Stillaguamish Tribe of Indians

Natural Resources Department

Stillaguamish Estuary Use by Juvenile Chinook
Final Report

June 2009

FY 2005 Pacific Coastal Salmon Recovery Funding

Introduction

In March 1999, Chinook salmon (*Oncorhynchus tshawytscha*) originating from the rivers and streams emptying into Puget Sound were listed as threatened under the Endangered Species Act (ESA). The decline of these fish populations in the Puget Sound region and more specifically the Stillaguamish watershed is not a recent phenomenon; populations of all salmonid species have been below their historic sizes for decades (WDF et al, 1993). A variety of factors have been implicated in the decline of the Puget Sound Chinook populations including: riparian and upland clearing, loss of wetland/beaver pond habitat, fish passage barriers, water quality degradation, over harvest, increases in peak flows, and perhaps least understood, estuarine saltmarsh and tidal channel loss (SIRC 2005). A high priority data gap identified in the watershed is a "nearshore habitat inventory and (habitat) use by anadromous and forge fish" (STAG 2000)

Historically, the land composing the Stillaguamish lowlands was a mixture of different forest types and wetlands with the active meandering channels of the Stillaguamish River cutting across the floodplain. Where the river met the salt water, a well-developed network of blind tidal channels drained large areas of saltmarsh wetland (Collins 1997). The lower floodplain also contained numerous, large, channel-spanning log jams that maintained adjacent subsidiary sloughs (IBID). As with other Puget Sound rivers, the historic Stillaguamish floodplain/estuary had an abundance of complex freshwater and estuarine habitat that helped to support healthy Chinook populations. However, since the 1870's, most of the forest canopy of the lower floodplain has been removed and the land converted to agricultural uses, many of the salt marsh and blind tidal areas have been diked and filled, and the large logjams have been removed to aid navigation of the main river channel (IBID). The result has been a loss of habitat complexity to a point where the watershed no longer supports the abundance of salmon that it did in the middle 19th century.

Prior to European settlement in the 1870's, there were roughly 4,448 acres of salt marsh habitat connected to the Stillaguamish River (IBID). By 1886, settlement of the floodplain had resulted in significant diking activity and the destruction of two thirds of the original salt marsh. By 1968, just 15% of the original salt marsh remained with a similar loss of blind tidal channels. From 1968 to the late 1990's, there was an accretion of some 863 acres of new salt marsh in Port Susan and Skagit Bay, however it lacked the well-developed network or tidal channels and was not of the same quality as the salt marsh that was destroyed (IBID).

It has been documented that ocean-type Chinook smolts use estuaries and nearshore areas extensively en route to the ocean (Northcote 1976, Levy and Northcote 1981). As both an area to adjust to the saline environment and an important feeding ground, estuaries provide critical habitat for a vulnerable life stage of the Chinook (Wedemeyer et al. 1980, Simenstad et al. 1982). It has even been postulated that total marine survival (juvenile to adult) of ocean-type Chinook is determined by the habitat conditions and food resources available in the estuary during this critical outmigration period (Simenstad et al. 1990, Magnusson and Hilborn 2003). Considering this information, it is probable that the loss of more than 75% of the estuarine habitat connected to the Stillaguamish watershed could be a major factor affecting the present size of the Chinook population.

Estuarine habitat condition may not be the most significant driver in the decline of the Stillaguamish Chinook; data on the variability in freshwater production must be examined to investigate whether freshwater habitat conditions may also be a significant factor limiting recovery. As is the case in the estuary, upland freshwater habitats have been significantly reduced from their former quality and extent. To gauge the effect of freshwater conditions on Chinook salmon populations, the Stillaguamish Tribe began a smolt-trapping project on the lower river in 2000. Fishing from February to June of each year, the trap captures emigrant salmonid smolts and collects data on size, timing and magnitude of migration for all species of Pacific salmonids. The project estimates the number of juvenile Chinook produced from the basin annually, and allows (using data from adult spawner surveys) an estimate of the annual egg-migrant survival rate. This year-to-year freshwater survival estimate has allowed the Tribe to identify peak flows as the major factor limiting freshwater production, while providing freshwater production data to help identify trends in estuary utilization by juvenile Chinook smolts (Griffith et al. 2009).

Between 2003 and 2007, the Stillaguamish Tribe Natural Resource Department sampled a range of locations in Port Susan in an effort to understand the impact of habitat degradation on the Stillaguamish Chinook populations. In the 2003, the Tribe was awarded a grant to document the current extent and distribution of habitat (eelgrass, saltmarsh, sandflat, mudflat, etc) accessible to juvenile Chinook during their estuarine residence. Under this grant, detailed color orthophotos were taken of the estuary, and habitat polygons were GPS mapped in the field and subsequently digitized into a GIS database. This is the first time detailed habitat information has been collected for the Stillaguamish estuary, and has allowed biologists to quantify the saltmarsh (and the associated blind tidal) habitat in the Stillaguamish estuary (Griffith 2005), and compare it to historical estimates. An additional grant in 2004 provided funds to monitor the food resources available to juvenile Chinook during their estuarine residency.

Analysis of the habitat mapping and food resource data suggests that the existing estuarine habitat in Port Susan is in relatively good shape, however marsh and shrub/scrub habitats are only a fraction of their former extent (Griffith 2005); high quality estuarine habitat is not much more than 15% of what was available historically. On the Skagit river to the north (with an estuary similarly reduced from its historic extent), there is evidence of density dependence within the more productive habitats (blind tidal channels, salt marsh, etc.) used by juvenile Chinook (Beamer et al. 2003). During years of high smolt abundance, densities plateau and growth rates begin to decline. This evidence has led Beamer to conclude that rearing area in the estuary is one of the important factors limiting Chinook recovery in the Skagit, and the some of the stakeholders in the basin have begun to focus restoration efforts accordingly. However, there is insufficient data to draw similar conclusions about the Stillaguamish estuary. Given this lack of information, the local watershed planning group, the Stillaguamish Implementation Review Committee (SIRC), states in their Chinook Recovery Plan for the Stillaguamish (2005) that a high priority is to "analyze juvenile Chinook salmon use of estuarine and lower river habitat (type of habitat used and timing)".

The Tribe's desire to obtain this data evolved into a pilot study (Stillaguamish Tribe 2005) examining juvenile Chinook distribution in the estuary. The main objectives of the pilot project were to test seining methods, select sites, and capture Chinook salmon throughout the spring outmigration. The pilot study laid the groundwork for the data collection efforts detailed in this report. From 2005-2007, the Tribe sampled four main habitat types in the Stillaguamish estuary (blind tidal, distributary, intertidal open beaches, and pocket estuaries) on a monthly basis from the late winter till mid summer months. The following narrative reviews methods, presents our results from the 2004-07 sampling seasons, and describes how the data can help support and guide the Chinook recovery efforts underway in the Stillaguamish watershed.

Methods

During the pilot study in 2004, the Tribe tested beach seining methods and scoped sampling sites. Based on this work, sampling methods were standardized and remained the same through the 2005-07 seasons. The budget allowed for monthly sampling of approximately eleven sites with another two sites sampled on a more sporadic basis (Figure 1). The Port Susan estuary is quite shallow even at high tide, and sites were selected based on their accessibility over a range of tidal elevations. Additionally, sites were stratified across the various areas in Port Susan in an effort to represent the range of habitats available to juvenile Chinook during their estuarine residence.

From February to August of each year, the estuary was beach seined on a monthly basis. Sites were broadly categorized as either blind tidal, delta distributary, intertidal beaches, or pocket estuary. Most sites were sampled monthly, however equipment breakdowns and tidal cycles conspired to limit the number or visits to certain sites (please see Figure and Table 1.). Among the sampling sites were two pocket estuaries, defined as sheltered bodies of water with reduced salinities, not connected to the Stillaguamish River mouth (Triangle Cove and Iverson/Lona). These sites were sampled as part of a regional effort documenting Chinook use of pocket estuaries in the Whidbey basin. The Stillaguamish Tribe was contracted by the Skagit River System Cooperative to sample these sites more intensively than Pacific Coastal Salmon Recovery funds would allow.

The net employed was made of 1/8 knotless mesh and measured 6'x 80', tapered on both ends. Other net styles (one much larger, along with a similar sized net with variable mesh sizes) and deployment methods (Puget Sound Protocol among others) were tested, however it the "small net method" developed by Skagit River System Cooperative (SRSC 2003) was settled on as best. This method does a good job of capturing "fry" and "parr" sized Chinook and was felt to be the most appropriate for the habitats sampled in Port Susan. At most sites, one end of the net was fixed on shore, and the remainder was pulled "upstream" (against the tidal current, using a floating tote to hold the net) and set in a semicircle (please see the photo on the cover of this report).

At the West and South Pass sites (often too deep to wade), however, the small method was modified and net set by boat. In these instances, one end of the net was fixed on shore and the boat pulled the other end "upstream". Subsequently, the boat brought the other end to shore, and the net retrieved. Regardless of the exact setting method, three sets were made at each sampling site, with each set separated by at least 50 feet of un-sampled beach. The field crew evaluated each set to determine what percentage of a perfect half circle the deployed net mirrored; this net "%" was recorded on the data sheet (please see Appendix 1. Datasheet)

