West Whidbey Nearshore Fish Use Assessment

West Whidbey Nearshore Fish Use Assessment 2005-2006

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Wild Fish Conservancy

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Section 1: Introduction

1.1 Introduction – *Purpose and Objectives*

We conducted surveys of fish use in nearshore habitats along the western coast of Whidbey Island, in Admiralty Inlet, Washington. Our goal was to identify juvenile-salmonid habitat occupation at potential conservation and restoration sites and to establish a baseline of data regarding juvenile salmonid habitat utilization on the west coast of Whidbey Island. Many salmonid species potentially utilizing nearshore habitats on western Whidbey Island originate from populations experiencing severe declines, including populations listed as Threatened under the Endangered Species Act (Puget Sound chinook; Hood Canal summer chum). Sampling occurred from February through August in 2005 and 2006 at ten sites representing the range of habitats available along the western coast of Whidbey Island. Additionally, an extensive sampling effort was conducted at sixty sites in May and June of 2006.

This assessment was conducted in response to a data gap identified in the *Salmon Recovery Strategy* (2000) produced by the Island County Salmon Recovery Committees. The strategy's authors recognized that while salmonid occupation of nearshore habitats had been established for the eastern half of the Island, in Whidbey Basin, little was known about salmonid habitat use along the western shore of the Island, in Admiralty Inlet and the Strait of Juan de Fuca. A more general goal for nearshore and marine aspects of Puget Sound salmon and bull trout recovery is to improve the body of knowledge about salmonid requirements of nearshore and marine environments. (Redmond et al 2005). This project was proposed, developed, and conducted by the Wild Fish Conservancy under a grant from the Salmon Recovery Funding Board.

The study had two main objectives:

> 1) Document the timing and extent of juvenile salmonid use of nearshore habitats along the west coast of Whidbey Island.

> 2) Determine the basin of origin for coded wire tagged juvenile chinook captured along the west coast of Whidbey Island

1.2 Introduction – *Study Area*

Admiralty Inlet is the northernmost portion of Puget Sound, and is bound to the west by the mainland of the Olympic Peninsula and to the east by Whidbey Island. No large estuaries drain directly into the Admiralty Inlet; however, numerous small streams and protected coastal lagoons provide a diversity of rearing habitats for the salmonids of Puget Sound and Hood Canal as they migrate to marine waters in the Pacific. The majority of habitat along the west shore of Whidbey Island is high-energy exposed

shoreline, most of which is in relatively undisturbed condition. The west Whidbey Island shoreline is exposed to high tidal and wind energy. Tidal currents in Admiralty Inlet are some of the strongest in Puget Sound, and are an important factor in the shaping of local nearshore features. Large open water fetches contribute to the high (for Puget Sound) wave action that characterizes the area, and combined with tidal current energy, drive drift cell functions in the sub-basin. Approximately 67% of the shoreline in Admiralty Inlet supports eelgrass beds (*Zostera marina* and *Zostera japonica*), and 11% of the shoreline has floating kelp (Redmond et al 2005).

The greatest impact to nearshore habitats along the west coast of Whidbey Island is from dikes and tidegates that restrict tidal access to marsh habitats in Cultus Bay, the Maxwelton Creek estuary, Deer Lagoon, and Mutiny Bay. Additionally, residential development has contributed to the direct loss of coastal salt marsh lagoon habitat in Cultus Bay, the Maxwelton Creek estuary, Deer Lagoon, Mutiny Bay, Bush Point, and Lagoon Point.
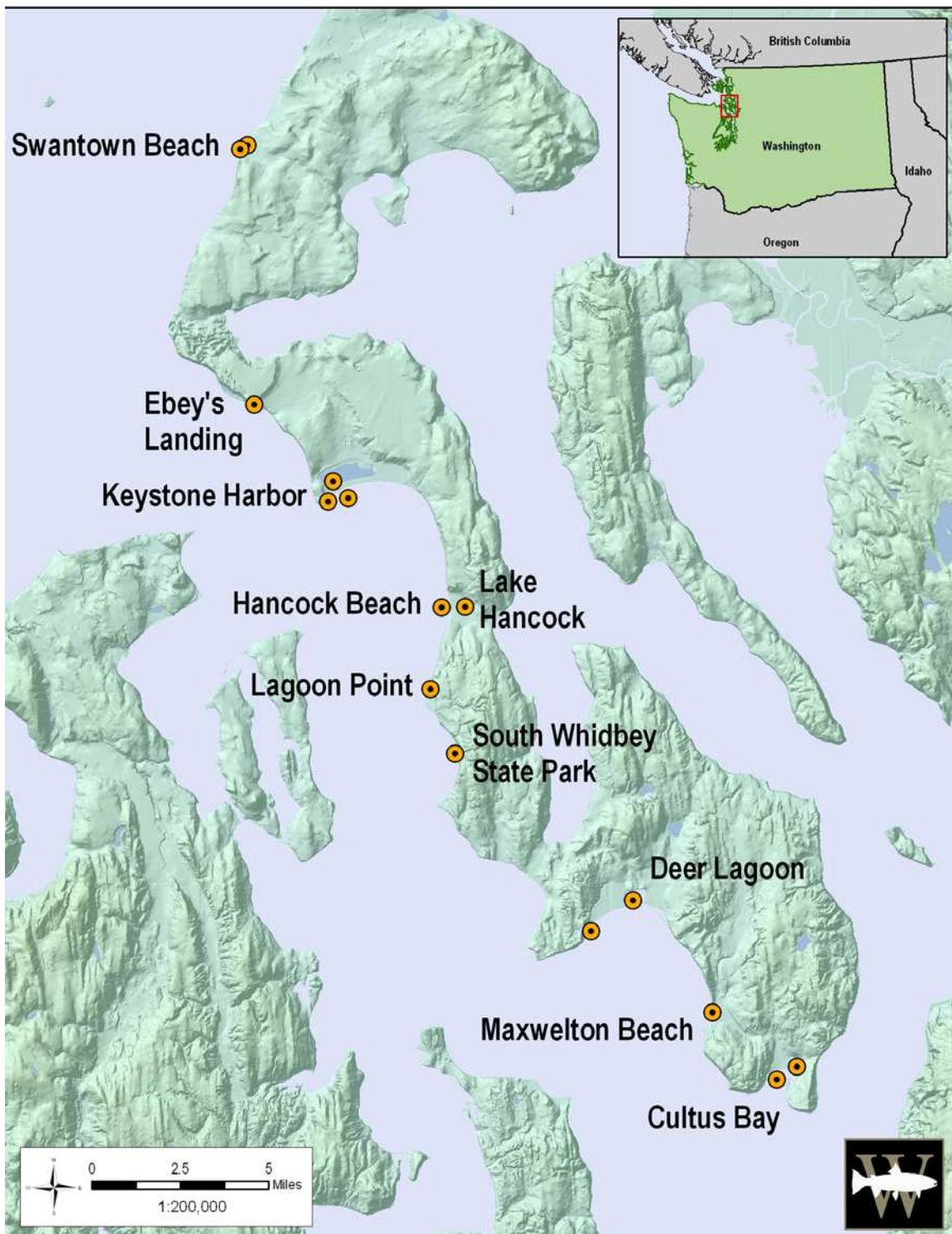
Figure 1. Map of Whidbey Island showing intensive sampling sites for 2005 and 2006 (South Whidbey State Park and Ebey's Landing were only sampled in 2005).

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Figure 2. Map of Whidbey Island showing extensive sampling sites for 2006. These sites were sampled one time only in May and June of 2006.

Section 2: Methods

2.1 Methods-*Sampling protocol*

We used a fish sampling methodology that parallels sampling efforts conducted in the Skagit Bay on the eastern shore of Whidbey Island by the Skagit River System Cooperative (Skagit River System Cooperative 2003). Sampling was conducted using fine meshed beach seines which were deployed using a motorized skiff, or set by hand.

The large set net has 1/8" mesh, and is 120' long and 12' deep in the middle of the net. The wing of the net that was tied to the beach tapered to 6', while the other wing had no taper.

The small set net has 1/8"mesh, and is 80' long, with no taper. This smaller net was rigged with 90' of net along 80' of lead and float line, creating a pucker, or pocket, in the net for holding fish.

Intertidal/subtidal habitats were sampled using the large-net protocol. At each large-net sample site three consecutive seine hauls were conducted using the large net, with the net anchored to the same spot for each of the sample hauls. The net was pulled off the beach behind a 17' aluminum skiff with a fifty horsepower four-stroke engine. At half the net length from the beach, the net was hooked to form a form a pocket, facing the current flow, and held in place for four minutes. The open end of the net was then brought to the beach to close off the semi-circle and the net was hauled to shore (Figures 3-6). To determine if the species assemblages caught were segregating within the range of habitats sampled by the large net, three successive small-net sets were conducted in the same location immediately following the large-net sets. The small net was loaded in a plastic floating dump tub, and the net was walked around in a semi-circle off the beach.

Shallow water intertidal habitats were sampled using the small-net protocol. At each small-net site consecutive hauls were conducted moving along the shore so that the same habitat was not sampled twice. The small net was loaded in a plastic floating dump tub, and the net was walked around in a semi-circle off the beach. Once the net was closed it was brought into shore for catch processing.

In 2005 for each beach-seine set the following data were collected:

- Time and date of set.

- Tidal stage (ebb, flood, high tide slack, low tide slack).

- Length of time the set is held open (large net only).

• Surface and bottom water temperature of area seined.

• Maximum depth of area seined.

• Average surface water velocity.

• Substrate of area seined.

• Vegetation of area seined.

• Complete fish catch records by species.

• Individual juvenile chinook fork lengths (FL) and weights for the first forty fish sampled.

• Individual fork lengths (FL) on all other fish species for the first twenty individuals of each species (2005 only).

All juvenile chinook captured were wanded with a Washington Department of Fish and Wildlife coded wire tag (CWT) detector. Fish that tested positive for a CWT were sacrificed in order to determine stock origin for a subsample of hatchery chinook encountered. All CWT reading was conducted by technicians from the Skagit River System Cooperative.

Sampling at extensive sites in 2006 sites did not involve use of the small net and consisted of one large net set or in some cases two if no salmon were captured in the first set. If no salmon were captured in a second set, no additional sets were made.

The extensive sampling protocol included a more detailed habitat sampling methodology that was used to correlate salmon abundance with habitat characteristics. A 30.5m transect (approximately the maximum distance of an average seine haul using the large net) was initiated from the location where the net met the waterline. The transect was extended out into the water perpendicular to the beach. Every 3.05m, the depth was measured, the substrate was quantitatively categorized according to the Wentworth classification system by the methods outlined in Bain et al. (1985), and the percentage cover of each species of vegetation estimated using a 0.5 m^2 quadrat. For standing kelps, which were uncommon at most sites, stipes were counted as a substitute for percent cover, as percent cover is not an effective way of quantifying standing kelps contribution to habitat structure and complexity. These data were gathered either by walking on exposed tidelands or by snorkeling depending upon the tide height and the depth at the end of the transect. No data were collected on substrate or vegetation deeper than 4.6 m because of the danger of snorkeling at these depths and because the maximum net depth was 3.9m. Methods used for collecting habitat data at the extensive sites, although modified as described, were adapted from Shaffer (1998).

Figure 3. Towing the large net beach seine with boat against the current

Figure 4. Hauling in the large net beach seine

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Figure 5. Closing the large net beach seine

Figure 6. Moving fish from the net pocket to temporary holding buckets

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3.2 **Methods**-*Data and Statistical Analyses*

Data
All data were originally recorded on a standard data form that was entered in the field; subsequently data from the field forms were entered into spreadsheets for analysis. Data were summarized into catch densities organized by sample site and date. Density was defined as:

Density = number of target species caught/area of habitat sampled

Catch densities were used to account for biases created by unequal sampling efforts across space or time. Monthly, daily, and instantaneous densities were calculated for all juvenile in 2005 and 2006.

Statistical analysis
It was recognized that spatial organization of sampling sites could be an important factor in determining the extent to which they were used by salmon, and whether spatial characteristics were related to temporal variation or size-assorted usage patterns. Using GIS, the "Embayment" of each sample site was calculated. Embayment was defined as the perpendicular distance from a site to a line drawn between the protruding island points on either side (Figure 7). Thus sites in bays or coves had high embayment values whereas as sites on exposed points or featureless coastline had low embayment values.

A second set of spatial variables called "population-weighted distances," were also calculated for each study site. This variable described the distance of a given study site to river mouths and estuarine hatchery release points weighted by the number of each species originating from that basin. The weighted distance of each contributing basin was then summed to create unique value for each species at each study site using the following equation:

$$\text{Population Weighted Distance} = \Sigma_{\text{all sources}} (P/D)$$

"D" represents the distance of the estuary entrance point to a study site. "P" represents the abundance of a particular species attributed to an estuary entrance point, be it a river mouth or a hatchery creek mouth or net pen. The abundance data vary by species depending upon the availability and completeness of existing WDFW Puget Sound data sets.

For pink and chum salmon, out-migrant data for Puget Sound are incomplete, so wild adult escapement data, which is correlated with juvenile out-migration, was used instead (Kyle Adicks, WDFW, unpublished data). Hatchery pink and chum were not considered for three reasons. First, adult escapement of hatchery fish has no relationship to out-migrants, as juvenile production is defined by anthropogenic constraints, therefore their

inclusion would be unrepresentative of actual hatchery contributions. While hatchery fry release data is available, it is not directly comparable with wild adult escapement data because the number of offspring being produced by a given number of adults is variable. Although a population-weighted distance variable could have been created separately for pink and chum, the lack of mass-marking in these species made them entirely indistinguishable from wild juveniles in the field. While unfortunate, their omission from the population-weighted distance model should not influence the analysis because their magnitude in comparison to the wild populations in Puget Sound, particularly in the case of pink, is minor.

In the cases of coho and chinook, which are almost all mass-marked either by CWT, a clipped adipose fin, or both, the creation of separate population-weighted distance models was made possible. Wild chinook out-migrant counts are incomplete for Puget Sound, so 2005 adult escapements were used for this species (B. Sanford, WDFW, unpublished data). Counts of hatchery-origin chinook spawning in the wild were included where counted with sympatric spawning native-origin chinook due to their potential to produce unmarked offspring (B. Sanford, WDFW, pers. comm.) For hatchery chinook, hatchery release goals, which are nearly always met, were used because actual hatchery releases were not available in time for inclusion in this paper (B. Sanford, WDFW, pers. comm.). For coho, both actual hatchery releases of juveniles for 2006, as well as adequately comprehensive estimates of 2006 wild out-migrants were available, and thus used (J. Haymes, WDFW, unpublished data).

Additionally, for all species, the spatial extent of originating populations from which CWT recoveries were made, was used to determine the list of potential juvenile salmon sources. Because no CWTs were recovered from salmon originating in southern Puget Sound (south of the Green River), potential sources of juveniles in these areas were not incorporated into the population-weighted distance model.

Analysis of the extensive sampling sites was conducted using stepwise multiple linear regression to analyze both juvenile salmon densities and fork lengths as dependant variables. This method of examining the effects of several predictor variables of a single response variable has bee frequently used to predict juvenile salmon catches using measured environmental variables in delta habitats (Bax et al. 1980; Healey 1980; Levy and Northcote 1981).
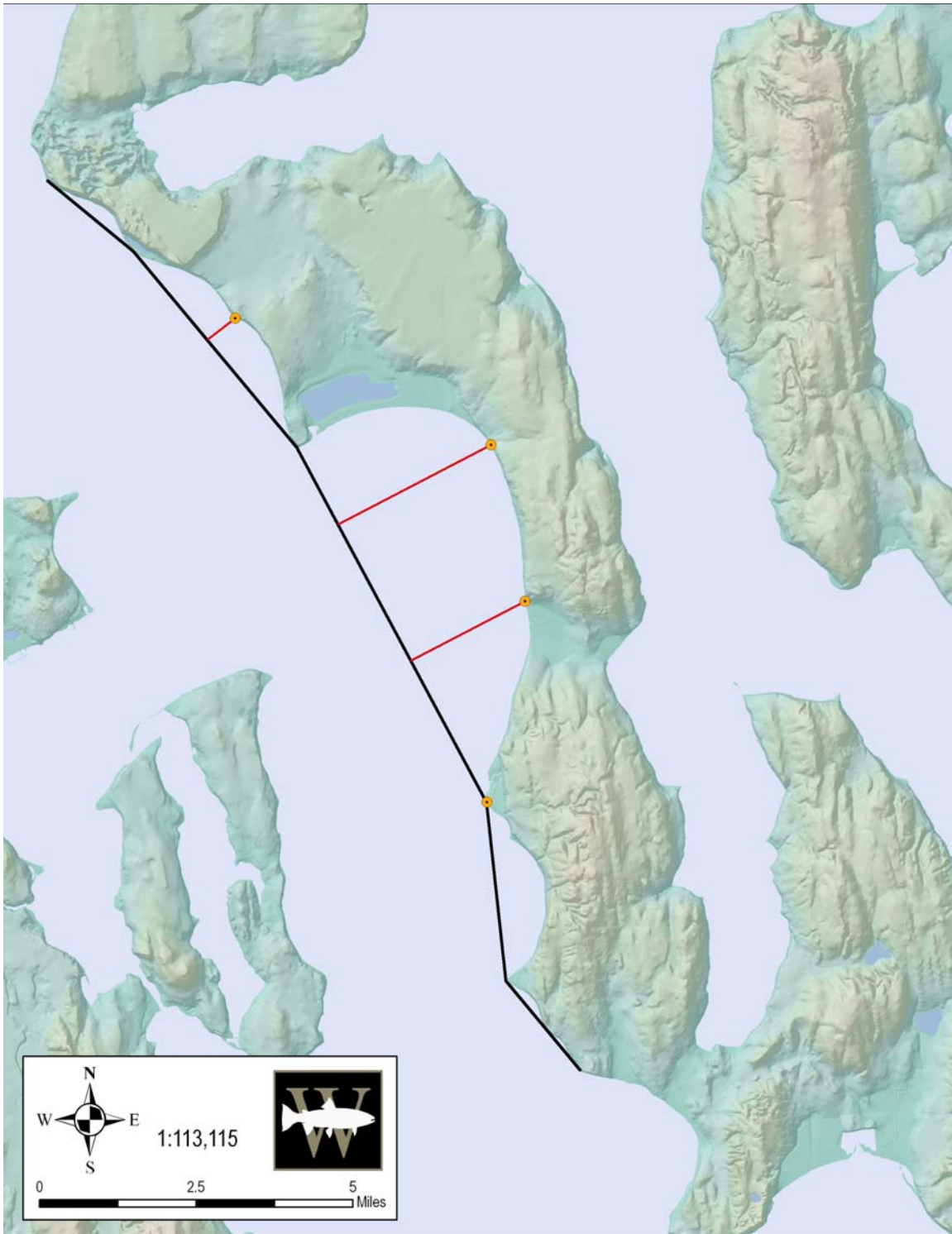
Figure 7. Map of Admiralty Bay depicting calculation of embayment distance to hypothetical sample sites. Embayment distances are shown as red lines, while line of no embayment is shown in black

Puget Sound Salmon Abundance Data

Species		Pink	Chum	Wild Chinook	Hatchery Chinook	Wild Coho	Hatchery Coho
Population Data Type[1,2]			AE	AE	HRG	WOE	HR
River Mouth or Estuary Entry Point	**Mean Distance to All Sample Sites (miles)**	×1000 rounded to nearest 100		Actual number	×1000 rounded to nearest 100		
Port Gamble Bay	23.6	0	0	0	0	0	540
Snohomish R.	33.3	482.2	21.1	4484	2950	681.9	800
Skagit R.	33.7	60	34	22379	822	735.9	993.4
Grovers Creek	34.7	0	12.6	0	0	46.5	0
Lake Washington	35.5	0	5.3	726	2180	90	453.3
Stillaguamish R.	39.4	117.9	12.5	963	220	288	0
Dosewallips R.	40.6	15.4	5.6	10	0	137.0	0
Duckabush R.	43.3	0.6	5.6	2	0	126.2	0
Samish R.	47.1	0	2.3	0	4100	100	100
Quilcene R.	48.0	0	4.0	0	703.8	47.3	703.8
Gorst Creek	50.0	0	12.6	0	2200	46.5	0
Nooksack R.	50.9	13.6	36.7	2047	2950	90	2357.4
HammaHamma R	51.3	1.5	10.6	33	70	159.7	0
Green R.	52.2	800	NA	4089	3500	81	610.6
Hoodsport	59.1	0	0	0	2900	0	0
Skokomish R.	66.5	0	20.5	2032	3920	375.9	290.6

Figure 8. Puget Sound salmon abundance data used in the construction of the population-weighted distance model for extensive sampling sites in 2006.

[1]**AE= 2005 Adult Escapement; HRG= Hatchery Release Goal; WOE= Wild juvenile Out-migrant estimate; HR= actual Hatchery 2006 Release.**
[2]**Population data were obtained from the following sources: Pink and Chum (K. Adicks, WDFW, unpublished data); Chinook (B. Sanford, WDFW, unpublished data); Coho (J. Haymes, WDFW, unpublished data). Some abundances were attributed to sites which were proximal rather than exact because they were the abundances were given generally rather than attributed to an exact location. For example: wild coho outmigrants in Hood Canal, are not assigned to specific rivers in WDFW data sets, so the total for Hood Canal was divided by and assigned to its 5 largest tributaries based on their annual baseflow.**

3.3 Methods-*Intensive Sample Sites*

Figure 9. Swantown Lake marsh and beach sites

Swantown Lake

The Swantown marsh and nearshore sites were the northern most of the intensively sampled sites. The nearshore habitats at Swantown Marsh are considered a part of the Strait of Juan de Fuca, and was the only intensively studied site not in Admiralty Inlet. The Swantown marsh is classified as a barrier marsh in an arcuate embayment (Collins 2005). The t-sheet maps show no connection between the Swantown Marsh and marine waters. Currently, a long ditch on the west side of the marsh is connected to marine waters via a tide-gate controlled culvert. Project investigators observed the tide gate draining the marsh on numerous occasions. Over the course of this project the marsh had very low measured salinity, and was not tidally inundated during high tides.

Sampling was conducted in the marsh using the small net beach seine. The beach sample site was ~300m south of the tide-gate outfall draining Swantown Marsh due to large rocks in the outfall vicinity that precluded beach seine sampling. The beach site had a sandy substrate with no vegetation, and was one of the shallowest sites sampled depths ranged from 0.82m to 1.95m. This site is intermittently exposed to large swells from the Strait of Juan de Fuca, and had the highest potential wave energy of any site in the survey. The beach site was sampled using the large-net protocol.

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Figure 10. Ebey's Landing

Ebey's Landing Beach Site

The Ebey's Landing beach site is a high energy shoreline in northern Admiralty Inlet, with adjacent bull (high) kelp beds. The beach was backed by a moderately stable mid-bluff bank behind a significant dune with abundant large driftwood. The substrate in the sample area was a mix of gravel and cobble with a low-kelp vegetation community. Water depths in the sample area ranged from 1.89m to 3.81m. The Ebey's Landing site was sampled using the large-net protocol.

Figure 11. Keystone Harbor and Crockett Lake

Keystone Harbor and Crockett Lake

Keystone Harbor is an artificially dredged bay that is the site for the Keystone-Port Townsend Washington State Ferry terminal. A tide-gate controlled culvert drains Crockett Lake into Keystone Harbor on low tides. Crockett Lake is classified as a barrier lagoon in an arcuate embayment (Collins 2005). The 1870 t-sheet shows no channel connection between marine water and Crockett Lake; however, prior to the coast survey dikes had already been built and ditches were constructed to drain the lake to a third of its original size (Collins 2005). Currently, the lake is saline, with most of the saltwater input coming as interstitial flow through the gravels of Keystone Spit. In late summer boards that prevent back flow from the harbor into the lake via the Keystone Harbor culvert are removed and saltwater input also enters the lake via this route.

The substrate at the harbor sampling site was a coarse mix with large gravel and no vegetation. As a result of dredging, this site was consistently the deepest sampled site with depths ranging from 3.66m to 7.96m. We sampled Keystone Harbor in the plume of the Crockett Lake culvert outfall, which during low tides would fill the sample area with dark, turbid, organic stained water from Crockett Lake. The Keystone Harbor site was sampled using the large-net protocol.

Figure 12. Keystone Spit, Keystone Harbor, and Crockett Lake

Keystone Spit and Crockett Lake Sites
The Keystone Spit (beach) site was chosen as a control for the Keystone Harbor and Crockett Lake sites. Keystone spit is exposed to high wind, wave, and tidal energy, and the substrate in the sample area reflected this, as large gravels and cobble dominated. The vegetation in the sample area was a low kelp mix of red and brown algae. Water depths in the sample area ranged from 2.19m to 7.01m. The Keystone Site was sampled using the large-net protocol.

The Crockett Lake sampling sites were on the southwestern shore of the lake, near and in the channel connecting the lake to the culvert. These sites were chosen because they were the only ones where field technicians could safely set the small net. Substrate in the lake was a mix of deep soft organic and silt sediments interlaced with peat and gravel deposits, with depths ranging from 0.3m to 1m.

Figure 13. Channel, Outflow, and Beach sites at Lake Hancock

Lake Hancock Sites

Lake Hancock is also classified as a barrier lagoon in an arcuate embayment (Collins 2005). The site provides an example of an undeveloped coastal lagoon with intact ecological function on the western shore of Whidbey Island. The coast survey t-sheet shows an open channel connecting Lake Hancock to Admiralty Inlet in the same location as today's channel. The lake is primarily saline with small freshwater seeps on the southwestern fringe of the lake. The body of the lake is shallow and ranges from 2-6 feet deep on high tides. The channel connecting to the body of the lake has tidal scour holes up to 22 feet deep that will hold water through the low tide due to a natural elevation control at the channel outflow. A peat lens underlies the entire lake and even emerges seaward of the barrier dune.

Water depth at the channel site ranged from 1.6m to 2.19m while the substrate was a mix of sand and peat with eelgrass beds on the sands. The channel site was sampled using the large-net protocol. The outflow site was sampled using the small net and was only sampled on outgoing tides in 2-4 feet of water. Substrate in the outflow site was cobble and gravel with low kelp vegetation. The beach site was relatively shallow with depths ranging from 0.52m to 2.07m. The sample area substrate was a coarse mix with a wide peat lens and eelgrass beds, and was sampled using the large net protocol.

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Figure 14. Lagoon Point

Lagoon Point Site
Lagoon point is a cuspate foreland, which is a triangular accretionary shoreform bound on both side by a barrier beach. The coast survey t sheet shows an extensive tidal lagoon in the interior with numerous connections between the lagoon and marine water. Currently the lagoon is a heavily developed residential area with significant hydromodifications resulting from dredging, filling, and a system of tide gate controlled culverts.

Sampling was conducted on the northern beach at a public access point using the large-net protocol. Depths in the sample area ranged from 2.01m to 3.17m deep, and there was no vegetation.

Figure 15. South Whidbey State Park

South Whidbey State Park Sites
These sites were on an open beach with numerous small creeks entering the shoreline. There is a steep heavily forested bluff above the beach. The creek sample site was in the nearshore plume of a small perennial creek. The beach site was away from any freshwater influences. At both sites sample depths ranged from 1.28m to 3.38m. The deepest areas of the sample areas had thick community of low kelp vegetation. Both sites were sampled using the large-net protocol.

Figure 16. Double Bluff

Double Bluff Site
The Double Bluff site was chosen as a control for the Deer Lagoon site. Double Bluff is a stretch of protected beach just west of Deer Lagoon. The sample area was extremely shallow with depths ranging from 0.7m to 1.3m. The substrate was entirely sand with no vegetation. The beach had very little slope and on low tides the edge of the water was over 100m from the sample site. The site was only sampled on higher tides using the small net.

Figure 17. Deer Lagoon

Deer Lagoon Site

Deer Lagoon is a large barrier estuary in an arcuate embayment (Collins 2005). Located in Useless Bay, Deer Lagoon has been significantly modified by a series of dikes on both the eastern and western arms of the Lagoon; these have reduced Deer Lagoon to 10% of it former size. The eastern arm of the lagoon had been drained and filled and is currently used as pasture. While the western arm has been converted to a mostly freshwater wetland connected to the saltmarsh by a tide-gate controlled culvert.

Sampling in Deer Lagoon was conducted along the western dike in the vicinity of the culvert outfall from the freshwater wetland. Water depths in the sample area ranged from 0.49m to 1.3m. The substrate in the sample area was sandy with some gravels and no vegetation. Sampling in Deer Lagoon was conducted using the small net.

Figure 18. Maxwelton Beach

Maxwelton Site
The Maxwelton site is at an open beach on southern Whidbey Island. The sampling site was 500m south of a tide-gate controlled culvert draining Maxwelton Creek. The Maxwelton site was extremely shallow and could only be sampled on high tides. Depths in the sample area ranged from 0.85m to 1.86m. The substrate in the sample area was sandy with no vegetation. The Maxwelton site was sampled using both the large net and small net protocols depending upon tide.
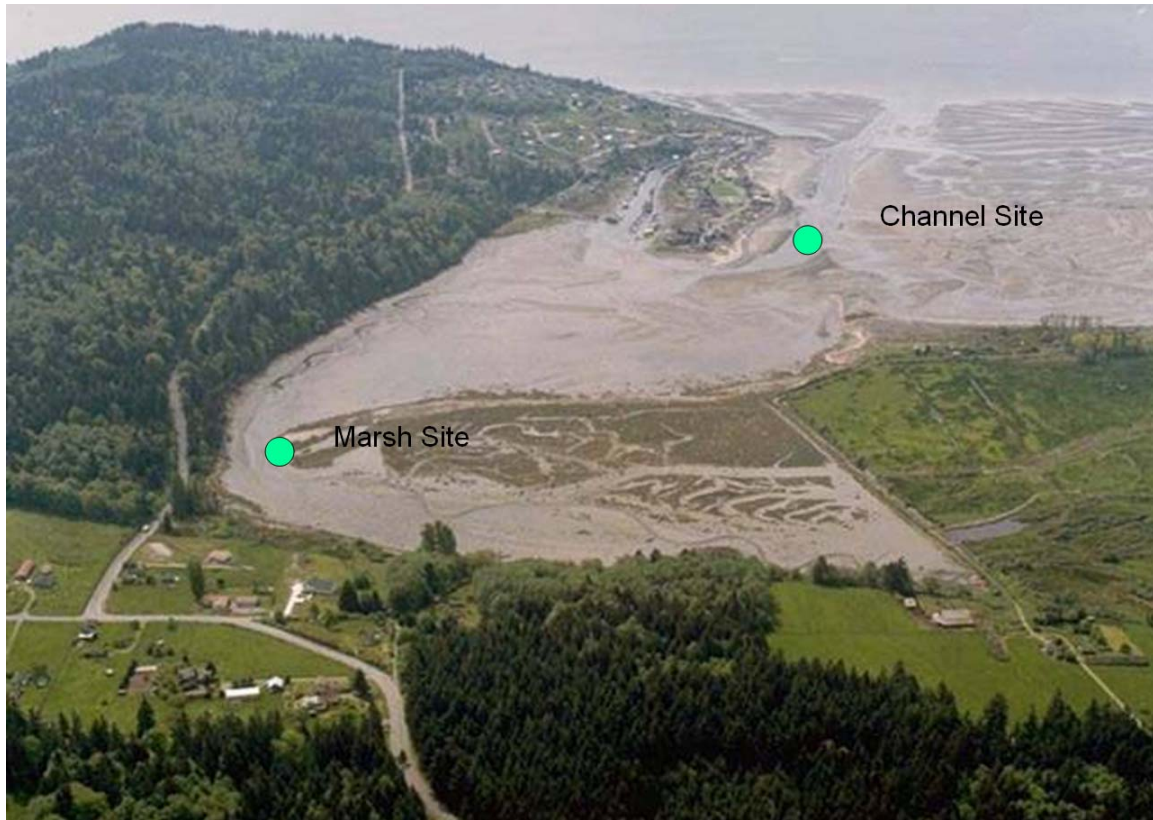
Figure 19. Cultus Bay marsh and channel sites

Cultus Bay Sites

Cultus Bay is at the southern terminus of Whidbey Island. Cultus Bay is classified as a barrier estuary in an arcuate embayment (Collins 2005). The outer spit has been converted to residential development, with dredging on both side of the spit to provide access to moorage. The saltmarsh behind the inner spit has been truncated by a dike, and converted to pasture.

The channel sample area was in a dredged area with water depth from 3.29m to 4.08m. The substrate was sandy with no vegetation. The channel site was sampled using the large-net protocol. The marsh site had a substrate of mixed fines with no vegetation. The marsh site was at the end of the interior barrier spit in Cultus Bay, and was sampled using the small-net protocol.

Section 3: Results

3.1 Results – *Juvenile Salmon Densities*

We observed juvenile salmon throughout the entire study period, from February through August in both years. At most sites the first salmon species observed were juvenile pink salmon. Juvenile pink densities were an order of magnitude greater in 2006, reflecting the prevalence of odd year pink spawning in Puget Sound. Juvenile chum densities were generally higher in 2005, reflecting the more general trend of decreased chum abundance in pink return years. Wild and hatchery chinook densities were also greater in 2005, while wild and hatchery coho densities were greater in 2006 (Figures 20 and 21).
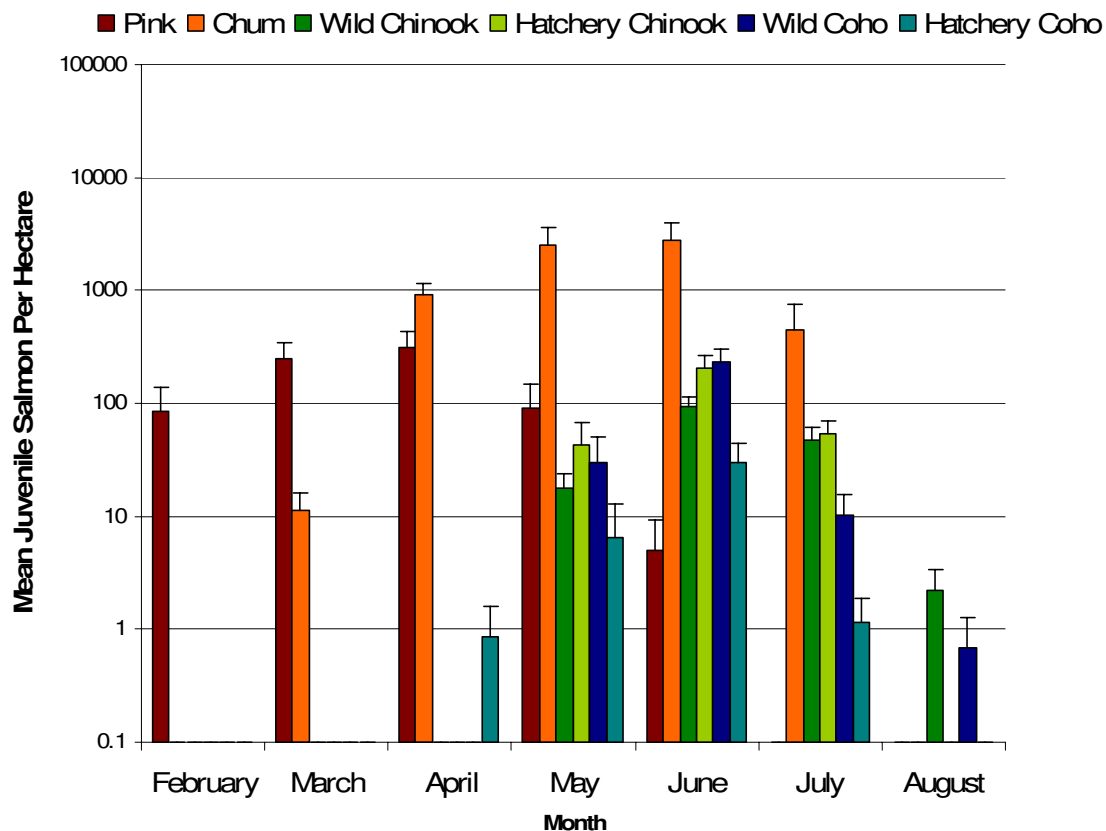
Figure 20. Juvenile Salmon densities by species for all sample sites in 2005.
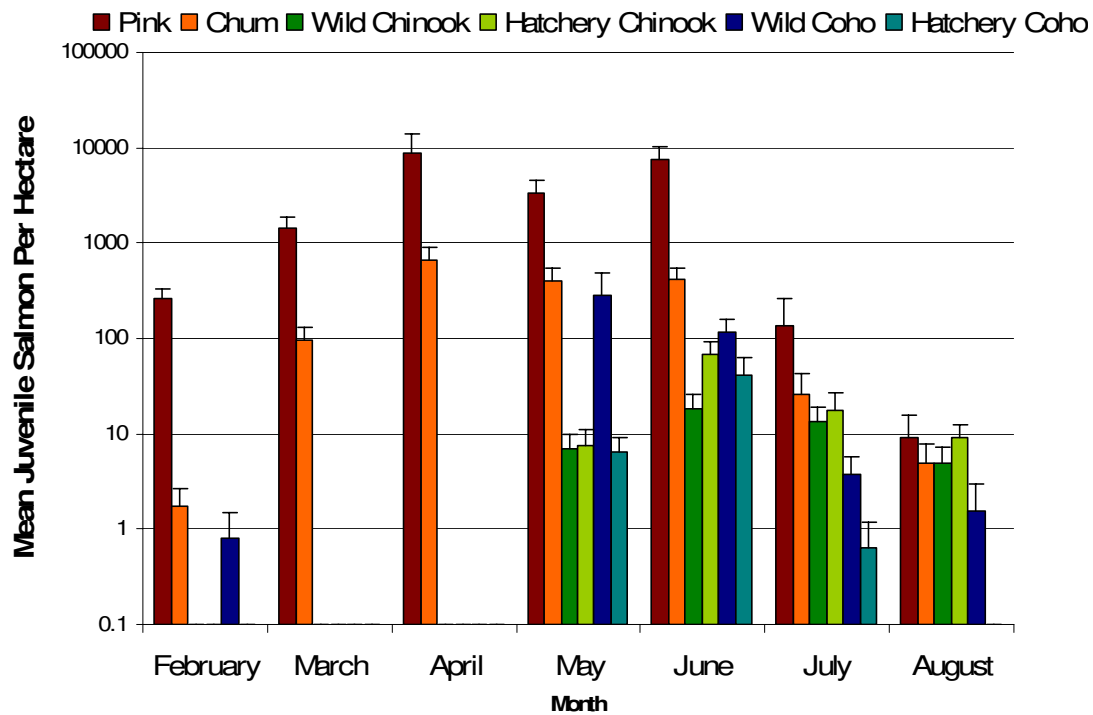
Figure 21. Juvenile Salmon densities by species for all sample sites in 2006.

Juvenile Salmon Densities at Intensive Sites

Swantown Marsh and Beach

The Swantown beach site was sampled 6 times in 2005 and 10 times in 2006. Swantown Marsh was sampled 4 times in 2005, and sampling was discontinued after no juvenile salmon were detected in any of the sets. Beach sampling in 2005 occurred once in March, once in April, twice in May, was not sampled in June and once each in July and August. In 2006 the beach site was sampled twice in February, March, and April, once in May, was not sampled in June, and was sampled once each in July and August. Sampling at the site was often cancelled due to large waves coming down the Strait of Juan de Fuca, which precluded sampling with a beach seine.

Juvenile salmon were observed at the site from February through August with peak catches in both years occurring in April (Figure 22). In 2005 juvenile chum were the most abundant salmonid, while in 2006 juvenile pinks were the most abundant salmonid. Wild juvenile chinook were observed at the site from May through August, with peak catches in both years in July (Appendix 1). Abundances of wild and hatchery chinook were similar in 2005, while there much fewer hatchery chinook in 2006.

