

**JUVENILE SALMON AND NEARSHORE FISH USE IN SHALLOW INTERTIDAL HABITAT  
ASSOCIATED WITH CORNET BAY RESTORATION, 2013**



2006 oblique aerial photo of Cornet Bay Day Use Area (photo WA Department of Ecology).  
2012 restoration area in red box

**Data collection by:**

Jim Somers, Ken Urstad, Tom Albrecht, Kurt Buchanen, Lee Chavez, Lori Clark,  
Finn Gatewood, Bob Gentz, Jill Hein, Russ Holmes, Mary Hulbert, Cheryl Lowe, Brynn  
McIntyre, Melissa Merickel, Dawn Pucci, Kristin Rine, Gary Skorheim, Terry Skorheim,  
Kestutis Tautvydas, Tom Vos

Island County Marine Resources Committee Juvenile Salmon Seining Project  
PO Box 5000; Coupeville WA 98239

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Report compiled for Island County Marine Resources Committee by  
Sarah Schmidt, 243 Rhodena Drive, Coupeville, WA 98239

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## CORNET BAY RESTORATION PROJECT

### Background

The marine waters of Island County provide valuable rearing and feeding grounds for juvenile salmon and serve as a migration corridor for adult salmon leaving and returning to their natal streams. The nearshore and beaches of Island County also provide spawning habitat for forage fish, such as surf smelt and herring, that salmon eat during various life stages.<sup>1</sup>

Cornet Bay is in the highest priority Geographic Area 1 in the WRIA 6 Salmon Recovery Plan. This area includes shorelines within ~5 miles of the mouths of the Skagit, Stillaguamish, and/or Snohomish rivers. The shorelines in Area 1 are used by the largest number of Chinook fry migrants from these rivers. Cornet Bay is located along the shortest path between those river-mouths and the open ocean (Figure 1). The WRIA6 Salmon Recovery Plan identifies the nearshore and pocket estuaries of Whidbey Basin as an immediate priority for conservation and restoration. Pocket estuaries are important habitat for juvenile Chinook salmon. The WRIA6 plan specifies Cornet Bay as an important refuge along a major migratory corridor for 6 of the 22 Puget Sound Chinook ESU populations.<sup>2</sup>

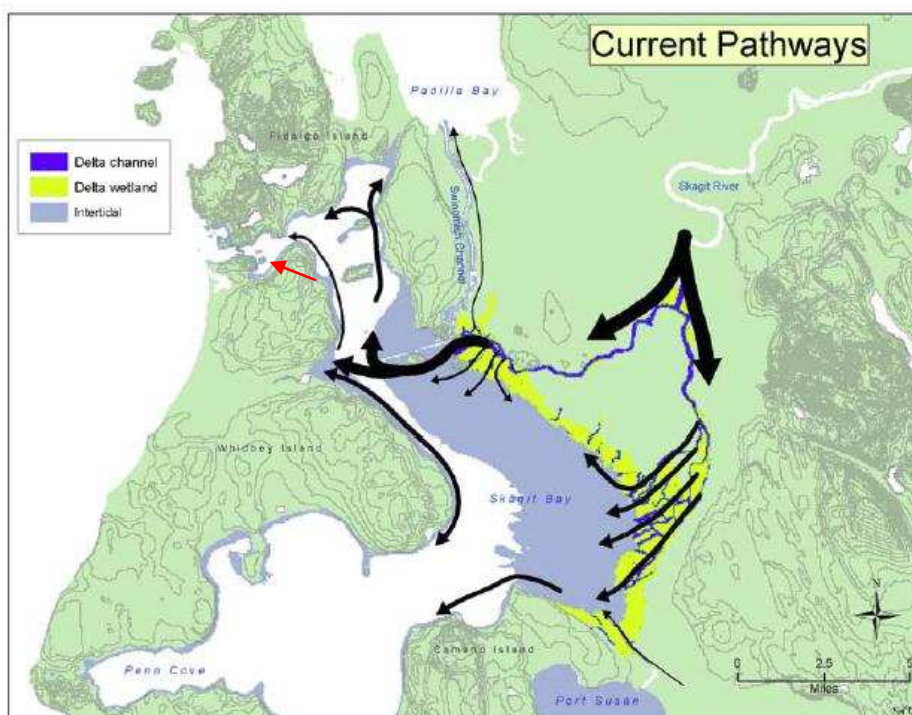


Figure 1. Juvenile Chinook salmon migration pathways in the Skagit delta. (Red arrow points to Cornet Bay and the vicinity of this study.) The arrow directions depict how juvenile Chinook salmon move through delta habitat and into Skagit Bay. Arrow thickness represents the number of juvenile Chinook salmon using each pathway based on current habitat amount and configuration. Wider arrows represent more fish than narrow arrows. (Excerpted from Skagit Chinook Recovery Plan, 2005. Appendix E: Intensively Monitored Watersheds Plan; Correigh and Beamer. “Monitoring of population responses by Skagit River Chinook salmon to estuary restoration.”)

<sup>1</sup> Redman, Scott, et al. 2005.

<sup>2</sup> WRIA 6 (Whidbey & Camano Islands) Multi-Species Salmon Recovery Plan, 2005.

In 2006, the Island County Marine Resources Committee secured grant funding to initiate a shoreline restoration project in Island County. The objectives were to improve nearshore habitat for use by multiple species including listed salmon and forage fish and to build awareness of the importance of nearshore habitat and forage fish to the recovery of salmon in Puget Sound.

The site selected was the Cornet Bay day use area of Deception Pass State Park. As has occurred on a large percentage of greater Puget Sound shoreline, in the day use area shoreline habitat processes have been disrupted by structures, bulkheads and lack of riparian vegetation (Figure 2). Anticipated elements of restoration included removing creosote contaminated bulkheads that extended well below the high tide line, removing imported fill covering the upper intertidal zone, re-establishing forage fish spawning habitat and native vegetation, and restoring sediment transport processes. Finally, the project would be a vehicle for increasing public understanding of the importance of nearshore habitat restoration to salmon recovery. The restoration area includes one of the most used boat launch sites in the state parks system. Outreach for this project will reach thousands of Washington residents.



Figure 2. The red box on this 2006 photo outlines the area selected for restoration. It contains four boat launch ramps, a T-shaped public pier used for mooring boats and for fishing, and on the right a Washington State Parks' Marine Crew maintenance pier, closed to the public. The shoreline had been armored with over 600 feet of creosote-contaminated bulkhead which held in place tons of fill imported in the 1970s, covering the upper intertidal beach. The fill created a flat bench planted with grass.

### **Restoration Activities, 2012-2013**

Following a feasibility study, project design, and acquisition of permits and funding, the beach restoration was completed this past year.

In autumn 2012, 65.1 tons (approximately 750 feet) of creosote bulkhead were removed and transported to an approved disposal site, and 79.68 tons of contaminated fill was separated from clean fill and also transported to an approved disposal site. Clean fill was screened; some was

reused and most stored elsewhere in the Park for later use. 1,200 tons of beach spawning gravel was imported and placed on the beach, and the beach was graded to a natural slope.

Upland areas were ripped to 10 inches and amended with three inches of compost. Planting took place in November 2012 and April 2013. The lower shoreline was planted with native grasses, rushes and perennials, and upland zones with a variety of species of native shrubs and trees.

In all, 1.24 acres of beach and upland were restored to natural elevation and substrate mix and 24,000 square feet was planted with native vegetation.

Appendix B documents the restoration actions with paired photographs.

### PURPOSE OF FISH SURVEYS

A 2009 assessment conducted by the Skagit River System Cooperative noted that Cornet Bay nearshore areas likely offer similar habitat functions as a pocket estuary because they are enclosed within the bay and protected from wave energy. Cornet Bay likely provides a critical refuge from the nearby high energy waters of Deception Pass for outmigrating juvenile salmon (Figure 3).<sup>3</sup>

Cornet Bay harbors extensive eelgrass meadows and kelp beds, which along shoreline habitats provide forage and shelter for salmon fry after they leave their natal estuary and before they venture through Deception Pass. These habitats should also support forage fish species such as surf smelt, sandlance and Pacific herring.