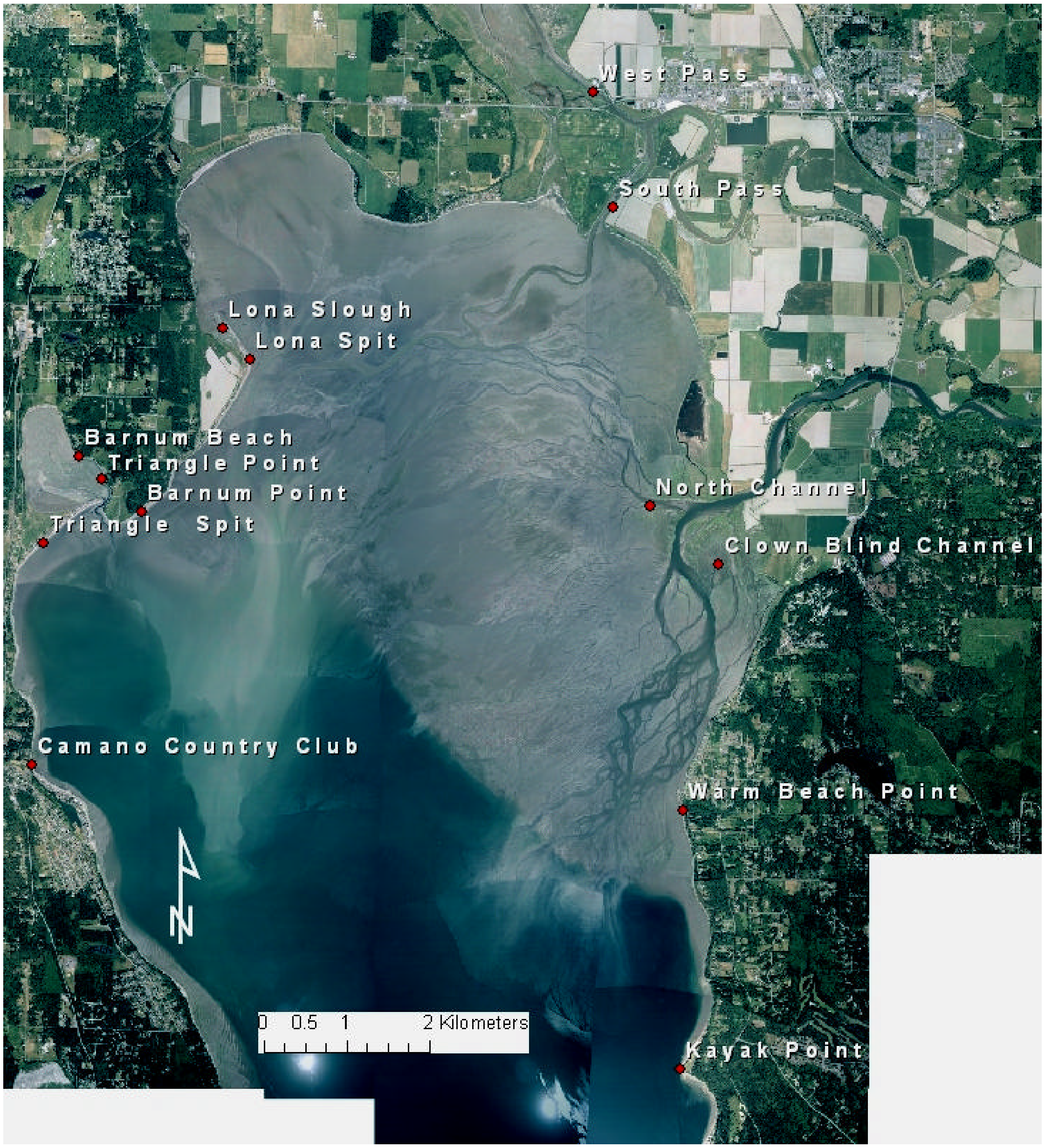

Figure 1. Map of the Port Susan Beach Seining Sites. The Stillaguamish River is visible in the upper right of the photo, its flow enters Port Susan via Hatt Slough (to the North Channel) and the Old Mainstem (to West and South Passes).

Catches from each set were held in buckets until the third set was completed. All fish were identified to species and enumerated, while the first 20 of each species were measured. Water temperature, salinity, and depth along with substrate and vegetation types were recorded for each sampling location. All Chinook and yearly coho were examined for Coded Wire Tags (CWTs), and a small number of hatchery Chinook were lethally sampled to extract CWTs and stomachs for further analysis. The stomachs and heads were sampled opportunistically; the analysis of these samples awaits funding.

Data Analysis

Data were collected on all species encountered while sampling, however this report focuses specifically on Chinook salmon juveniles. Catches were highly variable set to set and year-to-year, so summaries of the data are presented here to better illustrate trends in estuarine use. To remove the confounding effects of hatchery production on size, behavior, and timing, only natural origin Chinook (NOR) data is focused on here. For analysis purposes, sampling sites were organized into four categories: Blind Tidal (Clown Channel), Distributary (West and South Passes, North Channel), Intertidal (Kayak, Warm Beach, and Barnum Points; Camano Country Club, Triangle and Lona Spits), and Pocket Estuary (Lona Slough, Barnum Beach, Triangle Point) (Table 1.). For a given month in a given year, all data was pooled and summarized within each of these four categories to better show trends over time and habitat type. Based on the size of the sets (net % and style of set), Chinook catches were standardized to fish per hectare of habitat sampled. To add depth to the analysis, mainstem smolt production data from the Stillaguamish was used in plots to explain some of the year-to-year variability in habitat use. Mainstem smolt length data is also presented alongside lengths measured from Chinook encountered in the estuary, again to help explain year-to-year variability. Each year a screw trap operates in the mainstem Stillaguamish from February to June, estimating the total number of HOR and NOR Chinook smolts leaving the system.

Table 1: Characteristics of Seine Sites, and Sampling Frequency.

Site Name	Category	Typical Veg. Type	Typical Substrate Type	Total Sets
Clown Channel	Blind Tidal Channel	Unvegetated	Mud	67
North Channel	Distributary	Unvegetated	Sand	75
South Pass	Distributary	Unvegetated	Mud	55
West Pass	Distributary	Unvegetated	Mud	55
Barnum Point	Intertidal	Unvegetated	Fines with gravel	64
Camano Country Club	Intertidal	Unvegetated	Gravel	65
Kayak Point	Intertidal	Unvegetated	Gravel	80
Lona Beach	Intertidal	Unvegetated	Fines with gravel	30
Triangle Spit	Intertidal	Unvegetated	Gravel	60
Warm Beach Point	Intertidal	Unvegetated	Sand	76
Barnum Beach	Pocket Estuary	Unvegetated	Fines with gravel	64
Lona Slough	Pocket Estuary	Unvegetated	Mud	27
Triangle Point	Pocket Estuary	Unvegetated	Fines with gravel	42
			Total Sets	760

Results

Catch Summary, all seasons combined

Typically, the first beach seine set of the year occurred in February and the last in August, however some years weather truncated this schedule slightly. Over seven hundred and fifty sets were made throughout the 2004-07 seasons at the sampling sites (Figure 1 & Table 1), capturing thousands of fish across all of the sampling locations. The four most abundant species in the catches [shiner perch (*Cymatogaster aggregata*), three spine stickleback (*Gasterosteus aculeatus*), surf smelt (*Hypomesus pretiosus*), and peamouth chub (*Mylocheilus caurinus*)] comprised nearly 75% of all fish captured, with salmonids accounting for approximately sixteen percent of the total catch (Figures 2& 3). Most of the ultra abundant species were encountered in all of the habitats sampled, except peamouth chub, which were only encountered in the distributary and blind tidal channels of the Stillaguamish delta.

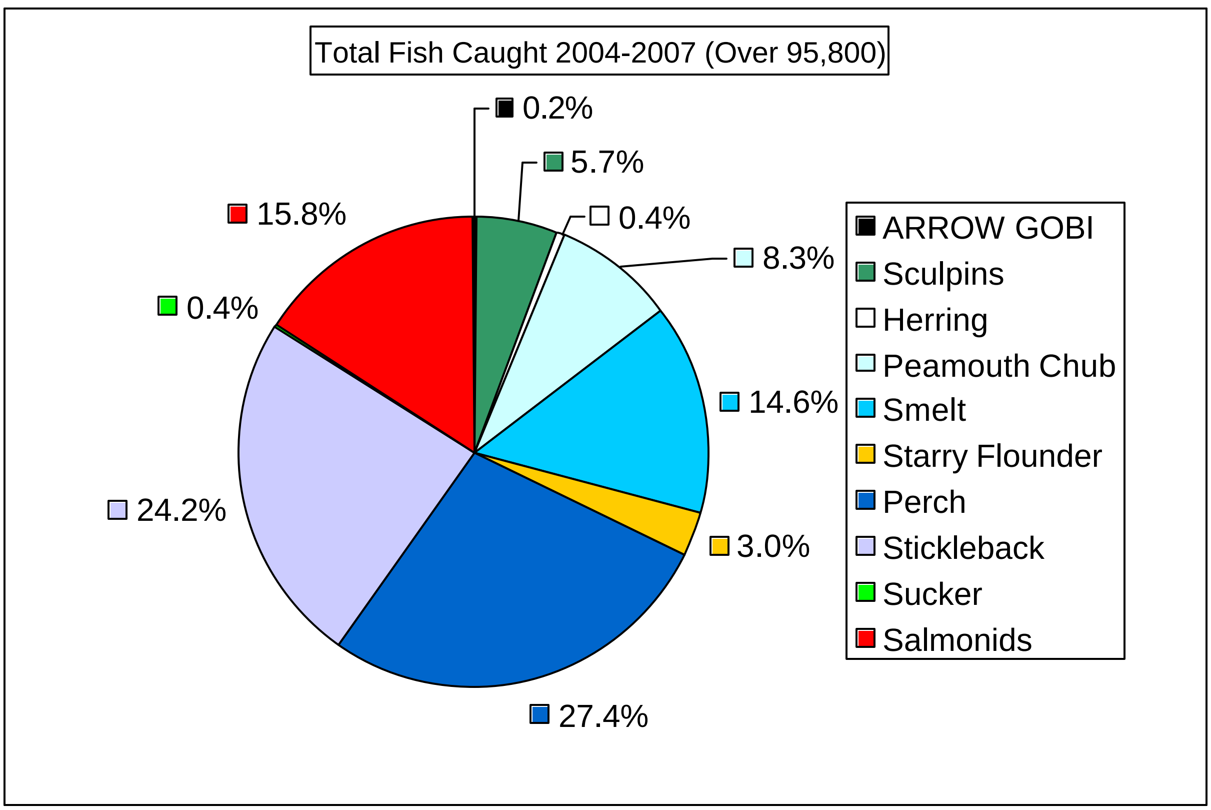

Figure 2. Catch breakdown for the most abundant species, all sets combined from all sites. There were numerous species where only a handful were captured over the years of sampling. These species were omitted from this figure.

