LONE TREE POCKET ESTUARY RESTORATION 2004 FISH SAMPLING AND PRE-RESTORATION PROJECT MONITORING REPORT

Eric Beamer, Aundrea McBride, and Rich Henderson

Skagit River System Cooperative
Research Program

October 2004

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INTRODUCTION

The primary objective for the Lone Tree Creek and Lagoon Pocket Estuary project is to increase the size and ecological capacity of the Lone Tree pocket estuary by restoring tidal hydrology to the historic lagoon and freshwater hydrology and sediment dynamics (transport and deposition) in Lone Tree Creek. The plans to restore tidal hydrology to the upper wetland of Lone Tree Lagoon primarily is removal of an undersized, perched culvert and replace it with a bridge, thus increasing the tidally influenced area of the lagoon (Figure 1). In the wetland area upstream of the culvert (referred to as the restoration project area) we hypothesized the following immediate (i.e., within one year after the culvert is removed) responses to restoration.

Hypothesis 1 - The tidal prism will increase above the culvert, as indicated by an increased frequency and area of tidal inundation.
Hypothesis 2 - The frequency and degree of estuarine mixing, as demonstrated by increased salinity above the culvert, will increase.
Hypothesis 3 - The fish community will change from a sparse to absent freshwater community to a more abundant and diverse community dominated by estuarine species.

This report describes pre-restoration water surface elevation, salinity, and fish use conditions. These data will be used to test the restoration hypotheses described above. We followed the protocols and schedule presented in the Lone Tree Pocket Estuary Restoration Fish Sampling Plan written by E. Beamer and others, February 2004. This report also includes recommendations for future monitoring based on this first year of data collection.

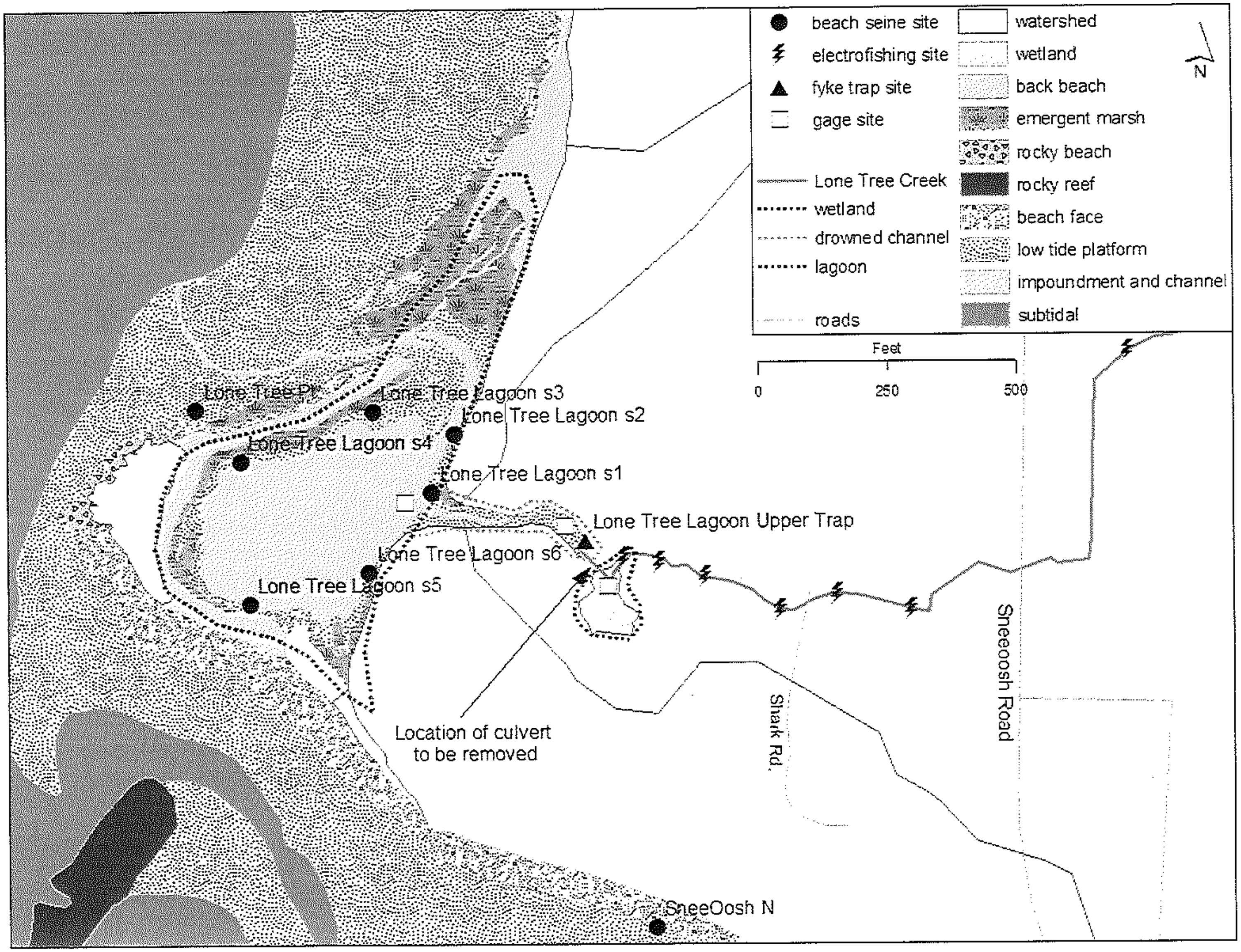

Figure 1. Location of water surface elevation, salinity, and fish use monitoring sites. Salinity was measured at all fish sampling sites and gage sites.

