

Bellingham Bay Forage Fish Spawning Assessment



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1.0 Executive Summary

Fairbanks Environmental Services, Inc. and Salish Sea Biological have completed an assessment of forage fish spawning on selected beaches in Bellingham Bay. The purpose of this study was to provide specific data on the spawning of surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) on beach sites in Bellingham Bay.

Study sites were selected in February 2014 which had suitable substrate and potential for forage fish spawning. Surveys for forage fish spawning was initiated on February 27, 2014 and continued through December 22, 2015.

Surf smelt spawning was documented at six of the study sites around Bellingham Bay with 93 percent of observed surf smelt eggs occurring in samples from the Little Squalicum Beach. The spawning period for surf smelt is primarily from April through October with very light spawning occurring in November through February. Surf smelt eggs were observed in samples collected from:

1. Little Squalicum Beach (93%)
2. Mt. Baker Plywood rip rap seawall (1.8%)
3. Squalicum Waterway pocket beach (5%)
4. Cornwall & Wharf Street beach (0.2%)
5. I&J waterway; only in September 2015.
6. Boulevard Park – beach at north end; only in November 2015

During summer months, surf smelt eggs were subject to warm and dry weather, and mortality of the eggs was high with as much as 100 percent of the eggs found dead.

Pacific Sand lance spawning was also documented at four locations with 90.6 percent of the sand lance eggs found in samples for the Fairhaven Shipyard study site. Sand lance spawning occurs in December and January. Sand lance eggs were observed in samples collected from:

- a. Little Squalicum Beach (3.8%)
- b. Squalicum Waterway pocket beach (1.9%)
- c. Cornwall & Wharf beach (3.8%)
- d. Fairhaven Shipyard beach (90.6%)

Study recommendations include allowing year-round work below the Ordinary High Water Mark (OHWM) at the study beaches with site-specific work restrictions. Work restrictions apply during the period of consistent heavy spawning; during this time, forage fish spawning surveys should be conducted to verify the absence or presence of forage fish eggs. If eggs are absent or, the density of eggs is low, then work may be allowed to proceed for a period of two weeks. If a moderate or high density of forage fish eggs are present, then work below the OHWM should be postponed for two weeks to allow development and hatching of the eggs. Work should be allowed year-round at other study-sites in Bellingham Bay.

Conservation and enhancement of forage fish spawning habitat should also be considered as an element of projects that are proposed along the shoreline.

2.0 Introduction

The Port of Bellingham contracted Fairbanks Environmental Services, Inc. and Salish Sea Biological to conduct an assessment of forage fish spawning on selected beaches in Bellingham Bay over a two-year period from January 2014 through December 2015. The purpose of study was to provide specific data on the spawning of surf smelt and Pacific sand lance on beach sites in Bellingham Bay. This information will help clarify and focus potential state and federal regulatory in-water work restrictions that affect the timing of cleanup and habitat restoration actions proposed through the Bellingham Bay Pilot Project. Objectives of this study were:

1. To verify that the intertidal substrate at beach sites in inner Bellingham Bay that have “potential forage fish spawning habitat” is suitable for surf smelt and/or sand lance spawning.
2. To document the occurrence of surf smelt and/or sand lance spawning at selected intertidal beach sites in inner Bellingham Bay that have suitable spawning substrate.
3. To clarify the period of surf smelt and/or sand lance spawning activity in Bellingham Bay at documented spawning beaches and selected study beaches.

3.0 Task I

The first task of this study was to assess several beaches in Bellingham Bay to determine if the sediment was appropriate for forage fish spawning. This initial survey of the beach habitat at recommended sites was conducted on January 21, 2014 by Chris Fairbanks and Dan Penttila; Renee LaCroix, City of Bellingham also assisted with the survey and provided access to restricted property. The objective of this initial survey was to verify that the study sites had suitable substrate for forage fish spawning. A second criteria for selection was whether the beach had a sufficient length (50 feet minimum) for conducting the spawning surveys. A list of the recommended beaches with general notes is provided below in Table 1.