The most abundant salmonids encountered across all habitat types were chum (*Oncorhynchus keta*) and pink (*O. gorbuscha*) salmon (Figures 3-6). Depending on the habitat type, chum salmon made up 50-80% of the salmonids encountered in catches. Pinks juveniles were only encountered in large numbers during even years (2004,2006), yet they still comprised over 15% of the salmon encountered over the duration of the study and upwards of 25% in some of the habitats sampled. Natural (NOR, or “wild”) and hatchery origin (HOR) Chinook (*O. tshawytscha*) smolts were a large percentage of the catch in some habitats (20-30% in distributary and blind tidal) and a much smaller percentage of the catches in intertidal and pocket estuary habitats (Figures 3-6). Coho (*O. kisutch*) salmon exhibited similar habitat use patterns as Chinook juveniles. The data (lengths and numbers) involving non-Chinook catches were collected and entered into a database, however it is not discussed further in this report.

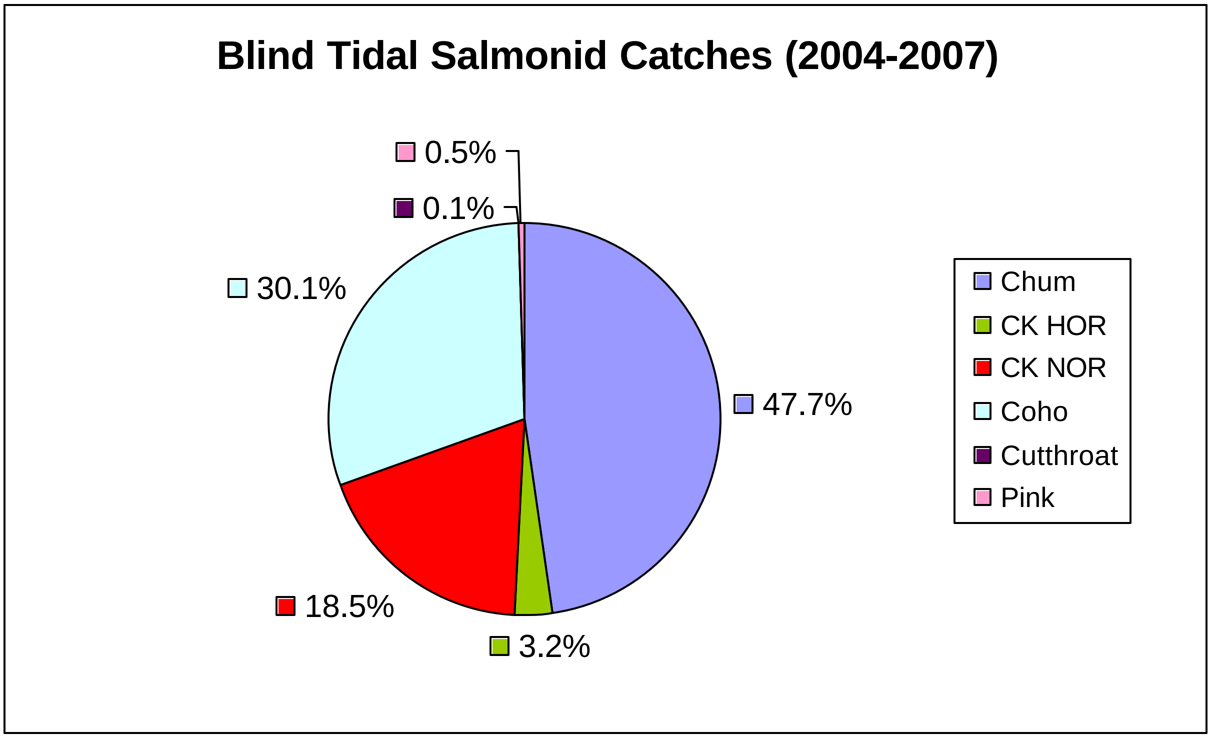

Figure 3. Breakdown of salmonid catches in blind tidal habitat. CK stands for Chinook. NOR is "wild" and "HOR" is hatchery.

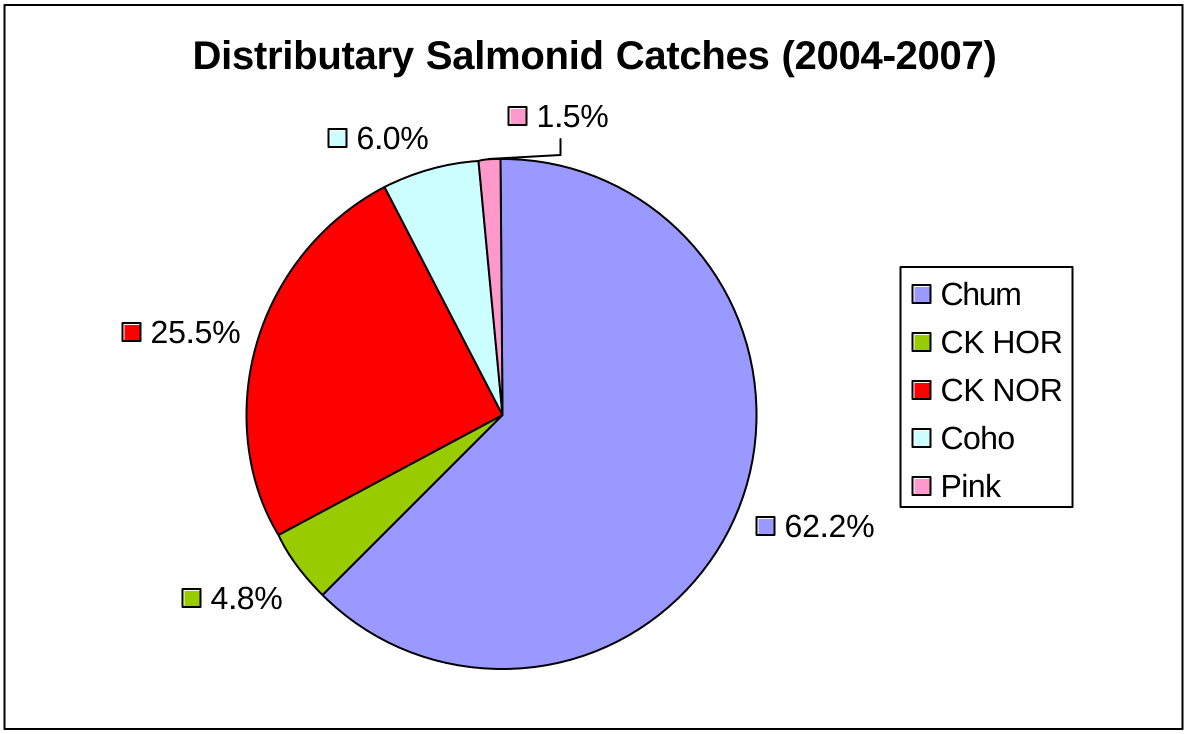

Figure 4. Breakdown of salmonid catches in distributary habitats of the Stillaguamish delta.

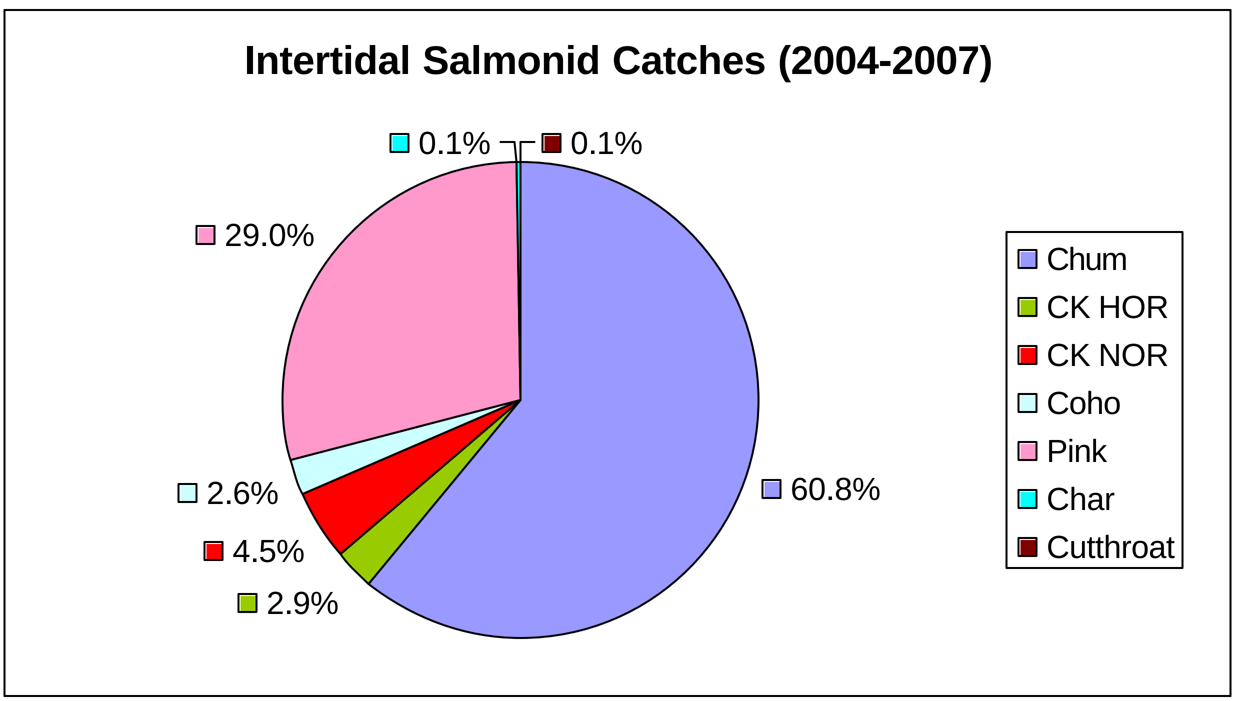

Figure 5. Breakdown of salmonid catches in intertidal habitats of Port Susan.