TIDAL PRISM AND WATER SURFACE ELEVATION

Methods

Relative water surface elevation was measured to the nearest centimeter at 3 gage stations during fish sampling. Gage sites are shown in Figure 1. Sampling started on January 14, 2004. The last sampling effort occurred on September 16, 2004. Each gage was surveyed to a benchmark located nearby so that relative elevation can be converted to tidal elevation in the future. In addition to recording the gage level, we recorded the time of observation and paired it with estimates of Lone Tree Creek discharge and tidal elevation for Ala Spit (the closest site to Lone Tree Lagoon with published tidal statistics). Lone Tree Creek discharge estimates were provided by Swinomish Planning Department. Ala Spit tidal height predictions were downloaded from the internet site: http://tbone.biol.sc.edu .

Results

Pre-project monitoring data show that sills hydraulically control each of the three impoundments: the main lagoon, the drowned channel, and the upper wetland (Figure 2). Lone Tree Lagoon is not influenced by tide until the tidal height at Ala Spit reaches approximately 7 feet or higher (Figure 2A). The drowned channel site, just downstream of the culvert, is not influenced by tide until 8 feet or higher (Figure 2B). The site upstream of the culvert, in the wetland, is not influenced by tide until tidal height reaches approximately 9 feet or higher (Figure 2C).

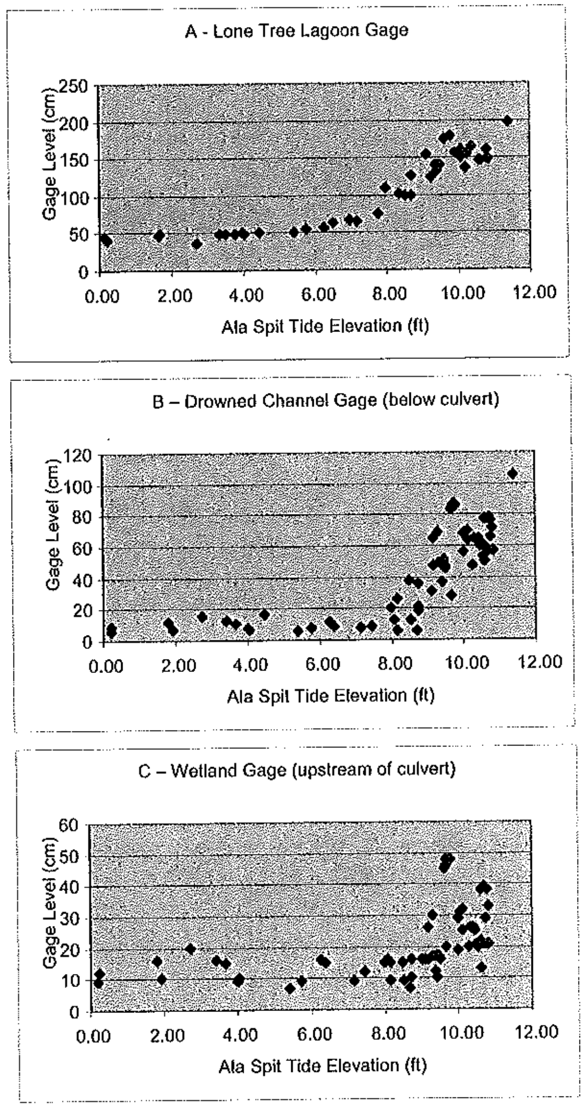

Figure 2. Relationship between predicted tidal elevation and gage height for three Lone Tree Lagoon monitoring sites. Gage levels are shown as relative water level. Results have not been converted to an elevation datum yet.

We developed pre-restoration project tidal prism models using regression relationships for all gage sites (Table 1). The independent variables are tidal level and creek flow. The response variable is water surface level at the gage site. While all regression relationships are significant, many are poor predictors of water surface level. We believe this is caused by differences in predicted and actual tidal elevation. Actual tidal elevation is influenced by climate conditions such as wind and barometric pressure. Tidal predictions do not account for these variables. We can use water surface level data collected at the Lone Tree Lagoon gage as our surrogate for the actual tidal conditions influencing the restoration project area. Models 6 and 7 in Table 1 show the results of using 'actual' tide level instead of predicted tide levels. Both these models have stronger prediction capability. Figure 3 shows the relationship between actual tide level and the gage in the drowned channel impoundment below the culvert. We see that tidal level tightly correlates to water level in the drowned channel. Referring back to Figure 2B, predicted tidal levels correlate also, but with much more scatter.