Total Juvenile Salmon
Swantown Beach
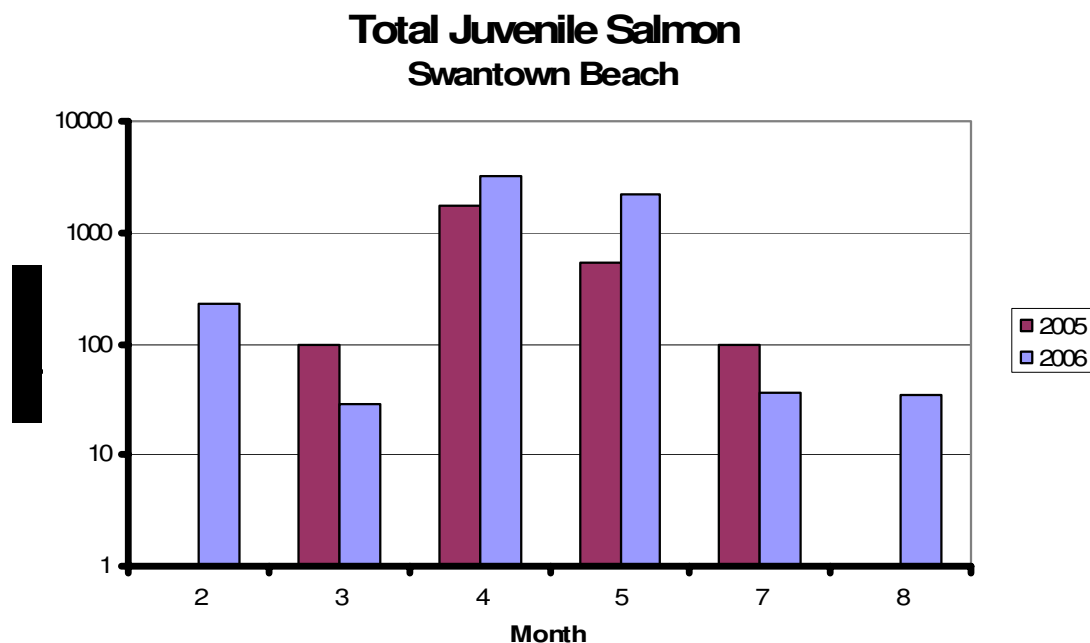
Figure 22. Total juvenile salmon densities in 2005 and 2006 at the Swantown Beach site. Note the log scale on the y-axis and no sampling in June of either year.

Ebey's Landing

Ebey's Landing was sampled 7 times in 2005 and was not chosen as a site in 2006. Sampling in 2005 occurred once a month from March through August, with an additional sampling in May. Similar to the Swantown site, Ebey's landing was often influenced by waves from the Strait of Juan de Fuca, which precluded sampling.

Juvenile salmon were observed from March through July, with peak catches in July (Figure 23). Chum salmon were the most abundant salmonid, followed by pink and chinook; no juvenile coho were observed (Appendix 1). Wild juvenile chinook were observed at the site from May through July, with peak catches in June. Roughly twice as many hatchery chinook were observed at the site than wild chinook.

Total Juvenile Salmon
Ebey's Landing
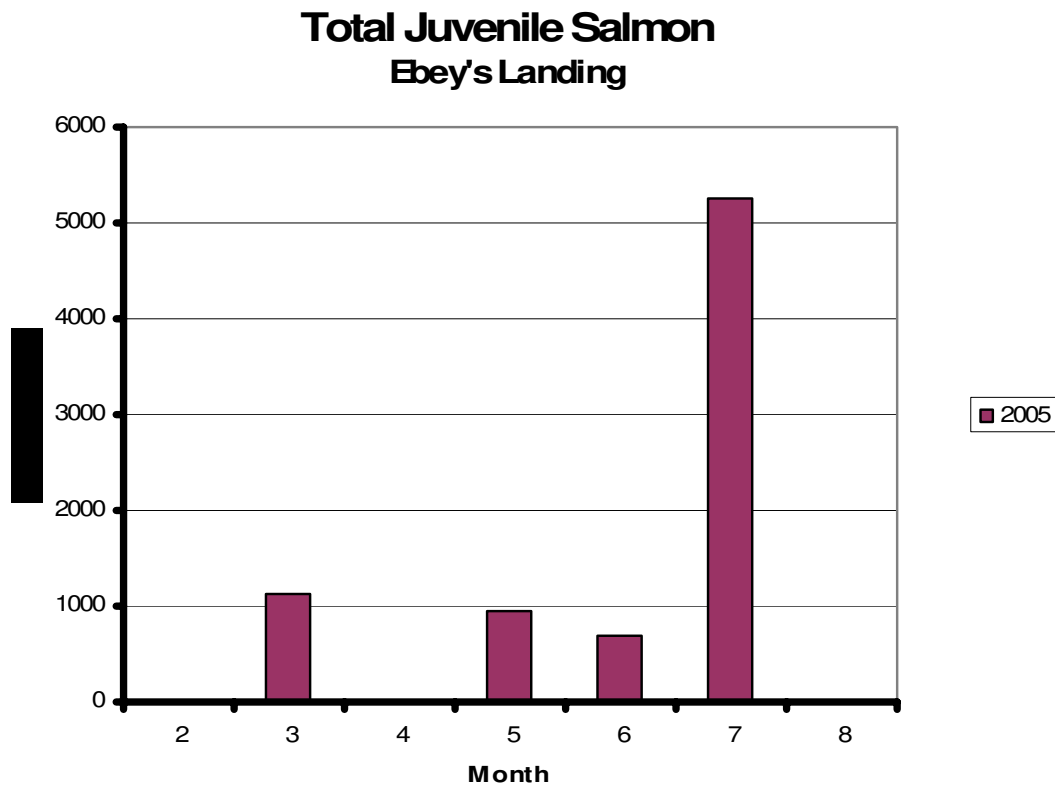
Figure 23. Total juvenile salmon densities at the Ebey's Landing site in 2005.

Keystone Harbor, Keystone Spit and Crockett Lake

Keystone Harbor was sampled 13 times in 2005 and 17 times in 2006. In 2005 the site was sampled once in February and April, and bi-weekly in March and from May through August. In 2006 the site was sampled at least bi-weekly from February through August. Keystone Spit was sampled once each in February and March of 2005 and thereafter was sampled bi-weekly. In 2006 Keystone Spit was sampled bi-weekly in February, April, and July, and once per month in March, May, June, and August. Crockett Lake was sampled five times from February through July in 2005, sampling in the lake was discontinued when no juvenile salmon were observed.

Juvenile Salmon were observed in Keystone Harbor from February through August with peak catches in 2005 in April and in 2006 in June (Figure 24). In 2005 chum salmon were the most abundant salmonid, and in 2006 pink salmon were the most abundant. Wild chinook were captured at the site from May through August, with catches peaking in June of both years. Peak catches of hatchery chinook, in June of both years, were much higher than peak catches of wild chinook, also in June of both years. However wild chinook catches were more evenly spread throughout the year (Appendix1).

Total Juvenile Salmon
Keystone Harbor
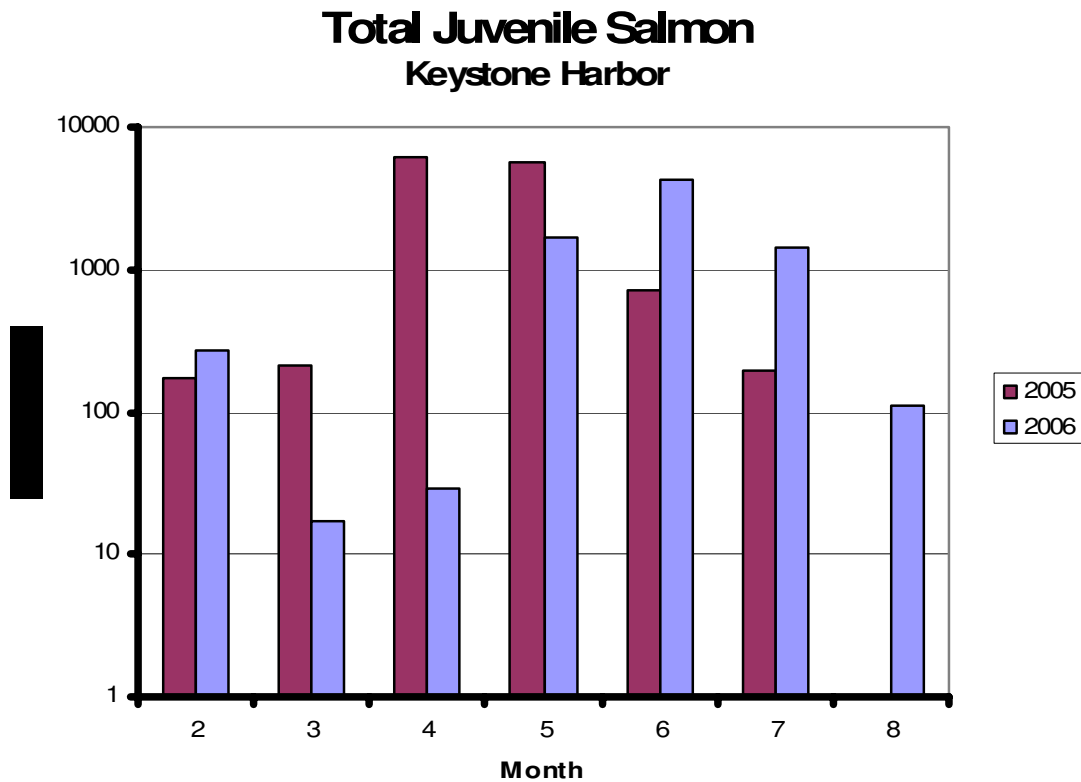
Figure 24. Total juvenile salmon densities in 2005 and 2006 at the Keystone Harbor site. Note the log scale on the y-axis.

Juvenile Salmon were observed at Keystone Spit from February through July in both years, with catches peaking in June of both years (Figure 25). Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were observed in May and June of 2005, and only in July of 2006 (Appendix 1).

Total Juvenile Salmon
Keystone Spit
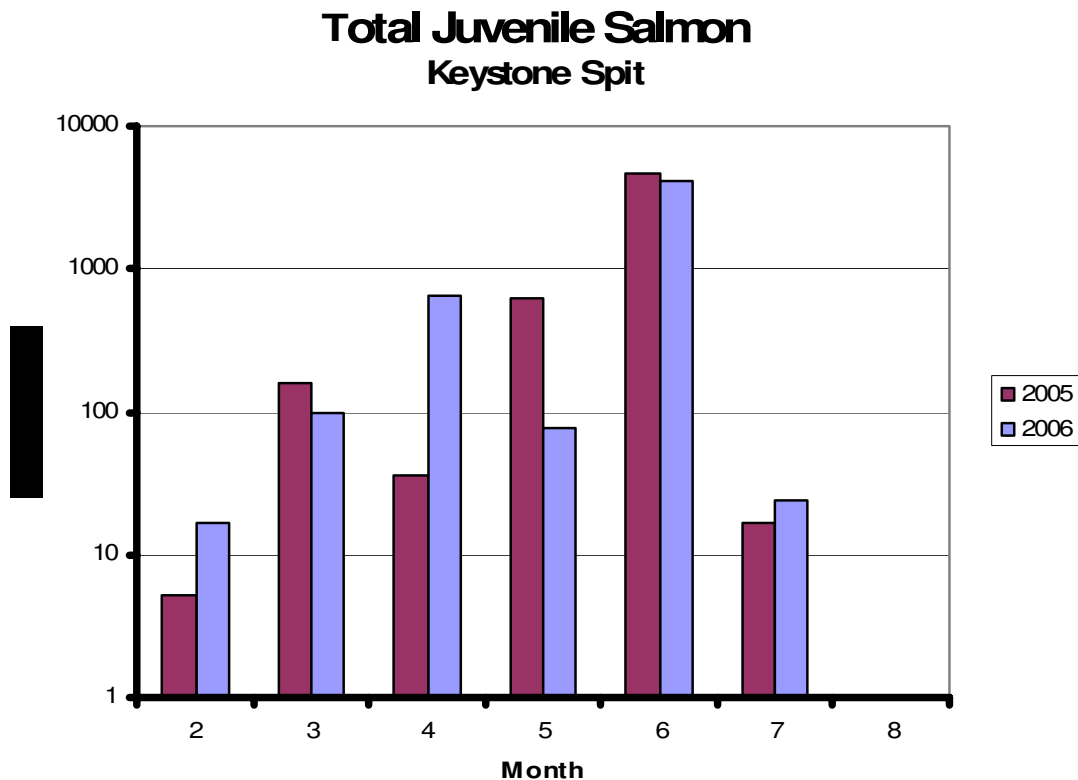
Figure 25. Total juvenile salmon densities in 2005 and 2006 at the Keystone Spit site. Note the log scale on the y-axis.

Lake Hancock lagoon and beach sites

The Lake Hancock lagoon was sampled 5 times in 2005 and 8 times in 2006. In 2005 sampling occurred once in March, twice in April, and once in June and July. In 2006 the lagoon was sampled twice in February, once in March, twice in April, and once each in June, July and August. Access to the lake by boat was limited by the shallow outlet, so sampling could only occur on particular tides. The Lake Hancock beach was sampled 7 times in 2005 and 14 times in 2006. In 2005 the beach site was sampled once monthly from February through August, while in 2006 the site was sampled bi-weekly from February through July, with no sampling in May and one sample in August.

Juvenile salmon were observed in the Lake Hancock lagoon from February through August, with peak catches in April of both years (Figure 26). In 2006 pink salmon with open belly slits from their egg yolks were observed in the lagoon, nearly 20 miles from the nearest likely natal river. Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were captured in the lagoon

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in July and August of 2005, however none were captured in 2006. In April of 2005 a mature (400mm+) bull trout was spotted by two Wild Fish Conservancy biologists; however the fish was not brought to hand. We believe that this is the first recorded observation of bull trout on the west coast of Whidbey Island.

Total Juvenile Salmon
Hancock Lagoon
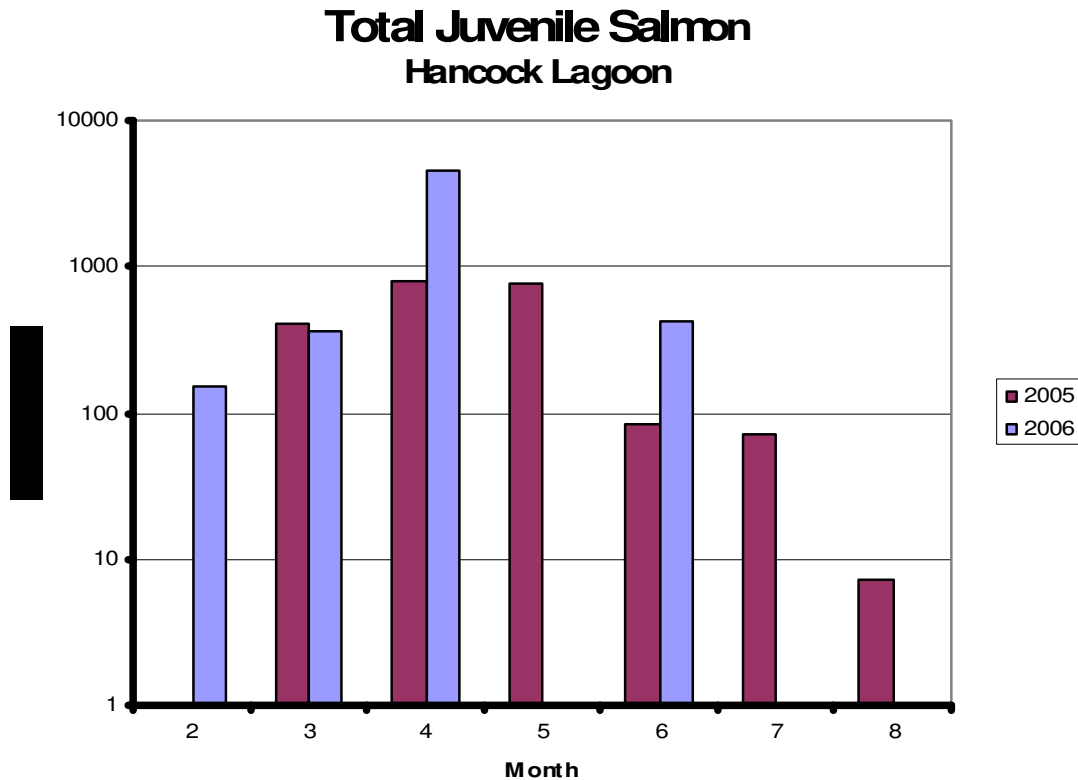
Figure 26. Total juvenile salmon densities in 2005 and 2006 at the Hancock Lagoon site. Note the log scale on the y-axis.

Juvenile salmon were observed at the Lake Hancock beach site from February through July, with peak catches occurring April of both years. Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were only observed in June of 2006, while hatchery chinook were observed in June and July of both years.
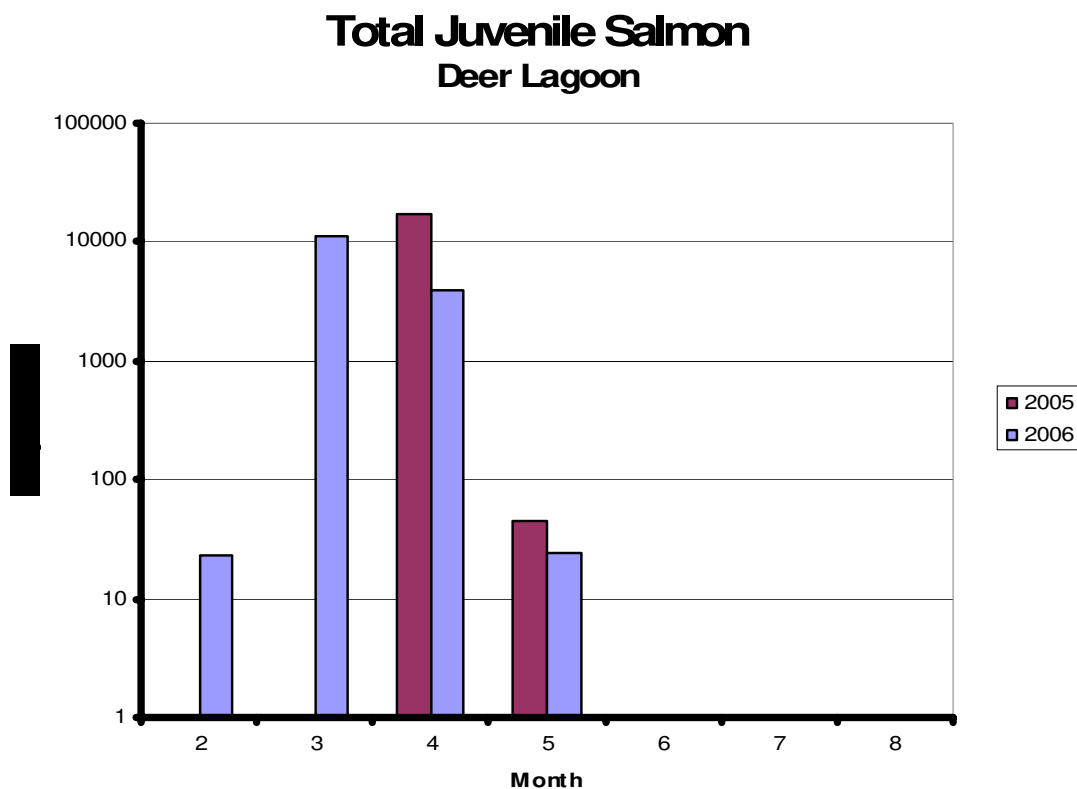
Total Juvenile Salmon
Hancock Beach
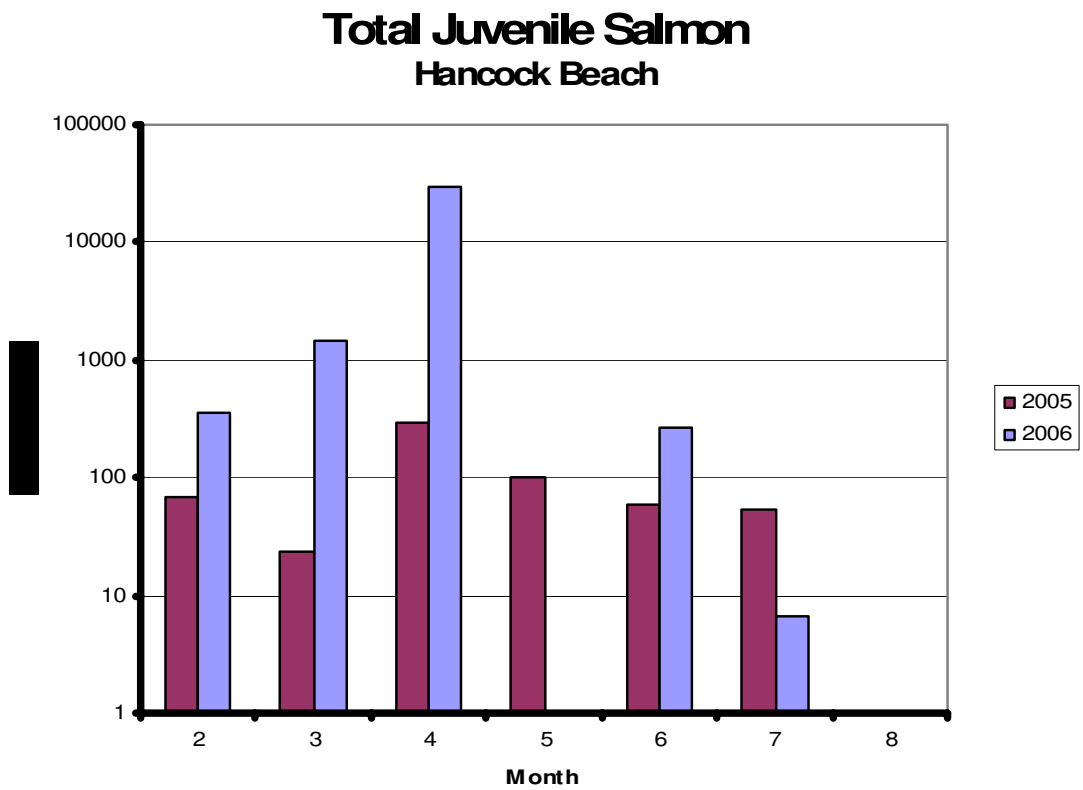
Figure 27. Total juvenile salmon densities in 2005 and 2006 at the Lake Hancock Beach site. Note the log scale on the y-axis.

Lagoon Point

Lagoon Point was sampled 9 times in 2005 and 7 times in 2006. In 2005 the site was sampled once in March, twice in April and May, once in June, and three times in July. In 2006 it was sampled twice in February, once in March, April, and May each, was not sampled in June, and was sampled twice in July.

Juvenile salmon were observed at Lagoon Point from February through July with peak catches in June in 2005 and May in 2006 (Figure 28). Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were observed from May through July in 2005 and in July of 2006.
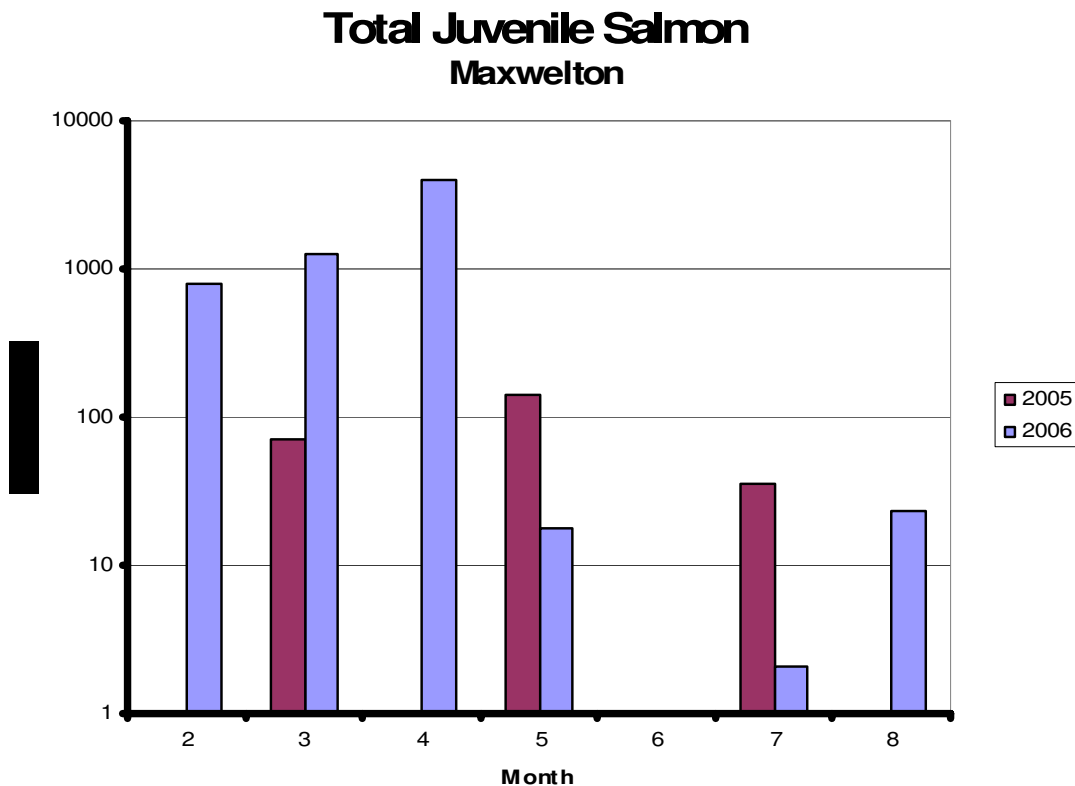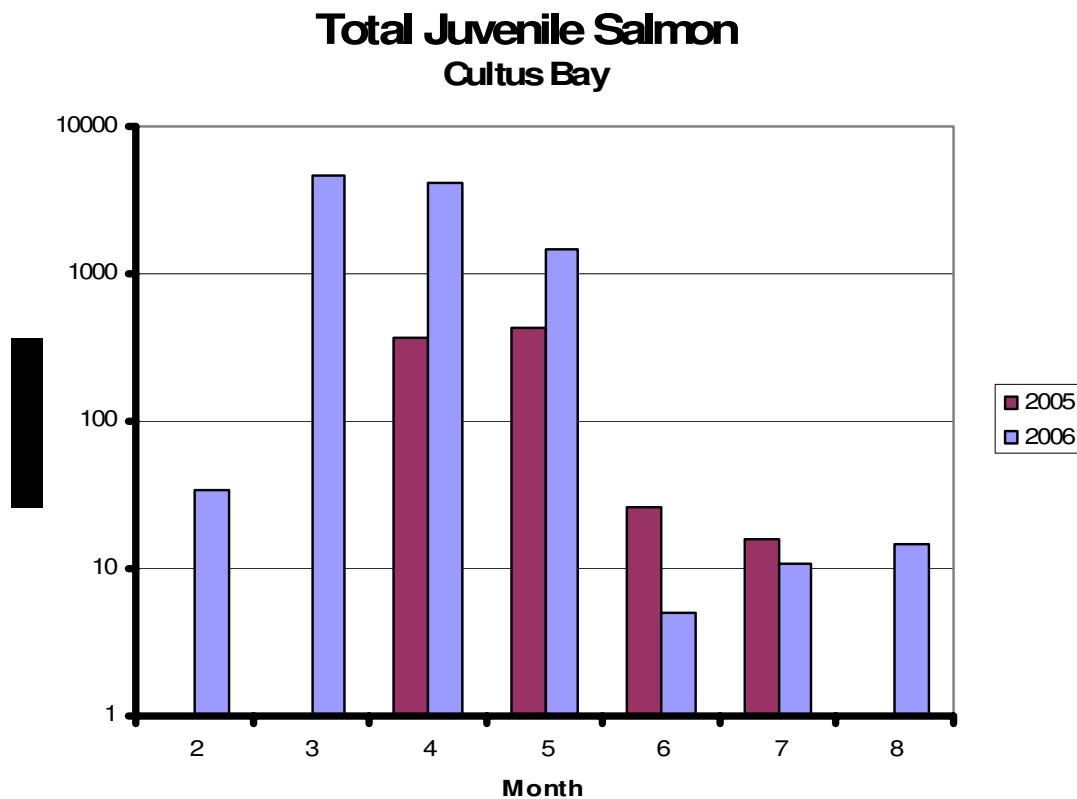
Total Juvenile Salmon
Lagoon Point
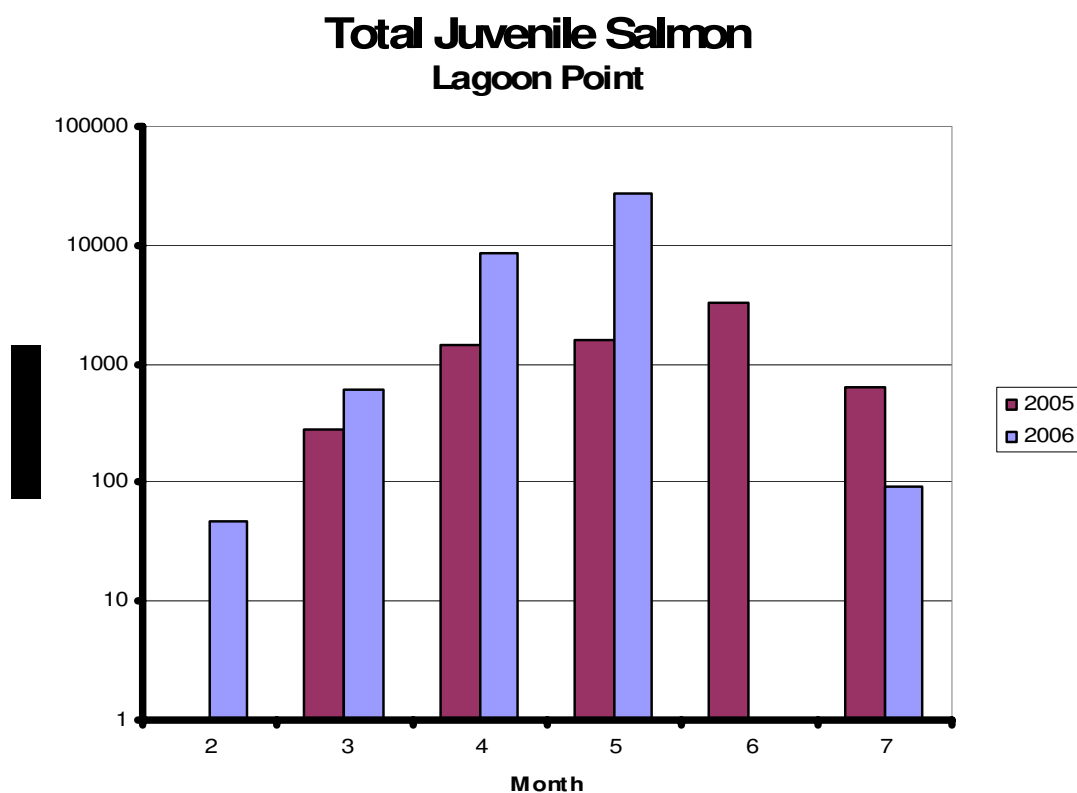
Figure 28. Total juvenile salmon densities in 2005 and 2006 at the Lagoon Point site. Note the log scale on the y-axis.

South Whidbey State Park creek and beach sites

The South Whidbey State Park creek site was sampled 10 times in 2005 and was not chosen as a sample site in 2006. The site was sampled once each in February, March, May, and July, and was sampled twice in the months April and June and August. The South Whidbey State Park beach site was sampled 7 times in 2005 and was not chosen as a sample site in 2006. The site was sampled once each in May, June, and August and twice in the months of April and July.

Juvenile salmon were observed at the SWSP creek site from February through June, with peak catches in June and no fish observed in July and August (Figure 29). Chum salmon were the most abundant salmonid. Wild chinook were only observed at the site in June.

Total Juvenile Salmon
South Whidbey State Park- Creek Site
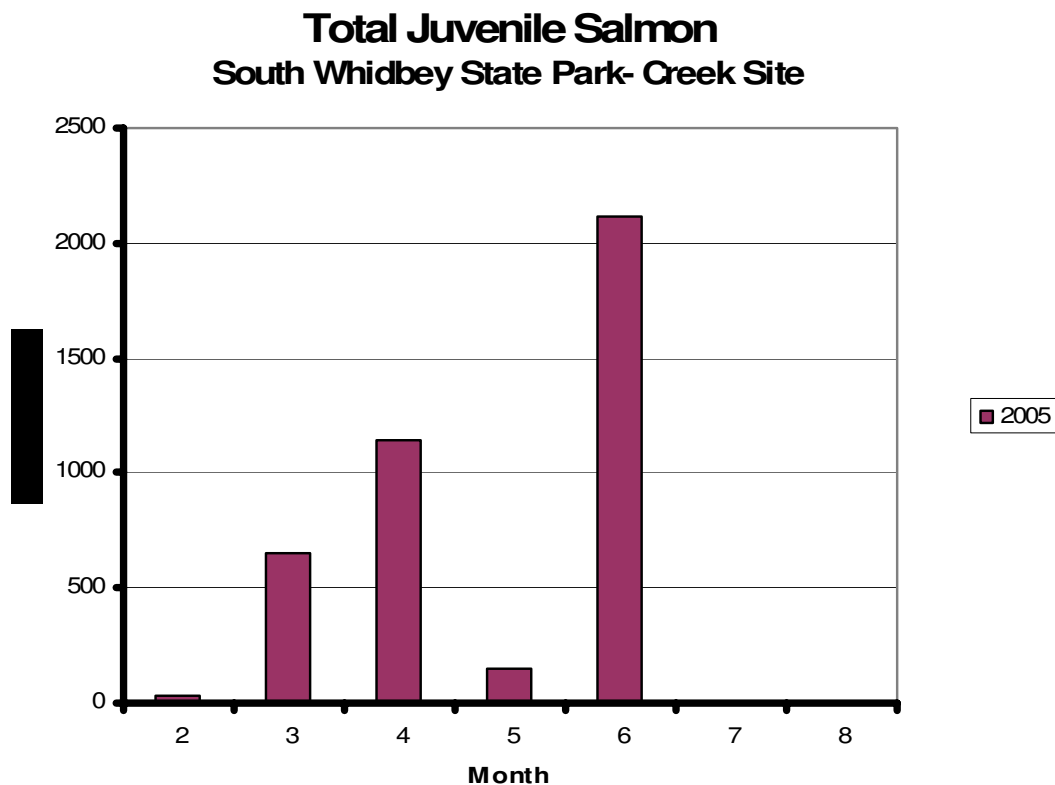
Figure 29. Total juvenile salmon densities in 2005 at the South Whidbey State Park creek site.

Juvenile salmon were observed at the SWSP beach site from April through June, with no sampling in February, March, or August (Figure 30). Peak catches were in May, and the most abundant salmonid observed were chum. Wild chinook were only observed in June.

Total Juvenile Salmon
South Whidbey State Park- Beach Site
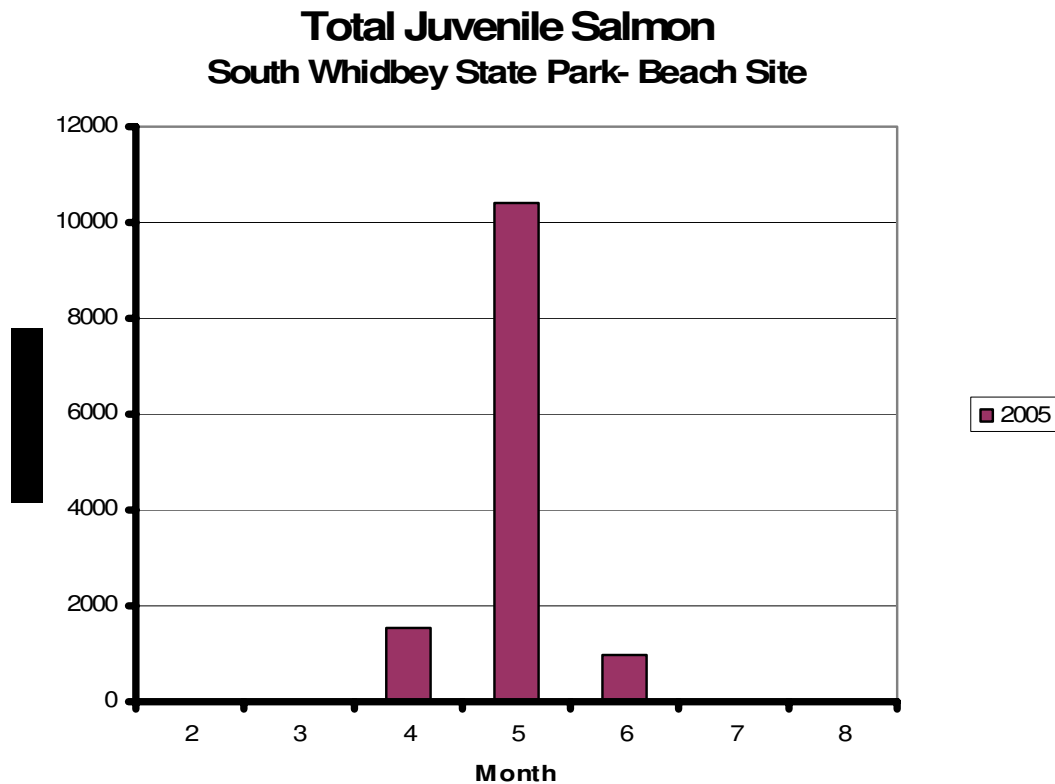
Figure 30. Total juvenile salmon densities in 2005 at the South Whidbey State Park beach site.

Double Bluff

The Double Bluff site was sampled 3 times in 2005 and 8 times in 2006. In 2005 the site was sampled one time each in April, June, and July. In 2006 the site was sampled twice in February, and then once monthly from March through August.

Juvenile salmon were observed at the site from February through July, with peak catches in April in 2005 and in March in 2006 (Figure 31). Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were not observed at the site.

Total Juvenile Salmon
Double Bluff
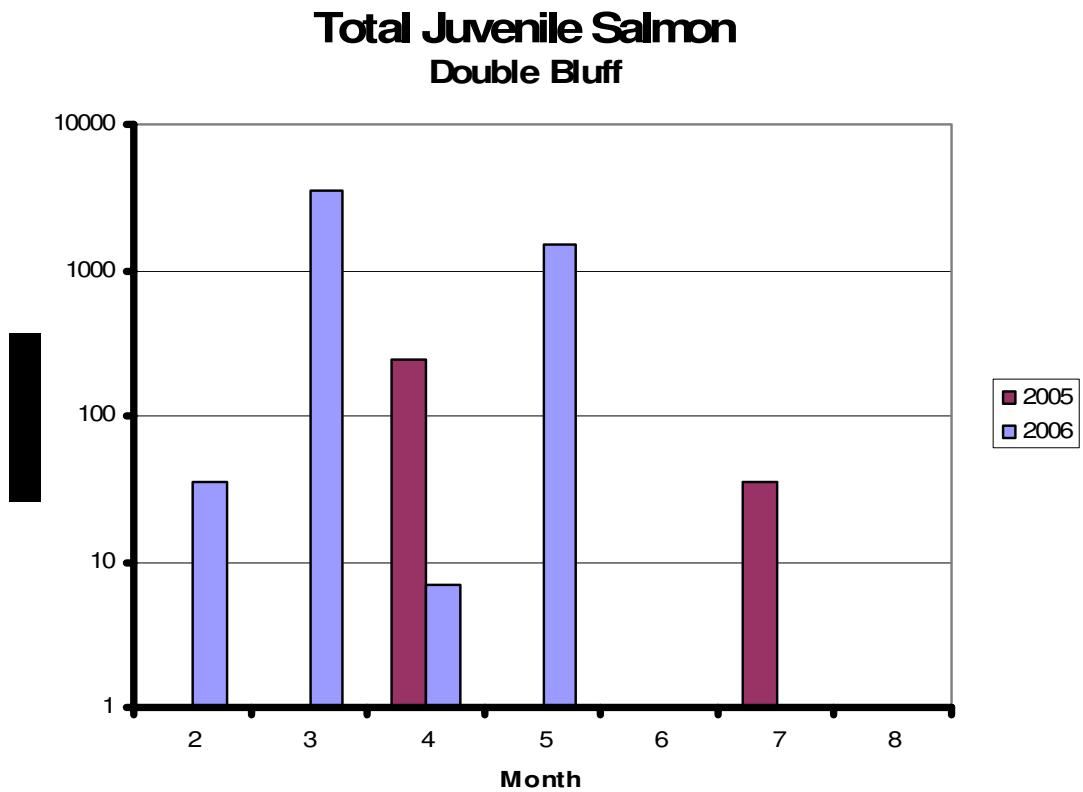
Figure 31. Total juvenile salmon densities in 2005 and 2006 at the Double Bluff site. Note the log scale on the y-axis.

