JUVENILE SALMON AND NEARSHORE FISH USE IN SHALLOW INTERTIDAL HABITAT ASSOCIATED WITH HARRINGTON LAGOON, 2005

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Oblique aerial photo of Harrington Lagoon (from http://apps.ecy.wa.gov/shorephotos)

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TABLE OF CONTENTS

PURPOSE

Fish use studies of pocket estuaries in the Whidbey Basin started in 2002. At first, research was limited to understanding juvenile Chinook salmon use of sites within Skagit Bay (Beamer et al 2003). In 2004, study expanded to sites throughout the Whidbey Basin, Fidalgo Bay and Samish Bay via a cooperative effort that was partially funded by the Northwest Straits Commission[3]. The focus of the expanded research is to understand landscape scale patterns of fish usage including what species and life history types use these systems, how connectivity or position within the larger landscape affects fish use, and how patterns of fish use relate to protection and restoration of these systems. This expanded research effort has continued voluntarily in 2005 and included sampling in Harrington Lagoon with the help of Island County WSU Beach Watchers. The focus of this report is on fish abundance and size in Harrington Lagoon during 2005. Although we primarily report only fish abundance and size in this one system, we will also briefly consider results within the context of the larger Whidbey Basin study of pocket estuaries. The results of this study can be used to inform local citizens about fish populations currently using the Harrington Lagoon area. The results may also be useful to Island County, or other agencies and groups interested in Puget Sound salmon recovery or nearshore fish ecology.

STUDY AREA

Harrington Lagoon is located on the eastern shoreline of Whidbey Island, in Saratoga Passage (Figure 1). This approximately 8.5 acre longshore coastal lagoon is located behind the leeward side of a spit beach formed by accreting sediments that originate from bluff backed beaches south of the lagoon. Harrington Lagoon historically was connected to Saratoga Passage via an outlet channel located near its northwest end. Under contemporary conditions, the Harrington Lagoon outlet channel is located roughly along the middle of the lagoon's outer margin. The northwest end of the historic lagoon is mostly developed with homes and the old outlet channel is no longer present.

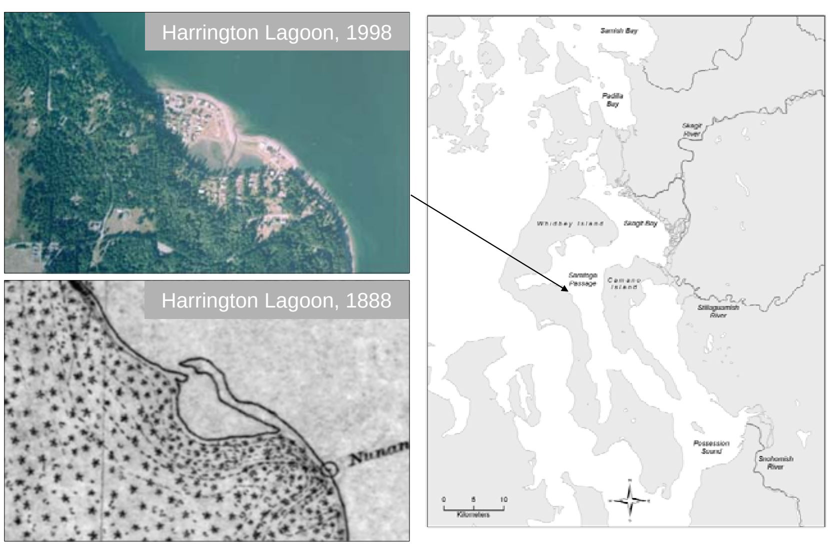


Figure 1. Location of Harrington Lagoon on the eastern Whidbey Island shoreline, along with contemporary (1998) and historic (1888) views of the site. The 1998 view is from an aerial photo, Washington Department of Natural Resources, Olympia, Washington. The 1888 view is from T-sheet # 2011 from the U.S. Coast and Geodetic Survey, available at the Puget Sound River History Project (http://riverhistory.ess.washington.edu).

[3] This effort included Skagit River System Cooperative, NOAA Northwest Fisheries Science Center, Stillaguamish Tribe, Tulalip Tribes, and Samish Nation. Results are reported in Beamer et al (2006).

METHODS

Nearshore areas like Harrington Lagoon and its vicinity can potentially have many different local-scale habitat types based on variations in water depth, aquatic vegetation, substrate, protection from wave energy, and freshwater inputs (creeks or seeps). We illustrate these differences using a conceptual nearshore beach cross-section that includes a lagoon impoundment behind a spit beach, similar to Harrington Lagoon (Figure 2). The different habitat types within this nearshore cross-section require different methods to effectively sample the fish community. Small beach seines can be used to sample for fish in shallow intertidal areas within the lagoon impoundment or along the outside of the spit beach (Figures 2A and 2B). Larger beach seines can sample the deeper habitat of the intertidal–subtidal fringe. Tow nets, or other non-shoreline-oriented gear, can be used to sample offshore areas. Fyke traps can be used to catch fish in tidal creeks or blind tidal channels that are often present along the margins of lagoon habitats. Photos of each method and their respective net dimensions are found within Skagit River System Cooperative (2003).

