JUVENILE SALMON AND NEARSHORE FISH USE IN SHALLOW INTERTIDAL HABITAT ASSOCIATED WITH RACE LAGOON, 2006 AND 2007

November 2007

Rich Henderson[1]
Anna Kagley[2]
Kurt Fresh[2]
Eric Beamer[1]
Aundrea McBride[1]
Karen Wolf[1]

2006 oblique aerial photo of Race Lagoon (courtesy WA Department of Ecology)

[1] Skagit River System Cooperative, 11426 Moorage Way, P.O. Box 368, LaConner, WA 98257; rhenderson@skagitcoop.org
[2] NOAA Fisheries, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112

ACKNOWLEDGEMENTS

The authors wish to thank the following people and organizations for their help with this study:

- Island County Washington State University (WSU) Beach Watchers for help with data collection: Bob Buck, Bill Pigott, Marty Crowley, Ken Urstad, Jim Somers, Joani Boose, Tom Albrecht, Finn Gatewood, Graham Johnson, Jill Hein, Melissa Merickel, Monem Mahmoud Abdel, Joe Beck, Stewart Congdon, and Toni Piazzon
- Skagit River System Cooperative staff: Bruce Brown for data entry
- Island County Marine Resources Committee for help with coordination and buying limited supplies in support of WSU Beach Watcher volunteers

TABLE OF CONTENTS

PURPOSE

This report on Race Lagoon is one in a series of reports on fish use of pocket estuary habitats in Whidbey Basin. The Skagit River System Cooperative (SRSC) began sampling fish use of pocket estuaries within Whidbey Basin in 2002. Initially this research focused on understanding juvenile Chinook salmon use of nearshore habitats within Skagit Bay (Beamer et al. 2003). Based upon the results of Skagit Bay research, in 2004 research expanded to include pocket estuary sites throughout 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 was to understand landscape-scale patterns of fish habitat usage, including: what species and life history types use pocket estuaries; how connectivity or position within the larger landscape affects fish use; and how patterns of fish use inform protection and restoration of these systems.

Race Lagoon was sampled once per year in 2004 and 2005 as part of a geographically extensive sampling effort to determine presence or absence of juvenile salmon. Sampling at Race Lagoon was expanded to twice per month in 2006 with the help of Island County WSU Beach Watchers and NOAA Fisheries staff. The more intensive sampling is intended to answer questions about fish habitat use over time.

This report focuses on fish abundance and size in Race Lagoon during 2006 and 2007. The results of this study can be used to inform local citizens about fish populations currently using the Race 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

Race Lagoon is located on the eastern shoreline of Whidbey Island, in Saratoga Passage (Figure 1). The approximately 11.2 hectare drowned channel lagoon was created by the formation of a spit across a stream valley embayment. Accreting sediments on the spit beach originate from bluff-backed beaches south of the lagoon. Race Lagoon receives some freshwater from a small stream at its southwest corner. The stream channel is inundated by tides for approximately the lowest 60 meters of the stream channel. The exit channel of the lagoon runs parallel to the spit for approximately 500 meters before entering Saratoga Passage. Though the margins of Race Lagoon are lined with homes, the lagoon's geomorphology is minimally impacted compared to pre-settlement conditions (Figure 1).

---

[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).

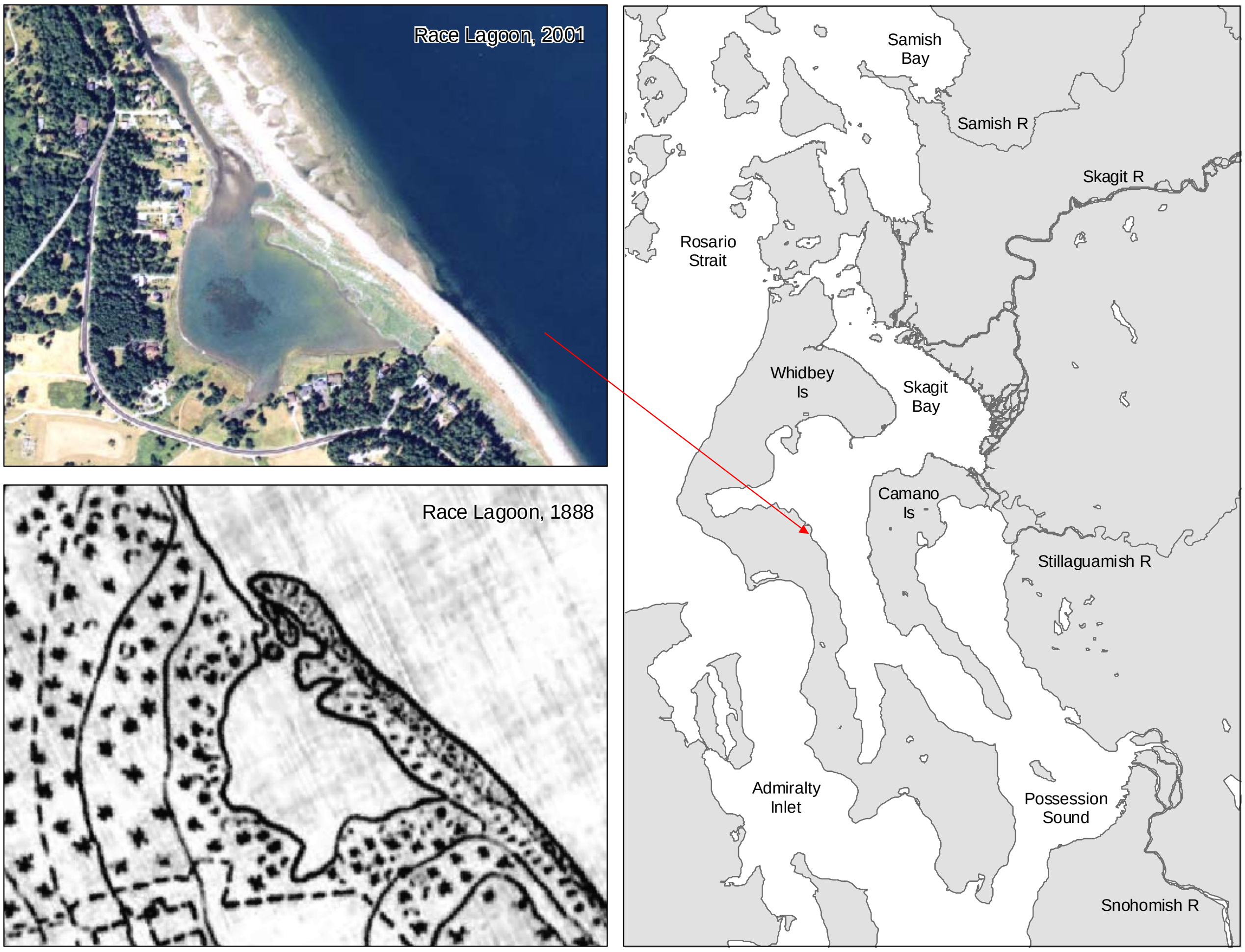

Figure 1. Location of Race Lagoon on the eastern Whidbey Island shoreline, along with contemporary (2001) and historic (1888) views of the site. The 2001 aerial photo is from WA Department of Natural Resources, Olympia. The 1888 T-sheet # 2011 is from the U.S. Coast and Geodetic Survey, available at the Puget Sound River History Project (http://riverhistory.ess.washington.edu).

METHODS

Nearshore areas like Race 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 Race Lagoon (Figure 2). The different habitat types within this nearshore cross-section require different methods to effectively sample the fish assemblage. 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 a methods paper published by Skagit System Cooperative (2003).

