JUVENILE SALMON AND NEARSHORE FISH USE IN SHORELINE AND LAGOON HABITAT ASSOCIATED WITH ELGER BAY, 2005-2007

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2006 oblique aerial photo of Elger Bay (courtesy WA Department of Ecology)

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Purpose of report

Studies of fish use in Puget Sound pocket estuaries began in 2002. At first, research was limited to understanding juvenile Chinook salmon use of sites within Skagit Bay (Beamer et al. 2003). In 2004, the 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[4]. The focus of this 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 areas. This expanded research effort has continued throughout 2007 and included sampling in Elger Bay with the help of Island County WSU Beach Watchers. The focus of this report is on fish abundance and size in Elger Bay from 2005 through 2007. Although we primarily report only fish abundance and fish size in this one system, we also briefly consider results within the context of the larger study of pocket estuaries.

Study area

Elger Bay is part of the Puget Sound nearshore (Figure 1). The Puget Sound nearshore, as defined by the Puget Sound Nearshore Ecosystem Restoration Program, includes the Puget Sound fjord, Hood Canal, Whidbey Basin, the Strait of Juan de Fuca, the San Juan Islands, and the mainland coast to the Canadian border. Within the nearshore, coastal and upland processes interact to form a diversity of intertidal, subtidal, and terrestrial habitats. Coastal processes (wind waves, tides) help create coastal landforms such as spits, dunes, tidal channels, and salt marshes, while watershed processes (streams, groundwater seeps, rivers) contribute freshwater to the nearshore and create landforms like delta flats, marsh islands, and distributary channels.

From a geomorphic perspective, we consider Elger Bay to be one of several tidal channel lagoons which are part of a group of nearshore habitats we commonly refer to as pocket estuaries. Pocket estuaries are partially enclosed bodies of marine water that are connected to a larger estuary (such as Puget Sound) at least part of the time, and are measurably diluted by freshwater from the land at least part of the year (after Pritchard 1967). These small estuaries are differentiated from larger estuaries as the watersheds they are associated with are not Chinook salmon spawning habitats (Beamer et al. 2003). Pocket estuaries like Elger Bay are an important habitat for wild Chinook salmon fry early in the year once they leave their natal estuary and enter nearshore areas of Puget Sound (Beamer et al. 2003 and 2006).

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[4] 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).

The Elger Bay pocket estuary has been relatively unchanged by humans from historic conditions except for a high accumulation of large drift logs associated with logging practices around Puget Sound (MacLennan 2005). Adjacent to and outside of the pocket estuary, parts of the watershed have been developed and the spit has been developed and armored (Beamer et al. 2006). Natural geomorphic changes at this site include a westward progradation of the spit. The USCGS t-sheets and USACE 1941 photos were helpful in marking the historic locations of larger channels and driftwood. The large channels are in almost exactly the same place throughout our period of record, though the encroaching driftwood covers and likely fills channels and salt marsh over time. One large channel that historically extended all the way to the head of the lagoon may have been connected to surface water runoff. This channel is now almost completely covered and filled with driftwood.

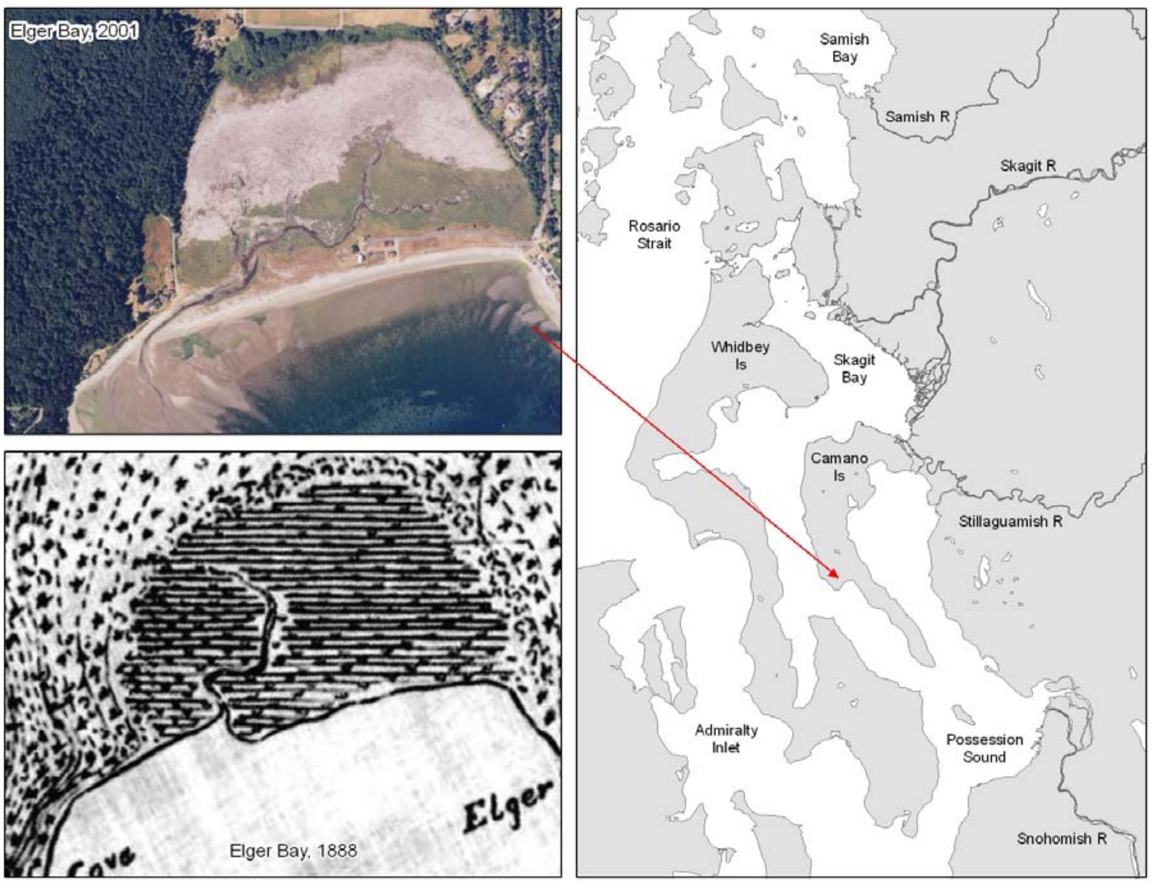


Figure 1. Location of Elger Bay along the western Camano Island shoreline, along with contemporary (2001) and historic (1888) views of the site.

Methods

We sampled two distinct habitat types, the lagoon habitat within the Elger Bay pocket estuary and the shallow intertidal habitat within the nearshore adjacent to the Elger Bay pocket estuary (Figure 2). Two sets were made at Elger Blind Channel 1 and 2 sites, one set was made at Elger Blind Channel 3 and 4 sites (lagoon sites), and three sets were completed at the Elger Spit and Elger Beach sites (adjacent nearshore sites), weather and tides permitting. Figure 3 illustrates conceptually the different habitats sampled. Although sampling frequency varied somewhat for all three years, we generally beach seined twice a month from February through June (Table 1).

