National Park Service
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Natural Resource Stewardship and Science

# Intertidal Monitoring in the North Coast and Cascades Network

## *Sand Beach Monitoring 2010 Annual Report*

Natural Resource Technical Report NPS/NCCN/NRTR—2012/592

**ON THE COVER**
Clockwise from upper left: The sand beach at Kalaloch (OLYM); Representative beach infauna, the isopod *Exirolana vancouverensis*; the polychaete *Euzonus mucronatus*; the amphipod *Eohaustorius spp*. Sampling infauna at Point of theArches (OLYM).
Photographs by: Steven C. Fradkin

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.



This report is available from The North Coast and Cascades Network website (http://science.nature.nps.gov/im/units/nccn/reportpubs.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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## Abstract

Sand beach monitoring is one component of the North Coast and Cascades Network Intertidal Monitoring Protocol. This monitoring component focuses on the community structure of infaunal marine invertebrates and the physical structure of 7 sand beaches within Olympic National Park. Sand beach infauna is closely linked to its physical habitat. Sand beaches are a major habitat type in Olympic National Park, making up approximately 30% of the intertidal zone. These beaches play an important role in both nutrient cycling and food web dynamics in the nearshore ocean. This report presents data from the 2010 field season. Three shore-normal transects were sampled at each beach. Sampling included infaunal organism abundance, beach sediment composition, and beach elevation profiles. Sediments for most beaches were characterized as well sorted, fine sand beaches with shallow slopes. The exception was Toleak beach, which had moderately sorted, medium sand. These physical differences translated to infaunal community structure differences. A total of 11 taxa were found on the Olympic beaches. All beaches, except Toleak, had similar community structure with an average of 8.3 taxa. The Toleak infauna was significantly different and was substantially depauperate relative to the other beaches, with only 4 taxa. In particular, Toleak lacked most species of amphipods, a group that plays an important role in sand beach energy transfer. Future analyses of historic data and data from the 2011 field season should clarify whether Toleak truly is an outlier and is appropriate for inclusion in this monitoring program, or whether the 2010 season was an anomalous year.

## Acknowledgments

The OLYM field crew included: B. Baccus, J. Jones, M. Nelson, J. Johnson, B. Blackie, A. Pfleeger, L. Loken. Roger Hoffman provided assistance with the composition of GIS maps. Dr. Megan Dethier (University of Washington Friday Harbor Laboratories) and Melissa Miner (UC Santa Cruz/MARINe) provided informal peer review of the draft manuscript.

# Introduction

This report presents data from the 2010 field season for the Sand Beach component of the North Coast and Cascades Network (NCCN) Intertidal Monitoring Protocol (Fradkin and Boetsch *in press*). The Intertidal Monitoring Protocol is part of the Inventory and Monitoring Program of the National Park Service (NPS). This program focuses on "vital signs", which are defined as "information-rich attributes that are used to track the overall condition, or "health" of park natural resources to provide early warning of situations that require intervention" (Fancy et al. 2009). Monitoring has been implemented throughout the National Park system; for this purpose, 270 park units have been organized by ecoregion into 32 networks (Fancy et al. 2009). As one of these networks, the NCCN is composed of eight NPS units, including three parks that contain intertidal resources: Olympic National Park (OLYM), Lewis and Clark National Historical Park (LEWI), and San Juan Island National Historical Park (SAJH). Intertidal communities, particularly those in sand beach habitats, were identified as a key vital sign at numerous workshops developing the NCCN Inventory and Monitoring Program from 2000-2005 (Weber et al. 2009). This prioritization was based on a combination of perceived resource value, logistical and budgetary feasibility, and the current state of scientific methodology. Emphasis was placed on vital sign components that may provide early warning responses to the effects of global climate change and pollution. In contrast to other intertidal habitats, such as rocky intertidal, sand beaches supporting productive infaunal communities are found only within Olympic National Park. The mixed-coarse sediment beaches occurring at the American Camp unit of SAJH are dominated by gravel and have correspondingly low productivity and diversity. Such coarse beaches require substantially different monitoring methodologies (McLachlan 1990, McLachlan and Jaramillo 1995) and are not considered in the NCCN protocol. In LEWI, there is only a single sand beach of which only a ¼-mile long segment of the entire beach (> 5 mi) is within the park boundary. As an Oregon state beach, this section of beach is considered a state highway and receives heavy automobile traffic. This beach is not feasibly sampled. As such, the sand beach monitoring component is conducted solely in Olympic National Park. Other monitoring components in the protocol include rocky intertidal community and intertidal temperature monitoring. The results from these components will be presented in separate reports.

## Study Area

The coastal unit of OLYM, located on the outer Pacific coast of northwest Washington on the Olympic Peninsula (Figure 1), was incorporated into Olympic National Park in 1953. The intertidal zone was added to the park in 1986. Approximately 75% of this continuous stretch of coastline was designated wilderness by Congress in 1988 (Klinger et al. 2007). The coastal unit with its offshore islands has approximately 98 miles of diverse intertidal habitats, including cliffs, rocky platforms, boulder field, cobble beaches, gravel beaches, sand/gravel beaches, high energy fine sand beaches, and several small estuaries. If considered as a separate NPS unit, the OLYM coastal strip would be the 4$^{th}$ largest park (of 8) in the NCCN. The OLYM intertidal is one of the most biologically- and habitat-diverse shorelines on the west coast of North America (Blanchette et al. 2008, Schoch et al. 2006). The park shoreline can be broken up into four segments, or nearshore cells (Figure 1), that are characterized by differences in temperature and salinity (Schoch 1999). There are 28 sand beaches on the OLYM coast, occupying ~30% of the park shoreline.