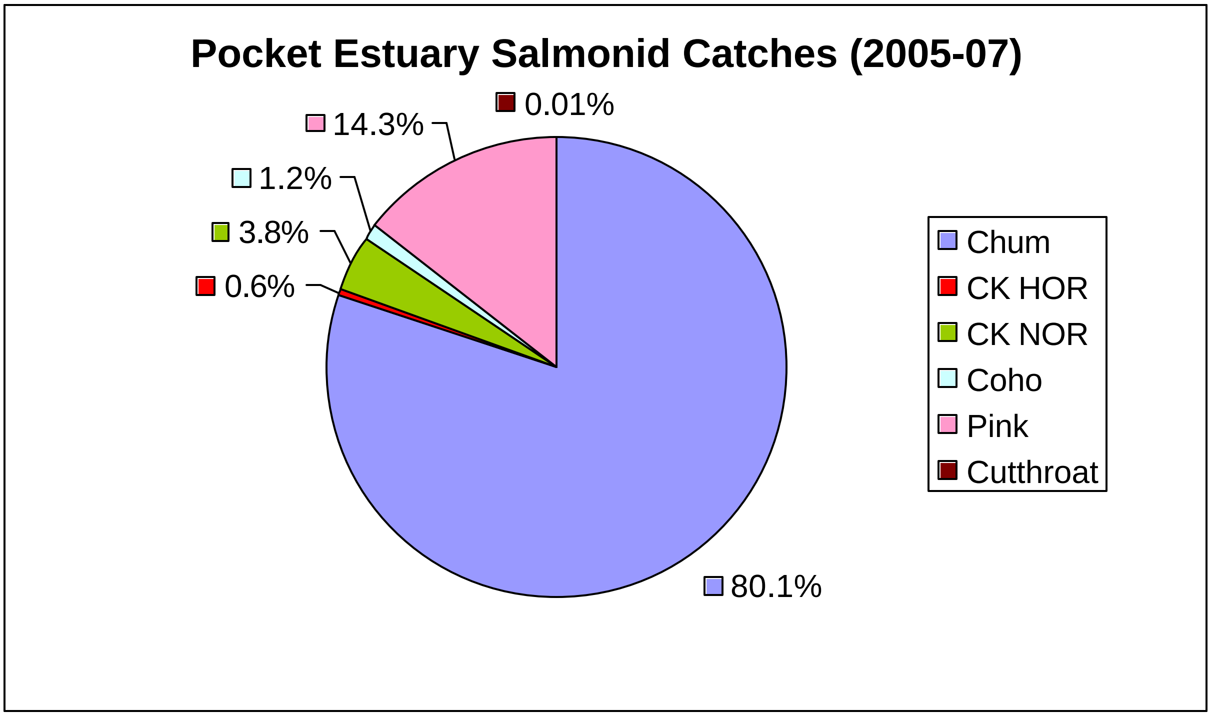

Figure 6. Breakdown of salmonid catches in pocket estuary habitat in Port Susan

Juvenile Chinook: Patterns of estuary use, sizes during residence.

Chinook juveniles were captured across all habitat types and months sampled. The highest densities (> 2000 per Ha) of Chinook were observed in blind tidal habitat (Figure 7.) with smaller (but still significant) densities (~500-1000 per Ha) observed in distributary, intertidal and pocket estuary (Figures 8-10). The patterns of use were slightly different in each of the habitats sampled, with uni-modal distributions primarily observed each year in distributary and blind tidal habitat, and bimodal distributions observed in intertidal and pocket estuary habitats (Figures 7-10). Depending on the habitat and the year, there were differences in which month was the absolute peak in abundance; generally April-June for blind tidal and distributary habitats, with additional peaks slightly earlier and later for intertidal and pocket estuary habitats. There were some exceptions to these patterns in some years and some habitats, however they generally held true throughout the seasons sampled during this study. A figure of the timing of the mainstem Chinook NOR smolt outmigrations (2004-2007) is included for perspective (Figure 11.)

The Chinook juveniles captured across the range of habitats exhibited similar growths patterns as the seasons progresses each year. In the late winter/early spring, small (<55mm) "fry type" migrants (Beamer et al. 2003) were encountered in all habitats sampled (Figures 12-15); some of these fry were rearing in their natal delta (west and south passes, north and clown channel sites), while others were encountered far from their natal rivers in open beach (Camano CC, kayak and warm beach points, etc.) and pocket estuary habitat (Triangle and Lona). As the seasons progressed (May onward), larger "parr type" migrants (55-100mm) were encountered across all of the habitats and sites. As parr grew beyond 100mm they were not encountered frequently; this size was usually attained about the same time that catches in all habitat types dropped near zero (Figures 7-10, 12-15).

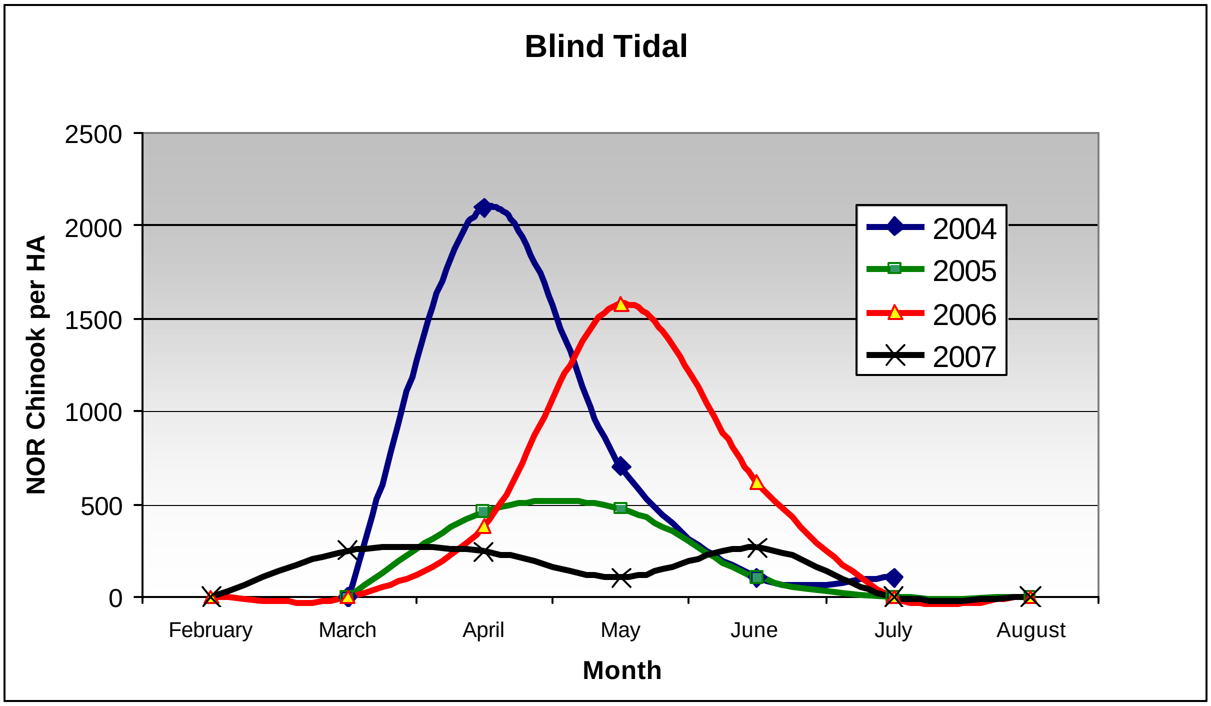

Figure 7. NOR Chinook density in blind tidal habitat 2004-2007.