Table 1. Beach sites selected for an Initial Beach Survey to assess suitable spawning sediment and potential for forage fish spawning.

Beach	Substrate	Comments
Little Squalicum	Gravel mixed with sand	Documented spawning site of surf smelt and sand lance – Reference Site – 1
Squalicum Waterway – Beach enhancement site	Coarse gravel	Recent enhancement has placed substrate that currently is too coarse for spawning. Over time, fine sediment may mix with placed material and substrate may become suitable for spawning
Squalicum Waterway West side pocket beach	Sand mixed with gravel	Suitable substrate and adequate length for study transect
I&J waterway Head of waterway	Gravel mixed with sand	Suitable substrate and adequate length for study transect
Log Pond	Sand	Suitable substrate for sand lance
Cornwall and Wharf	Gravel mixed with sand and glass	Documented spawning site of surf smelt and sand lance – Reference Site - 2

Beach	Substrate	Comments
Cornwall - west	Gravel mixed with sand	Small beach defined by rubble fill
Cornwall - south	Gravel mixed with sand	Viewed from a distance, locked gate barred access
Boulevard Park - north	Gravel mixed with sand	Pocket beach at north end of Park
Boulevard Park – west beach enhancement area	Coarse gravel	Recent enhancement has place substrate that currently is too coarse for spawning. Over time, fine sediment may mix with placed material and substrate may become suitable for spawning
Boulevard Park – south Inside of trestle walkway	Gravel mixed with sand	The pocket beach at south end of lagoon inside of the walkway was too narrow to place a 50-foot transect. The beach at the north end of the lagoon has been documented for spawning of surf smelt
Padden Creek North	Gravel mixed with sand	Documented spawning site of surf smelt and sand lance – Reference Site - 3
Fairhaven boat launch	Gravel mixed with sand	Small beach is too narrow to place a 50-foot transect
Fairhaven Shipyard	Sand	Small pocket beach between two piers
Marine Park	Gravel mixed with sand	This beach was enhanced with coarse material that has become mixed with gravel, sand and shell hash and is appropriate for surf smelt spawning. This is an alternate survey beach.
Whatcom Waterway Jalapeno parking lot	Sand, gravel, and shell mix	This site is located adjacent to Holly Street bridge on the east side of Whatcom Waterway near the Jalapeno restaurant. This site was suggested by Renee LaCroix as an alternative site. This site has more freshwater influence than other sites.
C Street interim action	Sand and gravel	An interim action removed contaminated soil and replaced it with a cap of clean sand and gravel. This is an alternate survey beach

Both the Boulevard Park-south and Fairhaven boat launch sites were eliminated because these beaches are too narrow to place a 50-foot transect along the beach. Both of these beaches are in close proximity to documented spawning beaches and we believe that the eliminating these beaches will not detract from the objectives of this study.

The Boulevard Park-west and Squalicum Waterway beaches have recently been enhanced with coarse gravel and at the present time the material is too coarse for forage fish spawning. Over time, these beaches may become mixed with gravel, sand, and shell that would be appropriate spawning material.

Washington State Department of Fish and Wildlife (WDFW) has documented forage fish spawning areas at several locations in Bellingham Bay (Figure 1) and three of the documented

sites were included in this study. The objective of studying these documented spawning sites was to determine the seasonal periodicity when surf smelt and sand lance are spawning. Eight additional study sites were selected to determine the presence or absence of spawning at these locations. After this initial survey, an additional study site along the rip rap shoreline at the Mt. Baker Plywood mill was requested by the Port of Bellingham and was included in the spawning surveys beginning in March 2014. Study sites that were selected for forage fish spawning surveys are listed below in Table 2 and the locations are illustrated in Figure 2.