**Figure 1**. Location of Sand Beach monitoring sites within the coastal strip of Olympic National Park (OLYM). Colored beach segments denote nearshore cells characterized by different temperature and salinity (Schoch 1999).

## Rationale

Open coast sand beaches that dissipate wave energy are broad and relatively low-sloped. Such beaches are highly productive and host relatively stable infaunal communities, while exposed sand/gravel beaches tend to have depauperate, ephemeral communities (Brown and McLachlan 2002). Sand beaches are major habitat in OLYM, and their infaunal organisms play an important role in nutrient recycling in the nearshore ocean (McLachlan and Brown 2006) and are key resources to migrating birds. These habitats and their infaunal communities are particularly susceptible to global climate change, shoreline modification, and oil spills (Brown and McLachlan 2002).

The overarching goal of sand beach monitoring component is to detect ecologically significant changes in infaunal biota and beach structure as indicators of ecosystem health and as an early warning of ecosystem impacts. Specific monitoring objectives are to characterize inter-annual natural variation and detect trends in the species abundance, community structure and physical structure of sand beach habitats. Ultimately, trend detection may help park managers to formulate appropriate management actions, adaptation strategies, and where appropriate, to trigger targeted research to identify causal stressors. Additionally, the results from this program will be converted into interpretive materials that will inform the American public about the status of key park resources.

## Sampling Design

The sand beach sampling design focuses on the high to mid zone beach elevations. Sampling of this zone allows for adequate sampling time before inundation by rising tides and targets an infaunal community with a tractable set of taxa that can be reliably identified by trained seasonal field staff. Two sand beaches were chosen at random from a list of potential beaches within each nearshore cell, with the exception of the northernmost, where only one sand beach is present. Beaches were sampled annually during late June and July on morning low tides of +1.0 ft or less to allow adequate working time. The sampling methodology employed was modified from a legacy OLYM monitoring program developed by Dethier (1997) and further modified using the methodologies of Jaramillo et al. (1995), Defeo and Rueda (2002), Schoeman et al. (2003), and McLachlan and Brown (2006).

# Methods

The methodology for sampling sand beaches is covered in detail in the NCCN Intertidal Monitoring Protocol (Fradkin and Boetsch 2012) and is briefly summarized here.

## Field Sampling

Three transects are randomly determined anew each year on each target beach. Transects were located in the field via GPS. Each vertical transect was shore-normal, starting from the most recent high tide line and extending to the water line. Sampling stations for biota were spaced every 7.5 m along the top 60 m of each transect, where four sediment cores were extracted and passed through a 1 mm sieve to retain all macroscopic infaunal organisms (Figure 2). Sediment cores were 10 cm diameter, extending to a depth of 10 cm. All organisms within cores were counted and identified to the appropriate taxonomic level (see Appendix A). Sand beaches can have short sections where coarse sediments (gravel) accumulate via variation in wave action and long-shore currents. These areas represent very different, physically harsh, habitat types that support few infauna. These areas are not comparable to the surrounding sand beach areas. Where random transect locations landed on such coarse substrates, a new random transect was selected.

Sediment samples were taken along the top 60 m of each transect at 15 m intervals (Figure 2). Cores were transported to the lab, where they were dried and sorted through a column of graded Tyler sieves. These size fractions were then weighed to determine sediment composition. Beach elevation profiles were also determined for the entirety of each transect. Profiles were surveyed using a laser auto-level to determine elevations from the most recent high tide line to the current water level at 7.5 m intervals.

## Analysis

Comparisons of sand beach community structure were made between beaches and nearshore cells. For each transect, invertebrate count data were used to estimate the number of individuals per strip transect (IST), after Defeo and Rueda (2002):

$$IST = \frac{\sum_i q_i}{n} w$$

where  is the density of infauna in each core,  is the number of cores per transect and *w* is the width of the transect. IST data were analyzed using the multivariate methods in PRIMER-V6 (Clarke and Gorley 2006). Data were square root transformed to deemphasize the most abundant organisms (*sensu* Clarke and Warwick 2001). Bray-Curtis similarities were generated and represented with non-metric multidimensional scaling (MDS). Similarity percentage analyses (SIMPER) were used to identify taxa contributing the most to average similarity within beaches, and analysis of similarity (ANOSIM) was used to test the significance of differences in community structure between beaches. An analysis of taxonomic distinctness (Warwick and Clarke 1995) of each beach was conducted using the TAXTDEST procedure and a master taxa list for all beaches.