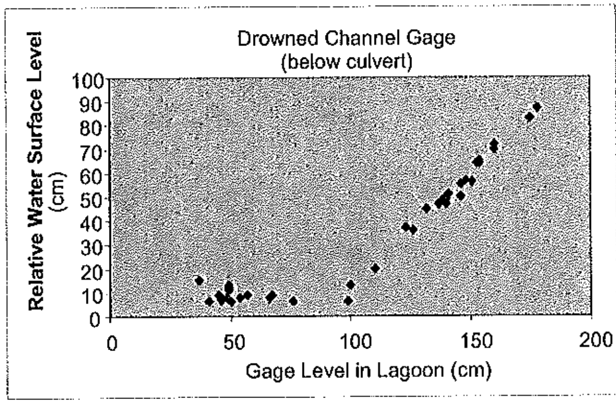

Figure 3. Relationship between actual tidal elevation and gage level. Gage levels are shown as relative water level. Results have not been converted to elevation datum yet.

Because regression models using actual tide level are precise, we will be able to detect differences in tidal influence to the restoration project area more easily. After post-restoration monitoring data have been collected we will compare the regression statistics (intercept and slope) for sites upstream and downstream of the removed culvert to determine whether restoration has increased tidal influence.

Table 1. Regression results for water surface level prior to culvert removal (ns = not significant).

Regression Model	R^2	Significance Level	Regression Coefficients	
			Tide Level	Creek Discharge (gal/min)
Model 1-Water level at Lone Tree Lagoon Gage (all data)	0.82	1.98E-15	13.37[a]	ns
Model 2-Water level at gage downstream of culvert (all data)	0.55	2.99E-12	7.34[a]	ns
Model 3-Water level at gage downstream of culvert (only data where tide strongly influences level)	0.50	2.02E-08	18.92[a]	ns
Model 4-Water level at gage upstream of culvert (all data)	0.23	1.76E-04	2.00[a]	ns
Model 5-Water level at gage upstream of culvert (only data where tide strongly influences level)	0.23	1.26E-03	6.51[a]	ns
Model 6-Water level at gage downstream of culvert (only data where tide strongly influences level)	0.99	2.11E-19	0.98[b]	ns
Model 7-Water level at gage downstream of culvert (only data where creek flow strongly influences level)	0.57	4.09E-03	0.03[b]	0.020

[a] predicted tide elevation (in ft) at Ala Spit
[b] actual tide level (in cm)measured in Lone Tree Lagoon

Conclusions and Monitoring Recommendations:

Pre-restoration project monitoring objectives for water surface elevation have been met and sufficient water surface elevation data have been collected to test restoration hypothesis 1 (effect of tidal influence). However, additional data will likely improve our ability to test this hypothesis. We plan to continue collection of these data on a monthly basis until the culvert is removed. We need to convert relative water levels to an elevation datum so each site can be compared to the others and to post-restoration monitoring results. Each gage has been surveyed to a benchmark so this can be done in the future.

ESTUARINE MIXING AND INCREASED SALINITY

Methods

Salinity was measured just under the water's surface to the nearest 0.1 ppt at the three staff gage sites during the time of fyke trapping (Figure 1). Salinity was also measured at all beach seine sites at the time of beach seining to yield an average salinity for Skagit Bay water in the vicinity of Lone Tree Lagoon. In addition to measuring salinity, we recorded the time of each observation and paired it with estimates of Lone Tree Creek discharge and tidal height for Ala Spit. Sampling started on January 14, 2004. The last sampling effort occurred on September 16, 2004.

Results

Pre-restoration project monitoring data show that average salinity varies by site. Salinity in the main lagoon averaged 21.2 ppt. Salinity in the drowned creek channel averaged 10.6 ppt. The upstream wetland averaged 3.1 ppt. We developed pre-restoration project regression relationships for all gage sites to model salinity. We found that different variables control salinity at the three sites. Three independent variables were used in regression analysis: tidal level, average Skagit Bay salinity in the vicinity of Lone Tree Lagoon, and Lone Tree Creek flow. Regression results are shown in Table 2.