Deer Lagoon

The Deer Lagoon Site was sampled 6 times in 2005 and 14 times in 2006. In 2005 the site was sampled twice in April and three times in May. In 2006 the site was sampled biweekly from February through May, and was sampled once in June twice in July, and once in August.

Juvenile salmon were observed at the site from February through May, with peak catches in April in 2005 and in March in 2006 (Figure 32). Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were only observed in May.

Total Juvenile Salmon
Deer Lagoon

Figure 32. Total juvenile salmon densities in 2005 and 2006 at the Deer Lagoon site. Note the log scale on the y-axis.

Maxwelton

The Maxwelton site was sampled 6 times in 2005 and 9 times in 2006. In 2005 the site was sampled once monthly from March through August. In 2006 the site was sampled twice in February, April, and July, and was sampled once each in March, May, and August, with no June sampling.

Juvenile salmon were observed at the site from February through August, with peak catches in May in 2005, and in April in 2006 (Figure 33). Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were observed in May and in August.

Figure 33. Total juvenile salmon densities in 2005 and 2006 at the Maxwelton site. Note the log scale on the y-axis.

Cultus Bay

The Cultus Bay site was sampled 4 times in 2005 and 12 times in 2006. In 2005 the site was sampled once each in April, May, June, and August. In 2006 the site was sampled once each in February, May, and August, and was sample twice in March, April, June and July.

Juvenile salmon were observed at the site from February through August, with peak catches in March in 2005 and in May in 2006 (Figure 34). Chum salmon were the most abundant salmonid in 2005 and pink salmon were the most abundant in 2006. Wild chinook were observed from April through July.

Total Juvenile Salmon
Cultus Bay

Figure 34. Total juvenile salmon densities in 2005 and 2006 at the Cultus Bay site. Note the log scale on the y-axis.

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Juvenile Salmon Densities at Extensive Sites

Juvenile salmon were observed at 55 of the 60 sites sampled in the extensive survey during May and June 2006. The five sites where no salmon were observed were not clustered on a particular stretch of the coast and were adjacent to sites that did have juvenile salmon. Juvenile pink salmon had the highest frequency of occurrence, and were observed at 47 of the 60 sites. Hatchery coho had the lowest frequency of occurrence and were only observed at 9 of the 60 sites (Figure 35).

Species	Pink	Chum	Hatchery Chinook	Wild Chinook	Hatchery Coho	Wild Coho	Any Juvenile Salmon
Number of Sites with no occurrence	13	16	38	48	51	38	5
Number of Sites with occurrence	47	44	22	12	9	22	55

Figure 35. Table showing the number of site occurrences by species for the extensive sampling effort.

Log transformed juvenile salmon densities from the 60 extensive sites sampled during May and June 2006 were entered into a stepwise multiple linear regressions as single dependant variables (Figure 36). The following independent variables were entered and selected in a bi-directional stepwise fashion to yield the best predictive model: population-weighted distance, site embayment, percent of average high tide, log transformed maximum set depth, substrate size, substrate heterogeneity (standard deviation of mean substrate size at a site), aggregate vegetative percent cover, the three largest individual constituents of aggregate percent cover (sea lettuce, *Ulva* sp., low kelp *Laminaria saccharina*, and eelgrass, *Zostera marina*), and bull kelp, *Nereocystis luetkeana*, which was measured as a count of stipes per 0.5 m^2 and not included in percent cover. Julian date was also entered so that seasonal trends in abundance would not affect the selection of environmental and geospatial variables. If models selected aggregate percent cover, individual vegetative constituents were not also chosen because of a high degree of co-linearity, in order to satisfy model assumptions. A significance level of 0.15 was selected as the tolerance level for inclusion of individual variables in the model (Quinn and Keough 2002).
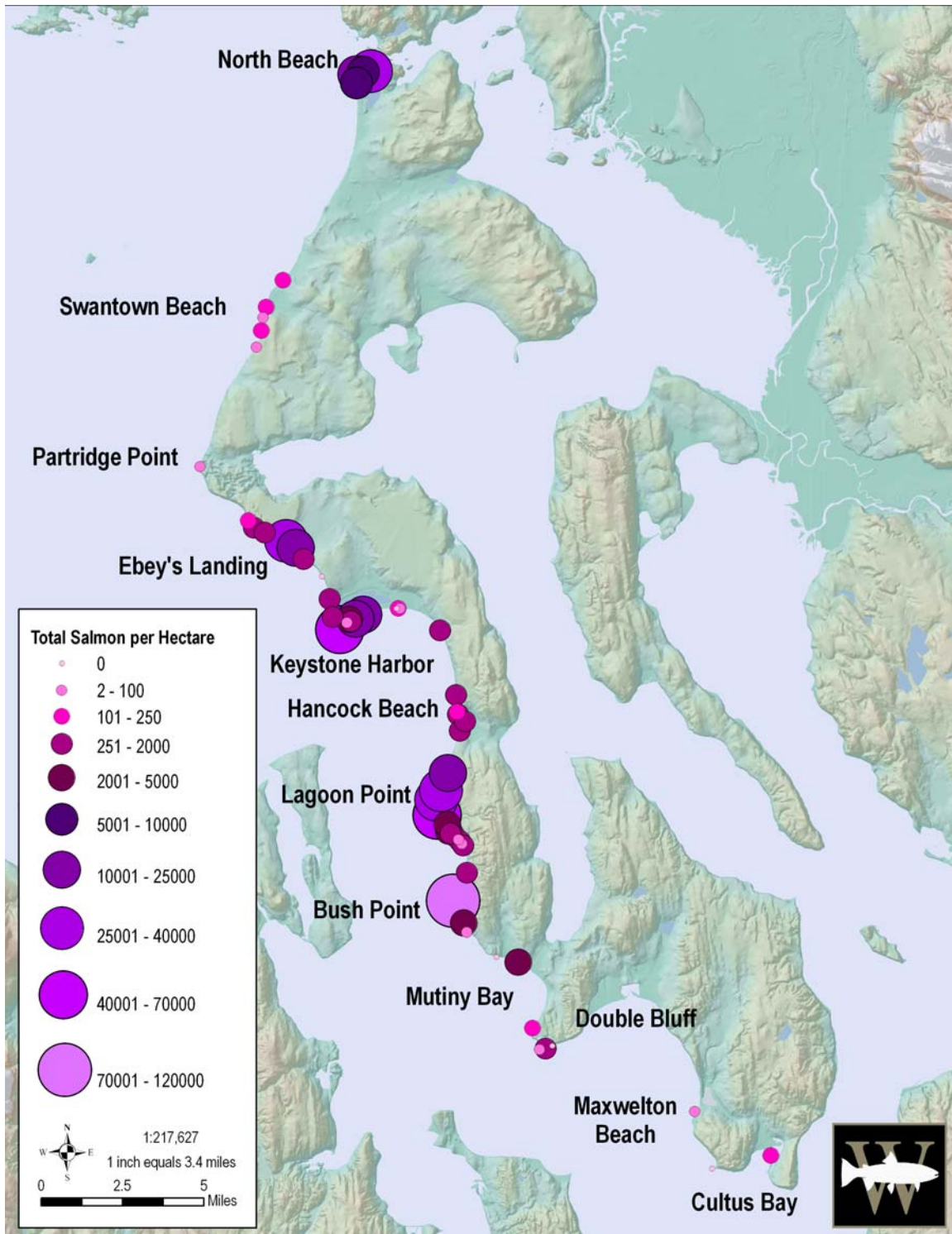
Figure 36. Map of total juvenile salmon densities at extensive sites sampled in May and June of 2006.

Light intensity, water temperature, and salinity were tested in separate analyses because missing observations of these variables would have eliminated too many cases had they been included in initial models. Water temperature and salinity, though varying by site (10-16ºC and 20-31 ppt), showed an overall increasing trend through May and June, and accounted for little variance in the densities of all species. Light intensity, which was only available in the month of June, was a strong predictor of pink, wild chinook, and both wild and hatchery coho abundances, with R^2 values often increasing dramatically by incorporating this variable. Abundances of these species were negatively correlated with light intensity.

Pink Salmon

Variable[1]	Direction of Relationship	t-value	Significance
Population-weighted Distance	–	-2.64	0.01
Log Set Depth	+	2.59	0.01
Embayment	–	-1.75	0.09
Percent Agg. Vegetative Cover	+	1.92	0.06
[1]Table values are listed only for variables selected in best stepwise model.		Multiple R^2 = 0.26	Overall Sig. = 0.002
		Overall F-Statistic= 4.849	

Figure 37. Environmental and spatial factors affecting the density of pink salmon at extensive sampling sites.

Stepwise multiple regression analysis accounted significantly for 26% of the variance in pink salmon abundance (Figure 37). Pink salmon abundance was negatively correlated with the population-weighted distance variable, meaning greater abundances were observed at sites with greater aggregate weighted-distance to rivers. Abundance was also lower at sites with a high degree of embayment, while it was positively correlated with set depth and aggregate vegetative cover.

Chum Salmon

Variable[1]	Direction of Relationship	t-value	Significance
Log Set Depth	+	2.37	0.02
Embayment	–	-3.24	<0.01
Low Kelp Percent Cover	+	2.05	0.04
[1]Table values are listed only for variables selected in best stepwise model.		Multiple R^2 = 0.25	Overall Sig. = 0.001
		Overall F-Statistic= 6.107	

Figure 38. Environmental and spatial factors affecting the density of chum salmon at extensive sampling sites.

Stepwise multiple regression analysis accounted significantly for 25% of the variance in chum salmon abundance (Figure 38). Chum salmon abundance was positively correlated

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with set depth and low kelp percent cover, while negatively correlated with the embayed-ness of sites.

Wild Chinook Salmon

Variable[1]	Direction of Relationship	t-value	Significance
Population-weighted Distance	+	6.40	<0.01
Julian Date	+	2.38	0.02
Substrate Heterogeneity	–	-2.41	0.02
Low Kelp Percent Cover	+	2.56	0.01
[1]Table values are listed only for variables selected in best stepwise model.		**Multiple R^2 = 0.49**	**Overall Sig. < 0.001**
		Overall F-Statistic= 12.99	

Figure 39. Environmental and spatial factors affecting the density of wild chinook salmon at extensive sampling sites.

Stepwise multiple regression analysis accounted significantly for 49% of the variance in wild chinook salmon abundance (Figure 39). Wild chinook abundance was positively correlated with the population-weighted distance variable and with percent cover of low kelp, increasing through May and June, while negatively correlated with substrate heterogeneity.

Hatchery Chinook Salmon

Variable[1]	Direction of Relationship	t-value	Significance
Julian Date	+	4.53	<0.01
Percent of Average High Tide	–	-2.08	0.04
[1]Table values are listed only for variables selected in best stepwise model.		**Multiple R^2 = 0.32**	**Overall Sig. <0.001**
		Overall F-Statistic= 13.14	

Figure 40. Environmental factors affecting the density of hatchery chinook salmon at extensive sampling sites.

Stepwise multiple regression analysis accounted significantly for 32% of the variance in hatchery chinook salmon abundance (Figure 40). Hatchery chinook salmon abundance increased through May and June and was higher during net sets made at lower tides.

Wild Coho Salmon

Variable[1]	Direction of Relationship	t-value	Significance
Population-weighted Distance	+	1.49	0.14
Julian Date	+	2.68	0.01
Log Set Depth	+	2.12	0.04
Sea Lettuce Percent Cover	+	2.82	0.01
Eelgrass Percent Cover	+	1.96	0.06

[1]Table values are listed only for variables selected in best stepwise model.	Multiple R^2 = 0.28	Overall Sig. = 0.003
	Overall F-Statistic= 4.165	

Figure 41. Environmental and spatial factors affecting the density of wild coho salmon at extensive sampling sites.

Stepwise multiple regression analysis accounted significantly for 28% of the variance in wild coho salmon abundance (Figure 41). Wild coho salmon abundance increased through May and June, and was positively correlated with the population weighted-distance variable, set depth, sea lettuce percent cover and eelgrass percent cover.

Hatchery Coho Salmon

Variable[1]	Direction of Relationship	t-value	Significance
Population-weighted Distance	+	2.65	0.01
Julian Date	+	1.69	0.10
Log Set Depth	+	2.88	0.01
Low Kelp Percent Cover	+	2.37	0.02

[1]Table values are listed only for variables selected in best stepwise model.	Multiple R^2 = 0.22	Overall Sig. = 0.008
	Overall F-Statistic= 3.837	

Figure 42. Environmental and spatial factors affecting the density of wild chinook salmon at extensive sampling sites.

Stepwise multiple regression analysis accounted significantly for 22% of the variance in hatchery coho salmon (Figure 42). Hatchery coho salmon abundance increased through May and June, and was positively correlated with the population-weighted distance model, set depth, and low kelp percent cover.

3.2 Results – *Coded Wire Tag Recovery*

Over the course of the project we recovered 107 hatchery origin juvenile salmon with Coded Wire Tag implants. In 2005 we recovered 55 tagged fish and in 2006 we recovered 52 tagged fish. Hatchery of origin data were only recovered for 52 fish in 2005, with 2 tags being lost while reading, and 1 tag being unreadable. In 2005 we recovered 53 tagged chinook and 2 tagged coho. In 2006 we recovered 42 tagged chinook and 10 tagged coho.

Over 85% of the recovered chinook came from the Snohomish, Stillaguamish, Skagit and Samish Rivers (Figure 43). We also recovered hatchery origin tagged chinook that were released in watersheds from the Hood Canal, East Kitsap Peninsula, and eastern central Puget Sound (Figure 44). In 2005 we recovered one tagged chinook from the Fraser River this was the northern most basin from which we recovered a chinook. The southern most basin of origin for a recovered CWT chinook was the Skokomish.

Coded Wire Tag Recovery

Chinook		n = 92
Basin of Origin	**Number of Fish Recovered**	**Percentage of Total**
Fraser	1	0.01
Nooksack	1	0.01
Samish	34	0.37
Skagit	14	0.15
Stillaguamish	8	0.09
Snohomish	23	0.25
Hamma Hamma	1	0.01
Hoodsport	2	0.02
Skokomish	4	0.04
Grover's Creek	2	0.02
Lake Washington	1	0.01
Green River	1	0.01

Figure 43. Table displaying the number of coded wire tagged juvenile chinook caught in 2005 and 2006 by river basin of origin. All fish are hatchery origin chinook, except for 3 tagged wild Skagit River chinook caught in 2005, and were recovered while sampling on the western shoreline of Whidbey Island.
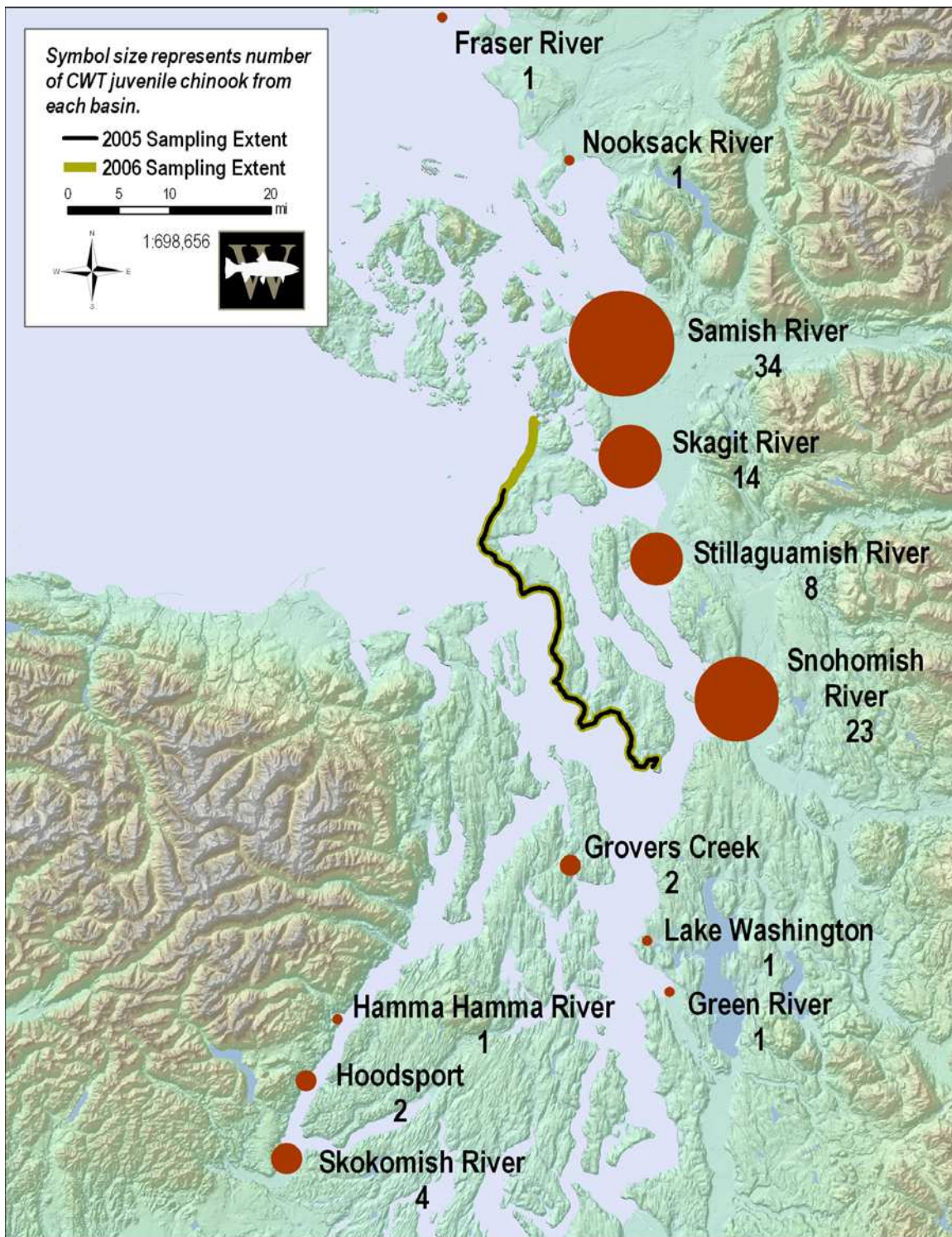
Figure 44. Basin of origin for coded wire tagged juvenile chinook captured in 2005 and 2006. Of the 23 tagged fish included in the Snohomish River count, 7 were from Tulalip Bay.

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We recovered 12 CWT juvenile coho over the course of the project, 2 in 2005 and 10 in 2006. Thirty-three percent of the CWT recovered fish originated in the Snohomish River Basin, and 25% came from the Green River Basin (Figure 45). The fish recovered from the northern most basin of origin was a Fraser River coho in 2006. The Green River fish were the southern most originating coho (Figure 46).

Coded Wire Tag Recovery

Coho		n = 12
Basin of Origin	Number of Fish Recovered	Percentage of Total
Fraser	1	8
Skagit	2	17
Snohomish	4	33
Port Gamble	1	8
Quilcene	1	8
Green River	3	25

Figure 45. Table displaying the number of coded wire tagged juvenile coho caught in 2005 and 2006 by river basin of origin. All fish are hatchery origin coho recovered sampling on the western shoreline of Whidbey Island.
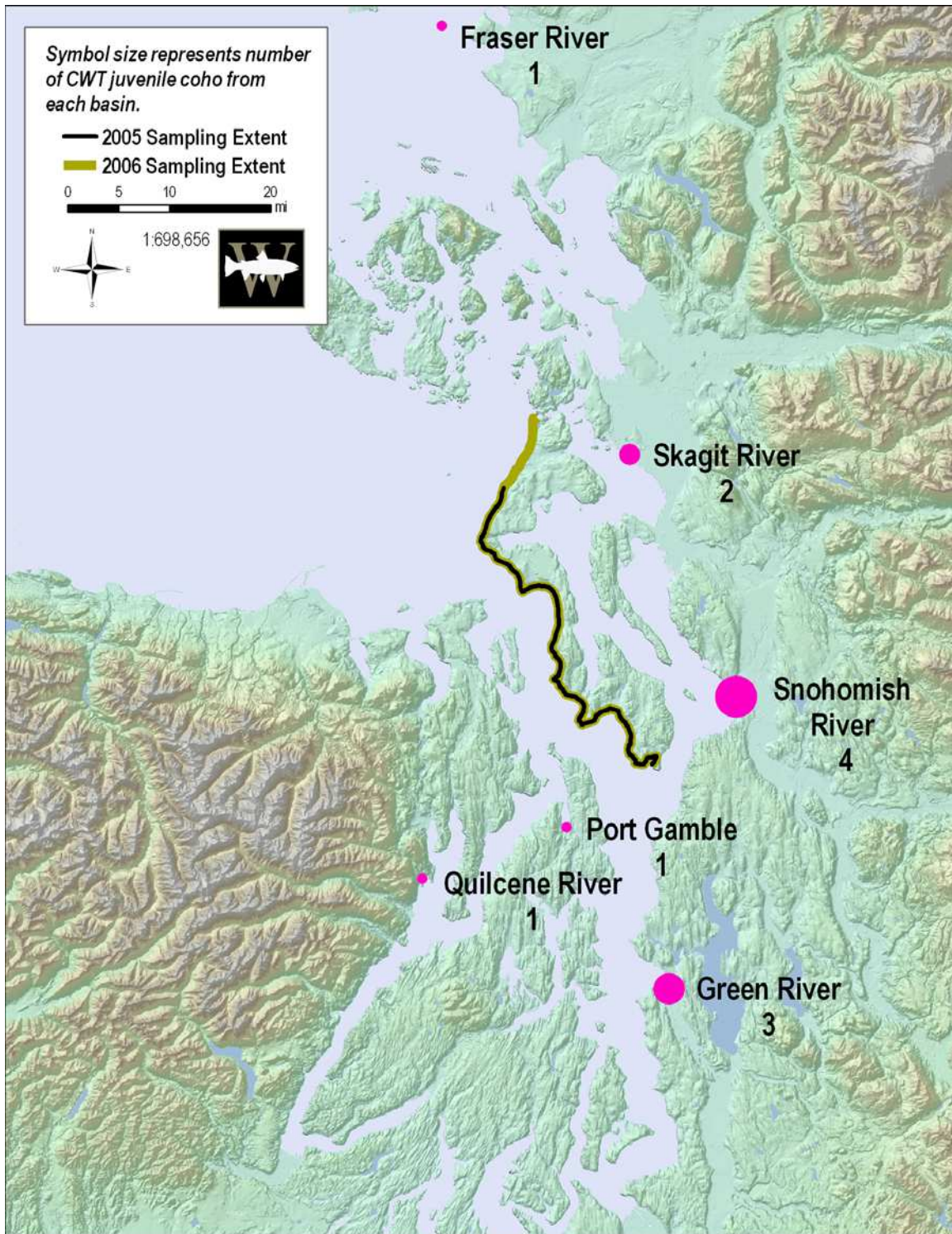
Figure 46. Basin of origin for coded wire tagged juvenile coho captured in 2005 and 2006. Of the 3 tagged fish included in the Green River count, 1 was from the Eliot Bay net pens.

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The Puget Sound Partnership is the new regional authority tasked with the recovery of the Puget Sound Ecosystem. The legislation that created the Partnership established 7 geographic Action Areas around Puget Sound to address and tackle problems specific to those areas. Over the course of sampling on the western shore of Whidbey Island we recovered CWT fish from 5 of the 7 Puget Sound Partnership Action Areas (Figure 47).

Puget Sound Partnership Action Areas

Puget Sound Action Area	Coded Wire Tags Recovered 2005	% of total	Coded Wire Tags Recovered 2006	% of total	Total Coded Wire Tags Recovered	% of total
Whidbey Island	43	83%	42	81%	85	81%
Hood Canal	6	12%	3	6%	9	1%
North Central Puget Sound	1	2%	1	2%	2	2%
South Central Puget Sound	1	2%	5	10%	6	6%
San Juan Island	0	12%	1	6%	1	9%

Figure 47. Table showing the recovery of CWT fish by Puget Sound Partnership Action Areas.

3.3 Results – *Juvenile Salmon Lengths*

Mean fork length per seine haul for all species varied throughout the sampling season and differed between years. Pink salmon was the smallest species, with a mean length of 50 and 48 mm is 2005 and 2006, respectively, followed by chum (64 and 61 mm), wild chinook (108 and 92 mm), hatchery chinook (110 and 105 mm), wild coho (126 and 120 mm), and hatchery coho (158 and 150 mm) (Figures 48 and 49). The monthly mean fork length per seine haul of chum and pink salmon increased throughout the spring and summer in both 2005 and 2006, while patterns in hatchery and wild coho and chinook salmon did not show linear increases (Figures 50 and 51). Paired t-tests by seine haul where both wild and hatchery fish of the same species were caught, and non-paired t-tests involving all seine hauls revealed that hatchery chinook and coho were significantly larger than their wild counterparts (2005: $p = 0.59$ for unpaired chinook; $p < 0.01$ for paired chinook, $p < 0.01$ for unpaired coho, $p = 0.015$ for paired coho, 2006: $p < 0.01$ for all tests)
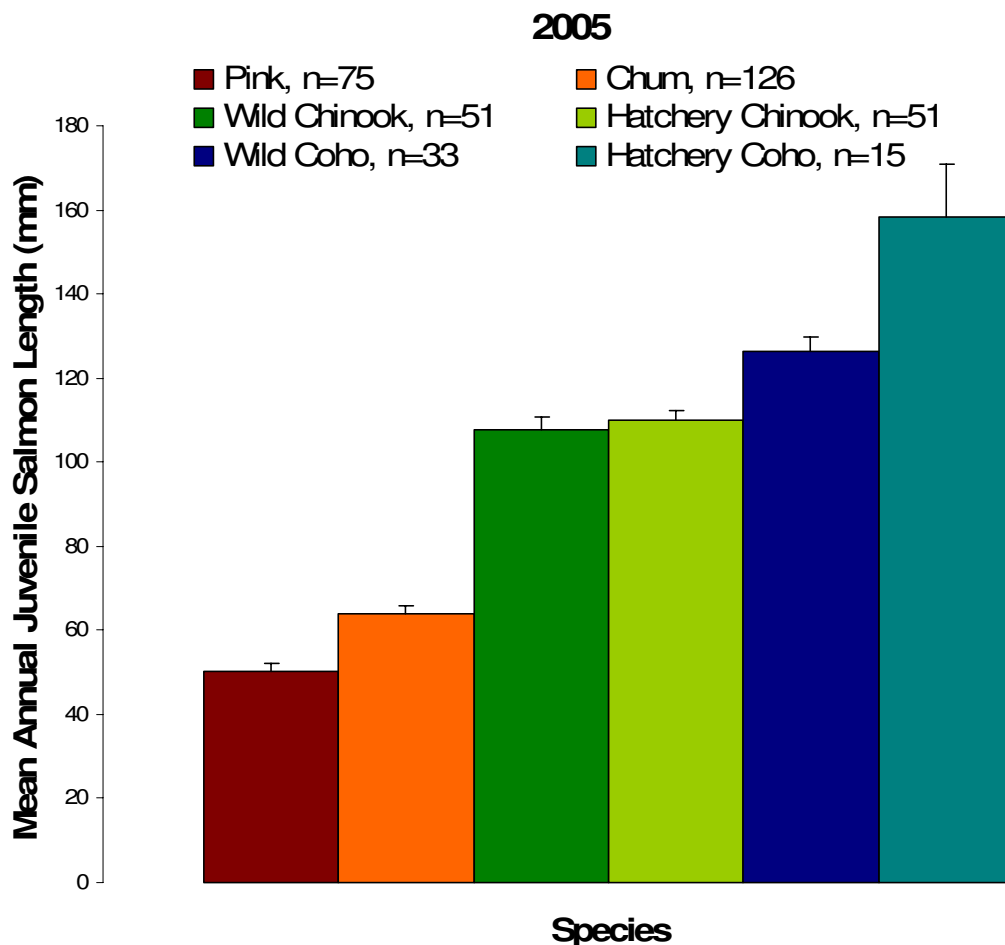
Figure 48. Mean annual length of each juvenile salmon species caught in 2005.
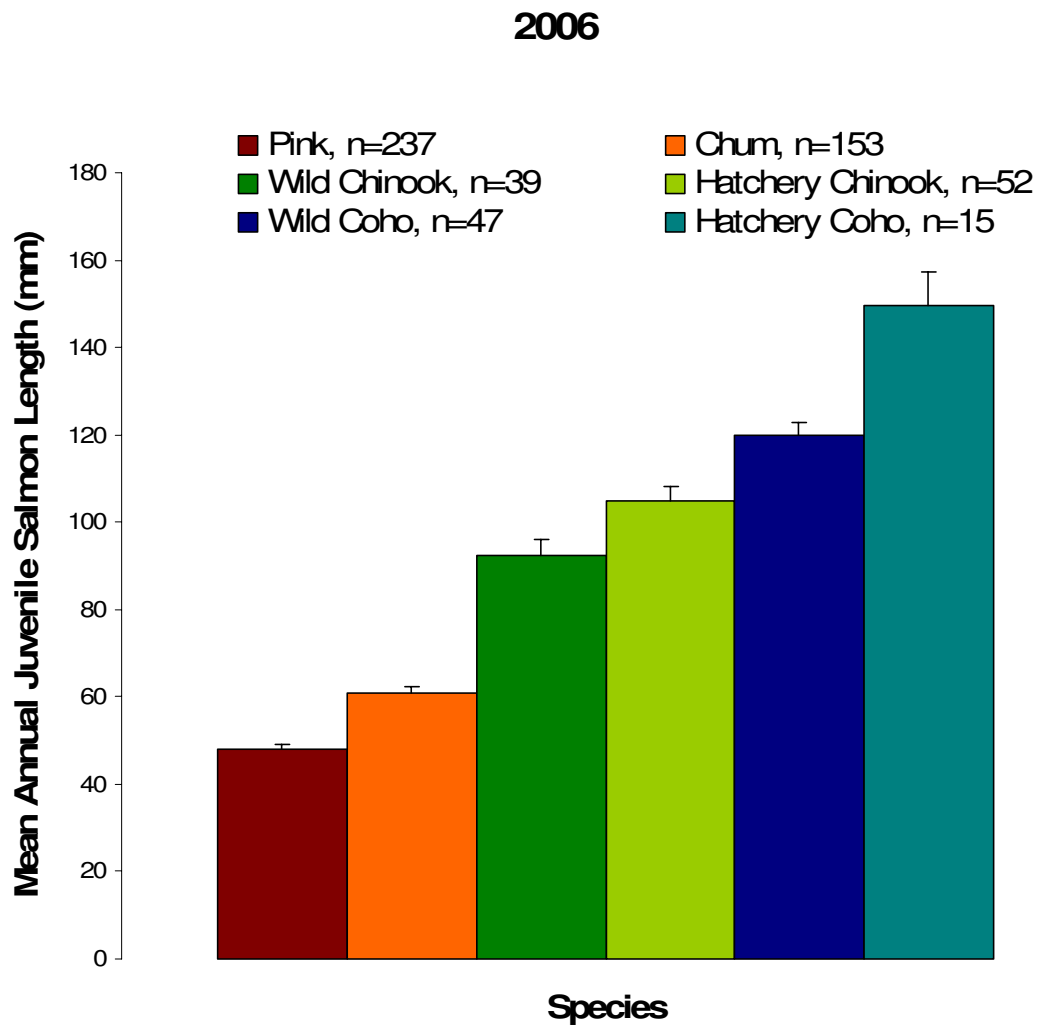
2006

Figure 49. Mean annual length of each juvenile salmon species caught in 2006.
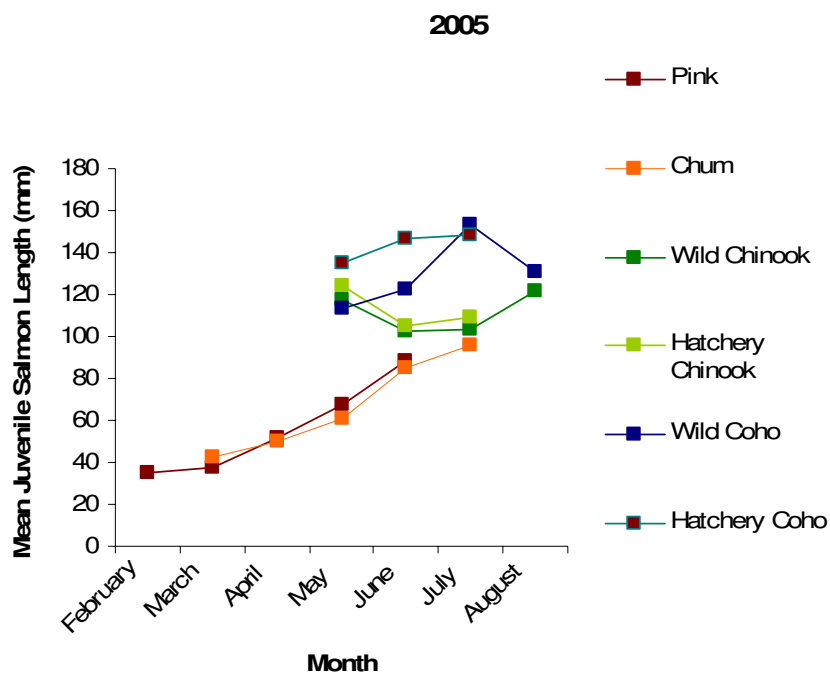
2005

Figure 50. Mean juvenile salmon lengths for each species by month in 2005.
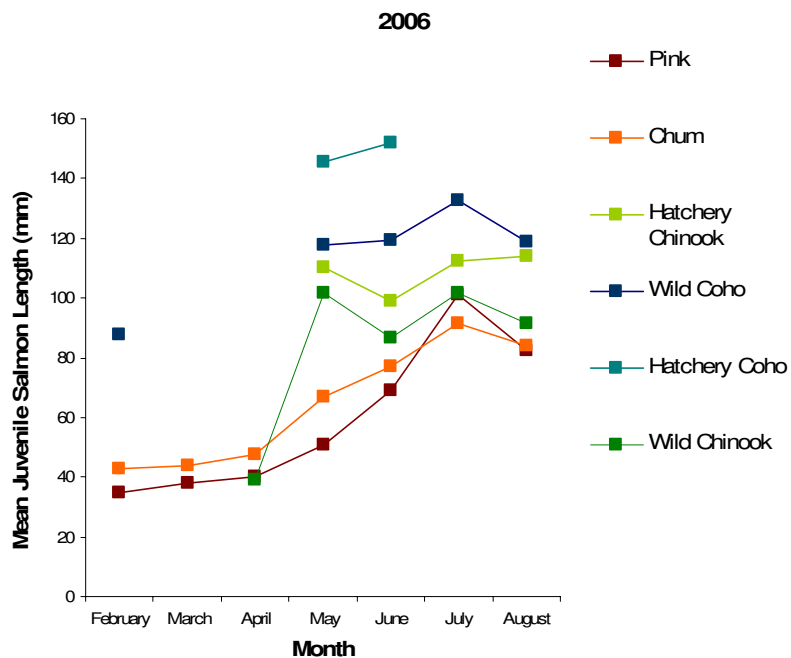
2006

Figure 51. Mean juvenile salmon lengths for each species by month in 2006.

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Environmental and spatial factors affecting the length of juvenile salmon.

Variable[1]	Significance followed by direction of relationship					
	Pink	Chum	Hatchery Chinook	Total Chinook	Wild Coho	Total Coho
Julian Date	0.00 +					
Max. Set Depth		0.00 +			0.04 +	0.02 +
Embayment	0.09 –	0.00 +				
Substrate Size					0.03 –	
Substrate Heterogeneity					0.06 +	
Aggregate Vegetative Cover					0.13 –	
Sea Lettuce Cover	0.02 +	0.14 +	0.09 +	0.05 +		
Eelgrass Cover		0.05 +				
Bull Kelp Stipes	0.12 –	0.11 –				0.09 –
Overall Model Sig.	0.000	0.002	0.050	0.096	0.059	0.018
Multiple R^2	0.60	0.47	0.16	0.13	0.40	0.33

[1]Table values are listed only for variables selected in best stepwise model.

Figure 52. Table showing the results of a stepwise multiple regression model of juvenile salmon lengths and environmental and spatial variables. Values displayed are the significance with the direction of correlation as either + or – indication positive or negative.

Stepwise multiple regression analysis accounted for 60% of the variance in pink salmon length in May and June of 2006 (Figure 52). Length was positively correlated with Julian date, and percent cover of sea lettuce, while negatively correlated with bull kelp density and embayment of a site. For chum salmon, the best model accounted for 47% of the variance. Chum length was positively correlated with maximum set depth, embayment, sea lettuce percent cover and eelgrass percent cover, while negatively correlated with bull kelp density. Hatchery and total (combined hatchery and wild) chinook lengths were positively correlated with sea lettuce cover, which accounted for only 16 and 13% of the variance respectively. Wild chinook lengths were not modeled, as the sample size was too small for this analysis. The best model accounted for 40% of the variance in wild coho lengths, their length being positively correlated with maximum set depth and substrate heterogeneity, and negatively correlated with aggregate vegetative cover and substrate size. The total coho model accounted for 33% of variance in combined hatchery and wild coho lengths, demonstrating a positive correlation with maximum set depth, and a negative correlation with bull kelp density.

3.4 Results – *Community Diversity*

During the 2005 sampling season (February through August), Wild Fish Conservancy netted a minimum of fifty-eight different species of marine fish comprising nine separate ecological guilds, including six species of salmonids, five types of forage fish, five species of gunnel *(Pholis spp),* at least one prickleback (*Lumpenus spp*), and a single juvenile wolf eel *(Anarrhichthys ocellatus)* captured in Keystone Harbor. We also encountered fourteen separate species of sculpin, although differentiating between the soft sculpin *(Gilbertidia sigalutes)* and tadpole sculpin *(Psychrolutes paradoxus)* proved to be difficult in the field.

Several species of mobile predators, those that actively chase their prey in the mid-water column as opposed to large predatory sculpins that stay near the bottom, were captured on occasion at several of the sample sites. These included three species of greenling *(Hexagrammos spp*) lingcod *(Ophiodon elongatus)*, quillback rockfish *(Sebastes maliger)*, and two big skates *(Raja binoculata)* that were netted at the Swantown beach.

