Forage Fish Spawning in Liberty Bay

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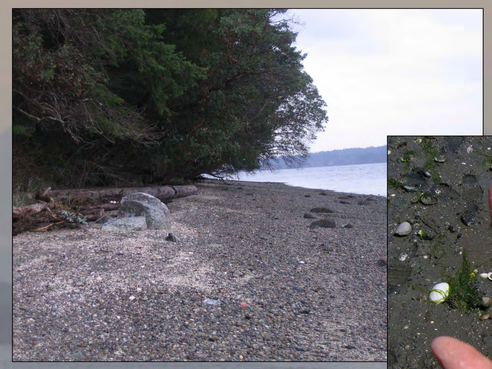
Introduction

Significant portions of the shorelines in Puget Sound have been armored to support urban development. In FY07 we conducted a study of how shoreline armoring might affect beach dynamics and forage fish spawning in Liberty Bay. Sampling activities were focused on Pacific sand lance and surf smelt, two species of forage fish that spawn in the upper intertidal zone. Beach habitat is particularly important for the spawning and successful rearing of these forage fish, which are a key link in the food chain of Puget Sound. Spawning habitats for these forage fish can be damaged by physical burial or armoring structures in the intertidal zone that disrupt the natural erosion and longshore transport of beach substrate. Since these species are so connected with nearshore processes, we consider them to be a good biological endpoint for a study of the effects of urbanization and shoreline armoring.

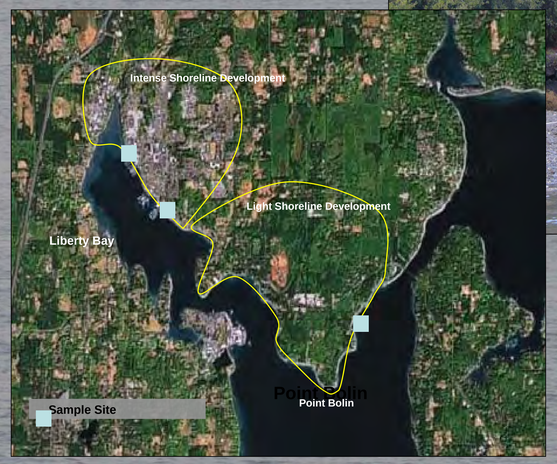
We plan to develop a model to predict the probability of observing forage fish eggs on a segment of shoreline based on its attributes. To begin model development we collected a variety of shoreline attributes (e.g., sediment grain size, land use patterns, freshwater inputs, upland condition, shade, and bulkhead material, location and age) at 20 study beaches in Liberty Bay. We plan to use a logistic regression approach, combining shoreline attribute data with urban indicators (e.g., densities of impervious surface, parcel size, septic systems).

We are currently building a logistic equation based on shorelines in Liberty Bay. Our next step will be to collect data from other shorelines, predict spawning on those shorelines, and then add the most recent data to the existing model to obtain a broadly applicable predictive equation. While the first years using this approach will be somewhat descriptive, ultimately this should lead us toward understanding the dynamics that lead to forage fish spawning on some beaches and not on others.



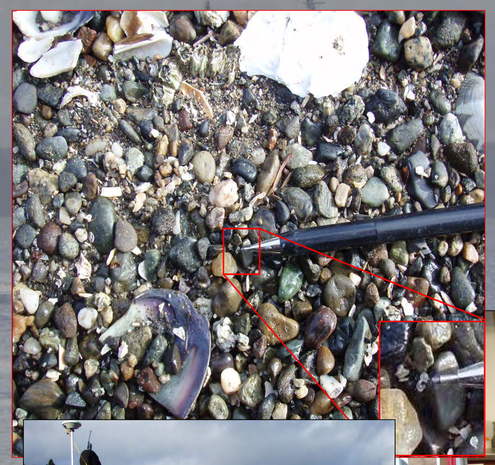
Study Area

Beach surveys in FY07 were focused along a 10 km shoreline on the northeast aspect of Liberty Bay. This section of shoreline was selected based on two broad criteria: 1) some evidence for forage fish spawning activity, and 2) a mix of armored and unarmored beach areas. The study area transitions from dominantly urbanized shoreline at the head of the bay, near the city of Poulsbo, toward more natural shoreline near the mouth of the bay.



Methods

We divided the 10 km shoreline study area into 30 m segments using a GIS. The 30 m segment was the base unit for sampling and was based on that of Moulton and Penttila (2001). Of the 10 km of shoreline, we randomly selected 20 segments (30 m each). At each segment we sampled using both transect and random sample approaches. For the transect approach we modeled after Moulton and Penttila (2001) and collected four samples (500 ml each) of beach material along a transect positioned at +8 ft MLLW elevation. Moulton and Penttila (2001) reported that spawning and incubation areas for these forage fish are generally in the +7 to +9 ft MLLW range. For the random sample approach we randomly selected 8 sample locations from a 1 m grid overlay of the exposed beach area. At each of these 8 points we collected 500 ml of beach material. Between the transect and random sample approaches, we collected 12 total samples from each study segment. Locations of each sample point were recorded with GPS. Beach material and forage fish eggs were preserved in Stockard's solution (5% Formalin) for later enumeration, species identification, and grain size analyses.