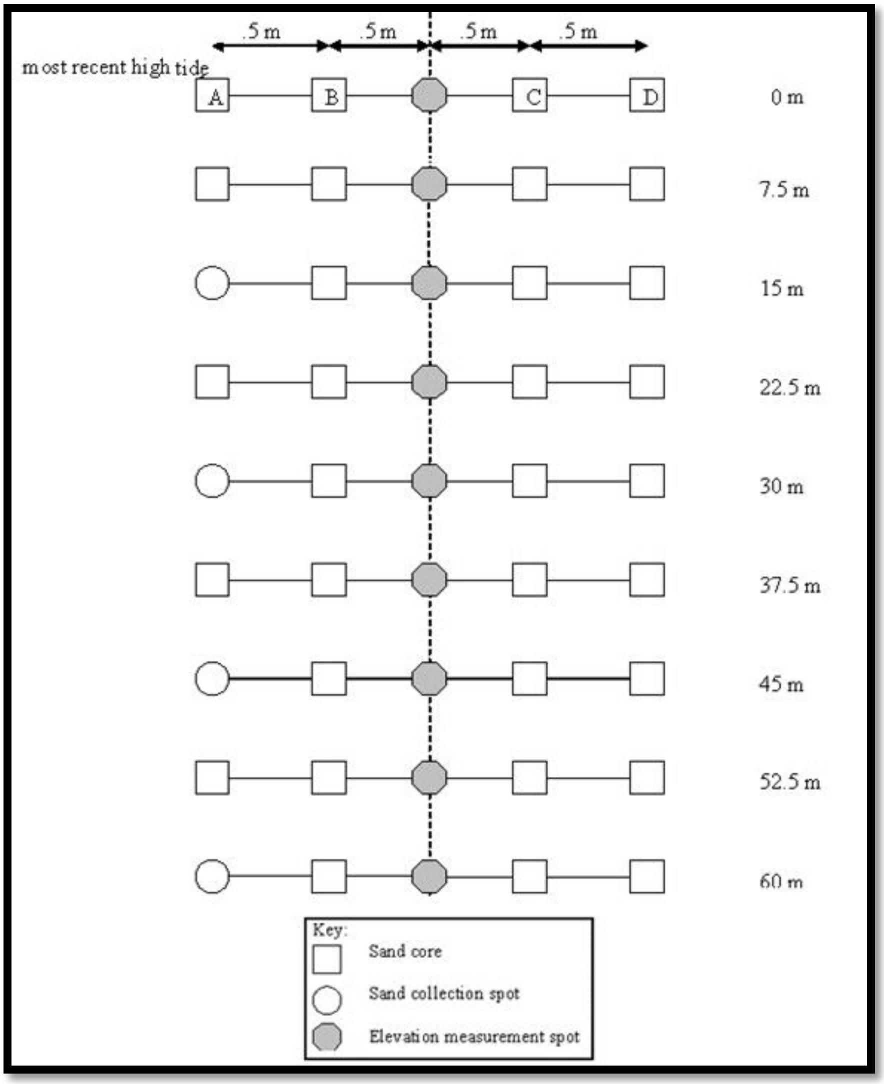


**Figure 2**. Schematic diagram of a sand beach monitoring transect. Each transect spans a shore normal 2 m wide belt from the most recent high tide line to 60 m seaward. Elevations were measured at each level along the centerline (shaded symbol), and beach infauna were sampled at 4 stations (open symbols) at each level. Sand cores were collected for sediment size composition at 4 levels (open circles).

Sediment composition and description was determined using the GRADISTAT (version 8.0) particle size analysis software (Blott and Pye 2001) following the analytic methods of Folk (1954). Beach Index (BI), an index combining slope, sand, and tidal values to characterize beach type was also computed according to McLaughlin and Brown (2006):

$$\mathrm{BI} = \log_{10} (\textit{sand} * \textit{tide}/\textit{slope})$$

where *sand* is the mean particle size (Φ), *tide* is the maximum spring tidal range (m), and *slope* is the beach face slope of each transect.. Beach elevation profile data were analyzed in JMP 7.0 (SAS 2007) to determine beach face slopes.

# Results and Discussion

## Sediment Composition and Beach Slope

Target OLYM sand beaches are classified as intermediate meso-tidal beaches as defined by McLachlan and Brown (2006). With the exception of Toleak beach, these beaches were all well sorted (i.e., relatively uniform sediment composition), fine sand, moderately sloping beaches that are intermediate in their dissipation of wave energy across their face (Table 1). The sediment grain size composition was dominated by fine sand (Table 1, Figure 3). Toleak beach was moderately sorted (i.e., less uniform sediment composition) and dominated by medium sand with a sizeable component of gravelly sand (Table 1, Figure 3).

Beach face profiles illustrate the moderate slopes found on the target beaches, with the exception of Toleak which was more steeply sloped (Table 1, Figure 4). Beaches with slopes less than 10 generally indicate coarse sand and gravel beaches (McLachlan and Brown 2006).

## Infaunal Community Structure

The infaunal community composition of replicate beach transects was similar, as illustrated by the clustering of triplicate points in the MDS analysis (Figure 5). Significant community structure differences between nearshore cell beaches were detected between the nearshore cell containing Toleak beach (cell 3) and two of the three other nearshore cells (cells 2 and 4; Figure 5). However, once Toleak was removed from the analysis, no differences in community structure between any of the four nearshore cells existed (Figure 6). This result is consistent with the similarity of sediment composition and slopes across beaches, implying that the relatively coarse grained, steeply sloped physical structure of Toleak beach favors a different infaunal community structure.

A SIMPER analysis examining similarities in community structure shows Olympic sand beaches in 2010 were structured around *Eohaustorius* amphipods, in addition to *Excirolana* isopods and the bloodworm *Euzonus mucronatus* (Table 2). Conversely, a SIMPER analysis of dissimilarities shows that Toleak differed from the other beaches largely due to the absence of *Eohaustorius* (Table 3). Haustoriid amphipods are known to be dominant taxa on North American fine sandy beaches (McLachlan and Brown 2006) and their absence at Toleak is consistent with the coarser grain size and steeper slopes found there.