Three species of surf perch *(Embiotocidae spp*) and several unrelated, relatively small-bodied fish including three-spine stickleback *(Gasterosteus aculeatus)*, arrow goby *(Clevelandia ios)*, and bay pipefish *(Syngnathus leptorhynchus)*, rounded out the catch for the season, along with eight species of fish consisting of only a few individuals that we were unable to positively identify. A single freshwater species, yellow perch *(Perca flavescens)*, was found to inhabit Swantown Lake along with numerous juvenile and adult three-spine stickleback.
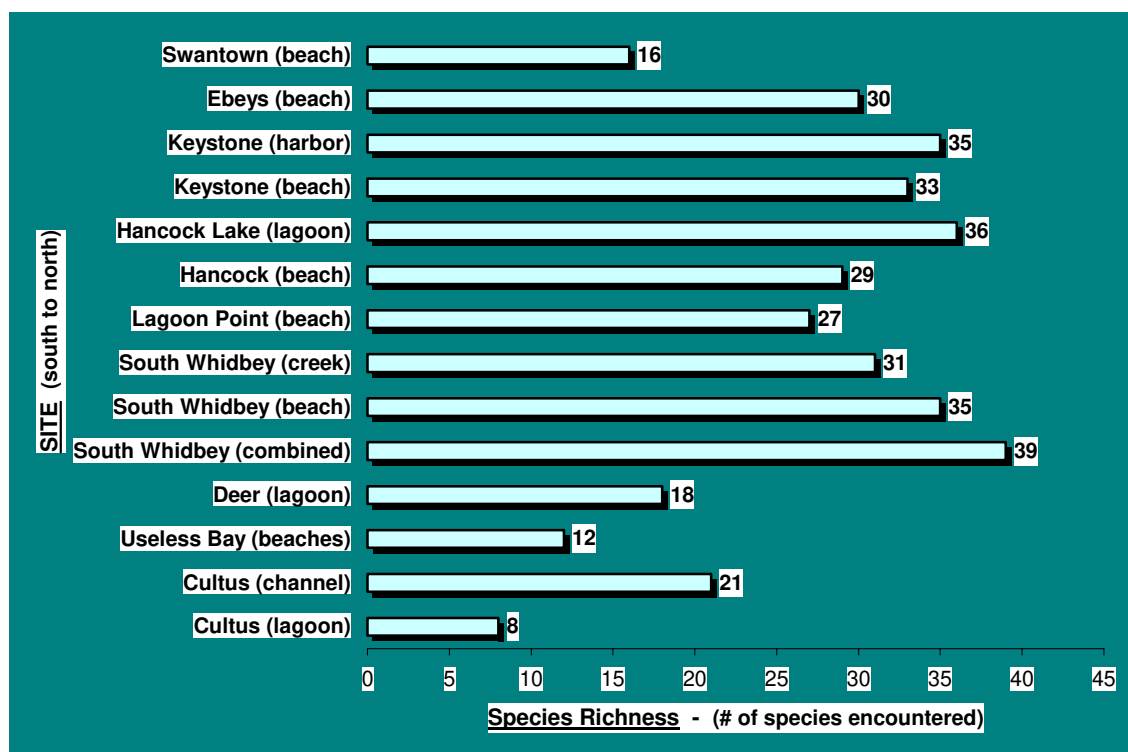
Figure 53. Species richness, the total number of nearshore fish species encountered at sample sites along the west coast of Whidbey Island (2005)

Although the types of fish encountered were somewhat variable from site-to-site, overall species richness was high, and did not differ greatly between sites along the north-to-south gradient from the beach at Ebey's Landing to South Whidbey State Park (Figure 53). The number of species only dropped off at the extreme northernmost and southern sites – Swantown and Cultus Bay respectively.

We calculated Shannon-Weiner diversity index scores for each of the ten sites that were sampled using the large beach seine, as well as the three sites that were only sampled effectively using a small hand net (Figures 54-55).
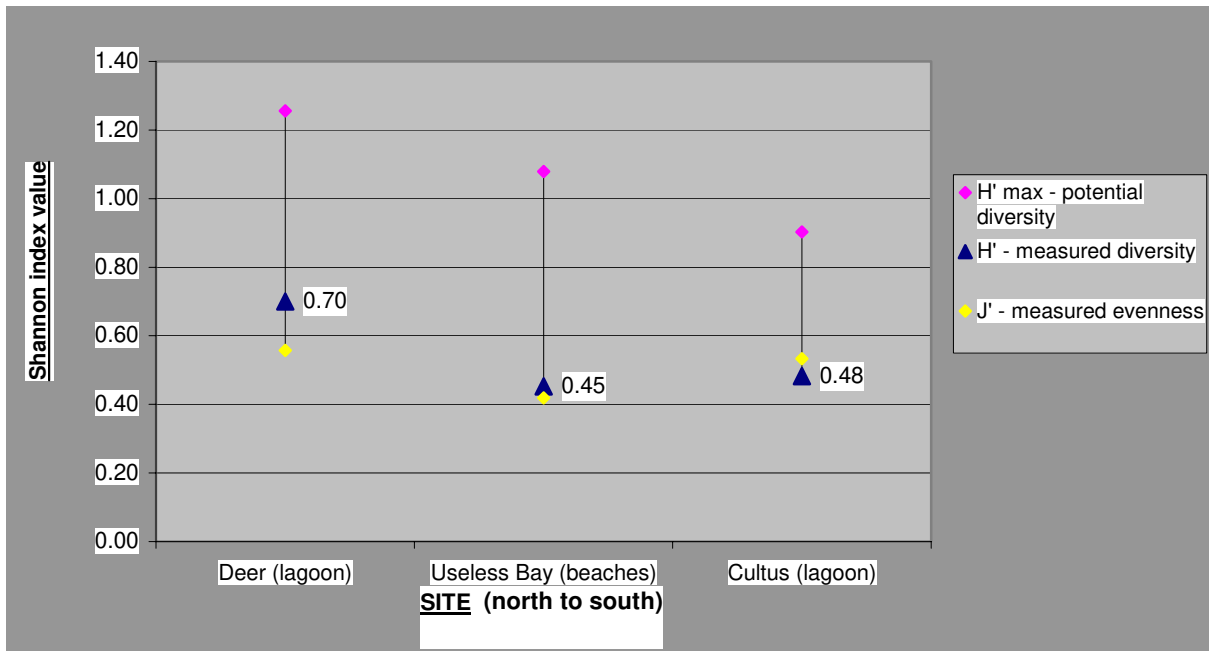
Figure 54. Species diversity and evenness for nearshore fish species sampled with the small net beach seine along the west coast of Whidbey Island (2005)
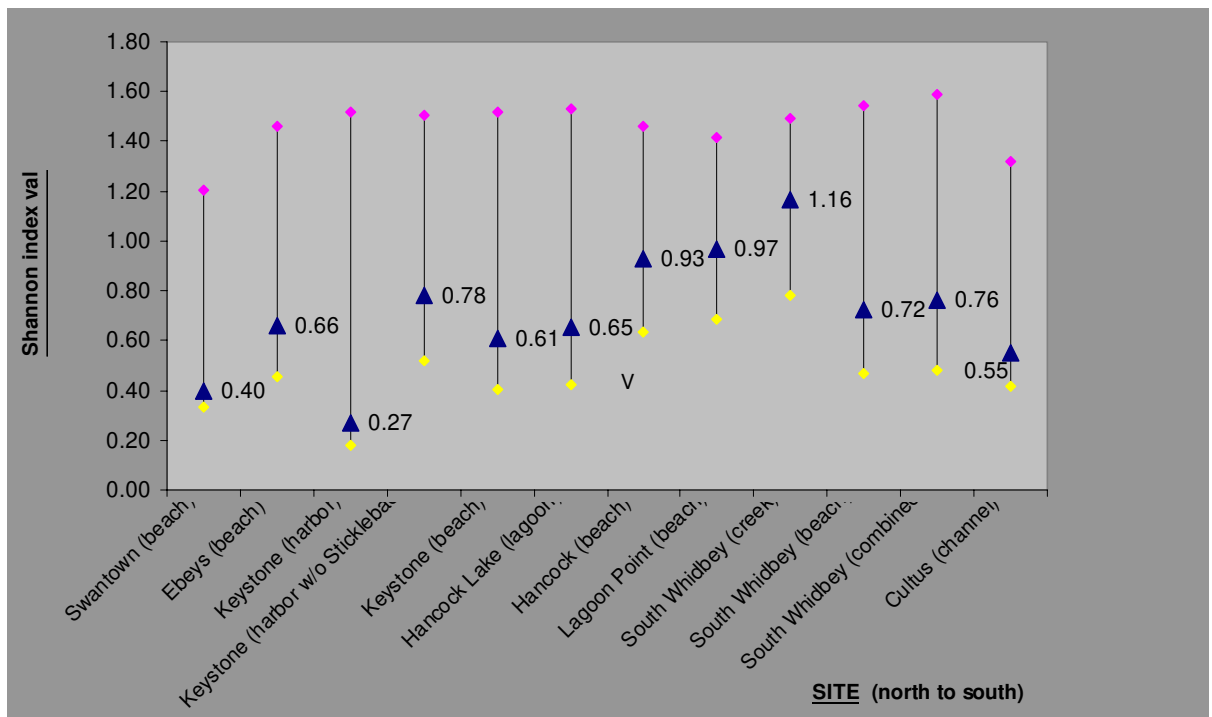
Figure 55. Species diversity and evenness for nearshore fish species sampled with the large net beach seine along the west coast of Whidbey Island (2005). Legend is the same as Figure 48

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3.5 Results – *Environmental Data*

Temperature (°C) and Salinity (ppt)

Site	February		March		April		May		June		July		August	
	°C	ppt	°C	ppt	°C	ppt	°C	ppt	°C	ppt	°C	ppt	°C	ppt
Swantown Beach	7.8	26.8	8.9	28.3	9.2	27.2	13.1	NA	12.1	NA	13.5	29.7	12.7	NA
Ebey's Landing	NA	NA	9.0	28.4	9.1	NA	11.5	NA	11.0	29.7	13.0	NA	14.6	NA
Keystone Harbor	8.4	26.8	9.1	26.4	9.1	26.0	12.6	28.5	11.8	29.4	12.5	29.8	12.1	30.5
Keystone Spit	8.6	26.7	9.0	28.7	9.3	27.0	10.8	29.9	12.0	29.4	13.1	29.0	13.6	29.9
Hancock Beach	8.8	27.3	8.8	28.2	9.5	27.1	10.9	NA	13.1	28.1	14.9	29.5	14.7	29.9
Hancock Lagoon	8.1	25.9	9.4	NA	10.0	26.7	NA	NA	14.1	27.8	14.4	29.2	12.7	29.9
Lagoon Point	8.6	26.5	9.2	27.6	10.0	26.7	10.7	29.4	NA	NA	13.8	29.5	NA	NA
SWSP- Creek Site	9.4	27.8	8.9	27.7	9.6	NA	10.2	NA	12.4	NA	13.2	NA	13.4	NA
SWSP- Beach Site	NA	NA	NA	NA	9.2	NA	NA	NA	NA	NA	14.4	NA	NA	NA
Double Bluff	8.7	24.6	11.1	NA	14.3	25.1	14.4	25.3	16.1	NA	14.0	27.6	20.0	28.1
Deer Lagoon	6.6	21.5	10.9	18.4	12.6	20.2	14.7	22.7	20.1	25.0	16.3	28.0	18.5	28.7
Maxwelton Beach	7.8	25.0	9.6	28.0	9.1	26.1	12.9	28.9	NA	NA	16.7	27.3	14.9	29.0
Cultus Bay	7.2	23.0	10.7	27.7	11.5	25.2	14.5	27.9	16.5	24.2	16.1	27.9	15.1	28.9

Figure 56. Table displaying the mean monthly temperature (°C) and salinity (ppt) data for the intensive assessment sites.

Environmental Data for the Intensive Assessment Sites.

Site	Tidal Current Velocity (m/s)		Water Depth at Deep End of Net (m)			Percentage Cover of Aquatic Vegetation[1]	Mean Substrate Size[1]
	min	max	min	max	mean		
Swantown Beach	0	0.05	0.8	2.0	1.5	6	Sand-Gravel
Ebey's Landing	0	0.19	1.9	4.2	3.2	45	Pebble
Keystone Harbor	0	0.05	3.7	8.5	6.1	14	Pebble
Keystone Spit	0	0.29	2.2	9.3	4.2	7	Pebble-Cobble
Hancock Beach	0	0.13	0.5	2.5	1.6	22	Gravel-Pebble
Hancock Lagoon	0	0.18	1.5	2.6	2.1	29	Sand
Lagoon Point	0	0.12	2.0	3.4	2.7	0	Sand-Gravel
SWSP- Creek Site	0	0.29	1.6	3.3	2.3	NA	Sand
SWSP- Beach Site	0	0.13	1.3	3.4	2.0	NA	Sand
Double Bluff	0	NA	0.7	1.3	0.7	0	Sand
Deer Lagoon	0	NA	0.2	1.4	0.7	0	Sand
Maxwelton Beach	0	0.07	0.6	1.9	1.2	29	Sand-Gravel
Cultus Bay	0	0.41	1.3	4.1	2.9	32	Sand

[1] Vegetation and substrate surveys were conducted at 0.5 m^2 quadrats every 10' along 100' transects at each site. Substrate was classified according to the Wenworth Scale as in Bain et al. (1985).

Figure 57. Table displaying select environmental data for the intensive assessment sites.

Section 4: Discussion

4.1 Discussion – *Juvenile Salmon Densities and Lengths*

The purpose of this project was to contribute information to Island County salmon recovery committees regarding juvenile salmonid use of marine nearshore habitats, and to provide an initial understanding regarding the timing, distribution, size, origin, and relative abundance of juvenile salmonids using the nearshore habitats of west Whidbey Island. Our results show substantial use of nearshore habitats in the study area by ESA-listed juvenile chinook salmon originating in both nearby and distant watersheds. These data have important implications for the salmon recovery process in Island County.

We observed juvenile salmon throughout the entire study period, from February through August in both years. The timing of peak abundance for pink and chum (April-June) and chinook (June-July) was similar to that found by Brennan et al. (2004) in nearshore sites in central Puget Sound. However, peak abundances were later than those observed in studies of nearshore habitats on the east side of Whidbey Island (Beamer et al 2006). Beamer et al. (2006) documented peak abundance of pink and chum salmon from March-May, and chinook from April-June. Hatchery-to-wild proportions in this study were similar to those found by Brennan et al. (2004), with hatchery individuals dominating chinook catches and wild individuals dominating coho catches.

Pink Salmon

 At most sites the first salmon species observed were juvenile pink salmon, the progeny of pink salmon that returned in the 2004 and 2005 spawning seasons. Most stocks of pink salmon in Puget Sound return in odd years, but watersheds in the Whidbey Basin, most notably the Snohomish River, support an even year run of pink salmon genetically distinct enough to warrant classification by NOAA Fisheries in a separate Evolutionarily Significant Unit from odd-year Puget Sound pink salmon (Hard et al 1996). The even year pink stocks tend to return earlier in Puget Sound than odd year fish and peak spawning for even year fish is about two weeks ahead of odd year fish. Densities of pink salmon were comparable in February of both years, but at least an order of magnitude higher for the remaining months of 2006. The similarity in February densities is likely a reflection of the earlier peak spawning for even year returning fish. Nearshore sampling in central Puget Sound, south of Admiralty Inlet, did not result in any observed pink salmon fry in winter of 2001 (Brennan et al 2004), suggesting that the majority of the outmigrating even year fish from Whidbey Basin rivers turn north as they leave natal rivers. Nearshore sampling in Skagit Bay consistently observes juvenile pink salmon in both odd and even years, with more observations in even years (Beamer et al 2006).

The multiple regression analysis of the extensive sampling data found that pink salmon were negatively correlated with population weighted distance and embayment, and positively correlated with set depth and vegetative cover. A negative correlation with the population weighted distance metric suggests that the abundance of juvenile pink salmon within the study area during the extensive sampling period did not decline at sites with a greater aggregate distance to source populations. This, when taken with the length data showing increases in mean fork length over the study period suggests the possibility of a longer residence time for pink salmon within the study area, with volitional movement between habitats within the study area as a possible cause for an increase in pink numbers at sites with greater aggregate distances. However it is interesting to note that embayed sites had lower pink densities indicating a lack of volitional movement as fish were concentrated in non-embayed sites by tidal currents. It should be noted that the extensive study took place at the tail end of the peak of pink salmon densities, and therefore only accurately describes habitat usage for the older and larger fish caught during this period.

Chum Salmon

Juvenile chum salmon had a long window of habitat occupation in the study area. The first chum salmon were caught in February, and we continued to catch chum salmon in high numbers through July. There was significant variability in the timing of peak chum catches between sites with peak catches occurring as early as the beginning of April and as late as the middle of July. This broad range of habitat occupation and use is likely a result of the variety of basins in which chum salmon spawn. In Puget Sound, chum salmon spawn in both the major river basins and the numerous small streams that drain directly into Puget Sound. The variety of life histories, spawn timing, and temperatures supported by these systems likely leads the greater complexity of nearshore habitat occupation patterns observed in our study.

In our multiple regression analysis, chum salmon density was positively correlated with set depth and percent cover of low kelp and negatively correlated with embayment. A negative correlation with embayment indicates non-embayed sites, or points, tended to accumulate more fish than embayed sites, as the currents within the study area concentrate fish at these sites, and suggests less volitional movement of chum salmon within the study area. Mean fork lengths for chum and pink salmon were lesser than mean fork lengths for chinook and coho during the extensive sampling period, and while chum and pink were negatively correlated with embayment, this variable did not predict densities of either hatchery or wild chinook and coho. This supports the concept of smaller fish being more planktonic and having less volitional movement, with larger fish displaying pelagic, volitional movements within nearshore habitats.

Chinook Salmon

The majority of juvenile chinook salmon utilizing the nearshore habitats of west Whidbey Island are greater than 80mm in size and are present from May through August. We only observed one fry migrant sized chinook in the two year study, a 39mm chinook caught in

April at Cultus Bay. In both years wild chinook densities peaked in June, but had similar values in July. These results indicate that the nearshore habitats of Whidbey Island are not heavily used by chinook during the fry migrant portion of their life history, as observed in Skagit Bay. Rather, they are used by larger fish that have reared for extended periods in the rivers, estuaries, and nearshore habitats closer to natal origins. In both years an initial pulse of yearling 1+ chinook observations were made in May, these fish had much higher fork lengths than the rest of the chinook observed over the season.

Habitat models developed from the extensive survey results showed that wild juvenile chinook densities were positively correlated with population weighted distance, percent cover of low kelp, and Julian date. Within the extensive surveys window, peak abundances of wild juvenile chinook did not occur at sites in closest proximity to the nearest river, but were instead observed at sites closest to the aggregate of rivers in Puget Sound and Hood Canal weighted by the magnitude of their potential contribution of outmigrants. This finding supports the hypothesis of declining nearshore habitat usage with increasing distance to nearest river and migration pathway complexity that has been observed for chinook in Skagit Bay and Sinclair Inlet (Beamer et al. 2005; Beamer et al. 2006; Fresh et al. 2005), and potentially expands it to the scale marine basins such as Admiralty Inlet and the Strait of Juan de Fuca which act as outlets for multiple marine basins and their contributing river watersheds.

Coho Salmon

Coho were the least frequently caught juvenile salmon in our study and had the highest mean fork lengths. Coho salmon typically rear for a year or more in freshwater or estuarine habitats before migrating into nearshore areas, and it is likely that these larger fish were less prevalent in our catches because of the generally shallow inshore waters in which we sampled. In both years we observed a significant increase in mean fork length for wild coho from May through July, possibly indicating a longer residence time in the study area, as individuals within the population grew. It is important to note the caveat that increasing fork length over the observation window does not preclude rapid migration through the study area, but that static fork lengths for a given species over the observation window strongly suggests that a species is moving through the study area rapidly.

Habitat models developed using the results from our extensive surveys showed positive correlations between wild juvenile coho densities and population weighted distance, Julian date, set depth, percent cover of eelgrass and percent cover of sea lettuce. The fact that wild coho, along with wild chinook were positively correlated with Julian date indicates that our extensive sampling window did not capture both tails of the peak of outmigrant density for these species, as catch numbers generally increased until the end of the extensive sampling time period. We chose May and June for the extensive sampling period as that captured the peak months for total salmon abundance, however it did have the limitation of missing the early part of the pink outmigrant peak, and the late portions of the coho and chinook peaks.

River Mouth Distances

We did not see a decline in fish numbers as distance from the nearest river mouth increased. Some of our highest catch totals were at central Island sites that were furthest from the large salmon producing rivers of Puget Sound. Within our sampling area we did not observe a decline in fish densities as distance to the nearest river mouth increased (Figure 58). While not significant, the regression data from the extensive sites showed an overall increase in abundance as distance from the nearest river mouth increased.

West Whidbey Extensive Sites 2006
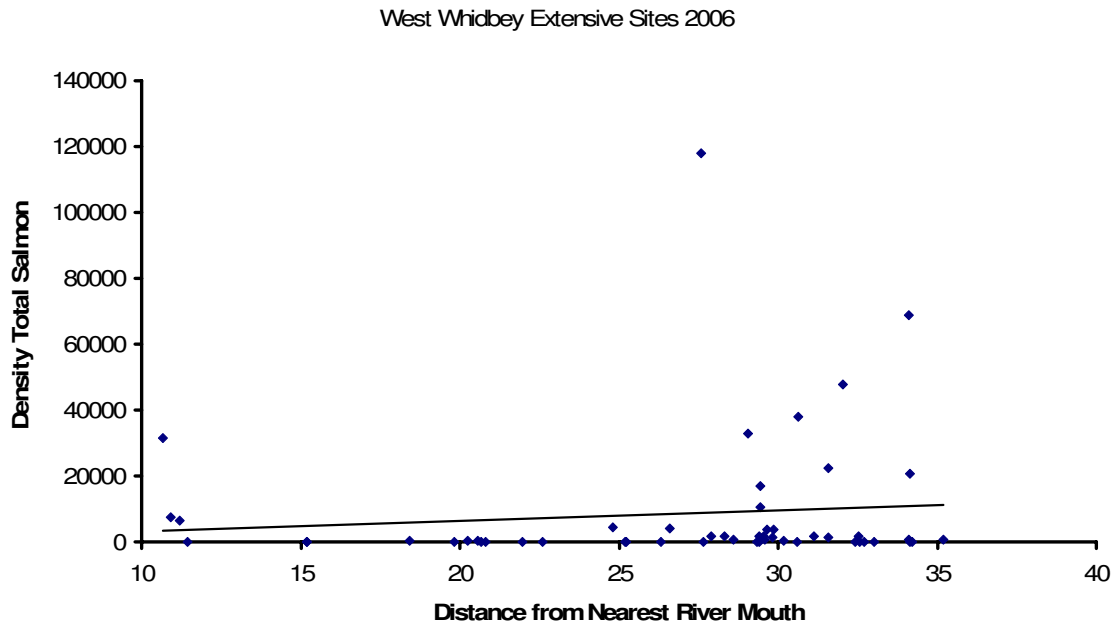
Figure 58. Density of total juvenile salmon (fish/hectare) caught at the 60 extensive sites, plotted against distance to the nearest river mouth (miles).

The model describing the abundance of juvenile salmon at any given nearshore site as a function of the distance to the nearest river mouth does not accurately describe our observed densities. While distance of any nearshore site to the mouth of a given river can roughly account for the abundance of juvenile salmon originating from *that* river basin, juvenile salmon abundance at nearshore sites that accumulate fish from a number of contributing rivers may be described better by looking at the sum of distances from those contributing rivers, and the number of outmigrants generated by those rivers.

Coastal marshes

Both of the sample sites that were in the drainage plume of culvert outflows from coastal wetlands, Keystone Harbor and Deer Lagoon, had higher catch rates than nearby sites with no culvert outflow. In 2005 t-tests showed a statistically significant difference in the

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mean instantaneous catch-per-unit-effort (CPUE) for chinook catches between Keystone Harbor and Keystone Spit, with the harbor site having greater catch rates. We did not see statistically different mean catch rates for juvenile salmon at the Deer Lagoon site, but this is mostly due to the tremendous variability in catch totals inside Deer Lagoon. Total catch numbers were considerably higher in Deer Lagoon than at the two control sites, Double Bluff and Maxwelton. At both sites the culvert effluent was stained dark with organics and was warmer and more turbid than the receiving waters. The effluent from these coastal lagoons likely acts as an attractant to juvenile salmon and forage fish moving along the nearshore for numerous reasons. Although we did not look at prey availability at our sample sights we would assume that the aquatic discharge from a lagoon would be rich with prey items that would attract juvenile salmonids and the forage fish upon which they feed. It is also possible that the juvenile fish are attracted to this water for osmoregulatory reasons, as the culvert discharges were less saline than the receiving waters.

Future research needs include a quantitative assessment and comparison of 2005 and 2006 fish use data for both sides of Whidbey Island. It is also possible that the use of the outputs from Puget Sound current/tidal models could be used as a variable in habitat models, substituting for our embayment metric.

4.2 Discussion – *Coded Wire Tag Recovery*

Given the central location of Whidbey Island- at the junction of Puget Sound, Georgia Basin, and the Strait of Juan de Fuca it is not surprising that we recovered fish from basins to the north, south, east, and west of the study area. It is likely that hatchery stocks other than the observed stocks utilize the west coast of Whidbey Island, but that they were not present in high enough numbers to be detected. We would also assume that wild stocks of chinook originating in basins without hatchery stocks or CWT marking are present in the west Whidbey nearshore.

The natal river basins that we recovered tagged fish from support 16 of the 22 independent populations that make up the Puget Sound chinook ESU (Figure 59). It is likely that some or all of these fish are present in the west Whidbey Nearshore, and utilize these habitats for some portion of the year. Habitat degradation along the west Whidbey shoreline affects the recovery of all the stocks that utilize these habitats, and links the functions of those river basins with the nearshore of Whidbey Island.

Independent populations of chinook salmon in the Puget Sound ESU

River Basin	Number of Independent Populations
Nooksack	2
Skagit	6
Stillaguamish	2
Snohomish	2
Lake Washington	1
Green/Duwamish	1
Hamma Hamma	1
Skokomish	1
Total Number of independent populations represented	16
Number of independent populations in the Puget Sound ESU	22
Percentage of independent populations in ESU with CWT fish recovered on west Whidbey	73%

Figure 59. Total number of independent populations in the Puget Sound Chinook ESU originating in basins from which we recovered coded wire tagged fish.

The Island County *Salmon Recovery Plan*, which provides technical guidance for funding proposals to the Salmon Recovery Funding Board in WRIA 6, rewards projects that target Whidbey Basin stocks. The CWT data generated by this study suggests that salmon recovery projects on the west side of Whidbey Island would primarily benefit chinook stocks from the Whidbey Basin, but would also conserve and/or improve habitat for chinook from the Hood Canal, north Puget Sound, central Puget Sound, and east Kitsap Peninsula.

4.3 Discussion – *Community Diversity*

Although the emphasis of this report has been juvenile salmon use of the Whidbey Island shoreline, it is important to keep in mind that salmon co-habit these sites with a variety of other fish species, benthic macro- and micro-invertebrates, and the vegetative communities that together make up the nearshore ecosystem. These varying components each have ecological roles contributing differentially to the survival (as prey items or escape cover) or detriment (as predators) of juvenile salmonids. From the standpoint of

community ecology, environmental factors that maintain or enhance biological diversity are generally beneficial in providing for the long-term viability of individual species, and the overall stability of the system, while those factors that lead to a reduction in diversity tend to destabilize the system. Unstable ecosystems, or those experiencing high rates of transition and change, are particularly vulnerable to human land- and water-use practices that could potentially harm the currently available nearshore habitat for salmon and all other marine species along the western shoreline of Whidbey Island.

Indices of community diversity consider several interrelated variables including species richness (i.e. the total number of species present at the site), proportional numbers of individuals making up those species, and species evenness or equitability – that is, how evenly distributed are the number of individuals among the several species.

While it is generally true that the higher the species richness, the higher the diversity, it must be remembered that the Shannon index (H') is a function of both species richness and proportional abundance among species (evenness – or J', the ratio of the measured diversity to the potential diversity). So, for example, a site like Keystone harbor with one of the highest species counts, and hence one of the highest *potential* diversity scores (H' max = 1.51), actually had a very low measured diversity score due to the fact that juvenile stickleback exiting from rearing grounds in Crockett Lake via the connecting culvert were netted in the tens of thousands, far outnumbering all other species combined. When stickleback are removed from the diversity calculation, we see the diversity score for Keystone harbor increase dramatically from 0.27 to approximately 0.78, corresponding to the relatively high number of species (35 total), and a moderate level of evenness (J' = .52 in the absence of stickleback, versus only 0.18 with stickleback included).

The Shannon index is already known to be a statistical underestimate of the *actual* community diversity, and the values we derived for species richness already underestimate the potential site richness because we did not catch all of the species that are present throughout the year at each of our sample sites. Richness is also lower because we lumped some species (for example all soles) into a single species group (flatfish) in order to make the most efficient use of our time while in the field.

Diversity score calculations were also slightly skewed because some of our proportional abundances are not completely representative of the actual capture data, as unidentified/unknown species could not be included in the abundance totals. Examples of numbers that were not included in the fish totals were several species of juvenile sculpin that were present in relatively high numbers at some sites, but were not correctly identified until later in the season when they had taken on visibly identifying morphological characteristics. Including them as a separate species group would have erroneously inflated the richness number with a corresponding change in the Shannon diversity score. These index values do not represent measures of the actual site diversity, but are legitimate measures of *relative* diversities across our sample sites.

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Swantown beach and the Cultus Bay channel site exhibited the lowest diversities (0.40 and 0.55 respectively), primarily because species richness was lowest for those sites where the large net was employed. This is probably attributable to the fact that these locales had the most homogeneous habitats and substrates of any of our sample sites, composed mostly of sand with very little vegetation or three-dimensional structure. The nearshore fish community at Swantown was completely dominated by flatfish species (76.8%) that preferentially select sandy substrates. Compare the community at Swantown beach to the next closest site, Ebey's Landing, where a gravel/cobble beach and significant kelp beds provide habitat for a much more diverse fish community, which is reflected in the higher diversity score at Ebey's Landing (0.66 versus 0.40). The Cultus Bay channel site scored somewhat higher than the similar habitat at Swantown, likely due to the fact that habitat structure is artificially enhanced through periodic dredging, providing a deep-water entry for larger and more mobile fish (particularly surf perch and juvenile Chinook salmon and Chum salmon) into an otherwise very shallow bay. At Deer Lagoon, where the channel entry remains at approximately the same depth as the interior waters of the lagoon, chum and chinook salmon did not utilize the lagoon once water temperatures warmed up by mid-summer.

Following the trend in species richness, the highest diversity scores were found along a mid-Island gradient from Hancock through Lagoon Point to South Whidbey. Because of their geographical positioning perpendicular to Admiralty Inlet, these sites experience the greatest upwelling/current velocities as tides flood the Inlet and upper Puget Sound. Even though the actual abundance counts were not very high relative to, for example, Keystone Harbor, these sites have the greatest concentrations of many different species. Apart from the dredging and filling to accommodate residential development at Lagoon Point, this is a relatively undisturbed stretch of the Whidbey Island shoreline, kept in a natural state under jurisdiction of the U.S. Navy and Washington State Parks. The beach at Ebey's Landing would appear to be equally undisturbed, but the diversity there isn't nearly as high. A few individuals of many different species (richness = 30) are present, but the community there is dominated by just a few species (chinook, chum, herring and sand lance) comprising only two of the nine fish guilds. When considering diversity scores and fish community structure, it is necessary to consider that it takes dozens, perhaps hundreds of individual small fish such as the juvenile sticklebacks in Keystone harbor, to equal the biomass of a single adult great sculpin found in the same location.

We were somewhat surprised to discover that the beach at Lake Hancock, which supported a moderate number of species (29), had a very high diversity score (.93) relative to other sites with much higher species richness. This site had what was perhaps the largest and least disturbed beds of eelgrass among any of our sites, and it could be that this vegetation type provides habitat equally for most species that utilize it (species evenness stays high regardless of how many or what types of fish species are present).

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Appendix A: Juvenile Salmon Densities by Species at all Intensive Sites

Total Juvenile Salmon
Swantown Beach
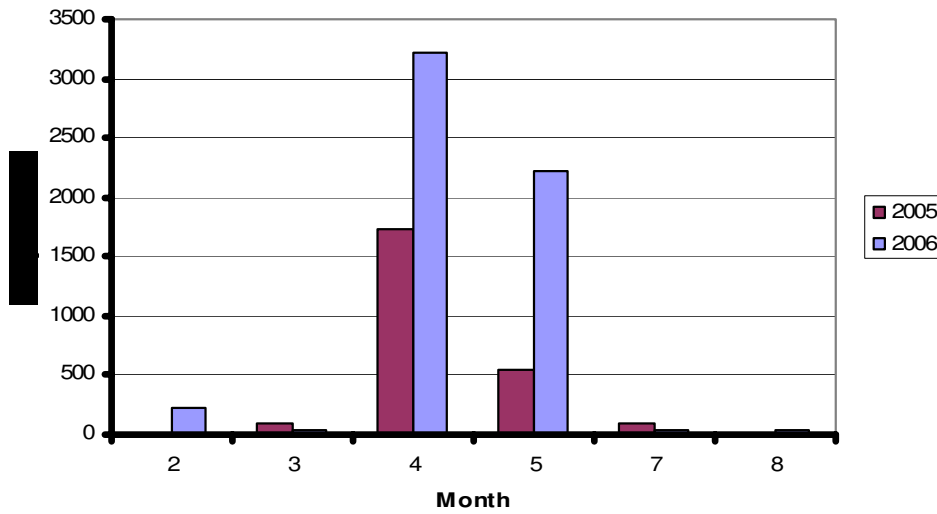
Pink Salmon
Swantown Beach

Chum Salmon
Swantown Beach

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 7, 8)
Y-axis: 0 to 1800
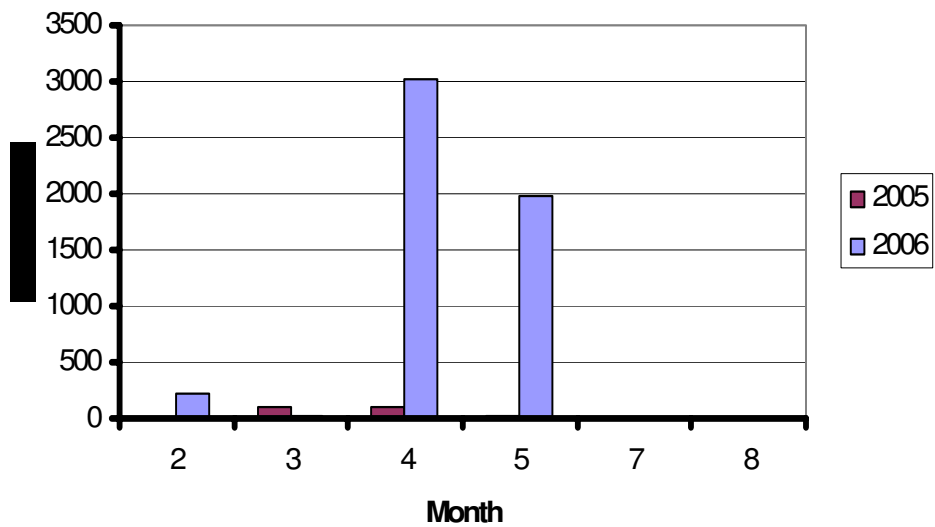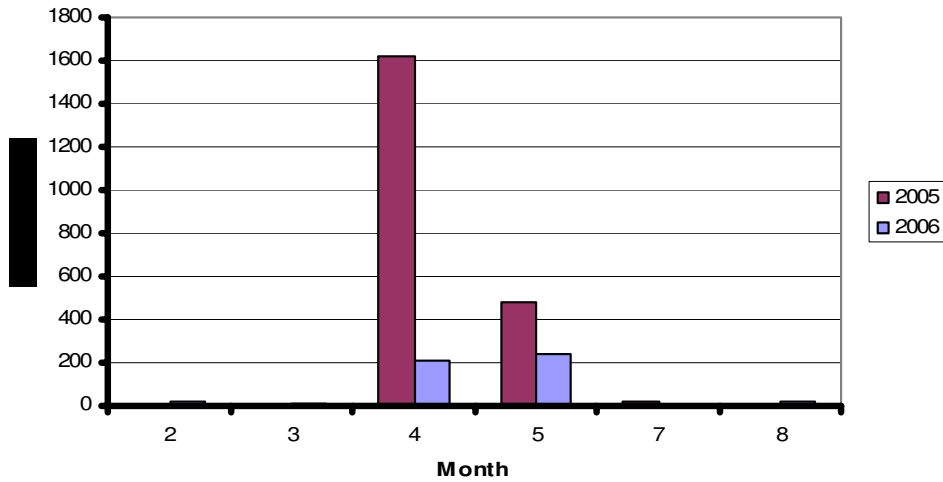
Total Juvenile Chinook
Swantown Beach

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 7, 8)
Y-axis: 0 to 90

Wild Chinook
Swantown Beach

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 7, 8)
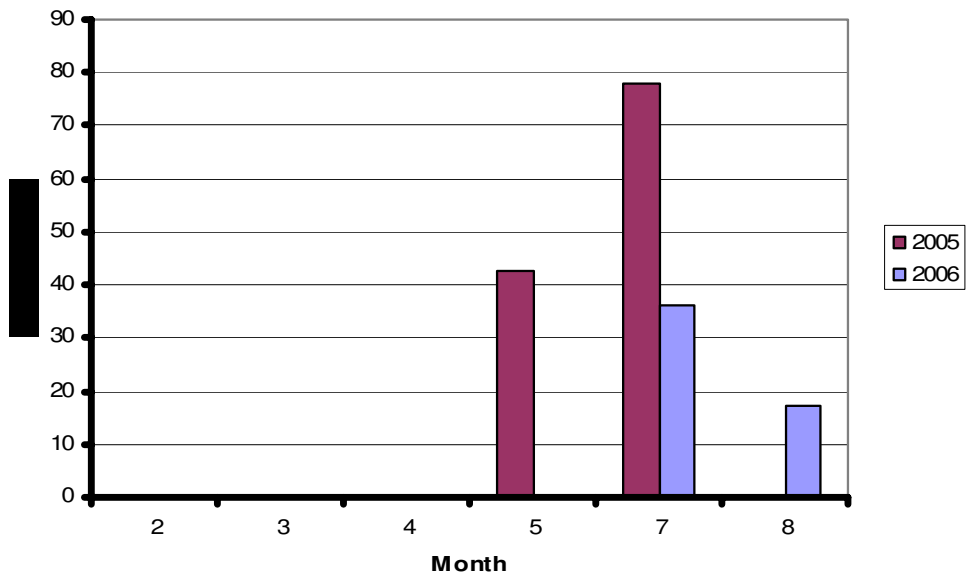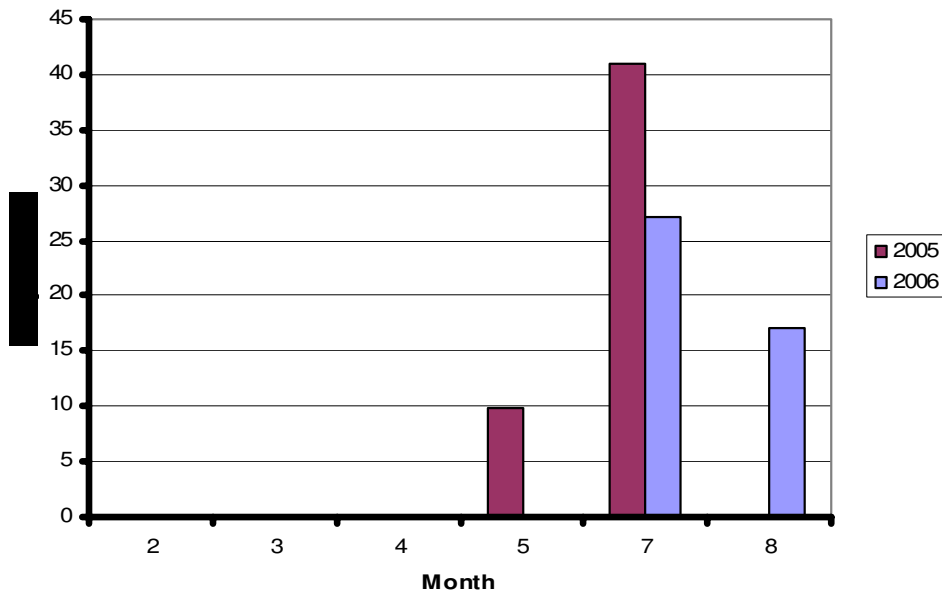
Hatchery Chinook
Swantown Beach

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 7, 8)

Total Juvenile Salmon
Ebey's Landing

Count (vertical axis label, 0 to 6000)