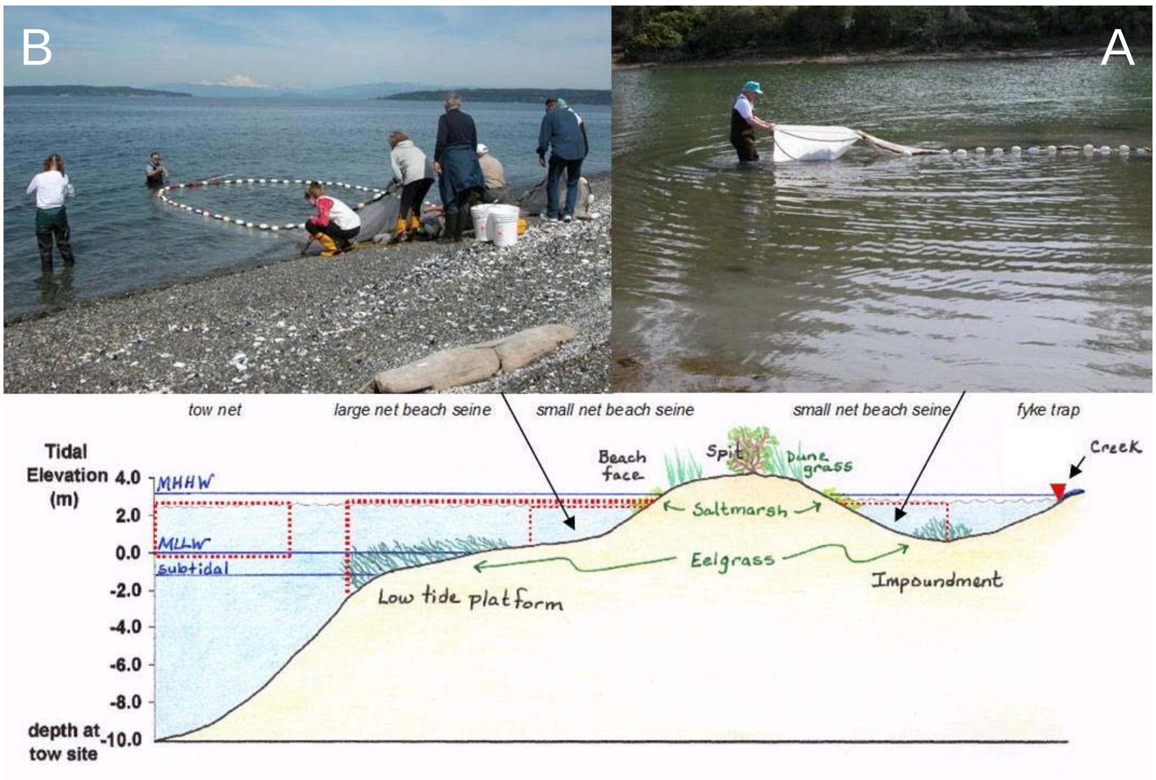

Figure 2. WSU Beach Watcher volunteers working with NOAA staff to beach seine sites near Race Lagoon. The diagram is a cross-sectional view of a spit and lagoon similar to Race Lagoon. The red dotted lines illustrate the relative differences in depth, cross-sectional area of the water column, and tidal zones 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 nearby Harrington Lagoon and (B) its adjacent shallow nearshore habitat. Although Race Lagoon has a creek flowing into it, we do not use fyke trap methods at this site. This study did not sample any deeper nearshore or offshore habitat adjacent to Race Lagoon (large net or tow net samples).

This study sampled two of the five habitat types shown in Figure 2 as described above. We sampled twice per month, February through May, using a small beach seine within Race Lagoon and outside the lagoon, in its adjacent shallow intertidal habitat.

The areas seined are typically less than four feet deep (1.2 m), and have relatively homogeneous habitat features (water depth, velocity, substrate, 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. The average beach seine set area made during this study at Race Lagoon is 97 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 :
    - Gravel - 75% of the surface is covered by clasts 4 to 64 mm 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%. Easy 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 Race Lagoon and outside the lagoon along the spit (Figure 3). The sampling sites were selected in order to compare the fish assemblage within the lagoon to that outside the lagoon and to compare fish use by habitat condition as defined in the above list. In this report all results are summarized as monthly averages (means) for all sites within the lagoon combined (Race Lagoon sites), compared to all sites outside the lagoon (Race Spit sites).

Figure 3. Location of beach seine sites at Race Lagoon. Yellow circles represent sites within Race Lagoon. White squares represent sites in the adjacent nearshore. The photo was taken at low tide. Since sampling was always done at the water's edge, independent of the tidal stage, beach seine sites shift accordingly.

RESULTS AND DISCUSSION

Beach Seine Effort

The Race Lagoon sampling effort consisted of 98 beach seine sets in 2006 and 84 sets in 2007 made during the February through June time period (Table 1A and 1B). Beach seine effort within the lagoon was approximately two times greater than the effort in adjacent shallow nearshore based on the number of sites sampled in the lagoon each sampling trip versus the number of sites sampled outside the lagoon.

Table 1A. Summary of beach seine sampling effort at Race Lagoon sites in 2006.
Sampling effort (number of beach seine sets) 2006

Month	Date	Adjacent nearshore	Lagoon
February	02/07/06	3	8
February	02/22/06	4	8
March	03/07/06	4	10
March	03/21/06	4	8
April	04/03/06	4	9
April	04/18/06	4	8
May	05/01/06	4	8
May	05/17/06	4	8
	Total	***31***	***67***

Table 1B. Summary of beach seine sampling effort at Race Lagoon sites in 2007.
Sampling effort (number of beach seine sets) 2007

Month	Date	Adjacent nearshore	Lagoon
February	02/09/07	4	10
March	03/12/07	4	9
March	03/26/07	4	4
April	04/09/07	4	9
April	04/23/07	4	8
May	05/08/07	4	8
May	05/21/07	4	8
	Total	***28***	***56***

Environmental Conditions During Sampling

Tidal Stage, Water Depth, and Substrate

Beach seine sampling occurred at various tidal stages (Table 2A). Sampling along the adjacent nearshore area mostly occurred on the flood stage or at high water in both years. Sampling within the lagoon occurred primarily on ebb tides in both years. Sampling at all locations was done at water depths averaging shallower than one meter (Table 2B). The substrates within areas seined at lagoon sites was finer grained (mixed fines and mud) than in adjacent nearshore sites, which consisted mostly of gravel (Table 2C).

The different substrates reflect differences in wave and tidal energy between the lagoon and its adjacent nearshore. The lower energy within the lagoon results in deposition of finer grained sediments by tides and waves, whereas higher wave energy outside the spit moves and deposits coarser grained sediments from sediment source areas and transports finer grained sediment off the beach face.

Table 2. Summary of tidal stage, water depth, and substrate conditions during the time of beach seine sampling at Race Lagoon sites in 2006 and 2007.