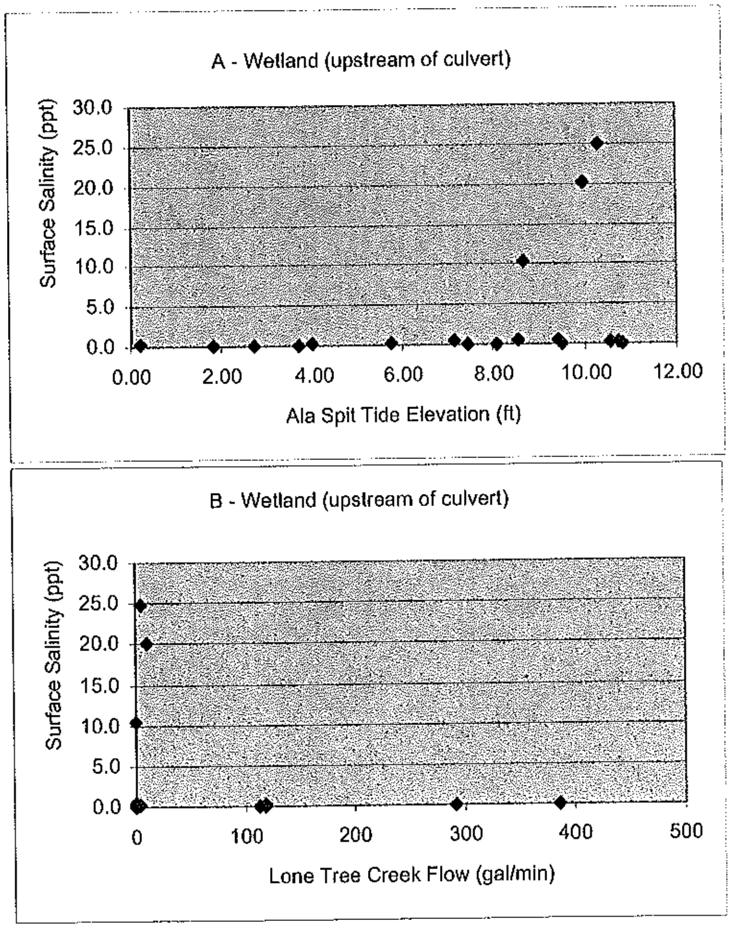

Figure 4. Relationship of salinity and tide height (A) and salinity and creek flow (B) for surface waters at the gage site upstream of the culvert.

Lone Tree Lagoon salinity is not strongly influenced by tide height or creek flow. Instead, average salinity in adjacent Skagit Bay nearshore habitat predicts Lone Tree Lagoon salinity (Model 8, Table 2). Salinity in the drowned channel impoundment of the pocket estuary is controlled by tide level and Skagit Bay salinity, but not creek flow (Model 9, Table 2). Salinity in the wetland upstream of the culvert is not predicted significantly by any variable (Model 10, Table

2). Salinity measurements upstream of the culvert were generally very low (near zero) except when the creek was low (or not flowing) and the tide was high enough to back up through the culvert (Figure 4). We do not currently have enough data to develop a statistically significant multiple regression model for this site. More measurements of salinity within the wetland at tides higher than 8.5 ft and under varying creek flow conditions are necessary.

Table 2. Regression results for salinity prior to culvert removal (ns = not significant).

Regression Model	R^2	Significance Level	Regression Coefficients		
			Predicted Tide Level (ft)	Creek Discharge (gal/min)	Skagit Bay Salinity (ppt)
Model 8-Surface salinity at Lone Tree Lagoon Gage	0.62	6.59E-03	ns	ns	0.797
Model 9-Surface salinity at gage downstream of culvert	0.72	5.39E-05	2.42	ns	1.389
Model 10-Surface salinity at gage upstream of culvert	0.29	1.41E-01	ns	ns	ns

Conclusions and Monitoring Recommendations

Pre-restoration project monitoring objectives for salinity have been met and sufficient salinity data have been collected to test restoration hypothesis 2. The fact we do not have a statistically significant salinity model for the restoration project area does not mean we can't test hypothesis 2 after culvert removal. We expect salinity in the restored area to look more like the drown channel area after culvert removal. If this is true, we will have ample ability to statistically detect change in the salinity regime in the restoration project area (i.e., wetland upstream of the culvert site) before and after restoration. However, additional data will improve our ability to test this hypothesis, especially for the site upstream of the culvert. We plan to continue collection of these data on a monthly basis until the culvert is removed.

FISH USE IN LONE TREE CREEK UPSTREAM OF THE RESTORATION PROJECT AREA

Methods

Fish sampling upstream of the lagoon in Lone Tree Creek was not part of the original monitoring plan. However, small fish were casually observed in January 2004 so we sampled the creek by electrofishing on January 22nd and 27th and again on February 4th of 2004 to determine whether salmon were present upstream of the restoration project area. Electrofishing sites are shown on Figure 1.

Results

A total of twenty-eight (28) juvenile salmon were captured during this effort including 20 age 0+ coho, 4 age 0+ chinook, 2 age 1+ coho, and 2 age 0+ steelhead (rainbow). In addition to juvenile salmon, stickleback and prickly sculpin were captured in Lone Tree Creek. No salmon were observed upstream of the culvert at Shark Road. No fish of any kind were observed above Sneeoosh Road (Figure 1).

It is likely that all salmon captured in the creek originated from areas outside of the Lone Tree Creek watershed and therefore moved into the stream via Skagit Bay. Since chinook salmon do not spawn in stream's this small, and the stream is generally dry during the time when chinook spawn, all chinook found in the creek must be non-natal in origin. Coho fry captured during electrofishing must also have originated outside the Lone Tree Creek watershed because the coho captured could not have over-summered in the creek. The surface flow in Lone Tree Creek ended on July 18, 2003 and did not resume continuously until October 6, 2003. The age 0+ coho were not young of the year sized (40 mm length). They averaged 65 mm in fork length suggesting they were progeny of 2002 parents.

Conclusions and Monitoring Recommendations:

Our results show that juvenile salmon originating from outside the Lone Tree Creek Watershed utilize the creek in addition to its pocket estuary. Actions that protect and restore fish passage and habitat conditions in the creek, especially the lower reaches, would benefit non-natal salmon.