Table 2. Beaches that have been selected as Study Sites for Task 2, forage fish spawning surveys.

Study Site	Location	Objective	Photo Number
1	Little Squalicum Beach	Reference Beach; spawning timing of surf smelt and sand lance	1
2	Squalicum Beach riprap; Mt. Baker Plywood	Presence or absence of spawning	2
3	Squalicum Waterway West side pocket beach	Presence or absence of spawning	3
4	I&J Waterway Pocket beach at head of waterway	Presence or absence of spawning	4
5	Whatcom Waterway East side of Whatcom estuary	Presence or absence of spawning	5
6	Log Pond Sand beach within log pond	Presence or absence of spawning	6
7	Cornwall & Wharf	Reference Beach; spawning timing of surf smelt and sand lance	7
8	Cornwall landfill-west Pocket beach along landfill shoreline	Presence or absence of spawning	8
9	Cornwall landfill – south Pocket beach at south end of landfill shoreline	Presence or absence of spawning	9
10	Boulevard Park Pocket beach at north end of park	Presence or absence of spawning	10
11	Padden Creek – north Beach to the north of Padden Creek , north of Reid boiler works	Reference beach; spawning timing of surf smelt and sand lance	11
12	Fairhaven Shipyard Sandy pocket beach along north shoreline of shipyard	Presence or absence of spawning	12

4.0 Task II

4.1 Methods

Forage fish spawning surveys were begun on February 27, 2014 to document presence or absence of eggs in the beach samples collected at each study site. Samples were collected along the same transect at each study site during the following sampling period listed below in Table 3. The survey frequency was altered in 2015 to more accurately define the beginning of the surf smelt spawning period in the early spring.

Table 3. Frequency of surveys in each month and year.

Year	Month	Frequency of Surveys	Total Surveys
2014	February - May	Once per month	18
	June - December	Twice per month	
2015	January	Twice per month	18
	February and March	Once per month	
	April – August	Twice per month	
	September - December	Once per month	

At each study site, one transect was selected and referenced to a permanent feature on the beach, large driftwood or tree for example, and GPS location of each end of the transects were recorded. Length of the transects ranged from 50 feet to 90 feet. Collection and processing of the collected samples followed the WDFW protocol developed by Moulton and Penttila (2001). During the subsequent surveys, beach samples were collected along the same transect at each beach. The beach samples were taken to the lab at Salish Sea Biological for processing and analysis. The number of live eggs, dead eggs, and the number of broods based on egg development were estimated in each sample.

4.2 Results

At Little Squalicum Beach, spawning activity occurs from April through February with the highest egg density occurring in May through mid-October. Low density of surf smelt eggs were observed in December, January, and February; less than 0.1% of the total observed eggs were observed samples collected during these months. A periodicity histogram of surf smelt spawning at Little Squalicum Beach is attached as Figure 3. Periodicity of surf smelt spawning with observations from all study sites is illustrated in Figure 4. These charts are nearly identical because 93 percent of the observed eggs are from samples collected at Little Squalicum Beach.

Surf smelt eggs were also found in samples from the nearby Mt. Baker Plywood study site (study site 2) from May through September during the time when egg density was highest at the Little Squalicum Beach site.

Study site 3, a small pocket beach in the Squalicum Waterway was used by surf smelt for spawning in June, July, and in September, November and December. One sand lance egg was found in a sample in January 2015.

Surf smelt eggs were found in only one sample collected from the small pocket beach at the head of the I&J Waterway (study site 4) which was collected in August 2015. No eggs were found in any other sample from this study site.

No eggs of either surf smelt or sand lance were found in samples collected at the Holly Street pocket beach or from the Log Pond beach (study sites 5 and 6). In October 2015 the Log Pond Beach was armored with angular boulders (Photo 13) and samples of the sandy beach material could not be collected during subsequent sampling dates.

