Benthic community changes within a disturbed habitat in Puget Sound

King County

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INTRODUCTION

In 2008, King County, WA constructed a new marine outfall north of the City of Seattle, which discharges highly treated effluent into Puget Sound's Central Basin (Figure 1). The outfall extends approximately one mile offshore and consists of two 63-in diameter pipes that are buried through the nearshore and lie on the seafloor from -80 to -600 ft mean lower low water (MLLW). Open-trench excavation was used for the onshore and nearshore portion of the project (to a depth of -80 ft MLLW). Excavated sediments were stored on a barge until replaced in the trench (Figure 2); due to the sediments being held on the barge during construction, no benthic organisms remained in the sediment following construction.

King County conducted a baseline benthic community characterization in 2006 at seven stations along the outfall trench corridor. Three sampling stations were placed along the trench centerline to monitor recovery in the area in which the benthic community was completely removed (Trench stations). Four sampling stations (two on either side) were placed just outside of the trenching corridor, which was 12 ft wide, to act as proximal reference stations or (Edge stations).

In 2007, additional baseline sampling was planned at the same stations, but were relocated due to unforeseen sampling issues. Post-construction samples were collected in 2009 and 2011, including reference samples from three sites sampled in 2006. See a summary of samples collected in Table 1.

Objective: *The combined four years of benthic community data, as well as information about the sediment characteristics, were used to determine if construction of the Brightwater outfall impacted nearshore benthic communities, and if so, to what degree communities have recovered.*

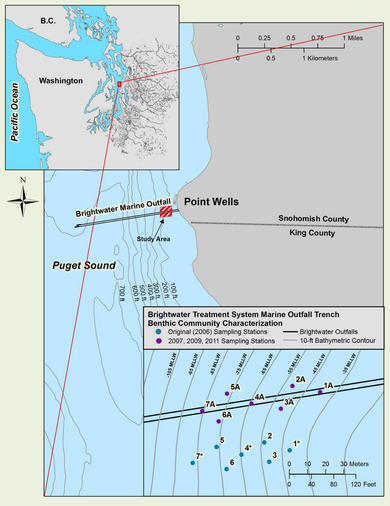

Figure 1. Map of study area located in the Central Basin of Puget Sound near the King/Snohomish County border, with orientation of sampling sites to Brightwater Marine Outfall. * = Reference stations

Figure 2. Replacement of sediments in nearshore trench (sheeted to -35 ft, and unsheeted, -35 to -80 ft).

Table 1. Samples collected from 2006 to 2011.

Station	Years Sampled	Station Type	Average Depth Sampled - m (ft)
1	2006, 2009, 2011	Reference	15.0 (49.2)
2	2006	Reference	15.0 (49.2)
3	2006	Reference	15.0 (49.2)
4	2006, 2009, 2011	Reference	23.0 (75.5)
5	2006	Reference	29.0 (95.1)
6	2006	Reference	27.0 (88.6)
7	2006, 2009, 2011	Reference	31.0 (101.7)
1A	2007, 2009, 2011	Trench	13.3 (43.6)
2A	2007, 2009, 2011	Edge	17.3 (56.8)
3A	2007, 2009, 2011	Edge	18.3 (60.0)
4A	2007, 2009, 2011	Trench	23.7 (77.8)
5A	2007, 2009	Edge	26.0 (85.3)
6A	2007, 2009, 2011	Edge	28.0 (91.9)
7A	2007, 2009, 2011	Trench	31.0 (101.7)

METHODS

- Sediment samples collected from 14 sites total (Figure 1, Table 1)
- Collected by tandem 0.1 m^2 vanVeen grab samplers (Figure 3).
- Contents of one grab used for benthic community characterization and one used for sediment conventional analysis:
  - Conventional sediment parameters
    - 1 sample/site/year (3 grabs composited)
    - Top 10 cm (biologically active zone)
    - Particle size distribution (PSD)
    - Total organic carbon (TOC)
    - Percent solids
  - Benthic fauna (infauna and epifauna)
    - 3 replicates
    - 1 full grab sample
    - Taxa identified and counted
    - Biomass of major groups
- Benthic community samples were sieved with a 1 mm sieve on deck and preserved with buffered formalin for future identification (Figure 4)
- All benthic taxonomy work was conducted by expert taxonomists, with individuals being identified to the lowest practical taxonomic unit (usually to species)

Figure 3. Tandem vanVeen grab sampler. Right grab used for benthic community analysis. Left grab used for sediment characterization.