**Table 1**. Beach slope*, beach index, sediment grain-size composition measures, and composition type description. Values are averages of 3 replicate transects per beach. Beach slope* is the reciprocal of the beach face slope. Beach index combines slope, mean sand particle size, and maximum spring tidal range (4.12 m) into a single beach characterization measure ranging from 0 to 4. 0 represents beaches with coarse sand, small tides and small waves, while 4 represents fine sand, large tides, and big waves. OLYM study beaches are intermediate meso-tidal beaches (McLachlan and Brown 2006).

| Beach | Beach slope* | Beach index (log Φ m) | Mean grain size | Mean Φ | Sediment type | Mean sorting value | Sorting type | Mean skewness | Skewness type | Mean kurtosis | Kurtosis type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SHI | 17.2 | 2.35 | 229.5 | 2.1 | fine sand | 0.12 | very well sorted | 0.13 | positive | 1.60 | very leptokurtic |
| SAN | 20.2 | 2.42 | 251.6 | 2.2 | fine sand | 0.89 | moderately sorted | 0.36 | strong positive | 4.03 | extremely leptokurtic |
| CED | 15.6 | 2.32 | 216.6 | 2.2 | fine sand | 0.41 | well sorted | 0.31 | strong positive | 4.57 | extremely leptokurtic |
| SEC | 15.8 | 2.31 | 230.9 | 2.1 | fine sand | 0.15 | very well sorted | -0.20 | negative | 2.05 | very leptokurtic |
| TOL | 6.6 | 1.85 | 334.4 | 1.6 | med sand | 0.83 | moderately sorted | -0.56 | strong negative | 1.87 | very leptokurtic |
| RUB | 14.9 | 2.31 | 201.9 | 2.3 | fine sand | 0.35 | well sorted | 0.60 | strong positive | 2.35 | very leptokurtic |
| KAL | 20.2 | 2.41 | 229.5 | 2.1 | fine sand | 0.15 | very well sorted | 0.23 | positive | 2.25 | very leptokurtic |

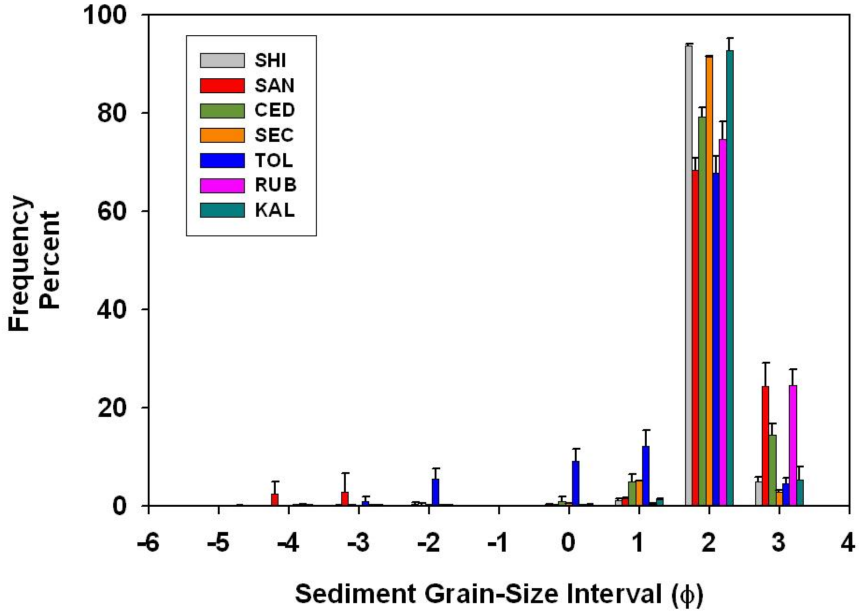


**Figure 3**. Beach sediment grain-size (Phi) frequency histogram for all 7 OLYM study beaches (from North to South). Histogram bars are average values (± 1 SE) for 3 replicate transects per beach. Small phi (Φ) values denote larger grain sizes. Sand has Φ values between -1 and 4. The most abundant grain-size (Φ = 2) was fine sand.

## Taxonomic Distinctness

Average taxonomic distinctness is the average taxonomic distance apart (phylogenetically) of all species pairs within a species list (Clarke and Gorley 2006). Taxonomic distinctness measures the taxonomic breadth of a sample. Figure 7 displays a funnel plot with simulated 95% probability limits for average taxonomic distinctness based on 999 taxa sub-lists drawn randomly from a master list of 11 taxa. Toleak beach had many fewer taxa (mean of 2.7) than other beaches (group average of 6.4; Appendix A). Several beaches (SAN, SEC, KAL) had individual transects with significantly narrower taxonomic breadths (i.e., low average taxonomic distinctness as determined by points falling outside of the 95% probability limit), illustrating the utility of replicate transects.

## Conclusions

The target sand beaches sampled as part of the NCCN Intertidal Monitoring Protocol span the latitudinal gradient of the 70-mile Olympic National Park shoreline. The 2010 sampling reported here suggests that, with exception of Toleak beach, the physical and biological structure of these beaches is very similar to each other. These beaches represent a reasonable array of sites to detect changes associated with climate change and oil spills along the Olympic coast. Toleak beach was found to be structurally and faunally different from the other target beaches. Legacy data from 2004 through 2011 will need to be examined to determine whether this result is consistent across years. If Toleak beach maintains such differences from the other beaches, we will cease future sampling at Toleak.