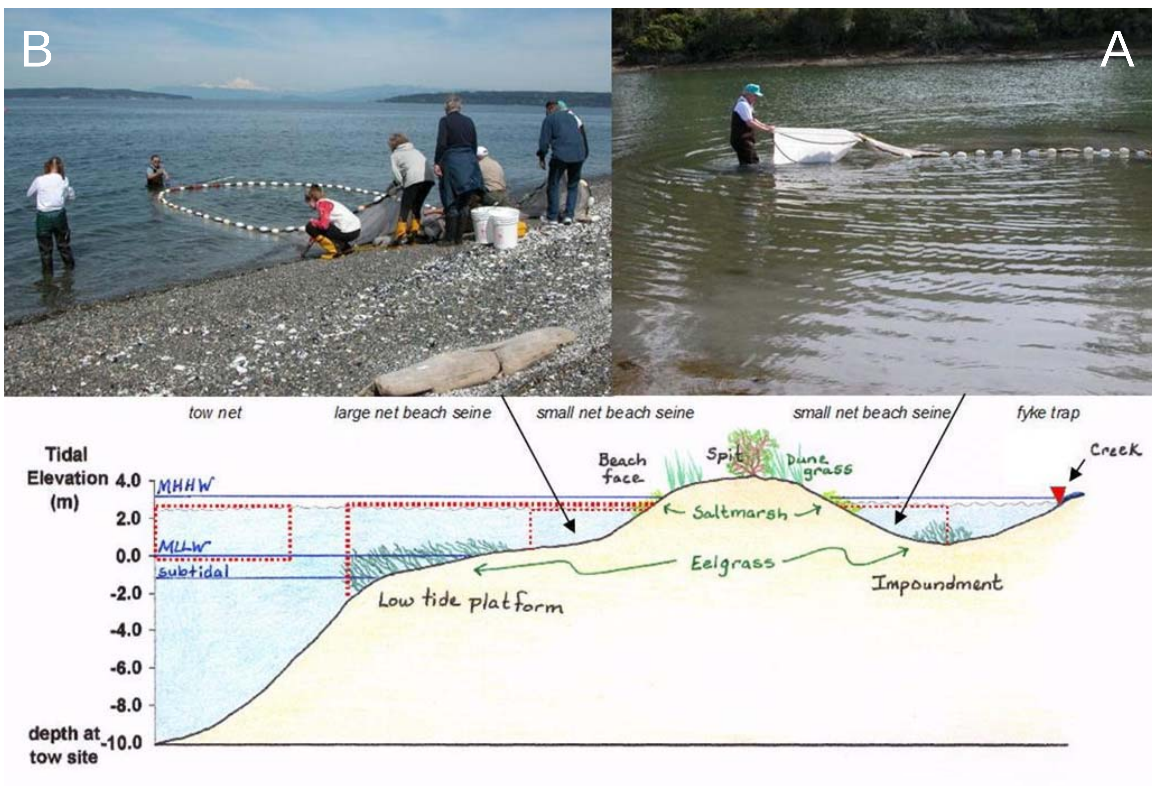


Figure 2. WSU Beach Watcher volunteers working with NOAA staff to beach seine sites at Harrington Lagoon. The diagram is a cross-sectional view of a nearshore beach that includes an impoundment similar to Harrington Lagoon. The red dotted lines illustrate the relative difference in depth, cross-sectional area of the water column, and position along the nearshore continuum that each gear type effectively samples. The different gear types are labeled directly above the red dotted lines. The two photos are of small net beach seine sets from (A) within Harrington Lagoon and (B) its adjacent shallow nearshore habitat. Harrington Lagoon does not have a creek flowing into the lagoon or blind tidal channels, therefore we do not use fyke trap methods at this site. This study did not sample any deeper nearshore or offshore habitat adjacent to Harrington Lagoon.

This study focused on only two of five habitat types shown in Figure 2 (briefly described above). We sampled monthly, February through June, using a small beach seine within Harrington Lagoon and its adjacent shallow intertidal nearshore habitat. The study did not sample the deeper intertidal-subtidal fringe habitats with larger beach seines or offshore habitat with tow nets. No tidal creeks or blind tidal channels are present within Harrington Lagoon, so use of fyke traps was not necessary.

The specific beach seine locations are shown in Figure 3. The areas seined are typically less than four feet deep (1.2 m), and have relatively homogeneous habitat features (water depth, velocity, substrate, and vegetation). Small net beach seine methodology uses an 80-foot (24.4 m) by 6-foot (1.8 m) by 1/8-inch (0.3 cm) mesh knotless nylon net. The net is set in "round haul" fashion by fixing one end of the net on the beach while the other end is deployed by wading "upstream" against the water current (if present), hauling the net in a floating tote (Figure 2A), and then returning to the shoreline in a half circle. Both ends of the net are then retrieved (Figure 2B), yielding a catch. One beach seine set was made at each site per sampling day. Average beach seine set area is 96 square meters.

For each beach seine set, we identified and counted the catch by species, and sub-sampled individual fish lengths by species. We also recorded the time and date of each beach seine set and measured several physical habitat parameters associated with each set, including:

- Tidal stage (ebb, flood, high, low)
- Substrate type defined as follows (based on Skagit River System Cooperative 2003):
    - Gravel - 75% of the surface is covered by clasts 4 to 64mm in diameter.
    - Mixed Coarse - No one size comprises > 75% of surface area. Cobbles and boulders are >6%.
    - Mixed Fines - Fine sand, silt, and clay comprise 75% of the surface area, with no one size class being dominant. May contain gravel (<15%). Cobbles and boulders make up <6%. Not difficult to walk on without sinking.
    - Mud - Silt and clay comprise 75% of the surface area. Often anaerobic, with high organic content. Tends to pool water on the surface and be difficult to walk on without sinking.
- Surface and bottom water temperature of the area seined using YSI meter.
- Surface and bottom salinity of the area seined using YSI meter.
- Maximum depth of area seined

Beach seine sites were selected both within Harrington Lagoon and its adjacent nearshore (Figure 3). The sampling sites were selected to compare the fish community, including juvenile salmon, within the lagoon and outside the lagoon, in its adjacent nearshore habitat. In this report results (fish or environment related) are summarized as monthly averages (means) or frequency distributions for the combined sites within the lagoon or sites within the nearshore habitat adjacent to the lagoon.

