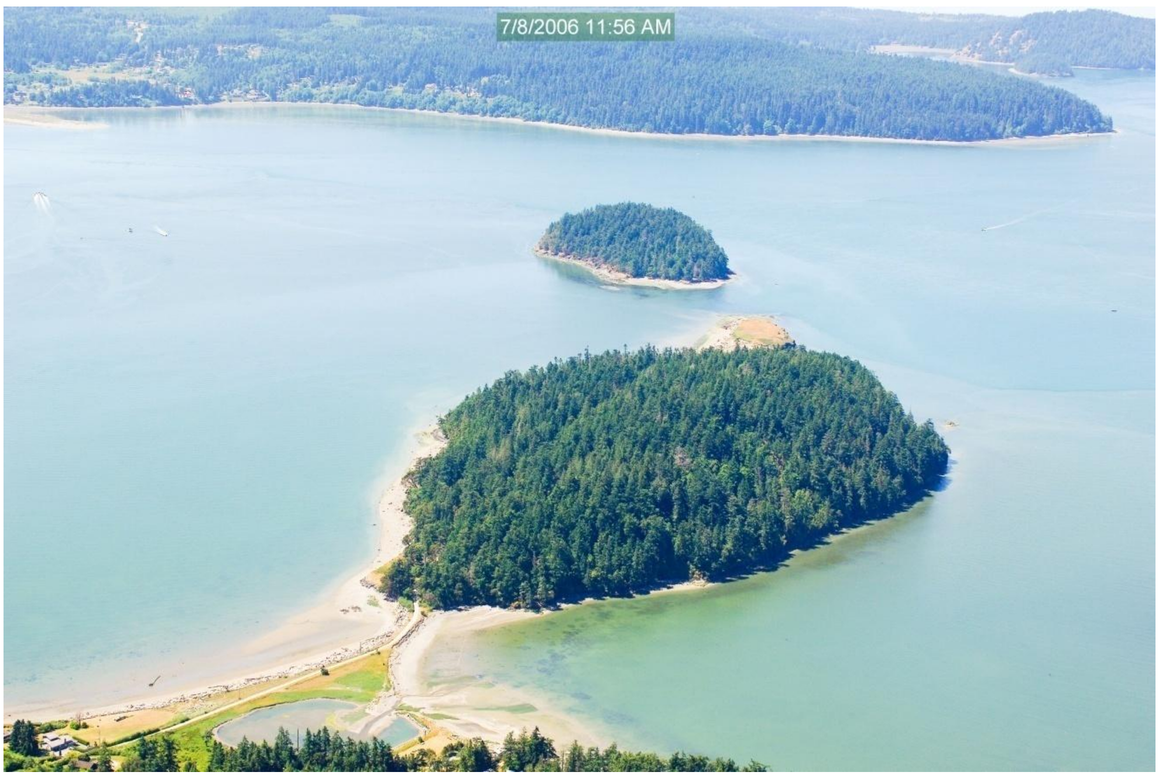
KUKUTALI PRESERVE JUVENILE CHINOOK SALMON AND FORAGE FISH ASSESSMENT

Eric Beamer, Josh Demma, and Rich Henderson
Skagit River System Cooperative
LaConner, WA

March 2014

Report prepared for:
Swinomish Indian Tribal Community,
Department of Planning and Community Development



Kukutali Preserve as seen from the air, courtesy WA Dept of Ecology

Table of Contents

Recommended Citation

Beamer, EM, J Demma, and R Henderson. 2014. Kukutali Preserve Juvenile Chinook salmon and forage fish assessment. Report prepared for Swinomish Indian Tribal Community Planning Department. Skagit River System Cooperative. LaConner, WA.

Acknowledgements

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

- Skagit River System Cooperative field sampling crew - Bruce Brown, Jason Boome, Jeremy Cayou, Len Rodriguez, Jeff Edwards, Josh Demma, and Ric Haase
- Karen Wolf for assistance with maps, figures, and editing of the report
- The Swinomish Indian Tribal Community Planning Department for funding to conduct the assessment

Abstract

Kukutali Preserve is located on the northeast side of Skagit Bay within the reservation boundaries of the Swinomish Indian Tribal Community. This assessment provides information on juvenile Chinook salmon and forage fish using the Preserve's beaches and is intended to: a) help inform a management plan for the Preserve, and b) provide juvenile Chinook salmon seasonal and abundance data necessary for determining the feasibility of restoration alternatives being considered for Kiket Lagoon.

Regarding juvenile Chinook salmon and Kiket lagoon, we found juvenile Chinook salmon currently use Kiket Lagoon in a manner consistent with the timing, abundance and fish size patterns of other Skagit Bay pocket estuaries. Increasing the lagoon's wetted area, if feasible, would benefit Skagit Chinook salmon populations. Protecting existing lagoon habitat from loss and degradation could be improved by ensuring freshwater flowing into the lagoon does not damage fish and other native biota. We also found juvenile Chinook salmon distributed on both sides of the tombolo connecting Fidalgo Island to Kiket Island. We do not predict an increase in juvenile Chinook salmon use of Kiket Lagoon solely from increased tidal connectivity across the tombolo.

Related to forage fish, we found surf smelt eggs on Kukutali Preserve beaches with summer spawning dominant. Actions that adequately protect beach substrate and egg incubation conditions should be part of the Preserve's management plan and should include maintaining healthy coastal sediment and marine riparian zone processes on Preserve beaches.

Introduction

Kukutali Preserve is located on the northeast side of Skagit Bay within the reservation boundaries of the Swinomish Indian Tribal Community (Figure 1). The Preserve includes 84 upland acres on Kiket and Flagstaff Islands and about nine upland acres on Fidalgo Island. The Preserve has more than two miles of nearly intact shoreline, with native eelgrass beds and diverse populations of fish and shellfish. Kukutali Preserve was purchased in June 2010 from private landowners and is now a state park jointly managed by the Swinomish Tribal Community and the Washington State Parks Department for conservation and research, public education, and limited recreational use. Kiket Lagoon, located within the Preserve's boundaries, was identified in the Skagit Chinook Recovery Plan (SRSC & WDFW 2005) as one of twelve restoration sites for actions related to pocket estuaries.

This assessment provides information on juvenile Chinook salmon and forage fish using the Preserve's beaches. This information is intended to: a) help inform a management plan for the Preserve, and b) provide juvenile Chinook salmon seasonal and abundance data necessary for determining the feasibility of restoration alternatives being considered for Kiket Lagoon. The assessment focused on three tasks:

1. Collection, analysis, and reporting of juvenile Chinook salmon timing and abundance within and adjacent to Kiket Lagoon
2. Collection, analysis, and reporting of juvenile Chinook salmon timing and abundance on either side (north and south) of the tombolo that connects Fidalgo Island to Kiket Island
3. Collection, analysis, and reporting of intertidal spawning forage fish egg presence, abundance, and condition on beaches within Kukutali Preserve