Figure 3. Satellite photo showing Deception Pass Bridge upper left and Cornet Bay lower center. Yellow line indicates approximate boundary of Cornet Bay. Red box delineates area of Island County MRC's Shoreline Restoration Project, in Deception Pass State Park..

The Island County Marine Resources Committee is working on this project collaboratively with WSU Beach Watchers, the Northwest Straits Foundation, and Washington State Parks. Seining surveys at Cornet Bay began in 2009 to document the fish assemblage living along the shoreline of the proposed restoration action. Of ten sampling sites, four were established along natural beach northeast of the armored shoreline, four along beach armored with creosote bulkheads extending into the intertidal zone, and two along the southwest portion of the day use area, which is not armored but where natural conditions have been altered with fill to build up the road bed and to create a grassy picnic area.

<sup>3</sup> Skagit River System Cooperative, 2009.

As part of the characterization process of the bay prior to nearshore habitat enhancement projects at this location, the project partners also instituted studies of eelgrass coverage, forage fish spawn, and beach elevation and composition. Appendix A discusses results to date from the surveys for forage fish eggs.

This report is meant to inform local citizens and Cornet Bay project partners about fish populations currently using the Cornet Bay area. Four years of pre-restoration fish surveys formed a basis for measuring fish species composition and relative abundance along the altered shoreline at the Cornet Bay day use area and adjacent natural nearshore habitat.<sup>4</sup> This report examines the results of seining surveys conducted in February-June 2013, the fifth sampling season and the first after restoration. At least three more years of post-restoration surveys are anticipated.

### **MONITORING HYPOTHESES**

Initially the purpose of the seining surveys was to establish a baseline picture of fish use of the shoreline in the proposed restoration area, with a focus on juvenile salmon. For the purposes of restoration monitoring, however, a study is ideally designed to test hypotheses about the results of the restoration actions. Although this was not done in the present study, there were some unstated hypotheses that could be tested with existing and future data.

If as speculated Cornet Bay does mimic some of the forage and shelter functions of a pocket estuary, one might expect a higher abundance of juvenile salmon than along a comparable length of nearby, less protected shoreline. This can be tested with the hypothesis:

1. Juvenile salmon are more abundant in Cornet Bay nearshore habitat than along open shoreline on the east side of Whidbey Island.

With the assistance of the Skagit River System Cooperative, we are in the process of testing this statistically on the four years of accumulated Cornet Bay data in comparison with other SRSC surveys along the shorelines of Skagit Bay.

Additionally, the sampling sites along “natural” beach were essentially selected as control variables—locations where the beach would be the same before and after restoration, as compared with the shoreline proposed for restoration area. The selection of natural and altered sites reflected two hypotheses which we plan to test statistically in the future. For the study area of the Cornet Bay Restoration Project:

2. Fish utilizing shallow shoreline habitats along natural and altered sites are different before restoration.
3. Fish utilizing shallow shoreline habitats along natural and altered sites are the same after restoration.

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<sup>4</sup> Keystone Ecological (2009) and Schmidt (2010, 2012, 2013)

## STUDY AREA

Cornet Bay is located on the northern shoreline of Whidbey Island, in Deception Pass (Figure 4). This bay is located behind Ben Ure Island on the south shoreline of Deception Pass. The bay shoreline has been developed with boating and other recreational facilities; a road along the shoreline; and residences.

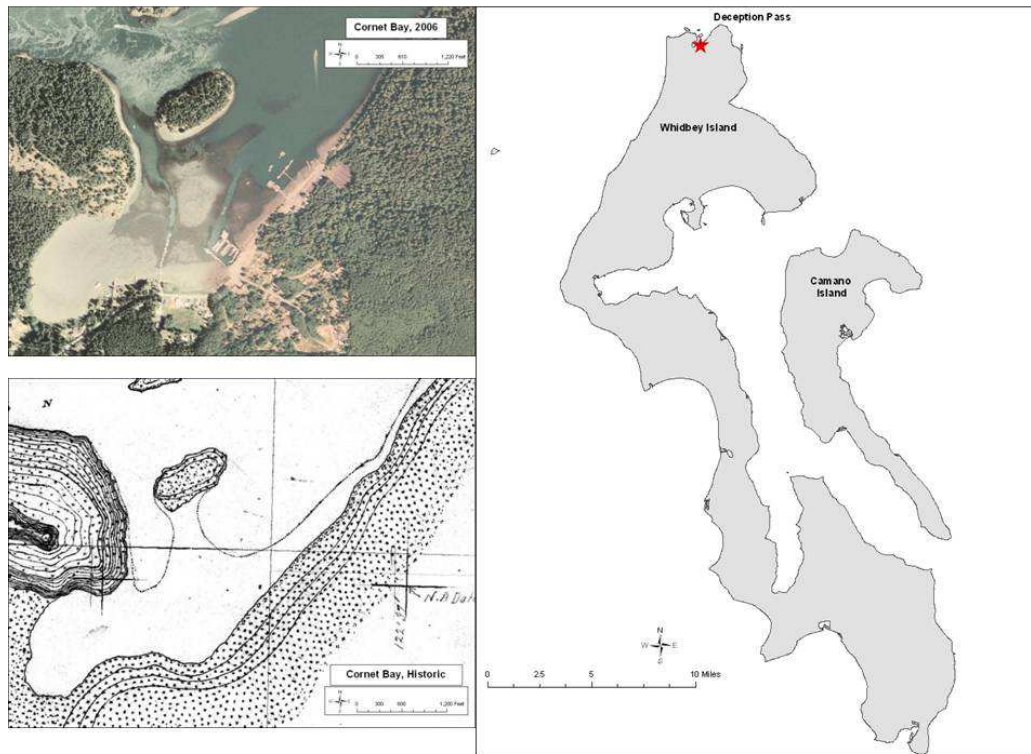


Figure 4. Location of Cornet Bay on north Whidbey Island, along with contemporary (2006) and historic (1871) views of the site. 2006 view from aerial photo, National Agriculture Imagery Program. Historic view from T-sheet 1252 (U.S. Coast and Geodetic Survey), available at the Puget Sound River History Project, University of Washington (<http://riverhistory.ess.washington.edu>).

## METHODS

Small beach seines were used to sample for fish in shallow intertidal areas along the shoreline of the Cornet Bay Day Use Area within Deception Pass State Park.

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 (SRSC Research Department, 2003). 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). 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 5A), and then returning to the shoreline in a half circle. Both ends of the net are then retrieved (Figure 5B), yielding a catch. One beach seine set was made at each site per sampling day. Average beach seine set area is 96 square meters.



Figure 5A. Hauling the net in a floating tote.



Figure 5B. Setting the seine in “round haul” fashion.

For each beach seine set, we identified and counted the catch by species. Fork length was recorded on the first 20 of each species. Fish are released at site of capture (Figure 6). We recorded the time and date of each beach seine set and measured several physical habitat parameters associated with each set, including water temperature, salinity and dissolved oxygen using a YSI meter.

Ten beach seine locations were established at the beginning of the study in 2009 (Figure 7). In 2013 these sites were sampled on nine days from February through June. The sampling sites were selected to compare the fish community, including juvenile salmon, at different sites along Deception Pass State Park’s Cornet Bay day use area that is used for recreation and boating.

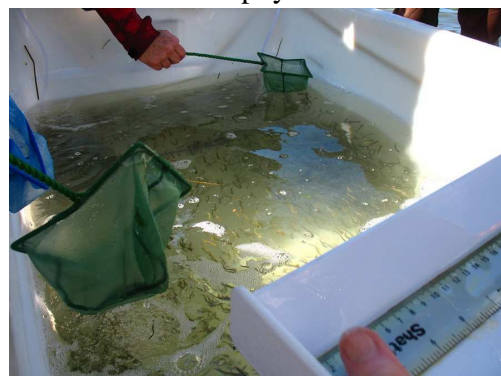


Figure 6. When large numbers of fish are captured in a single set, such as these pink salmon in 2012, they are maintained in aerated water, and released as quickly as possible.