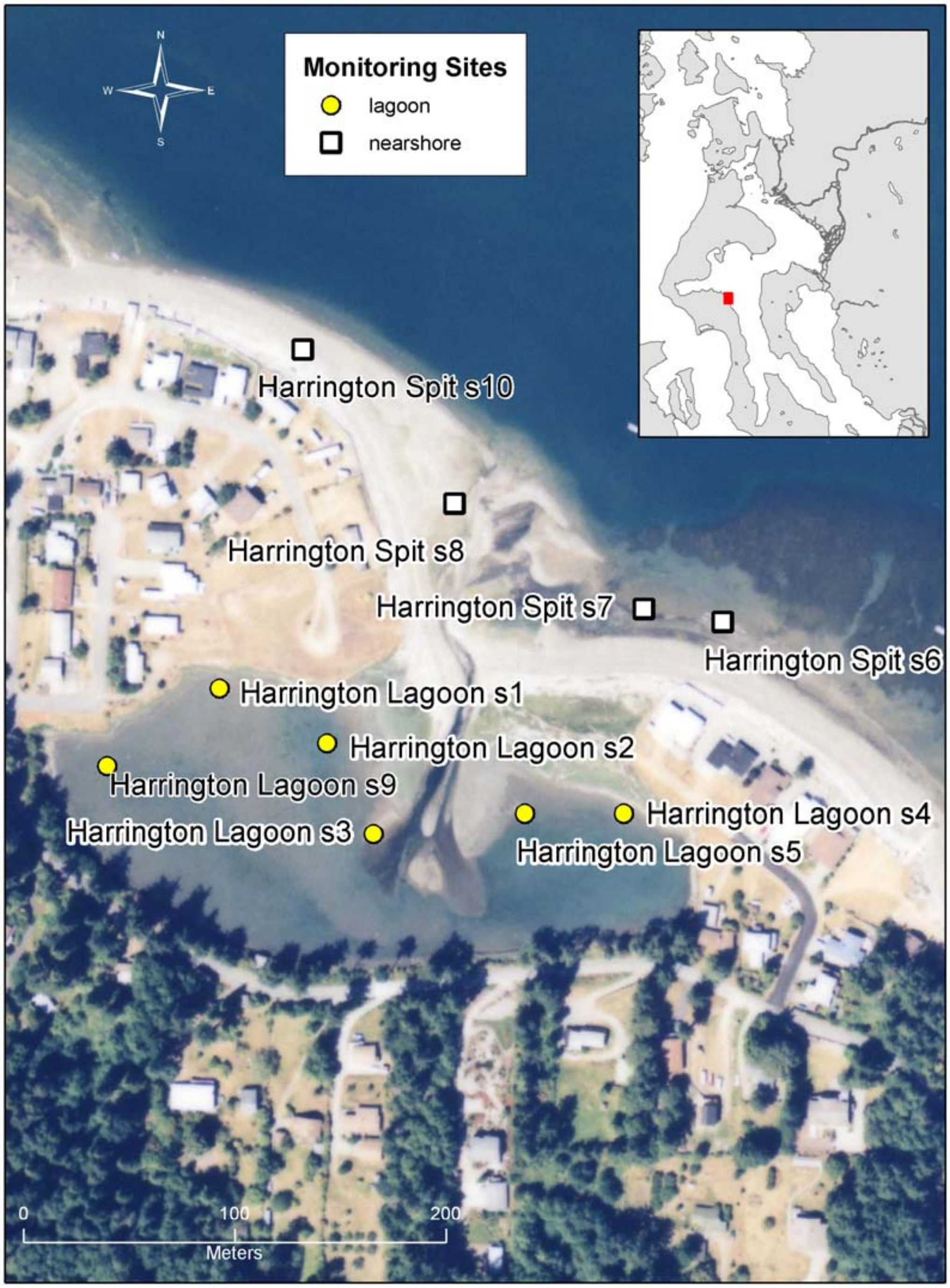


Figure 3. Location of beach seine sites at Harrington Lagoon, 2005. Yellow circles represent sites within Harrington Lagoon. White squares represent sites in the adjacent nearshore. The photo was taken at extreme low tide. Beach seining was always done at the water's edge, independent of tidal stage.

Results and Discussion

Beach Seine Effort

The Harrington Lagoon sampling effort in 2005 consisted of 77 beach seine sets made during the February through June time period (Table 1). Beach seine effort within the lagoon was approximately 50% greater than the effort in adjacent shallow nearshore based on the number of sites sampled in the lagoon each sampling trip.

Table 1. Summary of beach seine sampling effort at Harrington Lagoon sites in 2005.

A - Sampling effort (number of beach seine sets)		
Month	Adjacent nearshore	Lagoon
February	7	10
March	8	12
April	8	12
May	4	6
June	4	6
Total	31	46

Environmental Conditions During Beach Seine Sampling

Tidal Stage, Water Depth, and Substrate

The majority of beach seine sampling occurred on flooding (rising) tides (Table 2A) at depths slightly shallower than one meter of water (Table 2B). The beach seined area at lagoon sites was over finer grained substrate (mixed fines and mud) than adjacent nearshore sites, which consisted mostly of gravel (Table 2C).

Table 2. Summary of tidal stage, water depth, and substrate conditions during the time of beach seine sampling at Harrington Lagoon sites in 2005.

A - Percentage of beach seine sets by tidal stage		
Tidal Stage	Adjacent nearshore	Lagoon
Ebb	0.0%	8.7%
Flood	87.1%	80.4%
High	0.0%	4.3%
Low	12.9%	6.5%
B - Maximum depth of area beach seined		
	Adjacent nearshore	Lagoon
Average and 1 standard deviation (in parentheses)	0.93 (0.30) meters	0.81 (0.24) meters
C - Percentage of beach seine sets by substrate type		
Substrate Type	Adjacent nearshore	Lagoon
Gravel	90.3%	0.0%
Mixed Coarse	9.7%	2.8%
Mixed Fines	0.0%	55.6%
Mud	0.0%	41.7%

The difference substrate reflects differences in wave energy between the lagoon and its adjacent nearshore. The lagoon is more protected from waves so finer grained sediments are retained in the lagoon whereas higher wave energy transports the finer grained sediment off the beach face of the adjacent nearshore beach, leaving coarser grained substrate.

Temperature and Salinity

Monthly patterns of surface salinity and surface water temperature in Harrington Lagoon and its adjacent nearshore are shown in Figures 4A and 4B. Skagit River flow, which accounts for the majority of freshwater entering the Whidbey Basin, is shown in Figure 4C. The salinity and temperature measurements are spot measures taken during the time of beach seining and are not a continuously measured record.

We find little evidence that Harrington Lagoon salinity is consistently different (higher or lower) than salinity in the adjacent shallow nearshore. However, higher Skagit River flows are correlated with lower salinities at the Harrington sites (compare Figure 4A with Figure 4C). Since Skagit River flow is the dominant freshwater source entering the Whidbey Basin, we hypothesize that the monthly pattern of salinity for the Harrington Lagoon area varies as a function of overall Whidbey Basin salinity, which is strongly influenced by the major rivers flowing into the Whidbey Basin. These results might be expected for a site like Harrington Lagoon where no direct surface freshwater input from the adjacent watershed is present. Salinity patterns at Harrington Lagoon are also likely driven by local evaporation rates within Harrington Lagoon during low tide cycles. More frequent salinity monitoring might reveal differences in salinity between the lagoon and adjacent nearshore habitat due to this factor.

Water temperature within the lagoon and adjacent nearshore show a seasonal increase from February through May (Figure 4B). Temperature results for June are lower than May, which is likely related to different weather conditions on the days when sampling occurred rather than a true seasonal pattern. Starting in March, the lagoon surface water was warmer than the surface water in the adjacent nearshore by 1 to 3 degrees C. We would expect warmer water in the lagoon during spring and summer months than in adjacent nearshore because the lagoon is much shallower the adjacent water body of Saratoga Passage. The lagoon is also tidally disconnected from Saratoga Passage on a daily basis. Harrington lagoon water temperature will respond quicker and more dramatically to seasonal increases (or decreases) in air temperature and solar radiation.

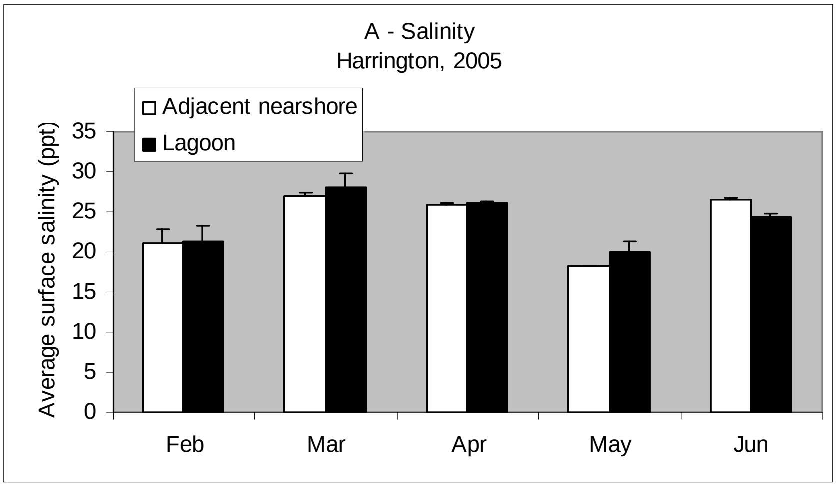


Figure 4A. Monthly average salinity at Harrington Lagoon taken at the beach seine sites during the time of beach seining. White bars are results for the shallow nearshore adjacent to the lagoon. Black bars are results for habitat within the lagoon. Error bars are one standard deviation.