Both surf smelt and sand lance eggs were found in samples collected at the Cornwall & Wharf beach (study site 7). This beach has been documented as a forage fish spawning beach by WDFW and was included as a reference beach. Surf smelt spawning occurred in June, and in August through December.

No forage fish eggs were found in samples collected at the two beaches of the Cornwall Landfill sites (study sites 8 and 9).

Surf smelt eggs were found in only one sample collected from the small pocket beach at the north end of Boulevard Park (study site 10) that was collected in November 2015. No eggs were found in any other sample from this study site.

No forage fish eggs were found in samples collected at the Padden Creek – north study site (study site 11). This beach has been documented as a forage fish spawning beach by WDFW and was included as a reference beach.

Sand lance eggs were found in samples collected from the Fairhaven Shipyard study site (study site 12) in December and January. No surf smelt eggs were found in samples from this site.

The estimated total number of eggs in the beach samples collected from each Study Site for each month and year are listed in Table 4. Observations of eggs includes both live eggs that are in various stages of development and dead eggs. The proportion of dead eggs in the collected samples ranged from 0 to 100 percent and was highest during the warm and dry summer months of July and August when the surf smelt eggs were exposed to dry air and high temperature. The percentage of dead eggs observed in samples from the Little Squalicum Beach, Mt. Baker Plywood, Squalicum Waterway and Cornwall & Wharf study sites are listed in Table 5.

Table 4. Bellingham Bay forage fish sampling results by month and year, from February 27, 2014 through December 22, 2015. Two figures are listed in months when samples were collected bi-monthly. Forage fish eggs observed are surf smelt unless noted with ‘sl’ for sand lance.

Study Site	Year	Total number of surf smelt and Pacific sand lance eggs observed											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 Little Squalicum Beach	2014	NS ¹	1	0	132	33,024	8,192 12,160 ²	3,352 2,176	400 816	1,904 5,344	2,136 56	360 148	16 4 + 2 sl ³
	2015	13 2	5	0	3,808 6,192	3,728 5840	31,552 5,344	4,352 872	4,752 768	984	NS	44	8
2 Squalicum Beach riprap Mt. Baker Plywood	2014	NS	NS	0	0	512	7 836	12 984	1 4	1 0	NS NS	0 0	NS NS
	2015	0 0	0	0	2 0	2 2	0 7	36 60	1 164	20	NS	0	NS
3 Squalicum Waterway West side pocket beach	2014	NS	0	0	0	0	1 ⁴ 0	0 0	0 0	0 0	1 ⁴ 0	64 300	15 1
	2015	1 sl 0	0	0	0 0	0 0	0 1,096	5,664 72	0 0	156	NS	24	32
4 I&J Waterway Pocket beach	2014	NS	0	0	0	0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	2015	0 0	0	0	0 0	0 0	0 0	0 0	0 24	0	NS	0	0
5 Holly Street pocket beach	2014	NS	0	0	0	0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	2015	0 0	0	0	0 0	0 0	0 0	0 0	0 0	0	NS	0	0
6 Log Pond	2014	NS	0	0	0	0	NS 0	0 0	0 0	0 0	0 0	0 0	0 0
	2015	0 0	0	0	0 0	0 0	0 0	0 0	0 0	0	NS	NS	NS
7 Cornwall & Wharf	2014	NS	0	0	0	0	0 0	0 0	0 0	8 41	2 0	0 0	0 1 sl
	2015	0 0	0	0	0 0	0 0	26 11	0 0	3 32	232	NS	4	4 + 1 sl ⁴