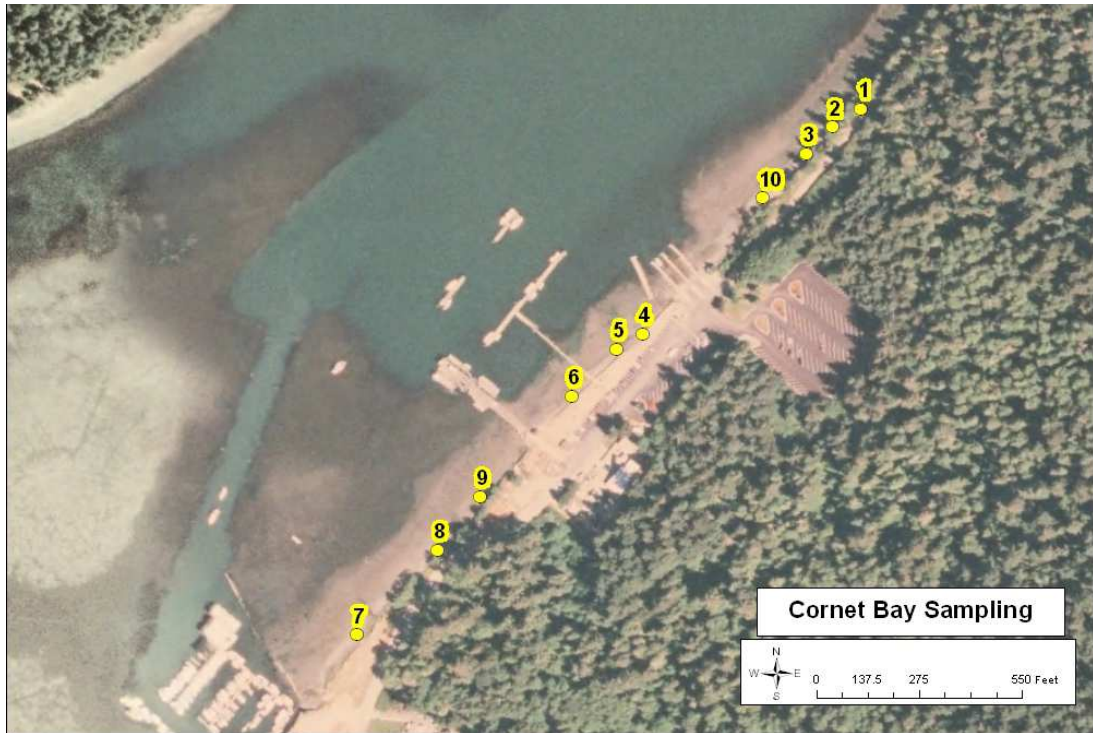


Figure 7. Location of beach seine sites at Cornet Bay. Yellow circles represent sampling sites. Beach seining was always done at the water's edge, independent of tidal stage. In the pre-restoration surveys six sites (#4-9) were along the modified shoreline west of the boat ramps and four (#1-3, 10) were along the natural shoreline east of the boat ramps. Restoration activities in autumn 2012 removed the creosote bulkheads and imported fill and replaced it with a natural beach slope, spawning gravel and native vegetation, so in 2013 sites 4, 5, 6, and 9 are now along restored shoreline.

## RESULTS AND DISCUSSION

### Beach Seine Effort

The Cornet Bay sampling effort in 2013 consisted of 90 beach seine sets made during the March through June time period (Table 1).

Table 1. Summary of beach seine effort (number of sets) at Cornet Bay, 2013.

<i>Sampling effort (number of beach seine sets)</i>	
<u>Month</u>	<u>Seine Sets</u>
February	10
March	30
April	20
May	20
June	10
Total	90

### Environmental Conditions During Beach Seine Sampling

#### Tidal Stage and Water Depth

The majority of beach seine sampling occurred at depths slightly shallower than one meter of water (Table 2). Sampling dates were selected for tides that fell between +9 and +5.

Table 2. Water depth during beach seine sampling at Cornet Bay sites in 2013.

<i>Depth of beach area seined</i>	
Maximum	1.1 meters
Minimum	0.1 meters
Average and 1 standard deviation (in parentheses)	0.9 (0.15) meters

#### Salinity, Temperature, and Dissolved Oxygen

Measurements of salinity, water temperature, and dissolved oxygen during each sampling session are shown in Figures 8A, 8B, and 8C. For each date, measures were recorded at each net set, then averaged for that day.<sup>5</sup>

In 2013 minimum daily salinity measured was 23.0 ppt and the maximum was 30.6 ppt. Water temperature in the Cornet Bay nearshore showed a seasonal increase from March through June.

<sup>5</sup> Because these Cornet Bay salinity, temperature and dissolved oxygen measurements are spot measures taken during the time of beach seining and are not a continuously measured record, they are likely insufficient for determining whether the monthly pattern of salinity for Cornet Bay varies as a function of overall Whidbey Basin salinity, which is known to be strongly influenced by the major rivers flowing into the Whidbey Basin.

Minimum water temperature was 7.7 degrees Celsius and the maximum was 10.5 degrees Celsius. Dissolved oxygen fluctuated between 5.5 mg/L and 8.5 mg/L.

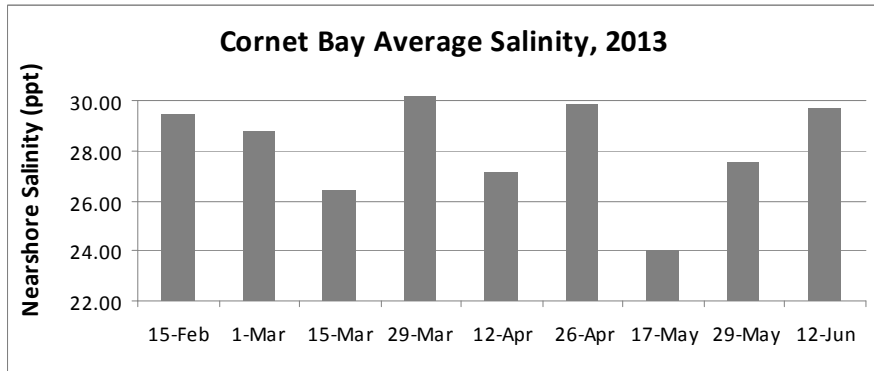


Figure 8A. Average salinity at Cornet Bay beach seine sites during the time of beach seining in 2013.

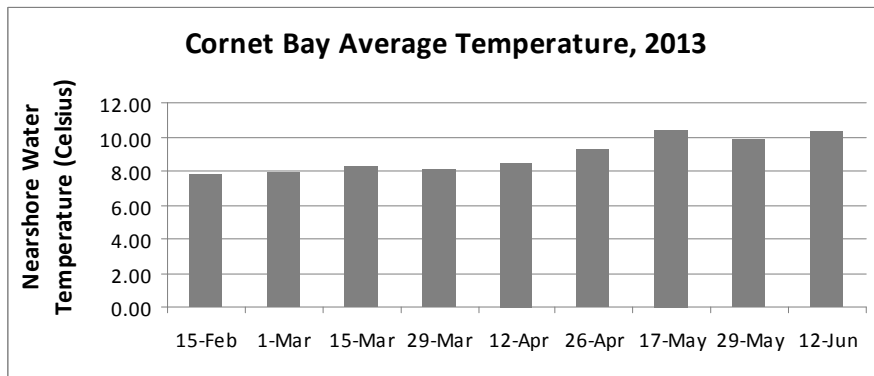


Figure 8B. Average temperature at Cornet Bay beach seine sites during the time of beach seining in 2013.

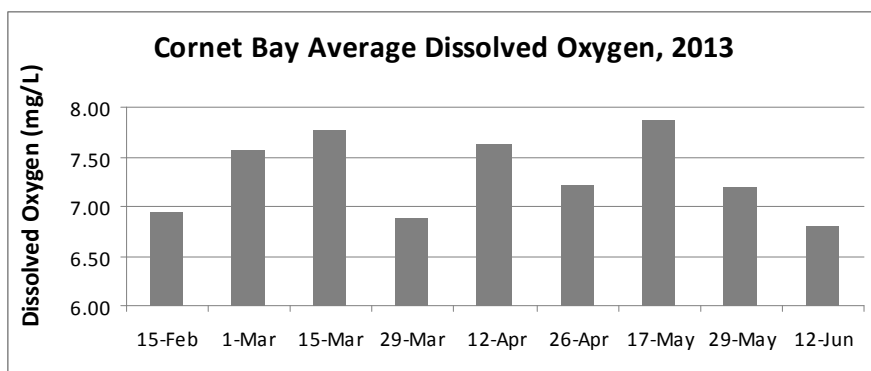


Figure 8C. Average dissolved oxygen at Cornet Bay beach seine sites during the time of beach seining in 2013.