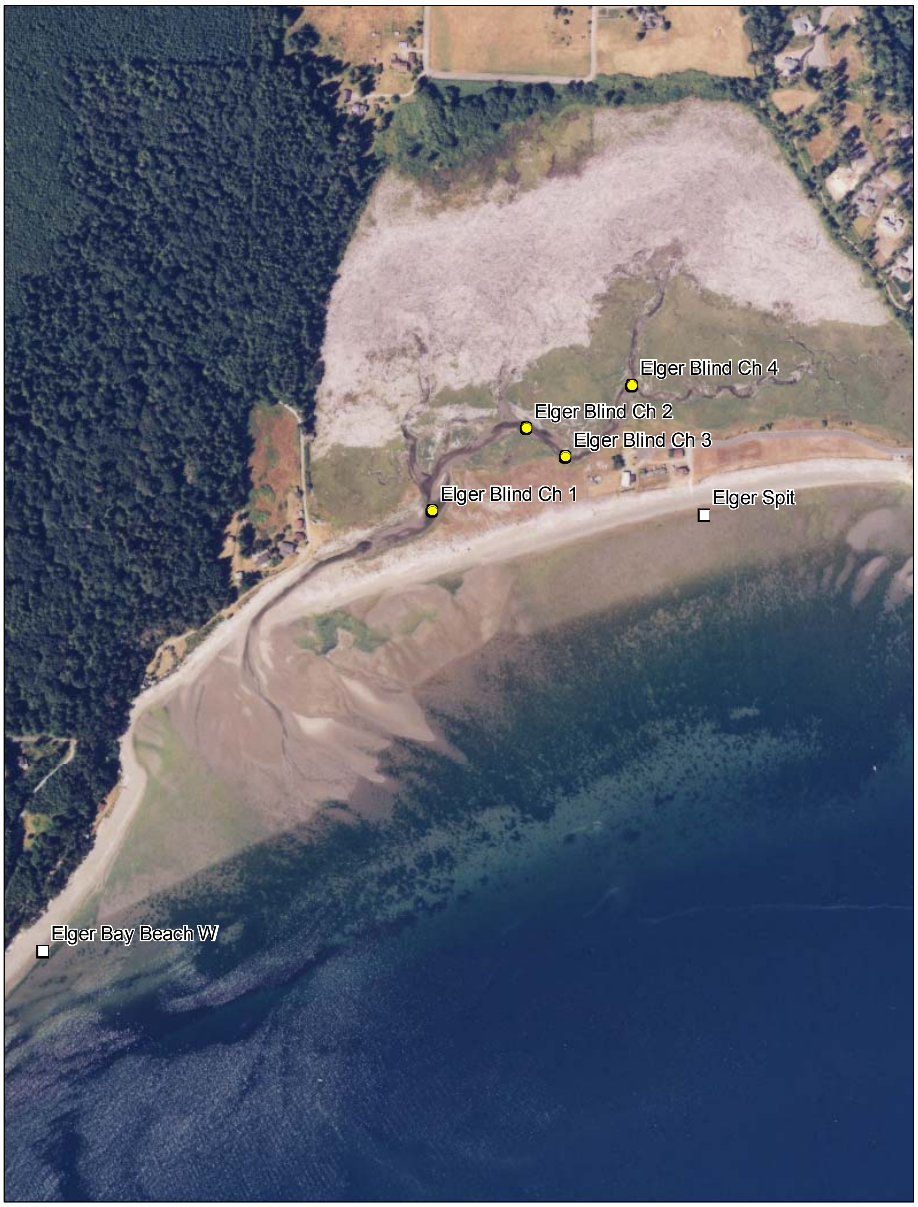


Figure 2. Location of beach seine sites at Elger Bay. Yellow dots represent lagoon sites within the pocket estuary. White squares represent sites in the adjacent nearshore.

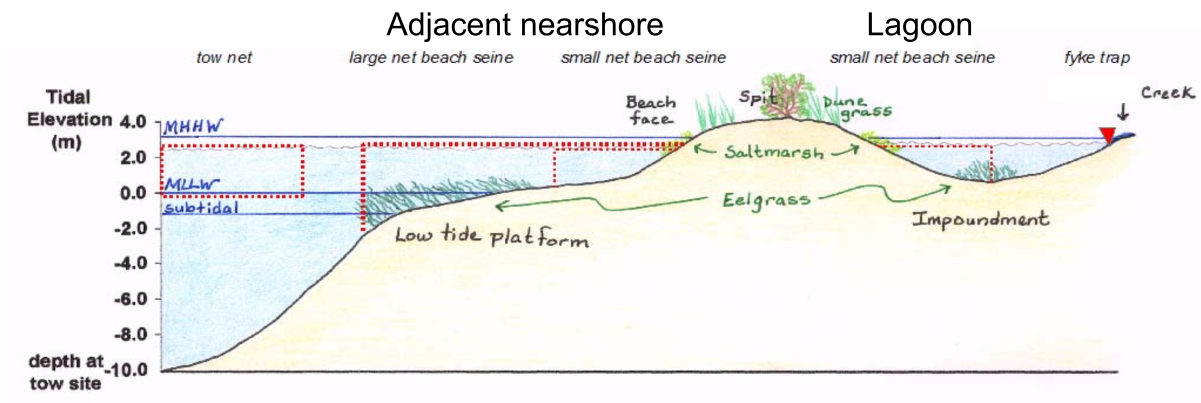


Figure 3. Cartoon of nearshore habitat associated with an area like Elger Bay.

Table 1. Summary of beach seine sampling effort (number of beach seine sets) at Elger Bay 2005-2007.

A. 2005

Year	Month	Day	Lagoon	Adjacent Nearshore
2005	February	03	6	6
	February	14	5	5
	March	04	6	6
	March	23	6	6
	April	01	7	3
	April	15	4	3
	May	05	6	6
	June	17	0	3
Total			***40***	***38***

B. 2006

Year	Month	Day	Lagoon	Adjacent Nearshore
2006	February	08	6	6
	February	24	3	6
	March	08	5	0
	March	23	6	6
	April	04	6	6
	April	19	6	6
	May	02	4	6
	May	24	6	6
	June	21	2	6
Total			***44***	***48***

C. 2007

Year	Month	Day	Lagoon	Adjacent Nearshore
2007	February	08	6	6
	February	23	6	6
	April	06	7	3
	April	20	6	6
	May	08	4	6
	May	11	0	12
	May	21	6	6
	June	12	5	3
Total			***40***	***48***

Most of the areas seined were less than one meter deep. The configuration used was a 25 m by 2 m net comprised of 0.3 cm knotless nylon mesh. The net was set in "round haul" fashion by holding one end of the net on the beach and deploying the remainder of the net from a floating tote in a horseshoe shape and returning the second end to the beach. Both ends of the net are drawn up the beach simultaneously, yielding a catch. The average beach seine area for this study was 92 m. Pages 51-54 of Beamer et al. (2005) provide more details, net schematics, and pictures of the seining methods.

Sites were sampled at similar tidal stages depending upon depth and water velocity limitations at each location. Substrate types were collected at each site, along with salinity, temperature, dissolved oxygen, conductivity and depth. The water quality measurements were taken with a YSI meter just below the surface and just above the bottom at four equidistant intervals inside the net circumference immediately after beach seining. Substrates were typed by one of four categories (per Skagit 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.

The catch was sorted by species on location. For non-salmonids, length (to the nearest mm) was recorded for up to 20 individuals of each species. The remaining fish were enumerated and released. All salmonids were examined for fin clips, external tags, or other marks, and scanned for coded-wire tags. The length of up to 20 non-Chinook salmonids were recorded at each site and the remainder were tallied and released. Lengths were recorded for all Chinook salmon captured in the net to provide additional length-frequency data. A small subsample of Chinook salmon (less than three/month) was periodically retained for laboratory analyses and will be reported elsewhere. These fish were collected for fin clips for genetic analyses, otoliths and scales for life history information, stomach for diet composition, and kidney for bacterial kidney disease (BKD).

Results

Tidal Stage

In order to access both the lagoon and adjacent nearshore habitats of Elger Bay we attempted to sample at the same tidal height each month (approximately 8-11 feet). Additionally, we have found that it is most productive to sample using a beach seine net during a tidal exchange. Therefore a majority of our sampling effort was conducted on the ebb and flow rather than at high or low slackwater (Table 2). No sampling was conducted throughout this study during low slack tide. In 2005, six percent of sampling occurred during high slack tides and the remaining sets were conducted during ebb or flood tides. This pattern was repeated for the remaining two years with 8% and 11% (2006 and 2007, respectively) of sets completed during high slack and all other sets were during periods of tidal movement.

Table 2. Tidal activity during sampling events at Elger Bay. Results are # of sets.

A. 2005

Tide Status	Lagoon	Nearshore	Total
Ebb	19	23	42
Flood	16	15	31
High Slack	5	0	5
Low Slack	0	0	0
Total	**40**	**38**	**78**

B. 2006

Tide Status	Lagoon	Nearshore	Total
Ebb	22	18	40
Flood	14	30	44
High Slack	8	0	8
Low Slack	0	0	0
Total	**44**	**48**	**92**

C. 2007

Tide Status	Lagoon	Nearshore	Total
Ebb	19	36	55
Flood	14	9	23
High Slack	7	3	10
Low Slack	0	0	0
Total	**40**	**48**	**88**

Substrate

Throughout all 3 years sampled substrate did not vary remarkably at the established sites. Mixed fines was the dominant substrate category, followed by mixed coarse. Areas with mud or gravel were negligible (Table 3). Mixed fines were mostly located in the lagoon and mixed course in the adjacent nearshore habitats of Elger Bay. Depending on the year, 65-77% of total mixed fines habitat sampled was located inside the lagoon, while 100% of all mixed coarse habitat sampled was located in the adjacent nearshore. Most sites sampled did not contain vegetation, although a small percentage was colonized by green algae.

