9 (0.27, SE=0.11)	2 (0.07, SE=0.04)
	Coho salmon (unmarked sub yearling)	2 (0.06, SE=0.05)	0
Marine Flatfish	Starry flounder	17 (0.51, SE=0.34)	0
Marine Forage Fish	Surf smelt	1 (0.03, SE=0.39)	4 (0.14, SE=0.09)
	Shiner surf perch	1163 (34.9, SE=13.3)	65 (2.3, SE=1.65)
	Peamouth chub	10 (0.30, SE=0.18)	2 (0.07, SE=0.06)
Marine Sculpin	Pacific staghorn sculpin	162 (4.9, SE=1.56)	29 (1.01, SE=0.54)
Freshwater Sculpin	Prickly sculpin	6 (0.18)	0
Common Estuarine	Three spine stickleback	141 (4.2, SE=0.83)	28 (0.97, SE=0.36)
	Arrow goby	1 (0.03, SE=0.04)	4 (0.14, SE=0.08)

Salmonid Densities

After adjusting for total wetted area for each of the channels sampled, the trends mirror that of the total catch patterns. Over the monitoring period, sub yearling chum salmon were more dense than sub yearling NOR Chinook salmon, with sub yearling coho salmon (all ages), sub yearling HOR Chinook salmon and Dolly Varden/Bull trout (Table 6) with limited occurrence. There was

more sub yearling NOR and HOR Chinook caught within the reference areas compared to the restoration area over the monitoring period (Figure 3). Sub yearling NOR Chinook salmon exhibited a seasonal curve of densities which was skewed toward earlier in spring for both reference and restored sites in 2019.

The fundamental question motivating this work is; do the restoration actions result in more sub yearling Chinook salmon (and other fishes) at the site compared to before the restoration action? Utilizing the calculate WSE-wetted area relationships calculated according Beamer et al. (2017) and Beamer et al. (2018) can be used with the entire annual time series of information to calculate overall abundance. Further monitoring work and analysis of pre-restoration and post-restoration sub yearling salmonid abundance is needed to further determine the extent of salmonid use within zis a ba restoration area.

Table 6: Mean CPUE (# of fish/ha) of sub yearling salmonids by channel network over the monitoring period extending from March 12th, 2019 to August 5th, 2019. CH 0+= sub yearling chum salmon subyearling, CO 0+ = sub yearling coho salmon, CK 0+ HOR = sub yearling Chinook salmon hatchery origin, CK 0+ NOR = sub yearling Chinook salmon natural origin, DV/BT = Dolly Varden/ Bull Trout.

Site	Strata	CH 0+	CO 0+	HOR CK0+	NOR CK0+	DV/BT
Grand Junction	Reference	42.3 (26.4)	3.3 (3.2)	6.9 (4.6)	6.5 (4.4)	0
South Pass		141.5 (79.4)	0	6.3 (6.3)	28.4 (10.4)	3.3 (3.3)
West Pass		310.8 (128.6)	3.2 (3.2)	3.2 (3.2)	48.0 (24.1)	0
Davis Slough		316.9 (154.5)	0	0	96.0 (60.8)	0
West Pass Blind		33.7 (33.7)	8.4 (8.4)	0	37.9 (18.3)	0
W of 3		4.0 (2.6)	0	0	1.0 (0.7)	0
DSIT	Restoration	0	0	0	0	0
L1		0	0	0	0	0
L2		41.7 (32.7)	0	0	0	0
L3		0	0	0	0	0