### Catch by Species

We recorded 15,583 fish representing at least 20 different species during the sampling period February through June, 2013 (Tables 3 and 4). Although all species in Table 3 were identified on one or more occasions, accuracy of identification of sculpin, gunnel and flatfish species was variable depending on the knowledge of the crew and the intensity of the catch to be processed on any given day. Therefore for quantitative analysis they are combined under “unspecified” sculpins, flatfish and gunnels.

Juvenile salmon represented over 91% of the total catch (Table 5). The salmon catch was dominated by chum salmon (14,114), but included 71 Chinook, 2 coho, and 2 cutthroat trout.

Less than 8% of the catch consisted of 16 other fish species: sculpins, primarily Pacific staghorn, snake prickleback, gunnels, flatfish and a very small number of the other species.

Table 3. Fish species captured in 2013.

<i>Fish Species</i>
Chinook salmon <i>Oncorhynchus tshawytscha</i>
Chum salmon <i>Oncorhynchus keta</i>
Coho salmon <i>Oncorhynchus kisutch</i>
Cutthroat trout <i>Oncorhynchus clarkii clarkii</i>
Surf smelt, postnatal <i>Hypomesus pretiosus</i>
Sandlance <i>Ammodytes hexapterus</i>
Pacific herring <i>Clupea pallasii</i>
Pacific staghorn sculpin <i>Leptocottus armatus</i>
Silverspot sculpin <i>Blepsias cirrhosus</i>
Sharpnose sculpin <i>Clinocottus acuticeps</i>
Buffalo sculpin <i>Enophrys bison</i>
Great sculpin <i>Myoxocephalus polyacanthocephalus</i>
Threespine stickleback <i>Gasterosteus aculeatus</i>
Starry flounder <i>Platichthys stellatus</i>
Snake prickleback <i>Lumpenus sagitta</i>
Whitespot Greenling <i>Hexagrammos stelleri</i>
Pipefish sp. <i>Syngnathus</i> sp.
Penpoint gunnel <i>Apodichthys flavidus</i>
Saddleback gunnel <i>Pholis ornate</i>
Shiner perch <i>Cymatogaster aggregate</i>

Table 4. Total fish catch by species at Cornet Bay sites in 2013. (Mean catch per beach seine set is in parentheses; there were 90 sets.)

<i>Fish species</i>	<i>Nearshore catch</i>	
<u>Juvenile salmonids:</u>		
Chinook salmon <i>Oncorhynchus tshawytscha</i>	71	(0.8)
Chum salmon <i>Oncorhynchus keta</i>	14,114	(156.8)
Coho Salmon <i>Oncorhynchus kisutch</i>	2	(<0.1)
Cutthroat trout <i>Oncorhynchus clarkii clarkii</i>	2	(<0.1)
<b>Total juvenile salmonids</b>	14,189	( )
<u>Sculpin species:</u>		
Unspecified sculpin	784	(8.7)
<u>Flatfish species:</u>		
Unspecified flatfish	94	(1.0)
<u>Forage fish species:</u>		
Sandlance <i>Ammodytes hexapterus</i>	3	<0.1)
Surf smelt (P.L.) <i>Hypomesus pretiosus</i>	16	(0.1)
Pacific herring <i>Clupea pallasii</i>	1	(<0.1)
<u>Gunnel species</u>		
Unspecified gunnel	147	(1.6)
<u>Other nearshore or estuarine fish species:</u>		
Whitespot greenling <i>Hexagrammos stelleri</i>	65	(0.7)
Threespine stickleback <i>Gasterosteus aculeatus</i>	9	(0.1)
Snake prickleback <i>Lumpenus sagitta</i>	243	(2.7)
Shiner perch <i>Cymatogaster aggregata</i>	21	(0.2)
Pipefish sp. <i>Syngnathus</i> sp.	2	(<0.1)
Unidentified juvenile fish	9	(0.1)
<b>All fish</b>	<b>15,583</b>	<b>(173)</b>

This was the fifth consecutive year that fish were sampled in shallow intertidal habitat at these sites in Cornet Bay. Juvenile salmon have consistently comprised the large majority of fish captured (Table 5). Among non-salmon species, the most abundant have been sculpin, flatfish and gunnel species (Table 6).

Table 5. 2009-2013 fish seining at Cornet Bay – salmonid species.

<i>Year</i>	<i>No. of days</i>	<i>No. of sets</i>	<i>Total catch</i>	<i>Chinook salmon</i>	<i>Chum salmon</i>	<i>Pink salmon</i>	<i>Coho salmon</i>	<i>Cutthroat trout</i>	<i>Other fish species</i>	<i>% catch salmonid</i>
2009	7	65	6,877	2	5,058	0	0	0	1,817	<b>74%</b>
2010	10	99	17,152	102	396	15,893	0	0	761	<b>95%</b>
2011	8	80	8,260	31	7,625	0	0	0	600	<b>93%</b>
2012	6	60	50,596	139	778	49,029	38	0	612	<b>97%</b>
2013	9	90	15,583	71	14,114	0	2	2	1,394	<b>91%</b>

Table 6. Non-salmon species caught in Cornet Bay seining 2009-2013 (all species with >20 captures in one or more years).

<i>Year</i>	<i>Sculpin sp.</i>	<i>Flatfish sp.</i>	<i>Gunnel sp.</i>	<i>Greenling sp.</i>	<i>Snake prickle-back</i>	<i>Surf smelt</i>	<i>Herring</i>	<i>Shiner perch</i>	<i>% catch not salmonid</i>
2009	1173	366	154	31	62	2	22	0	<b>26%</b>
2010	447	27	67	43	48	18	2	28	<b>5%</b>
2011	509	39	7	19	9	14	0	2	<b>8%</b>
2012	353	139	17	4	5	89	0	1	<b>3%</b>
2013	784	94	147	65	243	15	1	21	<b>9%</b>

### Juvenile Salmon

Four salmon species were captured (Figure 8). Salmon numbers peaked in late March (Table 7). The decline in salmon numbers in nearshore by June is not necessarily evidence that they have left the vicinity of Cornet Bay. Smaller juvenile Chinook salmon (< 70 mm) appear to prefer low gradient, shallow water with fine-grained substrates (silts and mud), low salinity and low wave energy. As they increase in size, they move to deeper water and use a greater diversity of Puget Sound habitats. Habitat use for chum salmon also appears to be size dependent. Chum fry < 50-60 mm tend to migrate along the shore in water < 2 meters deep, and to move farther offshore as they increase to more than 60 mm.<sup>6</sup>

Table 7. Number of salmon captured at Cornet Bay sites in 2013 on each survey day, by species.

	<i>Chinook</i>	<i>Chum</i>	<i>Coho</i>	<i>Cutthroat</i>	<i>Total salmon</i>
15-Feb	3	1	0	0	4
1-Mar	9	66	0	0	75
15-Mar	6	345	1	0	352
29-Mar	11	6,877	0	0	6,888
12-Apr	7	1,798	0	0	1,805
26-Apr	8	2,677	0	0	2,685
17-May	3	725	1	2	731
29-May	24	1,536	0	0	1,560
12-Jun	0	89	0	0	89



Figure 8. Juvenile salmon photographed in Photarium. Clockwise from top left: Chinook, chum, cutthroat, coho..

<sup>6</sup> Fresh, K, 2006.

## Fish Size

At each draw of the net, the first 20 fish of each species were measured before release. Additional fish were just counted and released. For abundant species therefore, the number measured (Figure 9) was much less than the overall number captured (Table 6). The size of juvenile salmon was characterized by measuring fork length. For comparison, we calculated mean fork length for each species on each sampling date (Figure 10). Coho and cutthroat were omitted from the figure due to small sampling size.

### *Chinook*

Juvenile Chinook salmon were present from February through May. Of 71 captured, 70 were measured. Fork length ranged from 38 mm to 110 mm, with an average of 65 mm (1 standard deviation = 20.8). As the season progressed, Chinook transitioned from fry (< 50 mm fork length) to the parr migrant stage (Figure 10).