A - Percentage of beach seine sets by tidal stage				
	2006		***2007***	
Tidal Stage	*Adjacent nearshore*	*Lagoon*	*Adjacent nearshore*	*Lagoon*
Ebb	38.7%	65.7%	3.6%	53.6%
Flood	41.9%	17.9%	46.4%	21.4%
HW	19.4%	16.4%	50.0%	25.0%

B - Maximum depth of area beach seined, in meters				
	2006		***2007***	
	Adjacent nearshore	*Lagoon*	*Adjacent nearshore*	*Lagoon*
Average (1 standard deviation)	0.78 (0.17)	0.61 (0.16)	0.76 (0.19)	0.37(0.17)

C - Percentage of beach seine sets by substrate type				
	2006		***2007***	
Substrate Type	*Adjacent nearshore*	*Lagoon*	*Adjacent nearshore*	*Lagoon*
Fines with gravel	0.0%	1.5%	0.0%	1.8%
Gravel	100.0%	7.5%	60.7%	5.4%
Mixed coarse	0.0%	1.5%	21.4%	1.8%
Mixed fines	0.0%	40.3%	3.6%	35.7%
Mud	0.0%	49.3%	0.0%	55.4%
Sand	0.0%	0.0%	14.3%	0.0%

Temperature and Salinity

Monthly patterns of surface salinity and surface water temperature experienced at Race Lagoon and its adjacent nearshore are shown for each year in Figures 4A and 4B (2006) and Figures 5A and 5B (2007). Skagit River flow, which accounts for the majority of freshwater entering the Whidbey Basin, is shown in Figure 4C (2006) and Figure 5C (2007). The salinity and temperature measurements are point measurements taken during the time of beach seining.

The Skagit River is the nearest to Race Lagoon of the three large rivers entering Whidbey Basin. Since Skagit River flow is the dominant freshwater source, we hypothesize that the pattern of salinity for Saratoga Passage near Race Lagoon varies inversely with Skagit River flow. During 2006 the monthly salinity average differed less than 1 ppt between the lagoon and the adjacent shallow nearshore. The salinity within both the lagoon and the adjacent nearshore appears to inversely follow changes in Skagit River flow (Figures 4A and 4C). During sampling in 2007 the salinity within the lagoon was 1.6 to 3.4 ppt higher than in the adjacent shallow nearshore for March, April and May. During February there was only a 0.6 ppt difference observed.

Salinities in both the lagoon and adjacent nearshore are lower in 2007 than in 2006, except for the month of February. Two large freshets occurred in the Skagit River in March of 2007 (Figure 5C). The large amount of freshwater from these freshets likely contributed to the lower salinity in Saratoga Passage in 2007. In 2006 there were no freshets from the Skagit River during the beach seine sampling period[4] (Figure 4C). Continuous monitoring of salinity and Skagit River flow may elucidate the complexity of salinity differences between the lagoon and adjacent nearshore habitat as determined by the timing of tidal cycling and freshwater input via the Skagit River and the small stream within the lagoon, especially in the case of storm water peaks in freshwater flow.

Water temperature within the lagoon and adjacent nearshore shows a seasonal increase from February through May (Figures 4B and 5B). In 2006 the temperature inside the lagoon ranged from a low of 5.9 degrees Celsius (C) in February to a high 11.6 C in May. Temperature along the adjacent shoreline of the spit ranged from 5.9 C to 10.6 C during the same time period. Water temperature was the same inside and outside the lagoon in February. As the season progressed, the monthly average water temperature in the lagoon increased at a faster rate than outside the lagoon. By May the water inside the lagoon was 1.3 degrees C warmer than the water along the spit. In 2007 the temperature inside Race Lagoon ranged from 7.5 C to 13.7 C and along the spit from 7.5 C to 11.7 C. Starting in March, the monthly average for the lagoon surface water was 0.7 to 2.0 degrees C warmer than the surface water in the adjacent nearshore.

We would expect warmer water in the lagoon during spring and summer months compared to the adjacent nearshore because the water impounded in the lagoon is much shallower than the adjacent waterbody of Saratoga Passage. The lagoon is also tidally disconnected from Saratoga Passage on a daily basis. Inside lagoon water temperature thus will respond more quickly and more dramatically to seasonal increases (or decreases) in air temperature and solar radiation.

[4] A freshet occurred in May shortly after the last day of beach seine sampling at Race Lagoon. Any effect it might have had on salinity would not have been detected in this study.

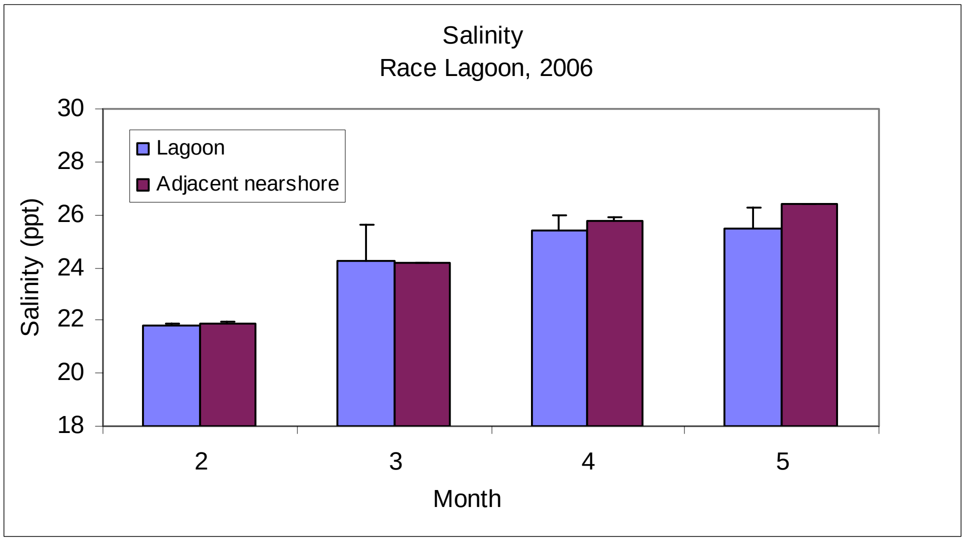

Figure 4A. Monthly average salinity at Race Lagoon taken at the beach seine sites during the time of beach seining in 2006. Error bars are one standard deviation.

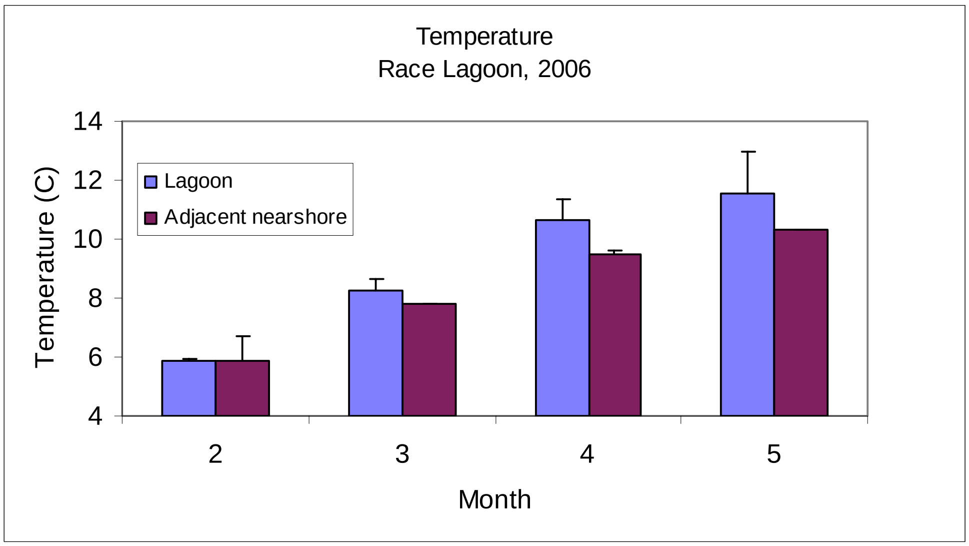

Figure 4B. Monthly average temperature at Race Lagoon taken at the beach seine sites during the time of beach seining in 2006. Error bars are one standard deviation.