Table 3. Substrate composition of areas seined at Elger Bay. Results are # of sets.

A. 2005

Substrate	Lagoon	Nearshore	Total
Gravel	0	3	3
Mixed Coarse	0	23	23
Mixed Fines	40	12	52
Mud	0	0	0
Total	**40**	**38**	**78**

B. 2006

Substrate	Lagoon	Nearshore	Total
Gravel	0	0	0
Mixed Coarse	0	25	25
Mixed Fines	44	23	67
Mud	0	0	0
Total	**44**	**48**	**92**

C. 2007

Substrate	Lagoon	Nearshore	Total
Gravel	0	3	3
Mixed Coarse	0	24	24
Mixed Fines	37	20	57
Mud	3	1	4
Total	**40**	**48**	**88**

Water Quality

Salinity

Surface salinity inside the lagoon ranged from 8.0 to 29.3 ppt over the 3 years sampled (Table 4, Figure 4). Adjacent to Elger Bay, surface salinity ranged from 16.4 to 29.5. Yearly salinity averages were slightly lower inside the lagoon compared to adjacent nearshore habitats, however this was not always observed in every month sampled. Bottom salinities followed a similar overall pattern. Variations in salinity also followed a weak seasonal pattern each year where lower salinities occur in the early winter months and higher salinities are observed in the late spring. Freshwater input into the system, such as nearby riverflow, could also contribute to lower salinities in and near Elger Bay.

Table 4. Salinity ranges (ppt) for the lagoon and adjacent nearshore sites at Elger Bay, taken 15 cm below the surface and 15 cm from the bottom.

Location	2005 min	2005 max	2006 min	2006 max	2007 min	2007 max
Surface – Lagoon	14.0	29.3	8.0	25.6	15.5	24.1
Surface – Adjacent Nearshore	18.4	29.5	16.5	25.7	17.6	25.7
Bottom – Lagoon	18.3	29.3	13.6	25.5	15.4	24.1
Bottom – Adjacent Nearshore	18.5	29.5	18.1	25.2	17.6	25.7

Volunteers studying fish sampled at Elger Bay.

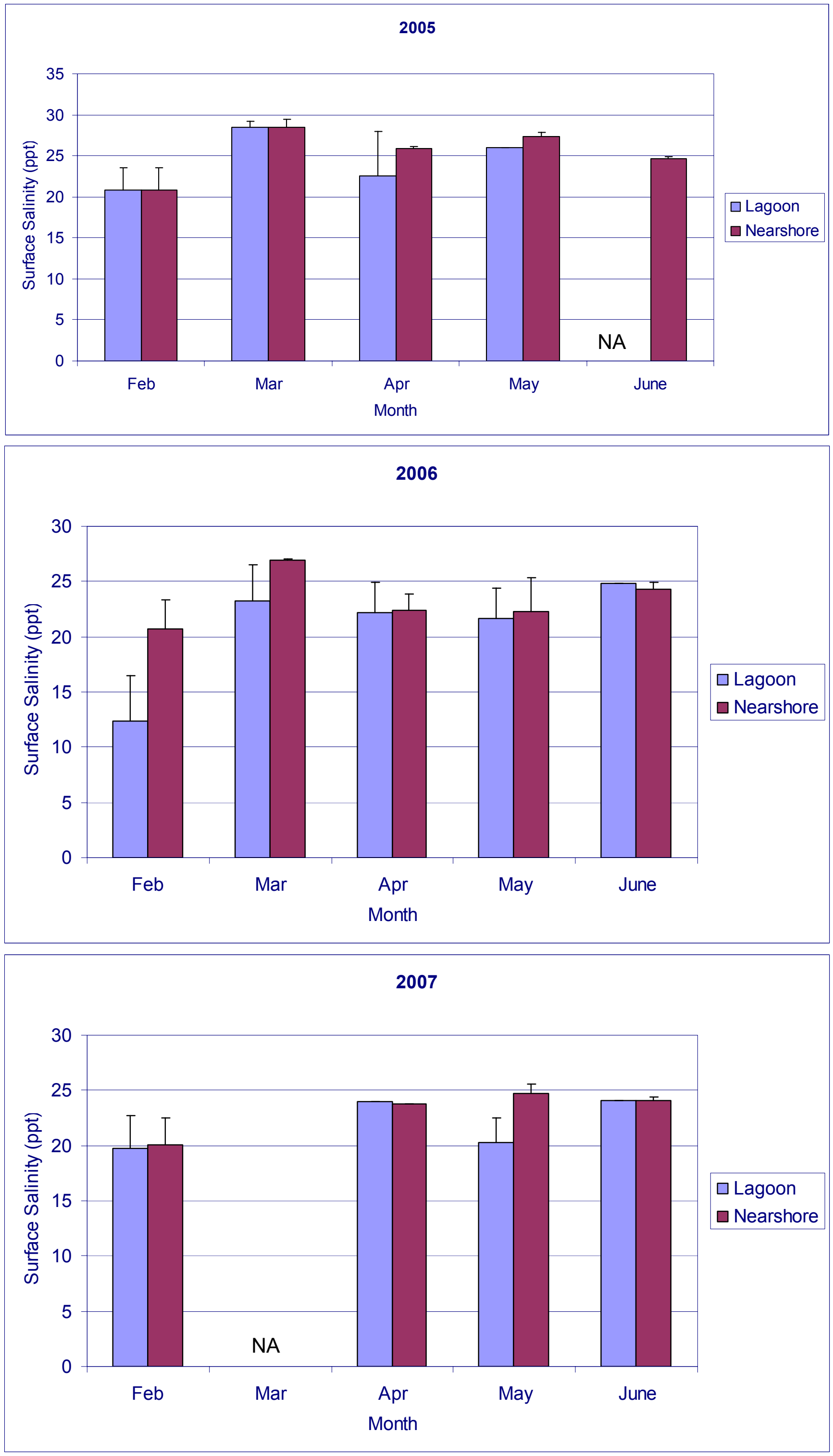


Figure 4. Salinity (ppt) in the nearshore and lagoon habitat of Elger Bay. Results are monthly averages of surface salinity measured during beach seine sampling and graphed for individual years
(NA = data not available)

Temperature

Water temperatures ranged from 5.7 – 23.7°C (Table 5, Figure 5). Throughout the study, variation in temperature followed a typical seasonal pattern of increase from winter through late spring/summer. Over all the years examined, water temperatures (at both the surface and the bottom) displayed a similar seasonal pattern in both the lagoon and adjacent nearshore habitat. Temperature inside the lagoon became generally higher than adjacent waters in the late spring/early summer, as exhibited by the disparity of temperatures between the sites for these later months as shown in Figure 5.

Table 5. Temperature ranges (°C) for the lagoon and adjacent nearshore sites of Elger Bay, taken 15 cm below the surface and 15 cm from the bottom.

Location	**2005 min**	**2005 max**	**2006 min**	**2006 max**	**2007 min**	**2007 max**
Surface – Lagoon	7.1	19.1	5.7	23.7	7.4	18.5
Surface – Adjacent Nearshore	7.4	18.1	6.3	15.7	7.5	15.2
Bottom – Lagoon	6.9	17.7	5.7	23.7	7.4	19.0
Bottom – Adjacent Nearshore	7.4	17.1	6.3	15.5	7.5	14.7

Volunteers beach seining at Elger Bay.