Fish Use in the Lagoon, Restoration Project Area, and Adjacent Skagit Bay Nearshore

Methods

Shallow Intertidal Nearshore: Small net beach seine methods were used to sample shallow intertidal shoreline areas along the beaches outside of the existing lagoon (Figure 1). These sites are SneeOosh N (located southeast of the lagoon) and Lone Tree Pt (located northwest of the lagoon). Small net beach seine methodology uses an 80' (24.4m) by 6' (1.8m) by 1/8" (0.3cm) 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 wading the net "upstream" against the water current using a floating tote, and then returning to the shoreline in a ½ circle. Both ends of the net are then retrieved yielding a catch. We conducted three sets at each site per sampling day. The average area sampled by small net beach seine was 72 m^2 and the average maximum depth equaled 0.89 m.

Intertidal-Subtidal Nearshore: Large net beach seine methods were used to sample deeper intertidal-subtidal shoreline habitat at the Lone Tree Point site (Figure 1). Large net beach seine methodology uses a 120' (36.6m) by 12' (3.7m) by 1/8" (0.3cm) mesh knotless nylon net where one end of the net is fixed on the beach while the other end is set by boat across the current at an approximate distance of 60% of the net's length. After the set has been held open against the tidal current for a period of about 4 minutes, the boat end is brought to the shoreline edge and both ends are retrieved yielding a catch in the net's bunt section. We conducted three sets at this site per sampling day. The average area sampled by large net beach seine was 583 m^2 and the average maximum depth equaled 3.1 m.

Lagoon Below the Culvert: Small net beach seine methods were also used for sampling six sites located along the perimeter of the existing lagoon (Figure 1). Small net beach seine methodology is described in a previous section of this report (shallow intertidal nearshore methods). The average area sampled by small net beach seine was 72 m^2 and the average maximum depth equaled 0.52 m. One beach seine set was conducted at each of the six lagoon sites per sampling day.

Lagoon Above the Culvert: The Lone Tree Lagoon Upper Trap site samples habitat in the restoration project area, upstream of the existing lagoon (Figure 1). We sampled this area by attaching a fyke trap to the downstream end of the culvert. Our fyke trap uses a net cone constructed of 1/8" (0.3cm) mesh knotless nylon with a 2' (0.6m) diameter by 9' (2.7m) long. The net cone is sewn into a larger block net used to collect fish draining out of the channel during an ebbing tide. The block net dimensions are 60' (18.3 m) by 10' (3 m), sized to completely cutoff fish movement (except through the trap) at any tidal height. The net was set across the channel at high tide and "fished" through the ebb tide yielding a catch. We were unable to adjust the juvenile chinook catch by a trap recovery efficiency (RE) estimate using mark-recapture experiments as planned due to lack of juvenile chinook salmon at the site this year. The site completely drains at low tide so we estimate RE to be 80% based on RE estimates measured at other sites that completely drain. The tidally influenced bankfull channel area upstream of the trap is approximately 92 m^2.