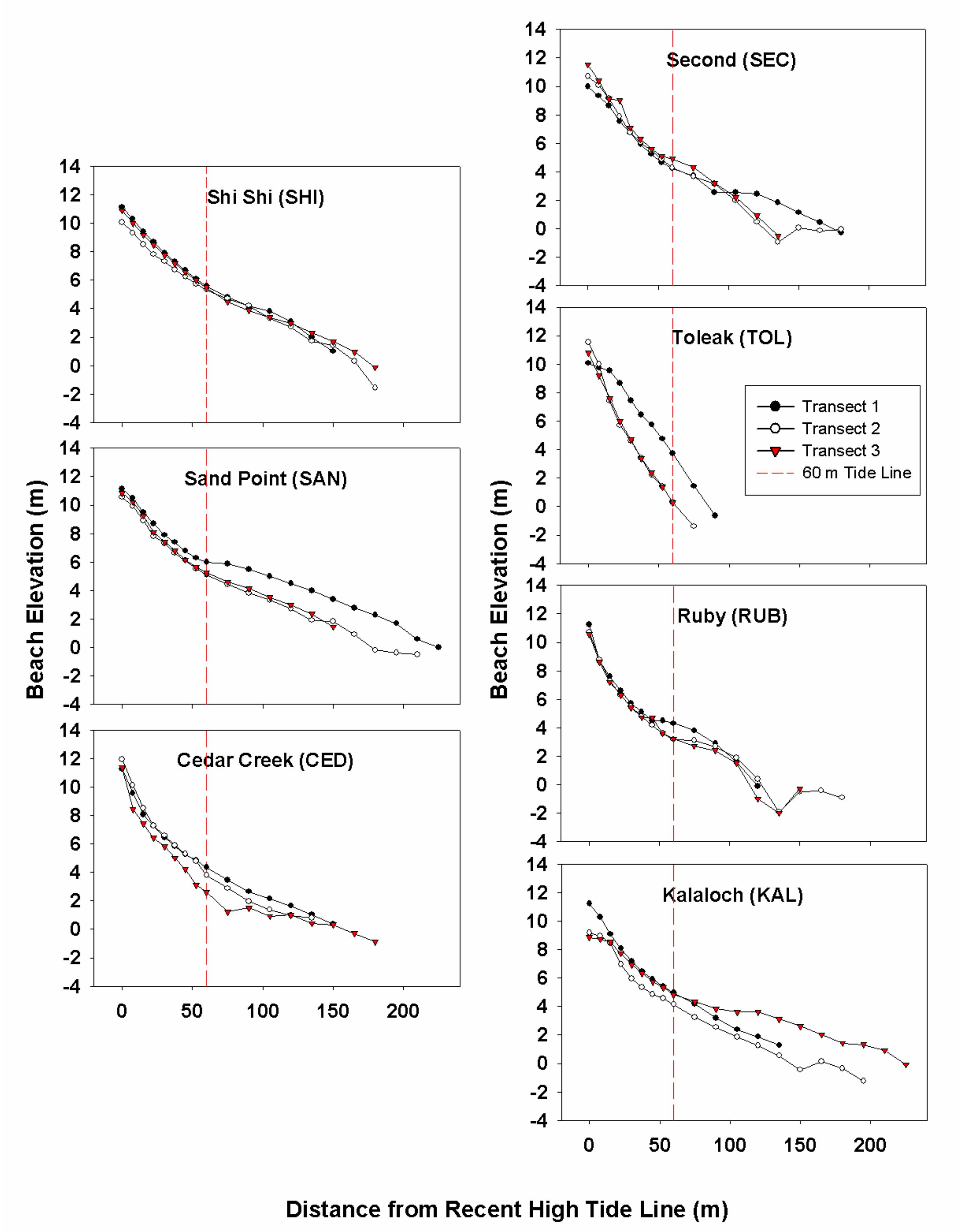


**Figure 4**. Beach face profiles of triplicate shore normal transects at each sand beach monitoring site in OLYM in 2010. Transects start from most recent high tide line and extend to water level at time of sampling. Red vertical dotted lines denote the lowest extent of benthic infaunal sampling (60 m).