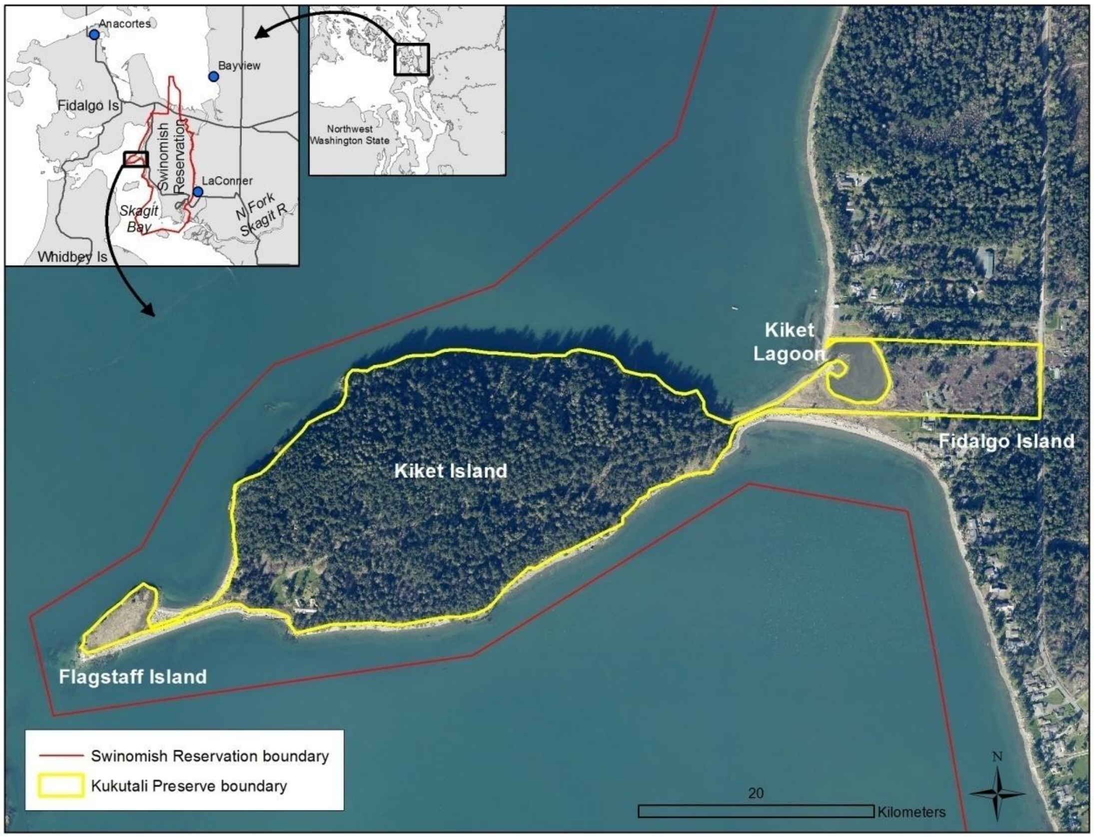


Figure 1. Location of Kukutali Preserve and Kiket Lagoon.

Juvenile Chinook salmon use of Kiket Lagoon

Background

All six Skagit Chinook salmon populations include delta rearing and fry migrant life history types in their populations (Beamer et al. 2005). These life history types currently rear in Skagit River delta and pocket estuary habitats. At contemporary Chinook salmon population levels, limitations in current delta habitat conditions are displacing juvenile Chinook salmon fry from delta habitat to Skagit Bay habitat and forcing a change in their life history type from delta rearing to fry migrant (Beamer et al. 2005). Fry migrants emerge from egg pockets in their natal river and migrate quickly downstream to Skagit Bay. They enter Skagit Bay from January through March at an approximate fork length of 40 mm (observed range from otoliths is 30-46 mm fork length). Some fry migrant Chinook salmon rear and take refuge in pocket estuaries of Skagit Bay and the Whidbey Basin (Beamer et al. 2003 & 2006). These areas are thought to provide fry migrants with a survival or growth advantage over other nearshore habitats. Restoration of pocket estuary habitat can be a strategy to partially mitigate delta density dependence and improve survival of naturally occurring fry migrants. Kiket Lagoon, located within Kukutali Preserve, was included as a potential restoration project in the Skagit Chinook Recovery Plan (SRSC and WDFW 2005).

Two ways Kiket Lagoon could be influenced by restoration are: 1) restoration occurring within the lagoon itself, such as increasing its size by removing fill, and 2) restoring natural processes influencing the lagoon, such as coastal sediment dynamics or freshwater hydrology and water quality. As part of considering the feasibility of these types of restoration, we monitored juvenile Chinook salmon timing and abundance in the lagoon and its adjacent nearshore to confirm whether juvenile Chinook salmon were using the lagoon and whether fish use was consistent with levels in other pocket estuaries within the Whidbey Basin. Also, pre-restoration monitoring data are essential to determine the fish response after restoration.

Methods

The purpose of this beach seining effort was to compare wild (unmarked) juvenile Chinook salmon use between two strata: Kiket Lagoon and its adjacent nearshore habitat.

<u>Sites and effort</u>: A field crew beach-seined sites within Kiket lagoon and its adjacent nearshore habitat (Figure 2). Sites Kiket Lagoon s1-s4 make up the “lagoon” stratum. Sites Kiket Tombolo N and Kiket Beach N make up the “adjacent nearshore” stratum. Beach seining started in March of 2009, February of 2010, and January of 2013, ending after June each year as we do not expect fry migrant Chinook salmon to rear in pocket estuaries within the Whidbey Basin after that month (Beamer et al. 2006). Beach seining occurred every other week during the sampling period. A total of 254 beach seine sets were made (Table 1).

Table 1. Number of beach seine sets made by year, month, and strata.

Year	Month	Strata	
		Lagoon	Adjacent Nearshore
2009	3	8	8
	4	8	8
	5	8	8
	6	8	8
2010	2	8	8
	3	8	8
	4	8	8
	5	8	8
	6	8	8
2013	1	4	6
	2	8	12
	3	8	12
	4	8	12
	5	8	12
	6	8	12

Beach seining: We used small net beach seine methodology (Skagit System Cooperative 2003). The small net beach seine methodology employed an 80-ft (24.4 m) by 6-ft (1.8 m) by 1/8-inch (0.3 cm) mesh knotless nylon net. The net was set in "round haul" fashion by fixing one end of the net on the beach, while the other end was deployed by setting the net "upstream" against the water current, if present, and then returning to the shoreline in a half circle. Both ends of the net were then retrieved, yielding a catch. The small net beach seine was usually deployed from a floating tub that was pulled while wading along the shoreline.

Data collected: All fish captured were identified to species, counted, and measured for length. Environmental variables (temperature, salinity, DO, depth, substrate) associated with each beach seine set were also collected. All data were entered into an existing Access database. However, in this report we are only focusing on juvenile Chinook salmon density and size.

Fish density: We calculated the density of wild (unmarked) juvenile Chinook salmon for each set (the number of fish divided by set area). Set area is determined in the field for each beach seine set.

Statistical analysis: We used Generalized Linear Models (GLM) to evaluate the effects of temporal (year, month) and habitat (two strata: lagoon, adjacent nearshore) variables on juvenile Chinook salmon density. Fish densities were log (x+1) transformed to reduce the effects of high skew and unequal variance across groups. Year, month, and strata were evaluated for main effects as fixed factors for their influence on juvenile Chinook salmon density.

Figure 2. Location of beach seine sites used for juvenile Chinook salmon analyses related to Kukutali Preserve and Kiket Lagoon. Some sites were used in the lagoon study (page 7) and some in the tombolo study (page 19).

Results

Juvenile Chinook salmon timing and abundance

Generalized Linear Model testing for effects of fixed factors revealed log-transformed Chinook density was not influenced by years or months but was influenced by strata (Table 2, Figures 3 and 4). Juvenile Chinook salmon were present in Kiket Lagoon or its vicinity the first month of beach seining in each of the three years we sampled. Juvenile Chinook salmon peaked in Kiket Lagoon in April each year. The period of presence for juvenile Chinook salmon in Kiket Lagoon was January through May and is consistent with the Chinook fry migrant rearing period for other pocket estuaries within the Whidbey Basin (Beamer et al. 2006). Density of juvenile Chinook salmon was higher inside Kiket Lagoon than in adjacent nearshore habitat during these months in every year sampled.

Table 2. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Chinook salmon density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Strata (lagoon or adjacent nearshore)	11.535	1	11.535	11.996	**0.001**
Year	0.007	1	0.007	0.008	0.931
Month	1.863	1	1.863	1.938	0.165
Error	240.392	250	0.962		