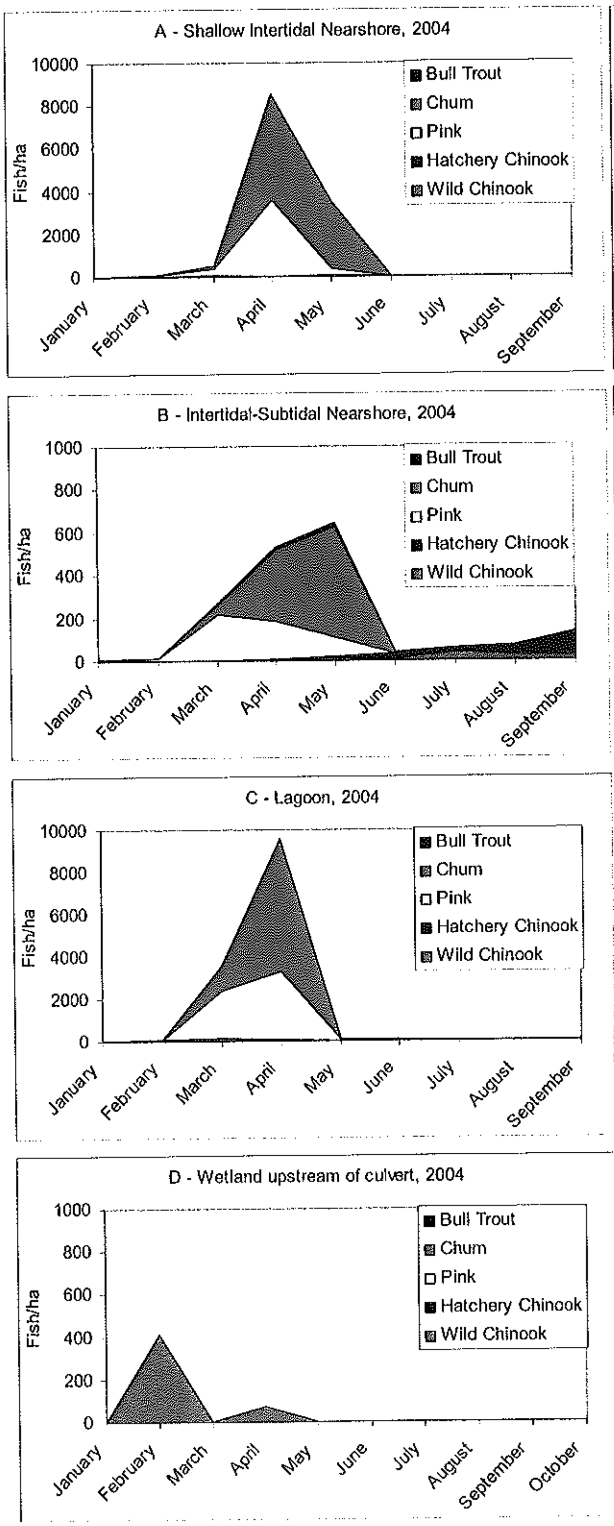

Figure 5. Salmon, trout, and char community in 2004 for Lone Tree monitoring sites: (A) shallow intertidal nearshore, (B) intertidal-subtidal nearshore, (C) lagoon, and (D) wetland upstream of the culvert

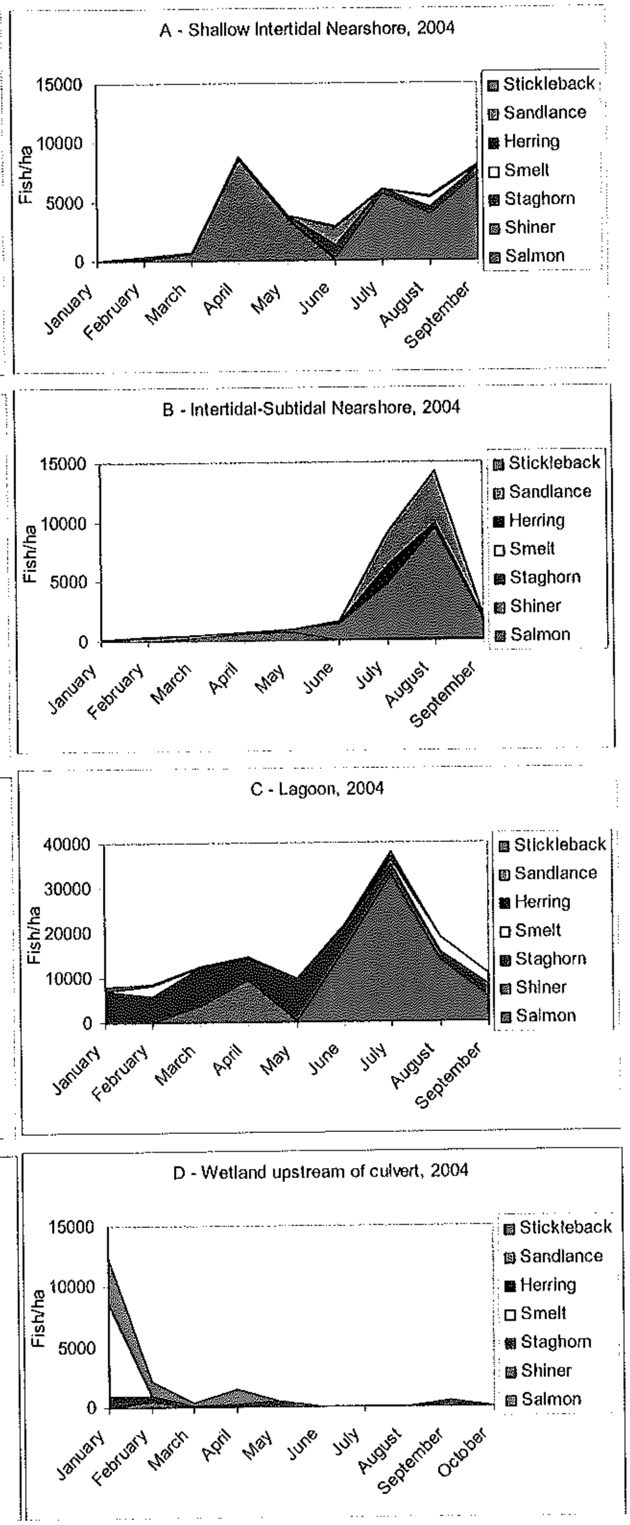

Figure 6. Fish community in 2004 for Lone Tree monitoring sites: (A) shallow intertidal nearshore, (B) intertidal-subtidal nearshore, (C) lagoon, and (D) wetland upstream of the culvert.

Results

Shallow Intertidal Nearshore: Seventy-four (74) beach seine sets were completed between February 13, 2004 and September 16, 2004. We captured a total of 2,363 fish, representing 23 different species. Complete fish catch results are available in a spreadsheet as an appendix to this report. Average monthly density is shown for the salmon (Figure 5A) and entire fish community (Figure 6A).

Age 0+ pink and chum salmon, peaking in April, dominated the juvenile salmon community. However, wild chinook salmon were present February through May at low densities (< 100 fish/ha). No hatchery chinook salmon, larger salmon, trout, or bull trout were captured in shallow intertidal habitat.

