Quantifying modern baselines for an uncertain future: Results from a shoreline biological inventory

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Introduction

Impacts to biological communities are difficult to measure without establishing baselines prior to the environmental change. Although modern records do not provide a quantitative dataset of past ecological function or productivity, they still can provide resource managers with valuable information when assessing current or impending threats. The Swinomish Indian Tribal Community (SITC) has a vested interest in ensuring that biological communities in nearshore habitats around the Reservation support the health and wellbeing of the Swinomish community for the next seven generations. The goal of this project is to refine the 2009 *Swinomish Climate Change Impact Assessment* to include a more detailed analysis of the impacts of sea level rise (SLR) and future storm conditions on rearing habitats for cultural keystone species across Reservation beaches and their influence on Swinomish community health and well-being.

Specifically we addressed **two questions** relating to juvenile salmon and crab and clams**:**

1) Where are the biological hot-spots (clam habitat examined here)? and,

2) What are the site-specific risks to those habitats ?

Methods

Field Survey: 16 transects were sampled during summer 2017 following methods used in 1970 and 2011 (Houghton 1973) on Kiket Island (transects 21, 11, 12, & 16, Figure 1) where samples were collected at 0.61m intervals from 0 to 2.44m (relative to MLLW) at each transect. At each elevation three 0.25m^2 quadrats were placed on the substrate (Figure 2) and percent cover of algae/eelgrass, barnacles, and mussels and abundance of all other surface fauna were collected. Quadrats were excavated to 30cm and processed through a 7mm sieve. All organisms retained were identified to the lowest taxonomic level possible and counted in the field.

Elevation Profiles: Elevation profiles for each transect were derived from a digital elevation model (Grossman et al. 2018) and scenarios of change associated with 0.91 m of SLR expected ~2100 were superimposed to calculate linear distance affected.

Habitat Vulnerability Assessment: Results from this study and from a storm-surge/SLR model were collated into a table and ranked in terms of vulnerability to habitats that support juvenile stages of salmon, crab, and clams by beach site.

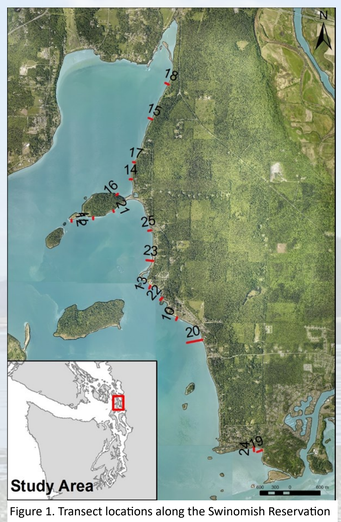

Figure 1. Transect locations along the Swinomish Reservation

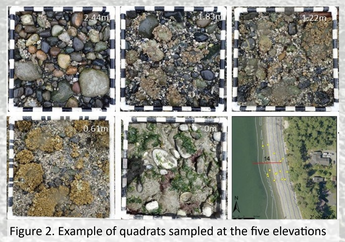

Figure 2. Example of quadrats sampled at the five elevations (2.44, 1.83, 1.22, 0.61, and 0m MLLW) along transect 14. Map depicts sample elevation contours and distribution of points.

Results

Habitat and Biological Characterization

- 5,086 individuals organisms representing 62 species across the 16 transects.
- Beaches south of transect 22 or north of 17 are not ideal for bivalves, most likely due to unsuitable substrate (mud) and/or salinity regimes (Figure 3a) at the lower intertidal elevations.
- South facing beaches at Lone Tree and Kiket had fewer species at 0m relative to more protected west facing beaches (Figure 3b). Transect 13 had a lower abundance of infaunal organisms at 0 and 0.61m between these sites.

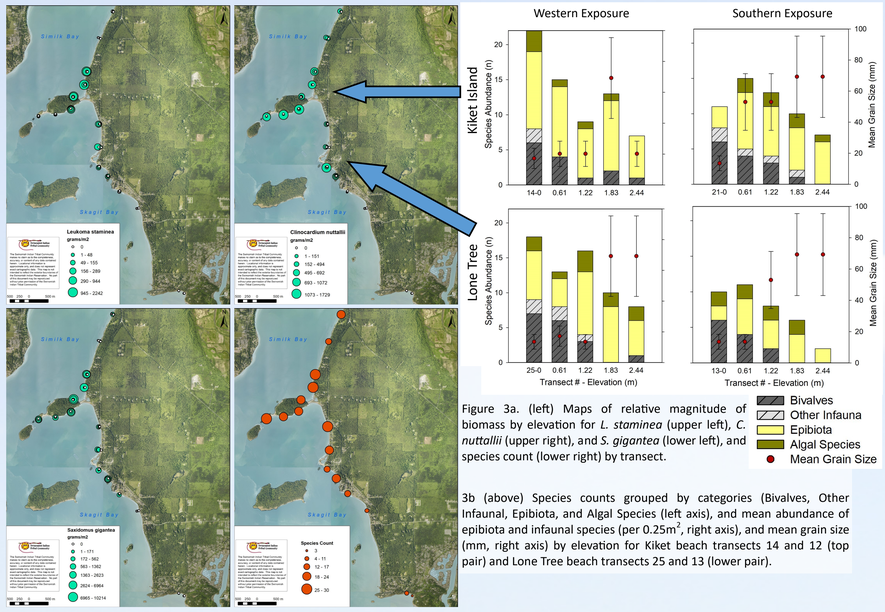

Figure 3a. (left) Maps of relative magnitude of biomass by elevation for *L. staminea* (upper left), *C. nuttallii* (upper right), and *S. gigantea* (lower left), and species count (lower right) by transect.