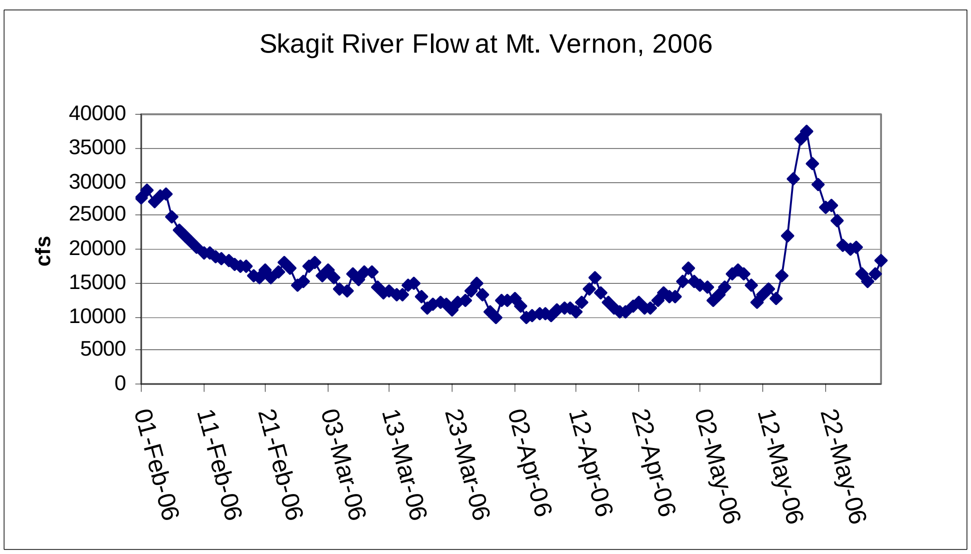

Figure 4C. Daily average flow of the Skagit River at Mount Vernon for 2006.

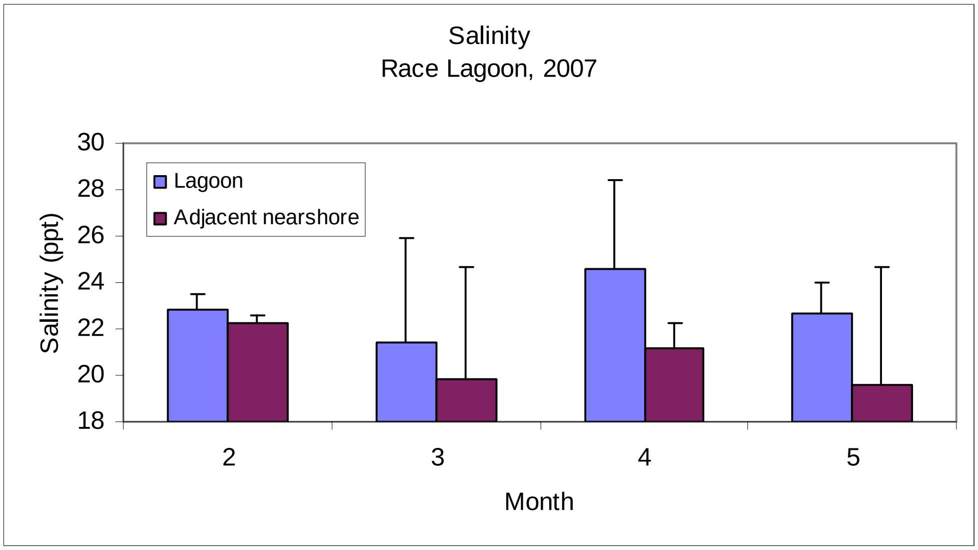

Figure 5A. Monthly average salinity at Race Lagoon taken at the beach seine sites during the time of beach seining in 2007.. Error bars are one standard deviation.

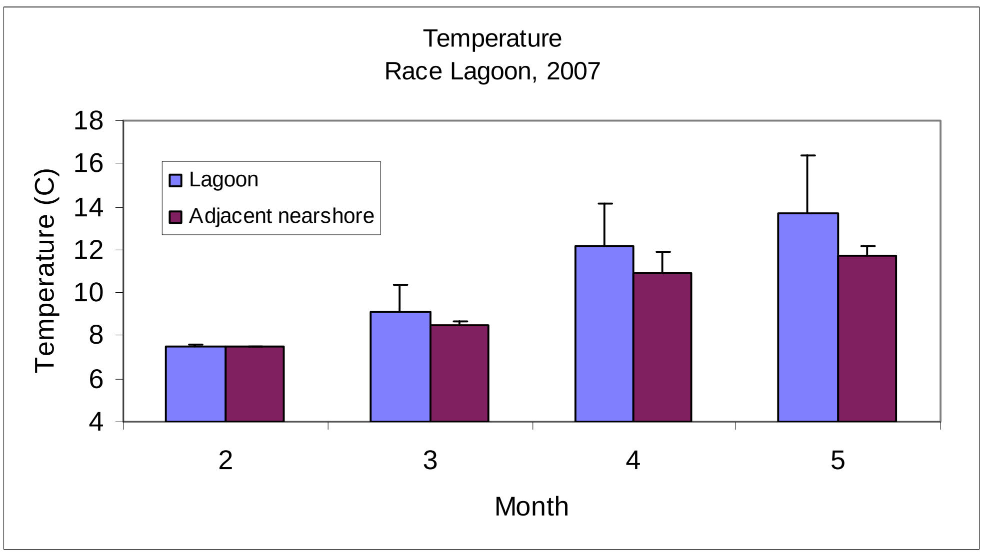

Figure 5B. Monthly average temperature at Race Lagoon taken at the beach seine sites during the time of beach seining in 2007.. Error bars are one standard deviation.

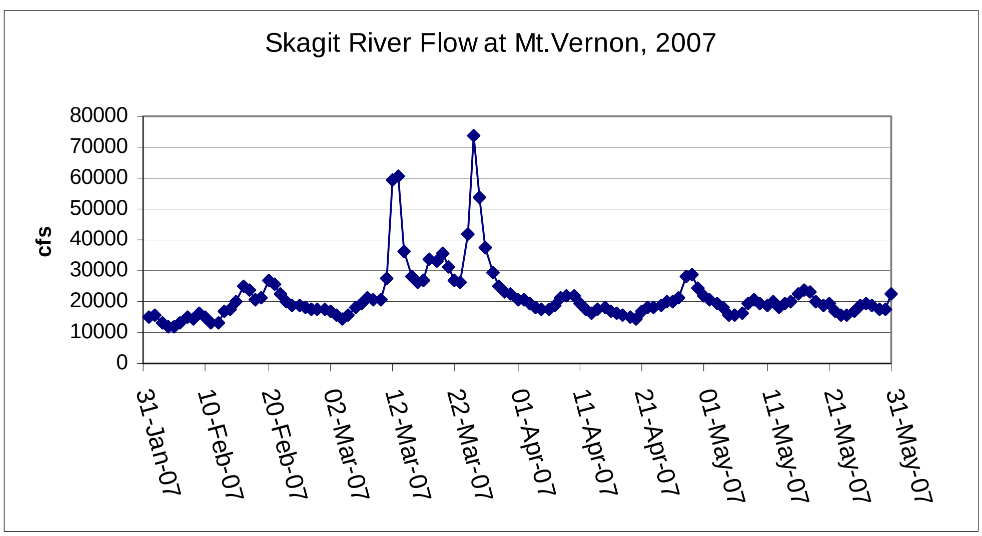

Figure 5C. Daily average flow of the Skagit River at Mount Vernon for 2007.