Juvenile salmon and shiner perch dominate the fish community. A clear seasonal pattern was evident. Salmon were most abundant before June and shiner perch were most abundant after June. Staghorn sculpin were consistently captured throughout the entire sampling period. Total fish density ranged between 5,000 – 9,000 fish/ha after March, and remained relatively constant compared to the seasonality of other monitored habitats.

Intertidal-Subtidal Nearshore: Eighty (80) beach seine sets were completed between January 14, 2004 and September 22, 2004. We captured a total of 14,653 fish, representing 31 different species. Complete fish catch results are available in a spreadsheet as an appendix to this report. Average monthly density is shown for the salmon (Figure 5B) and entire fish community (Figure 6B).

Similar to shallow intertidal habitat, the salmon community in deeper intertidal-subtidal habitat was dominated by age 0+ pink and chum salmon. However, the deeper and more exposed intertidal-subtidal habitat differed from shallow intertidal and lagoon habitat in that total juvenile salmon densities were lower and wild age 0+ chinook salmon were lower in density (< 40 fish/ha) and later in the year (April through September). Also, hatchery chinook salmon were present from June through September which was not the case in other monitored habitats. Adult and sub-adult bull trout were caught in January and again from March through May. The later timing of juvenile chinook salmon caught in the deeper intertidal-subtidal habitat characterizes a natural progression of habitat utilization from shallow protected areas to deeper and more exposed habitats, as fish grow larger throughout the summer.

Looking at the whole fish community, juvenile salmon and shiner perch dominate intertidal-subtidal habitat. The later salmon peak in the deeper habitat, compared to shallow nearshore, is present, but subtler because so few juvenile salmon are captured in the deeper habitat compared to other species. Juvenile salmon are more abundant before June while shiner perch dominate the fish community after June. Staghorn sculpin, surf smelt, and stickleback were all captured throughout the sampling period, although generally at low densities. Total fish density was not constant over the sampling period. We observed a strong peak in overall fish density during July and August. In addition to shiner perch, sandlance and herring made up a significant part of the catch during this time.

Lagoon Below the Culvert: Seventy-eight (78) beach seine sets were completed between January 14, 2004 and September 16, 2004. We captured a total of 8,334 fish representing 16 different species. Complete fish catch results are available in an Excel spreadsheet as an appendix to this report. Average monthly density is shown for the salmon (Figure 5C) and entire fish community (Figure 6C).

Age 0+ pink and chum salmon, peaking in April, dominated the juvenile salmon community. Wild age 0+ chinook salmon were present February through May at densities twice those observed in shallow intertidal habitat. Hatchery chinook salmon were caught in June, but not in later months. No larger salmon, trout, or char were captured in lagoon habitat.

Juvenile salmon and shiner perch again dominate the seasonal composition of the fish community. Juvenile salmon are more abundant before June while shiners are more abundant after June. Salmon density was similar to those observed in shallow intertidal habitat (peak in April at over 9,000 fish/ha). But, shiner perch density was three or four times higher than any other monitored habitat (peak in July at nearly 33,000 fish/ha). Staghorn sculpin and stickleback are common throughout the sampling period. Staghorns dominated during winter months. Juvenile and post-larval surf smelt were also an important part of the fish community early (January and February) and later (July through September) in the year.

Lagoon Above the Culvert: Eleven (11) fyke trap sets were completed between January 14, 2004 and October 14, 2004. We captured a total of 156 fish representing seven different species. Complete fish catch results are available in an Excel spreadsheet as an appendix to this report. Average monthly density is shown for the salmon (Figure 5D) and entire fish community (Figure 6D). No sampling was done during June or July because the creek was dry and daytime high tides were not high enough to backwater through the culvert on days when other Lone Tree sampling was done. No fish were caught during the August or October sampling.

We captured age 0+ chinook salmon in February and April – the only salmon species captured at this site (Figure 5D). This site recorded the earliest (February) and highest density (408 fish/ha) of juvenile chinook salmon for all monitored habitats in 2004 possibly suggesting the lower salinity water from the creek is an attraction to very young chinook salmon and/or preference to this type of habitat.

Overall fish densities upstream of the culvert were low compared to all other monitored habitats and show a strong a decline over the season (Figure 6D). This pattern is the reverse compared to other monitored habitats where higher fish abundance occurred well after the January peak found at this site. Surf smelt (post larval and juvenile sized) and stickleback were most abundant early in the season. Staghorn sculpin and stickleback were present in the catch on the majority of sampling days. Both these species can tolerate a wide range of salinities, including very low salinities. No purely freshwater (saltwater intolerant) fish species were captured. Shiner perch were present in late summer, but were not abundant (< 300 fish/ha) compared to other monitored sites where shiner perch densities are consistently in the 1,000s – 10,000s from July through September (Figure 6). It is likely that the lack of shiner perch at this site is a response to lower salinities and an infrequent connection to the lagoon and surrounding Skagit Bay nearshore. If true, shiner perch abundance might be a good biotic response variable to restoration of tidal and salinity influence for this area.