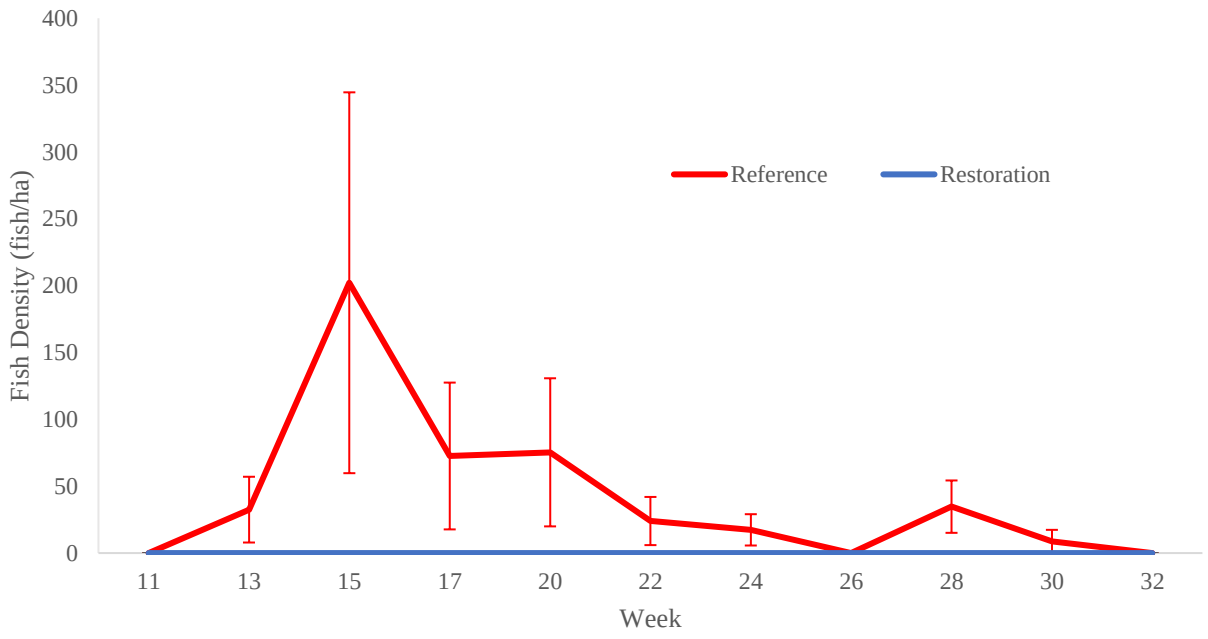

Figure 3. Mean CPUE (# of fish/ha) and standard error of NOR sub yearling Chinook in reference and restoration areas over the monitoring period by sampling week.

Sub yearling Chinook salmon Length

Previous work has demonstrated that sub yearling Chinook salmon (Bottom et al. 2005) and sub yearling chum salmon (Levy and Northcote 1982) will rear in Pacific Northwest estuaries for a limited time and exhibit a seasonal increase in body size during their rearing period. For this report we compare the expected (and observed) seasonal increase in length of presumed NOR sub yearling Chinook salmon in aggregate by reference and restoration areas (Figure 4). Fish caught within the restoration area were the same size as reference areas in March but were larger in the restoration area in May. No sub yearling Chinook salmon were caught within the restoration area after June.

April is a confounding month due to the unintentional hatchery release of unmarked Chinook salmon from the Stillaguamish hatchery being caught within the reference areas. This is attributed to an unintentional release from the Stillaguamish hatchery in early April before individual fish could be marked with either a coded wire tag or an adipose clip (personal communication STI NRD staff). DNA samples were taken from the suspected HOR juvenile Chinook. DNA assignment can determine the parental origin and future monitoring reports will correct for mis-assignment of HOR or NOR juvenile Chinook salmon in length analyses. Further analysis in subsequent years will be needed to determine what effect, if any, restoration had on sub yearling salmonid growth.