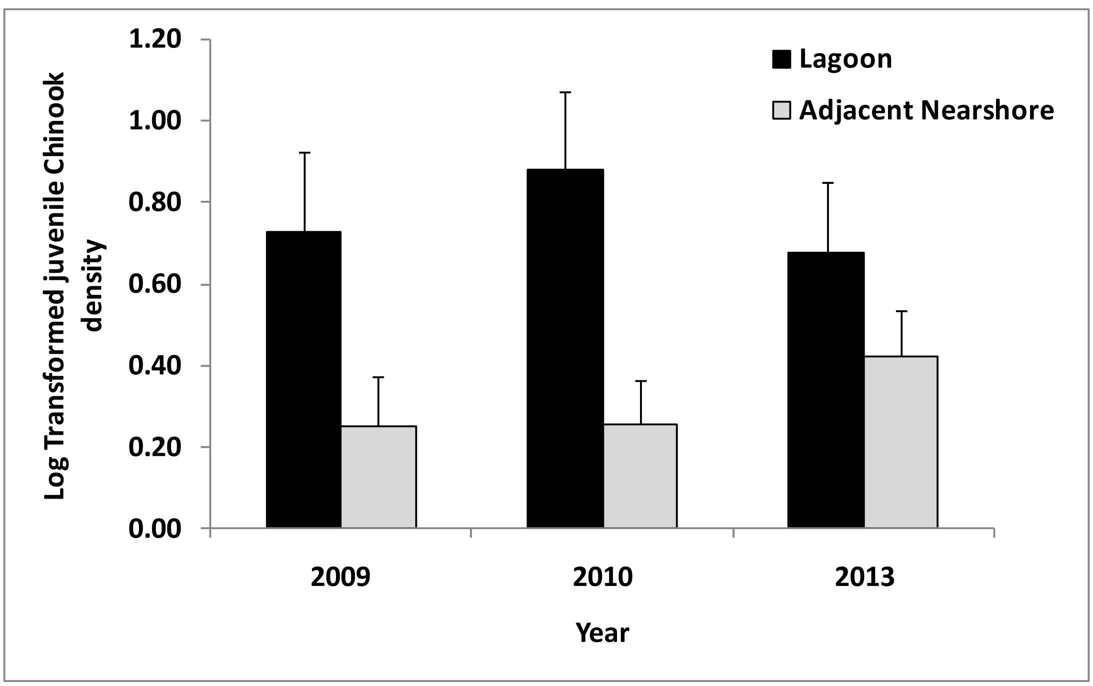


Figure 3. Log transformed wild juvenile Chinook salmon density by year and strata (lagoon, adjacent nearshore) for Kiket Lagoon. Error bars are standard error.

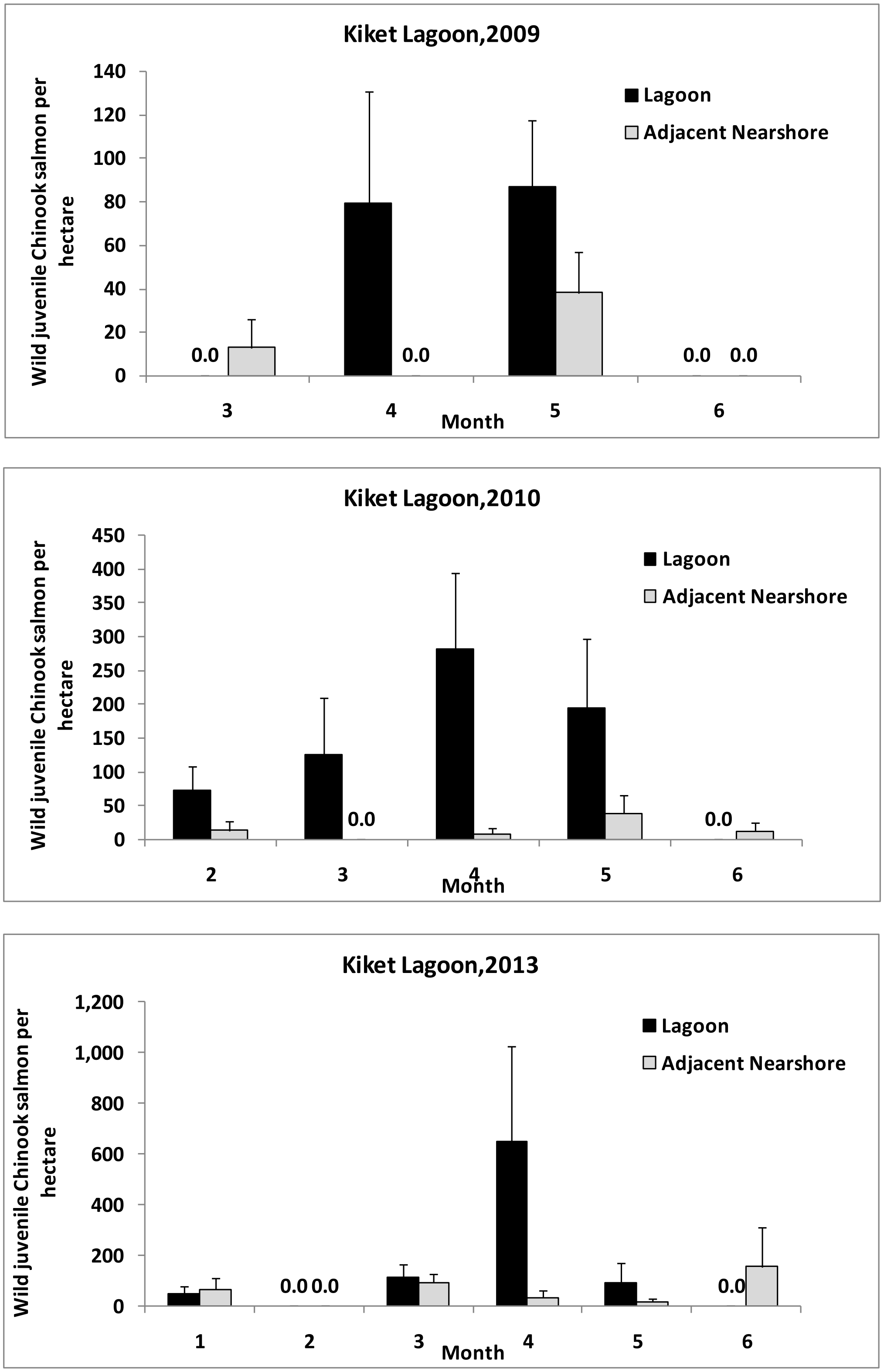


Figure 4. Wild juvenile Chinook salmon density by year, month, and strata (lagoon, adjacent nearshore) for Kiket Lagoon. Error bars are standard error. Fish density is fish/per hectare of wetted area beach seined.

Juvenile Chinook salmon size

Juvenile Chinook salmon increased in length over the period (January through May) when fry migrants rear in pocket estuaries (Table 3 and Figure 5). Juvenile Chinook salmon caught in the lagoon during that period were larger than juvenile Chinook salmon caught in adjacent nearshore habitat at the same time. This suggests that the juvenile Chinook salmon within Kiket Lagoon may be a more isolated (and a rearing rather than migrating) population, or that lagoon habitat may be more productive than the more exposed adjacent nearshore environment during January through May.

Table 3. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Chinook length for all years combined during the months when fry migrants rear in pocket estuaries.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Strata (lagoon or adjacent nearshore)	0.021	1	0.021	5.438	0.021
Month (January through May)	0.105	1	0.105	26.680	0.000
Error	0.613	156	0.004		

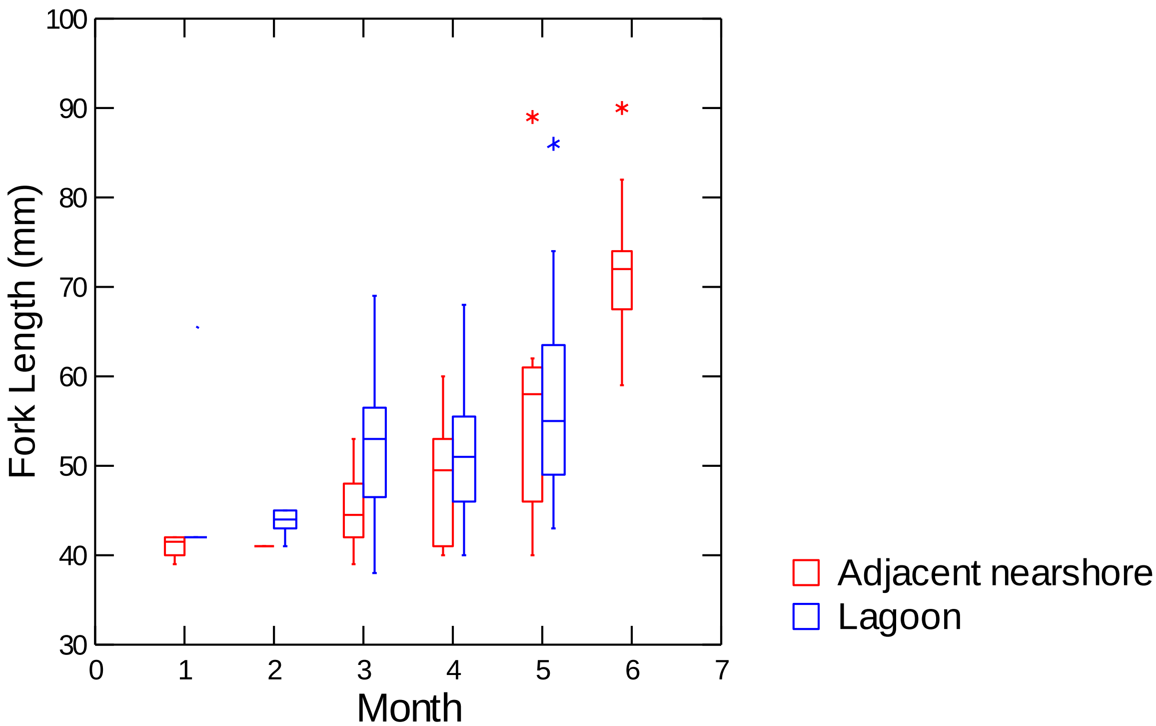


Figure 5. Box plot of juvenile Chinook salmon lengths by month and strata. We combined length data from all years in order to have enough samples for each month shown. Boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Stars are individual fish that are still within the full distribution. Circles (if present) are individual fish outside the full distribution.