Legend: ■ 2005

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
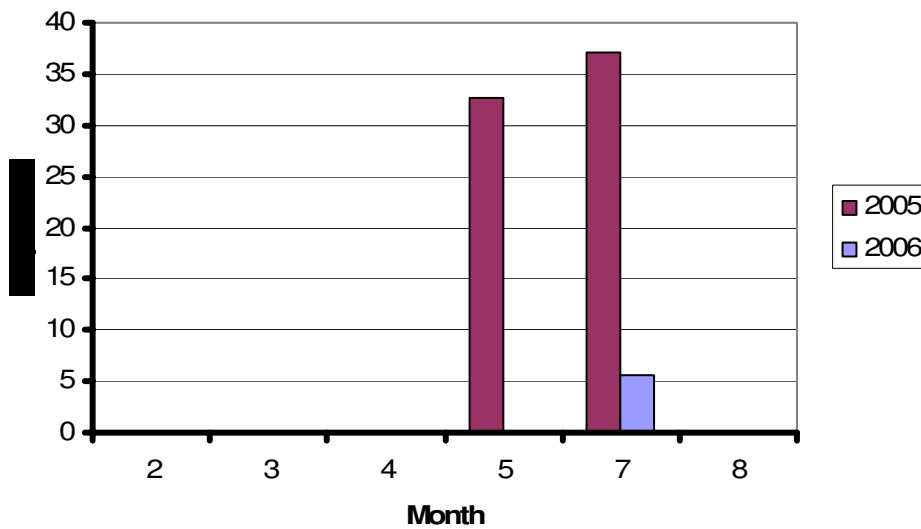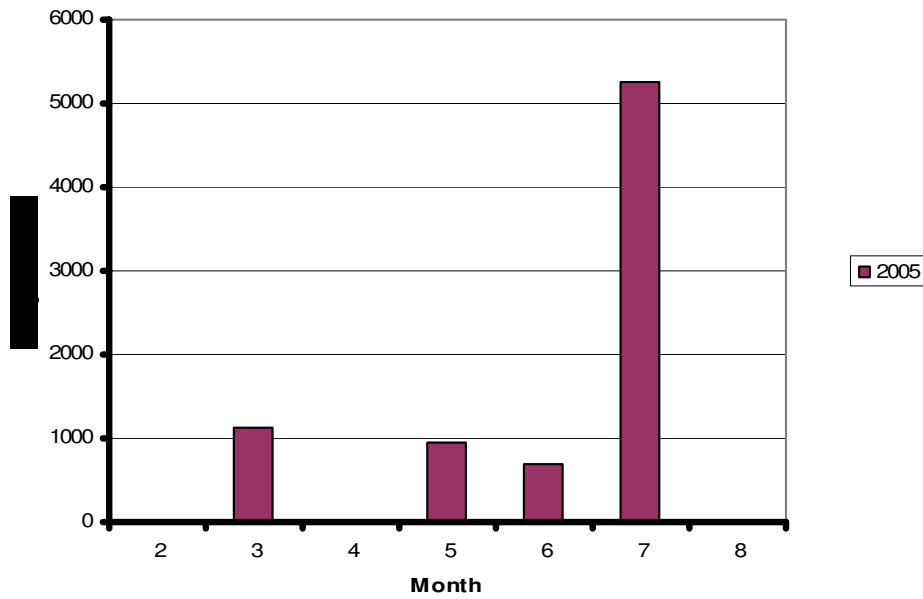
Pink Salmon
Ebey's Landing

Count (vertical axis label, 0 to 1200)

Legend: ■ 2005

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
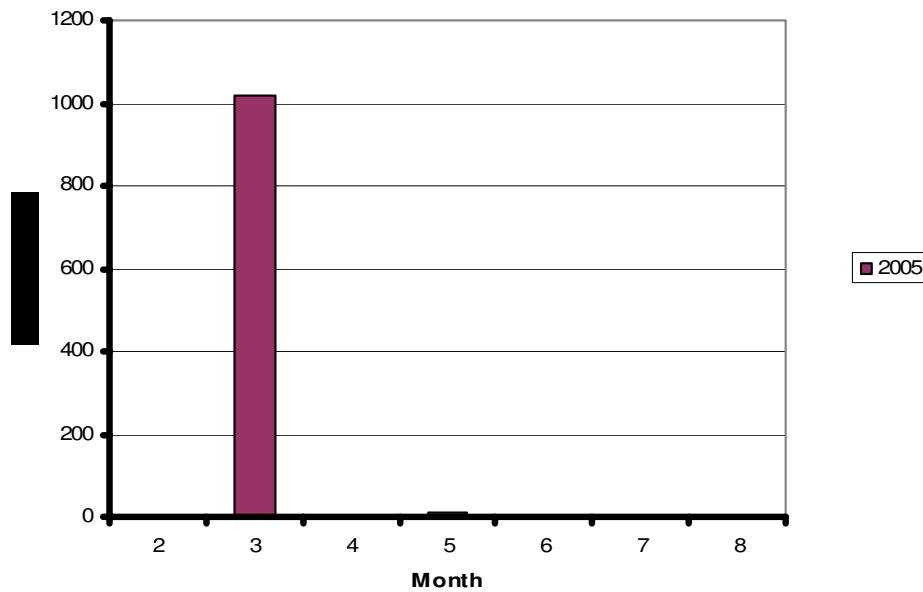
Chum Salmon
Ebey's Landing
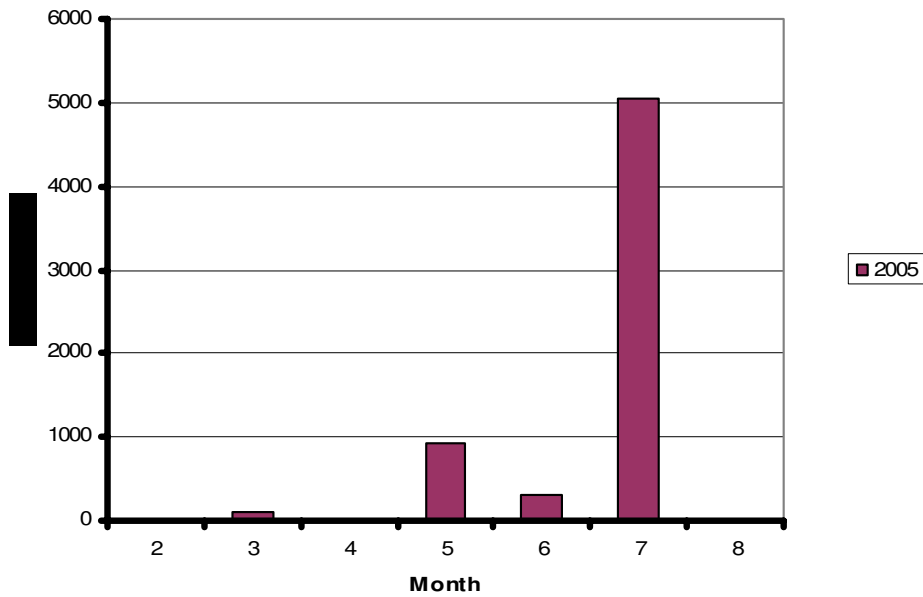
Total Juvenile Chinook
Ebey's Landing
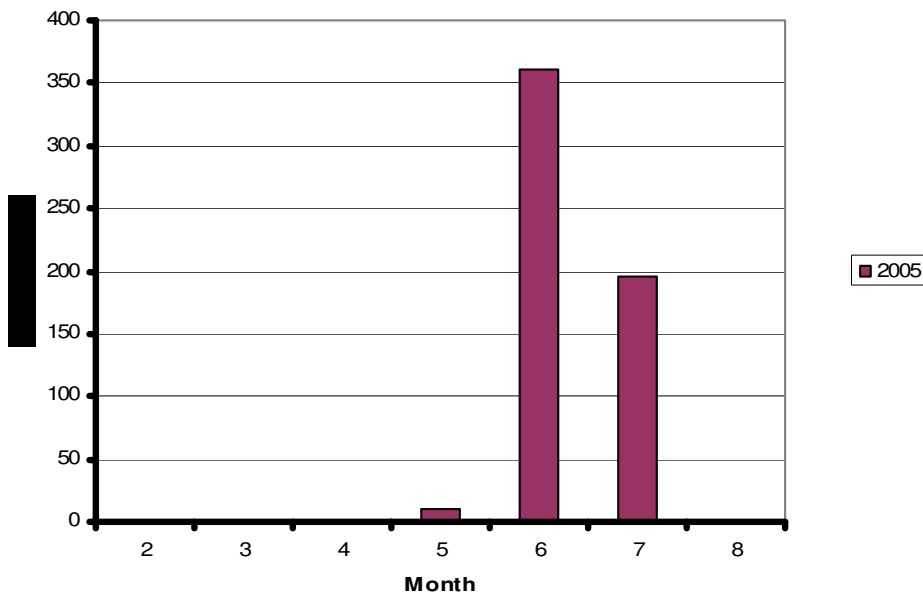
Wild Chinook
Ebey's Landing

Month

2005
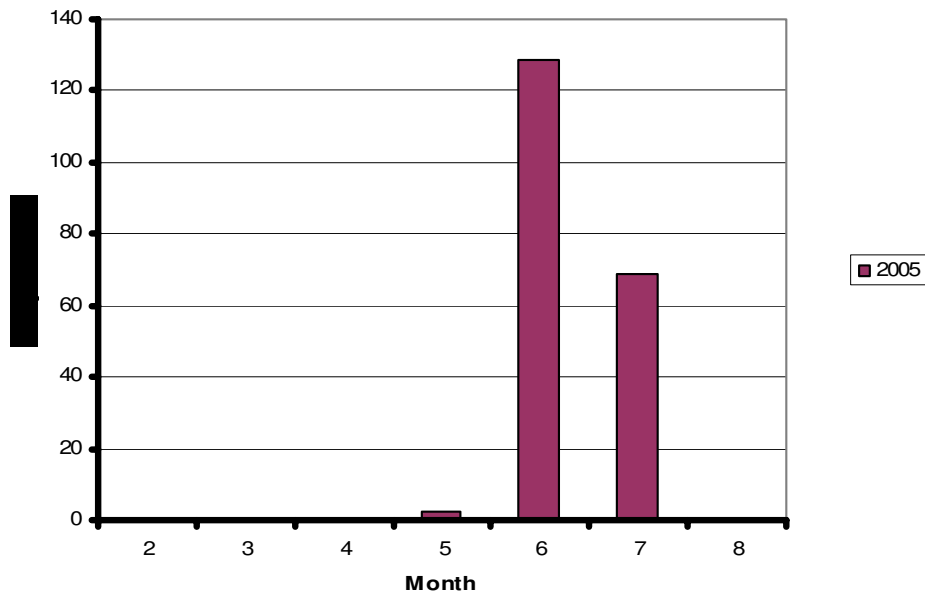
Hatchery Chinook
Ebey's Landing

Month

2005
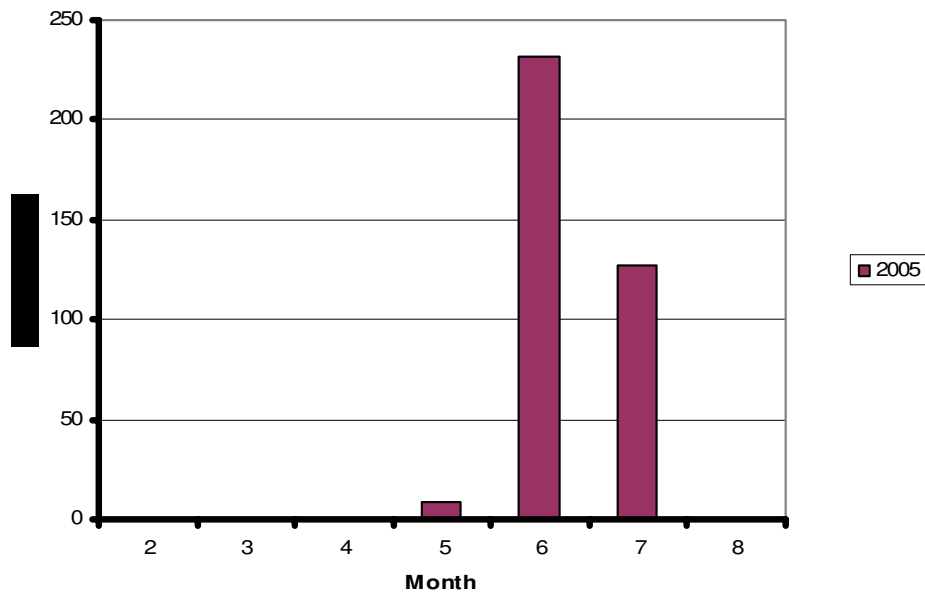
Wild Coho
Ebey's Landing

Total Juvenile Salmon
Keystone Harbor

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 7000

Pink Salmon
Keystone Harbor

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 3000
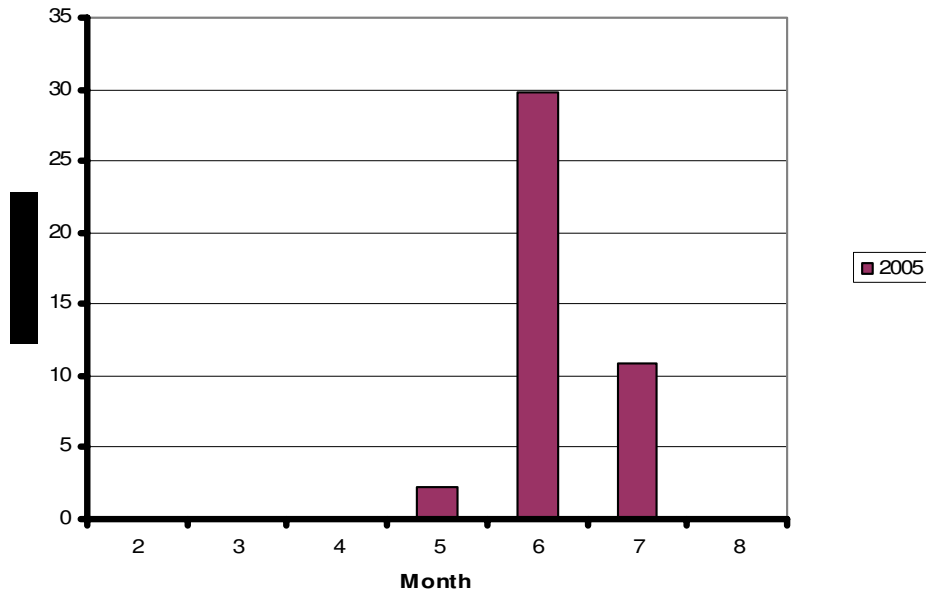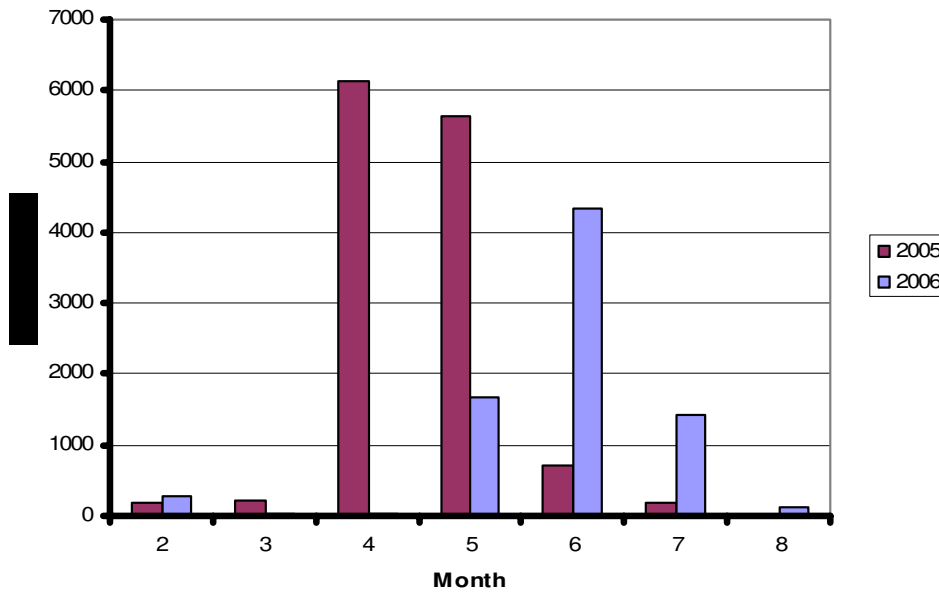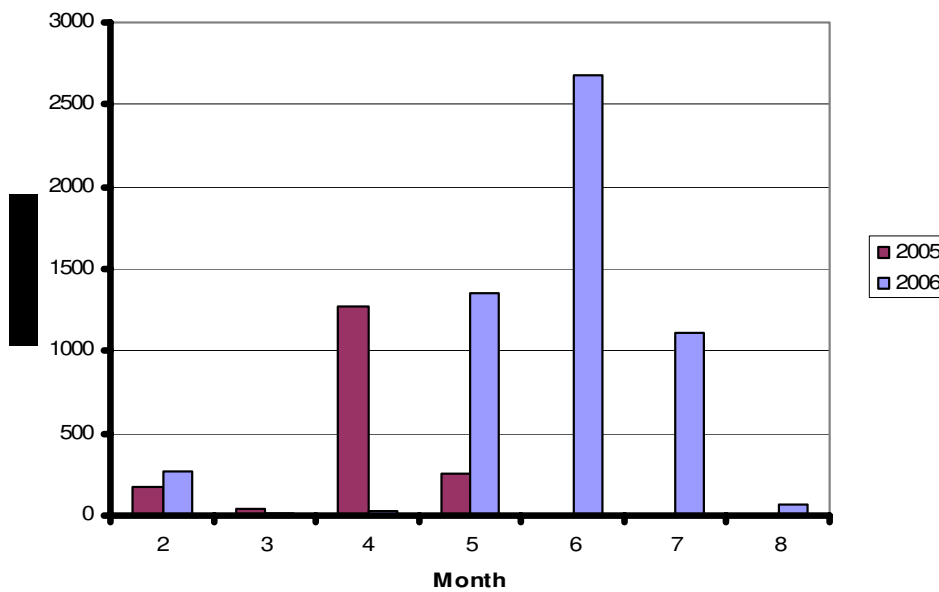
Chum Salmon
Keystone Harbor
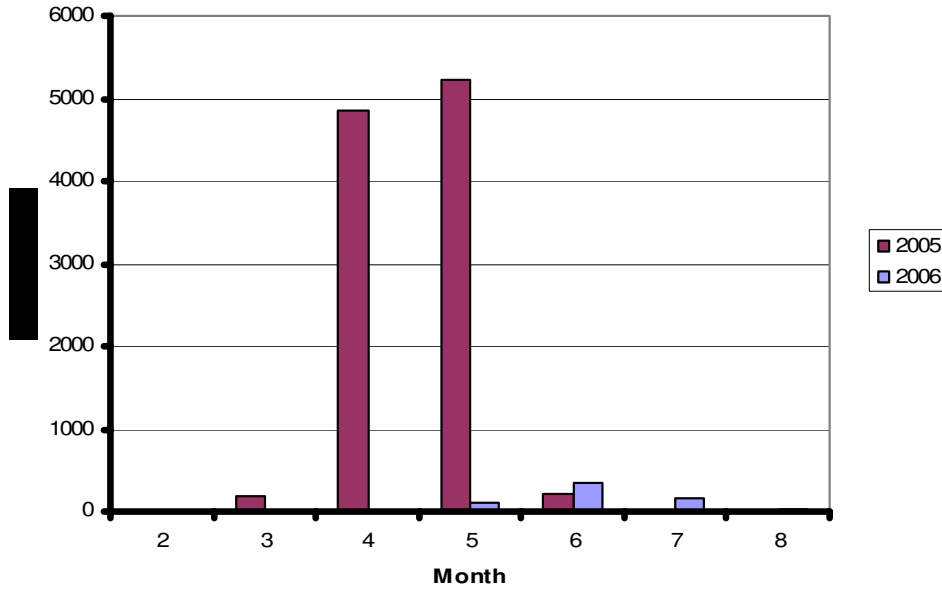
Total Juvenile Chinook
Keystone Harbor
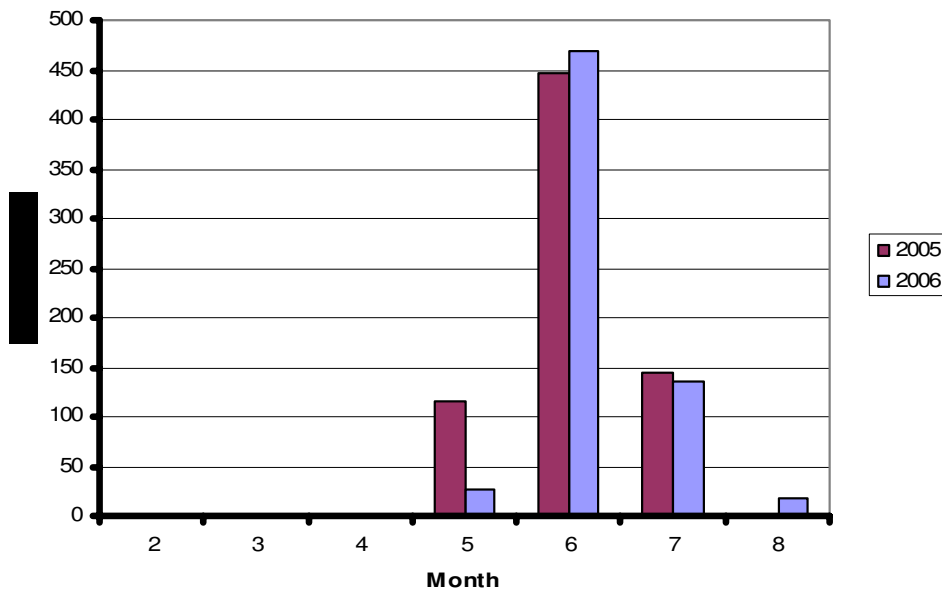
Wild Chinook
Keystone Harbor
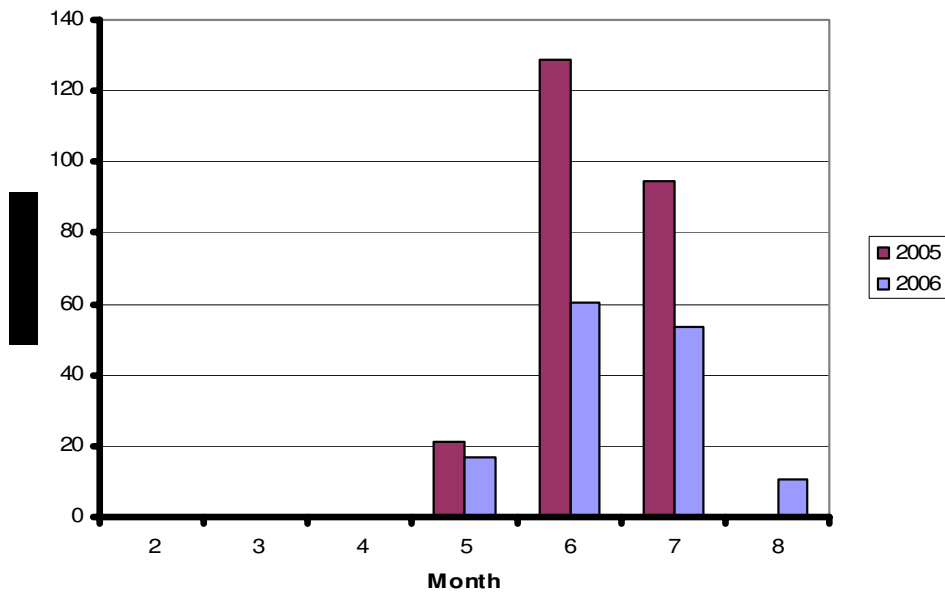
Hatchery Chinook
Keystone Harbor
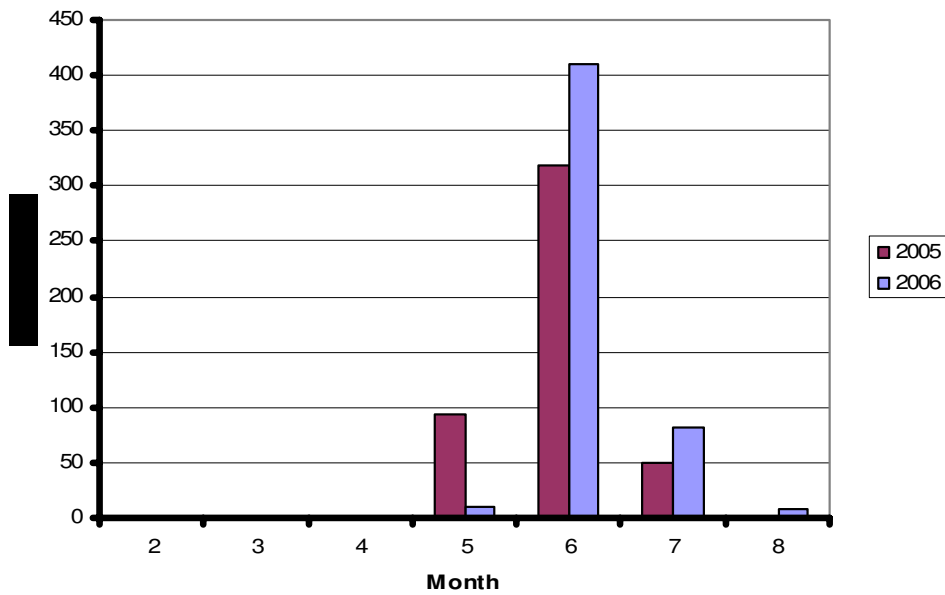
Total Juvenile Coho
Keystone Harbor
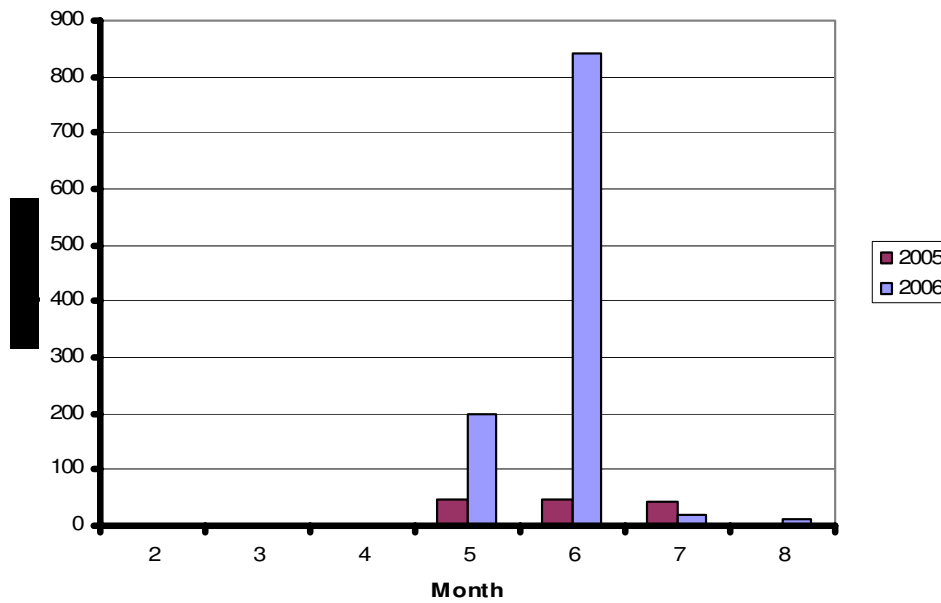
Wild Coho
Keystone Harbor
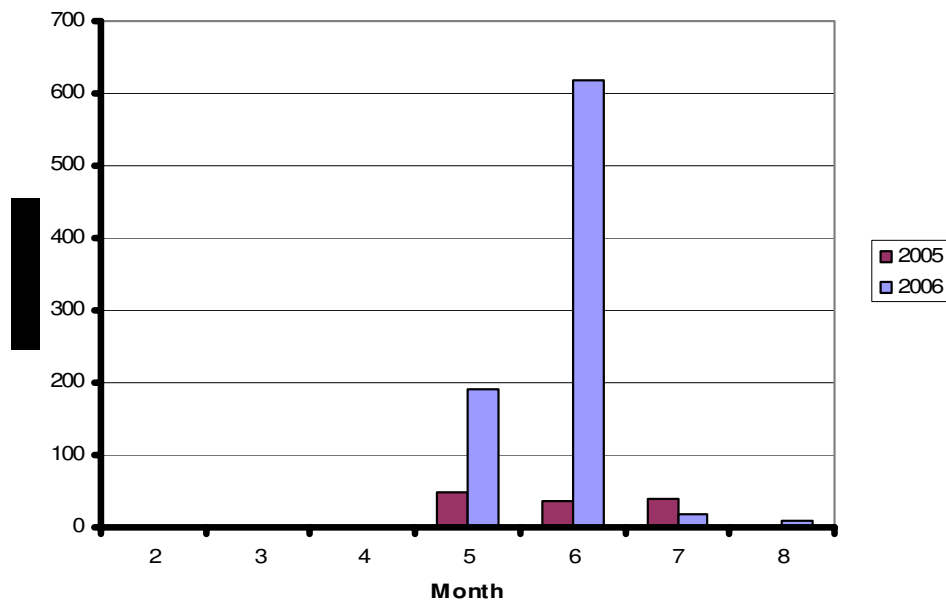
Hatchery Coho
Keystone Harbor
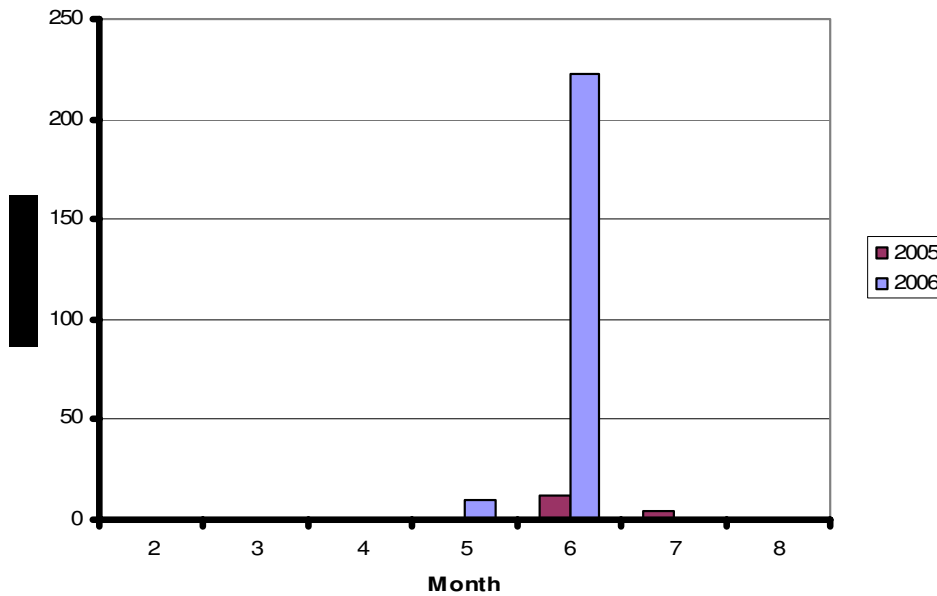
Total Juvenile Salmon
Keystone Spit
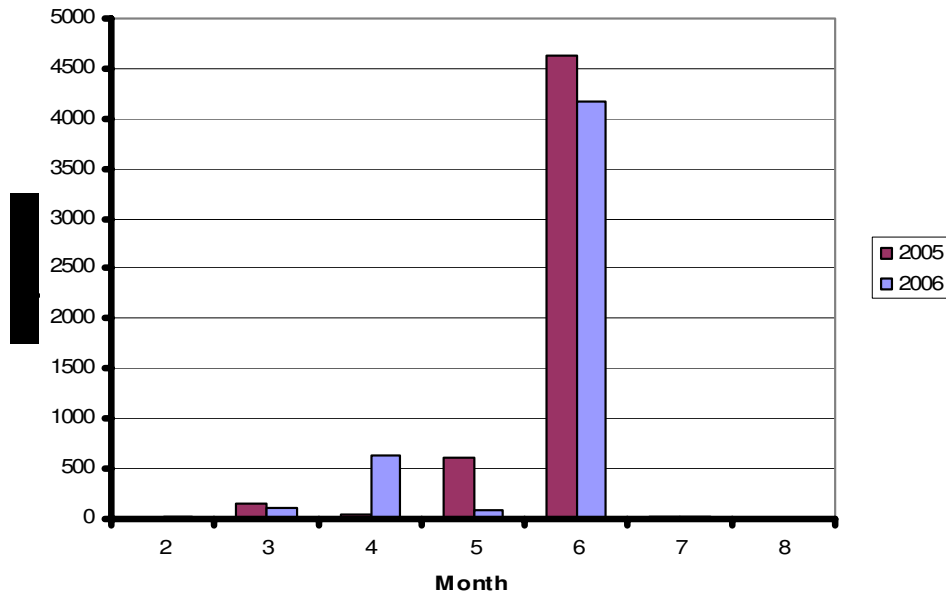
Pink Salmon
Keystone Spit
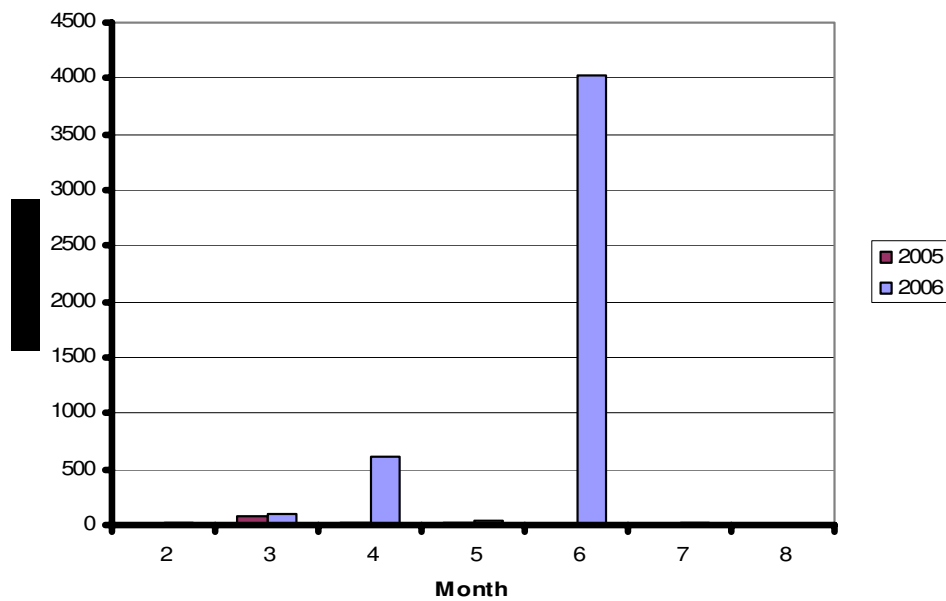
Chum Salmon
Keystone Spit
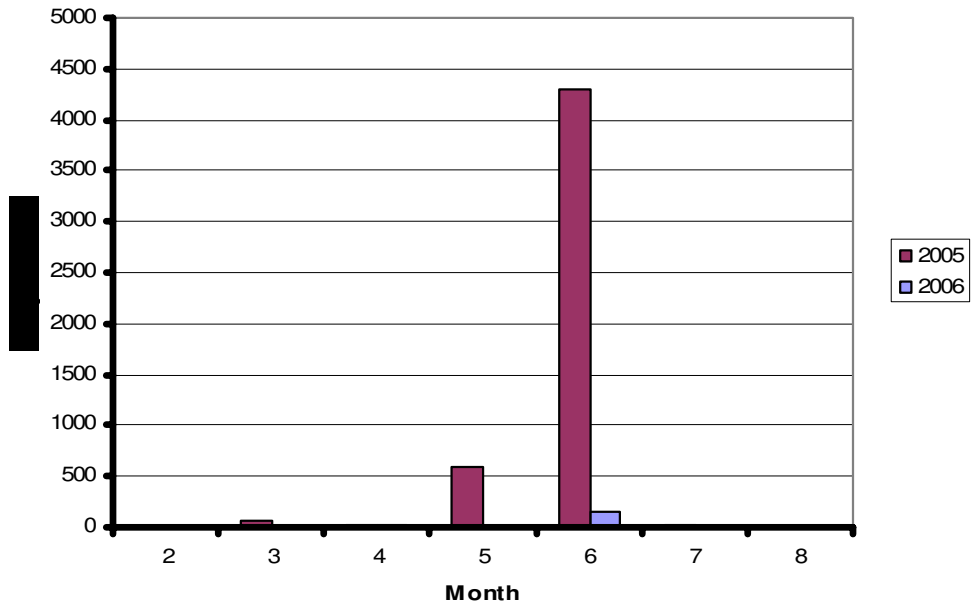
Total Juvenile Chinook
Keystone Spit

Wild Chinook
Keystone Spit

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 25

Hatchery Chinook
Keystone Spit

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 60

Total Juvenile Coho
Keystone Spit
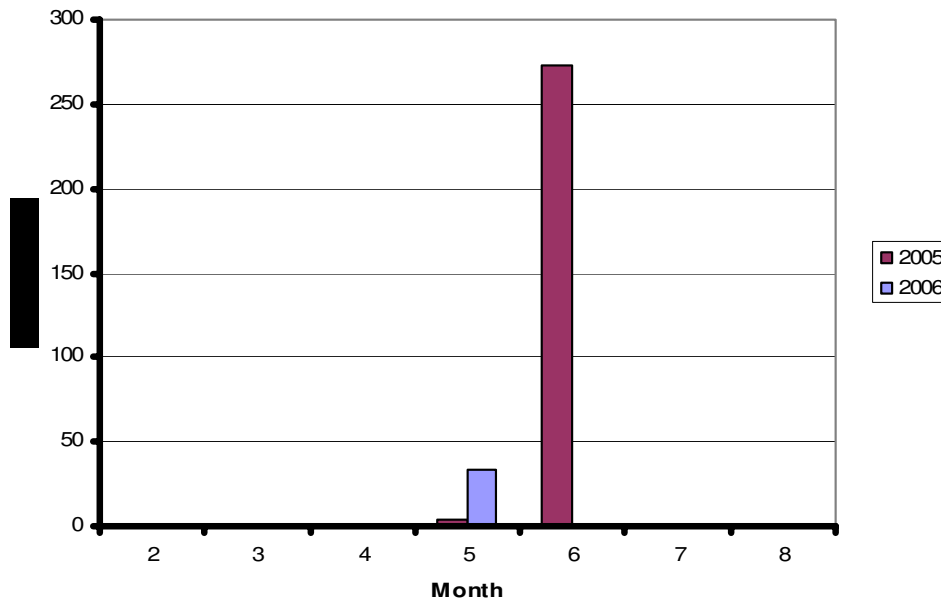
Wild Coho
Keystone Spit
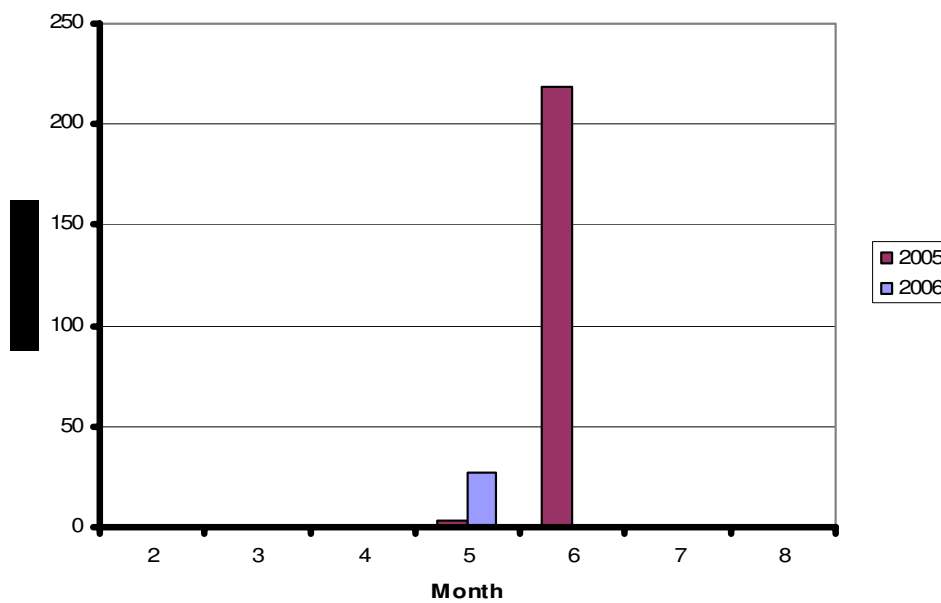
Hatchery Coho
Keystone Spit