Catch by Species

In this section we summarize the composition of the total catch by species for each of the sampling years. Changes in the fish assemblage composition over time (February through May) and differences in fish assemblage composition within the lagoon compared to adjacent nearshore habitat are discussed in more detail later in this document.

The 2006 sampling effort caught over 9,600 fish, including at least 14 different species (Table 3). Juvenile salmon represented 20.0% of the total catch. The juvenile salmon catch was dominated by sub-yearling pink salmon (71.7% of the total juvenile salmon catch). Chum salmon comprised 25.2% of the salmon catch. Wild juvenile Chinook salmon comprised 3.0% of the salmon catch. In 2007, February through May, there were over 3,200 fish caught, representing at least 10 different species (Table 3). Juvenile salmon made up 63.0% of the total catch. The juvenile salmon catch was dominated by sub-yearling chum salmon, comprising 99.9% of the total juvenile salmon catch. There were only two wild juvenile Chinook salmon and one juvenile pink salmon caught in 2007, all three inside the lagoon. We discuss the abundance and timing of each juvenile salmon species later in this report.

In addition to salmonids, both the 2006 and 2007 catches included forage fish species (surf smelt, herring, Pacific sandlance), sculpins (Pacific staghorn sculpin), 3-spine stickleback, shiner perch, pile perch, starry flounder, tubesnout, and arrow gobi (Table 3). All of these species, except for tubesnouts, were most abundant inside the lagoon.

More than 3,000 forage fish were caught in 2006, with surf smelt accounting for 32% of the total fish catch. All but 11 of the surf smelt caught in 2006 were found in the lagoon. Surf smelt abundance peaked in April. In addition to the smelt there were nine herring and one sandlance found in the lagoon in 2006. Only nine surf smelt, and no other forage fish, were caught in 2007. The surf smelt found at Race Lagoon were all juvenile sized, with an average fork length of 62.4 mm and a maximum of 76 mm.

Sculpins, primarily Pacific staghorn, accounted for 40.2% of the total catch in 2006 and 22.2% of the total catch in 2007. They were the most abundant species captured during the sampling in 2006 (Table 3). In both years, 98.1% of the sculpins were found in the lagoon habitat. In 2007 there were 463 staghorns measured for length. These sculpins were primarily juvenile sized, with an average length of 46.3 mm and a range from 10 to 128 mm. No sculpins were measured during 2006.

Flatfish, all of which were starry flounder, were not abundant in our catches (accounting for less than 1.4% of the total catch in both years). Shiner perch accounted for 2.2% and 1.3% of the total catch of each year, respectively. Eighty percent of the shiners caught in 2006 were found in the lagoon; 97.6% in 2007. A total of 15 pile perch (0.2% of the total catch) were caught in the lagoon in April of 2006. No pile perch were caught in 2007. Threespine stickleback accounted for 1.2% and 1.7% of the total catch of each year, respectively. All the sticklebacks were found in the lagoon habitat. Arrow goby accounted for 2.2% of the total catch in 2006 and 10.0% of the total catch in 2007. All the goby were found in lagoon habitat. Tubesnouts accounted for 0.8% of the total catch in 2006; none were caught in 2007.

Table 3. Total catch by fish species at Race Lagoon sites in 2006-07. Mean catch per beach seine set is in parentheses.

	2006		2007	
Fish species	**Adjacent Nearshore**	**Lagoon**	**Adjacent Nearshore**	**Lagoon**
Juvenile salmon:				
Chinook salmon, unmarked subyearling (*Oncorhynchus tshawytscha)*	0 (0.00)	58 (0.87)	0 (0.00)	2 (0.04)
Chum salmon, subyearling *(Oncorhynchus keta)*	79 (2.55)	408 (6.09)	438 (15.64)	1586 (28.32)
Pink salmon, subyearling *(Oncorhynchus gorbuscha)*	297 (9.58)	1087 (16.22)	0 (0.00)	1 (0.02)
Total juvenile salmon	***376 (12.13)***	***1553 (23.19)***	***438 (15.64)***	***1589 (28.38)***
Forage fish species:				
Herring (*Clupea harengus pallasi*)	0 (0.00)	9 (0.13)	0 (0.00)	0 (0.00)
Surf smelt (*Hypomesus pretiosis)*	11 (0.35)	3067 (45.78)	3 (0.11)	6 (0.11)
Sandlance (*Ammodytes hexapteus)*	0 (0.00)	1 (0.01)	0 (0.00)	0 (0.00)
Total forage fish	***11 (0.35)***	***3077 (45.78)***	***3 (0.11)***	***6 (0.11)***
Sculpin species:				
Pacific staghorn sculpin (*Leptocottus armatus)*	71 (2.29)	3811 (56.88)	5 (0.18)	712 (12.71)
Buffalo sculpin (*Enophrys bison)*	2 (0.06)	1 (0.01)	10 (0.36)	1 (0.02)
Total sculpins	***73 (2.45)***	***3812 (56.88)***	***15 (0.48)***	***713 (12.71)***
Other nearshore or estuarine fish species:				
Starry flounder (*Platichtys stellatus)*	1 (0.03)	113 (1.69)	2 (0.07)	43 (0.77)
Pile perch (*Rhacochius vacca)*	0 (0.00)	15 (0.22)	0 (0.00)	0 (0.00)
Shiner perch (*Cymatogaster aggregate)*	41 (1.32)	169 (2.52)	1 (0.04)	41 (0.73)
Threespine stickleback (*Gasterosteus aculeatus)*	0 (0.00)	119 (1.78)	0 (0.00)	54 (0.96)
Tubesnout (*Aulorynchus flavidus)*	76 (2.45)	3 (0.04)	0 (0.00)	0 (0.00)
Arrow goby (*Clevelandia ios)*	0 (0.00)	217 (3.24)	0 (0.00)	322 (5.75)
Total other species	***118***	***636***	***3***	***562***
Total catch	**578**	**9078**	**459**	**2768**

Juvenile Chinook Salmon

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

Timing and Abundance

In 2006 juvenile Chinook salmon were present only in the lagoon. They were not found in adjacent shallow nearshore habitat during the entire sampling period (February through May). The presence of the Chinook salmon peaked within the lagoon during March of 2006. At that time the density was 306 Chinook salmon per hectare of area seined (Figure 6A). Chinook salmon were still present within lagoon when sampling ended in May, but at a very low density. In 2007, juvenile Chinook salmon were not caught until April (Figure 6D). There were only two wild Chinook salmon caught that month, and they were the only juvenile Chinook salmon caught that year. This resulted in a density of 12.3 fish per hectare for 2007.

These results demonstrate that juvenile Chinook salmon were present in Race Lagoon habitat early in the year, and that juvenile Chinook salmon density varied dramatically between years. This difference in Chinook salmon density is likely due to the difference in the Skagit juvenile Chinook salmon outmigration population size. In 2006, 6.2 million wild juvenile Chinook salmon outmigrated from the Skagit River (Kinsel et al. 2007), while in 2007 only 1.7 million wild juvenile Chinook salmon outmigrated (Kinsel pers. comm. 2007). The 2006 timing curve and abundance pattern for juvenile Chinook salmon shown in Figure 6A is typical of other lagoons in the Whidbey Basin (Beamer et al. 2006). The 2006 pattern also coincides with the period when we would expect migrating Chinook salmon fry to be present in Saratoga Passage. Race Lagoon is approximately 20 kilometers from the mouth of the Skagit River (the nearest Chinook salmon-bearing river).