Comparison with other Skagit Bay pocket estuaries

Lagoon type pocket estuaries with natural outlet conditions in Skagit Bay consistently have much higher densities of wild juvenile Chinook salmon inside their lagoon or marsh habitat than in adjacent nearshore habitat (Figure 6). The mean value is 6.8 times more juvenile Chinook salmon per unit area inside pocket estuary habitat than its adjacent nearshore for the rearing period February through May. Over the six-year period of studying four different pocket estuaries, we did not find a cumulative seasonal density of wild juvenile Chinook salmon inside the pocket estuary to be lower than in any pocket estuary's adjacent nearshore habitat for the rearing period of fry migrant Chinook salmon. Juvenile Chinook salmon results for the three years (2009, 2010, and 2013) of sampling in Kiket Lagoon are similar to other Skagit Bay pocket estuaries with natural outlet channels. The mean value of 4.9 times more juvenile Chinook salmon per unit area inside Kiket Lagoon than in its adjacent nearshore for the fry migrant rearing period is somewhat lower than the other Skagit pocket estuary sites. However, in all three years, cumulative seasonal density of wild juvenile Chinook salmon inside Kiket Lagoon was always higher than in its adjacent nearshore habitat, and the Kiket Lagoon results are consistent with the range of variability observed at the other Skagit Bay pocket estuary sites.

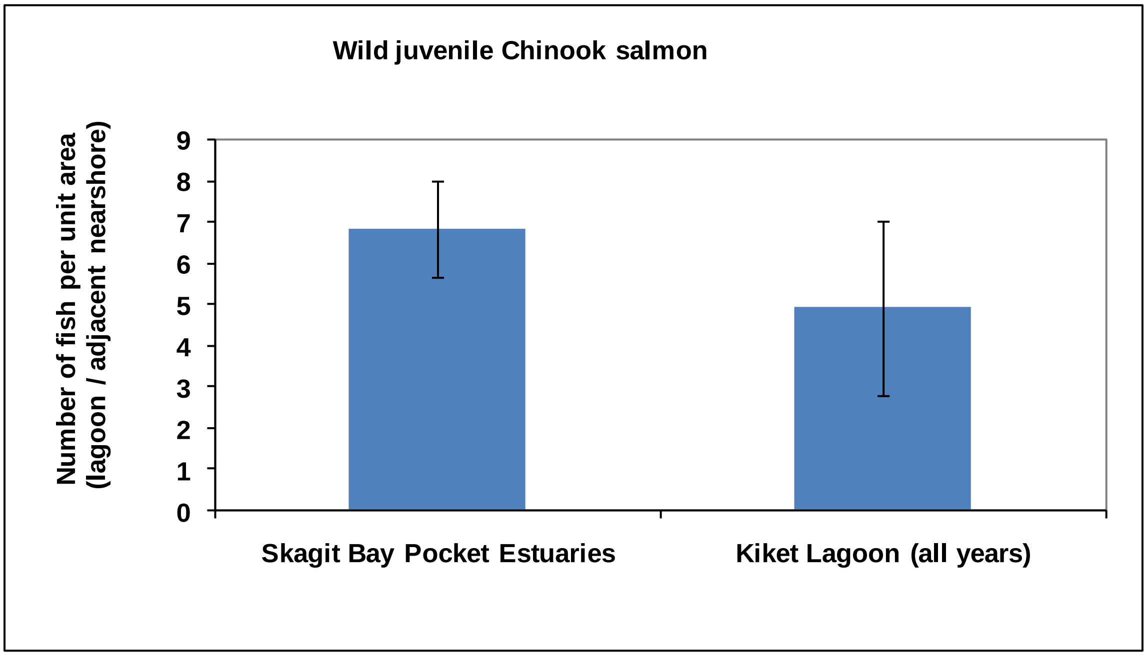


Figure 6. Relative difference in wild juvenile Chinook salmon density in pocket estuary habitat compared to adjacent nearshore habitat during the fry migrant Chinook rearing period. All pocket estuaries in this figure have natural outlet conditions (i.e., no culvert or tidegate). Graphed bar height is the average value; error bars are standard error. The Skagit Bay Pocket Estuaries result is from four pocket estuaries (Arrowhead Lagoon, Lone Tree Lagoon, Old Bridge Saltmarsh, and Turners Bay) over 6 years (2003 – 2007, and 2009). Results for Kiket Lagoon are from 2009, 2010 and 2013.

Conclusions & Recommendations

Juvenile Chinook salmon use of Kiket Lagoon

- **Juvenile Chinook salmon currently use Kiket Lagoon in a manner consistent with the timing and abundance patterns of other Skagit Bay pocket estuaries.**

  Monitoring in 2009, 2010, and 2013 consistently confirm that juvenile Chinook salmon were using the lagoon and that juvenile Chinook salmon timing and abundance levels are consistent with other pocket estuaries within Skagit Bay. The three years of pre-restoration monitoring data are useful to determine a fish response after restoration, should any restoration occur.

Restoration of the lagoon

- **Increasing the lagoon's wetted area, if feasible, would benefit Skagit Chinook salmon.**

  Because of the limited extent of pocket estuary habitat throughout Skagit Bay and Whidbey Basin (Beamer et al. 2006) and fry migrant Chinook salmon dependence on it (Beamer et al. 2003), any increase in Kiket lagoon's wetted area would benefit fry migrant Chinook salmon. Such restoration is consistent with objectives of the Skagit Chinook Recovery Plan (SRSC & WDFW 2005). The Skagit Chinook Recovery Plan suggests that a portion of Kiket Lagoon has been filled, reducing its size.

Protection of the lagoon

- **Protecting existing lagoon habitat from loss and degradation could be improved by ensuring freshwater flowing into the lagoon does not damage fish and other native biota.**

  We want to draw attention to drainage issues in the area upslope and east of Kiket Lagoon because they have the potential to improve or degrade Kiket Lagoon's ecosystem depending on how they are handled long-term. Issues with road drainage in this area have been a concern recently and repeatedly. Skagit County worked on drainage along SneeOosh Road in 2012 and 2013, resulting in Swinomish Public Works having to take action to prevent the Kukutali Preserve access road from washing out. Currently SneeOosh Road drainage is routed toward Kiket Lagoon alongside the Kukutali Preserve entrance road. The photos in Figures 7-10 show the water is turbid, and after the pictured late-January 2013 freshet receded, the small pools/retention areas formed by the fist-sized rock dams in the ditch were completely filled with fine sediment. The rapid filling of sediment in these impoundments suggests that fine sediment is being transported to the lagoon. The ditch does not extend all the way to the lagoon (Figure 10), but there is not sufficient distance, nor a defined retention area, between the ditch and the lagoon to allow for adequate water quality biofiltering or sediment settlement.

Because the flow in the drainage ditch is collected by roadside ditching, the water may contain contaminants (e.g., petroleum products, brake pad material) known to be harmful to fish and other native biota (e.g., Olympia oysters) living in the lagoon. Best Management Practices (BMPs) for freshwater flow should attenuate runoff rates during freshets and increase flow during drought periods, improve water quality through biofiltration, and allow for settlement of fine sediment before entering the lagoon. BMPs could also be implemented to utilize the freshwater flow as a beneficial factor for fry migrant Chinook salmon by attracting them to the lagoon and providing lower salinities in the lagoon than in Skagit Bay, which improves a young fish's physiological transition to saltwater.

Figure 7. Roadside drainage at the entrance gate to Kukutali Preserve at SneeOosh Road. Photo by Bruce Brown, 1/30/2013.

Figure 8. Looking upstream toward the entrance gate on SneeOosh Road from where the caretaker’s driveway intersects the access road. Photo by Bruce Brown, 1/30/2013.