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 60
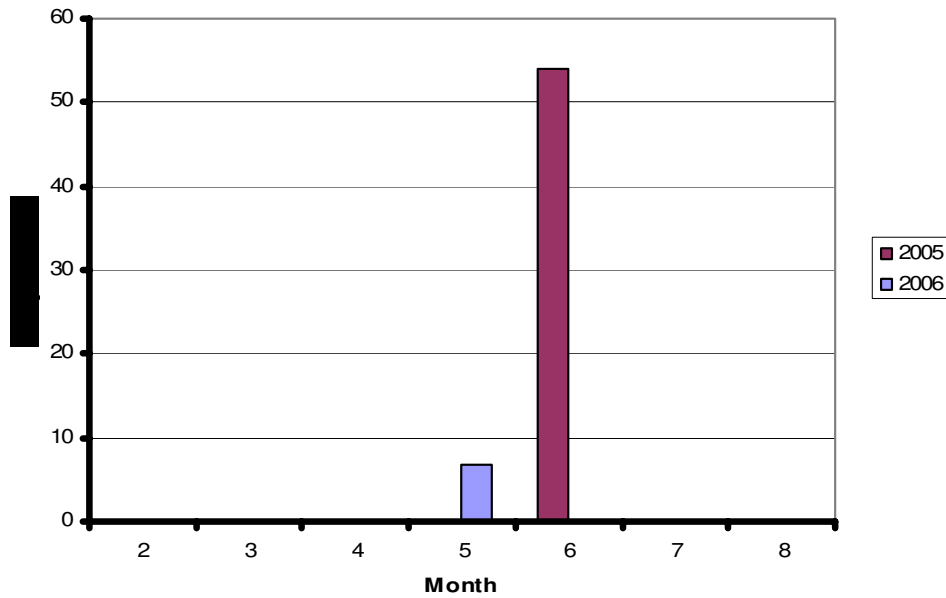
Total Juvenile Salmon
Hancock Lagoon
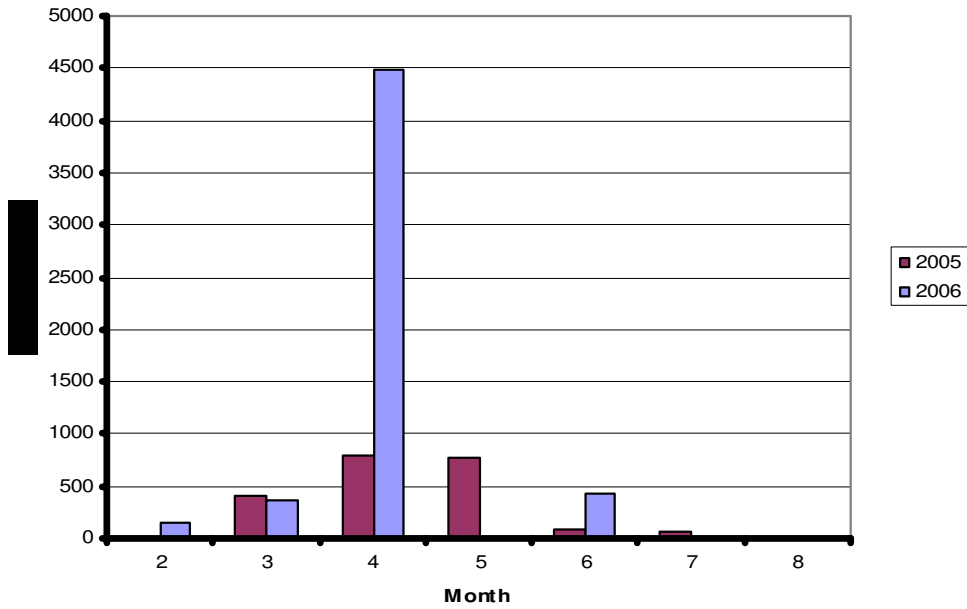
Pink Salmon
Hancock Lagoon
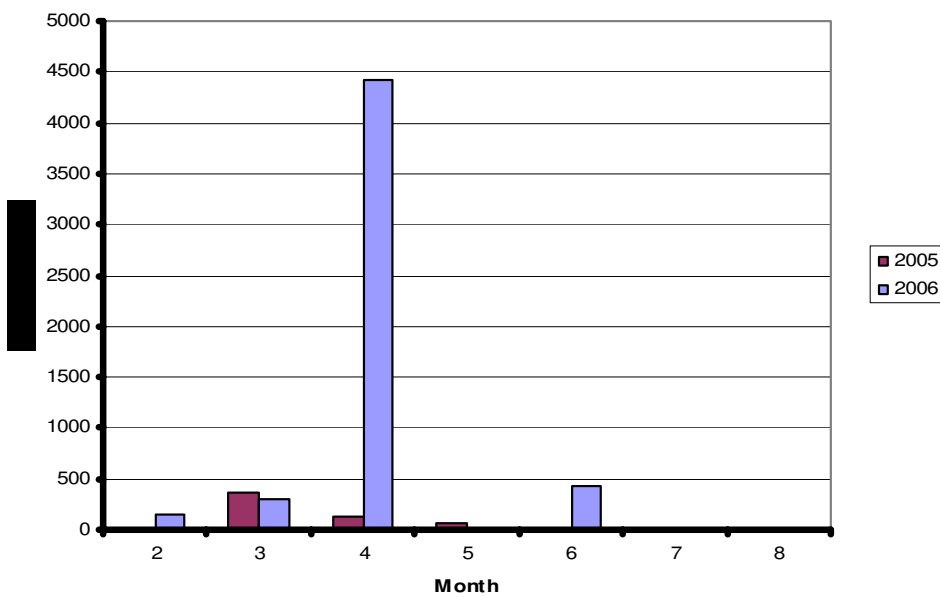
Chum Salmon
Hancock Lagoon
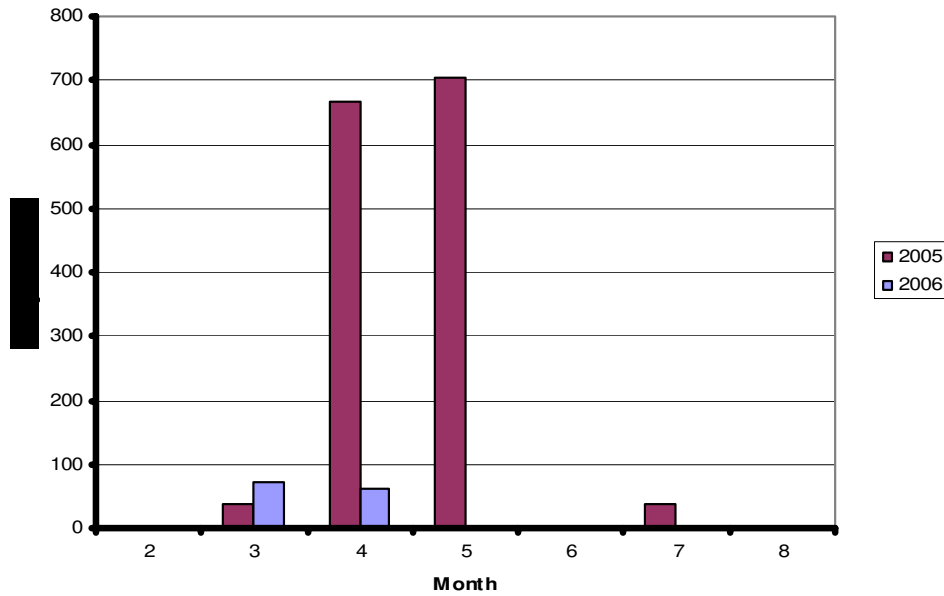
Total Juvenile Chinook
Hancock Lagoon

Wild Chinook
Hancock Lagoon

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 40
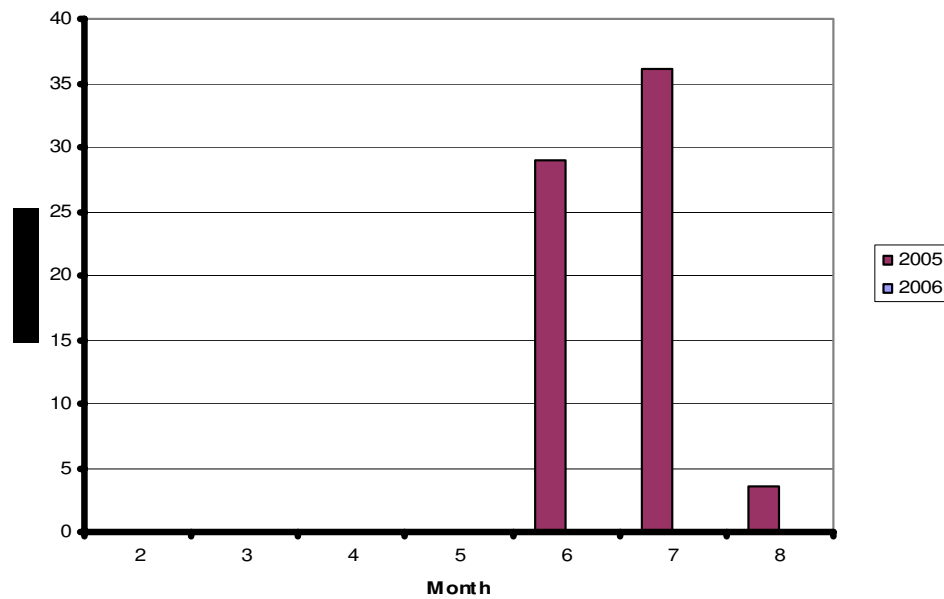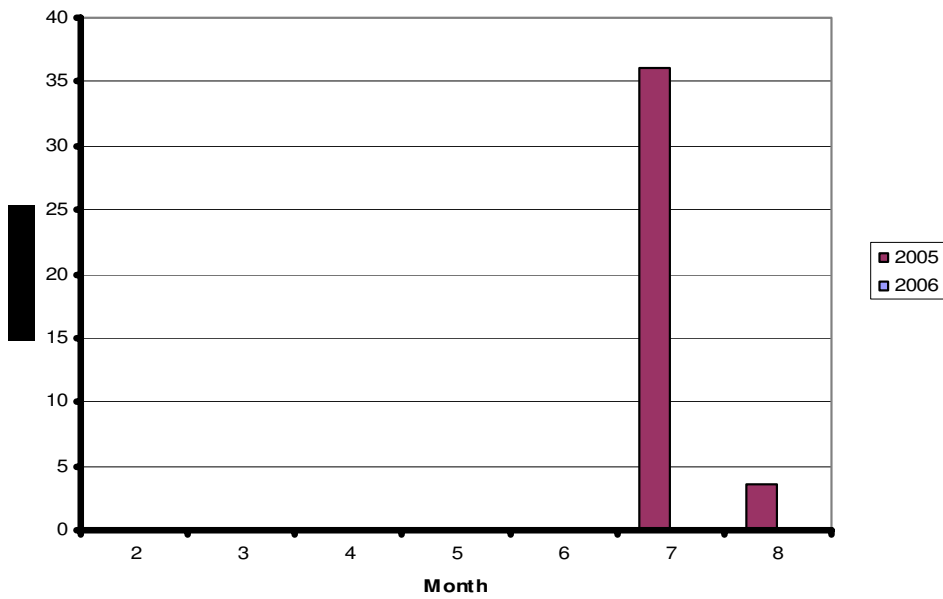
Hatchery Chinook
Hancock Lagoon

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 35
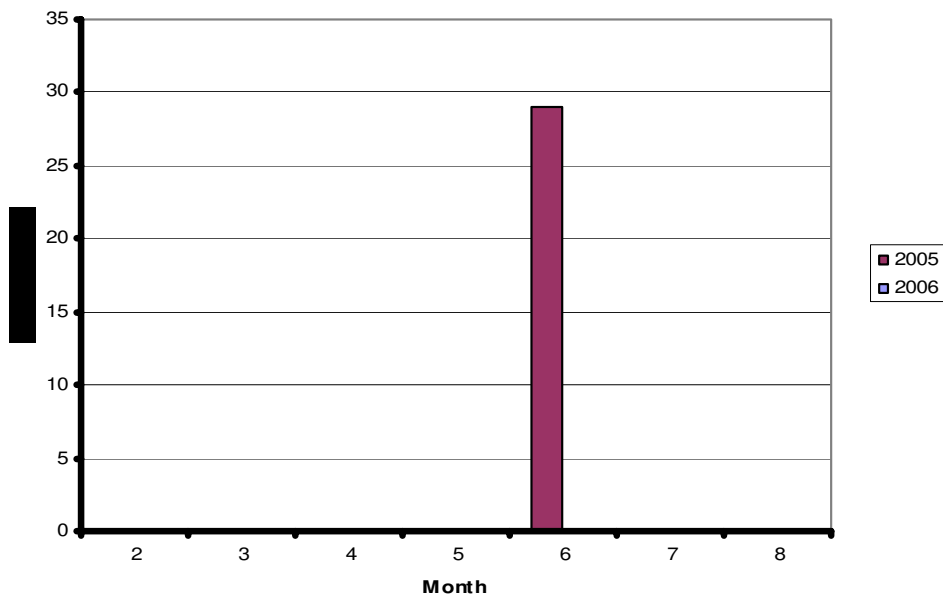
Wild Coho
Hancock Lagoon
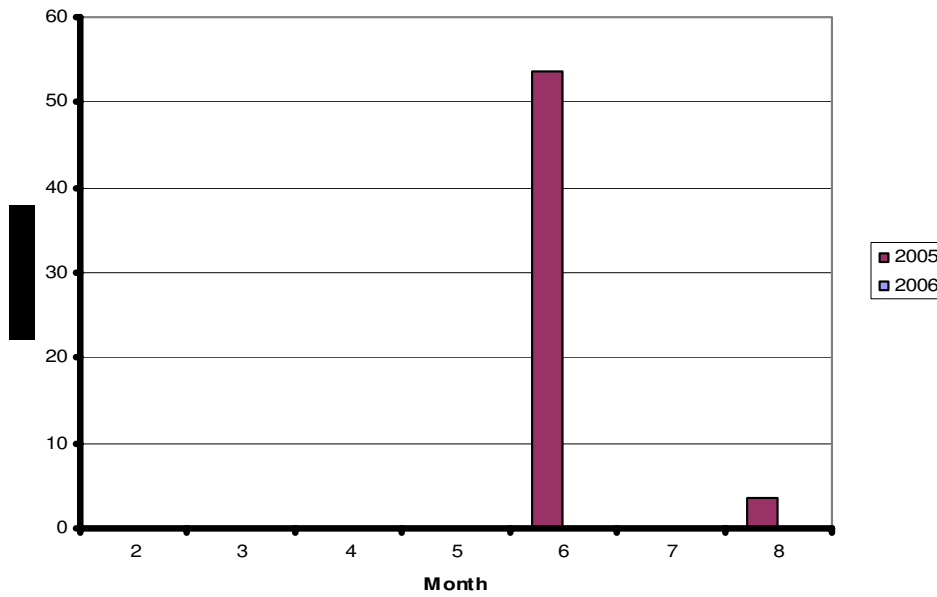
Total Juvenile Salmon
Hancock Beach
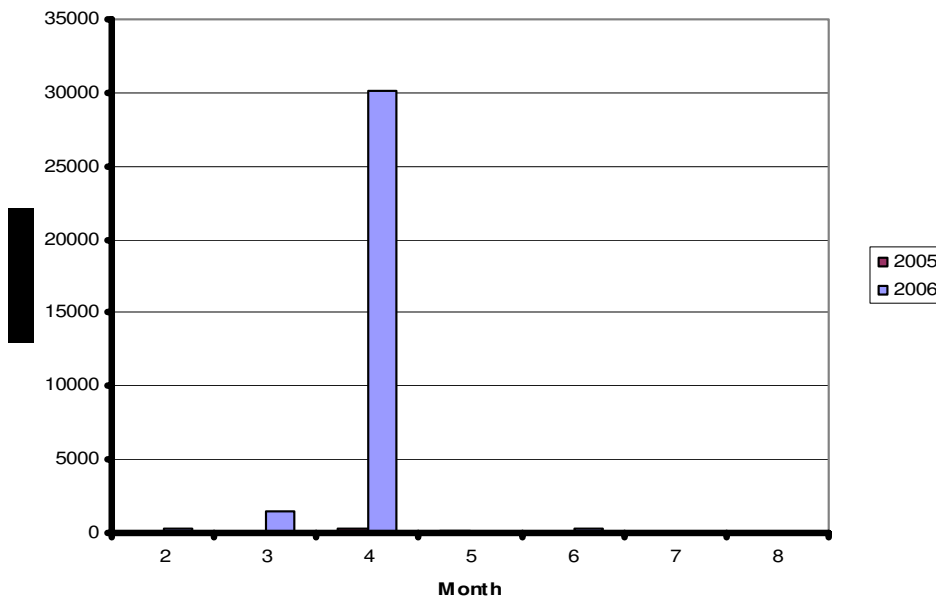
Pink Salmon
Hancock Beach
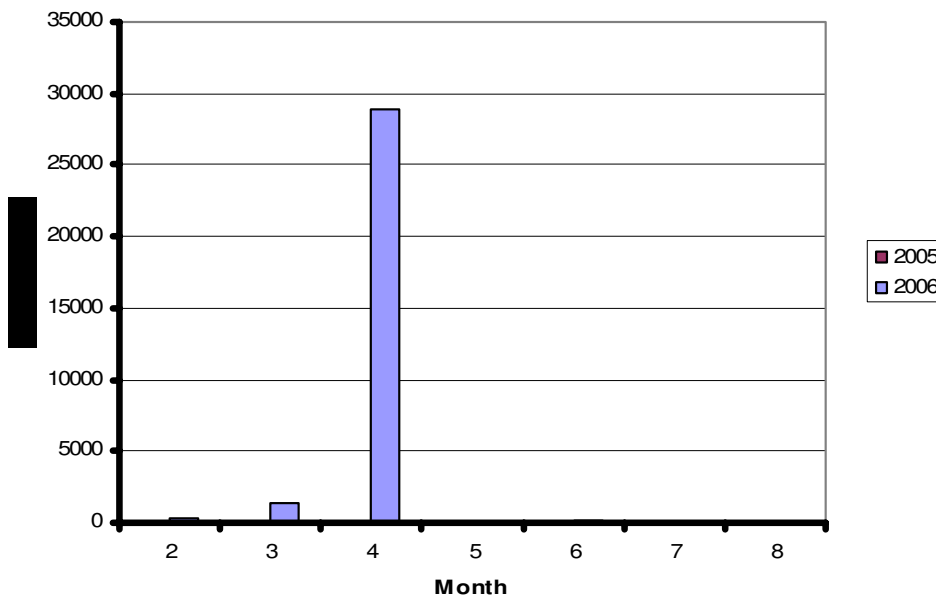
Chum Salmon
Hancock Beach
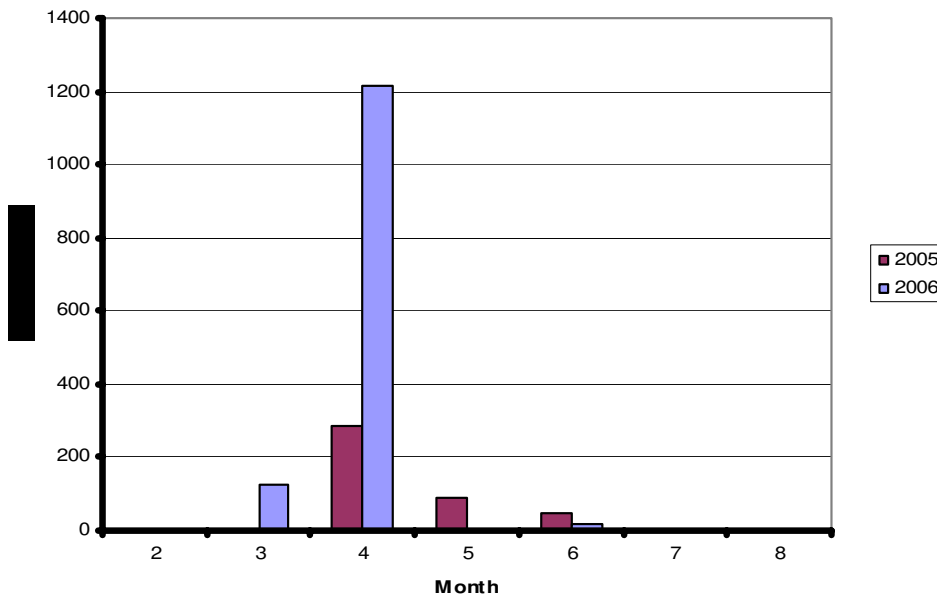
Total Juvenile Chinook
Hancock Beach

Wild Chinook
Hancock Beach

Legend: 2005, 2006

Y-axis: 0 to 12
X-axis: Month (2, 3, 4, 5, 6, 7, 8)