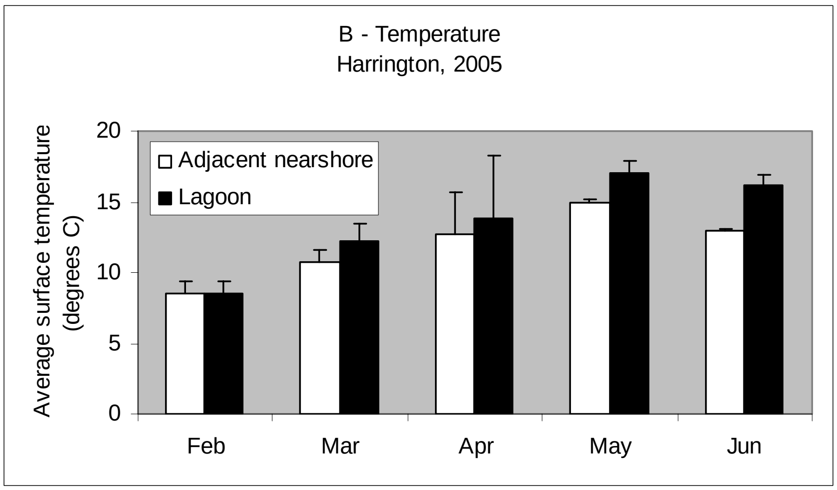


Figure 4B. Monthly average temperature at Harrington Lagoon taken at the beach seine sites during the time of beach seining. White bars are results for the shallow nearshore adjacent to the lagoon. Black bars are results for habitat within the lagoon. Error bars are one standard deviation.

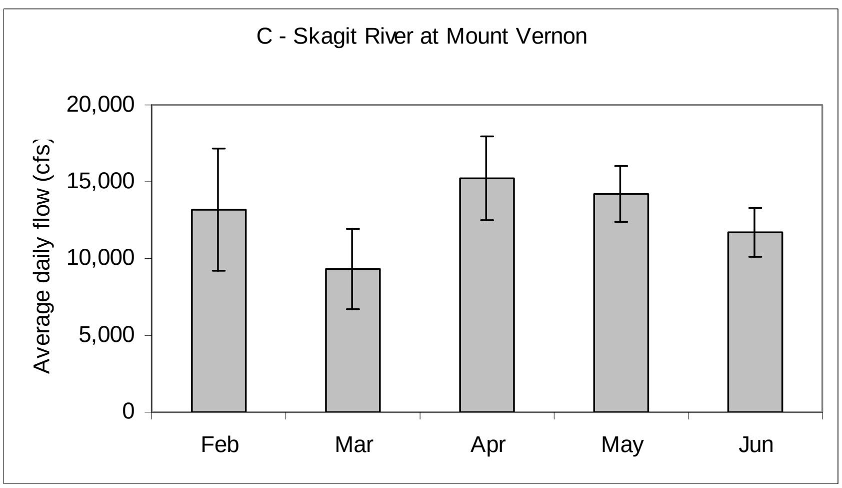


Figure 4C. Monthly flow of the Skagit River at Mount Vernon. Error bars are one standard deviation.

Catch by Species

We caught over 4,500 fish representing at least 14 different species during the sampling period February through June, 2005 (Table 3). Juvenile salmon represented about 34% of the total catch. The juvenile salmon catch was dominated by subyearling chum and Chinook, but subyearling pinks and yearling coho salmon were also caught. Juvenile pink salmon in 2005 were the progeny of even-year spawning adults, which are not common in Puget Sound. Few yearling coho salmon were caught likely because they do not readily occupy shallow intertidal habitats due to their larger size and later timing. We discuss juvenile Chinook and chum salmon later in this report.

Sculpins, primarily Pacific staghorns, accounted for 24% of the total catch. Based on catch per unit effort (CPUE) calculated as fish per beach seine set, sculpins were nearly six times more abundant in the lagoon than in the adjacent shallow nearshore habitat. Flatfish, primarily starry flounder, were not dominant in our catches (accounting for less than 2% of the total catch), but were caught only in the lagoon. Shiner perch accounted for 20% of the total catch. Based on CPUE, shiner perch were nearly five times more abundant in the lagoon than in the adjacent shallow nearshore habitat. Threespine stickleback accounted for 10% of the total catch. Based on CPUE, sticklebacks were over 10 times more abundant in the lagoon than in the adjacent shallow nearshore habitat. Snake pricklebacks were not common (accounting for less than 2% of the total catch), but were caught only in the lagoon. Arrow goby accounted for 8% of the total catch. Based on CPUE, goby were nearly 19 times more abundant in the lagoon than in the adjacent shallow nearshore habitat.

Table 3. Total fish catch (and mean catch per beach seine set in parentheses) by fish species at Harrington sites in 2005.

Fish species	**Adjacent nearshore**	**Lagoon**
Juvenile salmon:		
Chum salmon, subyearling (*Oncorynchus keta*)	706 (22.8)	663 (14.4)
Chinook salmon, unmarked subyearling (*Oncorynchus tshawytscha*)	10 (0.3)	134 (2.9)
Pink salmon, subyearling (*Oncorynchus gorbuscha*)	14 (0.5)	15 (0.3)
Coho salmon, unmarked yearling (*Oncorynchus kisutch*)	3 (0.1)	0 (0.0)
Total juvenile salmon	733 (23.6)	812 (17.7)
Sculpin species:		
Pacific staghorn sculpin (*Leptocottus armatus*)	102 (3.3)	738 (16.0)
Buffalo sculpin (*Enophrys bison*)	3 (0.1)	0 (0.0)
Unidentified sculpin	16 (0.5)	245 (5.3)
Total sculpins	121 (3.9)	983 (21.4)
Flatfish species:		
Starry flounder (*Platichtys stellatus*)	0 (0.0)	54 (1.2)
English sole (*Parophrys vetulus*)	0 (0.0)	1 (0.0)
Unidentified flatfish	0 (0.0)	14 (0.3)
Total flatfish	0 (0.0)	69 (1.5)
Forage fish species:		
Surf smelt (*Hypomesus pretiosis*)	0 (0.0)	7 (0.2)
Other nearshore or estuarine fish species:		
Shiner perch (*Cymatogaster aggregate*)	114 (3.7)	804 (17.5)
Threespine stickleback (*Gasterosteus aculeatus*)	29 (0.9)	419 (9.1)
Snake prickleback (*Lumpenus sagitta*)	0 (0.0)	81 (1.8)
Bay pipefish (*Syngnathus griseolineatus*)	1 (0.0)	1 (0.0)
Arrow goby (*Clevelandia ios*)	11 (0.4)	347 (7.5)
Total catch	1,009 (32.5)	3,523 (76.6)

Juvenile Chinook

In this section we discuss the timing, abundance, and size of juvenile Chinook salmon in Harrington Lagoon and its adjacent shallow nearshore habitat.