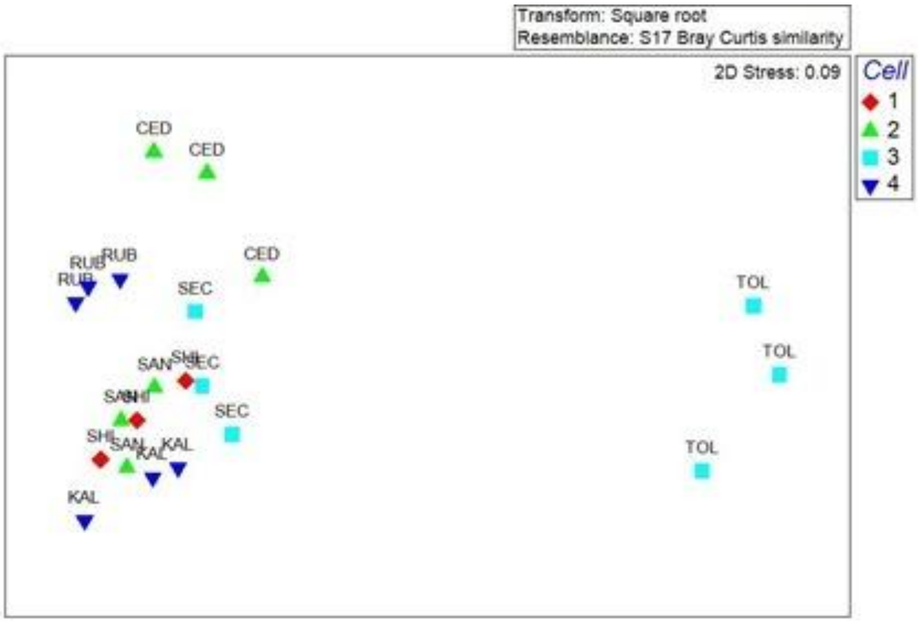


**Figure 5**. Sand beach infaunal assemblages from all OLYM study beaches. MDS plot for square root transformed taxa counts from 11 taxa from 3 replicate transects within each of 7 beaches. Symbols represent nearshore cells and labels represent beach codes. One way analysis of similarities (ANOSIM) shows a significant difference between cells (R=0.145, p=0.043) driven by the Toleak beach samples. Pairwise comparisons show significant differences between cells 2 and 3, and cells 3 and 4 (R=0.287, p = 0.03 and R=0.33, p = 0.015 respectively).

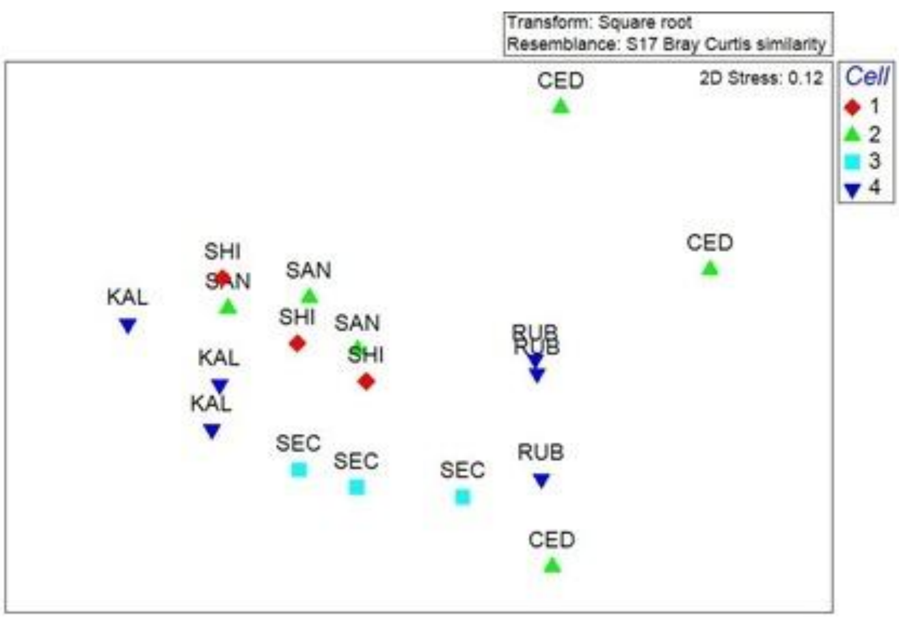


**Figure 6.** Sand beach infaunal assemblages from all OLYM study beaches except Toleak beach. MDS plot for square root transformed taxa counts from 11 taxa from 3 replicate transects within each of 6 beaches. One way analysis of similarities (ANOSIM) shows no significant difference between cells (R=0.025, p=0.373).

**Table 2**. Infaunal taxonomic contribution to similarity of community structure at 7 OLYM study beaches as determined by SIMPER analysis. Taxa shown are those contributing up to a cut-off of ~80% cumulative percent contribution. Beaches are arranged latitudinally from north to south.

| Beach | Species | Average Abundance | Average Similarity | Similarity SD ratio | Percent Contribution | Cumulative Percent |
|---|---|---|---|---|---|---|
| SHI | *Eohaustorius spp.* | 5.38 | 41.84 | 8.99 | 53.69 | 53.69 |
| | *Excirolana spp.* | 1.74 | 14.72 | 9.44 | 18.89 | 72.58 |
| | *Euzonus mucronatus* | 1.41 | 10.66 | 8.93 | 13.68 | 86.25 |
| SAN | *Eohaustorius* spp. | 5.66 | 44.15 | 12.51 | 54.86 | 54.86 |
| | *Euzonus mucronatus* | 2.01 | 14.96 | 20.17 | 18.59 | 73.45 |
| CED | *Eohaustorius spp.* | 1.75 | 34.43 | 3.2 | 58.66 | 58.66 |
| | *Excirolana spp.* | 0.73 | 8.96 | 2.05 | 15.27 | 73.93 |
| | *Euzonus mucronatus* | 1.4 | 7.48 | 0.58 | 12.74 | 86.68 |
| SEC | *Eohaustorius spp.* | 3.93 | 46.29 | 17.7 | 64.57 | 64.57 |
| | *Excirolana spp.* | 1.27 | 15.93 | 3.03 | 22.23 | 86.8 |
| TOL | *Excirolana spp.* | 0.63 | 36.8 | 3.17 | 60.8 | 60.8 |
| | *Megalorchestia spp.* | 0.86 | 23.72 | 2.55 | 39.2 | 100 |
| RUB | *Eohaustorius spp*. | 3.07 | 54.34 | 12.43 | 65.19 | 65.19 |
| | *Eteone spp.* | 0.5 | 7.67 | 7.65 | 9.21 | 74.39 |
| | Unidentified nemertean | 0.34 | 5.52 | 3.52 | 6.62 | 81.01 |
| KAL | *Eohaustorius spp.* | 7.15 | 41.48 | 9.24 | 58.73 | 58.73 |
| | *Proboscinotus loquax* | 2.04 | 10.26 | 2.32 | 14.53 | 73.25 |
| | *Excirolana spp.* | 1.46 | 7.75 | 4.77 | 10.97 | 84.23 |