This study did not sample the deeper intertidal-subtidal fringe or offshore habitat adjacent to Race Lagoon. Therefore, we should not infer that the sampling at Race Lagoon captures the pattern of juvenile Chinook salmon use of deeper, more offshore habitats adjacent to Race Lagoon. However, it is likely that larger, older juvenile Chinook salmon move offshore later in the season, and are present in the deeper offshore habitat, based upon the pattern observed at similar sites, where juvenile Chinook salmon transition from shallow to deeper habitat as they become larger later in the year (Beamer et al. 2003).

Fish Size

We measured the fork length for 35 of the 58 juvenile Chinook salmon caught at the Race Lagoon sites in 2006 and all (two) juvenile Chinook salmon caught in 2007 (Table 4, Figures 7A and 7D). All juvenile Chinook salmon measured were sub-yearling sized and determined to be of a wild stock origin. Juvenile Chinook salmon caught in Race Lagoon in 2006 had an average size of 48.0 mm in February, 49.5 mm in March, 54.5 mm in April, and 60.0 mm in May (Figure 7A). The Chinook salmon captured in April 2007 had an average fork length of 49.0 mm (Figure 7D). The increasing length of juvenile Chinook salmon over time may suggest they are lingering in the nearshore environment, possibly in Race Lagoon, long enough to exhibit growth. Unlike chum and pink salmon (see sections below), we did not catch any Chinook salmon in adjacent nearshore habitat so we can not compare the size of fish caught in the lagoon with fish caught in adjacent nearshore habitat.

Table 4. Number of juvenile Chinook salmon fork length samples collected at Race Lagoon sites.

	2006		2007	
Month	Adjacent nearshore	Lagoon	Adjacent nearshore	Lagoon
February	0	2	0	0
March	0	30	0	0
April	0	2	0	2
May	0	1	0	0
Total	0	35	0	2

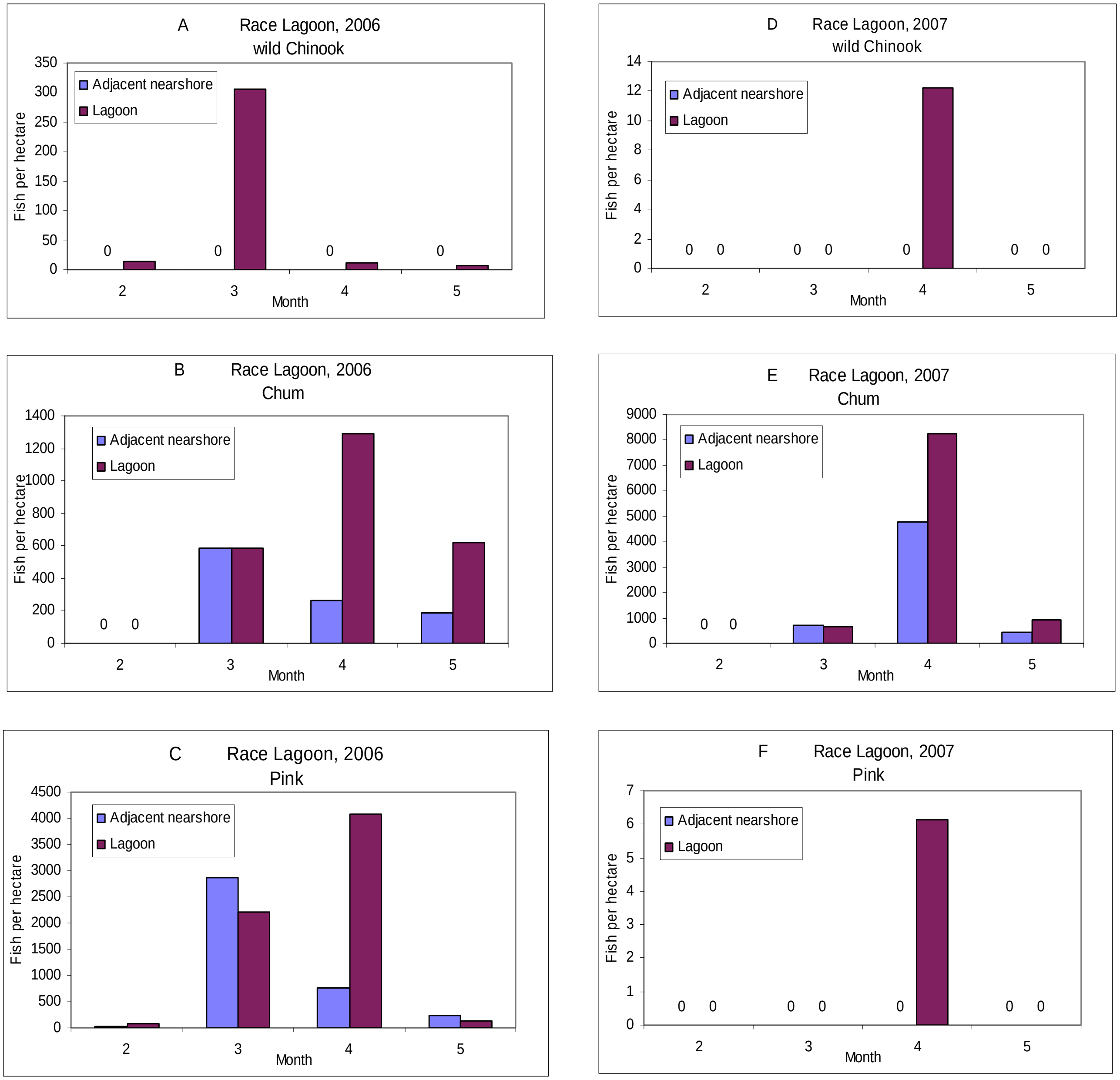

Figure 6. Monthly average juvenile salmon density (fish per hectare) at Race Lagoon sites in 2006 and 2007. Note the different scales on the Y axis. There were no juvenile Chinook salmon found in the adjacent shallow nearshore habitat sites in either 2006 or 2007. There were no juvenile pink salmon found in the adjacent shallow nearshore habitat sites in 2007.