Study Site	Year	Total number of surf smelt and Pacific sand lance eggs observed											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
8 Cornwall landfill-west	2014	NS	0	0	0	0	0	0	0	0	0	0	0
	2015	0 0	0	0	0	0	0	0	0	0	0	NS	0
9 Cornwall landfill-south	2014	NS	0	0	0	0	0	0	0	0	0	0	0
	2015	0 0	0	0	0	0	0	NS	0	0	0	NS	0
10 Boulevard Park-north	2014	NS	0	0	0	0	0	0	0	0	0	0	0
	2015	0 0	0	0	0	0	0	0	0	0	0	NS	4
11 Padden Creek-north	2014	NS	0	0	0	0	0	0	0	0	0	0	0
	2015	0 0	0	0	0	0	0	0	0	0	0	NS	0
12 Fairhaven Shipyard	2014	NS	0	0	0	0	0	0	0	0	0	0	0
	2015	4 sl 0	0	0	0	0	0	0	0	0	0	NS	0

1. NS = No Sample collect
2. Sample collected during second half of the month
3. sl = Pacific sand lance
4. A single dead egg was observed in beach sample

Table 5. Percentage of dead eggs observed in collected samples for each month and year. Shaded cells indicate when no eggs were observed in the collected sample. When two samples were collected in one month, then two figures are given. Summer months with warm and dry conditions have the highest mortality in forage fish eggs.

Study Site	Year	Percent mortality of observed eggs											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 Little Squalicum Beach (LSB)	2014	NS	0	0	53	13	88 32	99 72	94 20	56 19	39 0	4 43	56 0
	2015	23 50	80		52 18	62 95	76 86	99 97	99 98	26	NS	9	0
2 Squalicum Beach riprap Mt. Baker Plywood (MBP)	2014	NS	NS	NS		20	71 16	100 73	100 no eggs	0 no eggs	NS NS		NS NS
	2015				0 no eggs	50 100	no eggs 29	100 80	0 71	0	NS		NS
3 Squalicum Waterway West side pocket beach (SWW)	2014	NS					100 no eggs				100 no eggs	6 8	7 0
	2015	0 no eggs					no eggs 99	100 100		5	NS	0	25
7 Cornwall & Wharf (C&W)	2014	NS								75 61	50 no eggs		no eggs 0
	2015						61 91		100 100	29	NS	0	0

5.0 Discussion

Surf smelt eggs were found in samples collect from six of the study sites and sand lance eggs were found at four study sites. The presence and period of forage fish spawning at each study site is listed below in Table 6. The density of eggs was highest in samples from the Little Squalicum Beach study site from April through mid-October. The Mt Baker plywood study site is close in proximity to the Little Squalicum Beach and spawning activity occurred from May through September. These two study sites are at the north shoreline of Bellingham Bay.

Table 6. Presence and absence of spawning activity at each Study Site with period when spawning occurred.

Study Site	Location	Surf Smelt	Period	Sand Lance	Period
1	Little Squalicum Beach	Yes	High density: April – mid-October Very low density: November -February	Yes	December
2	Squalicum Beach riprap Mt. Baker Plywood	Yes	May – September	No	
3	Squalicum Waterway West side pocket beach	Yes	May – September	Yes	January
4	I&J Waterway Pocket beach at head of waterway	Yes	September 2015	No	
5	Holly Street pocket beach East side of Whatcom estuary	No		No	
6	Log Pond Sand beach in log pond	No		No	
7	Cornwall & Wharf beach	Yes	June - September	Yes	December
8	Cornwall landfill-north Pocket beach along landfill shoreline	No		No	
9	Cornwall landfill – south Pocket beach at south end of landfill	No		No	
10	Boulevard Park Pocket beach north end of park	Yes	November 2015	No	
11	Padden Creek north of Reid boiler works	No		No	
12	Fairhaven Shipyard Sandy pocket beach	No		Yes	December - January

Three of the study site were previously documented by WDFW as spawning beaches for both surf smelt and sand lance. During this study, eggs of both surf smelt and sand lance were observed at two of these beaches, Little Squalicum Beach and Cornwall & Wharf. No spawning however, was observed at the Padden Creek study site during the two-year sampling period of 2014-2015. Samples collected from the Padden Creek site by WDFW in January and December 1995 contained sand lance eggs. Surf smelt eggs were found in samples collect in samples collected at two stations in September 1995. Although forage fish spawning was not observed during the current two-year study, this does not indicate that spawning activity is absent from

this location. Forage fish spawning does not occur consistently year to year at documented spawning beaches; approximately 30 percent of documented spawning beaches support forage fish spawning in any given year (D. Penttila, as cited in Quinn et al. 2012).