Figure 9. Ditch collecting flow just uphill of the caretaker house and conveying the water to the roadside ditch. Photo by Bruce Brown, 1/30/2013.


Figure 10. The ditch empties into wetland immediately uphill of Kiket lagoon. Photo by Bruce Brown, 1/30/2013.

Juvenile Chinook salmon use along the tombolo

Background

Within the delta and nearshore ecosystems of the Skagit River, Beamer et al. (2005) used habitat connectivity as an attribute to help predict the use of specific habitats within the Skagit River delta and nearshore landscape. Landscape connectivity was defined as a function of both the length and the complexity of the pathway that juvenile Chinook salmon must follow to certain types of habitats, like blind tidal channels in the Skagit River delta, or pocket estuaries in adjacent nearshore areas of Skagit Bay. Habitat connectivity decreases as the complexity of the route fish must swim increases and as the distance the fish must swim increases. Beamer et al. (2005) show results from 2003, which had an outmigration population size of 5,500,000 juvenile Chinook salmon. In this year, landscape connectivity explained 68% of the variation in seasonal density of Chinook salmon at monitored sites within the Skagit River estuary and pocket estuaries (see pages 20-21 of Beamer et al. 2005).

Restoration of landscape connectivity is a general restoration strategy within the Skagit Chinook Recovery Plan for estuarine and nearshore areas (SRSC and WDFW 2005). Thus, increasing the connectivity between Kiket Lagoon and the source of juvenile Chinook salmon (i.e., the Skagit River) is considered a potential restoration action within the boundaries of Kukutali Preserve. Increasing connectivity to Kiket Lagoon conceptually includes removal of road fill material (and replacement with bridge) at the end of the tombolo that links Fidalgo Island with Kiket Island. If this restoration action were to occur, juvenile salmon migrating along the south shoreline of the tombolo at high tide could be expected have a shorter and more direct pathway to Kiket Lagoon by swimming through the passage rather than traveling around Kiket Island to find rearing habitat within Kiket Lagoon. Presumably, the longer pathway results in more fry migrant Chinook salmon being dispersed to less preferred habitats within Skagit Bay and fewer Chinook finding Kiket Lagoon. To estimate whether there could be a benefit to juvenile Chinook salmon by such a restoration action, we measured juvenile Chinook abundance on either side of the tombolo. If more fish were found on the south side of the tombolo than on the north side, we can infer that some of those fish could be attracted to Kiket Lagoon by creating a shorter pathway as conceptually described above.

Methods

The purpose of this beach seining effort was to compare wild (unmarked) juvenile Chinook salmon density on either side of the tombolo connecting Fidalgo Island to Kiket Island.

<u>Sites and effort</u>: A field crew beach seined sites on either side of the tombolo during the 2013 Chinook salmon fry migrant pocket estuary rearing period (Figure 2 above). Sites Kiket Beach S and Kiket Tombolo S make up the “south” stratum. Sites Kiket Tombolo N and Kiket Beach N make up the “north” stratum. Beach seining started in January and ended after June, coinciding with the period fry migrant Chinook salmon rear in pocket estuaries within the Whidbey Basin (Beamer et al. 2006). Beach seining occurred every

other week during the sampling period. A total of 88 beach seine sets were made (Table 4).

Table 4. Number beach seine sets made in 2013 by month and strata.

	Strata	
Month	**North side of tombolo**	**South side of tombolo**
1	4	4
2	8	8
3	8	8
4	8	8
5	8	8
6	8	8

Beach seining: We used small net beach seine methodology (Skagit System Cooperative 2003). The small net beach seine methodology employed an 80-ft (24.4 m) by 6-ft (1.8 m) by 1/8-inch (0.3 cm) mesh knotless nylon net. The net was set in "round haul" fashion by fixing one end of the net on the beach, while the other end was deployed by setting the net "upstream" against the water current, if present, and then returning to the shoreline in a half circle. Both ends of the net were then retrieved, yielding a catch. The small net beach seine was usually deployed from a floating tub that was pulled while wading along the shoreline.

Data collected: All fish captured were identified to species, counted, and measured for length. Environmental variables (temperature, salinity, DO, depth, substrate) associated with each beach seine set were also collected. All data were entered into an existing Access database. However, in this report we are only focusing on juvenile Chinook salmon results.

Fish density: We calculated the density of wild (unmarked) juvenile Chinook salmon for each set (the number of fish divided by set area). Set area is determined in the field for each beach seine set.

Statistical analysis: We used GLM to evaluate the effects of temporal (month) and habitat (two strata: north side of tombolo, south side of tombolo) variables on juvenile Chinook salmon density. Fish densities were log (x+1) transformed to reduce the effects of high skew and unequal variance across groups. Month and strata were evaluated for main effects as fixed factors for their influence on juvenile Chinook salmon density.

Results

Juvenile Chinook salmon were caught on both sides of the tombolo (Figure 11). In the later months (May and June), juvenile Chinook were only caught on the south side. The largest monthly mean density of juvenile Chinook salmon occurred in June and was on the south side of the tombolo. However, juvenile Chinook salmon had left Kiket Lagoon by June in each of the three years we beach seined (Figure 4) and are larger than the size that typically use pocket estuaries (Figure 5). Juvenile Chinook salmon typically move out of pocket estuaries by June (Beamer et al. 2006) likely because they have outgrown their need for this type of refuge habitat and because environmental conditions (e.g., water temperature) begin to exceed the preference levels for juveniles at that time of year (Beamer et al. 2003). Therefore, we excluded catches from June in our fish density analysis.

We did not detect a difference in mean density of juvenile Chinook salmon between the north and south side of the tombolo during the time period when fry migrant Chinook salmon rear in pocket estuaries (Table 5) or when fry migrants are present in Skagit Bay looking to colonize refuge habitats, such as pocket estuaries (Table 6).

Table 5. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Chinook salmon density during the fry migrant rearing period of pocket estuaries (January through May).

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Strata: (north side of the tombolo; south side of the tombolo)	0.349	1	0.349	0.428	0.515
Month (January-May)	0.009	1	0.009	0.012	0.914
Error	56.283	69	0.816		

Table 6. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Chinook salmon density during the fry migrant outmigration period in Skagit Bay (January through March).

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Strata: (north side of the tombolo; south side of the tombolo)	0.076	1	0.076	0.086	0.771
Month (January-March)	3.189	1	3.189	3.605	0.065
Error	32.736	37	0.885		

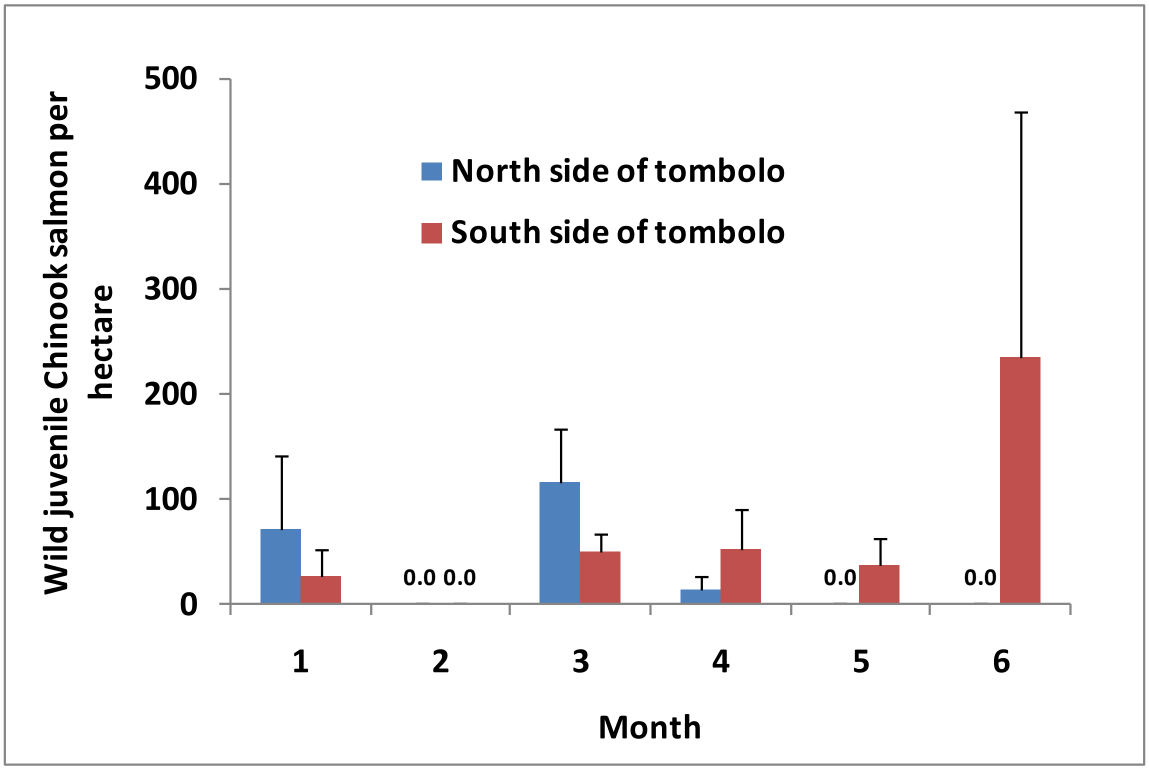


Figure 11. Wild juvenile Chinook salmon density by month and strata (north side of the tombolo, south side of the tombolo) in 2013. Error bars are standard error. Fish density is fish/per hectare of wetted area beach seined.