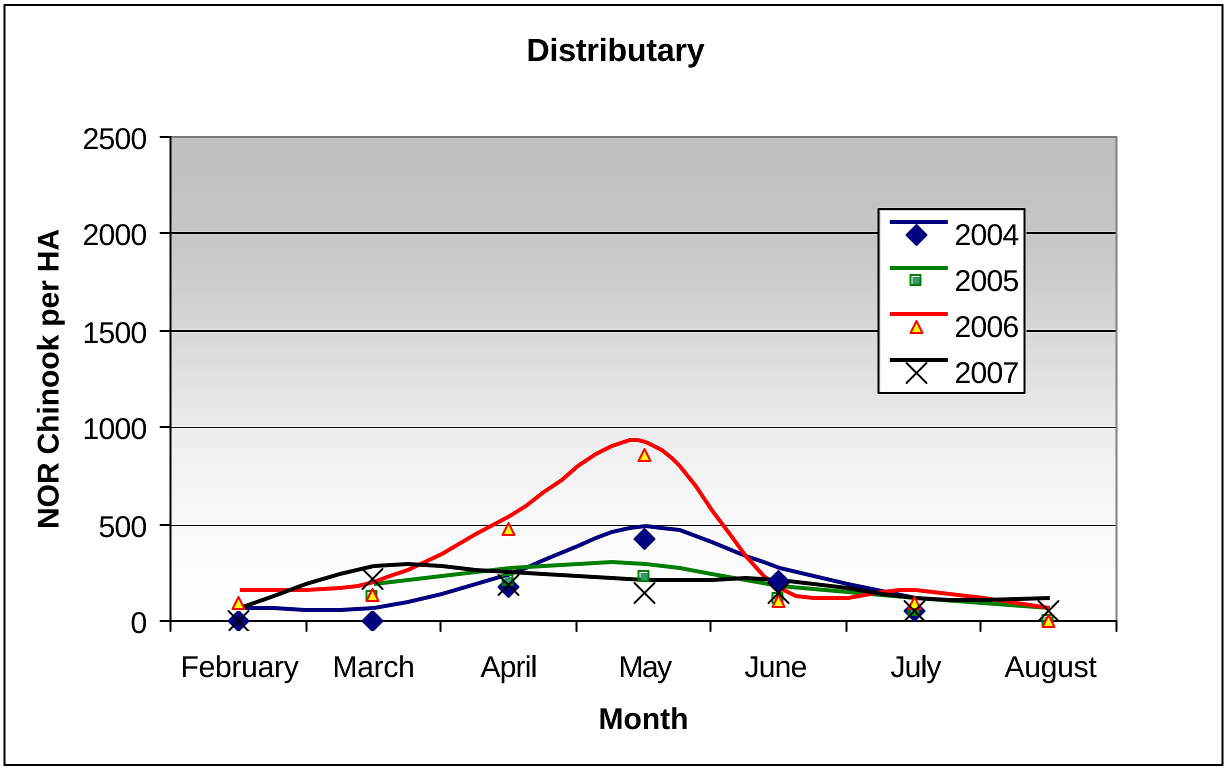

Figure 8. NOR Chinook density in distributary habitat 2004-2007

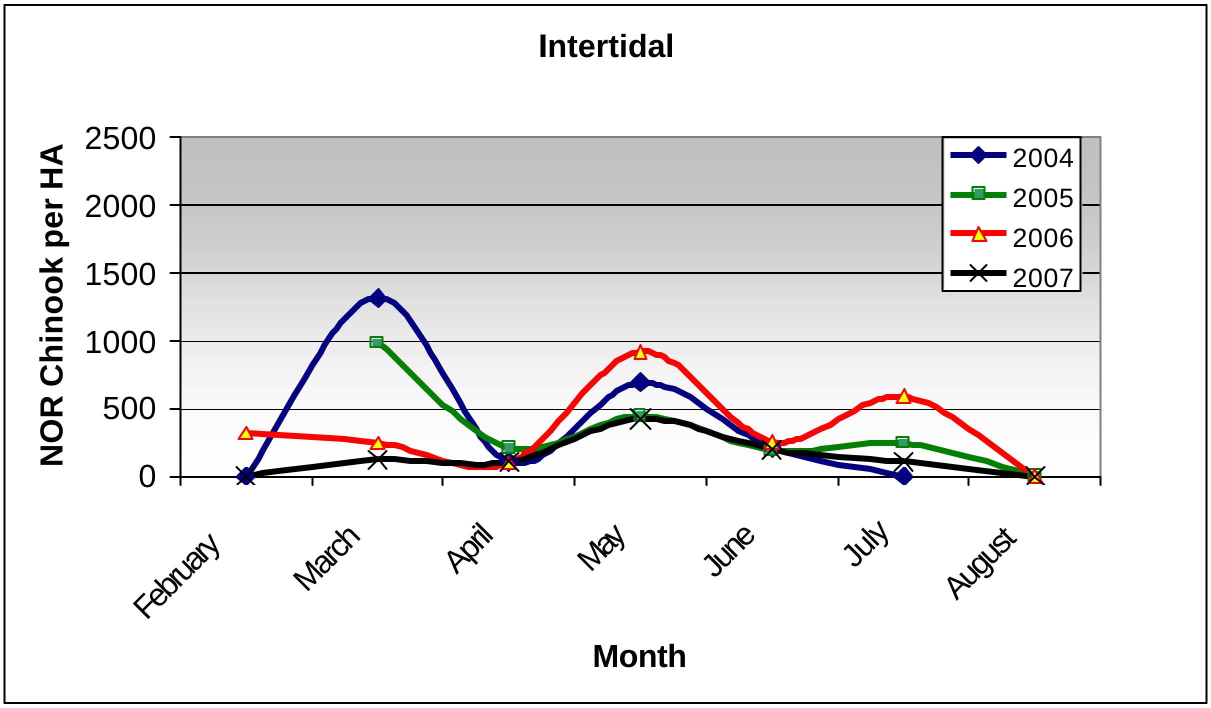

Figure 9. NOR Chinook Density in intertidal habitat 2004-2007

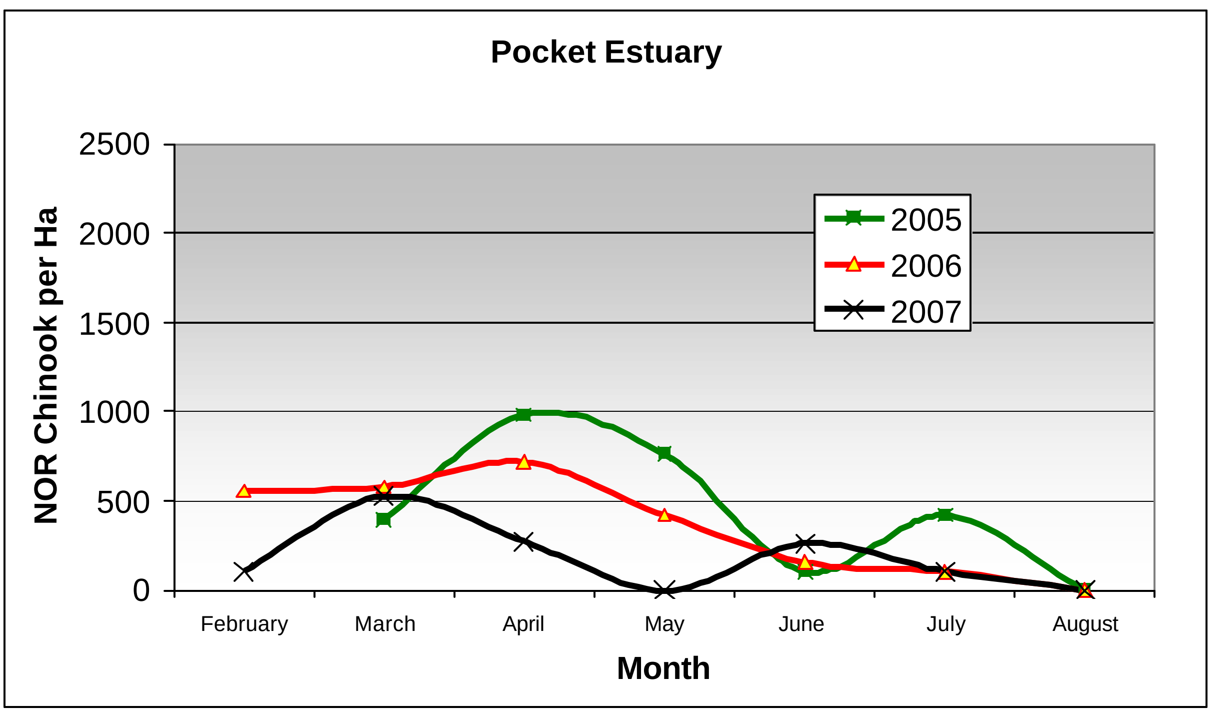

Figure 10. NOR Chinook density in pocket estuary habitat 2005-2007.

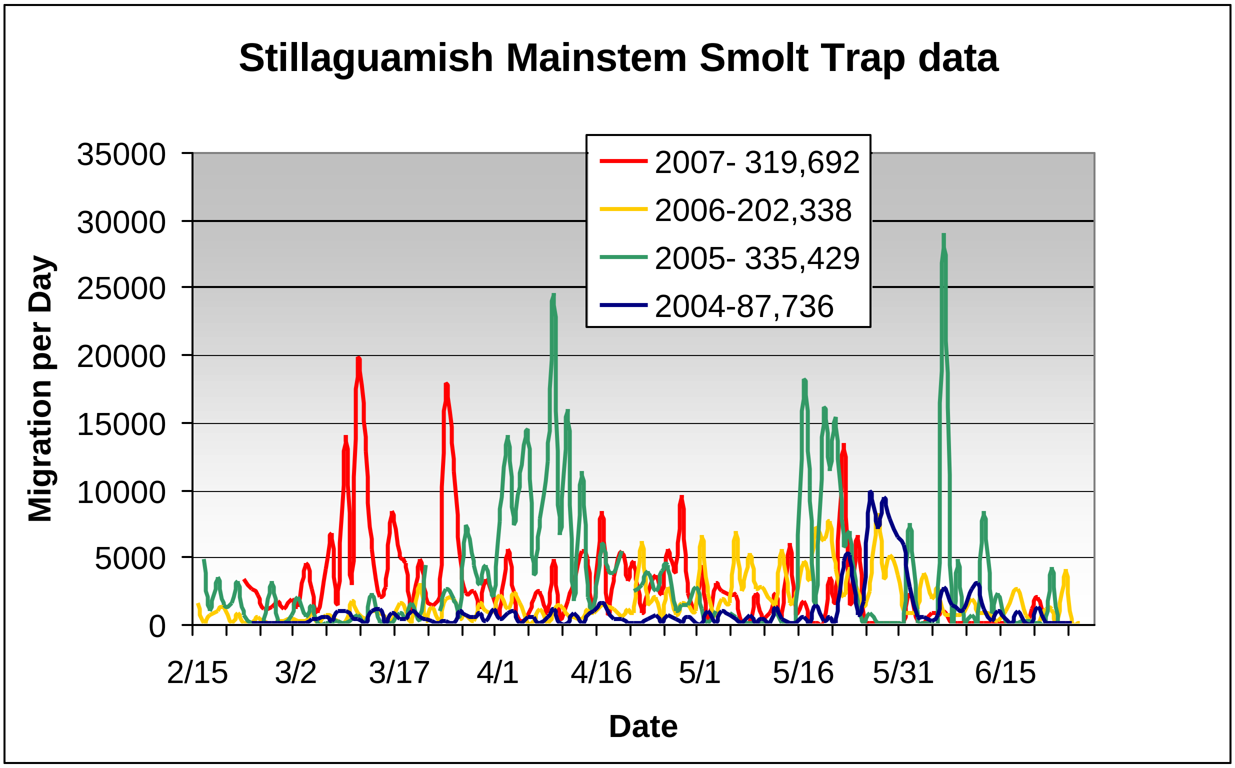

Figure 11. Mainstem Stillaguamish Chinook NOR smolt outmigration patterns 2004-2007. Total smolt production estimates are listed next to the year in the legend.

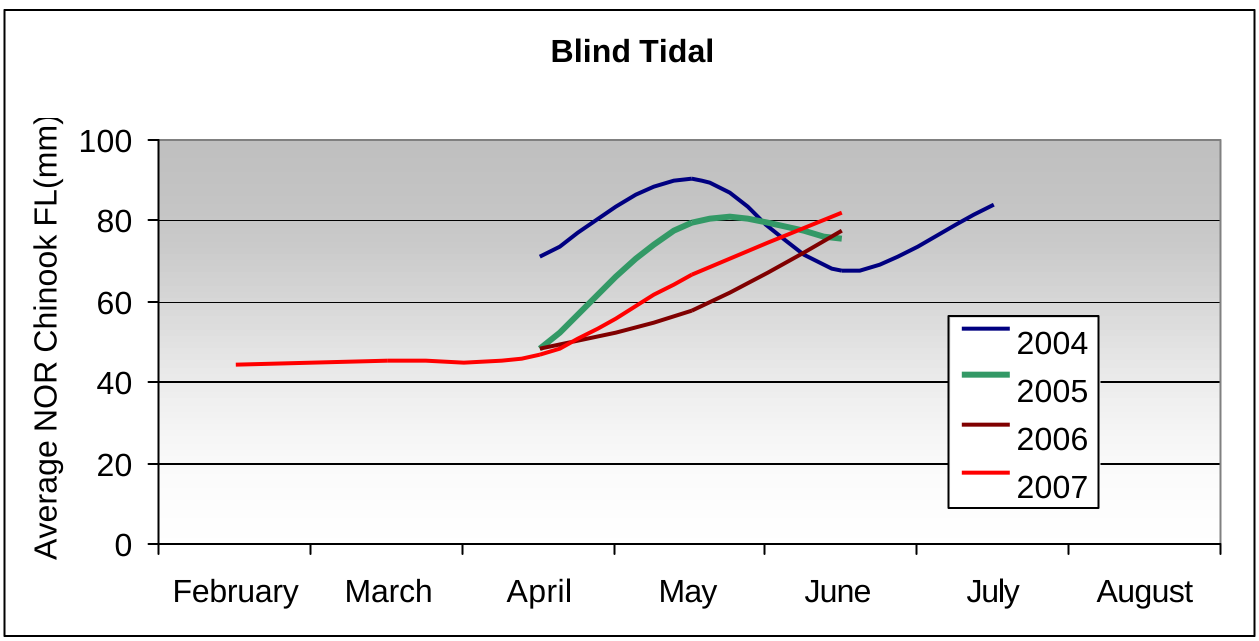

Figure 12. Average fork length for NOR Chinook caught in blind tidal habitat.