Timing and Abundance

Juvenile Chinook salmon were present in either the lagoon or its adjacent shallow nearshore habitat during the entire sampling period (February through June). However, juvenile Chinook salmon were more abundant, based on CPUE results, in Harrington Lagoon habitat than in adjacent shallow nearshore in February and March of 2005. The timing curve and abundance pattern of juvenile Chinook salmon in Figure 5 is typical of lagoons nearer the Skagit River (Beamer et al 2003). While the juvenile Chinook salmon period is somewhat abbreviated (i.e., does not extend through April and into May like we have seen in other years for lagoons in Skagit Bay), it does coincide with the period when we would expect migrating Chinook salmon fry to be present in Saratoga Passage. Harrington Lagoon is over 18 kilometers from the mouth of the Skagit River (the nearest Chinook salmon river), and these results demonstrate that juvenile Chinook salmon use Harrington Lagoon habitat early in the year.

This study did not sample the deeper intertidal-subtidal fringe or offshore habitats adjacent to Harrington Lagoon. Therefore, we should not infer that the decline of juvenile Chinook salmon in the lagoon after March and the low Chinook salmon catches throughout the sampling period in adjacent shallow nearshore represents the pattern of juvenile Chinook salmon use in deeper or more offshore habitats adjacent to Harrington Lagoon. Rather, it is more likely that larger and older juvenile Chinook salmon are present in the deeper, more offshore habitats, following the pattern observed at similar sites where juvenile Chinook salmon transition from shallow to deeper habitats as they become larger later in the year (Beamer et al 2003).

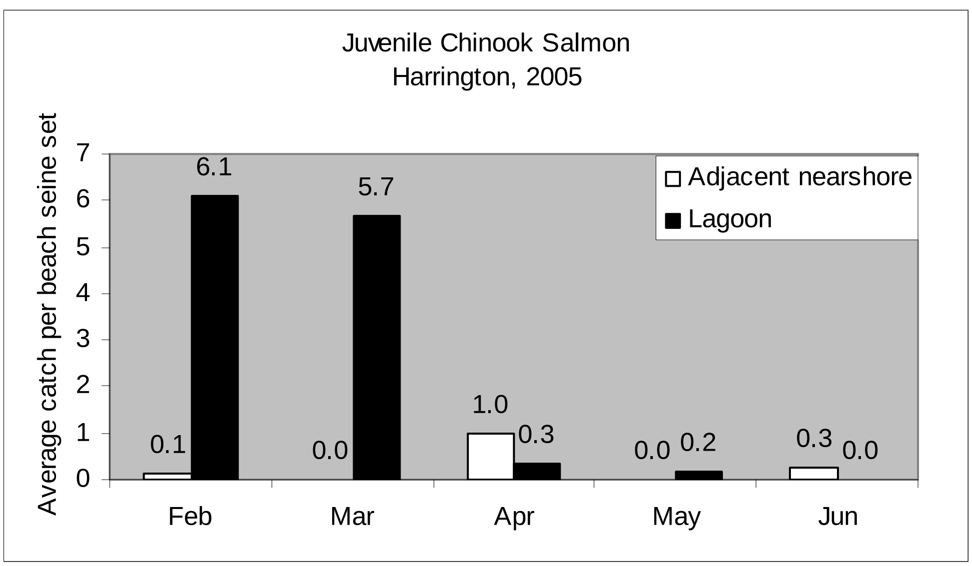


Figure 5. Average juvenile Chinook salmon CPUE for Harrington Lagoon and its adjacent nearshore habitat, 2005. All juvenile Chinook salmon captured were unmarked. Average CPUE values are shown above bar.

Fish Size

The size of Chinook salmon was characterized by measuring fork length on 71 of the 144 juvenile Chinook salmon caught at the Harrington Lagoon sites (Table 4, Figure 6). Only one fish was large enough to be considered a yearling Chinook salmon. It measured 108 mm fork length and was caught in adjacent nearshore habitat in April. All remaining juvenile Chinook salmon were subyearling sized.

Table 4. Number of juvenile Chinook salmon fork length samples collected at Harrington Lagoon sites, 2005.

Month	Adjacent nearshore	Lagoon
February	1	24
March	0	32
April	8	4
May	0	1
June	1	0
Total	10	61

We caught too few juvenile Chinook salmon in the shallow nearshore habitat adjacent to Harrington Lagoon to compare size to that of fish using the lagoon. However, there are sufficient numbers of juvenile Chinook salmon length samples from the lagoon sites in February and March to reasonably characterize the size of juvenile Chinook salmon using the lagoon during these months.

Juvenile Chinook salmon caught in Harrington Lagoon in February 2005 ranged from 39 to 55 mm fork length with a median length of 47 mm (Figure 6A). In March 2005, juvenile Chinook salmon caught in Harrington Lagoon ranged from 39 to 77 mm and their median fork length increased to 55 mm (Figure 6B). Length frequency results from both months are normally distributed.

The pattern of increasing fish size between February and March did not continue into April or May (Figure 6). While few juvenile Chinook were caught after March (Figure 5), those that were caught in both the lagoon and its adjacent shallow nearshore were typically much smaller than the median size of juvenile Chinook caught in March. The fish captured after March appear to be from a different group of fish than those caught in the lagoon in February and March. This suggests that at least two different groups of juvenile Chinook salmon used the Harrington Lagoon area during 2005. The earlier group used the lagoon more extensively than the later group. The later group might have been much smaller in numbers. However, it is also possible that water temperatures in April (primarily late April) began to exceed the thermal tolerance or preference of juvenile Chinook salmon (Figure 4B). Early April water temperatures (measured on April 4th) were similar to those measured in March (ranging from 9.2 to 10.2 degrees C) while late April water temperatures (measured on April 20th) were very high (ranging from 15.3 – 19.4 degrees C).

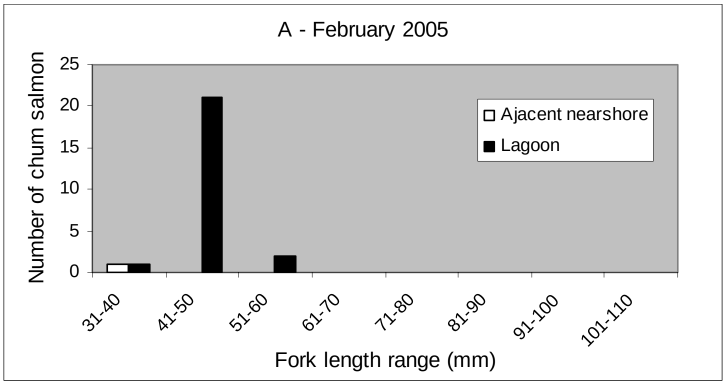


Figure 6A. Fork length frequency distribution of juvenile Chinook salmon captured at Harrington Lagoon sites in February, 2005.