Conclusions and Recommendations

The results from this one year of study suggest juvenile Chinook salmon are distributed on both sides of the tombolo. We would not predict a statistically detectable increase in juvenile Chinook salmon use of Kiket Lagoon solely from increased connectivity between Fidalgo Island and Kiket Island. However, there is no downside (i.e., no harm to juvenile Chinook salmon) to increasing connectivity between Fidalgo and Kiket Islands. Our conclusion of 'no effect' may be driven by a lack of data. Improved connectivity would help restore the currently impaired natural processes (e.g., tidal and coastal sediment dynamics) and beach conditions (e.g. presence of riprap) at the site of the tombolo; we did not study these topics as they would be addressed in a feasibility analysis.

Forage fish spawning within Kukutali Preserve

Background

Surf smelt and sand lance are the two forage fish species that lay their eggs on intertidal beaches in Puget Sound and are therefore susceptible to human activities on beaches or activities that change beach substrate characteristics. Within the Whidbey Basin smelt spawning can be year round, however summer spawning appears to be the dominant time period (Quinn et al. 2012). Little is known about the seasonal patterns of smelt or sand lance spawning along Kukutali Preserve's shoreline other than limited data from WDFW documenting presence of smelt eggs. Forage fish egg surveys were done by WDFW one day each in December 2002, September 2003, and November 2003 at five sites nearby or within the Preserve area. Smelt eggs were present at most sites in September and one site in November, but no eggs were found in December. To help fill this data gap in intertidal forage fish spawning, we documented intertidal spawning forage fish egg presence, abundance, and condition from beaches within Kukutali Preserve in 2013. Results will be used to help formulate protection or restoration actions in the Preserve's natural resource management plan.

Methods

The purpose of this monitoring effort was to document surf smelt and sand lance egg presence, abundance, and condition from beaches within Kukutali Preserve.

<u>Sites and effort</u>: We sampled Kukutali beaches monthly for ten months (January 2013 through October 2013) to identify a) the presence of eggs, b) relative abundance of eggs when present, and c) condition of eggs when present. Monitoring occurred on four beach areas within the Preserve identified by the Swinomish Planning Department for assessment. The four beaches are located 1) north of the tombolo, 2) south of the tombolo, 3) on the north-facing cove between Kiket and Flagstaff Islands, and 4) immediately south of this cove (Figure 12).

Figure 12. Location of beaches sampled for forage fish eggs in 2013.

Sample collection: Sampling for forage fish eggs consisted of taking approximately 400-500ml scoops of surface beach substrate to a depth of approximately 5 cm at three to four locations along each beach each month. Each scoop of beach substrate was placed in a separate jar and fixed with Stockard's solution to preserve its contents. The number of sample jars per site and month are shown in Table 7. Samples were collected on or slightly below the high tide wrack line. Unlike Quinn et al. (2012) we did not combine all scoops of substrate from a beach site into one large sample and conduct the wet sieving and winnowing process to reduce the amount of beach substrate material examined for forage fish eggs. Instead, we examined the contents of all collected beach substrate for forage fish eggs.

Table 7. Number of sampling jars of beach substrate per site and month for Kukutali Preserve beaches in 2013.

Month	Kiket Cove North	Kiket Cove South	Kiket Tombolo North	Kiket Tombolo South
1	3	3	3	3
2	3	3	3	3
3	4	4	4	4
4	4	4	4	3
5	4	4	4	4
6	4	4	4	4
7	4	3	3	4
8	4	4	4	4
9	4	4	4	4
10	3	3	3	3

<u>Data collected</u>: We examined the entire beach substrate sample under a dissecting scope and identified all eggs found to species and classification of smelt egg development according to the simplified egg developmental and health stages shown in Figure 13.

<u>Analysis</u>: We did not conduct statistical analysis on the resulting egg data. We report simple summaries of the results by site and month: presence by species, smelt egg timing, abundance, health, and developmental condition.

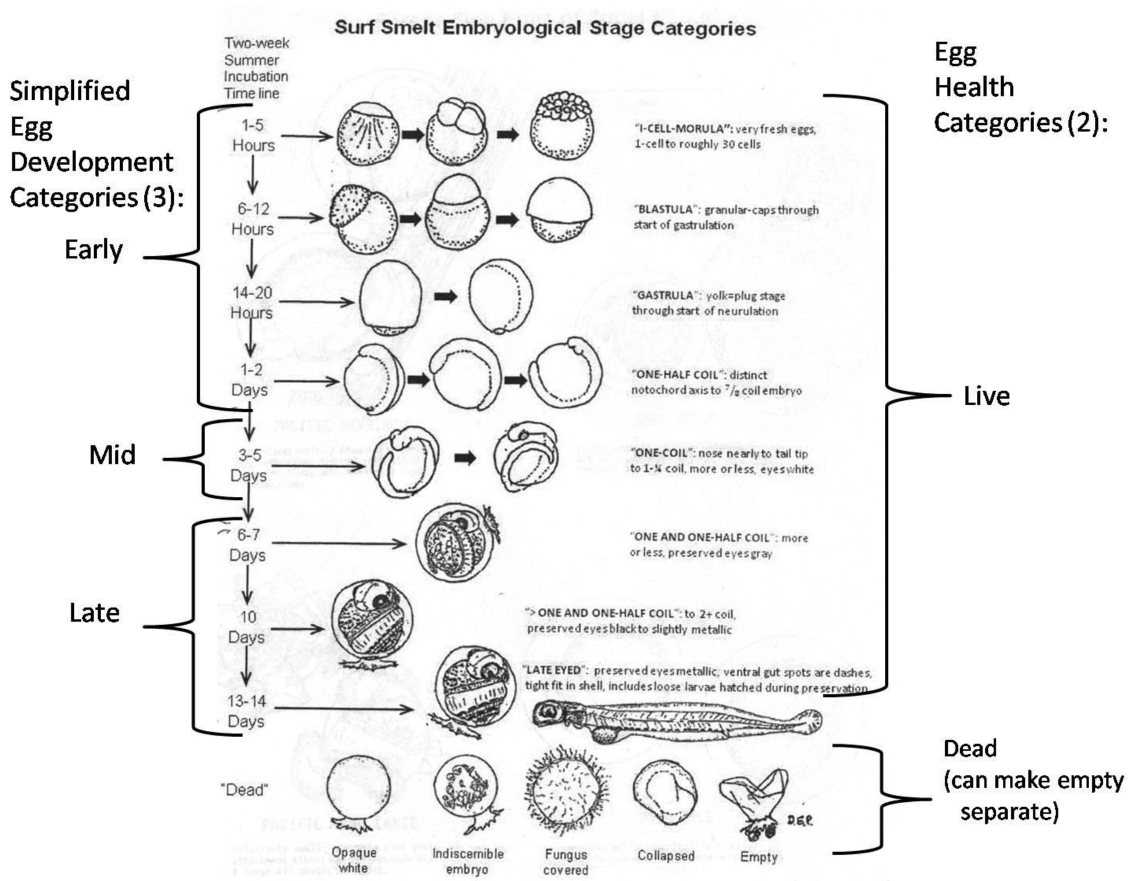


Figure 13. Simplified surf smelt egg developmental stages for summer conditions (drawing from Dan Penttila of WDFW). Empty eggs could be the result of a dead egg (after crushing and the contents have evacuated) or a live egg that has hatched. Due to this uncertainty, we considered empty eggs a separate category.