Surf smelt spawning was documented on three study sites that were not identified by WDFW as forage fish spawning sites. The Squalicum Waterway pocket beach (study site 3) was used by both surf smelt and sand lance. The beach at the head of the I&J waterway and the beach at the north end of Boulevard Park were used by surf smelt. Only one survey sample from each of two study sites, contained surf smelt eggs. One sample collected in August 2015 from the I & J Waterway study site contained 24 surf smelt eggs and the November 2015 sample collected at the Boulevard Park study site contained 4 surf smelt eggs. All other samples collected over the two years at these sites were void of forage fish eggs.

6.0 Management implications

The Army Corp of Engineers (ACOE) revised the approved work windows for work below the Ordinary High Water Mark (OHWM) on August 14, 2012. Bellingham Bay is included in tidal reference area 9 (Blaine) and the approved work window for surf smelt and Pacific sand lance is listed below in Table 7. Using the results of this study, periods for allowable work below the OHWM can be prescribed with site specific detail. These recommended work windows with site specific restrictions are listed below in Table 7. Work restrictions apply during the period of consistent heavy spawning; during this time, forage fish spawning surveys should be conducted to verify the absence or presence of forage fish eggs. If eggs are absent or the density of eggs is low, then work may be allowed to proceed for a period of two weeks. If a moderate or high density of forage fish eggs are present, then work below the OHWM should be postponed for two weeks to allow development and hatching of the eggs. Work should be allowed year-round at other study-sites in Bellingham Bay.

Table 7. ACOE and recommended work windows for work below the OHWM with site specific work restrictions.

	ACOE Approved Work Window¹	Recommended Work Window	Recommended Site Specific Work Restrictions²
Surf smelt	Year Round	Year Round	Little Squalicum Beach: April 1 – Oct 31 Mt. Baker Plywood: May 1 – Sept 30 Cornwall & Wharf: June 1 – Sept 30
Pacific sand lance	March 2 – Oct 14	Year Round	Fairhaven Shipyard: Dec 1 – Jan 31

1. Approved work windows for fish protection for all marine/estuarine areas August 14, 2012 Tidal Reference Area 9 (Blaine)
2. Recommended periods when a forage fish spawning survey should be conducted prior to disturbing beach sediment at specific sites. If forage fish eggs are absent or, light density of eggs are found, then work may proceed.

Conservation and enhancement of forage fish spawning habitat should be considered as an element of projects that are proposed along the shoreline. Forage fish spawning habitat is largely dependent on the establishment and maintenance of fine-grained beach surfaces at the upper

intertidal elevation. Restored beaches should include engineering structures that hold fine-grained sediment at the appropriate tidal elevation.

Enhancement of the marine riparian habitat with trees and shrubs also benefit forage fish spawning habitat by providing shade over the beach. Egg mortality was highest during the warm and dry months and shade moderates the heat and humidity in the beach sediment (Rice 2006). For example, trees and shrubs around and to the south of the pocket beach in Squalicum Waterway would provide shade over the beach in the afternoon; temperature of the beach sediment would be moderated and egg mortality may be reduced.

Three new spawning beaches have been identified in this study and continued surveys in Bellingham Bay beyond the boundary of this study may identify additional spawning sites.