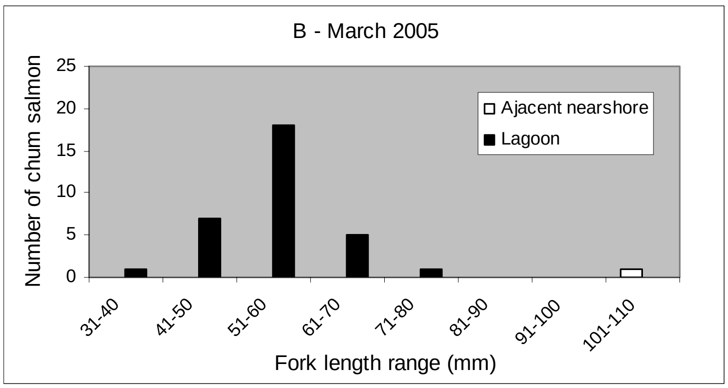


Figure 6B. Fork length frequency distribution of juvenile Chinook salmon captured at Harrington Lagoon sites in March, 2005.

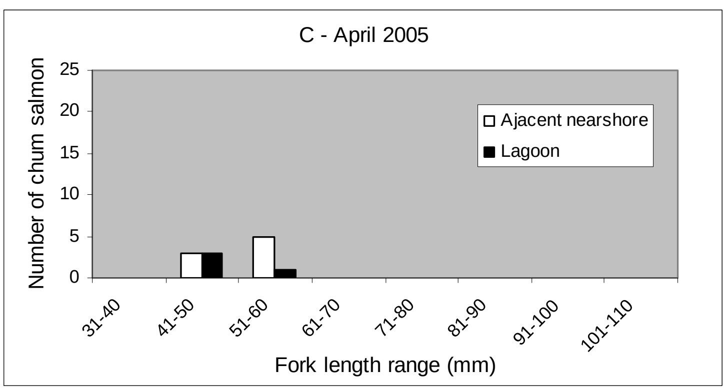


Figure 6C. Fork length frequency distribution of juvenile Chinook salmon captured at Harrington Lagoon sites in April, 2005.

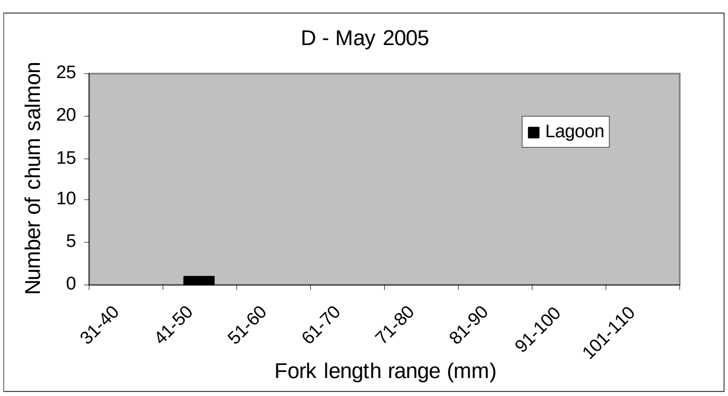


Figure 6D. Fork length frequency distribution of juvenile Chinook salmon captured at Harrington Lagoon sites in May, 2005.

Juvenile Chum

In this section we discuss the timing, abundance, and size of juvenile chum salmon in Harrington Lagoon and its adjacent shallow nearshore habitat.

Timing and Abundance

Juvenile chum salmon were present in either the lagoon or its adjacent shallow nearshore habitat over the majority of the sampling period (Figure 7). Juvenile chum salmon were caught in Harrington Lagoon habitat and not in its adjacent shallow nearshore habitat during February and March. Chum salmon abundance was low during this time. Peak chum salmon abundance in the lagoon and its adjacent shallow nearshore habitat occurred in April. During April, based on CPUE results, chum salmon abundance in shallow nearshore habitat was nearly double the chum abundance found in Harrington Lagoon. Chum salmon abundance declined in May for both habitats. June was the only month that juvenile chum salmon were not caught.

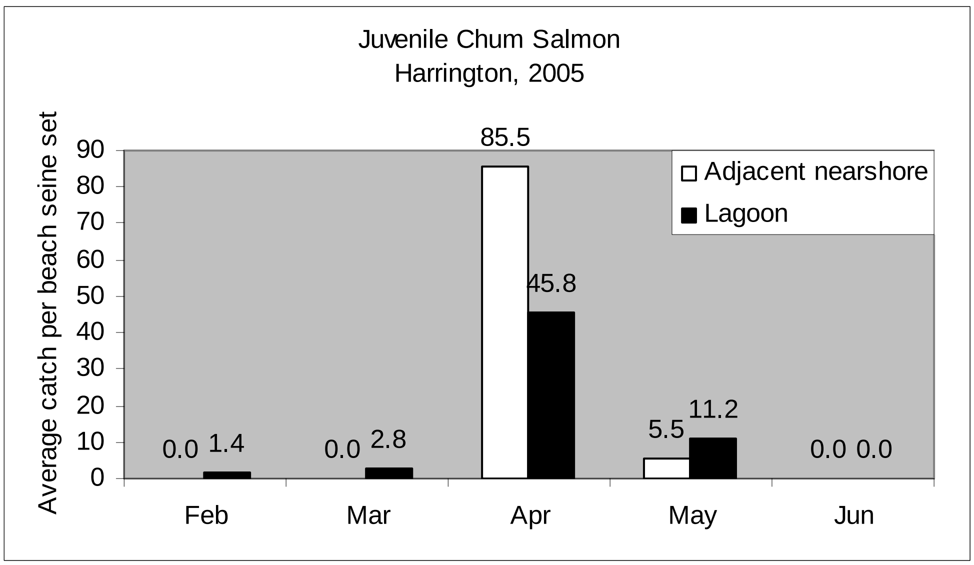


Figure 7. Average juvenile chum salmon CPUE for Harrington Lagoon and its adjacent nearshore habitat, 2005. Average CPUE values are shown above bar.

Fish Size

The size of chum salmon was characterized by measuring fork length on 299 of the 1369 juvenile chum salmon caught at the Harrington Lagoon sites (Table 5, Figure 8).

Table 5. Number of juvenile chum salmon fork length samples collected at Harrington Lagoon sites, 2005.

Month	Adjacent nearshore	Lagoon
February	0	14
March	0	32
April	127	71
May	22	33
June	0	0
Total	149	150

In February and March of 2005 juvenile chum salmon were caught only at lagoon sites (Figure 7, 8A, and 8B). They ranged from 37 to 48 mm fork length with a median length of 44 mm. In March, juvenile chum salmon ranged from 38 to 65 mm with a median fork length of 45 mm. Length frequency results for chum salmon caught in February are normally distributed, but the length distribution for fish caught in March is skewed toward a higher percentage of larger fish.