Hatchery Chinook
Hancock Beach

Legend: 2005, 2006

Y-axis: 0 to 60
X-axis: Month (2, 3, 4, 5, 6, 7, 8)
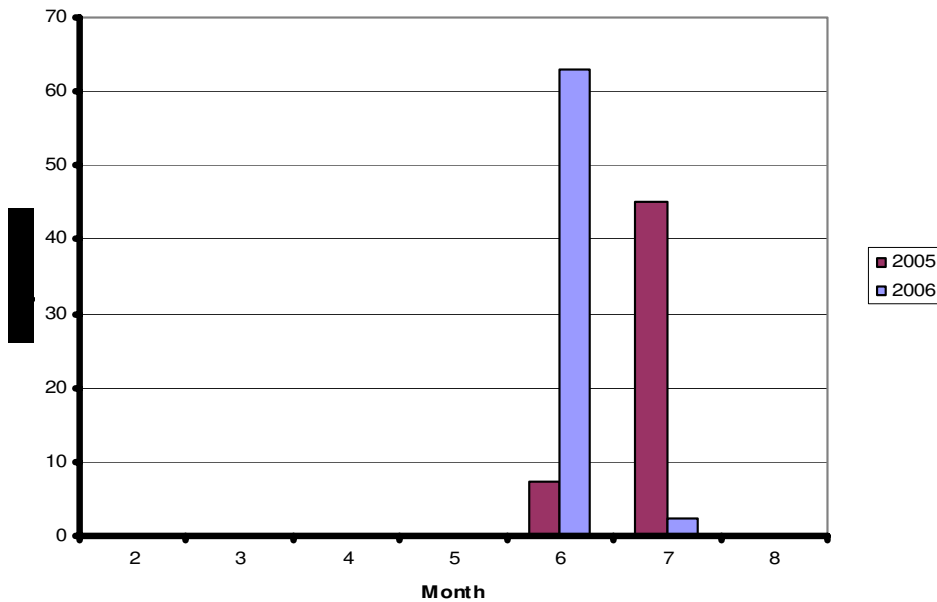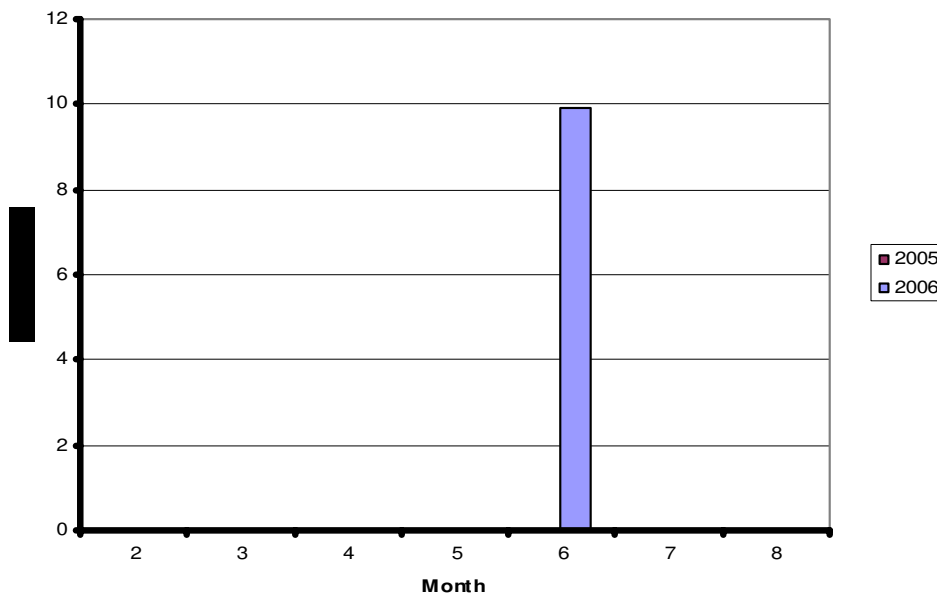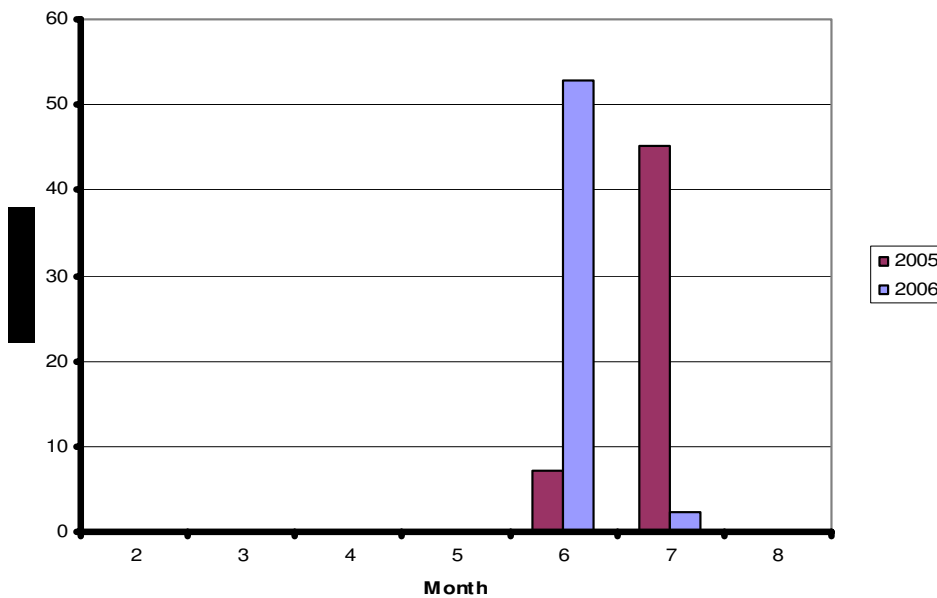
Wild Coho
Hancock Beach
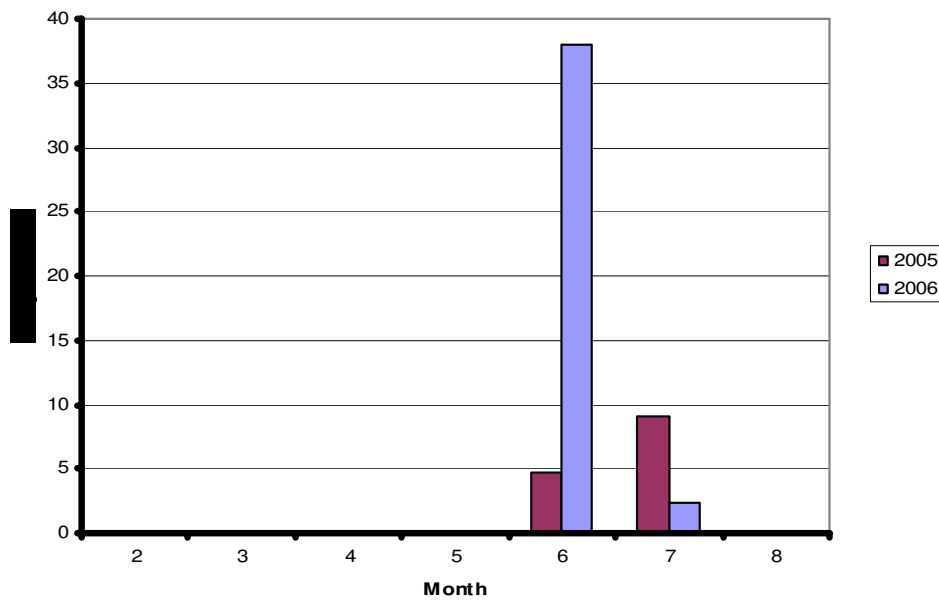
Total Juvenile Salmon
Lagoon Point
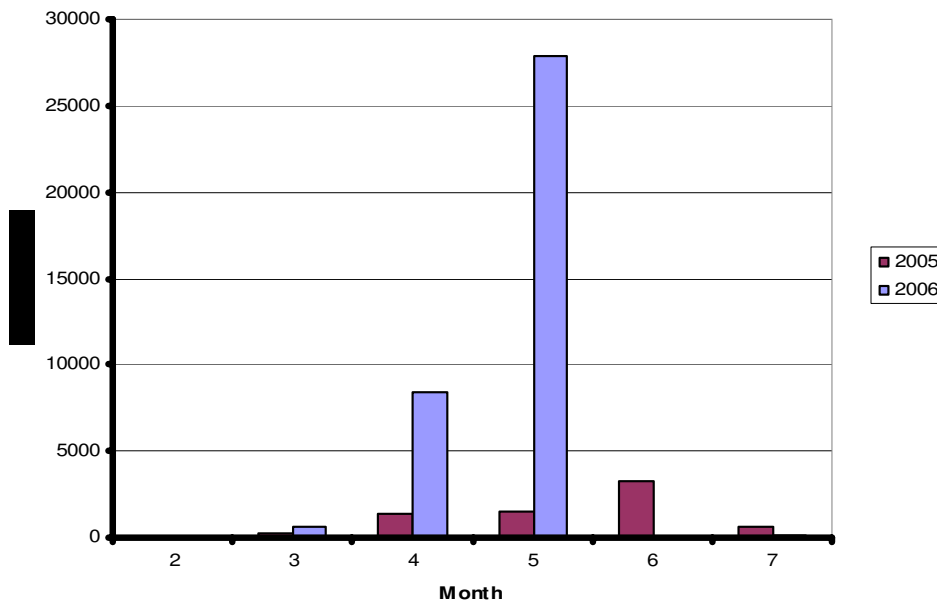
Pink Salmon
Lagoon Point
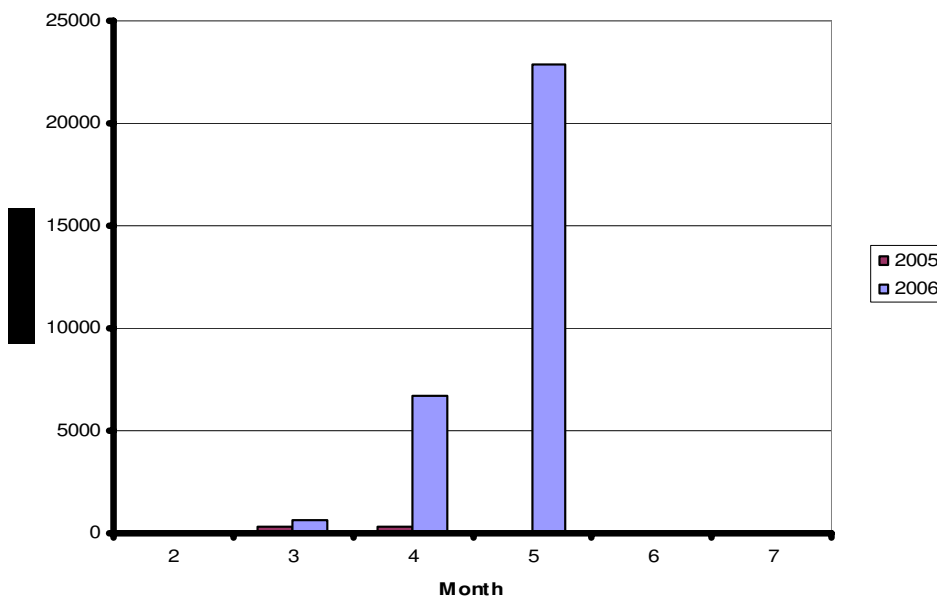
Chum Salmon
Lagoon Point
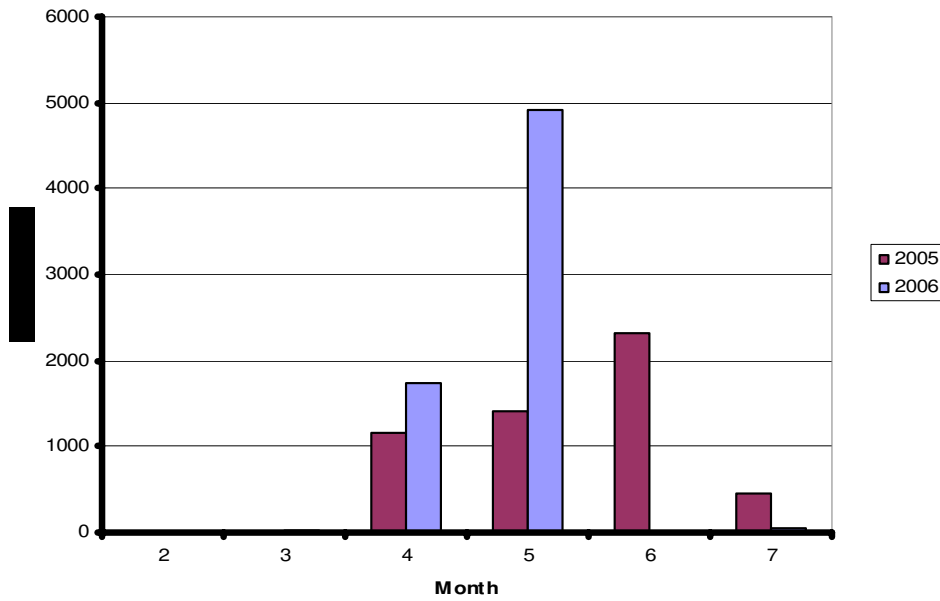
Total Juvenile Chinook
Lagoon Point
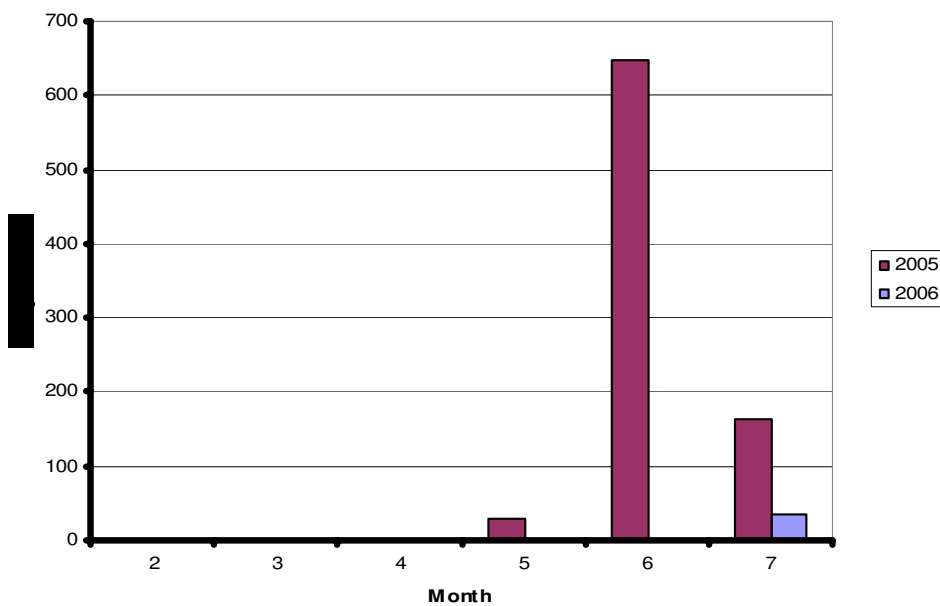
Wild Chinook
Lagoon Point
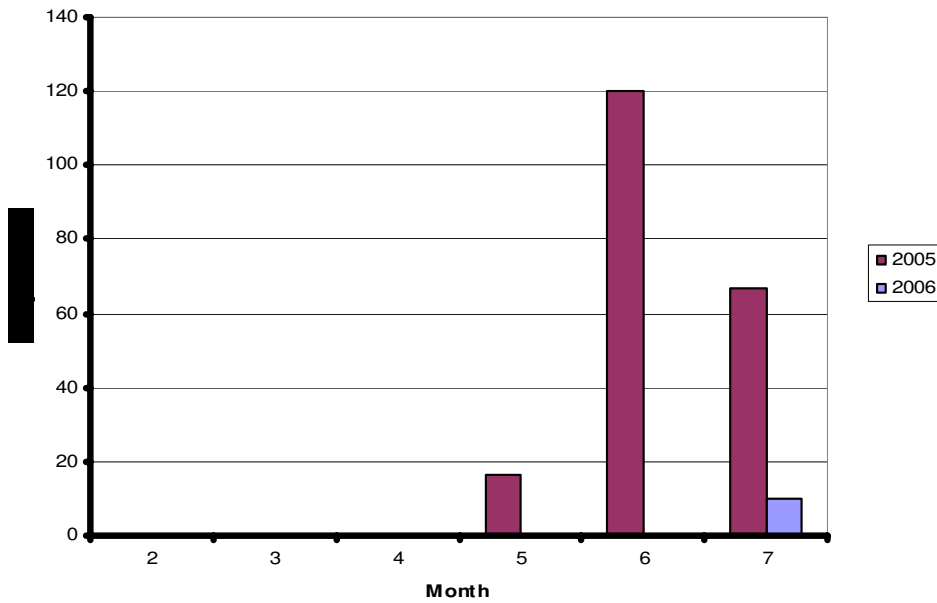
Hatchery Chinook
Lagoon Point
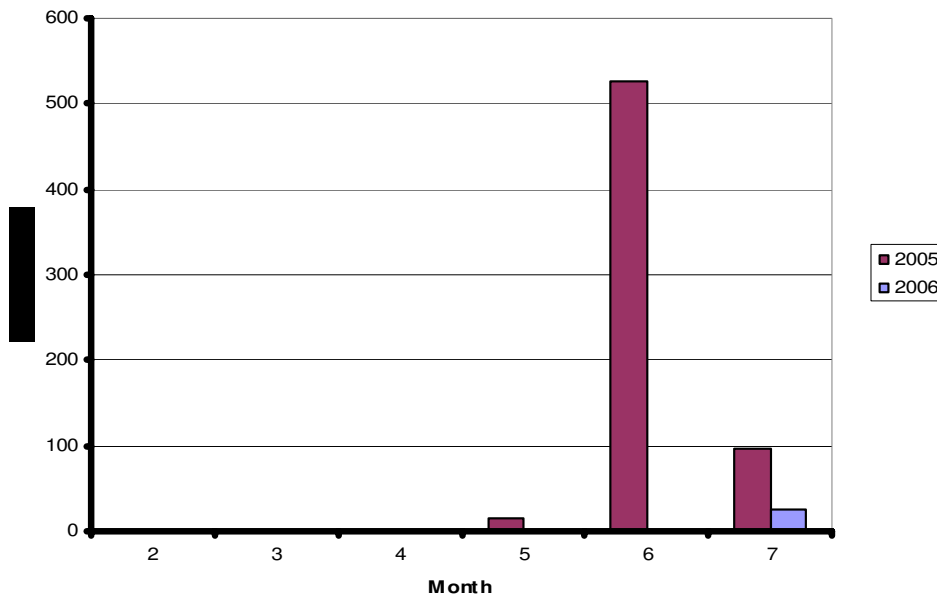
Total Juvenile Coho
Lagoon Point
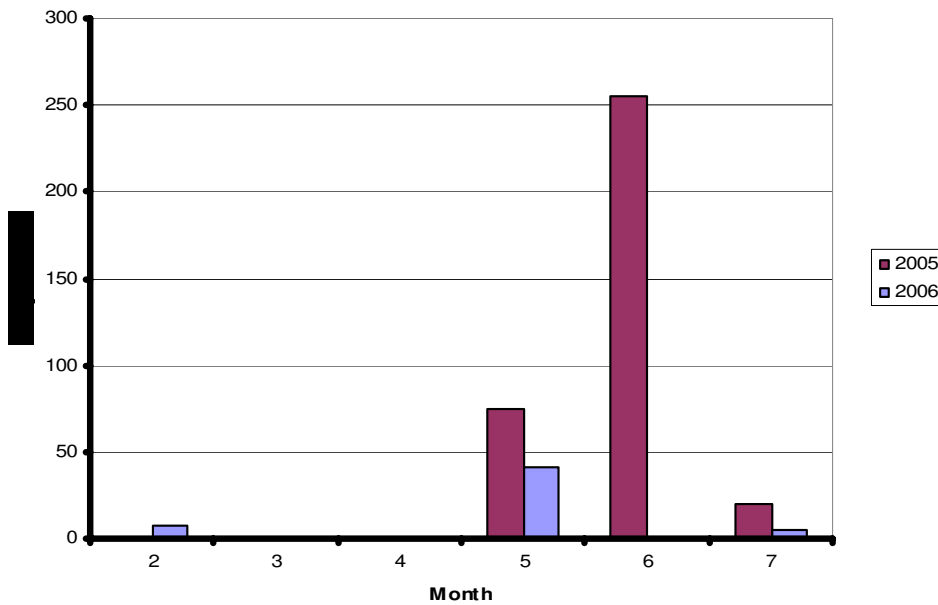
Wild Coho
Lagoon Point
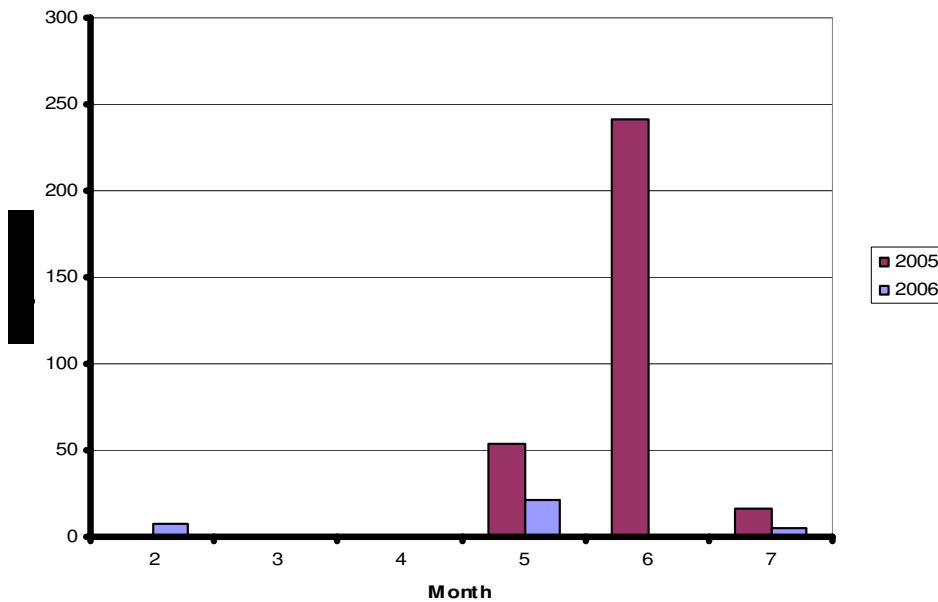
Hatchery Coho
Lagoon Point
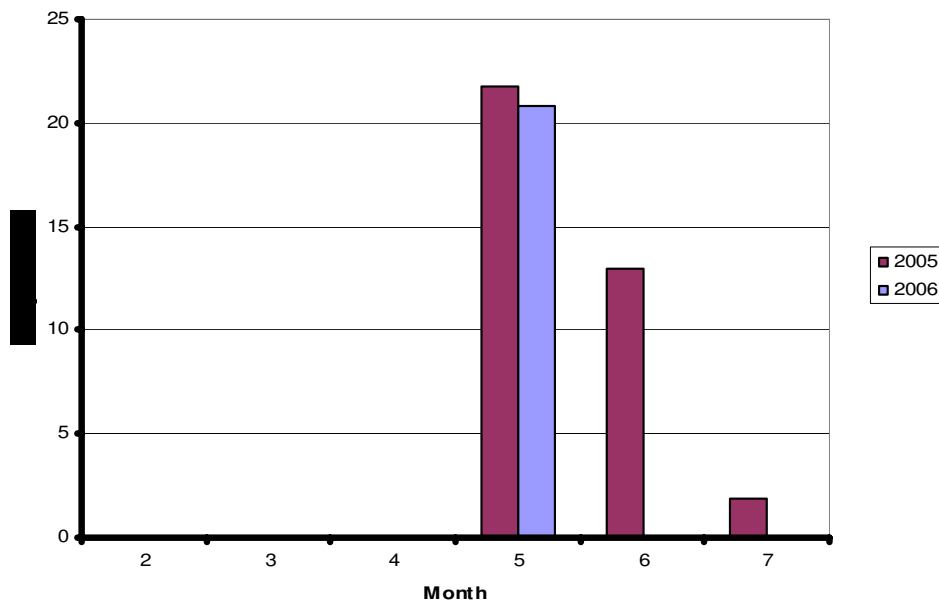
Total Juvenile Salmon
South Whidbey State Park- Creek Site
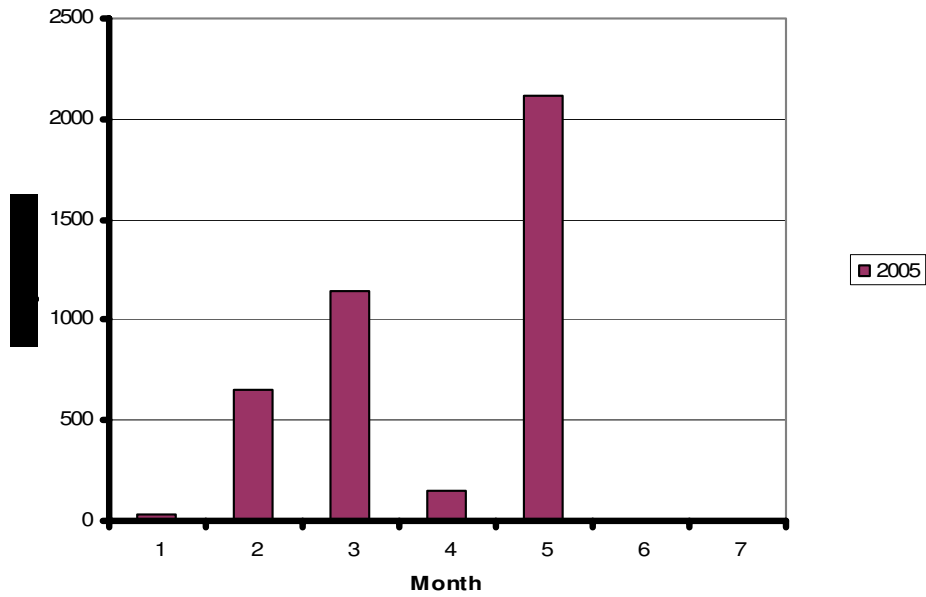
Pink Salmon
South Whidbey State Park- Creek Site
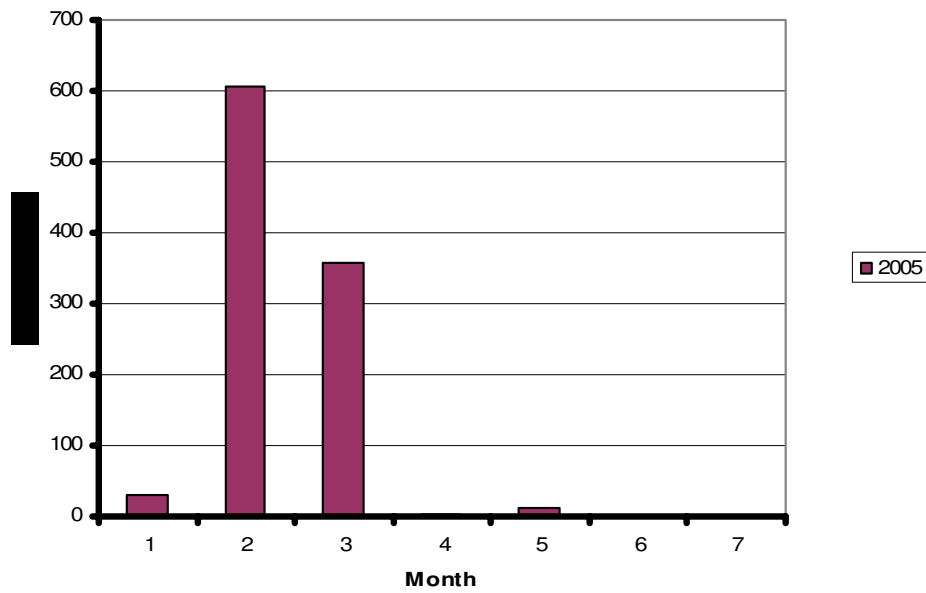
Chum Salmon
South Whidbey State Park- Creek Site
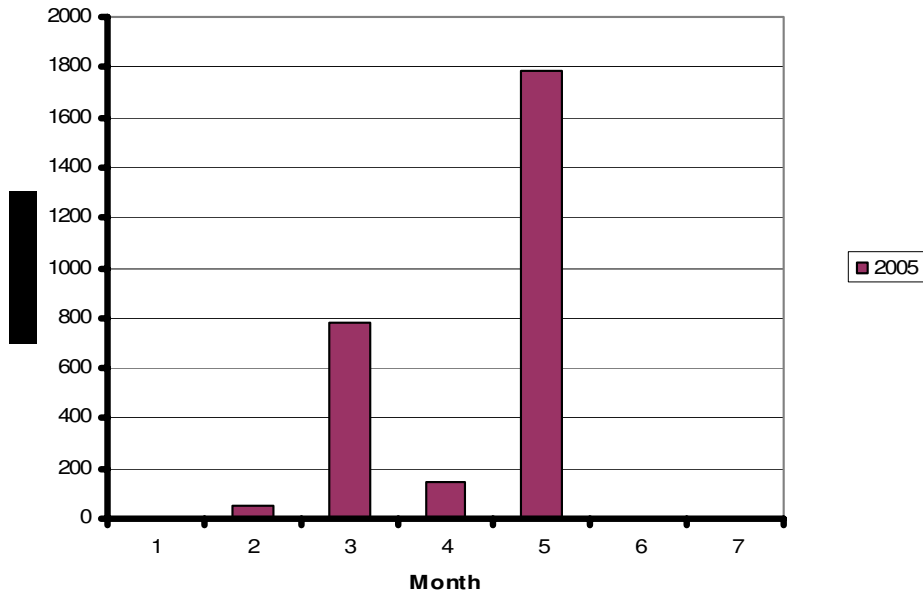
Total Juvenile Chinook
South Whidbey State Park- Creek Site
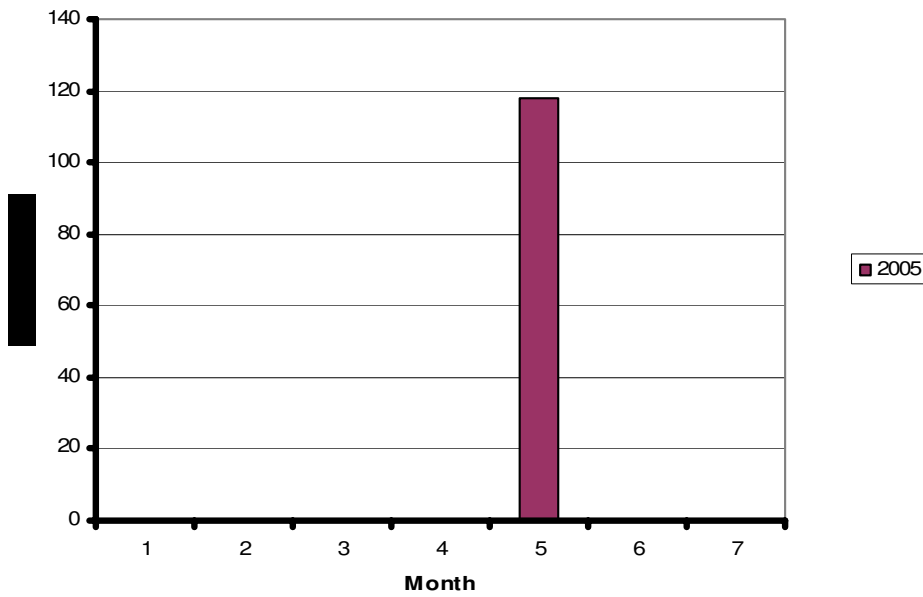
Wild Chinook
South Whidbey State Park- Creek Site
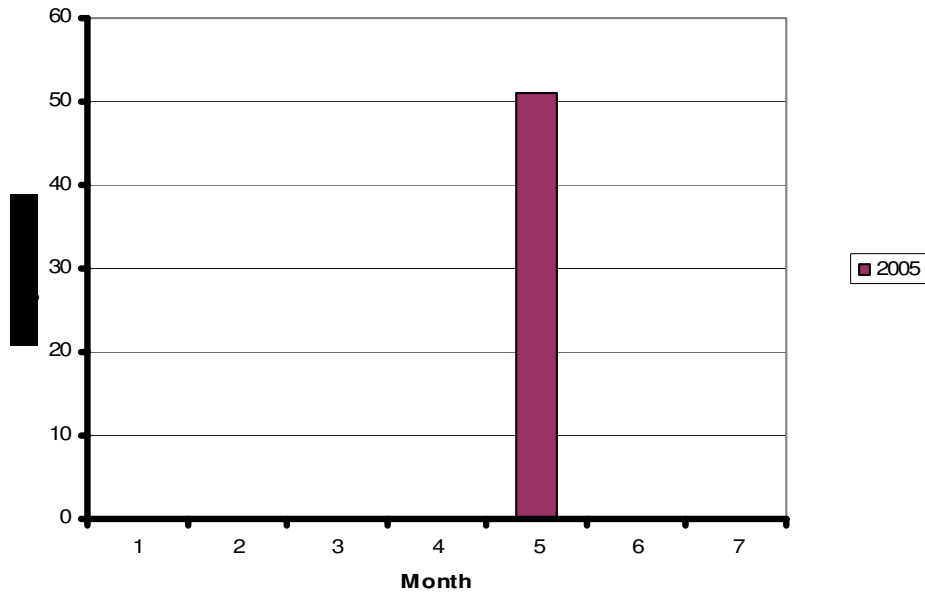
Hatchery Chinook
South Whidbey State Park- Creek Site
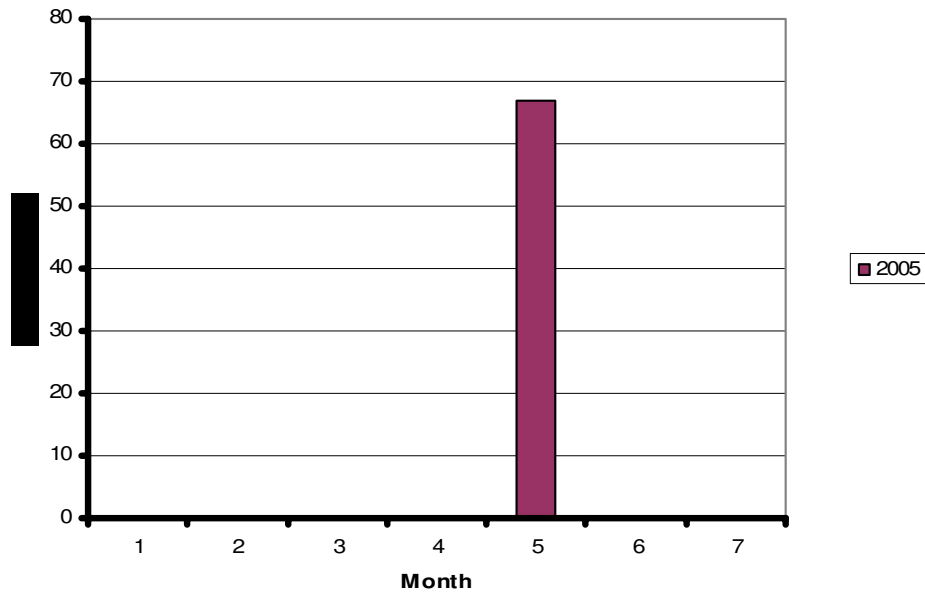
Total Juvenile Coho
South Whidbey State Park- Creek Site
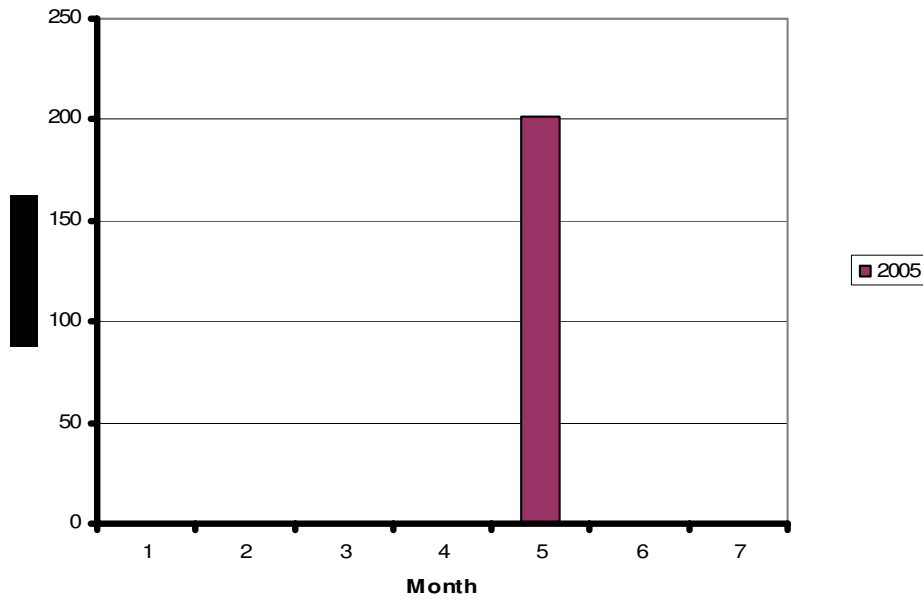
Wild Coho
South Whidbey State Park- Creek Site
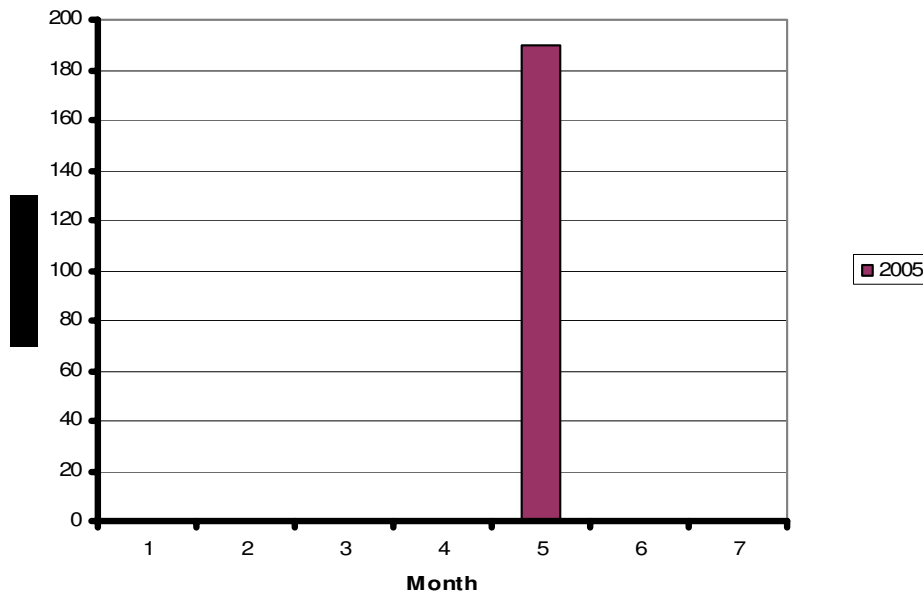
Hatchery Coho
South Whidbey State Park- Creek Site

Month

Legend: ■ 2005
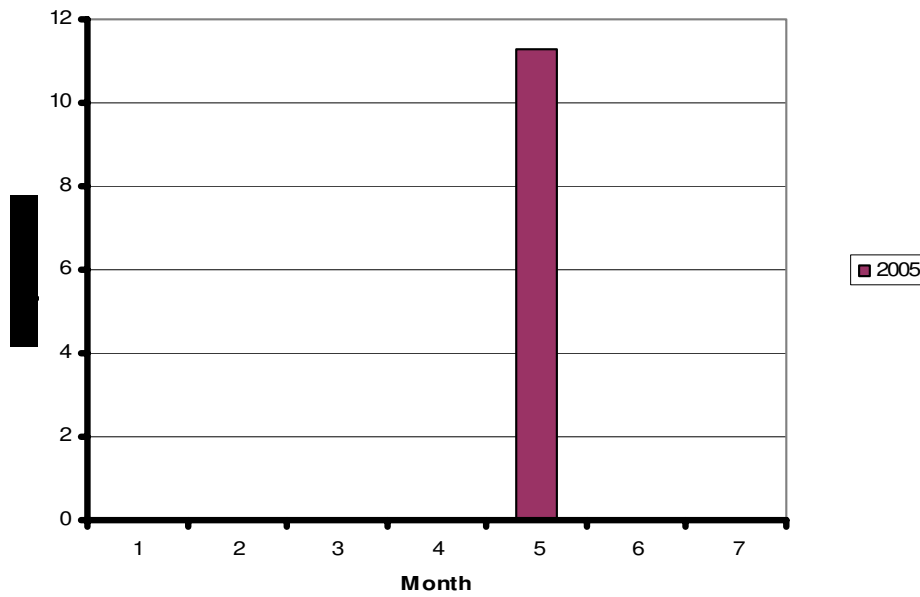
Total Juvenile Salmon
South Whidbey State Park- Beach Site
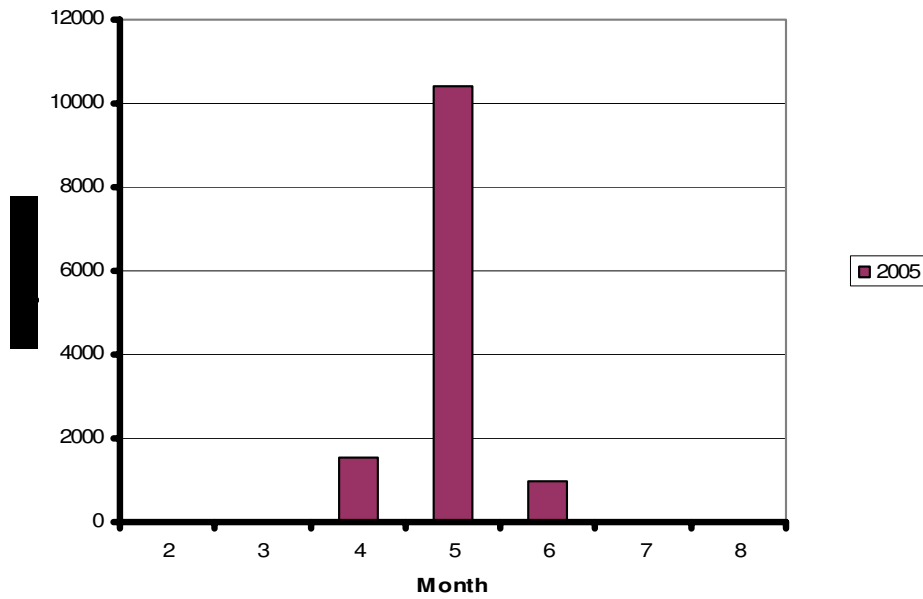
Pink Salmon
South Whidbey State Park- Beach Site
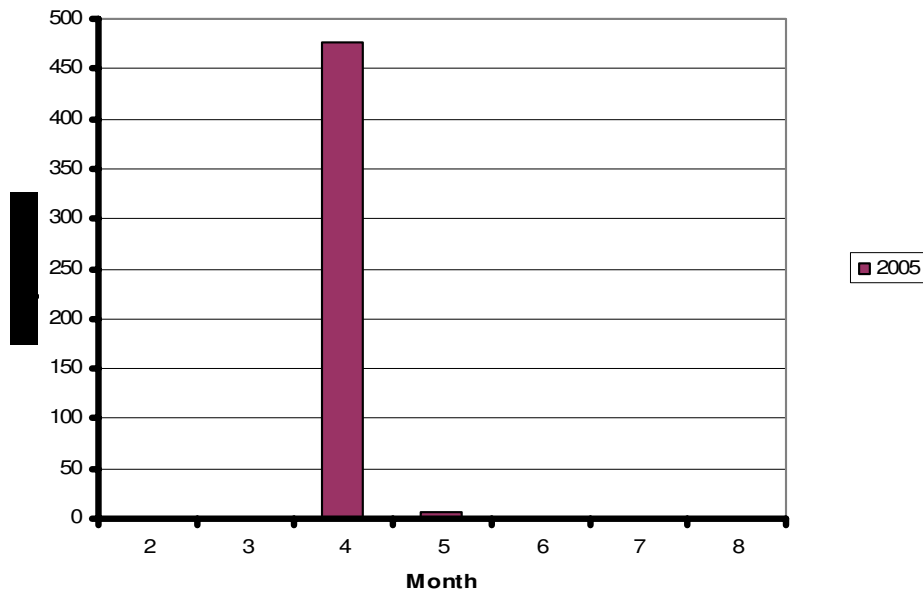
Chum Salmon
South Whidbey State Park- Beach Site
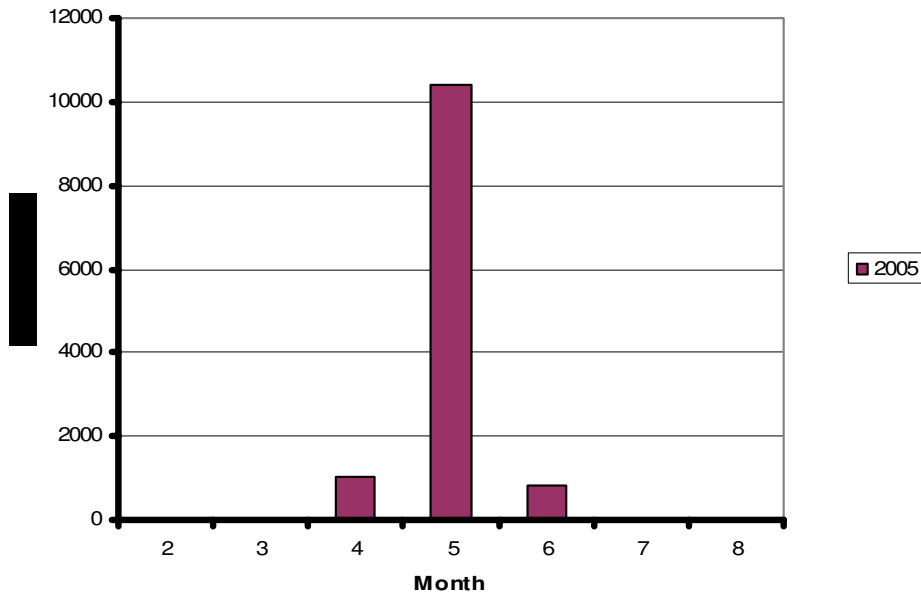
Total Juvenile Chinook
South Whidbey State Park- Beach Site

Wild Chinook
South Whidbey State Park- Beach Site

Legend: 2005

Y-axis: 0, 5, 10, 15, 20, 25, 30, 35
X-axis (Month): 2, 3, 4, 5, 6, 7, 8

Hatchery Chinook
South Whidbey State Park- Beach Site

Legend: 2005

Y-axis: 0, 2, 4, 6, 8, 10, 12, 14
X-axis (Month): 2, 3, 4, 5, 6, 7, 8

Total Juvenile Coho
South Whidbey State Park- Beach Site
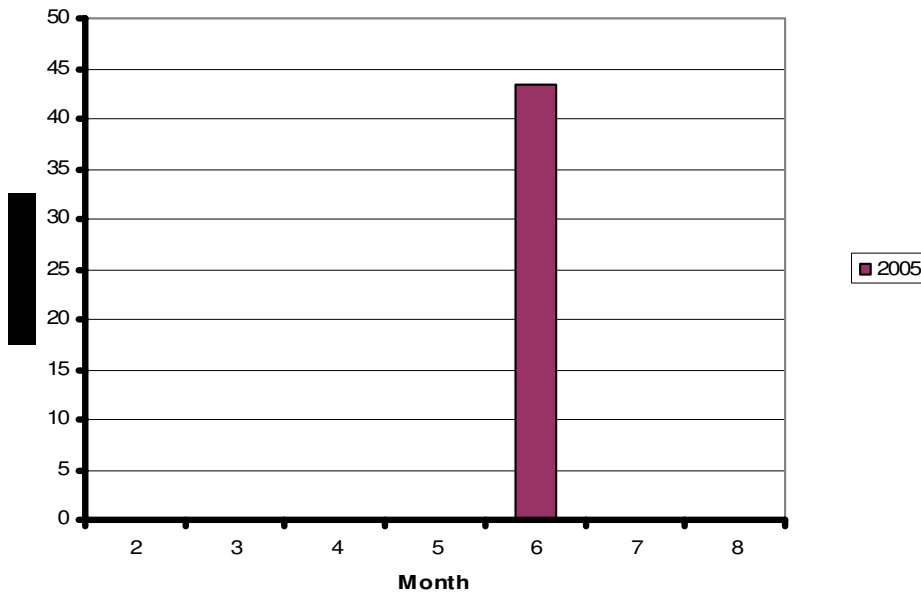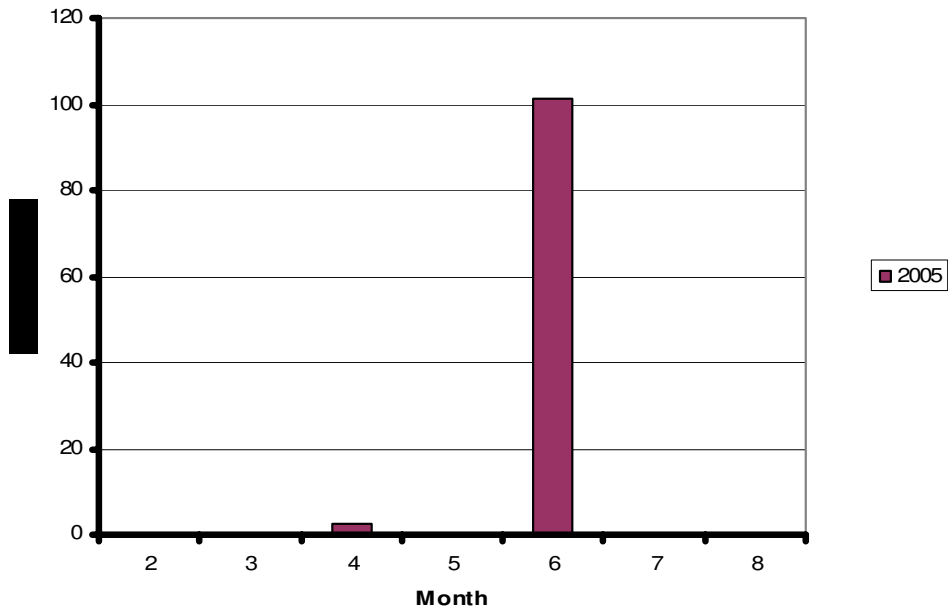
Wild Coho
South Whidbey State Park- Beach Site

Hatchery Coho
South Whidbey State Park- Beach Site

Legend: 2005

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
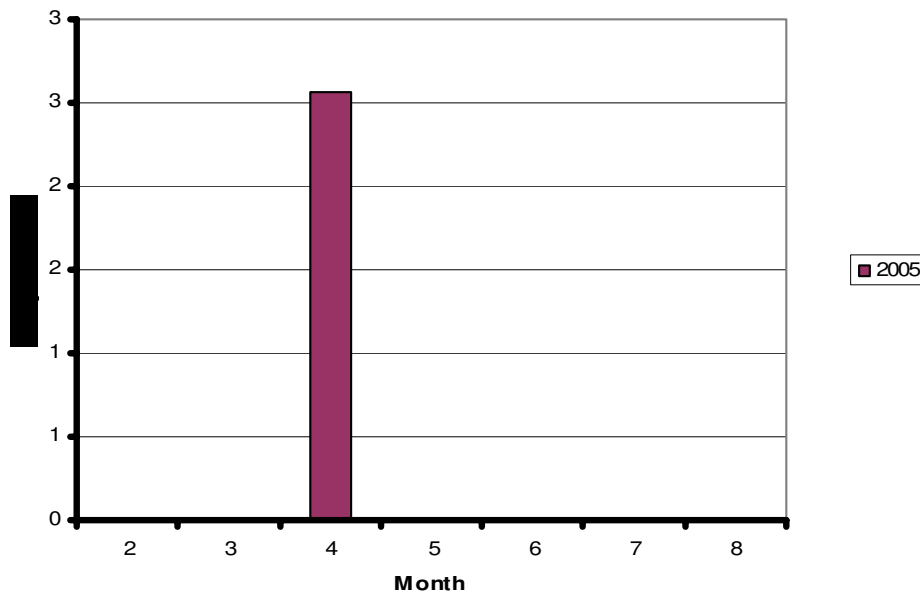
Total Juvenile Salmon
Double Bluff

Pink Salmon
Double Bluff
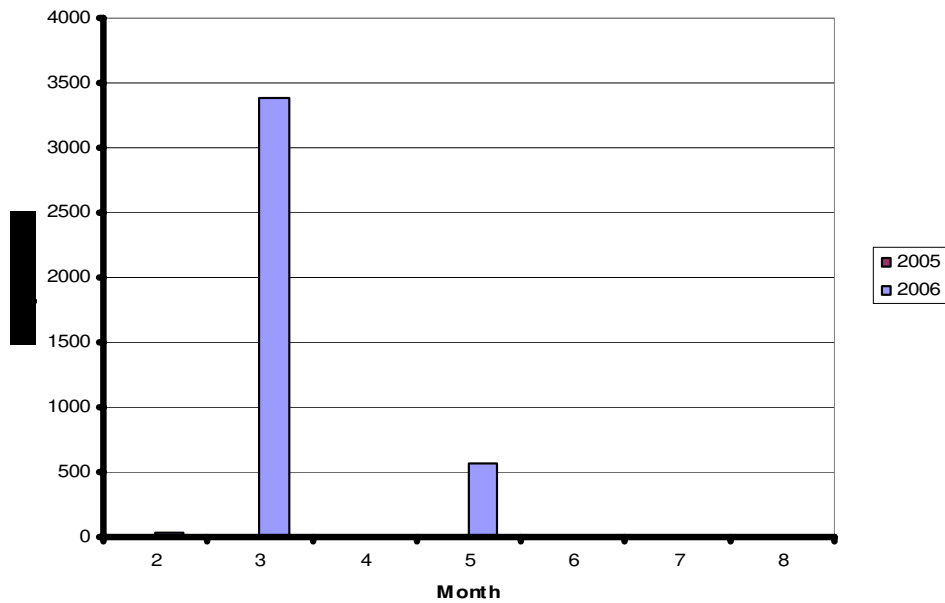
Chum Salmon
Double Bluff
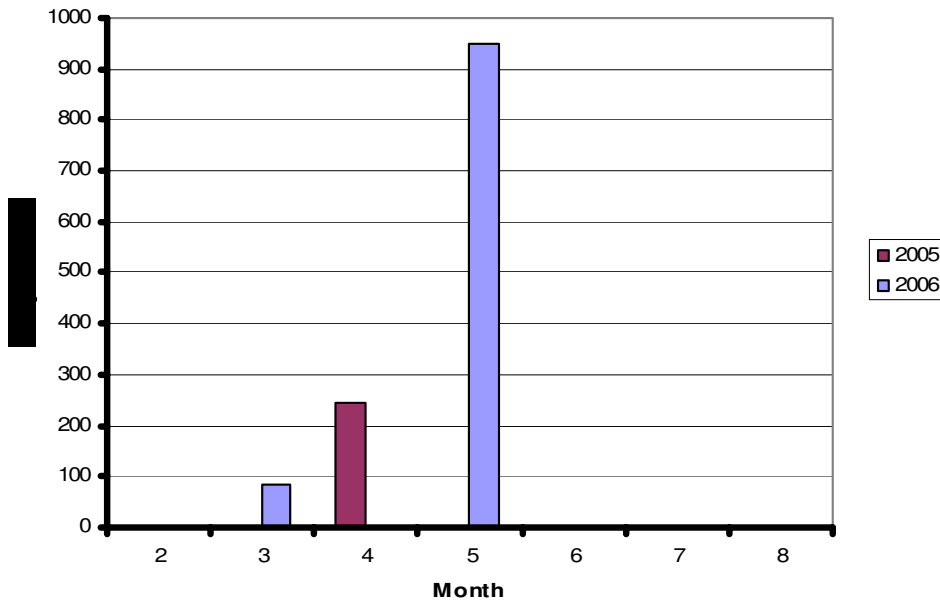
Hatchery Chinook
Double Bluff
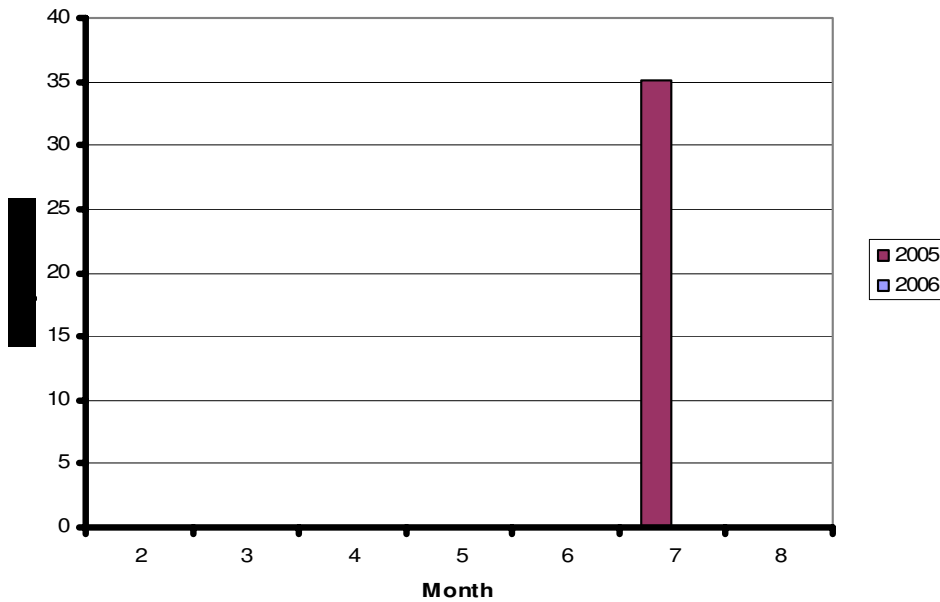
Total Juvenile Salmon
Deer Lagoon
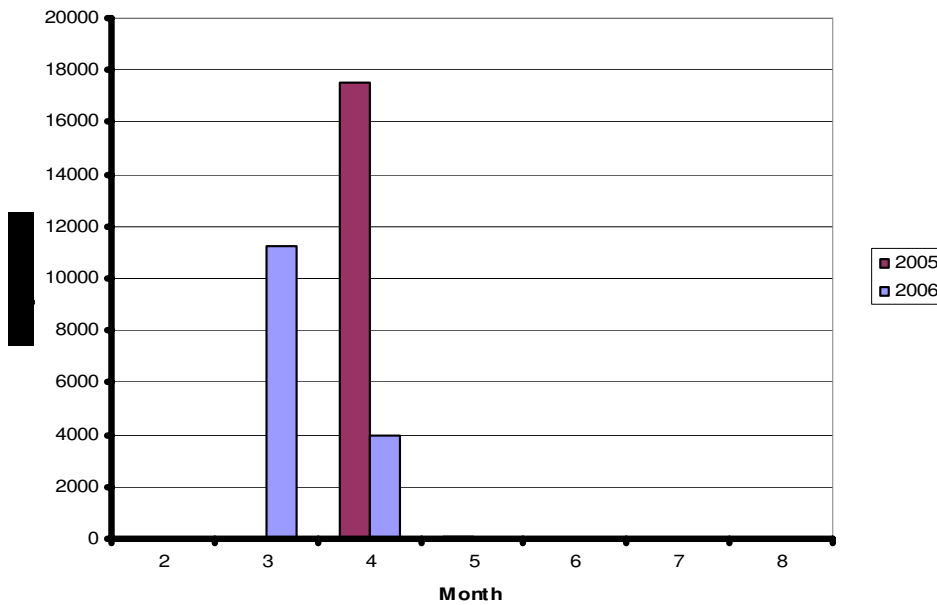
Pink Salmon
Deer Lagoon
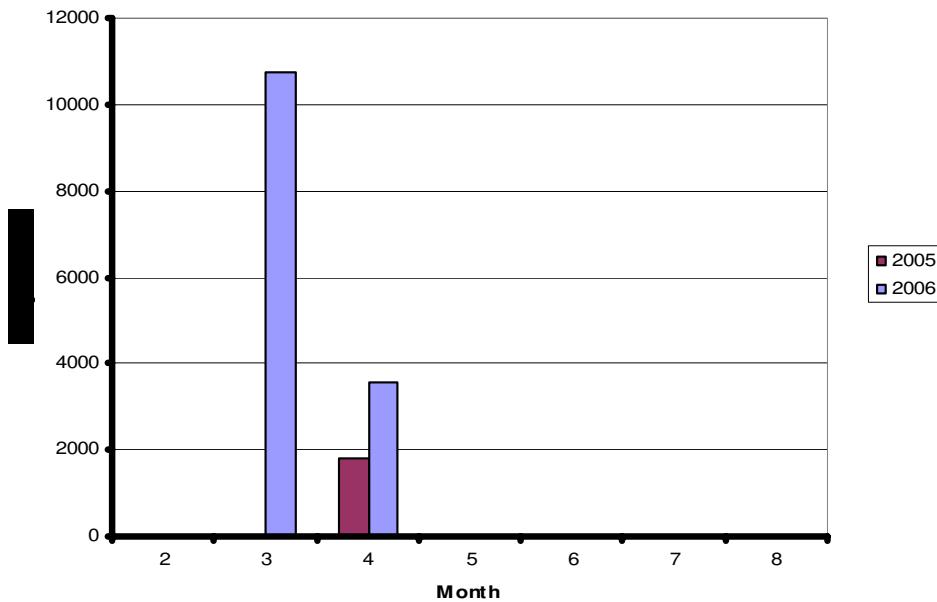
Chum Salmon
Deer Lagoon
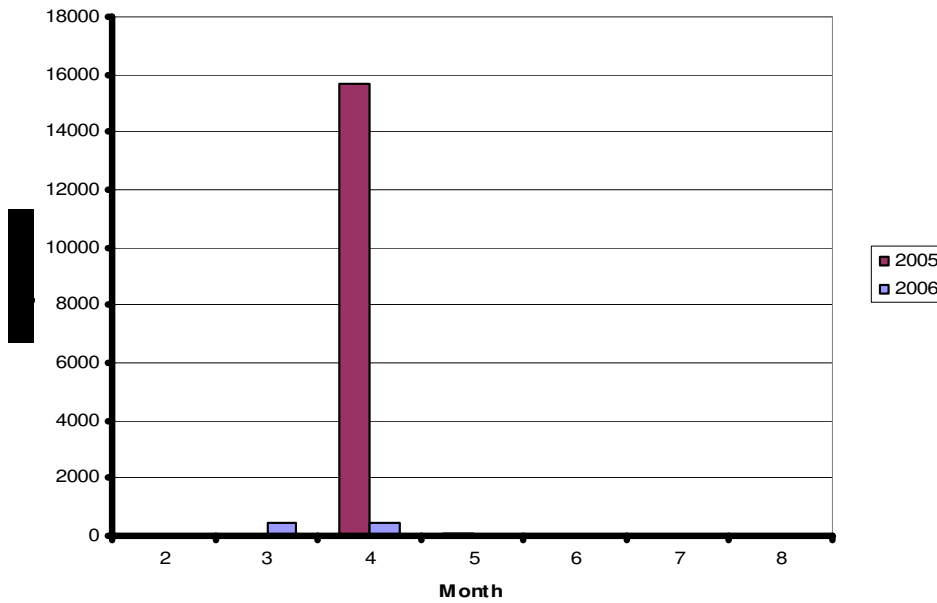
Wild Chinook
Deer Lagoon