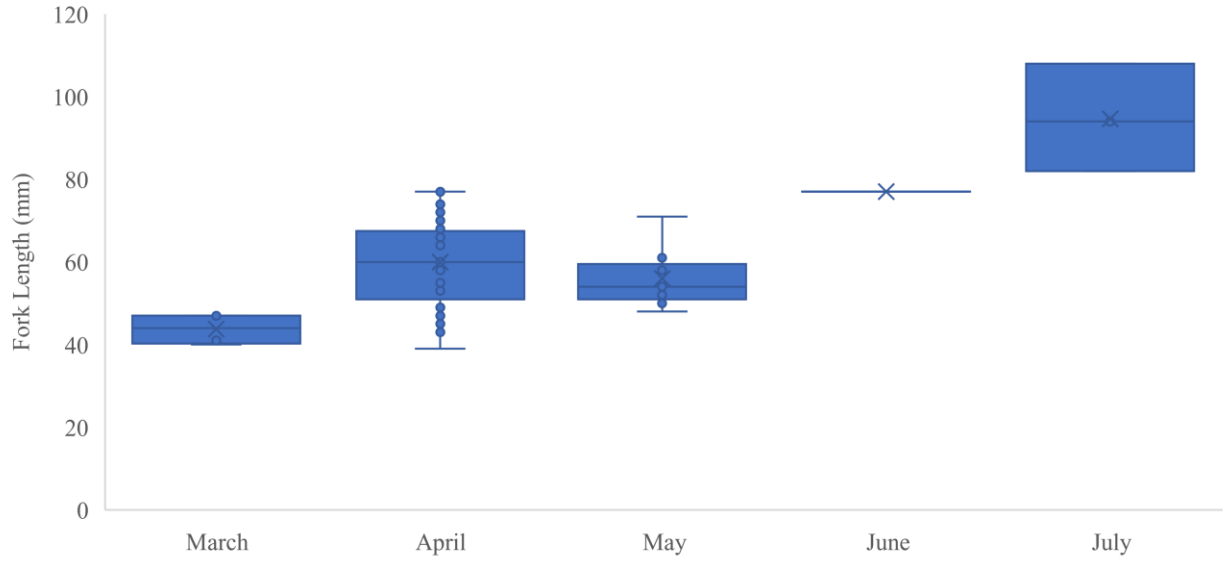

Figure 4. Boxplots of sub yearling Chinook salmon fork length reference areas, no Chinook salmon were caught within restoration area. Central line of the box represents the median, the shaded box represents the inter-quartile range (25%-75%) and the whiskers represent the 95% Confidence Interval. Dots are outliers of the 95% distribution.

Water Parameters

Dissolved oxygen (DO), salinity and temperature are graphically compared between restoration and reference areas over the monitoring period. In the Leque Island restoration area and the nearby reference areas, there were seasonal trends apparent in all three water parameters. DO decreased and temperature increased over the monitoring period (Figure 5, Figure 6). Salinity remained constant at the beginning and end with a large decrease in in both reference and restoration locations, corresponding with the spring melt (Figure 7). DO in the restoration areas were higher, on average, then the reference area starting in the month of May. The restoration area had large growths of filamentous green algae (Henrichs personal observation). This may suggest the wetted habitats in the restored area are eutrophic and can result in high biological oxygen demand and low overnight dissolved oxygen.

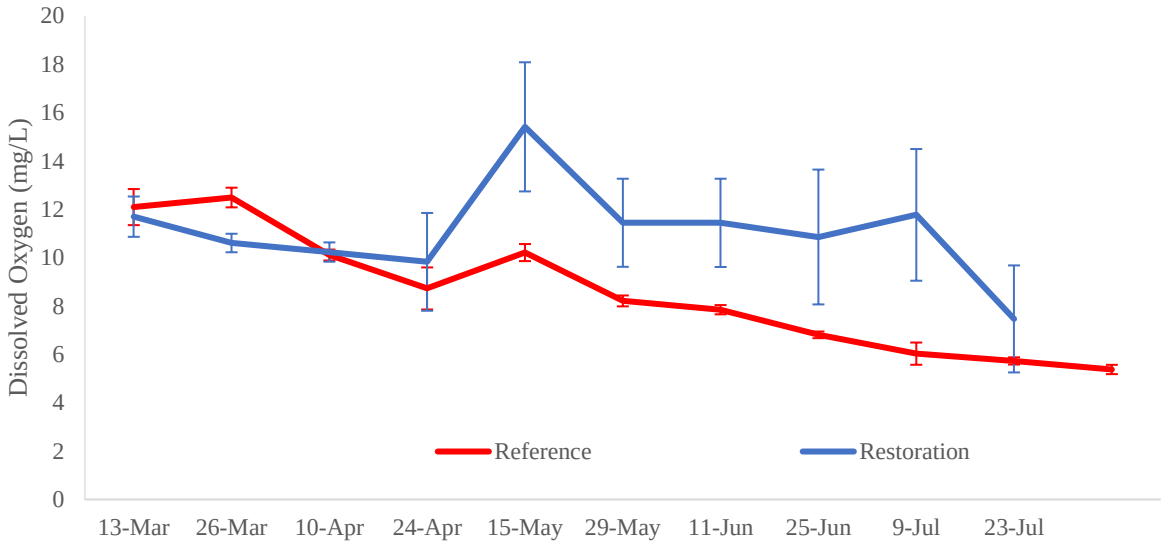

Figure 5. Average dissolved oxygen (DO) (mg/L) in the Leque Island restoration area and the adjacent reference areas over the monitoring period. DO in the restoration and reference areas decreased over the monitoring period (Restoration: start = 11.7 mg/L, end = 7.5 mg/L. Reference: start = 12.1 mg/L, end = 5.4 mg/L).