In April and May of 2005 juvenile chum salmon were caught in both lagoon and adjacent shallow nearshore sites (Figure 7, 8C, and 8D). In April, juvenile chum salmon caught at lagoon sites ranged from 34 to 60 mm fork length with a median length of 42 mm while chum caught at adjacent nearshore sites ranged from 32 to 99 mm fork length with a median length of 42 mm. In May, juvenile chum salmon caught at lagoon sites ranged from 35 to 60 mm fork length with a median length of 48 mm while chum caught at adjacent nearshore sites ranged from 42 to 60 mm fork length with a median length of 52 mm.

The monthly chum salmon length results suggests there were at least two different groups of juvenile chum salmon using the Harrington Lagoon area during February through May of 2005. However, it is likely that more than two groups used the area, or that there was significant overlap in use by two groups. One group of juvenile chum salmon was caught only in the lagoon during February and March. The second group was caught in April and May in both lagoon and adjacent shallow nearshore habitats. The length frequency distributions of both groups increased over their respective two-month periods, inferring that chum salmon were growing during their time in the Harrington area. There was little difference in the size distribution of chum salmon using lagoon or its adjacent shallow nearshore habitat for the second group.

Over a three-month period (March, April, and May) we observed that the largest chum salmon reached, but never exceeded, the 60 – 65 mm range in Harrington Lagoon. The same pattern was observed for chum caught in adjacent shallow nearshore habitat, except for two much larger individuals caught in April (measuring 97 and 99 mm fork length). This may indicate that juvenile chum outgrow lagoon and shallow nearshore habitat after they reach the 60 – 65 mm fork length range. Also, there was always a fraction of the chum catch that was very small-sized (40 mm fork length or less) over the February through May period, indicating that new chum salmon were arriving at the Harrington Lagoon area during each of these four months.

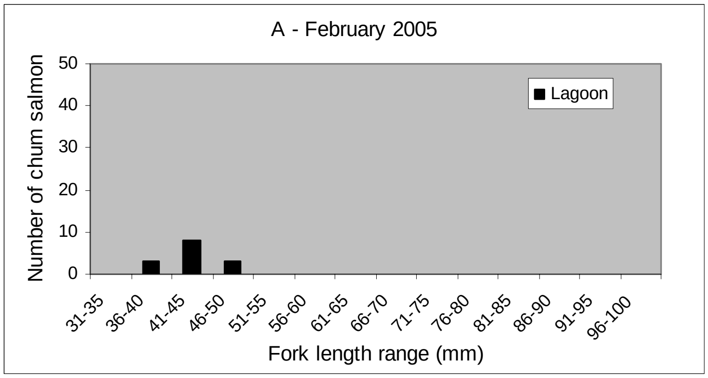


Figure 8A. Fork length frequency distribution of juvenile chum salmon captured at Harrington Lagoon sites in February, 2005.

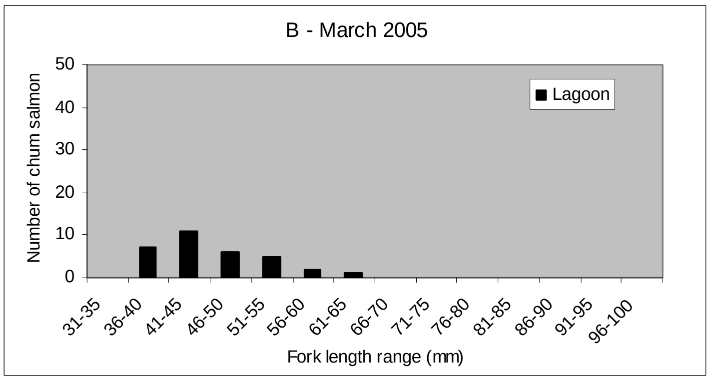


Figure 8B. Fork length frequency distribution of juvenile chum salmon captured at Harrington Lagoon sites in March, 2005.

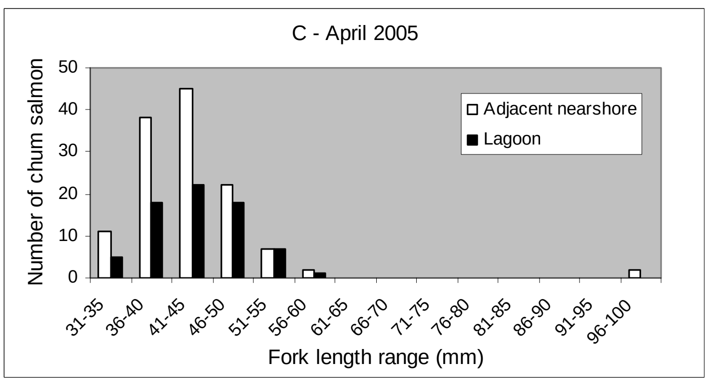


Figure 8C. Fork length frequency distribution of juvenile chum salmon captured at Harrington Lagoon sites in April, 2005.

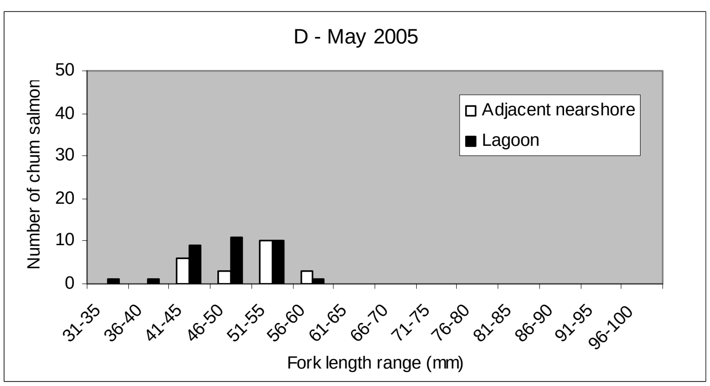


Figure 8D. Fork length frequency distribution of juvenile chum salmon captured at Harrington Lagoon sites in May, 2005.

Fish Community Composition

This section describes the fish community composition over the February through June sampling period in 2005 for Harrington Lagoon sites and its adjacent shallow nearshore habitat. We selected seven fish species, or species groups, that are either common nearshore fish species in Puget Sound or were common in the catch at the Harrington sites. The seven species (or species groups) are: juvenile salmon, Shiner perch, sculpins, flatfish, Arrow goby, Threespine stickleback, and Surf smelt (Figure 9). The fish shown in Figure 9 represent 98% of the total catch.