7.0 References

- Moulton, L.L. and D.E. Penttila. 2001. Field manual for sampling forage fish spawn in intertidal shre regions. Lopez Island. MJM Research and Washington State Department of Fish and Wildlife.
- Quinn. T., K. Krueger, K. Pierce, D. Penttila, K. Perry, T. Hicks, and D. Lowry. 2012. Patterns of surf smelt, *Hypomesus pretiosus*, intertidal spawning habitat use in Puget Sound, Washington State. *Estuaries and Coasts* 35(5) 1214-1228.
- Rice, C.A. 2006. Effects of shoreline modification in northern Puget Sound: beachmicroclimate and embryo survival in summer spawning surf smelt (*Hypomesus pretiosus*). *Estuaries and Coasts* 29(1): 63-71.



Figure 1. Forage fish spawning areas documented by WDFW
<http://wdfw.maps.arcgis.com/home/webmap/viewer.html?webmap=19b8f74e2d41470cbd80b1af8dedd6b3&extent=-126.1368,45.6684,-119.6494,49.0781>



Figure 2. Bellingham Bay Forage Fish Assessment study sites.

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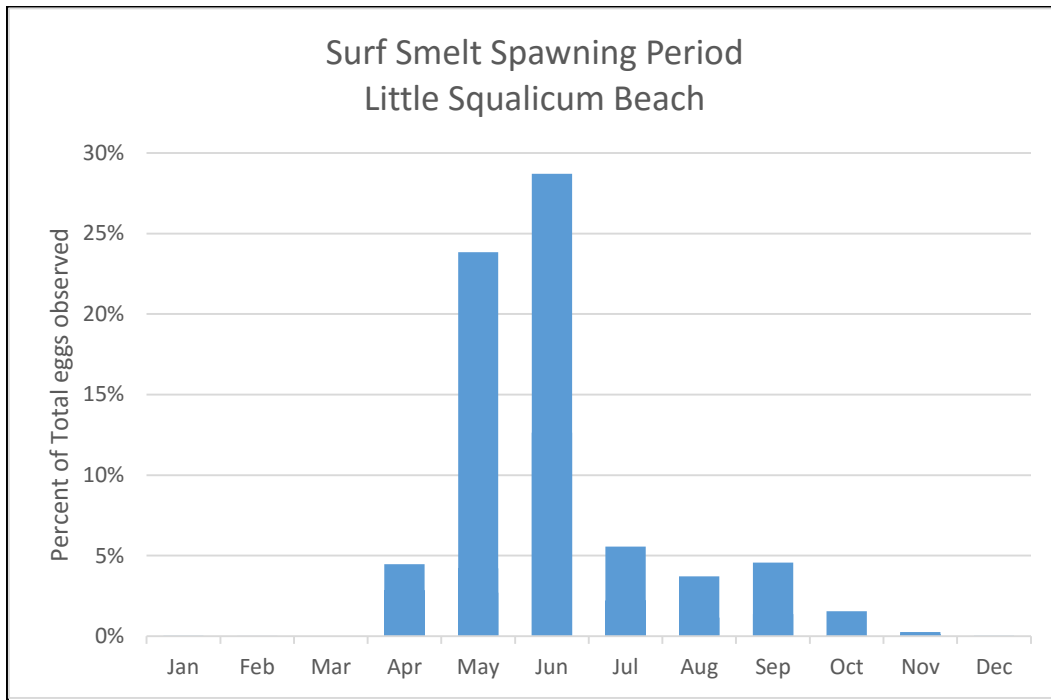


Figure 3. Spawning period and relative density of eggs as a percentage of the total number of surf smelt eggs observed in samples collected at Little Squalicum Beach. Less than 0.1% of the total eggs were observed in December, January and February.