### *Chum*

Juvenile chum salmon were found from February into June. Of 14,114 captured, 953 were measured. Fork length ranged from 30 mm to 105 mm, with an average of 45 mm (1 standard deviation = 7.7).

### *Coho*

Two coho were captured. The one on March 15 escaped before being measured. The individual on May 17 was 97 mm.

### *Cutthroat Trout*

We captured 2 cutthroat trout on May 17. One was 175 mm, the other 205 mm.

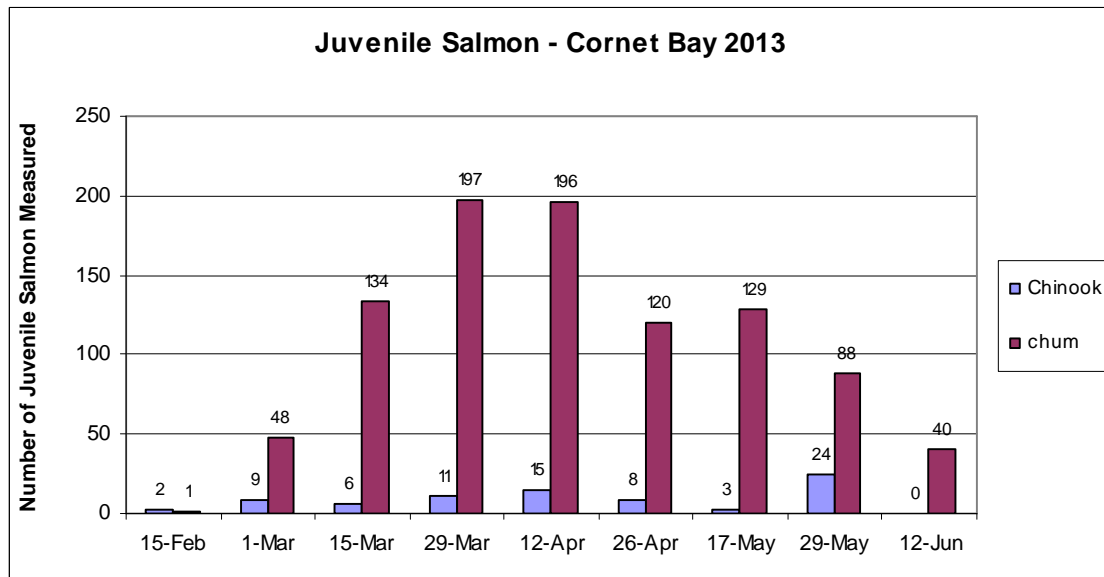


Figure 9. Number of juvenile salmon measured at Cornet Bay, 2013.



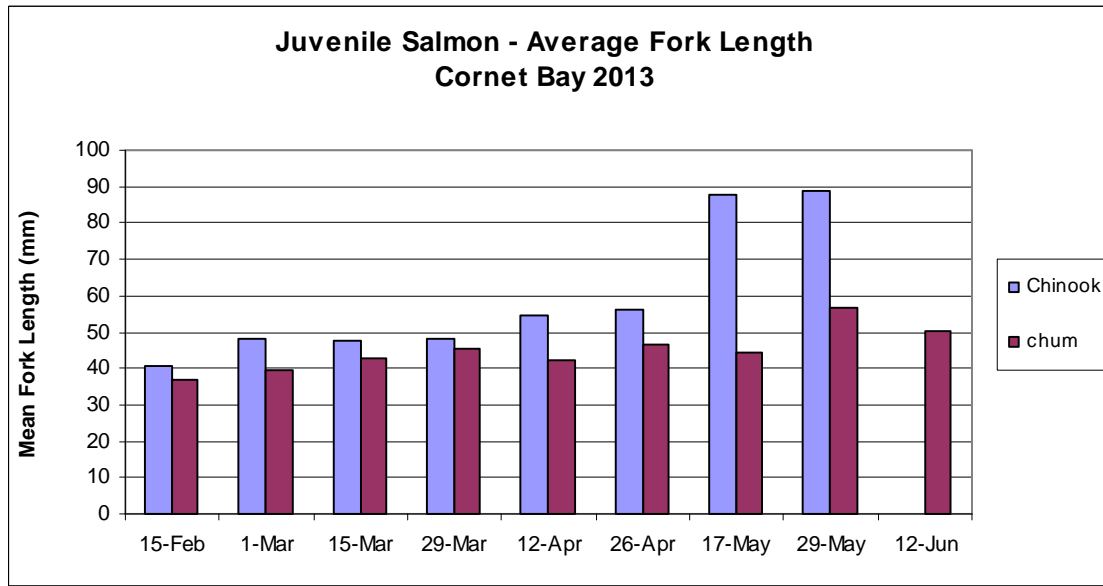


Figure 10. Average fork length of juvenile salmon measured at Cornet Bay, 2013. Note variation in sample size (Figure 10). Coho and Cuthroat omitted due to sample size of two each.

### Fish Community Composition

Together salmon and sculpin represented over 99% of the total catch. Other fish species, comprising less than 1% of the catch, have been combined (Figure 11). Peak fish density was on March 29 and was driven by juvenile chum salmon.

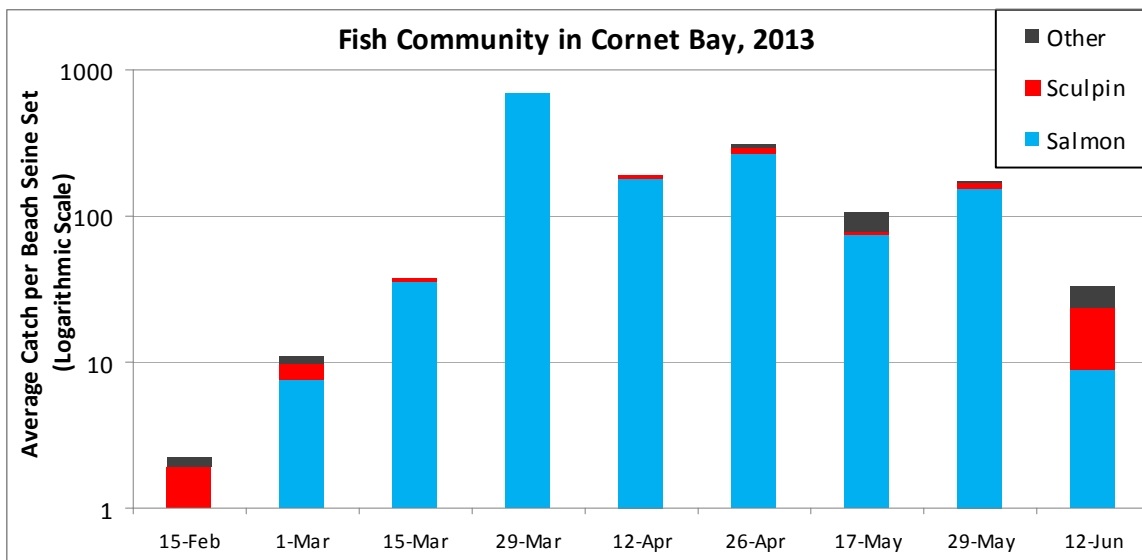


Figure 11. Fish community and relative abundance in Cornet Bay, 2013.

### Variation in Fish Catch Among Sites

Each year we have been looking at the number of fish netted at each sample site to see whether there might be any clear differences in fish use among the ten sites. All fish captures at each site over the season were combined. Four survey sites located along the “natural” shoreline northeast of the day use area are shown in green, the six sites along altered shoreline in red (Figures 12A-12E).

These graphs, although interesting, are not clear indicators of shoreline areas preferred by fish, as netting a single large school of fish can have a strong influence on the data.