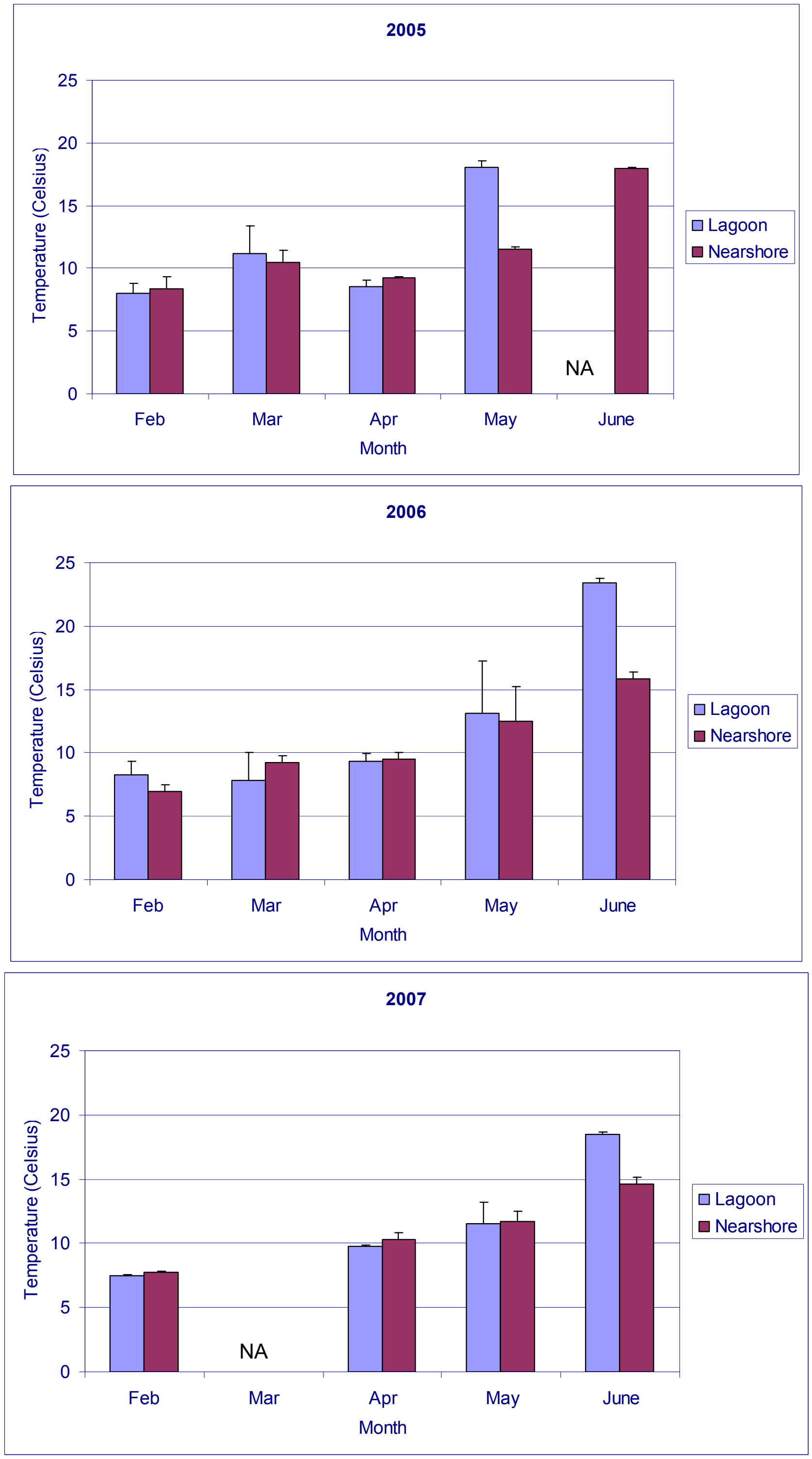


Figure 5. Temperature (°C) in the nearshore and lagoon habitat of Elger Bay. Results are monthly averages of surface temperature measured during beach seine sampling and graphed for individual years.
(NA = data not available)

Dominant Fish Assemblages

We caught over 16,900 fish (2860, 6679, and 7369 in 2005, 2006, and 2007, respectively) representing 20 different species. The most prevalent species were pink salmon, chum salmon, shiner perch and Pacific staghorn sculpin (Figure 6). In 2007, adult sandlance contributed over 12% of the total catch for the year. Unlike other pocket estuaries from surrounding areas where smelt and arrow goby make up a significant portion of the catch, very few of either species were collected from the Elger Bay sites. Catch per unit effort (CPUE) results for each species per year per area (lagoon or nearshore) is shown in Table 6. In 2005 more fish were caught inside the lagoon than from the adjacent nearshore. This pattern was dominated by large numbers of shiner perch entering the lagoon. In 2006, an abundance of pink salmon caught in the nearshore led to higher total numbers of fish captured from the nearshore when compared to catches in the lagoon. Large numbers of chum collected from the adjacent nearshore led to a similar pattern in 2007, with fewer total numbers of fish captured from the lagoon when compared to adjacent nearshore catches.

Fish catches were separated by month, year, and species to evaluate the timing abundance and assembly of fish communities using Elger Bay. It is interesting to note that for all three years sampled, Pacific staghorn sculpin and shiner perch were always captured in greater numbers inside the lagoon than in the adjacent nearshore area (Figure 7). Elger Bay is similar to other pocket estuaries, displaying a “changing of the guard” in the dominant nearshore fish species. At some time during the spring, the juvenile salmon-dominated fish community typically begins to give way to a shiner perch dominated community. Shiner perch, found throughout the Puget Sound region, show up in large schools in shallow nearshore areas in late spring for birthing where they stay through summer before retreating to deeper marine waters during winter months. This is possibly driven by seasonally elevating water temperatures and the increasing size of juvenile salmon as they presumably “outgrow” shallow lagoon habitat, and could be confirmed by sampling throughout the summer months.

Volunteers sampling water conditions.

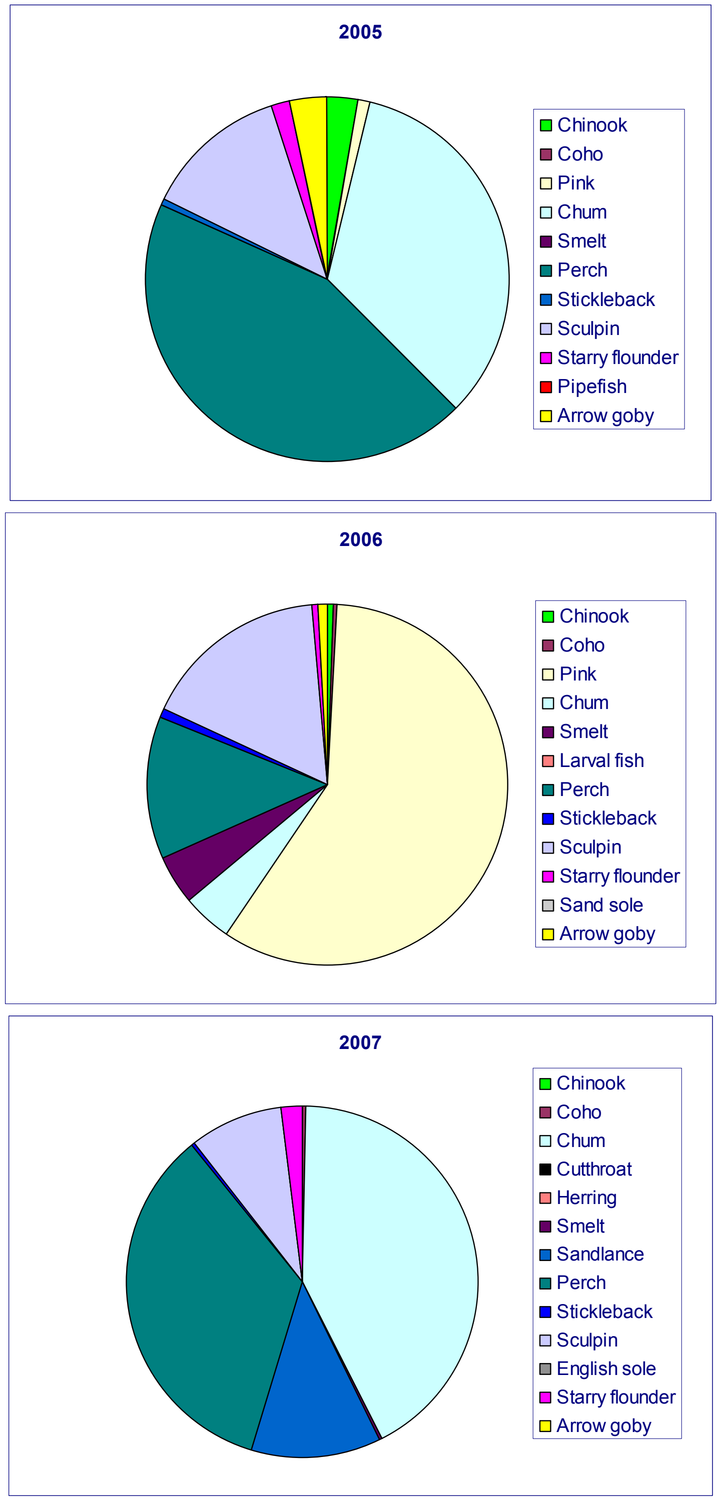


Figure 6. Percentage of individuals collected per species and graphed by individual year.