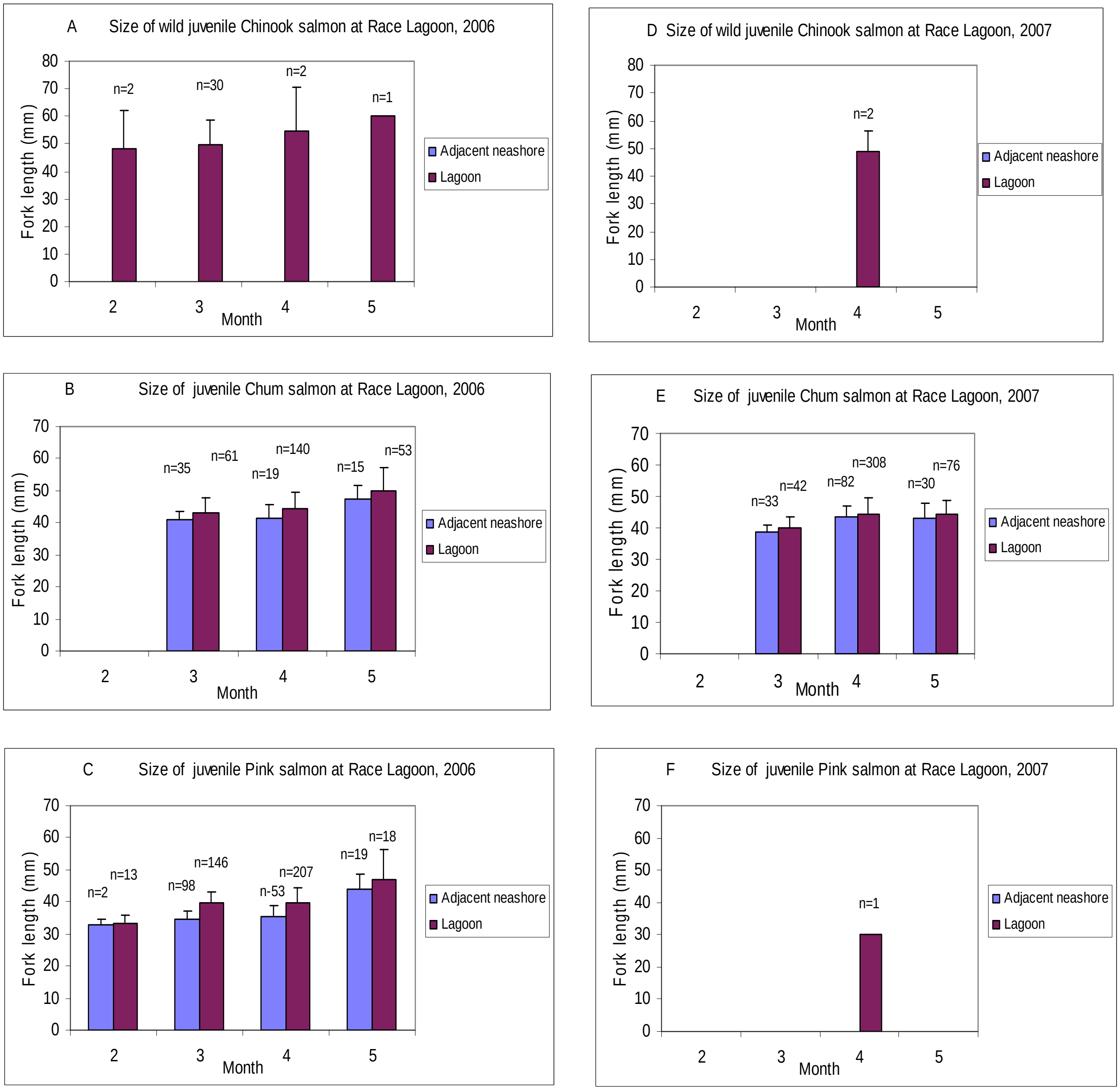

Figure 7. Average fork length (mm) distribution of juvenile salmon at Race Lagoon sites in 2006 and 2007. Error bars are one standard deviation. Numbers shown above the bars are the number of fish measured for each species. There were no juvenile Chinook salmon found in the adjacent shallow nearshore habitat sites in either 2006 or 2007. There were no juvenile pink salmon found in the adjacent shallow nearshore habitat sites in 2007.

Juvenile Chum Salmon

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

Timing and Abundance

Juvenile chum salmon were caught in both in Race Lagoon habitat and in its adjacent shallow nearshore habitat during March through May both in 2006 and 2007. The density of the chum salmon in both years is shown in Figures 6B and 6E as the monthly average density per hectare of area seined for lagoon and shallow nearshore habitat sites. Chum salmon were not found in either area in February. The catch in March of both years showed an almost equal distribution of chum between the lagoon habitat and the adjacent shallow nearshore habitat. Peak chum salmon abundance in the lagoon and its adjacent shallow nearshore habitat occurred in April of both years. During April 2006, based on average monthly density of fish per hectare, chum salmon abundance in the lagoon was nearly four times greater than the abundance found in the adjacent shallow nearshore habitat. In May 2006 the density decreased but was still three times higher within the lagoon habitat than along the shallow nearshore habitat (Figure 6B). In 2007 a similar distribution was observed. Chum salmon density in 2007 was about four times greater than in 2006. Chum salmon were present in both habitats for both sampling years when the sampling effort stopped in May.

Fish Size

Fork length was measured on 323 of the 487 juvenile chum salmon caught in 2006, and 671 of the 2,024 juvenile chum salmon caught in 2007 (Table 5, Figure 7B). In 2006 juvenile chum salmon had an average fork length of 40.8 mm in March, 41.6 mm in April, and 47.2 mm in May at the adjacent shallow nearshore habitat sites. At the same time, the chum salmon inside the lagoon had an average fork length of 43.1 in March, 44.2 mm in April, and 50.1 mm in May. The size of the fish measured within the lagoon habitat was consistently 2 to 3 mm larger than fish at the nearshore habitat for each month (Figure 7B). In 2007, average fork length was 38.7 mm in March, 43.5 in April, and 43.1 in May of the fish measured at the shallow nearshore habitat sites. The chum measured in the lagoon sites had an average fork length of 40.1 mm in March, 44.2 mm. in April, and 44.4 mm in May (Figure 7E). The fact that chum salmon in the lagoon are larger on average than those outside the lagoon may indicate the lagoon is a good growing environment for chum, or that juvenile chum are residing longer within the lagoon relative to fry passing by the lagoon.

Table 5. Number of juvenile chum salmon fork length samples collected at Race Lagoon sites.

	2006			2007	
Month	Adjacent nearshore	Lagoon		Adjacent nearshore	Lagoon
February	0	0		0	0
March	35	61		33	42
April	16	140		82	308
May	15	53		30	76
Total	69	254		145	426

Juvenile Pink Salmon

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

Timing and Abundance

Pink salmon were found in both the lagoon and shallow nearshore habitat during all months of the 2006 sampling period. Abundance of pink salmon in both years is shown in Figures 6C and 6F as the monthly average density per hectare of area seined for lagoon and adjacent habitat. In February 2006 an average density of 30 pinks per hectare was found in the adjacent nearshore, while an average density of 85 pink salmon per hectare was found in the lagoon habitat. The abundance of pink salmon increased dramatically after February. In March 2006 pink density increased in both habitat types compared to February, with an average density of 2,800 and 2,200 pink salmon per hectare for the nearshore and lagoon habitats, respectively. Pink salmon peaked in April, with more than five times as many pinks found within the lagoon than in adjacent nearshore habitat. The average density in the lagoon was 4,078 pinks per hectare, while the density outside the lagoon was only 754 pinks per hectare. By May the density of pink salmon had decreased dramatically. The density within the lagoon was 131 and the density on the nearshore was 245 pinks per hectare of area seined. During the sampling in 2007 only one juvenile pink salmon was caught. It was caught inside the lagoon during April (Figure 6F). Juvenile pink salmon in 2007 are the progeny of even-year spawning adults, which are not common in Puget Sound.

Fish Size

Fork length was measured on 401 of the 1,387 juvenile pink salmon caught in 2006, and all of the (one) juvenile pink salmon caught in 2007 (Table 6, Figure 7F). In 2006 juvenile pink salmon had an average fork length of 33.0 mm in February, 33.4 mm in March, 35.5 mm in April, and 43.9 mm in May at the adjacent shallow nearshore sites (Figure 7C). At the same time, the pink salmon inside the lagoon had an average fork length of 33.2 mm in February, 39.7 mm in March, 39.7 mm in April, and 46.9 mm in May. During February there was no size difference between pink salmon caught in the lagoon and in the shallow nearshore. In March through May the fish measured in the lagoon were consistently 3 to 5 mm larger than the fish measured in the shallow nearshore. The fact that pink salmon in the lagoon are larger on average than those outside the lagoon may indicate the lagoon is a good growing environment for them, or that juvenile pink salmon are residing longer within the lagoon relative to fry passing by the lagoon.

Table 6. Number of juvenile pink salmon fork length samples collected at Race Lagoon sites.