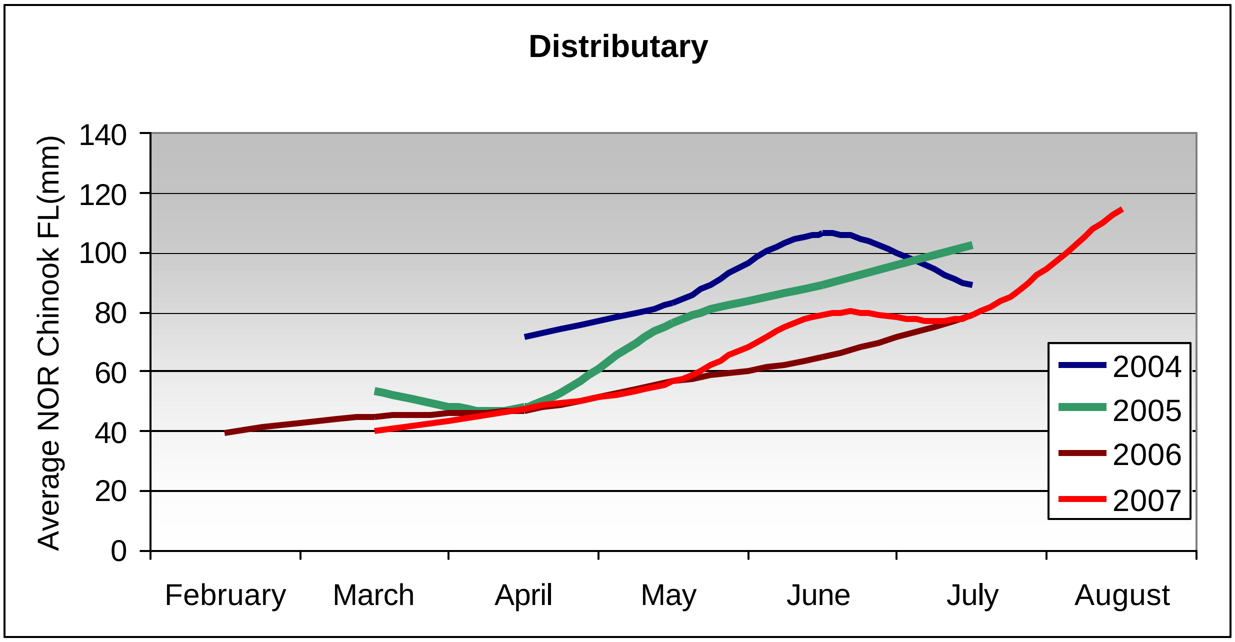

Figure 13. Average fork length for NOR Chinook caught in distributary habitat.

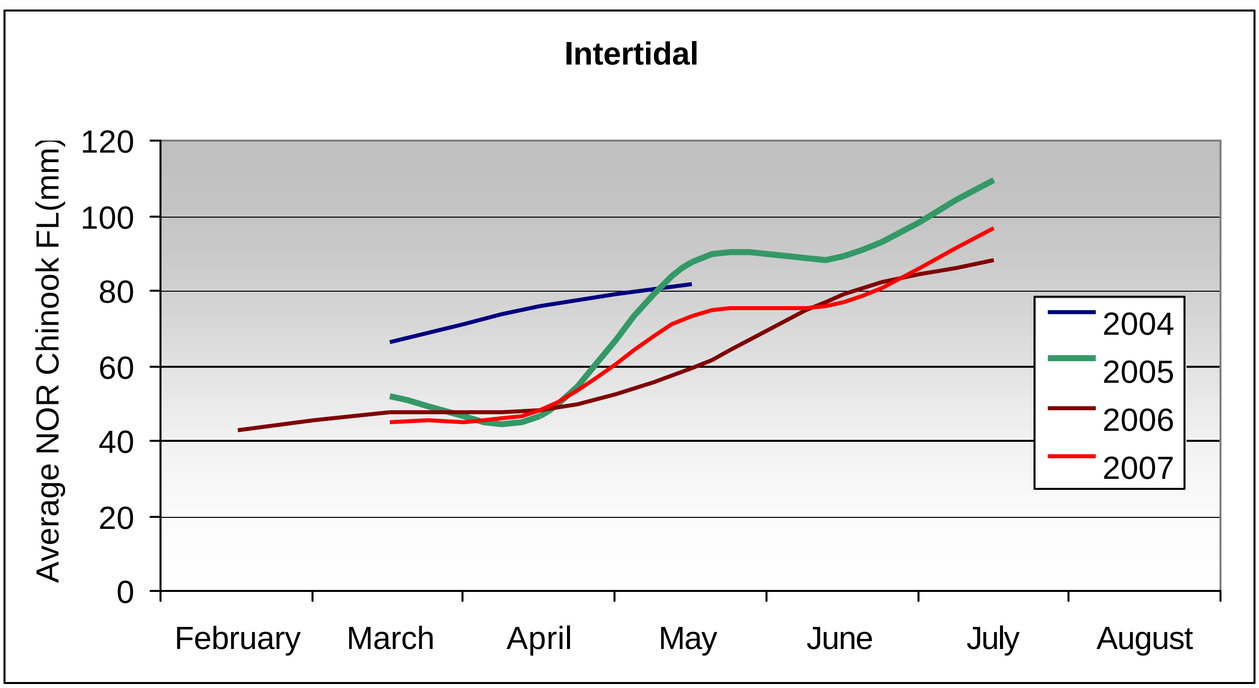

Figure 14. Average fork length for NOR Chinook caught in intertidal habitat.

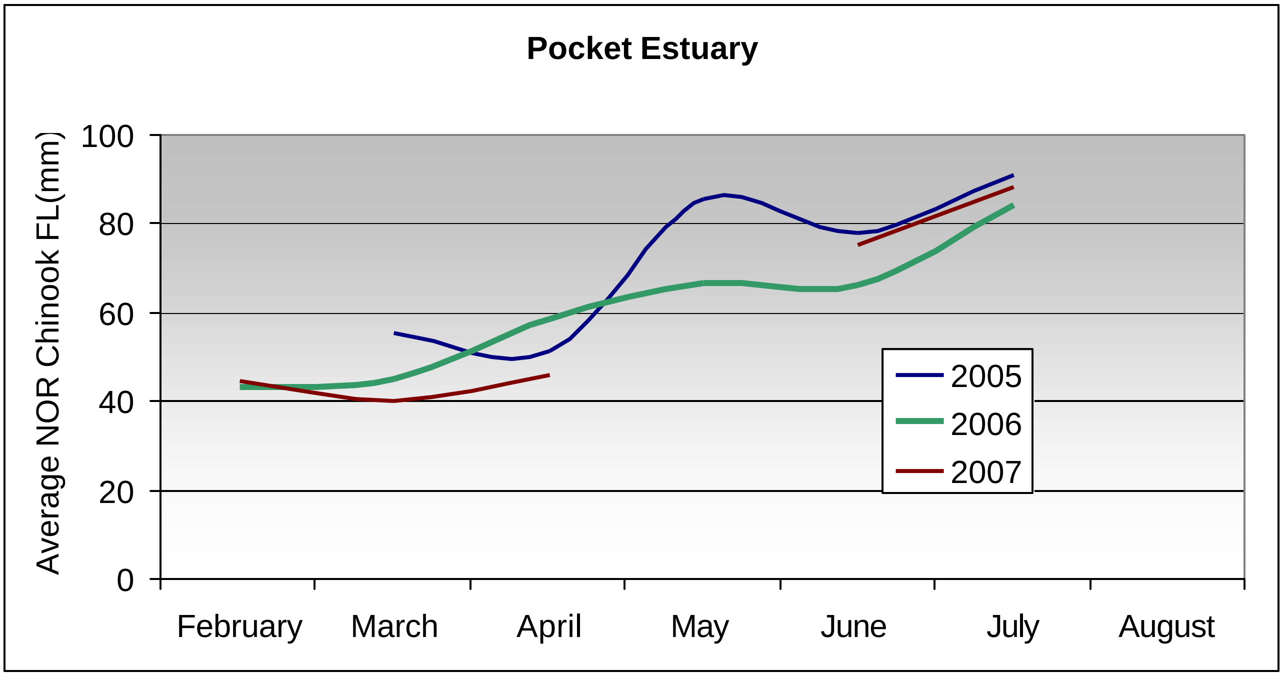

Figure 15. Average fork length for NOR Chinook caught in pocket estuary habitat.

Estuarine use by juvenile Chinook as a function of Stillaguamish smolt production

The four years of sampling indicate that there is a good deal of variability in the Chinook NOR catches throughout the various habitat types found in Port Susan (Figures 7-10). Some of this variation is better explained when smolt production numbers are added into the analysis. As mainstem smolt production increases, there is a marked decrease in observed densities of NOR Chinook in distributary and blind tidal habitats. The relationship becomes weaker the farther from the Stillaguamish delta the sampling sites are, especially by the time Chinook smolts reach pockets estuaries (Triangle Cover, and Lona) on the far side of Port Susan (Figure 16).