Table 6. Catch per unit effort (CPUE) of fish captured from inside the lagoon and the adjacent nearshore of Elger Bay per year (# of each species caught/# of sets per year per area). Numbers in parentheses represent total number of fish caught *(n)*.

Common Name	2005 Lagoon	2005 Nearshore	2006 Lagoon	2006 Nearshore	2007 Lagoon	2007 Nearshore
Chinook 0+, unmarked	1.65 *(66)*	0.26 *(10)*	0.52 *(23)*	0.02 *(1)*	0.13 *(5)*	
Chinook 1+, marked		0.03 *(1)*				0.02 *(1)*
Coho salmon, all		0.03 *(1)*	0.25 *(11)*	0.08 *(4)*		0.19 *(9)*
Pink salmon	0.18 *(7)*	0.68 *(26)*	5.45 *(240)*	76.85 *(3689)*		
Chum salmon	4.83 *(193)*	20.21 *(768)*	2.23 *(98)*	4.13 *(198)*	5.68 *(227)*	60.25 *(2892)*
Cutthroat trout						0.02 *(1)*
Herring, adult						0.04 *(2)*
Smelt, adult						0.13 *(6)*
Smelt, post-larval		0.05 *(2)*		5.71 *(274)*	0.03 *(1)*	0.06 *(3)*
Smelt, unidentified		0.03 (1)		0.35 (17)		18.38 (3)
Larval fish				.08 (4)		
Sandlance, adult					0.03 *(1)*	18.38 *(882)*
Pile perch						1.06 *(51)*
Shiner perch	25.65 *(1026)*	6.18 *(235)*	18.09 *(796)*	1.40 *(67)*	35.73 *(1429)*	22.19 *(1065)*
Threespine stickleback	0.25 *(10)*	0.08 *(3)*	0.73 *(32)*	0.27 *(13)*	0.13 *(5)*	0.27 *(13)*
Sharpnose sculpin				0.02 *(1)*		0.13 *(6)*
Pacific stag-horn sculpin	6.15 (246)	3.05 (116)	23.09 (1016)	2.27 (109)	12.3 (492)	2.58 (124)
Unidentified sculpin	0.1 *(4)*			0.02 *(1)*		0.04 *(2)*
English sole						0.15 *(7)*
Starry flounder	0.55 *(22)*	0.63 *(24)*	0.64 *(28)*	0.19 *(9)*	1.55 *(62)*	0.02 *(77)*
Sand sole				0.02 (1)		
Bay pipefish		0.03 *(1)*				
Arrow goby	24.25 *(97)*	0.03 *(1)*		0.98 *(47)*		0.06 *(3)*

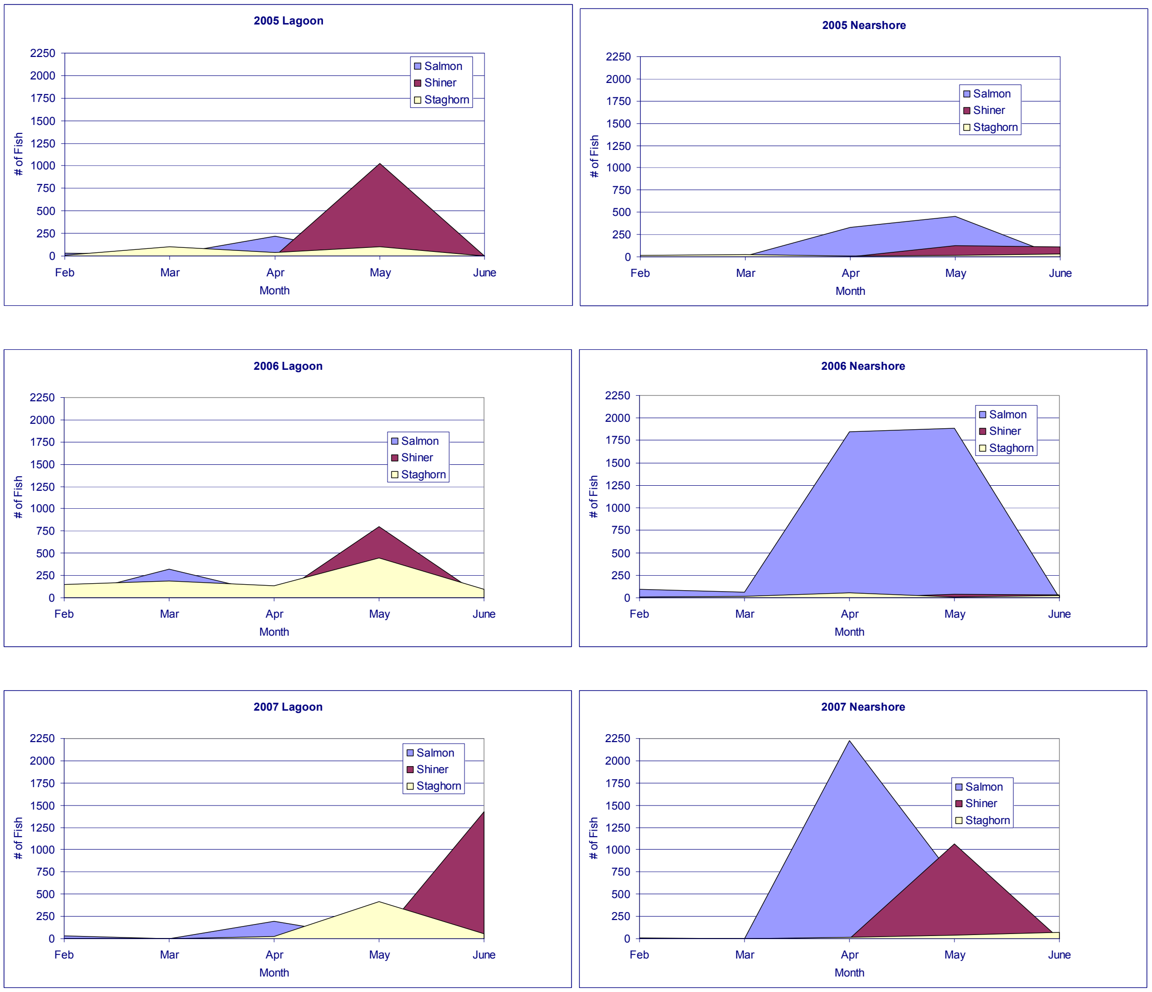


Figure 7. Number of individuals of the three most prevalent types of fish captured inside the lagoon and from the adjacent nearshore of Elger Bay per month and graphed by individual year.
Note: we did not sample in March 2007 due to storm events.

Juvenile Salmon Assemblages

Pink salmon

In years when present, pink salmon were more abundant in the nearshore habitat than in the lagoon area sampled. Pink salmon were captured in 2005, but a significantly higher number were captured in 2006 (Figure 8). This is the result of the odd year dominance of returning adult pink salmon to Puget Sound rivers. Juvenile pink salmon typically peaked in April through early May and were gone by the end of May. In 2006 pink salmon were found both in the lagoon and adjacent nearshore areas of Elger Bay, but were more abundant in the adjacent nearshore habitat. In 2006 sizes of pink salmon both inside the lagoon and in the adjacent nearshore increased throughout the season on average more than 5 mm (Figure 9).