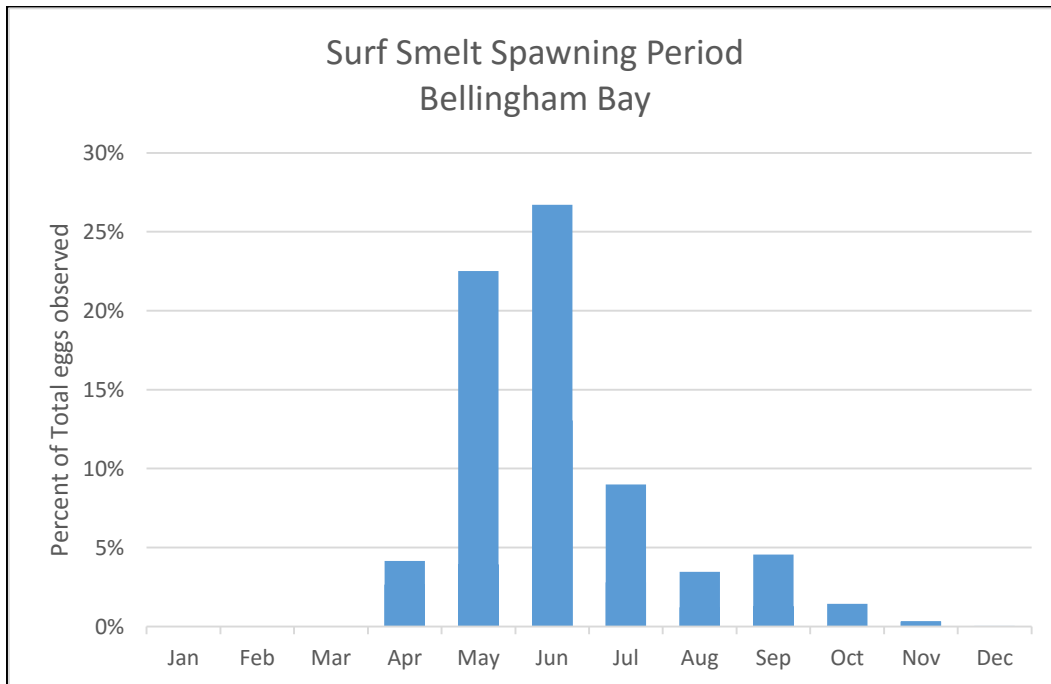


Figure 4. Spawning period and relative density of eggs as a percentage of the total number of surf smelt eggs observed in samples collected from all study sites. Little Squalicum Beach samples contained 93% of the surf smelt eggs observed.



Photo 1 Study site 1; Little Squalicum Beach: Surf smelt and sand lance spawning has been documented at this site. This beach was selected as a reference beach to determine the seasonal spawning timing.



Photo 2. Study site 2; Mt. Baker Plywood riprap. Surf smelt spawning occurred at this study site from May through September.



Photo 3. Study site 3; Squalicum Waterway. Surf smelt spawning occurred at this study site from May through September and sand lance spawning occurred in January.



Photo 4. Study site 4; I&J Waterway. Surf smelt eggs were found in one sample collected in September 2015.



Photo 5. Study site 5; Holly Street pocket beach. No forage fish eggs were found in samples collected at this study site.



Photo 6. Study site 6; Log Pond. No forage fish eggs were found in samples collected at this study site.



Photo 7. Study site 7. Cornwall & Wharf beach. Surf smelt and sand lance spawning has been documented at this site. Surf smelt spawning occurred from June through September and sand lance spawning occurred in December.



Photo 8. Study site 8; Cornwall landfill-west. No forage fish eggs were found in samples collected at this study site.



Photo 9. Study site 9; Cornwall landfill-south. No forage fish eggs were found in samples collected at this study site.



Photo 10. Study site 10; Boulevard Park. Surf smelt eggs were found in one sample collected in November 2015.

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Photo 11. Study site 11; Padden Creek. Surf smelt and sand lance spawning has been documented on this beach however, forage fish eggs were not found in any samples collected at this site during this study.



Photo 12. Study site 12; Fairhaven shipyard. Sand lance spawning occurs on this beach in December and January.



Photo 13. Study site 6 after a revetment was constructed along this shoreline. This work was completed to protect the redevelopment of the Waterfront District.