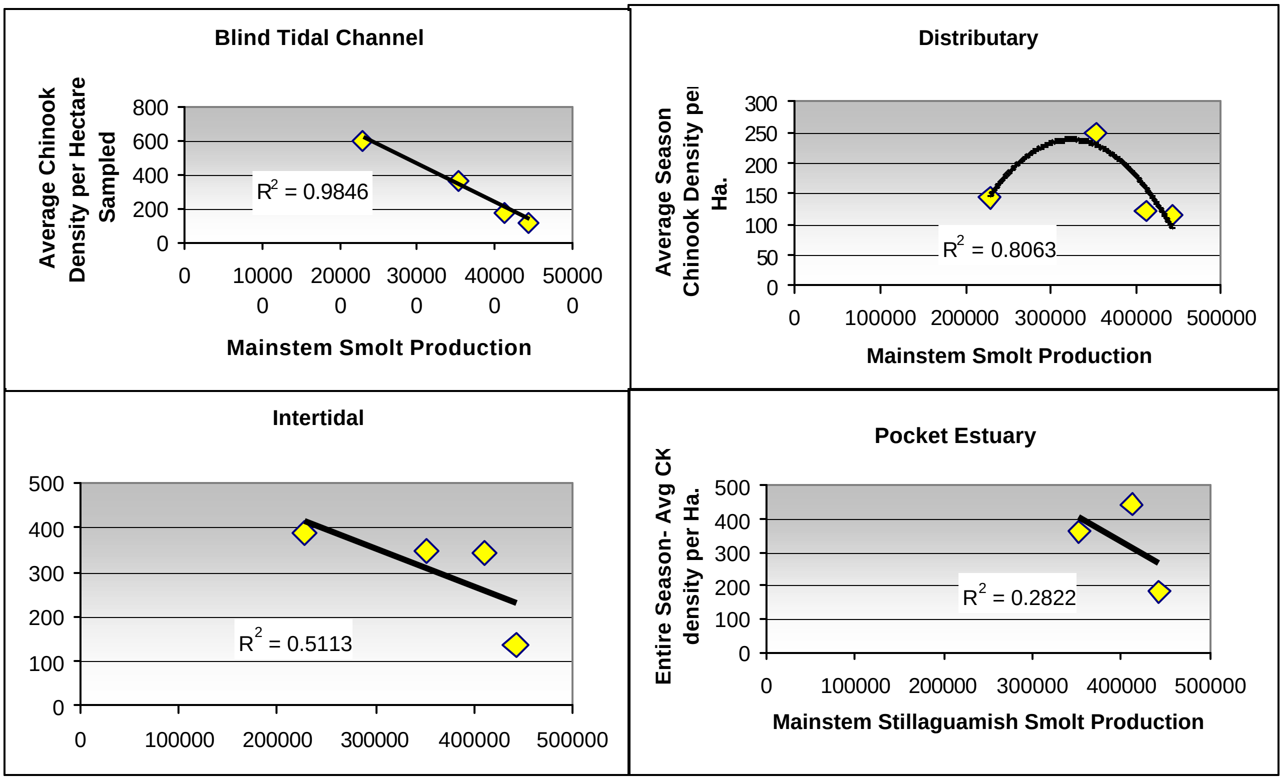

Figure 16. Relationship between NOR Chinook density in various habitat types of Port Susan and mainstem Stillaguamish Chinook smolt production (NOR+HOR. 2004-2007.

Similarly, there is a trend of decreasing average size (fork length, mm) of NOR Chinook smolts as mainstem Stillaguamish Chinook smolt production increases (Figure 17.). This trend is most pronounced in blind tidal, distributary and pocket estuary habitats, and absent in intertidal habitats. This figure was generated by averaging all lengths for chinook caught within each habitat type in a give year, and plotting it against the mainstem Chinook production for that year. To add perspective to these regressions, Figure 18 plots average size of NOR Chinook (over the entire season) captured on the mainstem smolt trap against mainstem Chinook production. Figure 19 depicts trends in temperature and flow on the Stillaguamish as related to total Chinook smolt production. The trend of decreasing size with increasing smolt production (Figure 18) can be partially explained by the unrelated patterns in flow and temperature during the years sampled.

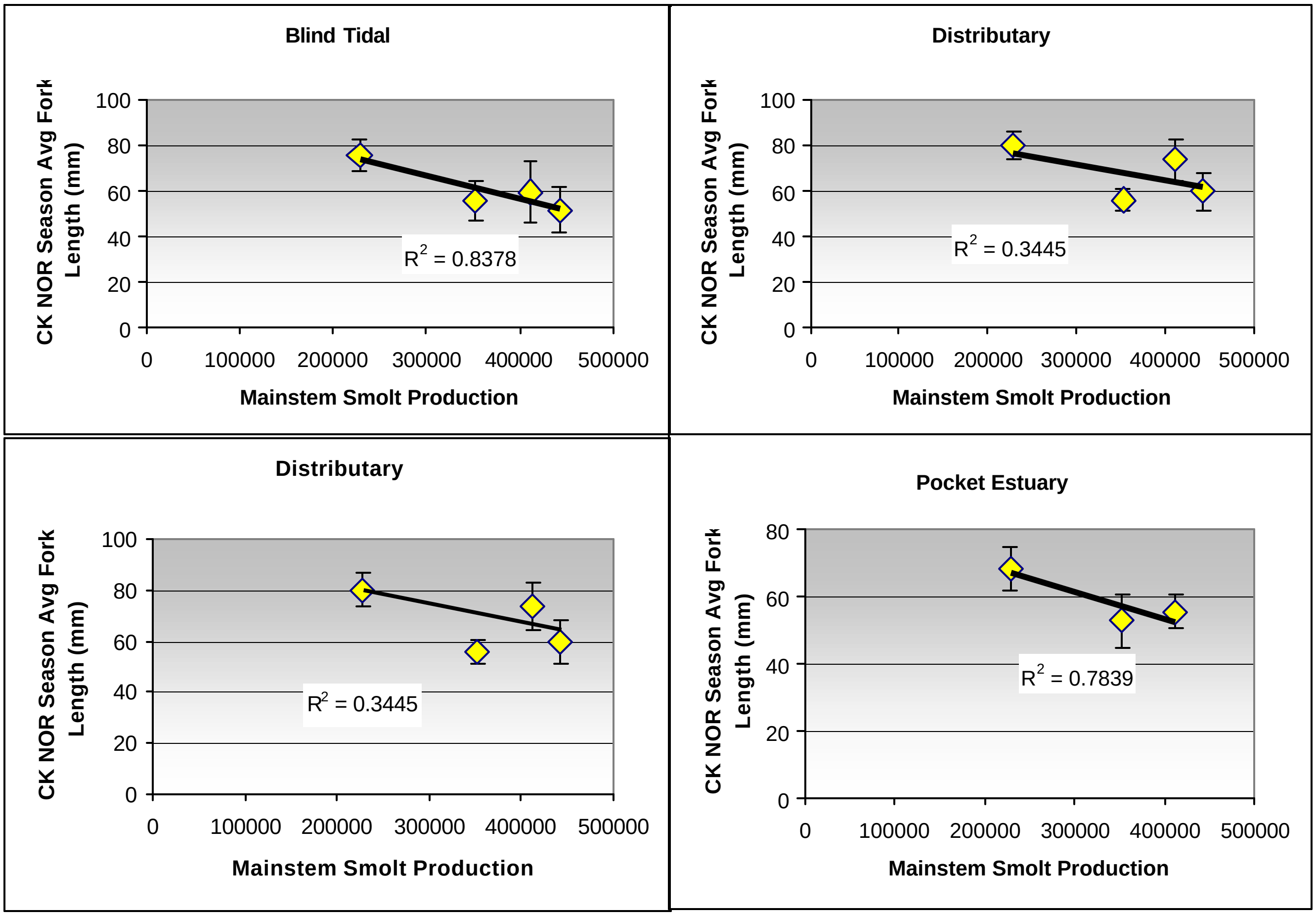

Figure 17. Regressions relating the average size (over the entire sampling season) of all NOR Chinook captured within individual habitat types to mainstem Stillaguamish Chinook smolt production (2004-2007). Bars represent 95% confidence intervals around the means.

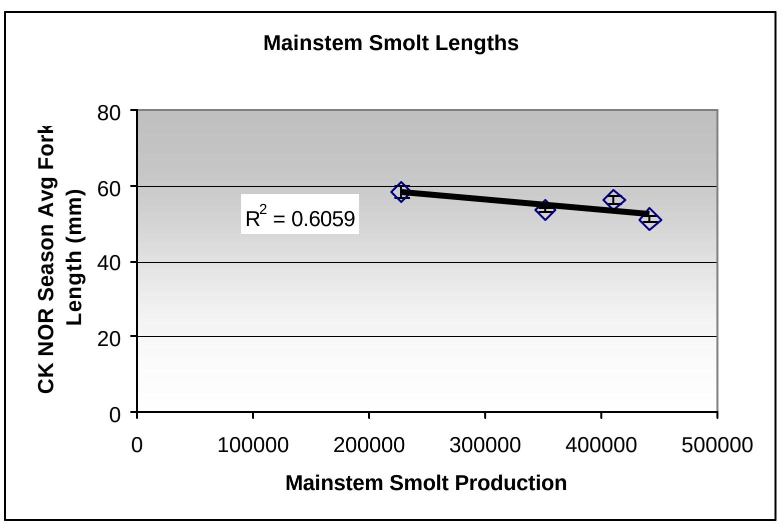

Figure 18. Seasonal average mainstem Chinook NOR smolt lengths plotted against mainstem smolt production. Bars representing the 95% confidence interval around the mean are tight enough to be hidden by the size of the markers.