**Table 3**. Pairwise comparisons of infaunal taxonomic contribution to differences (dissimilarity) in community structure between all OLYM study beaches and Toleak beach (TOL) as determined by SIMPER analysis. Taxa shown are those contributing up to a cut-off of ~80% cumulative percent contribution. The average dissimilarity of all beaches (except TOL) from each other is 41.76 ± 11.73.

| Beach | Average Dissimilarity from TOL | Taxa | Comparative Beach Average Abundance | TOL Beach Average Abundance | Average Dissimilarity | Dissimilarity SD ratio | Percent Contribution | Cumulative Percent |
|---|---|---|---|---|---|---|---|---|
| CED | 80.11 | *Eohaustorius spp.* | 1.75 | 0 | 30.78 | 2.79 | 38.42 | 38.42 |
| | | *Euzonus mucronatus* | 1.4 | 0.09 | 20.29 | 1.2 | 25.32 | 63.74 |
| | | *Megalorchestia spp.* | 0 | 0.86 | 13.45 | 1.61 | 16.78 | 80.52 |
| KAL | 86.31 | *Eohaustorius spp.* | 7.15 | 0 | 45.08 | 9.14 | 52.23 | 52.23 |
| | | *Proboscinotus loquax* | 2.04 | 0 | 13.03 | 2.85 | 15.1 | 67.33 |
| | | *Excirolana spp.* | 1.46 | 0.63 | 5.68 | 1.34 | 6.58 | 73.91 |
| | | *Eteone spp.* | 0.68 | 0 | 4.2 | 2.56 | 4.87 | 78.77 |
| | | *Megalorchestia spp.* | 0.33 | 0.86 | 3.8 | 1.21 | 4.4 | 83.17 |
| RUB | 93.65 | *Eohaustorius spp.* | 3.07 | 0 | 43.36 | 6.42 | 46.3 | 46.3 |
| | | *Megalorchestia spp.* | 0 | 0.86 | 11.23 | 1.61 | 11.99 | 58.29 |
| | | *Excirolana spp.* | 0.09 | 0.63 | 7.49 | 4.06 | 8 | 66.29 |
| | | *Eteone spp.* | 0.5 | 0 | 7 | 5.87 | 7.48 | 73.76 |
| | | *Euzonus mucronatus* | 0.53 | 0.09 | 6.7 | 1.41 | 7.15 | 80.92 |
| SAN | 85.3 | *Eohaustorius spp.* | 5.66 | 0 | 44.46 | 9.08 | 52.13 | 52.13 |
| | | *Euzonus mucronatus* | 2.01 | 0.09 | 15.31 | 3.61 | 17.94 | 70.07 |
| | | *Excirolana spp.* | 1.77 | 0.63 | 9.06 | 2.46 | 10.63 | 80.7 |
| SEC | 76.94 | *Eohaustorius spp.* | 3.93 | 0 | 45.94 | 6.5 | 59.71 | 59.71 |
| | | *Megalorchestia spp.* | 0.47 | 0.86 | 8.02 | 1.32 | 10.42 | 70.13 |
| | | *Excirolana spp.* | 1.27 | 0.63 | 7.91 | 2.02 | 10.28 | 80.4 |
| SHI | 84.62 | *Eohaustorius spp.* | 5.38 | 0 | 42.89 | 11.5 | 50.68 | 50.68 |
| | | *Proboscinotus loquax* | 1.71 | 0 | 12.51 | 1.81 | 14.78 | 65.46 |
| | | *Euzonus mucronatus* | 1.41 | 0.09 | 10.52 | 4.92 | 12.44 | 77.9 |
| | | *Excirolana spp.* | 1.74 | 0.63 | 9.03 | 4.24 | 10.68 | 88.58 |