Results

Egg presence by species

Eggs of herring, surf smelt, sand lance, and rock sole could be predicted to be present on the intertidal beaches of Kukutali Preserve. Herring eggs would be found in lower intertidal and subtidal areas attached to submerged aquatic vegetation, such as eelgrass and kelp; our sampling method did not target detection of herring eggs. The eggs of sand lance, smelt, and rock sole would be found within intertidal beach substrate, where we sampled.

Over the ten month period we found only surf smelt eggs in samples collected from Kukutali Preserve beaches. No sand lance eggs, or eggs of any other fish species, were observed in our samples.

Surf smelt egg timing and abundance

No smelt eggs were found at any Kukutali Preserve site before June, nor in October (Table 8). Three of the four sites had eggs present at least one time during the ten months of sampling. For sites with egg presence, peak smelt egg abundance was in August and September, dropping sharply to no eggs in October (Figure 14). Smelt eggs were found consistently at Kiket Cove North during summer months (June through September). Smelt eggs were found at Kiket Cove South in August and September. We found smelt eggs present, but at low abundance, in only one month (September) at Kiket Tombolo South. The timing and relative abundance pattern of smelt eggs at Kukutali Preserve in 2013 is similar to patterns observed by Quinn et al. (2012) on Camano Island, where no or low abundance of smelt eggs were found during winter months and peak smelt egg abundance was found during summer months.

Table 8. Presence of surf smelt egg by site and month at Kukutali Preserve beach, 2013.

Month	Kiket Cove North	Kiket Cove South	Kiket Tombolo North	Kiket Tombolo South
1	Not found	Not found	Not found	Not found
2	Not found	Not found	Not found	Not found
3	Not found	Not found	Not found	Not found
4	Not found	Not found	Not found	Not found
5	Not found	Not found	Not found	Not found
6	**Present**	Not found	Not found	Not found
7	**Present**	Not found	Not found	Not found
8	**Present**	**Present**	Not found	Not found
9	**Present**	**Present**	Not found	**Present**
10	Not found	Not found	Not found	Not found

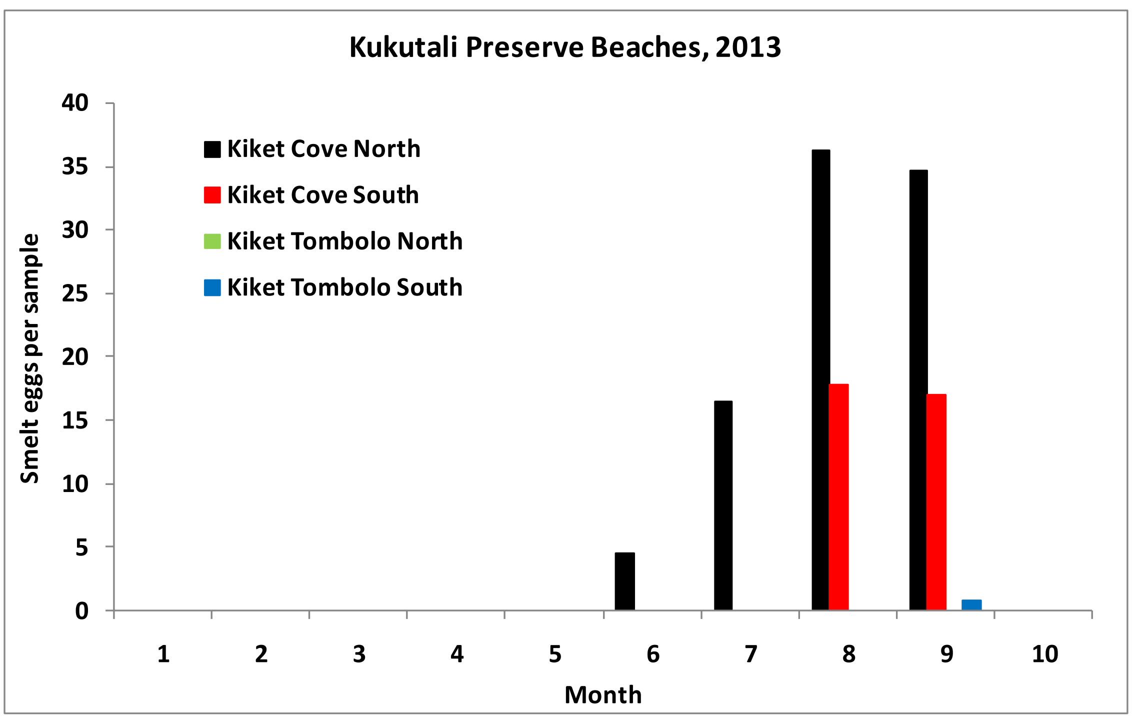


Figure 14. Average number of surf smelt eggs per sample jar by Kukutali Preserve beach site and month in 2013. Each sample jar has an average of 465 grams (wet weight) of beach substrate. Three to four jars were collected at each beach site per month.

Surf smelt egg health

Smelt eggs are classified as either live, empty, or dead (Figure 13). Empty eggs could be the result of a dead egg (after crushing and the contents have evacuated) or a live egg that has hatched. Due to this uncertainty, we considered empty eggs a separate category from live or dead. We report monthly findings of smelt egg health by beach in Table 9.

Table 9. Percentage of live/empty/dead surf smelt eggs by month and site in 2013 when eggs were present.

Month	Kiket Cove North	Kiket Cove South	Kiket Tombolo South
6	61/22/17		
7	36/35/29		
8	8/25/67	82/4/14	
9	27/14/59	22/32/46	100/0/0

Number of surf smelt spawning cohorts

Smelt eggs classified as live were also differentiated by their development stage as: early (hours-2 days old), mid (3-5 days old), or late (6-14 days old) (Figure 13). Since smelt spawn at high tide and all the eggs in a specific spawning event are exposed to the same environmental conditions (e.g., temperature) they develop at approximately the same rate. Therefore, by including egg development stage in our results we can determine whether multiple spawning events are present in our samples. We found up to three different development stages present in our samples by month at beaches in Kukutali Preserve in 2013 (Table 10).

Table 10. Minimum number of smelt spawning cohorts present by month and site at Kukutali Preserve beaches in 2013.

Month	Kiket Cove North	Kiket Cove South	Kiket Tombolo North	Kiket Tombolo South
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	**3**	0	0	0
7	**3**	0	0	0
8	**2**	**2**	0	0
9	**2**	**2**	0	**1**
10	0	0	0	0

The temperature experienced by smelt eggs influences their rate of development and therefore the number of days to hatch (Middaugh et al. 1987). As smelt eggs are positioned in the intertidal zone, both water and air temperature influence the eggs with the diurnal tidal cycle. In summer, periods of water inundation tend to be the cooler part of the day (Rice 2006). In winter, the time when eggs are inundated may be the warmer part of the day because water temperatures may be warmer than the air. Smelt eggs will incubate and hatch in approximately two weeks during summer months and take up to a month during winter (Middaugh et al. 1987). Therefore, our monthly sampling at Kukutali Preserve could have missed complete spawning cohorts in the warmer summer months but likely not in the colder winter and early spring months.

By keeping track of stage of development in our results we can identify a minimum number of spawning aggregations (cohorts). Assuming a two-week incubation period for smelt eggs during summer, a minimum of six different spawning aggregations occurred on Kukutali Preserve beaches in the summer of 2013.

Annual variability in surf smelt spawn timing

Surf smelt are known to spawn year round, but are thought to be summer dominant in the northern Whidbey Basin (Quinn et al. 2012). We have no direct measure of annual variability in spawn timing of surf smelt on Kukutali Preserve beaches because we only measured smelt eggs on Kukutali Preserve beaches in 2013. However, beach seining has occurred on Kukutali Preserve beaches in two additional years, 2009 and 2010, as a result of a long-term Chinook salmon monitoring effort implemented in the Skagit River estuary and Skagit Bay (Figure 15).

If beach seine data indicates spawner-sized (> 120 mm) smelt are present along Kukutali Preserve beaches, then it is reasonable to assume they will spawn nearby and approximately at the same time as when we catch them. Also, if a significant part of the beach-seined smelt are very small (e.g., in the 40 mm range) then we assume a cohort of newly hatched smelt are present. Thus, fork length data of smelt caught by beach seine from all seining effort within Kukutali Preserve can give a sense of possible spawn timing for the additional two years (2009 and 2010) to go along with the one year (2013) we monitored smelt eggs directly on Kukutali Preserve beaches.