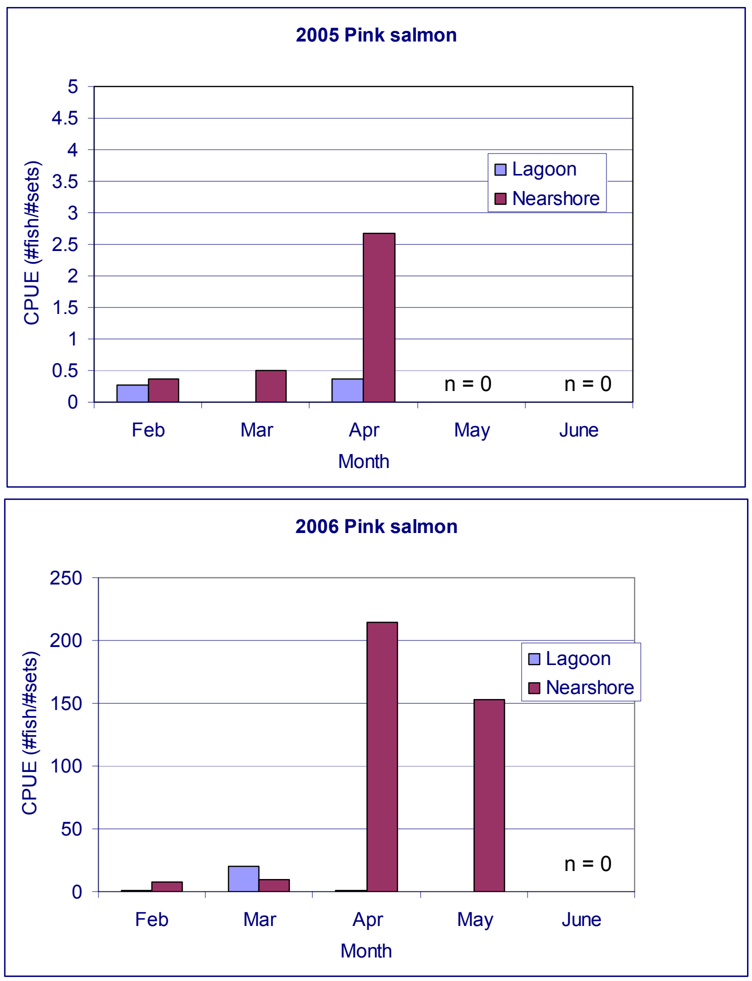
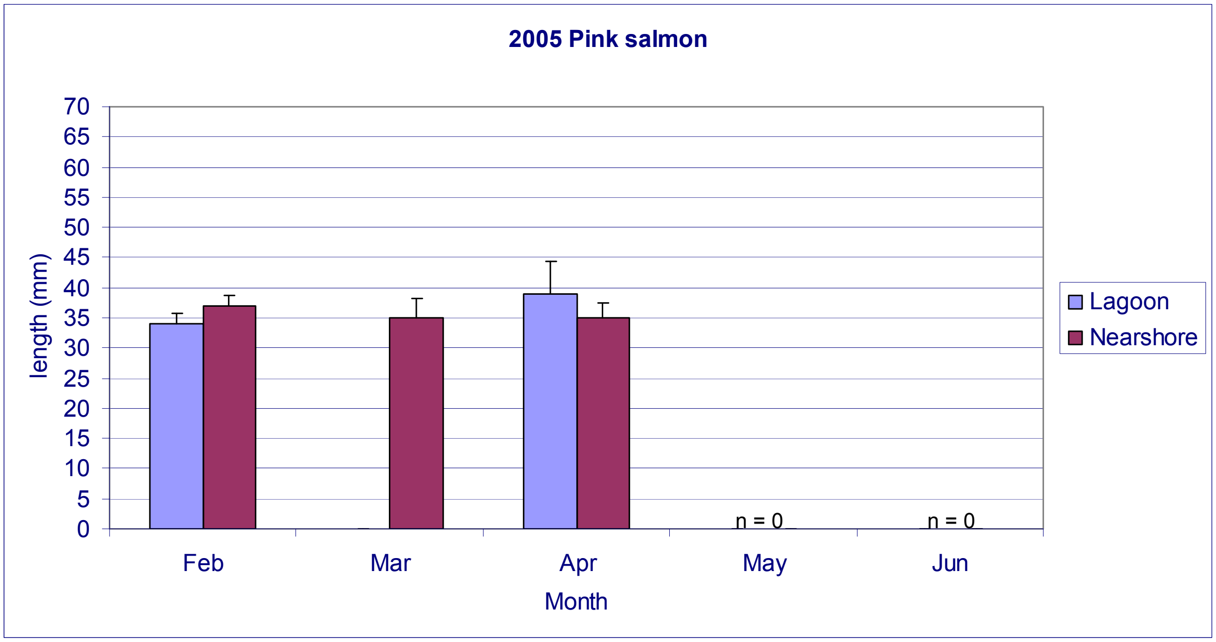


Figure 8. Catches of pink salmon over time by location (expressed as catch per unit effort or CPUE). Note different Y-axis scales for 2005 and 2006. *Note: no pink salmon were captured in 2007.*



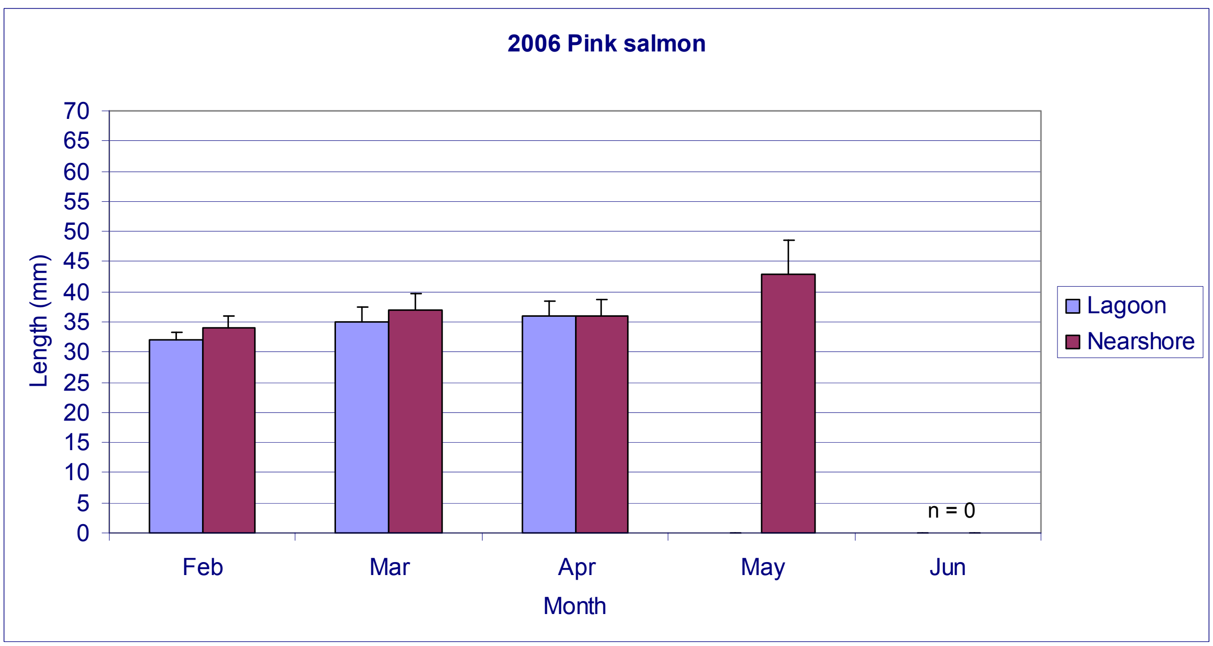


Figure 9. Average (mean) lengths (mm ± stdev) of pink salmon over time by location per year for Elger Bay.
Note: no pink salmon were captured in 2007.

Chum salmon

Chum salmon were captured every year, typically peaking in April (Figure 10). Chum salmon began to arrive in February each year and were gone by the end of May. Although the number of chum captured was very low, there were more collected inside the lagoon early in the year (February and March). Later in the year (April and May) and over the entire sampling period more chum salmon were captured in the adjacent nearshore habitat. All the chum salmon collected from both areas appeared to be fry-sized; larger fry were collected from both habitats as each season progressed (Figure 11).