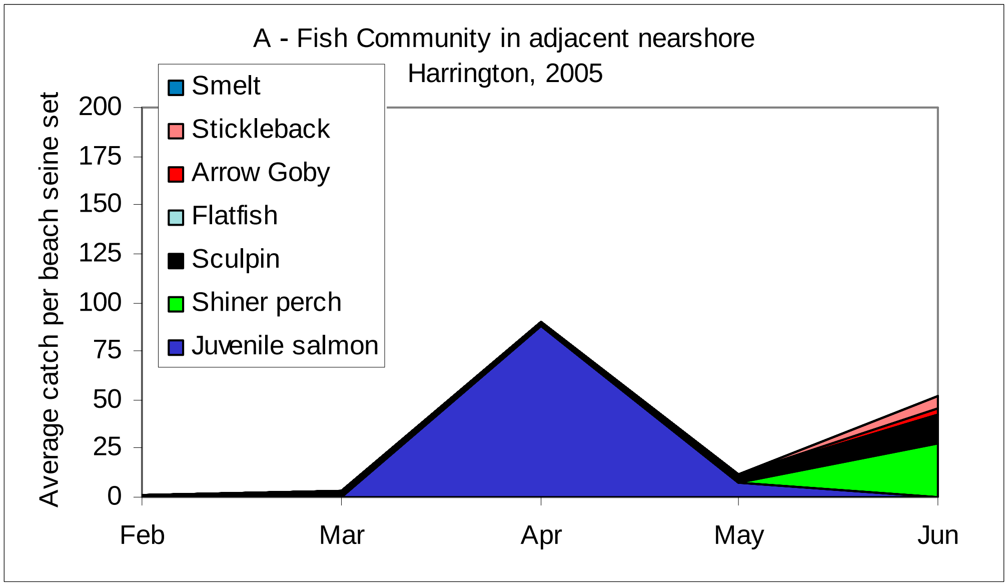
The shallow nearshore habitat adjacent to Harrington Lagoon had its lowest overall fish density in February and its peak in April. The peak fish density was driven primarily by juvenile chum salmon (Figures 7 and 9A). These sites had their highest species diversity in June when Shiner perch and a few stickleback and Arrow goby were caught.

Harrington Lagoon habitat had its lowest overall fish density in February, but it was still 23 times higher than adjacent nearshore habitat (Figure 9B). Its highest overall fish density was in June when Shiner perch and Arrow goby density increased. Peak fish density in lagoon habitat was 3.5 times higher than the fish density in adjacent shallow nearshore habitat at the same time. In April, overall fish density was very similar between the lagoon and adjacent nearshore sites. Species diversity was higher in lagoon habitat than adjacent shallow nearshore throughout the February through June sampling period.

Figure 9 illustrates a "changing of the guard" picture of the nearshore fish community for shallow nearshore areas and coastal lagoons in the Whidbey Basin. At some time during spring to early summer, a juvenile salmon-dominated fish community gives way to a Shiner perch-dominated community, possibly related to seasonally increasing water temperatures and the increasing size of juvenile salmon as they presumably "outgrow" shallow habitat. Shiner perch, a marine and estuarine species found throughout the Puget Sound region, show up in large schools in shallow nearshore areas in late spring or early summer for birthing where they stay through summer and early fall months before retreating to deeper marine waters during winter months. Other species, such as Arrow goby, seem to be associated with protected lagoon or soft substrate habitats. Pacific staghorn sculpin are generally a constant in the shallow nearshore environment, especially in finer grained substrate areas like those present in Harrington Lagoon.

The lack of Surf smelt in the Harrington results stands out when compared to other sites studied in Skagit Bay or other parts of the Whidbey Basin. Beamer et al. (2006) reported Surf smelt were a common part of the fish community within lagoon and adjacent shallow nearshore habitat at eight of nine sites sampled on a monthly basis in 2004. The 2004 study used the same beach seine methods as this study and sampled at a similar frequency and time of year. The 2004 study sites included four sites in Skagit Bay and one site each in Port Susan, Penn Cove, Saratoga Passage, Possession Sound, and Samish Bay. In the 2004 study, the Skagit Bay and Penn Cove sites were sampled longer than the February through June time period sampled for this Harrington study. Surf smelt were common both early in the year and again in fall months at the Skagit Bay and Penn Cove sites, so it is possible that surf smelt were using the Harrington Lagoon area after beach seining ended in June of 2005.

Elger Bay was the one site (of the nine sampled on a monthly basis in the 2004 study) that did not consistently have Surf smelt in either its lagoon or adjacent shallow nearshore beach seine catches (Beamer et al. 2006). Like Harrington Lagoon, Elger Bay is located in Saratoga Passage, but it is along the Camano Island shoreline rather than the Whidbey Island shoreline. Harrington and Race Lagoons along with their adjacent shallow nearshore habitat were also beach seined on April 14, 2004. No Surf smelt were caught in this effort either (Beamer et al 2006). However, Penttila (1999) documented Surf smelt spawning beaches nearby or adjacent to all three coastal lagoon systems (Harrington, Race, and Elger). Monitoring Harrington Lagoon in future years, and possibly over a longer time period, will help determine whether the lack of Surf smelt in 2005 is a consistent annual pattern.



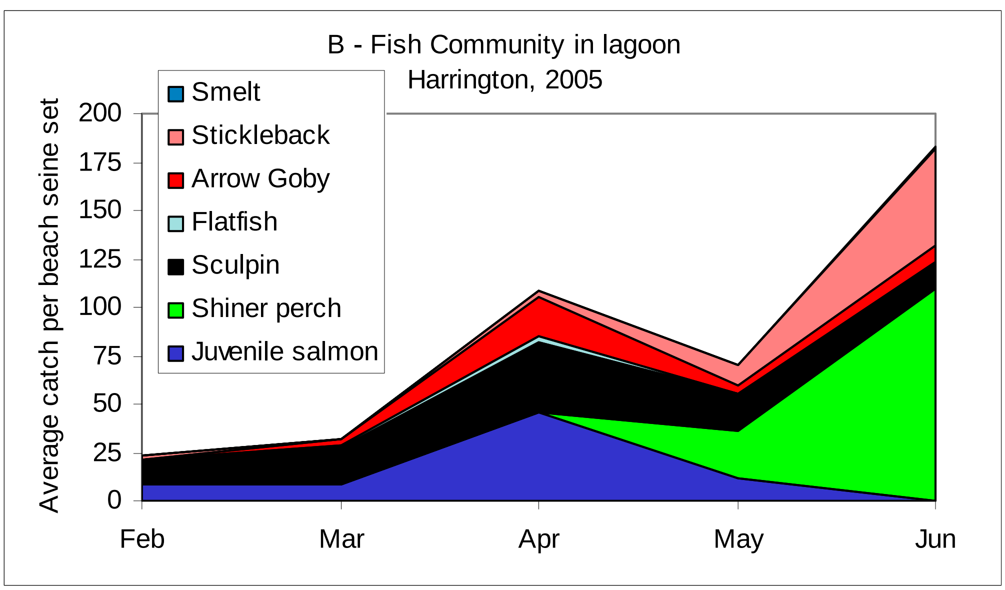


Figure 9. Monthly average fish community composition and abundance for (A) adjacent shallow nearshore habitat and (B) Harrington Lagoon, 2005. Results are the average fish catch per beach seine set of seven possible species or specie groups displayed using a filled line graph where the catch per set of individual species and the total fish community are visible. In Harrington Lagoon (Figure A), for example, we caught an average of 109 total fish per beach seine set in April, where 46 were juvenile salmon, 36 were sculpins, 20 were Arrow goby, and the remaining 7 fish were minor amounts flatfish and stickleback (46+36+20+7=109).

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