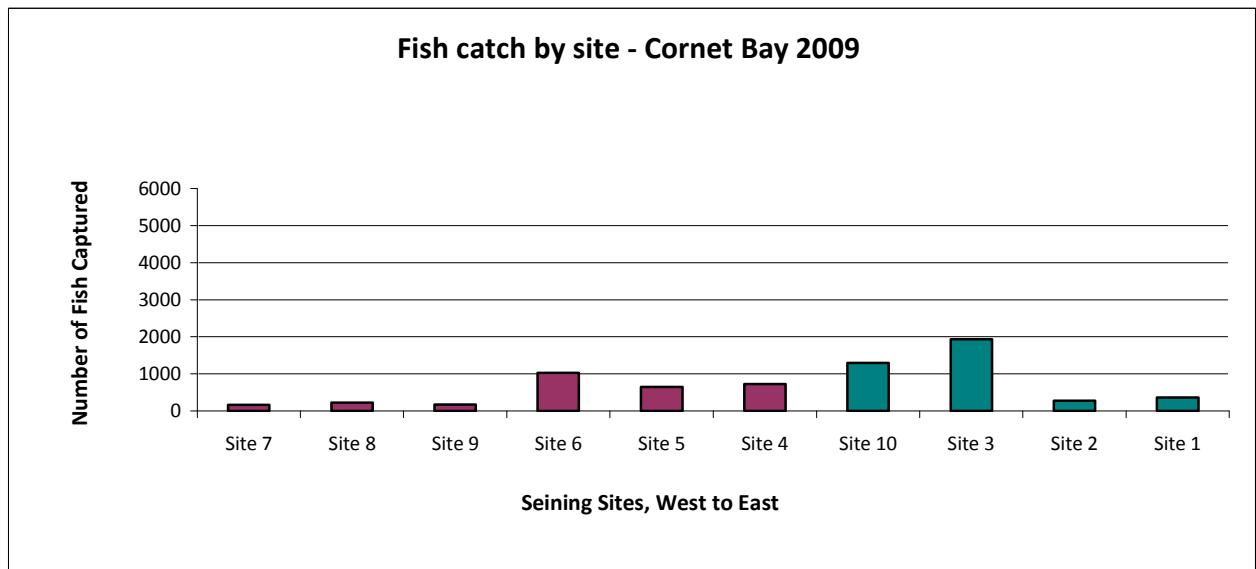


Figure 12A. Fish captures Cornet Bay, 2009: green sites on “natural shoreline, red on “altered” shoreline.

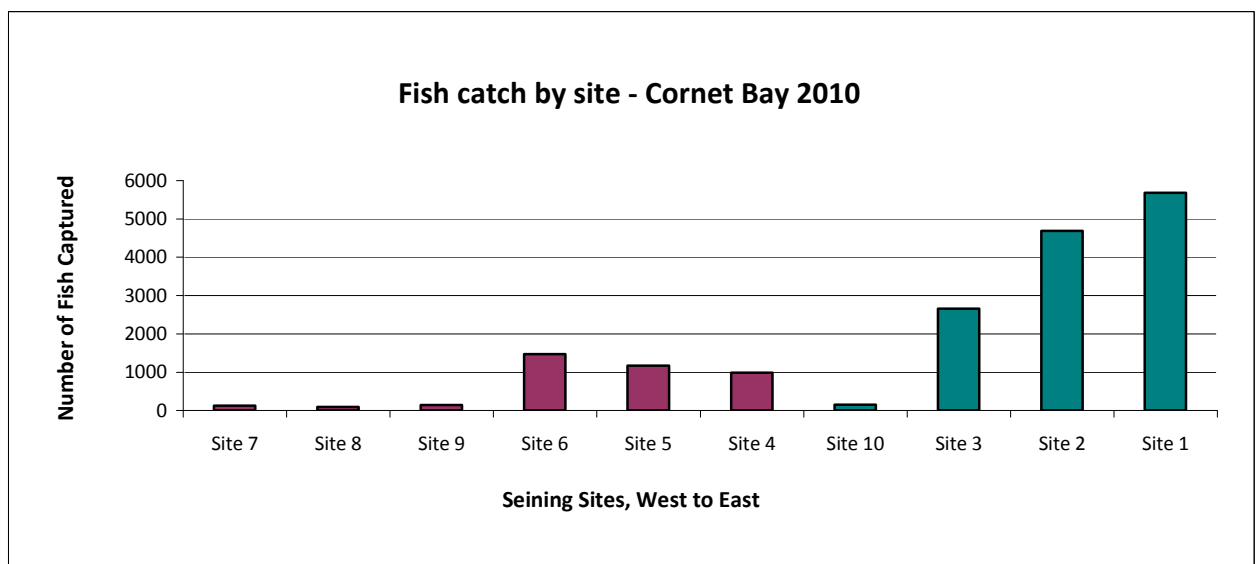


Figure 12B. Fish captures Cornet Bay, 2010: green sites on “natural shoreline, red on “altered” shoreline.

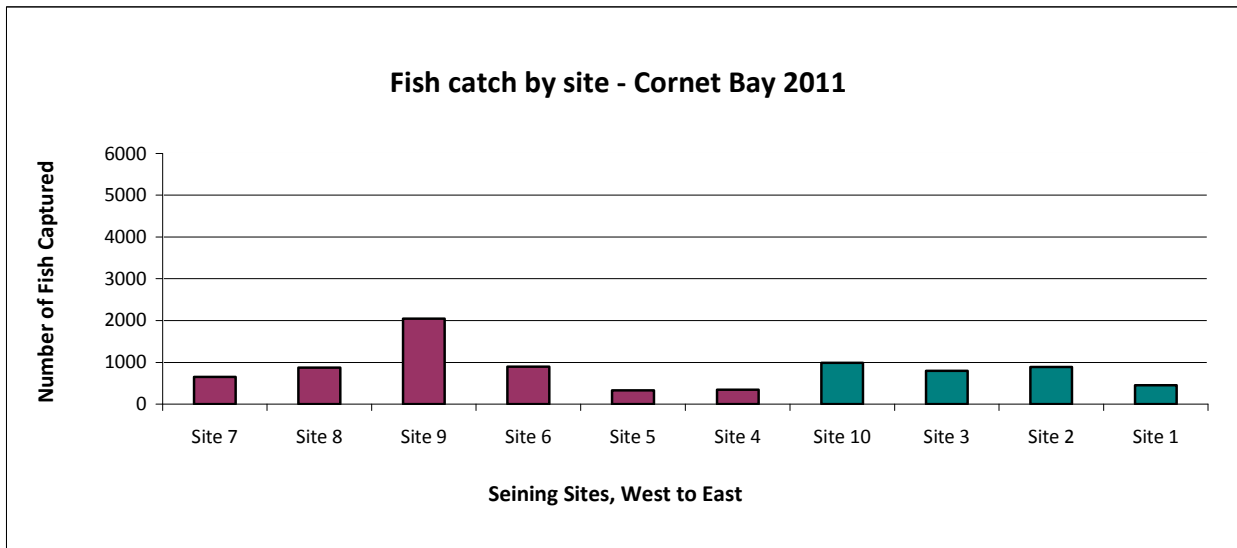


Figure 12C. Fish captures Cornet Bay, 2011: green sites on “natural shoreline, red on “altered” shoreline.

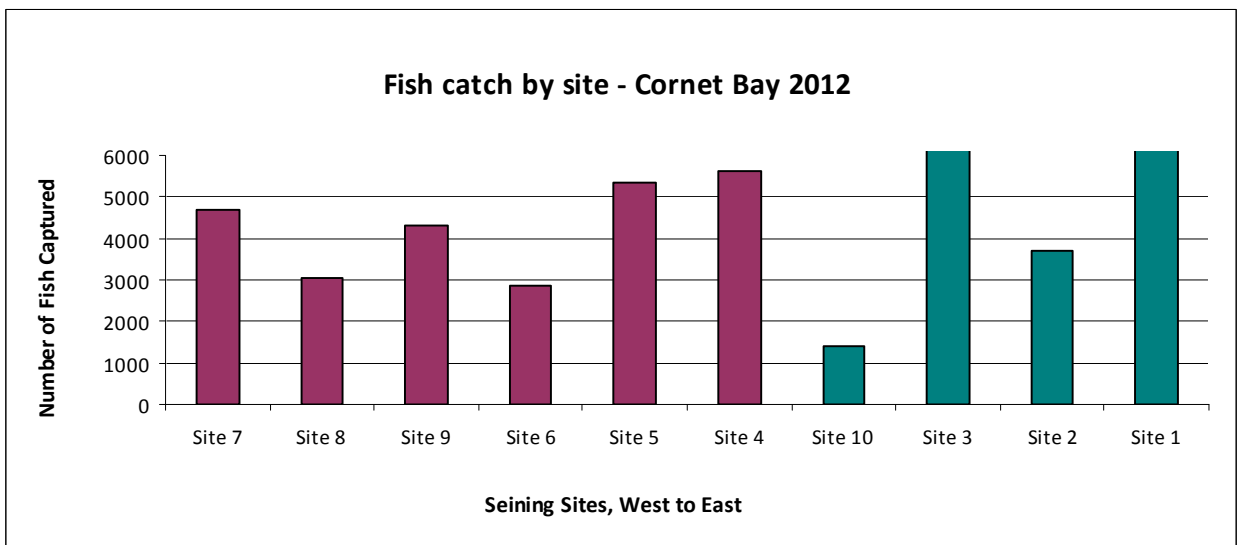


Figure 12D. Fish captures Cornet Bay, 2012: green sites on “natural shoreline, red on “altered” shoreline.