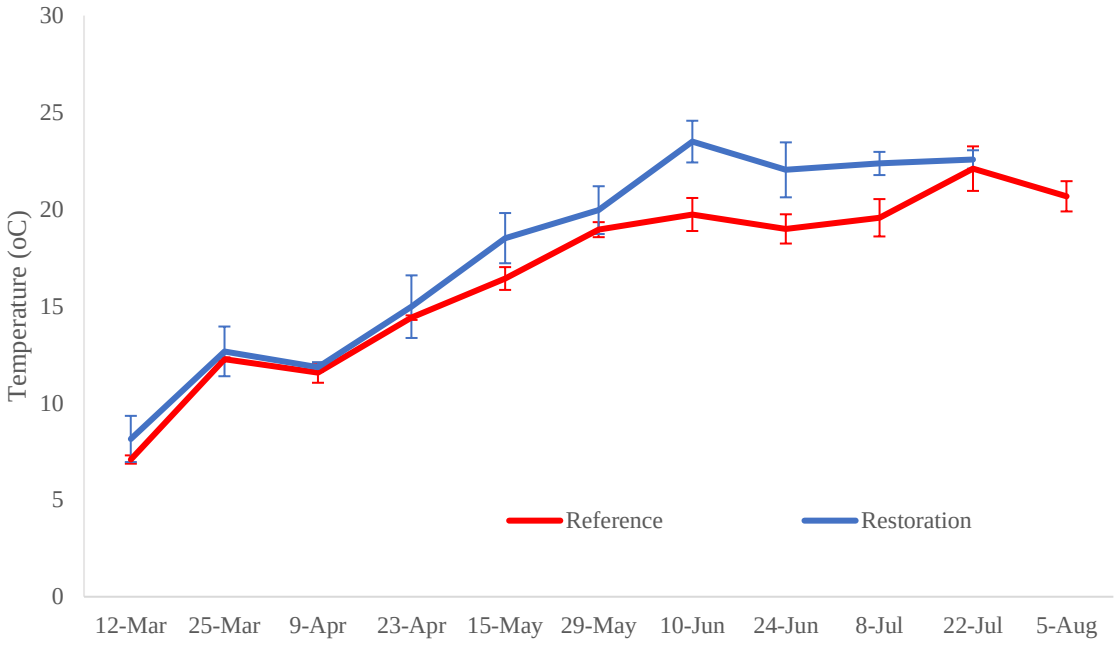

Figure 6. Average temperature (degrees Celsius) in the Leque Island restoration areas and the adjacent reference areas over the monitoring period. Temperatures increased in the reference areas from a minimum = 7.1 ^{o}C to a maximum = 22.1 ^{o}C and in the restoration areas from a minimum = 8.1 ^{o}C and a maximum = 23.5 ^{o}C.

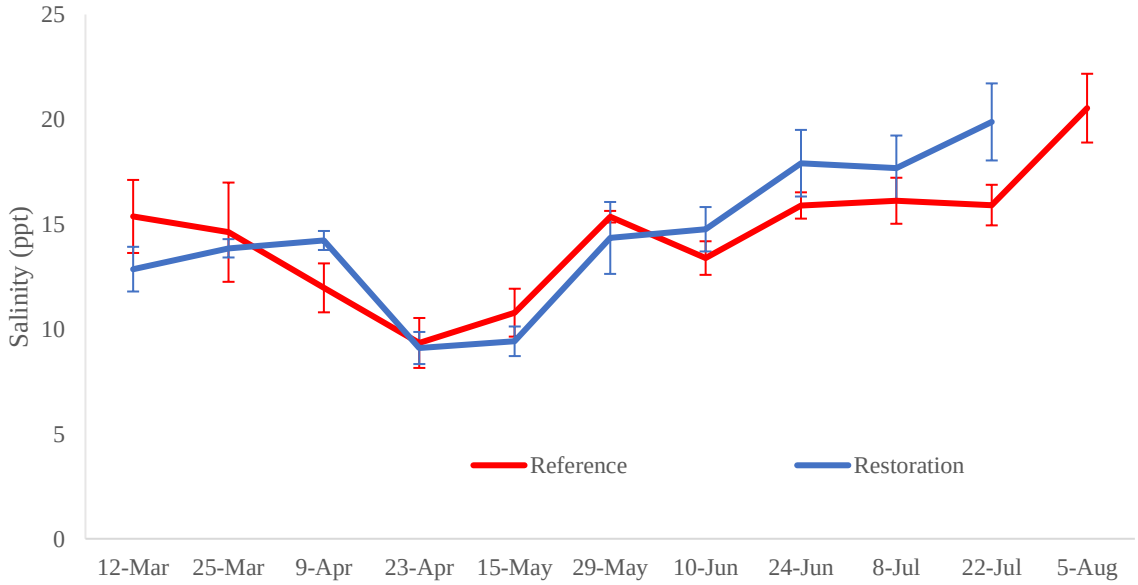

Figure 7. Average salinity (ppt) in the Leque Island restoration and adjacent reference areas over the monitoring period. Salinity increased over time in both restoration and reference areas (Restoration: start = 12.9 ppt, end = 19.9 ppt, Reference: start = 13.9 ppt, end = 18.3 ppt) with a sharp decrease in measured salinities in the month of April corresponding with the spring melt.

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