Wild Coho
Deer Lagoon
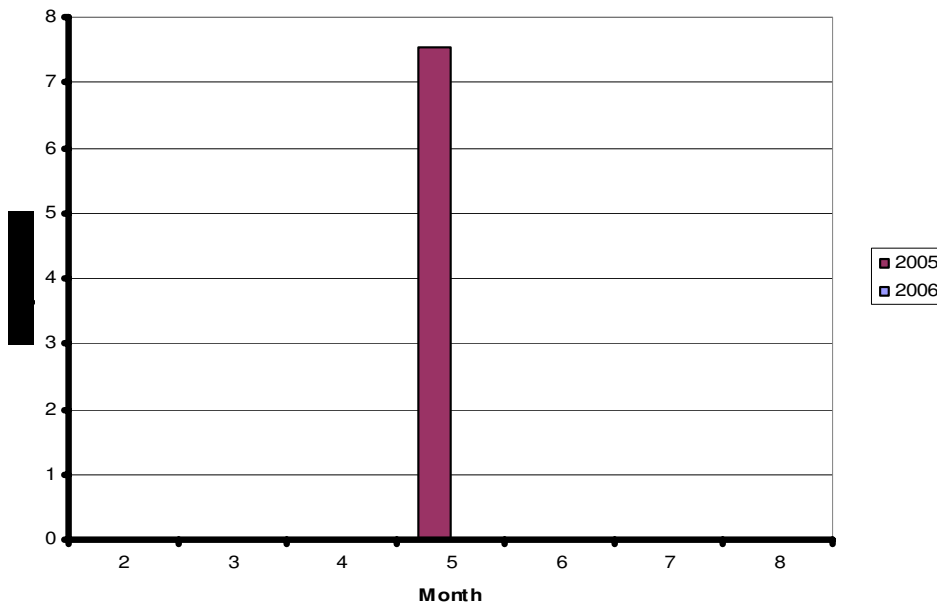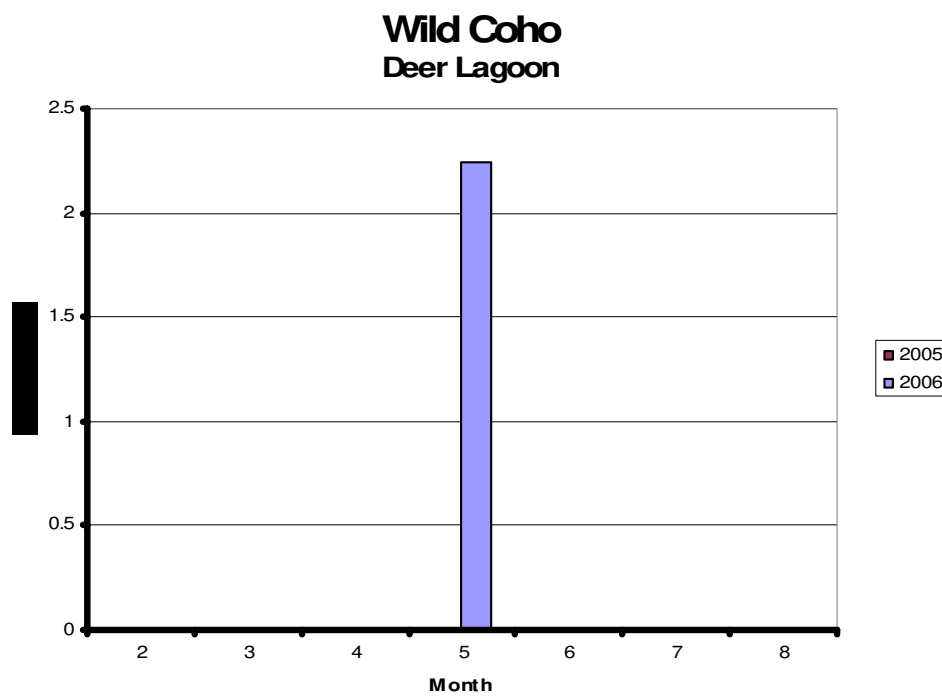
Total Juvenile Salmon
Maxwelton
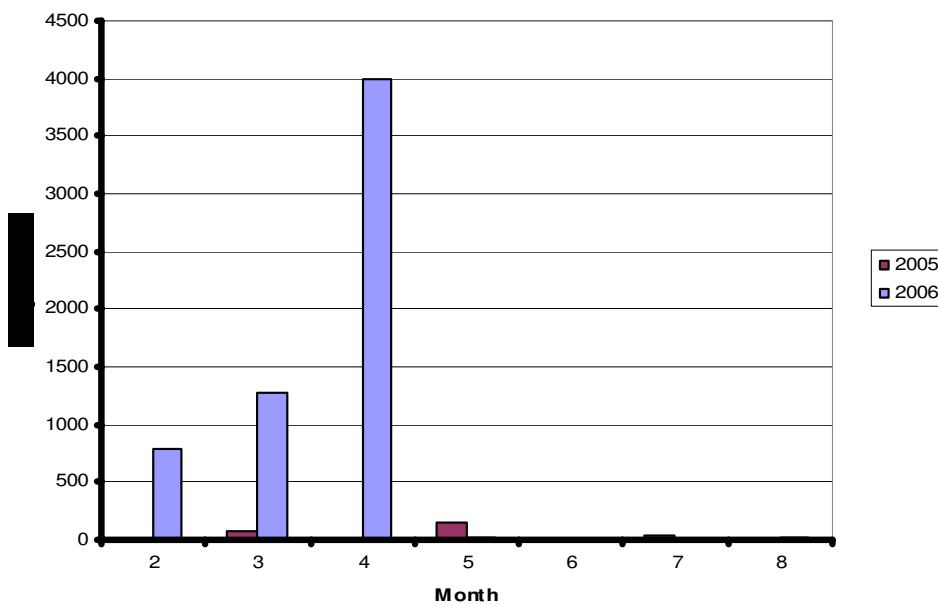
Pink Salmon
Maxwelton
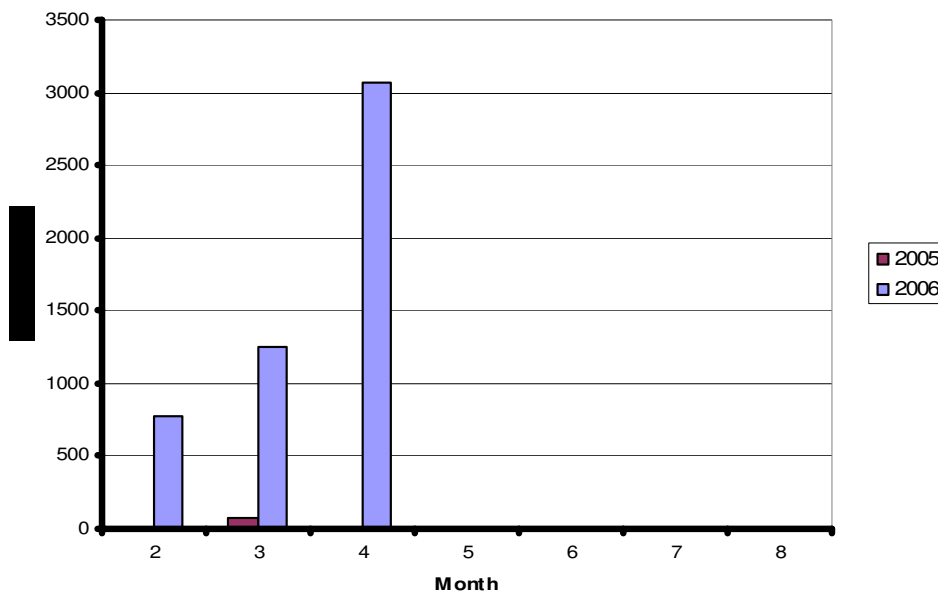
Chum Salmon
Maxwelton

Legend: 2005, 2006
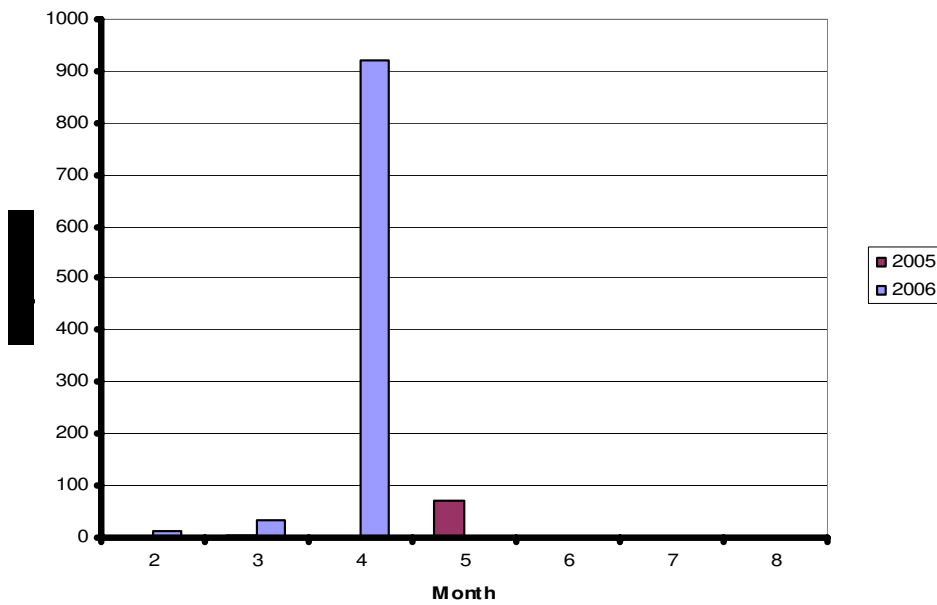
Total Juvenile Chinook
Maxwelton

Legend: 2005, 2006
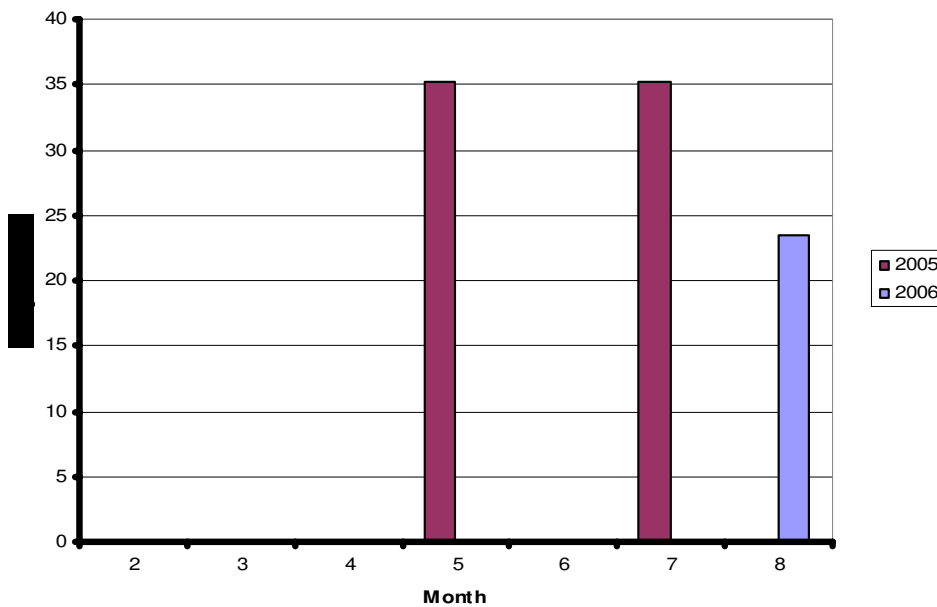
Wild Chinook
Maxwelton

,
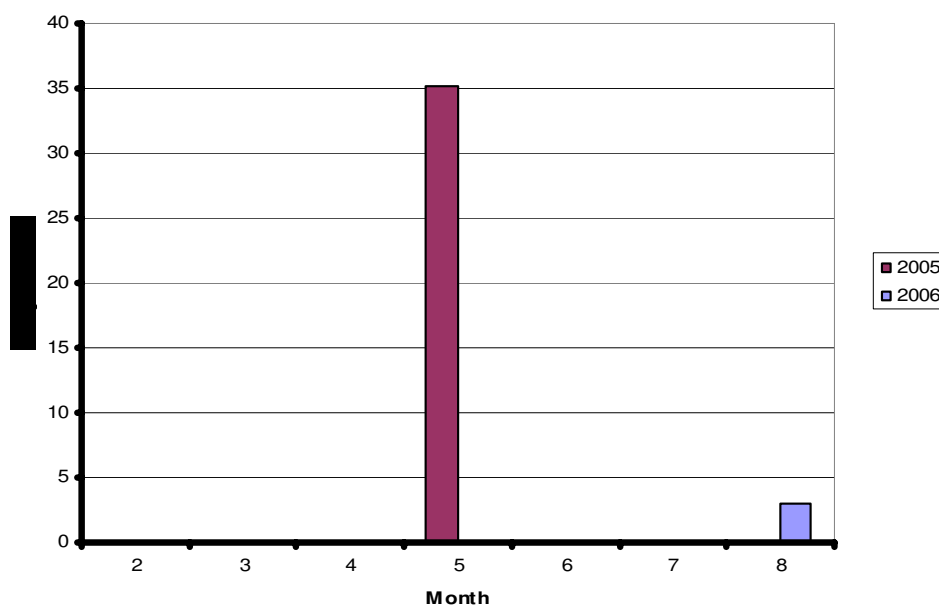
Hatchery Chinook
Maxwelton
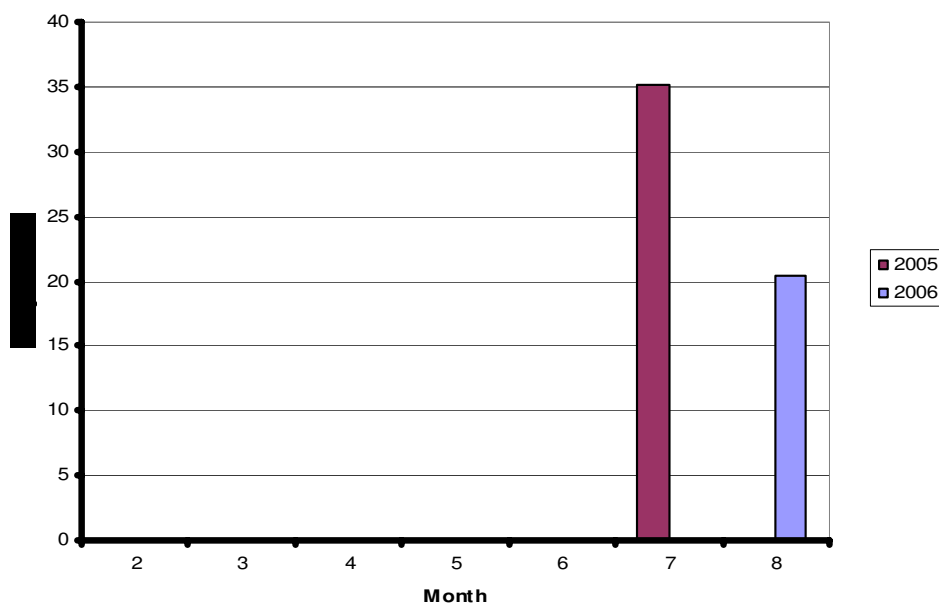
Total Juvenile Coho
Maxwelton
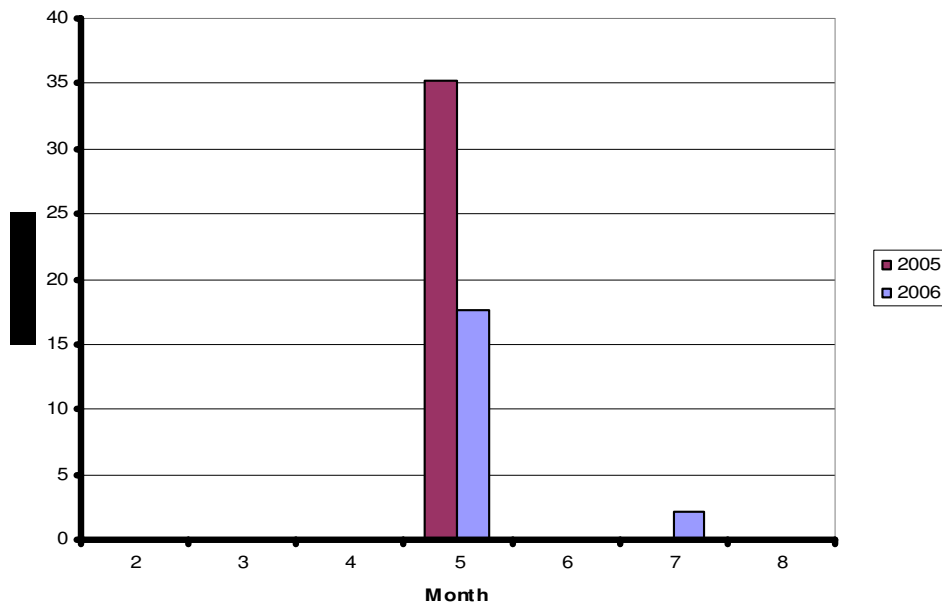
Wild Coho
Maxwelton
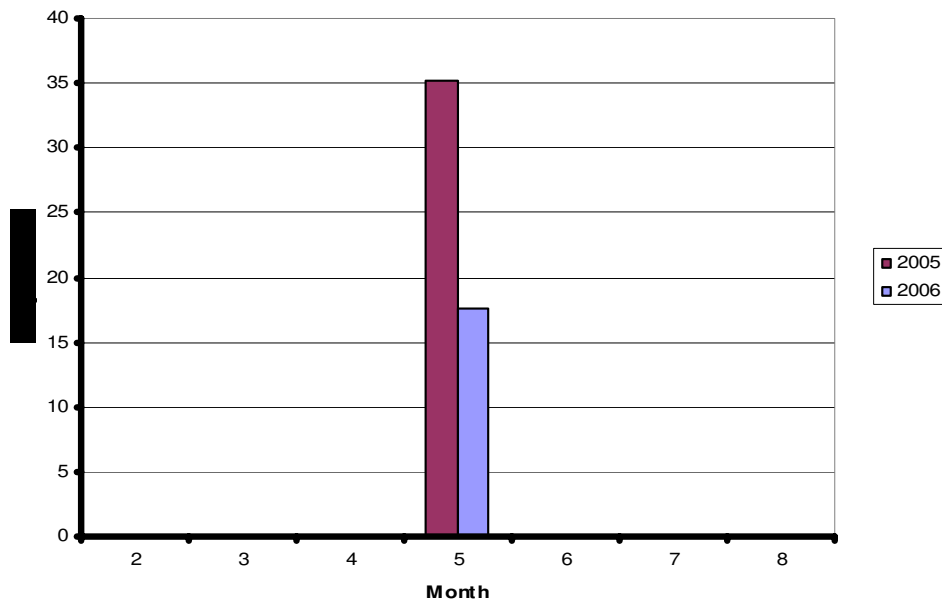
Hatchery Coho
Maxwelton

Legend:
- 2005
- 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 2.5
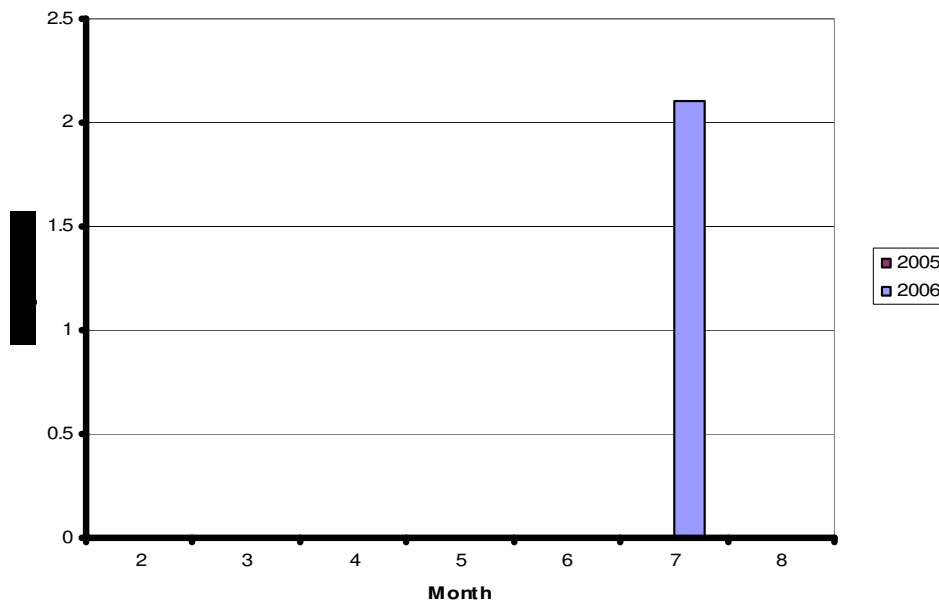
Total Juvenile Salmon
Cultus Bay
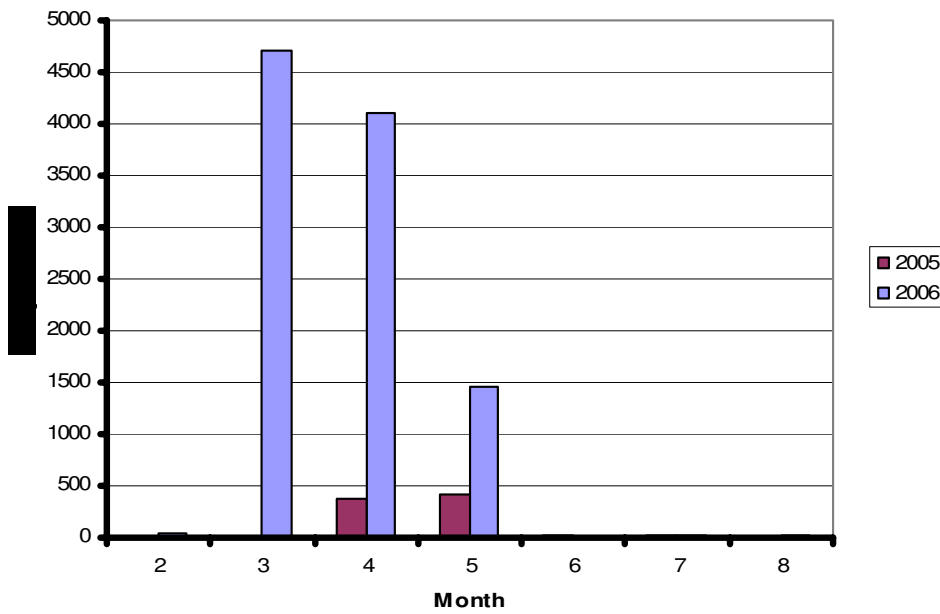
Pink Salmon
Cultus Bay

Chum Salmon
Cultus Bay

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 600

Wild Chinook
Cultus Bay

Legend: 2005, 2006

X-axis: Month (2, 3, 4, 5, 6, 7, 8)
Y-axis: 0 to 20
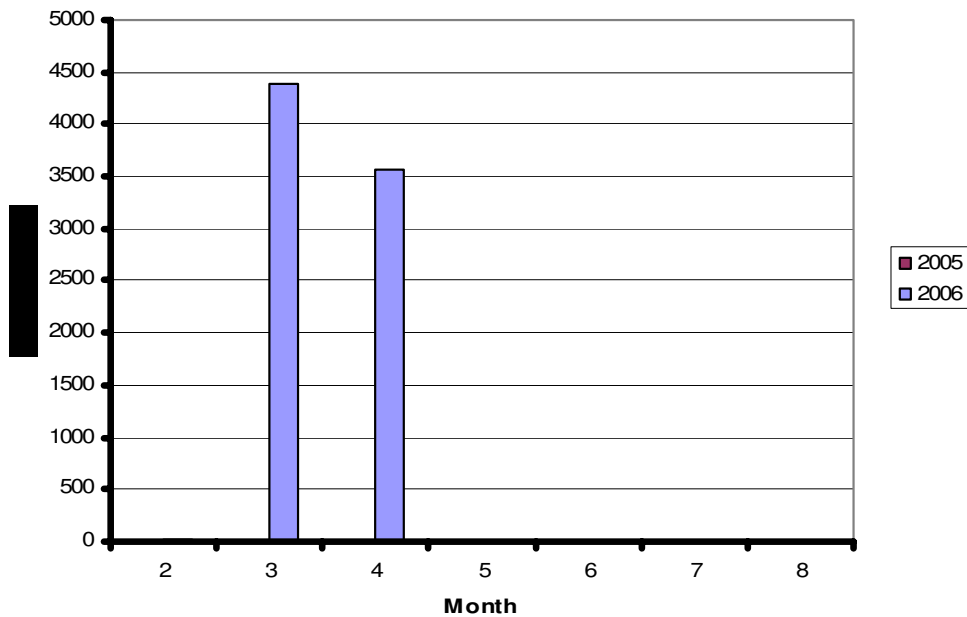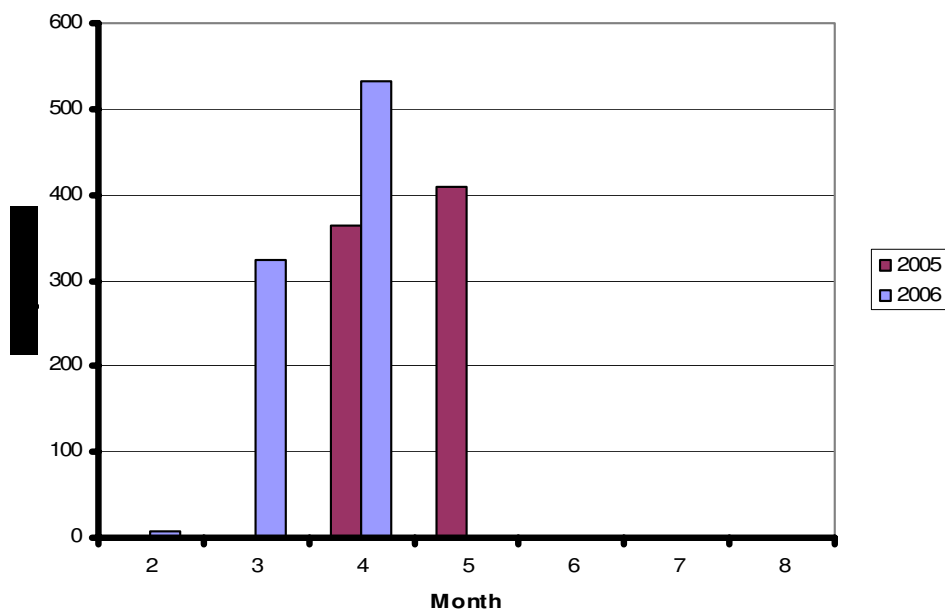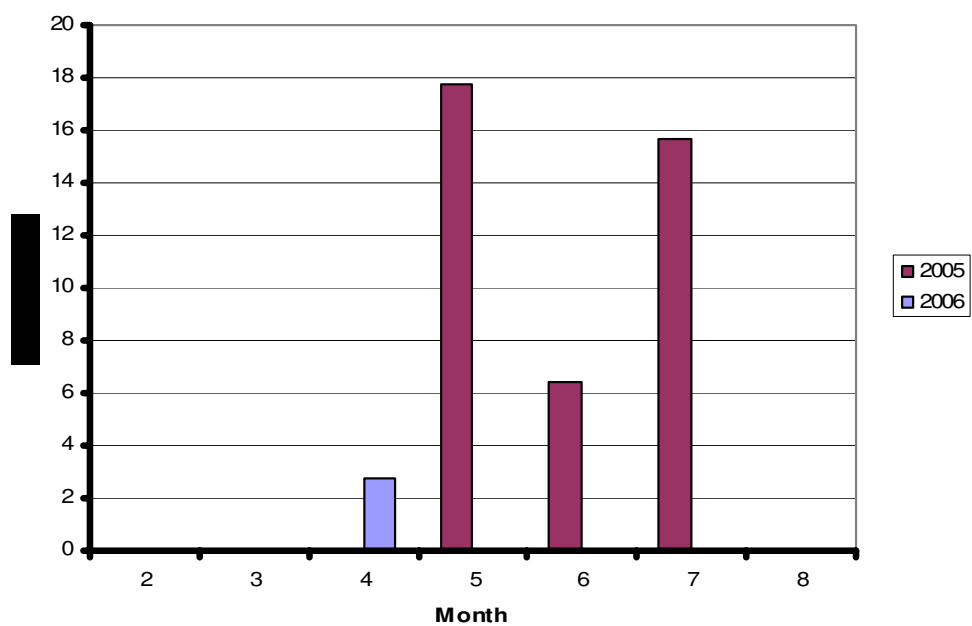
Hatchery Chinook
Cultus Bay
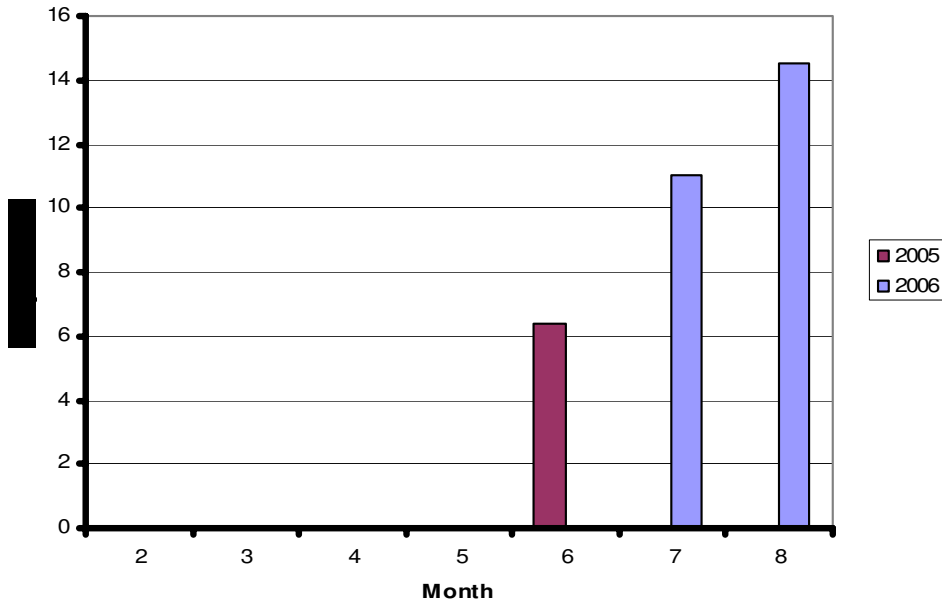
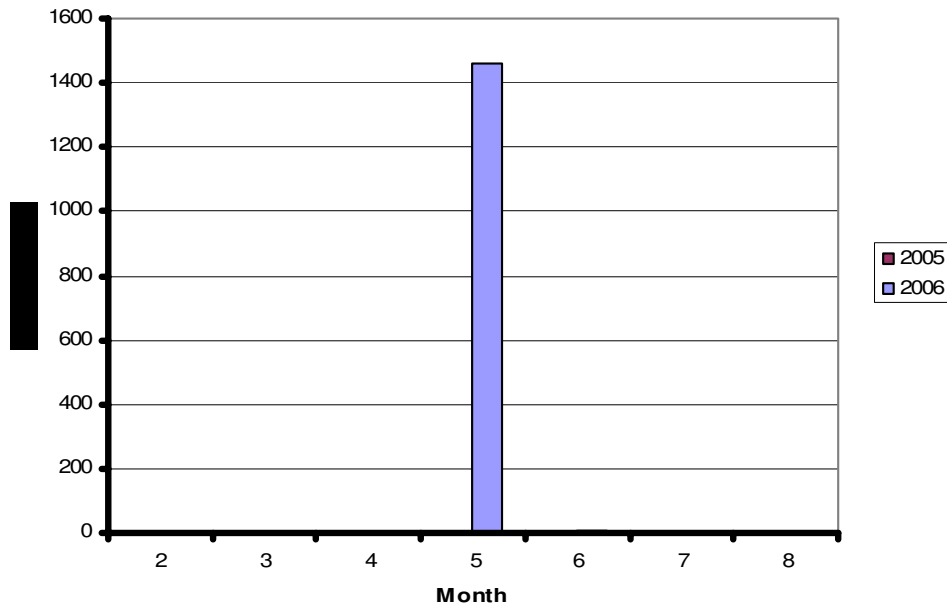# Total Juvenile Chinook
Cultus Bay
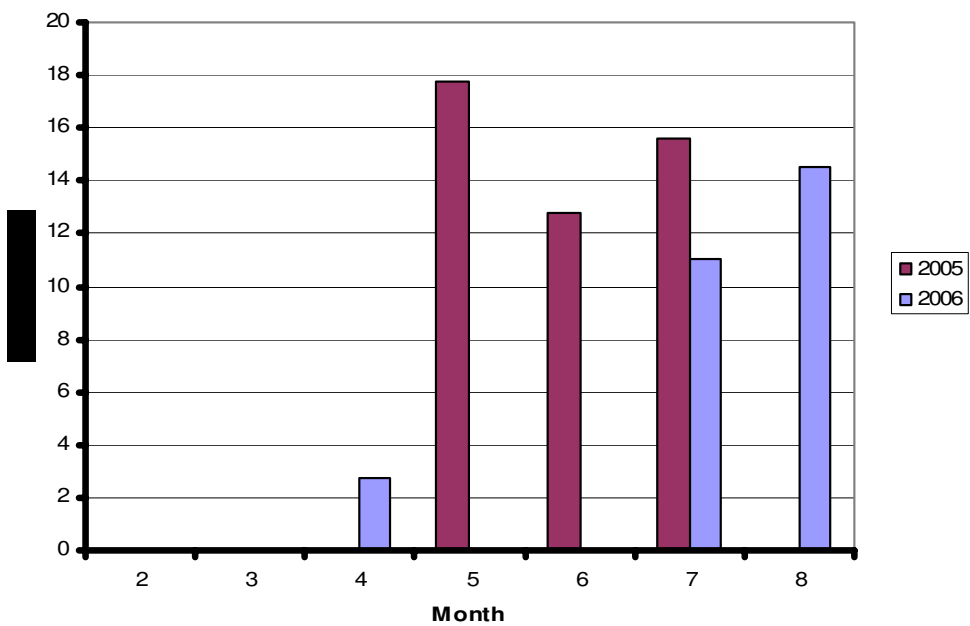
Wild Coho
Cultus Bay

Hatchery Coho
Cultus Bay
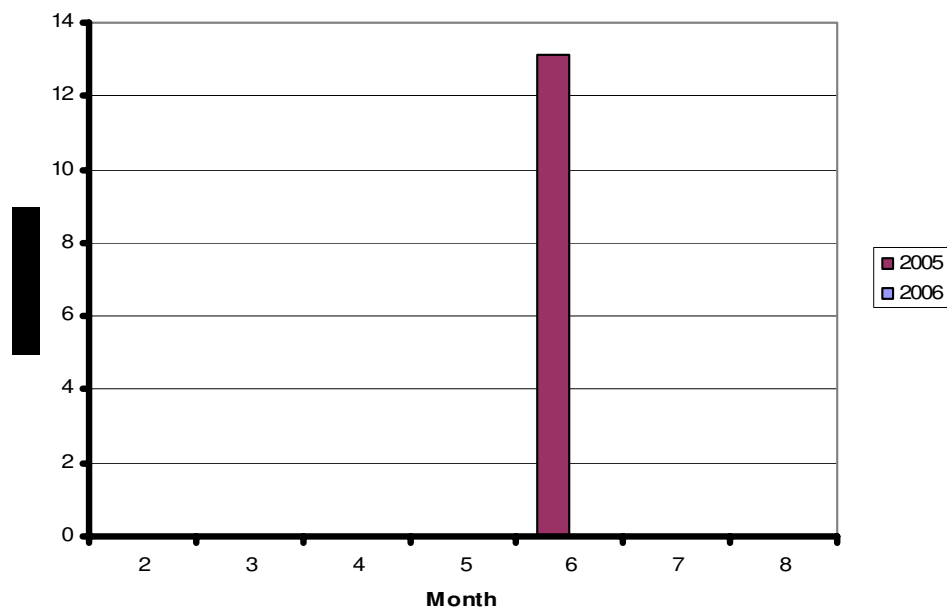
Total Juvenile Coho
Cultus Bay