Figure 4. Sieved benthic sample.

RESULTS

Sediment Characteristics

- Pre-construction sediment samples demonstrated that, like much of Puget Sound at those depths, the sediments were largely sandy (Figure 5)
- Sediment characteristics at reference stations were similar throughout the course of the study
- Several sampling stations had higher % gravel post-construction than pre-construction
  - Most apparent at the – 50 ft MLLW line (Stations 2A and 3A) where % gravel changed from, at its maximum, 0.5% in 2007 to 53.6% by 2011 at station 2A (Figure 5)

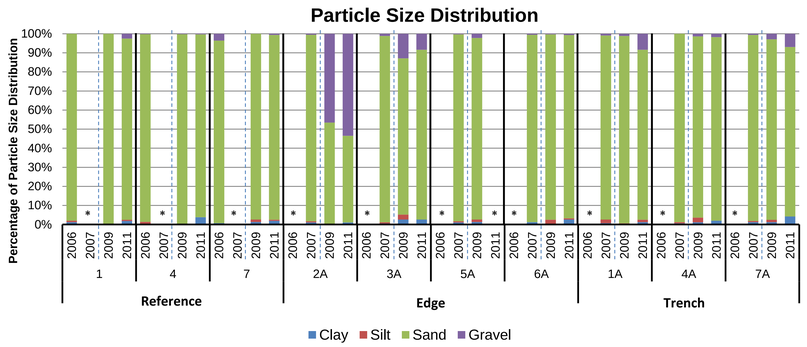

Figure 5. Grain size distribution changes over time within or near the Brightwater trench corridor (2006-2011). Dashed lines indicate separation of pre- and post-construction samples. * = *no sample collected*

Benthic Community Characteristics

- Although sediments were devoid of life when replaced in 2008, by 2009 many species had re-colonized the trenching corridor
- Impacts of construction were greatest at trench stations, but also noticeable at edge stations
- Abundance and biomass were reduced at trench and edge stations in 2009, but were similar to reference stations by 2011; richness remained stable at both trench and edge stations (Figure 6)
- There was an increase in proportional annelid abundance post-construction at trench and edge stations likely due to disturbance (Figure 7)
- Miscellaneous stress sensitive species like nemerteans and echinoderms were most abundant post-construction at trench and edge stations, particularly in 2011
- Diversity, evenness, and dominance post-construction (2009, 2011) at both trench and edge stations were greater than at reference stations during the same time (Figure 8)

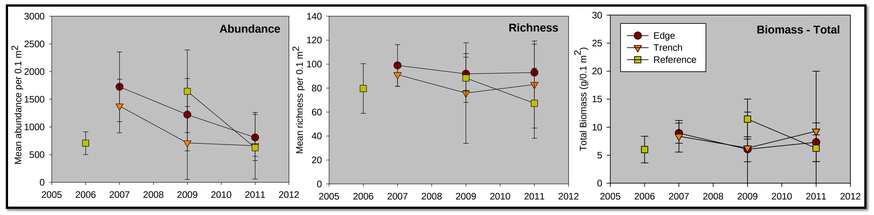

Figure 6. Results of benthic indices at trench, edge, and reference sites from 2006 to 2011. Reference n = 9 replicates (includes only those sites sampled all three years), Edge n = 12 (except for 2011, n = 9), Trench n = 9.