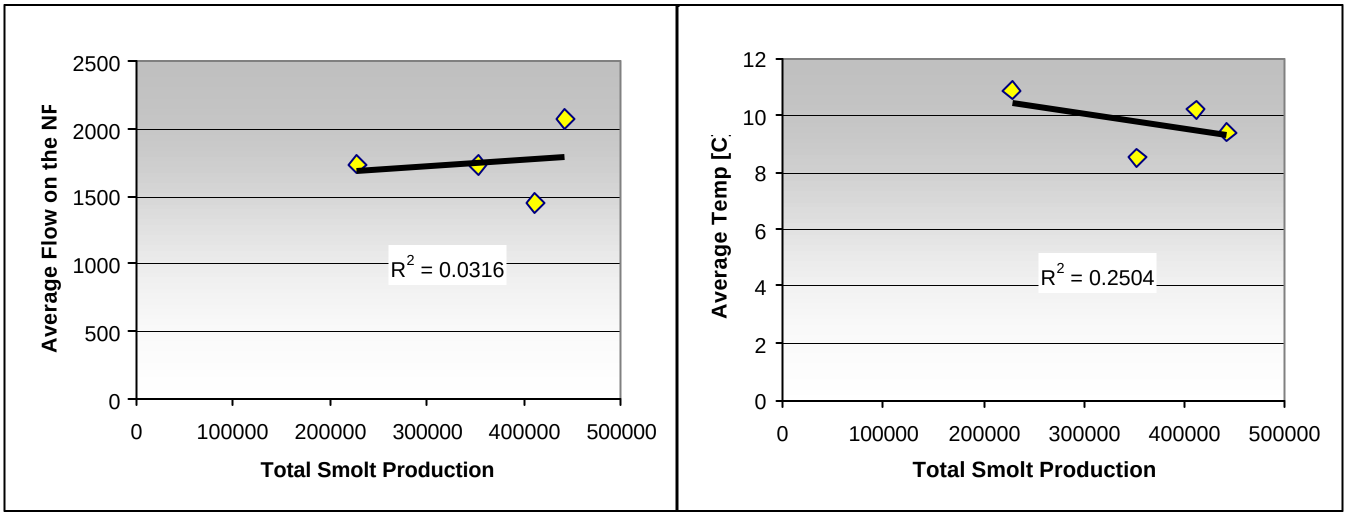

Figure 19. Total smolt production and patterns of average temperature and flow during the corresponding year. While smolt production does not affect temperature or flow, the trends suggest that smolt production might not be driving the relationship in Figure 18.

Discussion

The data collected by the Tribe between 2004-07 is the first to document patterns of juvenile Chinook use of estuarine habitat in Port Susan. Throughout the years sampled, a range a habitats were sampled consistently from the late winter to summer months. Not surprisingly, salmonids were not the most abundant species in the catches, indicating that Port Susan habitats support a wide range of species during all months of the year (Figure 2). Even amongst the salmonids captured, Chinook were never the most abundant species encountered, usually only contributing to a significant percentage of the catch in distributary and blind tidal habitats (Figures 3-6). Given that Chinook salmon represent a small portion of all of the salmonids that spawn in area rivers (WDFW unpublished data), this is not surprising.

The distribution and densities of juvenile Chinook observed in Port Susan during this study follow patterns similar to those observed in nearby estuarine systems connected to the Skagit and Snohomish Rivers. Like the Chinook from these neighboring rivers, Stillaguamish Chinook are mostly ocean-type, meaning that they migrate from their natal river in the first spring after emergence, and rear extensively in the estuary before moving into offshore waters (Beamer et. al 2003, Healy 1991). For ocean type Chinook, low salinity and energy environments such as saltmarsh (and the associated blind tidal channels) shrub/scrub wetlands provide key habitat that the small fish use for growing and adjusting to the marine environment, especially for chinook that migrate at what is termed the “fry” stage (usually 35-45 mm, Healy 1991). Not surprisingly, beach seining and fyke trapping efforts in neighboring estuaries have found that densities of juvenile Chinook are significantly higher in these habitat types (Beamer et al 2003). For fry Chinook migrants, total marine survival is influenced during this critical rearing period (Magnusson and Hilborn 2003).

Our limited results from sampling Port Susan corroborate these observations, with the highest density (> 2000 Chinook/Ha) of Chinook observed in blind tidal habitat (Figure 7). While variable year to year, densities of juvenile Chinook in blind tidal habitat were clearly highest in two of the four years sampled.

Lesser, but still significant, densities of Chinook salmon were found in the other three habitat types (intertidal, pocket estuary, and distributary- Figures 8-10), with the patterns of use varying year to year. Sometimes it was a uni-modal peak in abundance, other years a bimodal distribution was observed, with the month of peak abundance anywhere from March to May (Figures 8-11).

These patterns become more understandable once Stillaguamish mainstem smolt outmigration data is examined (Figure 11). This figure shows that in some years the Chinook leave the river in one main pulse, while in other years there are two peaks in outmigration. An added factor is that Port Susan is used by Chinook from other nearby river systems (Stillaguamish Tribe unpublished data), and these populations are not likely follow that same timing patterns as Stillaguamish Chinook. While there were consistently low densities observed in all habitats in August, during most other months significant numbers of Chinook juveniles used some or all of the habitat types available in Port Susan. From work in neighboring systems (Beamer et al. 2003), Chinook are likely still present in Port Susan in August, but located in deeper water where the small net method will not capture them. Chinook salmon exhibit complex life histories, and the data presented here supports that the full range of estuarine habitats are utilized by Chinook at some point during the year.

Patterns of juvenile Chinook size by month and habitat type were similar across all years sampled, albeit with significant year-to-year variability (Figures 12-15). Fry migrant (~40-55mm) Chinook dominate the catches in all habitats during March and April, with sizes rapidly increasing during the spring and summer months as parr migrants (>55mm) enter the nearshore and start growing rapidly. In any given month, the average size in a particular habitat type might vary by as much as 40mm! This is mostly due to small sample sizes, but also differences in the relative contribution of fry vs. parr migrants coming out of the river systems (can vary significantly year to year- Stillaguamish Tribe unpublished data). Once juvenile Chinook reach 100mm (July-August), they were no longer present in large numbers in the shallow habitats sampled in Port Susan. This is evidenced by dearth of length data from the August sampling events. Salmonids of this size (cutthroat, and charr) were readily captured at other times of year by the netting method, so it unlikely that they were missed in the August samples year after year.

Interesting trends are observed when juvenile Chinook densities and lengths in the various habitat types are plotted against total smolt production (HOR+NOR) from the Stillaguamish (Figures 16 & 17). It was a fortunate coincidence that smolt production varied as greatly as it did during the four years of sampling, and some sort of linear or asymptotic relationship between estuarine Chinook densities and smolt production would be expected (i.e. as Chinook production goes up, densities would climb or climb and plateau). However, this is not the case, with observed densities *decreasing* as Chinook production increases. The mechanism that would drive this trend is unclear, but is likely related to food supply during the spring months, when Chinook densities are the highest. Perhaps large numbers of smolts cause the zooplankton biomass to crash, drastically limiting the numbers of Chinook the nearshore areas can support. As the Chinook densities fall off the farther from the Stillaguamish delta, so does the relationship (Figure 16). Or there might be interactions with other more abundant species that better compete with Chinook for limited food resources. Although it is a very few data points, Figure 16 suggests that the present range of Chinook spawning populations in the Stillaguamish may be limited by the rearing capacity of the various estuarine habitats in Port Susan.

Similarly, average lengths in all habitats decreased with increasing mainstem smolt production (Figure 17). At first glance, this would appear to be another density dependent effect of limited rearing habitat. However, this size trend is partially explained by the trend of decreasing size also observed on the mainstem Stillaguamish smolt trap as production numbers increased (Figure 18). The decreasing size of juvenile Chinook measured on the mainstem trap is likely driven by coincidental flow and temperature trends (Figure 19). In those years with higher production there also happened to be lower temperatures (slower growth=smaller fish), and higher flows (fish are pushed out earlier/quicker=smaller fish). However, the slope of the trend line from the mainstem trap data (Figure 18) is significantly shallower than those observed in estuarine habitat (Figure 17), indicating that there still may be some interplay between Chinook densities and growth rates.

Recommendations

The data presented in this report lends credence to theory that the reduced extent of estuarine habitat is a significant limiting factor affecting the status of the Stillaguamish Chinook populations (Griffith 2005), and helps to fill an important data gap (SIRC 2000). Those habitats most utilized by outmigrating Chinook juveniles (blind tidal and other high marsh habitats) are the same habitats that have suffered the greatest reductions in area, in most cases more than 75% (Collins 1997, Griffith 2005). While marsh areas are used most heavily by juvenile Chinook, all other habitats are used extensively throughout the winter, spring and summer months. The Stillaguamish Chinook recovery plan (SIRC 2005) has a simplistic estuarine restoration target that is limited to marsh restoration and does not lay out targets for the numerous other estuarine habitat types present in Port Susan (shrub scrub, riverine tidal wetland, distributaries, pocket estuary, open beaches, spits, etc.). Clearly, the data collected within this report details the importance of the full suite of habitats historically available to Chinook salmon populations, and indicates that restoration targets should be expanded to include proportionally the same amount (i.e. 80% of historic) of other habitat types in Port Susan and the lower Stillaguamish delta. As in freshwater habitats used by Chinook, functional estuary restoration in Port Susan will depend on restoring the processes (tidal inundation, longshore drift, riparian function, channel migration, etc.) that support the creation, resilience, and maintenance of estuarine habitat. Re-connection and restoration of estuarine habitat is often contentious, however this report indicates that Chinook recovery in the Stillaguamish is unlikely to progress significantly without such projects.

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Appendix 1. Data sheet for Stillaguamish Beach Seining

Site:	Date:	**Time:**	**Set #:**	**Net%:**	**Tide Stage**	LW	HW	EBB	FLD

habitat & water quality

Habitat Type:	blind channel: 1.mouth 2.glide 3.impoundment	flooded intertidal shoreline: 4.edge 5.non-edge	6.Intertidal/sub-tidal fringe	7.flooded marsh	**Vegetation:**	**Substrate:**

Water Depth (m)	**Velocity Depth** (class)	**Current Velocity** (ft/sec)	**S-T Depth** (class and m)	**Salinity** (ppt)	**Temp** ('C)	**NOTES:**
	surface		surface			
			bottom: m			

catch

Species																			
CATCH TALLY																			
TOTAL																			

fork length

Species	CK____	Wt. (g)	Mark	Vial#	CK____	Wt. (g)	Mark	Vial#	CH____	PK____	CO____	Mark	STAG	STAR					
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
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15																			
16																			
17																			
18																			
19																			
20																			

permit

Morts:	**life stage:**	**Reason:**	
Collects:	**life stage:**	**Reason:**	