Figure 15. Location of all beach seine sites with fish catch data within Kukutali Preserve. The nine additional fish sampling sites shown in this figure (compared to the sites shown in Figure 2) are a result of beach seine sampling for long-term monitoring of juvenile Chinook salmon in Skagit Bay (Greene and Beamer 2006).

Year 2009: Results for the fork length of smelt caught along Kukutali Preserve beaches in 2009 is shown in Figure 16, the top left panel. In the three months that beach seining occurred this year there is no evidence of winter or early spring spawning.

Year 2010: Results for the fork length of smelt caught along Kukutali Preserve beaches in 2010 is shown in Figure 16, the top right panel. Except for February 2010 there is not much evidence of spawner-sized smelt along Kukutali Preserve beaches. The presence of spawner-sized fish in February 2010 did not result in catching very small smelt (e.g. 40 mm) a month or two later in 2010 which would have been the progeny of a spawning event had it occurred in February. However, the smelt fork length distribution in June 2010 is narrower and smaller than in previous months. The smaller fish caught in June 2010 may be progeny of a spawning event that occurred within or near Kukutali Preserve beaches in late April or May.

Year 2013: Results for the fork length of smelt caught along Kukutali Preserve beaches in 2013 is shown in Figure 16, the bottom left panel. Smelt fork length results match closely with our observed in smelt egg counts in 2013. Juvenile smelt dominated the catches January through May (Figure 16, bottom left panel) and we did not observe any smelt eggs in our samples (Figure 14). In June, larger spawner-sized smelt were caught and we observed smelt eggs on one of the four Kukutali Preserve beaches that month. In fact, spawner-sized smelt made up most of the smelt catch in the summer months of 2013.

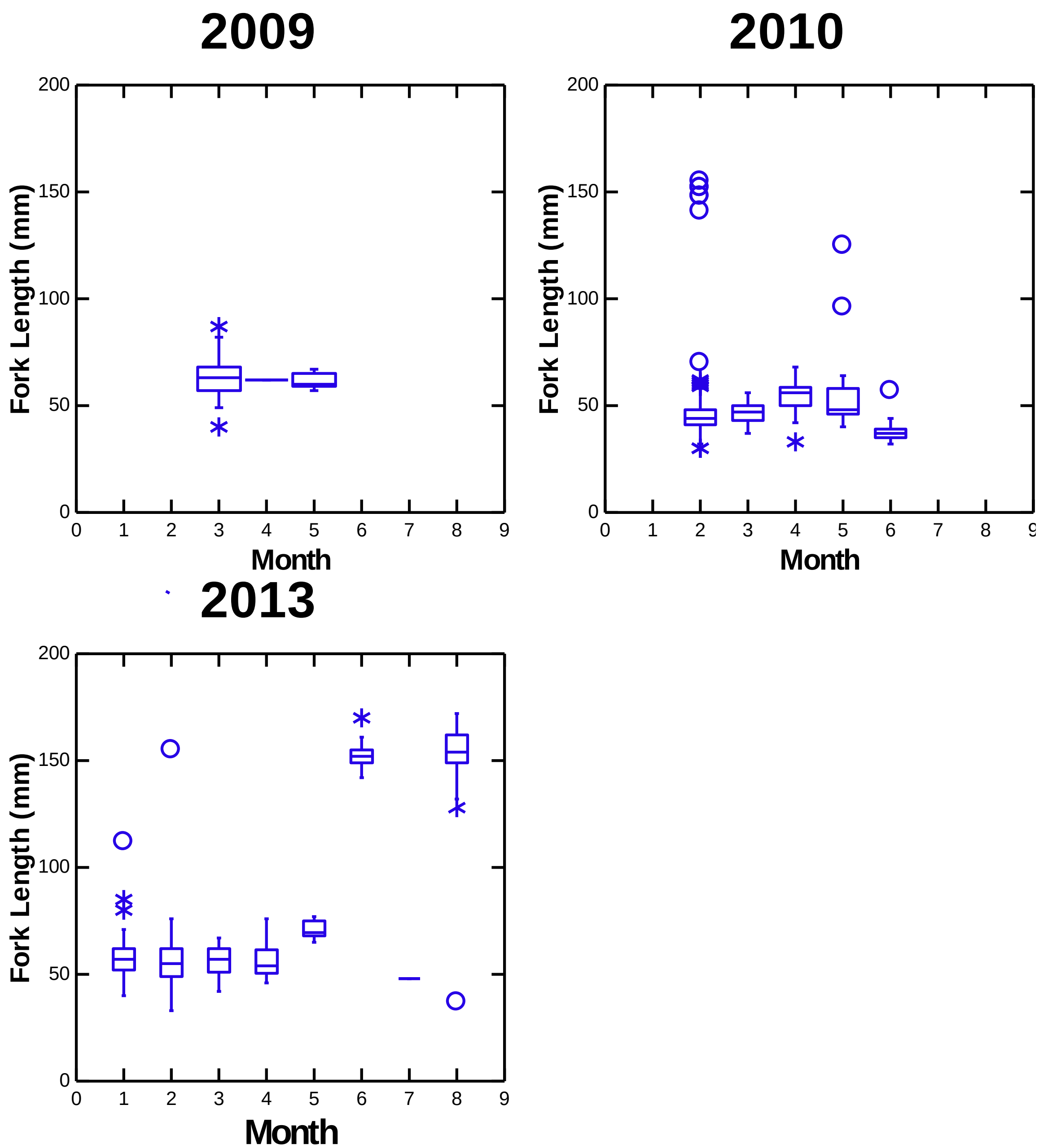


Figure 16. Box plot of surf smelt fork lengths by month and year. Boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentiles. Stars are individual fish that still within the full distribution. Circles are individual fish outside of the full distribution. In 2009 beach seining occurred during the months of March through June. In 2010 beach seining occurred during the months of February through June. In 2013 beach seining occurred during the months of January through August.

While all our data related to smelt spawning (fish size and egg surveys) are temporally limited, there is not much evidence of smelt spawning at Kukutali Preserve beaches in winter nor early spring months. The three years of beach seining during winter and spring months did not find many spawner-sized surf smelt (except in February 2010) nor post-larval smelt, indicating a nearby successful smelt spawning event did not occur a month prior. In contrast to winter, we observed smelt eggs on Kukutali Preserve beaches during summer months and caught spawner-sized smelt along beaches of the Preserve. The limited WDFW smelt spawn data (see background subsection) also do not indicate a strong winter smelt spawning on Kukutali Preserve beaches. Thus, we conclude year round surf smelt spawning on Kukutali Preserve beaches is possible, but summer spawning is clearly dominant. The summer spawning period could start as early as May and go through September.

Conclusions and Recommendations

We found only surf smelt eggs in samples collected from Kukutali Preserve beaches. Like other Whidbey Basin beaches, year round surf smelt spawning is possible, but summer spawning is clearly dominant. Actions that adequately protect beach substrate and egg incubation conditions should be part of the management plan of Kukutali Preserve. These actions should include:

1. **Maintain healthy, and improve impaired, coastal sediment processes influencing Kukutali Preserve beaches**. This action category would include removal or prevention of the use of bulkheads or groins on non-bedrock beaches. These structures block the supply or transport of sediments to beaches.
2. **Maintain healthy, and improve impaired, marine riparian zones on Kukutali Preserve beaches**, especially related to beach shading. Shaded beach areas are an important contributor to egg survival for summer spawning smelt (Rice 2006).

References

Beamer, E, A McBride, C Greene, R Henderson, G Hood, K Wolf, K Larsen, C Rice, and K Fresh. 2005. Delta and nearshore restoration for the recovery of wild Skagit River Chinook salmon: linking estuary restoration to wild Chinook salmon populations. Appendix to the Skagit Chinook Recovery Plan. Available at www.skagitcoop.org/.

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

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

Greene, C, and E Beamer. 2006. Monitoring of population responses by Skagit River Chinook salmon to estuary restoration. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org/.

Middaugh, DP, M Hemmer, and D Penttila. 1987. Embryo Ecology of the Pacific Surf Smelt, *Hypomesus pretiosus* (Pisces: Osmeridae). Pacific Science 41(1-4):44-53.

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, CA. 2006. Effects of shoreline modification on a northern Puget Sound beach: microclimate and embryo mortality in surf smelt (Hypomesus pretiosus). Estuaries and Coasts 29:63–71.

Skagit River System Cooperative and Washington Department of Fish and Wildlife. 2005. Skagit Chinook Recovery Plan. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org/.

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