3b (above) Species counts grouped by categories (Bivalves, Other Infaunal, Epibiota, and Algal Species (left axis), and mean abundance of epibiota and infaunal species (per 0.25m^2, right axis), and mean grain size (mm, right axis) by elevation for Kiket beach transects 14 and 12 (top pair) and Lone Tree beach transects 25 and 13 (lower pair).

Climate Change Impacts—Sea Level Rise

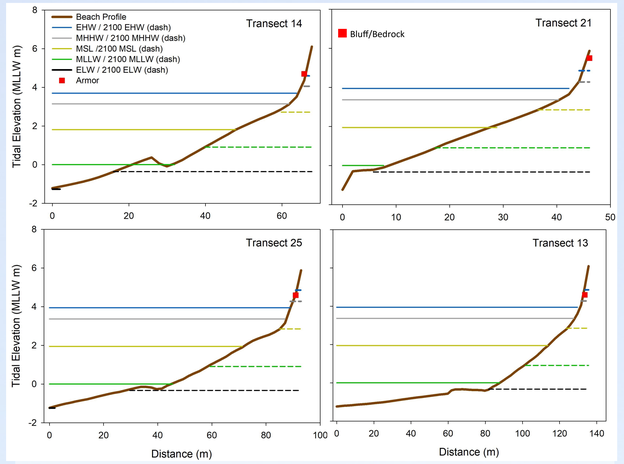

Figure 4. Elevation profiles depicting transects 14 and 21 from Kiket Island and transects 25 and 13 from Lone Tree beach. Each profile (brown) is annotated with lines representing Extreme High Water (EHW, blue), Mean Higher High Water (MHHW, grey), Mean Sea Level (MSL, yellow), Mean Lower Low Water (MLLW, green), and Extreme Low Water (ELW, black) under present (solid line) and 2100 conditions (+0.91m SLR, dotted line). Red squares indicate location of shoreline armoring or the toe of a bluff or bedrock (transect 21 only).

- The south facing transect at Lone Tree beach (13) is the most vulnerable to SLR and could lose 26 linear meters (44.8% loss) of clam habitat by 2100. Southern Kiket Island beaches, transect 21, are the least vulnerable with a loss of < 1 linear m (3.6% loss) of clam habitat by 2100 (figure 4).
- The beach areas could be reduced by 7.2 (25% loss) and 5.3 ha (20% loss) at Lone Tree and Kiket beaches, respectively (figure 5).

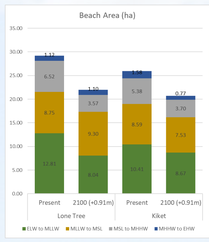

Figure 5. Beach areas at Lone Tree and Kiket Island under present and projected 2100 sea level positions.

Discussion

- This study was able to provide SITC with a modern baseline inventory of biological communities and habitats across Swinomish Reservation beaches and an initial assessment of risk associated with sea level rise, which is projected to squeeze out habitats where armoring or bedrock will preclude shoreline migration.
- Project partners have developed a SLR and storm surge model that shows significant spatial variability in exposure of SITC beaches to wave energy (Figure 6). Ongoing modeling of wave impacts are expected to refine the results shown here and help guide SITC Fisheries research, restoration, and management of clam beaches.
- Beach and species specific vulnerabilities (Table 1) will inform programmatic plans and be cross-walked with a set of environmental community health indicators to determine how changes to these natural resources will in turn impact the Swinomish people and community health.

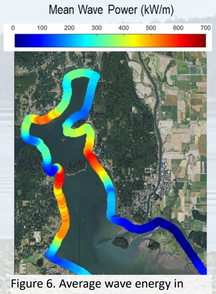

Figure 6. Average wave energy in Skagit and Similk Bays.

Table 1. Risk assessment matrix to first foods salmon, crab, and clam rearing habitat at project study sites on the Swinomish Reservation. Red indicates high relative risk and green indicates low relative risk. Our work presented here focused on updating the clam section of this table.

FIRST FOOD	Similk Beach	Turner's Bay	KuKutali Preserve	Lone Tree Lagoon	Snee Oosh Beach	Martha's Beach	Risk Key
Salmon	M	M	MH	H	M	M	HIGH
							MEDIUM HIGH
Crabs	MH	M	MH	MH	MH	ML	MEDIUM
							MEDIUM LOW
Clams	MH	M	M	MH	M	NA	LOW
							NA: Species not present
Overall Risk (15 max)	11	9	11	13	10	6	

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