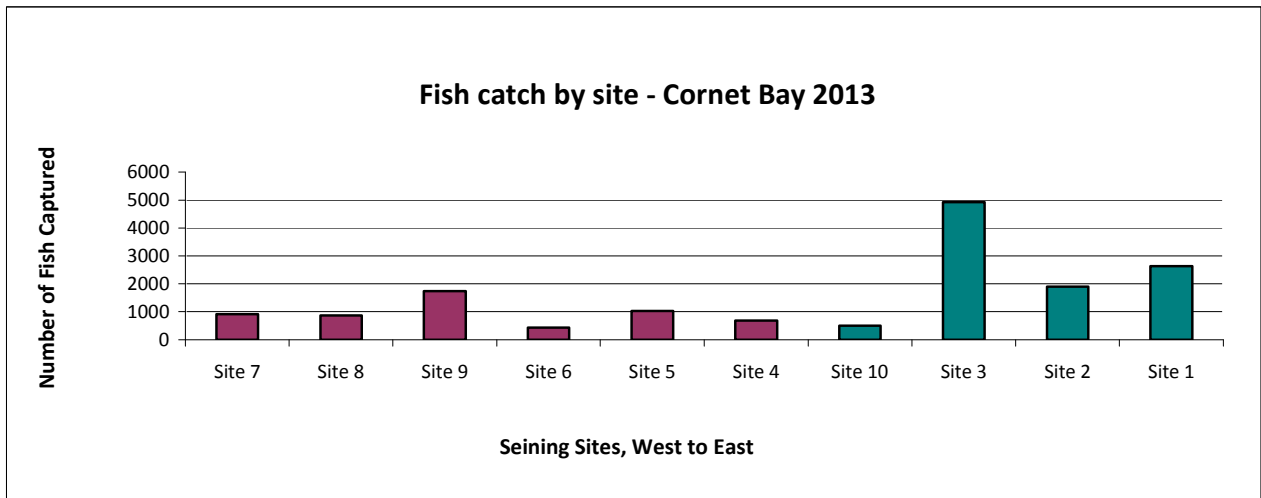


Figure 12E. Fish captures Cornet Bay, 2013, the first post-restoration year of monitoring. Green sites on “natural shoreline, red on “altered” shoreline.

## SUMMARY

This report documents the fifth season of recording fish species composition and relative abundance in the shallow nearshore of the Cornet Bay day use area – four years of pre-restoration surveys along the altered shoreline and adjacent natural nearshore habitat, and this year’s surveys in February-June 2013, after the restoration activity. At least three more years of post-restoration surveys are anticipated.

The surveys have established consistent use of the Cornet Bay shoreline by juvenile salmon in fry and parr stages, as well as by sculpins, gunnels, flatfish and other species. The sampling sites should be examined on a species by species basis to look for variation in fish use among altered versus natural sites, or differences within sites pre- versus post-restoration. Such differences are more likely to occur in resident non-salmon species than in the migratory salmon. The 2009-2012 data will be compared with surveys of other areas of Skagit Bay shoreline to determine whether migratory salmon are more abundant in Cornet Bay than other nearshore habitats. As the comparative pre- and post-restoration datasets accumulate, hypotheses should be established and tested statistically to look for effects of the restoration actions on the fish community.

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## APPENDIX A. FORAGE FISH SPAWN SURVEYS

Surveys to look for eggs from beach-spawning forage fish (surf smelt and Pacific sand lance) were conducted for two years prior to restoration, and post-restoration surveys have begun.

### METHODS

In 2009, a cadre of WSU Beach Watcher volunteers were trained in sampling protocols by Dan Penttila, then with Washington Department of Fish and Wildlife. Six sites were established (Figure 1).

1. 160 ft east of boat launch, a natural beach northeast of the altered shoreline with excellent-looking smelt substrate and overhanging riparian vegetation.
2. In front of a gap in the bulkhead west of boat launch
3. Between two state park piers, in front of bulkhead, with accretion east of marine pier
4. Along toe of western-most section bulkhead; unsuitable-looking sandy substrate with anaerobic layer half inch below surface
5. Sand-gravel beach in partially shaded site
6. Near west end state park land toward marina, in area with emergent salt marsh

The sites were sampled each survey day. A bulk 50-foot sample of surface substrate was collected for each site, then processed down through sieves and winnowed to preserve light fractions, and preserved with Stockards solution. The refined sample from each site was then examined for fish eggs in lab analysis.



Figure 1. Location of forage fish sampling sites at Cornet Bay. Numbers indicate approximate location along the beachfront of each sampling site. In 2012 restoration actions were taken in the area of altered shoreline marked by the red box: bulkheads and imported fill were removed, beach substrate and grade was returned to natural conditions, and uplands were planted with native vegetation.

### RESULTS

Pre-restoration surveys conducted by WSU Beach Watcher volunteers:

Sampled once a month July 2009 through June 2010. No fish eggs were found in analysis.

Sampled once a month July 2009 through June 2011. No fish eggs were found in analysis.

Bulkhead removal and beach restoration was completed in October 2012.

Post-restoration surveys were conducted by Dan Penttila, now with Salish Sea Biological: The six pre-established points along the shoreline were relocated using GPS and sampled on 5/15, 6/25, 7/12, and 8/22. No fish eggs were found in analysis.

The following is excerpted from Penttila's report:<sup>7</sup>

**BACKGROUND:**

“Surf smelt and Pacific sand lance are known to spawn at many sites in the general area of northern Whidbey and adjacent Fidalgo Islands. The Washington Department of Fisheries and, after agency merger, Fish and Wildlife undertook numerous spawning habitat surveys for these species in the general area of the Cornet Bay restoration project in the decades leading up to the restoration action. During that time, the shoreline within the subsequently-restored shoreline was documented to be used by spawning Pacific sand lance on November 17, 1993. Eventually, this site of sand lance egg collection would be incorporated into the project site's forage fish spawn sample array as site #3.

“While the state park piers in the immediate vicinity of the project site were known to be the sites of successful surf smelt sport-jig fishery harvests for several months each year, spawning habitat surveys did not ever detect surf smelt eggs within the project site in its pre-restoration condition. The reasons for this are unknown, except to note that the pre-project shoreline armoring did, in fact, intrude significantly seaward from the high tide line, burying the landward portions of the hypothetical surf smelt spawn deposition zone, in terms of tidal elevation and substrate type. This intrusion of armoring structures into the intertidal zone was to be remediated by the restoration action, in part for the enhancement of surf smelt spawning habitat quality.

“The presence of a surf smelt sport-jig fishery in the immediate area of the pre-project shoreline in Cornet Bay could not be construed as indicating that surf smelt must spawn on the beaches around the piers. Sport-jig-caught surf smelt in Puget Sound are almost entirely of actively-feeding smelt in a non-spawning/recovering-spent condition, as judged by biological data taken from similar jig-fishery smelt catches at nearby LaConner in previous years.

“Surf smelt spawning activity has been documented approximately one statute mile northeast of the Cornet Bay project site, on the west side of Hoypus Point, northernmost Whidbey Island (Figure 2)(Penttila 1999). It is likely that the surf smelt caught on the Cornet Bay piers are attributable to the fish spawning on the extensive summer-time surf smelt spawning areas known to occur throughout the Skagit Bay-Saratoga Passage region.”