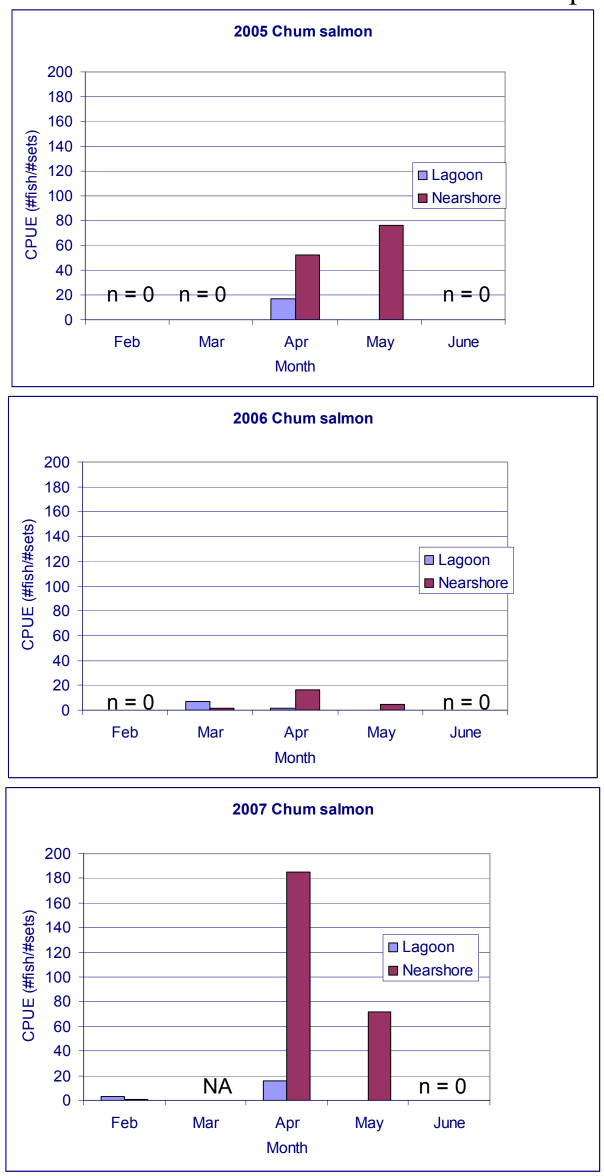


Figure 10. Catches of chum salmon over time by location (expressed as catch per unit effort or CPUE).
Note: we did not sample in March 2007 due to storm events.

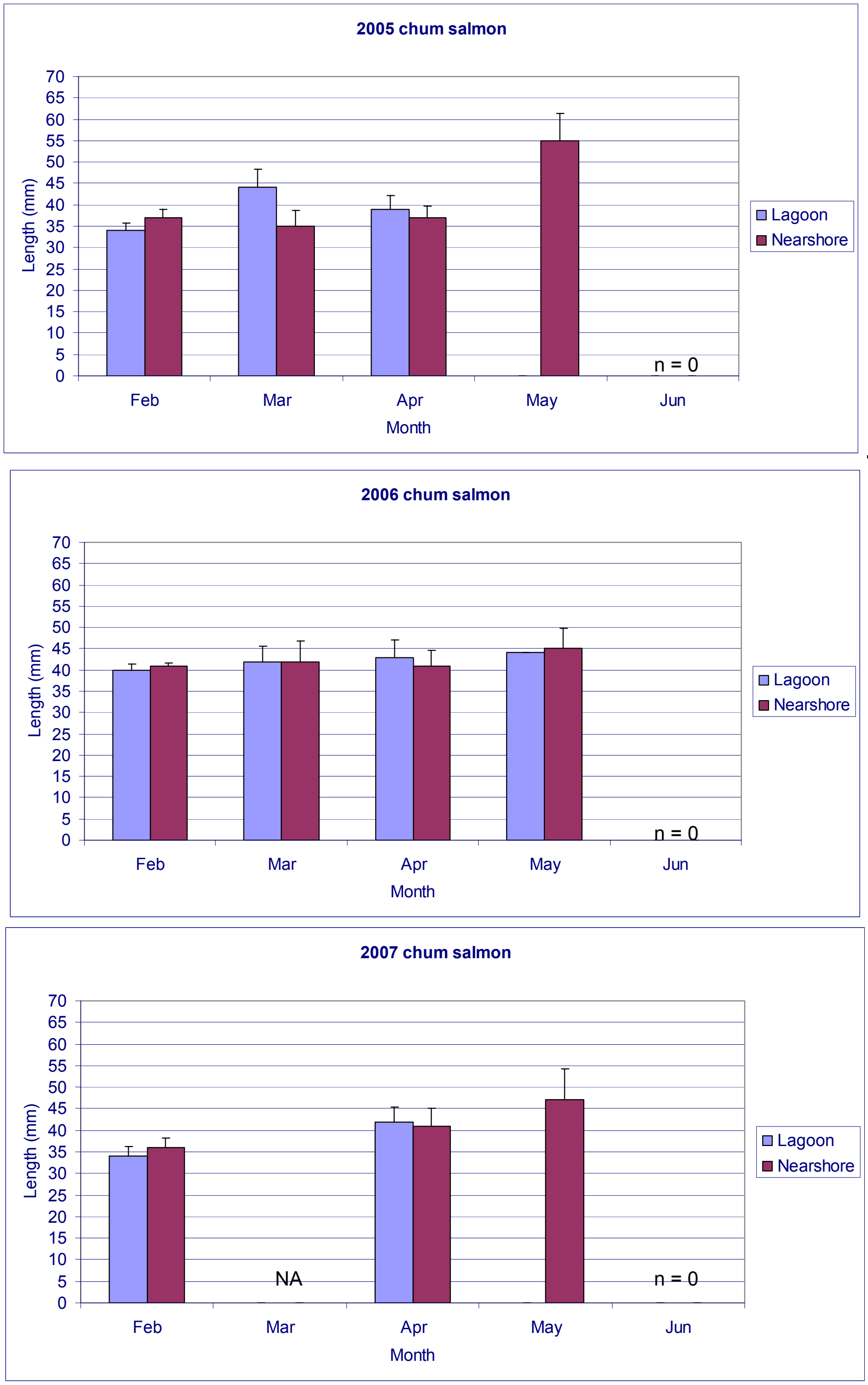


Figure 11. Average (mean) lengths (mm ± stdev) of chum salmon over time by location per year for Elger Bay.
Note: we did not sample in March 2007 due to storm events.

Coho salmon

Very few coho salmon were collected during this three-year period. Eleven fry sized unmarked coho salmon were collected inside the lagoon in March of 2006 (average fork length 44.9 mm +/- 4.28 mm) and fourteen coho salmon were collected from the adjacent nearshore sites in May 2005, May 2006, and May 2007 combined. Coho salmon collected in May of 2006 averaged 89.3 mm +/- 5.69 mm. The single coho salmon collected from the adjacent nearshore in May 2005 was 39 mm long. In 2006 and 2007 the remaining coho salmon collected in May were much larger and presumed to be yearling fish, with average fork lengths of 89.3 mm ± 5.68 mm and 105.2 mm ± 18.63 mm, respectively. Only a single hatchery adipose-clipped coho salmon was captured throughout this study. The observation of fry sized coho salmon within lagoon habitat of Elger Bay is evidence of non-natal use of this pocket estuary by coho salmon.

Chinook salmon

Wild Chinook salmon were captured every year (Figure 12). Wild Chinook salmon were found in February and were usually still present in May and June, depending on the year. Wild Chinook salmon peaked in different months in different years. In every year, Chinook salmon displayed a strong preference for lagoon versus adjacent nearshore habitat. Chinook salmon inside the Elger Bay lagoon tended to be larger than fish from the adjacent nearshore (Figure 13). Two adipose-clipped coded wire tag hatchery fish were also collected, representing <2% of the total Chinook salmon catch and far less than <1% of the total salmon catch. One of these hatchery fish was from the adjacent nearshore in June 2005 (fork length 98 mm) and the other was also collected from the nearshore of Elger Bay in May 2007 (fork length 98 mm). Juvenile Chinook salmon abundance varied by year and is largely explained by fluctuations in the size of Skagit River's outmigrating juvenile Chinook salmon population (Beamer et al. 2005 and 2006). In 2005 and 2006, 4.5 and 6.2 million wild juvenile Chinook salmon outmigrated from the Skagit River respectively (Kinsel et al. 2007), while in 2007 only 1.7 million wild juvenile Chinook salmon outmigrated (Kinsel pers. comm. 2007).

Volunteers sampling.