Conclusions and Monitoring Recommendations:

We have met the planned pre-restoration project monitoring objectives for fish sampling and sufficient pre-restoration project fish data have been collected to test restoration hypothesis 3 (response of fish community to restoration). However, another season of data would benefit our post-restoration analysis. Lone Tree Lagoon chinook densities were unusually low in 2004 compared to other years (Figure 7A) probably due to the very low numbers of juvenile chinook salmon migrating from the Skagit River (Figure 7B). The monitoring results in 2004 may pose a problem in interpreting post-restoration monitoring data if juvenile salmon populations are much larger than the 2004 season. Another season of monitoring would also provide more information on other variables that may affect habitat use at Lone Tree Lagoon. For example, high Skagit River flow events may be another factor in explaining abundance of chinook salmon in Lone Tree Lagoon. High flow events may be a mechanism for delivering juvenile salmon to nearshore areas from their natal river. In 2003, a flood event occurred in January (after many chinook fry had emerged from their redds) and chinook abundance in Lone Tree Lagoon more than doubled compared to the previous year, even though both years had similar juvenile chinook outmigration population sizes (Figure 7B).

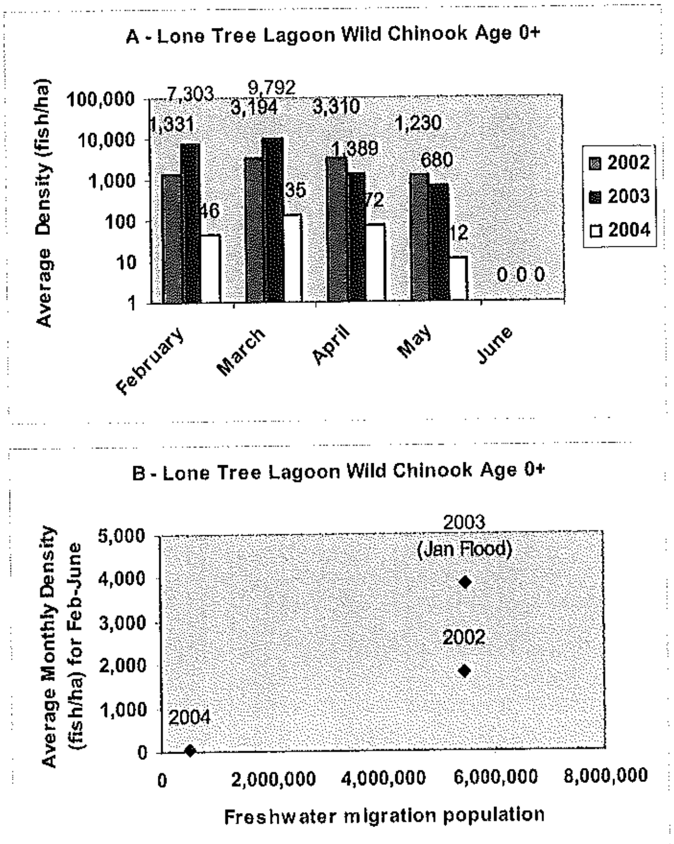

Figure 7. (A) Monthly average juvenile chinook salmon density in Lone Tree Lagoon. Density is shown above bars. (B) Relationship between juvenile chinook salmon density in Lone Tree Lagoon and Skagit River chinook salmon outmigration population size. Outmigration estimates are from WDFW.

We plan to continue data collection at all fish monitoring sites on a monthly basis until the culvert is removed in late summer of 2005. Hopefully the 2005 season will have larger juvenile salmon populations so we will have a better opportunity to observe where juvenile salmon congregate within the existing lagoon and the area upstream of the culvert. Also, variability in the entire fish community may be significant annually. An additional pre-restoration monitoring season would help us interpret post-restoration project results for the entire fish community.

We do not recommend or plan to implement any specific changes or additions to monitoring at sites in the lagoon below the culvert or adjacent nearshore area. For fish sampling above the culvert, we can improve our estimates of fish density with additions to our current monitoring. We converted fyke trap catches to density based on assumptions of trap recovery efficiency. Future monitoring will conduct recovery efficiency tests to calibrate the catch data. Also, we adjusted the fyke trap catch data by an estimate of bankfull channel area upstream of the trap. However, different combinations of tidal height and creek flow change the actual wetted area our gear samples. Future monitoring will develop a gage height to wetted area or volume relationship so that fyke trap data can be more accurately compared to beach seine-derived fish densities.

ACKNOWLEDGEMENTS

We thank the Skagit Marine Resources Committee and Northwest Indian Fisheries Commission for their participation in funding this effort. The Swinomish Tribal Community and Thousand Trails graciously provided access to the Lone Tree Lagoon study area. The Swinomish Tribe's Planning Department collected Lone Tree Creek stream flow data, which is critical to understanding certain habitat conditions within the study area. Thank you to Karen Wolf for her help in making Figure 1. Lastly, we thank our field technicians: Bruce Brown, Jason Boome, Donald Damien, Ed Williams, John Grossglass, and Shaun Beasley for their diligent field efforts collecting data often at odd hours of the day.