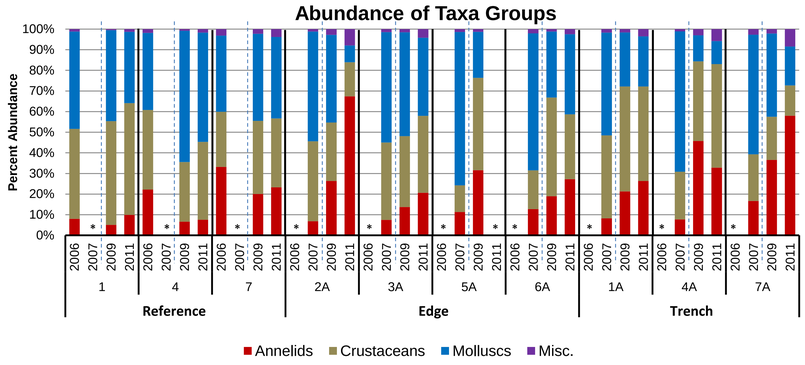

Figure 7. Percent abundance of major taxonomic groups within or near the Brightwater trench corridor (2006-2011). Dashed lines indicate separation of pre- and post-construction samples. * = *no sample collected*

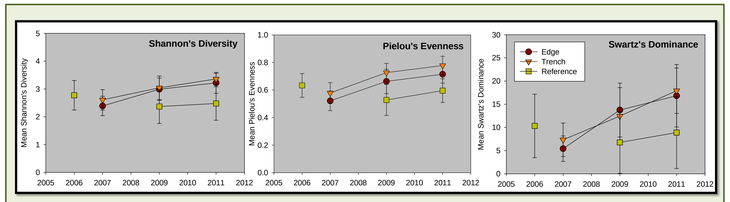

Figure 8. Results of benthic indices at trench, edge, and reference sites from 2006 to 2011. Reference n = 9 replicates (includes only those sites sampled all three years), Edge n = 12 (except for 2011, n = 9), Trench n = 9.

RESULTS cont.

- Multidimensional Scaling Analysis (MDS) of replicate-averaged samples demonstrate that samples largely group together by year and generally arrange along the x-axis according to depth (Figure 9)
- Pre-construction samples collected in 2006 and 2007 did not overlap with one another, likely demonstrating interannual variation within the study area (Figure 9).
- Post-construction samples shared a 55% similarity with samples collected in 2007 with few exceptions. Exceptions included:
  - Two stations with very low richness values (2011 reference and 2009 trench station)
  - Two stations with very high abundance and diversity (2011 one trench, one edge)
- Site 2A, which had the greatest increase in percent gravel post-construction, more closely resembled the deep and diverse station 7A rather than those of similar depth.

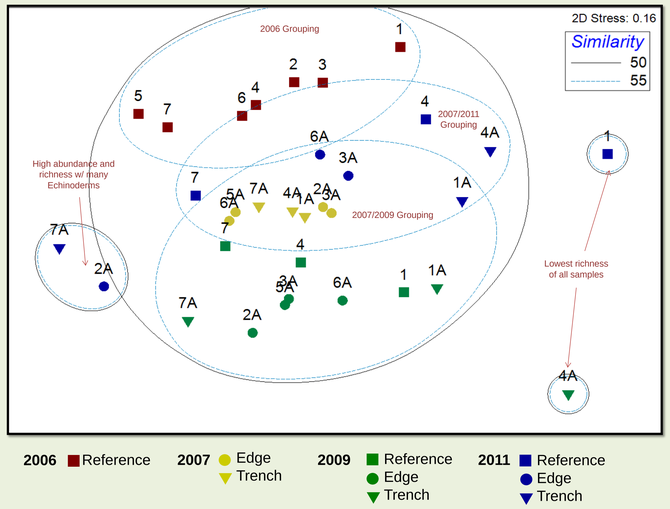

Figure 9. MDS plot of benthic community similarities from nearshore pre- and post-construction monitoring with cluster analysis overlaid. Sites further apart are more dissimilar and different colored circles represent different degrees of similarity. (Fourth-root transformed data used for Bray Curtis similarity matrix)

CONCLUSIONS

Changes in sediment characteristics at trench and edge stations, particularly the increase in percent gravel, indicate that both were impacted by trench construction. Results of the analyses including benthic indices, MDS analysis, and changes in abundance of important taxa in the community, indicate that natural recovery of the denuded subtidal trench area, and likely disturbed edge habitat, occurred during the three years following construction of the Brightwater outfall trench. Benthic community indices at the trenched and edge stations in 2011 indicated a community with characteristics considered healthier than those at reference stations. Those communities at trench and edge stations will continue to mature with additional succession, and any future benthic samples from those stations will likely be indistinguishable from samples taken from reference stations.

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