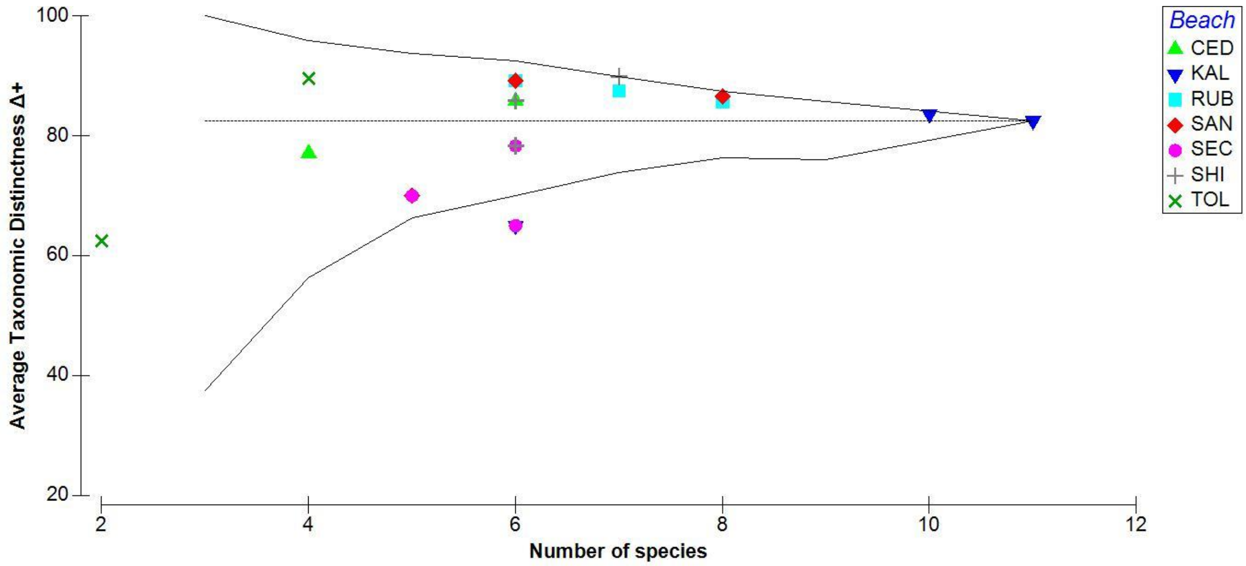


**Figure 7**. Funnel plot of average taxonomic distinctness (Δ+) versus number of species in taxonomic sub-list for sand beach infaunal assemblages in each transect at each beach. Thick lines indicate 95% probability limits for simulated Δ+ values. The dotted line denotes Δ+ for the entire taxa list. Symbols denote actual Δ+ values for the beach/transect combinations.

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# Appendix A: Sand Beach Infauna IST abundances.

**Table A.11**. Number of individuals per strip transect (IST) at each replicate transect on the 7 study beaches in OLYM.

| | SHI | | | SAN | | | CED | | | SEC | | | TOL | | | RUB | | | KAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Row Labels** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| Arthropoda | | | | | | | | | | | | | | | | | | | | | |
| Crustacea | | | | | | | | | | | | | | | | | | | | | |
| Amphipoda | | | | | | | | | | | | | | | | | | | | | |
| *Eohaustorius spp.* | 41.50 | 31.71 | 16.50 | 46.93 | 31.50 | 20.29 | 4.71 | 1.93 | 2.86 | 13.36 | 27.00 | 8.64 | 0 | 0 | 0 | 10.07 | 9.14 | 9.07 | 96.07 | 35.70 | 32.14 |
| *Megalorchestia spp.* | 0 | 0 | 0.14 | 0.07 | 0 | 0.07 | 0 | 0 | 0 | 0.07 | 1.29 | 0 | 0.07 | 0.43 | 2.71 | 0 | 0 | 0 | 0 | 0.15 | 0.36 |
| Phoxocephalidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0.14 | 0.07 | 0.07 | 0 | 0.21 | 0 | 0 | 0 | 0.07 | 0 | 0.14 | 0.36 | 0.07 | 0.21 |
| *Proboscinotus loquax* | 11.29 | 1.14 | 0.50 | 1.71 | 0.93 | 0.14 | 0 | 0 | 0 | 1.07 | 0.14 | 0.14 | 0 | 0 | 0 | 0.14 | 0.07 | 0.07 | 8.14 | 1.11 | 4.93 |
| Isopoda | | | | | | | | | | | | | | | | | | | | | |
| *Excirolana spp.* | 2.79 | 3.93 | 2.43 | 4.36 | 1.43 | 4.07 | 1.50 | 0.50 | 0.07 | 2.29 | 0.86 | 1.86 | 0.50 | 0.29 | 0.43 | 0 | 0.07 | 0 | 1.86 | 0.89 | 4.29 |
| Annelida | | | | | | | | | | | | | | | | | | | | | |
| Polychaeta | | | | | | | | | | | | | | | | | | | | | |
| *Euzonus mucronatus* | 3.64 | 1.43 | 1.29 | 3.36 | 7.00 | 2.43 | 0.00 | 9.71 | 1.14 | 0.00 | 0 | 0 | 0 | 0 | 0.07 | 0.71 | 0 | 0.57 | 0.50 | 0.37 | 0 |
| *Nephtys spp.* | 0.07 | 0.07 | 0.14 | 0 | 0 | 0.07 | 0.07 | 0.07 | 0 | 0 | 0.07 | 0.07 | 0 | 0 | 0.07 | 0.29 | 0.07 | 0.14 | 0.07 | 0.15 | 0 |
| *Eteone spp.* | 0.07 | 0.07 | 0 | 0 | 0.07 | 0.07 | 0 | 0.14 | 0 | 0 | 0.07 | 0 | 0 | 0 | 0 | 0.29 | 0.14 | 0.36 | 0.93 | 0.67 | 0.07 |
| *Pygospio sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.14 | 0 | 0 | 0.36 | 1.41 | 0 |
| Unidentified # 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0.52 | 0 |
| Nemertea | | | | | | | | | | | | | | | | | | | | | |
| Unidentified nemertean | 0 | 0.07 | 0 | 0 | 0.14 | 0.14 | 0 | 0 | 0 | 0.07 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0.14 | 0.14 | 0.14 | 0.44 | 0 |
| **Number of taxa** | 6 | 7 | 6 | 5 | 6 | 8 | 4 | 6 | 4 | 6 | 6 | 5 | 2 | 2 | 4 | 8 | 6 | 7 | 10 | 11 | 6 |
| **Mean number of taxa** | | 6.3 | | | 6.3 | | | 4.7 | | | 5.7 | | | 2.7 | | | 6.3 | | | 9.0 | |

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