	2006			2007	
Month	Adjacent nearshore	Lagoon		Adjacent nearshore	Lagoon
February	2	13		0	0
March	69	146		0	0
April	53	207		0	1
May	19	18		0	0
Total	***172***	***384***		***0***	***1***

Changes in Fish Assemblage Composition Over Time

This section describes the fish assemblage composition over the February through May sampling periods in 2006 and 2007 for Race Lagoon sites. Of the fish caught at Race Lagoon, we selected seven fish species, or species groups, to represent the fish assemblage. These include juvenile salmon, surf smelt, shiner perch, staghorn sculpin, starry flounder, arrow goby, and threespine stickleback (Figure 8). The seven species or groups represent 99.7% of the total catch in both 2006 and 2007.

Fish density in the adjacent shallow nearshore peaked in March of 2006 (Figure 8A). In 2007, the peak density happened a month later, in April (Figure 8C). During both of these years the fish assemblage was dominated by juvenile salmon. The 2006 peak was driven by the presence of juvenile pink salmon, while the 2007 peak was due to juvenile chum salmon. Beamer (2007) shows that in 12 years of data collection in Skagit Bay, to the north of Race Lagoon, April is the peak month for the outmigration of chum salmon. The numbers of fish at peak density in the shallow nearshore is similar both years. In 2006 there were approximately 5,000 fish per hectare and in 2007 there were 5,800 fish per hectare during the peak time period.

Total fish density increased each month inside Race Lagoon in 2006, with a peak at the end of sampling in May (Figure 8B). In March and April juvenile salmon, surf smelt and staghorn sculpins were found inside the lagoon at similar densities. The May peak was driven by the increasing presence of staghorn sculpin. Additionally, shiner perch, stickleback, arrow gobi, and starry flounder populations increased in May. The juvenile salmon population decreased between April and May, while the surf smelt population remained the same.

In 2007, the fish density in the lagoon habitat was approximately one half of the density seen in 2006. The peak in 2007 came in April and was dominated by the presence of juvenile salmon (Figure 8D). Juvenile chum salmon drove this peak, just as they did in the adjacent nearshore. In 2007, there were very few surf smelt found inside the lagoon (all found in March). This contributed to the decrease in overall fish density in 2007 compared to 2006.

We found a higher fish density within the lagoon habitat than along the adjacent shallow nearshore for both years of data collection. In May, the peak density in the lagoon for 2006 was 8.5 times higher than in the nearshore habitat at that time. In 2007, both habitat areas showed a peak fish density occurring in April. At that time the density was 2.4 times higher inside the lagoon than along the shallow nearshore. The species diversity was higher inside the lagoon than along the spit during both years. In 2006 there were 14 fish species found within the lagoon habitat sites, compared to eight fish species found at the shallow nearshore sites. In 2007, there were ten fish species found inside the lagoon, while only six species were found along the shallow nearshore of the spit (Figure 8).

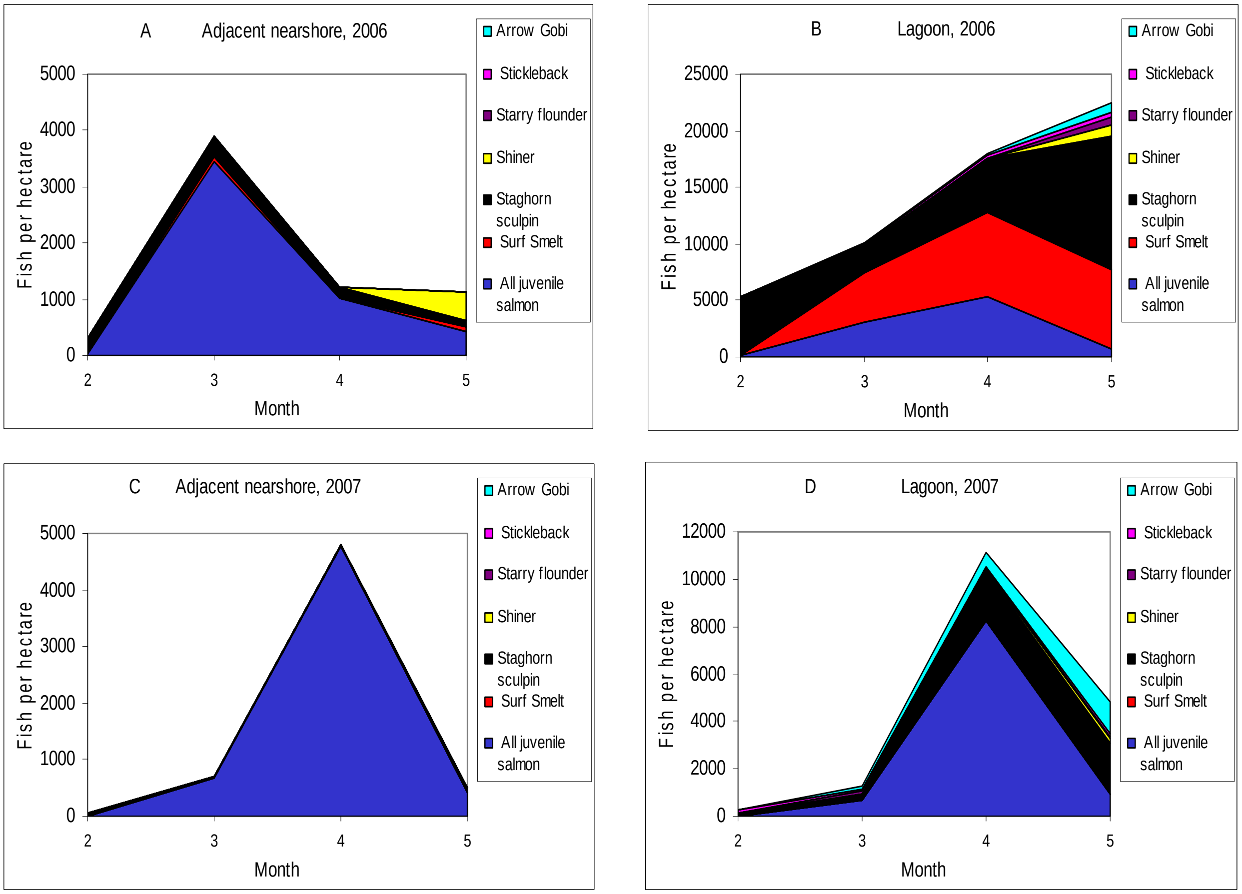

Figure 8. Monthly average fish assemblage composition and abundance for adjacent shallow nearshore habitat and lagoon habitat in 2006 and 2007. Results are reported as average density of fish per hectare of area seined. Note the different scales on the Y axis.

References Cited

Beamer, E. 2007. Juvenile salmon and nearshore fish use in shoreline and lagoon habitat associated with Ala Spit, 2007. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org.

Beamer, EM, A McBride, R Henderson, J Griffith, K Fresh, T Zackey, R Barsh, T Wyllie-Echeverria, and K Wolf. 2006. Habitat and fish use of pocket estuaries in the Whidbey Basin and north Skagit County bays, 2004 and 2005. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org.

Beamer, EM, A McBride, R Henderson, and K Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org.

Kinsel, C. 2007. Personal communication October 19, 2007. Washington Department of Fish and Wildlife, Olympia.

Kinsel, C, G Volkhardt, L Kishimoto, and P Topping. 2007. 2006 Skagit River wild salmon production evaluation annual report. Report No. FPA 07-05. Washington Department of Fish and Wildlife, Olympia.

Skagit System Cooperative. 2003. Estuarine fish sampling methods. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org.