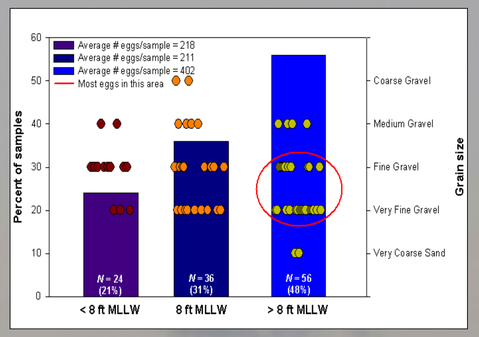


At each study segment we recorded segment attributes, including: armoring characteristics (if present), upland condition, adjacent shoreline condition, shade cover, LWD, overwater structures, and freshwater inputs. Sampling effort was repeated for the 20 study segments, and each segment was sampled twice between December 2006 and January 2007.

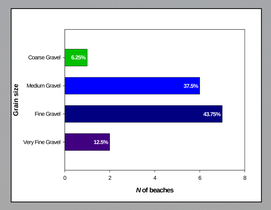
The 480 samples collected during field efforts were processed, and forage fish eggs were enumerated in each sample. The first 50 eggs were removed from each sample for later species identification, and the remaining eggs were counted. We enumerated live eggs separately from dead eggs. Reference samples from Dan Penttila with the Washington Department of Fish and Wildlife were used to verify species identification. We greatly appreciate his assistance.

Results

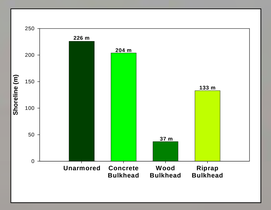
Total forage fish eggs counted = 40,043
Egg mortality = 17%



Estimated beach elevation and grain size for high egg density samples (≥ 75 percentile)

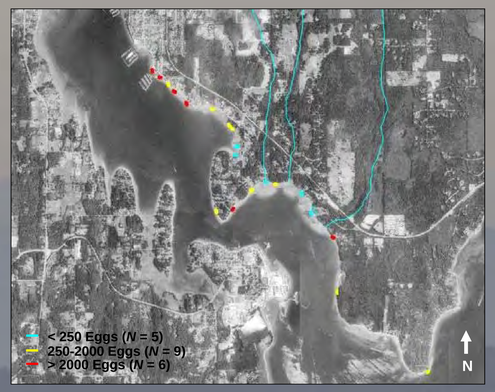


Grain size for 20 study segments (pooled across12 samples/segment)

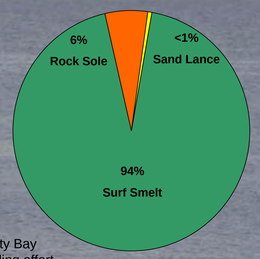


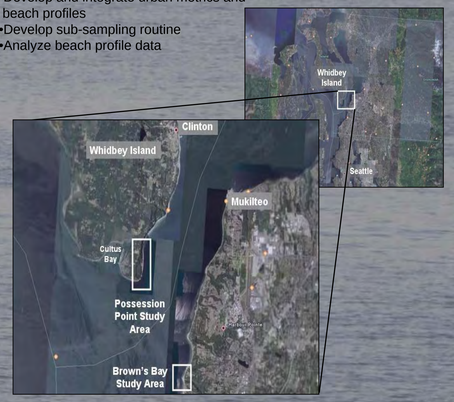
Summary of shoreline condition (armored or unarmored) for 600 m of sampled shoreline

Attribute	# (%) of segments
Shade present	10 (50%)
Shade absent	10 (50%)
Sediment input: none to light	16 (80%)
Sediment input: moderate to heavy	4 (20%)
Freshwater input: none to light	14 (70%)
heavy	6 (30%)
LWD present	7 (35%)
LWD absent	13 (65%)
Shell fragment zone present	10 (50%)
Shell fragment zone absent	10 (50%)



Locations of 20 study segments showing low egg counts (< 250 eggs) in blue, medium (250 – 2000 eggs) in yellow, and high egg counts (> 2000 eggs) in red



Next Steps

- Develop logistic regression for Liberty Bay
- Increase spatial and temporal sampling effort
  - Possession Point
  - Brown's Bay
- Develop and integrate urban metrics and beach profiles
- Develop sub-sampling routine
- Analyze beach profile data