**CONCLUSIONS:**

“The results of forage fish spawn sampling during the first summer following the restoration of more natural upper intertidal beach habitat at the Cornet Bay project site indicated that summer-spawning surf smelt were not using the site for egg deposition. Given that no evidence of surf smelt egg deposition had been found during previous forage fish spawn surveys by WDFW and the Island County Beach Watchers' pre-project survey, the results are not surprising, in spite of the project's obvious success in restoring very suitable-looking potential habitat to the site.

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<sup>7</sup> Dan Penttila, Salish Sea Biological, September 2013, Forage fish spawn surveys, Cornet Bay Beach Restoration Project Site, Deception Pass State Park, Whidbey Island, WA, June-August, 2013: Summary Report.

“Surf smelt spawning activity has been documented on about 10% of the shoreline of the Puget Sound Basin (Penttila 2007). Most of the “outwardly suitable-looking beaches” in the Puget Sound basin, as suggested by the presence of the proper texture of beach substrates at the proper tidal elevations, have not yielded evidence of smelt spawning activity using the current survey protocols. There appears to have been a “natural selection” of perennially-used surf smelt spawning sites during the last approximately 5000 years since the last Ice Age glaciers retreated from the region, and the combination of isostatic rebound upland of the formerly glaciated land surface and the rise of sea level with the world-wide melting of those Ice Age glaciers stabilized sea level and evolving shorelines in their present positions. The precise mechanisms of this spawning-site selection process are as yet unknown.

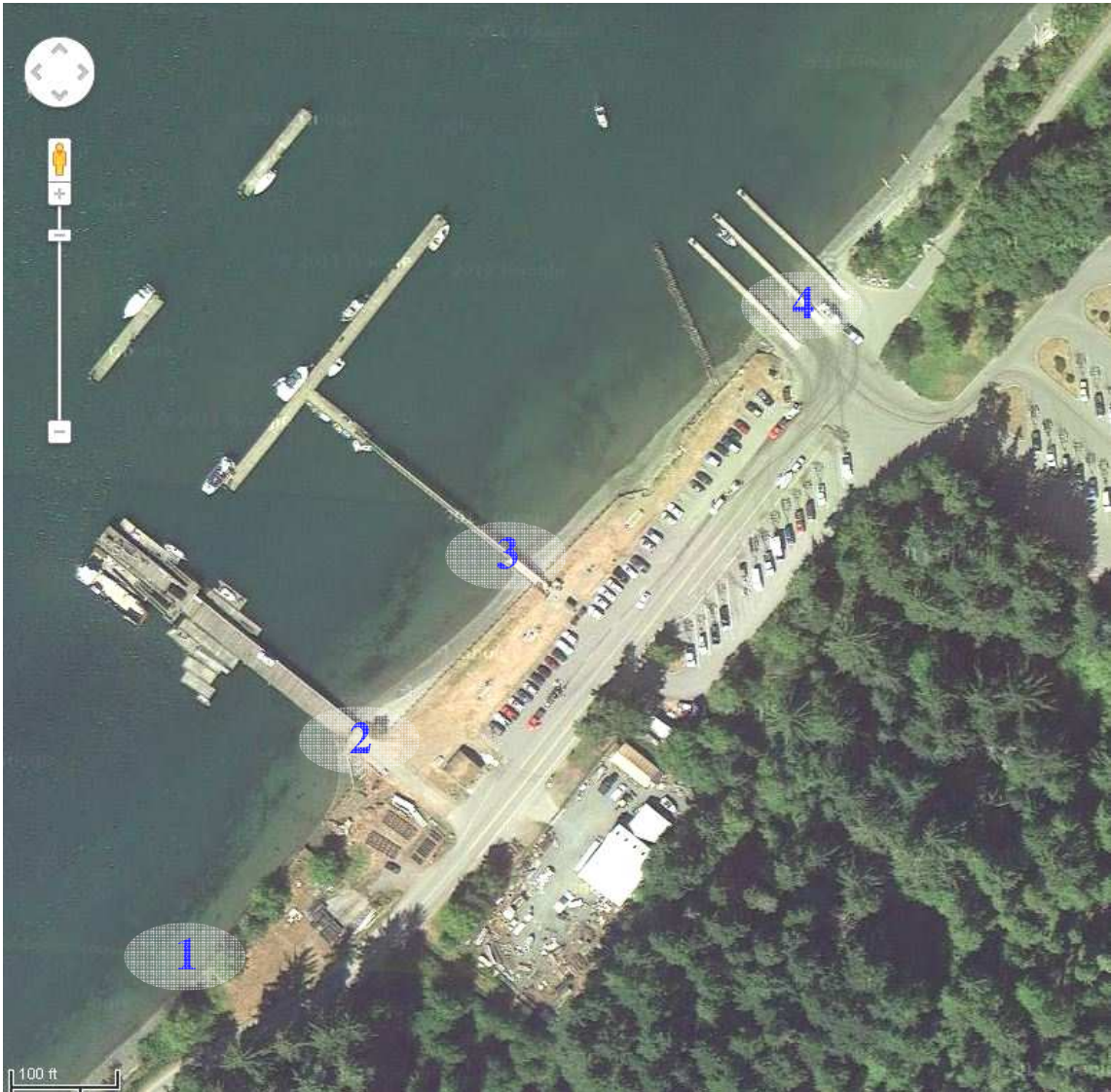
“Whether or not surf smelt will ever be found to use the restored beaches at Cornet Bay for spawning remains an open experimental question. Surf smelt are known to spawn within about one mile of the site at present. Non-spawning surf smelt are known to occur in very close proximity to the restored area seasonally in large numbers, as judged by the on-going pier-based sport-jig fishery. The degree to which surf smelt “home” back to their beaches of hatching, if at all, is unknown, as is the rate at which surf smelt spawning activity “roves” over the outwardly suitable post-glacial habitat landscape over time, if at all. It is obvious that this species (along with all the rest of the local marine/estuarine species of plants and animals) had to have some capacity for “exploration” of new spawning sites, to have re-populated the entire length and breadth of the Puget Sound Basin in the geologically-short period of time since the glaciers most-recently retreated.

“While several recent beach restoration projects in the Puget Sound Basin have succeeded in enhancing surf smelt spawning on beaches where it was still persisting on degraded habitat, projects like the Cornet Bay restoration action, producing suitable potential habitat at varying physical distances from existing spawning sites, are important experiments within the still-youthful realm of forage fish beach restoration. Periodic monitoring for surf smelt eggs over coming years may provide important answers to the question of how soon spawning surf smelt will find their way to adjacent “wholly new” beaches of outwardly suitable quality.

“Regardless of the surf smelt usage questions, it is clear that the Cornet Bay restoration action conserved the existing documented Pacific sand lance spawning site (sample station #3) in a suitable condition for future spawning usage. The expansion of upper intertidal mixed sand-gravel beach substrate coverage in adjacent sectors of the project site suggests that the potential sand lance spawning habitat may have been increased in physical area and quality. Proposed additional sampling at the Cornet Bay project site during the winter of 2013-2014 will monitor the site for evidence of both sand lance spawning activity and that of winter-spawning surf smelt.”



**APPENDIX B. RESTORATION PHOTOGRAPHS**



Google Earth image from November 2011. In 2012 bulkhead and imported fill were removed, beach was re-graded and replenished with spawning substrate, and grass was replaced with native perennials, shrubs and trees. Numbers indicate photo stations.



Station 1, looking northeast from west end of restoration area. Photos taken March 20, 2009 (left) and March 4, 2013 (right)



Station 2, looking southwest from maintenance dock. Photos taken July 26, 2012 (left) and May 3, 2013 (right).



Station 2, looking northeast from maintenance dock. Photos taken July 26, 2012 (left) and May 3, 2013 (right).



Station 3, looking southwest from public pier. Photos taken July 26, 2012 (left) and May 3, 2013 (right).



Station 3, foot of public pier looking toward new comfort station. Photos taken July 26, 2012 (left) and March 4, 2013 (right).



Station 3, looking northeast from public pier. Photos taken July 26, 2012 (left) and May 3, 2013 (right).



Station 4, looking southwest from boat ramps. Photos taken July 26, 2012 (left) and May 3, 2013 (right).



Station 4, looking northeast from boat ramps. Photos taken March 20, 2009 (left) and May 3, 2013 (right).