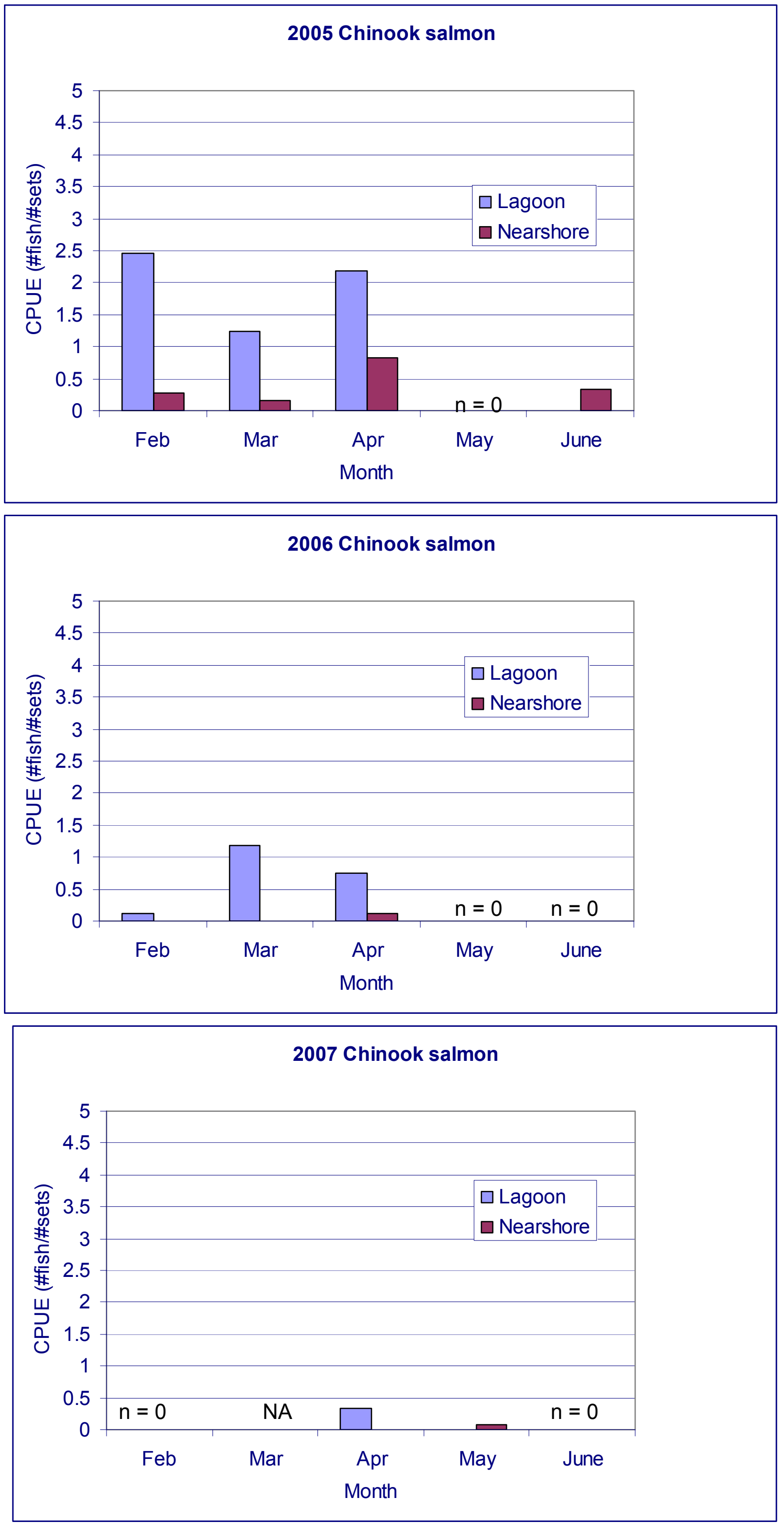
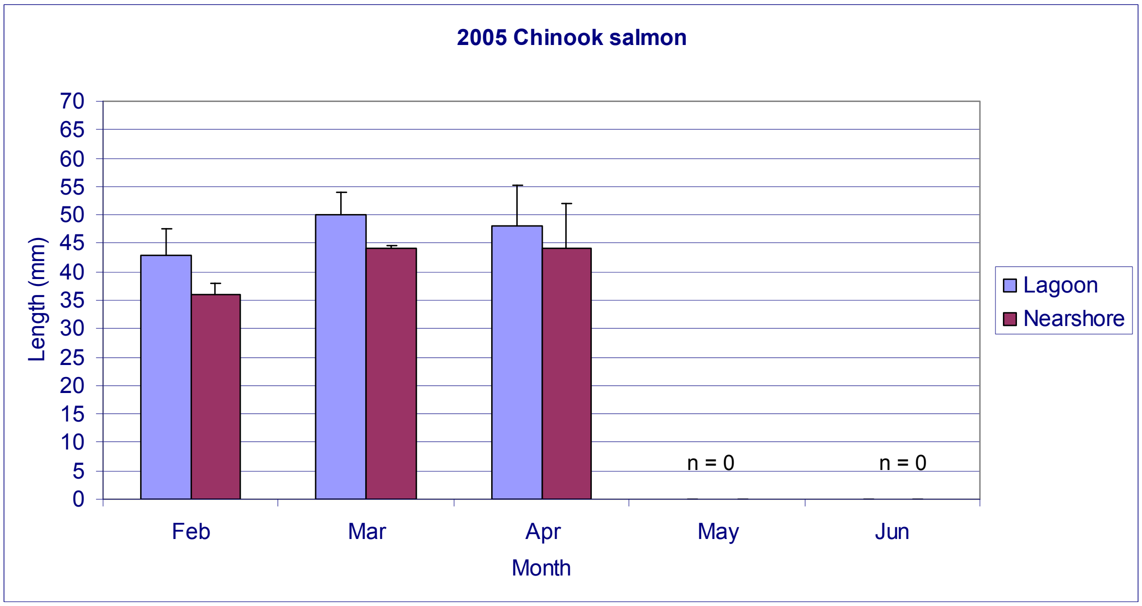


Figure 12. Catches of Chinook salmon over time by location (expressed as catch per unit effort or CPUE).
Note: we did not sample in March 2007 due to storm events.



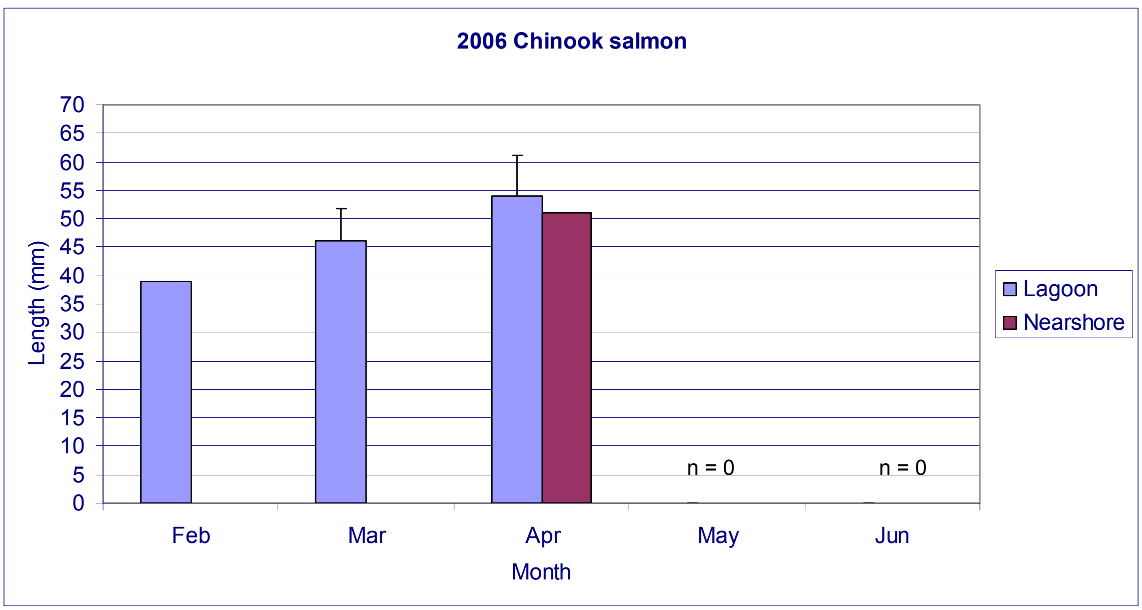


Figure 13. Average (mean) lengths (mm ± stdev) of Chinook salmon over time by location per year for Elger Bay.

Summary Statement

The results of this study can be used to inform local citizens about fish populations currently using Elger Bay lagoon and adjacent nearshore waters. The results may also be useful to Island County or other agencies and groups interested in Puget Sound salmon recovery or nearshore fish ecology.

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